13.5 L OEM Diesel Engines Base Engine Repair

TECHNICAL MANUAL

POWERTECH 13.5 L Diesel Engines— Base Engine

CTM415 30JAN08 (ENGLISH)

For complete service information also see:

POWERTECH® 13.5L Diesel Engines—Level 15 Electronic Fuel Systems	CTM370
OEM Engine Accessories	CTM67 (English Only)
Alternators and Starter Motors	CTM77

John Deere Power Systems
LITHO IN U.S.A.

Introduction

Forward

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 (CTM415) covers only the base engine. It is one of two volumes on 13.5 L engines. The following companion manual covers electronic fuel system repair, operation and diagnostics:

- CTM370—Level 15 Electronic Fuel Systems With Delphi/Lucas EUIs

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

This manual covers the base engine repair for all 13.5 L models:

- Tier II PowerTech™
- Tier III PowerTech™ E.
- Tier III PowerTech™Plus

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 Section 01, Group 001 identifies product-model/component type-model relationship.

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

Before beginning repair on an engine, clean the engine and mount on a repair stand. (See Section 2, 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.

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 this and for engine removal and installation procedures.

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

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.

POWERTECH is a trademark of Deere & Company

RE38635,0000079 –19–31JAN08–1/1

John Deere Dealers

The changes listed below make your CTM obsolete. Repair, operation and diagnostics on 13.5 L diesel engines is covered in two manuals. Fuel system repair and engine diagnostics can be found in CTM370.

Following is a listing of major sections of this manual. Future revisions to CTM415 will be documented in this section.

SECTION 01, GROUP 000 (Safety)

SECTION 01, GROUP 001 (Engine Identification and Applications)

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

SECTION 02, GROUP 010 (Engine Rebuild)

SECTION 02, GROUP 020 (Cylinder Head and Valves)

SECTION 02, GROUP 030 (Cylinder Block, Liners, Pistons and Rods)

SECTION 02, GROUP 040 (Crankshaft, Main Bearings and Flywheel)

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

SECTION 02, GROUP 060 (Lubrication System)

SECTION 02, GROUP 070 (Cooling System)

SECTION 02, GROUP 080 (Air Intake and Exhaust System)SECTION 02, GROUP 081 (Air Intake and Exhaust System — PowerTech™ E)

GROUP 100 (Starting and Charging Systems)

SECTION 03—GROUP 120 (Base Engine Operation)

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

SECTION 04—GROUP 150 (Observable Diagnostics and Tests)

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

SECTION 5 (Tools and Other Materials)

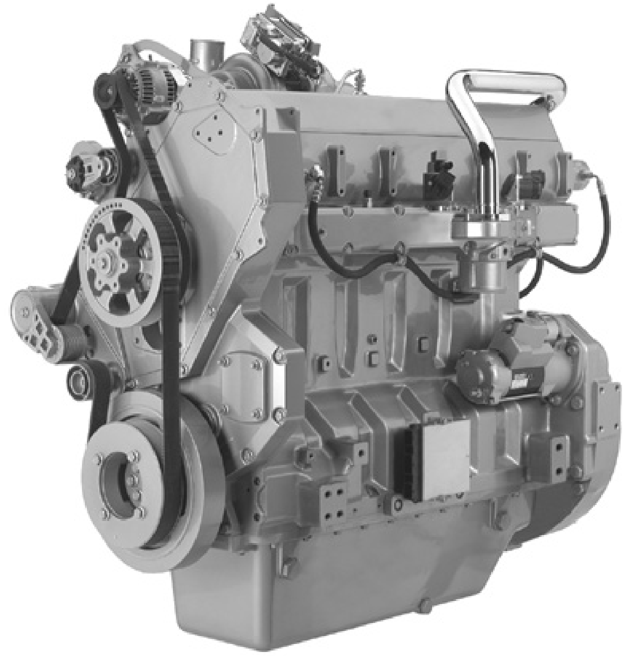
- All essential tools, service tools, dealer fabricated tools and other materials listed throughout this manual are consolidated in this section for ease of reference.

SECTION 6 (Specifications)

- All repair, test and diagnostic specifications listed throughout this manual are consolidated in this section for ease of reference.
- Updated dynamometer test specifications.
- Updated intake manifold pressure specifications.

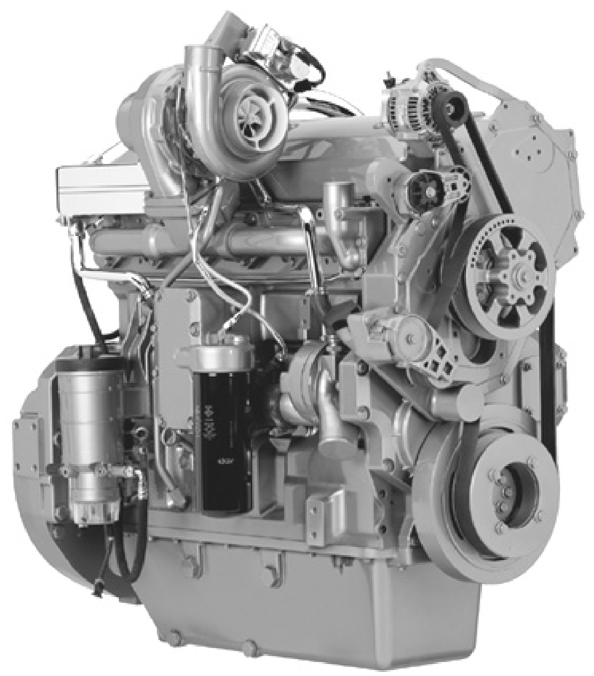
OUO1004,0000BBC –19–11OCT00–1/1

PowerTech™ Plus 6135HF485 Engines



RG13885 –UN–19MAY05

13.5L Engine - Left Front View

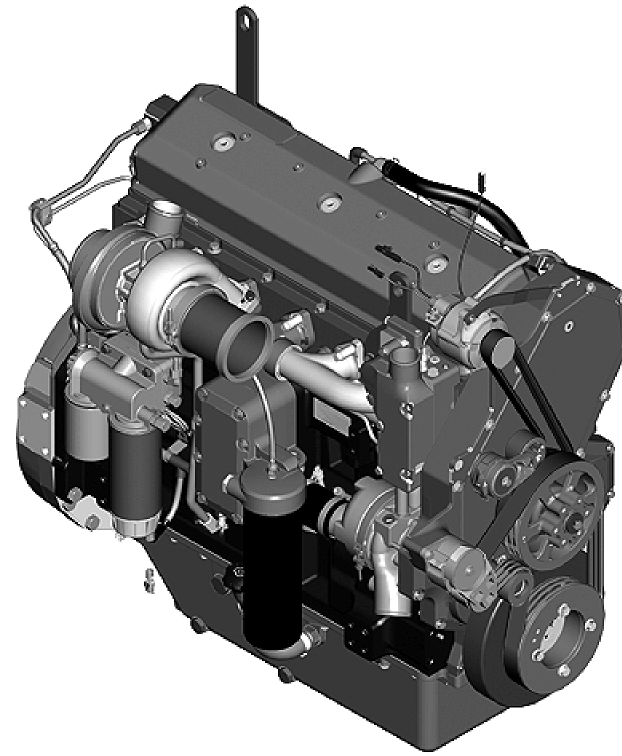


RG13886 –UN–19MAY05

13.5L Engine - Right Front View

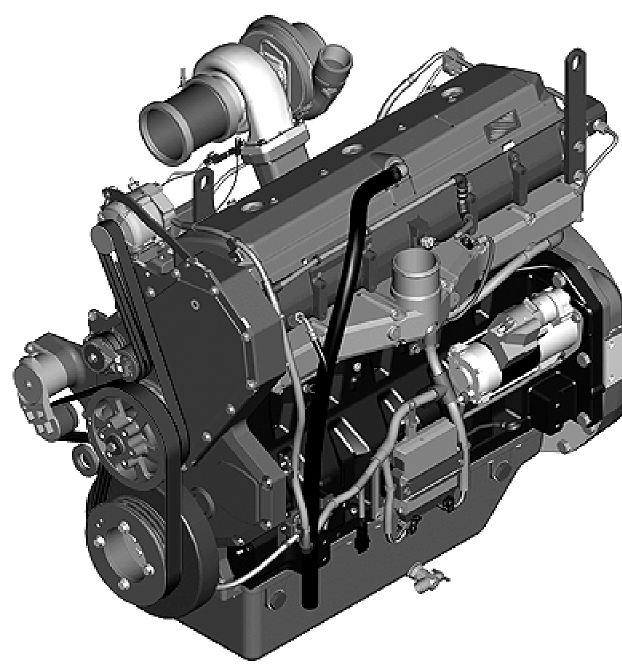
RE38635,0000107 –19–09NOV07–1/1

PowerTech™ E 6135HF475 Engines



RG15665 –UN–23OCT07

13.5 L Engine - Right Front View

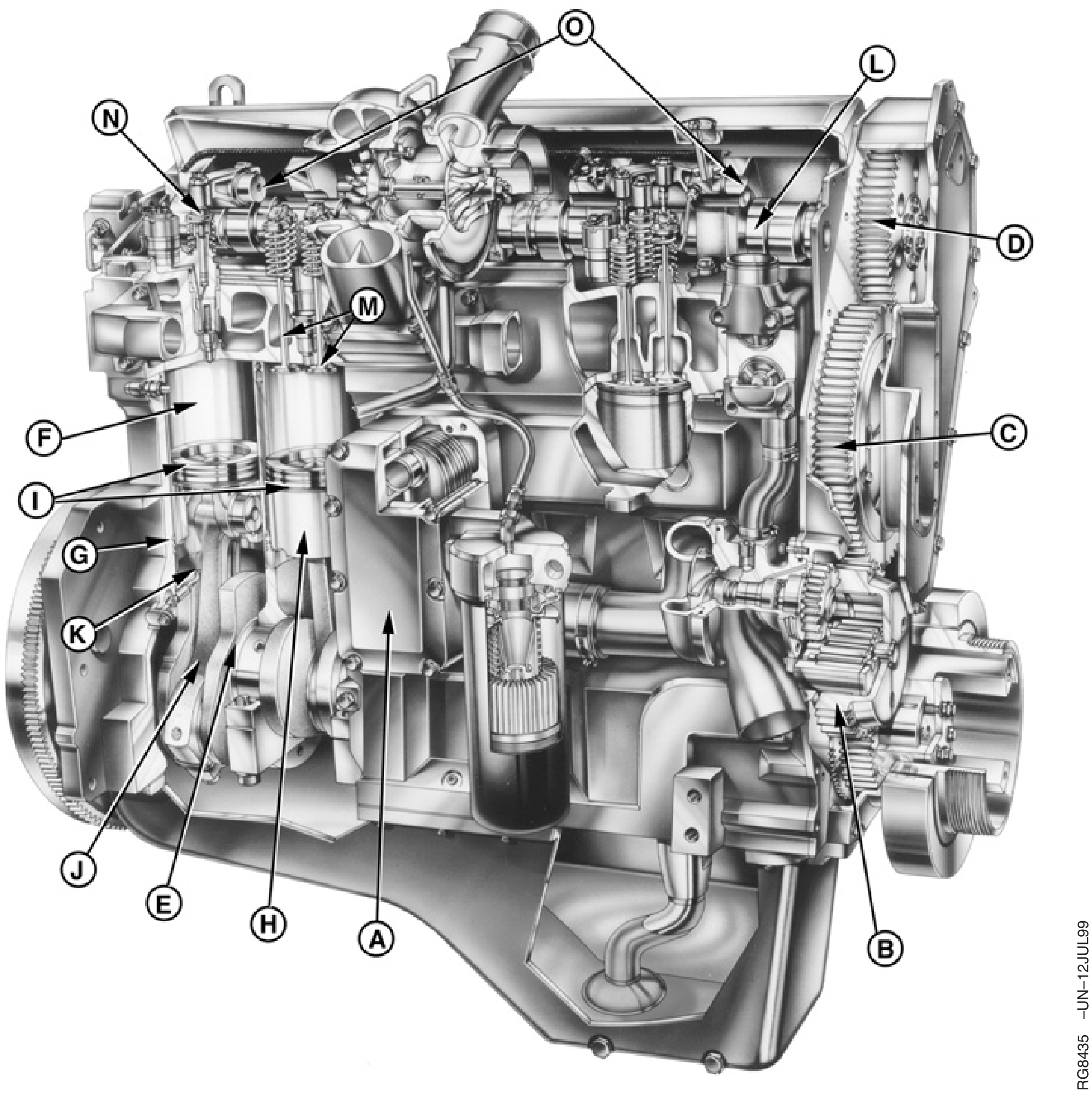


RG15666 –UN–23OCT07

13.5 L Engine - Left Front View

RE38635,00000EA –19–30NOV07–1/1

6135 PowerTech™ Engine Cutaway View



Engine Cutaway View

A—Oil Cooler
B—Oil Pump Drive Gear
C—Idler Gear
D—Camshaft Gear
E—Crankshaft
F—Cylinder Liner
G—Cylinder Liner O-Rings
H—Piston
I—Piston Rings
J—Connecting Rod
K—Oil Spray Jet
L—Camshaft
M—Valves
N—Electronic Unit Injector
O—Two-Piece Rocker Arm Shaft

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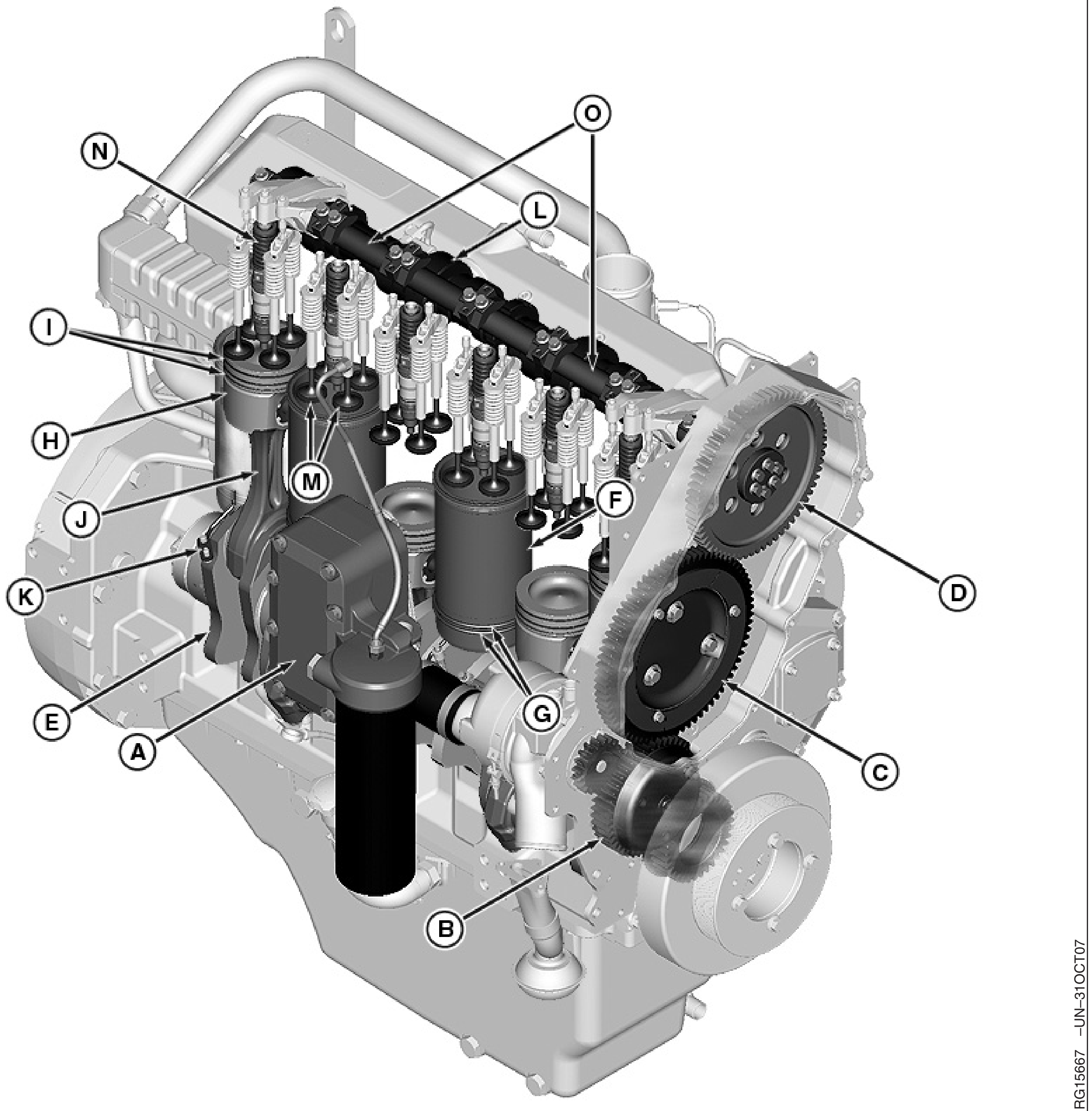
6135 PowerTech™ Plus Engine Cutaway View



6135 PowerTech Plus Cutaway View

A—Oil Cooler
B—Oil Pump Drive Gear
C—Idler Gear
D—Camshaft Gear
E—Crankshaft
F—Cylinder Liner
G—Cylinder Liner O-Rings
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K—Oil Spray Jet
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RE38635,00000FB –19–01NOV07–1/1

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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

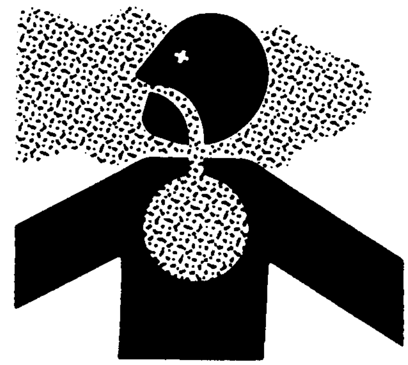
Section 01
General Information

Contents

Work In Ventilated Area

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

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



TS220 –UN–23AUG88

DX,AIR –19–17FEB99–1/1

Recognize Safety Information

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

Follow recommended precautions and safe operating practices.

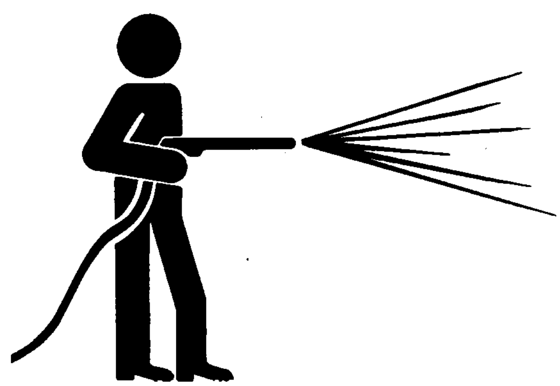
T81389 –UN–07DEC88

DX,ALERT –19–29SEP98–1/1

Work in Clean Area

Before starting a job:

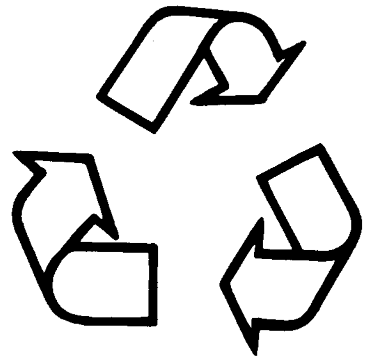
- Clean work area and machine.
- Make sure you have all necessary tools to do your job.
- Have the right parts on hand.
- Read all instructions thoroughly; do not attempt shortcuts.



T6642EJ –UN–18OCT88

DX,CLEAN –19–04JUN90–1/1

Dispose of Waste Properly



TS1133 –UN–26NOV90

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

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

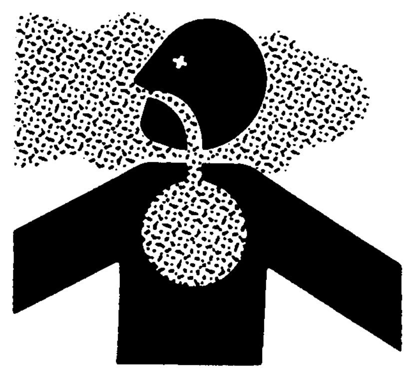
Do not pour waste onto the ground, down a drain, or into any water source.

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

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

DX,DRAIN –19–03MAR93–1/1

Avoid Harmful Asbestos Dust



TS220 –UN–23AUG88

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

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

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

Keep bystanders away from the area.

DX,DUST –19–15MAR91–1/1

Handle Fuel Safely—Avoid Fires

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

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

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

TS202 –UN–23AUG88

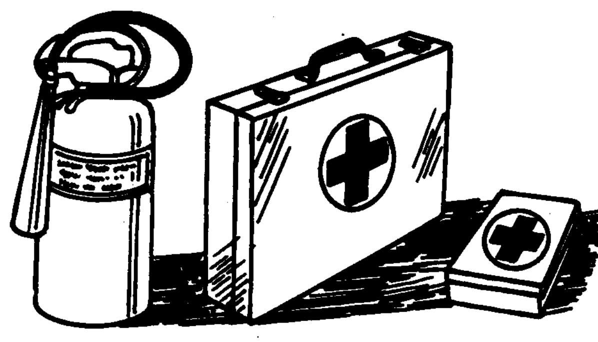
DX,FIRE1 –19–03MAR93–1/1

Prepare for Emergencies

Be prepared if a fire starts.

Keep a first aid kit and fire extinguisher handy.

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



TS291 –UN–23AUG88

DX,FIRE2 –19–03MAR93–1/1

Handle Starting Fluid Safely

Starting fluid is highly flammable.

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

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

Do not incinerate or puncture a starting fluid container.

TS1356 –UN–18MAR92

DX,FIRE3 –19–16APR92–1/1

Handle Fluids Safely—Avoid Fires

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

Store flammable fluids away from fire hazards. Do not incinerate or puncture pressurized containers.

Make sure machine is clean of trash, grease, and debris.

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

TS227 –UN–23AUG88

DX,FLAME –19–29SEP98–1/1

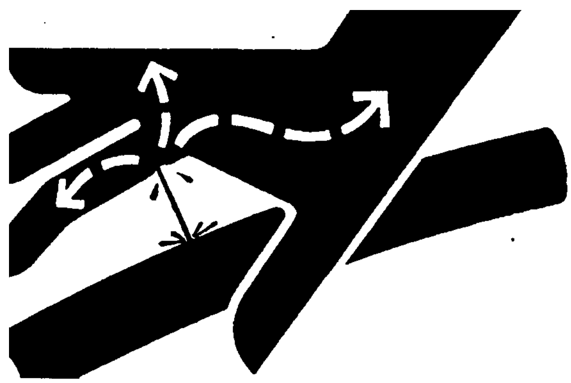
Avoid High-Pressure Fluids

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

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

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

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



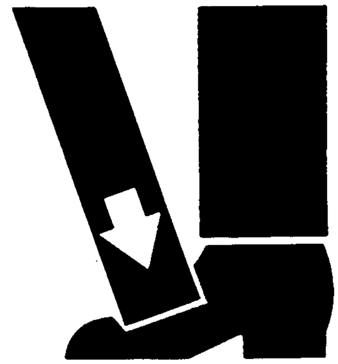
X9811 –UN–23AUG88

DX,FLUID –19–03MAR93–1/1

Use Proper Lifting Equipment

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

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

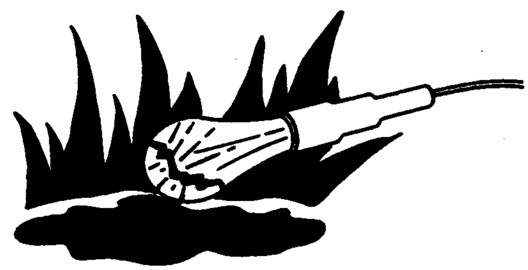


TS226 –UN–23AUG88

DX,LIFT –19–04JUN90–1/1

Illuminate Work Area Safely

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



TS223 –UN–23AUG88

DX,LIGHT –19–04JUN90–1/1

Live With Safety

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

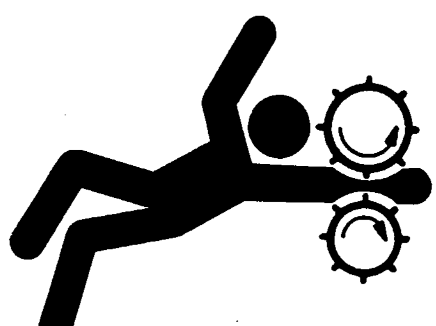
TS231 –19–07OCT88

DX,LIVE –19–25SEP92–1/1

Service Machines Safely

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

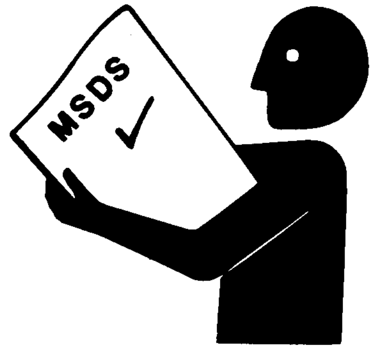
Remove rings and other jewelry to prevent electrical shorts and entanglement in moving parts.



TS228 –UN–23AUG88

DX,LOOSE –19–04JUN90–1/1

Handle Chemical Products Safely



TS1132 –UN–26NOV90

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

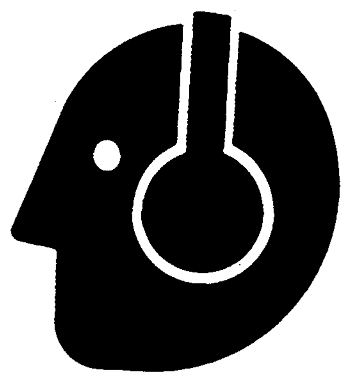
A Material Safety Data Sheet (MSDS) provides specific details on chemical products: physical and health hazards, safety procedures, and emergency response techniques.

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

(See your John Deere dealer for MSDS's on chemical products used with John Deere equipment.)

DX,MSDS,NA –19–03MAR93–1/1

Protect Against Noise



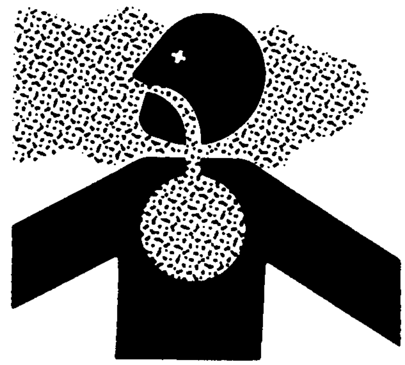
TS207 –UN–23AUG88

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.

DX,NOISE –19–03MAR93–1/1

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

Stay Clear of Rotating Drivelines

TS1644 –UN–22AUG95

Entanglement in rotating driveline can cause serious injury or death.

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

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

DX,PTO –19–12SEP95–1/1

Service Cooling System Safely

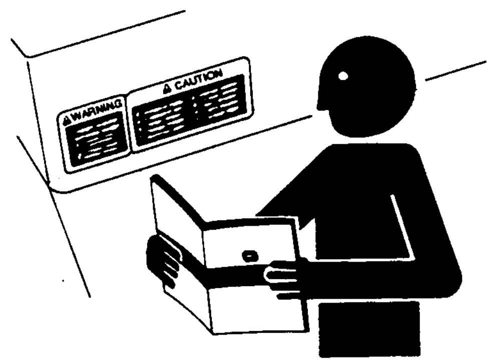
TS281 –UN–23AUG88

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

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

DX,RCAP –19–04JUN90–1/1

Follow Safety Instructions



TS201 –UN–23AUG88

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

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

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

If you do not understand any part of this manual and need assistance, contact your John Deere dealer.

DX,READ –19–03MAR93–1/1

Use Proper Tools

TS779 –UN–08NOV89

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

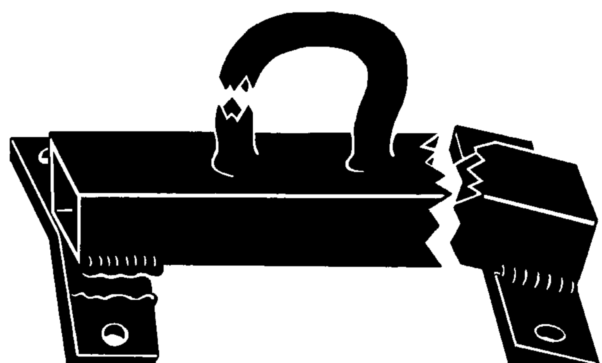
Use power tools only to loosen threaded parts and fasteners.

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

Use only service parts meeting John Deere specifications.

DX,REPAIR –19–17FEB99–1/1

Construct Dealer-Made Tools Safely



LX1016749 –UN–01JUL97

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

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

DX,SAFE,TOOLS –19–10OCT97–1/1

Practice Safe Maintenance

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

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

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

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

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

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

TS218 –UN–23AUG88

DX,SERV –19–17FEB99–1/1

Understand Signal Words

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

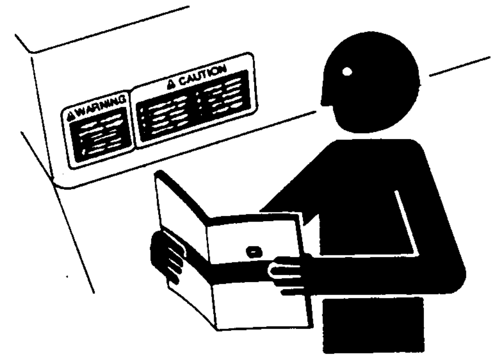
DANGER or WARNING safety signs are located near specific hazards. General precautions are listed on CAUTION safety signs. CAUTION also calls attention to safety messages in this manual.

TS187 –19–30SEP88

DX,SIGNAL –19–03MAR93–1/1

Replace Safety Signs

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



TS201 —UN—23AUG88

DX,SIGNS1 –19–04JUN90–1/1

Prevent Battery Explosions

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

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

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

TS204 —UN—23AUG88

DX,SPARKS –19–03MAR93–1/1

Protect Against High Pressure Spray

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

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

TS1343 —UN—18MAR92

DX,SPRAY –19–16APR92–1/1

Avoid Heating Near Pressurized Fluid Lines

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

TS953 –UN–15MAY90

DX,TORCH –19–10DEC04–1/1

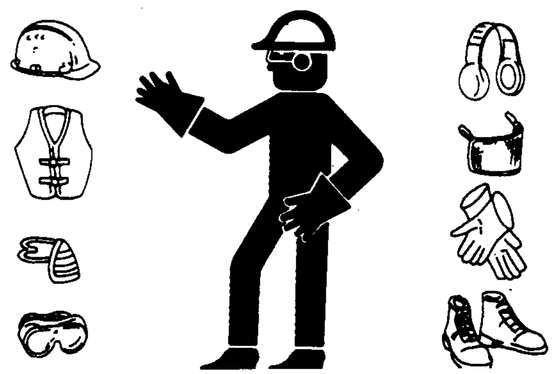
Wear Protective Clothing

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

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

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

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



TS206 –UN–23AUG88

DX,WEAR –19–10SEP90–1/1

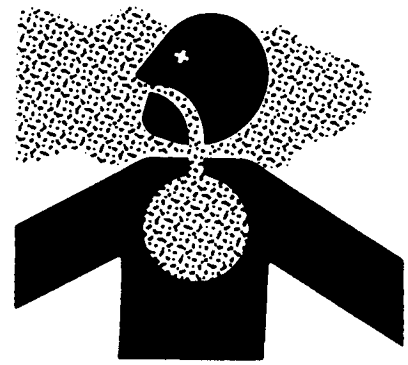
Handle Agricultural Chemicals Safely

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

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

Reduce risk of exposure and injury:

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



TS220 –UN–23AUG88

A34471

A34471 –UN–11OCT88

DX,WW,CHEM01 –19–05APR04–1/1

Handling Batteries Safely

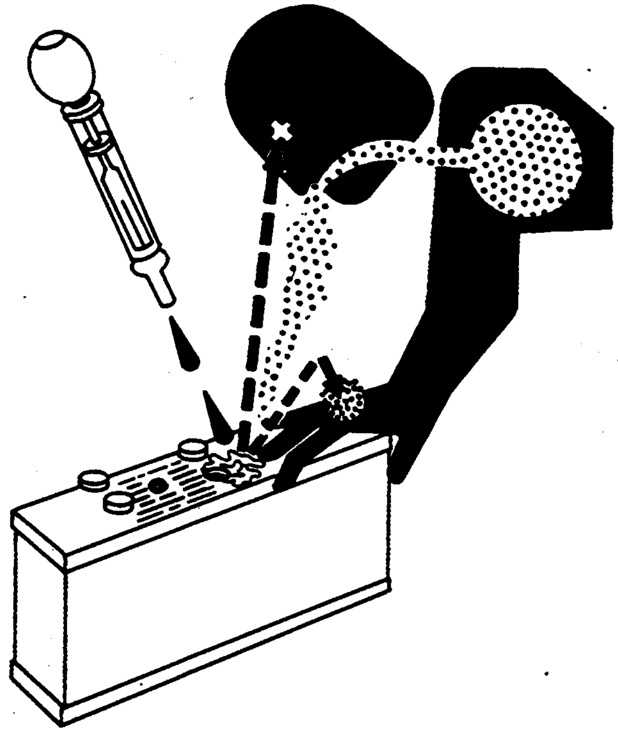
TS204 –UN–23AUG88

Explosion

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.



TS203 –UN–23AUG88

Acid

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. **Using 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 qt.).**
3. **Get medical attention immediately.**

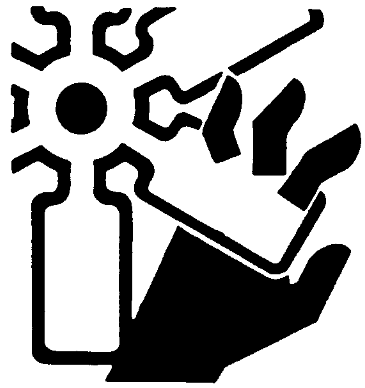
WARNING: Battery posts, terminals, and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm. **Wash hands after handling.**

DPSG,OUO1004,2758 –19–15OCT07–1/1

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



TS677 –UN–21SEP89

Rotating Fan

OUO1083,00005FE –19–15OCT07–1/1

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).

TS271 –UN–23AUG88

Hot Surface

OUO1083,00005FF –19–22DEC05–1/1

Engine Model Designation

Example: John Deere Engine Model—6135HRW01

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

6135HRW01 Engine

6	Number of cylinders
13.5	Liter designation
H	Aspiration
RW	User code
01	Application Code

Aspiration Code

H	Turbocharged and air-to-air aftercooled

User Code

DW	Davenport (Construction Equipment) Works
F	OEM (Outside Equipment Manufacturers)[a]
H	Harvester (Combines) Works
RW	Waterloo (Tractor) Works
T	Dubuque (Construction Equipment) Works
T8	Cameco
Z	Zweibrucken (Forage Harvester) Works

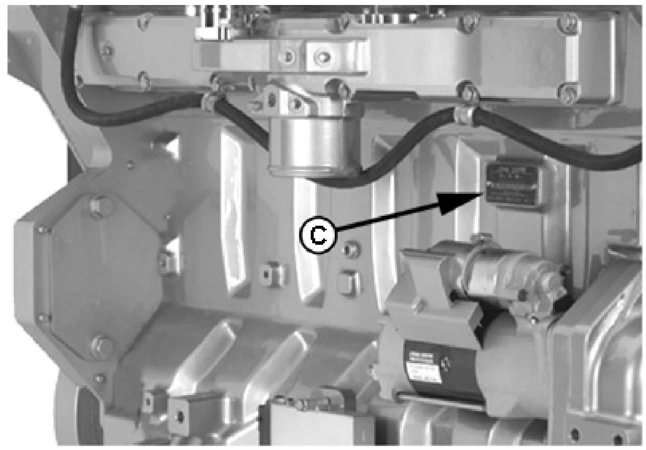
[a]OEM users are non-Deere users of John Deere engines.

Application Code

01, 02, etc.,	Code for specific application

RG13879 –UN–06MAY05

Engine Serial Number Plate



RG13887 –UN–26JUL05

Serial Number Plate Location

RE38635,000003D –19–21JUL05–1/1

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.

1. Example 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:

RG6135H000000
RG .... Factory code producing engine
6135H .... Engine model designation
000000 .... Sequential number

Factory Code Producing Engine
RG .... Waterloo Engine Works

Engine Model Designation
6135H .... See Engine Model Designation on previous page

Sequential Number
000000 .... 6-digit sequential number

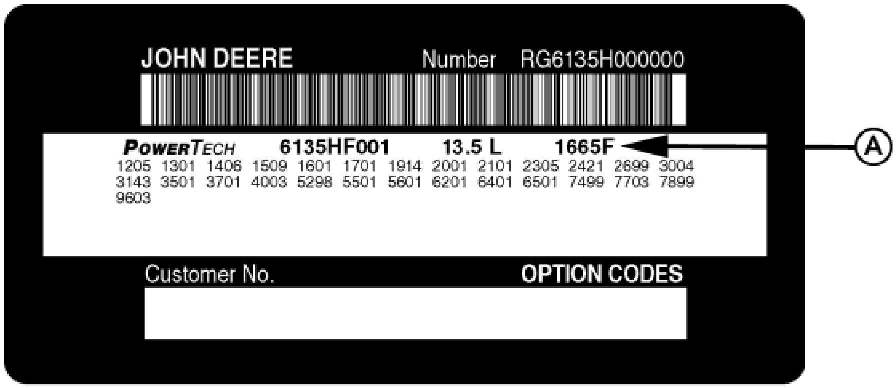
2. Engine Application Data (B)

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

Engine Serial Number Plate

RE38635,000003E –19–21JUL05–1/1

Engine Option Code Label



RG13880 –UN–06JUL05

Option Code Label

In addition to the serial number plate, OEM engines have an engine option code label affixed to the rocker arm cover. These codes indicate which of the engine options were installed on your engine at the factory.

When in need of parts or service, furnish your authorized servicing dealer or engine distributor with these numbers.

RE38635,000003F –19–21JUL05–1/1

Engine Application Chart — PowerTech™ Plus Engines

John Deere Agricultural Equipment Applications

Machine Model No.	
WATERLOO TRACTORS—4-WHEEL DRIVE	
9330	
9430	
9530	
9630	
9430 4WD Articulating Scraper Tractor	
9530 4WD Articulating Scraper Tractor	
9630 4WD Articulating Scraper Tractor	
WATERLOO TRACTORS—TRACK TYPE	
9430T	
9530T	
9630T	
HARVESTER—COMBINES	
9870 STS (North America Only)	
S690 Euro Combine (Europe Only)	
ZWEIBRUCKEN—COMBINES/FORAGE HARVESTERS	
7350	6135HZ006
7450	6135HZ006
7550	6135HZ006
7650	6135HZ006
7750	6135HZ006
CANE HARVESTER (CAMECO—THIBODAUX, LA)	

John Deere Construction and Forestry Equipment Applications

Machine Model No.	Engine Model

Original Equipment Manufacturers (OEM) Applications

Machine Model No.	Engine Model
OEM	6135HF485

RE38635,0000102 –19–07NOV07–1/1

Engine Application Chart — PowerTech™ E Engines

John Deere Agricultural Equipment Applications

Machine Model No.	Engine Model
WATERLOO TRACTORS—4-WHEEL DRIVE	
9330	6135HRW04
9430	6135HRW04
9530	6135HRW04
9630	6135HRW04
WATERLOO TRACTORS—TRACK TYPE	
9430T	6135HRW04
9530T	6135HRW04
9630T	6135HRW04
HARVESTER—COMBINES	
9870	6135HH002
S690/S690 Hillmaster Export	6135HH002
ZWEIBRUCKEN—COMBINES/FORAGE HARVESTERS	
7350	6135HZ008
7450	6135HZ008
CANE HARVESTER (CAMECO—THIBODAUX, LA)	

John Deere Construction and Forestry Equipment Applications

Machine Model No.	Engine Model

Original Equipment Manufacturers (OEM) Applications

Machine Model No.	Engine Model
OEM	6135HF485

RE38635,0000103 –19–07NOV07–1/1

Diesel Fuel

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

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

Diesel fuels specified to EN 590 or ASTM D975 are recommended. Renewable diesel is basically identical to petroleum diesel fuel that is created by Hydrotreating fats and oils. Renewable diesel that meets EN 590 or ASTM D975 is acceptable for use at all percentage mixture levels.

Required fuel properties

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

Cetane number of 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) should be at least 5°C (9°F) below the expected lowest temperature or **Cloud Point** below the expected lowest ambient temperature.

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

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 as shown in the table.
- BEFORE using diesel fuel with sulfur content greater than 0.50% (5000 ppm), contact your John Deere dealer.

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 –19–05OCT07–1/1

Bio-Diesel Fuel

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

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

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

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

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

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

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

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

Consult your John Deere dealer for approved biodiesel fuel conditioners to improve storage and performance with biodiesel fuels.

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

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

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

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

- Possible coking and/or blocked injector nozzles, resulting in power loss and engine misfire if John Deere approved fuel conditioners containing detergent/dispersant additives are not used
- Possible crankcase oil dilution, requiring more frequent oil changes
- Possible corrosion of fuel injection equipment
- Possible lacquering and/or seizure of internal components
- Possible formation of sludge and sediments
- Possible thermal oxidation of fuel at elevated temperatures
- Possible elastomer seal and gasket material degradation (primarily an issue with older engines)

Continued on next page

DX,FUEL7 –19–04OCT07–1/2

- Possible compatibility issues with other materials (including copper, lead, zinc, tin, brass, and bronze) used in fuel systems and fuel handling equipment
- Possible reduction in water separator efficiency
- Potential high acid levels within fuel system
- Possible damage to paint if exposed to biodiesel

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

DX,FUEL7 –19–04OCT07–2/2

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 Blend Diesel Fuel

When temperatures fall below -10°C (14°F), winter blend diesel fuel is best suited for cold weather operation. Winter blend diesel fuel has a lower cloud point and a lower pour point.

Cloud point is the temperature at which wax will begin to form in the fuel and this wax causes fuel filters to plug. **Pour point** is the lowest temperature at which movement of the fuel is observed.

NOTE: On an average, winter blend diesel fuel has a lower BTU (heat content) rating. Using winter blend diesel 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 staring.

Ether

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

CAUTION: Do not use ether when (1) starting with an engine equipped with glow plugs or (2) when starting with an air intake heater.

Coolant Heater

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

Seasonal Viscosity Oil and Proper Coolant Concentration

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

Diesel Fuel Flow Additive

Use John Deere Premium Diesel Fuel Conditioner (winter formula) which contains anti-gel chemistry, or equivalent to treat Grade No.2-D fuel during the cold weather season. This generally extends operability about 10°C (18°F) below its Cloud Point. For operability at temperatures further below, winter grade fuel (a blend of No.2-D and No.1-D, or straight No.1-D fuel) is best suited for cold weather operation.

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.

CAUTION: Do not use ether when starting with an air intake heater.

Biodiesel

When running with BIODIESEL blends wax formation can generate at warmer temperatures. Begin to use John Deere Premium Biodiesel Conditioner (winter) at 5°C (40°F) to treat biodiesel fuels during the cold weather season. Below 0°C (32°F) John Deere requires the use of B5 or lower blends. Below -10°C (14°F) John Deere requires the use of winter blend diesel fuel.

Continued on next page

DX,FUEL10 –19–04OCT07–1/2

Winterfronts

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

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

Radiator Shutters

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

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

For more information, see your John Deere dealer.

DX,FUEL10 –19–04OCT07–2/2

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 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.

Lubricity of Biodiesel Fuel

Significant improvement in lubricity can occur with biodiesel blends up to B20. The gain in lubricity above a 20% blend is limited.

DX,FUEL5 –19–05OCT07–1/1

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.

DIESELSCAN is a trademark of Deere & Company

DX,FUEL6 –19–14NOV05–1/1

Engine Oil and Filter Service Intervals

See applicable operator’s manual for service intervals.

DM80898,000025E –19–15OCT07–1/1

Diesel Engine Oil

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

John Deere PLUS-50™ oil is preferred.

Oils meeting one of the following specifications are also recommended:

- ACEA Oil Sequence E7
- ACEA Oil Sequence E6

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

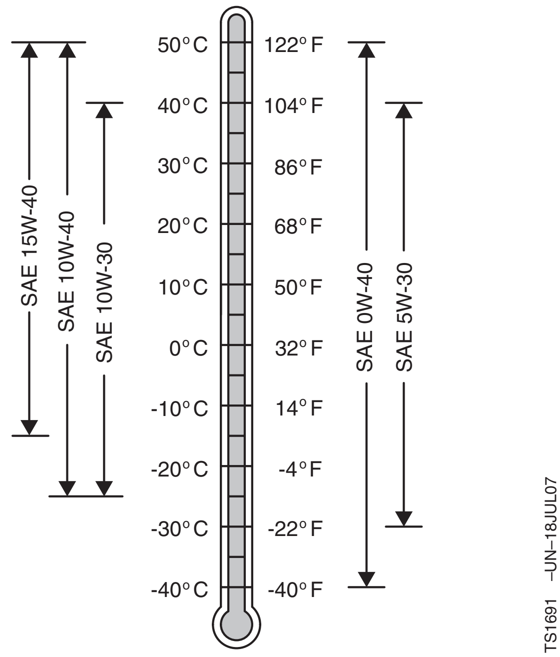
Other oils may be used if they meet one or more of the following:

- John Deere TORQ-GARD SUPREME™
- API Service Category CJ-4
- API Service Category CI-4 PLUS
- API Service Category CI-4
- ACEA Oil Sequence E5
- ACEA Oil Sequence E4

Multi-viscosity diesel engine oils are preferred.

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

DO NOT use diesel fuel with sulfur content greater than 1.0% (10 000 ppm).



Oil Viscosities for Air Temperature Ranges

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

DX,ENOIL11 –19–26JUL07–1/1

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

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

PLUS-50 is a trademark of Deere & Company.

DX,ENOIL4 –19–13SEP06–1/1

Oil Filters

Filtration of oils is critical to proper operation and lubrication.

Always change filters regularly as specified in this manual.

Use filters meeting John Deere performance specifications.

DX,FILT –19–18MAR96–1/1

Grease

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

John Deere SD POLYUREA GREASE is preferred.

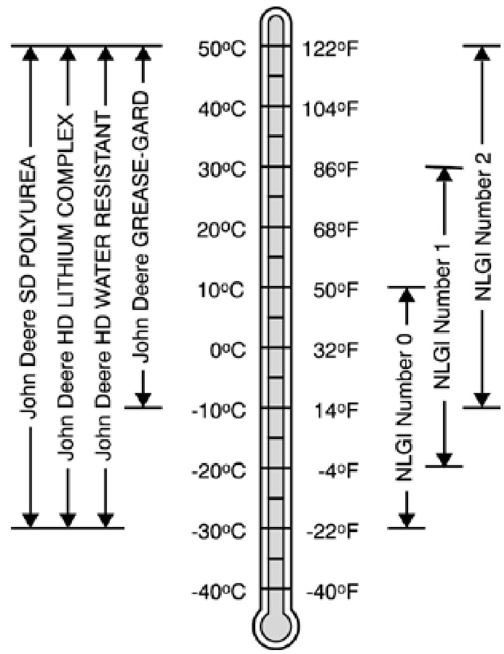
The following greases are also recommended

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



TS1673 –UN–31OCT03

GREASE-GARD is a trademark of Deere & Company

DX,GREA1 –19–07NOV03–1/1

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.

DX,ALTER –19–15JUN00–1/1

Lubricant Storage

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

Use clean containers to handle all lubricants.

Whenever possible, store lubricants and containers in an area protected from dust, moisture, and other contamination. Store containers on their side to avoid water and dirt accumulation.

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

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

DX,LUBST –19–18MAR96–1/1

Mixing of Lubricants

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

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

Consult your John Deere dealer to obtain specific information and recommendations.

DX,LUBMIX –19–18MAR96–1/1

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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Continued on next page

DX,COOL3 –19–27OCT05–1/2

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

Supplemental Coolant Additives

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

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

IMPORTANT: Do not add a supplemental coolant additive when the cooling system is drained and refilled with John DeereCOOL-GARD™.

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

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

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

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DX,COOL4 –19–07NOV03–1/1

Operating in Warm Temperature Climates

John Deere engines are designed to operate using glycol base engine coolants.

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

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

Additional Information About Diesel Engine Coolants and Supplemental Coolant Additives

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

Coolant specifications

Some products, including John Deere COOL-GARD™ 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.

Coolants meeting ASTM D6210 do not require an initial charge of supplemental coolant additives.

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

Coolants meeting ASTM D4985 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 or another fully formulated coolant 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 or propylene 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). These coolants do not contain the correct additives to protect heavy-duty diesel engines. They often contain a high concentration of silicates and may damage the engine or cooling system.

Water quality

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

Chlorides	<40 mg/L
Sulfates	<100 mg/L
Total dissolved solids	<340 mg/L
Total hardness	<170 mg/L
pH	5.5 to 9.0

Freeze protection

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

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Continued on next page

DX,COOL7 –19–19DEC03–1/2

Ethylene Glycol	Freeze Protection Limit
40%	-24°C (-12°F)
50%	-37°C (-34°F)
60%	-52°C (-62°F)
Propylene Glycol	**Freeze Protection Limit**
40%	-21°C (-6°F)
50%	-33°C (-27°F)
60%	-49°C (-56°F)

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

DX,COOL7 –19–19DEC03–2/2

Diesel Engine Coolant

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

John Deere COOL-GARD is preferred for service.

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

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

Freeze protection

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

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

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

Water quality

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

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

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

DX,COOL8 –19–16NOV01–1/1

Testing Diesel Engine Coolant

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™ and COOLSCAN PLUS™

For a more thorough evaluation of your coolant, perform a COOLSCAN or COOLSCAN PLUS analysis, where available. See your John Deere dealer for information.

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COOLSCAN PLUS is a trademark of Deere & Company

DX,COOL9 –19–19DEC03–1/1

Drain Intervals for Diesel Engine Coolant

Drain the factory fill engine coolant, flush the cooling system, and refill with new coolant after the first 3 years or 3000 hours of operation.

Subsequent drain intervals are determined by the coolant used for service. At each interval, drain the coolant, flush the cooling system, and refill with new coolant.

When John Deere COOL-GARD™ is used, the drain interval may be extended to 5 years or 5000 hours of operation, provided that the coolant is tested annually AND additives are replenished, as needed, by adding a supplemental coolant additive.

If John Deere COOL-GARD is used but the coolant is not tested OR additives are not replenished by adding a supplemental coolant additive, the drain interval is 3 years or 3000 hours of operation

If COOL-GARD is not used, the drain interval is reduced to 2 years or 2000 hours of operation.

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DX,COOL11 –19–19DEC03–1/1

02

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 (blue) 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.
- High engine blow-by

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.

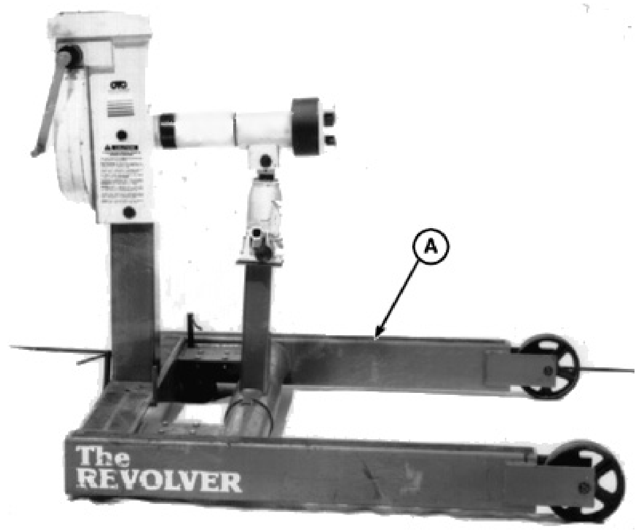
RE38635,00000EC –19–25OCT07–1/1

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 Class 12.9 or SAE Grade 8 or higher cap screws must be used to mount adapters and engine to repair stand. Tighten cap screws to specifications given. See ENGINE LIFTING PROCEDURE later in this group.

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.

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 and the possibility of tipping low.

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

RE38635,00000ED –19–25OCT07–1/1

Disconnect Turbocharger Oil Inlet Line

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

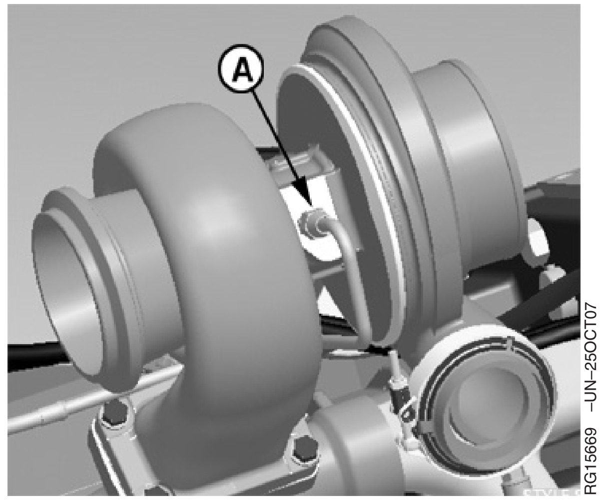
IMPORTANT: When servicing turbocharged engines on a rollover stand, disconnect turbocharger oil inlet line from oil filter housing (B) or turbocharger (A) before rolling engine over. Failure to do so may cause a hydraulic lock upon starting engine. Hydraulic lock may cause possible engine failure.

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.

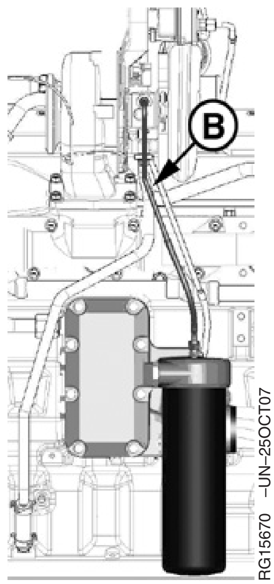
After starting the engine, the trapped oil in the manifold and head is released into the cylinder(s) filling them with oil causing hydraulic lock and possible engine failure.

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

A—Oil Supply Line - PowerTech E
B—Oil Supply Line - PowerTech Plus



Turbocharger Oil Supply Line - PowerTech E Engine



Turbocharger Oil Supply Line - PowerTech Plus Engine

RE38635,00000EE –19–25OCT07–1/1

Install Engine Adapter Onto Repair Stand

Attach the No. 205466 Adapter Assembly to engine repair stand using three 1 1/32 inch diameter SAE Grade 8 (or higher grade) allen head cap screws. Tighten cap screws to specification.

Specification

Engine Adapter-to-Repair Stand
Cap Screws—Torque .... 600 N•m (450 lb-ft)

RG8183 –UN–08DEC97

D05223ST Repair Stand with 205466 Adapter

RG,RG34710,46 –19–20JUN07–1/1

Engine Lifting Procedure

CAUTION: The only approved method for lifting the 6135 Engine is with the use of JDG23 Lifting Sling (D), JDG10199 Rear Lift Strap and JDG10200 Front Lift Strap. DO NOT USE ANY OTHER LOCATION ON THE ENGINE AS A LIFTING POINT. 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.

IMPORTANT: Ensure that engine lifting straps are secured with Class 12.9 (or higher class) cap screws.

1. Install JDG10199 Straight Lift Strap to left hand rear side of cylinder head. Tighten 2 flange head cap screws to specification.

Specification

Engine Lift Strap Cap Screws—
Torque .... 90 N•m (66 lb-ft)

2. Install JDG10200 “S” shaped lift strap to right front side of cylinder head. Tighten 2 flange head cap screws to specification.

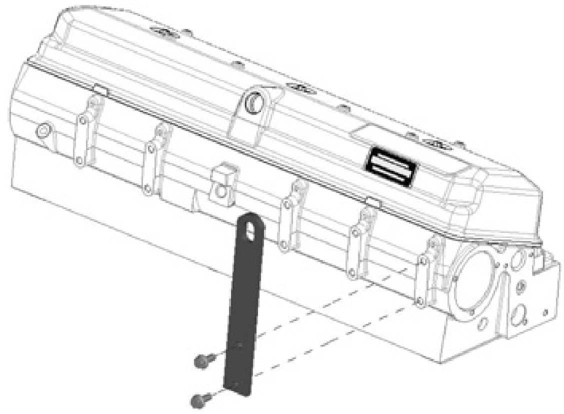
Specification

Engine Lift Strap Cap Screws—
Torque .... 90 N•m (66 lb-ft)

NOTE: Lift spacing on sling is adjustable. Position each lifting point so that engine hangs level when lifted.

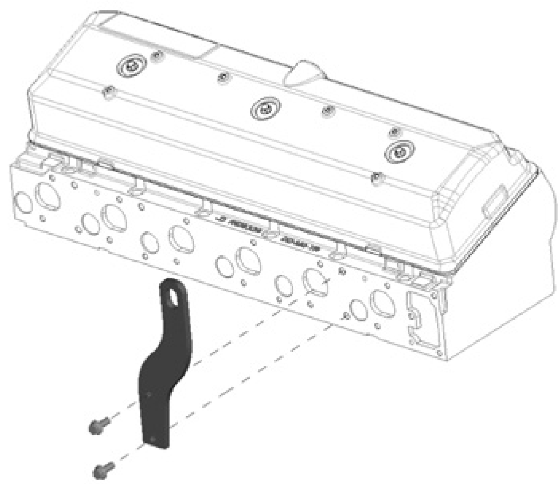
3. Attach the JDG23 Engine Lifting Sling (D) to lift straps and overhead hoist or floor crane of adequate lifting capacity.

4. Carefully lift engine to desired location.



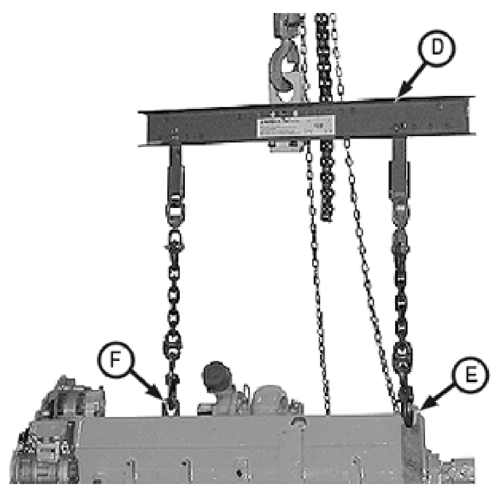
RG15447 –UN–27JUL07

Install JDG10199 Rear Lift Strap



RG15448 –UN–27JUL07

Install JDG10200 Front Lift Strap



RG10350 –UN–13OCT99

Engine Lifting

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RE38635,00000EF –19–25OCT07–1/2

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.

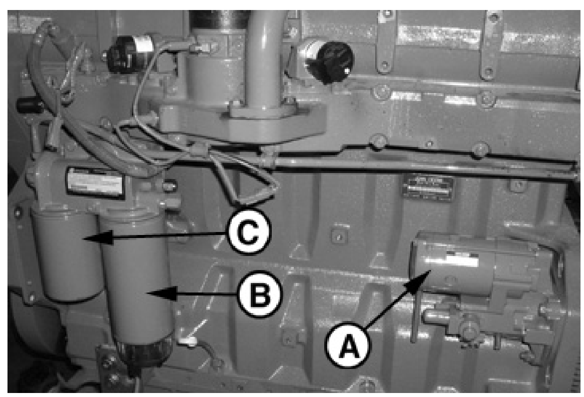
RE38635,00000EF –19–25OCT07–2/2

Mount Engine Onto Repair Stand

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

1. Remove starter motor (A).

2. On engines with primary fuel filter/water separator (B) on left side of engine, remove primary fuel filter/water separator.



RG15671 –UN–25OCT07

Component Removal for Repair Stand Mounting

A—Starter Motor
B—Primary Fuel Filter
C—Final Fuel Filter

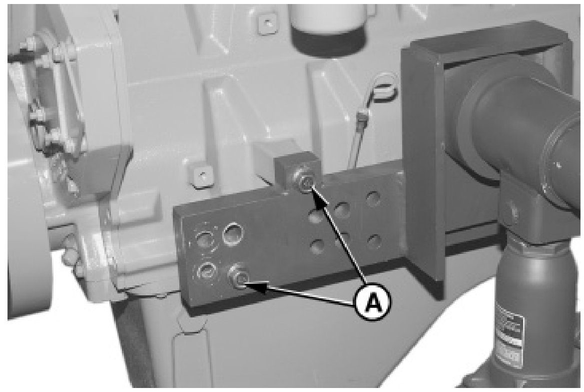
Continued on next page RE38635,00000F0 –19–25OCT07–1/3

IMPORTANT: DO NOT use shorter cap screws than recommended since mounting threads in block bore may be stripped when tightening to specified torque. USE ONLY JDG980 METRIC BOLT KIT for mounting engine to repair stand.

3. Mount engine to front engine adapter using two[1] M16 x 2.0 x 65 mm (Class 12.9) cap screws (A). Tighten cap screws to specification.

Specification

Engine-to-Stand Adapter Cap Screws—Torque	400 N•m (300 lb-ft)



RG8185 –UN–05DEC97

Front Repair Stand Cap Screws

A—Cap Screws

[1] *From JDG980 Metric Bolt Kit.*

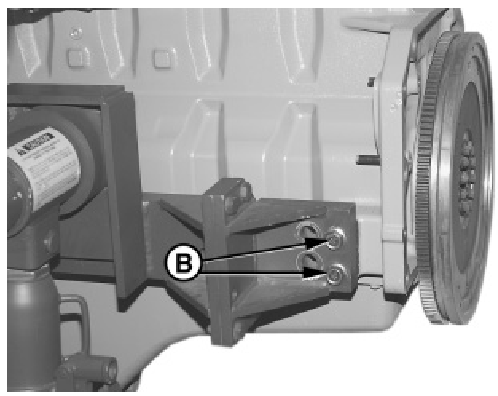
RE38635,00000F0 –19–25OCT07–2/3

4. Mount engine to rear engine adapter using two[1] M16 x 2.0 x 65 mm (Class 12.9) cap screws (B). Tighten cap screws to specification.

Specification

Engine-to-Stand Adapter Cap Screws—Torque	400 N•m (300 lb-ft)

B—Cap Screws



RG8186 –UN–05DEC97

Rear Repair Stand Cap Screws

[1] *From JDG980 Metric Bolt Kit.*

RE38635,00000F0 –19–25OCT07–3/3

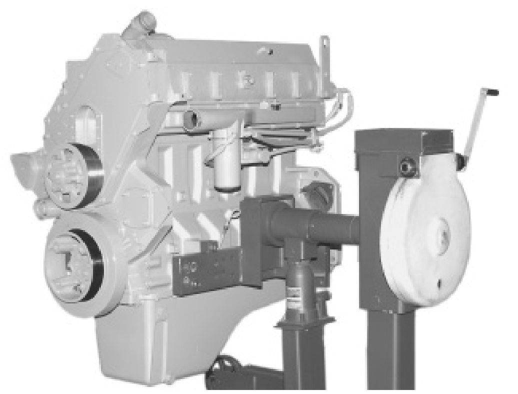
Clean Engine

1. Cap or plug all openings (air intake, exhaust, fuel, coolant, etc.).

2. Remove electrical components (starter, alternator, etc.). Cover electrical components that are not removed with plastic and tape securely to prevent moisture damage.

3. Thoroughly steam clean engine.

IMPORTANT: Never steam clean or pour cold water on an engine while it is still hot. To do so may cause seizure of precision parts.


RG8188 –UN–21MAY98

6125HRW Engine on Repair Stand

RG,RG34710,49 –19–21DEC00–1/1

6135 Engine Disassembly Sequence

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

NOTE: Remove starter motor and primary fuel filter/water separator before mounting engine onto repair stand.

ENGINE DISASSEMBLY SEQUENCE	
Procedure	**Reference**
Drain all coolant, fuel and engine oil.	See DISPOSING OF COOLANT in Section 01, Group 002.
Perform John Deere COOLSCAN™ and OILSCAN® analysis. Dispose of remaining fluids properly.	See OILSCAN AND COOLSCAN in Section 01, Group 002. See TESTING DIESEL ENGINE COOLANT in Section 01, Group 002.
Remove starter motor.	See REMOVE AND INSTALL STARTER MOTOR in Group 100.
Remove fuel filter assemblies with mounting bases as required.	See REPLACING PRIMARY FUEL FILTER/WATER SEPARATOR in CTM370, Section 02, Group 090 (dual rail fuel systems). See REPLACE FINAL (SECONDARY) FUEL FILTER ELEMENT in CTM370, Section 02, Group 090 (dual rail fuel systems). See FUEL FILTER/WATER SEPARATOR ASSEMBLY in CTM370 Section 02, Group 091 (single rail fuel systems).
Mount engine onto recommended safety approved repair stand.	See MOUNT ENGINE ONTO REPAIR STAND in this group.
Remove fan, drive belts, and fan drive assembly.	See Group 070.
Remove alternator.	See REMOVE AND INSTALL ALTERNATOR in Group 100.
Remove compressor.	See CTM67, OEM Engine Accessories.
Remove vibration damper and pulley assembly from crankshaft.	See REMOVE CRANKSHAFT VIBRATION DAMPER AND PULLEY in Group 040.
Disconnect all air intake/exhaust piping and turbocharger oil & coolant inlet/drain lines. Remove turbocharger.	See REMOVE TURBOCHARGER in Group 080.
Disconnect Exhaust Gas Recirculator (EGR) cooler inlet/return coolant lines, remove EGR cooler (PowerTech Plus - 6135HF485 - engines only)	SeeREMOVE EGR in Group 80.
Remove exhaust manifold and gaskets.	See REMOVE, INSPECT AND INSTALL EXHAUST MANIFOLD in Group 080.
Remove oil filter and oil filter housing.	See REMOVE OIL FILTER AND VALVE HOUSING/OIL COOLER COVER AND VALVE HOUSING in Group 060.
Remove oil cooler assembly.	See REMOVE, CLEAN AND INSPECT ENGINE OIL COOLER in Group 060.
Remove coolant pump assembly.	See REMOVE COOLANT PUMP in Group 070.
Remove water manifold/thermostat housing assembly.	See REMOVE AND INSTALL THERMOSTAT HOUSING in Group 070.
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OILSCAN is a registered trademark of Deere & Company.

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ENGINE DISASSEMBLY SEQUENCE—CONTINUED	
Procedure	**Reference**
Remove air intake manifold.	See REMOVE, INSPECT AND INSTALL INTAKE MANIFOLD in Group 080.
Remove all fuel lines, identify for reassembly in correct location.	See CTM370, Section 02, Group 090.
Remove engine oil pan.	See REMOVE ENGINE OIL PAN in Group 060.
Remove oil pickup tube.	See REMOVE AND INSTALL OIL PICKUP TUBE in Group 060.
Remove front gear train access cover and timing gear cover.	See REMOVE TIMING GEAR COVER in Group 040.
Remove rocker arm cover.	See REMOVE AND INSTALL ROCKER ARM COVER in Group 020.
NOTE: Identify valve train components and electronic unit injectors for reassembly in same location as removed. Remove front and rear rocker arm and shaft assembly and EUI wiring harness.	See REMOVE ROCKER ARM ASSEMBLY in Group 020.
Remove electronic injectors on John Deere ECU controlled fuel systems.	See REMOVE AND INSTALL ELECTRONIC INJECTORS in CTM370, Section 02, Group 090
Remove camshaft gear and idler gear assembly. Remove camshaft position sensor and remove camshaft.	See REMOVE AND INSTALL CAMSHAFT in Group 050.
Remove oil pump drive gear and remove oil pump assembly.	See REMOVE ENGINE OIL PUMP in Group 060.
Remove cylinder head and gasket.	See REMOVE CYLINDER HEAD in Group 020.
Remove flywheel.	See REMOVE FLYWHEEL in Group 040.
Remove flywheel housing.	See REMOVE AND INSTALL FLYWHEEL HOUSING in Group 040.
Remove rear crankshaft seal and seal housing.	See REMOVE REAR CRANKSHAFT OIL SEAL AND HOUSING ASSEMBLY in Group 040.
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Continued on next page RE38635,00000F1 –19–25OCT07–2/3

ENGINE DISASSEMBLY SEQUENCE—CONTINUED	
Procedure	**Reference**
Remove all six piston spray jets.	See REMOVE AND INSTALL PISTON SPRAY JETS in Group 030.
Remove cylinder block front plate.	See REMOVE AND INSTALL CYLINDER BLOCK FRONT PLATE in Group 030.
Perform wear checks on connecting rod bearing surfaces using PLASTIGAGE®. Remove piston and connecting rod assemblies.	See REMOVE PISTONS AND CONNECTING RODS in Group 030.
Check crankshaft end play.	See CHECK CRANKSHAFT END PLAY in Group 040.
Remove main bearing caps with bearings. Perform wear checks on main bearing surfaces with PLASTIGAGE®.	See REMOVE CRANKSHAFT MAIN BEARINGS in Group 040. See CHECK MAIN BEARING-TO-JOURNAL OIL CLEARANCE in Group 040.
Remove crankshaft.	See REMOVE CRANKSHAFT in Group 040.
Remove cylinder block plugs and serial number plate if block is to be put in a hot tank.	See COMPLETE DISASSEMBLY OF CYLINDER BLOCK in Group 030.
Inspect and repair individual components.	See appropriate repair groups.

PLASTIGAGE is a registered trademark of the DANA Corp.

RE38635,00000F1 –19–25OCT07–3/3

Sealant Application Guidelines

Listed below are sealants which have been tested and are used by the John Deere factory to control leakage and ensure hardware retention. ALWAYS use the following recommended sealants when assembling your John Deere Diesel Engine to ensure 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 exist, clean with solvent. Refer to John Deere Merchandise and Parts Sales Manual for ordering information.

IMPORTANT: LOCTITE® gasket materials are NOT designed to work with oil residue present. Oil residues must be cleaned from surfaces before applying gasket material.

LOCTITE® **242 Thread Lock & Sealer (Medium Strength) (blue):**

10 mL (0.34 oz) bottle

- Threaded plugs and fittings: cylinder block (oil galley).
- Cap screws: coolant pump, timing gear cover, camshaft gear access cover, oil pump.
- Oil pressure sending unit.
- Turbocharger oil inlet fitting.
- Fuel filter check valve or elbow (filter header end) dual rail fuel system.
- Piston spray jets.
- Timing gear cover gasket and camshaft gear access cover gasket on earlier engines using Fel-Pro gaskets.
- Idler gear carrier cap screws, camshaft gear retainer cap screws and fuel supply pump drive coupler cap screws.
- EUI hold-down clamp cap screws.

LOCTITE®**243 Thread Lock Oil Resistant (Medium Strength) (blue)** 10 mL (0.34 oz) bottle.

- For fasteners between 6 and 20 mm (1/4 and 3/4 inch)

LOCTITE® **271 Thread Lock & Sealer (High Strength) (clear):** 10 mL (0.34 oz) bottle.

- Oil filter adapter-to-base.

LOCTITE® **277 Thread Lock & Sealer (High Strength) (red):**

50 mL (1.7 oz) bottle

- Expansion plugs in cylinder head and block.

LOCTITE® **515 Flexible Sealant (General Purpose) (purple):**

50 mL (1.7 oz) bottle

- Timing gear cover and camshaft gear access cover gasket on earlier engines using Fel-Pro gasket.

LOCTITE® **592 Pipe Sealant with** TEFLON® **(white):**

6 mL (0.2 oz) tube

- Pipe plugs: cylinder block (water manifold), thermostat housing, air intake manifold, and coolant pump.
- Temperature sending unit.
- Coolant heater.
- Oil pan drain valve/hose.

LOCTITE® **680 Maximum Strength Retaining Compound (green):**

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LOCTITE is a trademark of Loctite Corp.
TEFLON is a registered trademark of Du Pont Company

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6 mL (0.2 oz) tube

- Crankshaft flange and ID of front wear sleeve for front and rear oil seal/wear sleeve installation.
- Steel cup plugs on cylinder head and block.

PT569 NEVER-SEEZ® **Compound**

PT569 227 g (8 oz) Brush

453 g (16 oz) Spray

- Cap Screws: exhaust manifold, intake manifold, aftercooler, turbocharger oil return line, and turbocharger cap screws/nut.

LOCTITE® **222 Small Screw Threadlocker (Removable) (Purple)**

0.5 mL (0.02 oz) tube

- EUI solenoid terminal nuts.

LOCTITE® **17430 High Flex Form-in-Place Gasket**

50 mL (1.7 oz) bottle

- Oil pan-to-cylinder block (timing gear cover and rear seal housing T-joints).

LOCTITE® **7649 Clean-and-Cure Primer**

- Clean mating gasket surfaces on timing gear cover, camshaft gear access cover, oil pan, and block sealing surfaces.

RE38635,00000F2 –19–25OCT07–2/2

6135 Engine Assembly Sequence

The following assembly sequence is suggested when engine has been completely disassembled. Be sure to check runout, clearance, and all critical physical part specifications prior to assembling engine. Replace parts as necessary and tighten retaining hardware to specifications given. Refer to the appropriate repair group when assembling engine.

Continued on next page

RE38635,00000F3 –19–25OCT07–1/3

IMPORTANT: ALWAYS replace vibration damper whenever crankshaft is replaced or after a major engine overhaul.

ENGINE ASSEMBLY SEQUENCE	
Procedure	**Reference**
Install all plugs in cylinder block that were removed to service cylinder block.	See COMPLETE DISASSEMBLY OF CYLINDER BLOCK in Group 030.
IMPORTANT: If new piston and liner kits are being installed, install them as an assembly after crankshaft has been installed. Install cylinder liners without O-rings and measure liner stand-out. Install liners with packing.	See INSTALL CYLINDER LINERS in Group 030.
Install crankshaft.	See INSTALL CRANKSHAFT in Group 040.
Install main bearings.	See INSTALL MAIN BEARING INSERTS IN BLOCK in Group 040.
Rotate crankshaft by hand to ensure correct assembly. Check crankshaft end play.	See CHECK CRANKSHAFT END PLAY in Group 040.
Install pistons and connecting rods. Rotate crankshaft by hand to ensure correct assembly.	See in INSTALL PISTONS AND CONNECTING RODS in Group 030.
Install piston spray jets	SeeINSTALL PISTON SPRAY JETS in Group 030.
Install crankshaft rear oil seal housing.	See INSTALL CRANKSHAFT REAR OIL SEAL HOUSING in Group 040.
Install rear oil seal and wear sleeve assembly.	See INSTALL CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE ASSEMBLY in Group 040.
Install flywheel.	See INSTALL FLYWHEEL in Group 040.
Install flywheel housing.	See REMOVE AND INSTALL FLYWHEEL HOUSING in Group 040.
Install cylinder block front plate.	See REMOVE AND INSTALL CYLINDER BLOCK FRONT PLATE in Group 030.
Install engine oil pump and drive gear.	See INSTALL ENGINE OIL PUMP in Group 060.
Install cylinder head using a new gasket.	See INSTALL CYLINDER HEAD in Group 020.
Install camshaft and camshaft drive gear.	See REMOVE AND INSTALL CAMSHAFT in Group 050.
Install timing gear cover.	See INSTALL TIMING GEAR COVER in Group 040.
Install oil pickup tube.	See REMOVE AND INSTALL OIL PICKUP TUBE in Group 060.
Install engine oil pan.	See INSTALL ENGINE OIL PAN in Group 060.
Install idler gear. Pin camshaft and crankshaft. Adjust idler gear-to-camshaft gear and idler gear-to-oil pump gear backlash.	See ADJUST FRONT TIMING GEAR BACKLASH in Group 050.
Install **new** crankshaft vibration damper and pulley assembly (with oil seal).	See INSTALL CRANKSHAFT VIBRATION DAMPER AND FRONT OIL SEAL in Group 040.
(Continued on next page)	

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ENGINE ASSEMBLY SEQUENCE—CONTINUED	
Procedure	**Reference**
Install electronic unit injectors on John Deere ECU controlled fuel systems.	See REMOVE AND INSTALL ELECTRONIC UNIT INJECTORS in CTM188, Section 02, Group 090 (dual rail fuel systems). See REMOVE AND INSTALL ELECTRONIC UNIT INJECTORS in CTM188, Section 02, Group 091 (single rail fuel systems).
Install valve bridges and push tubes. Install front and rear rocker arm shaft assemblies. Install EUI wiring harness.	See INSTALL ROCKER ARM ASSEMBLY in Group 020.
Preload unit injectors and adjust valve clearance.	See CHECK AND ADJUST VALVE ASSEMBLY CLEARANCES AND INJECTOR PRELOAD in Group 020.
Install front camshaft gear access cover.	See INSTALL TIMING GEAR COVER in Group 040.
Install fuel supply pump.	See REMOVE AND INSTALL FUEL SUPPLY PUMP in CTM370, Section 02, Group 091.
Install all remaining fuel lines, identify for reassembly in correct location.	See CTM370, Section 02, Group 090.
Install air intake manifold.	See REMOVE, INSPECT AND INSTALL INTAKE MANIFOLD in Group 080.
Install fuel filter assemblies with mounting bases as required.	See FUEL FILTER/WATER SEPARATOR ASSEMBLY in CTM370, Section 02, Group 091.
Install coolant pump assembly.	See INSTALL COOLANT PUMP in Group 070.

(Continued on next page)

ENGINE ASSEMBLY SEQUENCE—CONTINUED	
Procedure	**Reference**
Install water manifold/thermostat housing assembly.	See REMOVE AND INSTALL THERMOSTAT HOUSING in Group 070.
Install oil filter housing/oil cooler assembly.	See INSTALL OIL COOLER/OIL FILTER VALVE HOUSING ASSEMBLY OR OIL COOLER COVER/VALVE HOUSING ASSEMBLY in Group 060.
Install EGR cooler and coolant lines (PowerTech Plus - 6135HF485 - engines only).	SeeINSTALL EGR ASSEMBLY in Group 080.
Install exhaust manifold assembly.	See REMOVE, INSPECT AND INSTALL EXHAUST MANIFOLD in Group 080.
Install turbocharger. Connect all turbocharger oil lines and intake/exhaust piping.	See INSTALL TURBOCHARGER in Group 080.
Install alternator.	See REMOVE AND INSTALL ALTERNATOR in Group 100.
Install compressor.	See CTM67, OEM Engine Accessories.
Install fan drive, fan and fan belt.	See Group 070.
Mount engine into vehicle.	See vehicle repair manual.
Flush cooling system. Fill engine systems with recommended fuel, lubricant, and coolant.	See FLUSH AND SERVICE COOLING SYSTEM in Section 01, Group 002.
Perform engine break-in and normal standard performance checks.	See PERFORM ENGINE BREAK-IN in this group.

RE38635,00000F3 –19–25OCT07–3/3

Engine Break-In Guidelines

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

Pistons, rings, or liners have been replaced.

Electronic unit injectors have been removed or critical adjustments have been made while they are on the engine. (Primary objective of break-in is to check power).

RE38635,00000F4 –19–25OCT07–1/1

Perform Engine Break-In

IMPORTANT: If engine has a PTO, break-in can be performed at the PTO if it is done as specified below. To prevent possible damage to the PTO gear box, DO NOT apply full load through the PTO for any longer than the specified 10 minutes below.

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

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

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

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

1. Fill engine crankcase to proper level with John Deere ENGINE BREAK-IN OIL during break-in operation. Use break-in oil regardless of ambient temperature. This oil is specifically formulated to enhance break-in of John Deere diesel engines.

   Under normal conditions, do not exceed 100 hours with break-in oil.

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

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

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

PRELIMINARY ENGINE BREAK-IN AFTER MAJOR OVERHAUL

Time	Load	Engine Speed
1 minute	No load	850 rpm
1 minute	No Load	1500 rpm
2 minutes	No load	Fast Idle
10 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.

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.

4. 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 100 hour break-in period is recommended using a new change of John Deere ENGINE BREAK-IN OIL and new John Deere oil filter.

Continued on next page

RE38635,00000F5 –19–25OCT07–1/2

Check engine oil level more frequently during engine break-in period. As a general rule, makeup oil should not need to be added during 100-hour break-in period. However, if makeup oil is required in the first 100-hour break-in, an additional 100-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 100 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.

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

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

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

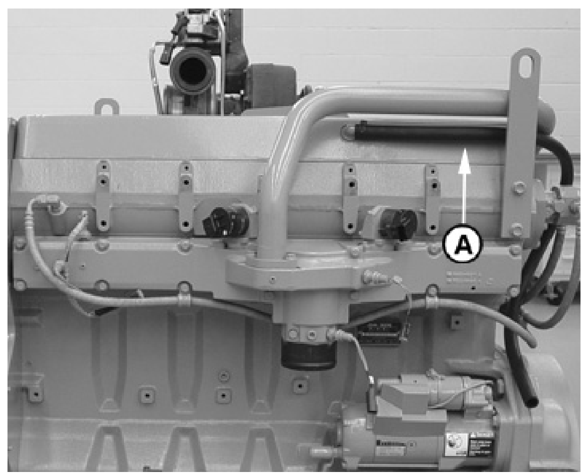
RE38635,00000F5 –19–25OCT07–2/2

Check Crankcase Ventilation System

1. Inspect crankcase ventilation system for restrictions. There should be no dips, pinching or kinking (bending) of the hose. 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 Vent Tube



RG14464 –UN–22AUG05

Crankcase Vent Tube

RE38635,00000F6 –19–25OCT07–1/1

Check Air Intake System

1. Replace air cleaner primary filter element. Replace secondary element if primary element has holes in it. (See REPLACING AIR CLEANER FILTER ELEMENTS in operator's manual.)

2. Check condition of air intake hose(s). Replace hoses that are cracked, split, or otherwise in poor condition.

3. Check hose clamps 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.

4. If air cleaner has an automatic dust unloader valve (A), inspect valve for dust buildup or restrictions.

5. Check air intake restriction indicator gauge (B) (if equipped) to determine if air cleaner needs to be serviced.

6. If air intake is restricted, a diagnostic trouble code will be generated. Check for any codes related to air intake system.

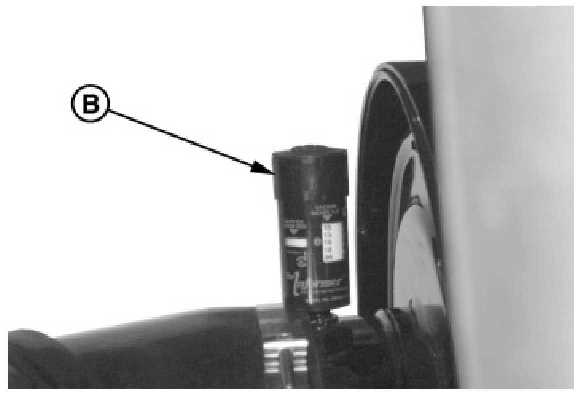
   If engine is equipped with an air restriction indicator gauge (B), check gauge and service air cleaner if it exceeds specification.

Specification

Maximum Air Intake Restriction—
Vacuum.. 25 in. (.625 inch) H[sup2]O (6.25 kPa) (o.06 bar) (1.0 psi)

RG8717A –UN–12JUL99

Unloader Valve



RG8719A –UN–12JUL99

Restriction Indicator Gauge

A—Unloader Valve
B—Restriction Indicator Gauge

RE38635,00000F7 –19–25OCT07–1/1

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 elbow adapter 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.

RG,RG34710,1057 –19–23OCT97–1/1

Check and Service Cooling System

TS281 –UN–23AUG88

Service Cooling System Safely

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.

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.

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

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

RE38635,00000F8 –19–25OCT07–1/1

Check Electrical System

Prevent Battery Explosions

TS204 –UN–23AUG88

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.

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 operator's manual.

7. Check operation of starter motor and gauges.

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

RG,RG34710,1059 –19–23OCT97–1/1

Remove and Install Rocker Arm Cover

Remove Rocker Arm Cover

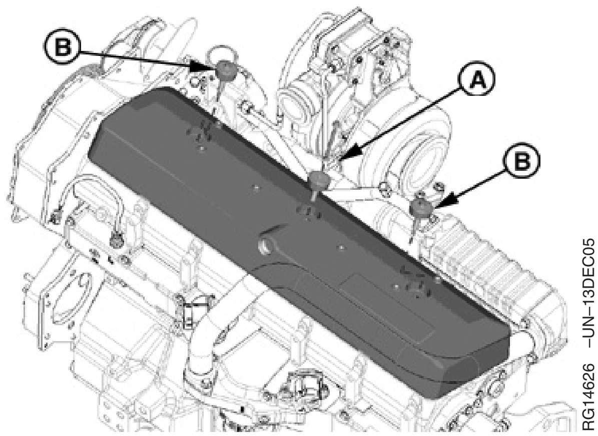
1. Remove air intake crossover tube if necessary.

2. Remove center hold-down cap screw with isolator (A).

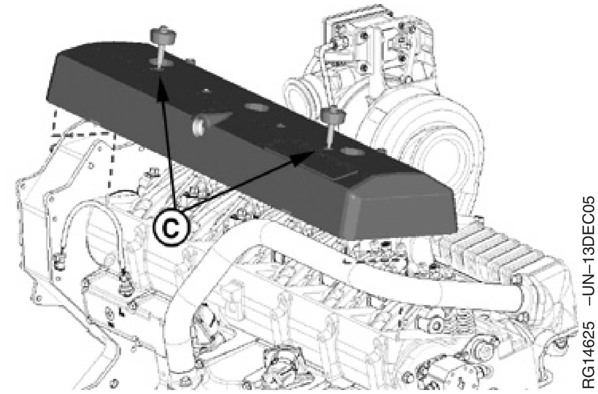
3. Remove two outside cap screws with isolators (B), and thread cap screws into rocker arm cover lift holes (C) as shown.

NOTE: Rocker arm cover gasket is reusable if no visible damage is detected. Do not store cover resting on gasket surface.

4. Lift rocker arm cover off engine.



Rocker Arm Cover Isolators



Rocker Arm Cover Lift Holes

A—Center Hold Down Cap Screw
B—Outside Hold Down Cap Screws -2-
C—Lift Hole Positions -2-

Install Rocker Arm Cover

IMPORTANT: Always check routing of unit injector wiring before installing rocker arm cover. Wiring should be positioned so that rocker arms never contact wire.

1. Inspect rocker arm cover gasket to ensure that gasket is properly seated in groove and that contact face is clean.

2. Position rocker arm cover onto two locating dowels in cylinder head.

3. Install center hold-down cap screw with isolator. Finger tighten cap screw to rocker arm hold down.

4. Remove 2 outside hold down cap screws from lift holes and install in adjacent grommet holes into valve cover. Finger tighten both cap screws to rocker arm hold down.

Continued on next page RE38635,00000A3 –19–13DEC05–1/2

NOTE: Tighten middle cap screw first, then outside cap screws.

5. Tighten 3 cap screws to specification.

Specification

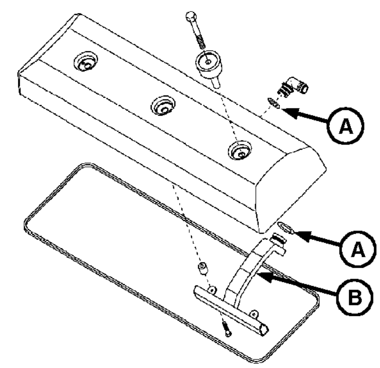
Rocker Arm Cover Hold-Down Cap Screws[1]—Torque .... 30 N•m (22 lb-ft)

6. Install air intake crossover tube, if necessary, and tighten connections securely.

[1]Tighten center cap screw first, then tighten sides.

RE38635,00000A3 –19–13DEC05–2/2

Clean and Inspect Crankcase Ventilation Assembly



RG10242 –UN–20JUL99

Crankcase Ventilation Assembly

A—O-Rings
B—Ventilator Assembly

1. Remove ventilation outlet tube from rocker arm cover (shown removed).

NOTE: Ventilator assembly-to-rocker cover self-tapping cap screws have been replaced by flange head cap screws with pre-applied sealant. Discard old self-tapping cap screws and replace with new cap screws.

2. Remove two cap screws securing ventilator assembly (B) to cover and remove.

3. Clean ventilator assembly in solvent and dry with compressed air.

4. Install ventilator assembly in reverse order of removal. Replace O-rings (A) as necessary.

5. Tighten ventilator assembly-to-rocker arm cover cap screws to specifications.

Specification

Crankcase Vent Baffle-to-Rocker
Arm Cover Cap Screws—Torque .... 15 N•m (11 lb-ft) (133 lb-in.)

6. Install ventilator outlet tube onto elbow attached to rocker arm cover.

RG,RG34710,61 –19–03SEP02–1/1

Replace Rocker Arm Cover Gasket

1. Remove rocker arm cover. (See REMOVE AND INSTALL ROCKER ARM COVER earlier in this group.)

2. Remove existing gasket from cover and discard. Clean gasket groove as needed.

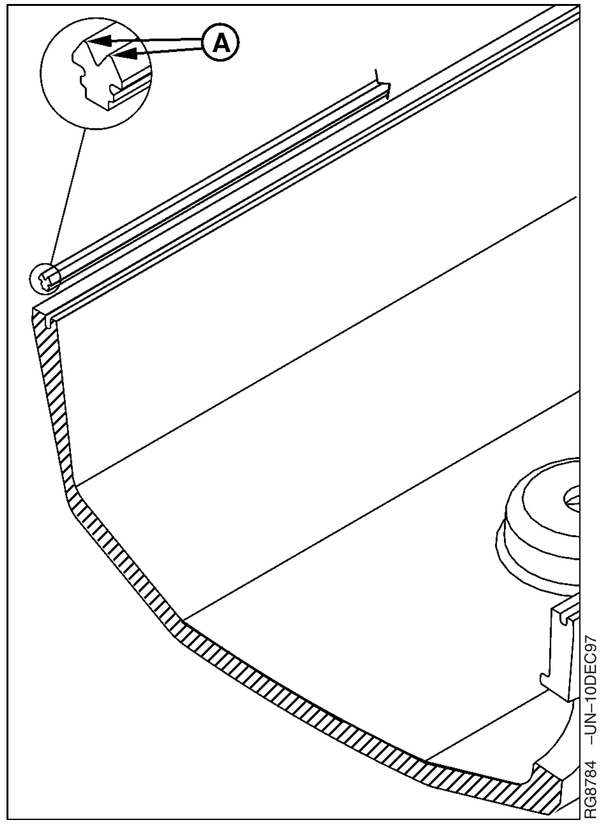
3. Position new gasket at two front corners of cover with double lips (A) of gasket facing up.

IMPORTANT: DO NOT stretch gasket while seating in groove of cover.

4. Seat gasket on front side of cover and proceed around entire cover gasket groove using a deep-well socket.

5. Re-seat gasket again (especially in corners) after entire gasket is installed in groove.

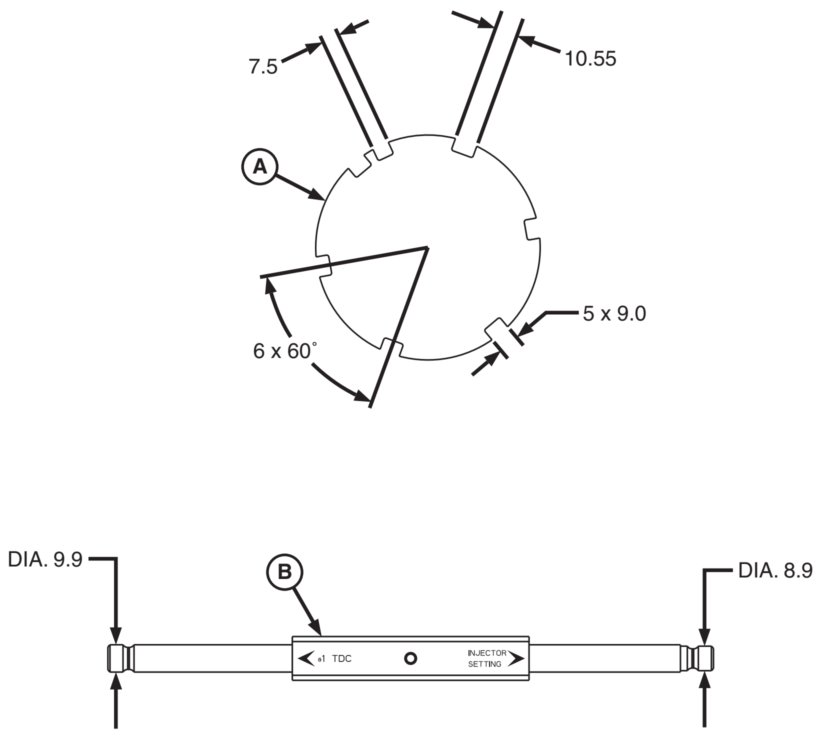
A—Gasket Double Lips



Replacing Rocker Arm Cover Gasket

RG,RG34710,62 –19–30SEP97–1/1

Check and Adjust Valve Assembly Clearances and Injector Preload



13.5L Camshaft Timing Slot & Tool

A—Camshaft Timing Wheel **B—JDG10246 Camshaft Timing Pin.**

IMPORTANT: IT IS EXTREMELY IMPORTANT TO FOLLOW THIS PROCEDURE, AS DEFINED. DEVIATION FROM THIS PROCEDURE WILL RESULT IN SEVERE DAMAGE TO INJECTORS.

The 13.5L engine requires a different method of adjusting valve lash and injector preload than the 12.5L engine.

The design of the camshaft timing wheel changed, which required a new camshaft timing pin. The timing slot to lock the engine at #1 top dead center (TDC) is 10.055 mm wide, as shown. This slot is also the position in which injector preload is set on #5 cylinder. The 5 remaining slots, used to set injector preload on the remaining 5 cylinders, are 9.0 mm wide.

The new JDG10246 camshaft timing pin is used to both lock the engine at TDC, and to set individual injector preload, as described in detail later in this group. The larger end is used with the 10.055 mm slot to lock the engine at TDC and set preload on #5 injector. The smaller, 8.9 mm end is to be used when setting injector preload. The body of the timing pin is is marked to indicate the TDC and Injector Preload Setting ends of the pin. Use JDG10246 camshaft timing pin with the already existing crankshaft timing pin that is part of JDG971 pin set (12.5L engines).

Rocker arm assembly adjustments consist of intake and exhaust valve clearance (lash) and electronic injector preload adjustment.

Continued on next page

CAUTION: To prevent accidental starting of engine while performing rocker arm adjustment, ALWAYS disconnect NEGATIVE (–) battery terminal.

IMPORTANT: All rocker arm assembly adjustments MUST BE performed with engine COLD.

1. Remove rocker arm cover. (See REMOVE AND INSTALL ROCKER ARM COVER earlier in this group.)

2. Remove plug from cylinder block and install JDG820 Flywheel Turning Tool.

Continued on next page RE38635,0000111 –19–21MAR06–2/12

3. Remove threaded plug from timing hole below oil cooler and filter housing assembly (B).

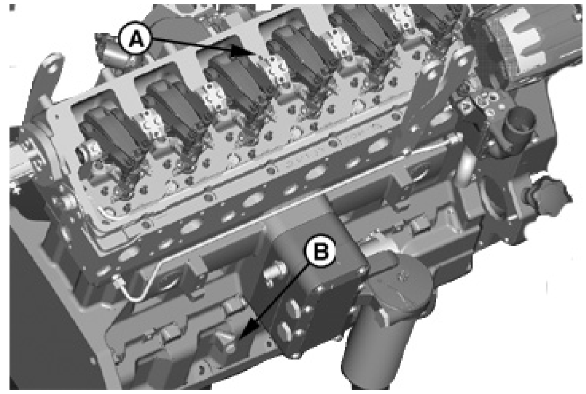
IMPORTANT: Timing pin MUST BE installed in slot of camshaft first, then install second timing pin in crankshaft slot by carefully rotating flywheel back and forth.

4. Rotate engine flywheel in running direction (counterclockwise as viewed from rear of engine) until **large end**of JDG10246 Timing Pin engages wide timing slot (C) in camshaft. The proper timing slot can be found by viewing camshaft timing lobe through camshaft timing pin bore while rotating engine. The double timing slot (D) will be at approximately 11 o'clock (viewed from rear of engine) when pin is installed in slot (C).This ensures that engine is locked at TDC of No. 1 cylinder's compression stroke. Intake and exhaust rocker arms on No. 1 cylinder should be loose.

IMPORTANT: DO NOT insert timing pin full depth into cylinder block crankshaft timing hole when rotating engine flywheel until double slot on camshaft timing lobe is at approximately 11 o'clock (viewed from rear of engine). This will avoid crankshaft counterweight bending timing pin.

5. Slightly move engine flywheel back and forth with turning tool until the crankshaft timing pin part of JDG971 Timing Pin can be installed in slot in crankshaft. This ensures that camshaft and crankshaft are in sync (properly timed).

   If timing pin does not enter crankshaft timing slot, crankshaft is not properly timed with camshaft. Crankshaft MUST BE timed to camshaft. (See CHECK AND ADJUST CAMSHAFT-TO-CRANKSHAFT TIMING in Group 050.)

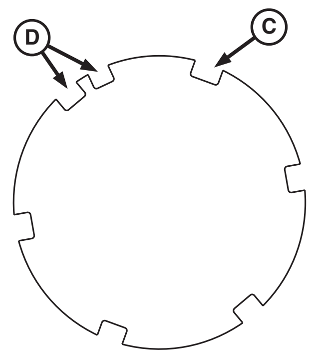


RG14547 –UN–31OCT05

Camshaft and Crankshaft Timing Holes

RG14808 –UN–21MAR06

JDG10246 Camshaft Timing Pin



RG14549 –UN–16MAR06

Camshaft Timing and Injector Preload Slots

A—Camshaft Timing Hole & JDG10246 Timing Pin
B—Crankshaft Timing Hole
C—#1 Top Dead Center Timing Slot
D—Double Timing Slot

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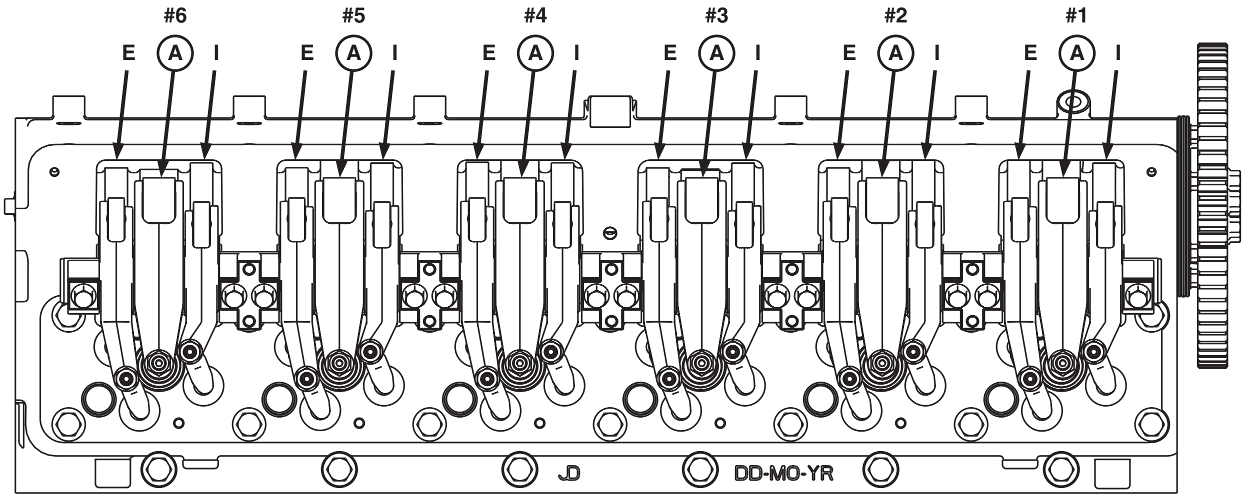
RE38635,0000111 –19–21MAR06–3/12



Rocker Arm Assembly Identification

A—Injector Rocker Arm

6. Set injector preload by backing out rocker arm adjusting screw until roller turns freely. Then tighten screw until roller is in direct contact with camshaft but at zero load. Then turn screw an additional 3/4 turn (to stroke injector plunger travel to 0.75 mm) and tighten adjusting screw lock nut to specification.

Specification

Electronic Injector Adjusting
Screw Lock Nut—Torque .... 65 N•m (48 lb-ft)

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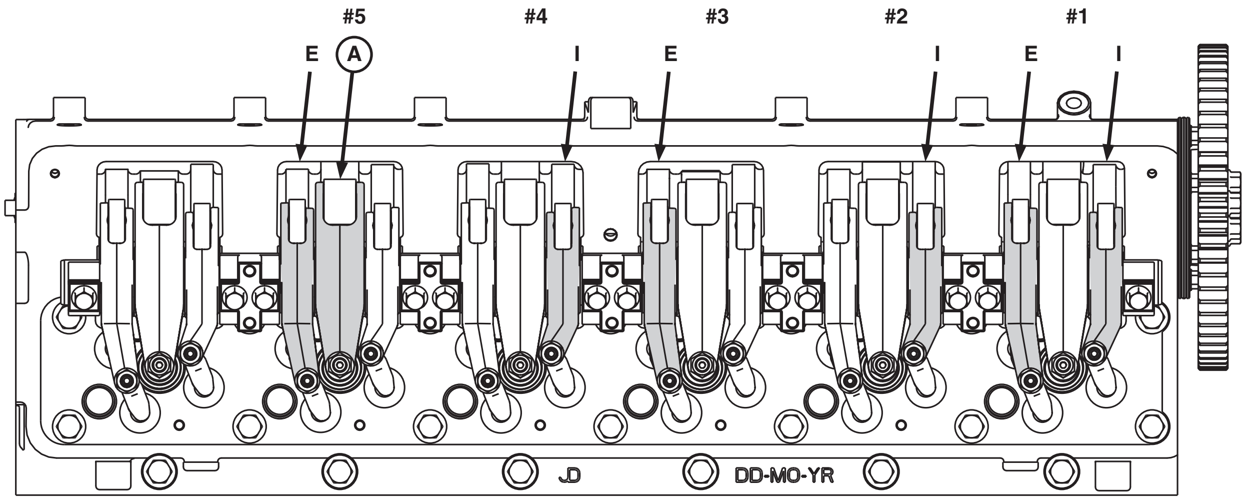


Setting Valve Lash & Injector Preload

With engine crankshaft set at #1 TDC cylinder (firing) and **large end of camshaft timing pin in wide camshaft slot**, run down adjusting screw and set injector preload on injector #5 (A). Set rocker arm valve lash in intake #1, #2, and #4 (see shaded rocker arms). Set rocker arm lash on exhaust #1, #3, and #5 (see shaded locations).

Valve clearance is adjusted using JDG1333 Feeler Gauge Set or equivalent 1/4 inch (6.0 mm) wide automotive ignition point-type feeler gauge installed at the joint between the valve bridge and valve stem tip that is near the exhaust (right) side of engine. Loosen lock nuts, set clearance with adjusting screw and tighten lock nut to specified torque while holding adjusting screw stationary.

Valve Stem-to-Bridge Clearance (Engine Cold)—Specification

Intake Valve—Clearance .... 0.58 mm (0.023 in.)
Exhaust Valve—Clearance .... 1.10 mm (0.043 in.)

7. Tighten intake and exhaust valve adjusting screw lock nuts to specifications.

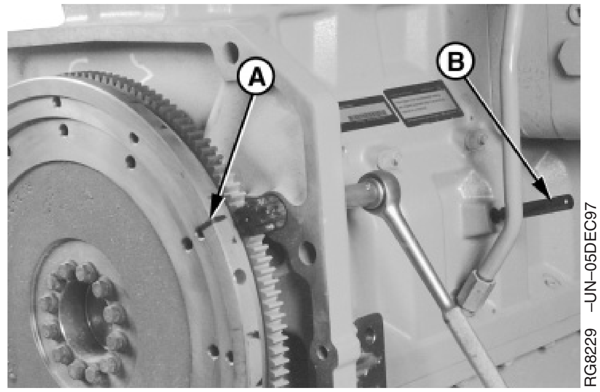
Specification

Intake and Exhaust Valve
Adjusting Screw Lock Nuts—
Torque.. 50 Nm (37 lb-ft)

Continued on next page RE38635,0000111 –19–21MAR06–5/12

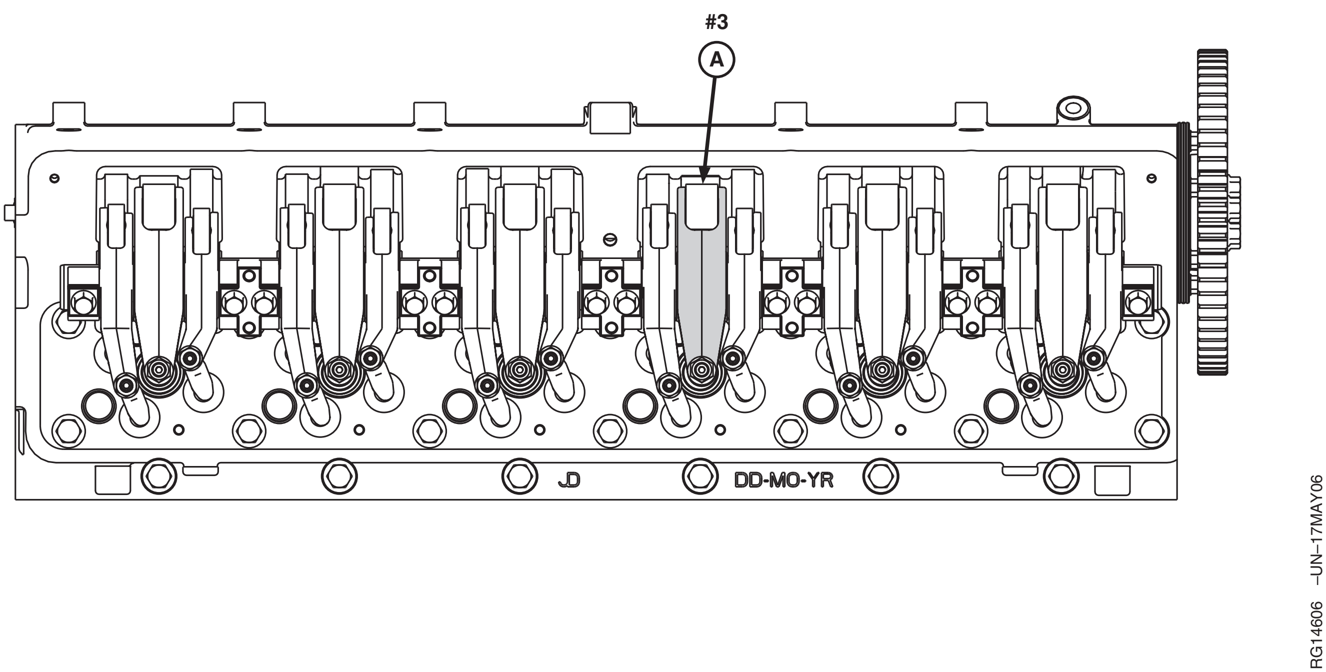
8. Reference mark flywheel (A), as shown, with engine locked at #1 TDC compression stroke. This aids in locating #6 TDC to adjust remaining valve lash settings.

A—Flywheel Reference Mark
B—Crankshaft Timing Pin



Flywheel Reference Mark

RE38635,0000111 –19–21MAR06–6/12



#3 Injector Preload

A—#3 Injector

9. Remove crankshaft and camshaft timing pins and rotate crankshaft 120° clockwise (when looking at front of engine). Insert the **small end of camshaft pin in narrow camshaft slot**. Tighten adjusting screw and set injector preload on injector #3. Tighten injector adjusting screw lock nuts to specifications.

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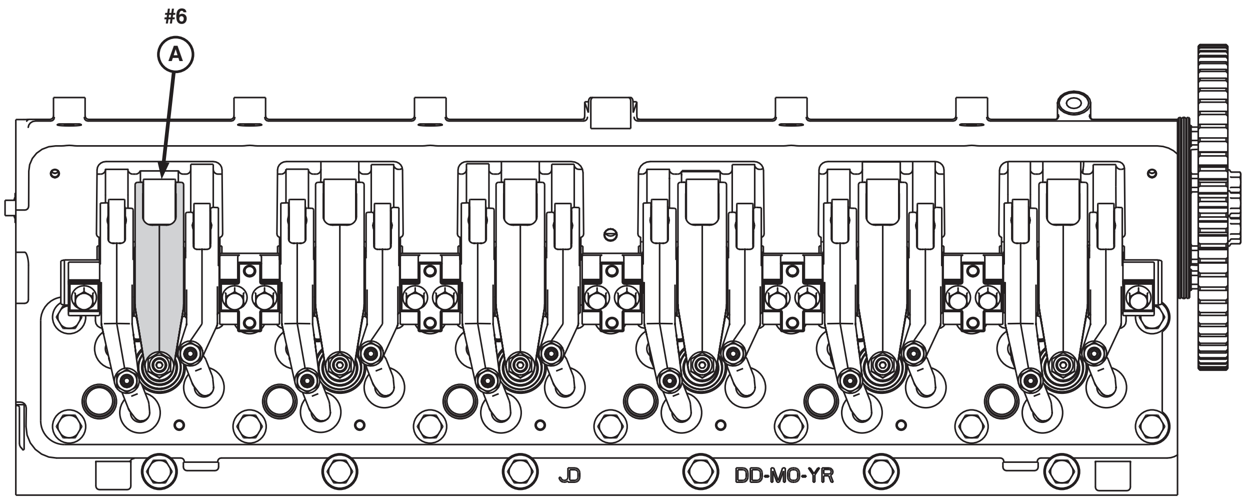
RE38635,0000111 –19–21MAR06–7/12



RG14607 –UN–17MAY06

#6 Injector Preload

A—#6 Injector

10. Remove crankshaft and camshaft timing pins and rotate crankshaft 120° clockwise (when looking at front of engine). Insert the **small end of camshaft pin in narrow camshaft slot**. Tighten adjusting screw and set injector preload on injector #6. Tighten injector adjusting screw lock nuts to specifications.

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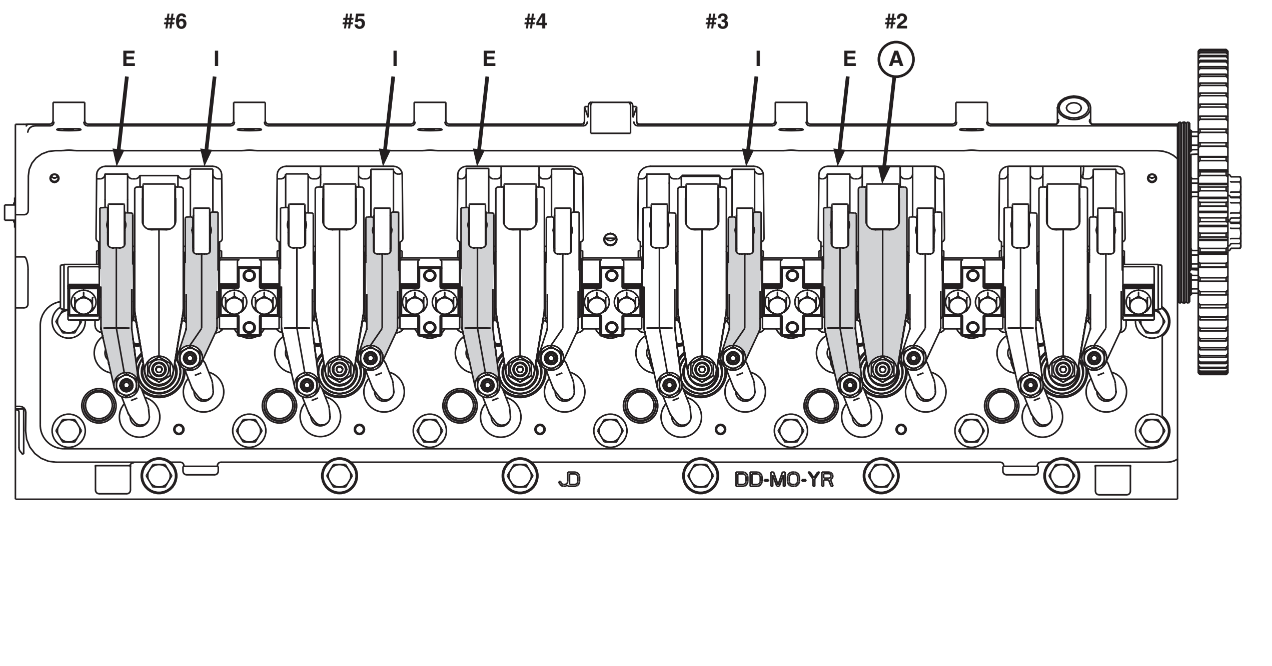

Rocker Arm Assembly Identification

A—#2 Injector

IMPORTANT: DO NOT insert timing pin full depth into cylinder block when rotating engine flywheel until reference mark is within a few degrees of a full crankshaft revolution to eliminate possibility of crankshaft counterweight bending timing pin.

11. Remove crankshaft and camshaft timing pins and rotate engine 120° to #6 TDC and install **crankshaft timing pin only**. Tighten adjusting screw and set injector preload on injector #2. Set rocker arm lash on intake #3, #5, and #6 (see shaded areas), and exhaust #2, #4, and #6 (see shaded areas). Tighten injector adjusting screw lock nuts to specification.

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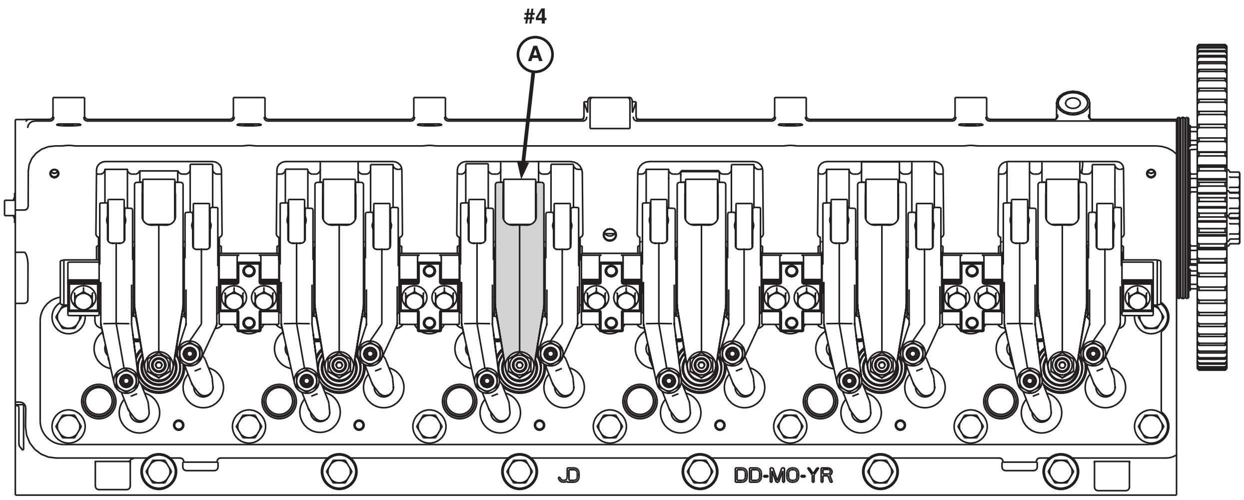

#4 Injector Preload

A—#4 Injector

12. Remove crankshaft timing pin and rotate crankshaft 120° clockwise (when looking at front of engine). Insert the **small end of camshaft timing pin in narrow slot**. Run down adjusting screw and set injector preload on injector #4. Tighten adjusting screw to specifications.

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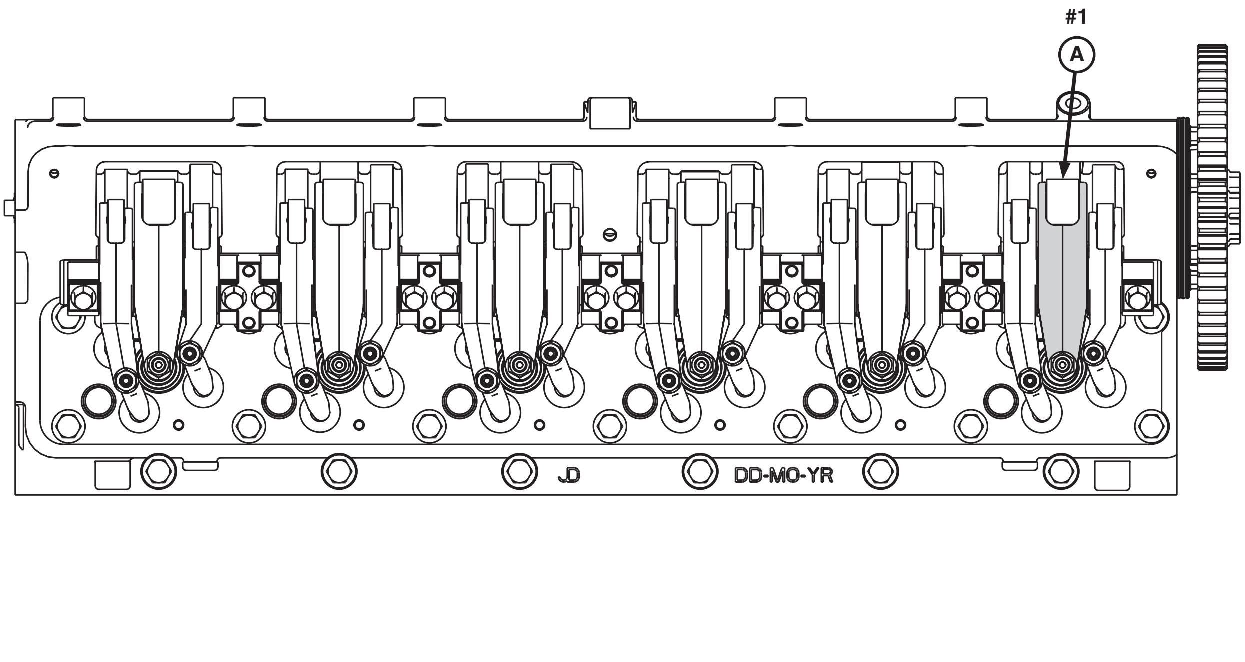


#1 Injector Preload

A—#1 Injector

13. Remove crankshaft timing pin and rotate crankshaft 120° clockwise (when looking at front of engine). Insert the **small end of camshaft timing pin in narrow slot**. Tighten adjusting screw and set injector preload on injector #1. Tighten adjusting screw to specifications.

Continued on next page RE38635,0000111 –19–21MAR06–11/12

IMPORTANT: Thoroughly inspect ALL intake and exhaust valve bridges (A) for proper seating on valve stems (B) from both sides of engine. Also, be sure that push tubes (C) are properly seated in top of valve bridge.

Use a flashlight and carefully check each bridge (for proper seating on valve stems) from both sides of the engine, by lifting up on each bridge to verify proper seating. VALVE BRIDGES THAT ARE NOT PROPERLY SEATED ON VALVE STEMS WILL RESULT IN MAJOR ENGINE VALVE TRAIN FAILURE.

14. Inspect the placement of all bridges to ensure proper location on valve stems.

15. Check that all rocker arm and electronic injector adjusting screws have approximately the same number of threads visible above lock nut. This will normally be zero threads to a maximum of two threads.

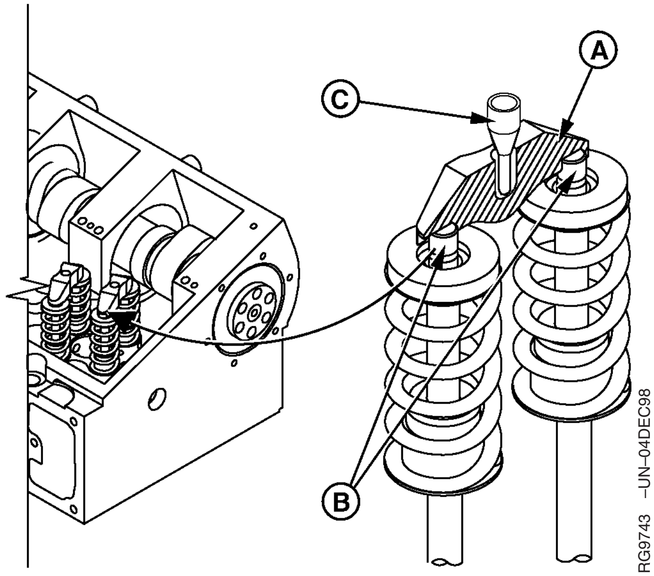
    If the number of threads above lock nut at any location is visually different, verify bridge seating and readjust valve clearance to ensure everything is within specification at this location.

16. Lubricate all rocker arm rollers and rocker arm assembly with clean engine oil.

17. Remove crankshaft and camshaft timing pins. Install lock pin timing hole plug to cylinder block and tighten to specification.

Specification

Timing Pin Hole Plug to Cylinder Block—Torque .... 15 N•m (12 lb-ft)



Inspect Valves

A—Valve Bridge
B—Valve Stems
C—Push Tubes

RE38635,0000111 –19–21MAR06–12/12

Remove Rocker Arm Assembly

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

1. Remove rocker arm cover.

2. Lock camshaft and crankshaft at TDC of No.1 cylinder's compression stroke.

3. Remove electronic injector wiring harness from rocker arm shaft clamps.

IMPORTANT: To relieve pressure, ALWAYS loosen all intake, exhaust and electronic injector (EI) rocker arm adjusting screws before removal or installation of rocker arm assembly . This allows for a more uniform rocker arm cap screw clamp load and reduces the possibility of damage to valve train components.

Remove push rods and valve bridges immediately after relieving rocker arm pressure. Push rods can fall into oil drain opening of cylinder head causing oil pan removal to retrieve rods.

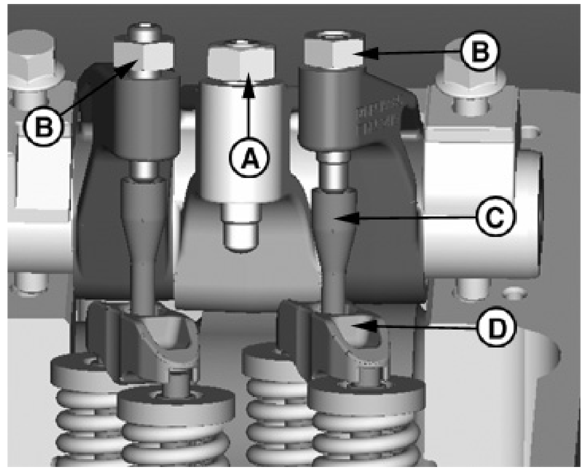
4. Loosen EI (A), intake and exhaust valve rocker arm adjusting screw lock nuts (B) to relieve pressure at all locations.

5. Remove push rods (C) and valve bridges (D) from all valve stems.

6. Remove rocker arm shaft hold down clamps.

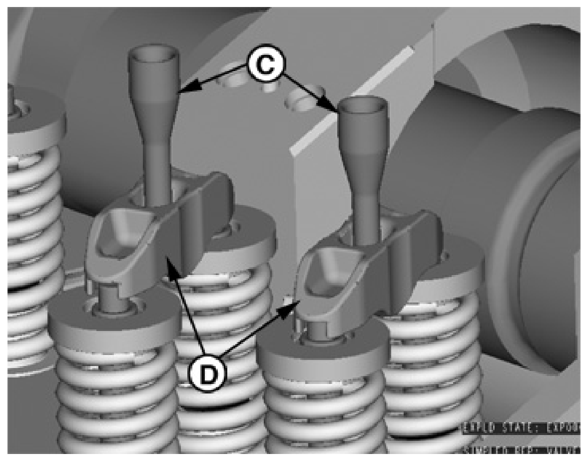
IMPORTANT: Rocker arm shaft hold-down clamp cap screws can not be reused. Use new cap screws for reassembly.

7. Install shaft clamp cap screw in end hole of each rocker arm shaft so that rocker arms do not slide off shaft when lifted.



RG14664 –UN–14DEC05

Remove Valve Bridges and Push Rods



RG14665 –UN–14DEC05

Valve Bridges and Push Rods

A—Injector Adjusting Lock Screw
B—Intake and Exhaust Valve Adjusting Screws
C—Push Rods
D—Valve Bridges

Continued on next page

RE38635,00000A5 –19–14DEC05–1/2

CAUTION: To safely handle rocker arm assembly during removal from engine, be certain to use pins marked JDG1847 with JDG970A Rocker Arm Lifting Fixture.

8. Depress actuator (ball) pins and install JDG970A Rocker Arm Lifting Fixture (B) into rocker arm shaft cap screw holes as shown. Replace pins to seat ball locks.

9. Remove both front and rear rocker arm and shaft assemblies using JDG970A Rocker Arm Lifting Fixture.

10. Discard rocker arm shaft hold-down clamp cap screws.

RE38635,00000A5 –19–14DEC05–2/2

Remove Cylinder Head

On some applications, it may be necessary to remove engine from machine to service cylinder head. Refer to your Machine Technical Manual for engine removal procedure.

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

DO NOT drain coolant until the coolant is below operating temperature. Only remove radiator filler cap when cool enough to touch with bare hands. Slowly loosen cap to first stop to relieve pressure before removing completely.

1. Drain all oil and coolant.

2. Remove intake manifold and crossover tube. (SeeREMOVE, INSPECT AND INSTALL INTAKE MANIFOLD in Group 080.)

3. Remove turbocharger (A). (See REMOVE TURBOCHARGER in Group 080.)

4. Remove exhaust gas recirculator (EGR). See REMOVE EGR in Group 080.

5. Remove exhaust manifold (B). (See REMOVE, INSPECT AND INSTALL EXHAUST MANIFOLD in Group 080.)

6. Remove thermostat housing/water manifold (C). (See REMOVE AND INSTALL THERMOSTAT HOUSING in Group 070.)

7. Remove rocker arm assembly. (See REMOVE AND INSTALL ROCKER ARM ASSEMBLY, earlier in this group).

8. Remove electronic injectors and wiring harness.

9. Remove fan drive hub and camshaft gear access cover.

Continued on next page

RE38635,00000E4 –19–23JAN06–1/3

10. Remove six cap screws securing camshaft gear retaining washer (A) and remove camshaft gear (B).

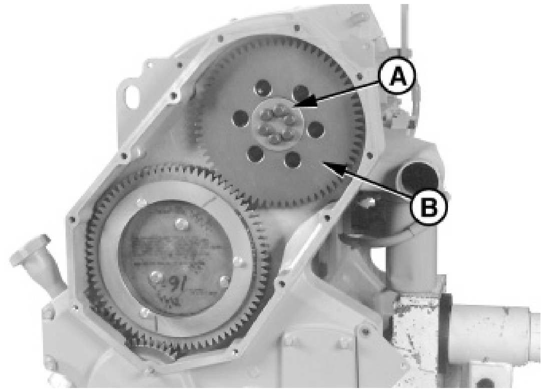
11. Remove fuel supply pump.

NOTE: Cylinder head can be removed without removing camshaft.

IMPORTANT: If cylinder head is removed with camshaft installed, secure camshaft in bushings with DFRG4 Camshaft Locking Tool (E) so that camshaft journals and bushings are not damaged by camshaft sliding out of bushings. (See DFRG4-CAMSHAFT LOCKING TOOL in Section 05, Group 190 for details on this dealer fabricated tool.)

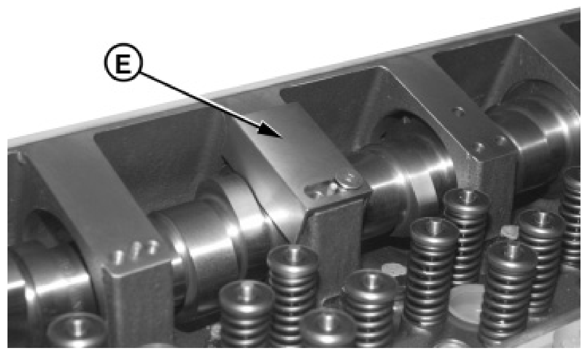
Camshaft position sensor MUST BE removed from air intake side of cylinder head when removing or installing camshaft to prevent camshaft binding on sensor.

12. Remove camshaft front thrust ring. Remove camshaft position sensor and remove camshaft if desired (see REMOVE AND INSTALL CAMSHAFT in Group 050).



RG8251A –UN–06DEC97

Removing Camshaft Gear



RG8544B –UN–10DEC97

DFRG4 Camshaft Locking Tool

A—Gear Retaining Washer
B—Camshaft Gear
E—DFRG4 Camshaft Locking Tool

Continued on next page RE38635,00000E4 –19–23JAN06–2/3

NOTE: If removing head with camshaft installed, camshaft will have to be rotated to remove two of the cylinder head cap screws.

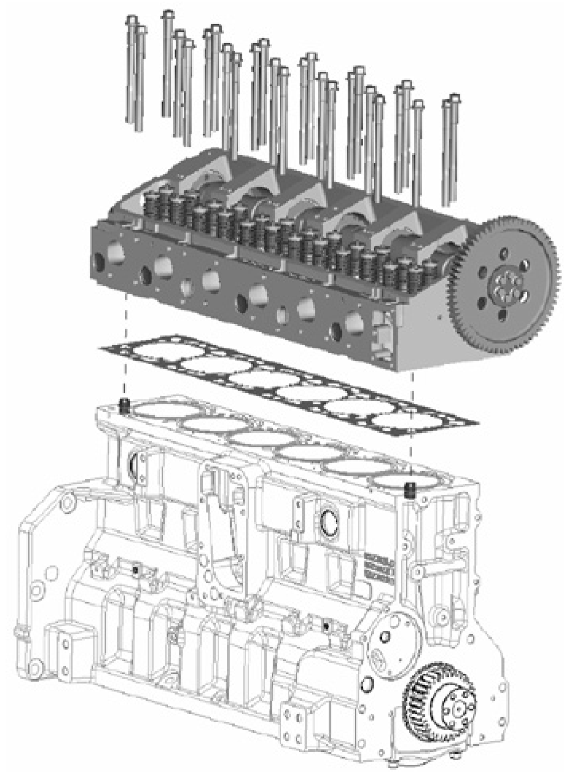
13. Remove 26 cylinder head cap screws with washers and discard.

IMPORTANT: DO NOT use screwdrivers or prybars between cylinder block and head to loosen gasket seal. Screwdrivers and prybars can damage head and block gasket surfaces.

14. Carefully lift cylinder head from block using an overhead hoist or floor crane. Place head on a clean, flat surface.

15. Remove cylinder head gasket. Inspect gasket for any manufacturing imperfections. Inspect head, gasket, and check for possible oil, coolant, or combustion chamber leakage.

NOTE: DO NOT rotate engine crankshaft with cylinder head removed unless all cylinder liners are secured with cap screws and large, flat washers. (See REMOVE PISTONS AND CONNECTING RODS in Group 030.)



RG14715 –UN–23JAN06

Removing Cylinder Head

RE38635,00000E4 –19–23JAN06–3/3

Diagnosing Head Gasket Joint Failures

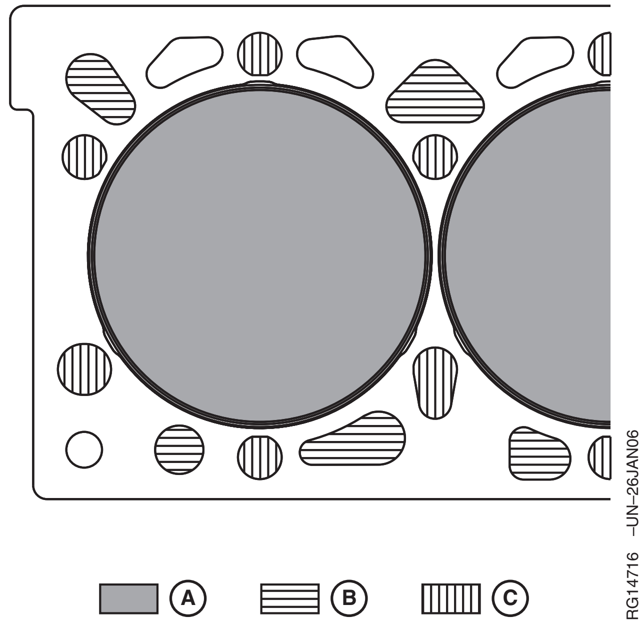
Head gasket failures generally fall into three categories:

- Combustion seal leakage.
- Coolant seal leakage.
- Oil seal leakage.

Combustion seal leakage 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.

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



Cylinder Head Sealing Area

A—Combustion Sealing
B—Coolant Sealing
C—Cylinder Head Cap Screws

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 pressure cap.
   - Presence of oil in coolant.
   - Low coolant levels or improper coolant.
   - Unusually high or low oil levels.
   - Oil degradation, dilution, or contamination.
   - Correctly specified electronic unit injectors.
   - Indications of fuel delivery or gear train not properly timed.
   - Unburned fuel or coolant in exhaust system.

Continued on next page

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 measurement equipment, check for the following:

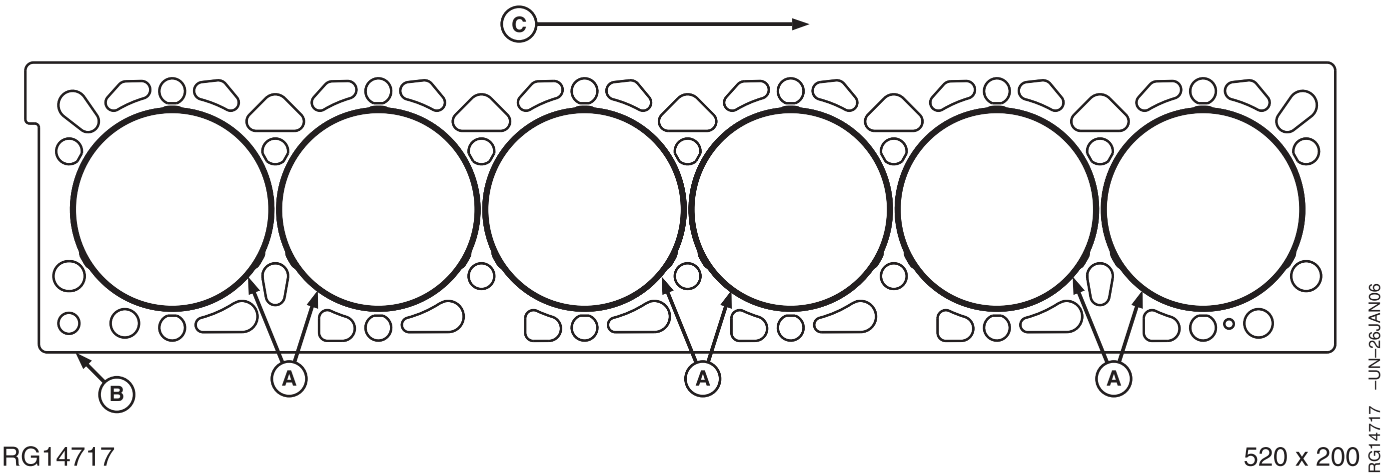
   - White smoke, excessive raw fuel, or moisture in exhaust system.
   - Rough, irregular exhaust sound, or misfiring.
   - Air bubbles, gas entrainment in radiator or overflow tank.
   - Loss of coolant from overflow.
   - Excessive cooling system pressure.
   - Coolant overheating.
   - Low coolant flow.
   - Loss of cab heating (air lock).

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 appropriate diagnostic procedures in Section 04, Group 150. 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.

RE38635,00000F4 –19–26JAN06–2/2

Head Gasket Inspection and Repair Sequence



Cylinder Head Gasket Inspection

A—Combustion Seal (Flange) B—Gasket Body C—Front of Engine

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. Upon removal, check cap screw length differences.

4. Remove cylinder head using appropriate lifting devices to prevent handling damage to head gasket. (See REMOVE CYLINDER HEAD in this group.)

5. Observe surfaces of removed head gasket.

   Examine combustion seals (A) 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/abraided/channelled.

   Examine gasket body (B) 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 cylinder block. (See INSPECT AND CLEAN CYLINDER BLOCK in Group 030.) Clean cylinder head. (See CLEAN AND INSPECT CYLINDER HEAD in this group.) Clean liners. (See CLEAN CYLINDER LINERS in Group 030.)

8. Proceed with the following dimensional checks and visual inspections:

   - Cylinder Head (this group)
     – Check surface flatness/finish.

Continued on next page RE38635,00000F5 –19–26JAN06–1/2

- Inspect for surface damage.
- Check cylinder head thickness, if resurfacing.

• Cylinder Block and Liners (assembled and clamped) (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 condition of threads.
  – Check length.

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 appropriate repair groups of this manual.

RE38635,00000F5 –19–26JAN06–2/2

Disassemble and Inspect Rocker Arms and Shaft Assembly

1. Remove rocker arms from shaft and identify for installation in same position as removed.

2. Inspect rocker arm shaft for scoring and excess wear at rocker arm contact points. Roll on a flat surface and check for bends or distortion.

3. Check rocker arm adjusting screws and lock nuts for thread damage.

4. Check valve bridges and push tubes for contact wear.

5. Clean all parts with clean solvent. Dry with compressed air.

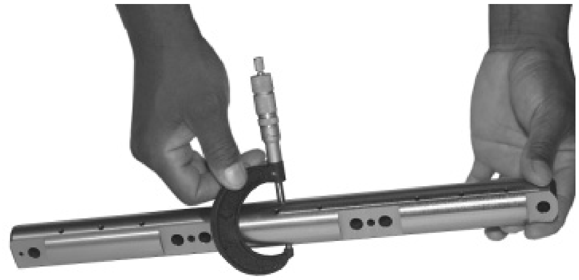
6. Measure rocker arm shaft OD and rocker arm bushing ID. Compare measurements with specifications below.

7. Inspect rocker arm roller for uneven wear. Measure roller OD and compare with specifications below.

Specification

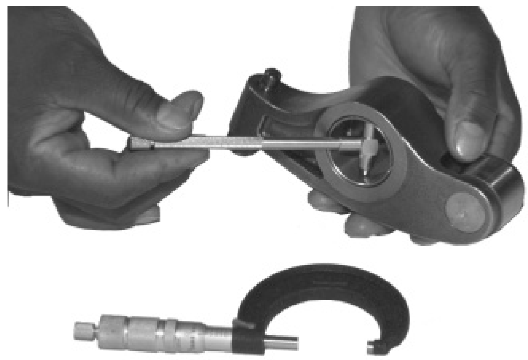
Rocker Arm Bushing—ID	38.064 ± 0.013 mm (1.4986 ± 0.0005 in.)
Rocker Arm Shaft—OD	38.000 ± 0.013 mm (1.4961 ± 0.0005 in.)
Rocker Arm Shaft-to-Bushing—Oil Clearance	0.064 ± 0.026 mm (0.0025 ± 0.0010 in.)
Rocker Arm Shaft Intake and Exhaust Roller—OD	39.995—40.045 mm (1.5746—1.5766 in.)
Rocker Arm Shaft Unit Injector Roller—OD	37.995—38.045 mm (1.4959—1.4978 in.)

Replace parts as necessary.



RG8395 –UN–21MAY98

Measure Rocker Arm Shaft



RG8392 –UN–21MAY98

Measure Rocker Arm Bushing

RG8390 –UN–21MAY98

Measure Rocker Arm Roller

RG,RG34710,71 –19–30SEP97–1/1

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 or 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.
- 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 seats.
- Bent valves.
- Debris passed through valve train.

RG,RG34710,72 –19–30SEP97–1/1

Assemble Rocker Arms and Shaft Assembly

1. Make sure that rocker arm shaft end plugs are firmly seated in each shaft end bore.

2. Assemble parts on rocker arm shaft in reverse sequence as removed.

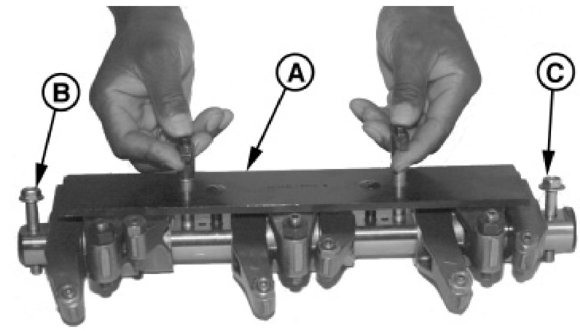
3. Install cap screws (B) and (C) in holes at each end of rocker arm shaft to keep rocker arms from sliding off shaft during installation.

4. Install JDG970A Rocker Arm Lifting Fixture (A) onto rocker arm and shaft assembly.

A—JDG970A Rocker Arm Assembly Lifting Fixture
B—Cap Screw
C—Cap Screw

RG8460 –UN–21MAY98

Rocker Arm and Shaft Assembly



RG8304 –UN–06DEC97

Lifting Rocker Arm Assembly

RG,RG34710,73 –19–13AUG99–1/1

Check Valve Height in Relation to Head Surface (Valve Recess)

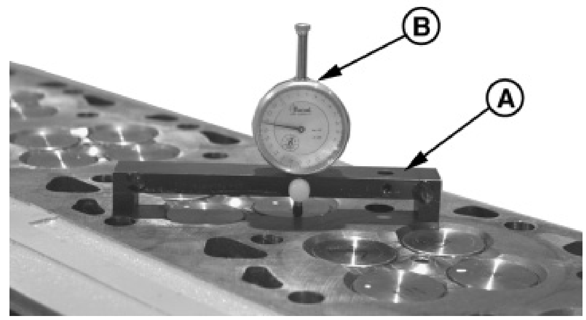
1. Thoroughly clean all gasket material from cylinder head combustion face.

2. Measure and record valve recess using JDG451 (English) or KJD10123 (Metric) Height Gauge (A) along with D17526CI (English, in.) or D17527CI Dial Indicator (Metric) (B). Measurements must be made a maximum of 3.0 mm (0.12 in.) in from edge of valve head.

Specification

Intake and Exhaust Valves—
Recess.. 1.80—2.40 mm (0.071—0.094 in.)

Install new valves, inserts, or grind existing valves and inserts (as necessary) to obtain specified valve recess.



RG8330A –UN–09DEC97

Measure Valve Recess

A—Height Gauge
B—Dial Indicator

RE38635,00000A0 –19–27JUL07–1/1

Remove Valve Assembly

NOTE: A small magnet may be used to aid removal of valve retainer locks (D).

1. Place cylinder head on a clean flat surface with combustion face down.

2. Using JDG982 Valve Spring Compressor (A), compress valve spring far enough to remove retainer locks as shown.

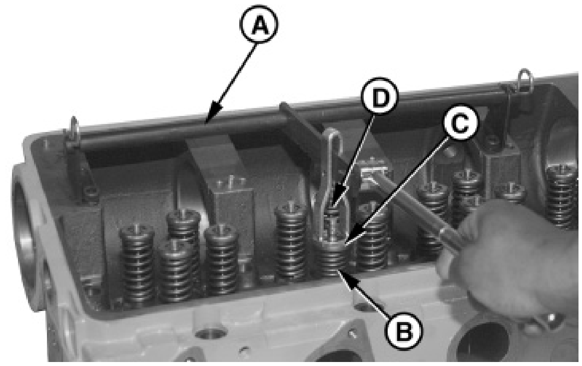
3. Release spring tension, remove valve rotator (C) and valve spring (B).

4. Remove valve stem seals (E) from valve guide tower.

5. Lay cylinder head on air intake side using a 1016 x 51 x 102 mm (40 x 2.0 x 4.0 in.) block of wood.

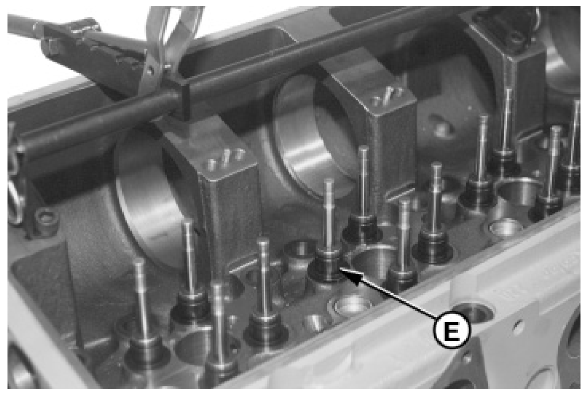
6. Remove valves and identify for assembly in same location.

A—JDG982 Valve Spring Compressor
B—Valve Springs
C—Valve Rotators
D—Valve Retainer Locks
E—Valve Stem Seals



RG8305 –UN–06DEC97

Removing Valve Springs



RG8306B –UN–06DEC97

Removing Valve Stem Seals

RG,RG34710,75 –19–30SEP97–1/1

Inspect and Measure Valve Springs

IMPORTANT: Valve springs must be replaced in sets of two with new rotators. DO NOT intermix springs across valve bridges.

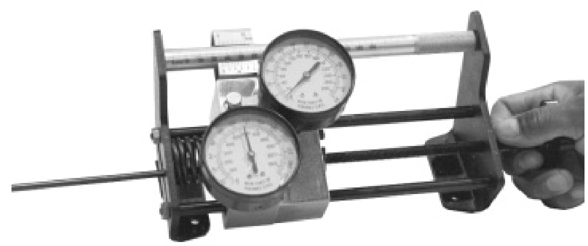
RG2732 –UN–04DEC97

Valve Spring

1. Inspect valve springs for alignment, wear, and damage.

2. Using D01168AA Spring Compression Tester, check valve spring tension. Compressed height must be within specification given below.

Specification	
Intake and Exhaust Valve Springs[1]—Height at 0 N (0 lb-force) Free Length	67.9—72.1 mm (2.67—2.84 in.)
Intake and Exhaust Valve Springs—Height at 527—593 N (118—133 lb-force) (Valve Closed)	59.4 mm (2.34 in.)
Intake and Exhaust Valve Springs—Height at 1187—1313 N (267—295 lb-force) (Valve Open)	46.4 mm (1.83 in.)



RG7427 –UN–21MAY98

Measuring Valve Spring Compression

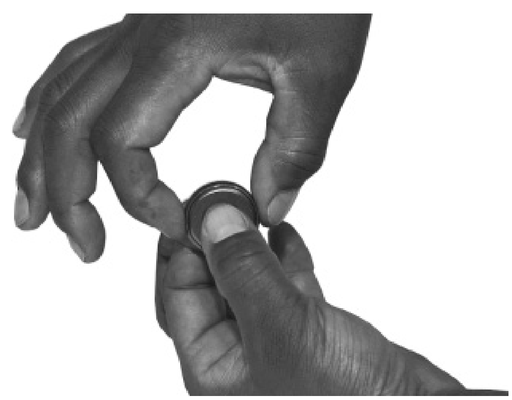
[1] *Free length of springs may vary slightly between springs.*

RE38635,00000E5 –19–26JAN06–1/1

Inspect Valve Rotators

Valve rotators cannot be repaired. Replace valve rotators when valves are replaced or reground.

Ensure that valve rotators turn freely in both directions. Replace if defective.



RG8323 –UN–21MAY98

Inspecting Valve Rotator

RG,RG34710,77 –19–30SEP97–1/1

Clean, Inspect, and Measure Valves

1. Hold each valve firmly against a soft brass or copper wire wheel on a bench grinder.

IMPORTANT: Any carbon left on the stem will affect alignment in valve refacer. DO NOT use a wire wheel on plated portion of valve stem. Polish the valve stem with steel wool or crocus cloth to remove any scratch marks left by the wire brush.

2. Make sure all carbon is removed from valve head, face, and unplated portion of stem.

3. Inspect valve face, stem, tip, and retainer lock groove.

4. Measure valve stem OD Record measurements and compare with valve guide ID. (See MEASURE VALVE GUIDE ID, later in this group.)

Specification

Intake and Exhaust Valve
Stems—OD.. 8.999 ± 0.013 mm (0.3543 ± 0.0005 in.)

5. Using a valve inspection center, determine if valves are out of round, bent, or warped.

Specification

Intake and Exhaust Valve
Face[1]—Maximum Runout...................................... 0.038 mm (0.0015 in.)

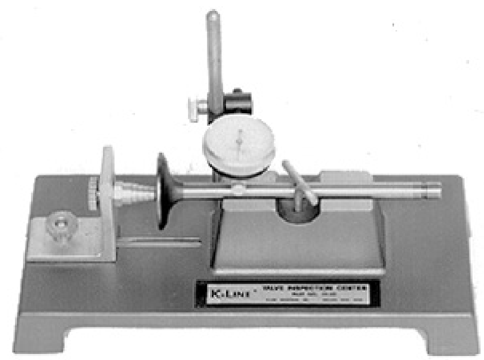
6. Measure valve head OD.

Specification

Intake and Exhaust Valve Head—
OD .... 43.87—44.13 mm (1.727—1.737 in.)

RG8322 –UN–21MAY98

Measuring Valve Stem



RG4234 –UN–05DEC97

Measuring Valve Face Runout

[1]*Maximum runout measured at 42 mm (1.65 in.) diameter.*

RE38635,00000E6 –19–23JAN06–1/1

Grind Valves

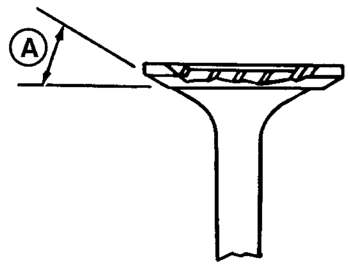
Reface serviceable valves to specified angle (A). Face angle on intake and exhaust valves is as follows:

Specification

Intake and Exhaust Valve Face—
Angle .... 29.25° ± 0.25°

IMPORTANT: DO NOT nick valve head-to-stem radius when grinding valves. A nick could cause the valve to break. Break all sharp edges after grinding.

A—Valve Face Angle



Valve Face Angle

RG,RG34710,79 –19–30SEP97–1/1

Clean and Inspect Cylinder Head

IMPORTANT: DO NOT USE scouring pads or wire brush to clean gasket sealing surface (combustion face). Doing so may affect sealing ability of gasket joint.

DO NOT "hot tank" clean cylinder head unless all plugs and valve guides are removed for replacement. Hot tank solution will destroy lubricating properties of valve guides.

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. Inspect around injector sleeve for evidence of fuel or coolant leakage.

3. Scrape gasket material, oil, carbon, and rust from head. Use a powered brass or copper (soft) wire brush to clean sealing surfaces. DO NOT use a steel wire brush.

4. Clean valve guides using a plastic brush.

IMPORTANT: During engine repair or overhaul, cleanliness of fuel supply rail is extremely important due to fuel flow through passages. Think of the fuel rails as internal passages of an injection pump; therefore, same cleanliness must be maintained.

5. Remove fuel rail expansion plugs in front of cylinder head and thoroughly clean fuel rail passages using a rifle-type cleaner (solvent). All debris must be removed from fuel rail.

6. Dry with compressed air and blow out all passages.

Continued on next page

RE38635,00000E7 –19–23JAN06–1/2

7. Final dry fuel rail passages with clean lint-free cloth and rifle cleaner or suitable push rod.

8. Coat new expansion plug with LOCTITE® 277 Plastic Gasket and install in front face of head.

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RE38635,00000E7 –19–23JAN06–2/2

Check Cylinder Head Flatness

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

Specification

Cylinder Head—Maximum Acceptable Out-of-Flat for Entire Length of Head	0.10 mm (0.004 in.)
Maximum Acceptable Out-of-Flat for Every 305 mm (12.0 in.)	0.025 mm (0.0009 in.)

If out-of-flat exceeds specifications, the cylinder head must be resurfaced or replaced. (See MEASURE CYLINDER HEAD THICKNESS later in this group.)

RG8309 –UN–21MAY98

Measuring Cylinder Head Flatness

RG,RG34710,81 –19–30SEP97–1/1

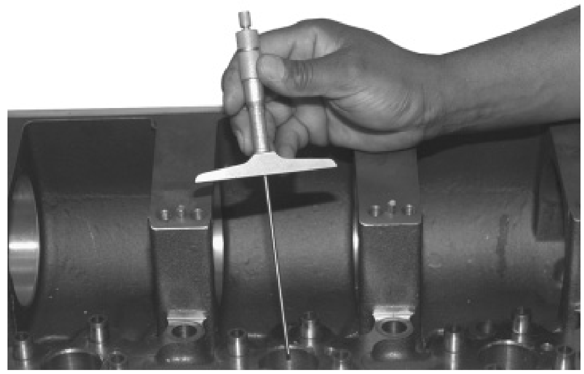
Measure Cylinder Head Thickness

Measure cylinder head thickness from rocker cavity-to-combustion face.

If cylinder head thickness is outside of specification, DO NOT attempt to resurface. Guidelines have not yet been established. Install a new cylinder head.

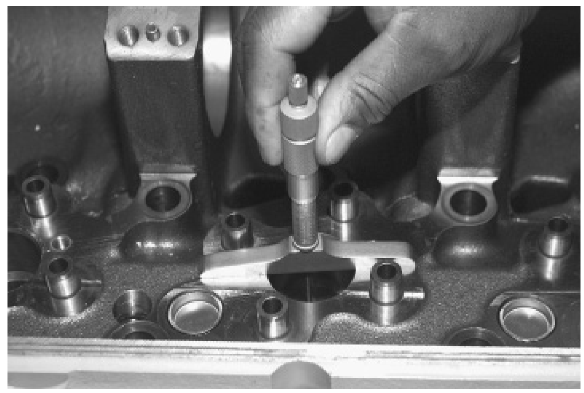
Specification

Cylinder Head (Rocker Arm Cover-to-Combustion Face)—
New Part Thickness .... 124.975—125.025 mm (4.9203—4.9222 in.)
Minimum Acceptable Thickness........................ 124.840 mm (4.9150 in.)



RG8324 –UN–21MAY98

Using Depth Gauge



RG8325 –UN–21MAY98

Measuring Cylinder Head Thickness

RE38635,00000E8 –19–24JAN06–1/1

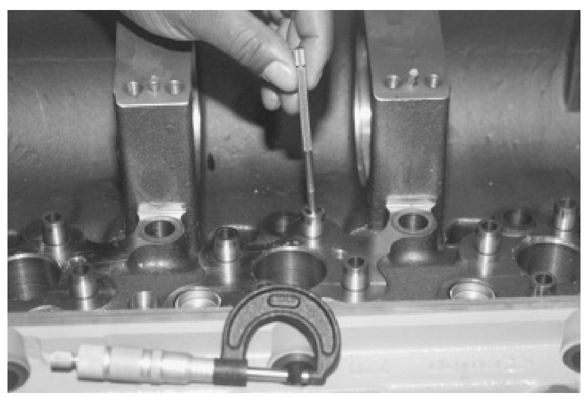
Measure Valve Guide ID

1. Measure valve guides ID using a telescopic gauge.
2. Record measurements and compare readings with valve stem OD to determine stem-to-guide clearance.

Specification

Valve Guide—ID - Before Assembly to Cylinder Head........................... 9.065 ± 0.013 mm (0.357 ± 0.0005 in.)
Valve Guide—ID - After Assembly to Cylinder Head... 9.045 +/- 0.013 (0.356 +/- 0,0005in.)
Valve Stem—OD .... 8.999 ± 0.013 mm (0.354 ± 0.0005 in.)
Valve Stem-to-Guide—Clearance .... 0.020—0.072 mm (0.0008—0.028 in.)

Replacement valve guides are available if valve guide ID is not within specification for specified guide-to-stem clearance (See REPLACE VALVE GUIDES, later in this group).



RG8308 –UN–21MAY98

Measuring Valve Guide ID

RE38635,00000A1 –19–27JUL07–1/1

Replace Valve Guides

Remove Valve Guides

1. Position cylinder head with combustion face facing up.

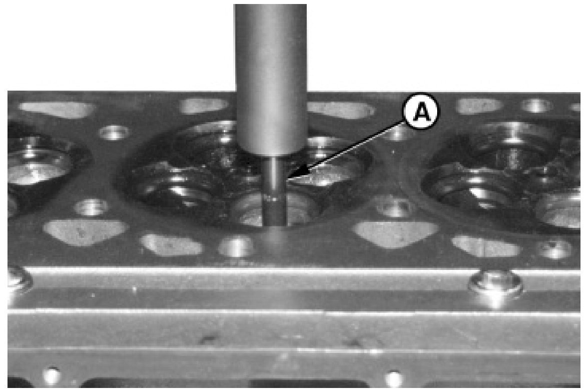
2. Drive valve guides from combustion face side of cylinder head using JDG164A Driver (A) and a press.

3. Inspect valve guide bore for cracking or excessive metal transfer. Thoroughly clean valve guide bore.

4. Measure valve guide bore in cylinder head. Replace cylinder head if valve guide bore is not within specification.

Specification

Valve Guide Bore in Head—ID .... 14.94 ± 0.02 mm (0.5882 ± 0.0008 in.)



RG8823 –UN–11DEC97

Removing Valve Guide with JDG164A

A—JDG164A Valve Seat Pilot Driver

RE38635,00000EA –19–26JAN06–1/2

Install Valve Guides

1. Assemble JDG164A Valve Guide Installation Adapter (A) and JDG10254 Driver (B) onto replacement valve guide (C).

2. Position cylinder head resting on combustion face.

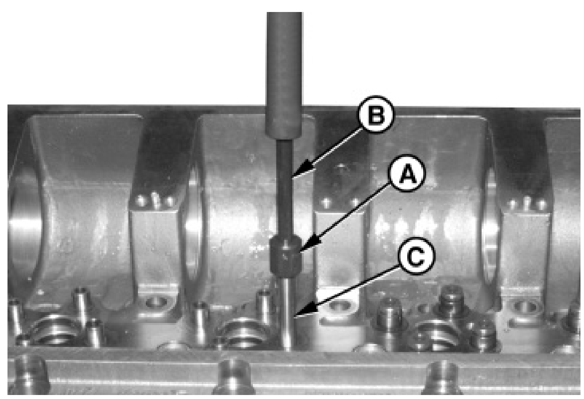
3. Position valve guide over bore in cylinder head and press guide in head until adapter bottoms on machined surface.

4. Measure valve guide installed height. Installed height should be as follows:

Specification

Valve Guide—Installed Height .... 15.0 +/- 0.5 mm (.591 +/- .020 in.)

5. Insert a valve stem through valve guide to check for adequate clearance. Valve stem should move freely in valve guide.



RG8824 –UN–11DEC97

Installing Valve Guide

A—JDG1167 Valve Guide Installation Adapter
B—JDG1164A Valve Seat Pilot Driver
C—Replacement Valve Guide

RE38635,00000EA –19–26JAN06–2/2

Clean and Inspect Valve Seats

1. Use an electric hand drill with copper or brass (soft) wire brush to remove all carbon on valve seats.

2. Inspect seats for excessive wear, cracks, or damage.

3. Check entire combustion face for rust, scoring, pitting, or cracks.

RG,RG34710,86 –19–30SEP97–1/1

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 valve guides and work area clean when grinding valve seats to maintain valve guide bore-to-seat runout.

Grinding valve seats increases seat width and valve recess in cylinder head. DO NOT grind excessively. Only a few seconds are required to recondition the average valve seat. Dress grinding stone as necessary to maintain specified seat angle.

Support the weight of grinder to avoid excessive pressure on the stone.

Blend or radius all sharp edges 0.50 mm (0.02 in.) maximum corner break to eliminate burrs after grinding valve seats.

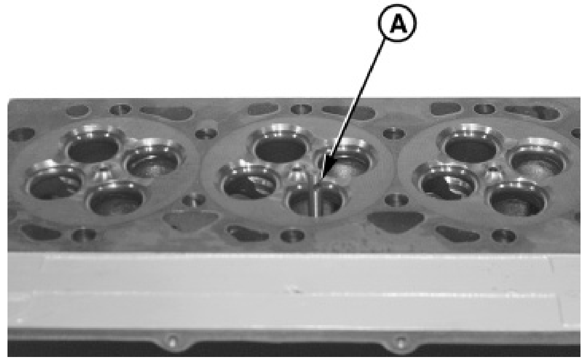
1. Install appropriate pilot (A) in valve guide bore.

2. Install appropriate grinding stone (B) on arbor (C) and position onto valve seat and pilot.

3. Using drill from JT05893 Heavy-Duty Seat Grinder Set, grind valve seats to the following specifications:

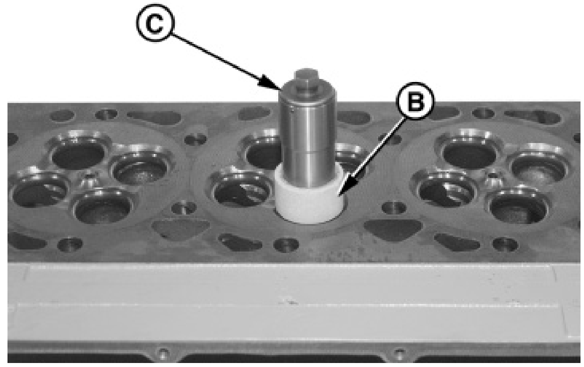
Specification

Valve Seat Grinding—Contact	
Angle	30°
Width	1.50—2.00 mm (0.059—0.079 in.)
Maximum Runout	0.16 mm (0.006 in.)



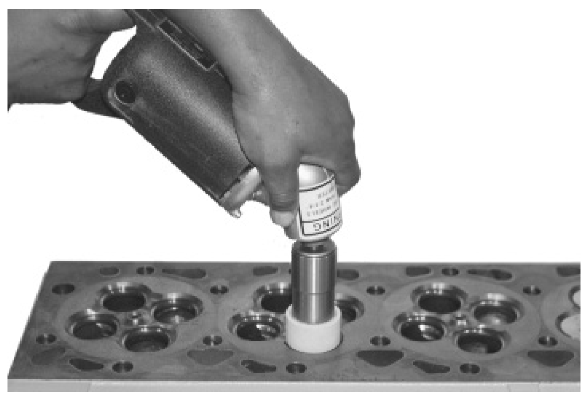
RG8311 –UN–06DEC97

Valve Seat Grinding Pilot



RG8312 –UN–06DEC97

Valve Seat Arbor and Grinding Stone



RG8313 –UN–21MAY98

Grinding Valve Seat

A—Pilot
B—Grinding Stone
C—Arbor

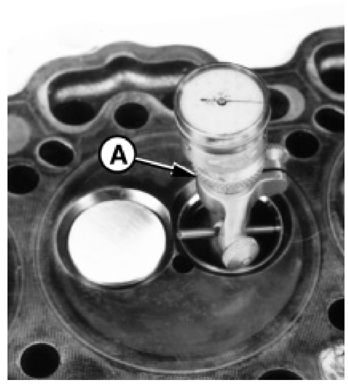
Continued on next page RG,RG34710,87 –19–28NOV00–1/2

4. Use a vernier caliper or scale to measure seat width. If valve seat is too wide, reduce the width with a narrowing stone.

NOTE: A narrowing stone will change the top angle of the seat and reduce the outer diameter of the valve seating area. Varying the width changes the fine contact between valve face and seat. If seat width is too narrow, valve may burn or erode.

5. If valve does not seat properly, use an eccentrimeter (A) to check valve seat runout. Use a new or refaced valve and blueing to check contact between valve seat and face. If necessary, lap the valve onto its seat using a lapping tool and lapping compound. Replace valves and inserts as necessary.

6. Install new or refaced valve and check valve recess in cylinder head after grinding. (See CHECK VALVE HEIGHT IN RELATION TO HEAD SURFACE earlier in this group.)



RG6318 –UN–03NOV97

Measuring Valve Seat Runout

A—Eccentrimeter

RG,RG34710,87 –19–28NOV00–2/2

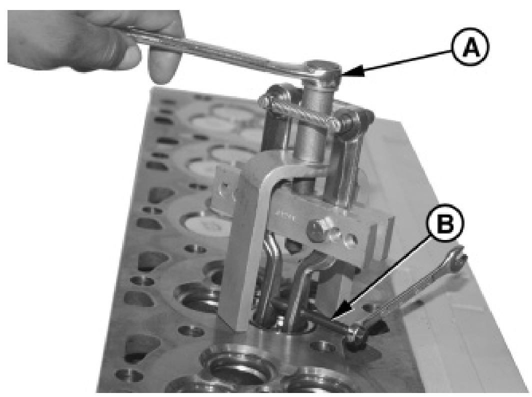
Remove Valve Seat Inserts

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

Use JDE41296 Valve Seat Puller (A). Adjusting screw (B) may need to be retightened during removal of inserts.

After removal of inserts, thoroughly clean area around valve seat bore and inspect for damage or cracks. Measure bore ID. (See MEASURE VALVE SEAT BORE IN CYLINDER HEAD in this group.)

A—JDE41296 Valve Seat Puller
B—Adjusting Screw



RG8314 –UN–06DEC97

Removing Valve Seat Insert

RG,RG34710,88 –19–30SEP97–1/1

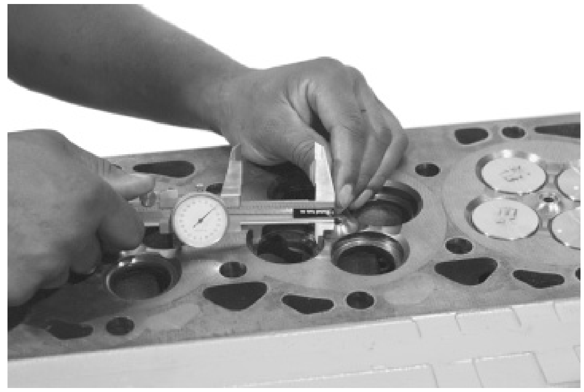
Measure Valve Seat Bore in Cylinder Head

1. Measure valve seat bores in cylinder head and compare with specifications given below.

Specification

Intake and Exhaust Valve Seat Bore—ID	46.424 ± 0.013 mm (1.8277 ± 0.0005 in.)
Bore Depth	10.65 mm (0.419 in.)
Radius at Lower Bore	0.64 ± 0.25 mm (0.025 ± 0.001 in.)
Standard Intake and Exhaust Valve Seat—OD	48.520 +/- 0.013 mm (1.910 +/- .0005 in.)

2. Oversize valve seats are not yet available.



RG8315 –UN–21MAY98

Measuring Valve Seat Bore

RE38635,00000EB –19–25JAN06–1/1

Install Valve Seat Inserts

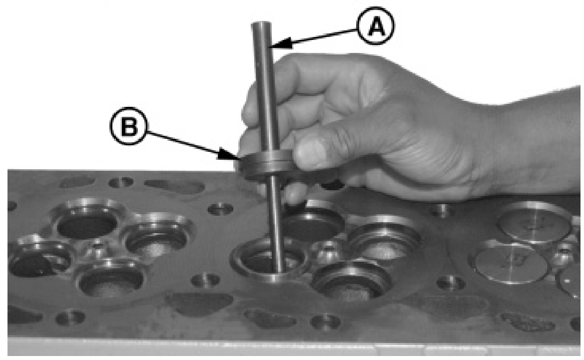
1. Use JDG164A Pilot Driver (A) and JDG10249 Valve Seat Insert Installing Adapter (B) to install valve seat inserts in cylinder head.

2. Install valves and measure valve recess. (See CHECK VALVE HEIGHT IN RELATION TO HEAD SURFACE, earlier in this group.)

3. Grind valve seats as required to maintain correct valve recess and valve face-to-seat seal. (See GRIND VALVE SEATS earlier in this group.)

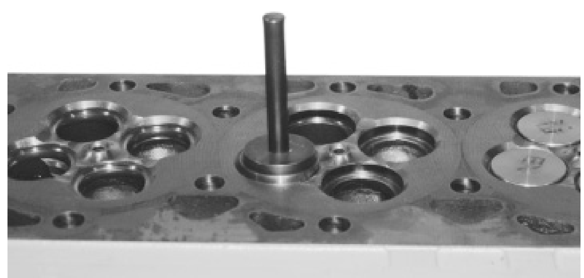
IMPORTANT: A common practice is to chill valve seat inserts in a freezer before installing. This chilling process allows for less interference when pressing in valve seats. Once inserts heat up to room temperature, original press-fit is restored.

A—JDG164A Pilot Driver
B—JDG10249 Adapter



RG8319 –UN–06DEC97

Valve Seat Pilot Driver

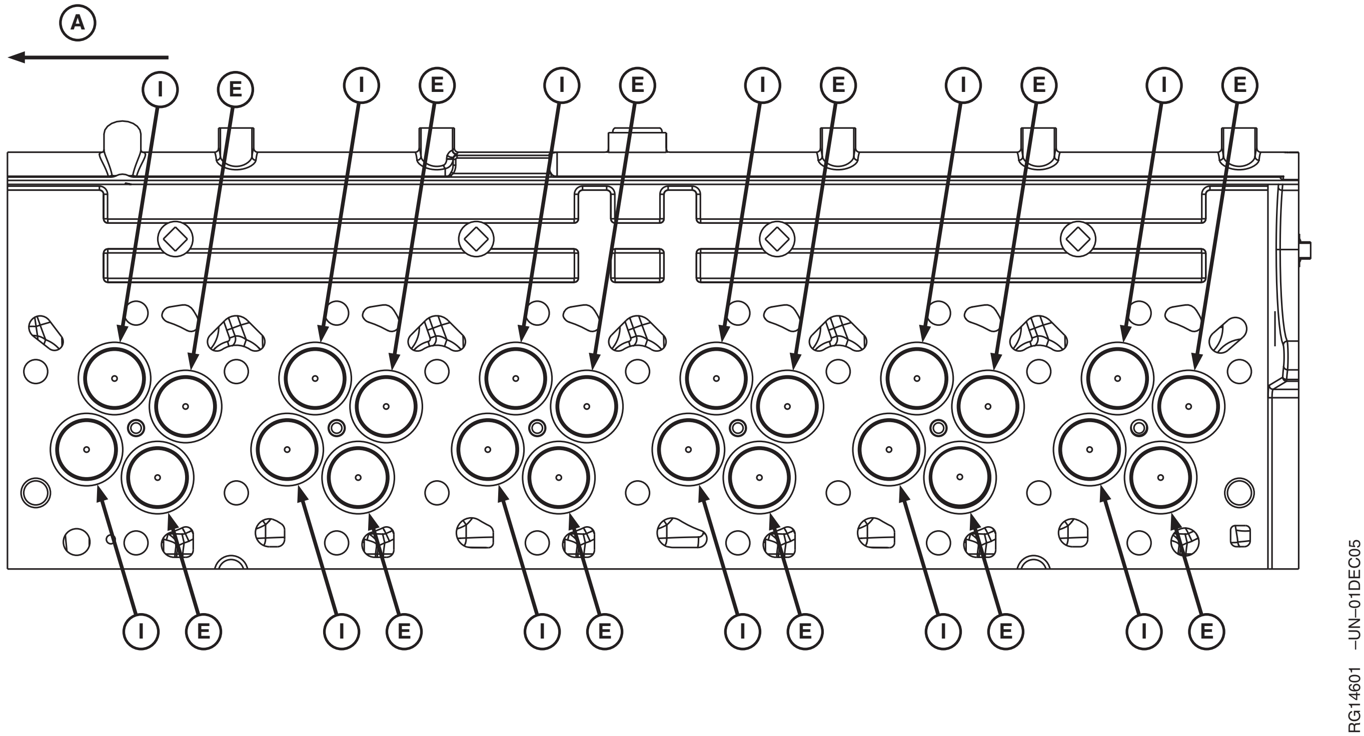


RG8318 –UN–21MAY98

Installing Valve Seat Insert

RE38635,00000EC –19–25JAN06–1/1

Install Valves



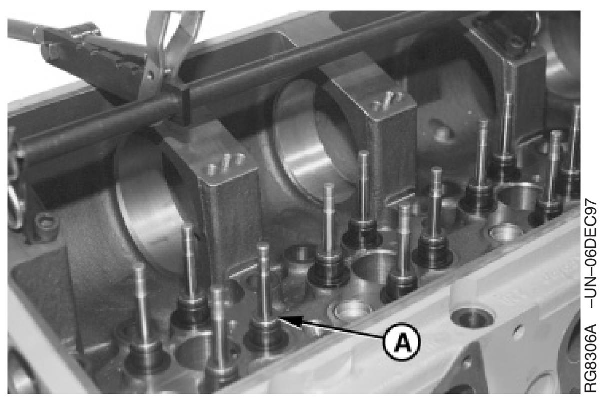
Installing Valves

1. Lubricate valve stems and guides with AR44402 Valve Stem Lubricant or clean engine oil.

NOTE: Valve must move freely in guide and seat properly with inserts to form an effective seal.

2. Insert valves in head (if valves are reused, install in same location from which removed).

3. Slide valve stem seals (A) over valve stems and onto intake and exhaust valve guide tower until firmly seated.



Installing Valve Stem Seals

A—Valve Stem Seals

Continued on next page

RE38635,00000ED –19–25JAN06–1/2

IMPORTANT: Valve springs must be replaced in sets of two with new rotators. DO NOT intermix springs across valve bridges.

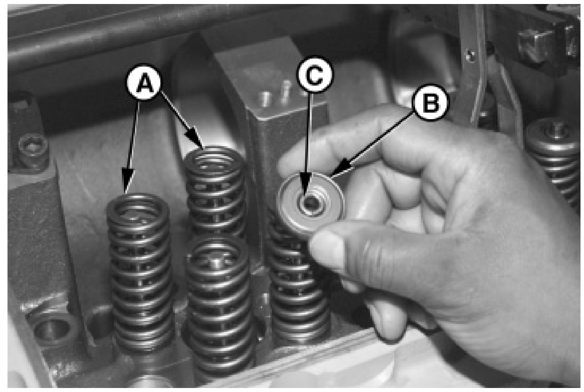
4. With cylinder resting on combustion face, install valve springs (A) and rotators (B) with retainer locks (C).

5. Compress valve springs using JDG982 Valve Spring Compressor and install retainer locks on valve stems.

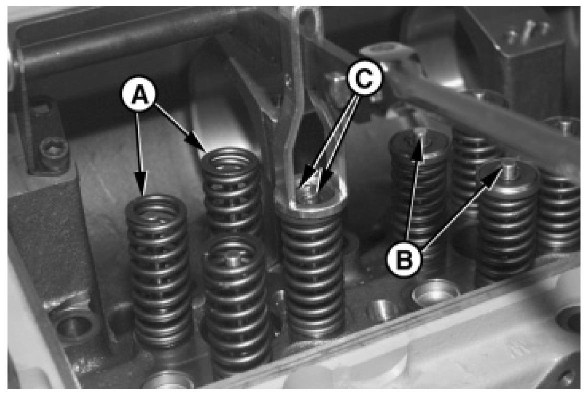
6. Strike end of each valve several times with a soft, (non-metallic) hammer to ensure retainer locks are properly seated.

7. Recheck valve recess. (See CHECK VALVE HEIGHT IN RELATION TO HEAD SURFACE, earlier in this group.)

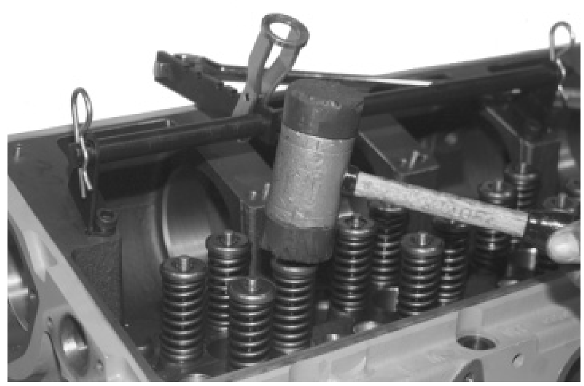
A—Valve Springs
B—Rotators
C—Retainer Locks



Installing Valve Rotators



Installing Valve Retainer Locks



Seating Valve Retainer Locks

RE38635,00000ED –19–25JAN06–2/2

Replace Unit Injector Sleeve in Cylinder Head Using JDG981

Remove Unit Injector Sleeve

NOTE: Cylinder head must be removed to replace EUI sleeve using JDG981 Unit Injector Sleeve Installation Set. To replace EUI sleeve with head installed refer to REPLACE UNIT INJECTOR SLEEVE IN CYLINDER HEAD USING JDG1184 later in this group.

IMPORTANT: Whenever EUI is replaced, sleeve in cylinder head must be replaced also.

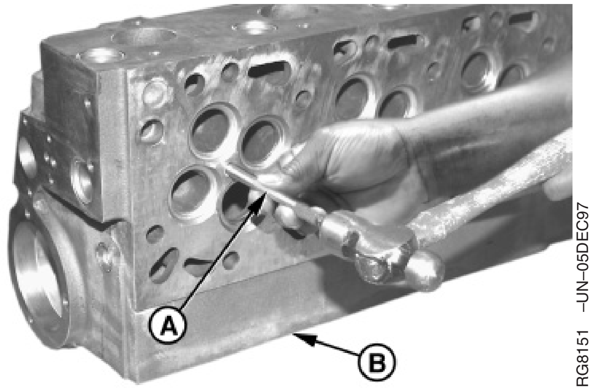
1. Remove cylinder head from engine. (See REMOVE CYLINDER HEAD, earlier in this group.)

2. Remove valves from cylinder head. (See REMOVE VALVE ASSEMBLY, earlier in this group.)

3. Using a 51 mm by 102 mm (2.0 in. by 4.0 in.) block of wood (B) at least 914.4 mm (36.0 in.) long, lay cylinder head on its side with air intake manifold mounting surface resting on block of wood.

4. Drive injector sleeve from combustion face side of cylinder head using MAY-25010 Punch (A) from JDG981 Unit Injector Sleeve Installation Set and hammer.

5. Thoroughly clean sleeve bore and inspect sleeve tip seating area for damage.



Removing Injector Sleeve

A—MAY-25010 Punch
B—Wood Block

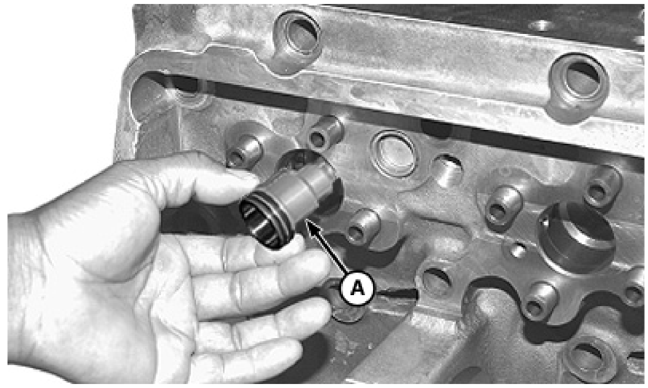
Continued on next page RE38635,0000112 –19–12NOV07–1/5

Install Unit Injector Sleeve

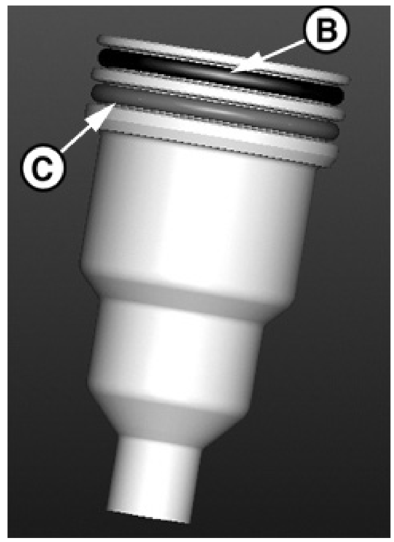
IMPORTANT: DO NOT use engine oil or any petroleum based product as a lubricant for the injector sleeve o-rings. A chemical reaction will occur, leading to o-ring failure. Instead use AR54749 soap lubricant (or similar) to lubricate the packing.

1. Push injector sleeve (A) into sleeve bore with minimal pressure until tightly seated.

A—Injector Sleeve
B—Upper O-Ring (Black)
C—Lower O-Ring (Purple)



Installing Injector Sleeve

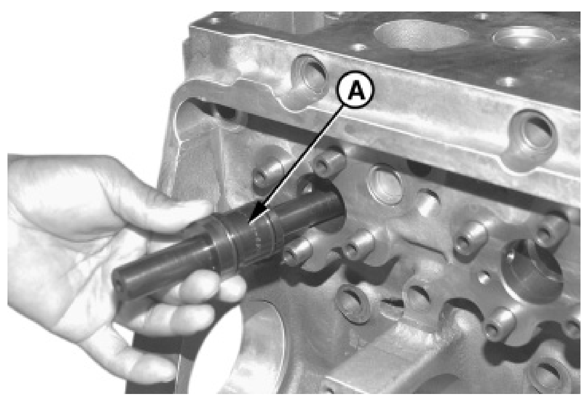


Injector Sleeve

RE38635,0000112 –19–12NOV07–2/5

2. Grease polished tip of JDG981-1 Guide Sleeve (A) and install inside injector sleeve.

A—JDG981-1 Guide Sleeve



Installing Injector Sleeve Guide

Continued on next page

RE38635,0000112 –19–12NOV07–3/5

NOTE: Carefully inspect threads on 8 mm cap screw prior to use to avoid damaging injector hold-down clamp threads in cylinder head. Replace cap screw as needed.

3. Install JDG981-3 Guide Sleeve Holding Bar (A) as shown. Install 220213 (8 mm) cap screw (B) finger tight.

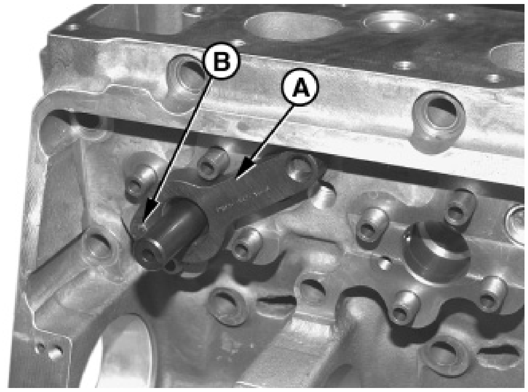
4. Install 220089 (16 mm) cap screw (C) from combustion face side of head using a phosphate washer from cylinder head mounting cap screw finger tight.

5. Install JDE131-2 Driver Nut (D) finger tight.

6. Tighten cap screws and nut in following order to specification given:

    - 16 mm Cap Screw (C) to 115 N•m (85 lb-ft)
    - 8 mm Cap Screw (B) to 47 N•m (35 lb-ft)
    - Guide Sleeve Nut (D) to 150 N•m (110 lb-ft)

A—JDG981-3 Guide Sleeve Holding Bar
B—220213 (8 mm) Cap Screw
C—220089 (16 mm) Cap Screw
D—JDE131-2 Driver Nut

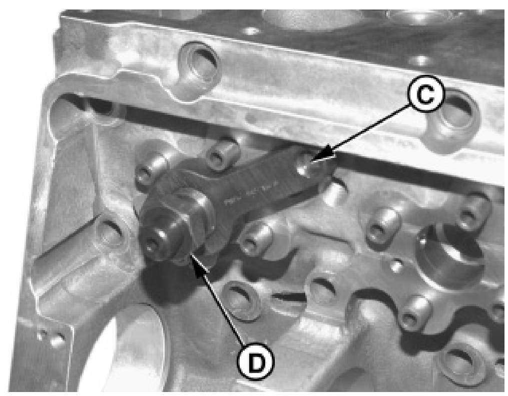


RG8155 –UN–05DEC97

Installing Guide Support Bar

RG8157 –UN–05DEC97

Guide Support Bar Cap Screw



RG8156 –UN–05DEC97

Guide Sleeve Arbor Nut

Continued on next page RE38635,0000112 –19–12NOV07–4/5

7. Clean and inspect JDG1184-2-1 Swedge Arbor (A) for raised or foreign material.

8. Assemble small end of 8132 Adapter (B) onto swedge arbor (A).

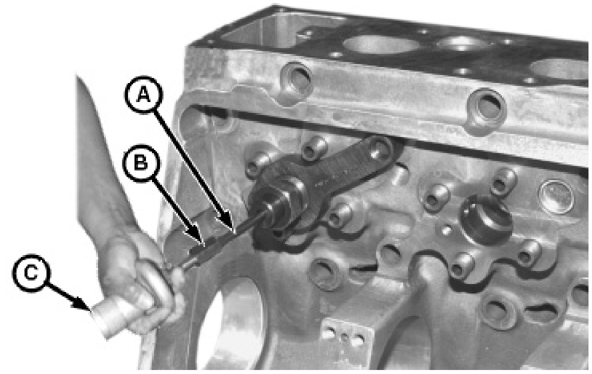
9. Assemble large end of adapter onto D01300AA 2.2 kg (5 lb) Slide Hammer (C).

10. Position tip of swedge into guide sleeve and drive swedge through sleeve tip. Withdraw swedge with slide hammer.

11. Remove injector sleeve replacement tool set from cylinder head and inspect for proper installation of injector sleeve.

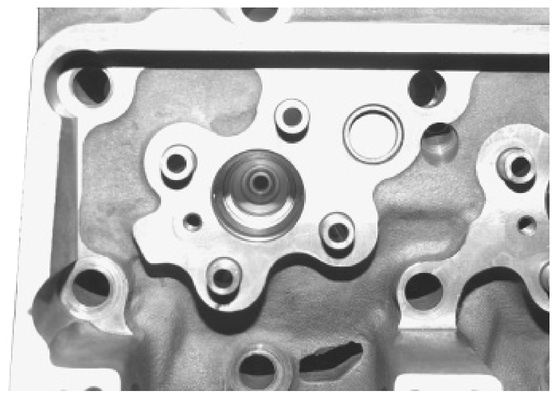
12. Repeat procedure on remaining injector sleeves.

A—JDG1184-2-1 Swedge Arbor
B—8132 Adapter
C—D01300AA Slide Hammer



RG10279 –UN–13AUG99

Using Expansion Arbor


RG8159 –UN–21MAY98

Installed Injector Sleeve

RE38635,0000112 –19–12NOV07–5/5

Replace Unit Injector Sleeve in Cylinder Head Using JDG1184

Remove Injector Sleeve

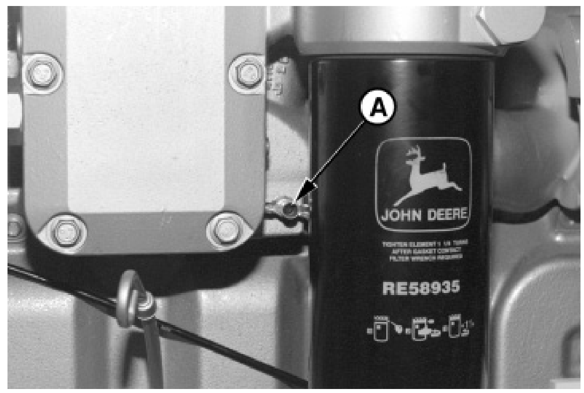
NOTE: EUI sleeve can be removed from the cylinder head with head removed or installed on engine using JDG1184 Nozzle Sleeve Replacement Set.

IMPORTANT: Whenever EUI is replaced, sleeve in cylinder head must be replaced also.

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

TS281 –UN–23AUG88

Service Cooling System Safely



RG8708A –UN–21JUL99

Drain Coolant

A—Coolant Drain Valve

1. Attach a long hose to drain valve (A). Drain coolant into a clean container to a level below cylinder head.

2. Loosen fuel rail inlet line. Disconnect outlet line and drain fuel into a clean container.

3. Tighten temperature sensor to specifications.

Specification

Fuel Temperature Sensor—
Torque .... 10 N•m (7.5 lb-ft)

4. Reconnect fuel lines and tighten to specifications.

Specification

Fuel Lines—Torque .... 24 N•m (18 lb-ft)

Continued on next page

RE38635,0000113 –19–12NOV07–1/14

5. Plug oil drain cavities in cylinder head with clean, lint-free shop towels to prevent debris and hardware from falling into drain cavity.

6. Remove rocker arm cover. (See REMOVE AND INSTALL ROCKER ARM COVER in this group.)

7. Remove appropriate rocker arm assembly:

    - Remove front rocker arm assembly for replacement of injector sleeves 1 and 2.
    - Remove both front and rear rocker arm assemblies for replacement of injector sleeve 3.
    - Remove rear rocker arm assembly for replacement of injector sleeves 4, 5, and 6.

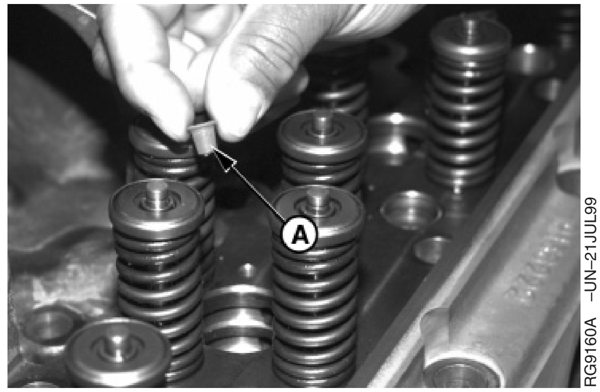
    (See REMOVE ROCKER ARM ASSEMBLY in this group.)

NOTE: If all six injector sleeves are to be replaced, replace sleeves for cylinders 1 and 6, 2 and 5, 3 and 4 at the same time so crankshaft has to be rotated only three times.

8. Remove electronic unit injector from injector sleeve that is to be replaced. Refer to CTM370 fuel system repair and diagnostics manual.

IMPORTANT: Injector sleeve tip MUST BE plugged to keep debris out of power cylinder while tapping (threading) sleeve for removal.

9. Install small red cap plug (A) into injector sleeve tip. Be sure plug is firmly seated in tip of sleeve.



Cap Plug

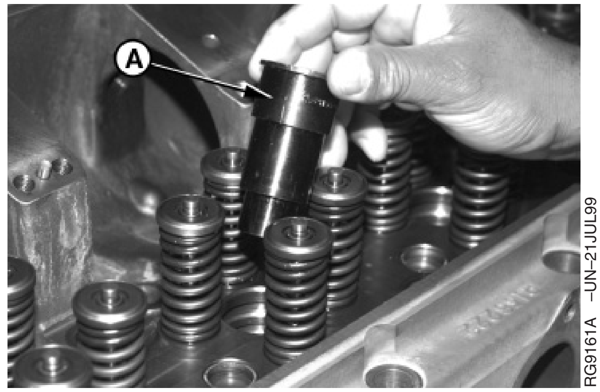
A—Cap Plug

Continued on next page RE38635,0000113 –19–12NOV07–2/14

IMPORTANT: DO NOT attempt to tap threads in injector sleeve (for removal) unless JDG1184-1-3 Protector Sleeve (A) is anchored against injector sleeve with EUI hold-down clamp. This will eliminate injector sleeve turning in swedged bore of cylinder head.

10. Thoroughly clean and dry JDG1184-1-3 Protector Sleeve as needed. Install protector sleeve into EUI bore until it is seated with injector sleeve.

A—JDG1184-1-3 Protector Sleeve

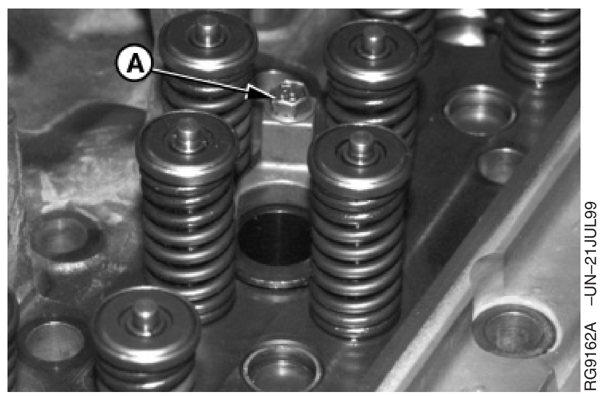


JDG1184-1-3 Protector Sleeve

RE38635,0000113 –19–12NOV07–3/14

11. Install EUI hold-down clamp and cap screw (A) over protector sleeve. Tighten cap screws to 40 N•m (30 lb-ft).

A—Hold-Down Cap Screw



Hold-Down Cap Screw

Continued on next page RE38635,0000113 –19–12NOV07–4/14

12. Apply a generous amount of all-purpose grease to JDG1184-1-1 Tap (A).

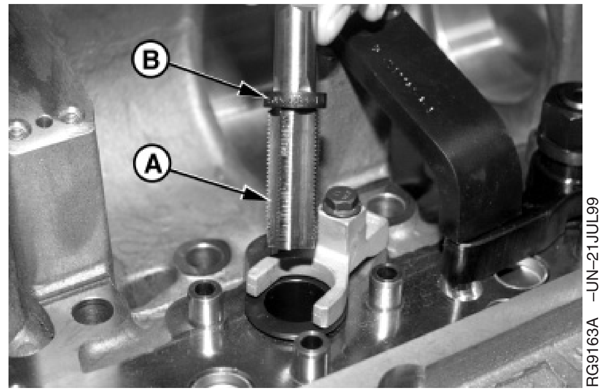
13. Position JDG1184-1-5 Tap Guide (B) over shaft of tap to center tap in protector sleeve.

14. Tap at least five full threads in ID of injector sleeve using a 5/8 in., 12-point socket and extension with a ratchet or T-handle.

15. Once resistance increases on tap, reverse direction and remove tap.

IMPORTANT: DO NOT remove protector sleeve from nozzle sleeve after tapping screw threads. Sleeve MUST BE removed as an assembly with JDG1184-1-2 Screw Adapter and JDG1184-1-4 Spacer to contain shavings and protect fuel rail in head.

16. Remove cap screw and EUI hold-down clamp from protector sleeve. Do not remove sleeve at this time.



JDG1184-1-1 Tap

A—JDG1184-1-1 Tap
B—JDG1184-1-5 Tap Guide

RE38635,0000113 –19–12NOV07–5/14

17. Thread JDG1184-1-2 Screw Adapter (A) with JDG1184-1-4 Spacer (B) into threaded injector sleeve finger tight. This will keep shavings out of fuel rail.

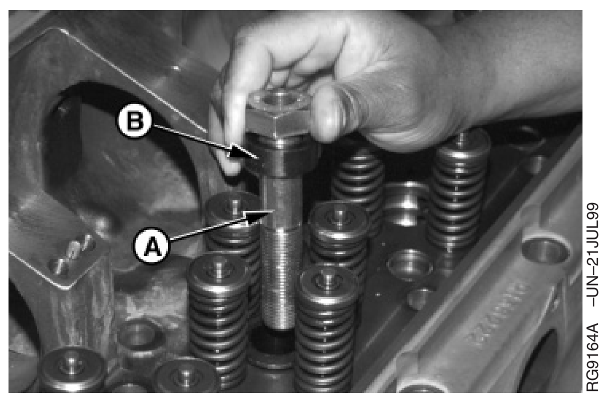
18. Thread D01300AA 2.2 kg (5 lb) Slide Hammer into screw adapter.

19. Pull injector sleeve from cylinder. Remove puller attachments from injector sleeve.

20. Remove injector sleeve packing from groove in cylinder head using O-ring pick.

21. Thoroughly clean and dry protector sleeve for future use. Clean remaining components as necessary.

A—JDG1184-1-2 Screw Adapter
B—JDG1184-1-4 Spacer



Adapter and Spacer

Remove Sleeve

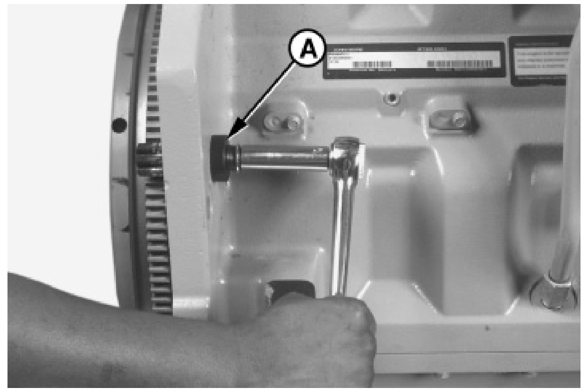
Continued on next page RE38635,0000113 –19–12NOV07–6/14

Check Piston Position in Liner

1. After injector sleeve is removed, look into sleeve bore of cylinder head to be sure that piston is at or near bottom of its stroke.

2. If piston is not near bottom, rotate engine flywheel using JDG820 Flywheel Rotation Tool (A).

A—JDG820 Flywheel Rotation Tool



RG8226 –UN–05DEC97

Rotate Engine Flywheel

RE38635,0000113 –19–12NOV07–7/14

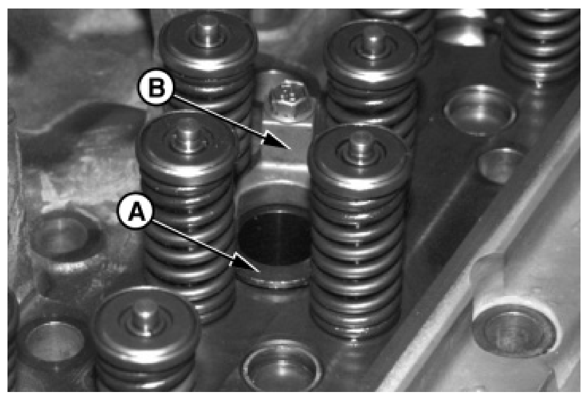
Install Injector Sleeve

1. Install JDG1184-1-3 Protector Sleeve (A) into injector sleeve bore (without injector sleeve).

2. Install EUI hold-down clamp (B) and cap screw over protector sleeve. Tighten cap screw to 40 N•m (30 lb-ft).

3. Thoroughly clean injector sleeve bore with a small brush.

4. Remove protector sleeve.



RG9162B –UN–21JUL99

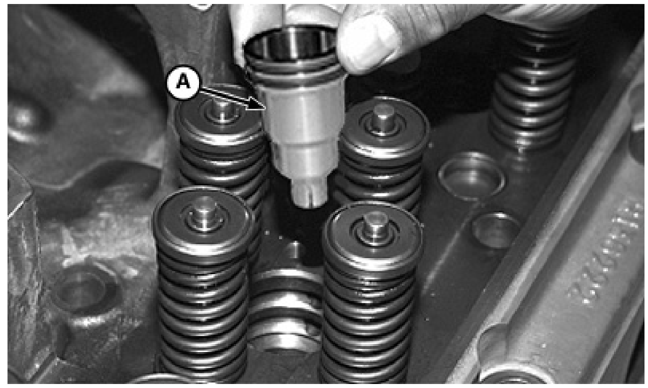
Install Protector Sleeve

A—JDG1184-1-3 Protector Sleeve
B—Hold-Down Clamp

Continued on next page RE38635,0000113 –19–12NOV07–8/14

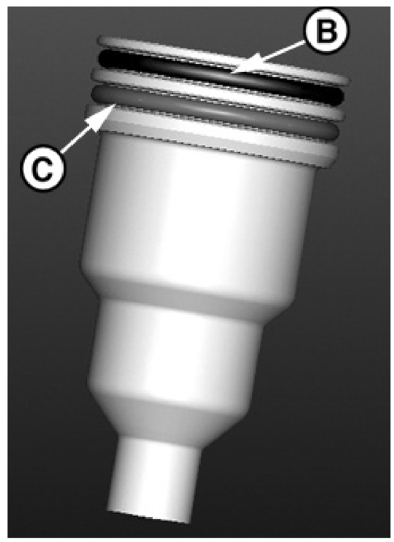
5. Lubricate injector sleeve O-rings (B) and (C) with AR54749 Soap Lubricant (or similar) and install injector sleeve (A) into cylinder bore.

A—Injector Sleeve
B—Upper O-Ring (Black)
C—Lower O-Ring (Purple)



RG12418 –UN–04SEP02

Installing Sleeve



RG14723 –UN–25JAN06

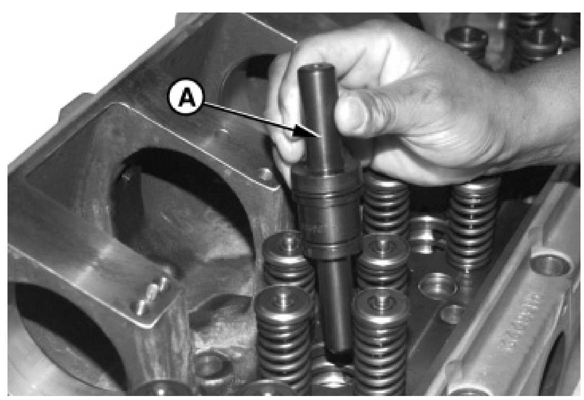
Injector Sleeve

RE38635,0000113 –19–12NOV07–9/14

6. Position JDG981-1 Guide Sleeve (A) into injector sleeve and seat sleeve using a plastic or rubber hammer. Be careful not to cut O-rings.

NOTE: When injector sleeve is fully seated, top of JDG981-1 Guide Sleeve should be slightly lower than top of valve rotators.

A—JDG981-1 Guide Sleeve



RG9167A –UN–21JUL99

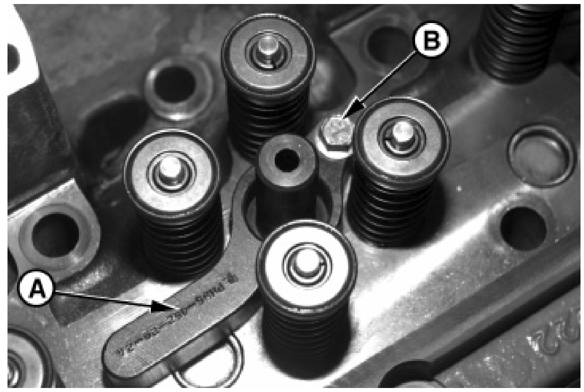
Seat Sleeve

Continued on next page

RE38635,0000113 –19–12NOV07–10/14

7. Position JDG1184-2-2 Guide Sleeve Holding Bracket (A) over guide sleeve and tighten cap screw (B) finger tight.

A—JDG1184-2-2 Guide Sleeve Holding Bracket
B—Cap Screw

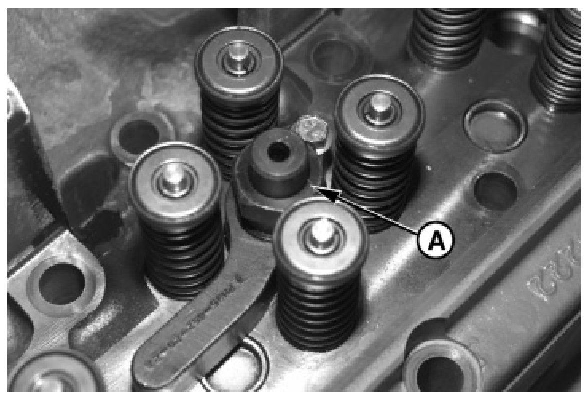


Guide Sleeve Holding Bracket

RE38635,0000113 –19–12NOV07–11/14

8. Thread JDG1184-2-4 Drive Nut (A) into holding bracket but do not tighten.

A—Drive Nut



Drive Nut

Continued on next page

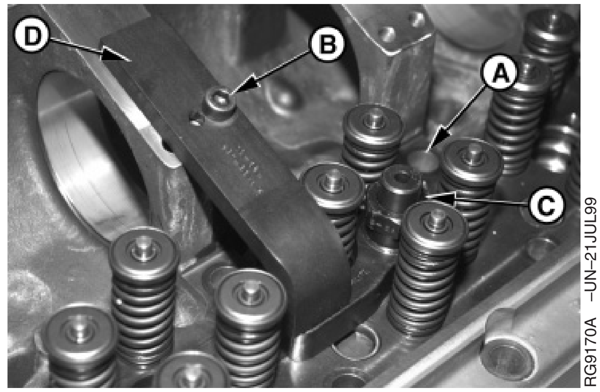
RE38635,0000113 –19–12NOV07–12/14

9. Install JDG1184-2-3 Bracket Clamp (D) onto rocker arm rail as shown, and tighten cap screw (B) finger tight.

IMPORTANT: Use only the 10 mm cap screw (B) that is provided in JDG1184 Nozzle Sleeve Replacement Set. Cap screws exceeding 35 mm (1.375 in.) can damage the camshaft bushings.

10. Tighten cap screws and nut to the following specifications.

- Guide screw holding bracket cap screw (A) to 40 N•m (30 lb-ft.).
- Bracket clamp cap screw (B) to 68 N•m (50 lb-ft).
- Driver nut (C) to 115 N•m (85 lb-ft).



Tighten Hardware

A—Guide Sleeve Holding Bracket Cap Screw
B—Bracket Clamp Cap Screw
C—Driver Nut
D—JDG1184-2-3 Bracket Clamp

RE38635,0000113 –19–12NOV07–13/14

11. Assemble small end of 8132 Adapter (A) onto JDG1184-2-1 Swedge Arbor (B).

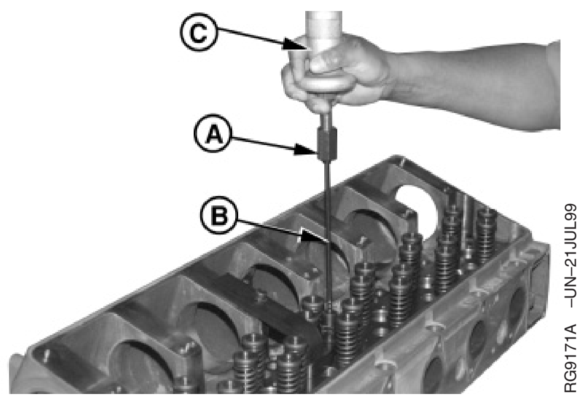
12. Assemble large end of adapter onto D01300AA 2.2 kg (5 lb) Slide Hammer (C).

13. Position tip of swedge into guide sleeve and drive swedge through sleeve tip. Withdraw swedge with slide hammer.

14. Remove all tooling. After all required sleeves are replaced, refill cooling system and pressure test for leakage.

15. Install electronic unit injector and wiring harness. Refer to CTM370 fuel system repair and diagnostics manual.

16. Install rocker arm assembly. (See INSTALL ROCKER ARM ASSEMBLY in this group.)



Remove Swedge

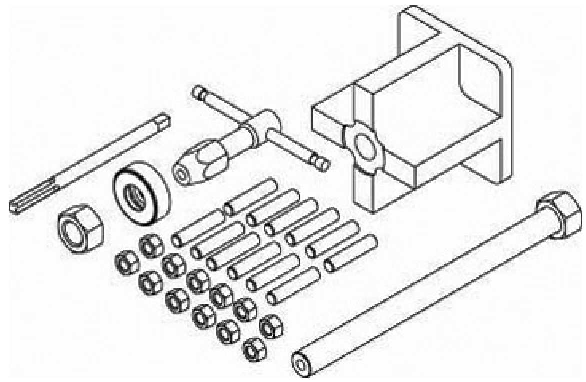
A—8132 Adapter
B—JDG1184-2-1 Swedge Arbor
C—D01300AA Slide Hammer

RE38635,0000113 –19–12NOV07–14/14

Remove Unit Injector Sleeve Using JDG10014

NOTE: The threaded tip and hex nut (JDG10014P1), and the M10 tap (JDG10014P2) of the removal tool set are available as a purchase separate item. When removing the sleeve, the tip of the tool can become "swedged" into the sleeve. The tip is then very difficult to remove from the sleeve, and a new tip is needed for each additional sleeve removal.

IMPORTANT: The tapping procedure on the small diameter of the injector sleeve will result in a few metal chips being loose after the sleeve is removed from the head. Take the necessary step with a magnet and/or vacuum to remove as many of these chips as possible.



RG14902 –UN–22JUN06

JDG10014 EUI Sleeve Removal Tool Set

Continued on next page RE38635,0000121 –19–24OCT06–1/2

1. Install JDG10014P2 M10 tap (A) from JDG10014 tool set into tap collet with T handle (B).

2. Apply a generous amount of grease to the tap to catch chips cut from the EUI sleeve while threading is completed.

3. Tap the entire length of the small diameter of EUI sleeve.

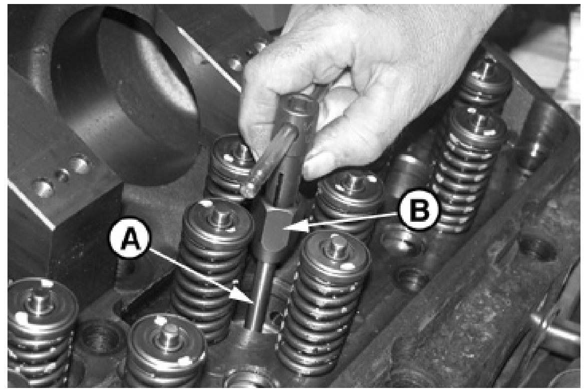
4. Install a JDG10014P1 threaded tip and hex nut to bottom of forcing screw.

5. Install the forcing screw, special washer, and hex nut through the locating block (C). Locate the block on top of cylinder head between the 4 valve springs, as shown. Thread the tip of the forcing screw into the tapped diameter of the EUI sleeve.

6. Using a double wrench method, turn the hex nut/washer on the forcing screw clockwise to remove the EUI sleeve (D) from the cylinder head.

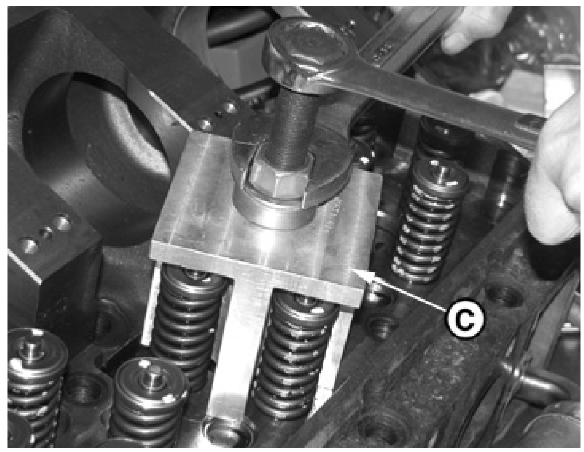
7. Thoroughly clean sleeve bore of chips or other debris and inspect sleeve tip seating area for damage.

A—M10 Tap
B—Tap Collet
C—Locating Block and Forcing Screw
D—EUI Sleeve Removed from Cylinder Head



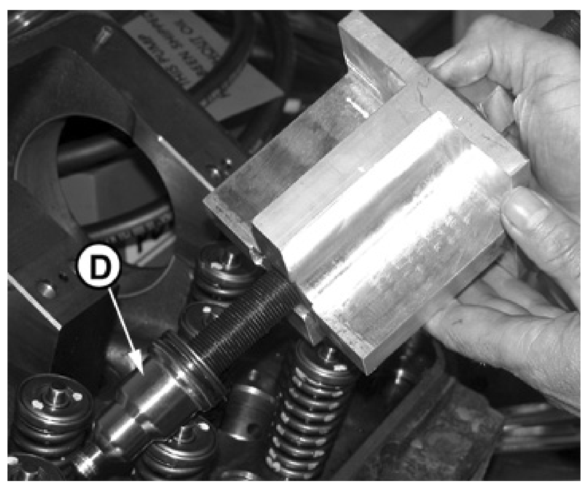
RG14891 –UN–15JUN06

Threading EUI Sleeve



RG14892 –UN–15JUN06

Removing EUI Sleeve from Cylinder Head



RG14893 –UN–15JUN06

Removed Sleeve

RE38635,0000121 –19–24OCT06–2/2

Clean and Inspect Top Deck of Cylinder Block

1. Remove gasket material, rust, carbon, and other foreign material from top deck using a powered brass or copper (soft) wire brush. DO NOT use a steel wire brush.

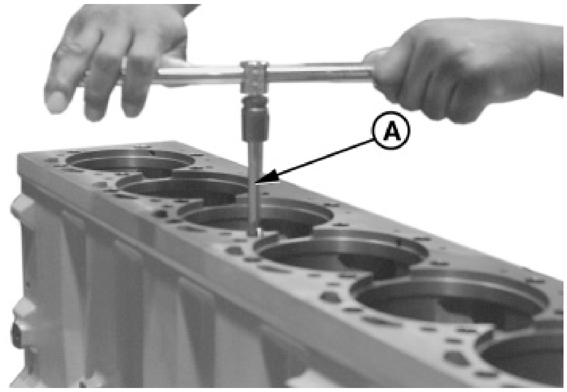
2. Clean threaded holes in cylinder block using JDG978 Special Tap (A) or an equivalent M16 x 2.0 x 140 mm (5.50 in.) long tap.

3. Use compressed air to remove debris and fluids from cap screw holes. Replace block if thread damage is detected.

4. Inspect and measure top deck for flatness. Service as required. (See MEASURE CYLINDER BLOCK, in Group 030.)

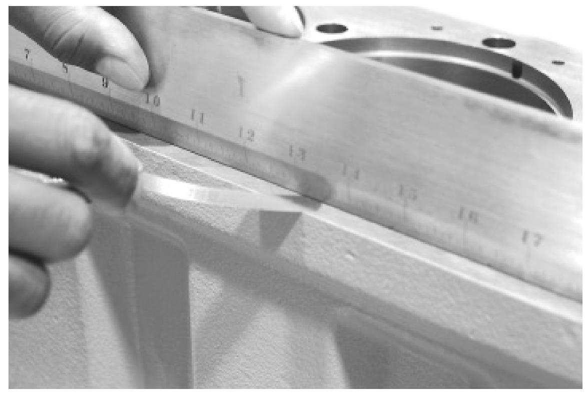
5. Clean all oily residue and dirt from top deck before installing head gasket.

A—JDG978 Special Tap



RG8210A –UN–05DEC97

Cleaning Head Bolt Threads



RG8208 –UN–21MAY98

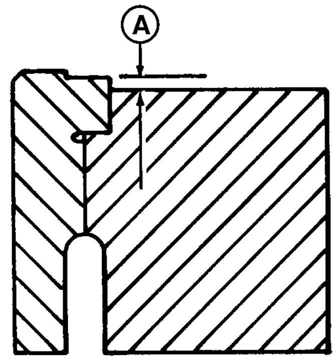
Measuring Block Top Deck Flatness

RG,RG34710,93 –19–16OCT00–1/1

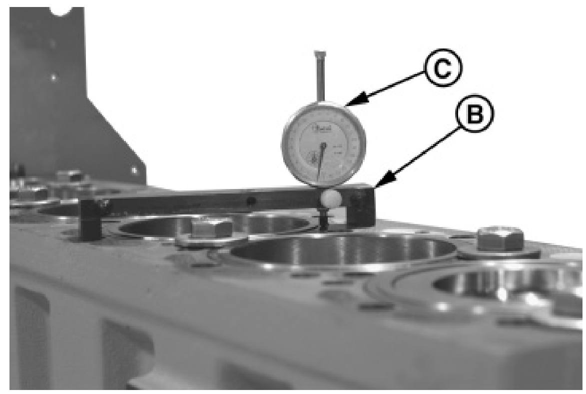
Measure Cylinder Liner Standout (Height Above Block)

1. Secure liners using cap screws and flat washers. Flat washers should be at least 3.18 mm (1/8 in.) thick. Tighten cap screws to 68 N•m (50 lb-ft).

2. Using JDG451 or KJD10123 Height Gauge (B) and D17526CI or D17527CI Dial Indicator (C), measure liner height (A) at approximately 1, 5, 7, and 11 o'clock positions as viewed from flywheel end of engine. Record all measurements by cylinder number.



Liner Standout



Measuring Liner Standout

A—Liner Height
B—Height Gauge
C—Dial Indicator

Specification

Cylinder Liner—Height Above Block (Standout)	0.030—0.117 mm (0.0012—0.0046 in.)
Cylinder Liner—Max. Height Difference at Nearest Point of Two Adjacent Liners or Within One Liner	0.051 mm (0.0020 in.)

IMPORTANT: ONE LINER SHIM ONLY may be installed under any given liner flange.

3. Remove liner, add shims or replace any liner that does not fall within allowable standout specification.

   Two sizes of shims are available:

R81276	0.05 mm (0.002 in.)
R87277	0.10 mm (0.004 in.)

RG,RG34710,94 –19–30SEP97–1/1

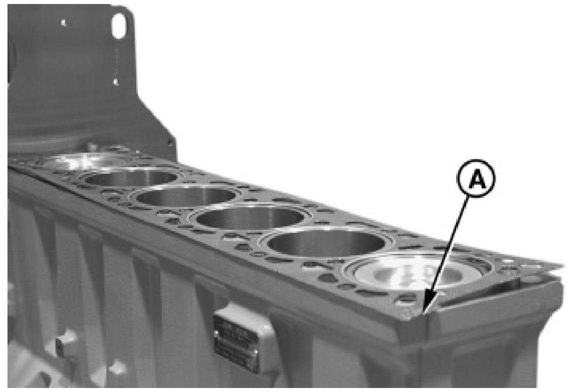
Install Cylinder Head

IMPORTANT: Be sure cylinder head and block gasket surfaces are clean, dry, and free of any oily residue. ALWAYS thoroughly inspect new cylinder head gasket for possible manufacturing imperfections. Return any gasket that does not pass inspection.

1. Place a new head gasket on top of cylinder block. Do not use sealant on gasket. Tab (A) on gasket goes to left rear corner of cylinder block (as viewed from flywheel end).

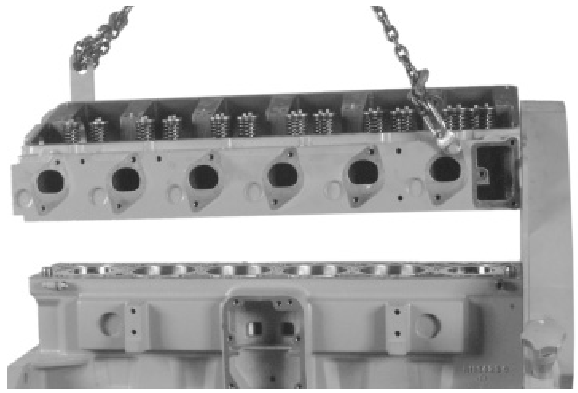
IMPORTANT: If cylinder head is lowered onto cylinder block and you discover that the head is not positioned correctly on locating dowels, remove cylinder head and install a new gasket. DO NOT try to reposition cylinder head on the same gasket again since the fire ring will possibly be damaged.

2. Lower cylinder head in correct position on block using lifting straps and a hoist. Make sure that head is positioned correctly over dowels and that it is all the way down on gasket.



RG8189 –UN–05DEC97

Installing Cylinder Head Gasket

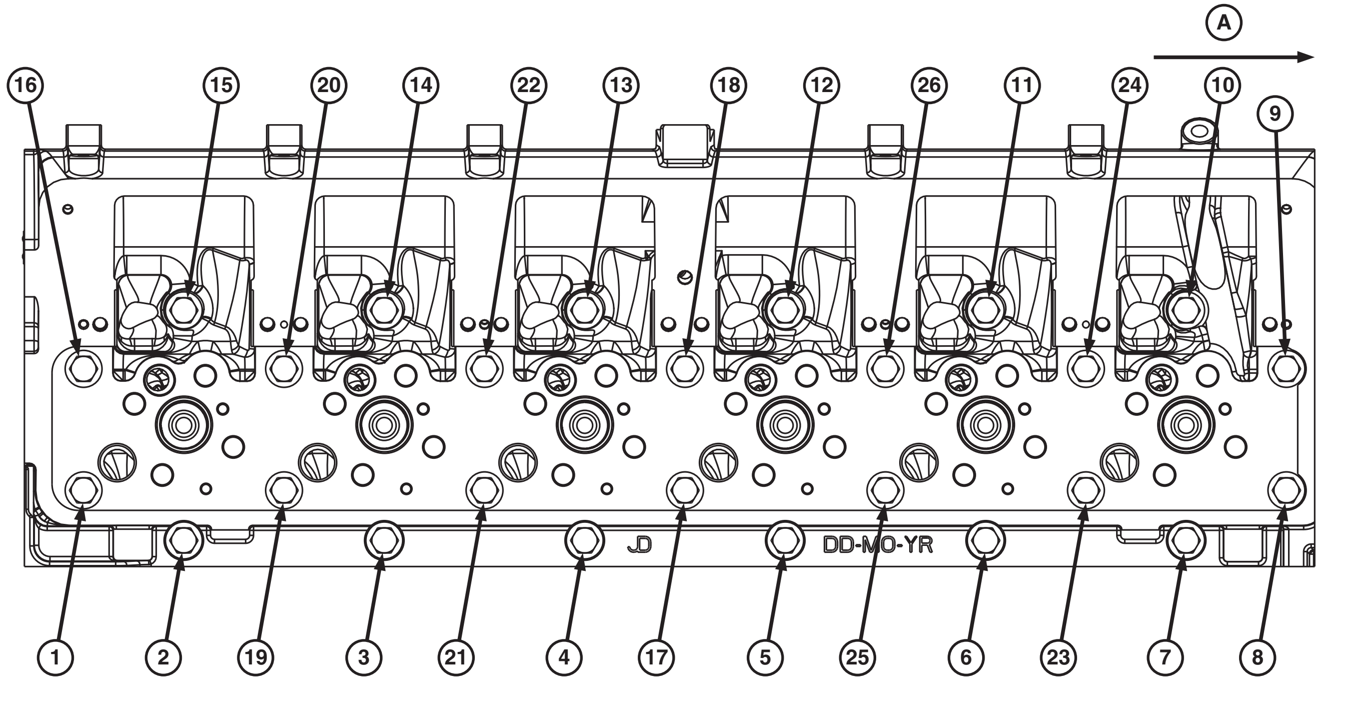


RG8285 –UN–21MAY98

Installing Cylinder Head

A—Tab

Continued on next page RE38635,00000F0 –19–25JAN06–1/2



Cylinder Head Cap Screw Sequence

A—Front of Engine

IMPORTANT: Whenever cylinder head is removed for service, all cap screws MUST BE replaced when head is installed. These cap screws can only be used one time.

NOTE: All 26 cylinder head cap screws are the same length.

3. Dip new cap screws and washers in clean SAE 30 engine oil. Allow excess to drain off threads.

4. Initially tighten No. 17 cap screw to specifications.

Specification

Step 1—Cylinder Head No. 17
Cap Screw—Initial Torque...................................... 100 N•m (74 lb-ft)

This prevents head from tipping during tightening sequence.

5. Use torque-turn method to tighten all cylinder head cap screws to specifications. (See TORQUE-TURN CYLINDER HEAD CAP SCREWS next in this Group.)

RE38635,00000F0 –19–25JAN06–2/2

Torque-Turn Cylinder Head Cap Screws

Arrow (A) points toward front of engine.

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

1. Lubricate cap screws with clean SAE 30 engine oil and install in their proper locations as outlined previously.

2. If not done, initially tighten cap screw No. 17 to specification to prevent head from tipping during tightening sequence.

Specification

Step 1—Cylinder Head No. 17
Cap Screw—Initial Torque .... 100 N•m (74 lb-ft)

Following figure on previous page, sequentially start at cap screw No. 1 and proceed through cap screw No. 26 and tighten all cap screws to 163 N•m (120 lb-ft).

Specification

Step 2—All Cap Screws (Nos. 1—26)—Initial Torque .... 163 N•m (120 lb-ft)

3. Wait 5 minutes and verify above torque.

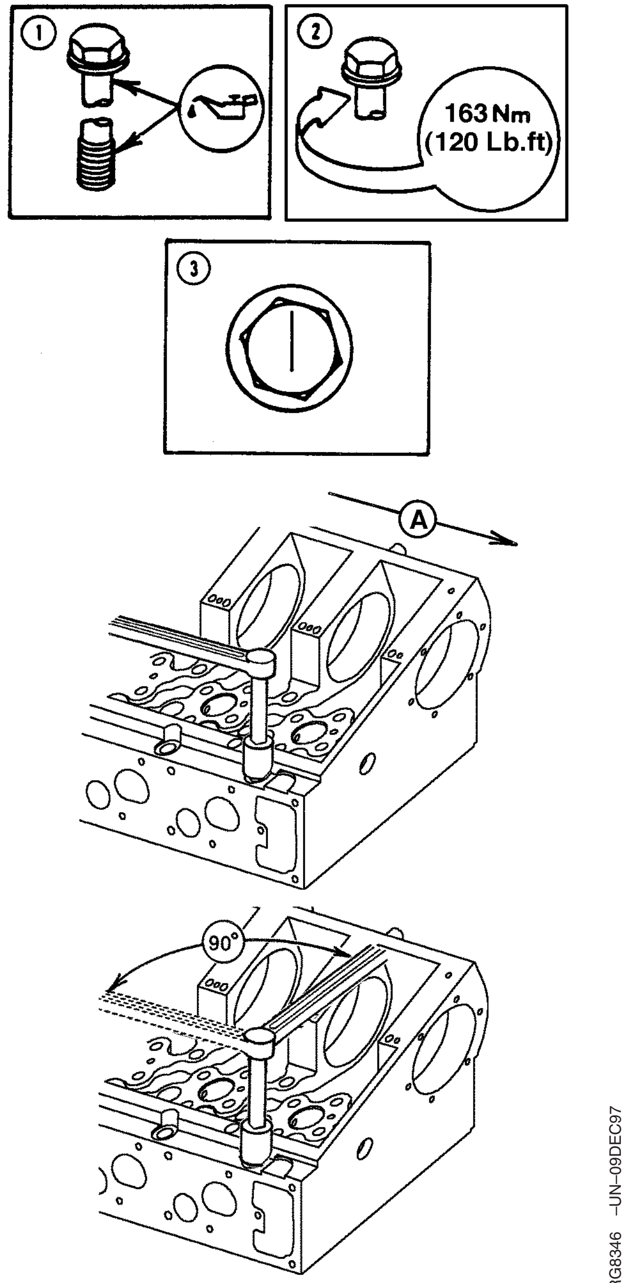
Specification

Step 3—Verify All Cap Screws
(Nos. 1—26)—Torque .... 163 N•m (120 lb-ft)

4. 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.

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

5. 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.



Torque-Turn Cylinder Head Cap Screws

A—Front of Engine

Continued on next page

RE38635,00000F1 –19–25JAN06–1/2

Specification

Step 4—All Cap Screws (Nos. 1—26)—Initial Torque-Turn	90°

IMPORTANT: Cap screws MUST NOT be tightened more than a total of 180°—190°.

6. Finally, sequentially (start at cap screw No. 1 and proceed through cap screw No. 26) turn each cap screw an additional 90°, SO THAT LINE ON TOP OF CAP SCREW IS AS CLOSE AS POSSIBLE TO BEING PARALLEL TO THE CRANKSHAFT. It is not necessary to obtain the final turn in one swing of the wrench. TOTAL AMOUNT OF TURN FROM STEPS 5, and 6, is 180°—190°.

Specification

Step5—All Cap Screws (Nos. 1—26)—Final Torque-Turn	90°

Cylinder head torque procedure summarized as follows:

Cylinder Head—Specification

Step 1—No. 17 Cap Screw—Initial Torque	100 N•m (74 lb-ft)
Step 2—All Cap Screws (Nos. 1—26)—Initial Torque	163 N•m (120 lb-ft)
Step 3—Wait 5 Minutes and Verify All Cap Screws (Nos. 1—26)—Torque	163 N•m (120 lb-ft)
Step 4—All Cap Screws (Nos. 1—26)—Initial Torque-Turn	90°
Step 5—All Cap Screws (Nos. 1—26)[1]—Final Torque-Turn	90°

[1] *Total torque-turn for steps 4 and 5 is 180°.*

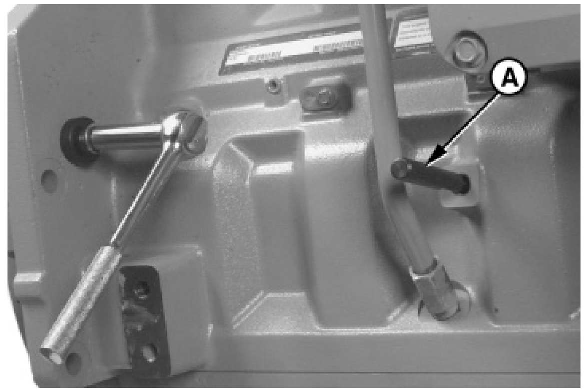
RE38635,00000F1 –19–25JAN06–2/2

Install Rocker Arm Assembly

IMPORTANT: Use LARGE end of camshaft timing pin when locking engine at #1 top dead center.

1. Make sure crankshaft and camshaft are locked at No. 1 cylinder TDC with timing pins (A) installed.

A—Timing Pin



RG8227A –UN–05DEC97

Timing Pin in Crankshaft

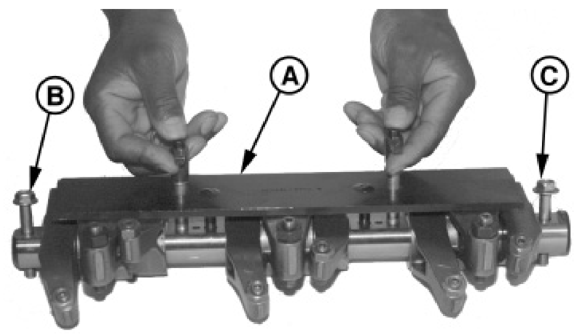
RE38635,00000F2 –19–25JAN06–1/5

2. With rocker arms properly spaced on shaft and cap screws (B) and (C) on each end, install JDG970A Rocker Arm Assembly Lifting Fixture (A) onto rocker arm and shaft assembly.

3. Firmly depress buttons on two lifting arms, install lifting plate with two locator pins and lifting arms positioned in holes of rocker arm shaft. Release buttons so that ball actuating pins lock onto shaft and can be safely lifted.

IMPORTANT: ALWAYS loosen all intake, exhaust and EUI rocker arm adjusting screws before removal or installation of rocker arm assembly to relieve pressure. This allows for a more uniform rocker arm cap screw clamp load and reduces the possibility of damage to valve train components.

4. Install front and rear rocker arm and shaft assembly onto locating roll pins of cylinder head. Make sure all push rods are aligned properly.



RG8304 –UN–06DEC97

Lifting Rocker Arm Assembly

A—JDG970A Rocker Arm Lifting Fixture
B—Cap Screw
C—Cap Screw

Continued on next page

RE38635,00000F2 –19–25JAN06–2/5

IMPORTANT: DO NOT reuse rocker arm shaft hold-down clamp cap screws. Ensure that new cap screws are used for reassembly.

5. Install rocker arm hold-down clamps. Install cap screws finger tight.

IMPORTANT: The positioning of valve bridges is critical for feeler gauge access to set valve clearance.

6. Install twelve valve bridges (A) with slots (B) facing exhaust manifold side of engine. Be sure each bridge is properly seated onto two respective intake and exhaust valves within a given cylinder.

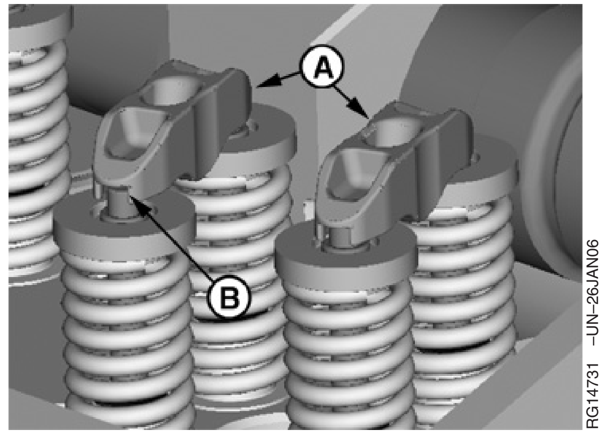
7. Install twelve push tubes (C) on top of bridges.

NOTE: Apply clean engine oil to flange of each of the 12 rocker arm shaft cap screws (E). The oil allows the cap screws to reach proper clamp load when tightened using torque turn.

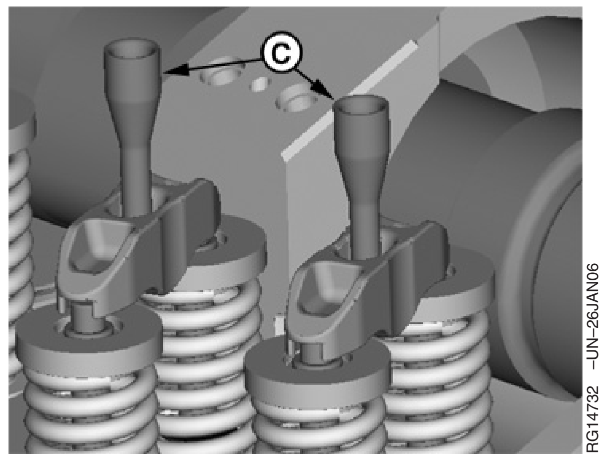
8. Engage the valve adjusting screws into top end of push rods (D), and finger start 12 rocker arm shaft cap screws (E) into cylinder head.

9. Make sure intake, exhaust, and injector rocker arm adjusting screws are loose to eliminate binding shaft as clamps are tightened.

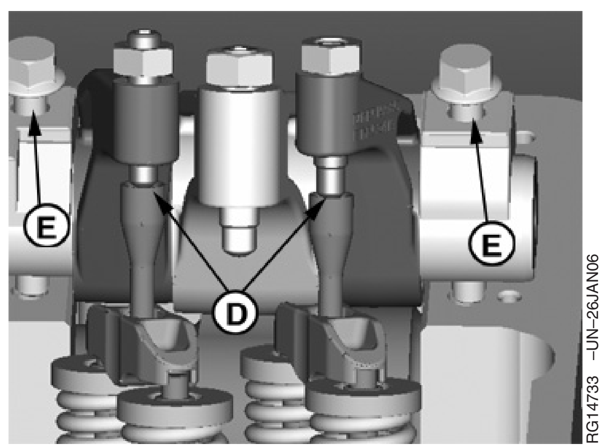
A—Valve Bridges
B—Open End of Valve Bridge to Set Valve Clearance
C—Push Rods
D—Valve Adjusting Screw to Push Rod
E—Rocker Arm Assembly Cap Screws



Valve Bridges



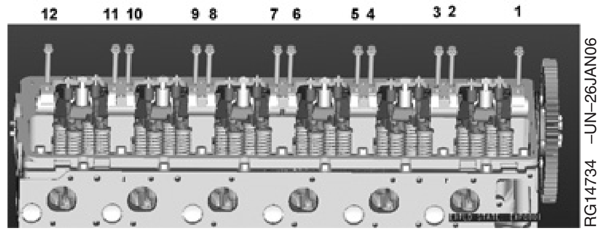
Push Rods



Valve Actuation Assembly

Continued on next page RE38635,00000F2 –19–25JAN06–3/5

10. Initially tighten rocker arm hold-down cap screws #1, 6, 7, and 12 halfway. Repeat the sequence and tighten all hold-down clamp cap screws to the following initial specification. This will seat the assembly to cylinder head.



Rocker Arm Shaft Assembly Cap Screws 1-12

Specification

Rocker Arm Shaft Hold-Down
Clamp Cap Screws—Initial
Torque .... 30 N•m (22 lb-ft)

Make an additional pass from front-to-rear and tighten remainder of the 12 cap screws to the initial torque specification above.

11. Torque-Turn rocker arm shaft hold-down cap screws to specification using sequence 1-12.

Specification

Rocker Arm Assembly to Cylinder
Head Cap Screws—Torque Turn.. Additional 90°

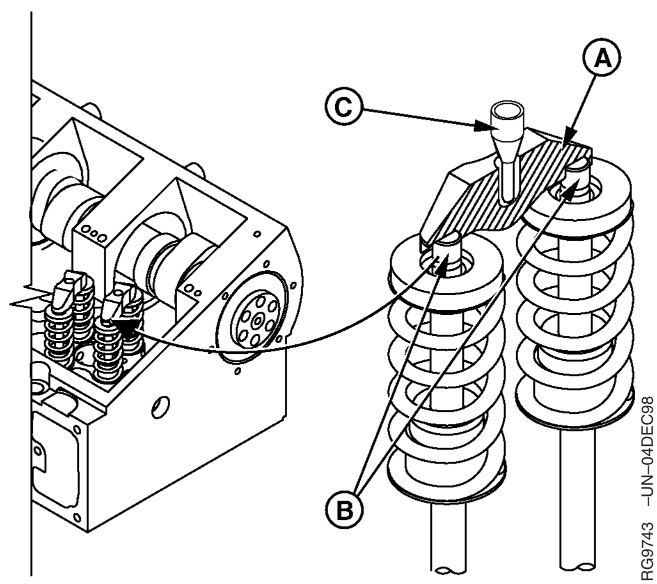
12. Adjust valve-to-bridge clearance and injector preload. See procedure and specifications earlier in this group.

RE38635,00000F2 –19–25JAN06–4/5

IMPORTANT: Thoroughly inspect intake and exhaust valve bridges (A) for proper seating on valve stems (B) from both sides of engine. Also, make sure that push tubes (C) are properly seated in top of valve bridges.

Use a flashlight and carefully check each bridge (for proper seating on valve stems) from both sides of the engine. Lift up on each bridge to verify proper seating. Valve bridges that are not properly seated on valve stems will result in major engine failure.

13. Install rocker arm cover.



Inspect Bridges and Push Tubes

A—Valve Bridge
B—Valve Stems
C—Push Tube

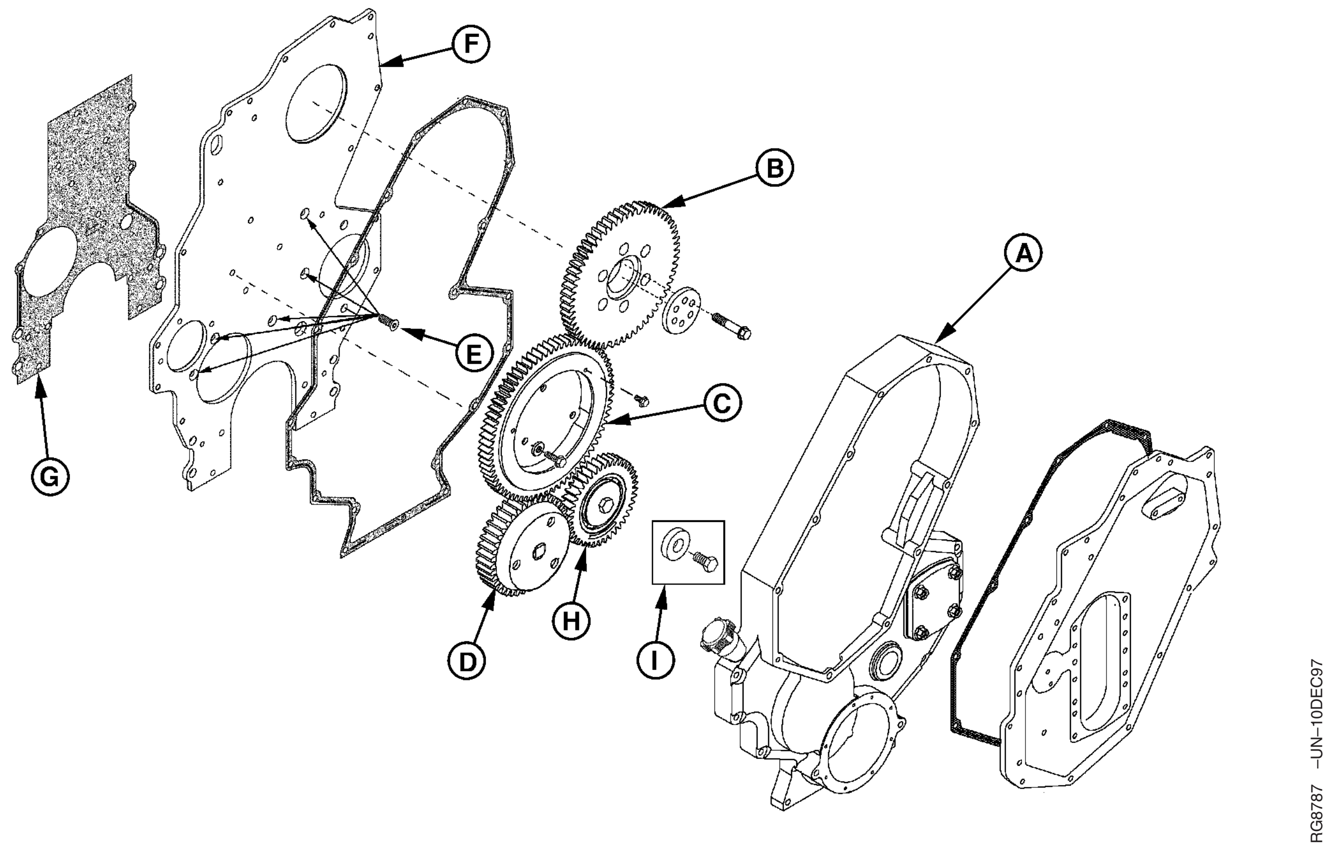
RE38635,00000F2 –19–25JAN06–5/5

Complete Final Assembly for Cylinder Head Installation

1. Install camshaft gear access cover.
2. Install thermostat housing/water manifold assembly.
3. Install intake manifold.
4. Install exhaust manifold and EGR assembly.
5. Install turbocharger.
6. Install fuel supply pump.
7. Install and securely tighten all fuel lines and fuel filter. (CTM370)
8. Fill engine with proper fuel and coolant. (Section 01, Group 002.)
9. Perform engine break-in.

RE38635,00000F3 –19–26JAN06–1/1

Remove and Install Cylinder Block Front Plate



Front Plate and Timing Gear Cover Exploded View

A—Timing Gear Cover
B—Camshaft Gear
C—Idler Gear
D—Oil Pump Gear
E—Screws (5 Used)
F—Front Plate
G—Front Plate Gasket
H—Auxiliary Drive Gear
I—Without Auxiliary Drive Gear

Remove Front Plate

1. Lock engine at No.1 TDC compression stroke by installing JDG971 Timing Pins in camshaft and crankshaft. (See CHECK AND ADJUST CAMSHAFT-TO-CRANKSHAFT TIMING in Group 050.)

2. Remove timing gear cover (A). (See REMOVE TIMING GEAR COVER in Group 040.)

3. Remove camshaft gear (B) and idler gear assembly (C). (See CHECK AND ADJUST CAMSHAFT-TO-CRANKSHAFT TIMING in Group 050.)

4. Remove engine oil pump assembly (D). (See REMOVE ENGINE OIL PUMP in Group 060.)

5. Remove auxiliary drive gear (H) if equipped. (See REMOVE AND INSTALL AUXILIARY DRIVE IDLER GEAR AND BEARING in CTM67, OEM Engine Accessories, Group 54.)

IMPORTANT: Tap head of countersunk cap screws sharply with a brass punch and use an Allen-head adapter that does not have corners rounded off.

6. Remove five countersunk screws (E) and remove front plate (F) from dowels.

7. Remove gasket (G) and discard. Thoroughly clean gasket surfaces on cylinder block and front plate. If present, ensure all sealant is removed.

Continued on next page
RE38635,0000047 –19–10AUG05–1/2

Install Front Plate

IMPORTANT: All gasket contact surfaces MUST BE clean, dry, and free of sealant and oil.

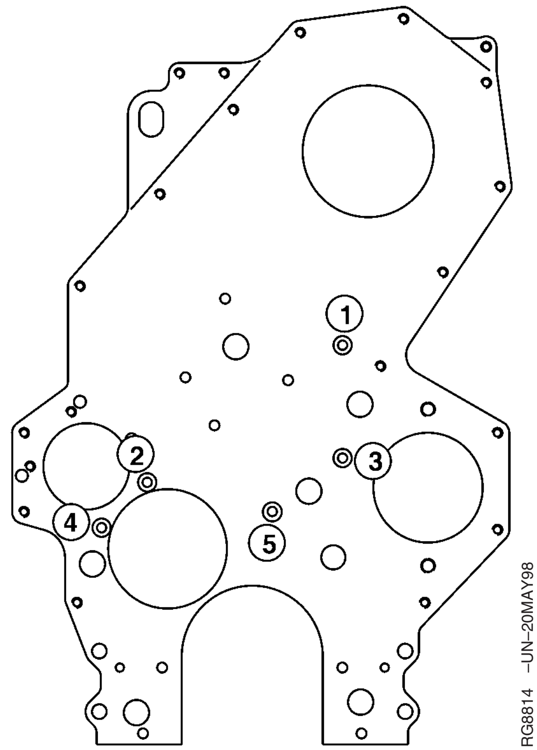
1. Install new gasket onto dowels in cylinder block.

2. Install front plate onto front face of block.

3. Install five countersunk screws and tighten to specifications, following sequence in illustration.

Specification

Front Plate-to-Cylinder Block Cap Screws—Torque .... 50 N•m (37 lb-ft)



Front Plate Torque Sequence

4. Install engine oil pump assembly. (See INSTALL ENGINE OIL PUMP in Group 060.)

5. Install idler gear and camshaft gear. Adjust gear backlash. (See CHECK AND ADJUST CAMSHAFT-TO-CRANKSHAFT TIMING in Group 050.)

6. Install auxiliary drive gear (if equipped). (See REMOVE AND INSTALL AUXILIARY DRIVE IDLER GEAR AND BEARING in CTM67, OEM Engine Accessories, Group 54.)

7. Install timing gear cover. (See INSTALL TIMING GEAR COVER in Group 040.)

8. Install engine oil pan. (See INSTALL ENGINE OIL PAN in Group 060.)

9. Install crankshaft vibration damper and pulley. (See INSTALL CRANKSHAFT VIBRATION DAMPER AND FRONT OIL SEAL in Group 040.)

10. Remove JDG971 Timing Pins and install rocker arm cover. (See REMOVE AND INSTALL ROCKER ARM COVER in Group 020.)

11. Install crankshaft timing pin plug and tighten to specifications.

Specification

Crankshaft Timing Pin Plug—Torque .... 33 N•m (24 lb-ft)

RE38635,0000047 –19–10AUG05–2/2

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.
- Failed or plugged piston spray orifice

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 liner.
- 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:

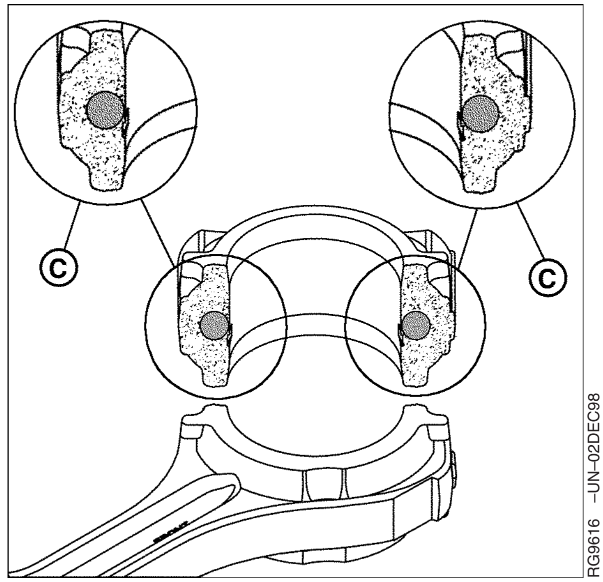
- Insufficient cooling.

RE38635,0000108 –19–09NOV07–1/1

Connecting Rods—General Information

The 6135 engine connecting rod joint (C) is the samePRECISION JOINT™ as that used on later 6125 engines. It is important to note that the rod cap should always stay with the rod from which it was removed. It is also important to not file, use any other tool, or machine the joint in any way. The connecting rod joint is also tightened using the “Torque-to-Yield” method, which elongates the connecting rod cap screws. Using this torque method means the cap screws can only be used (to torque) one time.

Connecting rods are sorted by weight into 9 classes. When a rod is replaced, a similar weight rod should be ordered. Each rod has a weight class number stamped on it, and this number should be used when ordering a new rod.



Connecting Rod PRECISION JOINT™

PRECISION JOINT is a trademark of Deere & Company

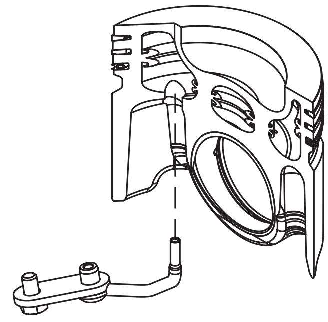
RE38635,0000109 –19–09NOV07–1/1

Remove Piston Spray Jets

IMPORTANT: To better cool the piston, the 6135 engine uses a directed stream of oil to a galley in the under crown of the piston, as shown. Therefore, the orientation of the piston spray jet is very critical, to ensure the oil spray is directed at this galley. If the piston and rod assemblies are to be removed for service, to avoid damaging the spray jet or compromising the orientation, it is required to remove the piston spray jets PRIOR to removing the pistons and connecting rod assemblies. If a spray jet is bent or damaged in any way, replace the part.

NOTE: If spray jet is removed for service or repair and will be reused, BE CERTAIN to apply LOCTITE® 243 (medium strength, oil resistant, blue, JD part number PM37418) to threads of spray jet prior to installation.

1. Rotate the engine, as necessary, to access piston spray jets for cylinders #1 and #6.
2. Loosen and remove cap screws (A) securing spray jet to block. Carefully remove spray jets and set aside.
3. Rotate engine to access #2 and #5 cylinders.
4. Loosen and remove cap screws (A) securing spray jet to block. Carefully remove spray jets and set aside.
5. Rotate engine to access #3 and #4 cylinders.
6. Loosen and remove cap screws (A) securing spray jet to block. Carefully remove spray jets and set aside.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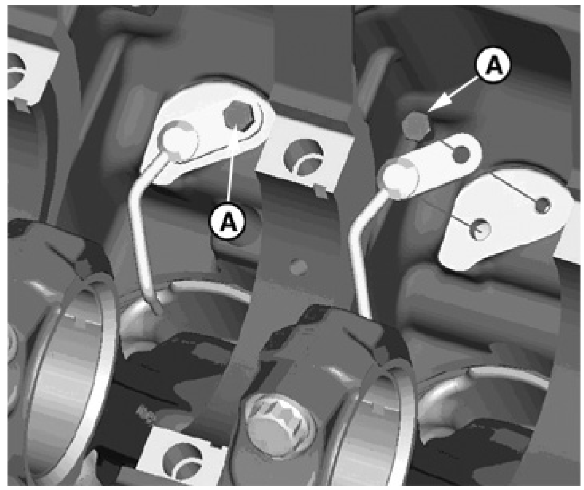
Piston Spray Jet to Piston Orientation



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Spray Jet Removal

LOCTITE is a trademark of Loctite Corp.

RE38635,000010A –19–09NOV07–1/1

Remove Pistons and Connecting Rods

The engine does not always have to be removed from the machine to service the pistons and connecting rods. If engine is to be removed, see your Machine Technical Manual.

CAUTION: DO NOT drain engine coolant until it cools below operating temperature.

1. Drain all coolant and engine oil.

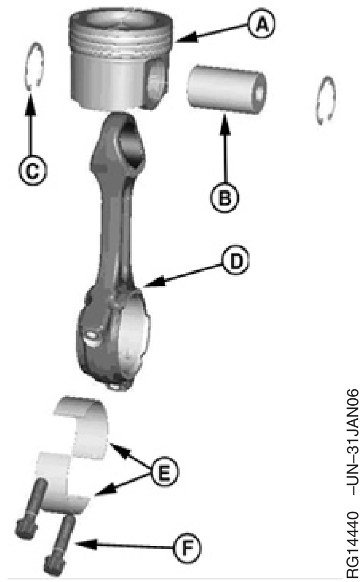
NOTE: Piston and Rod assemblies can not be removed from the engine without first removing the piston spray jets. The risk of damage to the spray jet is too great.

2. Remove all piston spray jets.

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

3. Remove cylinder head. (See REMOVE CYLINDER HEAD in Group 020.)

4. Remove oil pan. (See REMOVE ENGINE OIL PAN in Group 060.) Remove oil pick-up tube. (See REMOVE AND INSTALL OIL PICKUP TUBE in Group 060.)



Connecting Rod & Piston Assembly

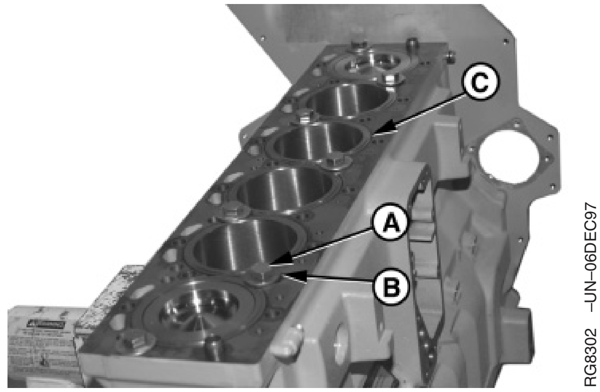
A—Piston & Rings
B—Piston Pin
C—Snap Ring (2 used)
D—Connecting Rod & Bushing
E—Rod Bearings

Continued on next page RE38635,000010B –19–09NOV07–1/4

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 68 N•m (50 lb-ft) to achieve an accurate reading when checking liner standout (height above block), as detailed later in this group.

5. Use seven M16 x 2.0 x 55 mm (2.17 in.) long cap screws (A) and 5/8 in. ID x 1-3/4 in. OD x 3.18 mm (1/8 in.) thick washers (B) to bolt down cylinder liners (C) in the seven locations as shown. Tighten cap screws to specifications.



Bolting Liners Down

A—Long Cap Screws
B—Thick Washers
C—Bolt Down Cylinder Liners

Specification

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

6. 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.

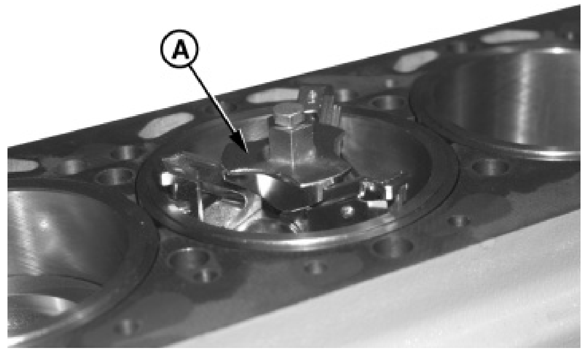
   No further inspection is required if any one of the above conditions is found.

Continued on next page RE38635,000010B –19–09NOV07–2/4

NOTE: Always follow manufacturer's directions provided with ridge reamer.

7. Remove carbon ridge from liner bore with a scraper or JT07277 Ridge Reamer (A). Use compressed air to remove loose carbon from cylinders.

A—JT07277 Ridge Reamer



Using Liner Ridge Reamer

Continued on next page RE38635,000010B –19–09NOV07–3/4

8. Mark rods, pistons, and caps to ensure correct assembly in same location.

IMPORTANT: Keep bearing inserts with their respective caps for rod and main bearings.

9. Remove all rod caps (A) with bearings.

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

10. Measure rod bearing-to-journal oil clearance with PLASTIGAGE® before removing piston and rod assembly. Record measurements. (See INSPECT AND MEASURE CONNECTING ROD BEARINGS, later in this group.)

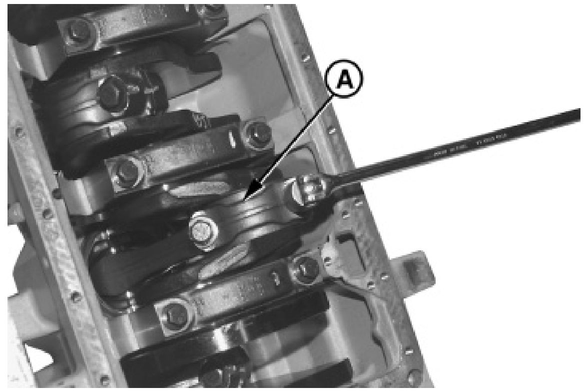
IMPORTANT: Hold on to piston to prevent piston from dropping. Piston will drop once piston rings have cleared cylinder liner bore.

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

Use a wood or plastic tool to drive piston from liner. DO NOT use metal.

11. Gently tap piston through top of cylinder block from the bottom.

12. Remove remaining pistons and rods from engine.



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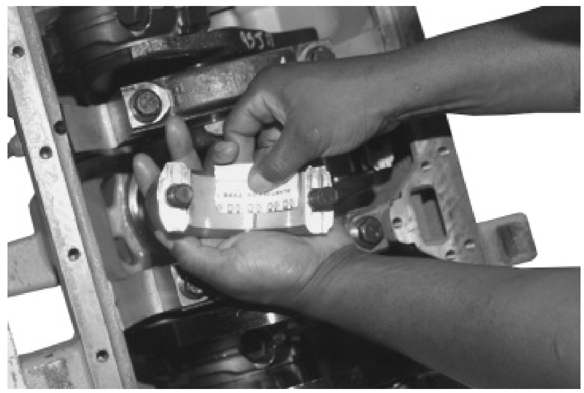
Removing Rod Caps



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Measuring Rod Bushing Oil Clearance

A—Rod Caps

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RE38635,000010B –19–09NOV07–4/4

Measure Cylinder Liner Standout (Height Above Block)

IMPORTANT: Remove all gasket material, rust, carbon and other foreign material from top deck of cylinder block. Use compressed air to remove all loose foreign material from cylinders and top deck.

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

1. Bolt liners down in seven locations using cap screws and washers. (See REMOVE PISTONS AND CONNECTING RODS, earlier in this group.) Tighten cap screws to 68 N•m (50 lb-ft).

Specification

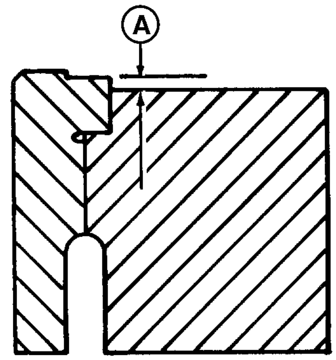
Cylinder Liner Cap Screws (For Checking Liner Standout)—Torque	68 N•m (50 lb-ft)

2. Using JDG451 Gauge along with D17526CI (English scale) or D17527CI (metric scale) Dial Indicator or KJD10123 Gauge, measure liner height (A) for all cylinders.

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

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

4. If liner standout is below specification, measure liner flange thickness. (See MEASURE LINER FLANGE THICKNESS later in this group.) Measure liner counterbore depth in cylnder block. (See INSPECT AND CLEAN CYLINDER BLOCK, later in this group.)



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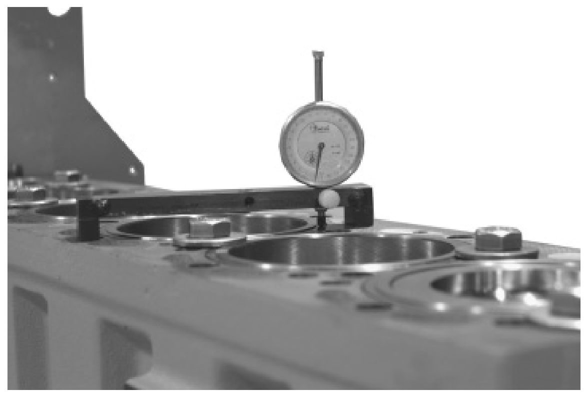
Liner Standout



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Measuring Liner Standout

Continued on next page RE38635,000004A –19–10AUG05–1/2

Specification

Cylinder Liner Height (Standout)—Height Above Block.................................. 0.030—0.117 mm (0.0012—0.0046 in.)

Maximum Permissible Height Difference at Nearest Point of Two Adjacent Liners or Within One Liner... 0.05 mm (0.002 in.)

5. Replace any liner that does not meet standout specification at any location.

RE38635,000004A –19–10AUG05–2/2

Remove Cylinder Liners Using D01062AA or D01073AA Cylinder Liner Puller

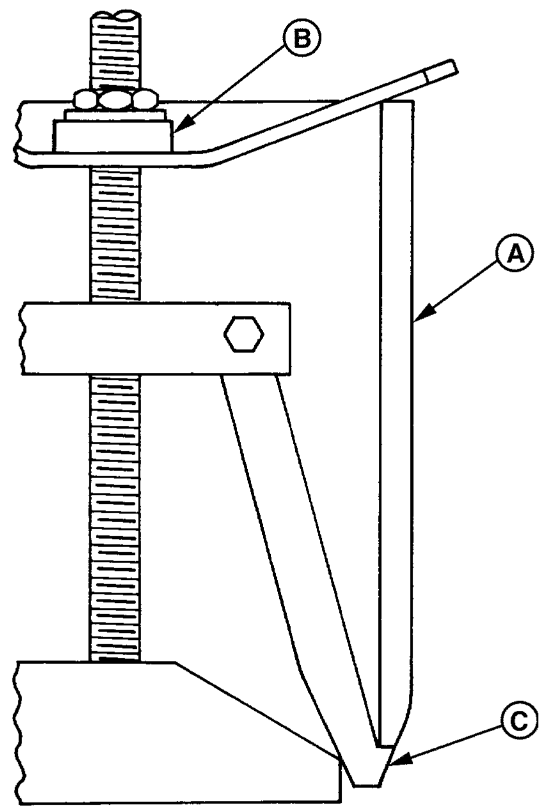
1. Remove cap screws and washers securing liners to cylinder block.
2. Number cylinder liners and mark fronts to ensure correct assembly.

NOTE: Each cylinder liner must be reinstalled in same cylinder bore from which removed. Always keep matched pistons and liners together.

3. Use D01062AA or D01073AA Cylinder Liner Puller (B) with a 2.27 kg (5.0 lb) slide hammer to remove cylinder liner (A).

IMPORTANT: When using D01062AA (or D01073AA) Cylinder Liner Puller (B) to remove liner (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.



Removing Cylinder Liners

A—Liner
B—Cylinder Liner Puller
C—Jaw

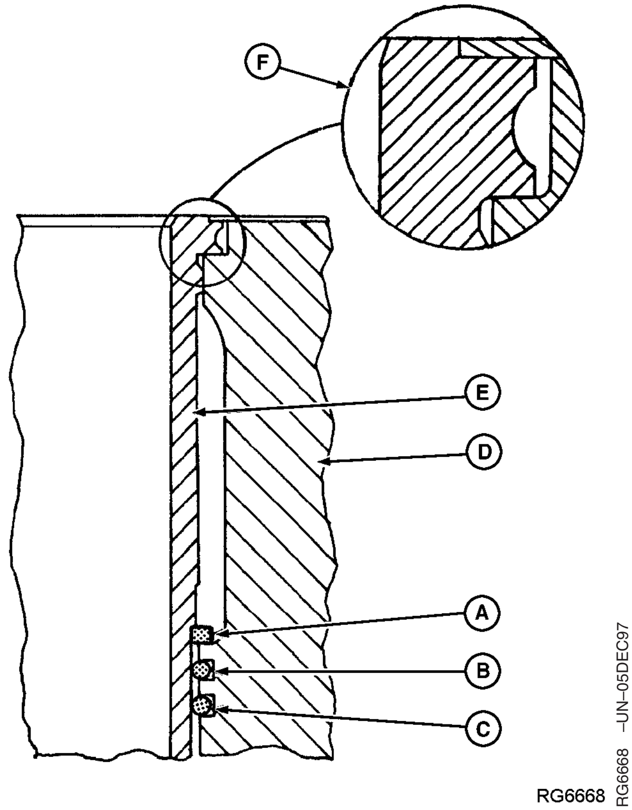
Continued on next page RG,RG34710,109 –19–13AUG99–1/2

02
030
12

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—Red O-Ring (Silicone)
C—Black O-Ring (Viton)
D—Cylinder Block
E—Cylinder Liner
F—Coolant Passage



Cylinder Liner Packing

RG,RG34710,109 –19–13AUG99–2/2

Remove Cylinder Liners Using JDG1145 Cylinder Liner Service Set

NOTE: JDG1145 Liner Puller (A) shown with liner removed to illustrate proper assembly of tool.

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

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

NOTE: Each cylinder liner must be reinstalled in same cylinder bore from which removed. Always keep matched pistons and liners together.

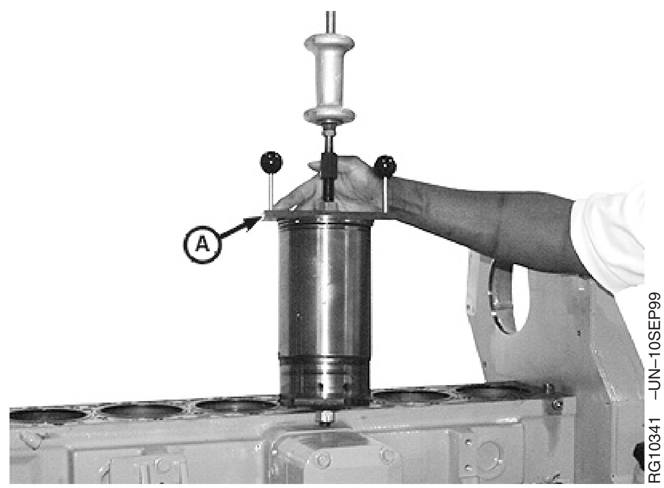
3. Use JDG1145 Cylinder Liner Service Set (A) with a 2.27 kg (5.0 lb) slide hammer (B) to remove cylinder liner.

IMPORTANT: When using JDG1145 as shown (A) to remove liners, make sure puller is properly assembled before attempting to remove liners. Step in bottom plate of puller assembly should fit in ID of liner.

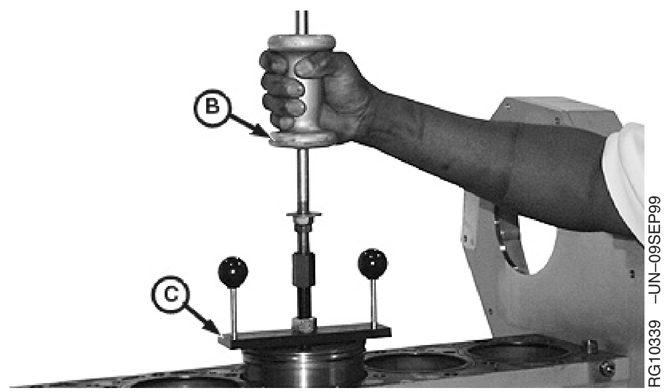
DO NOT over-tighten liner puller to remove liners. Doing so could easily break liners.

4. Install liner puller (C) in liner.

5. Attach a 2.27 kg (5.0 lb) slide hammer (B) to liner puller as shown and remove liner.



JDG1145 Installation



Remove Cylinder Liner

A—JDG1145
B—Slide Hammer
C—Liner Puller

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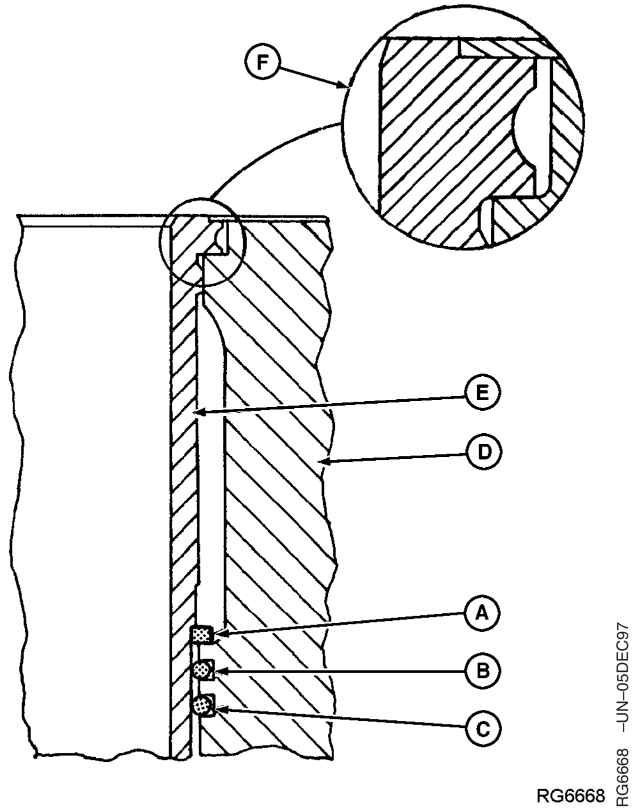
DPSG,OUO1004,1026 –19–09SEP99–1/2

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

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

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



Cylinder Liner Packing

DPSG,OUO1004,1026 –19–09SEP99–2/2

Visually Inspect Cylinder Liners

IMPORTANT: If 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 the depth of pits and erosion with a fine wire or needle.

   Replace piston and liner if:

   - Pitting depth is one-half liner thickness (C) or more.

Specification

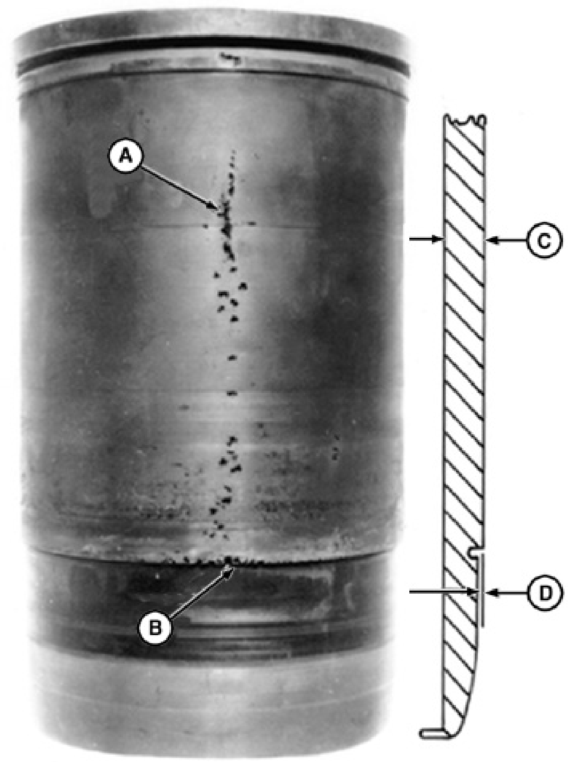
Cylinder Liner Wall—Thickness .... 6.36—6.50 mm (0.250—0.256 in.)

   - Erosion depth is one-half packing step (D) or more.

Specification

Cylinder Liner Packing Step—
Dimension... 2.14—2.30 mm (0.084—0.090 in.)

NOTE: Liners are reusable if the depth of pits or erosion is less than one-half the amount specified. When installing these liners, rotate 90° from original position. The liners should be deglazed and ring sets installed on pistons.



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Liner Visual Inspection

A—Liner Pitting
B—Erosion
C—Pitting Depth Is One-Half Liner Thickness
D—Erosion Depth Is One-Half Packing Step

Continued on next page RE38635,000004B –19–10AUG05–1/2

2. Visually examine liner ID. 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.

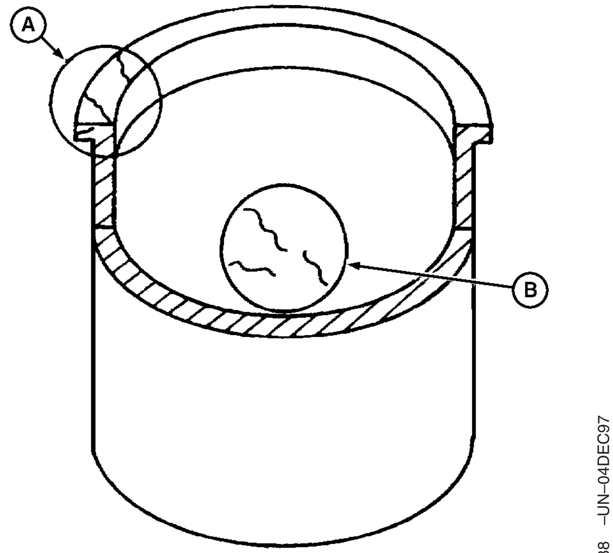
3. Carefully examine liner for signs of fatigue, such as fine cracks in the flange area (A) and cracks in the ring travel area (B).

NOTE: Inspect block for cracks or erosion in the O-ring packing areas. (See INSPECT AND CLEAN CYLINDER BLOCK, later in this group.)

4. Measure liner OD and compare to following specifications.

Cylinder Liners—Specification

Flange Area—OD	151.565—151.615 mm (5.9671—5.9691 in.)
Upper OD for Seating Liner—OD	145.795—145.845 mm (5.7400—5.7419 in.)
Water Jacket Area—OD	144.73—144.99 mm (5.698—5.708 in.)
Lower OD for Seating with O-Rings—OD	140.397—140.447 mm (5.5274—5.5294 in.)



Liner ID Inspection

A—Cracks In The Flange Area
B—Cracks In The Ring Travel Area

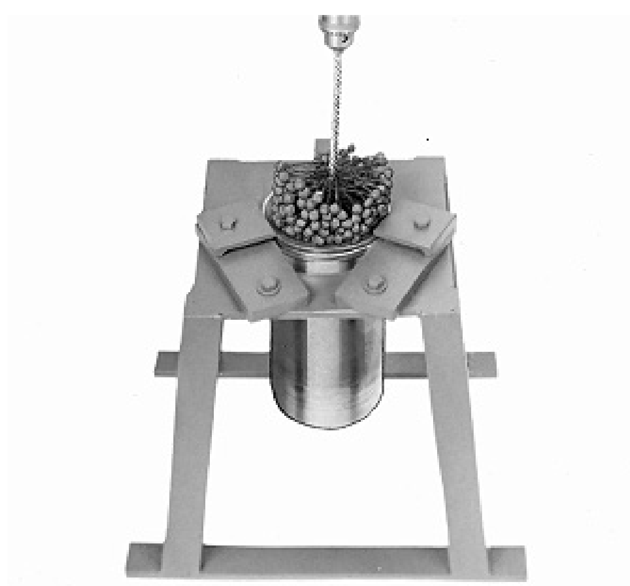
RE38635,000004B –19–10AUG05–2/2

Deglaze Cylinder Liners

1. Secure cylinder liner in a holding fixture. See DFRG3—CYLINDER LINER HOLDING FIXTURE, in Section 05, Group 190 for assembly of holding fixture.

2. Use D17006BR Flexible Cylinder Hone to deglaze cylinder liner.

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



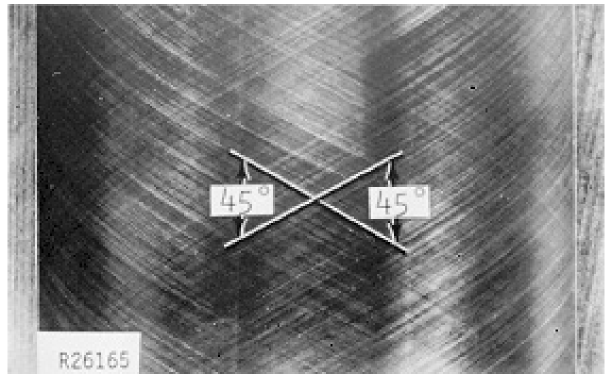
Deglazing Liners

Continued on next page

RG,RG34710,111 –19–30SEP97–1/2

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, next in this group.)



R26165 –UN–13DEC88

Liner Cross-hatch

RG,RG34710,111 –19–30SEP97–2/2

Clean Cylinder Liners

1. Use a stiff bristle brush to remove all debris, rust, and scale from OD 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 ID 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,RG34710,112 –19–30SEP97–1/1

Cylinder Liner Manufacturing Date Code Explanation

A manufacturing four-digit date code will appear on each liner. For example, HD05 means the liner is hardened and was manufactured in April, 2005.

Liner Date Code

HD05

H .... Liner Material Type
D .... Month Liner was Manufactured (A through L)
05 .... Year Liner was Manufactured

Liner Material Specification:

H .... Hardened Liner (C50 Material)

Month Liner was Manufactured

A .... January
B .... February
C .... March
D .... April
E .... May
F .... June
G .... July
H .... August
I .... September
J .... October
K .... November
L .... December

Year Liner was Manufactured:

05 2005
06 2006
etc.

RE38635,000004C –19–10AUG05–1/1

Disassemble Piston/Rod Assembly and Clean Piston

NOTE: Piston part numbers are marked on top of pistons for identification.

1. If necessary, check piston ring end gap prior to removing rings.

Specification

No. 1 Piston Compression Ring—End Gap	0.48—0.74 mm (0.019—0.029 in.)
No. 2 Piston Compression Ring (3 mm Ring)—End Gap	1.35—1.65 mm (0.053—0.065 in.)

2. Remove piston snap rings. Remove piston pin and connecting rod from piston.

NOTE: Discard snap rings. DO NOT reuse.

3. Remove piston rings using the JDG967 Piston Ring Expander. Discard rings.

CAUTION: Always follow manufacturer's instructions, and safety steps exactly.

4. Clean piston ring grooves using a piston ring groove cleaning tool.

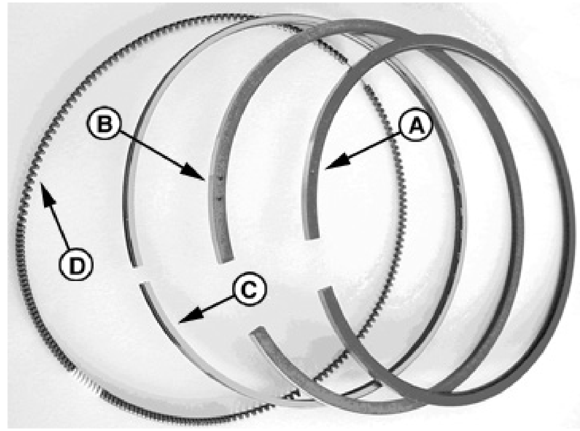
IMPORTANT: When washing pistons, always use a stiff bristle brush—NOT A WIRE BRUSH—to loosen carbon residue.

DO NOT bead blast ring groove areas.

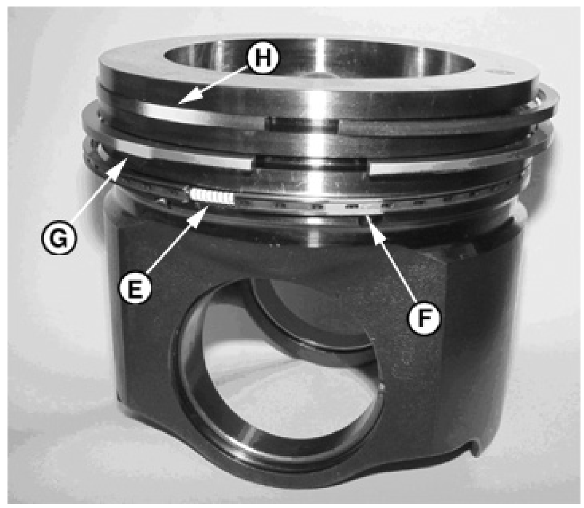
5. Clean pistons by any of the following methods:

- 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.



Piston & Ring Assembly



Piston Rings - Top View

RE38635,000010C –19–09NOV07–1/1

Check Piston Oil Control Ring Groove Wear

1. Check oil control ring-to-groove clearance by installing a new ring in groove.

2. Measure clearance with a feeler gauge at several points. Compare measurements with specifications given below.

Specification

Oil Control Ring-to-Groove—	
Clearance	0.041—0.091 mm (0.0016—0.0036 in.)
Maximum Clearance	0.132 mm (0.0052 in.)

NOTE: Replace piston and liner (as a set) if oil control ring clearance exceeds specifications given.

RG5234 –UN–05DEC97

Measuring Oil Control Ring Groove Wear

RE38635,000004F –19–10AUG05–1/1

Inspect Piston Pin and Pin Bore in Piston

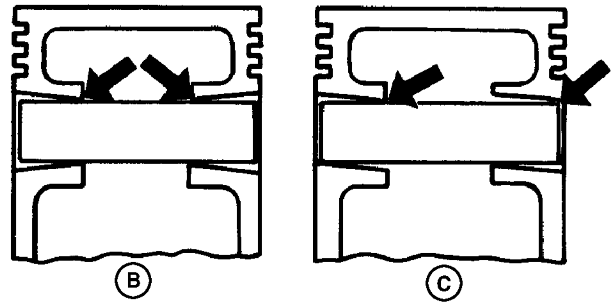
NOTE: Piston pin must be in good condition and not worn beyond specification given below.

1. Dip piston pin 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 and compare to specifications. If either are not within specification, replace pin, piston, and liner.

Specification

Piston Pin—OD	57.997—58.003 mm (2.2833—2.3836 in.)
Piston Pin Bore in Piston—ID	62.753—62.773 mm (2.4706—2.4714 in.)
Piston Pin Bushing—ID	58.05—58.07 mm (2.285—2.286 in.)



Piston Pin Bore Inspection

B—Tapered Bore
C—Opposite Side of Bore

RE38635,000010D –19–09NOV07–1/1

Inspect Piston Pin and Pin Bore in Piston

NOTE: Piston pin must be in good condition and not worn beyond specification given below.

1. Dip piston pin 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).

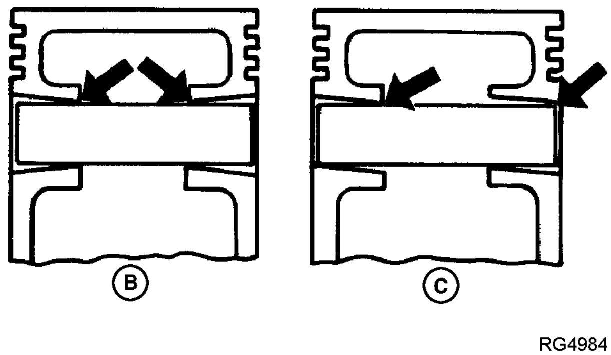
5. Measure piston pin and piston bore and compare to specifications. If either are not within specification, replace pin, piston, and liner.

Specification

Piston Pin—OD	57.997—58.003 mm (2.2833—2.3836 in.)
Piston Pin Bore in Piston—ID	62.753—62.773 mm (2.4706—2.4714 in.)
Piston Pin Bushing—ID	58.05—58.07 mm (2.285—2.286 in.)

RG5231 –UN–05DEC97

Installing Piston Pin



RG4984 –UN–05DEC97

Piston Pin Bore Inspection

A—Pin
B—Tapered Bore
C—Opposite Side of Bore

RE38635,0000050 –19–10AUG05–1/1

Determine Piston-to-Liner Clearance

1. Measure engine skirt OD at right angles to piston pin bore, 35.0 mm (1.38 in.) from bottom of skirt.

2. Record measurement and compare measurement obtained from matching liner.

Specification

Piston Skirt—OD 35.0 mm (1.380 in.) from Bottom of Skirt .... 131.855—131.885 mm (5.1911—5.1923 in.)

RG14443 –UN–31JAN06

Measuring Piston Skirt

Continued on next page

RE38635,0000051 –19–10AUG05–1/2

IMPORTANT: ALWAYS measure liners at room temperature.

3. Measure liner bore parallel to piston pin at top end of ring travel (A).

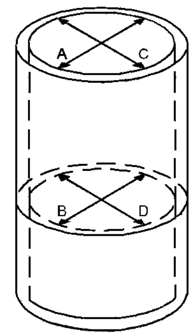
4. Measure bore in same position at bottom end of ring travel (B).

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 ID with matched piston OD.



RG10049 –UN–07JAN03

Measuring Liner ID

Specification

Cylinder Liner—ID	131.99—132.01 mm (5.1965—5.1972 in.)
Max. Out of Round	0.020 mm (0.0008 in.)
Max. Wear or Taper (Ring Travel Area)	0.030 mm (0.0012 in.)
Piston-to-Liner Clearance (New Part)—Clearance	0.060—0.100 mm (0.0024—0.0039 in.)
Max. Acceptable Wear	0.152 mm (0.0060 in.)

Replace piston and liners (as a set) if they exceed wear specifications given.

RE38635,0000051 –19–10AUG05–2/2

Measure Liner Flange Thickness

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

If liner flange is not within specification, replace piston and liner as a set.

Specification

Cylinder Liner Flange—Thickness .... 9.521—9.571 mm (0.3748—0.3768 in.)

Measuring Liner Flange Thickness

RE38635,000010E –19–09NOV07–1/1

Inspect and Measure Connecting Rod Bearings

Inspect rod bearings for damage of wear.

IMPORTANT: Never use new connecting rod cap screws when checking rod bearing ID. 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 ID of connecting rod bearings and compare with OD of crankshaft journal.

NOTE: Use PLASTIGAGE® as directed by the manufacturer. The use of PLASTIGAGE® will determine bearing journal clearance, but will not indicate the condition of either surface.

1. With crankshaft removed, measure connecting rod journal OD at several points.

2. Install connecting rod cap on rod with bearings (C) in correct position.

3. 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 .... 140 N•m (103 lb-ft) plus 90—100° turn clockwise

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

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PRECISION JOINT is a trademark of Deere & Company

Continued on next page RE38635,000010F –19–09NOV07–1/2

4. Using an inside micrometer, measure assembled ID of bearing in several places.

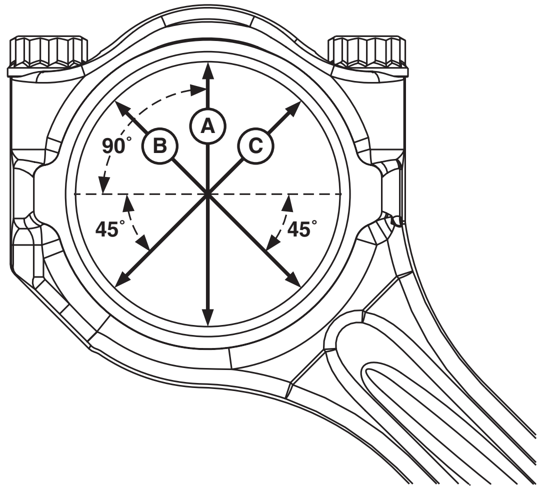
5. Subtract OD of each crankshaft journal from ID of each respective rod bearing to obtain oil clearance.

6. Compare measurements with the specifications given.

Specification

Crankshaft Rod Journal—OD.................................... 88.844—88.874 mm (3.4980—3.4990 in.)
Connecting Rod Bearing for Crankshaft Journal (Assembled)—ID .... 88.93—88.98 mm (3.501—3.502 in.)
Connecting Rod Bearing-to-Journal (New Part)—
Oil Clearance....................................... 0.06—0.13 mm (0.002—0.005 in.)
Max. Oil Clearance... 0.15 mm (0.006 in.)

7. Inspect connecting rod bearings for wear or damage. If bearings are worn or not within specification, replace both connecting rod bearing and rod pin bearing.



RG14444 —UN—11AUG05

Measuring Assembled Rod Bearing ID

RE38635,000010F —19—09NOV07—2/2

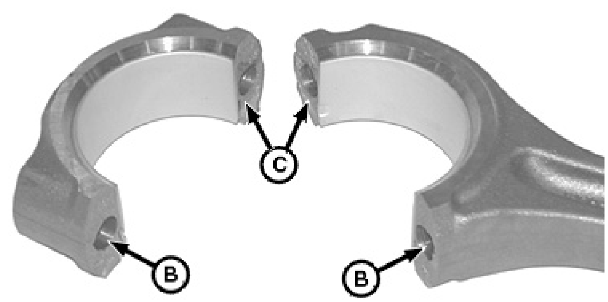
Inspect Connecting Rod and Cap

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 ensure proper seating. Never scrape joint surfaces (C) with a wire brush or other tool; the interlocking mating surfaces must be preserved, and remain free of any debris.

Rod cap MUST be kept with parent rod.

2. Inspect in and around cap screw holes (B) in cap. If any defects are found, replace rod and cap.



RG10301 —UN—27AUG99

PRECISION JOINT™ Rod and Cap

B—Cap Screw Hole
C—PRECISION JOINT™ Mating Surfaces

PRECISION JOINT is a trademark of Deere & Company

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3. Carefully clamp rod in a soft-jawed vise (cap end upward).

IMPORTANT: Never use new connecting rod cap screws when checking rod bearing ID. Use new cap screws only for final assembly of connecting rods.

4. Install cap WITHOUT bearing inserts.

5. Initially tighten rod cap screw closest to piston end, then tighten other cap screw to the following specifications.


RG4982 –UN–05DEC97

Assembled Rod Without Bearings

Specification	
PRECISION JOINT™ Connecting Rod Cap Screw—Torque	140 N•m (103 lb-ft) plus 90—100° turn clockwise

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

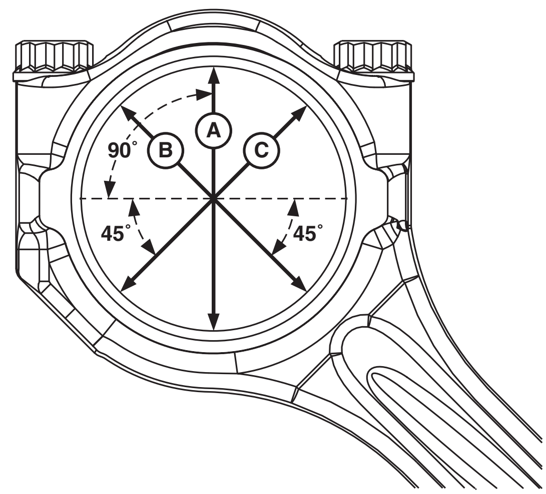
PRECISION JOINT is a trademark of Deere & Company

RE38635,0000110 –19–09NOV07–2/4

6. Using an inside micrometer, measure rod bore at center of bore and record measurements as follows:

- (A) At right angle to rod/cap joint.
- (B) At 45 degrees left of measurement (A).
- (C) At 45 degrees right of measurement (A).

7. Compare the measurements.



RG14444 –UN–11AUG05

Measuring Assembled Rod Bore

Specification	
Connecting Rod Bore (For Crankshaft Journal Bearing)—ID	93.76—93.79 mm (3.6915—3.6925 in.)

If difference between the greatest and least measurement is more than 0.038 mm (0.0015 in.), the rod and cap are out of round. Replace both connecting rod and cap.

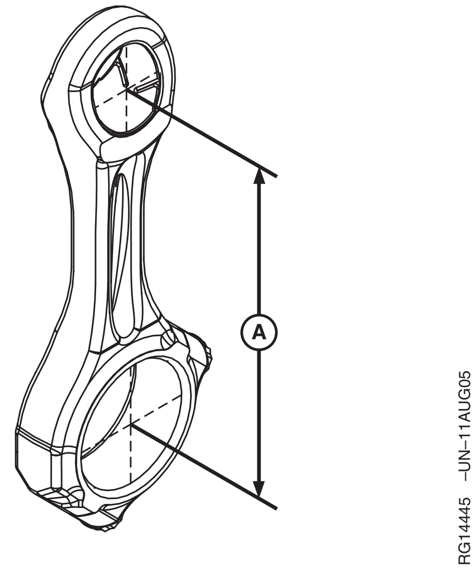
Continued on next page

RE38635,0000110 –19–09NOV07–3/4

8. Measure rod 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

Connecting Rod Centerline of Piston Pin Bore-to-Crankshaft Bore (New Part)—Dimension	263.95—264.05 mm (10.392—10.396 in.)



Measuring Rod Center-to-Center Bores

RE38635,0000110 –19–09NOV07–4/4

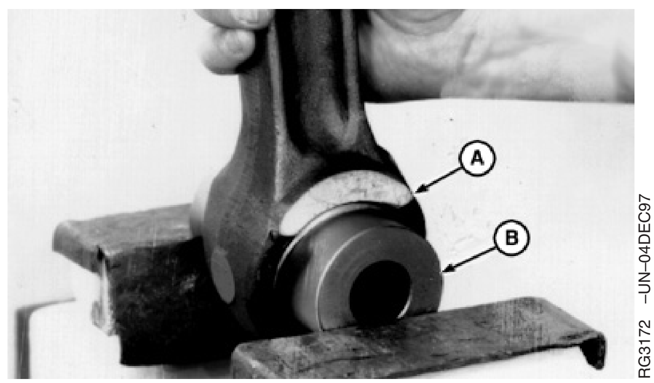
Inspect Piston Pins and Rod Bushings

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



Installing Piston Pin in Rod Bushing

Continued on next page

RE38635,0000055 –19–10AUG05–1/2

02
030
30

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).

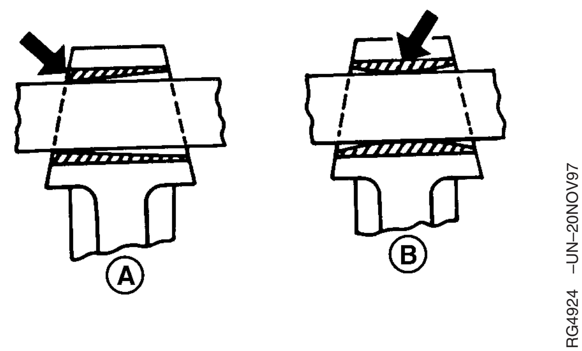
5. Inspect piston pin bushing lubrication hole in rod for damage, excessive wear or contaminants.

6. Measure pin bushing ID for specified clearance.

Specification

Piston Pin—OD	57.997—58.003 mm (2.2833—2.2836 in.)
Rod Pin Bore Without Bushing—ID	62.750—62.775 mm (2.4707—2.4715 in.)
Installed Rod Pin Bushing (Before Boring)—ID	57.750 mm (2.274 in.)
Installed Rod Pin Bushing (After Boring)—ID	58.020—58.046 mm (2.2843—2.2853 in.)
Piston Pin Bushing Bore—Out-of-Round	0.038 mm (0.0015 in.)
Piston Pin-to-Bushing—Oil Clearance	0.017—0.049 mm (0.0007—0.002 in.)
Max. Acceptable Wear	0.076 mm (0.0030 in.)
Press Fit of Bushing in Rod Pin Bore—Press Fit	0.075—0.140 mm (0.003—0.0055 in.)

7. If necessary, remove and replace piston pin bushing. (See REMOVE PISTON PIN BUSHING, CLEAN, AND INSPECT BUSHING BORE in this group.)



Inspecting Rod Piston Pin Bushing Bore

A—Tapered Bore
B—Bell-Mouthed Bore

RE38635,0000055 –19–10AUG05–2/2

Remove Piston Pin Bushing, Clean, and Inspect Bushing Bore

IMPORTANT: Do not use pneumatic tools to remove or install piston pin bushing.

Use care to properly align the JDE98-10 Bushing Remover/Installer (B) with bushing so that the connecting rod is not damaged.

1. Remove the used bushing with JDE98-8 Cup (A), JDE98-10 Bushing Remover/Installer, and STD36104 Forcing Screw (C) from the JDE98A Connecting Rod Bushing Service Set.

2. Clean rod bushing bore using a medium grit emery cloth, as burrs will distort bushing. Install bushing on side opposite rod burr.

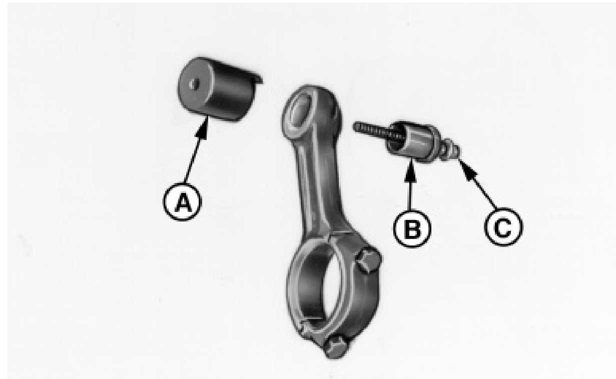
3. If necessary, file a slight chamfer around bushing bore to remove any sharp edges. Chamfer will also aid in bushing installation.

4. Measure rod bushing bore in three or more places approximately 45° apart.

Specification

Connecting Rod Pin Bushing Bore (Without Bushing)—ID	62.750—62.775 mm (2.4705—2.4715 in.)
Connecting Rod Pin Bushing—Press Fit in Rod Pin Bore	0.075—0.140 mm (0.003—0.0055 in.)

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



RG4723 –UN–20NOV97

Removing Rod Piston Pin Bushing

A—JDE98-8 Cup
B—JDE98-10 Bushing Remover/Installer
C—STD36104 Forcing Screw

RE38635,0000056 –19–10AUG05–1/1

Install Piston Pin Bushing

1. Lubricate connecting rod bore with clean engine oil.

IMPORTANT: Do not use power tools to install bushing.

2. Assemble JDE98-10 Bushing Remover/Installer (B) with JDE98-9 Pilot (C). Install new bushing (E) onto driver. Lubricate OD of bushing. Install and lubricate STD36104 Forcing Screw threads (D).

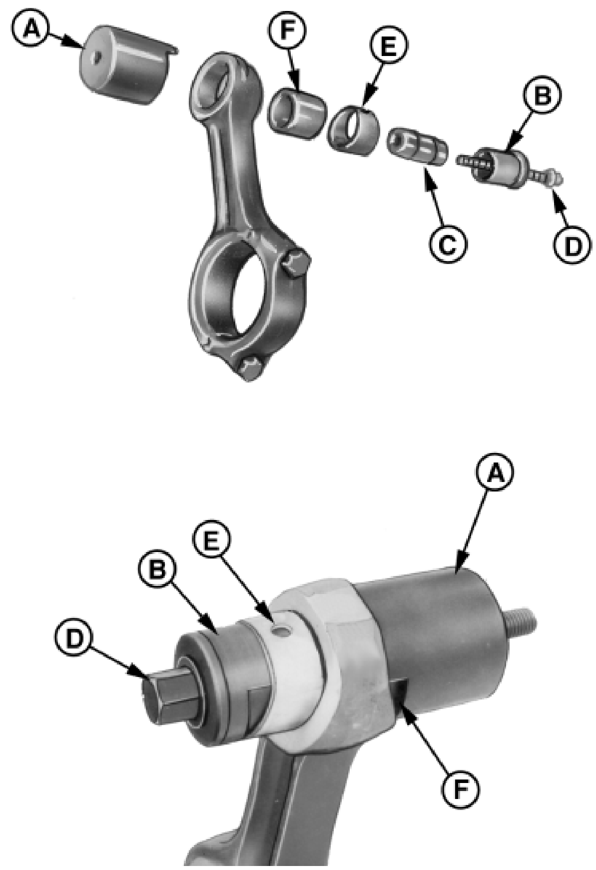
3. Assemble JDE98-6 Pilot (F) onto driver.

4. Engage forcing screw heads with threads in JDE98-8 Cup (A) and install new bushing.

IMPORTANT: Boring the connecting rod bushing should be done ONLY by experienced personnel on equipment capable of maintaining bushing finish specification.

5. Precision bore new bushing to specification to obtain pin-to-bushing clearance. Remove all debris from boring operation.

Specification	
Piston Pin Bushing (After Boring)—ID	58.020—58.046 mm (2.2843—2.2853 in.)
Piston Pin—OD	57.997—58.003 mm (2.2833—2.2836 in.)
Piston Pin-to-Bushing—Clearance	0.017—0.049 mm (0.0007—0.002 in.)



RG8421 –UN–09DEC97

Installing Rod Piston Pin Bushing

A—JDG10196P3 Cup
B—JDE98-10 Bushing Remover/Installer[1]
C—JDE98-9 Pilot[1]
D—STD36104 Forcing Screw[1]
E—Bushing
F—JDE98-6 Pilot[1]

[1] *From JDE98A Connecting Rod Bushing Service Set.*

RE38635,000013E –19–22SEP06–1/1

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. (See REMOVE CRANKSHAFT in Group 040.)

2. Remove coolant pump and all remaining cooling system components. (See REMOVE COOLANT PUMP in Group 070.)

3. Remove timing gear cover. (See REMOVE TIMING GEAR COVER in Group 040.). Remove front plate. (See REMOVE AND INSTALL CYLINDER BLOCK FRONT PLATE earlier in this group.)

4. Remove engine oil pump and all remaining lubrication system components. (See REMOVE ENGINE OIL PUMP in Group 060.)

Continued on next page RE38635,0000059 –19–11AUG05–1/2

5. Remove all components (water gallery plugs, oil gallery plugs, bushings, and engine serial number plate) before inspecting and cleaning cylinder block. Use JDG782 Oil Gallery Plug Tool to remove and install gallery plugs.

6. Install rivet plug (A) into hole on right side front, near head deck, flush to 1.5 mm below surface.

7. Apply LOCTITE® 680 to the 2 large frost plugs (B). Install frost plugs into the coolant holes on right side of block, as shown, to a depth of 1 mm below bottom edge of chamfer.

8. Install 2 pipe plugs (C) with pre-applied sealant to the oil galley holes on right side of block. Tighten to specification.

Specification

Oil Galley Pipe Plugs to Block—
Torque .... 25 N•m (19 lb-ft)

9. Install 1 pipe plug (D) with pre-applied sealant to oil galley hole in rear face of block, as shown. Tighten to specification.

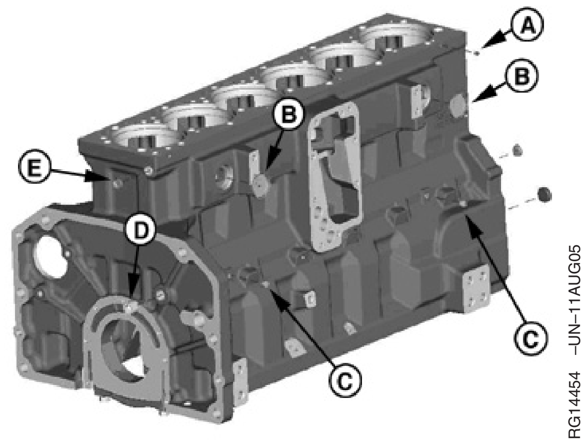
Specification

Rear Oil Galley Plug to Block—
Torque .... 60 N•m (45 lb-ft)

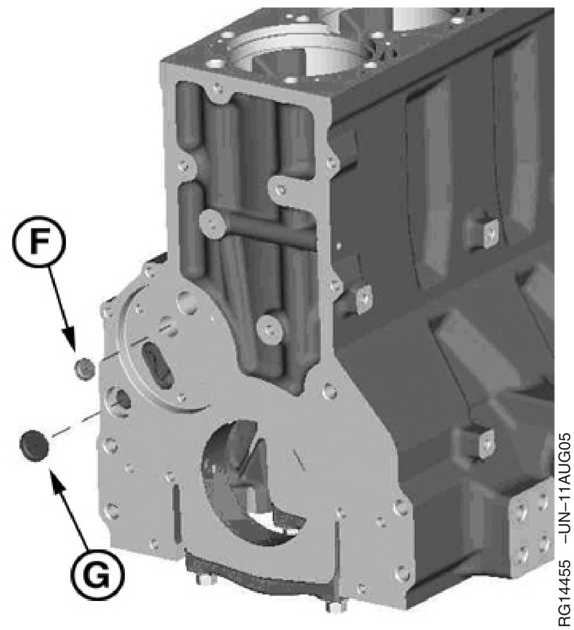
10. Apply LOCTITE® 680 to the rear plug bore for the top coolant cross hole. Install plug (E) flush to 1.5 mm below surface.

11. Apply LOCTITE® 680 to the plug bore for the front oil galley hole. Install the plug (F) flush to 1.5 mm below block face.

12. Apply LOCTITE® 680 to the plug bore for the oil pump core clean out hole. Install the plug (G) flush to 1.5 mm below front block face.



Cylinder Block



Cylinder Block - Front View

A—Rivet Plug
B—Coolant Hole Frost Plugs
C—Oil Galley Pipe Plugs - Right Side
D—Oil Galley Pipe Plug - Rear Face
E—Top Coolant Cross Hole Pipe Plug - Rear Face
F—Oil Galley Pipe Plug - Front Face
G—Oil Pump Core Cleanout Hole

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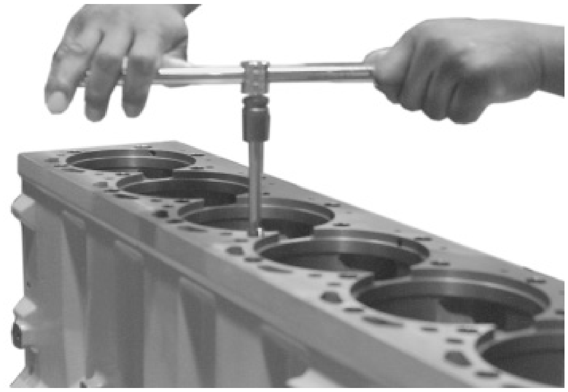
RE38635,0000059 –19–11AUG05–2/2

Inspect and Clean Cylinder Block



Cleaning Head Bolt Threads in Block

NOTE: All components, water 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 Groove 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 JDG978 Tap or an equivalent M16 x 2.0 tap approximately 152.4 mm (6.0 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.

3. Clean block thoroughly using cleaning solvent, pressure steam, or a hot tank.

Continued on next page RE38635,0000114 –19–12NOV07–1/2

NOTE: JDG1145 Cylinder Liner Service Set (D) can be used with lapping compound, as shown, to lap liner flange to block counterbore.

4. Inspect liner support flange (C) for burrs. If burrs are present, use respective liner with lapping compound to remove burrs.

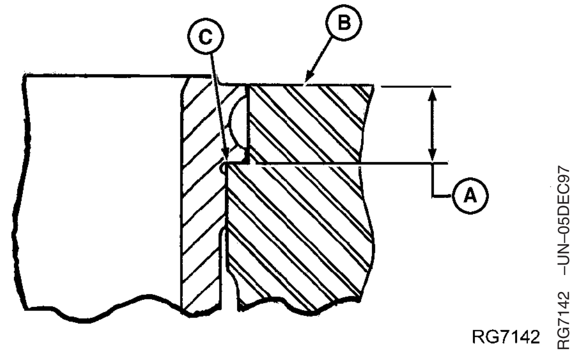
5. Measure liner flange counterbore depth (A) in block (B) and flange thickness on liner. Compare with specification given below.

Specification

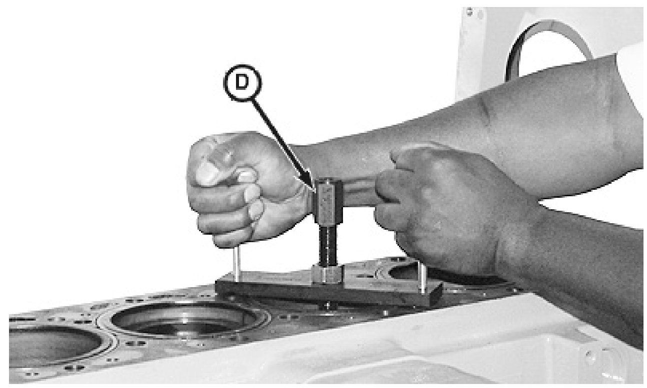
Cylinder Liner Flange Counterbore—Depth in Block	9.461—9.512 mm (0.3725—0.3745 in.)
Cylinder Liner Flange—Thickness	9.521—9.571 mm (0.3744—0.3768 in.)

6. Carefully inspect block for cracks or any other physical damage. If a cracked block is suspected, pressure-test the block. Replace block if there is evidence of a crack or physical damage.

A—Liner Flange Counterbore Depth
B—Block
C—Liner Support Flange
D—JDG1145 Liner Service Set



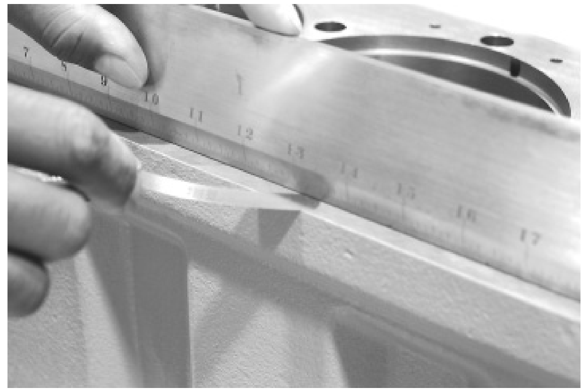
Liner Counterbore Depth



Lap Liner Flange

RE38635,0000114 –19–12NOV07–2/2

Measure Cylinder Block


RG8208 –UN–21MAY98

Measuring Block Top Deck Flatness

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

Main and Thrust Bearings—
Assembled ID Without Bearings .... 133.097—133.123 mm (5.2400—5.2410 in.)
Main Bearing Surface Width .... 37.77—38.03 mm (1.487—1.497 in.)
Thrust Bearing Surface Width
(No. 5 Main) .... 37.51—38.29 mm (1.476—1.507 in.)
Overall Thrust Bearing Cap Width .... 43.25—43.75 mm (1.703—1.722 in.)

If any main or thrust bearing cap assembled ID is not within specification, blank (generic) bearing caps are available and must be line bored to specification by a qualified machine shop. (See MEASURE ASSEMBLED ID OF MAIN BEARING CAPS in Group 040.)

2. Measure cylinder block top deck flatness using D05012ST Precision Straightedge and feeler gauge. Resurface as required.

Specification

Cylinder Block Top Deck Surface
Finish—Surface Finish (Surface
Mill Only)... 3.2 micrometers (125 micro-in.)
Max. Wave Height... 0.008 micrometers (0.0002 micro-in.)
Max. Wave Depth....................................... 2.0 micrometers (79 micro-in.)
Main Bearing Bore
Centerline-to-Top Deck—
Minimum Distance... 429.92—430.07 mm (16.926—16.932 in.)

Continued on next page RG,RG34710,128 –19–03AUG99–1/2

IMPORTANT: The centerline of the main bearing bore-to-top deck of cylinder block MUST be 429.92–430.07 mm (16.926–16.932 in.). If not, replace cylinder block.

3. Measure cylinder liner bores in block and compare to the following specifications.

Cylinder Block Bore for Seating Liner—Specification

Liner Flange Counterbore—ID	153.57—153.77 mm (6.046—6.054 in.)
Upper Block Bore for Seating Liner—ID	145.845—145.895 mm (5.7419—5.7439 in.)
Lower Block Bore for Seating Liner—ID	140.465—140.515 mm (5.5301—5.5321 in.)

RG,RG34710,128 –19–03AUG99–2/2

Recheck Cylinder Liner Standout (Height Above Block)

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

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

1. Install liners without O-rings and square packing. Secure with cap screws and washers, as outlined earlier in this group. (See REMOVE PISTONS AND CONNECTING RODS in this group.)

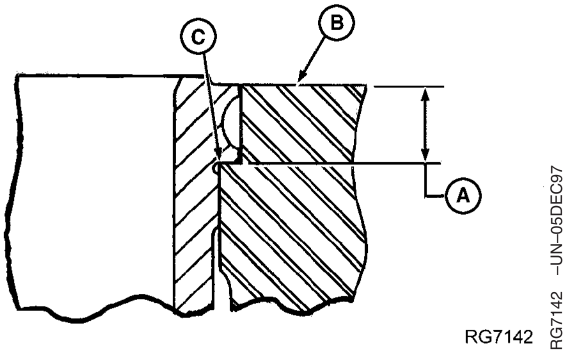
NOTE: Install liner with the identifying mark toward the front of the engine. Position the liner the same on each cylinder. The marking provides a reference for consistent rotating of liners in the future. Rotate 90° if pits or erosion exceed limits outlined during liner inspection.

2. Measure liner standout. (See MEASURE CYLINDER LINER STANDOUT earlier in this group.)

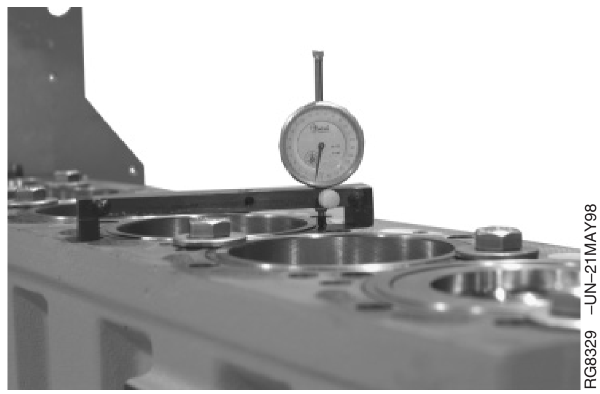
Specification

Cylinder Liner Standout—Height Above Block	0.030—0.117 mm (0.0012—0.0046 in.)

If liner standout is above specification, recheck liner support flange (C) for possible remaining burrs or incorrect counterbore depth (A) in block. If burrs are present, use respective liner and lapping compound to remove burr. Completely clean cylinder liner bore after lapping.



Liner Counterbore Depth



Measuring Liner Standout

A—Liner Flange Counterbore Depth
B—Block
C—Liner Support Flange

RE38635,000005B –19–11AUG05–1/1

Install Cylinder Liner O-Rings and Packings

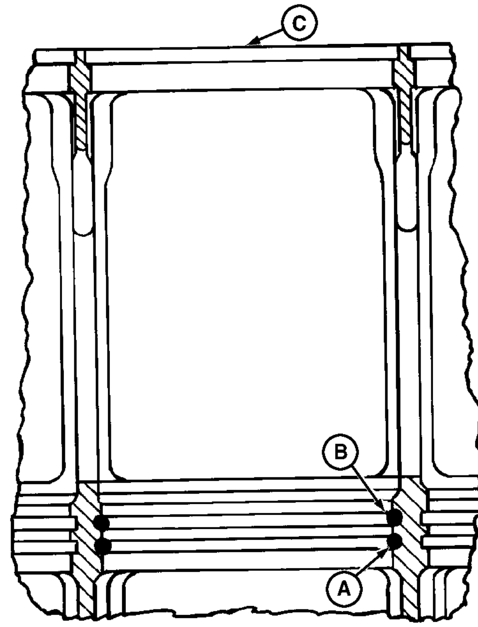
IMPORTANT: DO NOT use oil on cylinder liner packing or O-rings. Oil can cause the red packing to swell, which squeezes liner and could possibly cause a scored piston.

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-rings in soap to soak.

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

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



RG3826 RG3826 –UN–04DEC97

Liner O-Rings and Packing

A—Black Viton O-Ring
B—Red Silicone O-Ring
C—Cylinder Block

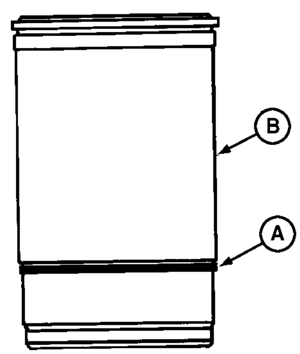
RE38635,000005C –19–11AUG05–1/2

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

6. Slide packing down firmly against second shoulder on the liner.

NOTE: Make sure the packing is not twisted.

7. Coat the liner packings, sealing area of the cylinder liner, and cylinder block O-rings with liquid soap.



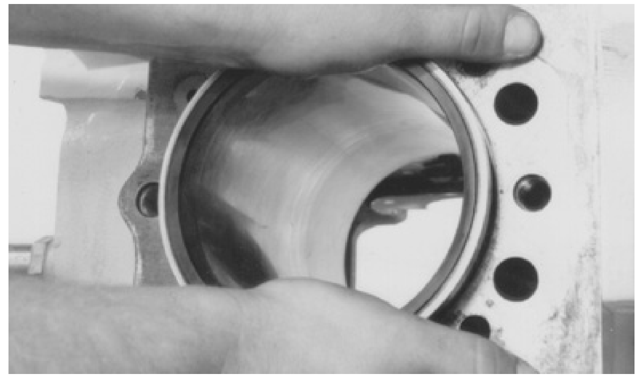
RG3827 RG3827 –UN–04DEC97

Install Square Packing on Liner

A—Neoprene Square Packing
B—Cylinder Liner

RE38635,000005C –19–11AUG05–2/2

Install Cylinder Liners



Installing Liner

IMPORTANT: Install cylinder liner into same cylinder block bore as removed. DO NOT scuff the packing across the upper bore.

When liner ODs are pitted or eroded and are under one-half the liner thickness, rotate liners 90° from their removed position. Rotate the pitted section of the liner toward either the front or rear of the engine.

If liners are not pitted or eroded, rotation will not be necessary. Install liners with the identifying mark (stamped on flange), toward the front of the engine.

1. Carefully place the cylinder liner, with packing installed, into the cylinder block bore.

NOTE: A resistance will be felt when cylinder liner is aligned in pilot bore.

2. Using only the pressure of both palms, the cylinder liner should drop to a point nearly flush at the upper flange of the cylinder liner and cylinder block.

Continued on next page RE38635,000005D –19–11AUG05–1/2

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

3. Finish seating cylinder liners using a clean hardwood block and hammer as shown in top figure or by using JDG1145 Liner Service Set (B) and a 2.27 kg (5 lb) slide hammer (A) shown in lower figure.

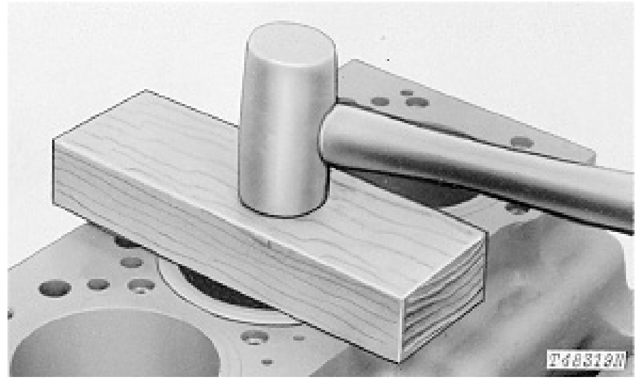
   Using either method, apply only enough force as necessary to seat liners.

IMPORTANT: If you suspect that a packing may have sheared or displaced during liner installation, remove liner and packing assembly. If no damage is found, check packing and O-rings for proper position. Resoap packings and reinstall liner assembly.

4. Hold liners in place with large flat washers and cap screws. Turn cap screws snug, but do not tighten.

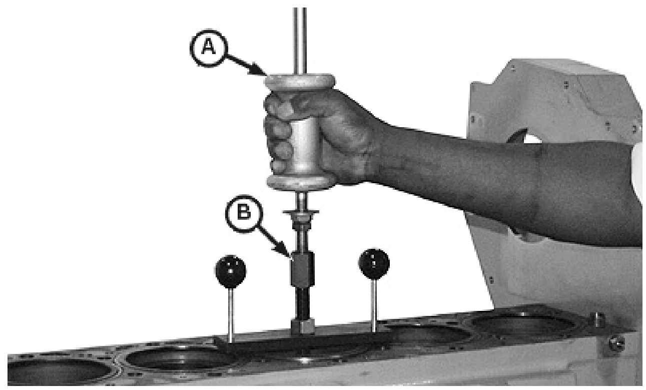
5. Clean cylinder liner bores with waterless hand cleaner after installation. Wipe dry with clean towels.

6. Apply clean engine oil to liner bores immediately to prevent corrosion.



T48319 –UN–23FEB89

Seating Liner



RG10342 –UN–10SEP99

JDG1145 Liner Service Set

A—Slide Hammer
B—Liner Service Set

RE38635,000005D –19–11AUG05–2/2

Assemble Pistons and Connecting Rods

IMPORTANT: Pistons must be installed on same connecting rods from which they were removed and NEW piston pin snap rings must be used.

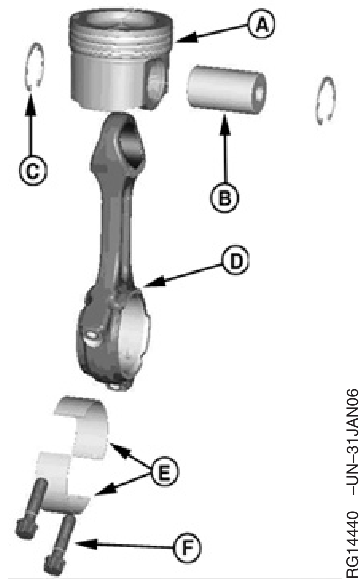
If a new piston and liner assembly is to be installed, DO NOT remove piston from liner. Push piston out of liner bottom only far enough to install piston pin.

1. Lubricate piston pin and bushings with clean engine oil.

NOTE: Pistons are symmetrical; new pistons can be installed either way. If pistons are being reused, align front reference mark made during disassembly with front of connecting rod.

2. Install piston pin through piston and connecting rod (C).

3. Install NEW piston pin snap rings in grooves. Make certain snap rings have completely expanded in grooves of piston. Sharp edge of snap ring MUST face toward outside of piston.

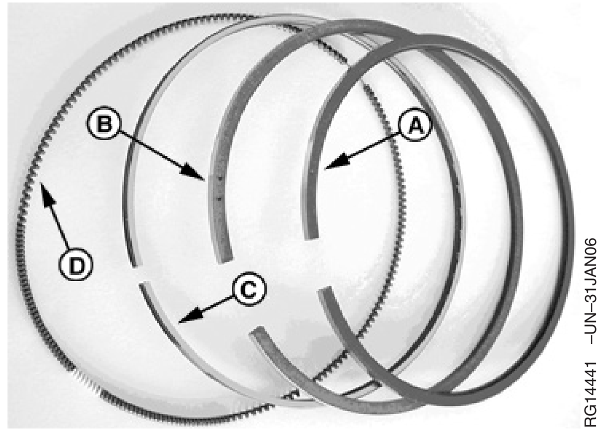


Piston & Connecting Rod Assembly

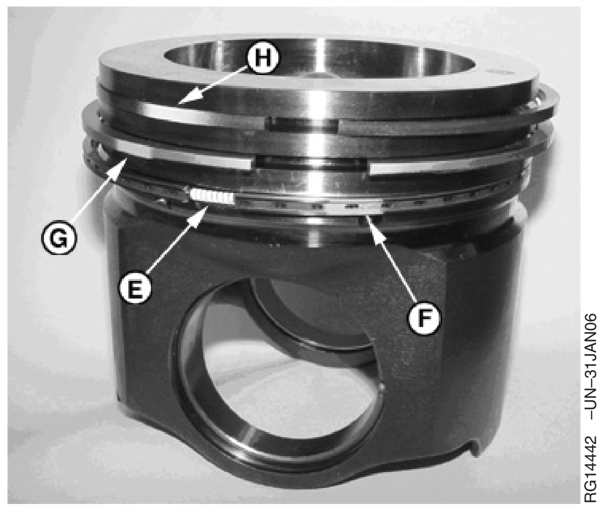
Continued on next page RE38635,000005E –19–11AUG05–1/2

NOTE: Keystone compression ring with one "Pip" mark goes in top piston ring groove and keystone ring with two "Pip" marks goes in second ring groove of piston. "Pip" mark(s) must face top of piston.

4. Use the JDG967 Ring Expander to install compression rings and oil control ring with expander ring.



Piston Ring Set



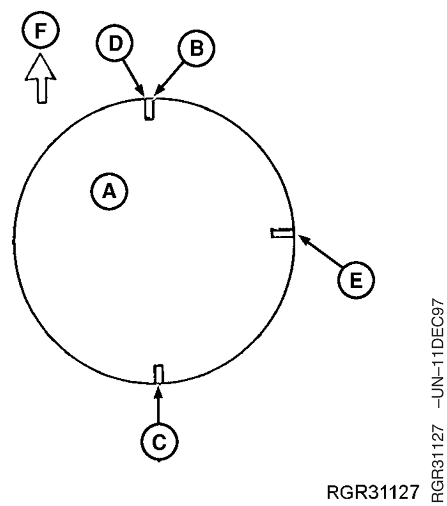
Piston & Ring Set Assembly

RE38635,000005E –19–11AUG05–2/2

Install Pistons and Connecting Rods

1. Stagger ring gaps on pistons as shown.

A—Piston Head
B—Top Compression Ring Gap
C—Oil Control Ring Gap
D—Expander Ring Gap
E—Bottom Compression Ring Gap
F—Front of Engine



Staggering Piston Ring Gaps

Continued on next page

RE38635,0000115 –19–12NOV07–1/4

2. Coat pistons, liners, and inside of JDG1969 Piston Ring Compressor with clean engine oil.

3. Insert piston rod assembly into tapered end of compressor.

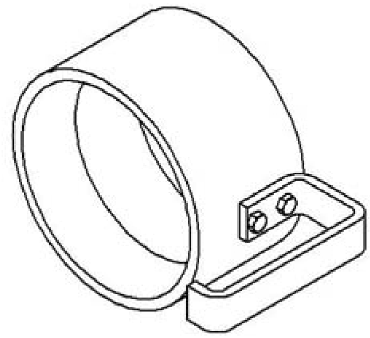
4. Lubricate rod bearing half and install onto rod with notches on bearing seated with notch in rod.

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

IMPORTANT: Be sure crankshaft journals and liner walls are not damaged when installing piston and rod liner.

NOTE: Be sure the word "FRONT" on connecting rod faces toward the front of the engine.

6. With piston centered in ring compressor and rings staggered correctly, push piston into liner.



RG15425 –UN–17JUL07

JDG1969 Ring Compressor

Continued on next page RE38635,0000115 –19–12NOV07–2/4

7. Apply clean engine oil to bearing inserts (B) and crankshaft rod journals (A).

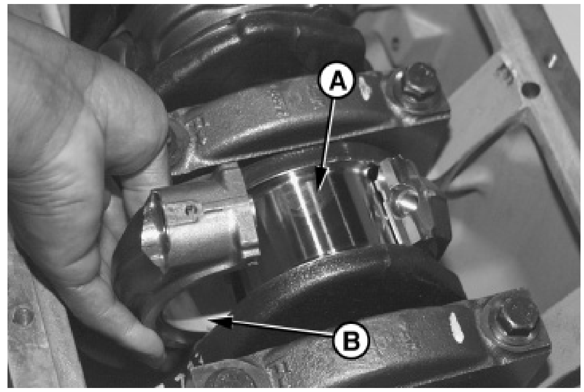
IMPORTANT: On PRECISION JOINT™ rods, make sure bearings are properly centered in the cap and rod. Make sure cap is properly aligned on rod, with interlocking surfaces sealing tightly and edges aligned. DO NOT reverse cap on rod. Match pads on side of rod and cap.

When installing caps, make sure stamped numbers on rod and cap are positioned on the same side.

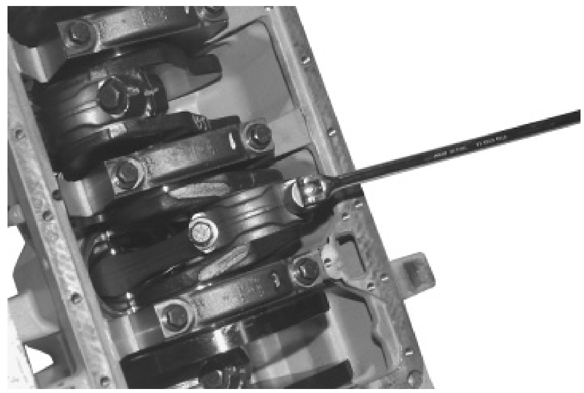
NEVER use connecting rod cap screws more than once for final engine assembly. Once rod cap screws have been tightened to final torque-turn specifications, they cannot be reused for final assembly.

8. Install connecting rod caps.

A—Crankshaft Rod Journals
B—Bearing Inserts



Installing Rod Caps



Tightening Rod Caps

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RE38635,0000115 –19–12NOV07–3/4

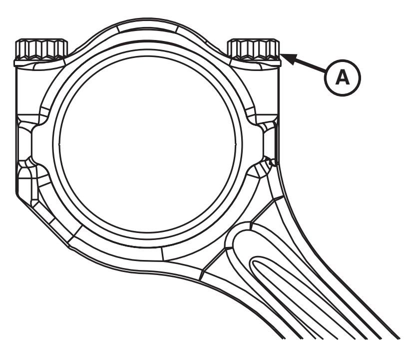
9. Dip new cap screws and washers in clean engine oil. Make sure tops of cap screws have oil on them also.

10. Initially, tighten cap screw closest to piston end to specifications. Next, tighten the other cap screw. Feel rod-to-cap joint to check for proper alignment.

Specification

PRECISION JOINT™ Connecting Rod Cap Screw—Torque	140 N•m (103 lb-ft) plus 90—100° turn clockwise

(See TORQUE-TURN CONNECTING ROD CAP SCREWS, next in this group.)



Tightening Rod Cap Screws

A—Blind Hole Cap Screw

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RE38635,0000115 –19–12NOV07–4/4

Torque-Turn Connecting Rod Cap Screws

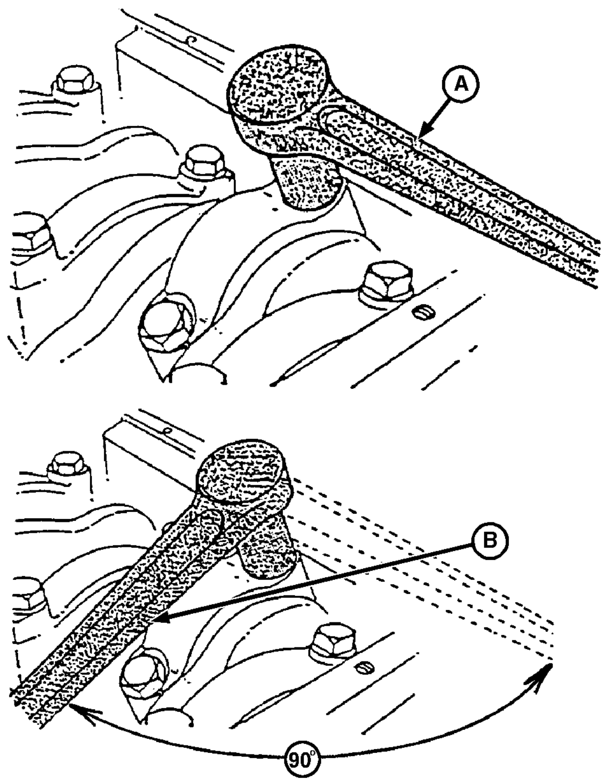
Using Engine Axis Method to Torque-Turn Connecting Rod Cap Screws

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 (A).

3. Tighten 1/4 turn (90—100°) clockwise until handle of wrench is perpendicular to centerline of engine crankshaft axis (B) as shown.

A—Wrench Parallel to Centerline of Engine Crankshaft Axis
B—Wrench Perpendicular to Centerline of Engine Crankshaft Axis



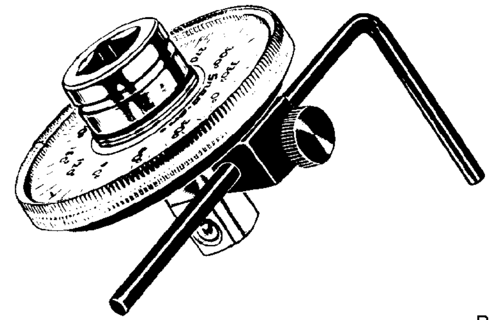
RG9102 –UN–27MAR98

Torque-Turn Rod Cap Screws

RG,RG34710,134 –19–03AUG99–1/2

Using JT05993 Torque Angle Gauge to Torque-Turn Connecting Rod Cap Screws

After tightening cap screws to torque values, follow directions provided with gauge and torque-turn each cap screw 90°—100°.



RG5698

RG5698 –UN–05DEC97

JT05993 Torque Angle Gauge

RG,RG34710,134 –19–03AUG99–2/2

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,RG34710,135 –19–30SEP97–1/1

Install Piston Spray Jets

IMPORTANT: To better cool the piston, the 6135 engine uses a directed stream of oil to a galley in the under crown of the piston, as shown. Therefore, the orientation of the piston spray jet is very critical, to ensure the oil spray is directed at this galley. To avoid damaging the spray jet or compromising the orientation, it is best to assemble the spray jet to the block AFTER the pistons and connecting rods have been pushed into the liners.

NOTE: If spray jet is removed for service or repair and will be reused, BE CERTAIN to apply LOCTITE® 242 (medium strength, blue, JD part number PM37418) to threads of spray jet prior to installation.

1. Rotate crankshaft as needed for access to install piston spray jets for cylinders #1 and #6.

2. Install a spray jet into the cylinder block for each cylinder. Start cap screw finger tight.

3. Tighten cap screw to specification,

Specification

Piston Spray Jet to Block Cap Screw—Torque.. 32 N•m (24 lb-ft)

4. Rotate crankshaft as needed to provide access to cylinders #2 and #5.

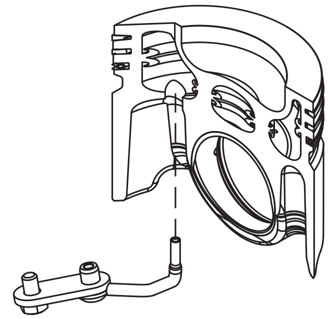
5. Install a spray jet into the cylinder block for each cylinder. Start cap screw finger tight.

6. Tighten cap screw to specification,

Specification

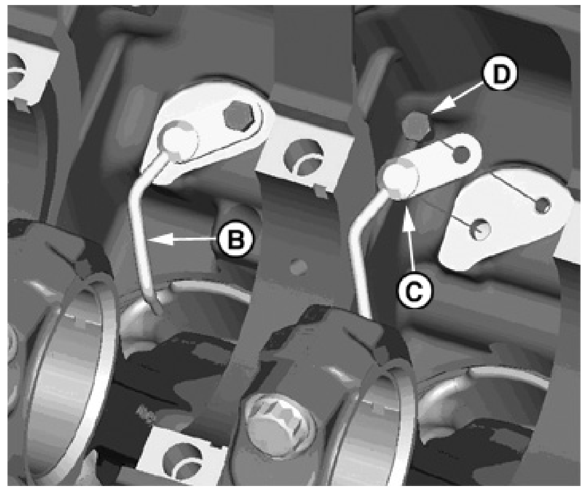
Piston Spray Jet to Block Cap Screw—Torque.. 32 N•m (24 lb-ft)

7. Rotate crankshaft as needed for access to install piston spray jets for cylinders #3 and #4.



RG14432 –UN–27JUL05

Piston Oil Cooling



RG14457 –UN–12AUG05

Piston Spray Jet Installation

B—Piston Spray Jet
C—Spray Jet-to-Oil Galley
D—Cap Screw - Spray Jet-to-Cylinder Block

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030
49

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Continued on next page

8. Install a spray jet into the cylinder block for each cylinder. Start cap screw finger tight.

9. Tighten cap screw to specification,

Specification

Piston Spray Jet to Block Cap Screw—Torque.. 32 N•m (24 lb-ft)

RE38635,00000AA –19–16AUG07–2/2

Measure Piston Protrusion

1. Press down on top of piston to remove oil clearances.

2. Use JDG451 Gauge along with D17526CI (English scale) or D17527CI (Metric scale) Dial Indicator to measure piston protrusion. Place gauge on top of cylinder block so dial indicator can be set to “zero” (0.000) with top of block.

3. Position gauge across top of piston. While pressing gauge downward, rotate crankshaft until piston is at “TDC.”

4. Measure and record piston height at several positions around top OD of piston.

5. Piston protrusion must be within the following specification to prevent piston-to-exhaust valve contact.

Specification

Piston—Protrusion Above Block Deck... 0.079—0.637 mm (0.003—0.025 in.)

6. Repeat procedure on remaining pistons and record measurements.

If protrusion does not meet specification, check dimensions of piston, connecting rod, cylinder block, crankshaft, and bearings to determine the cause.

RE38635,0000116 –19–12NOV07–1/1

Complete Final Assembly

NOTE: Refer to the proper group for installation of components.

1. Coat threads of oil gallery plugs with LOCTITE® 242 Thread Lock and Sealant (Medium strength blue). Install plugs and tighten to specifications.

Specification	
Oil Gallery Plug—Torque	60 N•m (45 lb-ft)
Main Oil Gallery (Front) Expansion Plug—Installed Depth	Flush—1.5 mm (0.059 in.) Below Surface

2. Install oil pickup tube. (See REMOVE AND INSTALL OIL PICKUP TUBE in Group 060.) Install oil pan. (See INSTALL ENGINE OIL PAN in Group 060.)

3. Install the cylinder head using new head gasket. (See INSTALL CYLINDER HEAD in Group 020.)

4. Install camshaft and valve train. (See REMOVE AND INSTALL CAMSHAFT in Group 050.) Install timing gear cover. (See INSTALL TIMING GEAR COVER in Group 040.)

5. Install electronic unit injectors. Refer to the appropriate fuel system repair manual.

   - See REMOVE AND INSTALL ELECTRONIC UNIT INJECTORS in CTM370, Section 02, Group 090.

6. Adjust clearances, preloads, and gear backlash. (Groups 020, 040, 050.)

7. Install remaining fuel injection system components. (CTM370 Section 02)

8. Install the coolant pump and water piping. (See INSTALL COOLANT PUMP in Group 070.)

9. Install lubrication system components. (Group 060.)

10. Install crankshaft pulley. (See INSTALL CRANKSHAFT VIBRATION DAMPER AND FRONT OIL SEAL in Group 040.)

11. Install the exhaust manifold. (See REMOVE, INSPECT AND INSTALL EXHAUST MANIFOLD in Group 080.) Install EGR Assembly. (SeeREMOVE AND INSTALL EGR in Group 80). Install intake assembly. (See REMOVE, INSPECT AND INSTALL INTAKE MANIFOLD in Group 080.)

12. Install starter motor. (See REMOVE AND INSTALL STARTER MOTOR in Group 100.)

13. Install alternator. (See REMOVE AND INSTALL ALTERNATOR in Group 100.)

14. Install fan and fan belts. (See Machine Technical Manual.)

15. Fill engine with clean oil. (See DIESEL ENGINE OIL in Section 01, Group 002.) Service engine with coolant. (See DIESEL ENGINE COOLANT RECOMMENDATIONS in Section 01, Group 002.)

16. Perform engine break-in. (See PERFORM ENGINE BREAK-IN in Group 010.)

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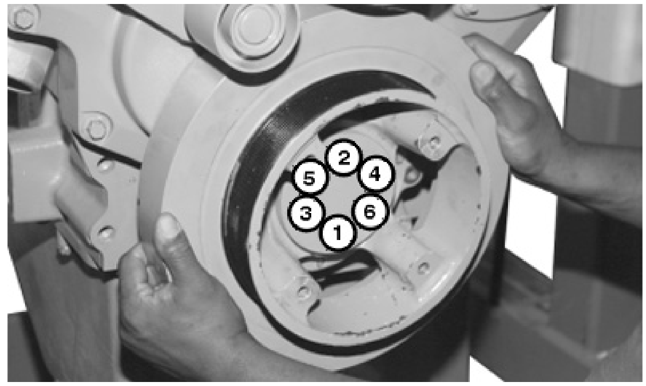
RE38635,0000063 –19–12AUG05–1/1

Crankshaft Vibration Damper Torque Sequence



Vibration Damper Torque Sequence

DPSG,OUO1004,940 –19–26JUL99–1/1

Inspect Crankshaft Vibration Damper

Refer to your machine operator's manual for recommended vibration damper inspection frequency.

1. Remove V-belt (shown removed).

IMPORTANT: The vibration damper assembly is not repairable and should be replaced every 5 years or 4500 hours, whichever occurs first.

ALWAYS replace vibration damper whenever crankshaft is replaced and at major engine overhaul. Also replace damper when a short block, complete block, or remanufactured basic engine is installed.

2. Carefully inspect vibration damper for torn or split rubber protruding from front and back of assembly.

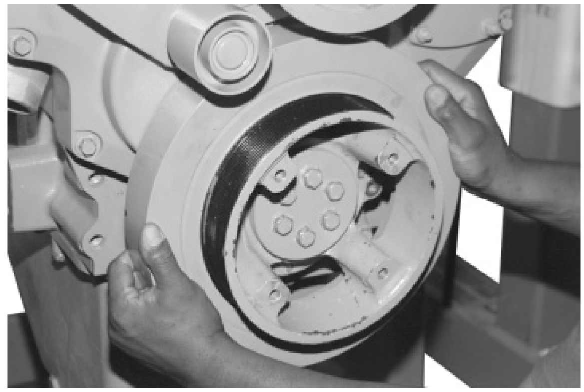
3. Grasp vibration damper with both hands and attempt to turn it in both directions. If rotation is felt, damper is defective and should be replaced.

4. Check vibration damper radial runout by positioning a dial indicator so probe (A) contacts damper OD.

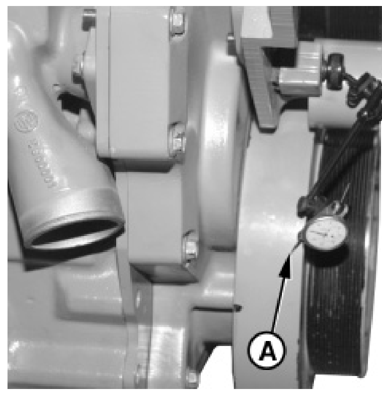
5. With engine at operating temperature, rotate crankshaft using JDG820 Flywheel Turning Tool.

6. Note dial indicator reading. Replace vibration damper if radial runout exceeds specifications.

Specification	
Vibration Damper—Maximum Radial Runout	0.76 mm (0.030 in.)


RG8536 –UN–20MAY98

Checking Damper Rotation



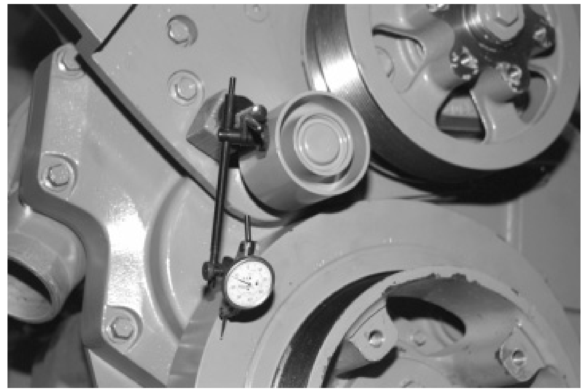
RG8537 –UN–10DEC97

Measuring Damper Radial Runout

A—Probe

RG,RG34710,149 –19–23OCT00–1/1

Check Crankshaft End Play



Checking Crankshaft End Play

1. Position dial indicator on end of crankshaft as shown.

2. Push crankshaft as far to rear of engine as possible.

3. Zero the dial indicator.

IMPORTANT: Do not apply too much pressure with bar, as this could damage thrust bearings.

4. Using a bar, gently pry the crankshaft as far forward as possible and record end play.

Specification

Crankshaft—End Play .... 0.038—0.380 mm (0.0015—0.0150 in.)

NOTE: If end play is not within specifications, new thrust bearings will usually restore proper end play.

RG,RG34710,150 –19–30SEP97–1/1

Remove Crankshaft Vibration Damper and Pulley

CAUTION: Damper and pulley are very heavy. Plan proper handling procedures to avoid injury. ALWAYS use an assistant when removing and installing pulley.

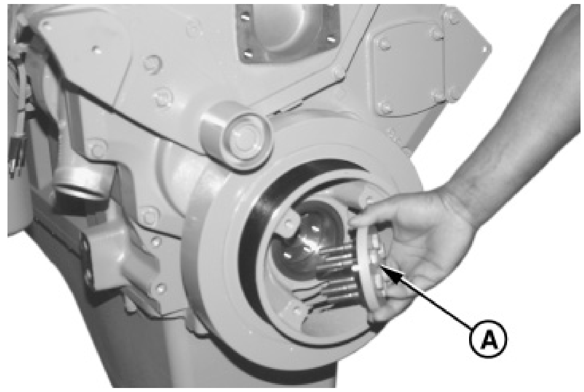
IMPORTANT: DO NOT immerse damper assembly in petroleum products (such as gasoline, oil, solvent, etc.). Doing so can damage the rubber portion of the assembly. Never apply thrust on outer ring of damper. The damper is sensitive to impact damage from being dropped or struck with a hammer.

NOTE: Remove front bolt-on pulley from vibration damper assembly for access to front nose of crankshaft, if equipped.

1. Remove six cap screws and large washer (A) from front nose of crankshaft.

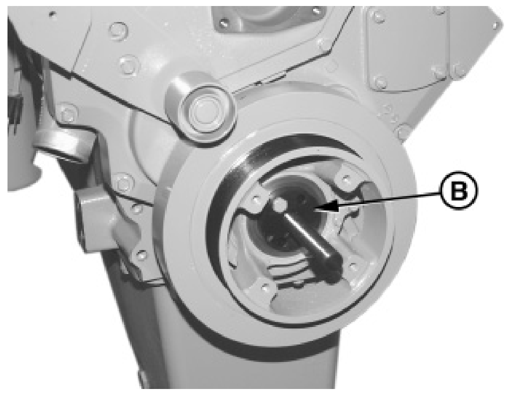
2. Install JDG973-1 Remover/Installer Hub (B) onto nose of crankshaft with two hex socket head cap screws provided in kit. Tighten cap screws until they bottom on hub.

3. Lubricate threads of remover/installer with multi-purpose grease.



RG8175A –UN–05DEC97

Removing Damper Retaining Ring



RG8176 –UN–05DEC97

Installing JDG973-1 Hub

A—Large Washer
B—JDG973-1 Remover/Installer Hub

Continued on next page

RG,RG34710,151 –19–30SEP97–1/2

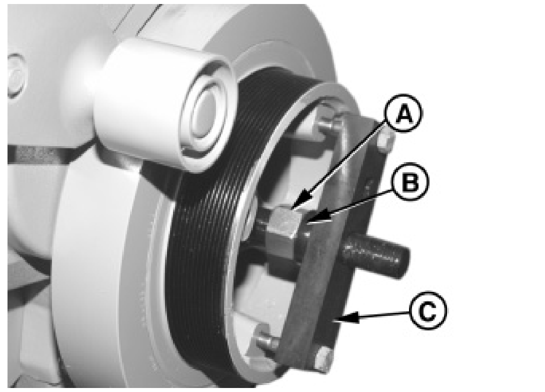
4. Thread large hex nut (A) onto hub and install thrust washer (B). Grease both sides of thrust washer.

5. Install JDG973-2 Cross Block (C) and secure with two hex head cap screws provided in kit. Thread cap screws into vibration damper deep enough to allow clearance for wrench on large nut.

6. Remove damper from crankshaft flange. Remover/installer hub will support damper after it is removed from crankshaft flange.

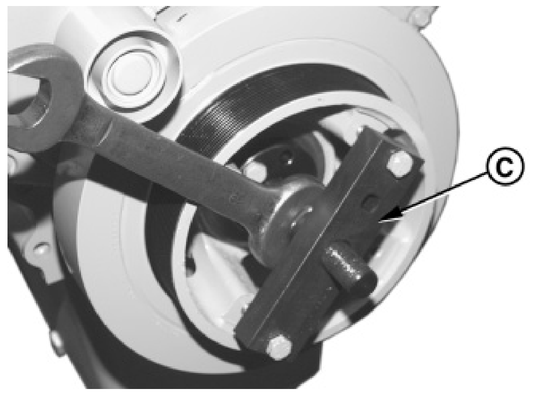
7. Remove hub from front nose of crankshaft.

A—Large Hex Nut
B—Thrust Washer
C—JDG973-2 Cross Block



RG8168 –UN–05DEC97

Installing JDG973-2 Cross Block



RG8169 –UN–05DEC97

Removing Vibration Damper

RG,RG34710,151 –19–30SEP97–2/2

Remove Viscous Damper and Front Crankshaft Oil Seal

CAUTION: Dampers are very heavy. Plan proper handling procedures to avoid injury. ALWAYS use an assistant when removing and installing damper.

IMPORTANT: DO NOT immerse damper assembly in petroleum products (such as gasoline, oil, solvent, etc.). The damper is sensitive to impact damage from being dropped or struck with a hammer.

IMPORTANT: The damper hub cap screws are tightened using the torque turn method. Be certain to discard these cap screws and use new before reassembly.

1. Remove center flange head cap screw (A) and 6 cap screws with washers (B) from damper hub and front nose of crankshaft.

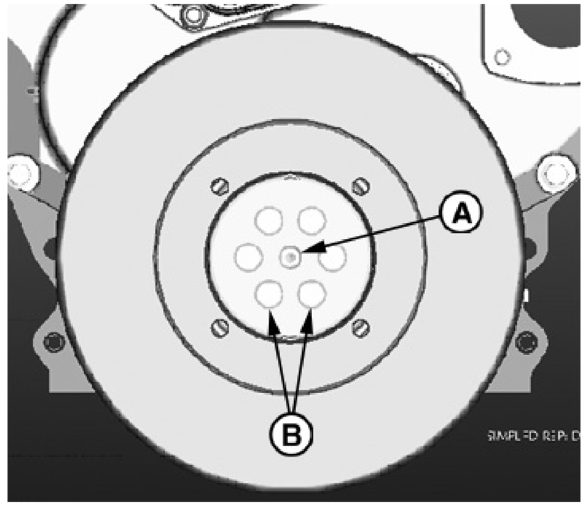
2. Install Forcing Screw (C) through damper hub (D) to nose of crankshaft. Use forcing screw to remove damper hub from damper assembly.

3. Install JDG973-1 Damper Puller/Installer Hub (from 6125 engine tool set) to crankshaft nose to provide support for damper during removal.

4. Remove 2 button head cap screws (E) from crankshaft hub and damper (F).

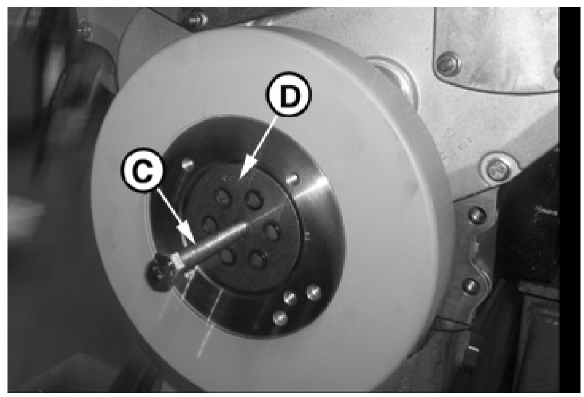
5. Remove damper from crankshaft hub and set aside.

A—Center Set Screw
B—Damper Hub Cap Screws
C—Forcing Screw
D—Damper Hub
E—Damper Button Head Screws
F—Damper
G—Rear Crankshaft Oil Seal Button Head Cap Screws
H—Rear Crankshaft Oil Seal



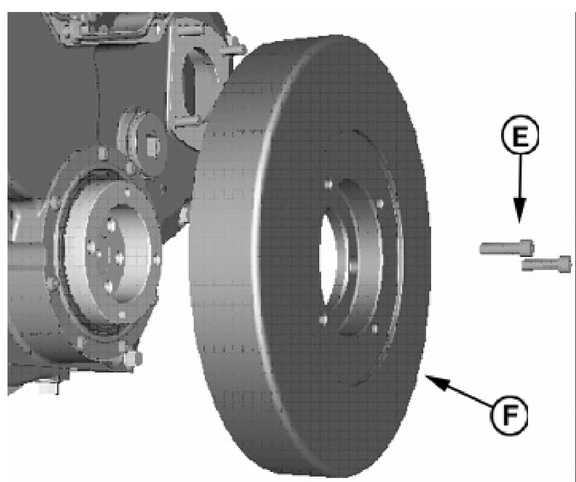
RG14894 –UN–15JUN06

Remove Set Screw & Damper Hub Cap Screws



RG14895 –UN–15JUN06

Remove Damper Hub



RG14896 –UN–15JUN06

Remove Damper

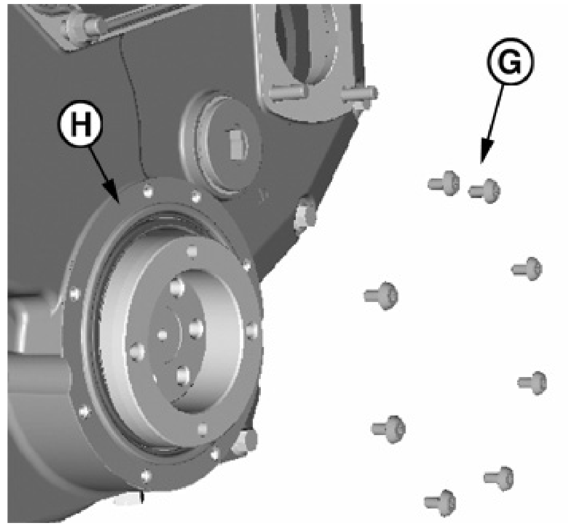
Continued on next page

RE38635,0000120 –19–24OCT06–1/2

6. Remove 8 button head cap screws (G) from front crankshaft oil seal (H).

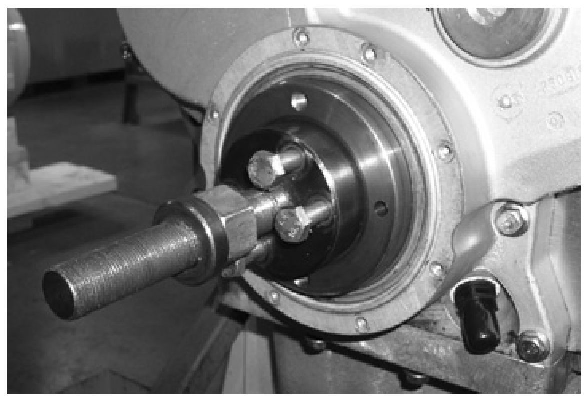
7. Install JDG10357P1 cross bar on to JDG973-1 forcing screw and secure with 2 cap screws through cross bar into crankshaft hub, as shown.

8. Using an open end wrench as shown, turn forcing screw counterclockwise to remove oil seal and crankshaft hub.

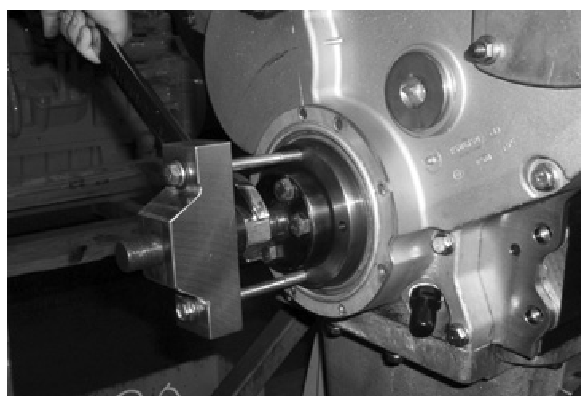


RG14897 –UN–15JUN06

Remove Front Crankshaft Oil Seal


RG14899 –UN–15JUN06

JDG973-1 Damper Puller/Installer Hub


RG14898 –UN–15JUN06

Remove Crankshaft Hub and Front Crankshaft Oil Seal

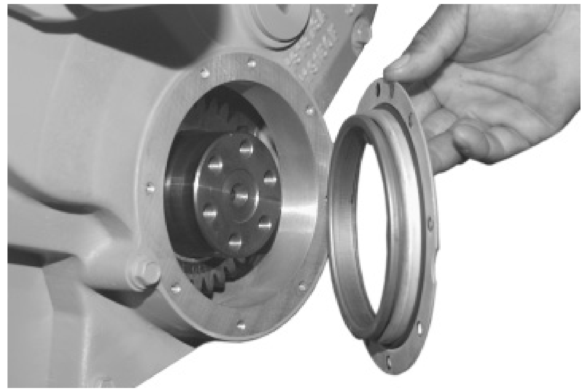
RE38635,0000120 –19–24OCT06–2/2

Remove Crankshaft Front Oil Seal

1. Remove vibration damper and pulley. (See REMOVE CRANKSHAFT VIBRATION DAMPER AND PULLEY, earlier in this group.)

2. Remove eight cap screws and remove front seal from timing gear cover.

   For front crankshaft oil seal replacement, oil seal must be installed onto vibration damper prior to damper installation. (See INSTALL CRANKSHAFT VIBRATION DAMPER AND FRONT OIL SEAL, later in this group.)

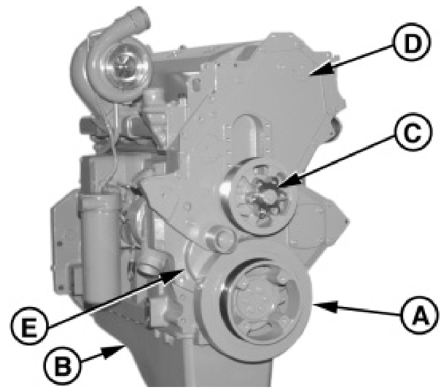


RG8119 –UN–21MAY98

Removing Crankshaft Front Oil Seal

RG,RG34710,152 –19–30SEP97–1/1

Remove Timing Gear Cover



Removing Timing Gear Cover

A—Vibration Damper
B—Oil Pan
C—Fan Drive Assembly
D—Camshaft Gear Access Cover
E—Timing Gear Cover

1. If not previously done, remove vibration damper and pulley (A). (See REMOVE CRANKSHAFT VIBRATION DAMPER AND PULLEY, earlier in this group.)

2. Drain engine oil if not previously done and remove engine oil pan (B). (See REMOVE ENGINE OIL PAN in Group 060.)

3. Disconnect crankshaft position sensor.

NOTE: On engines with fixed fan drive assembly, the fan drive housing is cast into the camshaft gear access cover.

4. Remove fan drive assembly (C). (See REPLACE BEARINGS IN FAN DRIVE ASSEMBLY in Group 070.)

NOTE: Mark location of cap screws to aid in reassembly.

5. Remove camshaft gear access cover (D) from timing gear cover. Mark location of cap screws to aid in reassembly.

6. Remove remaining cap screws and remove timing gear cover. Mark location of cap screws to aid in reassembly.

NOTE: On engines with fixed fan drive, the lower right cap screw (under pulley) will have to be reinstalled in camshaft gear access cover bore prior to installing pulley. Once pulley is installed, it interferes with the installation of this cap screw.

RG,RG34710,153 –19–12SEP02–1/1

Check Flywheel Housing Face Runout

1. Mount dial indicator on flywheel. Set pointer to contact PTO mounting surface on flywheel housing at right angles (A). 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.

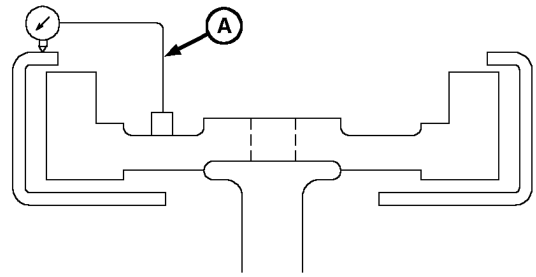
2. Rotate flywheel by turning crankshaft. Read total dial indicator movement and compare to specifications.

3. Remount set pointer to contact flywheel housing inner bore (B).

4. Rotate flywheel by turning crankshaft. Read total dial indicator movement and compare to specifications.

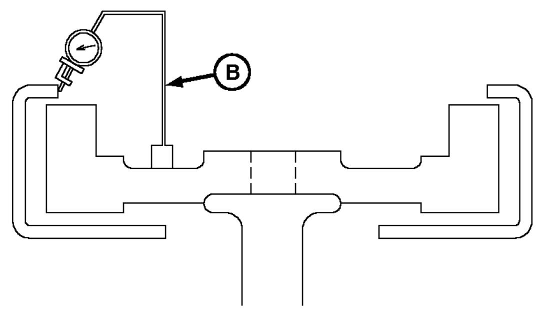
Specification

SAE 1 Flywheel Housing—	
Maximum Face Deviation (A)	0.30 mm (0.012 in.)
Maximum Bore Eccentricity (B)	0.30 mm (0.012 in.)
SAE 2 Flywheel Housing—	
Maximum Face Deviation (A)	0.28 mm (0.011 in.)
Maximum Bore Eccentricity (B)	0.28 mm (0.011 in.)
SAE 0 Flywheel Housing—	
Maximum Face Deviation (A)	0.41 mm (0.016 in.)
Maximum Bore Eccentricity (B)	0.41 mm (0.016 in.)



RG10271 –UN–02AUG99

Face Deviation



RG10272 –UN–02AUG99

Bore Eccentricity

A—Measure Face Deviation
B—Measure Bore Eccentricity

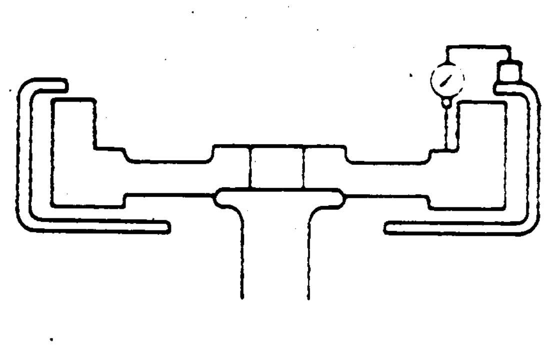
RG,RG34710,154 –19–12SEP02–1/1

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 flatness.

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



R22213 –UN–14DEC88

Measuring Flywheel Face Flatness

Specification

Flywheel Face Flatness—Maximum Variation	0.23 mm (0.009 in.)
Maximum Variation per 25 mm (1.0 in.) of Travel	0.013 mm (0.0005 in.)

RG,RG34710,155 –19–05SEP02–1/1

Remove Flywheel

CAUTION: Flywheel is heavy. Use proper lifting procedures to avoid personal injury.

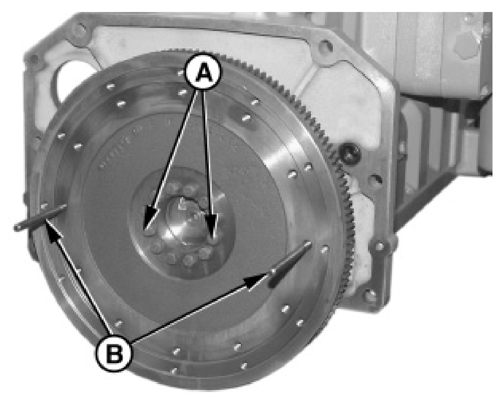
NOTE: SAE 1 flywheel housing must be removed before flywheel can be removed from engine. (See REMOVE AND INSTALL FLYWHEEL HOUSING, later in this group.)

1. Remove two flywheel attaching cap screws (A), and install two guide pins in their place.

2. Remove remaining cap screws, and carefully pull flywheel from crankshaft.

NOTE: Threaded guide pins (B) may also be used to ease handling of flywheel.

Once flywheel is removed, JDG976 Crankshaft Front Rotation Adapter can be used to rotate crankshaft if necessary.



RG8134A –UN–05DEC97

Removing Flywheel

A—Cap Screws
B—Threaded Guide Pins

RG,RG34710,156 –19–27JUL99–1/1

Inspect and Repair Flywheel

1. Inspect the clutch contact face for scoring, overheating or cracks.

2. Resurface clutch contact face, as necessary, to restore flatness for proper clutch contact.

3. Replace a defective flywheel.

4. Examine ring gear for worn or broken teeth. If ring gear is damaged, replace gear. (See REPLACE FLYWHEEL RING GEAR later in this group.)

RG,RG34710,157 –19–05SEP02–1/1

Replace Flywheel Ring Gear

CAUTION: Oil fumes or oil can ignite above 193°C (380°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. Place the flywheel on a solid flat surface.

2. Drive ring gear off with a brass drift and hammer.

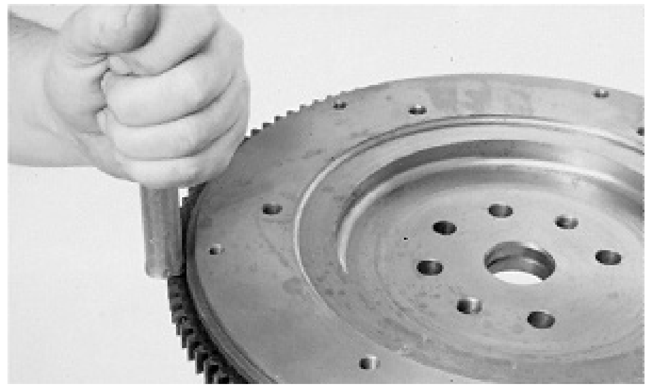
IMPORTANT: If flame heat is used, be sure gear is heated uniformly around circumference. DO NOT OVERHEAT above 232°C (450°F). SEE CAUTION. Overheating may also destroy original heat treatment of gear.

3. Heat new ring gear sufficiently to allow gear to fit flywheel hub without interference, but do not heat above 232°C (450°F) maximum, using either heated oil or oven heat.

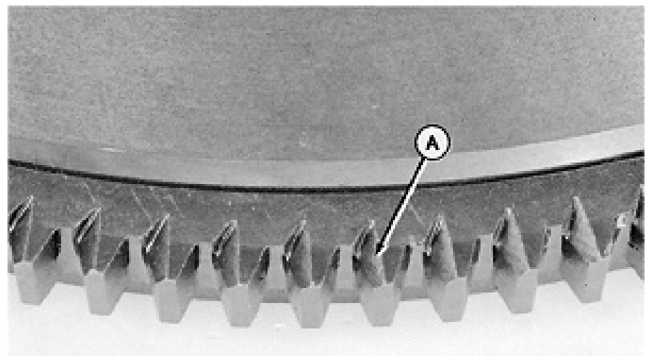
4. Turn gear so side with chamfer (A) is toward engine with flywheel installed.

5. Install ring gear flush within 0.25 mm (0.010 in.) against shoulder of flywheel.

   Ring gear will shrink to required fit as it cools.


T90596 –UN–14OCT88

Removing Flywheel Ring Gear



RG3838 –UN–14OCT88

Flywheel Ring Gear

A—Chamfer

RG,RG34710,158 –19–17DEC00–1/1

Remove and Install Flywheel Housing

Remove Flywheel Housing

CAUTION: Flywheel housing is heavy. Plan a proper lifting procedure to avoid personal injury.

NOTE: Flywheel must be removed before removing SAE 0 and SAE 2 flywheel housings. (See REMOVE FLYWHEEL earlier in this group.)

1. Remove attaching cap screws.

2. Remove flywheel housing.

3. Inspect dowel pins for damage. Replace pins as needed.

Install Flywheel Housing

CAUTION: Flywheel housing is heavy. Plan proper lifting procedures to avoid personal injury.

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

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	
Flywheel Housing-to-Cylinder Block Cap Screws (SAE 1 With Rear PTO)—Torque	325 N•m (240 lb-ft)
Flywheel Housing-to-Cylinder Block Cap Screws (SAE 0, 1 and 2 Without Rear PTO)—Torque	365 N•m (270 lb-ft)

4. Install flywheel housing front plate and timing hole covers, if removed. Tighten cap screws to specifications.

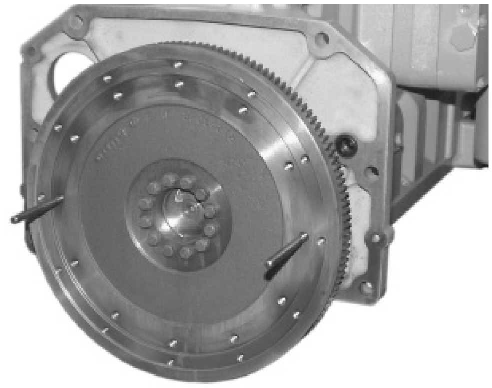
Specification	
Flywheel Housing Front Plate Cap Screws—Torque	50 N•m (37 lb-ft)
Flywheel Housing Timing Hole Cover Cap Screws—Torque	5 N•m (44 lb-in.)

5. If removed, install starter motor and tighten cap screws to specifications.

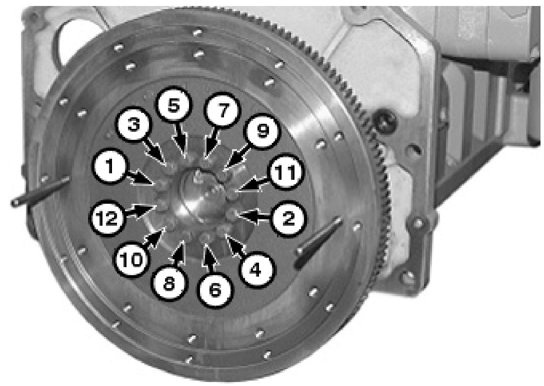
Specification	
Starter Motor Cap Screws—Torque	125 N•m (92 lb-ft)

RG,RG34710,159 –19–23OCT00–1/1

Install Flywheel



Installing Flywheel



Flywheel Tightening Sequence

CAUTION: Flywheel is heavy. Plan proper handling procedures to avoid injuries.

NOTE: SAE 0 and SAE 2 flywheel housings must be installed before installing flywheel. (See REMOVE AND INSTALL FLYWHEEL HOUSING earlier in this group.)

NOTE: ALWAYS use new cap screws when installing flywheel.

1. Install two pilot studs in crankshaft to aid in assembly. Position flywheel over pilot studs.

2. Install flywheel attaching cap screws. Remove pilot studs and install remaining two cap screws.

3. Tighten flywheel attaching cap screws in the sequence shown to the following specifications.

Specification	
Flywheel-to-Crankshaft Cap Screws—Torque	130 N•m (96 lb-ft)

4. After flywheel and housing are installed, perform flywheel-to-housing runout checks. (See CHECK FLYWHEEL HOUSING FACE RUNOUT earlier in this group.)

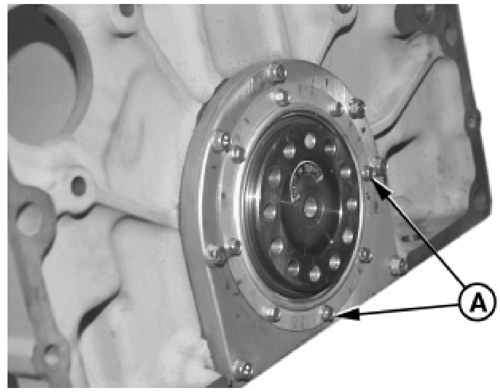
RG,RG34710,160 –19–27JUL99–1/1

Remove Rear Crankshaft Oil Seal and Housing Assembly

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

1. Remove engine oil pan, if not previously removed. (See REMOVE ENGINE OIL PAN, in Group 060.) Remove flywheel, if not previously removed. (See REMOVE FLYWHEEL earlier in this group.)

2. Remove eight cap screws (A) securing rear seal to housing.

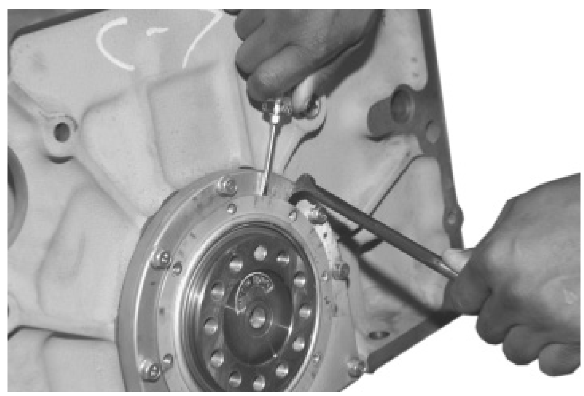


Removing Rear Oil Seal and Housing

A—Cap Screws

RG,RG34710,161 –19–13AUG99–1/4

3. Separate seal from housing using a small flat screwdriver and heel-type prybar as shown.



Separating Rear Seal From Housing

Continued on next page

RG,RG34710,161 –19–13AUG99–2/4

4. 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 o'clock position (C).

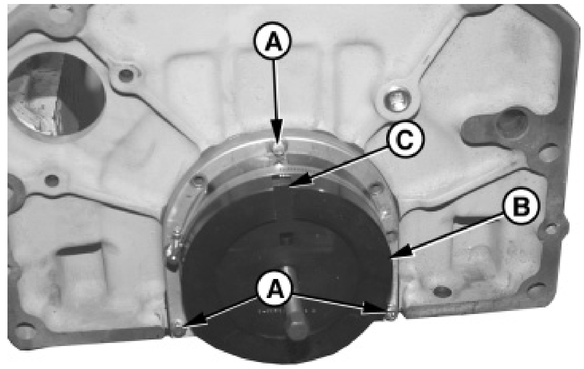
5. Install JDG1020 Rear Seal and Housing Remover (B) using knife-edge jaws with larger ID. Install puller jaws between seal carrier and seal housing.

6. Secure assembly by tightening band clamp securely.

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

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

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



Removing Rear Seal Carrier

A—Cap Screw
B—JDG1020 Rear Seal and Housing Remover
C—12:00 O'clock Position

RG,RG34710,161 –19–13AUG99–3/4

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

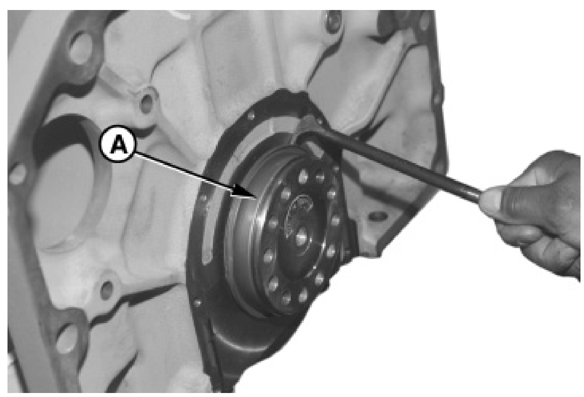
10. Install JDG1020 Remover (B) behind wear sleeve using smaller ID knife-edge jaws. Tighten band clamp securely.

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

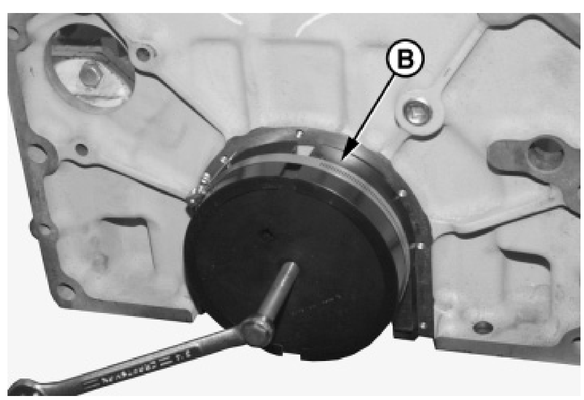
12. Inspect crankshaft flange for burrs and nicks.

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

A—Seal Assembly
B—JDG1020 Remover



Prying Rear Wear Sleeve



Removing Rear Wear Sleeve Using JDG1020

RG,RG34710,161 –19–13AUG99–4/4

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,15,DT7461 –19–18MAY00–1/1

Remove Crankshaft Main Bearings

NOTE: A drop in oil pressure, engine knock, or excessive crankshaft end play are indications of main bearing and main thrust bearing washer failures.

IMPORTANT: Before removing main bearing caps, 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 web. Keep matched bearing inserts with their respective main bearing caps for comparison with corresponding crankshaft journal to check surface wear.

NOTE: When removing main bearings and caps for crankshaft removal, leave No. 1 and 7 main bearing caps installed until all connecting rod caps have been removed.

1. Remove engine oil pan and pick-up tube. (See REMOVE ENGINE OIL PAN in Group 060.)

2. Remove front timing gear cover. (See REMOVE TIMING GEAR COVER in this group.)

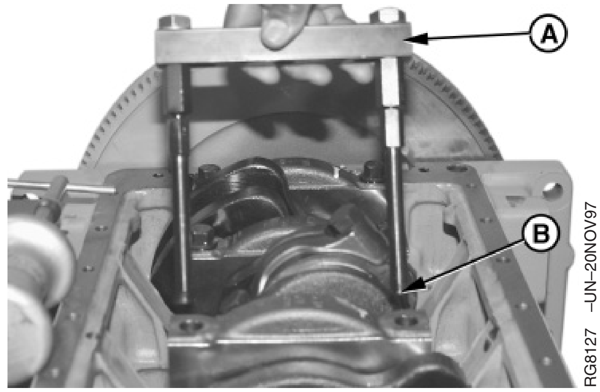
3. Remove rear oil seal and housing. (See REMOVE REAR CRANKSHAFT OIL SEAL AND HOUSING ASSEMBLY in this group.)

4. Remove main bearing cap screws.

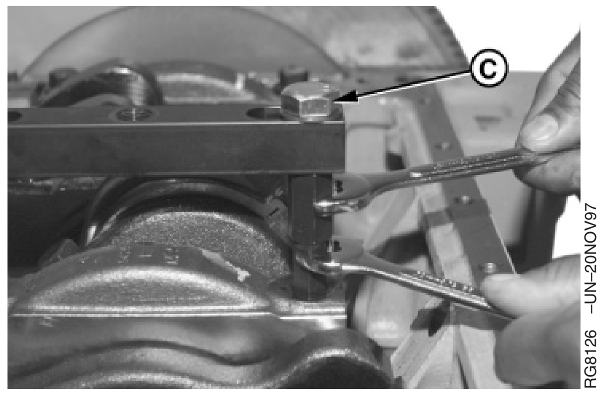
5. Install JDG996 Puller (A) so that tip (B) of blind hole puller legs are below bearing cap half.

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

7. Tighten both cap screws (C) on cross block finger tight.



JDG996 Main Bearing Cap Puller



Installing JDG996 Puller

A—JDG996 Puller
B—Tip
C—Cap Screws

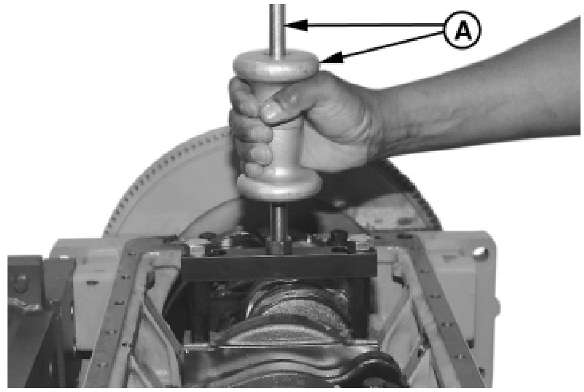
Continued on next page RG,RG34710,162 –19–13AUG99–1/2

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

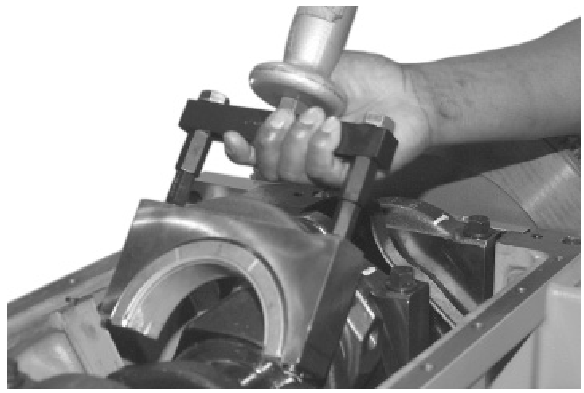
9. Remove main bearing cap by sliding up on hammer weight.

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

A—D01300AA Slide Hammer



Bearing Cap Puller and Slide Hammer



Main Bearing Cap Assembly Removed

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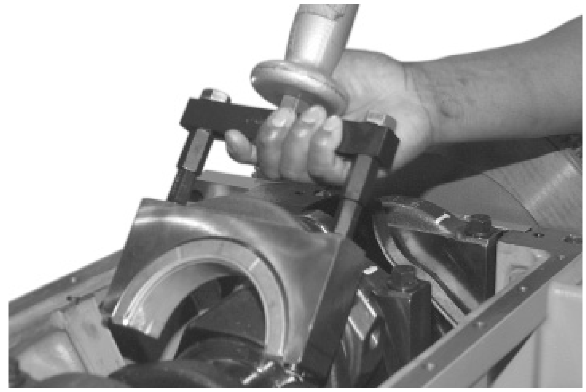
RG,RG34710,162 –19–13AUG99–2/2

Check Main Bearing-to-Journal Oil Clearance



Checking Oil Clearance

NOTE: The use of PLASTIGAGE® will determine wear (crankshaft-to-bearing oil clearance) but will not determine condition of either bearing or journal surface.

1. Place a strip of PLASTIGAGE® in the center of the main bearing cap about three-fourths of the width of the bearing.

2. Use clean SAE 30 engine oil on PLASTIGAGE® to prevent sticking.

3. Install cap and tighten cap screws to specification.

Specification

Crankshaft Main Bearing Cap
Screws—Final Torque .... 320 N•m (236 lb-ft)

4. Remove cap and compare width of PLASTIGAGE® with specifications below to determine clearance.

Specification

Crankshaft Main Bearings—Main
Bearing-to-Journal Clearance.. 0.046—0.122 mm (0.0018—0.0048 in.)
Maximum Acceptable Oil
Clearance .... 0.152 mm (0.0060 in.)

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RG,RG34710,163 –19–12SEP02–1/1

Remove Crankshaft

1. Remove timing gear cover. (See REMOVE TIMING GEAR COVER, earlier in this group.)

2. Remove flywheel. (See REMOVE FLYWHEEL, earlier in this group.)

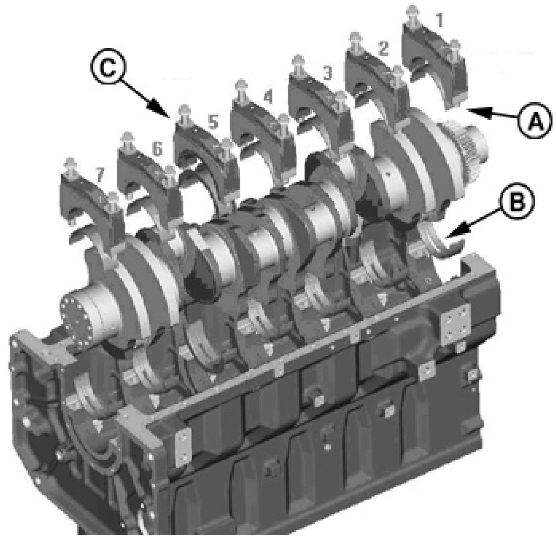
3. Remove flywheel housing. (See REMOVE AND INSTALL FLYWHEEL HOUSING, earlier in this group.)

4. Remove rear oil seal housing. (See REMOVE REAR CRANKSHAFT OIL SEAL AND HOUSING ASSEMBLY, earlier in this group.)

5. Remove main bearings 2 through 6. (See REMOVE CRANKSHAFT MAIN BEARINGS, earlier in this group.)

6. Rotate crankshaft using the JDG820 Flywheel Turning Tool until connecting rod caps can be removed easily. You will be able to remove two rod caps at each position.

7. Remove all connecting rod caps with bearings, then remove No. 1 and 7 main bearing caps and bearings. (See REMOVE PISTONS AND CONNECTING RODS in Group 030.)



RG14467 –UN–30AUG05

Removing Bearing Caps & Crankshaft

A—Upper Bearing Half
B—Lower Bearing Half
C—Thrust Bearing

RE38635,0000070 –19–30AUG05–1/2

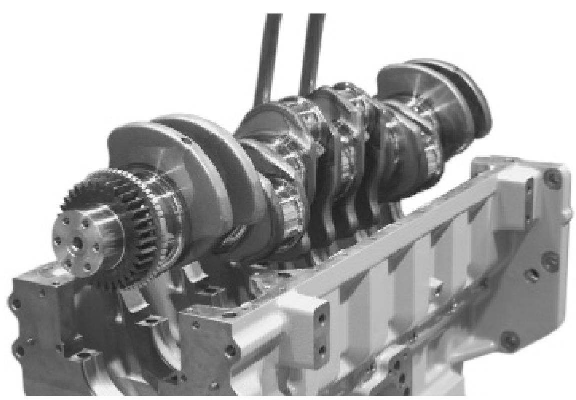
CAUTION: Crankshaft is very heavy. Plan a proper handling procedure to avoid injury.

8. Attach a lifting strap to crankshaft. Protect machined journals from damage with clean shop towels.

9. Using proper lifting equipment, carefully raise crankshaft out of cylinder block.

10. Clean crankshaft, especially oil passages, using solvent and compressed air.

11. Put crankshaft on clean V-blocks for inspection.



RG8200 –UN–21MAY98

Removing Crankshaft from Block

RE38635,0000070 –19–30AUG05–2/2

Inspect Crankshaft

NOTE: If crankshaft damper damage was discovered during teardown, it is recommended that the crankshaft be magna-fluxed. This will verify whether or not it has microscopic cracks or fissures. (See INSPECT CRANKSHAFT VIBRATION DAMPER, earlier in this group.)

1. Thoroughly clean crankshaft. Clear restrictions from all oil passages.

2. Inspect crankshaft for signs of load stress, cracks, or 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 timing wheel for cracks, chipped teeth, or excess wear. Inspect keyway and index pin for damage and proper indexing on flange. Replace gear(s) as required. (See REPLACE CRANKSHAFT DRIVE GEAR, later in this group.)

4. Inspect the keyway for evidence of cracks or wear. Replace crankshaft as necessary.

5. Carefully inspect the rear flange of the crankshaft in the area of the oil seal's wear sleeve contact surface for evidence of a rough or grooved condition. Any imperfections in this area will result in oil leakage. Slight ridges may be cleaned up with emery cloth and crocus cloth.

6. Check each journal for evidence of excessive overheating or discoloration. If either condition exists, replace crankshaft, since heat treatment has probably been destroyed.

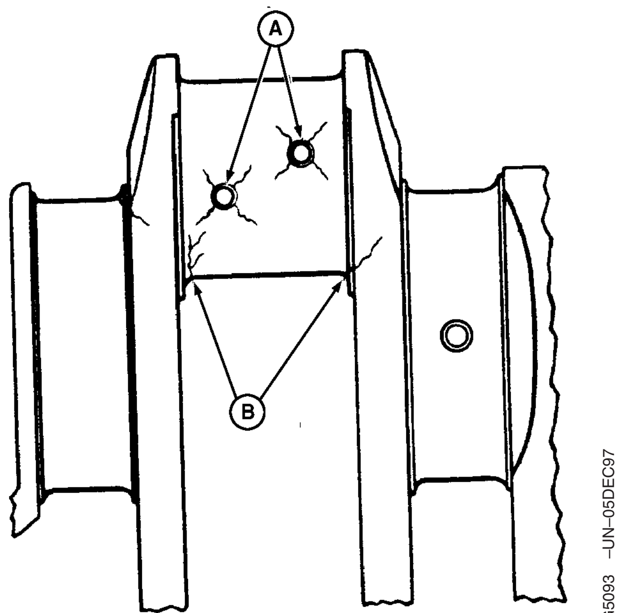
IMPORTANT: The vibration damper MUST BE replaced whenever the crankshaft is replaced.

Continued on next page RG,RG34710,165 –19–13AUG99–1/2

IMPORTANT: Small cracks may not be visible to the eye. Use procedure such as the Fluorescent Magnetic Particle method. This method magnetizes the crank, employing magnetic particles which are fluorescent and glow under "black light". The crankshaft must be de-magnetized after the test.

7. Carefully check the crankshaft for cracks in the area of rod journal oil holes (A) and at journal fillets (B). Replace crankshaft if any cracks are found.

A—Rod Journal Oil Holes
B—Journal Fillets



Crankshaft Stress Cracks

RG,RG34710,165 –19–13AUG99–2/2

Measure Assembled ID of Bearings and OD of Crankshaft Journals

1. With crankshaft out of cylinder block, install main bearing inserts and caps (be sure inserts are installed correctly).

2. Tighten main bearing cap screws to specification.

Specification

Crankshaft Main Bearing Cap Screws—Final Torque .... 320 N•m (236 lb-ft)

3. Measure ID of all bearings with an inside micrometer and compare measurements with respective crankshaft main journals.

Specification

Crankshaft Main Bearing—ID With Bearing .... 125.071—125.127 mm (4.9241—4.9263 in.)
ID Without Bearing .... 133.097—133.123 mm (5.2400—5.2411 in.)

NOTE: Inspect and measure assembled ID of connecting rod bearings. Compare measurements with connecting rod journal OD on crankshaft. (See INSPECT AND MEASURE CONNECTING ROD BEARINGS in Group 030.)

4. Measure OD of all respective crankshaft journals at several points around journal.

Specification

Crankshaft Main Bearing Journal—OD .... 124.983—125.017 mm (4.9206—4.9219 in.)

NOTE: If engine has previously had a major overhaul and undersized bearing inserts were used, above listed ID and OD dimensions may not be the same as those recorded. However, oil clearance should be within specifications. Oil clearance is 0.046—0.122 mm (0.0018—0.0048 in.). The maximum serviceable clearance is 0.152 mm (0.0060 in.).

Compare crankshaft journal OD measurements to determine if journal is out-of-round or tapered.

Specification

Crankshaft Main Journal—Max. Out-of-Round .... 0.025 mm (0.0010 in.)
Max. Taper per 25.4 mm (1.0 in.) of Journal Length.................................... 0.0025 mm (0.0001 in.)

RG,RG34710,166 –19–05SEP02–1/1

Measure Assembled ID of Main Bearing Caps (Without Bearings)

1. With crankshaft removed from cylinder block, install main bearing caps without bearing inserts.

2. Tighten main bearing cap screws to specification.

Specification

Crankshaft Main Bearing Cap Screws—Final Torque	320 N•m (236 lb-ft)

3. Measure ID of all bearing caps with an inside micrometer. Compare to specifications given.

   If any main bearing cap assembled ID is not within specification, blank (generic) bearing caps are available and must be line bored to specification. Replace individual bearing caps as needed.

Specification

Main Bearing Cap Bore Specifications—ID Without Bearings	133.097—133.123 mm (5.2400—5.2411 in.)
Max. Bore Diameter Variation	0.013 mm (0.0005 in.)
Max. Bore Diameter Taper	0.005 mm (0.0002 in.)
Max. Straightness (Any Bore-to-Adjacent Bore)	0.038 mm (0.0015 in.)
Max. Straightness (5 Center Bores-to-Adjacent Bore)	0.076 mm (0.0030 in.)
Centerline of Bore-to-Top Deck	429.92—430.07 mm (16.926—16.932 in.)

IMPORTANT: Main bearing cap line boring should be done ONLY by experienced personnel on equipment capable of maintaining bore specifications.

4. Measure main bearing cap surface width and compare to following specifications.

Specification

Crankshaft Main Bearing Cap—Surface Width	39.75—40.25 mm (1.565—1.585 in.)

RG,RG34710,167 –19–05SEP02–1/1

Crankshaft Grinding Guidelines

IMPORTANT: Crankshaft grinding should be done ONLY by experienced personnel on equipment capable of maintaining crankshaft size and finish specifications.

If undersize bearings are used, check bearing clearance after bearing caps have been tightened to specified torque. If undersize bearings are too tight and clearance is not within specifications, the journal and bearing will be wiped clean of all oil. This would result in premature wear of parts.

In addition to the standard size main and connecting rod bearings, the following undersize bearings are available.

	Specification
Crankshaft Main Bearings Available—Undersize	0.25, 0.50 mm (0.010, 0.020 in.)

If journals are tapered, out-of-round, scored or damaged, grind the crankshaft and install the proper undersize bearings.

If the crankshaft is to be reground, use the following recommended procedure:

1. Compare the crankshaft journal measurements taken during inspection and determine the size to which the journals are to be reground.

2. If one or more main or connecting rod journals require grinding, then grind all of the main journals or all of the connecting rod journals to the same required size.

3. All journal fillet radii must be free of any sharp grind marks or scratches. The fillet must blend smoothly into the journal and crank cheek. Check the radius with a fillet gauge.

IMPORTANT: Care must be taken to avoid localized heating which often produces grinding cracks.

4. Cool the crankshaft while grinding by using coolant generously. DO NOT crowd the grinding wheel into the work.

IMPORTANT: Grind crankshaft with journals turning clockwise, as viewed from the front end of crankshaft. Lap or polish journals in opposite direction of grinding.

5. Polish or lap the ground surfaces to the specified finish to prevent excessive wear of the journals.

NOTE: Production crankshafts are induction hardened and shotpeened at the factory. Field shotpeening is not recommended due to the equipment required and part geometry.

6. If the thrust surfaces of the crankshaft are worn or grooved excessively, regrind and polish. Maintain the specified radius between each thrust surface and the bearing journal. An oversize thrust washer set containing one standard washer and two 0.18 mm (0.007 in.) oversize washers is available. (See THRUST BEARING NEW PART SPECIFICATIONS, later in this group.)

NOTE: When thrust surfaces are reground and oversize washers used, crankshaft end play specification must be maintained to within 0.038—0.380 mm (0.0015—0.0150 in.). (See CHECK CRANKSHAFT END PLAY, earlier in this group.)

7. Stone the edges of all oil holes in the journal surfaces smooth to provide a radius of approximately 1.50 mm (0.060 in.).

Continued on next page

8. When finished grinding, inspect the crankshaft for cracks with the Fluorescent Magnetic Particle Method, or similar method.

9. De-magnetize the crankshaft.

10. Thoroughly clean the crankshaft and oil passages with solvent. Dry with compressed air.

RG,RG34710,168 –19–13AUG99–2/2

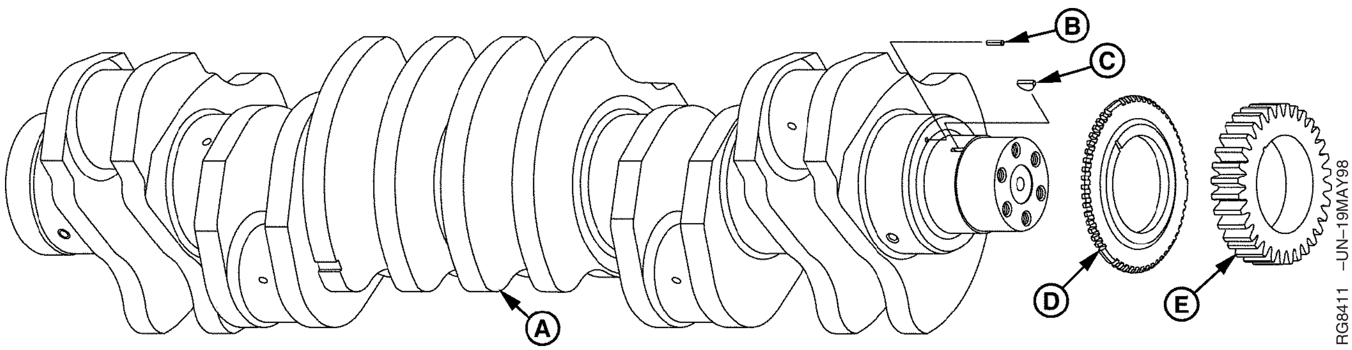
Crankshaft Grinding Specifications

Engine Stroke (6105)	138 mm (5.43 in.)
Engine Stroke (6125)	165 mm (6.50 in.)
Main and Rod Journal Surface Finish	Lap 0.25 Um (9.8 AA)
Thrust Journal and Fillet Radii Surface Finish	Lap 0.4 Um (16 AA)
Rod Journal Fillet Radius	4.49—4.85 mm (0.177—0.191 in.)
Main and Thrust Journal Fillet Radius	3.94—4.44 mm (0.155—0.175 in.)
Thrust Journal Width	48.97—49.07 mm (1.928—1.932 in.)

Bearing Size	Crankshaft Main Journal OD	Crankshaft Rod Journal OD
Standard	124.983—125.017 mm (4.9206—4.9219 in.)	88.844—88.874 mm (3.4980—3.4990 in.)
0.25 mm (0.010 in.)	124.733—124.767 mm (4.9107—4.9121 in.)	88.594—88.624 mm (3.4980—3.4990 in.)
0.50 mm (0.02 in.)	124.473—124.507 mm (4.9005—4.9019 in.)	88.334—88.364 mm (3.4777—3.4789 in.)

RG,RG34710,170 –19–13AUG99–1/1

Replace Crankshaft Drive Gear



Crankshaft, Timing Wheel, Gear

A—Crankshaft
B—Roll Pin
C—Woodruff Key
D—Timing Wheel
E—Crankshaft Drive Gear

IMPORTANT: Crankshaft must be removed before replacing drive gear (E).

NOTE: Remove crankshaft gear for replacement only; it is not necessary to remove gear for crankshaft removal.

1. Protect crankshaft machined wear sleeve surface with masking tape.

2. Remove crankshaft gear using D01074AA 17-1/2 Ton Puller Set.

3. Discard gear after removal.

4. Remove Woodruff key (C), crankshaft timing wheel (D), and roll pin (B) from crankshaft keyway.

5. Remove masking tape.

CAUTION: Oil fumes or oil can ignite above 193°C (380°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.

6. Heat crankshaft gear to 182°C (360°F) maximum, using either heated oil or oven heat.

7. Install new roll pin in crankshaft and position timing wheel over roll pin for proper indexing.

8. Install Woodruff key in crankshaft keyway.

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. Firmly seat gear and timing wheel against crankshaft flange using a driver.

    No clearance is allowed between gear, timing wheel, and crankshaft after gear cools.

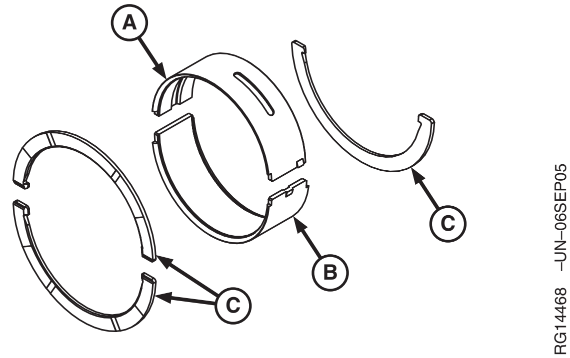
RG,RG34710,171 –19–30SEP97–1/1

Inspect Thrust Bearings

Check thrust surfaces of the thrust bearing and the thrust bearing journal on crankshaft and replace as necessary.

NOTE: Thrust bearing must be installed with slots facing crankshaft flange.

A—Main Bearing Block Thrust Bearing
B—Main Bearing Cap Thrust Bearing
C—Upper & Lower Front & Rear Thrust Washers



Thrust Bearing Assembly

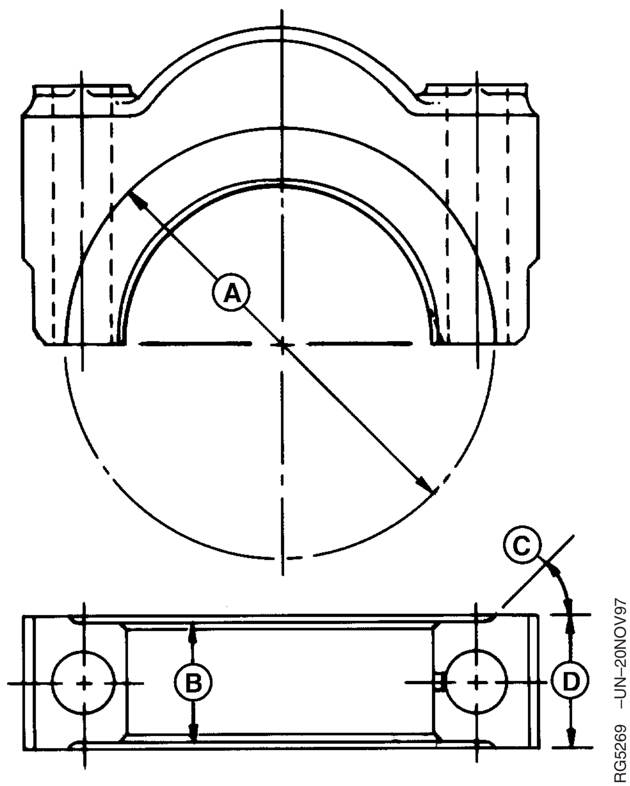
RE38635,0000097 –19–17NOV05–1/1

Thrust Bearing New Part Specifications

IMPORTANT: Install thrust bearing in cylinder block and tighten to specification before regrinding or polishing thrust surfaces to ensure that all surfaces on bearing and on block web are correctly aligned.

Specification	
Thrust Bearing New Part Specifications—Thrust Washer Clearance Base Circle (A)	162.24—163.76 mm (6.387—6.447 in.)
Thrust Surface Width (B)	42.05—42.12 mm (1.656—1.658 in.)
Relief Angle (C)	45°
Bearing Cap Overall Width (D)	43.46 mm (1.711 in.)
Thrust Surface Maximum Runout	0.025 mm (0.0010 in.)

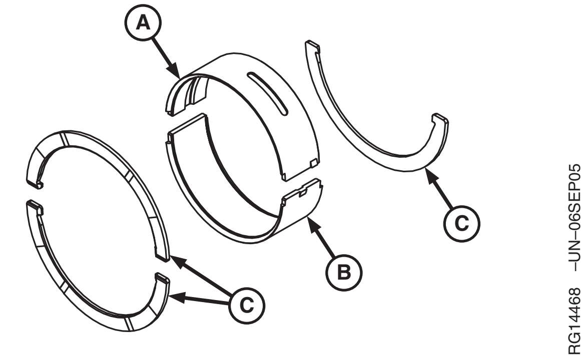
A—Thrust Washer Clearance Base Circle
B—Thrust Surface Width
C—Relief Angle
D—Bearing Cap Overall Width



Thrust Bearing Clearance

RG,RG34710,174 –19–13AUG99–1/1

Install Main Bearing Inserts in Block



Thrust Bearing Assembly

A—Main Bearing Block Thrust Bearing
B—Main Bearing Cap Thrust Bearing
C—Upper, Lower, Front & Rear Thrust Washers

IMPORTANT: If new main or thrust bearing inserts or thrust washers are installed, they must be installed as a matched set.

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

- Inside diameter of main bearing inserts, thrust bearing inserts, and thrust washers
- Entire OD of crankshaft main bearing journals

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.

IMPORTANT: Thrust washers (A) and (C) go on both sides of block web only, with the slots facing the crankshaft.

2. Install No. 5 main thrust bearing insert (A) in block. Install upper thrust washer on bearing insert at rear of block web. Be sure tangs on washer are properly positioned on thrust bearing insert.

3. Check to make sure that oil holes in main bearing web are properly aligned with oil holes in bearing inserts.

RE38635,0000132 –19–31JAN08–1/1

Install Main Bearing Inserts in Block

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:

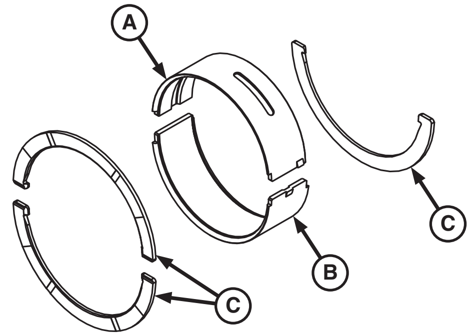
- All main bearing webs in block
- Both sides of main bearing inserts, thrust bearing inserts, and thrust washers
- Entire OD of crankshaft main bearing journals

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.

IMPORTANT: Thrust washers (A) and (C) go on both sides of block web only, with the slots facing the crankshaft.

2. Install No. 5 main thrust bearing insert (A) in block. Install upper thrust washer on bearing insert at rear of block web. Be sure tangs on washer are properly positioned on thrust bearing insert.

3. Check to make sure that oil holes in main bearing web are properly aligned with oil holes in bearing inserts.

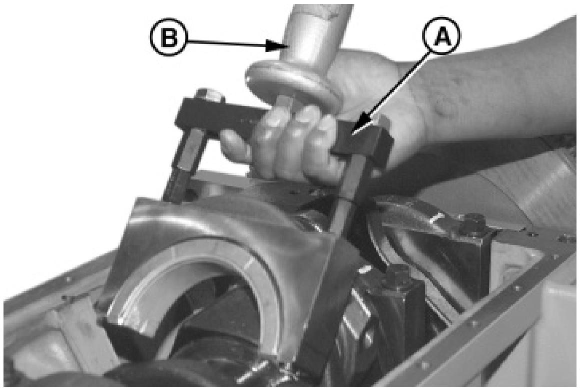


Thrust Bearing Assembly

A—Main Bearing Block Thrust Bearing
B—Main Bearing Cap Thrust Bearing
C—Upper, Lower, Front & Rear Thrust Washers

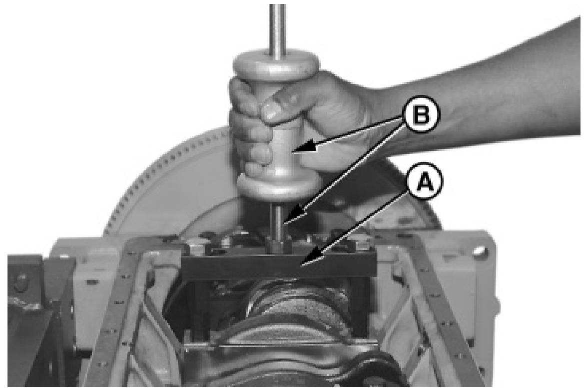
RE38635,0000098 –19–17NOV05–1/1

Install Crankshaft



RG8128A –UN–05DEC97

Installing Main Bearing Assembly



RG8125B –UN–20NOV97

Seating Main Bearing Cap

A—JDG996 Main Bearing Cap Puller/Installer
B—D01300AA Slide Hammer

CAUTION: Crankshaft is heavy. Plan a proper lifting procedure to avoid injuries.

NOTE: If crankshaft is being replaced, vibration damper should be replaced also.

1. Carefully position crankshaft onto main bearing inserts using a host and lift sling.

2. Dip all main bearing cap screws in clean engine oil. Apply a liberal amount of oil to bearing inserts in caps.

NOTE: Make sure main bearing caps are installed on the bearing bosses from which they were removed. The numbers stamped on the caps should be on the same side as the numbers on the block. Arrow on cap must point towards front of the engine. If bearing caps have been rebored, make sure bearing caps have numbers stamped on them.

3. Install each bearing cap and bearings with the recesses and tabs aligned in matching order using JDG996 Main Bearing Cap Puller/Installer (A) and D01300AA Slide Hammer (B). Make sure bearing tabs also match up before tightening cap screws.

NOTE: Main bearing caps may also be installed by evenly tightening both main bearing cap screws.

IMPORTANT: Do not use pneumatic wrench to install main bearing cap screws, as damage may occur to threads.

4. 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.

5. Tighten No. 1, 2, 3, 4, 6, and 7 main bearing cap screws to the following specification.

Specification

Crankshaft Main Bearing Cap
Screws—Initial Torque... 195 N•m (144 lb-ft)

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

Continued on next page

NOTE: DO NOT PRY crankshaft on No. 5 main thrust bearing.

6. Gently pry crankshaft rearward and then forward to align thrust washers on No. 5 main thrust bearing.

7. Tighten No. 5 main thrust bearing cap screws to the following specification.

Specification

Crankshaft Main Bearing Cap
Screws—Initial Torque... 195 N•m (144 lb-ft)

RE38635,0000099 –19–18NOV05–2/4

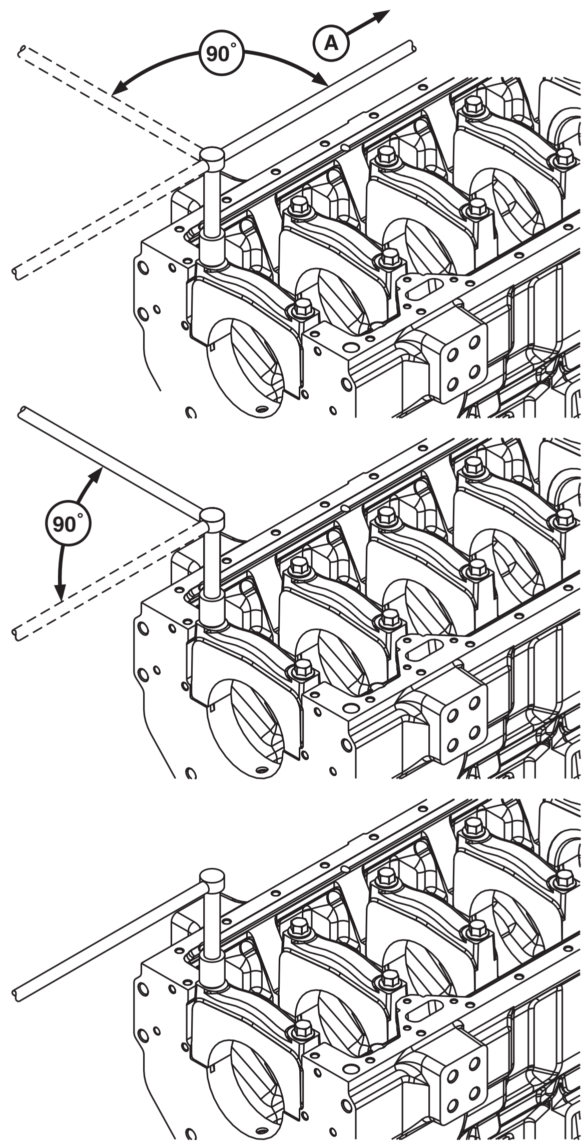
8. Torque-to-yield all main bearing cap screws (including No. 5) to the following specification, as shown.

Specification

Crankshaft Main Bearing Cap
Screws—Second Pass .... 90° Turn
—Torque-Yield... Additional 90° Turn

9. Turn crankshaft by hand. If it does not turn easily, disassemble parts and determine the cause.

A—Front of Engine



Torque-to-Yield Main Bearing Caps

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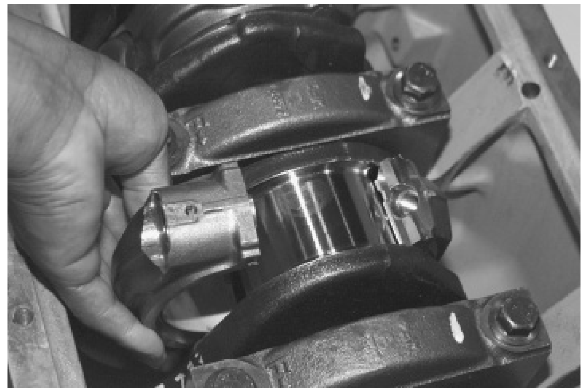
RE38635,0000099 –19–18NOV05–3/4

10. Install connecting rod caps with bearing using new cap screws. (See INSTALL PISTONS AND CONNECTING RODS in Group 030 for procedure to install and tighten connecting rod cap screws.)

IMPORTANT: Do not use pneumatic wrenches to tighten connecting rod cap screws. Threads can be damaged.

11. Install rear oil seal housing. (See INSTALL CRANKSHAFT REAR OIL SEAL AND HOUSING later in this group.)
12. Install rear oil seal and wear sleeve. (See INSTALL CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE ASSEMBLY later in this group.)
13. Install flywheel. (See INSTALL FLYWHEEL earlier in this group.)
14. Install flywheel housing. (See REMOVE AND INSTALL FLYWHEEL HOUSING earlier in this group.)
15. Install six piston spray jets. (See REMOVE AND INSTALL PISTON SPRAY JETS in Group 030.)
16. Check crankshaft end play. (See CHECK CRANKSHAFT END PLAY earlier in this group.)
17. Install timing gear cover. (See INSTALL TIMING GEAR COVER later in this group.)


RG8409 –UN–21MAY98

Installing Rod Caps

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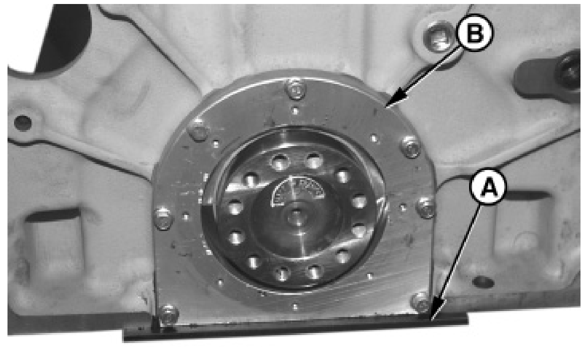
Install Crankshaft Rear Oil Seal Housing

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

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.

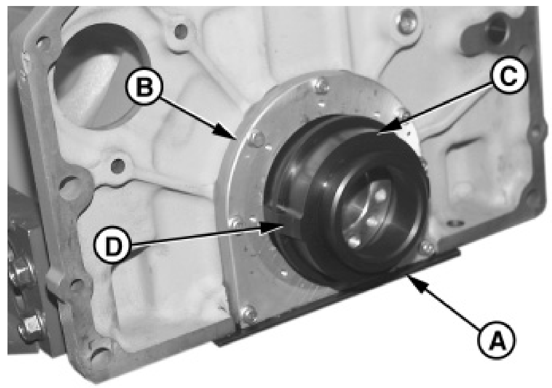


RG8162 –UN–05DEC97

Rear Seal Housing Installed on Aligner

1. Install JDG977 Pan Rail Aligner (A) onto rear pan rail (as shown) using two cap screws provided. Tighten cap screws securely.

2. Install rear seal housing (B) using a new gasket; bottom edge of gasket should extend through opening in alignment plate. Tighten housing cap screws finger tight.



RG8163 –UN–05DEC97

Centering Rear Seal Housing with JDG975

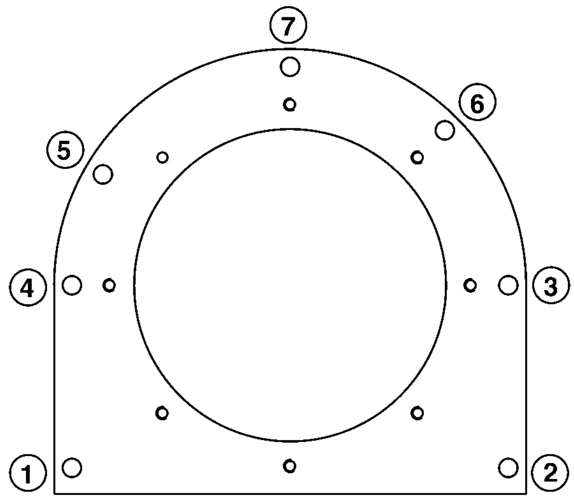
3. Install larger end of JDG975 Timing Gear Cover/Rear Seal Housing Aligner (C) onto crankshaft rear flange with tapered locators (D) at 3 o'clock and 9 o'clock position.

4. Center housing and tighten cap screws to specifications using torque sequence shown in lower illustration.

Specification

Rear Oil Seal Housing Cap Screws—Torque .... 25 N•m (18 lb-ft)

5. Remove alignment tools from engine and trim rear seal housing gasket flush with bottom of seal housing and oil pan gasket surface.



RG8816 –UN–20MAY98

Rear Seal Housing Torque Sequence

A—JDG977 Front/Rear Pan Rail Aligner
B—Rear Seal Housing
C—JDG975 Timing Gear Cover/Rear Seal Housing Aligner
D—Tapered Locators

RG,RG34710,177 –19–13AUG99–1/1

Install Crankshaft Rear Oil Seal and Wear Sleeve Assembly

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

2. Center JDG974A Forcing Screw (A) rear face of crankshaft and tighten cap screws securely.

3. Apply a light coat of LOCTITE® 680 (TY15969) Retaining Compound around OD of rear crankshaft flange.

4. Position rear seal assembly (B) and JDG974A Seal Installer (C) onto rear crankshaft flange and forcing screw.

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

5. Lubricate forcing screw threads and both sides of friction washer. Install washer and nut; tighten nut until installer bottoms.

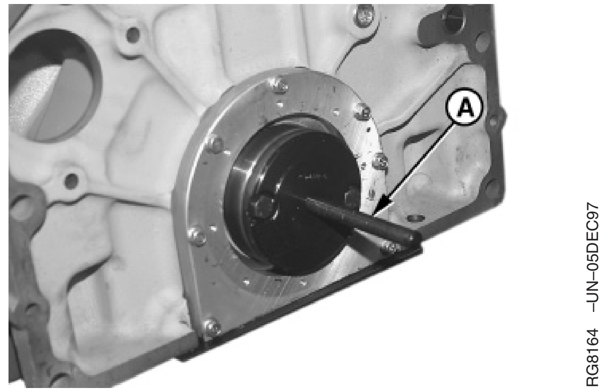
6. Remove seal installation tool set and clean any sealant from tool.

7. Center seal casing and tighten cap screws to specifications following sequence in lower illustration.

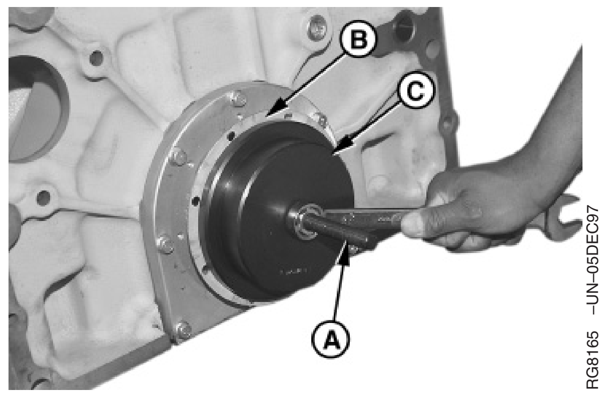
Specification

Rear Oil Seal-to-Housing Cap Screws—Torque .... 15 N•m (11 lb-ft)

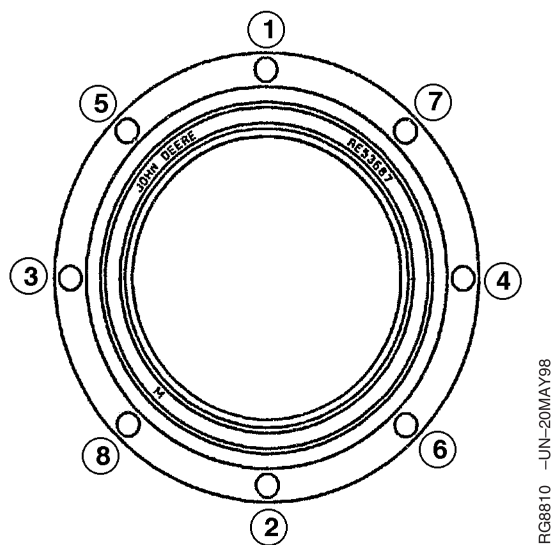
A—JDG974A Forcing Screw
B—Rear Seal Assembly
C—JDG974A Seal Installer



JDG974-2 Forcing Screw Installed



Installing Rear Crankshaft Oil Seal



Rear Seal Torque Sequence

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RG,RG34710,178 –19–13AUG99–1/1

Install Timing Gear Cover

1. Verify the pressed-in-place beaded gasket is in place on both sides (A & B) of timing gear cover.

2. Clean oil pan gasket rail.

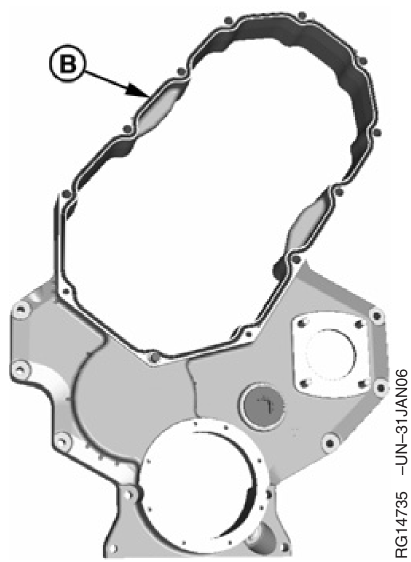
3. Install JDG977 Pan Rail Aligner onto front pan rail using cap screws provided. Tighten cap screws securely.

4. Install timing gear cover to cylinder block.

5. Align timing gear cover in level position using JDG977 Pan Rail Alignment Tool.

6. Install cap screws, starting with the long cap screw at #9 position on right hand side. Tighten cap screws finger tight only so that cover can be correctly centered.

Beaded Seal - Cylinder Block Side



Beaded Seal - Camshaft Gear Access Cover Side

Continued on next page RE38635,000009A –19–18NOV05–1/4

7. Install smaller end of JDG975 Timing Gear Cover/Rear Seal Housing Aligner (A) onto front crankshaft flange with tapered locators (B) at 3 o'clock and 9 o'clock position.

8. Center cover with crankshaft flange.

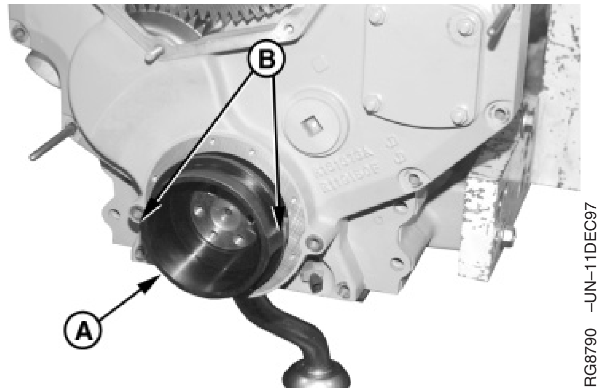
9. Tighten timing gear cover cap screws following sequence in lower illustration to the following specification.

Specification

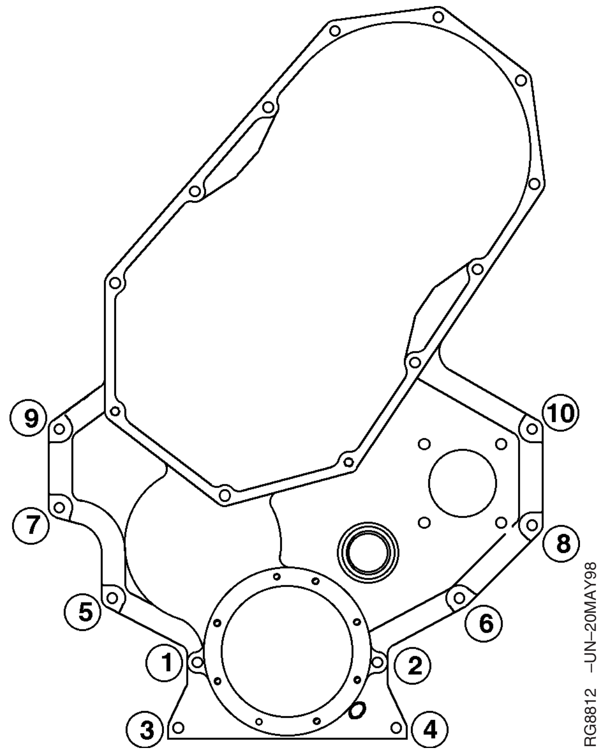
Timing Gear Cover Cap Screws—Final Torque .... 63 N•m (46 lb-ft)

10. Remove alignment tools from engine.

A—Seal Housing Aligner
B—Tapered Locators



Aligning Timing Gear Cover



Timing Gear Cover Torque Sequence

Continued on next page RE38635,000009A –19–18NOV05–2/4

11. Verify beaded gasket (A) is in place in timing gear cover and is not damaged.

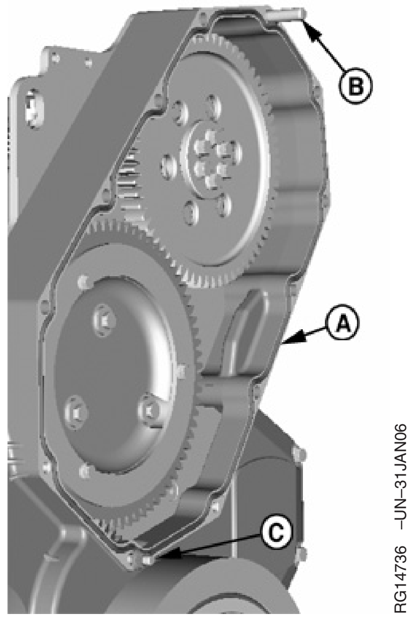
12. Install guide pin (B) to top hole in timing gear cover to aid assembly of camshaft access cover.

13. If necessary, remove cap plug and hex nut (C) from stud on timing gear cover.

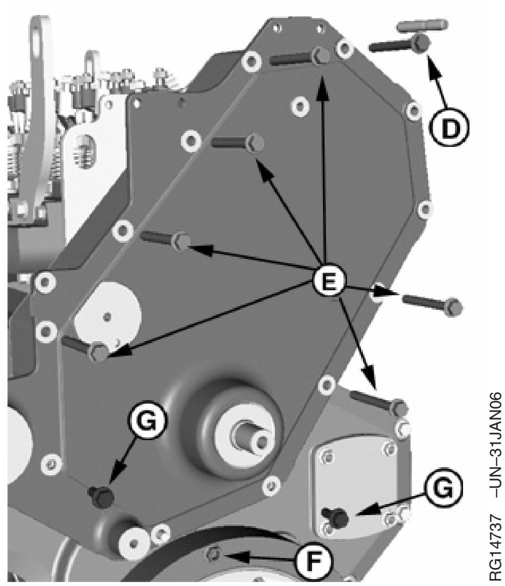
14. Install camshaft gear access cover over guide pin and fit to timing gear cover.

15. Install cap screws (D), (E) , (G) and hex nut (F) in respective locations.

A—Access Cover Beaded Gasket
B—Guide Pin (if used)
C—Cap Plug and Nut (if used)
D—Cap Screw M10 x 110 (1 used)
E—Cap Screws M10 x 100 (6 used)
F—Hex Nut
G—Cap Screws M10 x 30 (2 used)



Camshaft Access Cover Installation



Camshaft Access Cover

Continued on next page RE38635,000009A –19–18NOV05–3/4

16. Tighten camshaft gear access cover cap screws in sequence shown to specification.

Specification
Camshaft Gear Access Cover
Cap Screws—Final Torque .... 68 N•m (50 lb-ft)

17. Install engine oil pan. (See INSTALL ENGINE OIL PAN in Group 060.)

18. Install crankshaft vibration damper. (See INSTALL CRANKSHAFT VIBRATION DAMPER AND FRONT OIL SEAL next in this group.)

19. Install adjustable fan drive assembly and tighten cap screws to specifications.

Specification
Adjustable Fan Drive Assembly
Mounting Cap Screws—Torque .... 90 N•m (66 lb-ft)

NOTE: Whenever the timing gear cover has been removed and reinstalled, the crankshaft position sensor must be checked to ensure proper distance from crankshaft timing wheel. This applies even if the sensor was not removed from timing gear cover.

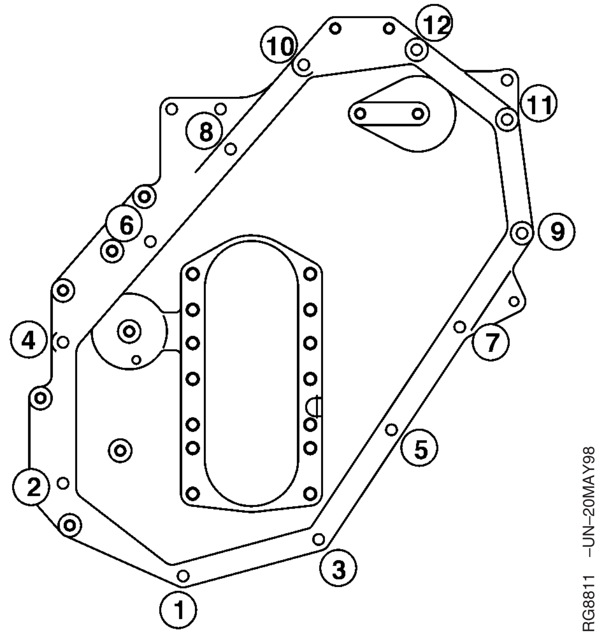
20. Install crankshaft position sensor, if removed, or check sensor-to-crankshaft timing wheel dimension. See REMOVE AND INSTALL CRANKSHAFT POSITION SENSOR in the appropriate fuel systems manual.

    Delphi/Lucas ECU controlled fuel systems:

    - See REMOVE AND INSTALL CRANKSHAFT POSITION SENSOR in CTM 115, Section 02, Group 110.

    John Deere Level 6 ECU controlled fuel systems:

    - See REMOVE AND INSTALL CRANKSHAFT POSITION SENSOR in CTM 188, Section 02, Group 110.



Camshaft Gear Access Cover Torque Sequence

Install Crankshaft Vibration Damper and Front Oil Seal

IMPORTANT: The vibration damper assembly is not repairable and should be replaced every 5 years or 4500 hours, whichever occurs first.

ALWAYS replace vibration damper whenever crankshaft is replaced and at major engine overhaul. Also replace damper when a short block, complete block, or reman basic engine is installed.

Front crankshaft oil seal (A) must be installed onto vibration damper before installing damper onto engine.

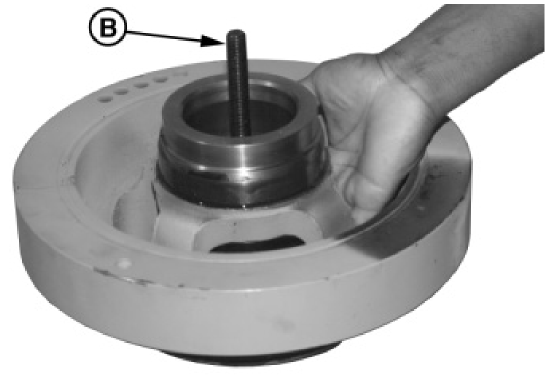
Install Front Seal onto Vibration Damper

1. Apply LOCTITE® 680 (TY15969) Retaining Compound around OD of crankshaft flange. Position front oil seal assembly on flange with rubber seal ring facing up as shown.

NOTE: Lubricate threads of forcing screw with multi-purpose grease.

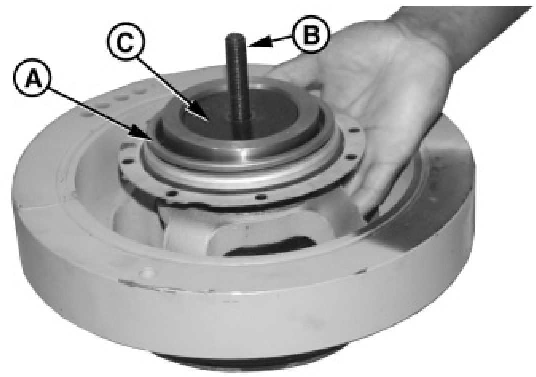
2. Lay vibration damper on table (front face down) with JDG974-2 Seal Installer Forcing Screw (B) extending through damper ID.

3. Hold forcing screw against front face of damper and position JDG974-3 Guide Plate (C) in ID of damper as shown.



RG8422 –UN–09DEC97

JDG974-2 Forcing Screw Installed on Damper



RG8423 –UN–09DEC97

Front Seal Positioned on Damper

A—Front Crankshaft Oil Seal
B—JDG974-2 Seal Installer Forcing Screw
C—JDG974-3 Guide Plate

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RE38635,000009B –19–18NOV05–1/4

4. Install JDG974-1 Seal Installer (A) with friction washer and nut.

5. Tighten nut until installer bottoms on rear face of damper.

6. Remove tools and clean any sealant from tools.

A—JDG974-1 Seal Installer

RG8424 –UN–09DEC97

Seating Front Seal on Damper

RG8535 –UN–20MAY98

Front Seal Installed on Damper

Continued on next page RE38635,000009B –19–18NOV05–2/4

Install Vibration Damper on Engine

IMPORTANT: IMPORTANT: Apply Loctite to INSIDE of bolt circle, as shown. Apply in a complete circle.

1. Before installing crankshaft damper, apply a bead of LoctiteLOCTITE®30516 to machined surface of timing gear cover.

2. Install JDG973-1 Damper Remover/Installer Hub (A) onto front face of crankshaft using two cap screws provided with kit. Tighten cap screws securely

3. Lubricate forcing screw threads with all purpose grease.

4. Position vibration damper and seal (B) on forcing screw hub as shown.

5. Install JDG973-2 Cross Block (C) onto forcing screw. Secure cross block with two cap screws finger tight.

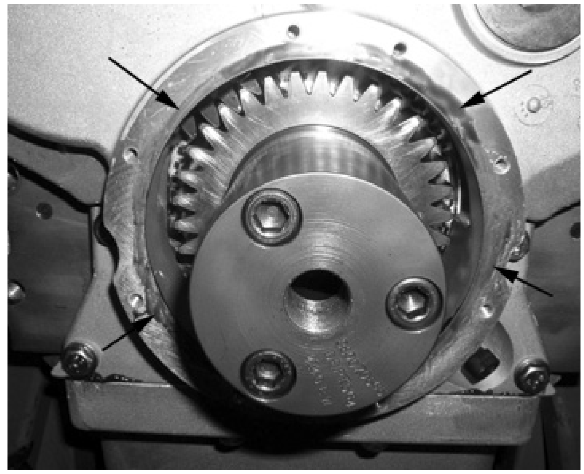
NOTE: Lubricate forcing screw and both sides of friction washer with multi-purpose grease prior to each use.

6. Install friction washer and nut against cross block.

NOTE: Cut-outs in seal casing should be at 3 o'clock and 9 o'clock position for timing gear cover cap screw clearance. Align holes in casing with cap screw holes as damper and seal are installed.

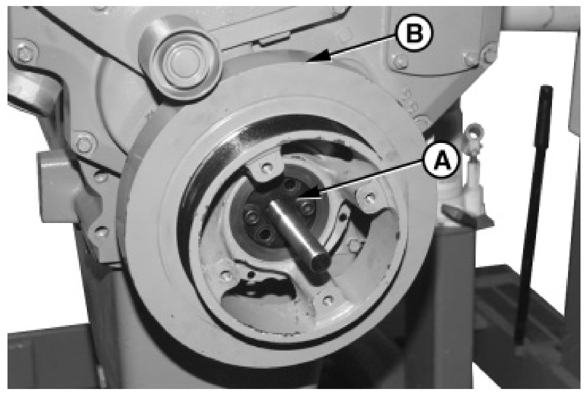
7. Tighten nut until damper bottoms on crankshaft flange. Remove JDG973 tool set from engine.

A—JDG973-1 Damper Remover/Installer Hub
B—Vibration Damper and Seal
C—JDG973-2 Cross Block



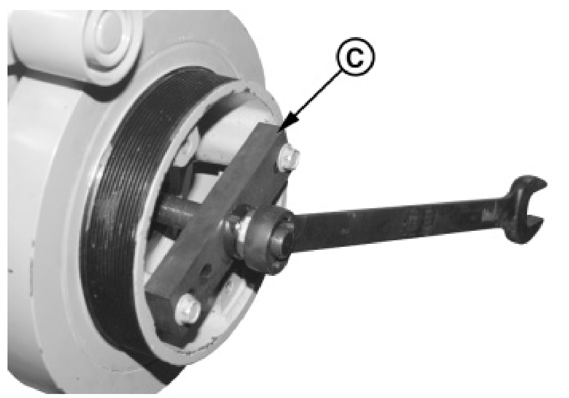
RG14600 –UN–18NOV05

Apply Loctite 30516 to Timing Gear Cover



RG8425 –UN–09DEC97

Installing JDG973-1 Hub



RG8426 –UN–09DEC97

Installing Vibration Damper

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8. Install large washer onto front nose of crankshaft to secure damper to crank. Tighten cap screws in sequence shown to specifications.

Specification

Damper Hub Cap Screws—
Torque .... 125 N•m (92 lb-ft)

9. If required, install pulley on damper and tighten cap screws to specifications.

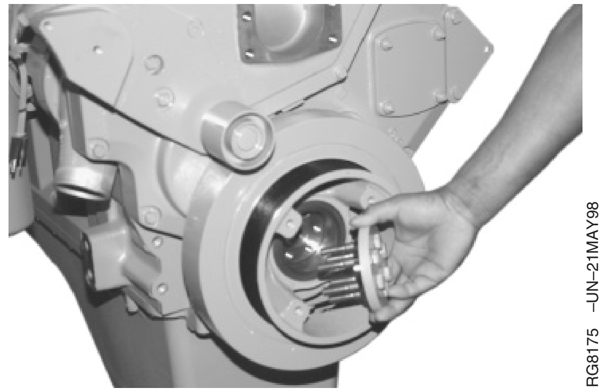
Specification

Pulley-to-Damper Cap Screws—
Torque .... 125 N•m (92 lb-ft)

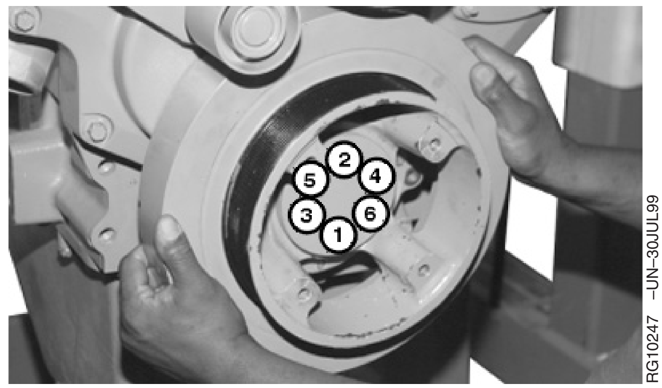
10. Install front seal-to-timing gear cover cap screws and tighten to specifications following sequence in lower illustration.

Specification

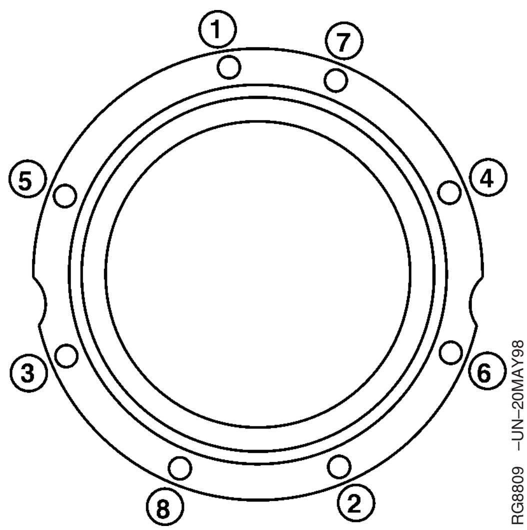
Front Oil Seal Cap Screws—
Torque .... 15 N•m (11 lb-ft)



Installing Damper Retainer Cap Screws



Damper Torque Sequence



Front Seal Torque Sequence

RE38635,000009B –19–18NOV05–4/4

02
040
46

Install Viscous Damper Assembly and Front Oil Seal

IMPORTANT: ALWAYS replace vibration damper whenever crankshaft is replaced and at major engine overhaul. Also replace damper when a short block, complete block, or reman basic engine is installed.

1. Install JDG10357P2 adapter guide (A) with forcing screw (D) to face of crankshaft nose. Tighten 3 cap screws securely.

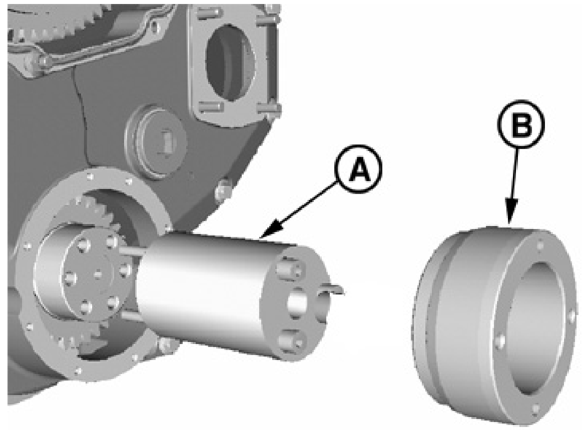
2. Locate engine crankshaft hub (B) over adapter guide.

3. Using JDG10357P4 Press Arbor (C) and Forcing Screw, press crankshaft hub (B) onto crankshaft nose until it bottoms against crankshaft gear.

IMPORTANT: Apply Loctite to INSIDE of bolt circle, as shown. Apply in a complete circle.

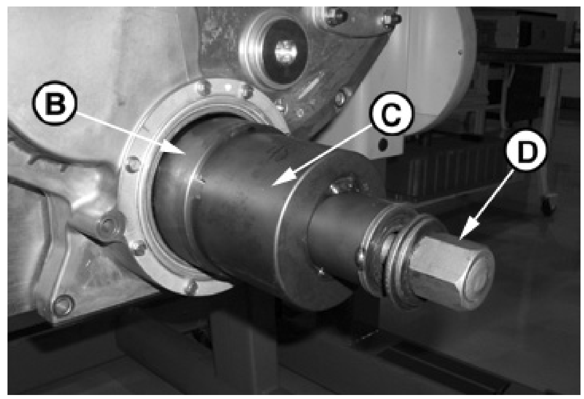
4. Before installing crankshaft front oil seal, apply a bead of LOCTITE® 30516 Sealant to machined surface of timing gear cover.

A—JDG10357P2 Adapter Guide
B—Engine Crankshaft Hub
C—JDG10357P4 Press Arbor
D—Forcing Screw



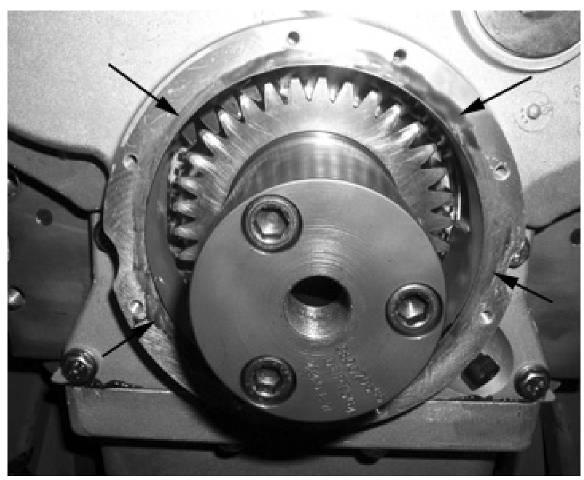
RG14900 –UN–15JUN06

JDG10357P2 Adapter Guide, and Engine Crankshaft Hub



RG14904 –UN–15JUN06

JDG10357P4 Press Arbor


RG14600 –UN–18NOV05

Apply Loctite Sealant to Timing Gear Cover

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RE38635,0000059 –19–13JUN07–1/4

5. Install 2 guide pins (A) into timing gear cover to aid in assembly of front crankshaft oil seal.

6. Position front crankshaft oil seal (B) over guide pins. Align the 2 oil seal indentations (C) with cast-in cap screw clearances (C) in timing gear cover seal flange.

7. Position JDG10357P3 seal installer (D) and JDG10357P4 press arbor (E) over forcing screw and adapter guide on crankshaft nose.

NOTE: The correct depth to seat the oil seal is designed into the seal press tool.

8. Using an open end wrench, turn forcing screw clockwise to force oil seal onto crankshaft hub until it bottoms at correct depth.

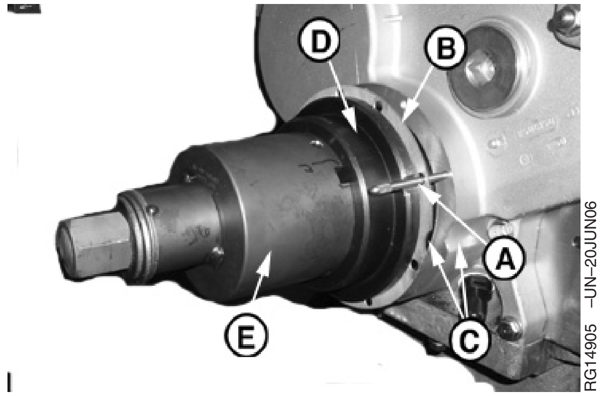
9. Remove press arbor and seal installation tools, leaving adapter guide with forcing screw in place.

10. Install 8 special cap screws through oil seal and into timing gear cover finger tight.

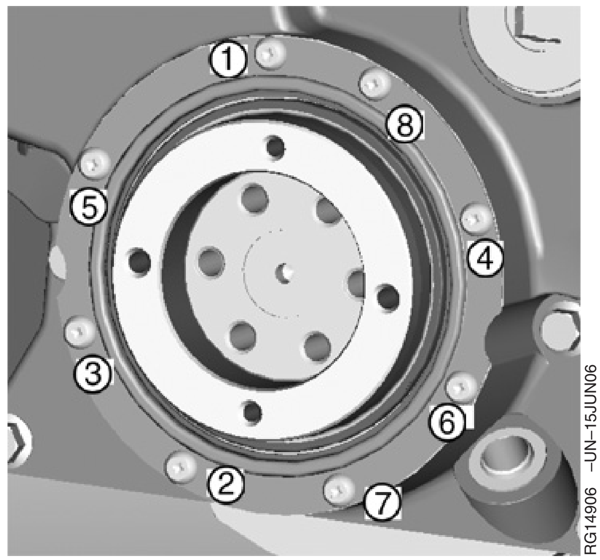
11. Tighten the cap screws, in sequence shown, to specification.

Specification

Front Crankshaft Oil Seal to
Timing Gear Cover—Torque .... 15 N•m (12 lb-ft)



Install Front Crankshaft Oil Seal



Torque Sequence - Front Oil Seal Cap Screws

A—Guide Pins
B—Front Crankshaft Oil Seal
C—Oil Seal & Timing Gear Cover Indentations
D—Seal Press Tool
E—JDG10357 Press Arbor & Forcing Screw

Continued on next page RE38635,0000059 –19–13JUN07–2/4

12. Position damper on crankshaft adapter guide (B) and install 2 TORX® head cap screws (A) finger tight.

13. Tighten 2 cap screws to specification.

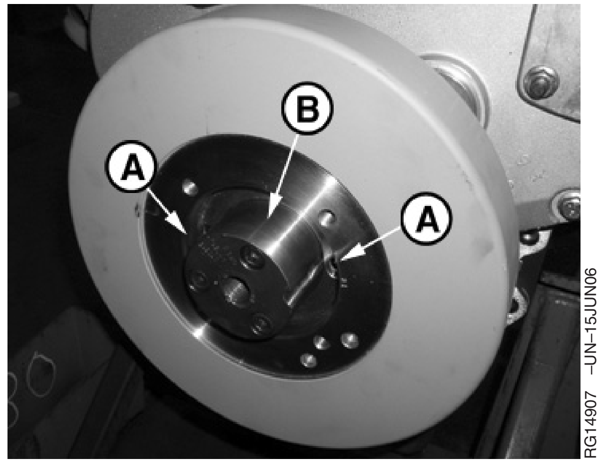
Specification

Damper to Crankshaft Hub—
Torque .... 25 N•m (19 lb-ft)

14. Remove adapter guide with forcing screw from crankshaft nose.

15. Insert 3 guide pins into crankshaft nose.

16. Install damper hub over guide pins.



Install Damper

A—TORX® Head Cap Screws -2-
B—Crankshaft Adapter Guide

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Continued on next page RE38635,0000059 –19–13JUN07–3/4

IMPORTANT: The damper hub to crankshaft cap screws are a torque turn joint. DO NOT reuse cap screws once torque turn method has been used to tighten joint.

17. Install 3 hex head cap screws with washers through damper hub into crankshaft nose finger tight.

18. Remove guide pins and install remaining 3 cap screws through damper hub into crankshaft nose

19. Drive damper hub into position against crankshaft nose by alternate tightening of the 6 cap screws. There is a slight press fit of the hub OD to damper ID, so maintaining alignment during tightening of cap screws is important.

20. Torque turn damper hub cap screws, in sequence shown, to specification.

Specification

Damper Hub to Crankshaft
Nose—Torque Turn....................................... 40 N•m (30 lb-ft) PLUS 90° additional turn

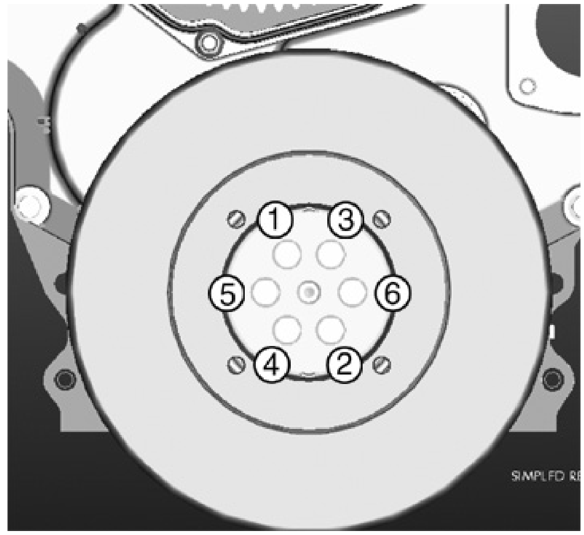
21. Install flange head cap screw (A) into center hole of damper hub (B) finger tight.

22. Tighten cap screw to specification.

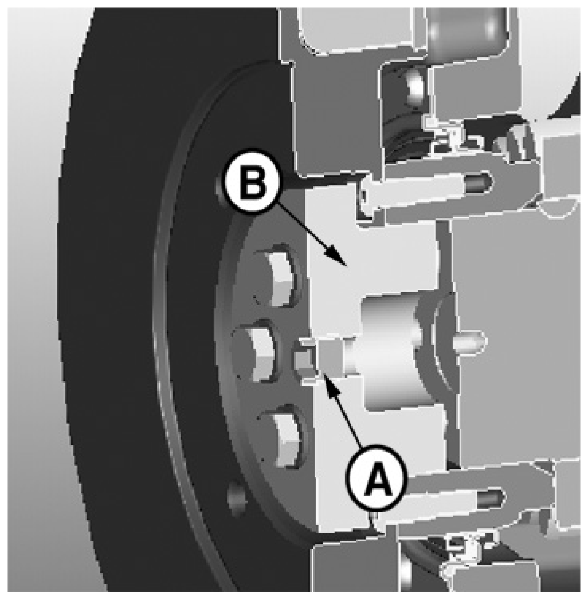
Specification

Flange Head Cap Screw to
Damper Hub—Torque .... 30 N•m (22 lb-ft)

A—Cap Screw
B—Damper Hub



Torque Turn Sequence Damper Hub to Crankshaft



Install Flange Head Cap Screw

RE38635,0000059 –19–13JUN07–4/4

Complete Final Assembly

1. Install idler pulley assembly. (See REPLACE BELT TENSIONER ASSEMBLY, in Group 070.)

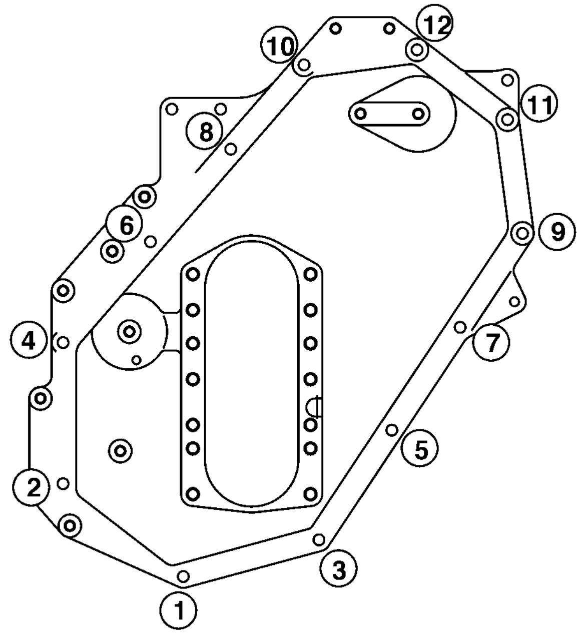
2. Install oil pan and service engine with clean engine oil. (See INSTALL ENGINE OIL PAN, in Group 060.)

3. Fill cooling system with proper coolant (See DIESEL ENGINE COOLANT RECOMMENDATIONS in Section 01, Group 002.)

4. Perform engine break-in. (See ENGINE BREAK-IN GUIDELINES in Group 010.)

RG,RG34710,182 –19–13AUG99–1/1

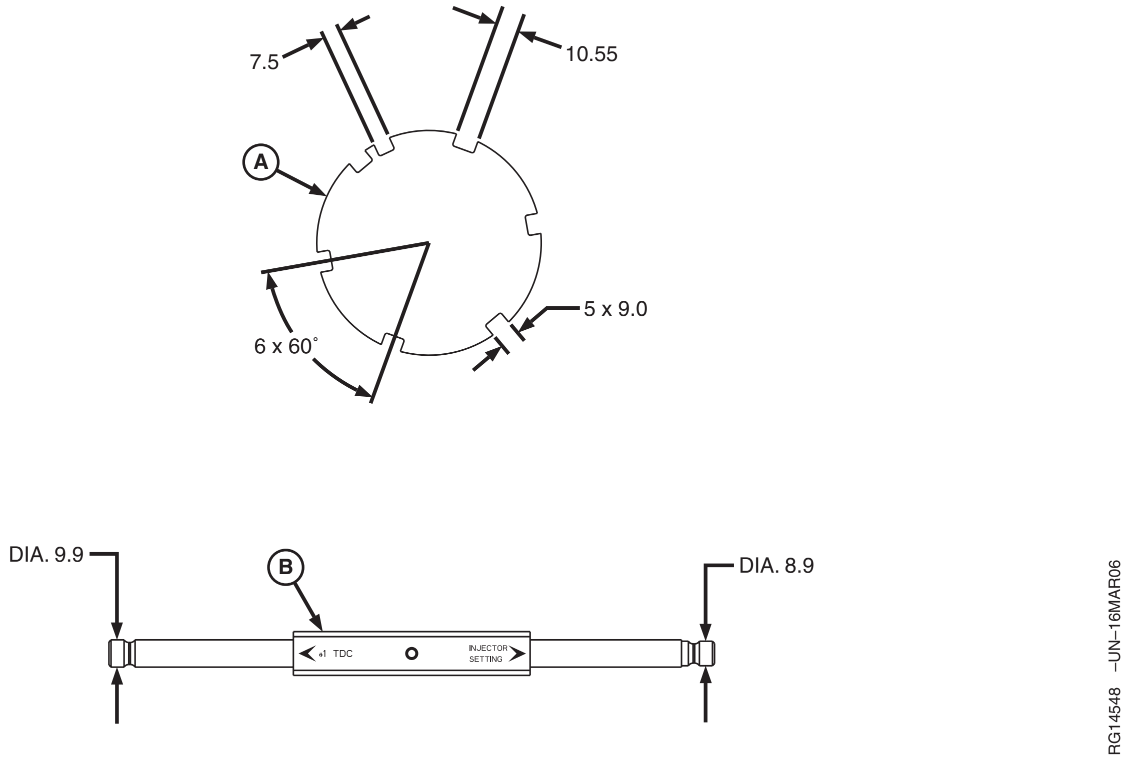
Camshaft Gear Access Cover Torque Sequence



Camshaft Gear Access Cover Torque Sequence

RG,RG34710,188 –19–30SEP97–1/1

Camshaft Timing Pin



6135 Camshaft Timing Slot and Timing Pin

The camshaft timing wheel design on the 6135 engine represents a significant change from the 6125 engine. The camshaft timing slot is shown as the engine is at Top Dead Center (TDC). The double slot will be in the 11:00 position, as viewed from the rear of the engine. The larger end (9.9 mm diameter) of the new Timing Pin (JDG10246) will engage the 10.055 mm wide slot when the engine is at TDC. The remaining five 9 mm wide slots, as well as the smaller (8.9 mm diameter) end of the Timing Pin, will be used to set preload on the remaining 5 Electronic Injectors. Refer to the section later in this group to set preload on injectors.

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Check and Adjust Camshaft-to-Crankshaft Timing

Check Camshaft-to-Crankshaft Timing

1. Remove rocker arm cover. See (REMOVE AND INSTALL ROCKER ARM COVER in Group 020.)

2. Remove plug from cylinder block and install JDG820 Flywheel Turning Tool.

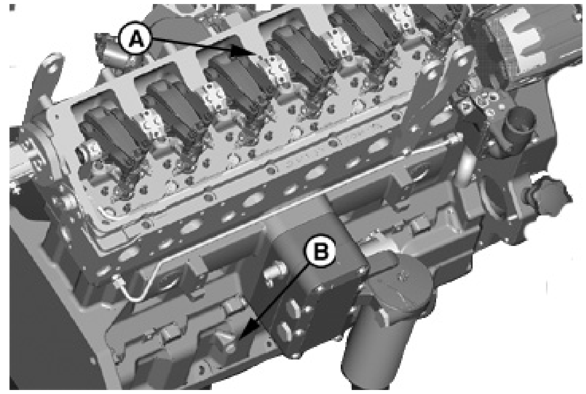
IMPORTANT: JDG10246 Timing Pin MUST BE installed into camshaft timing slot (A) first before attempting to install second timing pin into crankshaft timing slot (B).

3. Rotate engine flywheel in running direction (counterclockwise as viewed from rear) until large diameter of JDG10246 Timing Pin (marked “TDC” with arrow indicating large end of pin) engages single timing slot (C) in camshaft. The proper timing slot can be found by viewing camshaft timing lobe through camshaft timing pin bore while rotating engine. The double timing slot (D) will be at approximately 11 o’clock (viewed from rear of engine and as shown) when pin is installed in slot (C). This ensures that engine is locked at TDC of No. 1 cylinder’s compression stoke. Intake and exhaust rocker arms on No. 1 cylinder should be loose.

4. Remove threaded plug from crankshaft timing hole (B) below oil cooler and filter housing assembly.

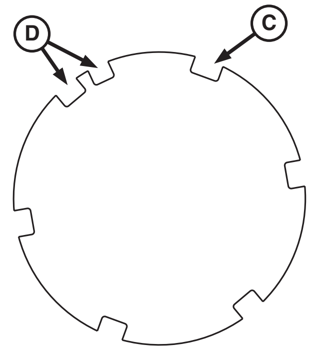
IMPORTANT: DO NOT insert timing pin full depth into cylinder block crankshaft timing hole when rotating engine flywheel until double slot on camshaft timing lobe is at approximately 11 o’clock (viewed from rear of engine) to avoid crankshaft counterweight bending timing pin.

5. Slightly move engine flywheel back and forth with turning tool until a second JDG10246 Timing Pin can be installed in slot in crankshaft (B). This ensures that camshaft and crankshaft are in sync (properly timed).



RG14547 –UN–31OCT05

Camshaft and Crankshaft Timing Holes



RG14549 –UN–16MAR06

Camshaft Timing Slot

A—Camshaft Timing Hole
B—Crankshaft Timing Hole
C—Top Dead Center (TDC) Timing Slot
D—Double Timing Slot

Continued on next page

RE38635,000008C –19–16NOV05–1/3

If timing pin does not enter crankshaft timing slot, crankshaft MUST BE timed to camshaft as detailed next in this group.

RE38635,000008C –19–16NOV05–2/3

Adjust Camshaft-to-Crankshaft Timing

1. Leave JDG10246 Timing Pin in camshaft timing slot and remove camshaft gear access cover (shown removed) from timing gear cover. (See REMOVE TIMING GEAR COVER in Group 040.)

2. Loosen camshaft gear retainer cap screws (A).

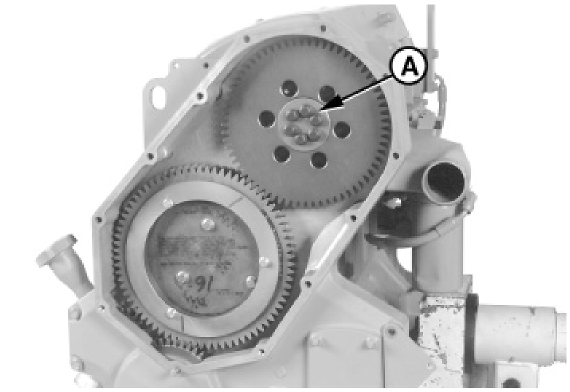
3. Rotate crankshaft with JDG820 Flywheel Turning Tool (B) and install second JDG10246 Timing Pin (C) in crankshaft timing slot.

4. Adjust gear train backlash and complete final assembly. (See ADJUST FRONT TIMING GEAR BACKLASH, next in this group.)

5. Tighten camshaft gear retainer plate to following torque:

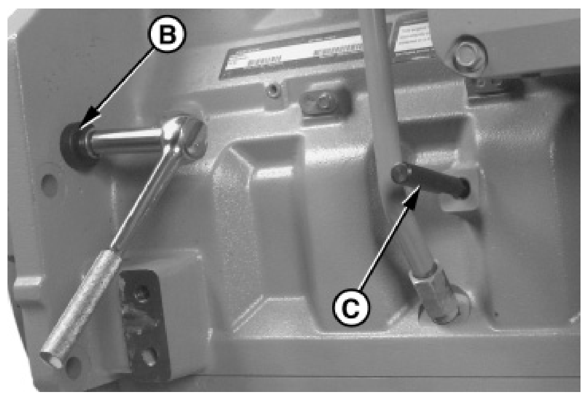
Specification

Camshaft Gear Retainer Plate-to-Camshaft—Initial Torque	100 N•m (74 lb-ft)
Second Torque	150 N•m (110 lb-ft)
Final Retorque	150 N•m (110 lb-ft)



RG8251C –UN–06DEC97

Camshaft Gear Retainer Cap Screws



RG8227D –UN–05DEC97

JDG10246 Timing Pin in Crankshaft

A—Camshaft Gear Retainer Cap Screws
B—JDG820 Flywheel Turning Tool
C—JDG10246 Timing Pin

RE38635,000008C –19–16NOV05–3/3

Adjust Front Timing Gear Backlash

1. Remove camshaft gear access cover from timing gear cover. (See REMOVE TIMING GEAR COVER in Group 040.)

2. Remove rocker arm cover from cylinder head. (See REMOVE AND INSTALL ROCKER ARM COVER in Group 020.)

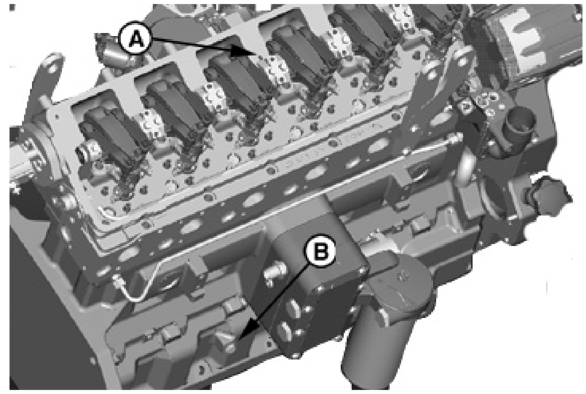
IMPORTANT: Rocker arm assembly should be completely installed before adjusting timing gear backlash.

3. Lock camshaft at No. 1 TDC compression stroke by rotating engine with JDG820 Flywheel Turning Tool until JDG10246 Timing Pin fully engages timing slot (C) in camshaft. This slot is 1 mm wider than the other 5 slots on the timing journal. The proper timing slot can be found by viewing camshaft timing lobe through camshaft timing pin bore while rotating engine. The double timing slot (D) will be at approximately 11 o'clock (viewed from rear of engine) when pin is installed in slot (C).

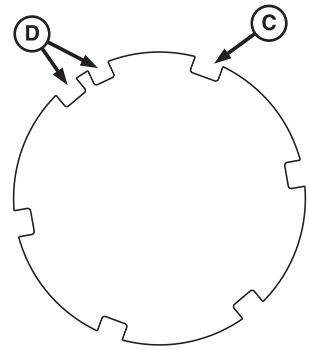
   This ensures that engine is locked at TDC of No. 1 cylinder's compression stoke. Intake and exhaust rocker arms on No. 1 cylinder should be loose.

IMPORTANT: DO NOT insert timing pin full depth into cylinder block crankshaft timing hole when rotating engine flywheel until double slot on camshaft timing lobe is at approximately 11 o'clock (viewed from rear of engine) to avoid crankshaft counterweight bending timing pin.

4. Remove plug and install a second JDG10246 Timing Pin in crankshaft timing hole (B) on right-hand side of cylinder block. Rotate engine flywheel back and forth with JDG820 Turning Tool until timing pin enters timing slot in crankshaft counterweight.



Camshaft & Crankshaft Timing Holes



Camshaft Timing Slot

Continued on next page

At this location the keyway in crankshaft drive gear will be at the 12 o'clock position, visible when vibration damper is removed. This is TDC of No. 1 cylinder's compression stroke. Also, with timing pin installed in camshaft and crankshaft slots, this ensures that camshaft-to-crankshaft timing is within specification.

RE38635,0000125 –19–30AUG06–2/6

5. Loosen all six camshaft gear retainer cap screws.

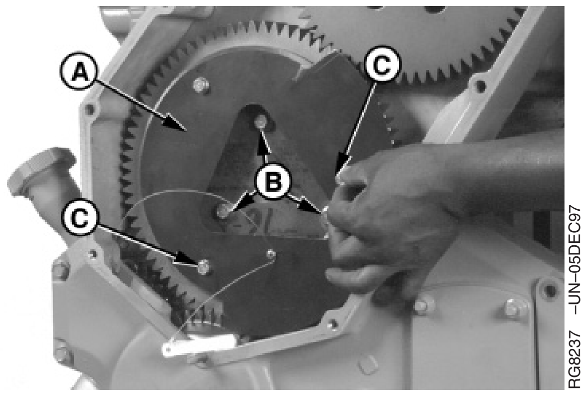
6. Loosen three upper idler gear bearing carrier cap screws (B), so that carrier can be moved by hand. Do not loosen more than required for ease of assembly.

NOTE: Upper hole on template is larger and fits over upper cap screw. This ensures proper placement of template when installed.

7. Remove two lower cap screws (C) from upper idler gear thrust plate and install JDG993 Timing Gear Backlash Template (A) as shown. Re-install two lower cap screws through template and tighten to specification.

Specification

Upper Idler Gear Thrust Plate
Cap Screws—Initial Torque.. 35 N•m (26 lb-ft)

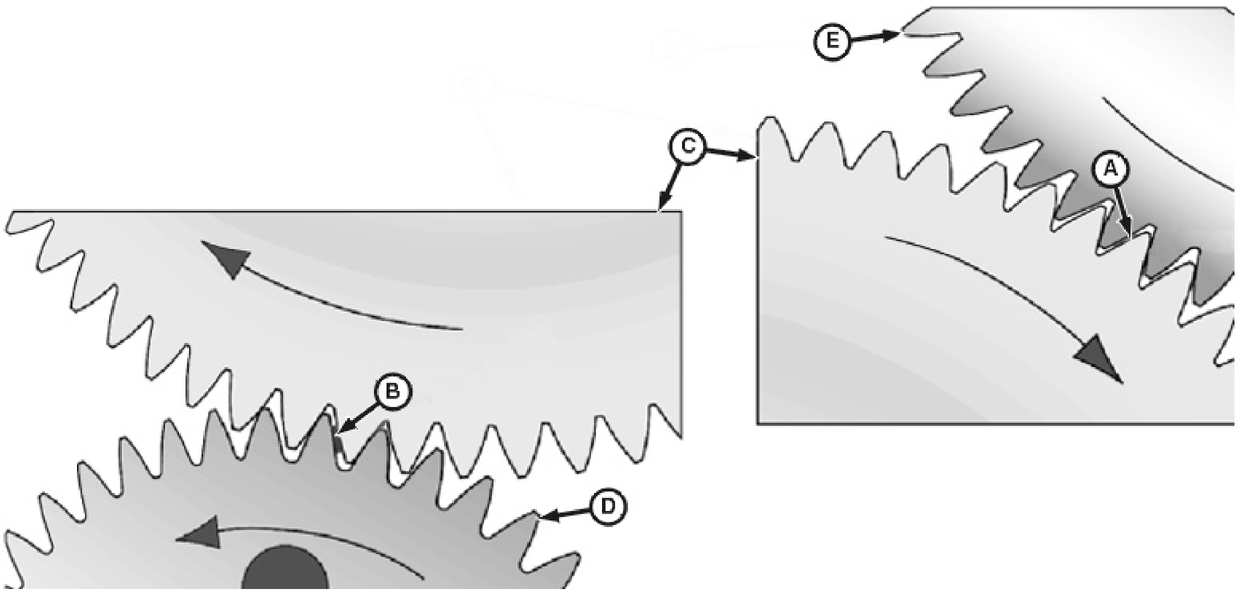


Installing JDG993 Backlash Template

A—JDG993 Timing Gear Backlash Template
B—Upper Idler Gear Bearing Carrier Cap Screws
C—Lower Cap Screws

Continued on next page

RE38635,0000125 –19–30AUG06–3/6



Backlash Adjusting Shim Placement

A—0.13 mm (0.005 in.) Shim
B—0.25 mm (0.010 in.) Shim
C—Idler Gear
D—Oil Pump Gear
E—Camshaft Gear

8. Install shims (A and B) in (non-loaded) side of gear teeth closest to tab on backlash template as shown. Also, shim must be installed between gear teeth that are meshing deepest in the root.

   - 0.13 mm (0.005 in.) shim (A) for idler gear-to-camshaft gear backlash.
   - 0.25 mm (0.010 in.) shim (B) for idler gear-to-oil pump gear backlash.

Specification

Camshaft Gear-to-Upper Idler Gear—Backlash	0.13 mm (0.005 in.)
Oil Pump Gear-to-Upper Idler Gear—Backlash	0.25 mm (0.010 in.)

Continued on next page RE38635,0000125 –19–30AUG06–4/6

IMPORTANT: Both shims MUST BE tight between gear teeth before and after tightening idler carrier cap screws.

IMPORTANT: Upper idler gear torque is a torque turn joint. DO NOT reuse cap screws.

IMPORTANT: Torque upper idler gear prior to camshaft gear.

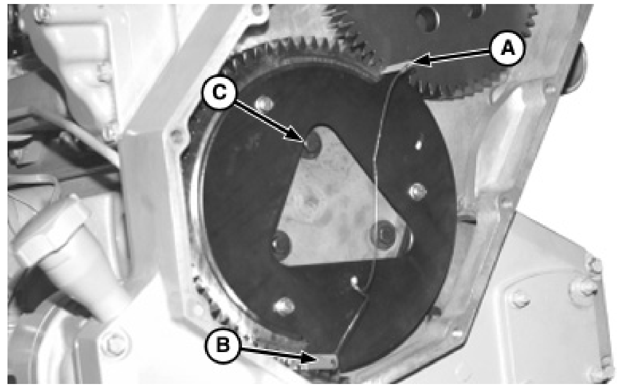
9. Weight of gear should seat idler gear and carrier assembly between shims (A and B) so that both shims are tight and cannot be removed from gear teeth.

10. Remove three idler gear carrier cap screws (C), one at a time, and discard. Apply LOCTITE® 243 Medium Strength Thread Lock and Sealer (Blue) to new cap screw threads. Install cap screws and tighten to specifications.

Specification

Upper Idler Cap Screws—Torque Turn .... 40 N•m (30 lb-ft) + 45°

Both shims MUST BE tight between gear teeth.



RG12422 –UN–16SEP02

Idler Gear Carrier Cap Screws

A—0.13 mm (0.005 in.) Shim
B—0.25 mm (0.010 in.) Shim
C—Cap Screws

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RE38635,0000125 –19–30AUG06–5/6

11. Remove six camshaft retainer cap screws, one and a time in sequence shown, and apply LOCTITE® 243 Thread Lock and Sealer. Reinstall and tighten to specification.

Specification
Camshaft Gear Retainer
Plate-to-Camshaft—Initial Torque .... 100 N•m (74 lb-ft)

12. Next, retorque cap screws to the following specification in sequence shown.

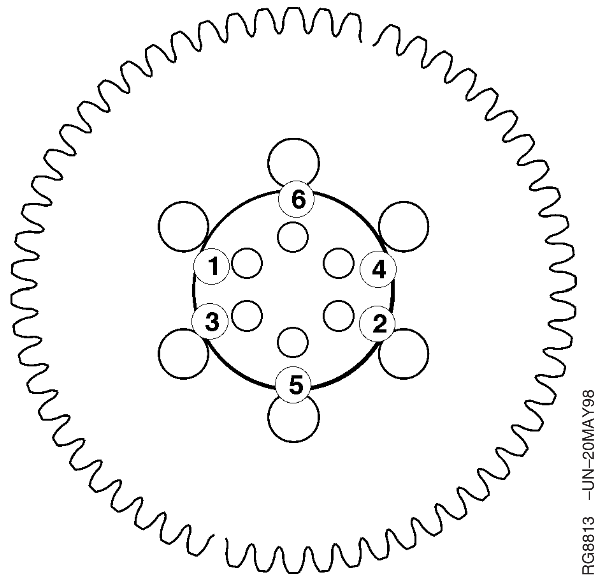
Specification
Camshaft Gear Retainer
Plate-to-Camshaft—Second
Torque .... 150 N•m (110 lb-ft)

13. Finally, retorque cap screws to the following specification in sequence shown.

Specification
Camshaft Gear Retainer
Plate-to-Camshaft—Final
Retorque .... 150 N•m (110 lb-ft)

14. Remove two lower idler gear thrust plate cap screws and backlash template and rotate engine flywheel to remove shims. Apply LOCTITE® 243 Thread Lock and Sealer to two cap screws. Reinstall and tighten to specifications.

Specification
Upper Idler Gear Thrust Plate
Cap Screws—Final Torque .... 35 N•m (26 lb-ft)



Camshaft Gear Retainer Torque Sequence

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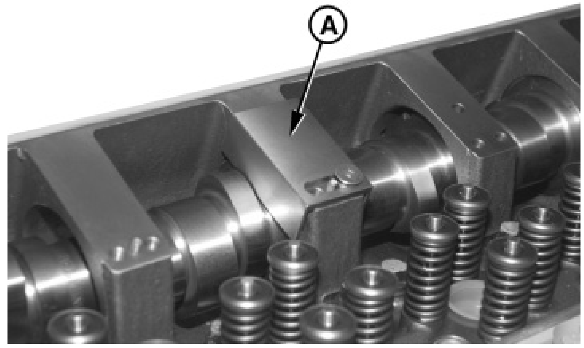
RE38635,0000125 –19–30AUG06–6/6

Remove and Install Camshaft

Remove Engine Camshaft

Engine camshaft can be removed with cylinder head installed or removed from engine.



DFRG4 Camshaft Locking Tool

A—Camshaft Locking Tool

1. Remove rocker arm assembly. (See REMOVE ROCKER ARM ASSEMBLY in Group 020.)

NOTE: See DFRG4—CAMSHAFT LOCKING TOOL in Section 05, Group 190 for instructions on how to fabricate tool.

2. Secure camshaft in bushings with DFRG4 Camshaft Locking Tool (A). Tighten cap screw and secure locking tool to head.

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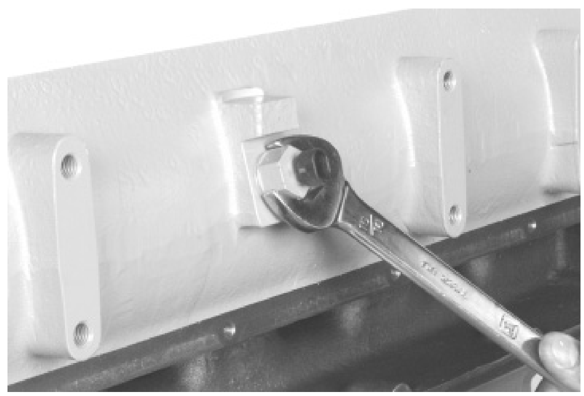
3. Remove camshaft position sensor from cylinder head.



Removing Camshaft Position Sensor

Continued on next page RE38635,0000095 –19–17NOV05–2/13

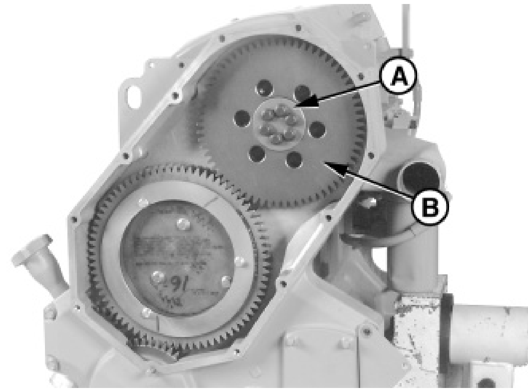
4. Remove camshaft gear access cover. (See REMOVE TIMING GEAR COVER in Group 040.)

5. Remove six cap screws securing camshaft gear retainer washer (A) and remove camshaft gear (B).

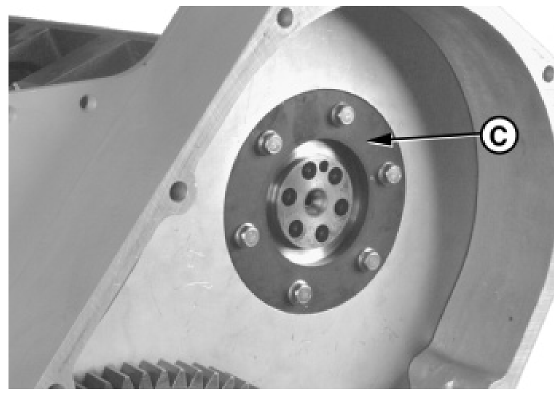
NOTE: Gently bump camshaft forward to remove thrust ring (C).

6. Remove camshaft thrust ring (C).

A—Camshaft Gear Retainer Washer
B—Camshaft Gear
C—Camshaft Thrust Ring



Removing Camshaft Gear

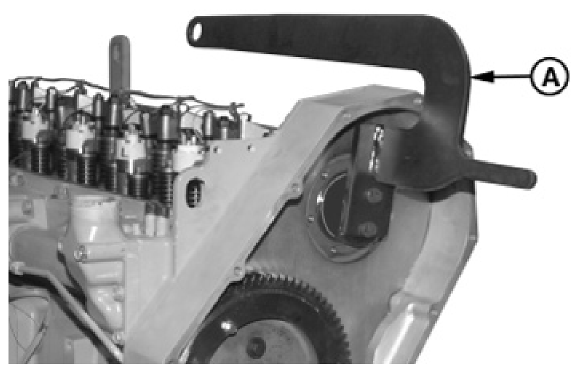


Removing Camshaft Thrust Ring

RE38635,0000095 –19–17NOV05–3/13

7. Install JDG969A Camshaft Holder (A) onto front face of camshaft using two camshaft gear retainer cap screws. Tighten cap screws securely.

A—Camshaft Holder

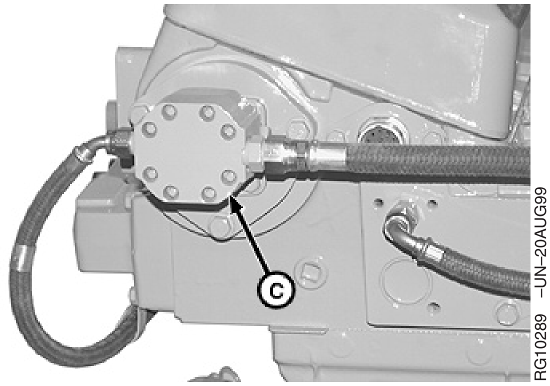


Installing JDG969A Camshaft Holder

Continued on next page RE38635,0000095 –19–17NOV05–4/13

8. Remove fuel supply pump and mounting bracket (C) from rear of cylinder head.

9. Remove supply pump drive coupler from drive pin in rear of camshaft.

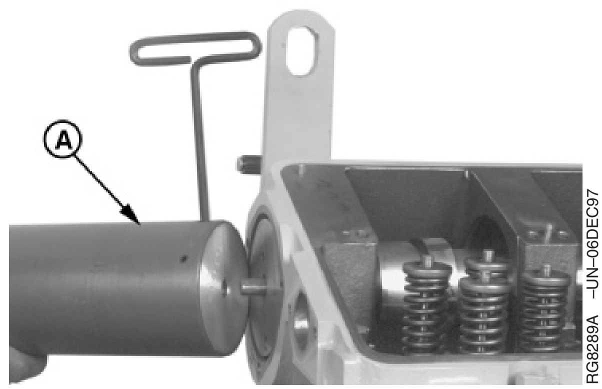


Fuel Supply Pump

RE38635,0000095 –19–17NOV05–5/13

10. Install JDG972 Camshaft Pilot (A) onto rear face of camshaft. Tighten two set screws securely. Lubricate pilot with clean engine oil or multipurpose grease.

A—Camshaft Pilot



Installing JDG972 Camshaft Pilot

Continued on next page

RE38635,0000095 –19–17NOV05–6/13

11. Support camshaft holder with a hoist. Ensure that engine repair stand is level to ease removal of camshaft.

12. Slowly remove camshaft from cylinder head. Traverse hoist (if possible) as camshaft is removed to avoid binding in bushing bores.

RG10244 –UN–30JUL99

Camshaft with Pilot and Holder

RE38635,0000095 –19–17NOV05–7/13

Install Engine Camshaft

1. If removed, install fuel supply pump drive pin in end of camshaft. (See REPLACE FUEL SUPPLY PUMP DRIVE PIN later in this group.)

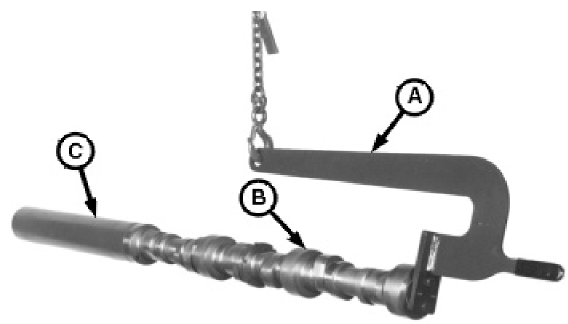
NOTE: Engine repair stand must be level during camshaft installation. Traverse hoist during installation so that camshaft bearings do not bind in bushing.

2. Attach JDG969A Camshaft Holder (A) to front face of camshaft (B). Attach JDG972 Camshaft Pilot (C) to rear face of camshaft. Securely tighten all mounting hardware.

3. Coat camshaft lobes and bearings with TY6333 or TY6347 High Temperature Grease.

4. Generously lubricate camshaft bushings with clean engine oil.

5. Support camshaft with overhead hoist and carefully guide camshaft into bushing bores. Traverse hoist (if possible) as camshaft is installed and keep engine repair stand level to ease installation.



RG10245 –UN–30JUL99

Camshaft with Pilot and Holder

A—JDG969A Camshaft Holder
B—Camshaft
C—JDG972 Camshaft Pilot

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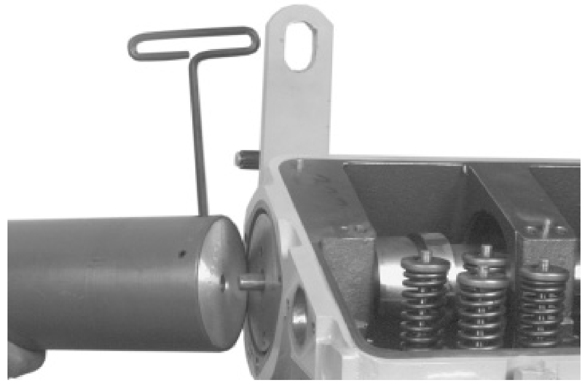
RE38635,0000095 –19–17NOV05–8/13

6. Push camshaft toward rear of engine until pilot set screws can be removed from rear face. Remove pilot from rear face of camshaft.



Removing JDG972 Pilot from Camshaft

RE38635,0000095 –19–17NOV05–9/13

7. Install fuel supply pump drive coupler (A) onto camshaft drive pin so that coupler is flush to 0.5 mm (0.020 in.) above pin. Apply LOCTITE® 242 Thread Lock and Sealer to set screws.

   Install set screws with the centerline of one screw perpendicular to flat on drive pin. Tighten set screws to specifications.

Specification

Camshaft and Supply Pump Drive Coupler Set Screw—Torque .... 4 N•m (3 lb-ft)

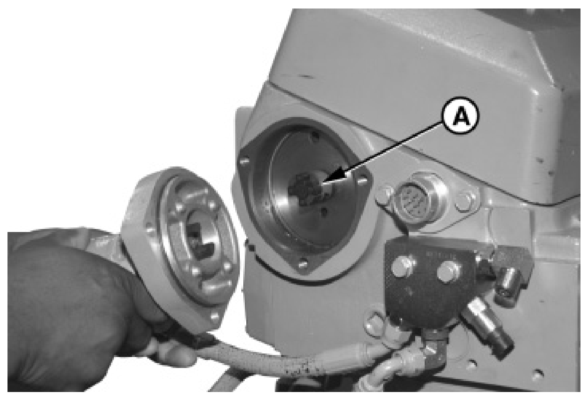
8. Install fuel supply pump.

   John Deere ECU controlled fuel systems:

   - See REMOVE AND INSTALL FUEL SUPPLY PUMP in CTM370.

Specification

Fuel Supply Pump-to-Cylinder Head—Torque .... 50 N•m (37 lb-ft)



Installing Supply Pump Drive Coupler

A—Fuel Supply Pump Drive Coupler

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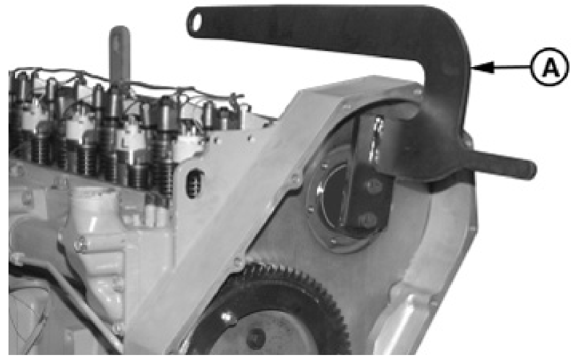
RE38635,0000095 –19–17NOV05–10/13

9. Remove JDG969A Camshaft Holder (A) from front face of camshaft.

A—JDG969A Camshaft Holder



RG10243 –UN–30JUL99

Removing JDG969A Camshaft Holder

RE38635,0000095 –19–17NOV05–11/13

10. Install a new thrust ring gasket. Lubricate O-ring with clean engine oil and install camshaft thrust ring (A) and tighten cap screws to specifications.

Specification

Camshaft Thrust Ring-to-Head—
Torque .... 35 N•m (26 lb-ft)

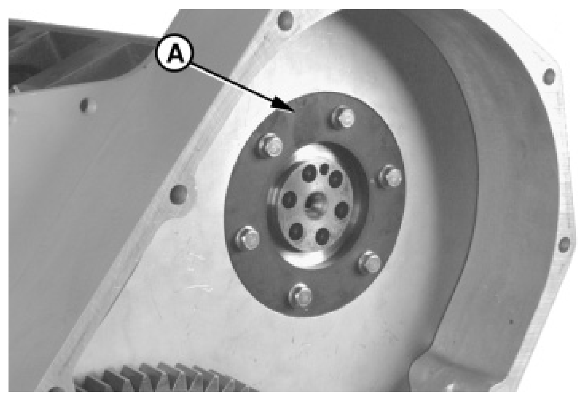
11. Rotate camshaft in bushings and install JDG10246 Timing Pin in camshaft timing slot.

12. Remove camshaft locking tool and install rocker arm assembly. (See INSTALL ROCKER ARM ASSEMBLY in Group 020.)

13. Install camshaft position sensor and tighten to specifications.

Specification

Camshaft Position Sensor—
Torque .... 14 N•m (10 lb-ft)



RG8286A –UN–06DEC97

Installing Camshaft Thrust Ring

A—Camshaft Thrust Ring

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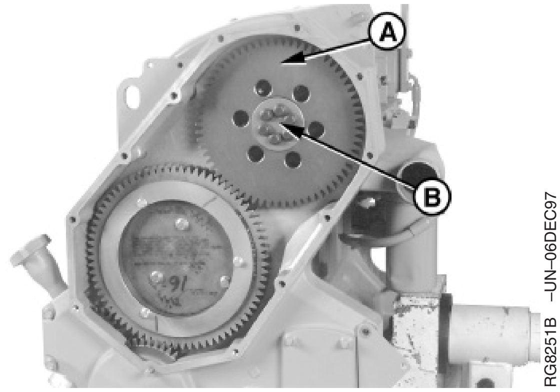
RE38635,0000095 –19–17NOV05–12/13

14. Install camshaft gear (A) and retainer washer (B) Install retainer cap screws finger tight. Adjust timing gear backlash. See ADJUST FRONT TIMING GEAR BACKLASH, earlier in this group, to set backlash and for torque procedure on camshaft retainer cap screws.

A—Camshaft Gear
B—Retainer Washer



Installing Camshaft Gear

RE38635,0000095 –19–17NOV05–13/13

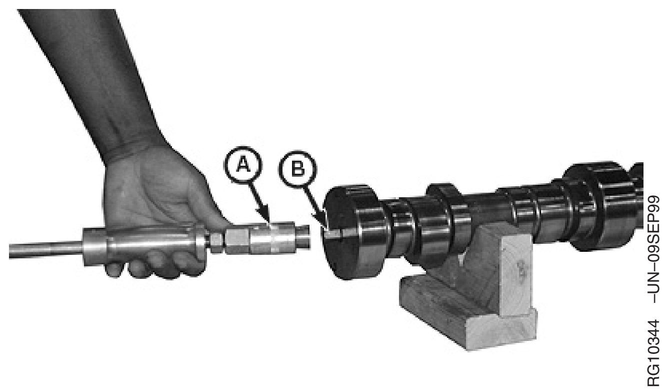
Replace Fuel Supply Pump Drive Pin

1. Remove camshaft. (See REMOVE AND INSTALL CAMSHAFT earlier in this group.)

2. Remove fuel supply pump drive pin (B) using Snap-On CG503 Dowel Pin Puller Set (A) or equivalent tool.

3. Press new drive pin into end of camshaft until it bottoms out. Pin should protrude 15.45—17.45 mm (0.608—0.687 in.) from end of camshaft.

4. Install camshaft. (See REMOVE AND INSTALL CAMSHAFT earlier in this group.)



Fuel Supply Pump Drive Pin

A—Dowel Pin Puller
B—Fuel Supply Pump Drive Pin

DPSG,OUO1004,1021 –19–08SEP99–1/1

Visually Inspect Camshaft and Roller Followers

1. Clean camshaft in solvent. Dry with compressed air.

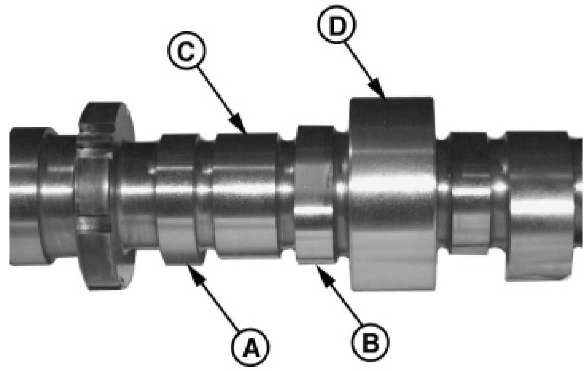
IMPORTANT: Very light score marks may be found on eccentric lobes, but are acceptable if valve lift is within specification. Pitting and galling dictates replacement.

2. Inspect all camshaft eccentric lobes and bushing journals (D) for wear or damage.

3. Inspect all corresponding rocker arm roller followers for uneven wear or damage.

   Replace individual roller followers as necessary.

A—Intake Lobe
B—Exhaust Lobe
C—Unit Injector Lobe
D—Bushing Journal



RG8385B –UN–09DEC97

Inspecting Camshaft Lobes

RG8388 –UN–21MAY98

Inspecting Roller Followers

RG,RG34710,192 –19–30SEP97–1/1

Inspect and Measure Camshaft Bushing ID and Journal OD

1. Measure each camshaft bushing journal OD and compare with specifications below.

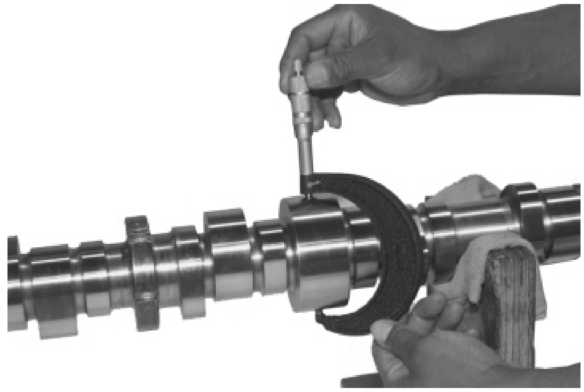
   Replace camshaft if journal OD is not within specification.

2. Measure camshaft bushing ID and compare with specifications below.

   Replace camshaft bushings if not within specification and if surface wear or scratching is detected.

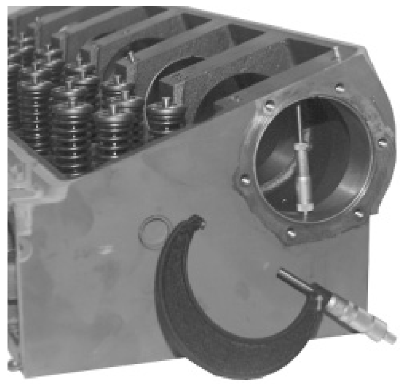
Specification

Camshaft Journal—OD	101.987—102.013 mm (4.0152—4.0162 in.)
Camshaft Bushing—ID	102.091—102.167 mm (4.0193—4.0223 in.)
Camshaft Journal-to-Bushing—Oil Clearance	0.078—0.180 mm (0.0031—0.0071 in.)
Camshaft Bushing—Bore in Head	105.987—106.013 mm (4.1727—4.1737 in.)



RG8341 –UN–21MAY98

Measuring Camshaft Journal OD



RG8331 –UN–21MAY98

Measuring Camshaft Bushing ID

RG,RG34710,193 –19–13AUG99–1/1

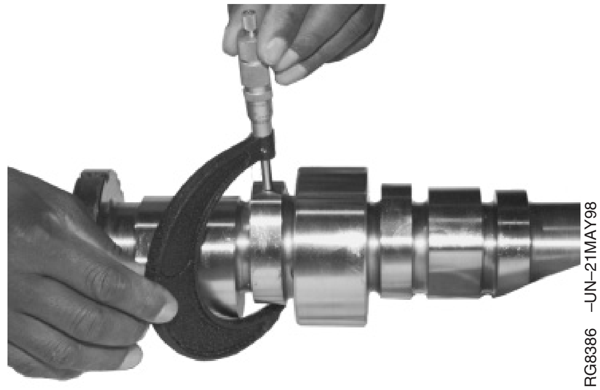
Measure Camshaft Lobe Lift Height

Measure each camshaft lobe at its highest point (lobe lift) and at its narrowest point (base circle). Subtract narrowest from highest height to find cam lobe lift.

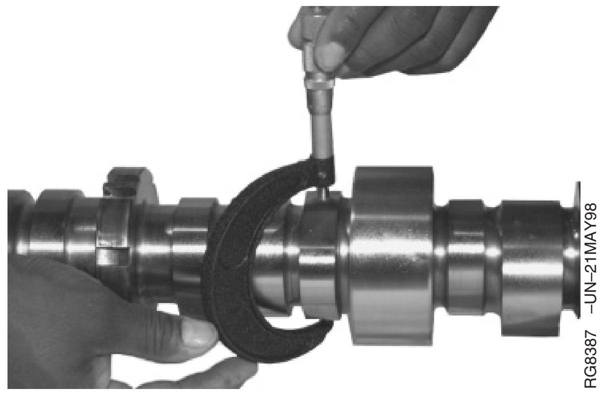
If camshaft lobe lift is not within specification on any one lobe, replace camshaft.

Camshaft Lobe—Specification

Intake Lobe—Lift	8.73—8.99 mm (0.343—0.353 in.)
Exhaust Lobe—Lift	7.93—8.19 mm (0.312—0.322 in.)
EUI Lobe—Lift	16.09—16.35 mm (0.633—0.643 in.)



Measuring Camshaft Lobe Base Circle



Measuring Camshaft Lobe Lift

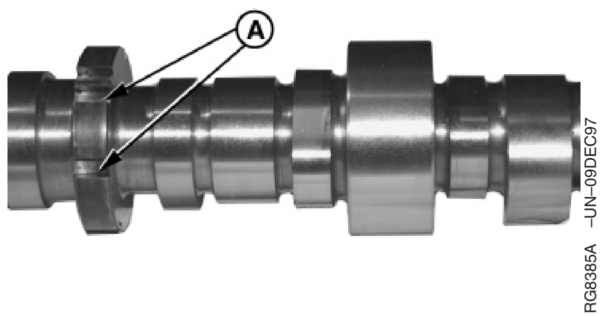
RE38635,0000096 –19–17NOV05–1/1

Inspect Camshaft Position Sensor Lobe

Visually inspect camshaft position sensor lobe slots (A) for damage or chips that may emit a false reading.

Replace camshaft as necessary.

A—Lobe Slots



Inspecting Camshaft Sensor and Timing Slots

RG,RG34710,195 –19–30SEP97–1/1

Replace Camshaft Bushings

Camshaft bushings MUST BE replaced with cylinder head removed from engine.

IMPORTANT: Use only hand tools for camshaft bushing removal and installation. DO NOT use pneumatic equipment for bushing replacement.

Remove Camshaft Bushings

1. Remove camshaft. (See REMOVE AND INSTALL CAMSHAFT, earlier in this group.)

2. Remove spring pins from camshaft towers 3 and 5 (bushing locations 2 and 3).

3. **No. 1 Bushing:**

   Install JDG968-1 Bushing Remover (A) in front side of No. 1 camshaft tower.

4. Lubricate 313793 Forcing Screw (B) and inset through remover with double nut and washer towards front of engine.

5. Install JDG968-3 Guide (C) in rear side of No. 2 tower with forcing screw through driver. Secure assembly with nut and washer.

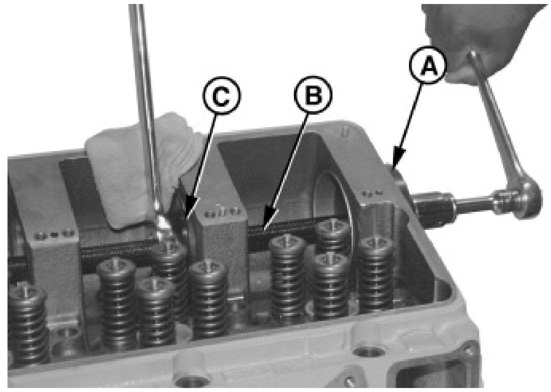
6. Remove bushing from bore using a 1/2-in. drive ratchet wrench with deep-well socket on double nut and a combination wrench to hold single nut. Protect cylinder head with a shop towel on wrench handle.

   Remove remaining bushings using the same procedure as above and by positioning tool set as follows:

7. **No. 2 Bushing:**

   Install JDG968-1 Bushing Remover in rear of No. 3 tower and JDG968-3 Guide in front of No. 2 tower.

8. Install 313793 Forcing Screw with double nut toward front of engine. Use a 152.4 mm (6.0 in.) extension with ratchet to reach double nut.



RG8333 –UN–09DEC97

Removing Camshaft Bushings

A—JDG968-1 Bushing Remover
B—313793 Forcing Screw
C—JDG968-3 Guide

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RG,RG34710,196 –19–25OCT00–1/7

9. **No. 3 Bushing:**

   Install JDG968-1 Bushing Remover in front of tower No. 5 and JDG968-3 Guide in rear of tower No. 6.

10. Install 313793 Forcing Screw with double nut toward rear of engine.

11. Use a 152.4 mm (6.0 in.) extension with ratchet to reach double nut.

12. **No. 4 Bushing:**

    Install JDG968-1 Bushing Remover in rear of No. 7 tower and JDG968-3 Guide in front of No. 6 tower.

13. Install 313793 Forcing Screw with double nut toward rear of engine. No extension needed.

14. Thoroughly clean bushing bores in cylinder head and inspect for damage. Clean lubricating oil holes as needed.

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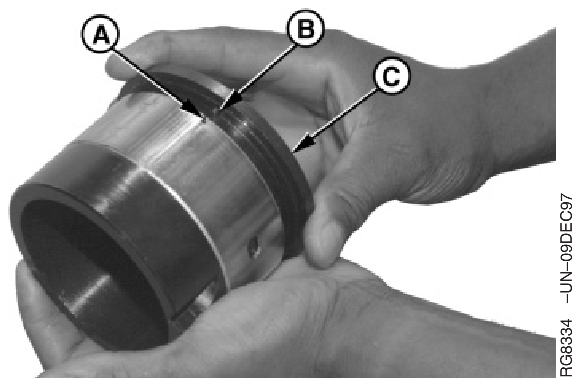
Install Camshaft Bushings

IMPORTANT: ALWAYS install bushings from front side of cylinder head bushing bore and drive toward rear.

1. **No. 1 Bushing:**

   Apply a light coat of TY6333 or TY6347 High Temperature Grease to ID of bushing bore in cylinder head.

2. Align notch (A) in new camshaft bushing with notch in JDG968-4 Alignment Sleeve (B). Position JDG968-2 Bushing Installer (C) onto end of sleeve with index slot engaged in notches in bushing and sleeve.



Positioning Replacement Bushing on Installer

A—Notch Alignment
B—Alignment Sleeve
C—Bushing Installer

Continued on next page RG,RG34710,196 –19–25OCT00–3/7

3. Position installer and sleeve with bushing on the front side of No. 1 tower with alignment groove (A) in guide sleeve positioned approximately as shown.

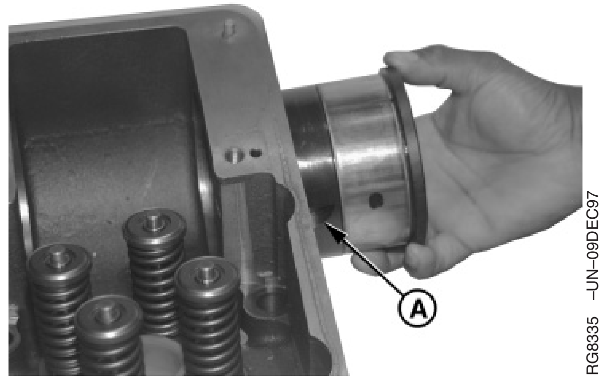
4. Install 313793 Forcing Screw with washer through installer with double nut towards front of engine.

5. Install JDG968-3 Guide (B) in the rear of tower No. 2 with 313793 Forcing Screw through guide. Secure assembly (finger tight) with nut and washer.

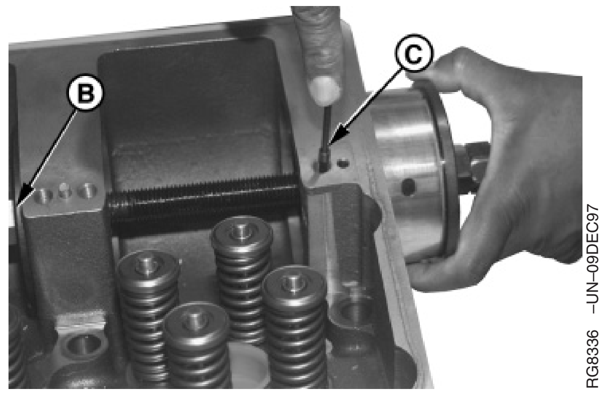
6. Install large end of JDG968-5 Alignment Pin (C) into oil hole (spring pin removed) until pin engages groove in alignment sleeve.

7. Once pin engages groove, rotate sleeve toward valves until you feel a positive stop. This ensures that the oil holes in bushing and cylinder head will be properly aligned after installation.

A—Alignment Groove
B—JDG968-3 Guide
C—JDG968-5 Alignment Pin



Positioning Bushing and Installer in Head



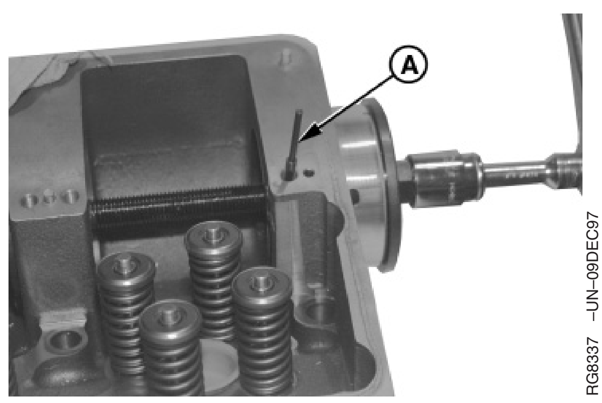
Indexing Bushing in Head

RG,RG34710,196 –19–25OCT00–4/7

8. Slowly install bushing in bore using a 1/2-in. drive ratchet wrench with deep-well socket on double nut and a combination wrench to hold single nut. Protect cylinder head with a shop towel on wrench handle.

9. Remove alignment pin (A) from oil hole once bushing is started in bore. Continue tightening double nut until shoulder of installer contacts tower.

A—Alignment Pin



Bushing Installation Alignment Pin

Continued on next page

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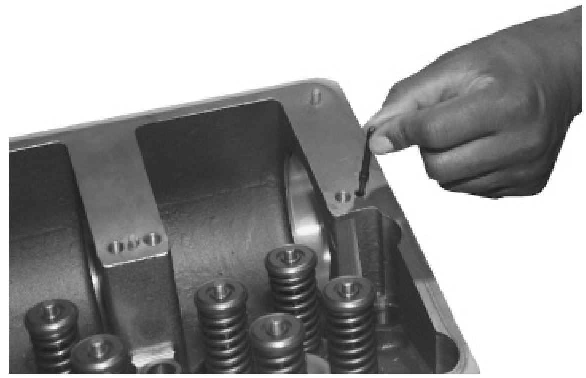
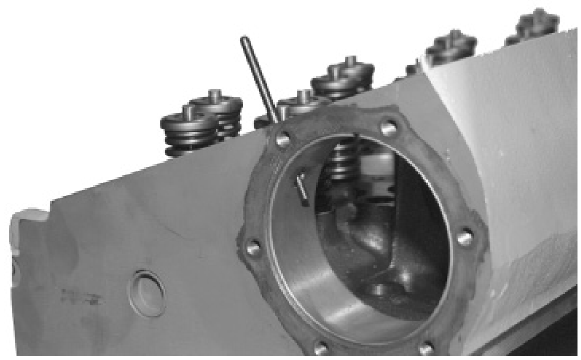
10. Remove tool set and insert the smaller end of JDG968-5 Alignment Pin from the TOP side of tower oil lube hole. This pin must pass through installed bushing completely to ensure proper lube hole alignment.

    If alignment pin does not pass through bushing oil hole, remove bushing and install a new one.

    Install remaining bushings using the same procedure as above and by positioning tool set as follows:


RG8338 –UN–21MAY98

Checking Bushing Oil Hole Alignment


RG8339 –UN–21MAY98

Index Pin Installed through Bushing

IMPORTANT: Protect previously installed bushings from tool damage with clean shop towels when installing 313793 Forcing Screw through bores.

11. **No. 2 Bushing:**

    Install JDG968-2 Bushing Installer and JDG968-4 Alignment Sleeve with bushing in front of tower No. 3 and JDG968-3 Guide in rear of tower No. 5.

12. Install 313793 Forcing Screw with double nut toward front of engine.

13. Use a 304.8 mm (12.0 in.) extension with ratchet to reach double nut.

14. **No. 4 Bushing:**

NOTE: Install bushing No. 4 before installing bushing No. 3.

    Adjust double nut position on forcing screw so that double nut is 51 mm (2.0 in.) from end of rod.

NOTE: JDG968-1 Bushing Remover can be positioned in tower No. 6 as a pilot, if desired.

15. JDG968-2 Bushing Installer and JDG968-4 Alignment Sleeve with bushing in front of tower No. 7 and JDG968-3 Guide in rear of No. 5 tower without bushing.

16. Install 313793 Forcing Screw with double nut and thrust washer against JDG968-3 Guide [51 mm (2.0 in.) with forcing screw extending through guide].

Continued on next page

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17. Install single nut and washer against JDG968-2 Bushing Installer. Put wrench on double nut and push bushing in with wrench on single nut.

18. **No. 3 Bushing:**

NOTE: Install bushing No. 4 before installing bushing No. 3.

Install JDG968-2 Bushing Installer and JDG968-4 Alignment Sleeve with bushing in front of tower No. 5 and JDG968-3 Guide in rear of No. 6 tower.

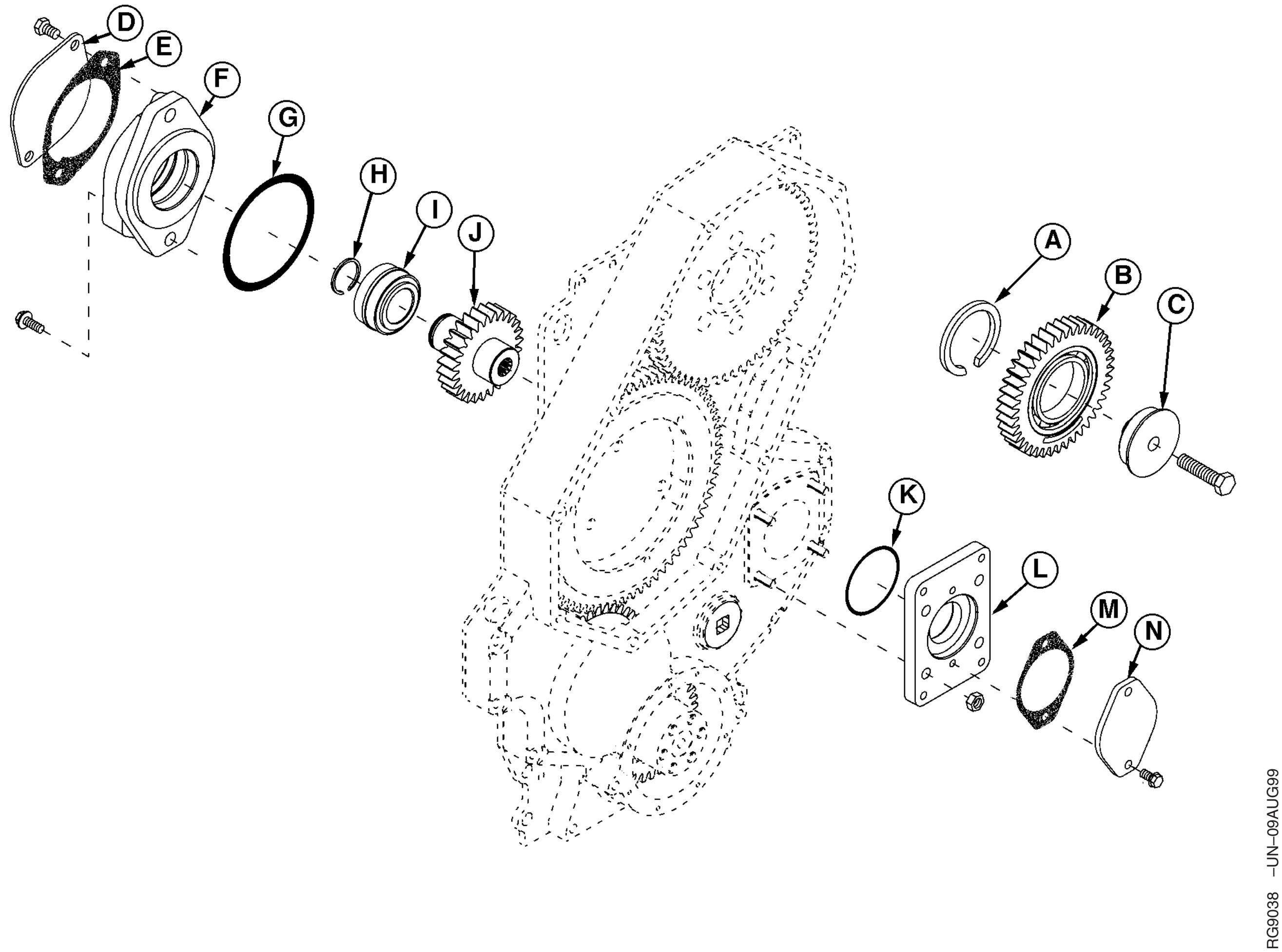
19. Install 313793 Forcing Screw with double nut toward rear of engine.

20. Use a 152.4 mm (6.0 in.) extension with ratchet to reach double nut.

21. Install a new spring pin in towers 3 and 5 (bushing locations 2 and 3).

RG,RG34710,196 –19–25OCT00–7/7

SAE “A” (Front) and SAE “B” (Rear) Auxiliary Drive Assembly



Auxiliary Drive Assembly

A—Snap Ring
B—Auxiliary Drive Idler Gear
C—Support Bushing
D—Cover Plate
E—Gasket
F—"B" Adapter Housing
G—O-Ring
H—Snap Ring[1]
I—Bearing
J—Splined Gear
K—O-Ring
L—"A" Adapter
M—Gasket
N—Cover Plate

NOTE: Refer to CTM67, OEM Engine Accessories, for repair of auxiliary drive assembly.

Torque specifications for adapter housing (F) and support bushing (C) are as follows:

Specification

SAE “A” Front Auxiliary Drive Adapter Housing Nuts—Torque .... 50 N•m (37 lb-ft)
SAE “A” Front Auxiliary Drive Idler Gear Support Bushing—Torque... 220 N•m (162 lb-ft)

[1] *A shim may be used with snap ring (H) to set gear shaft end play.*

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SAE “B” Rear Auxiliary Drive

Disassemble Rear Auxiliary Drive Assembly

NOTE: Refer to CTM67, OEM Engine Accessories, for repair of auxiliary drive assembly.

1. Remove rear auxiliary drive assembly (G) from front plate. Discard O-ring (B).
2. Support front face of adapter housing (A). Press gear (F) and bearing (E) out of housing bore.
3. Remove snap ring (C) from gear shaft. Discard snap ring.
4. Remove bearing from gear. Discard bearing.
5. Thoroughly clean and inspect gear and housing.

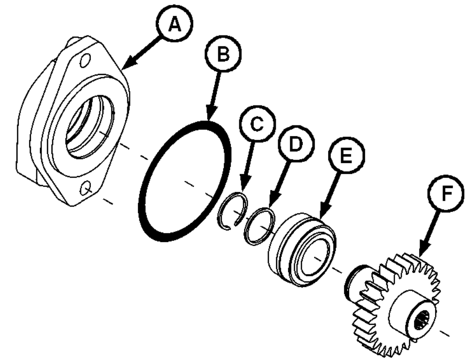
Assemble Rear Auxiliary Drive Assembly

1. Assemble bearing onto gear shaft. Press bearing flush with shoulder on gear.
2. Determine correct size snap ring (C) and shim (D) (if required) to achieve 0.11 mm (0.004 in.) maximum clearance between bearing cone and snap ring. See parts catalog for snap ring and shim sizes.
3. Support back side of adapter housing. Press gear and bearing assembly into housing until assembly bottoms.

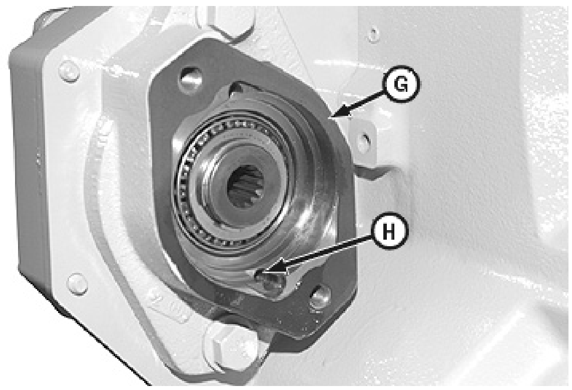
IMPORTANT: Make sure oil drain port (H) is positioned on bottom as shown.

4. Install assembly onto front plate using a new gasket. Tighten cap screws to specifications.

Specification
SAE “B” Rear Auxiliary Drive
Adapter—Torque .... 110 N•m (81 lb-ft)



SAE “B” Rear Auxiliary Drive Assembly



SAE “B” Rear Auxiliary Drive

A—SAE “B” Adapter Housing
B—O-Ring
C—Snap Ring[1]
D—Shim[1]
E—Bearing
F—Splined Gear
G—Rear Auxiliary Drive Assembly
H—Oil Drain Port

[1]Three snap ring sizes and one shim size are available to set gear shaft end play. See parts catalog for sizes and part numbers.

RG,RG34710,198 –19–26OCT00–1/1

Align SAE “A” Front Auxiliary Drive Adapter

IMPORTANT: Front auxiliary drive adapter (A) MUST BE properly aligned with center of gear spline whenever front or rear adapter is removed. Improperly aligned adapter may damage bearing assembly.

1. Install SAE “B” rear auxiliary drive adapter and tighten to specification.

Specification

SAE “B” Rear Auxiliary Drive
Adapter—Torque .... 110 N•m (81 lb-ft)

2. Install SAE “A” front adapter and tighten four mounting stud nuts (B) finger tight.

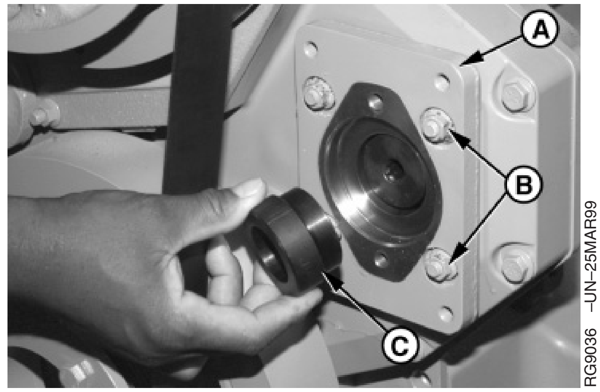
3. Install JDG1144 Alignment Tool (C) onto gear flange and into adapter bore to properly center adapter with gear spline.

4. Tighten mounting stud nuts to specifications.

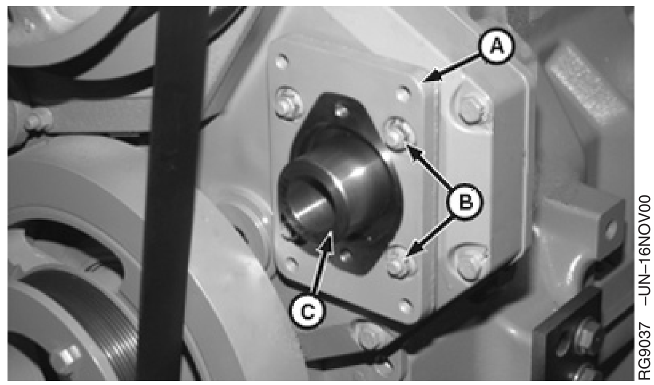
Specification

SAE “A” Front Auxiliary Drive
Adapter Housing Nuts—Torque .... 50 N•m (37 lb-ft)

Remove alignment tool.



Installing JDG1144 Alignment Tool

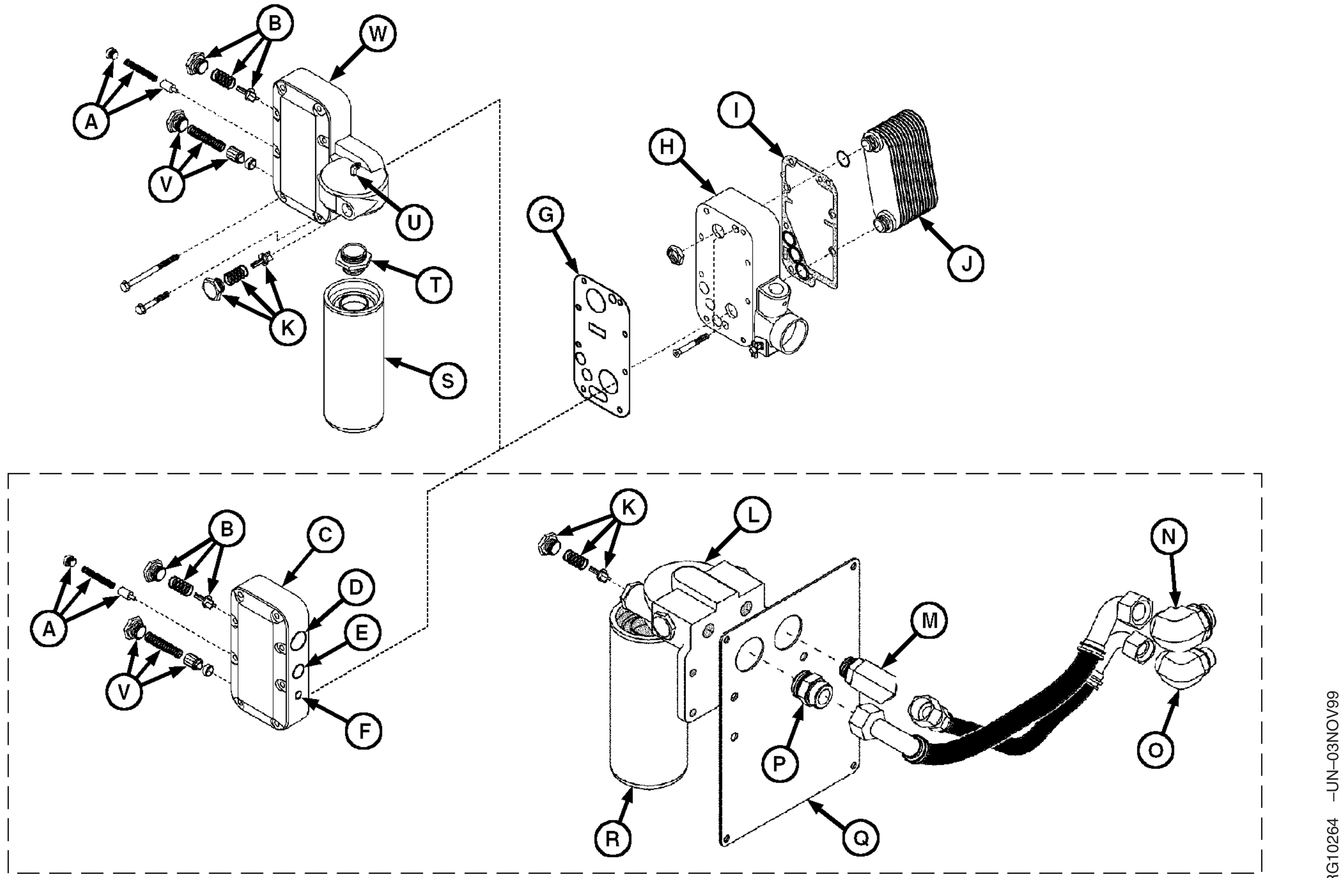


JDG1144 Alignment Tool Installed

A—Auxiliary Drive Adapter
B—Mounting Stud Nuts
C—JDG1144 Alignment Tool

RG,RG34710,199 –19–13AUG99–1/1

Oil Filter and Oil Conditioning Housing Assembly



Oil Filter Base, Oil Cooler, and Valve Assembly (Remote Filter Option Shown on Lower Portion of Figure)

A—Pressure Relief Valve Assembly (If Equipped)
B—Oil Cooler Bypass Valve Assembly
C—Oil Cooler Cover/Valve Housing (Remote Filter Applications)
D—Port to Remote Oil Filter Inlet
E—Port to Remote Oil Filter Outlet
F—Port to Turbocharger Oil Inlet (Remote Oil Filter Applications)
G—Gasket
H—Oil Cooler Housing
I—Gasket
J—Oil Cooler
K—Oil Filter Bypass Valve Assembly
L—Remote Oil Filter Housing
M—1 in. ID Elbow (Remote Oil Filter Applications)
N—1-1/4 in. ID Elbow (To Remote Oil Filter Inlet)
O—1 in. ID Elbow (To Remote Oil Filter Outlet)
P—1-1/4 ID Adapter (Remote Oil Filter Applications)
Q—Access Cover (Remote Oil Filter Applications)
R—Remote Oil Filter
S—Oil Filter
T—Filter Adapter
U—Port to Turbocharger Oil Inlet
V—Pressure Regulating Valve Assembly
W—Oil Filter and Valve Housing

RG,RG34710,206 –19–28JUL99–1/1

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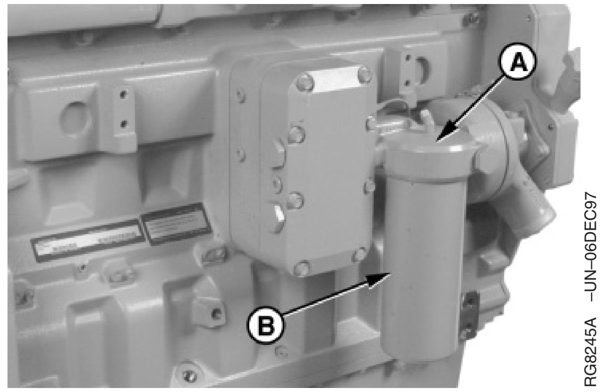
Remove Oil Filter and Valve Housing/Oil Cooler Cover and Valve Housing

NOTE: Standard oil filter/valve housing shown. Procedure for removal of remote oil cooler cover and valve housing is the same.

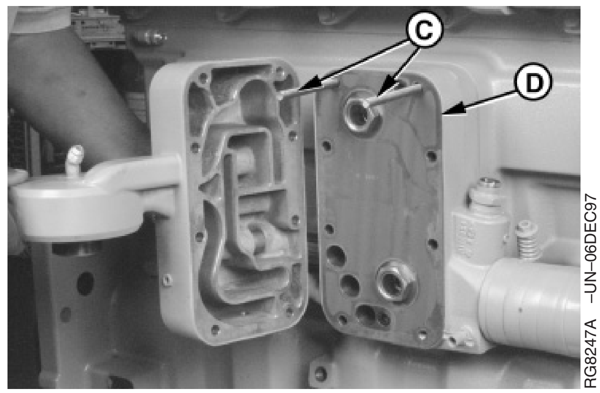
Guide pins (C) may be used as an aid for removing and installing oil filter housing.

1. Disconnect turbocharger oil inlet line (shown removed) from oil filter and valve housing (A).
2. Turn oil filter (B) counterclockwise using filter wrench and remove filter from housing.
3. Remove eight cap screws securing oil filter and valve housing to cylinder block and remove housing. Remove and discard gasket.
4. Remove valves and thoroughly clean all bores and passages in housing.

A—Oil Filter and Valve Housing
B—Oil Filter
C—Guide Pins
D—Gasket



Removing Filter and Valve Housing



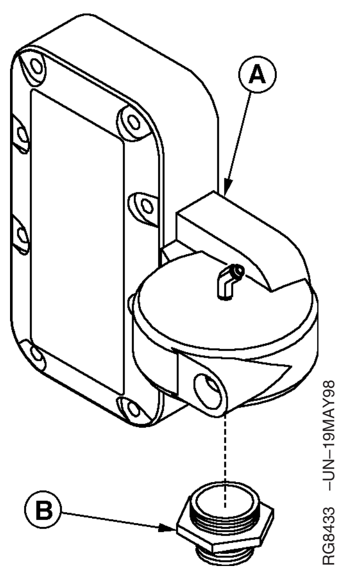
Filter and Valve Housing Removed

RG,RG34710,207 –19–28JUL99–1/1

Inspect and Replace Oil Filter Adapter

1. Inspect threads on oil filter adapter (B) for damage. Remove adapter from housing (A) and replace as necessary.
2. Coat adapter-to-oil filter housing threads with LOCTITE® 271 (TY9474) Thread Lock and Sealer before installing adapter in housing. Tighten adapter securely.

A—Oil Filter Housing
B—Oil Filter Adapter



Oil Filter Adapter

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RG,RG34710,208 –19–30SEP97–1/1

Remove, Inspect, and Install Oil Pressure Regulating Valve

NOTE: Refer to OIL FILTER AND OIL CONDITIONING HOUSING ASSEMBLY, earlier in this group, for illustrated location of valves.

Oil pressure regulating valve is in same location on oil cooler cover/valve housing for remote filter applications.

1. Remove oil pressure regulating valve assembly (C) from oil filter housing (G). Discard O-ring.

2. Inspect valve and valve bore for damage. Replace if necessary.

3. Clean all parts with a brass or copper wire brush and solvent. Dry with compressed air.

4. Check spring for proper compression.

Specification

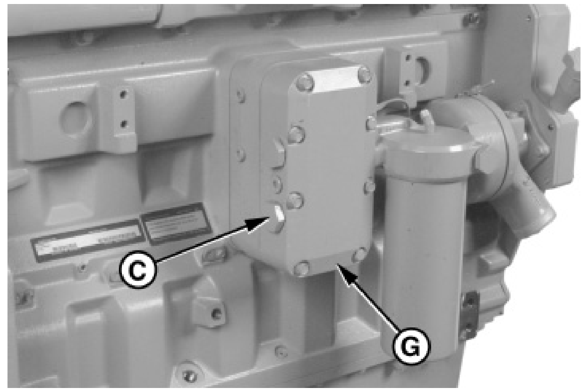
New Oil Pressure Regulating Valve Spring—Free Length .... 86.4 mm (3.40 in.)
Working Load at 76—84 N (17—19 lb-force) .... 42.0 mm (1.65 in.)

5. Dip all parts in clean engine oil. Insert valve and spring assembly in housing.

6. Install plug using a new O-ring and tighten to specifications.

Specification

Oil Pressure Regulating Valve Plug—Torque.. 100 N•m (74 lb-ft)



RG8245B –UN–06DEC97

Removing Pressure Regulating Valve

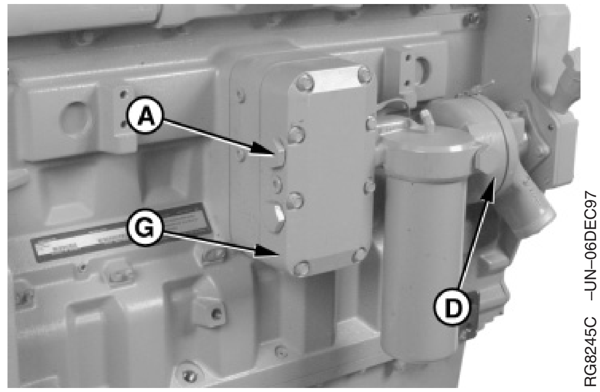
C—Oil Pressure Regulating Valve Assembly
G—Oil Filter Housing

RG,RG34710,209 –19–28JUL99–1/1

Remove, Inspect, and Install Oil Cooler and Oil Filter Bypass Valves

NOTE: Refer to OIL FILTER AND OIL CONDITIONING HOUSING ASSEMBLY, earlier in this group, for illustrated location of valves.

Oil cooler bypass valve is in same location on oil cooler cover/valve housing for remote filter applications. Oil filter bypass valve is in same location on face of remote oil filter housing.



Removing Oil Cooler and Oil Filter Bypass Valve

A—Oil Cooler Bypass Valve Assembly
D—Oil Filter Bypass Valve Assembly
G—Oil Filter Housing

1. Remove oil cooler bypass valve assembly (A) and oil filter bypass valve assembly (D) from oil filter housing (G). Discard O-rings.

2. Clean all parts with a brass or copper wire brush and solvent. Dry with compressed air.

3. Inspect bypass valves and valve bores for damage. Replace if necessary.

4. Check bypass valve springs for proper compression. Replace if not within specification.

Specification

New Oil Cooler Bypass Valve Spring—Free Length	44.0 mm (1.73 in.)
Working Load @ 64—78 N (14—18 lb-force)	30.0 mm (1.18 in.)
New Oil Filter Bypass Valve Spring—Free Length	44.0 mm (1.73 in.)
Working Load @ 64—78 N (14—18 lb-force)	30.0 mm (1.18 in.)

5. Dip all parts in clean engine oil. Insert valve and spring assembly in housing.

6. Install plug using a new O-ring and tighten to specifications.

Specification

Oil Cooler Bypass Valve Plug—Torque	100 N•m (74 lb-ft)
Oil Filter Bypass Valve Plug—Torque	100 N•m (74 lb-ft)

RG,RG34710,210 –19–06NOV00–1/1

Remove, Inspect, and Install Oil Pressure Relief Valve (If Equipped)

NOTE: Refer to OIL FILTER AND OIL CONDITIONING HOUSING ASSEMBLY, earlier in this group, for illustrated location of valves.

Oil pressure relief valve is in same location on oil cooler cover/valve housing on remote filter applications.

1. Remove oil pressure relief valve assembly (B) from oil filter housing (G).

2. Clean all parts with a brass or copper wire brush and solvent. Dry with compressed air.

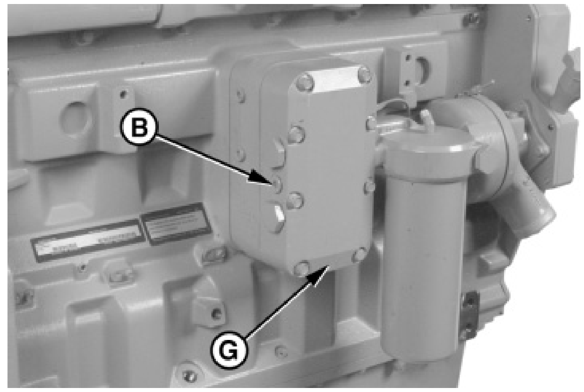
3. Inspect valve and valve bore for damage. Replace if necessary.

4. Check valve spring for proper compression. Replace if not within specification.

Specification	
Oil Pressure Relief Valve Spring—Free Length	79.0 mm (3.11 in.)
Working Load @ 196—222 N (44—50 lb-force)	65.0 mm (2.56 in.)

5. Dip all parts in clean engine oil. Insert valve and spring assembly in housing.

6. Install plug using a new O-ring and tighten securely.



RG8245D –UN–06DEC97

Removing Oil Pressure Relief Valve

B—Oil Pressure Relief Valve Assembly
G—Oil Filter Housing

RG,RG34710,211 –19–13AUG99–1/1

Remove, Clean, and Inspect Engine Oil Cooler

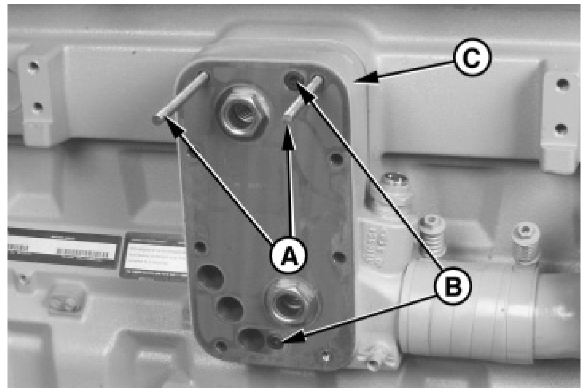
NOTE: Guide pins may be used as an aid for removing and installing oil filter housing.

1. Remove oil filter and valve housing (shown removed). (See REMOVE OIL FILTER AND VALVE HOUSING/OIL COOLER COVER AND VALVE HOUSING, earlier in this group.)

2. Install two guide pins (A) as shown (if desired). Remove two hex socket head cap screws (B) and remove oil cooler housing (C) with oil cooler (D).

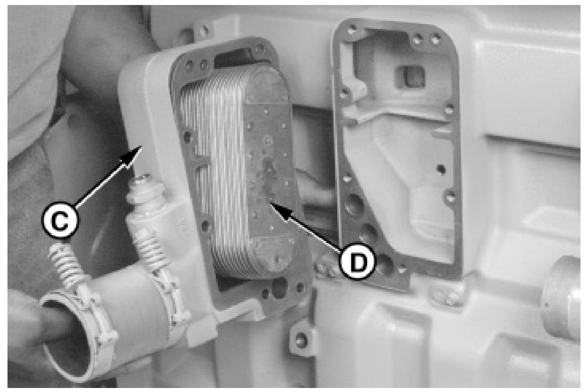
3. Remove and discard oil cooler-to-cylinder block gasket.

A—Guide Pins
B—Hex Socket Head Cap Screws
C—Oil Cooler Housing
D—Oil Cooler



RG8248A –UN–06DEC97

Removing Oil Cooler and Housing Assembly



RG8249B –UN–06DEC97

Oil Cooler and Housing Assembly Removed

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4. Remove two large hex nuts (D) securing oil cooler (C) to housing (A) and remove cooler from housing. Remove and discard gasket (B) and O-rings (E).

5. Clean all parts and flush oil cooler with solvent. Dry with compressed air.

6. Thoroughly inspect oil cooler for plugging, damage, or leaks.

NOTE: If mixing of oil and coolant is suspected, pressure test oil cooler in liquid and compressed air. Use specified air pressure for testing. Replace oil cooler as necessary.

Specification

Oil Cooler—Test Pressure .... 140—170 kPa (1.4—1.7 bar) (20—25 psi)

IMPORTANT: When installing oil cooler into housing, ensure that face of both mounting nuts is square to threads for proper torque.

7. Apply TY9473 LOCTITE® 242 Thread Lock and Sealer to oil cooler hex nuts.

8. Install oil cooler in housing using a new gasket and two new O-rings. Tighten two large hex nuts to specifications.

Specification

Oil Cooler-to-Housing Nuts—
Torque .... 50 N•m (37 lb-ft)

9. If removed, install oil cooler drain cock handle and tighten to specifications.

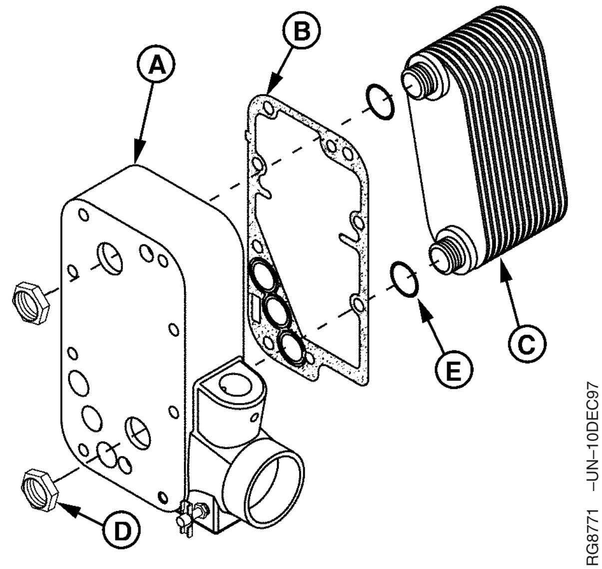
Specification

Oil Cooler Drain Cock Handle—
Torque .... 3 N•m (25 lb-in.)

10. If removed, install oil cooler housing expansion plug and tighten to specified depth.

Specification

Oil Cooler Expansion Plug—
Installed Depth... Flush to 1.5 mm (0.059 in.) Below Surface



Oil Cooler and Housing Assembly

A—Oil Cooler Housing
B—Gasket
C—Oil Cooler
D—Nut (2 Used)
E—O-Ring (2 Used)

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11. If removed, apply LOCTITE® 242 Thread Lock and Sealer to oil pressure sending unit. Install sending unit and tighten securely.

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RG,RG34710,212 –19–12AUG99–3/3

Install Oil Cooler/Oil Filter Valve Housing Assembly or Oil Cooler Cover/Valve Housing Assembly

NOTE: Standard filter/valve housing assembly shown. Procedure for remote filter applications is similar.

1. Remove all gasket material from cylinder block, oil cooler housing, and oil filter/valve housing. All sealing surfaces must be clean and free of oil.

NOTE: Use guide pins as an assembly aid if desired.

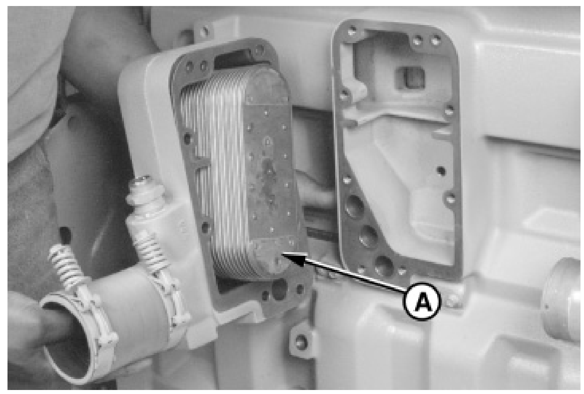
2. Install oil cooler and housing assembly (A) using a new gasket. Position oil cooler housing-to-coolant pump hose on coolant pump outlet elbow.

3. Install two hex socket head cap screws (B) and tighten to specifications.

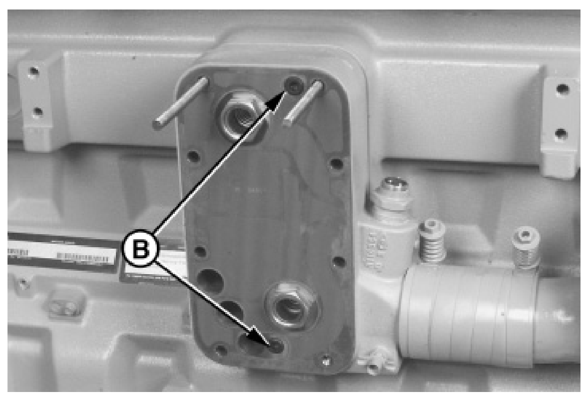
Specification

Oil Cooler Housing-to-Block Cap Screws—Torque .... 68 N•m (50 lb-ft)

A—Oil Cooler and Housing Assembly
B—Hex Socket Head Cap Screws



Installing Oil Cooler and Housing Assembly



Oil Cooler and Housing Assembly Installed

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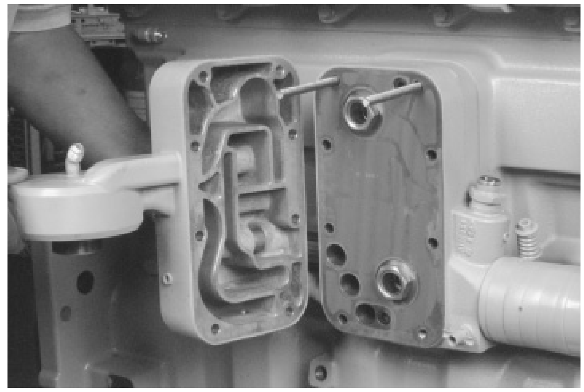
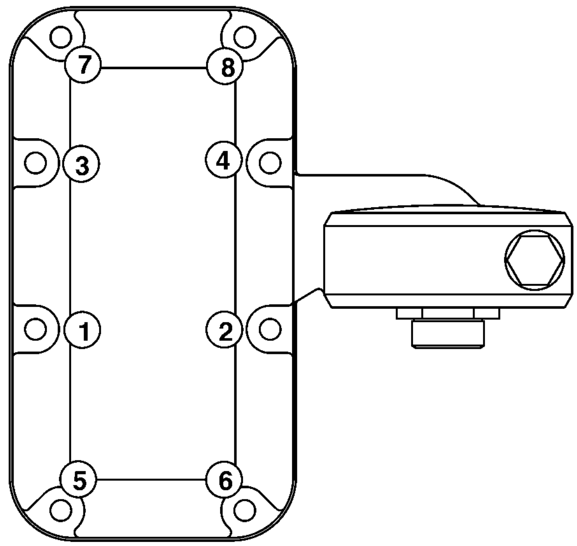


Install Filter and Valve Housing



Oil Filter Housing Torque Sequence

4. Install oil filter/valve housing (or oil cooler cover/valve housing on remote applications) using a new gasket. Tighten cap screws to specifications using sequence shown in lower illustration.

Specification

Oil Filter/Valve Housing or Oil Cooler Cover/Valve Housing[1]—Torque .... 68 N•m (50 lb-ft)

5. Retighten cap screws to specification using same sequence.

Specification

Oil Cooler Housing-to-Block Cap Screws—Retorque........ 68 N•m (50 lb-ft)

6. Tighten coolant pump-to-oil cooler housing hose clamps securely.

7. Coat oil filter gasket with clean engine oil. Install filter to housing until gasket contacts base, then tighten an additional 1/2—3/4 turn.

8. If equipped with a remote filter: Connect hose or line ends to oil cooler cover/valve housing and tighten hose or line ends to specification.

Specification

Remote Filter Inlet Hose or Line—Torque........ 190 N•m (140 lb-ft)
Remote Filter Outlet Hose or Line—Torque........ 142 N•m (105 lb-ft)

9. Install turbocharger oil inlet line onto housing adapter and tighten to specifications.

Specification

Turbocharger Oil Inlet Line-to-Oil Cooler Housing—Torque........ 16 N•m (12 lb-ft)

[1]Torque sequence and specification also applies to oil cooler cover/valve housing on remote filter applications.

RE38635,0000123 –19–23JUN06–2/2

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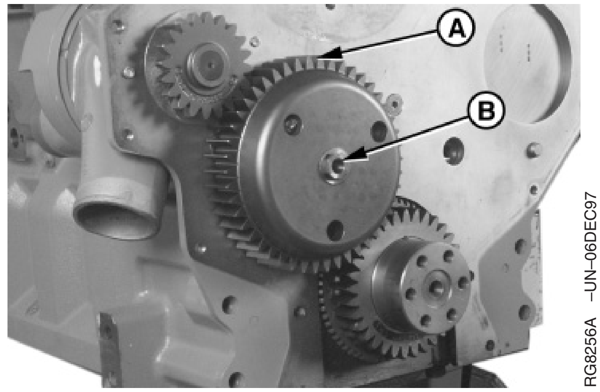
Remove Engine Oil Pump

1. Remove timing gear cover. (See REMOVE TIMING GEAR COVER in Group 040.)
2. Remove external snap ring (B) securing oil drive gear (A) to oil pump drive shaft.
3. Remove drive gear from shaft and oil pump housing.

A—Oil Drive Gear
B—External Snap Ring



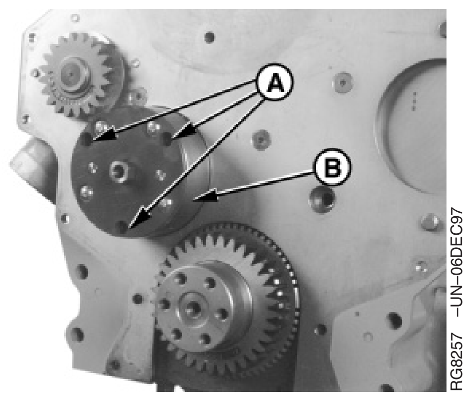
Removing Oil Pump Gear

RG,RG34710,214 –19–25OCT00–1/3

4. Remove three hex socket head cap screws (A) securing oil pump assembly (B) to cylinder block and remove oil pump.

IMPORTANT: DO NOT disassemble oil pump since no repair parts are available. Replace oil pump as a complete assembly as necessary.

A—Hex Socket Head Cap Screws
B—Oil Pump Assembly

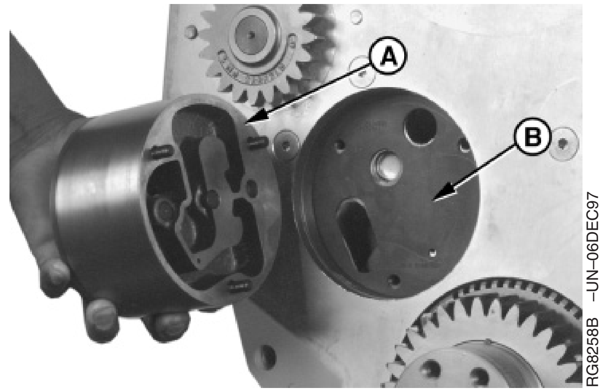


Removing Oil Pump

Continued on next page RG,RG34710,214 –19–25OCT00–2/3

5. Remove oil pump-to-cylinder block gasket (B). Discard gasket.

A—Oil Pump Assembly
B—Oil Pump-to-Cylinder Block Gasket



Oil Pump Removed

RG,RG34710,214 –19–25OCT00–3/3

Clean and Inspect Oil Pump and Drive Gear

IMPORTANT: DO NOT disassemble oil pump for repair or inspection. No repair parts are available. Replace pump as a complete assembly as necessary.

1. Completely flush oil pump with solvent while rotating input shaft by hand to clean any debris from housing and gears.

2. Using a good light source, look through rear cavities of pump to inspect all gear teeth for abnormal wear. Replace pump if excess wear is noticed.

3. Inspect back side of oil pump cover through cavities for evidence of gear contact with cover. Replace pump if gear contact is noticed.

4. Inspect oil pump drive gear teeth for wear. Inspect and measure drive gear bushing ID. Bushing ID must be within specifications. Replace drive gear and bushing assembly as necessary.

Specification

Oil Pump Drive Gear Bushing—ID	135.70—135.80 mm (5.343—5.346 in.)

RG,RG34710,215 –19–13AUG99–1/1

Install Engine Oil Pump

1. Position new gasket (A) in oil pump bore on front face of cylinder block.

2. Apply TY6333 or TY6347 High Temperature Grease to inside cavities of oil pump through openings in back of oil pump.

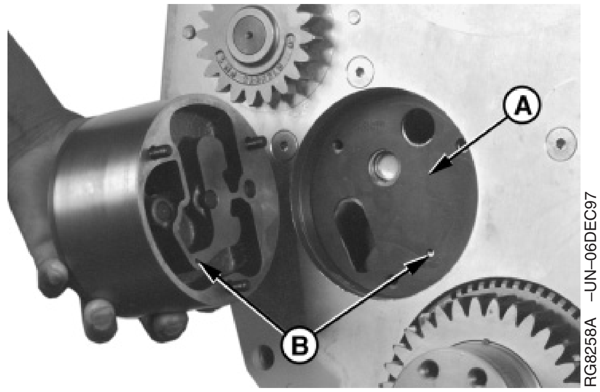
IMPORTANT: Holes (B) in cylinder block, gasket and oil pump housing must align to ensure proper lubrication for oil pump-to-gear bushing.

NOTE: 101.6 mm (4.0 in.) long guide pins may be used to aid oil pump cap screw hole alignment, if desired. Cap screw holes will be aligned only when oil pump is correctly installed.

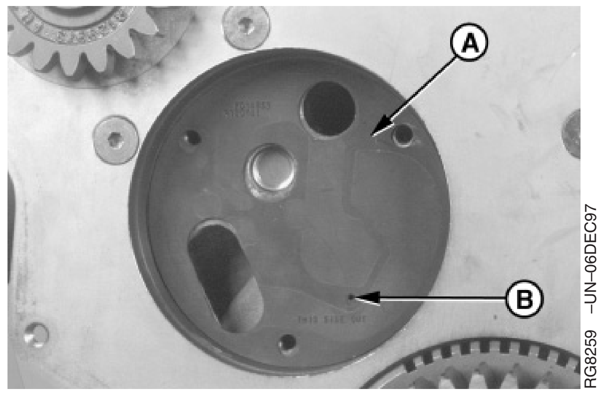
3. Install oil pump on cylinder block. Apply LOCTITE® 242 (TY9473) Thread Lock and Sealer to oil pump-to-cylinder block cap screw threads and tighten to initial torque specification.

Specification

Oil Pump-to-Block Cap Screws—
Initial Torque... 20 N•m (177 lb-in.)



Installing Oil Pump



Oil Pump Gasket

A—Gasket
B—Lubrication Holes

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Continued on next page RG,RG34710,216 –19–24SEP02–1/2

4. Second: Starting with first cap screw tightened, apply 90° torque turn to each cap screw.

Specification

Oil Pump-to-Block Cap Screws—
Torque Turn.. 90° (1/4 Turn)

5. Rotate input shaft full 360° after pump installation. If shaft does not turn freely for full 360°, remove pump and determine cause.

6. Apply TY6333 or TY6347 High Temperature Grease to ID of oil pump drive gear bushing.

7. Install oil pump gear with bushing over oil pump housing; align input shaft with opening in gear.

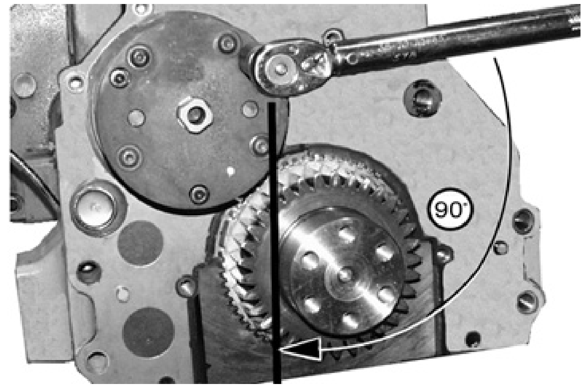
8. Install external snap ring in groove of input shaft.

9. Check oil pump drive gear-to-idler gear backlash.

Specification

Oil Pump Drive Gear-to-Idler
Gear—Backlash.. 0.25 mm (0.010 in.)

10. Install timing gear train cover and complete final assembly. (See INSTALL TIMING GEAR COVER in Group 040.)



RG12611 –UN–30AUG02

90° Torque Turn

RG8256 –UN–21MAY98

Installing Oil Pump Drive Gear

RG,RG34710,216 –19–24SEP02–2/2

Remove Engine Oil Pan

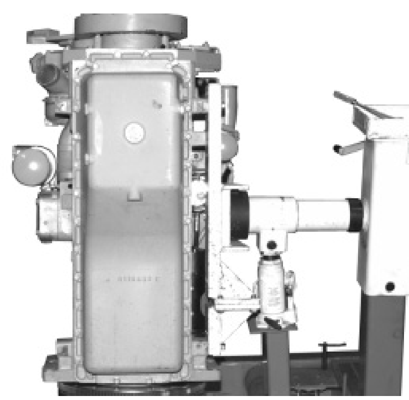
1. Disconnect turbocharger oil inlet line. Remove oil pan drain plug and drain all engine oil.

NOTE: It may be necessary to tap oil pan with a rubber or plastic dead-blow hammer to free oil pan from gasket seal.

2. Remove all 30 oil pan cap screws and remove oil pan from cylinder block.

3. Remove all gasket material from oil pan and cylinder block gasket sealing surfaces.

4. Clean all oil from oil pan and cylinder block sealing surfaces and dry completely.



RG8819 –UN–20MAY98

Removing Oil Pan

RG,RG34710,217 –19–30SEP97–1/1

Remove and Install Oil Pickup Tube

1. Remove engine oil pan. (See REMOVE ENGINE OIL PAN earlier in this group.)

NOTE: On engine option code 1903, oil pickup tube is mounted on the oil pan with two cap screws.

2. Remove three cap screws securing pickup tube to cylinder block and remove tube assembly with gasket.

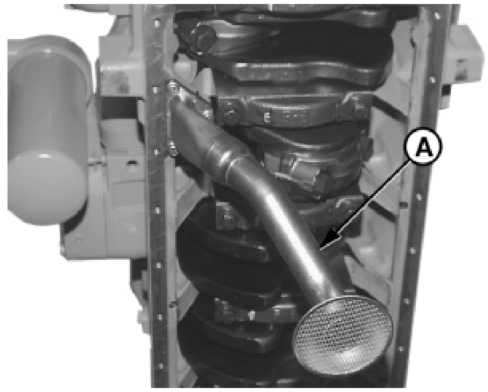
3. Clean pickup tube and screen completely with solvent. Dry with compressed air.

4. Inspect pickup screen for damage or holes. Inspect tube for weld breaks, bends, or any other damage. Replace as necessary.

5. Install pickup tube assembly to cylinder block using a new gasket. Tighten cap screws to specifications.

Specification

Oil Pickup Tube-to-Block Cap Screws—Torque	35 N•m (26 lb-ft)
Oil Pickup Tube-to-Oil Pan Cap Screws—Torque	25 N•m (18 lb-ft)



RG8122 –UN–20NOV97

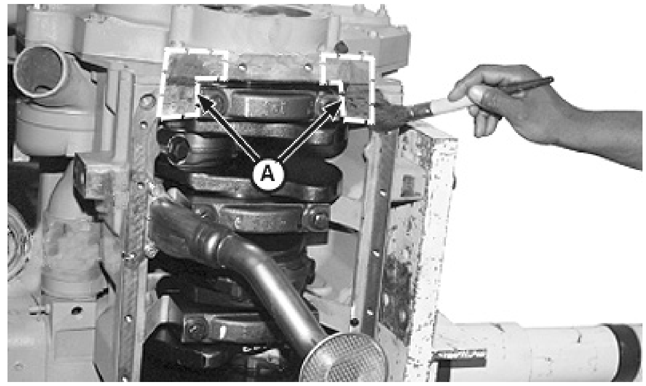
Oil Pickup Tube

A—Pickup Tube

RG,RG34710,218 –19–13AUG99–1/1

Install Engine Oil Pan

NOTE: When installing the oil pan gasket and pan, ensure that the oil pan bolts are installed loosely (leave approximately 1/4 inch gap between the pan and block pan rail).This will allow the gasket to center itself to the bolt and block pattern. Once the bolts are installed, follow the torque sequence defined later in this group.



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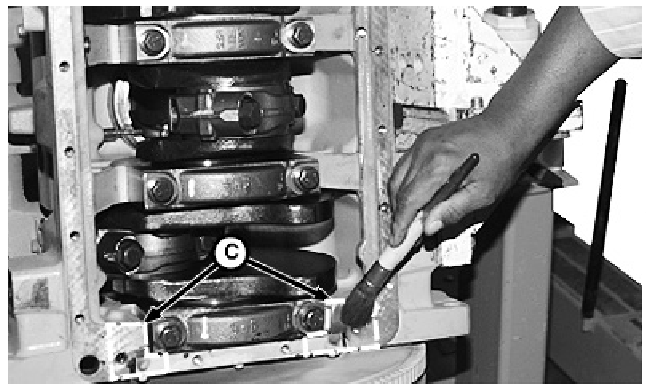

RG10274 –UN–06AUG99

Sealant Applications—Rear Rail

A—Front T-Joints
C—Rear T-Joints

All oil pan and cylinder block gasket sealing surfaces (including timing gear cover and rear seal housing) MUST BE free of gasket material and oil. Surface must be dry.

1. Apply LOCTITE® 7649 Solventless Primer to two front T-joint areas (A). At close to 5 minutes, apply a 3 mm (1/8 in.) bead of LOCTITE® 17430 High Flex Form-In-Place Gasket.

2. Apply a 3 mm (1/8 in.) bead of LOCTITE® 17430 High Flex Form-In-Place Gasket to two rear T-joint areas (C), and on inside edge of both cap screw holes for rear oil seal housing.

3. Position new oil pan gasket on cylinder block.

4. Apply a 3 mm (1/8 in.) bead of LOCTITE® 17430 High Flex Form-In-Place Gasket to face of oil pan gasket at same T-joint locations (A) and (C) on cylinder block in steps 1 and 2 above.

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RG,RG34710,219 –19–24SEP02–1/2

NOTE: Locate rear of oil pan flush to ± 0.05 mm (0.002 in.) with rear face of cylinder block.

5. Carefully install oil pan on cylinder block and tighten all oil pan-to-cylinder block cap screws in sequence shown to specifications. Start at right rear corner of oil pan (facing toward flywheel end) and proceed counterclockwise according to the sequence.

Specification

Oil Pan-to-Cylinder Block Cap Screws—Torque .... 25 N•m (18.5 lb-ft) plus 90° Turn Clockwise

6. Tighten oil pan-to-rear oil seal housing and oil pan-to-timing gear cover cap screws to specification.

Specification

Oil Pan-to-Rear Oil Seal Housing Cap Screws—Torque .... 25 N•m (18.5 lb-ft) plus 90° Turn Clockwise

Oil Pan-to-Timing Gear Cover Cap Screws—Torque .... 25 N•m (18.5 lb-ft) plus 90° Turn Clockwise

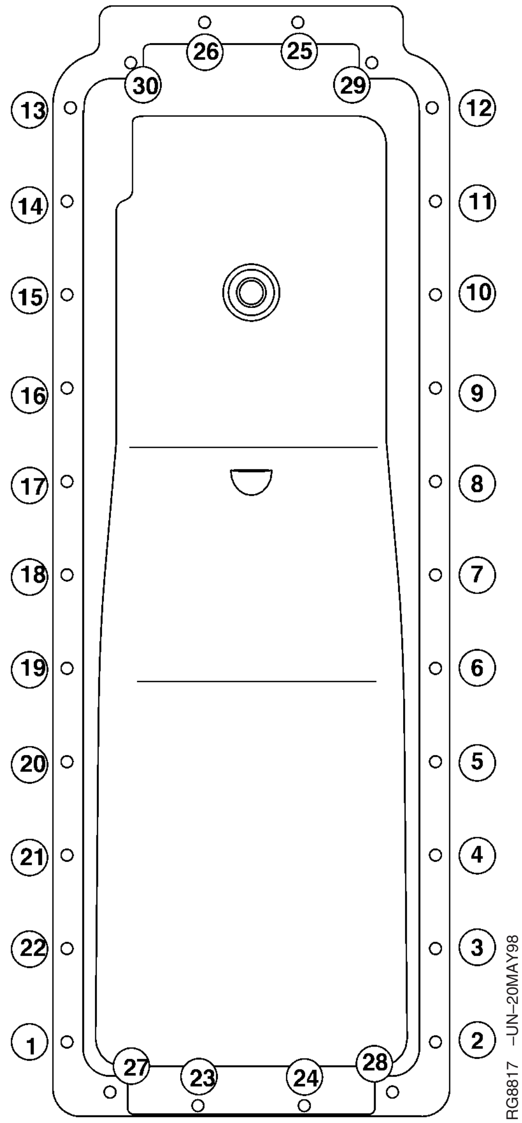
7. Install oil pan drain plug using a new O-ring and tighten to specifications.

Specification

Oil Pan Drain Plug 1-1/4 in. Hex Plug—Torque.. 46 N•m (34 lb-ft)

Oil Pan Drain Plug 1-1/2 in. Hex Plug—Torque.. 64 N•m (47 lb-ft)

8. If equipped, coat threads of drain hose and drain valve with LOCTITE® 592 Pipe Sealant with TEFLON®. Install and tighten securely.



Oil Pan Torque Sequence

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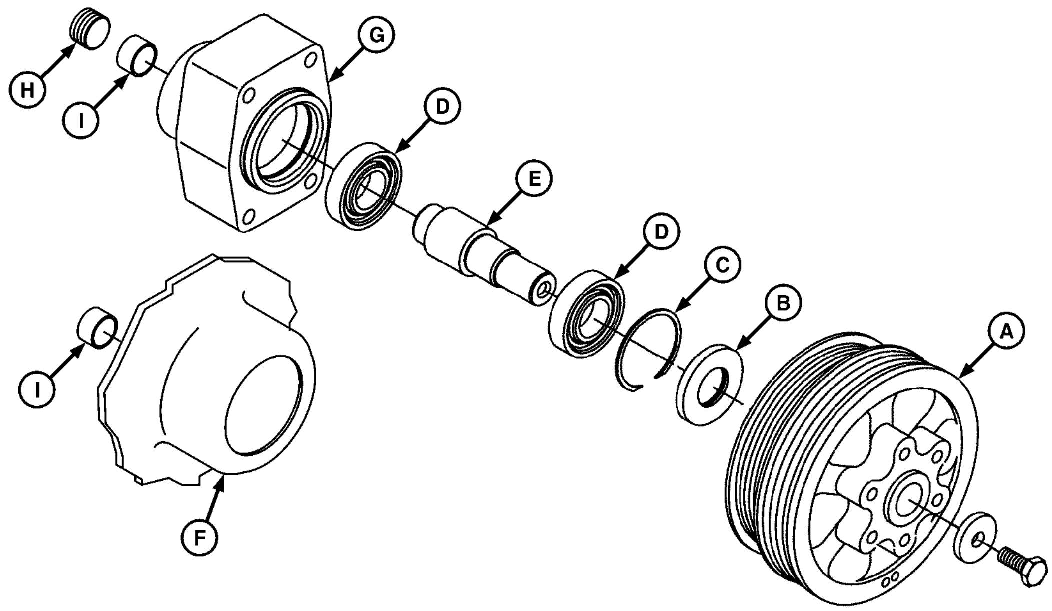
TEFLON is a registered trademark of Du Pont Co.

RG,RG34710,219 –19–24SEP02–2/2

Replace Bearings in Fan Drive Assembly



Fan Drive Exploded View

A—Fan Hub/Pulley
B—Grease Seal
C—Snap Ring
D—Ball Bearing (2 used)
E—Shaft
F—Bearing Housing (Fixed)[1]
G—Bearing Housing (Adjustable)
H—Pipe Plug
I—Plug

Disassemble Fan Drive

1. Remove V-belts and remove fan.

2. Using a suitable puller, remove fan hub (A) from shaft (E).

NOTE: ON engines with fixed fan drive assembly cast into camshaft gear access cover, cover must be removed from engine. (See REMOVE TIMING GEAR COVER in Group 040.)

3. Remove fan drive assembly from engine.

NOTE: Early adjustable bearing housings (G) will use threaded type pipe plug (H). Fixed bearing housings (F) and later adjustable bearing housings (G) will use press in type plug (I).

4. Remove pipe plug (H) or plug (I), grease seal (B), and snap ring (C). Discard seal and snap ring.

5. Remove shaft with bearings (D) by lightly tapping end of shaft (through pipe plug opening) with a hammer and brass drift.

6. Remove bearings from shaft using a bearing puller. Discard bearings.

7. Thoroughly clean and inspect shaft and bearing housing (F or G) for cracks or any other damage. Measure parts and compare with specifications given below.

[1] *Bearing housing is cast into camshaft gear access cover.*

Continued on next page

RG19661,0000154 –19–11JAN06–1/4

Specification

Heavy Duty Fan Drive—	
Housing ID	71.999—72.025 mm (2.8346—2.8356 in.)
Shaft OD	35.001—35.017 mm (1.3780—1.3786 in.)
Bearing ID	34.987—35.013 mm (1.3774—1.3785 in.)
Bearing OD	71.987—72.013 mm (2.8341—2.8351 in.)

Replace parts that are cracked or not within specification.

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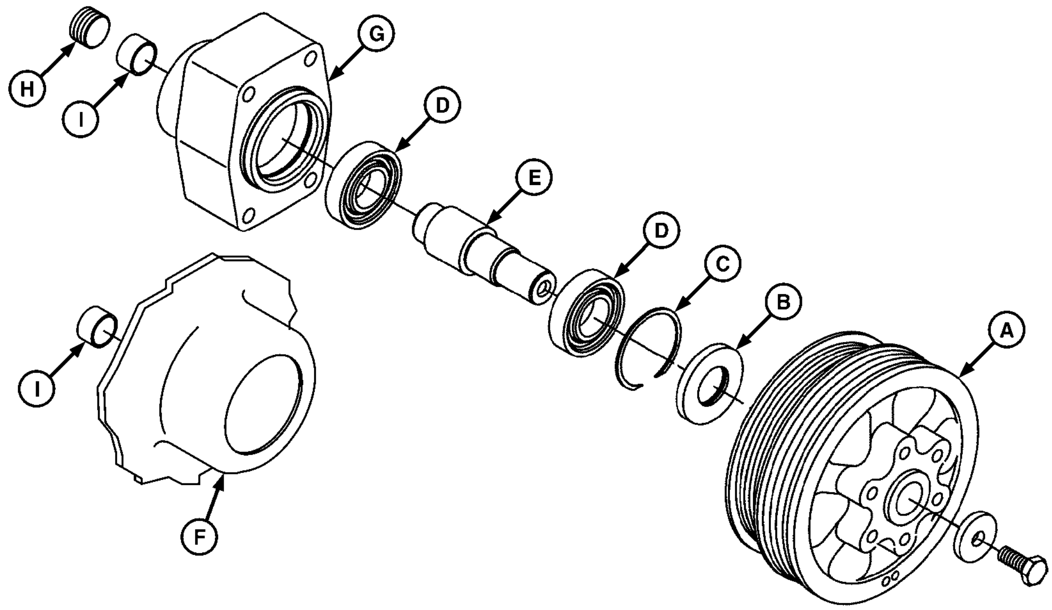
RG19661,0000154 –19–11JAN06–2/4



Fan Drive Exploded View

A—Fan Hub/Pulley
B—Grease Seal
C—Snap Ring
D—Ball Bearing (2 used)
E—Shaft
F—Bearing Housing (Fixed)[1]
G—Bearing Housing (Adjustable)
H—Pipe Plug
I—Plug

Assemble Fan Drive

1. Pack inner and outer bearings (D) with TY6333 or TY6347 High Temperature Grease. Apply clean engine oil to bearing ID and shaft OD

2. Support end of shaft (E) and install bearings against shoulder on each end of shaft. Apply force to bearing inner race only.

3. Support bearing housing (F or G) on a firm flat surface with bearing bore in the upward position.

4. Install bearing and shaft assembly into housing using JDG743A Bearing Driver. Small end of shaft should extend through housing.

5. Determine proper snap ring (C) thickness needed to obtain specified end play.

Specification

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.

NOTE: Install grease seal (B) with seal spring toward engine.

7. Apply a thin coat of clean engine oil to OD of seal casing (B) and to seal lips. Using a driver that contacts flat outside case of seal, press seal in housing bore until metal casing is flush to 0.50 mm (0.020 in.) below housing face.

[1] Bearing housing is cast into camshaft gear access cover.

Continued on next page

IMPORTANT: On engines with fixed pulleys, be sure the lower right access cover cap screw (3, in diagram on this page) is installed in the camshaft gear access cover before the pulley (A, figure on previous page) is pressed on. Otherwise, pulley will interfere with installation of this cap screw.

8. Apply clean engine oil to ID of fan hub/pulley (A, figure on previous page). Support end of shaft through pipe plug hole in bearing housing. Using a driver that bears on outside finished edge of hub, press hub onto other end of shaft until it bottoms against shoulder. Do not hammer fan hub onto shaft.

9. Install washer and cap screw. Tighten cap screw to specifications.

Specification	
Fan Drive Hub-to-Shaft—Torque	115 N•m (85 lb-ft)

On engines with dual pulleys, tighten pulley-to-pulley cap screws to the following specifications.

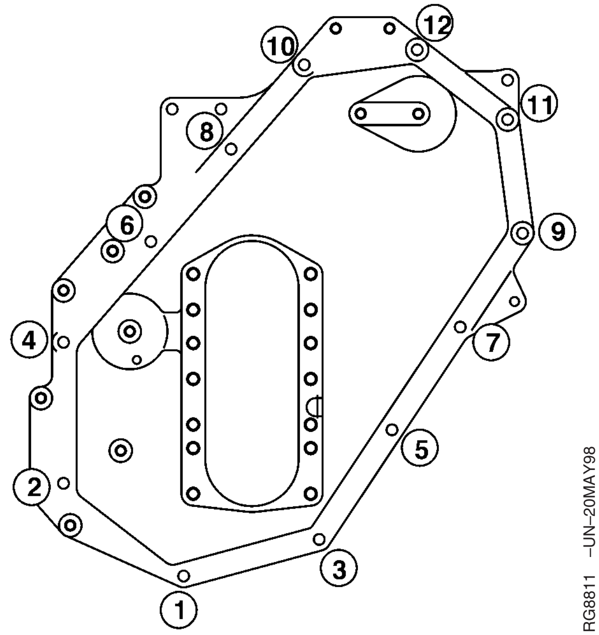
Specification	
Fan Pulley-to-Pulley Cap Screws—Torque	61 N•m (45 lb-ft)

10. On fixed fan drive and adjustable fan drive assemblies, plug (I, figure on previous page) should be driven in flush to slightly recessed in rear surface of camshaft gear access cover.

11. Install adjustable fan drive assembly onto engine and tighten cap screws to specifications.

Specification	
Adjustable Fan Drive-to-Camshaft Gear Access Cover Cap Screws—Torque	90 N•m (66 lb-ft)

To install fixed fan drive/camshaft gear access cover assembly, see INSTALL TIMING GEAR COVER in Group 040.



Camshaft Gear Access Cover

RG19661,0000154 –19–11JAN06–4/4

Inspect and Check Belt Tensioner Spring Tension

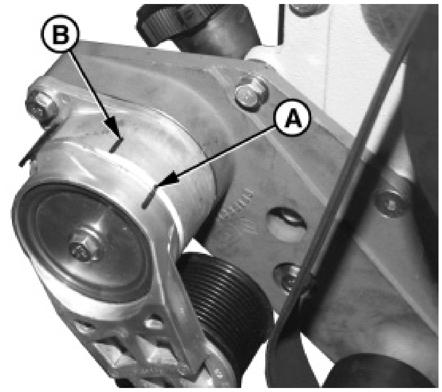
Checking Lower Tensioner Spring Tension

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:

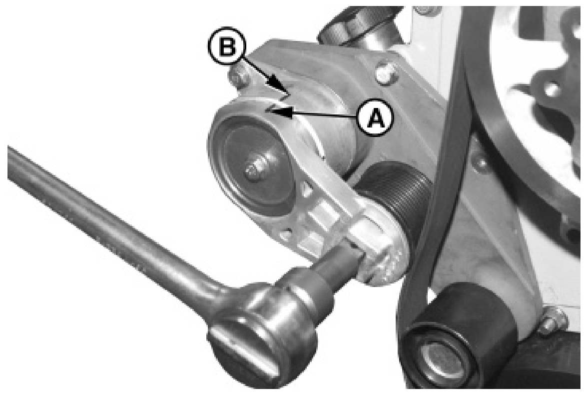
1. Release tension on belt using a long-handle 3/4-in. breaker bar in tension arm. Remove belt from pulleys.
2. Release tension on tension arm and remove breaker bar.
3. Put a mark (A) on swing arm of tensioner as shown.
4. Measure 25 mm (1.0 in.) from first mark (A) and put a second mark (B) on tensioner mounting base.
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 Lower Spring—
Tension .... 81—99 N•m (60—73 lb-ft)



Marking Lower Belt Tensioner



Testing Lower Tensioner

A—Mark on Swing Arm
B—Mark on Tensioner Base

Continued on next page RG,RG34710,225 –19–30SEP97–1/2

Checking Upper 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.

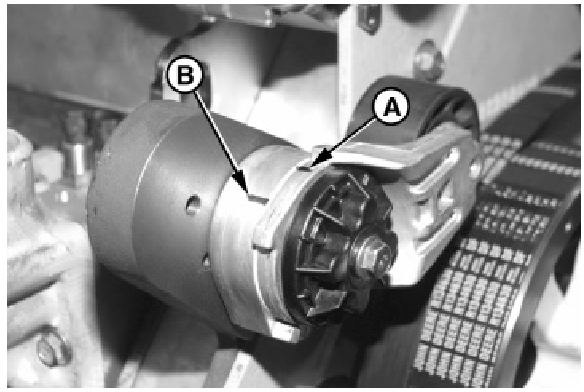
4. Measure 21 mm (0.83 in.) from first mark (A) and put a second mark (B) on tensioner mounting base.

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.

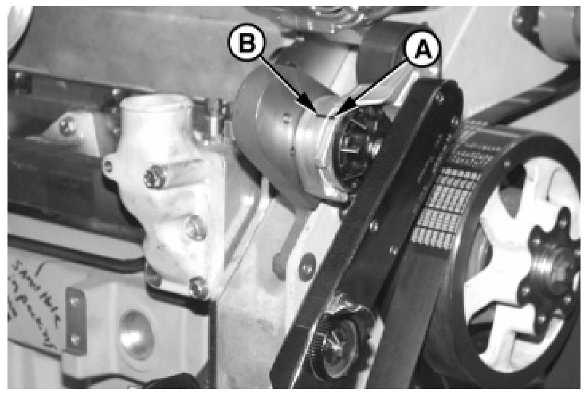
Specification

Belt Tensioner Upper Spring—
Tension .... 18—23 N•m (13—17 lb-ft)



RG8727 –UN–10DEC97

Marking Upper Belt Tensioner



RG8726 –UN–10DEC97

Testing Upper Tensioner

A—Mark on Swing Arm
B—Mark on Tensioner Base

RG,RG34710,225 –19–30SEP97–2/2

Replace Belt Tensioner Assembly

Follow same procedure for replacement of upper (A) and lower (C) belt tensioner.

1. Release tension on pulley and remove belt.

2. Check spring tension on tensioner. (See INSPECT AND CHECK BELT TENSIONER SPRING TENSION earlier in this group.)

NOTE: Later cam access covers will have two locator holes for positioning of the upper belt tensioner. Mark location of hole being used for ease of installation.

3. Remove cap screw and remove the tensioner assembly.

NOTE: If cam access cover is equipped with two upper tensioner locating holes, reinstall upper tensioner using locating hole previously marked on disassembly.

Apply LOCTITE® 242 Thread Lock and Sealer (TY9473) to tensioner shoulder bolt or cap screw before installing.

4. Install tensioner using locator in upper tensioner only and tighten shoulder bolt or flanged head cap screw to specifications.

Specification

Belt Tensioner Shoulder Bolt or Flanged Head Cap Screw—Torque .... 50 N•m (37 lb-ft)

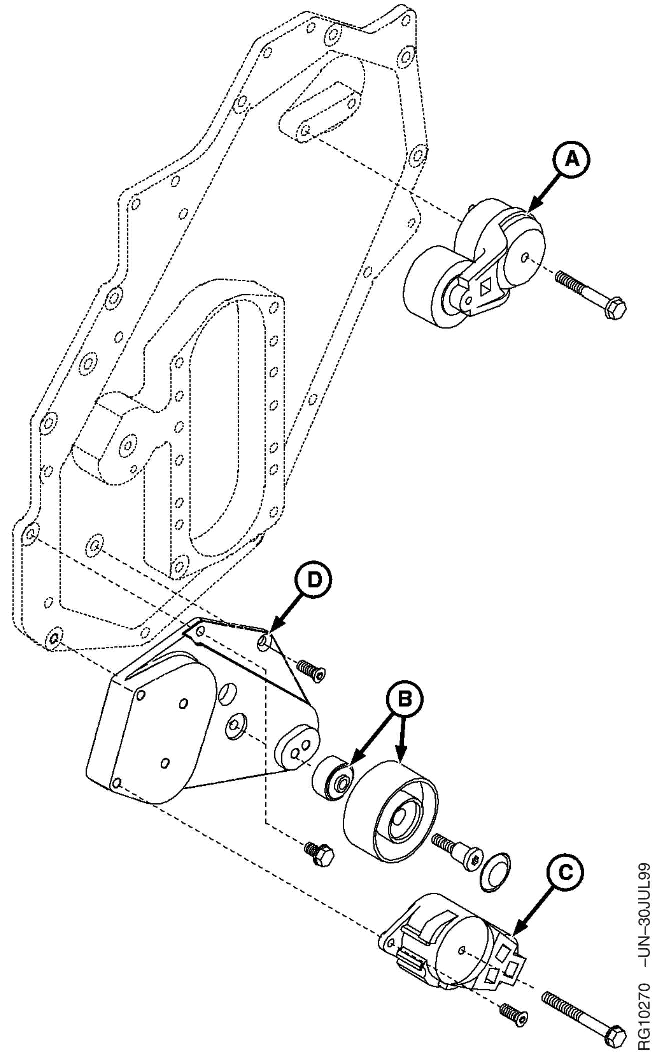
NOTE: Apply LOCTITE® 242 Thread Lock and Sealer (TY9473) to idler pulley mounting cap screw before installing.

5. Install idler pulley assembly.

6. Tighten idler pulley (B) cap screw to specifications.

Specification

Fan Belt Idler Pulley—Torque .... 68 N•m (50 lb-ft)



Upper and Lower Belt Tensioners

A—Upper Belt Tensioner
B—Belt Idler Pulley Assembly
C—Lower Belt Tensioner
D—Lower Tensioner Bracket

Continued on next page

RG,RG34710,226 –19–18SEP02–1/2

7. Install belt and position onto tensioner.

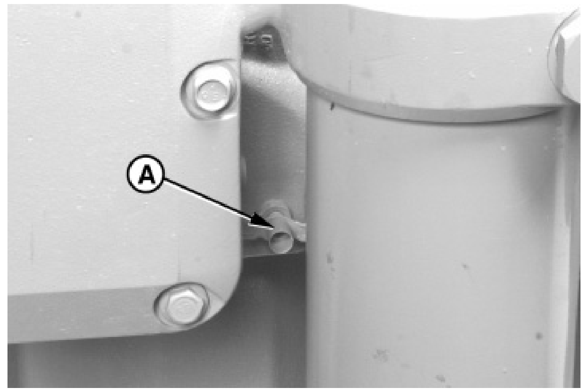
RG,RG34710,226 –19–18SEP02–2/2

Remove Coolant Pump

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

1. Loosen radiator pressure cap and open coolant drain valve (A) on oil cooler housing. Drain all coolant from engine block.

A—Coolant Drain Valve



RG8246 –UN–06DEC97

Coolant Drain Valve

RG19661,000014F –19–09JAN06–1/2

2. Some applications will require the removal of the primary fuel filter/water separator (A) and mounting bracket.

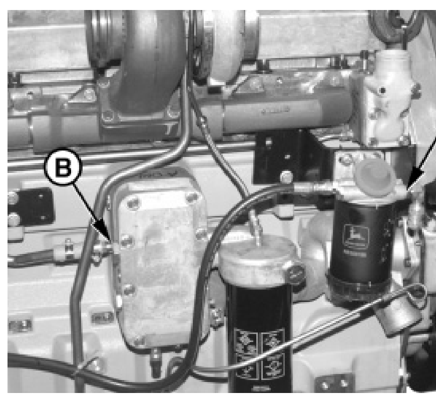
3. On all engines, remove engine oil cooler and housing assembly (B). (See REMOVE OIL FILTER AND VALVE HOUSING/OIL COOLER COVER AND VALVE HOUSING, in Group 060.)

4. Disconnect coolant pump-to-thermostat housing bypass hose and remove from coolant pump tube fitting.

5. Remove three cap screws securing coolant pump-to-front plate and remove coolant pump (C).

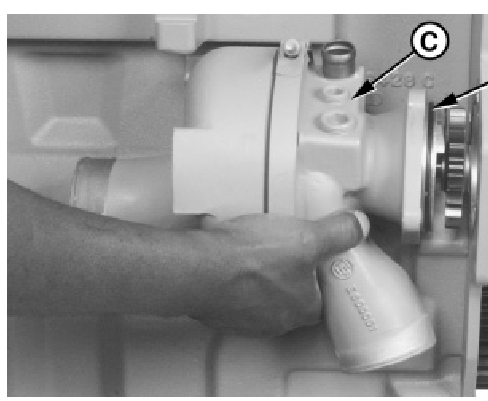
6. Remove and discard O-ring (D).

A—Primary Fuel Filter/Water Separator
B—Oil Cooler and Housing Assembly
C—Coolant Pump
D—O-Ring



RG8825 –UN–26JUL99

Removing Primary Fuel Filter



RG8261B –UN–06DEC97

Removing Coolant Pump

RG19661,000014F –19–09JAN06–2/2

Clean and Inspect Coolant Pump Parts

NOTE: There are no serviceable parts for the coolant pump. Do not disassemble pump. Replace entire assembly as required. Coolant pump assemblies are available through John Deere service parts as complete remanufactured assemblies.

1. Clean all parts with solvent and dry with compressed air.

2. Inspect coolant pump cover (A) and housing (C) for cracks or damage.

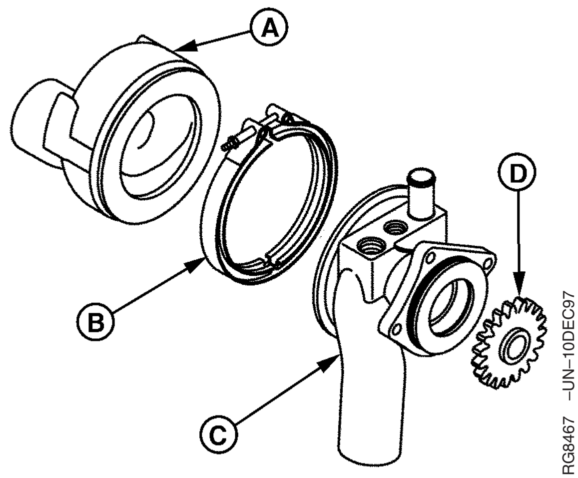
3. Inspect gear (D) for damage.

4. Be sure the “weep hole” in housing is clear and install new foam filter if required.

5. If removed, install coolant pump cover (A) with new O-ring. Tighten band clamp (B) to specifications.

Specification

Coolant Pump Housing-to-Cover
Band Clamp—Torque.. 10 N•m (7.5 lb-ft)

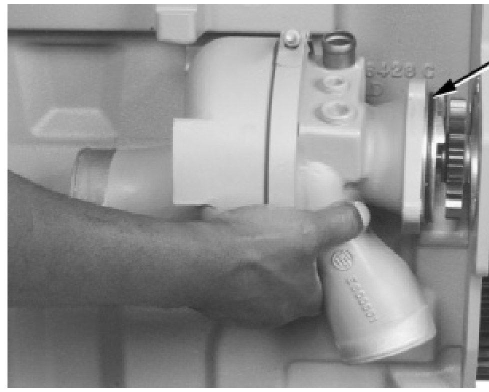


Coolant Pump Part Inspection

A—Coolant Pump Cover
B—Band Clamp
C—Pump Housing
D—Drive Gear

RG,RG34710,229 –19–29NOV00–1/1

Install Coolant Pump



Installing Coolant Pump

A—O-Ring

1. Install a new O-ring (A) on coolant pump mounting flange. Coat O-ring with clean engine oil.

2. Position thermostat housing-to-coolant pump bypass hose onto tube on coolant pump.

3. Install coolant pump to front plate. Be careful not to cut or damage O-ring.

NOTE: Apply LOCTITE® 242 Thread Lock and Sealer (TY9473) to coolant pump cap screws before installing.

4. Install three coolant pump-to-front plate cap screws and tighten to specifications.

Specification
Coolant Pump-to-Front Plate Cap Screws—Torque .... 50 N•m (37 lb-ft)

5. On engines with removable coolant pump inlet elbow, install elbow and tighten cap screws to following specifications.

Specification
Coolant Pump Inlet Elbow to Housing Cap Screws—Torque .... 41 N•m (30 lb-ft)

6. Install oil cooler and housing assembly. (See INSTALL OIL COOLER/OIL FILTER VALVE HOUSING ASSEMBLY OR OIL COOLER COVER/VALVE HOUSING ASSEMBLY in Group 060.)

7. Install all hoses and tighten hose clamps securely.

Specification
Coolant Bypass Hose Clamp—Torque .... 6 N•m (4.5 lb-ft)
Oil Cooler-to-Coolant Pump Hose Clamp—Torque .... 9 N•m (7 lb-ft)

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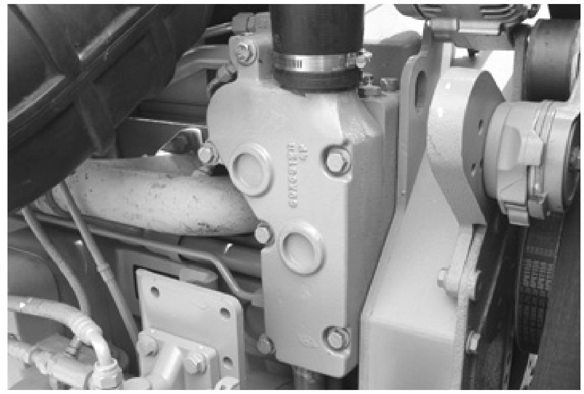
RG,RG34710,231 –19–29NOV00–1/1

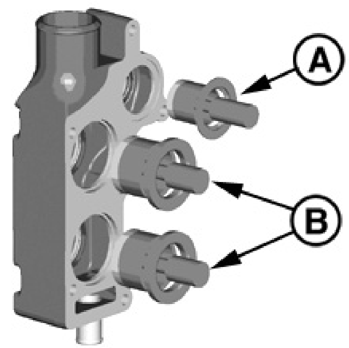
Remove and Install Thermostat Cover and Thermostats

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



RG14924 –UN–01SEP06

Thermostat Cover



RG14923 –UN–01SEP06

Thermostats

A—EGR Coolant Thermostat
B—Engine Coolant Thermostats

Remove Thermostat Cover and Thermostats

1. Visually inspect area around thermostat cover for leaks. Partially drain cooling system.

2. Loosen upper radiator hose and outer coolant bypass hose clamp.

3. Loosen top liner cooling return line front and rear fittings and remove.

4. Remove cap screws securing thermostat cover to thermostat housing.

5. Remove thermostat cover from thermostat housing.

6. Remove gasket or seal and remove EGR thermostat (A) and engine coolant thermostats (B).

7. Test each thermostat for proper opening temperature. (See TEST THERMOSTAT OPENING TEMPERATURE later in this group.)

Continued on next page RG19661,0000174 –19–05SEP06–1/2

Install Thermostats and Thermostat Cover

1. Clean all material from thermostat cover mounting surfaces.

2. Insert cover in outer coolant bypass hose and place thermostat cover in position using a new gasket or seal.

3. Install thermostats and tighten thermostat cover cap screws to specifications.

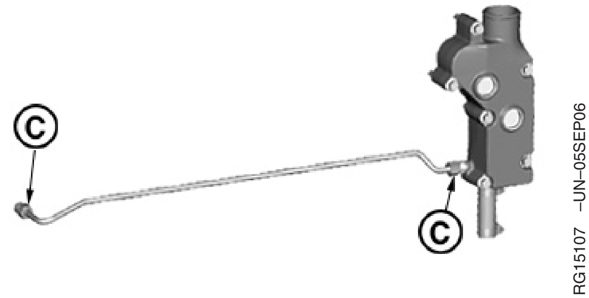
Specification
Thermostat Cover Cap Screws—
Torque .... 50 N•m (37 lb-ft)

4. Lubricate O-ring for the top liner cooling return line fitting with petroleum jelly and install line. Tighten fittings (C) to specifications.

Specification
Coolant Line Fittings—Torque.................................... 13.5 N•m (10 lb-ft)

5. Tighten upper radiator hose and outer bypass coolant hose clamp to specifications.

Specification
Hose Clamp—Torque.. 8 N•m (6 lb-ft) (71 lb-in.)



Upper Cylinder Coolant Line

RG19661,0000174 –19–05SEP06–2/2

Test Thermostat Opening Temperature

1. Remove thermostats. (See REMOVE THERMOSTATS earlier in this group.)

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

2. Visually inspect thermostats for corrosion or damage. Replace thermostats as a matched set as necessary.

3. Suspend thermostats and a thermometer in a container of water.

4. Stir the water as it heats. Observe opening action of thermostat and compare temperatures with specification given in chart below.

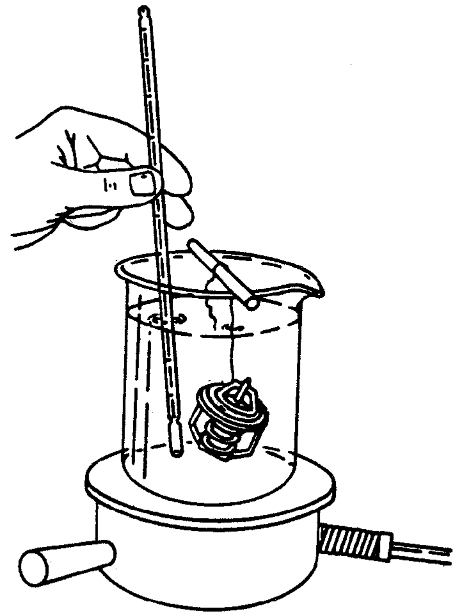
Specification

Thermostat Test—Rating	82°C (180°F)
Initial Opening (Range) Temperature	80—84°C (175—182°F)
Full Open (Nominal) Temperature	94°C (202°F)

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

5. 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.

6. If any one thermostat is defective, replace both thermostats.



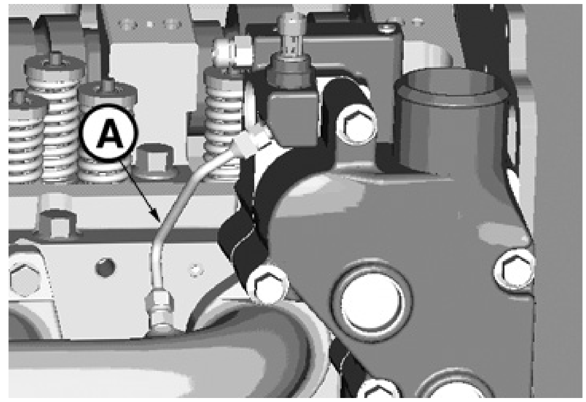
RG5971 –UN–23NOV97

Testing Thermostats

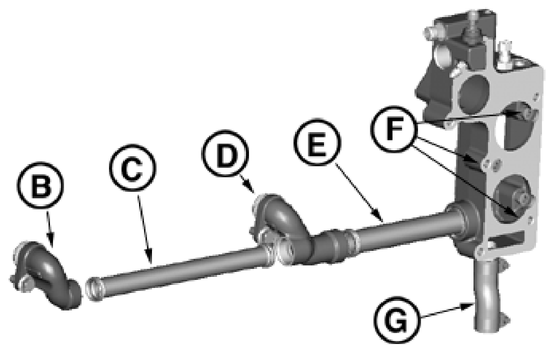
RG,RG34710,234 –19–30SEP97–1/1

Remove and Install Thermostat Housing and Coolant Tubes

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



Exhaust Temperature Tube



Thermostat Housing and Coolant Tubes

A—Exhaust Temperature Tube
B—Rear Coolant Manifold
C—Rear Coolant Tube
D—Front Coolant Manifold
E—Front Coolant Tube
F—Housing Socket Head Cap Screws
G—Inner Coolant Bypass Hose

Remove Thermostat Housing and Coolant Tubes

1. Remove exhaust temperature tube (A).
2. Remove thermostat cover. (See REMOVE THERMOSTAT COVER earlier in this group.)
3. Remove rear coolant manifold (B) and rear tube (C).
4. Remove front coolant manifold (D) and front coolant tube (C).
5. Loosen inner coolant bypass hose clamps.
6. Loosen three socket head cap screws (F) and remove thermostat housing from cylinder block and remove housing from bypass hose (G).

Install Thermostat Housing and Coolant Tubes

1. Insert thermostat housing into inner coolant bypass hose (G).
2. Place housing in a tilted position against the cylinder block and position the gasket using the socket head cap screws (F) as a guide as the housing is attached to the cylinder block. Tighten the cap screws to specifications. Tighten inner bypass hose clamp to specifications.

Specification

Thermostat Housing Cap screws—Torque.. 50 N•m (37 lb-ft)

Specification

Hose Clamp—Torque... 8 N•m (6 lb-ft) (71 lb-in.)

Continued on next page

3. Apply petroleum jelly lubricant to both O-rings on the front coolant tube (E). Insert the tube into the thermostat housing until the tube bottoms out in the housing. Insert the front coolant manifold (D) on the other end of the coolant tube and assemble to the cylinder block. Tighten the cap screw to specification.

Specification	
Front Coolant Manifold Cap Screw—Torque	50 N•m (37 lb-ft)

4. Apply petroleum jelly lubricant to both O-rings on the rear coolant tube (C) and insert into the front coolant manifold (B) until it bottoms out. Insert the rear coolant manifold on the other end of the coolant tube and assemble to the cylinder block. Tighten cap screw to specification.

Specification	
Rear Coolant Manifold Cap Screw—Torque	50 N•m (37 lb-ft)

5. Install exhaust temperature tube (A) and tighten fittings to specification.

Specification	
Exhaust Temperature Tube Fittings—Torque	20 N•m (15 lb-ft)

RG19661,000017D –19–06SEP06–2/2

Remove and Install Coolant Heater—if Equipped

CAUTION: To avoid shock or hazardous operation, always use a three-wire heavy-duty electrical cord. If a two-to-three contact adapter is used at the wall receptacle, always connect green wire to a good ground. Keep electrical connectors clean to prevent arcing.

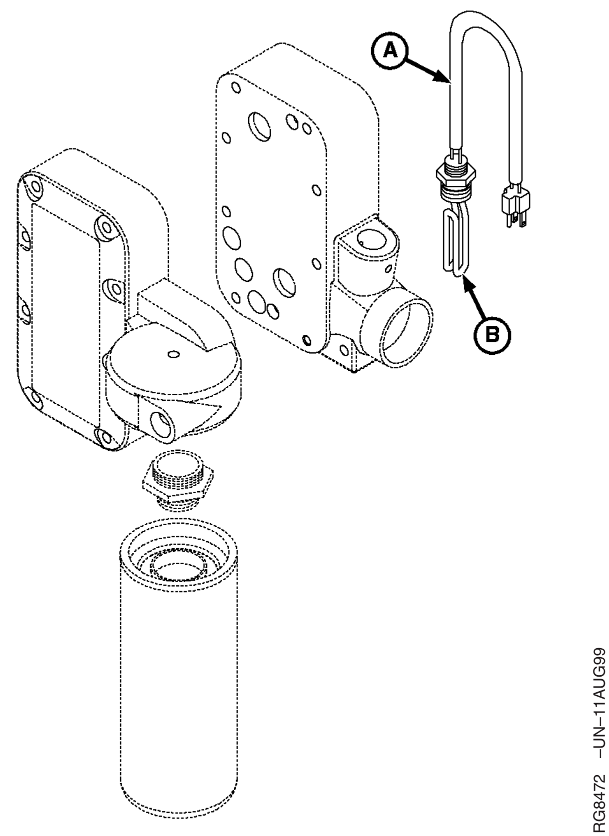
Only plug coolant heater into electrical power if heating element is immersed in coolant. Otherwise sheath could burst, causing personal injury.

Testing Coolant Heater

1. Unplug heater from electrical power source.
2. Partially drain cooling system.
3. Remove electrical cord (A), loosen nut, and pull heater element (B) out of oil cooler housing.

NOTE: The heater element cannot be repaired. If defective, replace it.

4. Apply LOCTITE® 592 Pipe Sealant with TEFLON® (TY9480) to coolant heater threads.
5. Install heater element in oil cooler housing and tighten hex nut securely.
6. Install cord.



Engine Coolant Heater

A—Electrical Cord
B—Heater Element

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TEFLON is a registered trademark of Du Pont Co.

RG,RG34710,236 –19–30SEP97–1/1

Bleed Air from Coolant System

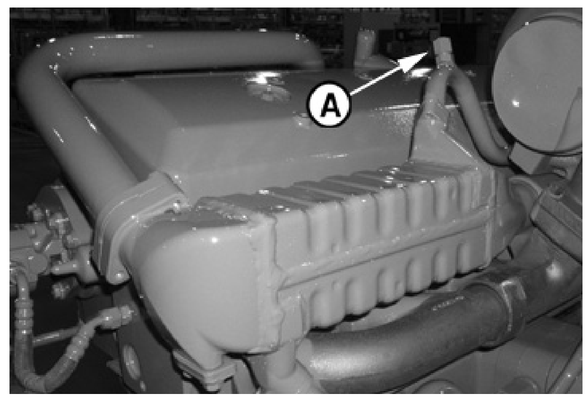

TS281 –UN–23AUG88

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 fitting (A) from top of coolant return line.
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 coolant return line, reinstall fitting and tighten to specification.



RG15740 –UN–30JAN08

Bleed Air from Coolant System

A—Air Bleed Fitting

Specification	
Coolant Return Line Fitting—Torque	20 N•m (15 lb-ft)

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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

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.

RE38635,000012E –19–30JAN08–2/2

Extending Turbocharger Life

Turbochargers are designed to last the life of the engine, but because they operate at such high speeds (100,000 rpm or more), a moment's carelessness can cause them to fail in seconds.

The major causes of turbocharger failures are attributed to:

- 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 principal 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 procedures.

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 possible bearing damage. It can also cause carbon and varnish deposits to form.

Oil Contamination

A second cause of turbocharger failures is contaminated oil. It can be caused by a worn or damaged oil filter or not changing the lube oil at recommended intervals. Expecting the oil filter to remove dirt, sand, metal chips, etc., from the oil before they reach the engine or turbocharger can be a costly mistake because contaminated oil may completely bypass the engine oil filter if the oil filter or oil cooler is clogged, if the filter element is improperly installed, or if the oil is thick during cold weather.

Four good ways of avoiding oil contamination are:

- Always inspect the engine thoroughly during major overhaul. Look especially for any sludge or debris left in lube oil galleries.
- Change lube oil at recommended intervals. Analysis of oil samples at filter change periods can help identify potentially harmful contaminants in the oil.
- Clean the area around the oil fill cap before adding oil.
- Use a clean container when adding oil.

Continued on next page RG,RG34710,1256 –19–23AUG02–1/2

Ingestion of Foreign Objects

A third cause of turbocharger damage is the ingestion of foreign objects. Foreign objects or 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.

RG,RG34710,1256 –19–23AUG02–2/2

Remove and Install Variable Geometry Turbocharger Actuator

IMPORTANT: Disconnect the battery cables before performing any work. Insure power supply is in the "off" position when performing work on the turbocharger actuator or 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.

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.

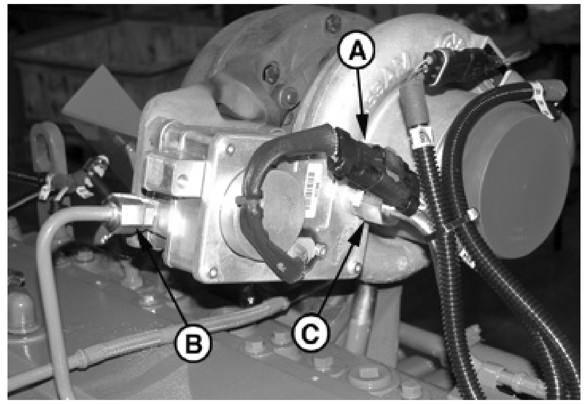
To install the actuator, reverse the steps shown above.

1. Position actuator to bracket and finger tighten 4 hex nuts.

2. Tighten nuts to specification

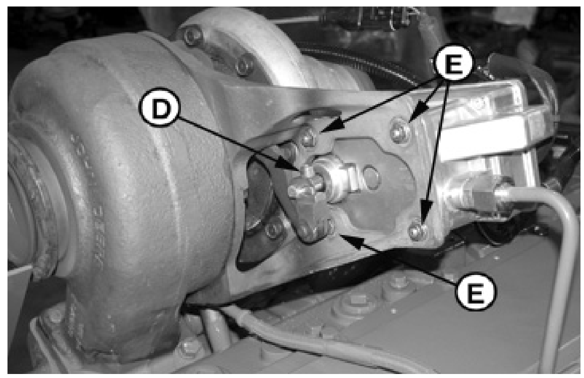
Specification

Actuator to Bracket Hardware—
Torque .... 13.5 N•m (10 lb-ft)



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

Continued on next page RG19661,000014C –19–09JAN06–1/2

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)

RG19661,000014C –19–09JAN06–2/2

Remove and Install Actuator Linkage

Remove Turbocharger Actuator Linkage

NOTE: Use caution when loosening or tightening linkage hardware. Stainless steel screws are brittle and break easily.

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

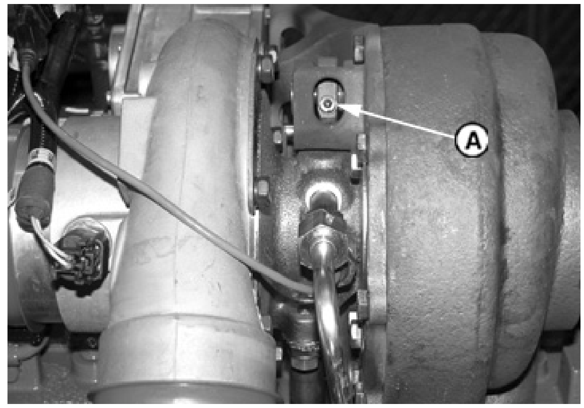
1. Position linkage arm so the inboard (turbocharger shaft) linkage set screw (A) is visible through bracket. Loosen and remove screw.

2. Lift actuator linkage off turbocharger shaft notch (linkage will not slide off end of shaft).

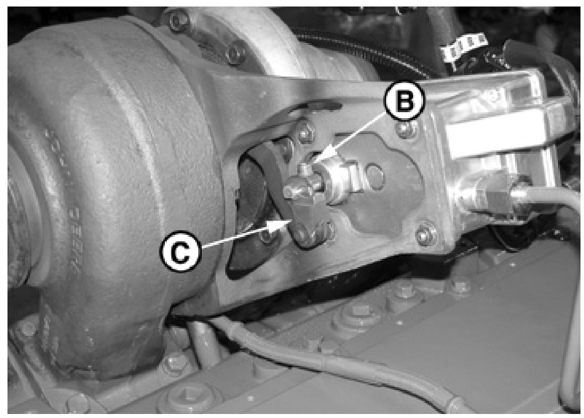
3. Position linkage on actuator shaft to access retainer screw (B). Loosen and remove screw.

4. Lift linkage assembly off notch in actuator shaft and set aside.

A—Actuator Linkage to Shaft Screw - Inboard
B—Actuator Linkage to Shaft - Outboard
C—Actuator Linkage Arm



RG14194 –UN–27MAY05



RG14195 –UN–27MAY05

Actuator Linkage Screw - Outboard Position

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RG19661,000014E –19–09JAN06–1/4

Install Turbocharger Actuator Linkage

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

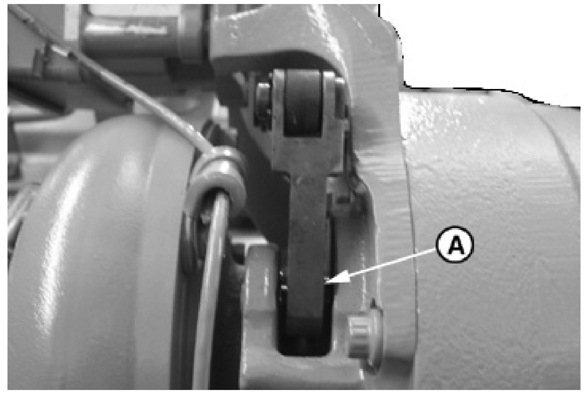
1. Insert linkage onto turbocharger pivot shaft flats (A).

NOTE: Use an open end wrench to exert slight pressure on linkage to align linkage with bolt hole in shaft. Additionally, use a wrench when tightening linkage hardware. Take care that the end link does not rotate on the shaft on an axis perpendicular to the axis of the shaft. This can cause binding of the linkage assembly.

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

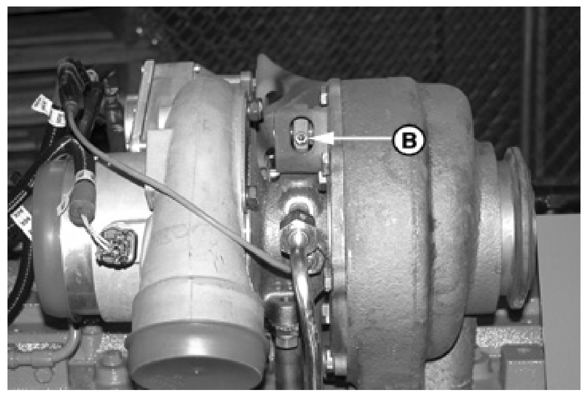
3. Position linkage to notch on turbocharger shaft (B) and assemble linkage over shaft. Install M5 bolt to secure finger tight.

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



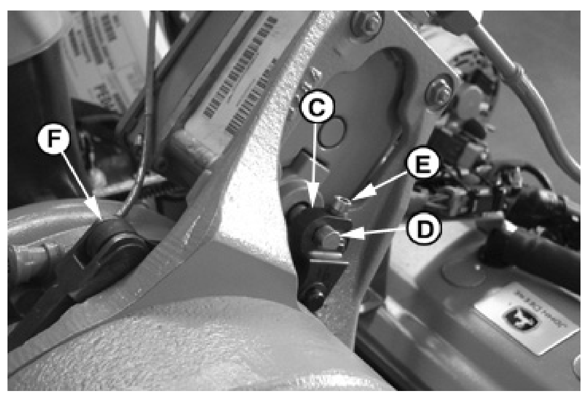
RG14210 –UN–28MAY05

Install Link to Turbocharger Shaft



RG14209 –UN–28MAY05

M5 Bolt - Turbocharger Shaft



RG14211 –UN–28MAY05

Install Link - Actuator Shaft

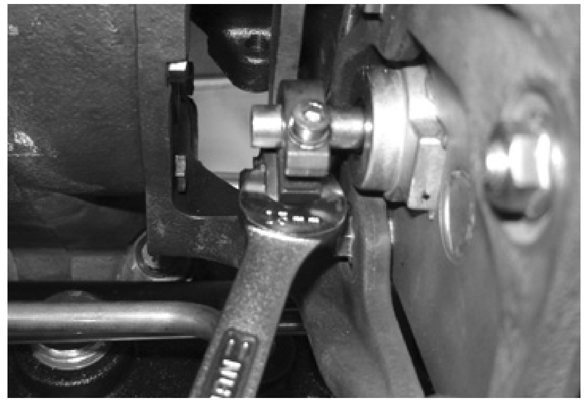
Continued on next page RG19661,000014E –19–09JAN06–2/4

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)



Using Wrench to Support Linkage

Continued on next page RG19661,000014E –19–09JAN06–3/4

5. Check linkage orientation for free travel (as shown) and to be sure there is no binding. The linkage should travel freely through its entire range of travel. Note example of proper linkage adjustment and how the linkage is perpendicular to the shaft.

IMPORTANT: Be constantly aware of any binding in the linkage. Use an open end wrench to align and secure the linkage as hardware is tightened (as shown). After bolts are tightened, linkage should travel freely at all times and return immediately to original position when manually tested. The center pivot joint should have some play when linkage shaft is wiggled. If binding of the linkage is noted, use a wrench to gently pry the end link into necessary position such that linkage moves freely throughout its full range and the binding condition is corrected.

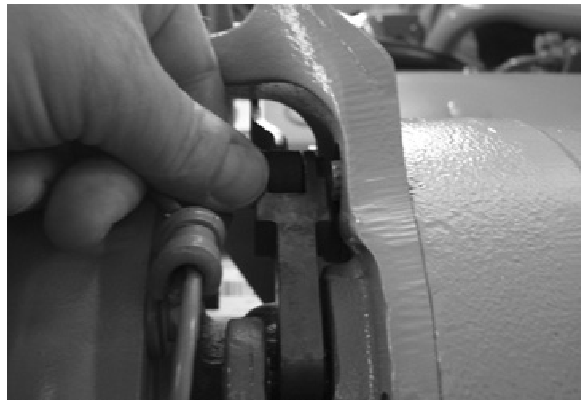
6. Verify again that the linkage moves freely and returns to original position when tested manually.

7. Connect engine harness to VGT actuator to turn on power.

CAUTION: When power to the actuator is “on”, BE CERTAIN to keep fingers clear of linkage when performing diagnostic checks. The linkage actuates very quickly and fingers can be pinched.

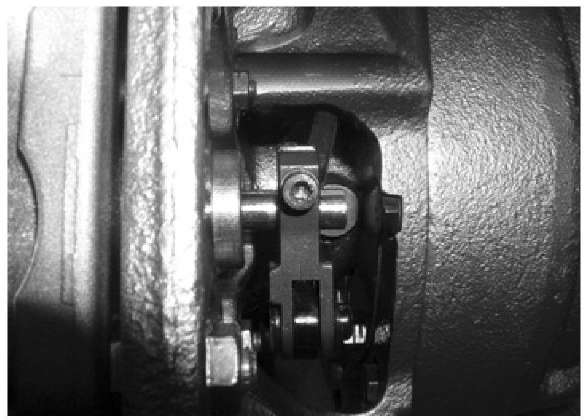
8. Reference Service Advisor, Interactive Test Tab, to run Learn Value Reset Test for actuator and linkage. This test allows the actuator and linkage to check travel stops when running the learn cycle.

9. Conduct a diagnostic check of the harness and actuator. Reference CTM370 for specific procedures.



RG14218 –UN–28MAY05

Check for Linkage Free Travel



RG14474 –UN–12SEP05

Proper Linkage Adjustment

RG19661,000014E –19–09JAN06–4/4

Remove Turbocharger

CAUTION: After operating engine, allow exhaust system to cool before removing turbocharger.

Thoroughly clean exterior of turbocharger and surrounding area to prevent entry of dirt into the air intake system during removal.

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 SEVEN-STEP INSPECTION later in this group.)

1. Refer to your machine technical manual to disconnect air inlet and exhaust piping.

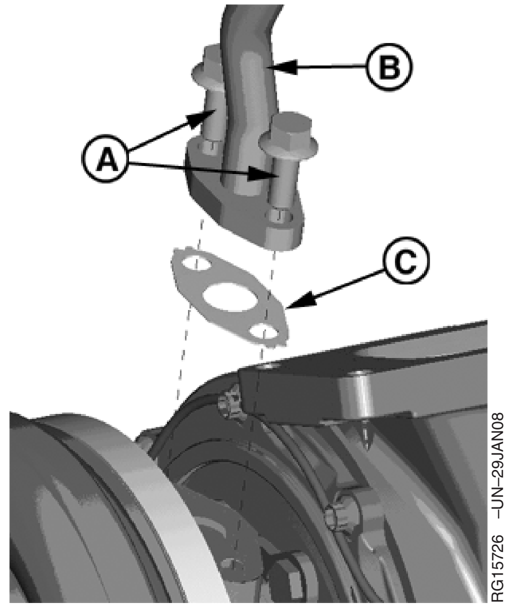
2. Remove turbocharger air intake hose and exhaust elbow. Remove turbocharger air outlet piping (shown removed).

NOTE: Turbocharger shown inverted to illustrate drain line removal.

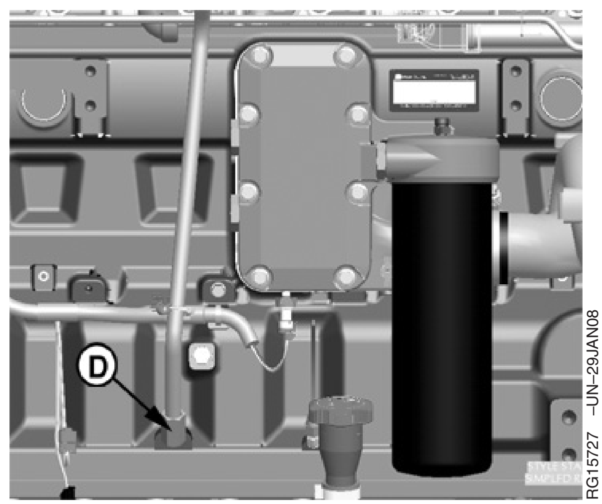
3. Loosen and remove 2 cap screws (A) in drain line flange. Remove drain line gasket (C) and discard.

4. Remove oil drain line from connector (D) in cylinder block. Set drain line aside.

A—Oil Drain Line Cap Screws -2-
B—Oil Drain Line Tube
C—Gasket
D—Oil Drain Line to Cylinder Block



Remove Oil Drain Line - Turbocharger End

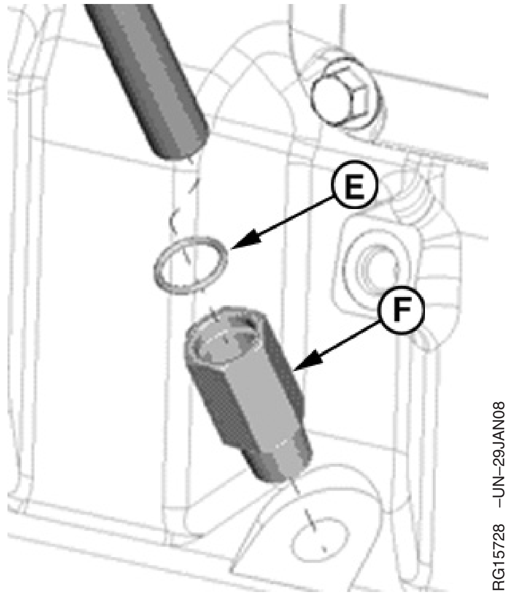


Remove Oil Drain Line - Cylinder Block

Continued on next page RE38635,000012C –19–30JAN08–1/4

5. If necessary, remove oil drain line fitting (F) and O-ring (E) from block.

E—Connector O-ring
F—Connector



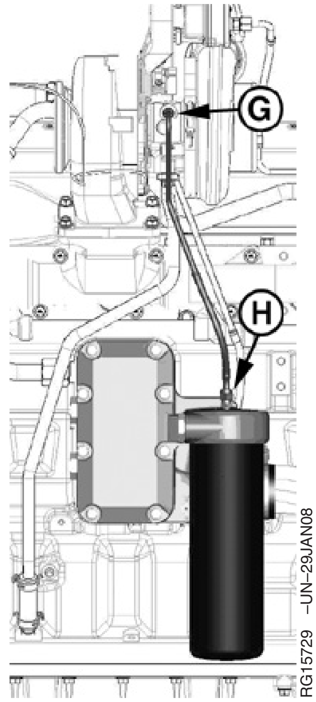
Remove Oil Drain Line Connector

Continued on next page RE38635,000012C –19–30JAN08–2/4

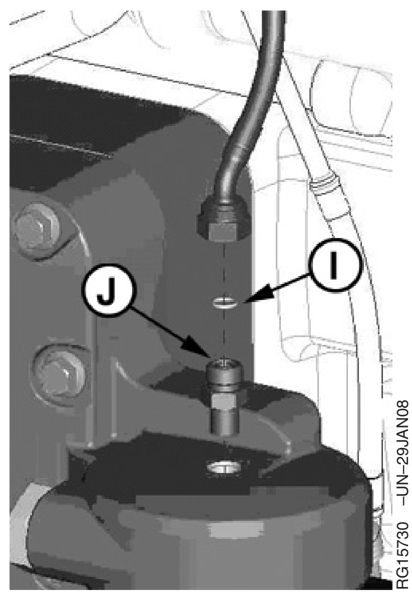
6. Disconnect oil supply line from fittings at turbocharger (G) and oil filter housing (H). Remove oil supply line and set aside.

7. If necessary, remove supply line fitting (J) and O-ring (I) from top of oil filter housing.

G—Oil Supply Line Fitting - Turbocharger End
H—Oil Supply Line Fitting - Oil Filter End
I—O-ring
J—Oil Supply Line Fitting



Remove Oil Supply Line



Remove Oil Supply Line Fitting

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RE38635,000012C –19–30JAN08–3/4

8. Loosen and remove 4 hex nuts (K) and washers securing turbocharger to exhaust manifold.

CAUTION: Turbocharger is very heavy. If possible, use a lifting device to safely handle removing turbocharger from manifold.

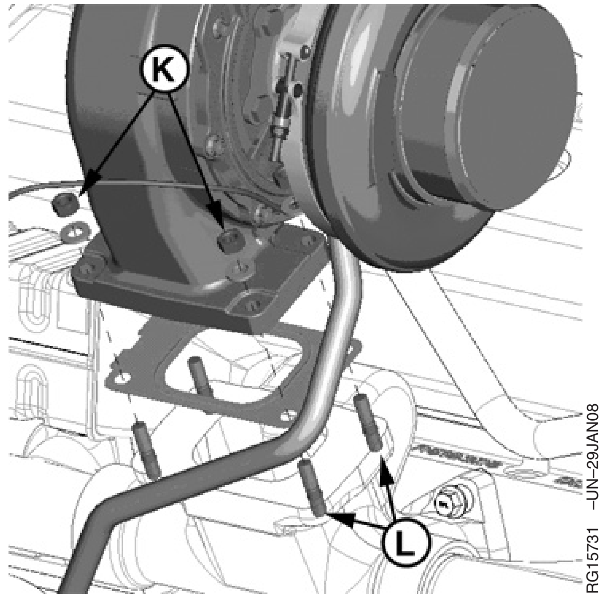
9. Carefully lift turbocharger from 4 studs (L) in exhaust manifold.

10. Place turbocharger on a clean flat surface. Cap or plug all air intake and exhaust openings.

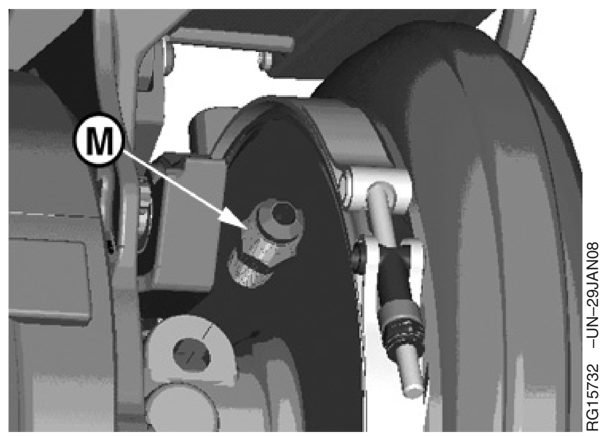
11. If a replacement turbocharger is to be installed, remove oil supply line fitting (M) from turbocharger center housing.

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

K—Turbocharger Hex Nuts -4-
L—Studs - Locate Turbocharger to Exhaust Manifold
M—Oil Supply Line Fitting - Turbocharger Center Housing



Remove Turbocharger



Remove Oil Supply Line Fitting

RE38635,000012C –19–30JAN08–4/4

Turbocharger Failure Analysis

The following is a guide for diagnosing the cause of turbocharger failures after removal from the engine.

Problem	Possible Cause	Suggested Remedy
COMPRESSOR HOUSING INLET DEFECTS		
Foreign Object Damage	Objects left in intake system.	Disassemble and inspect intake system for foreign objects (this group). Inspect engine for internal damage.
	Leaking and/or defective intake system.	Inspect air intake system connections including air filter; repair as required (this group). Inspect air intake related engine components.
Compressor Wheel Rub	Bearing failure.	Determine if engine and/or operator contributed to lack of lubrication, contaminated lubrication, excessive temperature, or debris generating engine failure in progress. Correct as required.
	Manufacturing defects.	Correct as required.
COMPRESSOR HOUSING OUTLET DEFECTS		
Oil and/or Dirt in Housing	Restricted air intake system.	Inspect and clean air cleaner.
	Prolonged periods of low rpm engine idling.	Check with operator to confirm conditions. (See Operator's Manual.)
	Defective oil seal ring.	Repair as required (this group).
	Restricted oil drain line.	Inspect and clear oil drain line as required.
TURBINE HOUSING INLET DEFECTS		
Oil in Housing	Internal engine failure.	Inspect and repair engine as required.
	Oil leaking from compressor housing seal.	Verify that oil is in compressor housing and refer to "Compressor Housing Outlet Defects" as listed earlier in this chart.
Center Wall Deteriorated	Excessive operating temperature.	Check for restricted air intake. Check engine for overfueling.

Continued on next page OUO1004,0000C21 –19–29NOV00–1/2

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. Correct as required.
	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.

OUO1004,0000C21 –19–29NOV00–2/2

Turbocharger Seven-Step 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 seven recommended inspection steps, which are explained in detail on the 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.
- Internal Center Housing.
- Turbocharger Bench 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.*

DPSG,OUO1004,945 –19–28JUL99–1/13

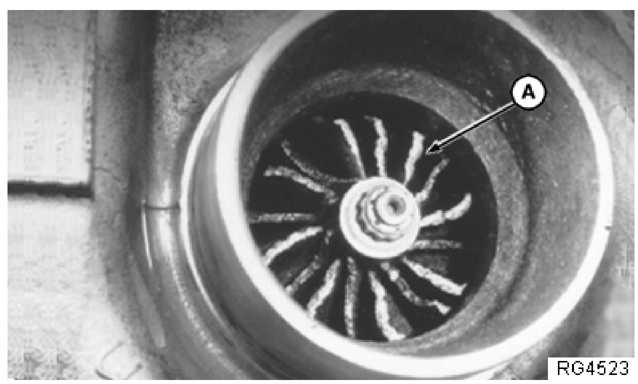
Compressor Housing Inlet and Compressor Wheel

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



RG4523 –UN–03NOV97

Checking Inlet and Compressor Wheel

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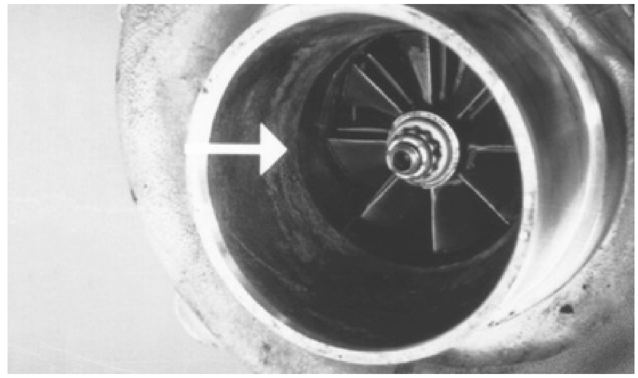
DPSG,OUO1004,945 –19–28JUL99–2/13

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

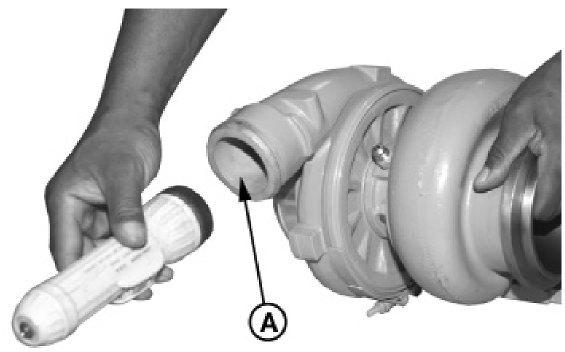
DPSG,OUO1004,945 –19–28JUL99–3/13

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



RG8539 –UN–10DEC97

Checking Compressor Outlet

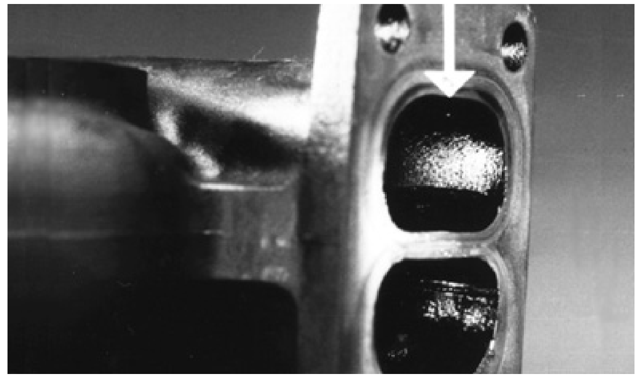
Continued on next page

DPSG,OUO1004,945 –19–28JUL99–4/13

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), indicates excessive exhaust temperature.



RG4526 –UN–05DEC97

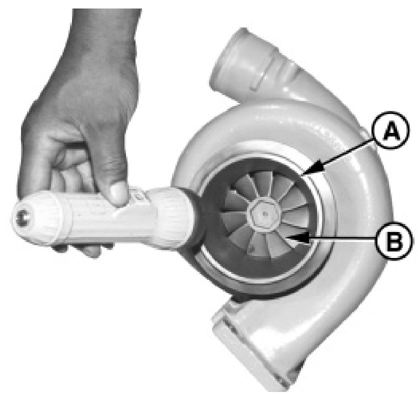
Checking Turbine Housing Inlet Ports

DPSG,OUO1004,945 –19–28JUL99–5/13

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

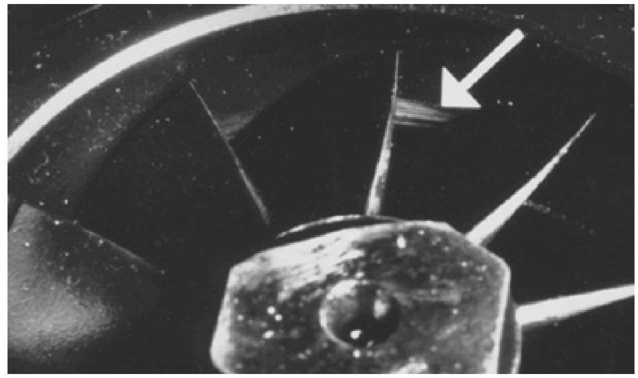


RG8540 –UN–10DEC97

Checking Turbine Wheel and Outlet

Continued on next page DPSG,OUO1004,945 –19–28JUL99–6/13

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

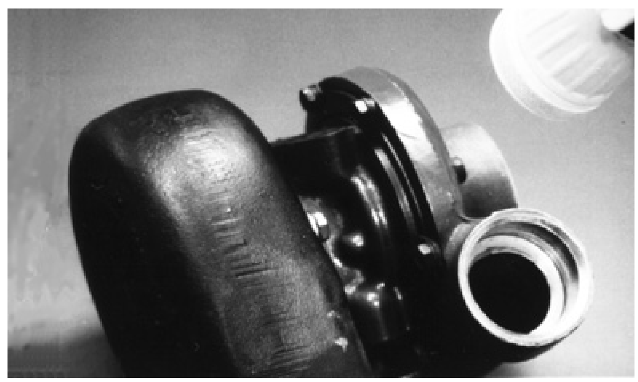
Checking Turbine Wheel Blades

DPSG,OUO1004,945 –19–28JUL99–7/13

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.



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Checking Center Housing

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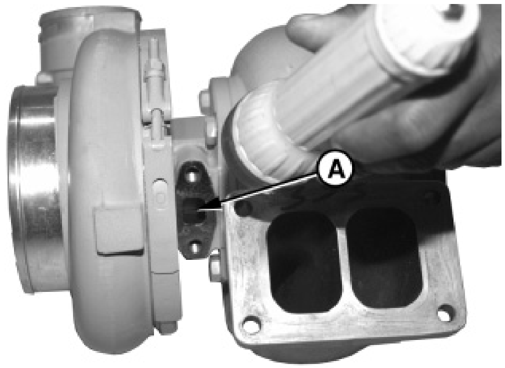
DPSG,OUO1004,945 –19–28JUL99–8/13

Internal Center Housing

1. Using a flashlight, look through the oil return hole (A), to check the condition of the shaft and/or bearings. There should not be excess carbon deposits on the shaft or in the housing.

A—Oil Return Hole



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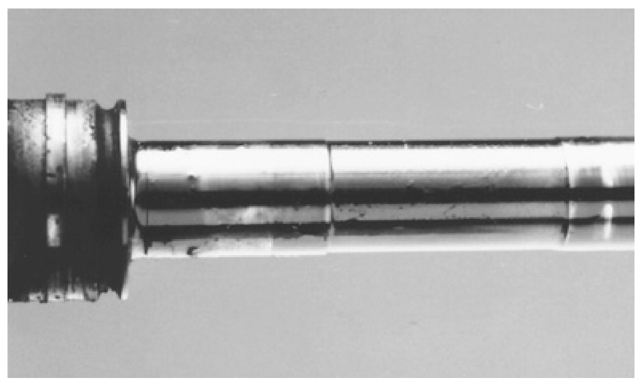
Checking Shaft and Bearings

DPSG,OUO1004,945 –19–28JUL99–9/13

2. Excessive “blueing” or “coking” of oil along the complete length of the shaft indicates a possible lack of lubrication caused by an engine failure, or improper operation, such as hot shutdowns.



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Checking for Oil “Coking” on Shaft

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DPSG,OUO1004,945 –19–28JUL99–10/13

Turbocharger Bench Test

1. Mount the turbocharger in a vise.

2. 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.

RG8498A –UN–10DEC97

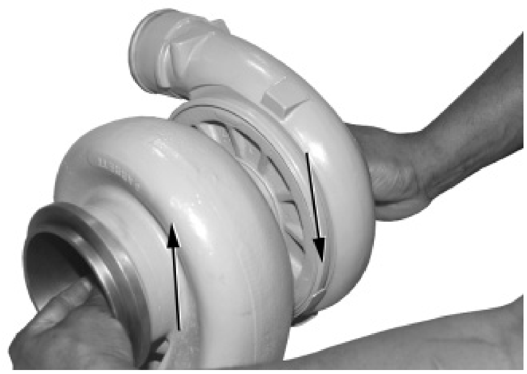
Checking Shaft Rotation and Clearance

DPSG,OUO1004,945 –19–28JUL99–11/13

IMPORTANT: Use only moderate hand force (3—4 pounds) on each end of shaft.

3. 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.



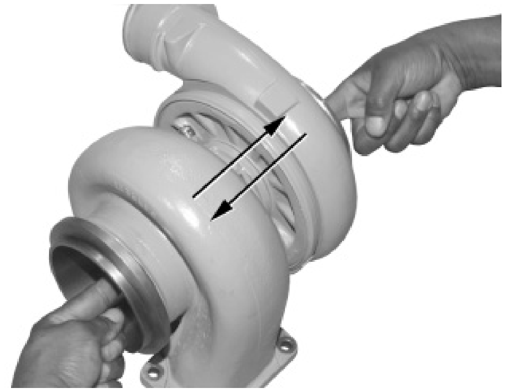
RG8498B –UN–10DEC97

Checking for Contact of Compressor and Turbine Wheels

Continued on next page

DPSG,OUO1004,945 –19–28JUL99–12/13

4. Next, check shaft end play by moving the shaft back and forth while rotating. There will be some end play but not to the extent that the wheels contact the housings.



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Checking Shaft End Play

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, 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.

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 end play with a dial indicator be performed. These procedures are not required if a failure mode has already been identified.

DPSG,OUO1004,945 –19–28JUL99–13/13

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.

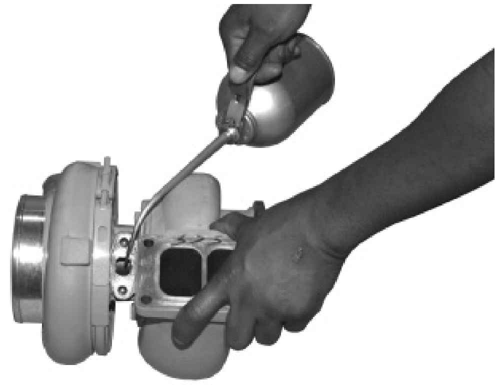
RG,RG34710,245 –19–30SEP97–1/1

Prelube Turbocharger

IMPORTANT: DO NOT spin the rotor assembly with compressed air. Damage to bearings can occur when using compressed air.

Fill oil inlet or 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.


RG8543 –UN–20MAY98

Prelubing Turbocharger Bearings

RG,RG34710,246 –19–30SEP97–1/1

Install 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.

If not done previously, prime (prelube) the turbocharger rotating assembly prior to mounting turbocharger on engine. Prelube center housing with clean engine oil through the oil drain hole. Turn rotating assembly by hand to lubricate bearings. (See PRELUBE TURBOCHARGER earlier in this group.)

1. Install 4 locating studs in exhaust manifold mounting pad with cup point ends (A) facing into manifold threaded holes and within 1 thread of stud body

2. Place turbocharger gasket over studs on exhaust manifold.

3. Install oil supply line fitting (B) to turbocharger center section and tighten to specification.

Specification

Oil Supply line Fitting to
Turbocharger—Torque .... 25 N•m (19 lb-ft)

4. Align oil drain line flange and gasket to turbocharger center section.

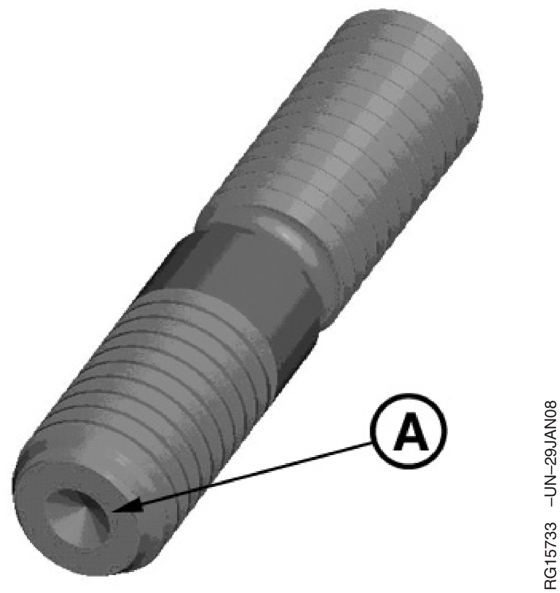
5. Install 2 cap screws through drain line flange into turbocharger center section finger tight.

6. Apply soap lubricant to O-ring (C) and install O-ring in groove inside oil drain line fitting (D).

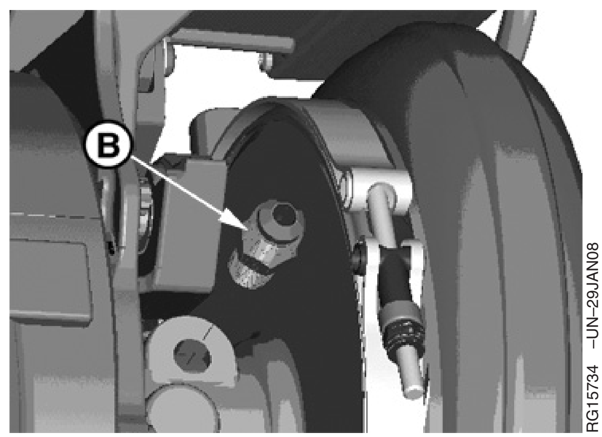
7. Apply thread sealant to oil drain line fitting (D) threads.

8. Insert fitting to turbocharger oil drain line tube end.

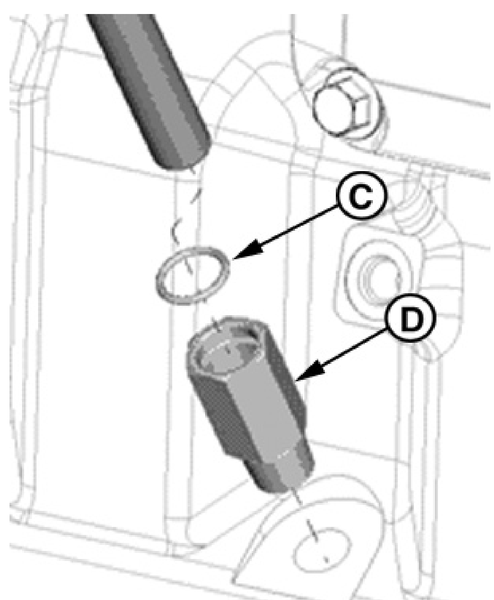
A—Locating Stud
B—Oil Supply Line Fitting
C—Oil Drain Line Fitting O-ring
D—Oil Drain Line Fitting - Cylinder Block



Turbocharger Locating Stud



Oil Supply Line Fitting - Turbocharger



Oil Drain Line Fitting - Cylinder Block

Continued on next page RE38635,000012D –19–30JAN08–1/3

CAUTION: Use extreme care when handling turbocharger. If possible, use a lifting device to position the turbocharger to the engine.

9. Position turbocharger with oil drain line assembly (F) over gasket (G) and locating studs (E) on exhaust manifold.

10. Install 4 washers and 4 hex nuts (H) over studs and tighten finger tight.

11. Locate oil drain line fitting (I) to cylinder block and tighten to specification.

Specification
Oil Drain Line Fitting to Cylinder
Block—Torque .... 45 N•m (33 lb-ft)

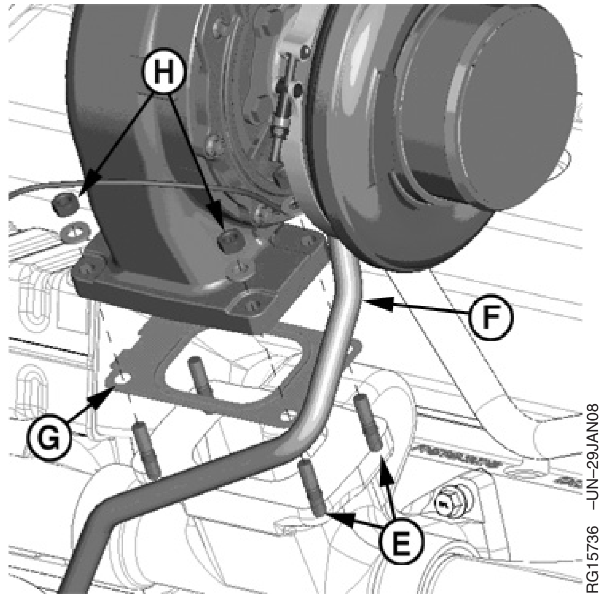
12. Tighten 4 hex nuts securing turbocharger to exhaust manifold to specification.

Specification
Turbocharger to Manifold Hex
Nuts - 4 -—Torque .... 50 N•m (37 lb-ft)

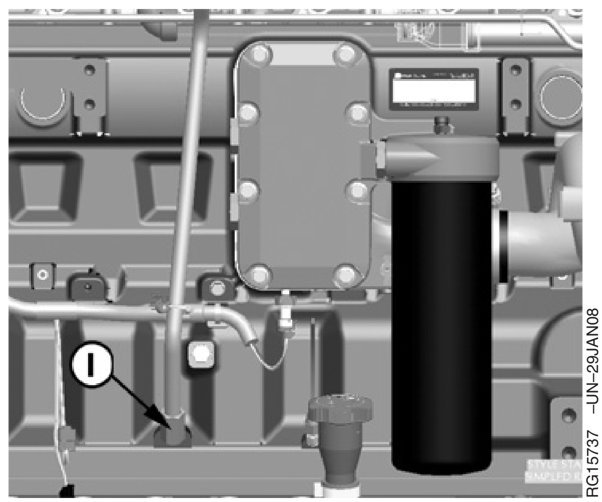
13. Tighten 2 cap screws securing oil drain line to turbocharger center housing to specification.

Specification
Oil Drain Line to Turbocharger
Cap Screws - 2-—Torque .... 50 N•m (37 lb-ft)

E—Locating Studs
F—Oil Drain Line
G—Gasket
H—Hex Nuts and Washers - 4 ea -
I—Oil Drain Line Fitting - Cylinder Block



Install Turbocharger



Connect Oil Drain Line to Cylinder Block

Continued on next page RE38635,000012D –19–30JAN08–2/3

14. Apply thread sealant to pipe threads of oil supply line fitting and install fitting (K) to top of oil filter housing. Tighten to specification.

Specification
Oil Supply Line Fitting to Oil Cooler Housing—Torque.. 35 N•m (26 lb-ft)

15. Install O-ring (J) to oil supply line fitting

16. Install turbocharger oil supply line to flare fitting on turbocharger (L) finger tight.

17. Install O-ring face seal end of line to fitting (M) on top of oil filter housing finger tight.

18. Tighten oil supply line to turbocharger fitting to specification.

Specification
Oil Supply Line Fitting to Turbocharger Fitting—Torque .... 35 N•m (26 lb-ft)

NOTE: When tightening supply line fitting, DO NOT bind flexible section of line.

19. Tighten oil supply line to fitting on oil filter housing to specification.

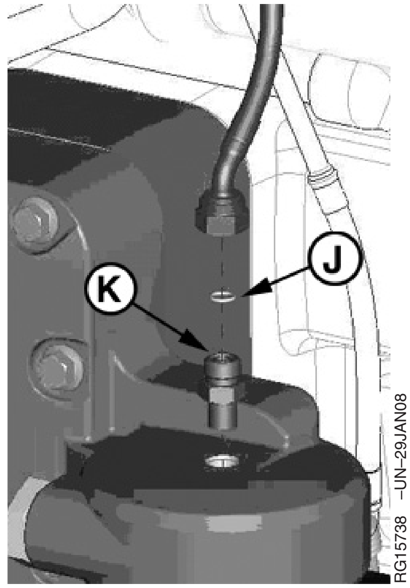
Specification
Oil Supply Line Fitting to Oil Filter Housing Fitting—Torque.. 24N•m (18 lb-ft)

20. Check lines to ensure at least 3 mm clearance, to avoid contact.

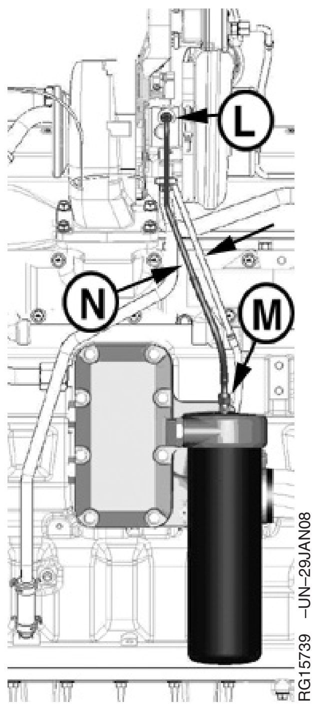
IMPORTANT: Since the greatest suction force occurs between air cleaner and turbocharger, ensure that hose connections are tight to prevent entry of dirt into system.

21. Connect air inlet hose-to-turbocharger compressor housing.

22. Install air intake and exhaust piping onto turbocharger compressor and turbine ends as detailed in machine technical manual.



Install Oil Supply Line Fitting to Oil Filter Housing



Install Oil Supply Line

J—O-ring
K—Oil Supply Line Fitting - Oil Filter Housing
L—Oil Supply Line Fitting - Turbocharger Center Housing
M—Oil Supply Line Fitting - Oil Filter Housing
N—Line Clearance 3 mm

Turbocharger Break-In

IMPORTANT: A new or repaired turbocharger DOES NOT have an adequate oil supply for immediate start-up of engine. Perform the steps below to prevent damage to turbocharger bearings.

1. Remove ECU power fuse so engine does not start.

IMPORTANT: DO NOT crank engine longer than 30 seconds at a time to avoid damage to starter motor.

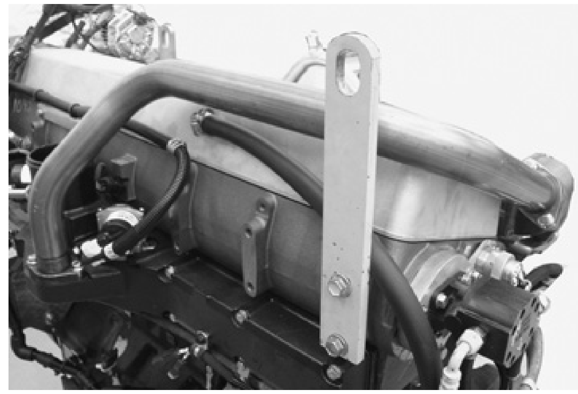
2. Crank engine over with starter motor until oil pressure gauge needle registers within the “GREEN” zone of pressure gauge.

3. Install ECU power fuse. Start and run engine at low idle while checking oil inlet and all piping connections for leaks.

RG,RG34710,248 –19–30SEP97–1/1

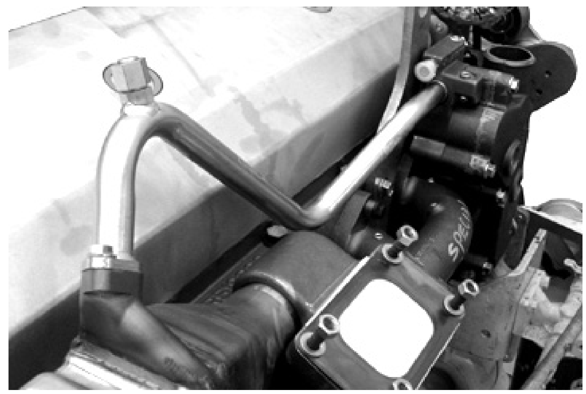
Remove, Inspect, and Install EGR Cooler

NOTE: For clarity, the turbocharger has been removed. Removing the turbocharger is not necessary to service the EGR cooler.



RG14679 –UN–12JAN06

EGR Crossover Pipe



RG14676 –UN–12JAN06

Remove EGR Cooler

1. Remove EGR crossover pipe.

2. Remove the cooler outlet tube cap screw and remove the tube by rotating and pulling from the thermostat housing.

3. Remove the EGR cooler inlet tube cap screw and loosen the large fitting to remove tube.

4. Remove two EGR cooler-to-support bracket cap screws and carefully remove cooler from the center exhaust manifold.

Inspect EGR Cooler

1. Check for signs of leakage.

2. Pressure-test cooler. Reference procedure

3. Replace sealing rings, if required.

Install EGR Cooler

1. Insure sealing rings are in place. Position ring gaps 120° apart and carefully slide the cooler inlet into the center exhaust manifold bore. Install, but do not tighten, the two cooler-to-support bracket cap screws.

2. Apply sealant to cooler inlet tube fitting. Apply O-ring lubricant to the flanged end of the coolant outlet tube and install in the engine coolant cooler housing.

3. Apply O-ring lubricant to the coolant outlet tube end and install by rotating and pushing the tube into thermostat housing.

4. Insure all tubes are in position and fully inserted into their respective housings. Tighten all cap screws to specifications.

Continued on next page

RG19661,0000157 –19–12JAN06–1/2

Specification

Cooler-to-Exhaust Manifold Cap Screws—Torque	50 N•m (37 lb-ft)

Specification

Coolant Inlet and Outlet Line Cap Screws—Torque	35 N•m (26 lb-ft)

Specification

Coolant Inlet Fitting—Torque	70 N•m (52 lb-ft)

5. Install EGR crossover pipe and gaskets. Tighten cap screws to specifications.

Specification

EGR Pipe Cap Screws—Torque	50 N•m (37 lb-ft)

RG19661,0000157 –19–12JAN06–2/2

Remove, Inspect, and Install Exhaust Manifold

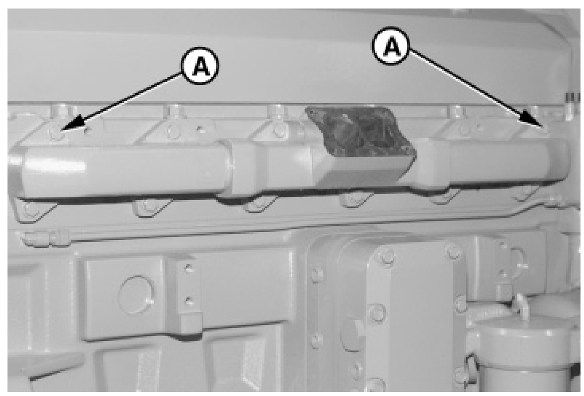
Remove Exhaust Manifold

1. Remove turbocharger (shown removed). (See REMOVE TURBOCHARGER earlier in this group.)

2. Remove upper cap screws (A) from front and rear exhaust manifold sections and install guide pins.

3. Remove remaining exhaust manifold-to-cylinder head cap screws and remove exhaust manifold as an assembly.

4. Separate three exhaust manifold sections. Remove exhaust manifold-to-cylinder head gaskets and discard.

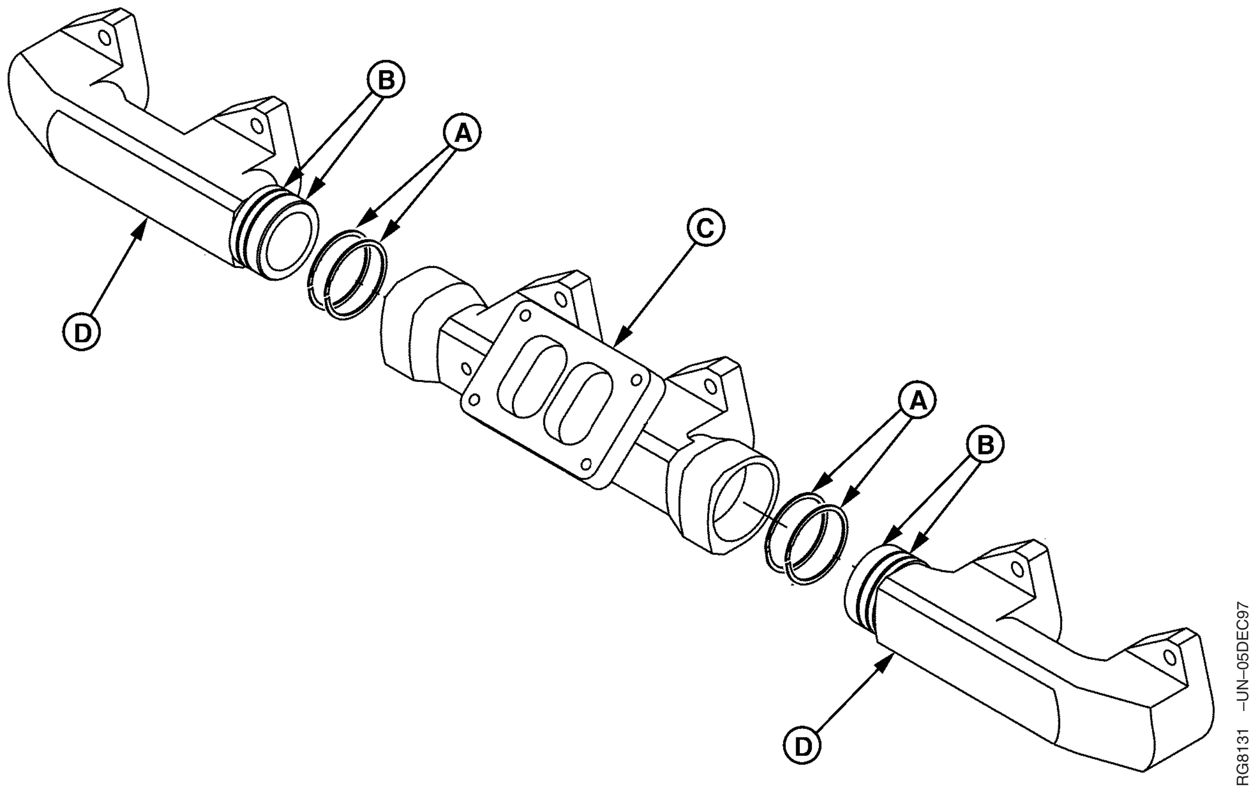


RG8130 –UN–05DEC97

Removing Exhaust Manifold

A—Upper Cap Screws

Continued on next page RG,RG34710,249 –19–13AUG99–1/3



Exhaust Manifold Exploded View

A—Sealing Rings (4 used) **B—Sealing Ring Grooves** **C—Center Manifold Section** **D—End Manifold Sections (2 used)**

Inspect Exhaust Manifold

1. Inspect machined mating surfaces (ID and OD) for burrs, cracks or other imperfections which may prevent sealing rings (A) from sealing properly.
2. Inspect area past sealing ring locations for evidence of exhaust leakage. Inspect all sections for cracks.
3. Inspect and clean cylinder head and exhaust manifold machined mounting surfaces.

Continued on next page RG,RG34710,249 –19–13AUG99–2/3

Install Exhaust Manifold

1. Install guide pins (A) at upper threaded hole of each exhaust port as shown.

2. Install gaskets (B) on each guide pin as shown.

3. Install two sealing rings on both exhaust manifold end sections and assemble with center section.

4. Install manifold assembly (C) onto guide pins.

5. Apply PT569 NEVER-SEEZ® Compound to exhaust manifold cap screws and tighten bottom row of cap screws finger tight. Be sure gaskets are properly positioned before installing cap screws.

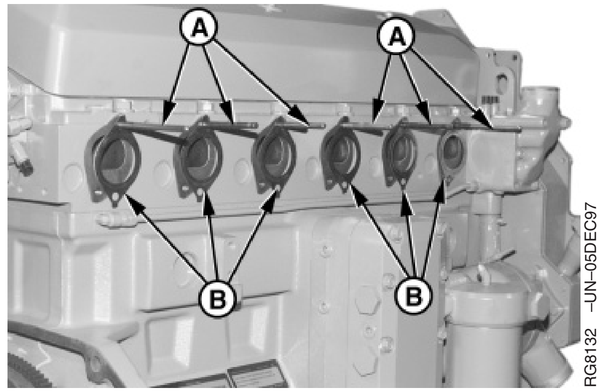
6. Remove guide pins from top row and install cap screws finger tight.

7. Tighten all cap screws to specifications.

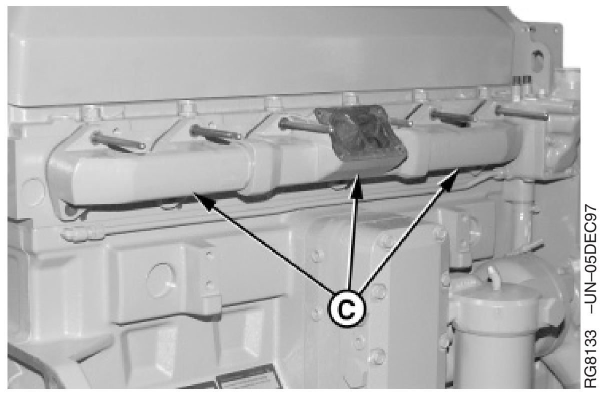
Specification

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

8. Install turbocharger. (See INSTALL TURBOCHARGER earlier in this group.)



Exhaust Manifold Gaskets



Installing Exhaust Manifold

A—Guide Pins
B—Gaskets
C—Manifold Assembly

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RG,RG34710,249 –19–13AUG99–3/3

Remove, Inspect, and Install Intake Manifold

NOTE: Intake manifolds differ between engine applications.

Remove Intake Manifold

1. If required, remove final fuel filter (A). Disconnect fuel lines (B) from filter mounting base.

2. Refer to your machine technical manual to disconnect intake piping, sensors, and starting aid that is connected to intake manifold.

NOTE: If required, note location of primary fuel filter/water separator bracket (C) for assembly in same location as removed.

3. Disconnect EGR wiring leads. Remove EGR tube.

4. Remove top cap screw on each end of intake manifold and install guide pins.

5. Remove remaining cap screws and remove intake manifold with gasket. Discard gasket.

Inspect Intake Manifold

1. Check intake manifold for damage or cracks.

2. Thoroughly inspect interior of manifold for dust or debris.

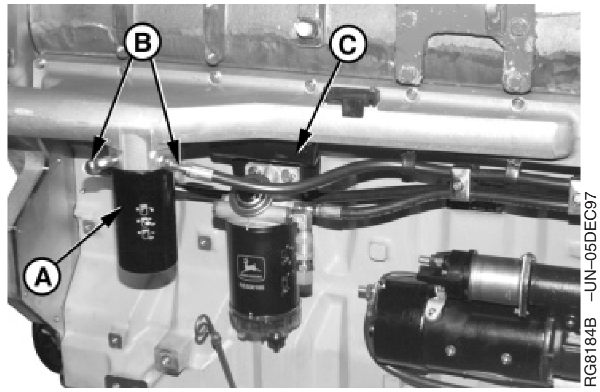
3. Clean all gasket material from intake manifold and cylinder head mounting surfaces.

Install Intake Manifold

1. Install guide pins at each end of top intake manifold cap screw locations.

2. Install a new gasket onto guide pins.

3. Install intake manifold onto guide pins. If required, install primary fuel filter/water separator in same location as removed.



Intake Manifold Assembly

A—Final Fuel Filter
B—Fuel Lines
C—Primary Fuel Filter/Water Separator Bracket

Continued on next page

4. Apply PT569 NEVER-SEEZ® Compound to intake manifold cap screws. Starting at center cap screws, alternating top to bottom and front to rear, tighten intake manifold-to-cylinder head cap screws to specifications.

Specification

Intake Manifold-to-Cylinder Head
Cap Screws—Torque .... 35 N•m (26 lb-ft)

5. If required, connect fuel lines to final fuel filter mounting base. Install final fuel filter.

6. Install EGR tube.

7. Reconnect intake piping, sensors, and starting aid detailed in machine technical manual.

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RG19661,0000152 –19–11JAN06–2/2

Remove, Inspect, and Install EGR Valve (Tier 3/Stage III A)

IMPORTANT: EGR valves should be considered as number 1 and number 2. Number 1 egr valve is closest to number 1 cylinder. If egr valves are removed and reused, reinstall in the same position they were when removed.

1. Disconnect wiring lead and remove two attaching screws (A). Place JDG10194 EGR removal tool at the base of the EGR valve and install tool forcing screws into the intake manifold. Carefully remove the valve without binding by alternately turning the two forcing screws until the valve lands are past the intake manifold port.

2. Remove gasket and clean mating surfaces. Vacuum debris and loose carbon deposits from intake housing.

3. Replace EGR O-rings (B) each time valve is removed.

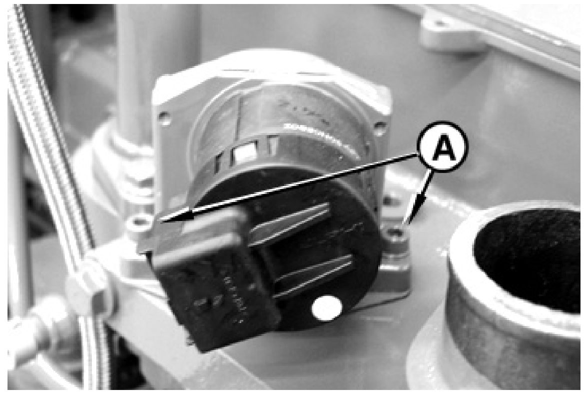
4. Inspect valve lands (C) for wear and damage. Remove carbon deposits and debris.

5. Lubricate O-rings with clean engine oil. Carefully install EGR valve and new gasket with the motor pointing away from the engine. Tighten attaching screws (A) to initial specifications.

Specification	
EGR Valve - Initial—Torque	5 N•m (4 lb-ft)

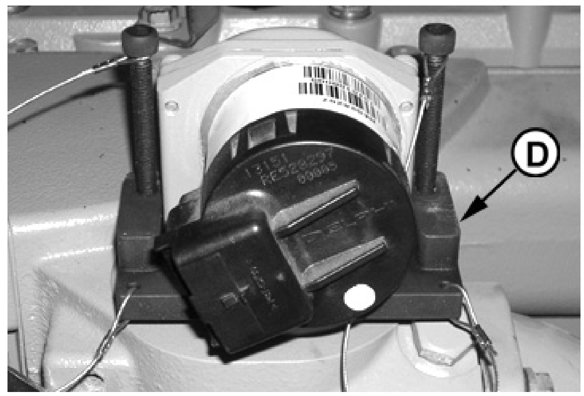
6. Tighten EGR attaching screws (A) to final specifications. Connect wiring lead.

Specification	
EGR Valve - Final—Torque	15 N•m (11 lb-ft)



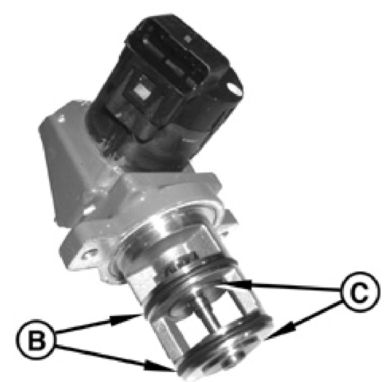
RG14089 –UN–22MAR05

EGR Valve



RG14881 –UN–26MAY06

JDG10194 EGR Removal Tool



RG14076 –UN–01APR05

Inspect EGR Valve

A—Attaching Screws
B—O-Rings
C—EGR Valve Lands
D—JDG10194 EGR Removal Tool with Screws

Continued on next page RE38635,0000111 –19–12NOV07–1/2

IMPORTANT: If installing a new EGR valve, re-calibrate using Service Advisor™, see EXHAUST GAS RECIRCULATION VALVE RECALIBRATION under the CALIBRATIONS tab. Leave key in "off" position for 30 seconds to finalize calibration.

If reusing the EGR valve, run HARNESS DIAGNOSTIC MODE TEST through Service Advisor™ under the interactive test tab - RETEST.

RE38635,0000111 –19–12NOV07–2/2

Exhaust Manifold — Remove

1. Remove turbocharger.

2. Loosen 12 hex head cap screws (A).

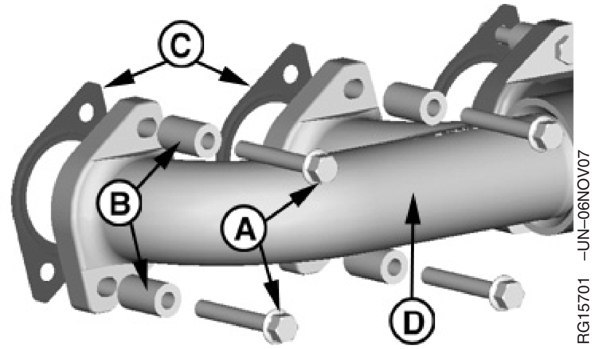
NOTE: To ease removal, remove 2 cap screws from top center of manifold and replace with guide pins to support manifold during removal from engine.

3. Remove 12 hex head cap screws and spacers (B).

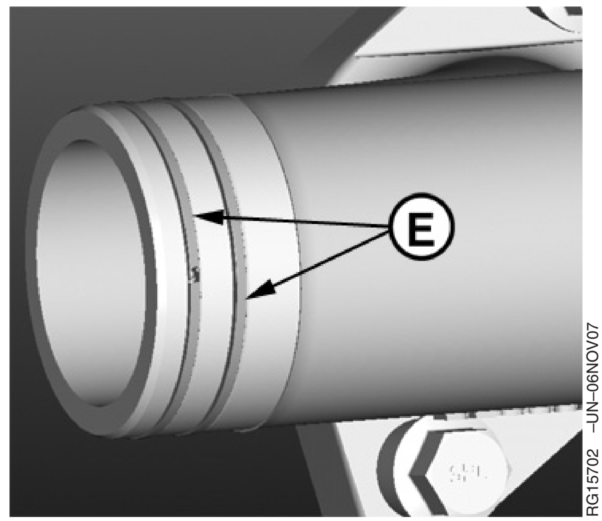
4. Remove exhaust manifold assembly (D) and gaskets (C).

5. Separate front and rear exhaust manifold from center manifold.

6. Remove 2 sealing rings (E) from front and rear exhaust manifolds. Discard sealing rings.



Remove Exhaust Manifold



Manifold Sealing Rings

RE38635,00000FC –19–06NOV07–1/1

Exhaust Manifold — Install

IMPORTANT: Orient gap of one sealing ring to inside of manifold (A). Orient the second ring gap 180° from the first - to the outside of manifold (B).

1. Install 2 new sealing rings to grooves in front and rear exhaust manifolds. Be sure ring gaps are oriented 180° apart.

2. Assemble front and rear manifold ends to center manifold.

NOTE: To ease assembly, guide pins can be used to locate and hold gaskets in position.

3. Locate exhaust manifold gaskets (C) to cylinder head.

4. Locate exhaust manifold assembly to cylinder head.

5. Assemble 12 cap screws (E) to 12 spacers (F).

NOTE: If guide pins are used to aid assembly, install cap screws to bottom holes of manifold first.

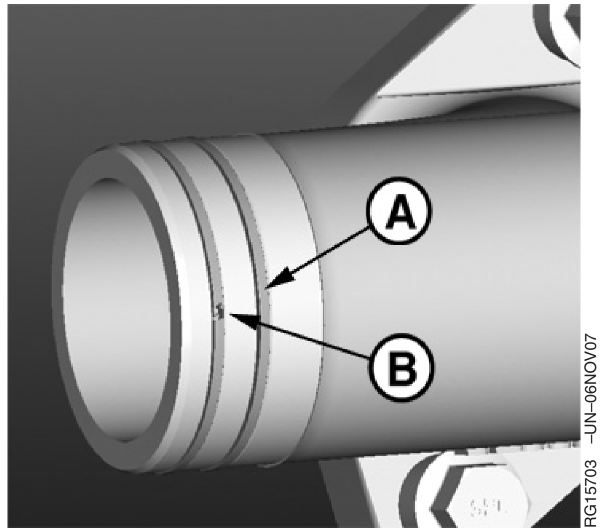
NOTE: Verify all gaskets are in correct position.

6. Install cap screws and spacers through exhaust manifold (D) and gaskets into cylinder head.

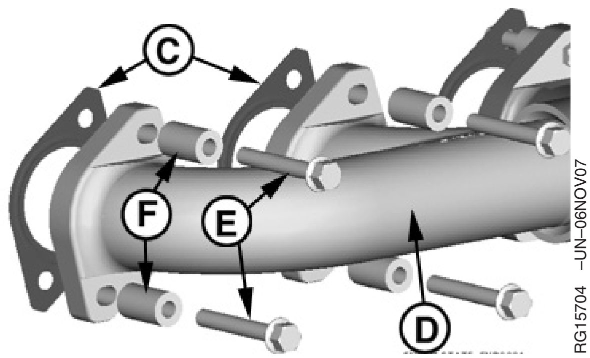
7. Tighten 12 cap screws to specification.

Specification

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



Sealing Rings



Install Exhaust Manifold

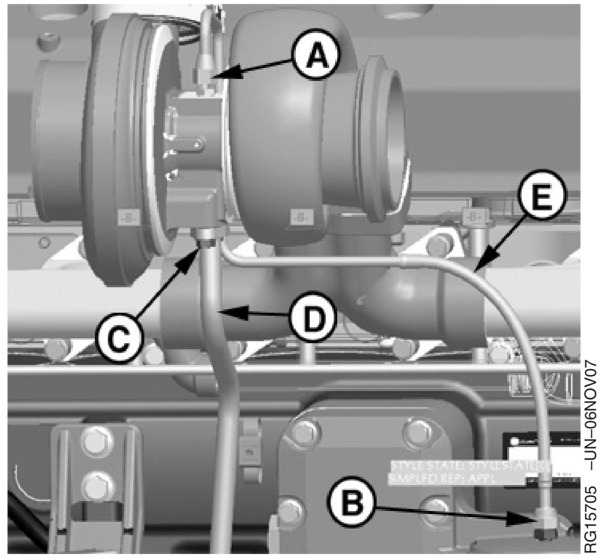
A—Sealing Ring Gap to Inside of Manifold
B—Sealing Ring Gap to Outside of Manifold
C—Gaskets
D—Exhaust Manifold
E—Cap Screws
F—Spacers

RE38635,00000FD –19–06NOV07–1/1

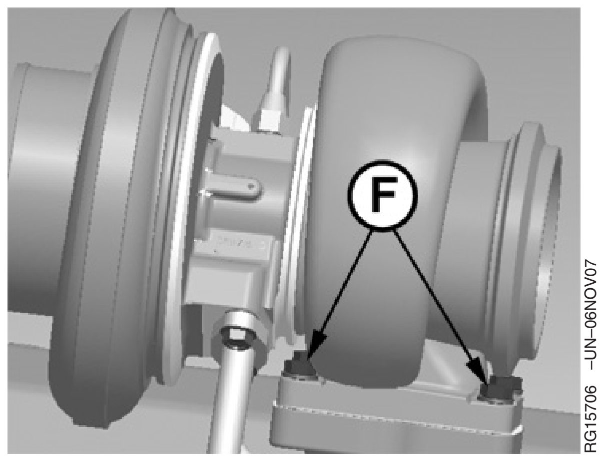
Turbocharger — Remove

1. Loosen oil supply line fitting (A) at turbocharger center housing.
2. Loosen fitting (B) at oil filter housing. Remove oil supply line (E) and set aside.
3. Loosen and remove oil supply line connector from turbocharger center housing. Cap or plug hole.
4. Loosen and remove 2 cap screws (C) securing oil drain line (D) to bottom of turbocharger center housing.
5. Loosen drain line from connector in cylinder block. Remove oil drain line, discard gasket, and set aside.
6. Loosen and remove 4 cap screws (F) securing turbocharger to exhaust manifold. Remove turbocharger and discard gasket.

A—Oil Supply Line Fitting - Turbocharger
B—Oil Supply Line Fitting - Oil Filter Housing
C—Oil Drain Line Flange Cap Screws
D—Oil Supply Line
E—Oil Drain Line
F—Turbocharger to Exhaust Manifold Cap Screws



Remove Oil Supply and Drain Lines



Remove Turbocharger

RE38635,00000FE –19–06NOV07–1/1

Turbocharger — Install

NOTE: Assembly of the gasket and turbocharger may be aided with the use of guide pins in the holes in exhaust manifold mounting surface.

1. Install turbocharger gasket (A) to mounting surface of exhaust manifold (B).

2. Install oil supply line connector to top of turbocharger center housing and tighten to specification.

Specification

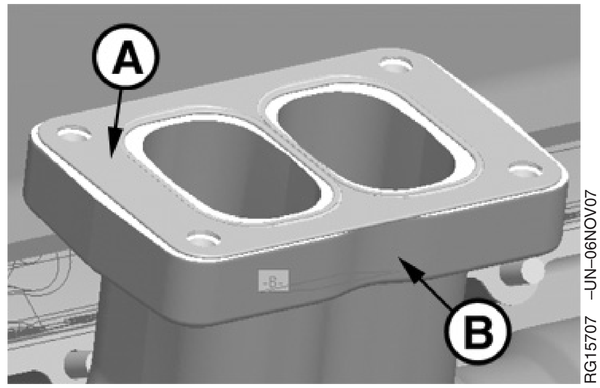
Oil Supply Line Connector to
Turbocharger Housing—Torque..................................... 25 N•m (18 lb-ft)

.

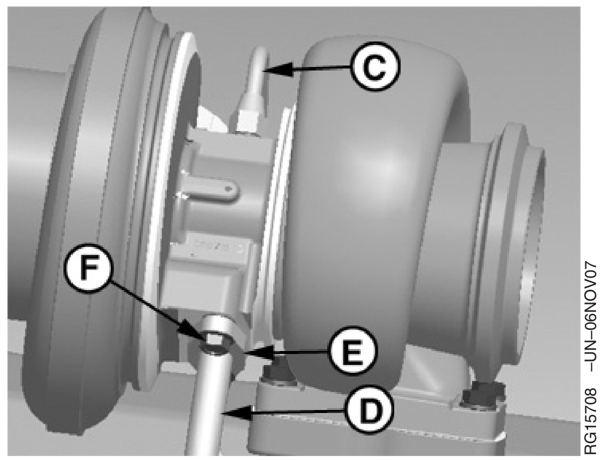
3. Align oil drain line flange (E) and gasket to bottom of turbocharger center housing.

4. Install 2 cap screws (F) through oil drain line flange and gasket and into turbocharger center housing finger tight.

A—Turbocharger Gasket
B—Exhaust Manifold
C—Oil Supply Line
D—Oil Drain Line
E—Oil Drain Line Flange
F—Oil Drain Line to Turbocharger Cap Screws



Install Turbocharger Gasket



Install Oil Supply Line Connector and Oil Drain line

Continued on next page RE38635,00000FF –19–08NOV07–1/3

5. Apply soap lubricant to oil drain line connector O-ring (G) and install O-ring in groove inside connector (H).

6. Apply LOCTITE® 242 Thread Sealant to connector threads.

7. Insert connector to end of turbocharger oil drain line.

8. Locate turbocharger with drain line assembly to gasket on exhaust manifold mounting surface.

9. Place washers on turbocharger cap screws.

10. Apply NEVER-SEEZ® to cap screw threads.

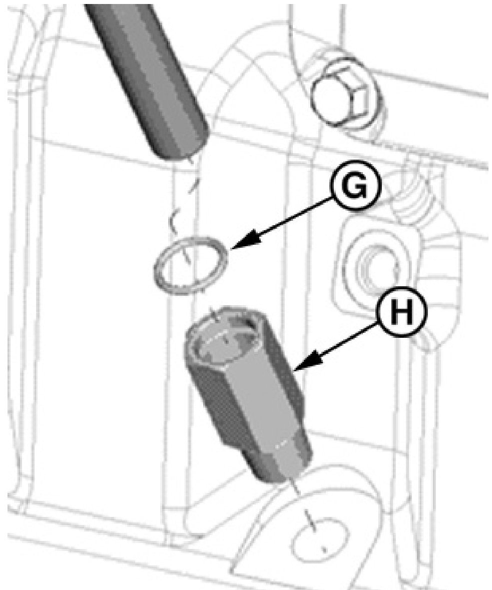
11. Install 4 cap screws (J) through turbocharger mounting surface into exhaust manifold finger tight.

12. Locate and install oil drain line connector (I) to cylinder block and tighten to specification.

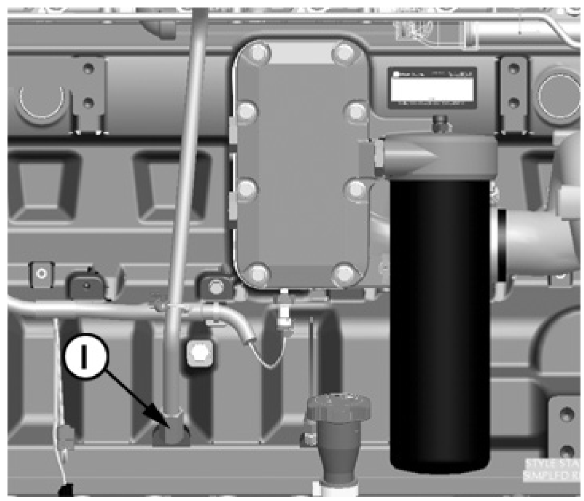
Specification

Oil Drain Line Connector to
Cylinder Block—Torque.. 45 N•m (33 lb-ft)

G—Drain Line Connector O-ring
H—Oil Drain Line Connector
I—Drain Line Connector Assembly Position to Cylinder Block



Install O-ring to Drain Line Connector



Install Drain Line Connector to Cylinder Block

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NEVER-SEEZ is a trademark of Emhart Chemical Group

Continued on next page RE38635,00000FF –19–08NOV07–2/3

13. Tighten turbocharger mounting cap screws (J) to specification.

Specification

Turbocharger to Exhaust Manifold
Cap Screws—Torque .... 50 N•m (37 lb-ft)

14. Tighten oil drain line flange cap screws (K) to specification.

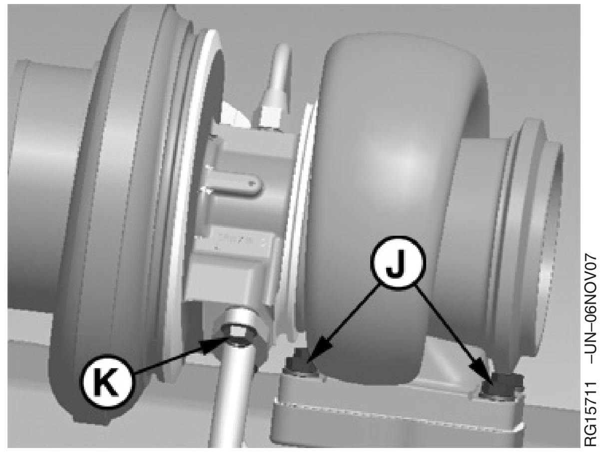
Specification

Oil Drain Line to Turbocharger
Cap Screws—Torque .... 50 N•m (37 lb-ft)

15. Install oil supply line to turbocharger and oil filter adapter. Tighten both ends of line to specification.

Specification

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

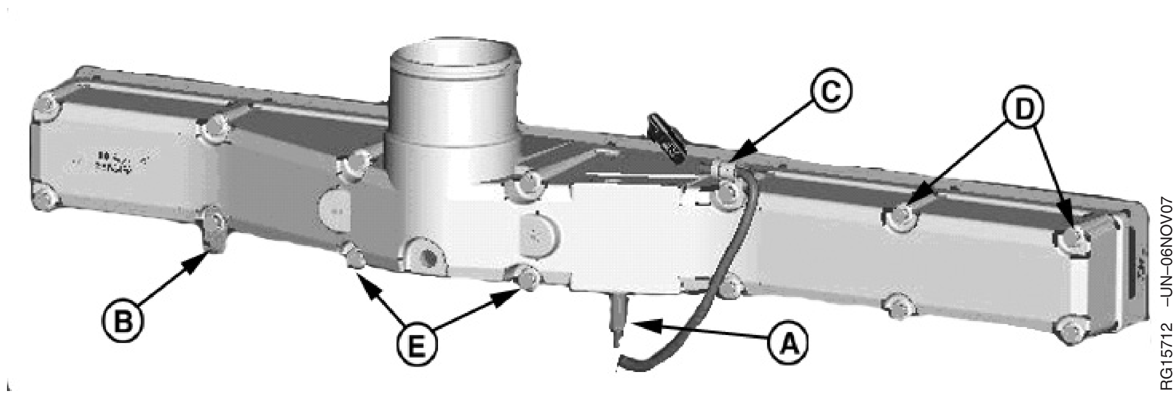


Tighten Drain Line and Turbocharger Mounting Cap Screws

K—Oil Drain Line to Turbocharger Cap Screws
J—Turbocharger to Exhaust Manifold Cap Screws

RE38635,00000FF –19–08NOV07–3/3

Air Intake Manifold — Remove



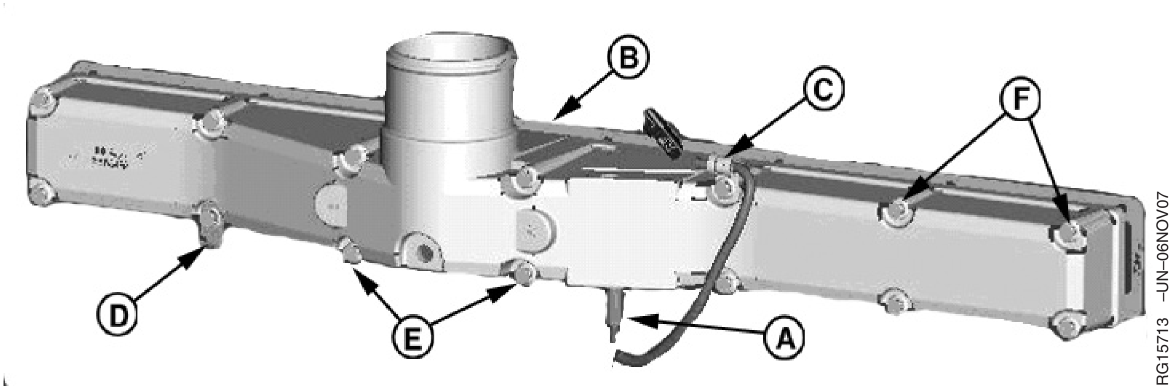
Remove Air Intake

A—Intake Air Temperature Sensor
B—Fuel Line P-Clamp
C—Wiring Harness P-Clamp
D—Short Cap Screws -10-
E—Long Cap Screws -4-

1. Remove air intake pipe from top of manifold.
2. Disconnect intake air temperature sensor (A).
3. If replacing manifold, loosen and remove sensor.
4. Loosen and remove Fuel Line P-clamp.
5. Loosen and remove wiring harness P-clamp.
6. Loosen and remove 10 short (D) and 4 long (E) cap screws.
7. Remove manifold and gasket from cylinder head mounting surface.

RE38635,0000100 –19–06NOV07–1/1

Air Intake Manifold — Install



Install Air Intake Manifold

A—Intake Air Temperature Sensor
B—Gasket
C—Wiring Harness P-clamp
D—Fuel Line P-clamp
E—Long Cap Screws -4-
F—Short Cap Screws -10-

1. Install and tighten air intake temperature sensor (A) to specification.

Specification
Air Intake Temperature Sensor—Torque.. 17 N•m (13 lb-ft)

2. Install wiring harness P-clamp (C), with “P” pointing away from engine. Insert sensor wire through clamp.
3. Install fuel line P-clamp (D) and screw with “P” pointing inward, toward engine.
4. Position new gasket (B) to face of manifold and install manifold assembly to cylinder head.
5. Install 4 long and 10 short cap screws through manifold into cylinder head finger tight.

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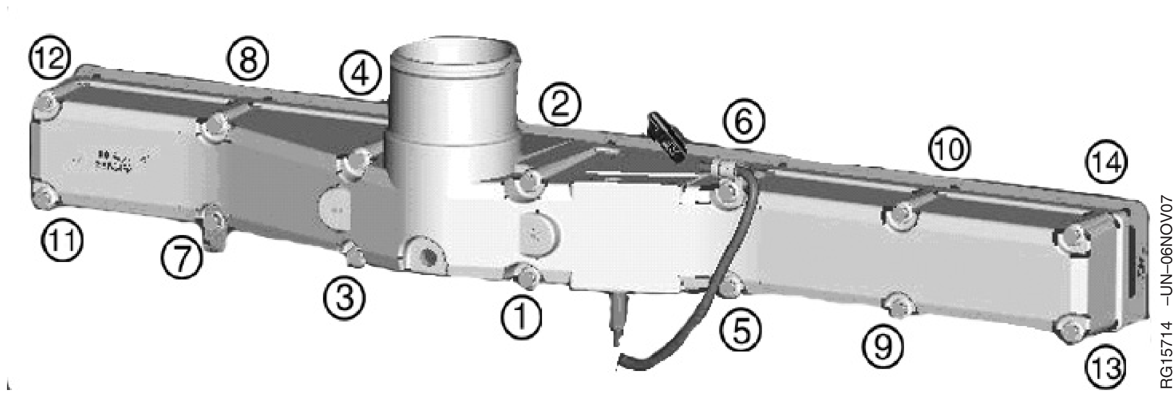


Torque Sequence - Air Intake Manifold

6. Tighten all cap screws to specification in the sequence shown.

Specification

Intake Manifold to Cylinder
Head - Cap Screws—Torque .... 35 N•m (26 lb-ft)

RE38635,0000101 –19–06NOV07–2/2

Fuel System

NOTE: Repair, operation, diagnostic, and testing procedures on fuel systems and electronic controls have been moved to the following manuals:

- CTM115—Delphi/Lucas Electronic Fuel Systems With Delphi/Lucas EUIs
- CTM188—Level 6 Electronic Fuel Systems With Delphi/Lucas EUIs

Later Tier II 12.5 L engines with dual- or single-rail fuel systems are covered in CTM188.

OUO1004,0000C2D –19–23AUG02–1/1

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 (A) and regulator connector (E) (shown disconnected).
3. Remove alternator belt using a 1/2 in. drive ratchet on the belt tensioner (C).
4. Remove mounting cap screws from adjusting strap (B). Remove cap screw and nut (D) and remove alternator.
5. Install alternator in reverse order.
6. Torque alternator mounting hardware to the following specifications.

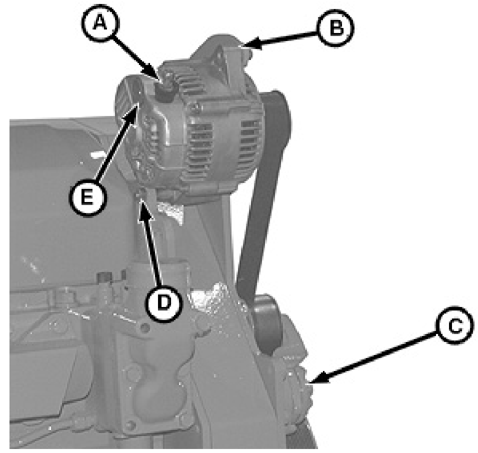
Alternator Strap Mounting Hardware—Specification

M8 Cap Screw—Torque	25 N•m (18 lb-ft)
M10 Cap Screw—Torque	50 N•m (37 lb-ft)
1/2 in. Cap Screw—Torque	61 N•m (45 lb-ft)

Alternator Foot Mounting Hardware—Specification

M10 Cap Screw—Torque	70 N•m (52 lb-ft)
M12 Cap Screw—Torque	60 N•m (44 lb-ft)

7. Inspect alternator belt for cracks and wear.



Alternator

A—Positive Wire Terminal
B—Alternator Strap
C—Belt Tensioner
D—Mounting Cap Screw and Nut
E—Regulator Connector Terminal

DPSG,OUO1004,1005 –19–23SEP02–1/1

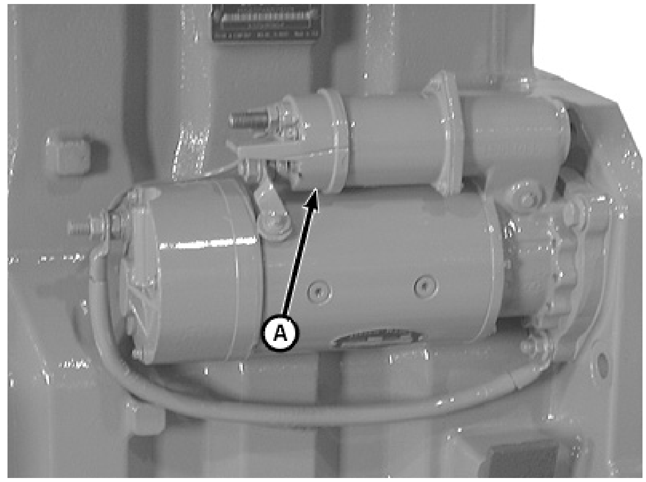
Remove and Install Starter Motor (OEM Engines)

NOTE: For test and repair of starter motor, refer to CTM 77.

1. Disconnect battery ground (-) cable.
2. Disconnect all cables and wires from starter solenoid (A) (shown disconnected).
3. Remove starter motor using JDE80 Starter Wrench.
4. Install starter motor in reverse order.
5. Torque motor mounting hardware to the following specifications.

Specification

Starter Motor Mounting Hardware—Torque .... 125 N•m (92 lb-ft)



RG10285 –UN–20AUG99

Starter Motor

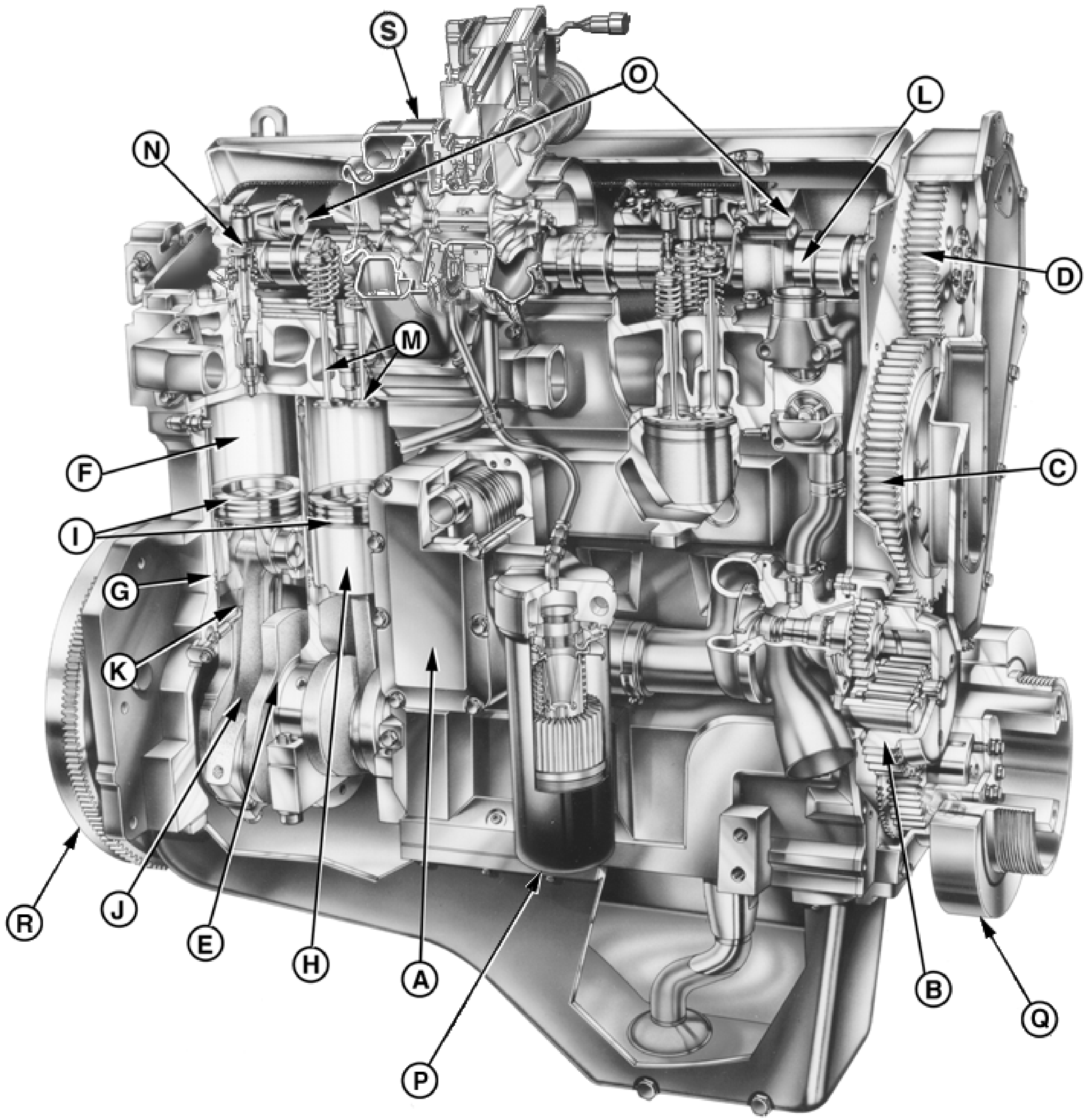
A—Starter Solenoid

DPSG,OUO1004,1006 –19–13AUG99–1/1

Section 03
Theory of Operation

Contents

General Engine Operation



6135 Engine Components

A—Oil Cooler
B—Oil Pump Drive Gear
C—Idler Gear
D—Camshaft Gear
E—Crankshaft
F—Cylinder Liner
G—Cylinder Liner O-Rings
H—Piston
I—Piston Rings
J—Connecting Rod
K—Oil Spray Jet
L—Camshaft
M—Valves
N—Electronic Unit Injector
O—Two Piece Rocker Arm Shaft
P—Oil Filter
Q—Crankshaft Damper
R—Flywheel
S—Variable Geometry Turbocharger

The 6135 engines are similar to the 6125 except for changes noted below. The 6135 includes the same cam in head design, actuating four valves per cylinder and an electronic unit injector (EUI) fuel system. The injector has changed in that the previous offset solenoid design is replaced by a unit injector with the quick connect electrical connector integral with the pump body. The increase in displacement is accomplished with a thinner wall cylinder liner. They are vertical stroke, in-line, 4 valve-in-head, 6-cylinder diesel engines. The firing order is 1-5-3-6-2-4.

Continued on next page
RE38635,0000064 –19–15AUG05–1/3

A major design change to the 650 series engine (6135) is the use of a variable geometry turbocharger (VGT) (S) and exhaust gas recirculator (EGR). The EGR is mounted between the exhaust and intake manifolds. The turbocharger has moveable vanes within the exhaust housing. These vanes are electronically controlled, and direct exhaust gases to the EGR. The exhaust gases are cooled via a coolant-air cooler. The EGR valve, also electronically controlled, mixes the cooled exhaust gases with the cooled intake air to increase the volume of air available to the cylinders, thus increasing engine power potential. Recirculating exhaust gases also reduces emissions.

The cast cylinder block has ribbed walls to add strength and rigidity, and to decrease noise and vibration. The block is similar to the 6125 block except for:

- Cosmetic changes to the oil cooler mounting for improved oil flow.
- 10 mm taller main bearing caps for increased strength to handle the higher firing pressures. Bearing cap hardware is also 10 mm longer, and the joint is now a torque-turn joint rather than a fixed torque.
- Internal piston spray jet mounting pad for directed oil cooling of the piston.

The engine oil filter (P) mounts to a combination oil filter housing and pressure regulator housing. These items then bolt together with the oil cooler housing (A) located on the right side of the block.

A gear train on the front of the engine consists of four gears connecting the crankshaft with the camshaft. The crankshaft gear drives the oil pump gear (B), which drives the engine coolant pump gear and the idler gear (C). The idler gear then drives the camshaft gear (D). A backlash adjustment is required during assembly. No timing marks are used on the gears.

No change was made to the timing pin procedure is used to increase the accuracy of the gear train adjustment. To locate top dead center of the crankshaft for number one and number six cylinders, a timing pin is installed through a timing hole on the right side of the block. The pin will engage a slot cut into a counterweight of the crankshaft.

The crankshaft (E) is a heat treated, dynamically balanced steel forging which rotates in replaceable main bearings. Thrust washers are added to the number five main bearing to reduce crankshaft defection and to limit end play during high load operation. There are no bearing design changes from 6125 to 6135 engines. A crankshaft damper (Q) is installed on the front of the crankshaft to reduce shock loads during engine operation. The flywheel (R) also dampens load changes.

Cylinder liners (F) are wet sleeve, flanged, and centrifugally cast using a strong durable alloy. 6135 liners utilize a thinner wall thickness, to increase bore diameter and engine displacement. O-ring design (G) is unchanged, and are used to seal the connection between the cylinder block and liners. Liners incorporate top liner cooling passages.

The piston is an all steel forging, capable of withstanding the higher firing pressures seen on 6135 engines. The piston undercrown includes an oil galley for a directed supply of oil for improved cooling.

The piston spray jet has been moved to an interior block mounted design for 13.5L. The spray jet is mounted directly to the main engine block oil galley. Orientation of the spray jet is critical to be sure a directed supply of oil reaches the piston oil galley.

The hardened piston pins are highly polished, fully floating, and held in place by snap rings.

Connecting rods (J) are made of forged steel and have replaceable bushing and bearing inserts. The rods for 6135 engine has heavier main beams and small end to handle the increased loads. The machining of the small end (teepee) of the rod has been eliminated..

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The cylinder head is an air-flow-through design. The exhaust manifold is located on the left side of the head; the intake manifold on the right. Intake and exhaust passages have been optimized for the most efficient air flow, raising the volumetric efficiency of the engine. Intake ports are short to reduce intake air heating. Exhaust ports are short to reduce heat rejection to the head. The head contains the camshaft (L), 4 valves per cylinder (M), the rocker arm assemblies, and the electronic unit injectors (N). The head has replaceable powdered metal or cast iron valve guides and valve seats. For 6135, the valve centers have been increased 4 mm. Additionally, the valve diameter has been reduced, from 46.5 to 44 mm.

The camshaft turns in the head on four replaceable bushings. The camshaft directly actuates the rocker arms for the valves and the rocker arm for the electronic unit injectors. Rocker arms rotate on a two-piece rocker arm shaft (O). The rocker arms for cylinders 1, 2, and 3 rotate on one half of the two piece shaft; the rocker arms for cylinders 4, 5, and 6 rotate on the other half. Rollers built in to each rocker arm ride on the camshaft lobes.

The electronic unit injector rocker arm directly actuates an injector for each cylinder. The injectors are located so that they spray fuel directly into the center of the cylinder. The injectors for 6135 deliver fuel at a higher pressure than what is delivered in 6125 engines. The unit injector wiring harness design has been improved, using clips inside the cylinder head to retain the wiring harness and provide protection from the valve springs. The harness connector is located at the injector body, as opposed to a separate solenoid used on 6125.

The valve rocker arms push on a short push rod. The push rod actuates a bridge that will then operate two valves.

Four valves per cylinder increases engine air flow compared to using one large intake and one large exhaust valve. The intake valves for each cylinder are located towards the front of engine. The exhaust valves are located towards the rear. The intake valves and exhaust valves are the same size. The difference between the two can be determined by the fact that the intake valves are all magnetic. The head of the exhaust valves are a stellite alloy and are not magnetic.

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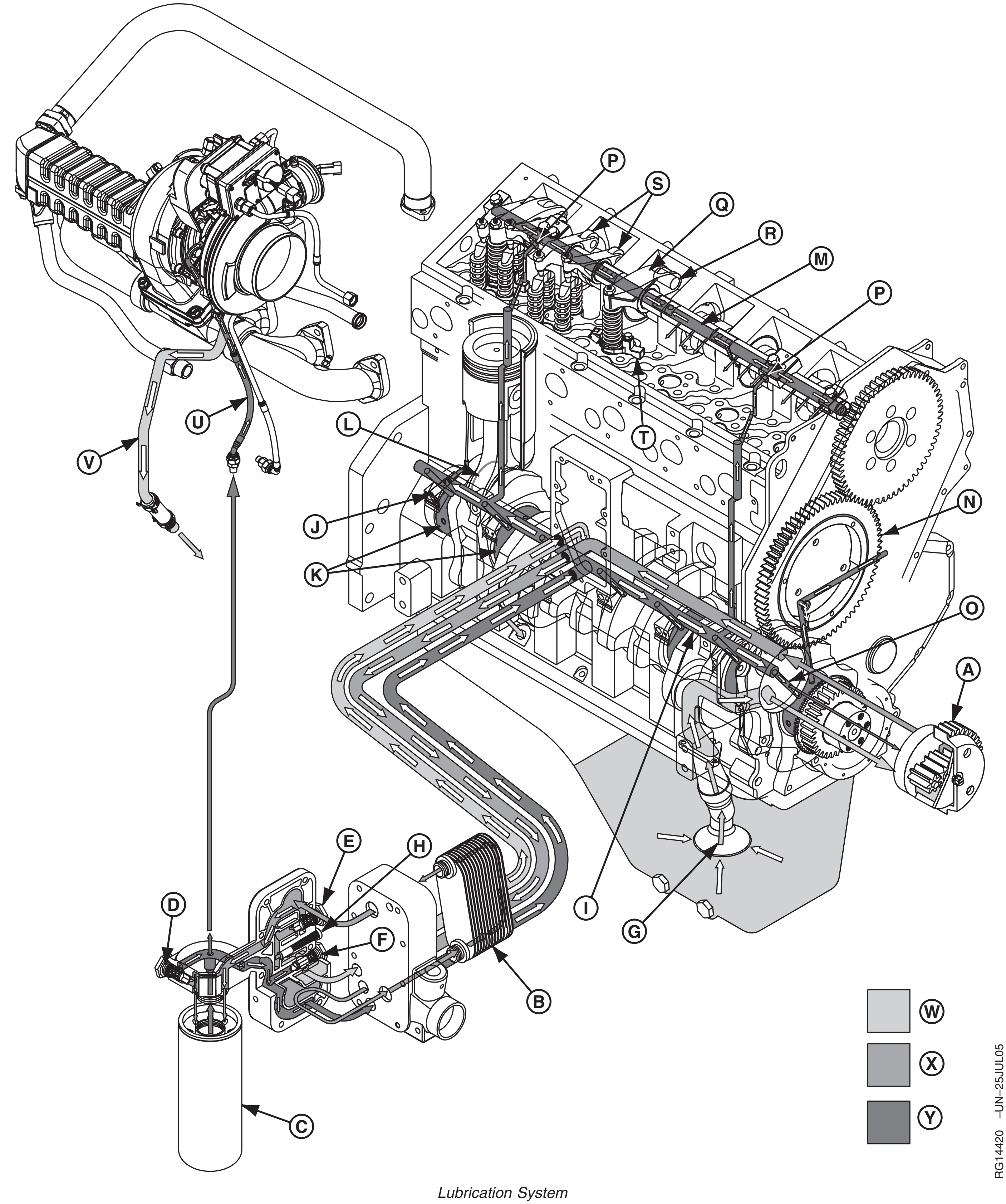
Lubrication System Operation



Lubrication System

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RE38635,0000065 –19–16AUG05–1/3

A—Oil Pump
B—Oil Cooler
C—Oil Filter
D—Oil Filter Bypass Valve
E—Oil Cooler Bypass Valve
F—Oil Pressure Regulating Valve
G—Pick-up Tube
H—Oil Cooler Relief Valve
I—Main Oil Galley
J—Piston Spray Jets
K—Crankshaft Main Bearing
L—Connecting Rod Bearing
M—Rocker Arm Shaft Assemblies
N—Idler Gear Bushing
O—Oil Pump Drive Gear Bushing Lube
P—Rocker Arm Shaft Oil Supply
Q—Unit Injector Rocker Arm
R—Unit Injector Rocker Arm Roller Bushing
S—Valve Rocker Arm Rollers
T—Electronic Unit Injector
U—Turbocharger Lube Line - Supply
V—Turbocharger Oil Drain Line
W—Return Oil
X—Pressurized Oil - Unfiltered
Y—Pressurized Oil - Filtered

The lubrication system consists of a crankshaft driven oil pump (A), oil cooler (B), oil filter (C), oil filter bypass valve (D), oil cooler bypass valve (E), and oil pressure regulating valve (F).

Oil is drawn from the sump via a pick-up tube (G) and an internal passage in the cylinder block. The oil pump sends the oil to the pressure regulating valve housing and then to the oil cooler through an internal passage in the cylinder block. An oil cooler relief valve (H) protects the oil cooler during cold oil starting by returning oil to sump. The cooler bypass valve allows oil to bypass the cooler and flow to the filter if the oil cooler is restricted. >From the oil cooler oil flows to the oil filter housing and into the filter. If the filter becomes restricted, the oil filter bypass valve will open sending oil to the main oil galley.

Oil flow from the filter is sensed by the oil pressure regulating valve. This valve regulates the pressure in the main oil galley (I). Excess oil is returned to sump.

Clean cool oil is routed directly from the top of the filter base (U) to the turbocharger. Turbocharger return oil is routed through a steel line to the cylinder block and then to sump.

The remaining oil is routed to the main oil galley then distributed to the piston spray jets (J), crankshaft main bearings (K), connecting rod bearings (L), the two rocker arm shaft assemblies (M), upper idler gear bushing (N), and auxiliary drive.

The piston spray jets receive oil directly from the main oil galley. These spray jets allow for precise targeting of the oil spray onto the bottom of the piston.

Drilled passage in the block route oil directly to each crankshaft main journal. The main bearing is slotted to allow oil to flow to the crankshaft cross-drilled passages. The crankshaft cross drilled passages route oil flow from a main journal to each connecting rod bearing.

A drilled passage (O) at the front of the block routes lubrication oil to the oil pump. A cross drilled passage in the pump housing routes this oil to the outside edge of the pump. This oil lubricates the oil pump gear bushing.

A drilled passage from the number one main bearing routes oil to the upper idler gear hub. A drilled passage in the hub routes oil to the outside edge of the hub. This oil lubricates the upper idler gear bushing.

A drilled passage in the cylinder block connects with the upper idler passage. This oil is available to lubricate auxiliary drive components.

Two drilled passages route oil from the main oil galley through the cylinder block towards the head. At the head gasket, oil flows into head bolt holes 19 and 23. Oil flows around these bolts and into a cross-drilled passage at the top of the head. Steel lines (P) connect with the cross drilled passages and routes oil to a rocker arm shaft hold down clamp for each rocker arm shaft.

At the rocker arm hold down clamp, oil flows around a cap screw and enters the rocker arm shaft assemblies (M). The rocker arm shaft is hollow and is sealed on each end. A hollow roll pin connects with each rocker arm shaft drilled passage and routes oil to the two center camshaft bushings.

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The front and rear camshaft bushings receive oil from a hole in the respective rocker arm shaft. A drilled passage lines up with a drilled passage in the head to route oil to the bushings.

The rocker arm shaft is cross-drilled to provide lubrication to each rocker arm bushing.

The unit injector rocker arms (Q) are cross-drilled to route oil from the bushing to each end of the rocker arm. At the roller end, oil flows through the roller bushing (R) and out to spray and lubricate the adjacent valve rocker arm rollers (S). Oil then sprays on to the camshaft lobes.

At the front of the unit injector rocker arms, oil sprays out the adjusting screw to lubricate the unit injector (T) and the adjacent valves and adjusting screws.

Some oil is routed from the top of the oil filter base through an external line to the turbocharger and is returned to the cylinder block crankcase through another external line.

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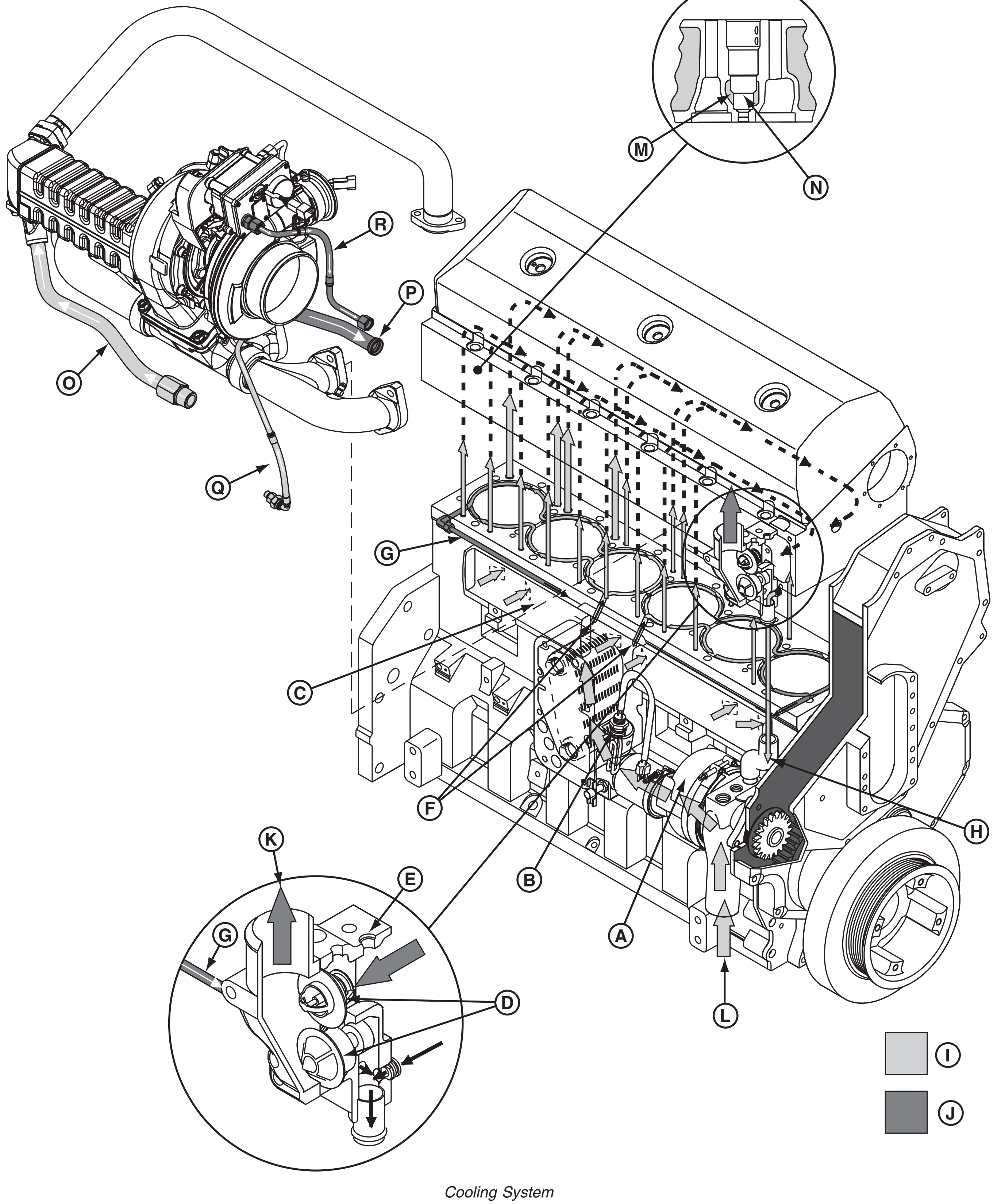
Cooling System Operation



Cooling System

Continued on next page RE38635,0000066 –19–29JAN07–1/3

A—Coolant Pump
B—Coolant Heater
C—Coolant Manifold
D—Thermostats
E—Thermostat Housing
F—Directed Top Liner Cooling Passages
G—Directed Top Liner Cooling Return Line
H—Coolant Bypass Tube
I—Low Temperature Coolant
J—High Temperature Coolant
K—To Radiator Top Tank
L—From Radiator
M—Unit Injector Sleeve Coolant Passage
N—Unit Injector Sleeve
O—EGR Cooler Supply Line
P—EGR Cooler Return
Q—Turbocharger Actuator Supply Line
R—Turbocharger Actuator Return Line

The pressurized cooling system consists of a radiator (not shown), coolant pump (A), coolant heater (B), coolant manifold (C), coolant passages in block and the cylinder head, exhaust gas recirculator (EGR) cooler lines, turbocharger actuator lines, thermostats (D), and thermostat housing (E).

The coolant pump draws coolant from the radiator through the lower radiator hose. Flow then goes past a coolant heater and into the oil cooler housing. Coolant flows around the oil cooler and then flows into one of three circuits.

The main circuit flows coolant from the oil cooler into the coolant manifold. The coolant manifold extends the length of the right side of the block. From the coolant manifold, coolant flows into each liner cavity. From the liners, coolant flows up into the cylinder head.

The coolant flow through the block and cylinder head is optimized to provide ample flow around each liner and to provide more flow to the rear of the cylinder head than into the front. To achieve this, the coolant passages from the block to the cylinder head vary in size and in number.

The holes on the right side of the block are smaller than the holes on the left side. Therefore, as coolant flows out of the coolant manifold on the right side of the block, it is forced to flow around the liners to escape through larger holes on the left of the block. This assures that each liner is surrounded by coolant flow.

In addition, there are more holes and larger holes at the rear of the cylinder head than at the front. Cylinders 1 and 2 have one 6.3 mm (0.25 in.) and one 9 mm (0.35 in.) hole. Cylinders 3 and 4 have two 6.3 mm (0.25 in.) and two 10 mm (0.39 in.) holes. Cylinders 5 and 6 have two 10 mm (0.39 in.) and two 16 mm (0.63 in.) holes.

The larger and higher number of coolant flow holes around cylinders 5 and 6 force more coolant to flow to the back of the cylinder head than to the front.

Once coolant is in the cylinder head, all flow is towards the front. Coolant from cylinder 6 flows forward and accumulates with flow from other cylinders. All coolant flow then exits out the head at number 1 cylinder to the thermostat housing.

The second circuit is called the “directed top liner cooling” system. Two drilled passages (F) at the top of the oil cooler cavity in the cylinder block route coolant to cylinders 3 and 4 liners for top liner cooling.

Coolant will flow around the top of cylinder 3 liner, then flow forward to cylinder 2 liner and then to cylinder 1 liner. Coolant will leave cylinder 1 through a drill passage to the thermostat housing. Coolant entering number 4 cylinder will flow rearward to number 5 and then to number 6. Coolant leaves number 6 cylinder through a drilled passage and flows though an external steel line (G) to the thermostat housing.

When the engine is cold, the thermostats will be closed. Coolant will flow through the bypass tube (H), into the inlet of the coolant pump.

When the engines warms to operating temperature, the thermostats will open and coolant will flow past the open thermostats to the radiator.

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The thermostat housing contains two thermostats. The bottom thermostat has a blocking poppet. When the engine gets to operating temperature, this thermostat will open and allow flow to the radiator. The blocking will close off the bypass path to the coolant pump inlet.

The top thermostat is a non-blocking type. When it opens, coolant will flow to the radiator. The non-blocking type has a vent notch to provide an air bleed when the cooling system is filled.

The third coolant circuit is unique to the Tier 3 engine design. The EGR system has an exhaust gas cooler that is liquid cooled, much like a radiator. Coolant flows (O) from the oil cooler housing to the cooler, and returns (P) to a fitting on the coolant pump inlet side. The variable geometry turbocharger (VGT) has an electronically controlled actuator that is liquid cooled as well. Coolant is supplied (Q) to the actuator from the EGR cooler and similarly returned (R) to the vehicle top tank via external lines.

Coolant also flows in passages (M) around the unit injector sleeves (N). This helps to regulate the temperature of injected fuel.

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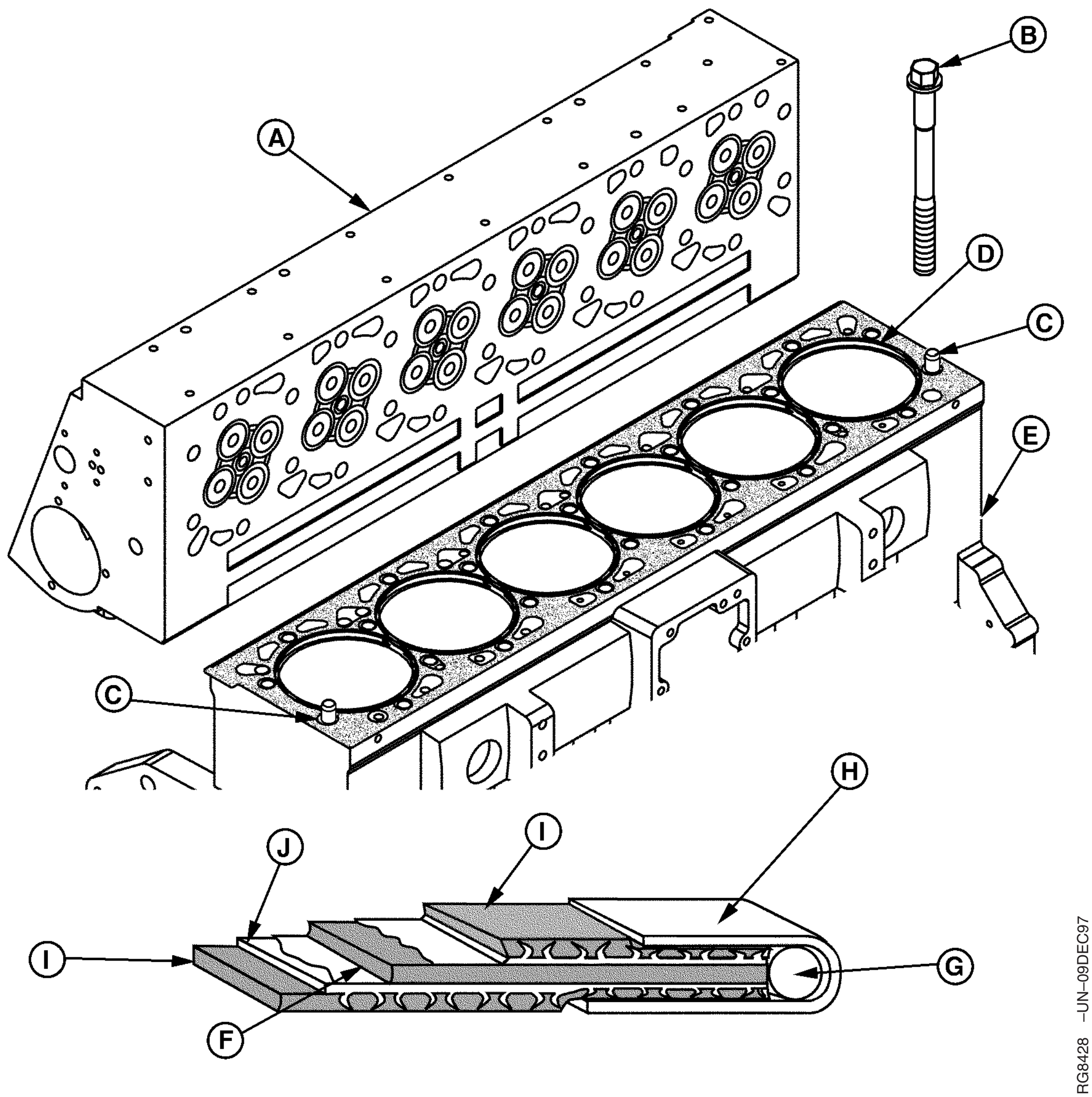
Fuel System Theory of Operation

NOTE: Fuel system operation is covered in the following companion manual:

- *CTM370—Level 15 Electronic Fuel Systems With Delphi EUIs*

RE38635,0000067 –19–16AUG05–1/1

Head Gasket Joint Construction and Operation



Cylinder Head Gasket Construction

A—Cylinder Head
B—Cylinder Head Cap Screws
C—Dowel Pins
D—Cylinder Liners
E—Cylinder Block
F—Solid Steel Core
G—Fire Ring Combustion Seal
H—Stainless Steel Flange
I—Graphite Gasket Body
J—Perforated Steel Core

The head gasket joint consists of:

- Cylinder head gasket body (I)
- Cylinder head (A)
- Cylinder block (E)
- Cylinder liners (D)
- Cylinder head cap screws (B)

Continued on next page

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 a solid steel core (F) covered by perforated steel core (J) and graphite body (I). The surface of gasket is treated to improve liquid sealing and anti-stick characteristics. A fire ring combustion seal (G) is located at each cylinder bore and is held in place by a U-shaped stainless steel flange (H).

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 form moving in the joint. Dowel pins (C) are used to properly locate head gasket on block.

The cylinder liners (D) 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 (B) 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.

Each of the above components contributes to the integrity of the head gasket joint. If any of these components do not conform to specification, 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 pressure persist.

RG,RG34710,67 –19–30SEP97–2/2

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 final filter elements in the air cleaner canister. Clean air travels through the intake air hose to the turbocharger, through the air-to-air aftercooler, through the exhaust gas recirculator (EGR) valves, and into the intake manifold.

Exhaust, as it is expelled out of the exhaust manifold, 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. A significant feature of the Tier 3/Stage IIIA engine series is the EGR and variable geometry turbocharger (VGT). The system is electronically controlled by the engine ECU. A portion of the exhaust gas is drawn through a liquid cooled cooler (much like a radiator) to cool the gases. Dual EGR valves, located on the intake manifold and controlled by the ECU, mixes the cooled exhaust and intake gases to provide additional air to the engine, as load conditions demand. The increased air volume available to the engine allows additional fuel to be delivered to the combustion chamber. Thus, power output of the engine is increased. An additional benefit of recirculating exhaust gases is harmful emissions released to the atmosphere are reduced.

An air-to-air aftercooler cools the turbocharger compressor discharge air by routing it through a heat exchanger before it enters the engine. The heat exchanger uses no liquid coolant but relies on air flow to cool the charge air.

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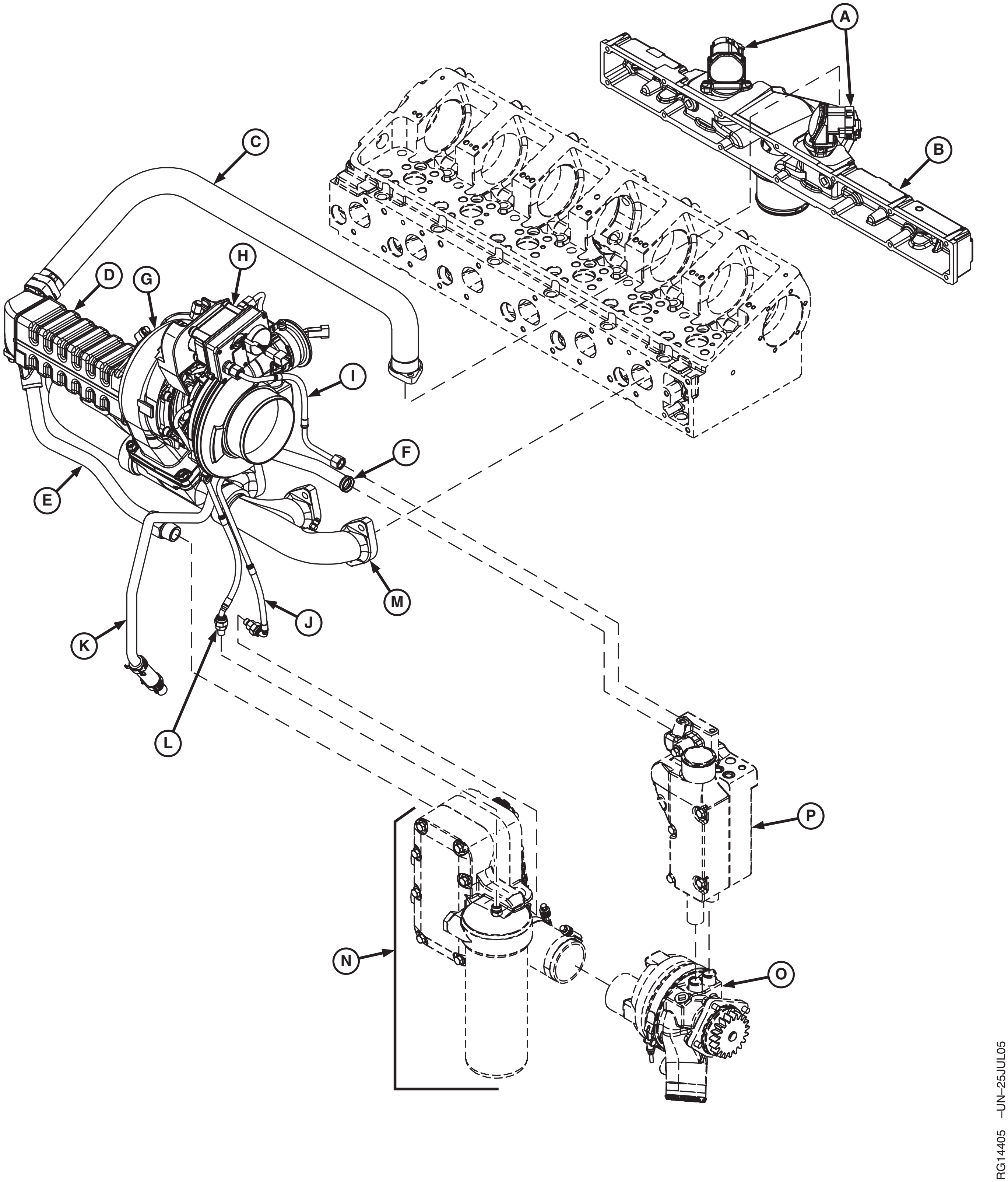
Exhaust Gas Recirculator (EGR) & Variable Geometry Turbocharger (VGT) Operation



EGR & VGT

Continued on next page RE38635,000006F –19–30AUG05–1/3

A—EGR Valves
B—Intake Manifold
C—Intake Crossover Tube
D—EGR Cooler
E—EGR Cooler Coolant Supply Line
F—EGR Cooler Coolant Return Line
G—Variable Geometry Turbocharger (VGT)
H—VGT Actuator
I—Actuator Coolant Return Line
J—Actuator Coolant Supply Line
K—VGT Oil Drain Line
L—VGT Oil Supply Line
M—Exhaust Manifold
N—Oil Cooler & Filter Assembly
O—Coolant Pump
P—Coolant Manifold

Design features new to the air system of the 13.5 L Tier III/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 (H), open or close to control the volume of exhaust gases to be routed through the cooler (D). The gases then pass through a cooler which is bolted to the exhaust manifold (M) and crossover pipe (C). After cooling, a portion of the exhaust gases are mixed with intake air by the dual EGR valves (A), located on the intake manifold (B). The engine control unit (ECU) controls the quantity of exhaust gas to be mixed with intake air for combustion, depending on load demand of the engine. Under full load conditions, as much as 10-12% of the intake air used for combustion is recirculated exhaust gases. The additional volume of air gained by recirculation of cooled exhaust gases allows the 13.5 L engine to run with higher boost pressures. This allows increased fuel delivery and increases in power output of the engine. Harmful emissions released to the atmosphere are also reduced.

The VGT has an electronically controlled, liquid cooled actuator (H) as a part of its assembly. The actuator is controlled by the engine control unit (ECU). The actuator, as stated, adjusts the vanes on the turbine wheel to ensure proper exhaust gas volumes to be directed to the cooler.. The actuator is cooled by engine coolant. The supply line (J) is plumbed from the engine oil cooler (N) to the actuator, and the return line (I) returns heated coolant to the thermostat housing (P). The variable output capability of the VGT provides the ability to increase low speed torque, provide a quicker transient response, and increase peak torque while also improving fuel economy.

As engine speed and load demands increase, the ECU signals the VGT actuator to close the vanes on the turbine wheel. This drives exhaust gas pressures and velocities upward, which in turn increases engine boost. The increase in boost pressures limits smoke and reduces emission particulates released to the atmosphere.

The exhaust gases are transmitted from the VGT to an exhaust gas cooler. The cooler is bolted to the exhaust manifold with a two-bolt flange. This cooler operates much like a radiator, in that it has internal fins, which, using engine coolant routed through an external line (E) directly from the engine oil cooler, 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 through another external line (F) to the engine thermostat housing. The exhaust gases enter the cooler at approximately 600° C and exit at approximately 200° C.

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The cooled exhaust gas passes from the cooler (D) through a crossover pipe C) to the opposite side of the engine to the intake manifold. (B). Dual EGR Valves (A), are located on top of the intake manifold and are a part of the intake manifold assembly. The function of the EGR valve, also controlled by the engine ECU, is to mix given volumes of exhaust gases with the intake air, depending on engine load demand. This mixture of exhaust gases and intake air serves two purposes: (1). It allows more cooled air to be introduced into the combustion chamber. This in turn allows more fuel to be introduced to the combustion process, allowing increased power levels. (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 start-up, when engine coolant is cold, and under no-to-light load conditions, the valve remains closed. 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 includeexhaust gas temperature, charge air temperature, mixed air (intake and exhaust) temperature, Manifold Air Pressure (MAP) intake, and MAP exhaust

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Turbocharger Operation

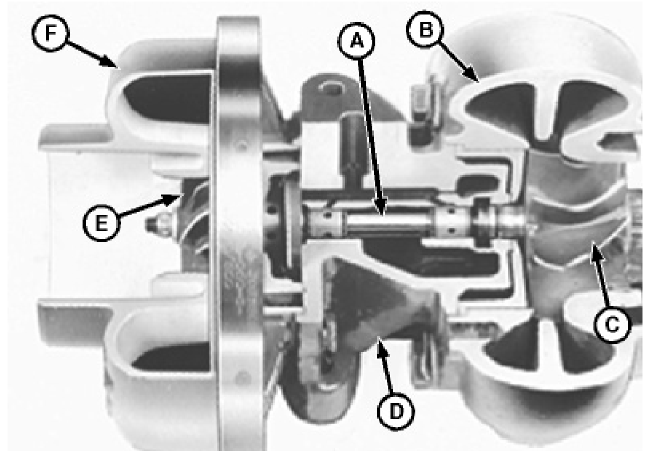
The turbocharger, which is basically an air pump that is driven by exhaust gases, allows the engine to produce added power without increasing displacement. Turbochargers are specially matched for the power ratio requirements of each specific application.

The turbine wheel (C) is driven by the hot engine exhaust gases. These gases flowing through the turbine housing (B) act on the turbine wheel causing shaft (A) to turn.

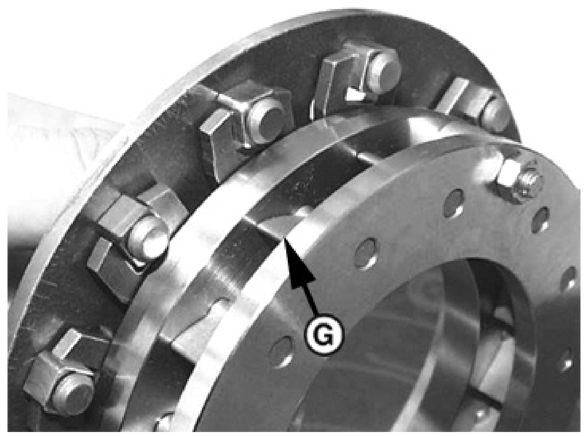
The variable geometry turbocharger used on Tier 3/Stage IIIA engines have adjustable vanes (G) on the exhaust (turbine) side. These vanes are opened and closed to regulate exhaust gases to the exhaust gas recirculator cooler, depending on engine load demand. The vanes are electronically controlled by the turbocharger actuator, which is liquid cooled and is part of the turbocharger assembly.

Compressor wheel (E) brings in filtered air and discharges the compressed air into the intake manifold where it is then delivered to engine cylinders.

Engine oil under pressure from the engine lubrication system is forced through passages in center housing (D) to bearings.



Turbocharger Components



VGT Adjustable Vanes

A—Shaft
B—Turbine Housing
C—Turbine Wheel
D—Center Housing
E—Compressor Wheel
F—Compressor Housing
G—Adjustable Vanes

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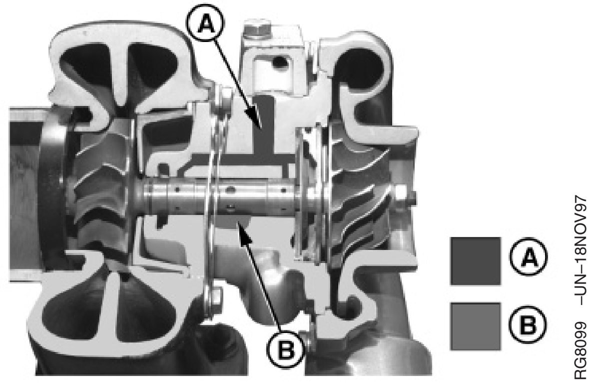
How the Turbocharger is Lubricated

Engine oil under pressure from the engine lubrication system is pumped through a passage in the bearing housing and directed to the bearings, thrust plate, and thrust sleeve. Oil is sealed from the compressor and turbine by a piston ring at both ends of the bearing housing.

The turbocharger contains two floating bearings. These bearings have clearance between the bearing OD and the housing bore as well as clearance between the bearing ID and the shaft OD. These clearances are lubricated by the oil supply (A) and the bearings are protected by a cushion of oil. Discharge oil (B) drains by gravity from the bearing housing to the engine crankcase.



Turbocharger Lubrication

A—Pressure Oil
B—Discharge Oil

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Group 121
Base Engine Operation — PowerTech & PowerTech E

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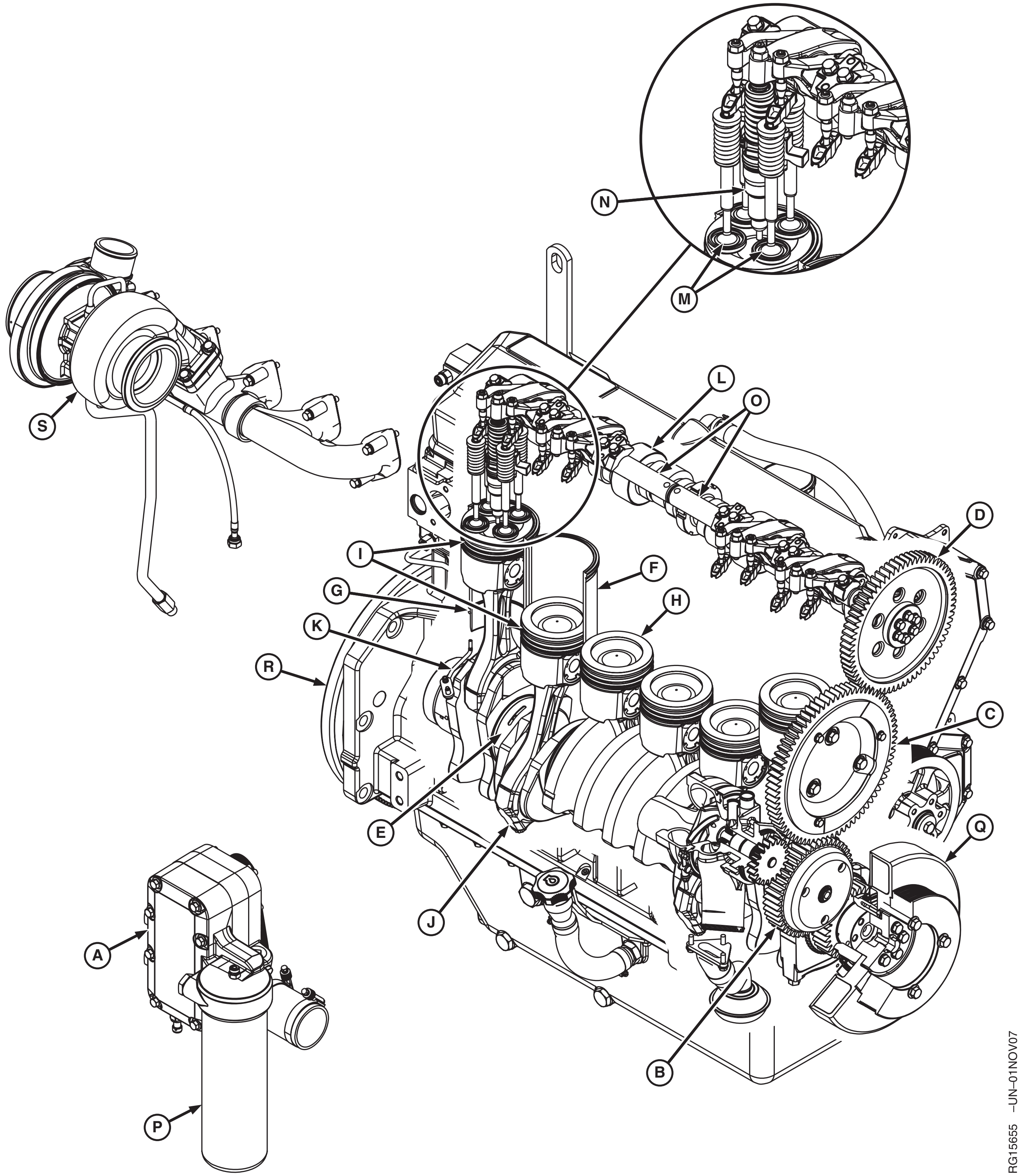
General Engine Operation



6135 Engine Components

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A—Oil Cooler
B—Oil Pump Drive Gear
C—Idler Gear
D—Camshaft Gear
E—Crankshaft
F—Cylinder Liner
G—Cylinder Liner O-Rings
H—Piston
I—Piston Rings
J—Connecting Rod
K—Oil Spray Jet
L—Camshaft
M—Valves
N—Electronic Unit Injector
O—Two Piece Rocker Arm Shaft
P—Oil Filter
Q—Crankshaft Damper
R—Flywheel
S—Variable Geometry Turbocharger

The 6135 POWERTECH™ and POWERTECH™E engines are similar to the 6125 except for changes noted below. The 6135 includes the same cam in head design, actuating four valves per cylinder and an electronic unit injector (EUI) fuel system. The injector has changed in that the previous offset solenoid design is replaced by a unit injector with the quick connect electrical connector integral with the pump body. The increase in displacement is accomplished with a thinner wall cylinder liner. They are vertical stroke, in-line, 4 valve-in-head, 6-cylinder diesel engines. The firing order is 1-5-3-6-2-4.

The cast cylinder block has ribbed walls to add strength and rigidity, and to decrease noise and vibration. The block is similar to the 6125 block except for:

- Cosmetic changes to the oil cooler mounting for improved oil flow.
- 10 mm taller main bearing caps for increased strength to handle the higher firing pressures. Bearing cap hardware is also 10 mm longer, and the joint is now a torque-turn joint rather than a fixed torque.
- Internal piston spray jet mounting pad for directed oil cooling of the piston.

The engine oil filter (P) mounts to a combination oil filter housing and pressure regulator housing. These items then bolt together with the oil cooler housing (A) located on the right side of the block.

A gear train on the front of the engine consists of four gears connecting the crankshaft with the camshaft. The crankshaft gear drives the oil pump gear (B), which drives the engine coolant pump gear and the idler gear (C). The idler gear then drives the camshaft gear (D). A backlash adjustment is required during assembly. No timing marks are used on the gears.

No change was made to the timing pin procedure is used to increase the accuracy of the gear train adjustment. To locate top dead center of the crankshaft for number one and number six cylinders, a timing pin is installed through a timing hole on the right side of the block. The pin will engage a slot cut into a counterweight of the crankshaft.

The crankshaft (E) is a heat treated, dynamically balanced steel forging which rotates in replaceable main bearings. Thrust washers are added to the number five main bearing to reduce crankshaft defection and to limit end play during high load operation. There are no bearing design changes from 6125 to 6135 engines. A crankshaft damper (Q) is installed on the front of the crankshaft to reduce shock loads during engine operation. The flywheel (R) also dampens load changes.

Cylinder liners (F) are wet sleeve, flanged, and centrifugally cast using a strong durable alloy. 6135 liners utilize a thinner wall thickness, to increase bore diameter and engine displacement. O-ring design (G) is unchanged, and are used to seal the connection between the cylinder block and liners. Liners incorporate top liner cooling passages.

The piston is an all steel forging, capable of withstanding the higher firing pressures seen on 6135 engines. The piston undercrown includes an oil galley for a directed supply of oil for improved cooling.

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The piston spray jet has been moved to an interior block mounted design for 13.5L. The spray jet is mounted directly to the main engine block oil galley. Orientation of the spray jet is critical to be sure a directed supply of oil reaches the piston oil galley.

The hardened piston pins are highly polished, fully floating, and held in place by snap rings.

Connecting rods (J) are made of forged steel and have replaceable bushing and bearing inserts. The rods for 6135 engine has heavier main beams and small end to handle the increased loads. The machining of the small end (teepee) of the rod has been eliminated..

The cylinder head is an air-flow-through design. The exhaust manifold is located on the left side of the head; the intake manifold on the right. Intake and exhaust passages have been optimized for the most efficient air flow, raising the volumetric efficiency of the engine. Intake ports are short to reduce intake air heating. Exhaust ports are short to reduce heat rejection to the head. The head contains the camshaft (L), 4 valves per cylinder (M), the rocker arm assemblies, and the electronic unit injectors (N). The head has replaceable powdered metal or cast iron valve guides and valve seats. For 6135, the valve centers have been increased 4 mm. Additionally, the valve diameter has been reduced, from 46.5 to 44 mm.

The camshaft turns in the head on four replaceable bushings. The camshaft directly actuates the rocker arms for the valves and the rocker arm for the electronic unit injectors. Rocker arms rotate on a two-piece rocker arm shaft (O). The rocker arms for cylinders 1, 2, and 3 rotate on one half of the two piece shaft; the rocker arms for cylinders 4, 5, and 6 rotate on the other half. Rollers built in to each rocker arm ride on the camshaft lobes.

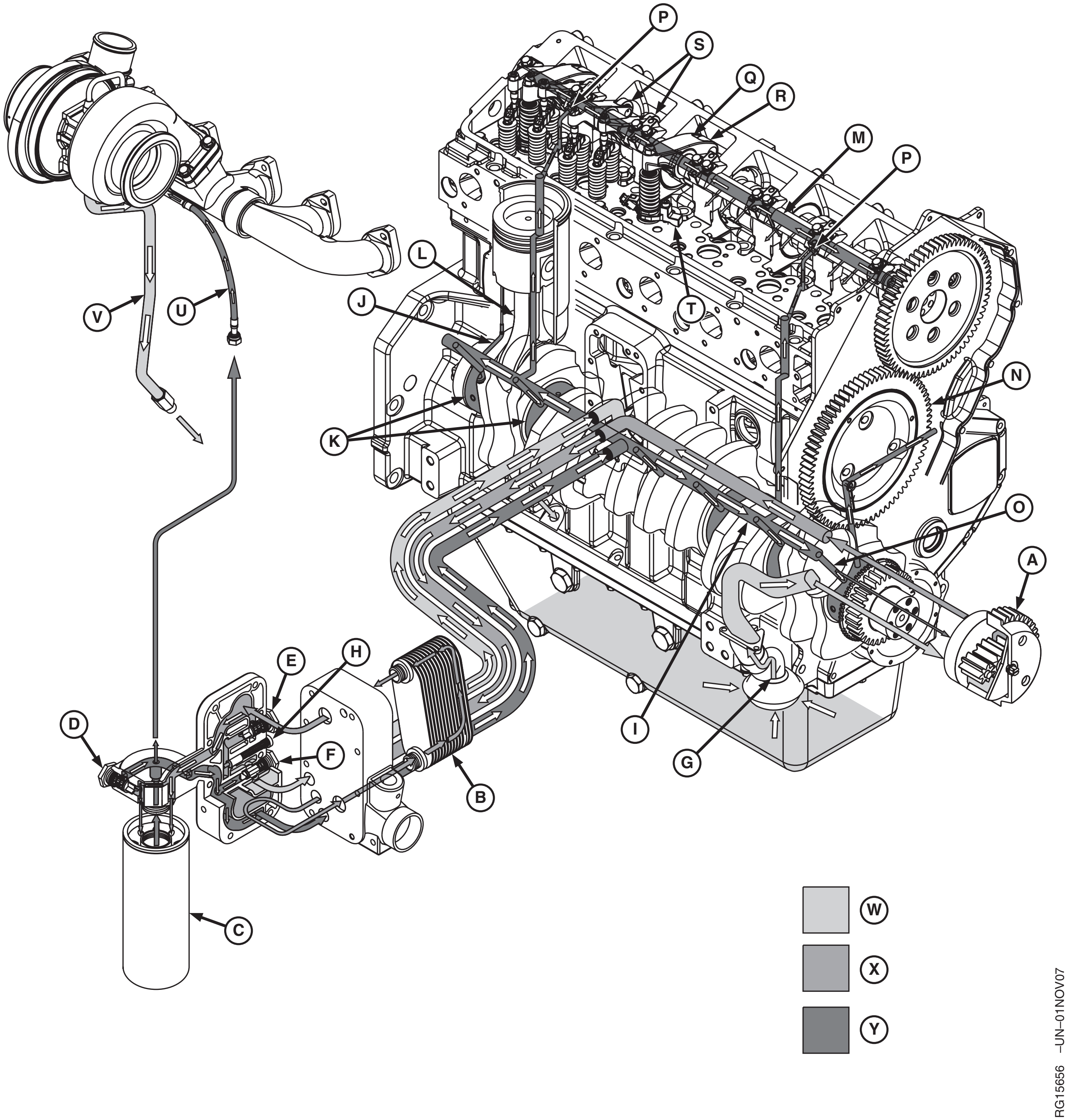
The electronic unit injector rocker arm directly actuates an injector for each cylinder. The injectors are located so that they spray fuel directly into the center of the cylinder. The injectors for 6135 deliver fuel at a higher pressure than what is delivered in 6125 engines. The unit injector wiring harness design has been improved, using clips inside the cylinder head to retain the wiring harness and provide protection from the valve springs. The harness connector is located at the injector body, as opposed to a separate solenoid used on 6125.

The valve rocker arms push on a short push rod. The push rod actuates a bridge that will then operate two valves.

Four valves per cylinder increases engine air flow compared to using one large intake and one large exhaust valve. The intake valves for each cylinder are located towards the front of engine. The exhaust valves are located towards the rear. The intake valves and exhaust valves are the same size. The difference between the two can be determined by the fact that the intake valves are all magnetic. The head of the exhaust valves are a stellite alloy and are not magnetic.

RE38635,00000E1 –19–22OCT07–3/3

Lubrication System Operation



Lubrication System

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A—Oil Pump
B—Oil Cooler
C—Oil Filter
D—Oil Filter Bypass Valve
E—Oil Cooler Bypass Valve
F—Oil Pressure Regulating Valve
G—Pick-up Tube
H—Oil Cooler Relief Valve
I—Main Oil Galley
J—Piston Spray Jets
K—Crankshaft Main Bearing
L—Connecting Rod Bearing
M—Rocker Arm Shaft Assemblies
N—Idler Gear Bushing
O—Oil Pump Drive Gear Bushing Lube
P—Rocker Arm Shaft Oil Supply
Q—Unit Injector Rocker Arm
R—Unit Injector Rocker Arm Roller Bushing
S—Valve Rocker Arm Rollers
T—Electronic Unit Injector
U—Turbocharger Lube Line - Supply
V—Turbocharger Oil Drain Line
W—Return Oil
X—Pressurized Oil - Unfiltered
Y—Pressurized Oil - Filtered

The lubrication system consists of a crankshaft driven oil pump (A), oil cooler (B), oil filter (C), oil filter bypass valve (D), oil cooler bypass valve (E), and oil pressure regulating valve (F).

Oil is drawn from the sump via a pick-up tube (G) and an internal passage in the cylinder block. The oil pump sends the oil to the pressure regulating valve housing and then to the oil cooler through an internal passage in the cylinder block. An oil cooler relief valve (H) protects the oil cooler during cold oil starting by returning oil to sump. The cooler bypass valve allows oil to bypass the cooler and flow to the filter if the oil cooler is restricted. >From the oil cooler oil flows to the oil filter housing and into the filter. If the filter becomes restricted, the oil filter bypass valve will open sending oil to the main oil galley.

Oil flow from the filter is sensed by the oil pressure regulating valve. This valve regulates the pressure in the main oil galley (I). Excess oil is returned to sump.

Clean cool oil is routed directly from the top of the filter base (U) to the turbocharger. Turbocharger return oil is routed through a steel line to the cylinder block and then to sump.

The remaining oil is routed to the main oil galley then distributed to the piston spray jets (J), crankshaft main bearings (K), connecting rod bearings (L), the two rocker arm shaft assemblies (M), upper idler gear bushing (N), and auxiliary drive.

The piston spray jets receive oil directly from the main oil galley. These spray jets allow for precise targeting of the oil spray onto the bottom of the piston.

Drilled passage in the block route oil directly to each crankshaft main journal. The main bearing is slotted to allow oil to flow to the crankshaft cross-drilled passages. The crankshaft cross drilled passages route oil flow from a main journal to each connecting rod bearing.

A drilled passage (O) at the front of the block routes lubrication oil to the oil pump. A cross drilled passage in the pump housing routes this oil to the outside edge of the pump. This oil lubricates the oil pump gear bushing.

A drilled passage from the number one main bearing routes oil to the upper idler gear hub. A drilled passage in the hub routes oil to the outside edge of the hub. This oil lubricates the upper idler gear bushing.

A drilled passage in the cylinder block connects with the upper idler passage. This oil is available to lubricate auxiliary drive components.

Two drilled passages route oil from the main oil galley through the cylinder block towards the head. At the head gasket, oil flows into head bolt holes 19 and 23. Oil flows around these bolts and into a cross-drilled passage at the top of the head. Steel lines (P) connect with the cross drilled passages and routes oil to a rocker arm shaft hold down clamp for each rocker arm shaft.

At the rocker arm hold down clamp, oil flows around a cap screw and enters the rocker arm shaft assemblies (M). The rocker arm shaft is hollow and is sealed on each end. A hollow roll pin connects with each rocker arm shaft drilled passage and routes oil to the two center camshaft bushings.

Continued on next page

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The front and rear camshaft bushings receive oil from a hole in the respective rocker arm shaft. A drilled passage lines up with a drilled passage in the head to route oil to the bushings.

The rocker arm shaft is cross-drilled to provide lubrication to each rocker arm bushing.

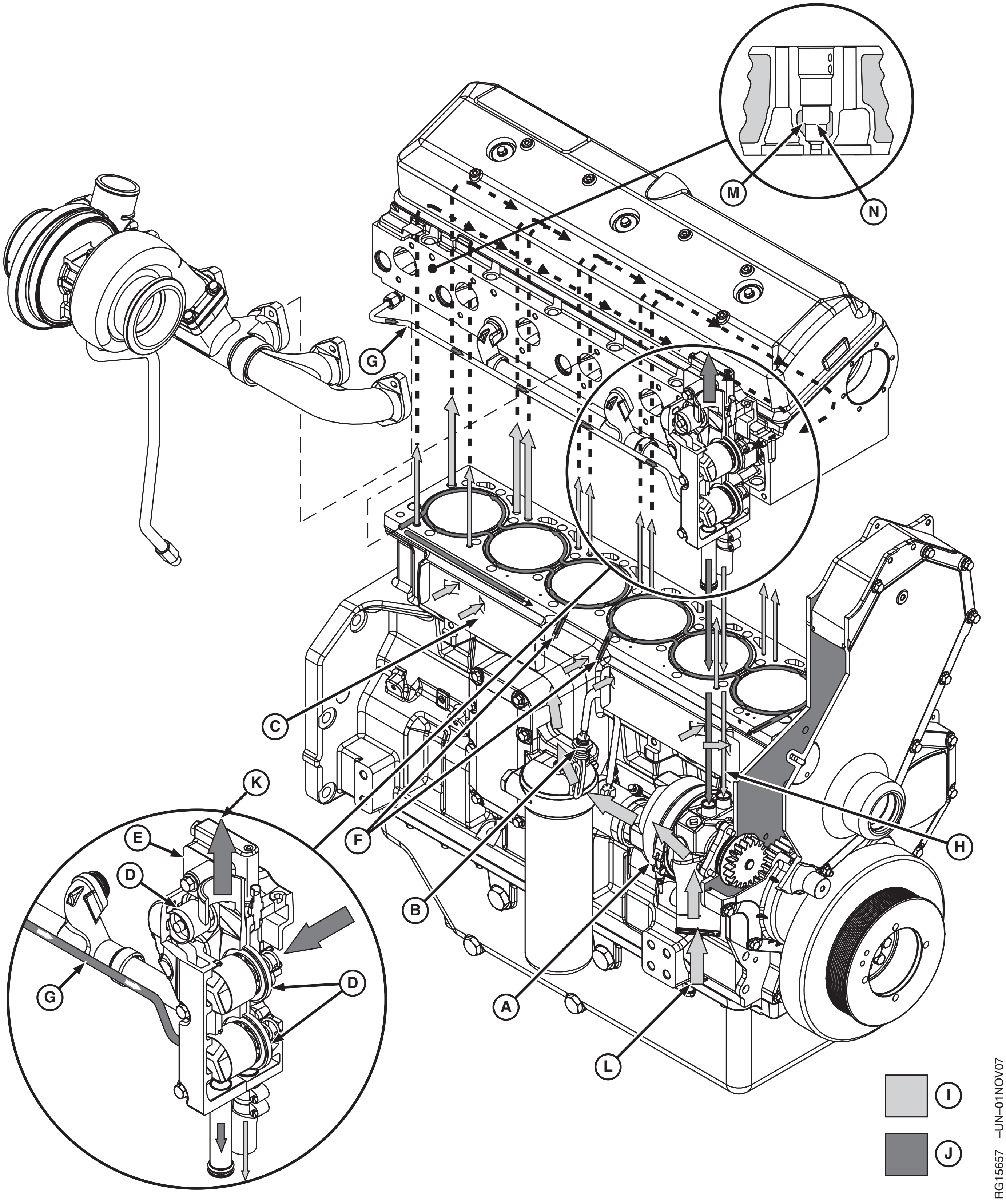
The unit injector rocker arms (Q) are cross-drilled to route oil from the bushing to each end of the rocker arm. At the roller end, oil flows through the roller bushing (R) and out to spray and lubricate the adjacent valve rocker arm rollers (S). Oil then sprays on to the camshaft lobes.

At the front of the unit injector rocker arms, oil sprays out the adjusting screw to lubricate the unit injector (T) and the adjacent valves and adjusting screws.

Some oil is routed from the top of the oil filter base through an external line to the turbocharger and is returned to the cylinder block crankcase through another external line.

RE38635,00000E2 –19–22OCT07–3/3

Cooling System Operation



Cooling System

Continued on next page

RE38635,00000E3 –19–22OCT07–1/3

A—Coolant Pump
B—Coolant Heater
C—Coolant Manifold
D—Thermostats
E—Thermostat Housing
F—Directed Top Liner Cooling Passages
G—Directed Top Liner Cooling Return Line
H—Coolant Bypass Tube
I—Low Temperature Coolant
J—High Temperature Coolant
K—To Radiator Top Tank
L—From Radiator
M—Unit Injector Sleeve Coolant Passage
N—Unit Injector Sleeve
Q—Turbocharger Actuator Supply Line
R—Turbocharger Actuator Return Line

The pressurized cooling system consists of a radiator (not shown), coolant pump (A), coolant heater (B), coolant manifold (C), coolant passages in block and the cylinder head, exhaust gas recirculator (EGR) cooler lines, turbocharger actuator lines, thermostats (D), and thermostat housing (E).

The coolant pump draws coolant from the radiator through the lower radiator hose. Flow then goes past a coolant heater and into the oil cooler housing. Coolant flows around the oil cooler and then flows into one of three circuits.

The main circuit flows coolant from the oil cooler into the coolant manifold. The coolant manifold extends the length of the right side of the block. From the coolant manifold, coolant flows into each liner cavity. From the liners, coolant flows up into the cylinder head.

The coolant flow through the block and cylinder head is optimized to provide ample flow around each liner and to provide more flow to the rear of the cylinder head than into the front. To achieve this, the coolant passages from the block to the cylinder head vary in size and in number.

The holes on the right side of the block are smaller than the holes on the left side. Therefore, as coolant flows out of the coolant manifold on the right side of the block, it is forced to flow around the liners to escape through larger holes on the left of the block. This assures that each liner is surrounded by coolant flow.

In addition, there are more holes and larger holes at the rear of the cylinder head than at the front. Cylinders 1 and 2 have one 6.3 mm (0.25 in.) and one 9 mm (0.35 in.) hole. Cylinders 3 and 4 have two 6.3 mm (0.25 in.) and two 10 mm (0.39 in.) holes. Cylinders 5 and 6 have two 10 mm (0.39 in.) and two 16 mm (0.63 in.) holes.

The larger and higher number of coolant flow holes around cylinders 5 and 6 force more coolant to flow to the back of the cylinder head than to the front.

Once coolant is in the cylinder head, all flow is towards the front. Coolant from cylinder 6 flows forward and accumulates with flow from other cylinders. All coolant flow then exits out the head at number 1 cylinder to the thermostat housing.

The second circuit is called the “directed top liner cooling” system. Two drilled passages (F) at the top of the oil cooler cavity in the cylinder block route coolant to cylinders 3 and 4 liners for top liner cooling.

Coolant will flow around the top of cylinder 3 liner, then flow forward to cylinder 2 liner and then to cylinder 1 liner. Coolant will leave cylinder 1 through a drill passage to the thermostat housing. Coolant entering number 4 cylinder will flow rearward to number 5 and then to number 6. Coolant leaves number 6 cylinder through a drilled passage and flows though an external steel line (G) to the thermostat housing.

When the engine is cold, the thermostats will be closed. Coolant will flow through the bypass tube (H), into the inlet of the coolant pump.

When the engines warms to operating temperature, the thermostats will open and coolant will flow past the open thermostats to the radiator.

Continued on next page

The thermostat housing contains two thermostats. The bottom thermostat has a blocking poppet. When the engine gets to operating temperature, this thermostat will open and allow flow to the radiator. The blocking will close off the bypass path to the coolant pump inlet.

The top thermostat is a non-blocking type. When it opens, coolant will flow to the radiator. The non-blocking type has a vent notch to provide an air bleed when the cooling system is filled.

Coolant also flows in passages (M) around the unit injector sleeves (N). This helps to regulate the temperature of injected fuel.

RE38635,00000E3 –19–22OCT07–3/3

Fuel System Theory of Operation

NOTE: Fuel system operation is covered in the following companion manual:

- *CTM370—Level 15 Electronic Fuel Systems With Delphi EUIs*

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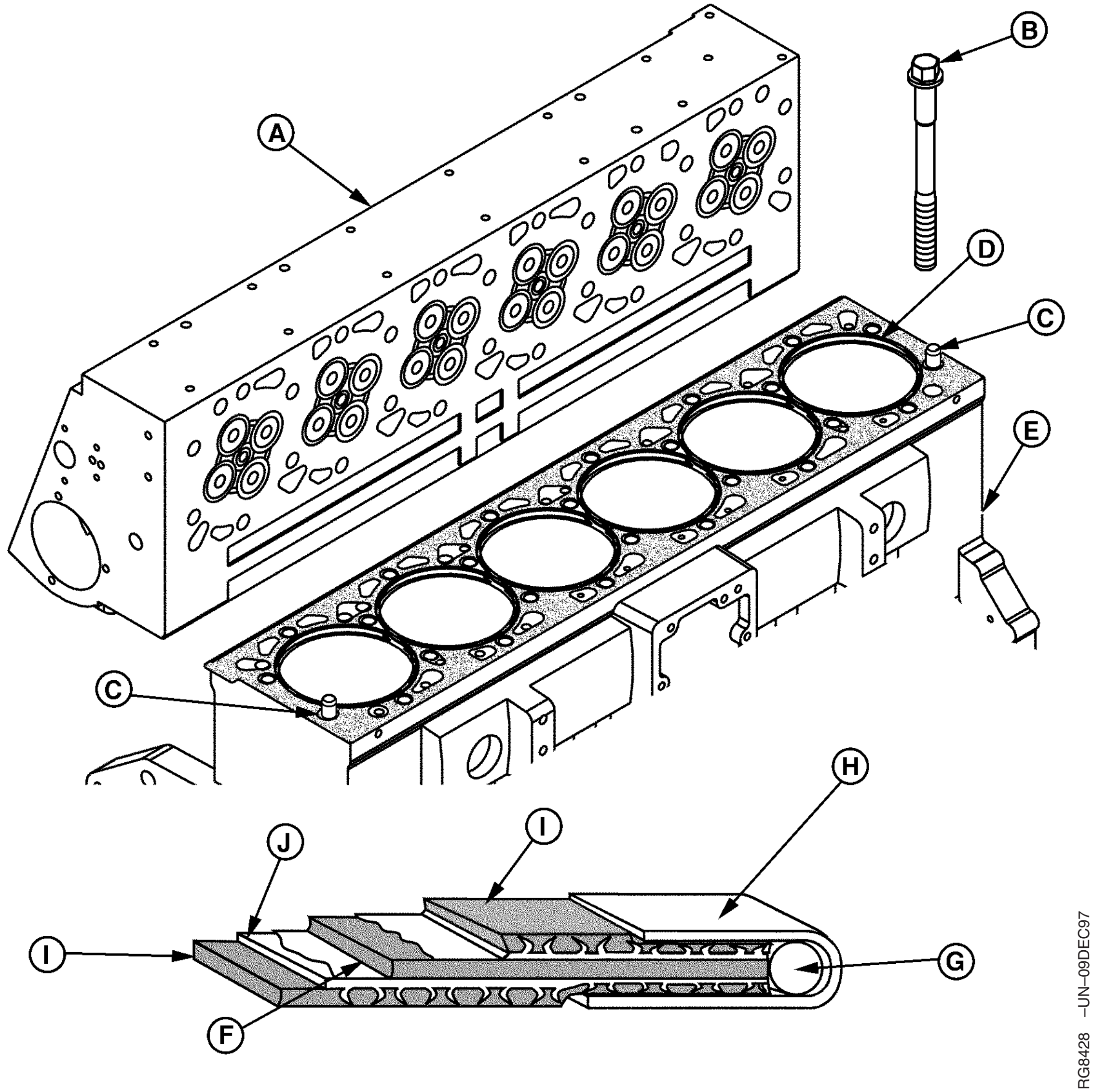
Head Gasket Joint Construction and Operation



Cylinder Head Gasket Construction

A—Cylinder Head
B—Cylinder Head Cap Screws
C—Dowel Pins
D—Cylinder Liners
E—Cylinder Block
F—Solid Steel Core
G—Fire Ring Combustion Seal
H—Stainless Steel Flange
I—Graphite Gasket Body
J—Perforated Steel Core

The head gasket joint consists of:

- Cylinder head gasket body (I)
- Cylinder head (A)
- Cylinder block (E)
- Cylinder liners (D)
- Cylinder head cap screws (B)

Continued on next page

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 a solid steel core (F) covered by perforated steel core (J) and graphite body (I). The surface of gasket is treated to improve liquid sealing and anti-stick characteristics. A fire ring combustion seal (G) is located at each cylinder bore and is held in place by a U-shaped stainless steel flange (H).

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 form moving in the joint. Dowel pins (C) are used to properly locate head gasket on block.

The cylinder liners (D) 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 (B) 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.

Each of the above components contributes to the integrity of the head gasket joint. If any of these components do not conform to specification, 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 pressure persist.

RE38635,00000E5 –19–22OCT07–2/2

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 final filter elements in the air cleaner canister. Clean air travels through the intake air hose to the turbocharger, through the air-to-air aftercooler, and into the intake manifold.

Exhaust, as it is expelled out of the exhaust manifold, 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 increased air volume available to the engine allows additional fuel to be delivered to the combustion chamber. Thus, power output of the engine is increased.

An air-to-air aftercooler cools the turbocharger compressor discharge air by routing it through a heat exchanger before it enters the engine. The heat exchanger uses no liquid coolant but relies on air flow to cool the charge air.

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Turbocharger Operation

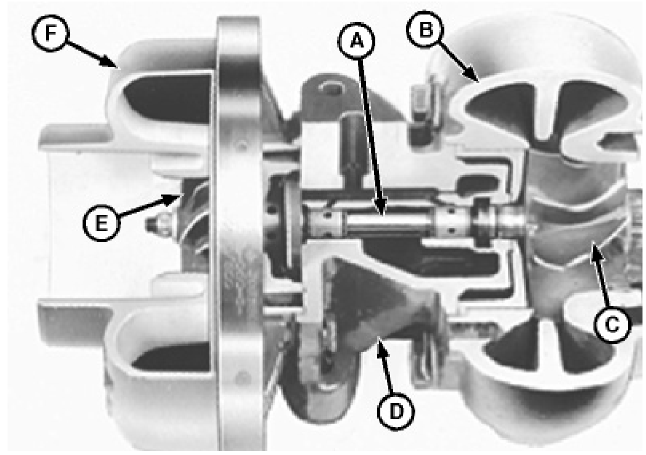
The turbocharger, which is basically an air pump that is driven by exhaust gases, allows the engine to produce added power without increasing displacement. Turbochargers are specially matched for the power ratio requirements of each specific application.

The turbine wheel (C) is driven by the hot engine exhaust gases. These gases flowing through the turbine housing (B) act on the turbine wheel causing shaft (A) to turn.

The variable geometry turbocharger used on Tier 3/Stage IIIA engines have adjustable vanes (G) on the exhaust (turbine) side. These vanes are opened and closed to regulate exhaust gases to the exhaust gas recirculator cooler, depending on engine load demand. The vanes are electronically controlled by the turbocharger actuator, which is liquid cooled and is part of the turbocharger assembly.

Compressor wheel (E) brings in filtered air and discharges the compressed air into the intake manifold where it is then delivered to engine cylinders.

Engine oil under pressure from the engine lubrication system is forced through passages in center housing (D) to bearings.



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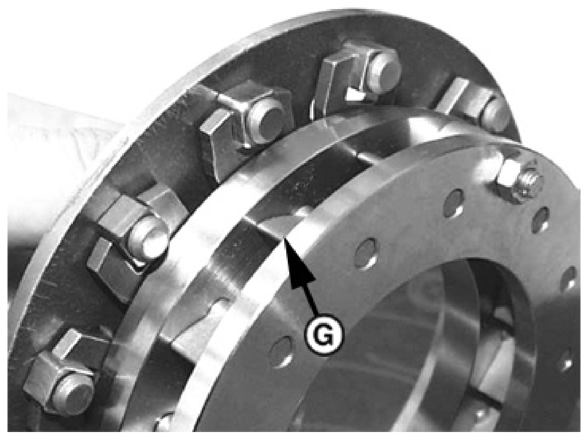
Turbocharger Components



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VGT Adjustable Vanes

A—Shaft
B—Turbine Housing
C—Turbine Wheel
D—Center Housing
E—Compressor Wheel
F—Compressor Housing
G—Adjustable Vanes

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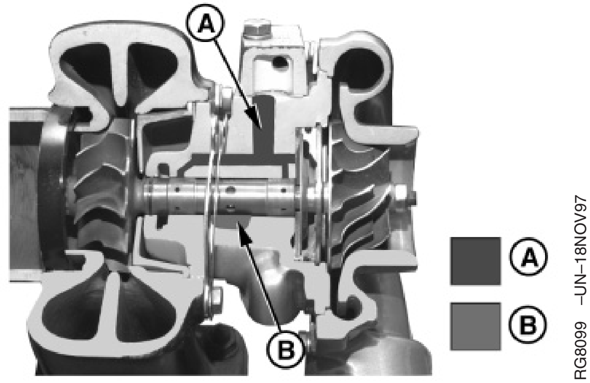
How the Turbocharger is Lubricated

Engine oil under pressure from the engine lubrication system is pumped through a passage in the bearing housing and directed to the bearings, thrust plate, and thrust sleeve. Oil is sealed from the compressor and turbine by a piston ring at both ends of the bearing housing.

The turbocharger contains two floating bearings. These bearings have clearance between the bearing OD and the housing bore as well as clearance between the bearing ID and the shaft OD. These clearances are lubricated by the oil supply (A) and the bearings are protected by a cushion of oil. Discharge oil (B) drains by gravity from the bearing housing to the engine crankcase.



Turbocharger Lubrication

A—Pressure Oil
B—Discharge Oil

RE38635,00000E9 –19–22OCT07–1/1

Section 04
Diagnostics

Contents

04

About this Section of the Manual

This section of the manual contains necessary information to diagnose problems with the base engine lubrication and cooling systems. This section is divided into two areas: diagnosing malfunctions and testing procedures. The diagnosing malfunction areas are further divided into the following headings, containing the following symptoms:

- **(L)** Diagnosing Lubrication System Malfunctions:
  - L1 - Excessive oil consumption
  - L2 - Engine oil pressure high
  - L3 - Engine oil pressure low
- **(C)** Diagnosing Cooling System Malfunctions
  - C1 - Coolant temperature above normal
  - C2 - 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 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:

- Lubrications 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
  - 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

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13.5L - L1 - Excessive Oil Consumption

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13.5L - L1 - Excessive Oil Consumption

Before using this diagnostic procedure:
Check for too low or too high engine oil level.
Check for too low viscosity, coolant in oil, or fuel diluted in engine oil.
Check for excessive external oil leaks.

– – –1/1

❶ **Oil in Coolant Test**	Check the coolant for signs of oil.	**No oil found in coolant:** GO TO 2 **Oil found in coolant:** See C3 - COOLANT IN OIL OR OIL IN COOLANT later in this Group.

– – –1/1

❷ **Excessive Crankcase Pressure Check**	Check for excessive crankcase pressure. See CHECK FOR EXCESSIVE ENGINE CRANKCASE PRESSURE (BLOW-BY) in this Group.	**No fumes and no dripping oil observed:** GO TO 3 **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. **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. See DST ENGINE TEST INSTRUCTIONS - RELATIVE COMPRESSION TEST in CTM115, Section 04, Group 160. OR See DST ENGINE TEST INSTRUCTIONS - RELATIVE COMPRESSION TEST in CTM188, Section 04, Group 160 – – –1/1

❸ **Turbocharger Oil Seal Leak Test**	Check for turbocharger oil seal leaks. See CHECK FOR TURBOCHARGER OIL SEAL LEAK in this Group.	**No signs of oil leakage:** GO TO 4 **Signs of oil leakage present:** Investigate problems associated with oil leakage as outlined in the test procedure, perform necessary repairs and retest. – – –1/1

❹ **Pistons, Rings, and Cylinder Liners Test**	At this point, the most likely cause of the excessive oil consumption is one of the following failures in the pistons, rings, and/or cylinder liners or in the valve guides. Check the most likely item as needed: • Oil control rings worn or broken • Scored cylinder liners or pistons • Piston ring groves excessively worn • Piston rings stuck in ring groves • Insufficient piston ring tension • Piston ring gaps not staggered • Cylinder liners glazed (insufficient load during break-in) • Worn valve guides or stems	**Problem found with pistons, rings, and/or liners or valve guides:** Repair problem as necessary. – – –1/1

13.5L - L2 Engine Oil Pressure High

Symptom	Problem	Solution
13.5L - L2 - Engine Oil Pressure High	Improper oil classification	Drain crankcase and refill with correct oil.
	Oil pressure regulating valve bushing loose (wanders)	Remove and inspect oil pressure regulating valve. See REMOVE, INSPECT, AND INSTALL OIL PRESSURE REGULATING VALVE in Section 02, Group 060.
	Improperly operating regulating valve	Remove and inspect oil pressure regulating valve. See REMOVE, INSPECT, AND INSTALL OIL PRESSURE REGULATING VALVE in Section 02, Group 060.
	Plugged piston spray jet	Replace piston spray jet. See REMOVE AND INSTALL PISTON SPRAY JETS in Section 02, Group 030.
	Stuck or damaged filter bypass valve	Remove and inspect filter bypass valve. See REMOVE, INSPECT, AND INSTALL OIL COOLER AND OIL FILTER BYPASS VALVES in Section 02, Group 060.
	Stuck or damaged oil cooler bypass valve	Remove and inspect oil cooler bypass valve. See REMOVE, INSPECT, AND INSTALL OIL COOLER AND OIL FILTER BYPASS VALVES in Section 02, Group 060.

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13.5L - L2 Engine Oil Pressure High

Symptom	Problem	Solution
13.5L - L2 - Engine Oil Pressure High	Improper oil classification	Drain crankcase and refill with correct oil.
	Oil pressure regulating valve bushing loose (wanders)	Remove and inspect oil pressure regulating valve. See REMOVE, INSPECT, AND INSTALL OIL PRESSURE REGULATING VALVE in Section 02, Group 060.
	Improperly operating regulating valve	Remove and inspect oil pressure regulating valve. See REMOVE, INSPECT, AND INSTALL OIL PRESSURE REGULATING VALVE in Section 02, Group 060.
	Plugged piston spray jet	Replace piston spray jet. See REMOVE AND INSTALL PISTON SPRAY JETS in Section 02, Group 030.
	Stuck or damaged filter bypass valve	Remove and inspect filter bypass valve. See REMOVE, INSPECT, AND INSTALL OIL COOLER AND OIL FILTER BYPASS VALVES in Section 02, Group 060.
	Stuck or damaged oil cooler bypass valve	Remove and inspect oil cooler bypass valve. See REMOVE, INSPECT, AND INSTALL OIL COOLER AND OIL FILTER BYPASS VALVES in Section 02, Group 060.

RE38635,0000086 –19–17JUL07–1/1

13.5L Engines - L3 - Engine Oil Pressure Low

Symptom	Problem	Solution
13.5L - L3 - Engine Oil Pressure Low	Low crankcase oil level	Fill crankcase to proper oil level.
	Clogged oil cooler or filter	Remove and inspect oil cooler. See REMOVE, CLEAN, AND INSPECT ENGINE OIL COOLER in Section 02, Group 060. Replace oil filter.
	Excessive oil temperature	Remove and inspect oil cooler. See REMOVE, CLEAN, AND INSPECT ENGINE OIL COOLER in Section 02, Group 060.
	Defective oil pump	Remove and inspect oil pump. See CLEAN AND INSPECT OIL PUMP AND DRIVE GEAR in Section 02, Group 060.
	Incorrect oil	Drain crankcase and refill with correct oil.
	Oil pressure regulating valve failure	Remove and inspect oil pressure regulating valve. See Group REMOVE, INSPECT, AND INSTALL OIL PRESSURE REGULATING VALVE in Section 02, Group 060.
	Broken piston spray jet	Replace piston spray jet. See REMOVE AND INSTALL PISTON SPRAY JETS in Section 02, Group 030.
	Clogged oil pump screen or cracked pick-up tube	Remove oil pan and clean screen. Replace pick-up tube. See REMOVE AND INSTALL OIL PICKUP TUBE in Section 02, Group 060.
	Excessive main or connecting rod bearing clearance	Determine bearing clearance. See CHECK MAIN BEARING-TO-JOURNAL OIL CLEARANCE in Section 02, Group 040.

RE38635,0000080 –19–17JUL07–1/1

13.5L - C1 - Engine Coolant Temperature Above Normal

Symptom	Problem	Solution
13.5L - C1 - Engine Coolant Temperature Above Normal	Lack of coolant in cooling system	Fill cooling system to proper level.
	Radiator core and/or side screens dirty	Clean radiator as required.
	Engine overloaded	Reduce engine load.
	Too low crankcase oil level	Fill crankcase to proper oil level.
	Loose or defective fan belt	Replace/tighten fan belt as required.
	Defective thermostat(s)	Test thermostat opening temperature; replace thermostats as required. See REMOVE THERMOSTATS in Section 02, Group 070.
	Damaged cylinder head gasket	Replace cylinder head gasket. See CHECK FOR HEAD GASKET FAILURES in this group.
	Defective coolant pump	Replace coolant pump. See REMOVE COOLANT PUMP in Section 02, Group 070.
	Defective radiator cap	Replace radiator cap as required.

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13.5L - C2 - Engine Coolant Temperature Below Normal

Symptom	Problem	Solution
13.5L - C2 - Engine Coolant Temperature Below Normal	Defective thermostat(s)	Test thermostats; replace thermostats as required. See REMOVE THERMOSTATS in Section 02, Group 070.

RE38635,0000082 –19–17JUL07–1/1

13.5L Engines - C3 - Coolant in Oil or Oil in Coolant

Symptom	Problem	Solution
13.5L - C3 - Coolant in Oil or Oil in Coolant	Faulty cylinder head gasket	Look for signs of head gasket failure. See CHECK FOR HEAD GASKET FAILURES in this group.
	Faulty oil cooler	Remove and inspect engine oil cooler. See REMOVE, CLEAN, AND INSPECT ENGINE OIL COOLER in Section 02, Group 060.
	Leaking cylinder liner seals	Remove and inspect cylinder liners. See VISUALLY INSPECT CYLINDER LINERS in Section 02, Group 030.
	Cracked cylinder head or block	Locate crack, repair/replace components as required.

RE38635,0000083 –19–17JUL07–1/1

Dynamometer Test

1. Connect engine to dynamometer using manufacturer's instructions.
2. Operate engine at one-half load until coolant and crankcase oil temperatures are up to normal.
3. Run engine at fast idle.
4. Gradually increase load on engine until speed is reduced to rated speed rpm.
5. Read horsepower on dynamometer and record reading.
6. Compare readings taken with power rating level for your engine application in Section 06, Group 210.

NOTE: Refer to appropriate machine technical manual for average power ratings of vehicle applications. Allow ± 5% for minimum and maximum power. Altitude and temperatures can also affect power levels. (See DYNAMOMETER TEST SPECIFICATIONS in Section 06, Group 210.)

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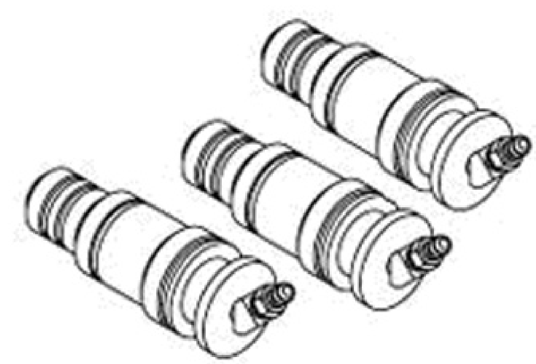
Check Cylinder Compression

1. Disconnect electronic fuel pump (if equipped).
2. Disconnect main engine wiring harness from rear of cylinder head.
3. Rotate engine flywheel and pin crankshaft at # 1 TDC.
4. Remove crossover tube.
5. Remove rocker arm cover. See REMOVE AND INSTALL ROCKER ARM COVER in Section 02, Group 020 earlier in this manual.
6. Remove one set of 3 rocker arm assemblies. See REMOVE ROCKER ARM ASSEMBLIES in Section 02, Group 020 earlier in this manual.
7. Disconnect wiring harness leads from unit injector terminals.
8. Remove injector clamps from 3 unit injectors.
9. Remove 3 unit injectors. See REMOVE ELECTRONIC UNIT INJECTORS in Section 02, Group 090 in CTM370.
10. Locate injector clamp (A) to top groove on JDG10668 compression test adapter (B), as shown, and install adapter into injector bore.
11. Repeat step 9 for remaining two compression adapters.
12. Tighten injector clamp cap screws to specification.

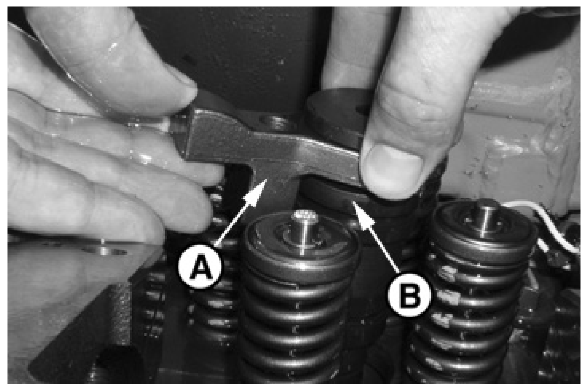
Specification

Injector Clamp to Cylinder Head—Torque .... 35 N•m (26 lb-ft)

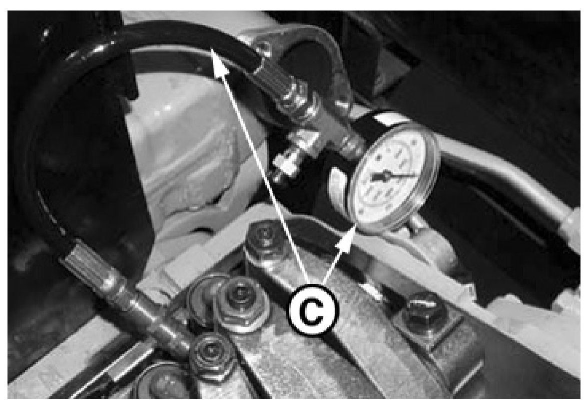
13. Install set of 3 rocker arm assemblies. See INSTALL ROCKER ARM ASSEMBLY in Section 02, Group 020 earlier in this manual.



JDG10668 Adapter



Install Injector Clamp and Compression Test Adapter



Test Hose and Gauge

A—Injector Clamp
B—Compression Test Adapter
C—Hose and Gauge Assembly

04
150
11

Continued on next page

NOTE: Be sure test gauge is calibrated to test compression in excess of 400 psi.

CAUTION: When running test, cover compression adapters with a clean rag or similar and turn engine over several revolutions before attaching hose and gauge. If it necessary to remove excess fuel from cylinder before checking compression.

14. Install hose and gauge assembly (C) from JT01674 Compression Test Kit to fitting on one JDG10668 Compression Test Adapter.

NOTE: If measured compression values are abnormally high (600 - 800 psi), it is likely fuel needs to be blown out of the cylinder. Remove hose and gauge and run engine, again, several revolutions to clear fuel. If necessary, remove fuel supply and return lines to sufficiently remove fuel from cylinder head.

15. Rotate engine and read cylinder compression. Compare to minimum specification.

Specification

Cylinder Compression—Pressure
- Minimum.. 350 psi (24.1 bar)

16. Repeat steps 12 and 13 on remaining 2 cylinders and compare compression values.

17. Repeat procedure for remaining set of 3 cylinders and compare measured compression values.

NOTE: Do not reuse injector clamp cap screws - this is a torque turn joint, so new cap screws must be used when injectors are removed.

18. Reinstall injectors and injector clamps. Install injector clamp cap screw through clamp and into cylinder head and torque turn to specification.

Specification

Injector Clamp Cap Screw to
Cylinder Head—Torque Turn .... 35 N•m (26 lb-ft) plus 90° additional turn

Continued on next page

RE38635,0000129 –19–30JAN08–2/3

19. Reinstall wiring harness leads to unit injector terminals.

NOTE: Do not reuse injector clamp cap screws - this is a torque turn joint, so new cap screws must be used when injectors are removed

20. Reinstall remaining set of rocker arm assemblies. Install new cap screws and tighten to specification.

Specification

Rocker Arm to Cylinder Head
Cap Screws—Torque Turn...................... 30 N•m (22 lb-ft) plus additional 90° turn

21. Check and adjust valve clearance settings. See CHECK AND ADJUST VALVE ASSEMBLY CLEARANCES AND INJECTOR PRELOAD in Section 02, Group 020 earlier in this manual for correct procedure and specifications.

22. Install rocker arm cover.

23. Install crossover tube.

24. Reattach wiring harness connector for electronic fuel pump.

25. Reattach main engine wiring harness at rear of cylinder head.

RE38635,0000129 –19–30JAN08–3/3

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.
- 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.

OUO1004,0000C2A –19–05DEC00–1/1

Check Engine Oil Pressure

1. Remove pipe plug from main oil galley using JDG782 Oil Galley Plug Tool.

2. Attach pressure gauge to oil galley.

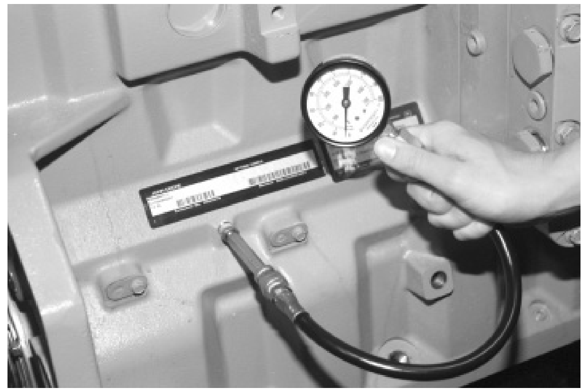
IMPORTANT: To achieve an accurate oil pressure reading, warm engine oil to 105°C (220°F).

3. Start engine, run at speeds given below, measure oil pressure, and compare readings.

Specification

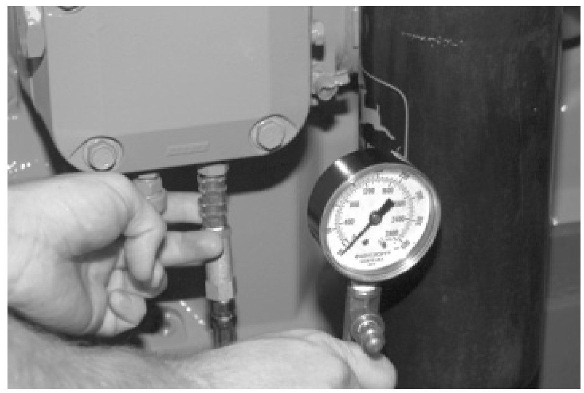
Engine Oil—Minimum Pressure at No Load (Idle)	138 kPa (1.38 bar) (20 psi)
Maximum Pressure at Full Load (Rated Speed)	310 kPa (3.1 bar) (45 psi)

NOTE: The oil pressure regulating valve is designed so that adjustment of oil pressure should not be required.



RG8531 –UN–26NOV97

Oil Pressure Gauge at Main Oil Galley

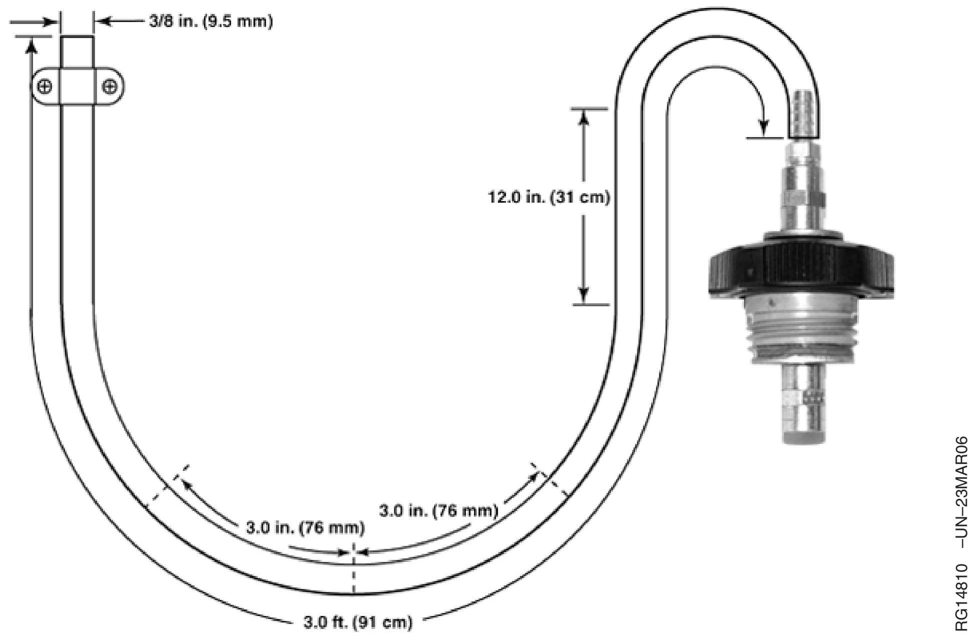


RG10633 –UN–30NOV99

Oil Pressure Gauge at Quick Disconnect on Oil Cooler

RG,RG34710,1547 –19–27NOV00–1/1

Check for Excessive Engine Crankcase Pressure (Blow-By)



Test Fixture for Testing Blow-By

Excessive blow-by coming out of the crankcase breather tube indicates that either the turbocharger seals are faulty or the piston rings and cylinder liners are not adequately sealing off the combustion chamber.

Worn valves and valve guides can also be a source for excessive blow-by. If the cylinder head is pulled, check and measure for wear on these components.

Blow-by will show up as excess vapor escaping from the blow-by tube, high blow-by will result in oil carryover (oil trapped in the vapor moving to fast for blow-by dampers to extract the oil droplets before it is released into the atmosphere) resulting in oil dripping from the blow-by tube.

Crank case pressure will increase as blow-by increases; Measuring crank case pressure is the best way to determine excess leakage past the rings or turbocharger seal.

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 the source.

The following items are required to measure crank case pressure:

- A section of 10 mm (.375 in) clear tubing at least 91 cm (3 ft) in length. Use this tube to form a “U”, with one end attached to the crank case, as shown.
- A small amount of antifreeze coolant or water to insert in the tube. Antifreeze will make it easier to visually monitor the test.
- A location on the engine to attach the hose; either the dipstick tube, or by modifying an oil fill cap, as shown.

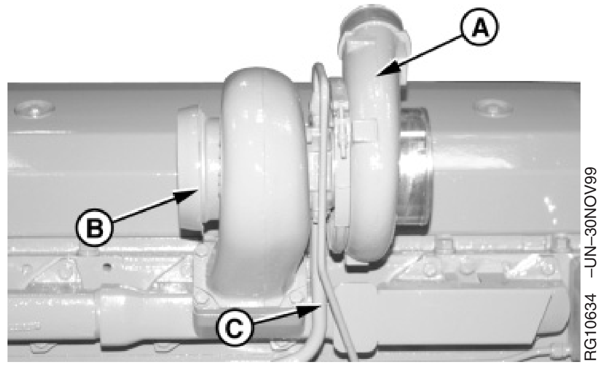
Continued on next page

DPSG,RG40854,282 –19–27MAR06–1/2

1. Set up procedure	1. Attach one end of the hose to the crankcase outlet and the other end to a fixed panel, brace or other surface. (there must be at least 12” of vertical hose on each side of the “U” tube) 2. Make sure both ends are not pinched closed restricting the pressure measurement. 3. Pour enough anti freeze or water into the tube to allow at least 3 in.of the liquid on each vertical side of the “U” tube. 4. When the liquid has settled in the tube mark the high point on both sides. Go to step # 2	
2. Measure crankcase pressure	1. Start the engine, let it stabilize and mark the liquid level line. 2. Go to high idle, let it stabilize and mark the liquid level line. 3. Slowly load the engine if possible to approximately 25% load, let the liquid stabilize and mark the level line. Did the liquid raise more then 2 inches on one side of the tube?	Yes: go to step # 3 No: The crank case pressure meets John Deere application guidelines, return to the previous diagnostic procedure or the customer.
3. Turbo Test	1. Remove the Turbo oil drain line and install a long remote drain line. 2. Plug the opening where the turbo drain line entered the crank case. (this will keep crankcase pressure from escaping at this point) 3. Take a clean 5 gallon bucket, put about a gallon of oil in the bottom. Put the open end of the long turbo drain line in the oil. If there is any combustion gas escaping from the turbo charger it may show up as bubbles in the oil. 4. Check the engine oil level making sure it is at the full level. Then monitor the oil level in the bucket to avoid oil spills. 5. Start the engine and go to fast idle slowly increase the load to about 25%. 5: when stabilized check crankcase pressure. Was the liquid height increase still greater then 2 inches?	Yes: See TEST ENGINE COMPRESSION PRESSURE WITH MECHANICAL GAUGE in the base engine manual for this engine. No: See AIR INTAKE AND EXHAUST SYSTEM REPAIR AND ADJUSTMENT in the base engine manual for this engine. Go to remove and then replace the turbo charger in the base engine manual for the engine replace and retest..

DPSG,RG40854,282 –19–27MAR06–2/2

Check for Turbocharger Oil Seal Leak



Turbocharger Oil Seal Leak

A—Intake Hose
B—Exhaust Flange
C—Oil Return Line

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 (A) and exhaust pipe (B).

NOTE: The intake tube from the air cleaner (not included in picture) would not have to be removed for this test.

2. Inspect the intake tube and turbocharger turbine casing for evidence of oil leakage.

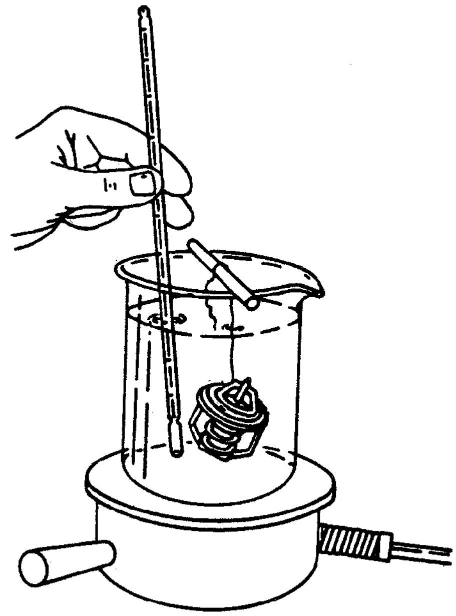
   If oil leakage is present, perform the following:

   - Inspect turbocharger oil return line (C) for kinks or damage. Replace if necessary.
   - Check the air intake filter, hoses, and crossover tube for restrictions.
   - Check the exhaust system for restrictions to include position of exhaust outlet.

3. Perform necessary repairs and retest.

DPSG,RG40854,283 –19–10AUG99–1/1

Inspect Thermostat and Test Opening Temperature



RG5971 –UN–23NOV97

Testing Thermostat Opening Temperature

Visually inspect thermostat for corrosion or damage. Replace as necessary.

Test thermostat as follows:

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

1. Remove thermostats. See REMOVE THERMOSTATS in Section 02, Group 070.
2. Suspend thermostat and a thermometer in a container of water.
3. Stir the water as it heats. Observe opening action of thermostat and compare temperatures with 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.

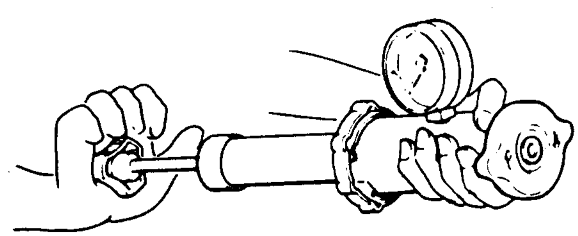
THERMOSTAT TEST SPECIFICATIONS

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)

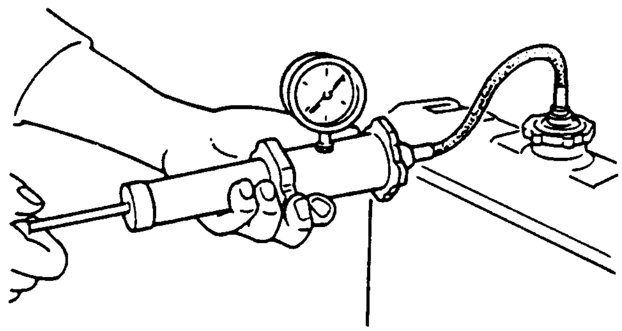
4. Remove thermostat and observe its closing action as it cools. In ambient air the thermostat should close completely. Closing action should be smooth and slow.
5. If any thermostat is defective on a multiple thermostat engine, replace all thermostats.

RG,RG34710,1548 –19–24SEP02–1/1

Pressure Test Cooling System and Radiator Cap


RG6557 –UN–20JAN93

Pressure Testing Radiator Cap


RG6558 –UN–20JAN93

Pressure Testing Cooling System

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

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

Test Radiator Cap:

1. Remove radiator cap and attach to D05104ST Tester using appropriate adaptor as shown.
2. Verify with the applications specification manual that the correct cap is being used.
3. Pressurize cap to cap's specified pressure.[1] Gauge should hold pressure for 10 seconds within normal range if cap is acceptable.
4. Remove the cap from gauge, turn it 180°, and retest cap. This will verify that the first measurement was accurate.

Test Cooling System:

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

1. Allow engine to cool, then carefully remove radiator cap.
2. Fill radiator with coolant to the normal operating level.

[1] *If gauge does not hold pressure, replace radiator cap.*

Continued on next page DPSG,RG40854,284 –19–24SEP02–1/2

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 specified pressure for application.[2].

4. With pressure applied, check all cooling system hose connections, radiator, and overall engine for leaks.

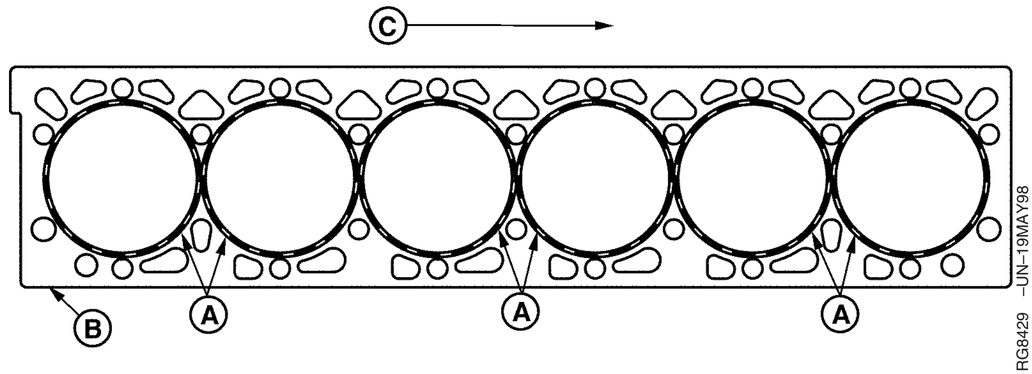
If leakage is detected, correct as necessary and pressure test system again.

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 in this group.

[2] *Test pressures recommended are for all Deere OEM cooling systems. On specific vehicle applications, test cooling system and pressure cap according to the recommended pressure for that vehicle.*

DPSG,RG40854,284 –19–24SEP02–2/2

Check for Head Gasket Failures



Head Gasket

A—Combustion Seals (Flanges) **B—Gasket Body** **C—Front of Engine**

Head gasket failures generally fall into three categories:

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

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

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

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

1. Start and warm up engine if it can be safely operated. Examine all potential leakage areas again as outlined previously. Using appropriate test and measurement equipment, check the following:
   - White smoke, excessive raw fuel, or moisture in exhaust system.
   - Rough, irregular exhaust sound, or misfiring.
   - Air bubbles, gas trapped in radiator/overflow tank.
   - Loss of coolant from overflow.
   - Excessive cooling system pressure.
   - Coolant overheating.
   - Low coolant flow.
   - Loss of cab heating (air lock)

2. Shut engine down. Recheck crankcase, radiator, and overflow tank for any significant differences in fluid levels, viscosity, or appearance.

3. Compare your observations from above steps with the diagnostic charts on the following pages. If diagnostic evaluations provide conclusive evidence of combustion gas, coolant, or oil leakage from head gasket joint, the cylinder head must be removed for inspection and repair of gasket joint components.

COMBUSTION SEAL LEAKAGE

Symptoms:

- Exhaust from head gasket crevice.
- Air bubbles in radiator/overflow tank.
- Coolant discharge from overflow tube.

Continued on next page

- 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.
- 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.

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.

OIL SEAL LEAKAGE

Symptoms:

- Oil discharge from head gasket crevice.
- Oil in coolant.
- Low crankcase oil level.
- Reduced oil to rocker arms (noisy).

Possible Causes:

- Excessive liner standout
- Excessive liner standout differential between cylinders.
- Low head bolt clamping loads
- Out-of-flat/damaged/rough block surface.
- Out-of-flat/damaged/rough cylinder head surface.
- Oil or coolant overheating.
- Cracks/creases in gasket body surfaces.
- Damage/voids in elastomer beading.
- Damaged/missing O-ring seal at oil port to rocker arms.

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

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

DPSG,RG40854,281 –19–27NOV00–2/2

Check Intake Manifold Pressure (Turbo Boost)

With the addition of the exhaust gas recirculator (EGR) and variable geometry turbocharger (VGT) to the 13.5L 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.

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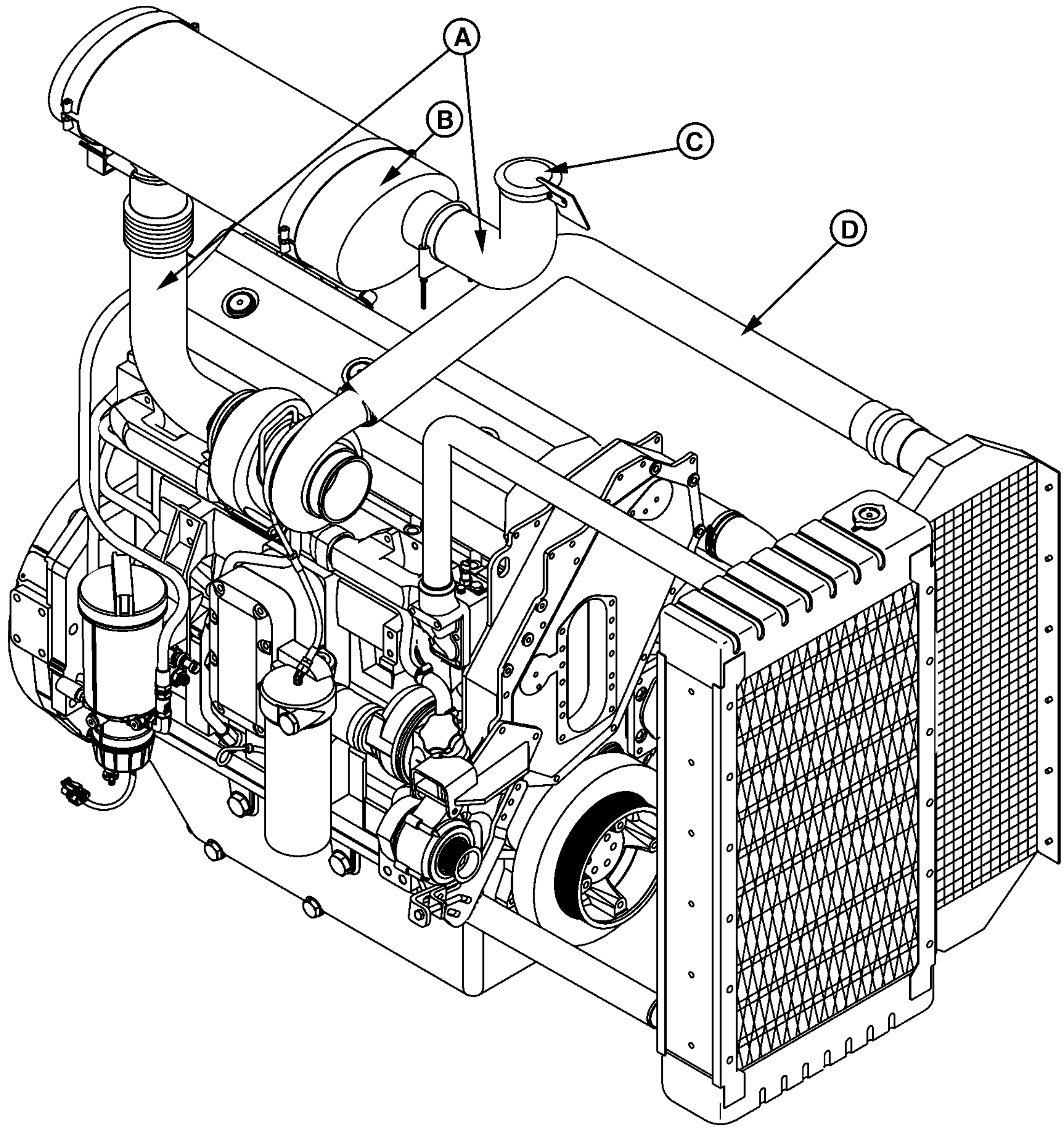
Check for Intake and Exhaust Restrictions



Check for Intake and Exhaust Restrictions

A—Exhaust piping **B—Muffler** **C—Rain Cap** **D—Intake Piping**

Low power, low boost pressure, and excessive black exhaust smoke can be caused by an intake air or exhaust restriction.

1. Inspect exhaust piping (A), the muffler (B), and the rain cap (C) for damage or any possible restrictions.
2. Inspect the intake piping (D), elbows, and any connections. Look for collapsed pipes, dented pipes and loose connections. Replace components as needed.

DPSG,RG40854,285 –19–10AUG99–1/1

Check for Intake Air Leaks

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 form 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 intake air filter is used as an example.

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

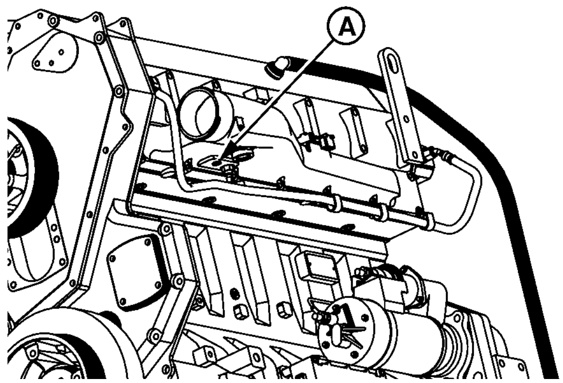
1. Remove air cleaner cover and main filter element.
2. Put a plastic bag over secondary filter element and install main element cover.
3. Remove plug from manifold and using a suitable adapter, connect a regulated air source.
4. Pressurize air intake system to the following specification.

Specification

Intake Manifold—Test Pressure .... 13.8—20.8 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.

Air Filter

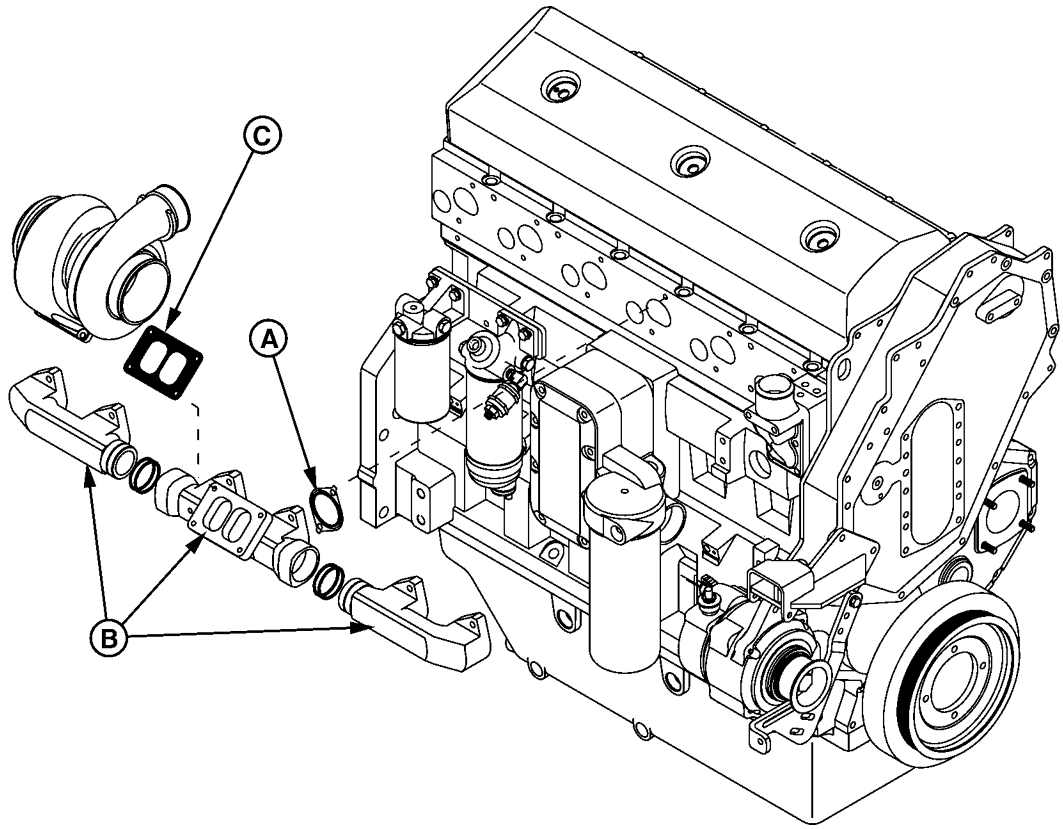


Intake Plug

A—Intake Plug

DPSG,RG40854,286 –19–07NOV00–1/1

Check for Exhaust Air Leaks



Check for Exhaust 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 reduced speed resulting in low boost pressure, low power, and excessive black smoke.

Inspect the exhaust manifold gasket, the exhaust manifold, and turbocharger gasket for damage and any signs of leakage. Replace components as needed. (See REMOVE, INSPECT AND INSTALL EXHAUST MANIFOLD in Section 02, Group 080.)

DPSG,RG40854,287 –19–10AUG99–1/1

Check Camshaft-to-Crankshaft Timing

Check Camshaft-to-Crankshaft Timing

1. Remove rocker arm cover. See (REMOVE AND INSTALL ROCKER ARM COVER in Group 020.)

2. Remove plug from cylinder block and install JDG820 Flywheel Turning Tool (B).

IMPORTANT: JDG971 Timing Pin MUST BE installed into camshaft timing slot (A) first before attempting to install second timing pin into crankshaft timing slot (C).

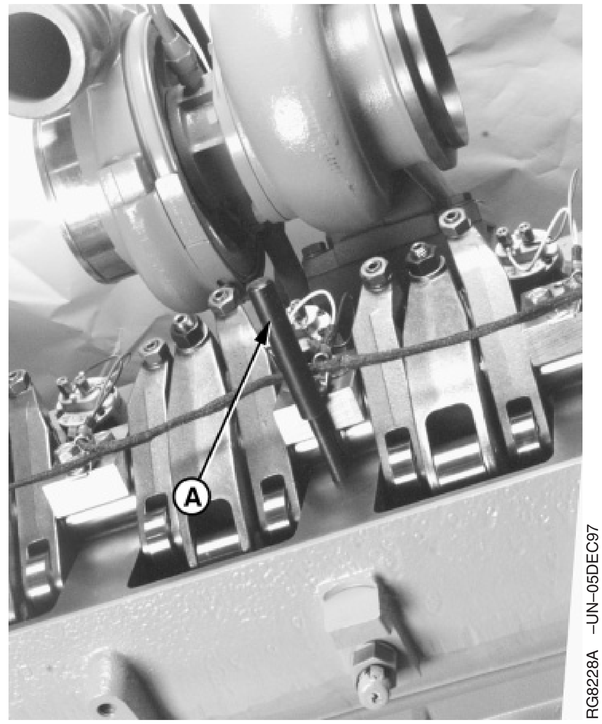
3. Rotate engine flywheel in running direction (Counter-clockwise as viewed from rear) until JDG971 Timing Pin (A) engages single timing slot (D) in camshaft. The proper timing slot can be found by viewing camshaft timing lobe through camshaft timing pin bore while rotating engine. The double timing slot (E) will be at approximately 11 o'clock (viewed from rear of engine) when pin is installed in slot (D). This ensures that engine is locked at TDC of No. 1 cylinder's compression stoke. Intake and exhaust rocker arms on No. 1 cylinder should be loose.

4. Remove threaded plug from crankshaft timing hole below oil cooler and filter housing assembly.

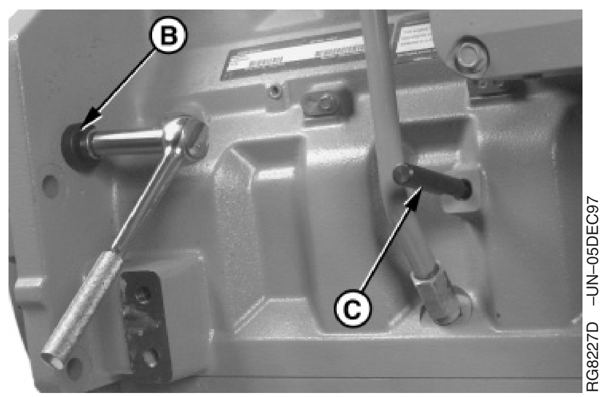
IMPORTANT: DO NOT insert timing pin full depth into cylinder block crankshaft timing hole when rotating engine flywheel until double slot on camshaft timing lobe is at approximately 11 o'clock (viewed from rear of engine) to avoid crankshaft counterweight bending timing pin.

5. Slightly move engine flywheel back and forth with turning tool until a second JDG971 Timing Pin (C) can be installed in slot in crankshaft. This ensures that camshaft and crankshaft are in sync (properly timed).

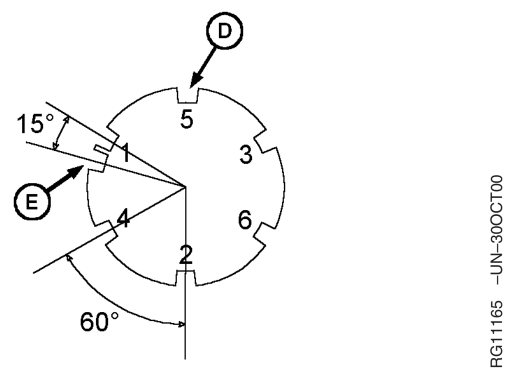
A—Timing Pin
B—Flywheel Turning Tool
C—Timing Pin
D—Single Timing Slot
E—Double Timing Slot



JDG971 Timing Pin in Camshaft



JDG971 Timing Pin in Crankshaft



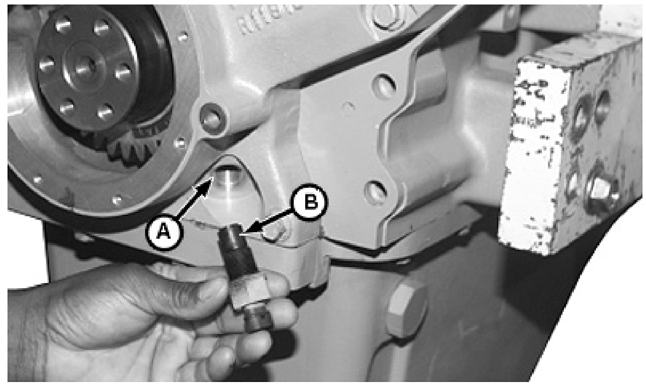
Camshaft Timing Slot

Continued on next page

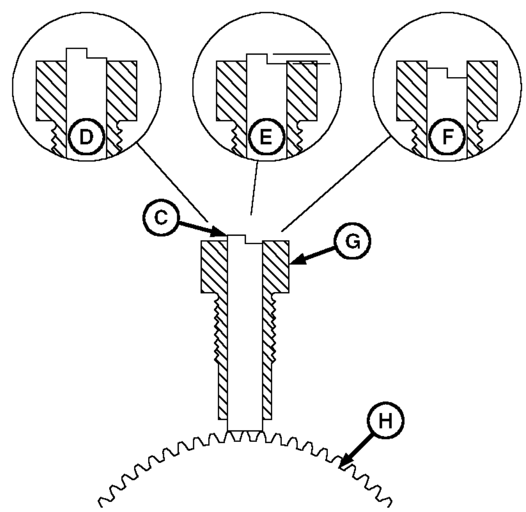
If timing pin does not enter crankshaft timing slot, crankshaft MUST BE timed to camshaft. See CHECK AND ADJUST CAMSHAFT-TO-CRANKSHAFT TIMING in Section 02, Group 050.

DPSG,RG40854,357 –19–06NOV00–2/2

Check Crankshaft Position Sensor Depth



Crankshaft Position Sensor



Using JDG1334 Depth Checking Tool

A—Machined Mounting Surface (Spotface)
B—Crankshaft Position Sensor
C—Pin (In JDG1334 Depth Tool)
D—Sensor Depth Low (Shim Required)
E—Sensor Depth Correct (No Shim Required)
F—Sensor Depth too High (Requires Investigation)
G—JDG1334 Depth Checking Tool
H—Crankshaft Timing Wheel

NOTE: Crankshaft vibration damper and front seal shown removed

The ECU monitors the position of the crankshaft and camshaft to determine piston position and the optimum time to start and stop injecting fuel. This crank sensor sends the crank position to the ECU.

1. Disconnect crankshaft position sensor wiring connector.

2. Remove sensor (B) from timing gear cover.

3. Install JDG1334 Tool (C) in sensor bore in timing gear cover until the tool is hand tight within the timing gear cover.

4. Push in on pin (C) until it contacts crankshaft timing wheel (H).

5. Check position of pin end in relation to end of tool as shown in (D, E, F)

   - If pin's lower shoulder extends above end of tool (D), add one R60756 shim to sensor.
   - If pin's lower shoulder is within range of marks (E), no shim is required on sensor.
   - If pin is below end of tool (F), call DTAC for assistance.

6. Grease O-ring with JDT405 High Temperature Grease

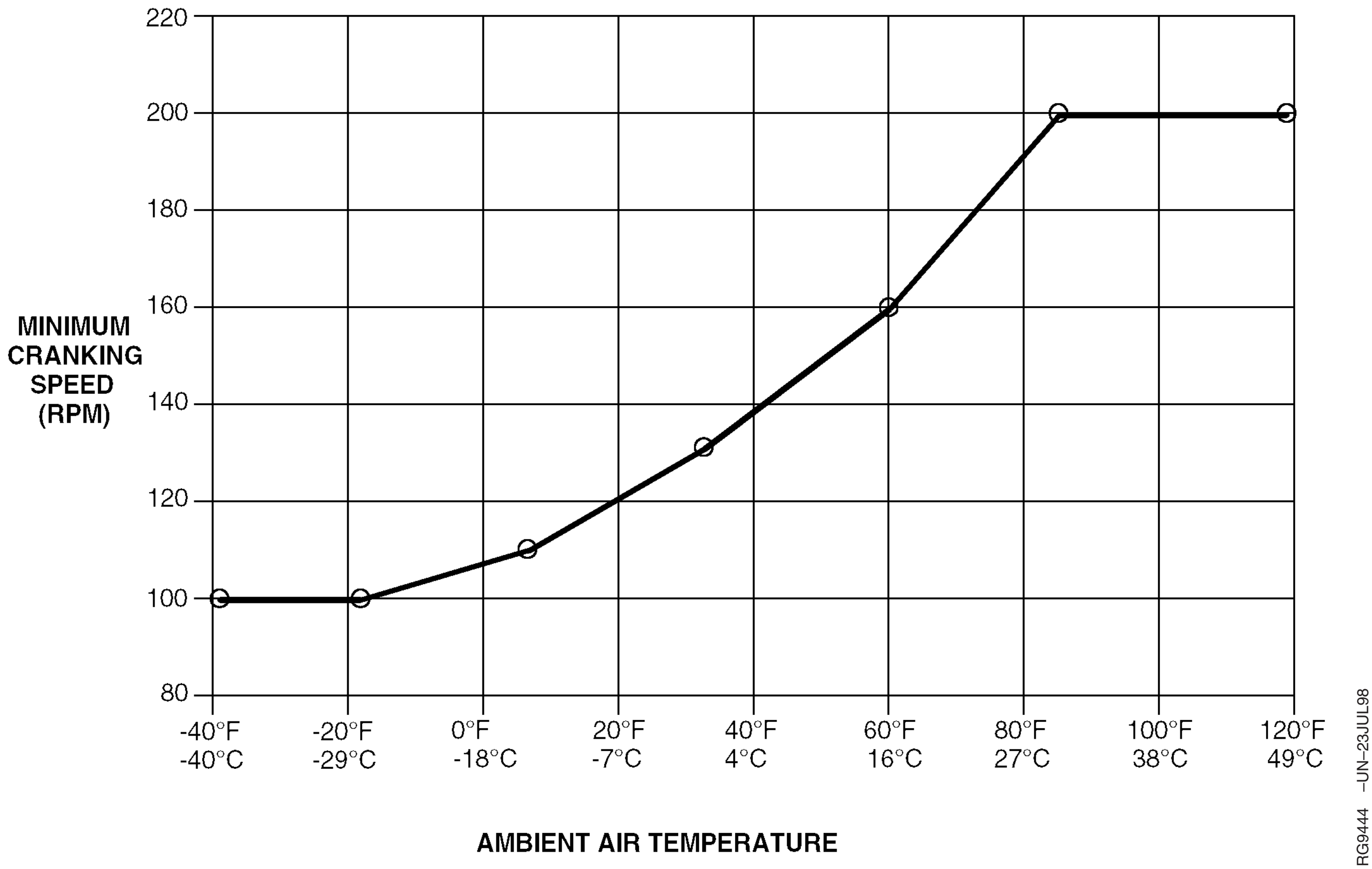
7. Install sensor in timing gear cover and tighten to specification.

Specification

Crankshaft Position Sensor—
Torque .... 14 N•m (10 lb-ft)

DPSG,RG40854,466 –19–07NOV00–1/1

Check Engine Cranking Speed



IMPORTANT: Make sure that batteries are fully charged before performing this test.

1. Disable the fuel supply system at the injection pump so fuel delivery is in the OFF position.

2. If not using the machine tachometer, install a photo tachometer.

3. Crank engine for 15 seconds and record engine speed.

4. Compare recorded engine speed to chart above.

Cranking speed should meet or exceed specified engine rpm for a given ambient air temperature. For example, at 85°F (29°C) ambient temperature, cranking speed should be at least 200 rpm.

If cranking speed is below specifications, check the following:

- Starting system problems (low battery, loose or defective wiring, defective starter, etc.)
- Excessive engine loads (hydraulic pumps/thick oil, thick engine oil, etc.).

DN22556,00006A3 –19–23JUL07–1/1

Section 05
Tools and Other Materials

Contents

05

Group 170
Repair Tools and Other Materials

Engine Rebuild Guide, Break-In and Tune-Up (Group 010) Other Material

Number	Name	Use
PM37477 (U.S.) PM38622 (Canadian) 242 (LOCTITE®)	Thread Lock and Sealer (Medium Strength)	Apply to engine lift strap cap screws.

LOCTITE is a registered trademark of Loctite Corp.

RE38635,0000087 –19–17JUL07–1/1

Cylinder Head and Valves (Group 020) Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

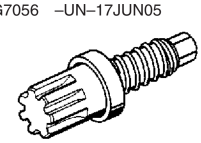
05
170
1

SERVICEGARD is a trademark of Deere & Company

RE38635,0000088 –19–18JUL07–1/18

RG7056 –UN–17JUN05

Flywheel Turning Tool JDG820



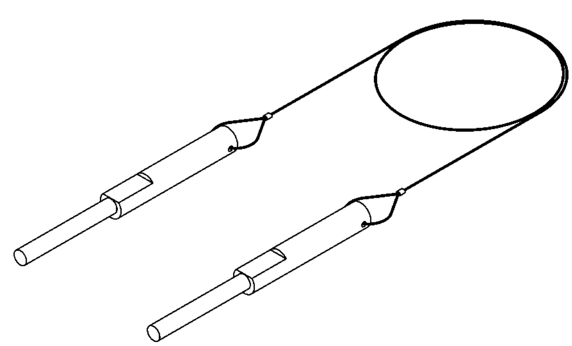
JDG820

Used to rotate engine flywheel to check engine timing and adjust valve stem-to-valve bridge clearance. Use with JDG971.

RE38635,0000088 –19–18JUL07–2/18

Cam/Crankshaft Timing Lock Pins JDG971

Set of two. Only one needed for 13.5L. Used to lock crankshaft at “Top Dead Center”. Use with JDG10246 Camshaft Timing Pin. Use on crankshaft only for valve clearance adjustments. Set consists of two 313796 Lock Pins.



RG8519 –UN–20MAY98

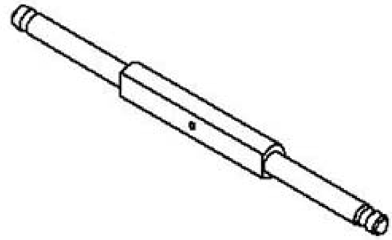
JDG971

Continued on next page

RE38635,0000088 –19–18JUL07–3/18

Camshaft Timing Pin JDG10246

Use with JDG971 to lock camshaft in the Top Dead Center position (large diameter of pin). Also use while adjusting injector preload (small diameter of pin).



RG15430 –UN–17JUL07

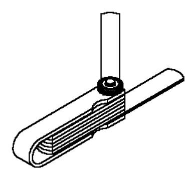
Camshaft Timing Pin

RE38635,0000088 –19–18JUL07–4/18

RG10382 –UN–05NOV99

Feeler Gauge Set JDG1333

Used to check intake and exhaust valve stem-to-bridge clearance.

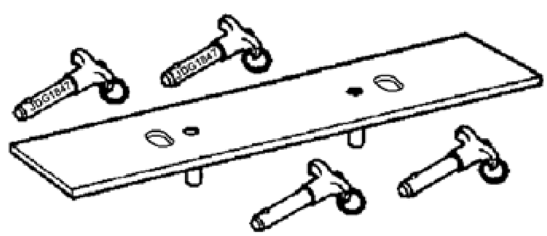


JDG1333

RE38635,0000088 –19–18JUL07–5/18

Rocker Arm Assembly Lifting Fixture JDG970A

Use to correctly position rocker arm assembly during removal and installation. Set consists of a holding plate and two 221808 Ball Locking Pins. **Note: Use JDG1847 pins with the 13.5L engine.**



RG8502A –UN–10MAR04

JDG970A

Continued on next page

RE38635,0000088 –19–18JUL07–6/18

RG6246 –UN–05DEC97

Dial Indicator . . . . . D17526CI (English, in.) or D17527CI (Metric, mm)

Use with JDG451 or KJD10123 to measure valve recess and cylinder liner height-to-cylinder block top deck.

RG6246

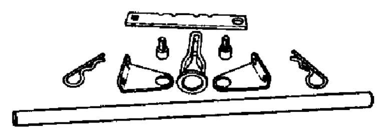
D17526CI/D17527CI

RE38635,0000088 –19–18JUL07–7/18

RG8506 –UN–20MAY98

Valve Spring Compressor JDG982

Use to compress exhaust and intake valve springs for removal and installation.



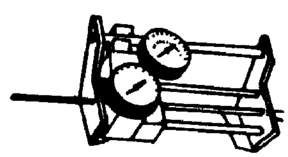
JDG982

RE38635,0000088 –19–18JUL07–8/18

RG5061 –UN–05DEC97

Spring Compression Tester D01168AA

Test valve spring compression.



RG5061

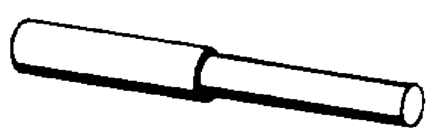
D01168AA

RE38635,0000088 –19–18JUL07–9/18

RG5065 –UN–05DEC97

Valve Seat Pilot Driver JDG164A

Use with JDG10249 Adapter to install intake and exhaust valve seat inserts, and with JDG1167 Adapter to install valve guides.



RG5065

JDG164A

Continued on next page

RE38635,0000088 –19–18JUL07–10/18

RG5067 –UN–06APR89

Valve Guide Installation Adapter. JDG1167

Use with JDG164A Pilot Driver to install valve guides.

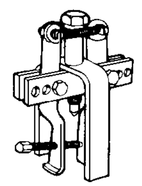
JDG1167

RE38635,0000088 –19–18JUL07–11/18

RG5071 –UN–05DEC97

Valve Seat Puller .JDE41296

Remove valve seat inserts.



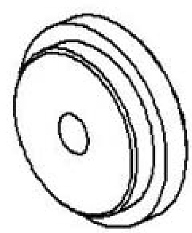
RG5071

JDE41296

RE38635,0000088 –19–18JUL07–12/18

Valve Seat Insert Installing Adapter. JDG10249

Use with JDG164A Pilot Driver to install intake and exhaust valve seat inserts.



RG15431 –UN–17JUL07

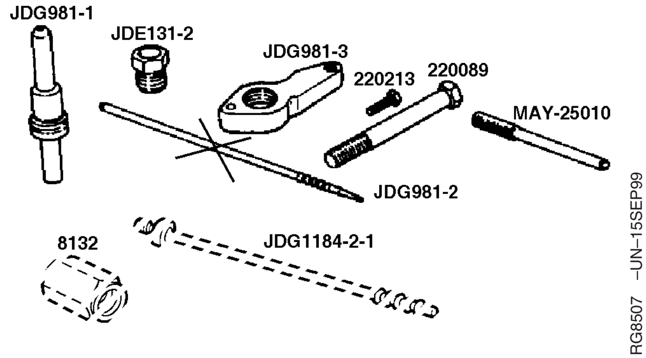
Valve Seat Insert Installation

Continued on next page

RE38635,0000088 –19–18JUL07–13/18

EUI Sleeve Installation Set JDG981

Use to replace unit injector sleeve. Unit injector sleeve tip bore must be swedged to seal off coolant passages from cylinder bore. Set consists of JDE131-2 Driver Nut, JDG981-1 Guide Sleeve, JDG981-3 Guide Sleeve Holding Bar, 220213 Hex Head Cap Screw (M8 x 1.25 x 40 mm), 220089 Hex Head Cap Screw (M16 x 2 x 150 mm), and MAY-25010 Punch. JDG981-2 Swedge is obsolete. Use JDG1184-2-1 Swedge Arbor and 8132 Adapter from JDG1184 EUI Nozzle Sleeve Replacement Kit in its place.

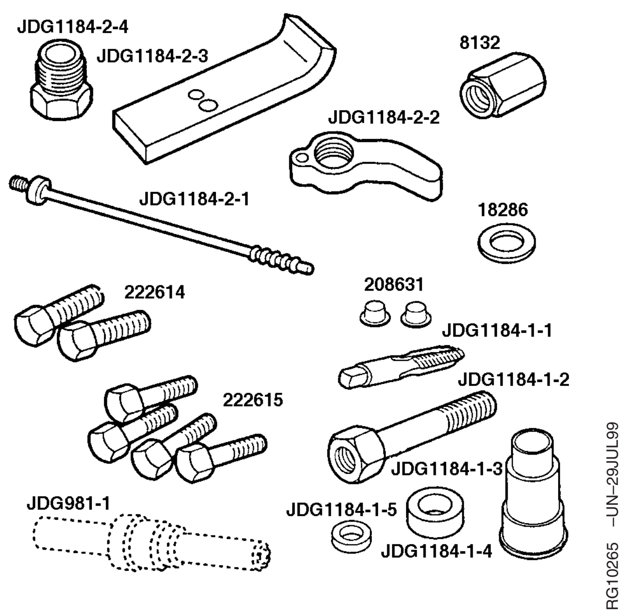


JDG981

RE38635,0000088 –19–18JUL07–14/18

EUI Sleeve Replacement Set. JDG1184

Used to install injector sleeves in cylinder head with head installed in engine. Must be used with JDG981-1 Guide Sleeve which can be ordered separately.

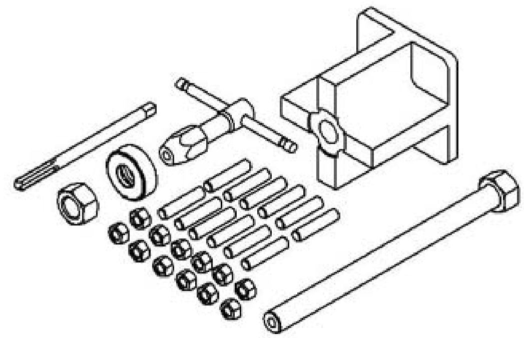


JDG1184

Continued on next page RE38635,0000088 –19–18JUL07–15/18

EUI Sleeve Removal Tool JDG10014

Used to remove injector sleeve from cylinder head.


RG15426 –UN–17JUL07

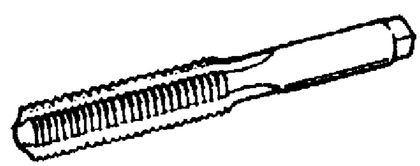
EUI Sleeve Removal Tool

RE38635,0000088 –19–18JUL07–16/18

RG8508 –UN–20MAY98

Tap JDG978

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



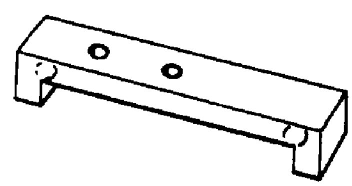
JDG978

RE38635,0000088 –19–18JUL07–17/18

RG7029 –UN–05DEC97

Height Gauge . . . JDG451 (English) or KJD10123 (Metric)

Used with D17526CI or D17527CI Dial Indicator to measure valve recess and cylinder liner height-to-cylinder block top deck.


RG7029

JDG451

RE38635,0000088 –19–18JUL07–18/18

Cylinder Head and Valves (Group 020) 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.

OUO1004,0000BC4 –19–01NOV00–1/9

Valve Inspection Center . . . .

Check valves for out of round.

OUO1004,0000BC4 –19–01NOV00–2/9

Plastic Brush . . . .

Clean valve guides.

OUO1004,0000BC4 –19–01NOV00–3/9

Precision “Bevelled Edge” Straightedge D05012ST

Check cylinder head flatness.

OUO1004,0000BC4 –19–01NOV00–4/9

End Brush D17024BR

Remove carbon on valve seats.

OUO1004,0000BC4 –19–01NOV00–5/9

Heavy-Duty Seat Grinder Set. JT05893

Grind valve seats.

OUO1004,0000BC4 –19–01NOV00–6/9

Eccentrimeter . . . .

Measure valve seat runout.

Continued on next page

OUO1004,0000BC4 –19–01NOV00–7/9

Slider Hammer D01300AA

Use with JDG1184-1-2 Adapter to remove EUI sleeve with cylinder head installed in engine.

OUO1004,0000BC4 –19–01NOV00–8/9

Torque Angle Gauge JT05993

Tighten flanged-head cylinder head cap screws.

OUO1004,0000BC4 –19–01NOV00–9/9

Cylinder Head and Valves (Group 020) Other Material

Number	Name	Use
PM38655 (U.S.) PM38627 (Canadian) 277 (LOCTITE®)	Plastic Gasket	Apply to expansion plugs in cylinder head and block.
AR44402 (U.S.)	Valve Stem Lubricant	Lubricate valve stems.
	High Temperature Grease	Apply to injector sleeve square packing.
PM38653 (U.S.) PM38645 (Canadian) 222 (LOCTITE®)	Thread Lock and Sealer (Low Strength)	Apply to EUI solenoid wire retaining nut.

LOCTITE is a registered trademark of Loctite Corp.

RE38635,0000089 –19–18JUL07–1/1

Cylinder Block, Liners, Pistons, and Rods (Group 030) Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

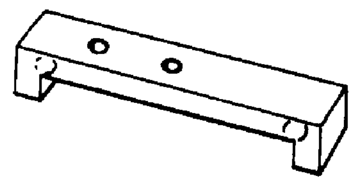
SERVICEGARD is a trademark of Deere & Company

RE38635,000008A –19–18JUL07–1/14

RG7029 –UN–05DEC97

Piston and Liner Height Gauge . . . . JDG451[1]

Measure piston and liner heights.



RG7029

JDG451

[1] *A dial indicator is not supplied with JDG451. Use D17526CI (English, in.) or D17527CI (Metric, mm) Dial Indicator with JDG451.*

RE38635,000008A –19–18JUL07–2/14

RG6246 –UN–05DEC97

Dial Indicator . . . . . D17526CI (English, in.) or D17527CI (Metric, mm)

Use with JDG451 to measure valve recess and cylinder liner height-to-cylinder block top deck.

RG6246

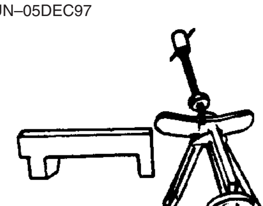
D17526CI/D17527CI

RE38635,000008A –19–18JUL07–3/14

RG5019 –UN–05DEC97

Cylinder Liner Puller . . . . D01062AA, D01073AA, or KCD10001

Use to remove and install cylinder liners.



RG5019

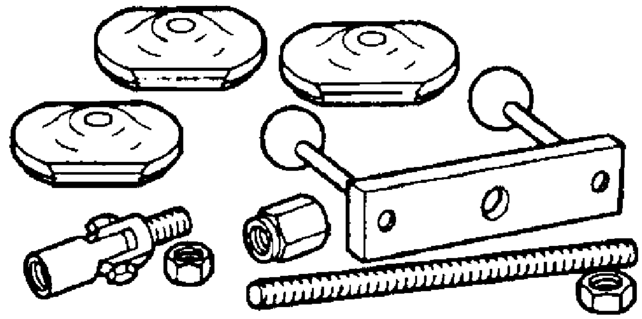
D01073AA

Continued on next page

RE38635,000008A –19–18JUL07–4/14

Cylinder Liner Service Set. JDG1145

Use to remove and install cylinder liners. Use with D01300AA 2.2 kg (5 lb) Slide Hammer. Also used with lapping compound to lap liner flange to block counterbore.



RG10280 –UN–13AUG99

JDG1145

RE38635,000008A –19–18JUL07–5/14

RG5074 –UN–07NOV97

Flexible Cylinder Hone D17006BR

Hone cylinder liners.

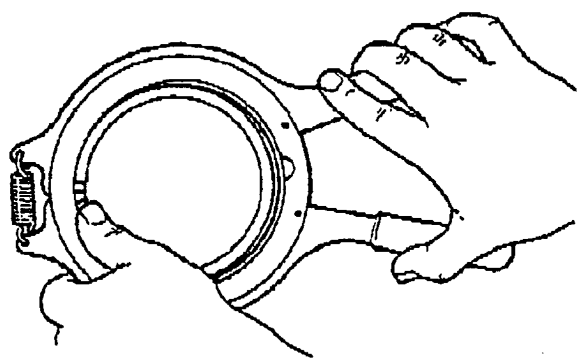
RG5074

D17006BR

RE38635,000008A –19–18JUL07–6/14

Piston Ring Expander JDG967

Use to control the expansion of the piston rings during removal and installation of the pistons. This tool prevents over expansion and damage to the rings.



RG7406 –UN–21MAY98

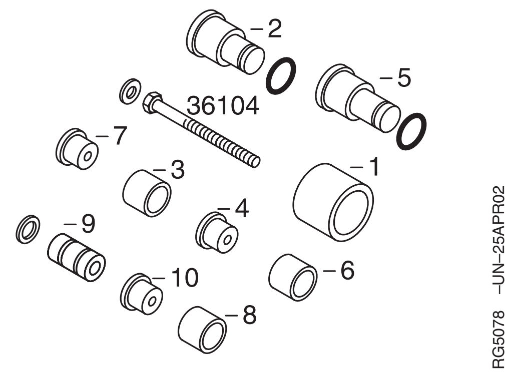
JDG967

Continued on next page

RE38635,000008A –19–18JUL07–7/14

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/Installer (10) and STD36104 Forcing Screw.

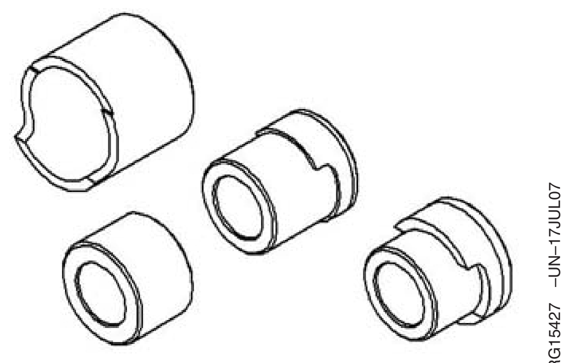


JDE98A

RE38635,000008A –19–18JUL07–8/14

Connecting Rod Bushing Service Set JDG10196

Use in combination with components of JDE98E tool set for the 12.5L engine. The 13.5L bushing is a different size than 12.5L.

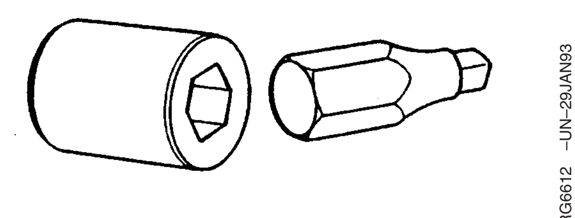


JDG10196

RE38635,000008A –19–18JUL07–9/14

Oil Gallery Plug Tool JDG782

Use to remove and install cylinder block oil gallery plug.



JDG782

Continued on next page

RE38635,000008A –19–18JUL07–10/14

O-Ring Groove Cleaning Brush D17015BR

Clean cylinder liner O-ring groove in block.

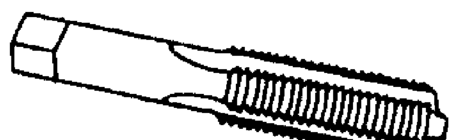
D17015BR

RE38635,000008A –19–18JUL07–11/14

RG5100 –UN–05DEC97

Tap JDG978

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

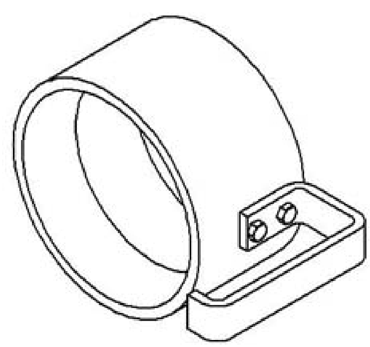


JDG978

RE38635,000008A –19–18JUL07–12/14

Piston Ring Compressor JDG1969

Use to compress piston rings during installation of the piston.



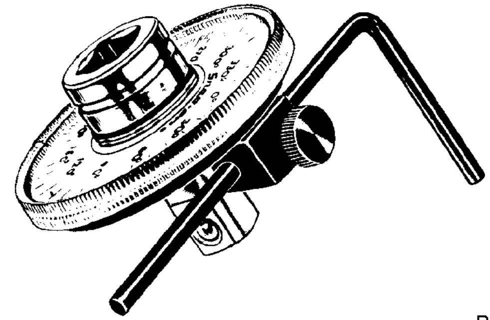
JDG1969 Piston Ring Compressor

Continued on next page

RE38635,000008A –19–18JUL07–13/14

Torque Angle Gauge JT05993

Used to torque-turn cylinder head and connecting rod cap screws.



JT05993

RE38635,000008A –19–18JUL07–14/14

Cylinder Block, Liners, Pistons, and Rods (Group 030) 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.

OUO1004,0000BC9 –19–01NOV00–1/4

Cylinder Liner Bore Ridge Reamer JT07277

Remove carbon from liner bore prior to piston removal.

OUO1004,0000BC9 –19–01NOV00–2/4

Piston Ring Groove Cleaning Tool

Used to clean piston ring grooves.

OUO1004,0000BC9 –19–01NOV00–3/4

Precision “Bevelled Edge” Straightedge D05012ST

Check cylinder head flatness.

OUO1004,0000BC9 –19–01NOV00–4/4

Cylinder Block, Liners, Pistons, and Rods (Group 030) Other Material

Number	Name	Use
(U.S.)	PLASTIGAGE®	Determine connecting rod bearing-to-journal oil clearance.
AR54749 (U.S.)	Soap Lubricant	Coat O-rings on cylinder liners.
	High Temperature Grease	Apply to O-rings for piston spray jets.
PM37477 (U.S.) PM38622 (Canadian) 242 (LOCTITE®)	Thread Lock and Sealer (Medium Strength)	Apply to threads of oil gallery plugs.

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PLASTIGAGE is a registered trademark of DANA Corp.
LOCTITE is a registered trademark of Loctite Corp.

RE38635,000008B –19–18JUL07–1/1

Crankshaft, Main Bearings and Flywheel (Group 040) Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

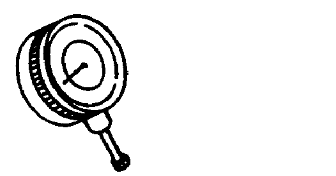
SERVICEGARD is a trademark of Deere & Company

RE38635,000008C –19–18JUL07–1/10

RG6246 –UN–05DEC97

Dial Indicator . . . . . D17526CI (English, in.) or D17527CI (Metric, mm)

Use to check vibration damper radial runout, crankshaft end play, flywheel housing runout and flywheel face flatness.



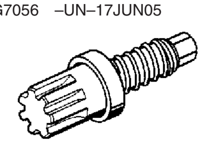
D17526CI / D17527CI

RE38635,000008C –19–18JUL07–2/10

RG7056 –UN–17JUN05

Flywheel Turning Tool JDG820

Use to rotate engine flywheel to check damper radial runout and piston protrusion.

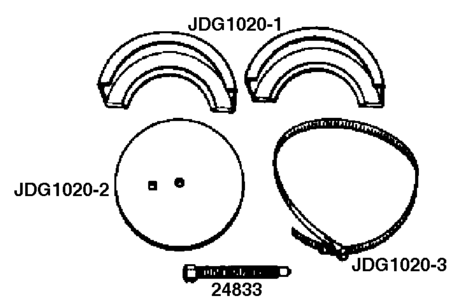


JDG820

RE38635,000008C –19–18JUL07–3/10

Rear Crank Seal Sleeve Remover JDG1020

Use to remove the rear seal assembly and seal housing. Tool helps protect the flange on rear of crankshaft.



JDG1020

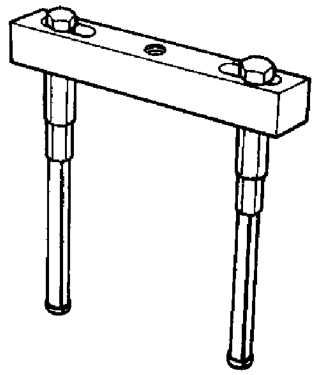
RG8513 –UN–13AUG99

Continued on next page

RE38635,000008C –19–18JUL07–4/10

Main Bearing Cap Puller/Installer JDG996

Use to remove and install the main bearing caps. Due to wider bearing surface, these caps are installed with an increased interference fit.



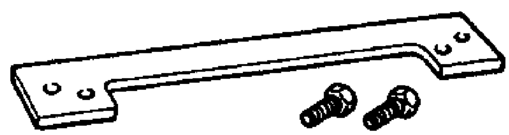
JDG996

RE38635,000008C –19–18JUL07–5/10

Timing Gear Cover/Rear Seal Housing Oil Pan Rail Aligner JDG977

Use to align the timing gear cover to the engine block oil pan mounting surface and align the rear seal housing to the same surface. When installing the timing gear seal housing, use JDG975 Timing Gear Cover/Rear Crankshaft Housing Centering Tool to center the seal housing bores with the crankshaft flange.

RG8510 –UN–20MAY98

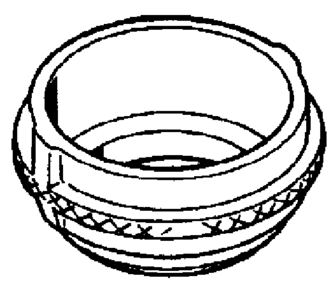


JDG977

RE38635,000008C –19–18JUL07–6/10

Front Timing Gear Cover/Rear Crankshaft Seal Housing Centering Tool JDG975

Use to center the front/rear seal housing bore with the rear crankshaft flange during installation of the housing. This tool is also used to center the front timing gear cover seal housing bore with the front crankshaft flange during installation of the timing cover. Use with JDG977.



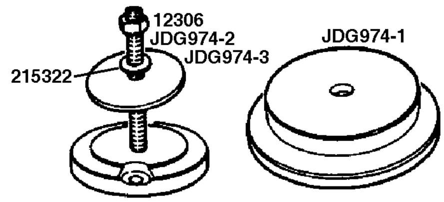
JDG975

Continued on next page

RE38635,000008C –19–18JUL07–7/10

Front/Rear Crankshaft Seal Installer JDG974A

Use to install the front crankshaft seal on damper prior to damper installation and to install rear oil seal in rear seal housing when housing is on engine.

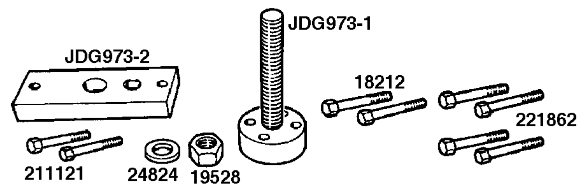


JDG974A

RE38635,000008C –19–18JUL07–8/10

Damper Puller/Installer JDG973

Use to safely remove and install engine damper with engine in vehicle chassis. The damper weighs approximately 18 kg (40 lb) and is mounted with an interference press fit.

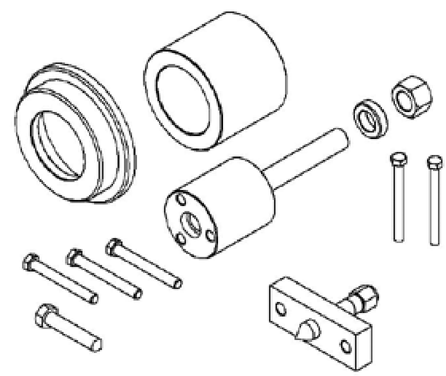


JDG973

RE38635,000008C –19–18JUL07–9/10

Viscous Damper Puller/Installer JDG10357

Use to safely remove and install the viscous damper assembly option.



JDG10357

RE38635,000008C –19–18JUL07–10/10

Crankshaft, Main Bearings and Flywheel (Group 040) Service Equipment and Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC). Some tools may be available from a local supplier.

SERVICEGARD is a trademark of Deere & Company

OUO1004,0000BD1 –19–02NOV00–1/4

Crankshaft Front Rotation Adapter JDG976

Used to rotate crankshaft when flywheel is removed from engine.

OUO1004,0000BD1 –19–02NOV00–2/4

Slide Hammer D01300AA

Use with JDG996 Puller to remove crankshaft main bearing caps.

OUO1004,0000BD1 –19–02NOV00–3/4

17-1/2 and 30-Ton Puller Set. D01047AA

Remove crankshaft gear from crankshaft.

OUO1004,0000BD1 –19–02NOV00–4/4

Crankshaft, Main Bearings and Flywheel (Group 040) Other Material

Number	Name	Use
(U.S.)	Brake Kleen or Ignition Cleaner	Remove sealant from crankshaft flange.
(U.S.)	PLASTIGAGE®	Check main bearing-to-crankshaft journal oil clearance during engine disassembly.
PM37485 (U.S.) PM38626 (Canadian) 680 (LOCTITE®)	Retaining Compound (Maximum Strength)	Coat OD of crankshaft flange for installation of rear oil seal/wear sleeve. Coat ID of front wear sleeve prior to installation.
PM37509 (U.S.) PM38611 (Canadian)	Clean and Cure Primer	Clean sealant from mating gasket surfaces on timing gear cover and camshaft gear access cover.
PM37477 (U.S.) PM38622 (Canadian) 242 (LOCTITE®)	Thread Lock and Sealer (Medium Strength)	Apply to both sides of timing gear cover gasket and to camshaft gear access cover gasket on earlier engines using Fel-Pro gaskets.
PM38655 (U.S.) PM38625 (Canadian) 515 (LOCTITE®)	Flexible Sealant	Apply to timing gear cover gasket and camshaft gear access cover gasket on earlier engines using Fel-Pro gasket.

PLASTIGAGE is a registered trademark of DANA Corp.
LOCTITE is a registered trademark of Loctite Corp.

RE38635,000008D –19–18JUL07–1/1

05
170
19

Camshaft and Timing Gear Train (Group 050) Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

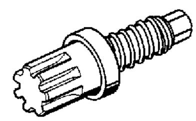
SERVICEGARD is a trademark of Deere & Company

RE38635,000008E –19–18JUL07–1/8

Flywheel Turning Tool JDG820

Use to rotate engine flywheel to check camshaft-to-crankshaft timing, adjust gear train backlash, and valve stem-to-valve bridge clearance.

RG7056 –UN–17JUN05

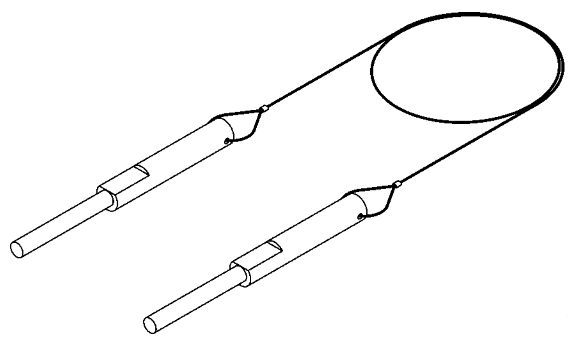


JDG820

RE38635,000008E –19–18JUL07–2/8

Cam/Crankshaft Timing Lock Pins JDG971

Set of two. Use to lock camshaft and crankshaft at “Top Dead Center” during timing gear backlash adjustment. Use on crankshaft only for valve clearance adjustments. Set consists of Holding Plate and 221808 Ball Locking Pins.



RG8519 –UN–20MAY98

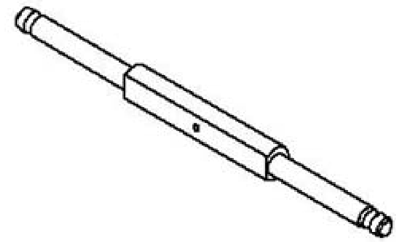
JDG971

Continued on next page

RE38635,000008E –19–18JUL07–3/8

Camshaft Timing Pin JDG10246

Use to lock engine camshaft at top dead center (large diameter) and while setting injector preload (small diameter). Use in conjunction with JDG971 crankshaft timing pin.



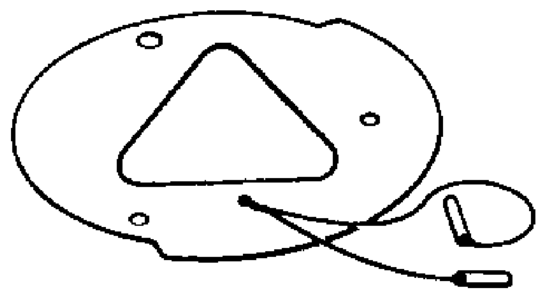
RG15430 –UN–17JUL07

JDG10246

RE38635,000008E –19–18JUL07–4/8

Gear Train Backlash Template. JDG993

Use to locate correct gear teeth on idler gear for accurate backlash adjustment. This measurement is critical for unit injector timing.



RG8520 –UN–20MAY98

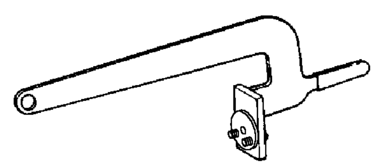
JDG993

RE38635,000008E –19–18JUL07–5/8

RG10275 –UN–04AUG99

Camshaft Holding Tool. JDG969A

Use with overhead hoist to control position of camshaft during removal and installation. Use with JDG972 Camshaft Pilot.



JDG969A

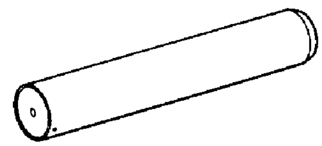
Continued on next page

RE38635,000008E –19–18JUL07–6/8

RG8504 –UN–20MAY98

Camshaft Pilot JDG972

Use with JDG969A Camshaft Holding Tool to remove and install the camshaft.

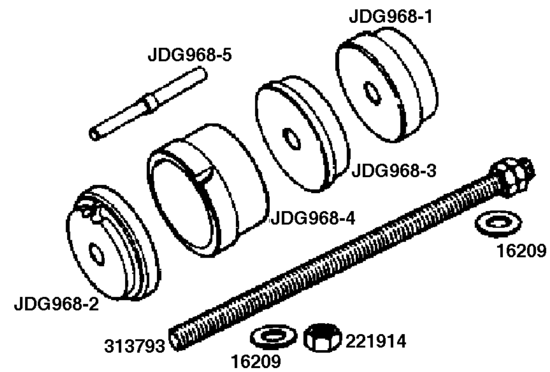


JDG972

RE38635,000008E –19–18JUL07–7/8

Camshaft Bushing Service Set. JDG968

Use to remove and install to specification the camshaft bushings. Pilots are designed to protect bushings during installation. Set consists of JDG968-1 Bushing Remover, JDG968-2 Bushing Installer, JDG968-3 Guide, JDG968-4 Alignment Sleeve, JDG968-5 Pin Alignment Checking, 221914 Hex Nut, 16209 Thrust Washers, 313793 Forcing Screw Assembly.



JDG968

RG8505 –UN–13AUG99

RE38635,000008E –19–18JUL07–8/8

Camshaft and Timing Gear Train (Group 050) 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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OUO1004,0000BD5 –19–02NOV00–1/2

Snap-On Dowel Pin Puller Set CG503

Remove fuel supply pump drive pin from end of camshaft.

OUO1004,0000BD5 –19–02NOV00–2/2

Camshaft and Timing Gear Train (Group 050) Other Material

Number	Name	Use
PM37477 (U.S.) PM38622 (Canadian) 242 (LOCTITE®)	Thread Lock and Sealer (Medium Strength)	Apply to idler gear carrier cap screws, camshaft gear retainer cap screws and fuel supply pump drive coupler cap screws.
TY6333 (U.S.)	High Temperature Grease	Coat cam roller followers, camshaft lobes, journals, and bushings during installation. Coat idler gear and bushing during installation.

LOCTITE is a registered trademark of Loctite Corp.

RE38635,000008F –19–18JUL07–1/1

Lubrication System (Group 060) Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

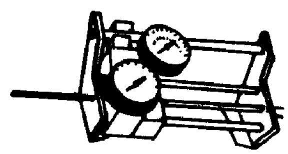
SERVICEGARD is a trademark of Deere & Company

OUO1022,0000008 –19–25OCT00–1/2

RG5061 –UN–05DEC97

Spring Compression Tester D01168AA

Test oil bypass valve spring and oil pressure regulating valve spring compression.



RG5061

D01168AA

OUO1022,0000008 –19–25OCT00–2/2

Lubrication System (Group 060) Other Material

Number	Name	Use
PM38654 (U.S.) PM38624 (Canadian) 271 (LOCTITE®)	Thread Lock and Sealer (High Strength)	Oil filter mounting adapter-to-filter base.
PM37477 (U.S.) PM38622 (Canadian) 242 (LOCTITE®)	Thread Lock and Sealer (Medium Strength)	Oil pump-to-block cap screws and oil pressure sending unit.
TY6333 (U.S.)	High Temperature Grease	Apply to inside cavities of oil pump and ID of oil pump drive gear bushing.
PM37509 (U.S.) PM38611 (Canadian) 7649 (LOCTITE®)	Clean and Cure Primer	Apply to oil pan and block sealing surfaces.
PM38657 (U.S.) PM38625 (Canadian) 17430 (LOCTITE®)	High Flex Form-In-Place Gasket	Used to seal oil pan.[1]
PM37397 (U.S.) PM38613 (Canadian) 592 (LOCTITE®)	Pipe Sealant	Apply to oil pan drain hose and drain valve.

LOCTITE is a registered trademark of Loctite Corp.

[1] See INSTALL ENGINE OIL PAN later in this group for specific locations to apply sealant.

RE38635,0000090 –19–18JUL07–1/1

Cooling System (Group 070) Essential Tools

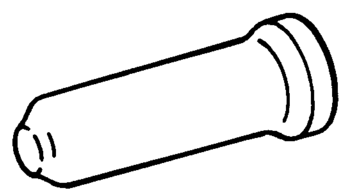
NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

SERVICEGARD is a trademark of Deere & Company

OUO1022,000000B –19–26OCT00–1/2

Coolant Pump Bearing Driver JDG743A

Use to install fan drive bearing assembly in fan drive housing.



RG6219 –UN–06MAR92

JDG743A

OUO1022,000000B –19–26OCT00–2/2

Cooling System (Group 070) Other Material

Number	Name	Use
TY6333 (U.S.)	High Temperature Grease	Pack bearings in fan drive and coolant pump.
PM37477 (U.S.) PM38622 (Canadian) 242 (LOCTITE®)	Thread Lock and Sealer (Medium Strength)	Tensioner mounting shoulder bolt or cap screw, idler mounting cap screw and coolant pump mounting cap screws.
PM37397 (U.S.) PM38613 (Canadian) 592 (LOCTITE®)	Pipe Sealant	Oil cooler housing drain valve, coolant heater, temperature sensor and pipe plugs.

LOCTITE is a registered trademark of Loctite Corp.

RE38635,0000091 –19–18JUL07–1/1

Air Intake and Exhaust System (Group 080) 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

OUO1004,0000C2C –19–06DEC00–1/2

RG6246 –UN–05DEC97

Dial Indicator . . . . . D17526CI (English, in.) or D17527CI (Metric, mm)

Use with magnetic base to measure turbocharger radial bearing clearance and axial bearing end play.


RG6246

D17526CI/D17527CI

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170
27

OUO1004,0000C2C –19–06DEC00–2/2

Air Intake and Exhaust System (Group 080) Other Material

Number	Name	Use
TY24811 (U.S.)	NEVER-SEEZ® Compound	Apply to turbocharger cap screws, intake manifold-to-cylinder head cap screws, exhaust manifold-to-cylinder head cap screws, aftercooler-to-cylinder head cap screws and turbocharger oil return line cap screws.
PM37477 (U.S.) PM38622 (Canadian) 242 (LOCTITE®)	Thread Lock and Sealer (Medium Strength)	Apply to turbocharger oil inlet fitting.

NEVER-SEEZ is a registered trademark of the Emhart Chemical Group.
LOCTITE is a registered trademark of Loctite Corp.

RE38635,0000092 –19–18JUL07–1/1

Starting and Charging Systems (Group 100) 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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DPSG,OUO1004,861 –19–28APR99–1/2

RW17441 –UN–16NOV89

Starter Wrench JDE80

Remove and install starter motor.

JDE80

DPSG,OUO1004,861 –19–28APR99–2/2

Observable Diagnostics and Tests Essential Tools

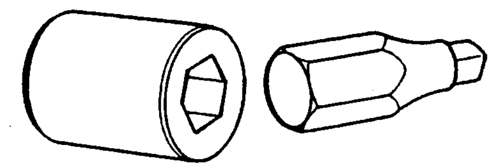
NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

SERVICEGARD is a trademark of Deere & Company

RE38635,000012A –19–24JAN08–1/9

Oil Galley Plug Tool. .JDG782

Used to remove and install oil galley plug.



RG6612 –UN–29JAN93

JDG782

RE38635,000012A –19–24JAN08–2/9

Cooling System Pressure Pump D05104ST

Used to pressure test radiator cap and cooling system.

R26406N –UN–29NOV88

D05104ST

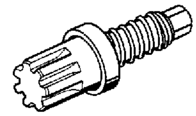
Continued on next page

RE38635,000012A –19–24JAN08–3/9

RG7056 –UN–17JUN05

Flywheel Turning Tool JDG820

Use to rotate engine flywheel to check camshaft-to-crankshaft timing, adjust gear train backlash, and valve stem-to-valve bridge clearance.

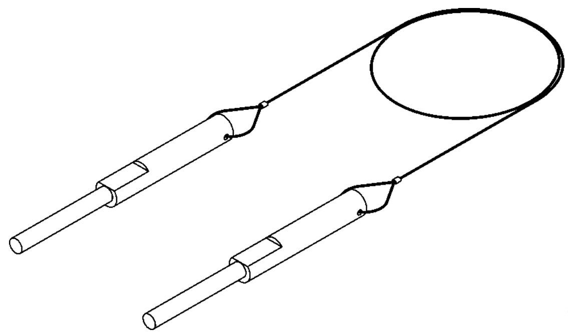


JDG820

RE38635,000012A –19–24JAN08–4/9

Cam/Crankshaft Timing Lock Pins JDG971

Set of 2. Use to lock camshaft and crankshaft at “Top Dead Center” during timing gear backlash adjustment. Use on crankshaft only for valve clearance adjustments. Set consists of Holding Plate and 221808 Ball Locking Pins.



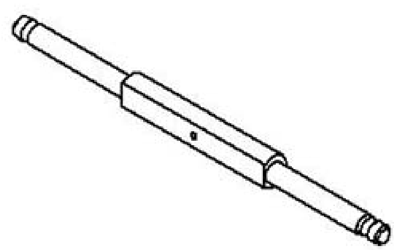
RG8519 –UN–20MAY98

JDG971

RE38635,000012A –19–24JAN08–5/9

Camshaft Timing Pin JDG10246

Used with crankshaft pin JDG971 to lock camshaft into top dead center location. Also used when setting injector preload.



RG15430 –UN–17JUL07

JDG10246

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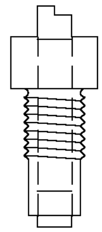
RE38635,000012A –19–24JAN08–6/9

Depth Tool. JDG1334

Check crankshaft position sensor depth.


RG10381 –UN–21OCT99

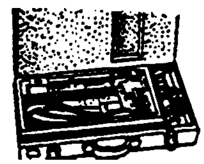
JDG1334

RE38635,000012A –19–24JAN08–7/9

Compression Test Set JT01674

Used to check cylinder compression pressure. Use gauge (> 400 psi) and hose assembly from set.

RG5161 –UN–23AUG88

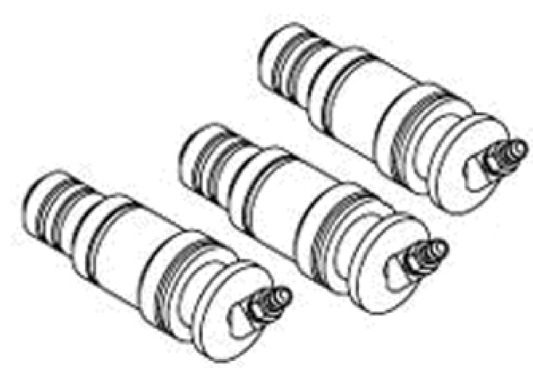


JT01674 Compression Test Set

RE38635,000012A –19–24JAN08–8/9

Compression Test Adapter (set of 3) JDG10668

Used with JT01674 to measure cylinder pressure in 12.5 & 13.5 L engines


RG15721 –UN–25JAN08

JDG10668 Compression Test Adapter

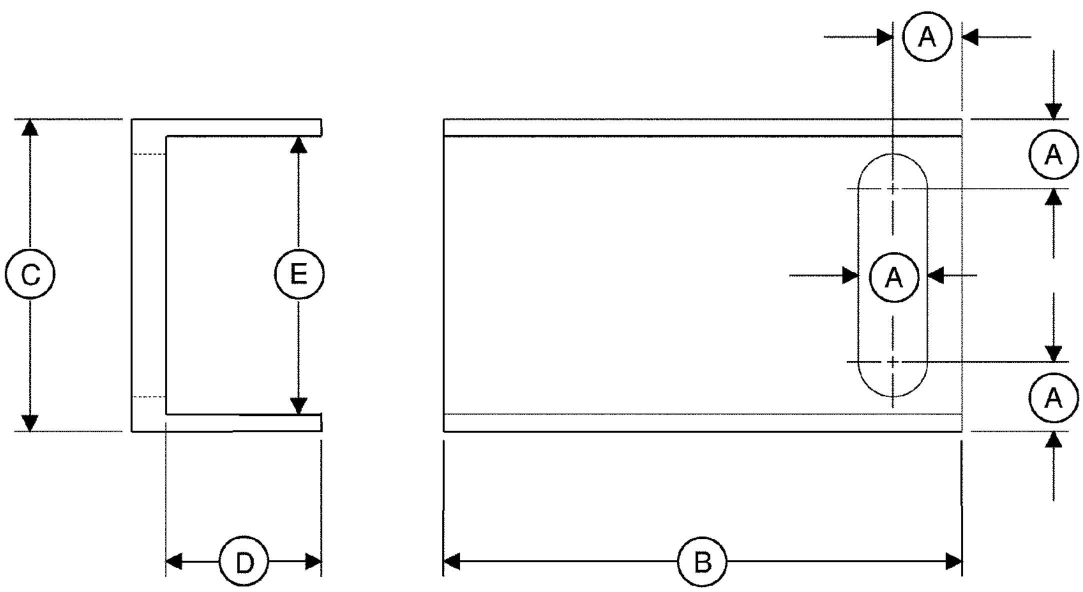
RE38635,000012A –19–24JAN08–9/9

How to Make Tools

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

RG,RG34710,275 –19–30SEP97–1/1

DFRG4—Camshaft Locking Tool

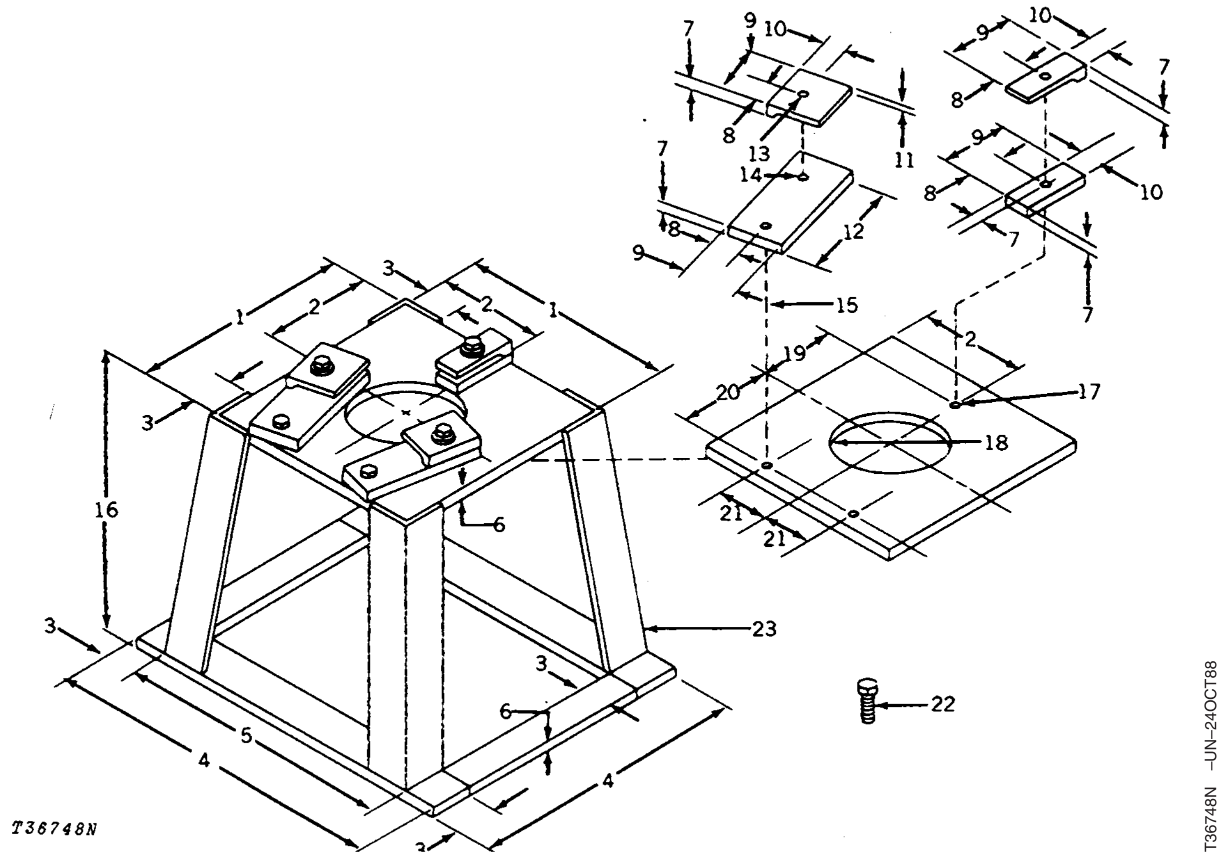


DFRG4 Camshaft Locking Tool

A—12.7 mm (0.50 in.)
B—95.25 mm (3.75 in.)
C—57.15 mm (2.25 in.)
D—30.57 mm (1.12 in.)
E—50.8 mm (2.00 in.)

RG,RG34710,276 –19–15NOV06–1/1

DFRG3—Cylinder Liner Holding Fixture



DFRG3 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 (0.25 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. [times] 1 in. Cap Screw
23—38.1 mm (1.5 in.) Angle Iron

RG,RG34710,277 –19–30SEP97–1/1

Section 06
Specifications

Contents

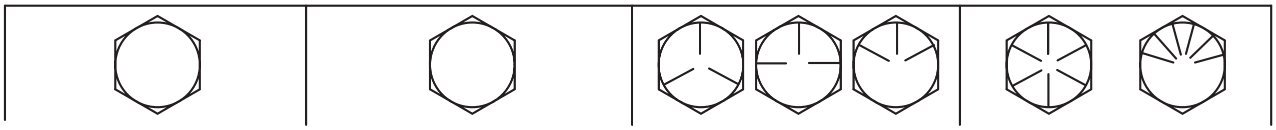
General OEM Engine Specifications

ITEM	UNIT OF MEASURE	6135HF
Number of Cylinders	——	6
Fuel	——	Diesel
Stroke	mm (in.)	165 (6.50)
Bore	mm (in.)	132 (5.20)
Displacement	L (cu in.)	13.5 (824)
Compression Ratio	——	16:1
Physical Dimensions:		
Width	mm (in.)	855 (33.7)
Height	mm (in.)	1512 (59.5)
Length	mm (in.)	1334 (52.5)
Basic Dry Weight	kg (lb)	1493 (3292)

RE38635,0000095 –19–18JUL07–1/1

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.

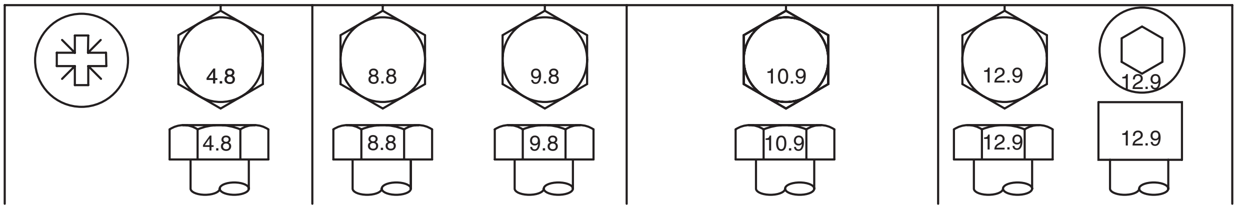
[a]Grade 2 applies for hex cap screws (not hex bolts) up to 6. in (152 mm) long. Grade 1 applies for hex cap screws over 6 in. (152 mm) long, and for all other types of bolts and screws of any length.

[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

Engine Rebuild Guide, Break-In and Tune-Up (Group 010) Specifications

Item	Measurement	Specification
Engine Adapter-to-Repair Stand Cap Screws	Torque	135 N•m (100 lb-ft)
Engine Lift Strap Cap Screws	Torque	90 N•m (66 lb-ft)
Engine-to-Stand Adapter Cap Screws	Torque	400 N•m (300 lb-ft)

RE38635,000009F –19–27JUL07–1/1

Cylinder Head and Valves (Group 020) Specifications

Item	Measurement	Specification
Rocker Arm Cover Hold-Down Cap Screws[1]	Torque	30 N•m (22 lb-ft)
Crankcase Vent Baffle-to-Rocker Arm Cover Cap Screws	Torque	15 N•m (11 lb-ft) (133 lb-in.)
Valve Stem-to-Bridge Clearance (Engine Cold)		
Intake Valve	Clearance	0.58 ± 0.05 mm (0.023 ± 0.002 in.)
Exhaust Valve	Clearance	1.10 ± 0.05 mm (0.043 ± 0.002 in.)
Intake and Exhaust Valve Adjusting Screw Lock Nuts	Torque	50 N•m (37 lb-ft)
Electronic Unit Injector	Preload	0.00 mm (in.) clearance plus 1/2 turn in (180°)
Electronic Unit Injector Adjusting Screw Lock Nuts	Torque	65 N•m (48 lb-ft)
Timing Pin Plug (Below Oil Cooler)	Torque	15 N•m (11 lb-ft)
Rocker Arm Bushing	ID	38.064 ± 0.013 mm (1.4986 ± 0.0005 in.)
Rocker Arm Shaft	OD	38.000 ± 0.013 mm (1.4961 ± 0.0005 in.)
Rocker Arm Shaft-to-Bushing	Oil Clearance	0.064 ± 0.026 mm (0.0025 ± 0.0010 in.)
Rocker Arm Shaft Intake and Exhaust Roller	OD	39.995—40.045 mm (1.5746—1.5766 in.)
Rocker Arm Shaft Unit Injector Roller	OD	37.995—38.045 mm (1.4959—1.4978 in.)
Intake and Exhaust Valves	Recess	1.80—2.40 mm (0.071—0.094 in.)

[1]*Tighten center cap screw first, then tighten sides.*

Continued on next page

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Item	Measurement	Specification
Intake and Exhaust Valve Springs (All)[2]	Height at 0 N (0 lb-force) Free Length	67.9—72.1 mm (2.67—2.84 in.)
Intake and Exhaust Valve Springs	Height at 527—593 N (118—133 lb-force) (Valve Closed)	59.4 mm (2.34 in.)
Intake and Exhaust Valve Springs	Height at 1187—1313 N (267—295 lb-force) (Valve Open)	46.4 mm (1.83 in.)
Intake and Exhaust Valve Stems	OD	8.999 ± 0.013 mm (0.3543 ± 0.0005 in.)
Intake and Exhaust Valve Face[3]	Maximum Runout	0.038 mm (0.0015 in.)
Intake and Exhaust Valve Head	OD	43.87—44.13 mm (1.727—1.737 in.)
Intake and Exhaust Valve Face	Angle	29.25° ± 0.25°
Cylinder Head	Maximum Acceptable Out-of-Flat for Entire Length of Head	0.10 mm (0.004 in.)
	Maximum Acceptable Out-of-Flat for Every 305 mm (12.0 in.)	0.025 mm (0.0009 in.)
Cylinder Head (Rocker Arm Cover-to-Combustion Face)	New Part Thickness	124.975—125.025 mm (4.9203—4.9222 in.)
	Minimum Acceptable Thickness	124.840 mm (4.9150 in.)
Cylinder Head (Rocker Arm Cavity-to-Combustion Face)	Minimum Overall Thickness	124.840 mm (4.9150 in.)
Cylinder Head Combustion Face Surface Finish (Surface Mill Only) (AA)	Surface Finish	1.5—2.8 micrometers (60—110 micro-in.)
Cylinder Head	Maximum Wave Height	0.008 micrometers (0.0002 micro-in.)
	Maximum Wave Width	2.0 micrometers (79 micro-in.)
Valve Guide	ID - Before Assembly	9.065 ± 0.013 mm (0.3569 ± 0.0005 in.)
Valve Guide	ID - After Assembly	9.045 +/- 0.013 (0.3561 in.)

[2] Free length of springs may vary slightly between springs.

[3]Maximum runout measured at 44 mm (1.73 in.) diameter.

Continued on next page

Item	Measurement	Specification
Valve Stem	OD	8.999 ± 0.013 mm (0.3543 ± 0.0005 in.)
Valve Stem-to-Guide	Clearance	0.077—0.129 mm (0.0030—0.0050 in.)
Valve Guide Bore in Head	ID	14.94 ± 0.02 mm (0.5882 ± 0.0008 in.)
Valve Guide	Installed Height	14.5—15.5 mm (0.57—0.61 in.)
Valve Seat Grinding	Contact Angle Width Maximum Runout	30° 1.50—2.00 mm (0.059—0.079 in.) 0.16 mm (0.006 in.)
Intake and Exhaust Valve Seat Bore	ID Bore Depth Radius at Lower Bore	46.424 ± 0.013 mm (1.8277 ± 0.0005 in.) 10.65 mm (0.419 in.) 0.64 ± 0.25 mm (0.025 ± 0.001 in.)
Standard Intake and Exhaust Valve Seat	OD	48.52 +/- 0.013 mm (1.910 +/- 0.0005 in.)
Fuel Temperature Sensor	Torque	10 N•m (7.5 lb-ft)
Fuel Lines	Torque	24 N•m (18 lb-ft)
Cylinder Liner	Height Above Block (Standout)	0.030—0.117 mm (0.0012—0.0046 in.)
Cylinder Liner	Max. Height Difference at Nearest Point of Two Adjacent Liners or Within One Liner	0.051 mm (0.0020 in.)
Cylinder Head[4]		
Step 1—No. 17 Cap Screw	Initial Torque	100 N•m (74 lb-ft)
Step 2—All Cap Screws (Nos. 1—26)	Initial Torque	163 N•m (120 lb-ft)
Step 3—Wait 5 Minutes and Verify All Cap Screws (Nos. 1—26)	Torque	163 N•m (120 lb-ft)

[4]*See INSTALL CYLINDER HEAD later in this group for proper torque sequence.*

Continued on next page

Item	Measurement	Specification
Step 4—All Cap Screws (Nos. 1—26)	Initial Torque-Turn	90°
Step 5—All Cap Screws (Nos. 1—26)[5]	Final Torque-Turn	90°
Rocker Arm Shaft Hold-Down Clamp Cap Screws	Initial Torque Additional Torque Pass Final Torque-Turn	30 N•m (22 lb-ft) 30 N•m (22 lb-ft) 90° + 10° — 0°
Unit Injector Wiring Harness Bracket-to-Rear of Head	Torque	25 N•m (18 lb-ft)
Unit Injector Wiring Harness Solenoid Wire Retaining Nut[6]	Torque	3.0 N•m (27 lb-in.)
Unit Injector Harness Clips-to-Rocker Arm Shaft Clamps	Torque	35 N•m (26 lb-ft)

06
200
8

[5]Total torque-turn for steps 4 and 5 is 180°.

[6]Apply LOCTITE 222 (TY24311) Thread Lock and Sealer (Low Strength) to nut only.

RE38635,0000099 –19–27JUL07–4/4

Cylinder Block, Liners, Pistons and Rods (Group 030) Specifications

Item	Measurement	Specification
Front Plate-to-Cylinder Block Cap Screws	Torque	50 N•m (37 lb-ft)
Crankshaft Timing Pin Plug	Torque	33 N•m (24 lb-ft)
Cylinder Liner Cap Screws (For Checking Liner Standout)	Torque	68 N•m (50 lb-ft)
Cylinder Liner Height (Standout)	Height Above Block	0.030—0.117 mm (0.0012—0.0046 in.)
	Maximum Permissible Height Difference at Nearest Point of Two Adjacent Liners or Within One Liner	0.05 mm (0.002 in.)
Cylinder Liner Shims Available	Thickness	0.05 mm (0.002 in.)
	Thickness	0.10 mm (0.004 in.)
Cylinder Liner Wall	Thickness	6.36—6.50 mm (0.250—0.256 in.)
Cylinder Liner Packing Step	Dimension	2.14—2.30 mm (0.084—0.090 in.)
Cylinder Liners		
Flange Area	OD	151.565—151.615 mm (5.9671—5.9691 in.)
Upper OD for Seating Liner	OD	145.795—145.845 mm (5.7400—5.7419 in.)
Water Jacket Area	OD	144.73—144.99 mm (5.698—5.708 in.)
Lower OD for Seating with O-Rings	OD	140.397—140.447 mm (5.5274—5.5294 in.)
No. 1 Piston Compression Ring (3-mm Rings)	End Gap	0.48—0.74 mm (0.019—0.029 in.)
No. 2 Piston Compression Ring (3-mm Rings)	End Gap	1.35—1.65 mm (0.053—0.065 in.)

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RE38635,000009A –19–27JUL07–1/4

Item	Measurement	Specification
Oil Control Ring-to-Groove	Clearance	0.041—0.091 mm (0.0016—0.0036 in.)
	Maximum Clearance	0.132 mm (0.0052 in.)
Piston Pin	OD	57.997—58.003 mm (2.2833—2.3836 in.)
Piston Pin Bore in Piston	ID	62.753—62.713 mm (2.4706—2.4714 in.)
Piston Pin Bushing	ID	58.050—58.070 mm (2.285—2.286 in.)
Piston Skirt	OD 35.0 mm (1.380 in.) from Bottom of Skirt	131.855—131.885 mm (5.1911—5.1923 in.)
Cylinder Liner	ID	131.990—132.010 mm (5.1965—5.1972 in.)
	Max. Out of Round	0.020 mm (0.0008 in.)
	Max. Wear or Taper (Ring Travel Area)	0.030 mm (0.0012 in.)
Piston-to-Liner Clearance	Clearance	0.060—0.100 mm (0.0024—0.0039 in.)
	Max. Acceptable Wear	0.152 mm (0.0060 in.)
Cylinder Liner Flange	Thickness	9.521—9.571 mm (0.3748—0.3768 in.)
PRECISION JOINT™ Connecting Rod Cap Screw	Torque	140 N•m (103 lb-ft) plus 90—100° turn clockwise
Crankshaft Rod Journal	OD	88.844—88.874 mm (3.4980—3.4990 in.)
Connecting Rod Bearing for Crankshaft Journal (Assembled)	ID	88.93—88.98 mm (3.501—3.502 in.)
Connecting Rod Bearing-to-Journal (New Part)	Oil Clearance	0.06—0.13 mm (0.002—0.005 in.)
	Max. Oil Clearance	0.15 mm (0.006 in.)
Connecting Rod Bore (For Crankshaft Journal Bearing)	ID	93.76—93.79 mm (3.6915—3.6925 in.)

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RE38635,000009A –19–27JUL07–2/4

Item	Measurement	Specification
Connecting Rod Centerline of Piston Pin Bore-to-Crankshaft Bore (New Part)	Dimension	263.95—264.05 mm (10.392—10.396 in.)
Rod Pin Bore Without Bushing	ID	62.750—62.775 mm (2.4707—2.4715 in.)
Installed Rod Pin Bushing (Before Boring)	ID	57.750 mm (2.2740 in.)
Installed Rod Pin Bushing (After Boring)	ID	58.020—58.046 mm (2.2843—2.2853 in.)
Piston Pin Bushing Bore	Out-of-Round	0.038 mm (0.0015 in.)
Piston Pin-to-Bushing	Oil Clearance	0.017—0.049 mm (0.0007—0.002 in.)
	Max. Acceptable Wear	0.076 mm (0.0030 in.)
Press Fit of Bushing in Rod Pin Bore	Press Fit	0.075—0.140 mm (0.003—0.0055 in.)
Connecting Rod Pin Bushing Bore (Without Bushing)	ID	62.750—62.775 mm (2.4705—2.4715 in.)
Connecting Rod Pin Bushing	Press Fit in Rod Pin Bore	0.075—0.140 mm (0.003—0.0055 in.)
Cylinder Liner Flange Counterbore	Depth in Block	9.461—9.512 mm (0.3725—0.3745 in.)
Cylinder Liner Flange	Thickness	9.525—9.575 mm (0.3750—0.3770 in.)
Main and Thrust Bearings	Assembled ID Without Bearings	133.097—133.123 mm (5.2400—5.2410 in.)
	Main Bearing Surface Width	37.77—38.03 mm (1.487—1.497 in.)
	Thrust Bearing Surface Width (No. 5 Main)	37.51—38.29 mm (1.476—1.507 in.)
	Overall Thrust Bearing Cap Width	43.25—43.75 mm (1.703—1.722 in.)
Cylinder Block Top Deck Surface Finish	Surface Finish (Surface Mill Only)	3.2 micrometers (125 micro-in.)
	Max. Wave Height	0.008 micrometers (0.0002 micro-in.)
	Max. Wave Depth	2.0 micrometers (79 micro-in.)

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RE38635,000009A –19–27JUL07–3/4

Item	Measurement	Specification
Main Bearing Bore Centerline-to-Top Deck	Minimum Distance	429.92—430.07 mm (16.926—16.932 in.)
Cylinder Block Bore for Seating Liner		
Liner Flange Counterbore	ID	153.57—153.77 mm (6.046—6.054 in.)
Upper Block Bore for Seating Liner	ID	145.845—145.895 mm (5.7419—5.7439 in.)
Lower Block Bore for Seating Liner	ID	140.465—140.515 mm (5.5301—5.5321 in.)
Cylinder Liner Standout	Height Above Block	0.030—0.117 mm (0.0012—0.0046 in.)
Cylinder Liner Shims Available	Thickness Thickness	0.05 mm (0.002 in.) 0.10 mm (0.004 in.)
Piston	Protrusion Above Block Deck	0.079—0.637 mm (0.003—0.025 in.)
Piston Spray Jet Cap Screws	Torque	32N•m (24 lb-ft)
Oil Galley Plug	Torque	20 N•m (15 lb-ft)
Rear Oil Galley	Torque	60 N m (44 lb-ft)
Main Oil Galley (Front) Expansion Plug	Installed Depth	Flush—1.5 mm (0.059 in.) Below Surface

RE38635,000009A –19–27JUL07–4/4

Crankshaft, Main Bearings and Flywheel (Group 040) Specifications

Item	Measurement	Specification
Vibration Damper	Maximum Radial Runout	0.76 mm (0.030 in.)
Crankshaft	End Play	0.038—0.380 mm (0.0015—0.0150 in.)
SAE 1 Flywheel Housing	Maximum Face Deviation	0.30 mm (0.012 in.)
	Maximum Bore Eccentricity	0.30 mm (0.012 in.)
SAE 2 Flywheel Housing	Maximum Face Deviation	0.28 mm (0.011 in.)
	Maximum Bore Eccentricity	0.28 mm (0.011 in.)
SAE 0 Flywheel Housing	Maximum Face Deviation	0.41 mm (0.016 in.)
	Maximum Bore Eccentricity	0.41 mm (0.016 in.)
Flywheel Face Flatness	Maximum Variation	0.23 mm (0.009 in.)
	Maximum Variation per 25 mm (1.0 in.) of Travel	0.013 mm (0.0005 in.)
Flywheel Housing-to-Cylinder Block Cap Screws (SAE 1 With Rear PTO)	Torque	325 N•m (240 lb-ft)
Flywheel Housing-to-Cylinder Block Cap Screws (SAE 0, 1 and 2 Without Rear PTO)	Torque	365 N•m (270 lb-ft)
Flywheel Housing Front Plate Cap Screws	Torque	50 N•m (37 lb-ft)
Flywheel Housing Timing Hole Cover Cap Screws	Torque	5 N•m (44 lb-in.)
Starter Motor Cap Screws	Torque	125 N•m (92 lb-ft)
Flywheel-to-Crankshaft Cap Screws	Torque	130 N•m (96 lb-ft)
Crankshaft Main Bearings	Main Bearing-to-Journal Clearance	0.046—0.122 mm (0.0018—0.0048 in.)
	Maximum Acceptable Oil Clearance	0.152 mm (0.0060 in.)
Crankshaft Main Bearing	ID With Bearing	125.071—125.127 mm (4.9241—4.9263 in.)
	ID Without Bearing	133.097—133.123 mm (5.2400—5.2411 in.)

Continued on next page

RE38635,000009B –19–27JUL07–1/3

Item	Measurement	Specification
Crankshaft Main Bearing Journal	OD	124.983—125.017 mm (4.9206—4.9219 in.)
Crankshaft Main Journal	Max. Out-of-Round	0.025 mm (0.0010 in.)
	Max. Taper per 25.4 mm (1.0 in.) of Journal Length	0.0025 mm (0.0001 in.)
Main Bearing Cap Bore Specifications	ID Without Bearings	133.097—133.123 mm (5.2400—5.2411 in.)
	Max. Bore Diameter Variation	0.013 mm (0.0005 in.)
	Max. Bore Diameter Taper	0.005 mm (0.0002 in.)
	Max. Straightness (Any Bore-to-Adjacent Bore)	0.038 mm (0.0015 in.)
	Max. Straightness (5 Center Bores-to-Adjacent Bore)	0.076 mm (0.0030 in.)
	Centerline of Bore-to-Top Deck	429.92—430.07 mm (16.926—16.932 in.)
Crankshaft Main Bearing Cap	Surface Width	39.75—40.25 mm (1.565—1.585 in.)
Crankshaft Main Bearings Available	Undersize	0.25, 0.50 mm (0.010, 0.020 in.)
Oversize Thrust Washers Available	Thickness	0.18 mm (0.007 in.)
Thrust Bearing New Part Specifications	Thrust Washer Clearance Base Circle	162.24—163.76 mm (6.387—6.447 in.)
	Thrust Surface Width	42.05—42.12 mm (1.656—1.658 in.)
	Relief Angle	45°
	Bearing Cap Overall Width	43.46 mm (1.711 in.)
	Thrust Surface Maximum Runout	0.025 mm (0.0010 in.)
Crankshaft Main Bearing Cap Screws	Final Torque	320 N•m (236 lb-ft)
Rear Oil Seal Housing Cap Screws	Torque	25 N•m (18 lb-ft)
Rear Oil Seal-to-Housing Cap Screws	Torque	15 N•m (11 lb-ft)
Timing Gear Cover Cap Screws	Final Torque	63 N•m (46 lb-ft)
Camshaft Gear Access Cover Cap Screws	Torque	68 N•m (50 lb-ft)
Adjustable Fan Drive Assembly Mounting Cap Screws	Torque	90 N•m (66 lb-ft)

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RE38635,000009B –19–27JUL07–2/3

Item	Measurement	Specification
Damper Hub Cap Screws	Torque	125 N•m (92 lb-ft)
Pulley-to-Damper Cap Screws	Torque	125 N•m (92 lb-ft)
Front Oil Seal Cap Screws	Torque	15 N•m (11 lb-ft)
Viscous Damper Assembly		
Front Crankshaft Oil Seal to Timing Gear Cover	Torque	15 N m (12 lb-ft)
Damper to Crankshaft Hub	Torque	25 N m (19 lb-ft)
Damper Hub to Crankshaft Nose	Torque Turn	40 N m (30 lb-ft) + 90°
Flange Head Cap Screw to Damper Hub	Torque	30 N m (22 lb-ft)

RE38635,000009B –19–27JUL07–3/3

Camshaft and Timing Gear Train (Group 050) Specifications

Item	Measurement	Specification
Camshaft Gear Retainer Plate-to-Camshaft	Initial Torque Second Torque Final Retorque	100 N•m (74 lb-ft) 150 N•m (110 lb-ft) 150 N•m (110 lb-ft)
Camshaft Gear-to-Upper Idler Gear	Backlash	0.13 mm (0.005 in.)
Oil Pump Gear-to-Upper Idler Gear	Backlash	0.25 mm (0.010 in.)
Upper Idler Gear Bearing Cup-to-Block	Torque	85 N•m (63 lb-ft)
Upper Idler Gear Thrust Plate Cap Screws	Initial Torque	35 N•m (26 lb-ft)
Upper Idler Gear Thrust Plate Cap Screws	Final Torque	35 N•m (26 lb-ft)
Upper Idler Cap Screws	Torque Turn	40 N m (30 lb-ft) + 45°
Camshaft and Supply Pump Drive Coupler Set Screw	Torque	4 N•m (3 lb-ft)
Fuel Supply Pump-to-Cylinder Head	Torque	50 N•m (37 lb-ft)
Camshaft Thrust Ring-to-Head	Torque	35 N•m (26 lb-ft)
Camshaft Position Sensor	Torque	14 N•m (10 lb-ft)
Camshaft Journal	OD	101.987—102.013 mm (4.0152—4.0162 in.)
Camshaft Bushing	ID	102.091—102.167 mm (4.0193—4.0223 in.)
Camshaft Journal-to-Bushing	Oil Clearance	0.078—0.180 mm (0.0031—0.0071 in.)
Camshaft Bushing	Bore in Head	105.987—106.013 mm (4.1727—4.1737 in.)
Camshaft Lobe:		
Intake Lobe	Lift	8.73—8.99 mm (0.343—0.353 in.)

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RE38635,000009C –19–27JUL07–1/2

Item	Measurement	Specification
Exhaust Lobe	Lift	7.93—8.19 mm (0.312—0.322 in.)
EUI Lobe	Lift	16.09—16.35 mm (0.633—0.643 in.)
SAE “A” Front Auxiliary Drive Adapter Housing Nuts	Torque	50 N•m (37 lb-ft)
SAE “A” Front Auxiliary Drive Idler Gear Support Bushing	Torque	220 N•m (162 lb-ft)
SAE “B” Rear Auxiliary Drive Adapter	Torque	110 N•m (81 lb-ft)
SAE “A” Front Auxiliary Drive Adapter Housing Nuts	Torque	50 N•m (37 lb-ft)

RE38635,000009C –19–27JUL07–2/2

Lubrication System (Group 060) Specifications

Item	Measurement	Specification
New Oil Pressure Regulating Valve Spring	Free Length Working Load at 76—84 N (17—19 lb-force)	86.4 mm (3.40 in.) 42.0 mm (1.65 in.)
Oil Pressure Regulating Valve Plug	Torque	100 N•m (74 lb-ft)
New Oil Cooler Bypass Valve Spring	Free Length Working Load @ 64—78 N (14—18 lb-force)	44.0 mm (1.73 in.) 30.0 mm (1.18 in.)
New Oil Filter Bypass Valve Spring	Free Length Working Load @ 64—78 N (14—18 lb-force)	44.0 mm (1.73 in.) 30.0 mm (1.18 in.)
Oil Cooler Bypass Valve Plug	Torque	100 N•m (74 lb-ft)
Oil Filter Bypass Valve Plug	Torque	100 N•m (74 lb-ft)
Oil Pressure Relief Valve Spring	Free Length Working Load @ 196—222 N (44—50 lb-force)	79.0 mm (3.11 in.) 65.0 mm (2.56 in.)
Oil Cooler	Test Pressure	140—170 kPa (1.4—1.7 bar) (20—25 psi)
Oil Cooler-to-Housing Nuts	Torque	50 N•m (37 lb-ft)
Oil Cooler Drain Cock Handle	Torque	3 N•m (25 lb-in.)
Oil Cooler Expansion Plug	Installed Depth	Flush to 1.5 mm (0.059 in.) Below Surface
Oil Cooler Housing-to-Block Cap Screws	Torque	68 N•m (50 lb-ft)
Oil Cooler Housing-to-Block Cap Screws	Retorque	68 N•m (50 lb-ft)
Oil Filter/Valve Housing or Oil Cooler Cover/Valve Housing[1]	Torque	68 N•m (50 lb-ft)

[1]Torque sequence and specification also applies to oil cooler cover/valve housing on remote filter applications.

Continued on next page

OUO1022,000000A –19–19SEP02–1/2

Item	Measurement	Specification
Remote Filter Inlet Hose or Line	Torque	190 N•m (140 lb-ft)
Remote Filter Outlet Hose or Line	Torque	142 N•m (105 lb-ft)
Turbocharger Oil Inlet Line-to-Oil Cooler Housing	Torque	35 N•m (26 lb-ft)
Oil Pump Drive Gear Bushing	ID	135.70—135.80 mm (5.343—5.346 in.)
Oil Pump-to-Block Cap Screws	Initial Torque	20 N•m (177 lb-in.)
Oil Pump-to-Block Cap Screws	Torque Turn	90° (1/4 Turn)
Oil Pump Drive Gear-to-Idler Gear	Backlash	0.25 mm (0.010 in.)
Oil Pickup Tube-to-Block Cap Screws	Torque	35 N•m (26 lb-ft)
Oil Pickup Tube-to-Oil Pan Cap Screws	Torque	25 N•m (18 lb-ft)
Oil Pan-to-Cylinder Block Cap Screws	Torque	25 N•m (18.5 lb-ft) plus 90° Turn Clockwise
Oil Pan-to-Rear Oil Seal Housing Cap Screws	Torque	25 N•m (18.5 lb-ft) plus 90° Turn Clockwise
Oil Pan-to-Timing Gear Cover Cap Screws	Torque	25 N•m (18.5 lb-ft) plus 90° Turn Clockwise
Oil Pan Drain Plug 1-1/4 in. Hex Plug	Torque	46 N•m (34 lb-ft)
Oil Pan Drain Plug 1-1/2 in. Hex Plug	Torque	64 N•m (47 lb-ft)

OUO1022,000000A –19–19SEP02–2/2

Cooling System (Group 070) Specifications

Item	Measurement	Specification
Heavy Duty Fan Drive	Housing ID	71.999—72.025 mm (2.8346—2.8356 in.)
	Shaft OD	35.001—35.017 mm (1.3780—1.3786 in.)
	Bearing ID	34.987—35.013 mm (1.3774—1.3785 in.)
	Bearing OD	71.987—72.013 mm (2.8341—2.8351 in.)
Fan Drive Shaft	End Play	0.10 mm (0.004 in.)
Fan Drive Hub-to-Shaft	Torque	115N•m (85 lb-ft)
Fan Pulley-to-Pulley Cap Screws	Torque	61 N•m (45 lb-ft)
Adjustable Fan Drive-to-Camshaft Gear Access Cover Cap Screws	Torque	90 N•m (66 lb-ft)
Belt Tensioner Lower Spring	Tension	81—99 N•m (60—73 lb-ft)
Belt Tensioner Upper Spring	Tension	18—23 N•m (13—17 lb-ft)
Belt Tensioner Shoulder Bolt or Flanged Head Cap Screw	Torque	50 N•m (37 lb-ft)
Fan Belt Idler Pulley	Torque	68 N•m (50 lb-ft)
Coolant Pump Housing-to-Cover Band Clamp	Torque	10 N•m (7.5 lb-ft)
Coolant Pump-to-Front Plate Cap Screws	Torque	50 N•m (37 lb-ft)
Coolant Pump Inlet Elbow to Housing Cap Screws	Torque	41 N•m (30 lb-ft)
Oil Cooler-to-Coolant Pump Hose Clamp	Torque	9 N•m (7 lb-ft)
Thermostat Cover/Housing Assembly-to-Block Cap Screws	Torque	85N•m (63 lb-ft)
Coolant Line Fittings	Torque	13.5 N m (10 lb-ft)
Hose Clamp - Bypass Coolant Hose	Torque	5 N m (44 lb-in)

Continued on next page

RE38635,000009D –19–27JUL07–1/2

Item	Measurement	Specification
Front Coolant Manifold Cap Screw	Torque	50 N m (37 lb-ft)
Rear Coolant Manifold Cap Screw	Torque	50 N m (37 lb-ft)
Exhaust Temperature Tube Fittings	Torque	20 N m (15 lb-ft)
Coolant Temperature Sensor	Torque	15 N m (11 lb-ft)
Thermostat Test	Rating Initial Opening (Range) Temperature Full Open (Nominal) Temperature	82°C (180°F) 80—84°C (175—182°F) 94°C (202°F)
Coolant Temperature Sensor	Torque	10 N•m (7.5 lb-ft)
Thermostat Housing Pipe Plugs	Torque	20 N•m (15 lb-ft)

RE38635,000009D –19–27JUL07–2/2

Air Intake and Exhaust System (Group 080) Specifications

Item	Measurement	Specification
Turbocharger Shaft	Radial Bearing Clearance (Allowable Movement)	0.56—0.81 mm (0.022—0.0.032 in.) (measured on end of shaft)
Turbocharger Axial Bearing	End Play	0.0635—0.1143 mm (0.0025—0.0045 in.)
Turbocharger-to-Exhaust Manifold	Torque	50 N•m (37 lb-ft)
Turbocharger Oil Inlet Fitting	Torque	50 N•m (37 lb-ft)
Turbocharger Oil Return Pipe-to-Turbocharger	Torque	50 N•m (37 lb-ft)
Turbocharger Oil Inlet Line (Both Ends)	Torque	35 N•m (26 lb-ft)
Exhaust Manifold-to-Head Cap Screws	Torque	70 N•m (52 lb-ft)
Intake Manifold-to-Cylinder Head Cap Screws	Torque	35 N•m (26 lb-ft)
Variable Geometry Turbocharger and Exhaust Gas Recirculator		
Turbocharger Actuator to Bracket	Torque	13.3 N m (10 lb-ft)
Linkage Arm to Actuator and Turbocharger Shaft	Torque	7 N m (5 lb-ft) (62 lb-in.)
Coolant Lines to Actuator	Torque	24 N m (18 lb-ft)
EGR Cooler to Exhaust Manifold	Torque	50 N m (37 lb-ft)
EGR Coolant Lines to Cooler	Torque	35 N m (26 lb-ft)
Coolant Inlet Fitting	Torque	70 N m (52 lb-ft)
EGR Pipe Cap Screw	Torque	50 N m (37 lb-ft)

Continued on next page

RE38635,000009E –19–27JUL07–1/2

Item	Measurement	Specification
EGR Valve to Intake Manifold Cap Screws	Initial Torque	5 N m (44 lb-in)
EGR Valve to Intake Manifold Cap Screws	Final Torque	15 N m (11 lb-ft) (133 lb-in.)

RE38635,000009E –19–27JUL07–2/2

Air Intake and Exhaust System (Group 081) Specifications

Item	Measurement	Specification
Turbocharger Shaft	Radial Bearing Clearance (Allowable Movement)	0.56—0.81 mm (0.022—0.0.032 in.) (measured on end of shaft)
Turbocharger Axial Bearing	End Play	0.0635—0.1143 mm (0.0025—0.0045 in.)
Turbocharger-to-Exhaust Manifold	Torque	50 N•m (37 lb-ft)
Turbocharger Oil Inlet Fitting	Torque	25 N•m (19 lb-ft)
Oil Drain Line Connector to Cylinder Block	Torque	45 N•m (33 lb-ft)
Turbocharger Oil Drain Line-to-Turbocharger	Torque	50 N•m (37 lb-ft)
Turbocharger Oil Inlet Line (Both Ends)	Torque	35 N•m (26 lb-ft)
Exhaust Manifold-to-Head Cap Screws	Torque	70 N•m (52 lb-ft)
Intake Air Temperature Sensor to Intake Manifold	Torque	17 N•m (13 lb-ft)
Intake Manifold-to-Cylinder Head Cap Screws	Torque	35 N•m (26 lb-ft)

RE38635,0000104 –19–08NOV07–1/1

Starting and Charging Systems (Group 100) Specifications

Item	Measurement	Specification
Alternator Strap Mounting Hardware		
M8 Cap Screw	Torque	25 N•m (18 lb-ft)
M10 Cap Screw	Torque	50 N•m (37 lb-ft)
1/2 in. Cap Screw	Torque	61 N•m (45 lb-ft)
Alternator Foot Mounting Hardware		
M10 Cap Screw	Torque	70 N•m (52 lb-ft)
M12 Cap Screw	Torque	60 N•m (44 lb-ft)
Starter Motor Mounting Hardware	Torque	125 N•m (92 lb-ft)

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Observable Diagnostics and Test Specifications

Item	Measurement	Specification
Engine Oil	Minimum Pressure at No Load (Idle)	138 kPa (1.38 bar) (20 psi)
	Maximum Pressure at Full Load (Rated Speed)	310 kPa (3.1 bar) (45 psi)
Intake Manifold	Test Pressure	13.8—20.8 kPa (0.13—0.21 bar) (2—3 psi)
Crankshaft Position Sensor	Torque	14 N•m (10 lb-ft)

OUO1004,0000C20 –19–27NOV00–1/1

Dynamometer Test Specifications (OEM Engines)

INDUSTRIAL ENGINE APPLICATIONS					
ENGINE MODEL	FUEL SYSTEM OPTION CODES	INTERMITTENT POWER RATING @ RATED SPEED WITHOUT FAN kW (hp)	RATED SPEED (rpm)	SLOW IDLE (rpm)	FAST IDLE (rpm)
6105AF	1601, 1602, 1603, 1604	224 (300)	2100	850	2225
6105HF	1609, 1610, 1620, 1621	242 (325)	2100	850	2225
	1601, 1602, 1611, 1612	261 (350)	2100	850	2225
6125AF	1610, 1620, 1631, 1641, 1642	242 (325)	2100	850	2225
	1601, 1611, 1622, 1632	261 (350)	2100	850	2225
	1602, 1612, 1623, 1633	280 (375)	2100	850	2225
	1603, 1613, 1624, 1634	298 (400)	2100	850	2225
6125HF (—29999)	1601, 1611, 1621, 1631	317 (425)	2100	850	2225
	1602, 1612, 1622, 1632	336 (450)	2100	850	2225
	1603, 1613, 1623, 1633	354 (475)	2100	850	2225
	1604, 1614, 1624, 1634	373 (500)	2100	850	2225
6125HF (30000—)	16A1, 16A2, 16A3, 16A4	224 (300)	2100	900	2225
	16B1, 16B2, 16B3, 16B4	242 (325)	2100	900	2225
	16C1, 16C2, 16C3, 16C4	261 (350)	2100	900	2225
	16D1, 16D2, 16D3, 16D4	280 (375)	2100	900	2225
	16E1, 16E2, 16E3, 16E4	298 (400)	2100	900	2225
	16F1, 16F2, 16F3, 16F4	317 (425)	2100	900	2225
	16G1, 16G2, 16G3, 16G4	336 (450)	2100	900	2225
	16H1, 16H2, 16H3, 16H4	354 (475)	2100	900	2225
	16J1, 16J2, 16J3, 16J4	373 (500)	2100	900	2225
	16L1, 16L2, 16L3, 16L4	410 (550)	2100		
6125AFM (Marine)	M1	254 (340)	1800	650	1950
	M2	280 (375)	1900	650	2225
	M3	298 (400)	2000	650	2225
	M4, 1601, 1602	336 (450)	2100	650	2225

Continued on next page DPSG,OUO1004,924 –19–13SEP02–1/2

GENERATOR SET (STANDBY) APPLICATIONS					
ENGINE MODEL	FUEL SYSTEM OPTION CODES	STANDBY POWER RATING @ RATED SPEED WITHOUT FAN kW (hp)	RATED SPEED (rpm)	SLOW IDLE (rpm)	FAST IDLE (rpm)
6125AF	1607, 1617, 1628, 1638	233 (312)	1500	900	1550
	1608, 1618, 1629, 1639	254 (341)	1500	900	1550
	1609, 1619, 1630, 1640	277 (371)	1500	900	1550
	1604, 1614, 1625, 1635	280 (375)	1800	900	1850
	1605, 1615, 1626, 1636	300 (402)	1800	900	1850
	1606, 1616, 1627, 1637	330 (442)	1800	900	1850
6125HF (—29999)	1607, 1617, 1627, 1637	302 (405)	1500	900	1550
	1608, 1618, 1628, 1638	352 (472)	1500	900	1550
	1606, 1616, 1626, 1636	360 (483)	1800	900	1850
	1605, 1615, 1625, 1635	420 (563)	1800	900	1850
	1639, 1640, 1641, 1642	460 (616)	1800	900	1850
6125HF (30000—)	164J, 164K, 164L, 164M	300 (402)	1500	900	1550
	163A, 163B, 163C, 163D	330 (442)	1800	900	1850
	165J, 165K, 165L, 165M	350 (469)	1500	900	1550
	164A, 164B, 164C, 164D	360 (483)	1800	900	1850
	166J, 166K, 166L, 166M	387 (519)	1500	900	1550
	165A, 165B, 165C, 165D	420 (563)	1800	900	1850
	166A, 166B, 166C, 166D	460 (617)	1800	900	1850

OEM MARINE APPLICATIONS					
Engine Model	**Fuel System Option Codes**	**Prime Power Rating kW (hp)**	**Rated Speed (rpm)**	**Slow Idle (rpm)**	**Fast Idle rpm**
6125AFM	1606, 1616	300 (402)	1800	900	1850
	1609, 1619	252 (338)	1500	900	1550

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Intake Manifold Pressure (Turbocharger Boost) Specifications

Engine Model	Fuel System Option Codes	Power Rating @ Rated Speed Without Fan kW (hp)	Rated Speed (rpm)	Boost Pressure Specification
OEM INDUSTRIAL APPLICATIONS				
6105AF	1601, 1602, 1603, 1604	224 (300)	2100	134—154kPa (1.3—1.5bar) (19—22 psi)
6105HF	1609,1610, 1620,1621	242 (325)	2100	128—148 kPa (1.3—1.5 bar) (19-21 psi)
	1601, 1602, 1611, 1612	261 (350)	2100	144—166 kPa (1.4—1.7 bar) (21-24 psi)
6125AF	1610, 1620, 1631, 1641, 1642	242 (325)	2100	134—154 kPa (1.3—1.5 bar) (19—22 psi)
	1601, 1611, 1622, 1632	261 (350)	2100	147—168 kPa (1.5—1.7 bar) (21—24 psi)
	1602, 1612, 1623, 1633	280 (375)	2100	159—183 kPa (1.6—1.8 bar) 23—27 psi)
	1603, 1613, 1624, 1634	298 (399)	2100	173—199 kPa (1.7—2.0 bar) 25—29 psi)
6125HF (—29999)	1601, 1611, 1621, 1631	317 (425)	2100	148—170 kPa (1.5—1.7 bar) (21—25 psi)
	1602, 1612, 1622, 1632	336 (450)	2100	162—186 kPa (1.6—1.9 bar) (23—27 psi)
	1603, 1613, 1623, 1633	354 (474)	2100	172—198 kPa (1.7—2.0 bar) (25—29 psi)
	1604, 1614, 1624, 1634	373 (500)	2100	182—210 kPa (1.8—2.1 bar) (26—30 psi)
6125HF (30000—)	16A1, 16A2, 16A3, 16A4	224 (300)	2100	102—116 kPa (1.0—1.2 bar) (15—17 psi)
	16B1, 16B2, 16B3, 16B4	242 (325)	2100	114—130 kPa (1.1—1.3 bar) (16—19 psi)
	16C1, 16C2, 16C3, 16C4	261 (350)	2100	126—145 kPa (1.3—1.4 bar) (18—21 psi)
	16D1, 16D2, 16D3, 16D4	280 (375)	2100	139—159 kPa (1.4—1.6 bar) (20—23 psi)
	16E1, 16E2, 16E3, 16E4	298 (400)	2100	144—165 kPa (1.4—1.6 bar) (21—24 psi)
	16F1, 16F2, 16F3, 16F4	317 (425)	2100	157—180 kPa (1.6—1.8 bar) (23—26 psi)
	16G1, 16G2, 16G3, 16G4	336 (450)	2100	168—193 kPa (1.7—1.9 bar) (24—28 psi)
	16H1, 16H2, 16H3, 16H4	354 (475)	2100	177—203 kPa (1.8—2.0 bar) (26—29 psi)
	16J1, 16J2, 16J3, 16J4	373 (500)	2100	185—212 kPa (1.8—2.1 bar) (27—31 psi)
OEM GENERATOR SET (STANDBY) APPLICATIONS				
6125AF	1607, 1617, 1628, 1638	233 (312)	1500	136—156kPa (1.4—1.6bar) (20—23 psi)
	1608, 1618, 1629, 1639	254 (341)	1500	150—172 kPa (1.5—1.7 bar) (22—25 psi)
	1609, 1619, 1630, 1640	277 (371)	1500	171—197 kPa (1.7—2.0 bar) (25—29 psi)
	1604, 1614, 1625, 1635	280 (375)	1800	182—210 kPa (1.8—2.1 bar) (26—30 psi)
	1605, 1615, 1626, 1636	300 (402)	1800	201—231 kPa (2.0—2.3 bar) (29—33 psi)
	1606, 1616, 1627, 1637	330 (442)	1800	223—257 kPa (2.2—2.6 bar) (32—37 psi)
6125HF (—29999)	1607, 1617, 1627, 1637	302 (405)	1500	184—212 kPa (1.8—2.1 bar) (27—31 psi)
	1608, 1618, 1628, 1638	352 (472)	1500	215—247 kPa (2.1—2.5 bar) (31—36 psi)
	1606, 1616, 1626, 1636	360 (483)	1800	210—242 kPa (2.1—2.4 bar) (30—35 psi)
	1605, 1615, 1625, 1635	420 (563)	1800	250—288 kPa (2.5—2.9 bar) (36—42 psi)
	1639, 1640, 1641, 1642	460 (616)	1800	270—309 kPa (2.7—3.1 bar) (39—45 psi)
6125HF (30000—	164J, 164K, 164L, 164M	300 (402)	1500	Not Available at Time of Printing
	163A, 163B, 163C, 163D	330 (442)	1800	Not Available at Time of Printing
	165J, 165K, 165L, 165M	350 (469)	1500	Not Available at Time of Printing
	164A, 164B, 164C, 164D	360 (483)	1800	Not Available at Time of Printing
	166J, 166K, 166L, 166M	387 (519)	1500	Not Available at Time of Printing

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Engine Model	Fuel System Option Codes	Power Rating @ Rated Speed Without Fan kW (hp)	Rated Speed (rpm)	Boost Pressure Specification
	165A, 165B, 165C, 165D	420 (563)	1800	Not Available at Time of Printing
	166A, 166B, 166C, 166D	460 (617)	1800	Not Available at Time of Printing

OEM MARINE APPLICATIONS				
Engine Model	**Fuel System Option Codes**	**Power Rating @ Rated Speed Without Fan kW (hp)**	**Rated Speed (rpm)**	**Pressure Specification**
6125AFM	M1	254 (340)	1800	124—152 kPa (1.2—1.5 bar) (18—22 psi)
	M2	280 (375)	1900	145—172 kPa (1.4—1.7 bar) (21—25 psi)
	M3	298 (400)	2000	159—187 kPa (1.6—1.9 bar) (23—27 psi)
	M4, 1601, 1602	336 (450)	2100	186—214 kPa (1.9—2.1 bar) (27—31 psi)
	Gen Set (Prime)	300 (402)	1800	165—193 kPa (1.6—1.9 bar) (24—28 psi)
	Gen Set (Prime)	252 (338)	1500	117—145 kPa (1.2—1.5 bar) (17—21 psi)

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Engine Model	Deere Model	Rated Speed (rpm)	Pressure Specification
JOHN DEERE VEHICLE APPLICATIONS			
6125ADW01	744H/MH Loader (4-Wheel Drive) 744H/MH Log Loader	2000	93—107 kPa (0.9—1.1 bar) (14—16 psi)
6125HDW01 (30000—)	744H/MH Log Loader	2000	93—107 kPa (0.9—1.1 bar) (14—16 psi)
6125ADW70	230LC Excavator	2000	93—107 kPa (0.9—1.1 bar) (14—16 psi)
6125HT001 (30000—)	450C LC Excavator	1800	149—170 kPa (1.5—1.7 bar) (22—25 psi)
6105HRW01	9200 (4-Wheel Drive Tractor)	2100	124—142 kPa (1.2—1.5 bar) (18—21 psi)
6125HRW05 (30000—)	9200 (4-Wheel Drive Tractor)	2100	102—117 kPa (1.0—1.2 bar) (15—17 psi)
6125HRW01	9300 (4-Wheel Drive Tractor)	2100	113—130 kPa (1.1—1.3 bar) (16—19 psi)
6125HRW07 (30000—)	9300 (4-Wheel Drive Tractor)	2100	131—150 kPa (1.3—1.5 bar) (1113—130 kPa (1.1—1.3 bar) (16—19 psi)9—22 psi)
6125HRW11	9300 (4-Wheel Drive Tractor)		
6125HRW02	9400 (4-Wheel Drive Tractor) 9200 (4-Wheel Drive Tractor)	2100	144—166 kPa (1.4—1.7 bar) (21—24 psi)
6125HRW09 (30000—)	9400 (4-Wheel Drive Tractor)	2100	153—175 kPa (1.5—1.7 bar) (22—25 psi)
6125HRW12	9400 (4-Wheel Drive Tractor)		
6125HRW03	9300T (Track-Type Tractor)	2100	113—130 kPa (1.1—1.3 bar) (16—19 psi)
6125HRW06 (30000—)	9300T (Track-Type Tractor)	2100	113—130 kPa (1.1—1.3 bar) (16—19 psi)
6125HRW04	9400T (Track-Type Tractor)	2100	144—166 kPa (1.4—1.7 bar) (21—24 psi)
6125HRW08 (30000—)	9400T (Track-Type Tractor)	2100	153—175 kPa (1.5—1.7 bar) (22—25 psi)
6125HZ001	6850 (Forage Harvester)	2100	149—172 kPa (1.5—1.7 bar) (22-25 psi)
6125HZ005	6850 (Forage Harvester)		
6125HZ002	6750 (Forage Harvester)	2100	115—132 kPa (1.1—1.3 bar) (17—19 psi)
6125HZ006	6750 (Forage Harvester)		
6125AT801	CH2500 Sugar Cane Harvester	2100	143—167 kPa (1.4—1.7 bar) (20—24 psi)
6125HRW10	9220 (4-Wheel Drive Tractor)	2100	125 kPa (1.2—1.3 bar) (22 psi)
6125HRW13	9220 (4-Wheel Drive Tractor)	2100	125 kPa (1.2—1.3 bar) (22 psi)
6125HRW16	9220 (4-Wheel Drive Tractor)		125 kPa (1.2—1.3 bar) (18 psi)
6125HRW13	9320 (4-Wheel Drive Tractor)	2100	153 kPa (1.5 bar))22 psi)
6125HRW16	9320 (4-Wheel Drive Tractor)		153 kPa (1.5 bar) (22 psi)
6125HRW14	9420 (4-Wheel Drive Tractor)	2100	173 kPa (1.7 bar) (25 psi)
6125HRW15	9420 (4-Wheel Drive Tractor)		173 kPa (1.7 bar) (25 psi)
6125HRW17	9420 (4-Wheel Drive Tractor)		173 kPa (1.7 bar) (25 psi)
6125HRW15	9520 (4-Wheel Drive Tractor)		175 kPa (1.7—1.8 bar) (25 psi)
6125HRW17	9520 (4-Wheel Drive Tractor)		175 kPa (1.7—1.8 bar) (25 psi)
6125HT001	450LL Forestry Logger/Excavator		See 6125HT001 above for reference
6125HT004	844H Loader		133 - 142 kPa (13.3 - 14.2 bar) (19 - 20.5 psi)

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Engine Model	Deere Model	Rated Speed (rpm)	Pressure Specification
6125HH003	9860 Special Canadian Combine		137 kPa (1.3-1.4 bar) (20 psi)

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