POWERTECH®
0.9, 1.1, 1.2, 1.3, 1.5, 1.6 & 2.0 L and Yanmar 4TNE98 Diesel Engines

TECHNICAL MANUAL

POWERTECH® 0.9, 1.1, 1.2, 1.3, 1.5, 1.6 & 2.0 L and Yanmar 4TNE98 Diesel Engines

CTM119 18JUN04 (ENGLISH)

For complete service information also see:

Alternators and Starter Motors	CTM77
Series 220 Diesel Engines (Yanmar)	CTM3

John Deere Power Systems

LITHO IN U.S.A.

Introduction

Foreword

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

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

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

Information is organized in sections and groups for the various components requiring service instruction. Section 05 summarizes all applicable essential tools, service equipment and tools, other materials needed to do the job, and service parts kits. Section 06 summarizes all specifications, wear tolerances, and torque values.

Before beginning repair on an engine, clean the engine and mount on a repair stand. (See Section 02, Group 010.)

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

Technical Manuals are concise guides for specific machines. They are on-the-job guides containing only the vital information needed for diagnosis, analysis, testing, and repair.

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.

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

This Component Technical Manual covers the recommended repair and troubleshooting information for John Deere *POWERTECH*® 0.9, 1.1, 1.2, 1.3, 1.5, 1.6 and 2.0 liter diesel engines sold through John Deere OEM engine distributors, and also the Yanmar 4TNE98 engines used in the John Deere 244H and 304H Loaders.

Engine sizes as referred to in this manual can be matched as follows:

- 3009—0.9 L
- 3011—1.1 L
- 3012—1.2 L
- 3013—1.3 L
- 3015—1.5 L
- 3016—1.6 L
- 4020—2.0 L
- 4TNE98—3.3 L

Coverage of engines includes all levels of emission certification: non-certified, Tier I certified, and Tier II certified.

Repair and diagnostic information for starting motors and alternators used on 3009, 3011, 3012, 3013, 3015, 3016 and 4020 engines is presented in Section 02, Group 100 and Section 04, Group 150. Use CTM77 Alternators And Starter Motors for starter and alternator information for 4TNE98 engines.

Dealers should retain CTM3 for servicing 3009 and 3011 engines marketed to OEMs as “John Deere Series 220 Diesel Engines.”

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OUO1083,000068D –19–19MAY04–1/2

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.

OUO1083,000068D –19–19MAY04–2/2

John Deere Dealers

The changes listed below make your CTM obsolete. **Discard CTM119 dated 15APR97 and replace with this new manual.**

The information in this manual has been reorganized and will appear in a different order than the previous edition.

Also, copy the pages listing changes and route through your Service Department.

INTRODUCTION

- Updated information to include models 3012, 3013 and 3016 engines.

SECTION 01—GROUP 000 (Safety)

- Updated all safety information.

SECTION 01—GROUP 001 (Engine Identification and Application Charts)

- Updated engine application charts.

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

- Revised diesel/bio-diesel fuel guidelines and specifications.
- Revised diesel engine oil guidelines.
- Revised engine coolant guidelines.

SECTION 02—GROUP 010 (Engine Rebuild)

- Revised all procedures to include specifications for 3012, 3013 and 3016 engines.
- Revised engine cleaning procedure.
- Revised engine disassembly procedure.
- Revised engine assembly procedure.
- Updated engine break-in guidelines and oil recommendations.

SECTION 02—GROUP 020 (Cylinder Head and Valves)

- Revised all procedures to include specifications for 3012, 3013 and 3016 engines.
- Revised rocker arm cover removal and installation to include 3012, 3013 and 3016 engines.
- Revised cylinder head removal procedure.
- Revised cylinder head installation procedure.

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

- Revised all procedures to include specifications for 3012, 3013 and 3016 engines.
- Revised reboring procedure.

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

- Revised all procedures to include specifications for 3012, 3013 and 3016 engines.

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

- Revised all procedures to include specifications for 3012, 3013 and 3016 engines.
- Updated procedure for removing timing gear cover to include 3012, 3013 and 3016 engines.
- Revised cam follower inspection procedure.
- Updated install timing gears procedure to include 3012, 3013 and 3016 engines.

SECTION 02—GROUP 060 (Lubrication System)

- Updated procedures to include 3012, 3013 and 3016 as needed.
- Revised procedures to include specifications for 3012, 3013 and 3016 engines as needed.
- Added remove and install oil pump procedure for 3013 and 3016 engines.
- Added disassemble, inspect and assemble oil pump procedure for 3013 and 3016 engines.

SECTION 02—GROUP 070 (Cooling System)

OUO1083,000064C –19–29APR04–1/2

- Revised all procedures to include specifications for 3012, 3013 and 3016 engines.

SECTION 02—GROUP 080 (Air Intake and Exhaust System)

- Revised all procedures to include specifications for 3012, 3013 and 3016 engines.

SECTION 02—GROUP 090 (Fuel System)

- Revised all procedures to include specifications for 3012, 3013 and 3016 engines.
- Added replace fuel supply pump for 3013 and 3016 engines.
- Added fuel filter and water separator for 3013 and 3016 engines.
- Added slow idle speed adjustment for 3013 and 3016 engines.
- Added fast idle speed adjustment for 3013 and 3016 engines.
- Added bleed fuel system for 3013 and 3016 engines.
- Added remove fuel injection pump for 3013 and 3016 engines.
- Added install fuel injection pump for 3013 and 3016 engines.
- Revised remove fuel injection pump for 4TNE98 engine.
- Revised install fuel injection pump for 4TNE98 engine.
- Revised fuel injection pump static timing for 4TNE98 engine.
- Revised remove and install fuel injection nozzles to include 3013 and 3016 engines.
- Revised fuel shutoff solenoid adjustment for 3011 and 3012 engines.

SECTION 02—GROUP 100 (Starting and Charging Systems)

- Revised all procedures to include specifications for 3012, 3013 and 3016 engines.

SECTION 03—GROUP 120 (Base Engine Operation)

- Revised all procedures to include specifications for 3012, 3013 and 3016 engines.
- Added fuel injection pump operational theory for 3013 and 3016 engines.
- Added timing controller and cold start advancer operational theory for 3013 and 3016 engines.

SECTION 04—GROUP 150 (Observable Diagnostics and Tests)

- Revised all procedures to include specifications for 3012, 3013 and 3016 engines.
- Updated crankcase ventilation check to include 3012, 3013 and 3016 engines.
- Added test fuel supply pump pressure for 3013 and 3016 engines.

SECTION 05—Groups 170, 180, and 190 (Tools and Other Materials)

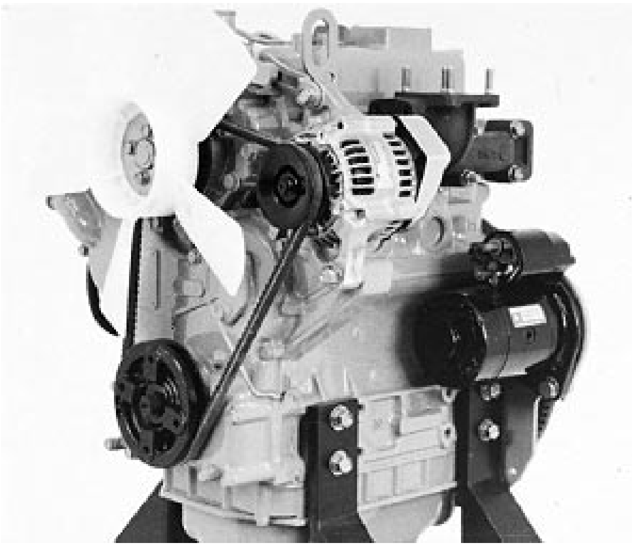
- Revised to include information for 3012, 3013 and 3016 engines.

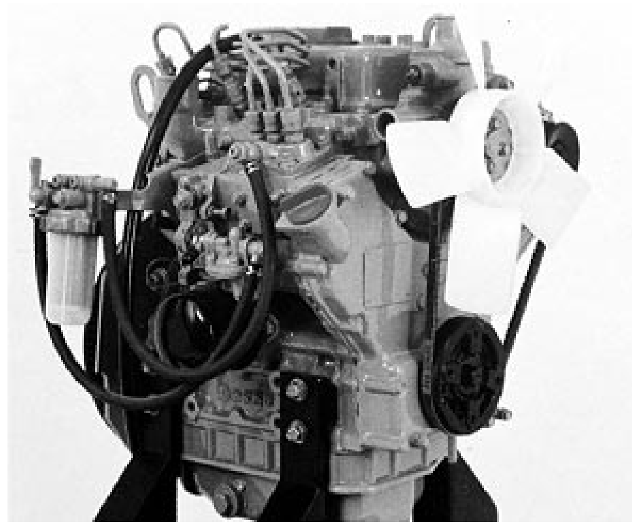
SECTION 06—Groups 200 and 210 (Specifications)

- Revised all procedures to include specifications for 3012, 3013 and 3016 engines.
- All repair, test and diagnostic specifications listed throughout this manual are consolidated in this section for ease of reference.

OUO1083,000064C –19–29APR04–2/2

POWERTECH® 3009DF001 Base Engine


RG6606 –UN–20JAN93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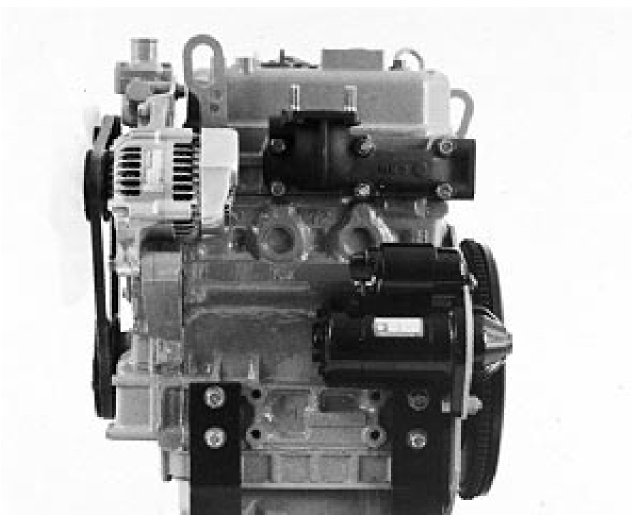
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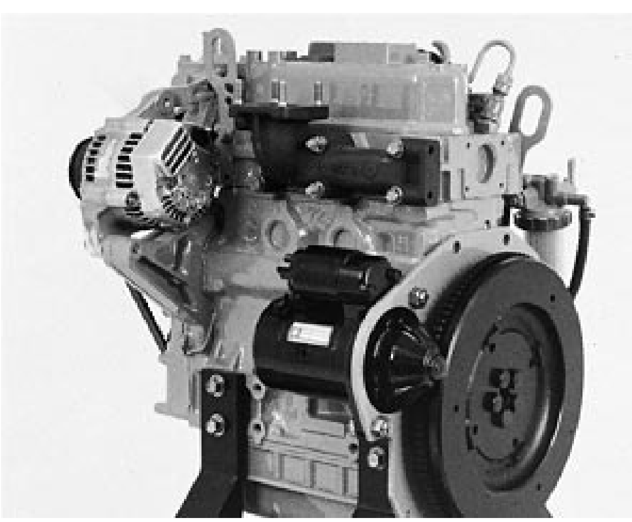
RG6609 –UN–20JAN93


RG6610 –UN–20JAN93


RG6611 –UN–20JAN93

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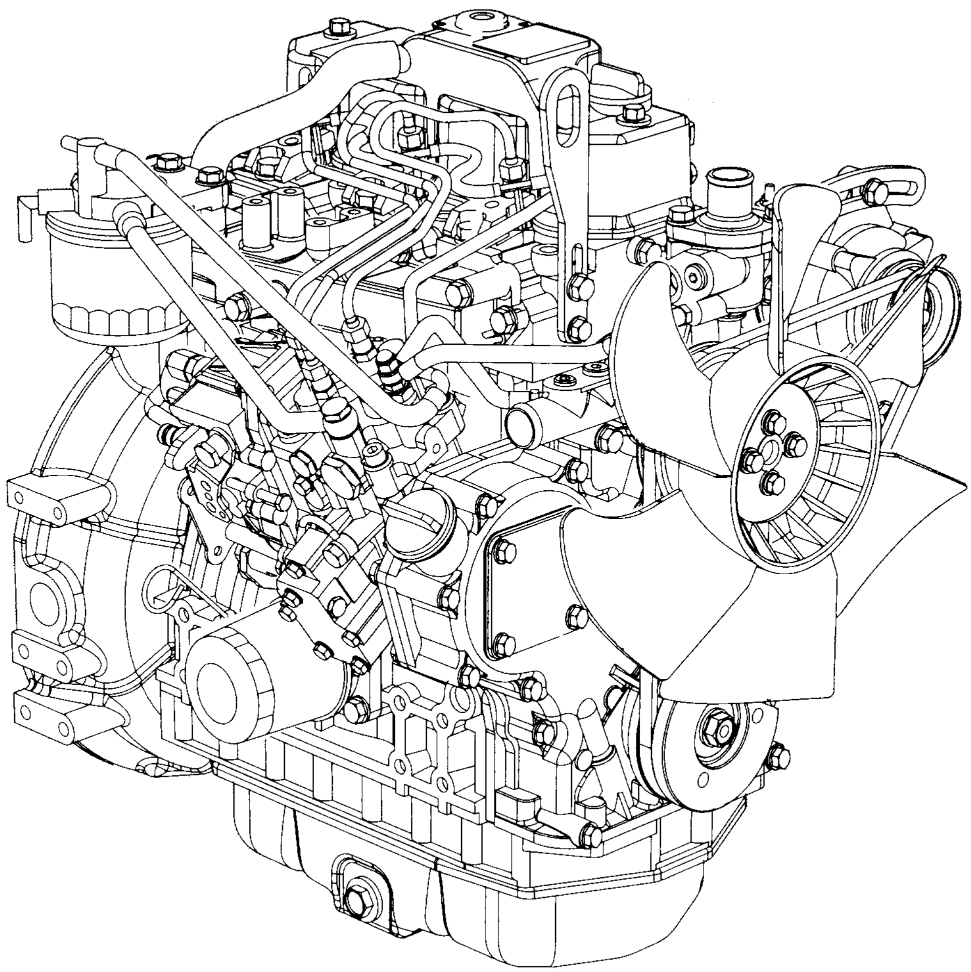
DPSG,OUOE003,205 –19–15APR97–1/1

POWERTECH® 3013DF270 Base Engine



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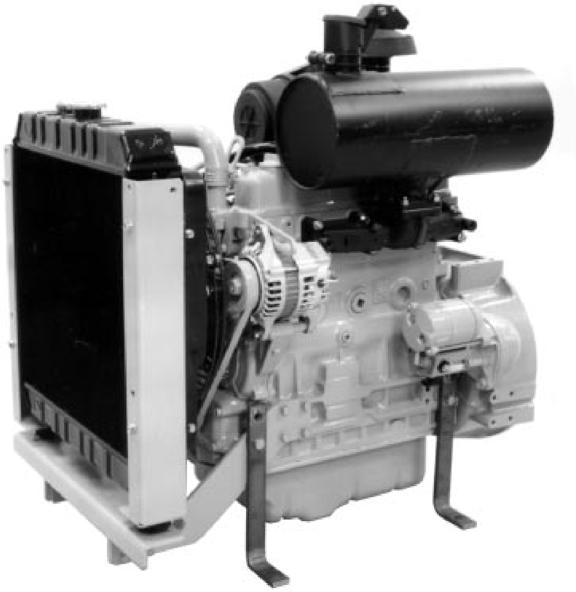
OUO1083,0000671 –19–11MAY04–1/1

POWERTECH® 4020DF006 Generator Drive Power Unit Engine



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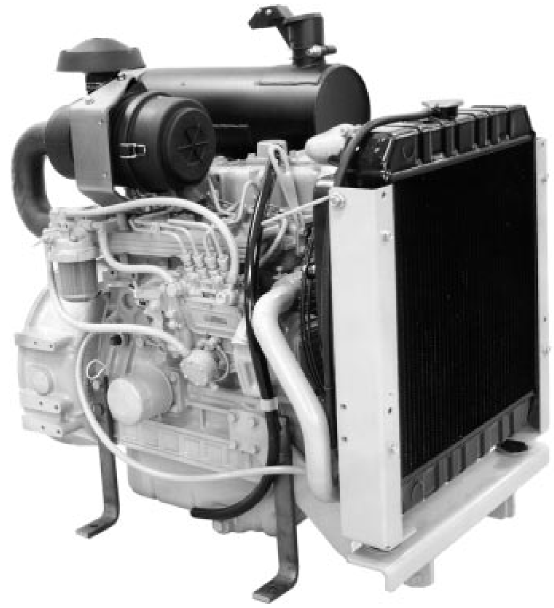

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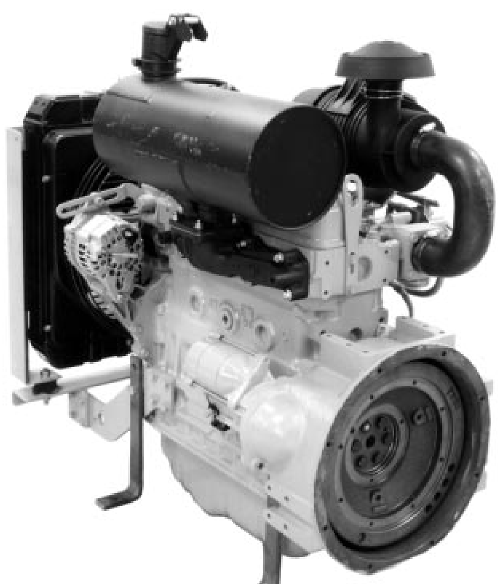

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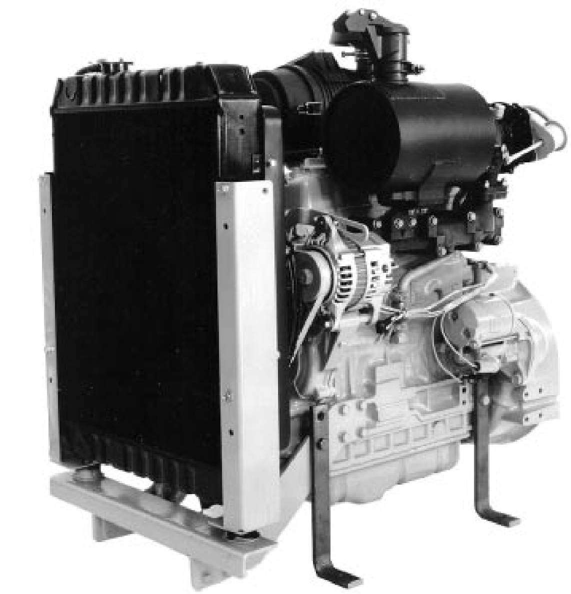
POWERTECH® 4020TF005 Industrial Power Unit Engine



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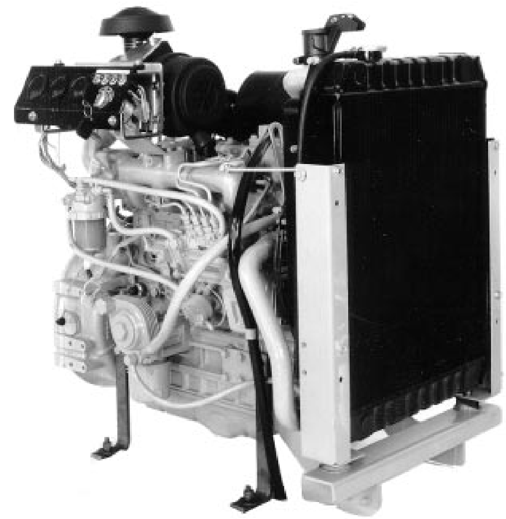

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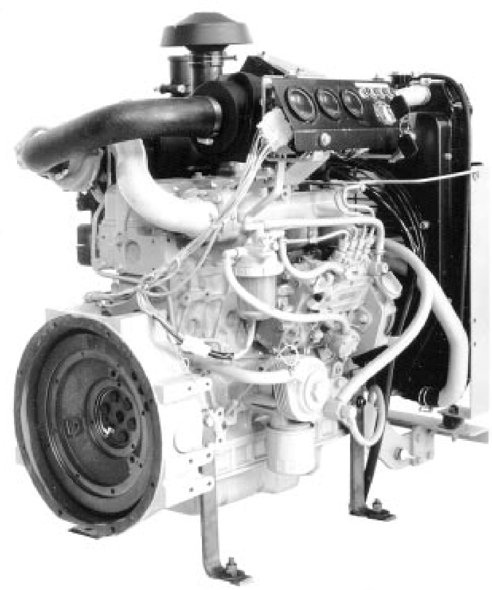

RG8482 —UN—25APR00

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RG,RG34710,8003 –19–15APR97–1/1

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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.

Section 01
General Information

Contents

Handle Fluids Safely—Avoid Fires

TS227 –UN–23AUG88

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

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

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

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

DX,FLAME –19–30APR04–1/1

Handle Starting Fluid Safely

TS1356 –UN–18MAR92

CAUTION: On later engines equipped with glow plugs, DO NOT USE ETHER STARTING FLUID. Use of starting fluids could cause explosion and possibility of personal injury.

Starting fluid is highly flammable.

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

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

Do not incinerate or puncture a starting fluid container.

DX,FIRE3 –19–17DEC03–1/1

Service Cooling System Safely

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

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

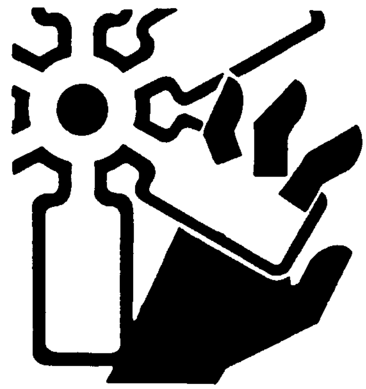
TS281 –UN–23AUG88

DX,RCAP –19–04JUN90–1/1

Install Fan Guards

Rotating cooling system fans can cause serious injury.

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



Rotating Fan

TS677 –UN–21SEP89

OUO1083,00005FE –19–17DEC03–1/1

Avoid Hot Parts

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

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

Hot Surface

TS271 –UN–23AUG88

OUO1083,00005FF –19–17DEC03–1/1

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

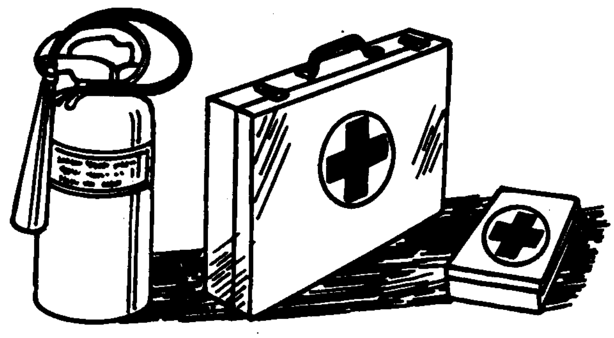
DX,SPARKS –19–03MAR93–1/1

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

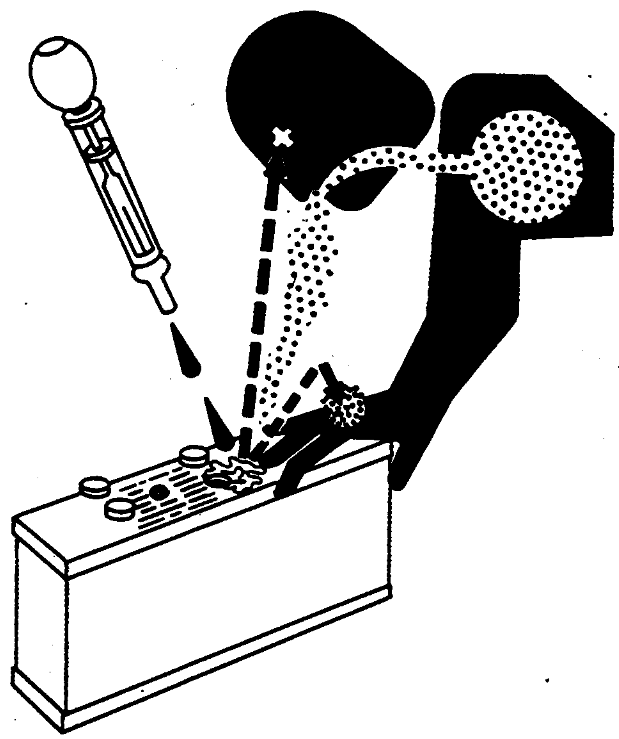
Handling Batteries Safely


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.


TS203 —UN—23AUG88

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

Avoid the hazard by:

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

If you spill acid on yourself:

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

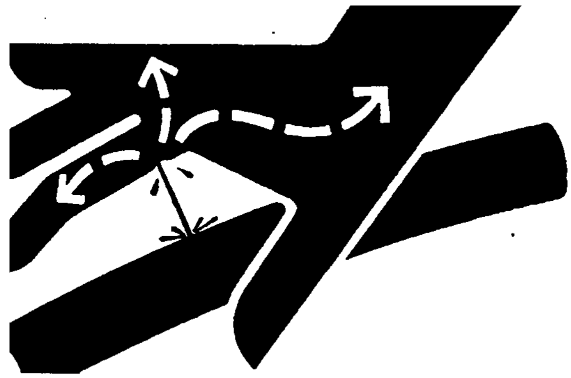
If acid is swallowed:

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

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

DPSG,OUO1004,2758 –19–11MAY00–1/1

Avoid High-Pressure Fluids



X9811 –UN–23AUG88

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

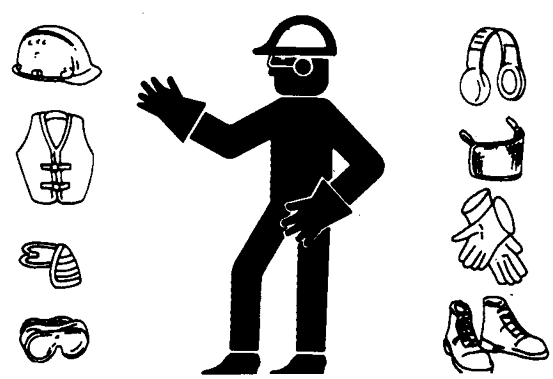
Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure.

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.

DX,FLUID –19–03MAR93–1/1

Wear Protective Clothing



TS206 –UN–23AUG88

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

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

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

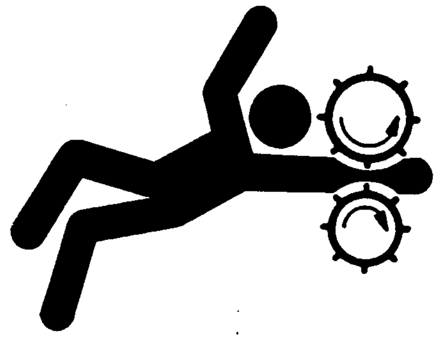
Operating equipment safely requires the full attention of the operator. Do not wear radio or music headphones while operating machine.

DX,WEAR –19–10SEP90–1/1

Service Machines Safely

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.



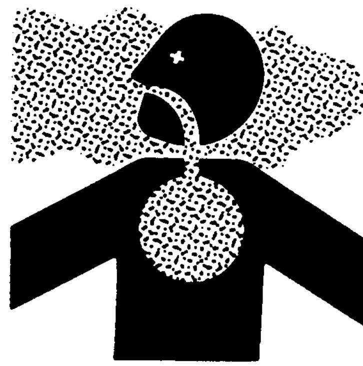
TS228 –UN–23AUG88

DX,LOOSE –19–04JUN90–1/1

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



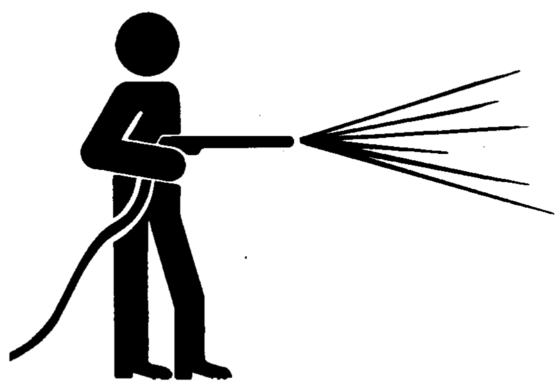
TS220 –UN–23AUG88

DX,AIR –19–17FEB99–1/1

Work in Clean Area

Before starting a job:

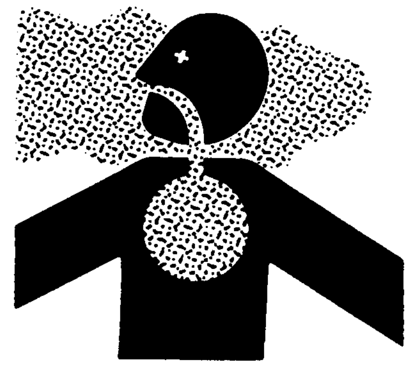
- Clean work area and machine.
- Make sure you have all necessary tools to do your job.
- Have the right parts on hand.
- Read all instructions thoroughly; do not attempt shortcuts.



T6642EJ –UN–18OCT88

DX,CLEAN –19–04JUN90–1/1

Remove Paint Before Welding or Heating



TS220 –UN–23AUG88

Avoid potentially toxic fumes and dust.

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

Remove paint before heating:

- Remove paint a minimum of 100 mm (4 in.) from area to be affected by heating. If paint cannot be removed, wear an approved respirator before heating or welding.
- If you sand or grind paint, avoid breathing the dust. Wear an approved respirator.
- If you use solvent or paint stripper, remove stripper with soap and water before welding. Remove solvent or paint stripper containers and other flammable material from area. Allow fumes to disperse at least 15 minutes before welding or heating.

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

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

Dispose of paint and solvent properly.

DX,PAINT –19–24JUL02–1/1

Avoid Heating Near Pressurized Fluid Lines

TS953 –UN–15MAY90

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

DX,TORCH –19–03MAR93–1/1

Illuminate Work Area Safely

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

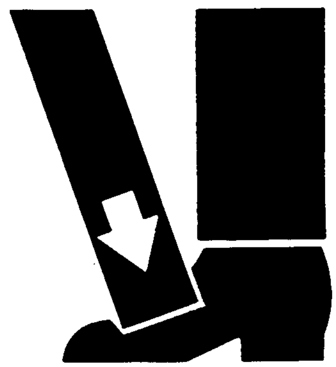
TS223 –UN–23AUG88

DX,LIGHT –19–04JUN90–1/1

Use Proper Lifting Equipment

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

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



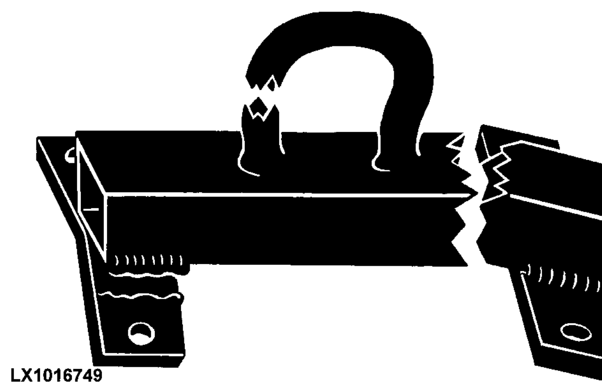
TS226 –UN–23AUG88

DX,LIFT –19–04JUN90–1/1

Construct Dealer-Made Tools Safely

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

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



LX1016749 –UN–01JUL97

Construct Dealer-Made Tools Safely

DPSG,OUO1004,899 –19–19MAY99–1/1

Practice Safe Maintenance

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

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

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

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

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

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

TS218 —UN—23AUG88

DX,SERV —19—17FEB99—1/1

Use Proper Tools

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

Use power tools only to loosen threaded parts and fasteners.

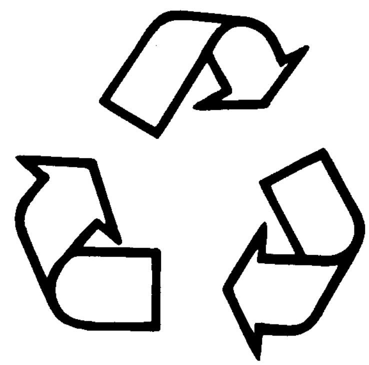
For loosening and tightening hardware, use the correct size tools. DO NOT use U.S. measurement tools on metric fasteners. Avoid bodily injury caused by slipping wrenches.

Use only service parts meeting John Deere specifications.

TS779 —UN—08NOV89

DX,REPAIR —19—17FEB99—1/1

Dispose of Waste Properly



TS1133 –UN–26NOV90

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

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

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

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

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

DX,DRAIN –19–03MAR93–1/1

Engine Model Designation

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

3009DF001 Engine

3	Number of cylinders
009	Liter designation
D	Aspiration code
F	User code
0	Configuration code
01	Application code

Aspiration Code

D	Naturally aspirated
T	Turbocharged

User Code

F	OEM

Configuration Code

0, 1 or 2	Indicates different internal engine components

Application Code (Suffixes)

01	Base Engine
05	Industrial Power Unit
06	Generator Drive Power Unit
270	Industrial Power Unit (Tier 2 Certified)
271	Generator Drive Power Unit (Tier 2 Certified)

RG,RG34710,8028 –19–15APR97–1/1

Engine Serial Number Plate Information

IMPORTANT: The engine serial number plate (A) can be easily destroyed. Before "hot tank" cleaning the block, remove the plate.

Each engine has a serial number plate (A) located on the rocker arm cover.The information on this plate is used for warranty information or ordering repair parts.

Engine Serial Number (B)

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:

CH4020D000000

CH	Factory producing engine
4020D	Engine model designation
000000	Sequential serial number

Factory Code

CH	Yanmar (Mfg.)

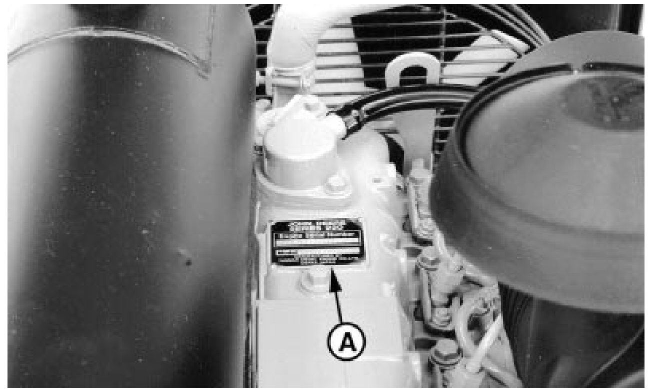
Engine Model Designation

4020D	Definition explained previously. (See ENGINE MODEL DESIGNATION earlier in this group.)

Sequential Number

000000	6-digit sequential serial number

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



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Location of Serial Number Plate—4020 Engine

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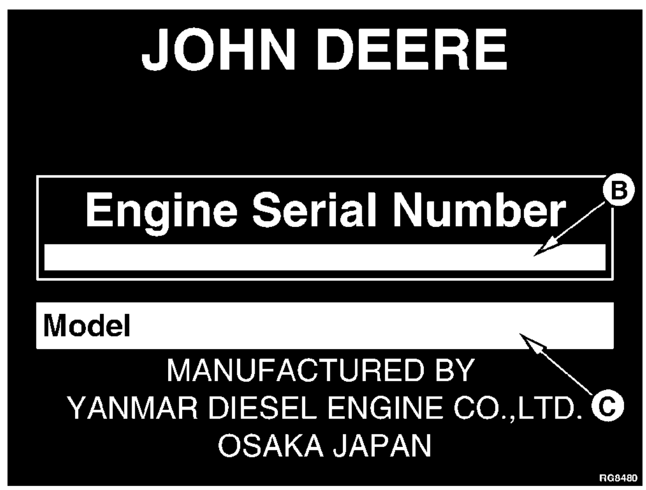
Location of Serial Number Plate—4TNE98 Engine



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Engine Serial Number Plate

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Information Relative to Emissions Regulations

Depending on the final destination, engines can meet the emissions regulations according to the US Environmental Protection Agency (EPA), California Air Resources Board (CARB) and for Europe, the Directive 97/68/EC relating the measures against the emissions of particles and gaseous pollutant from internal combustion engines. Such engines are called “CERTIFIED” and receive an emission label on the engine.

The regulations prohibit tampering with the emission-related components listed below which would render that component inoperative or to make any adjustment on the engine beyond published specifications. It is also illegal to install a part or component where the principle effect of that component is to bypass, defeat, or render inoperative any engine component or device which would affect the engine’s conformance to the emission regulations. **To summarize, it is illegal to do anything except return the engine to its original published specifications.**

List of emission-related components:

- Fuel injection system
- Intake manifold
- Turbocharger
- Charge air cooling system
- Piston

OUO1080,0000035 –19–29AUG01–1/1

Engine Application Charts

Naturally Aspirated				
Engine Model	**Size**	**Emission Certification**	**Application**	**Yanmar Model No.**
3009DF001	0.9L	Non-Certified	Base Engine	3TNA72-J
3009DF005	0.9L	Non-Certified	Industrial Power Unit	3TNA72-JS
3009DF007	0.9L	Non-Certified	Generator Drive Power Unit	3TNA72-JG2
3011DF001	1.1L	Non-Certified	Base Engine	3TNC78-J
3011DF005	1.1L	Non-Certified	Industrial Power Unit	3TNC78-JS
3011DF006	1.1L	Non-Certified	Generator Drive Power Unit	3TNC78-JG1
3012DF101	1.2L	Tier 1 Certified	Base Engine	3TNE78A-EJ
3012DF105	1.2L	Tier 1 Certified	Industrial Power Unit	3TNE78A-EJS
3012DF006	1.2L	Tier 1 Certified	Generator Drive Power Unit	3TNE78A-JG1
3013DF270	1.3L	Tier 2 Certified	Industrial Power Unit	3TNV82A
3013DF271	1.3L	Tier 2 Certified	Generator Drive Power Unit	3TNV82A
3015DF001	1.5L	Non-Certified	Base Engine	3TNE84-J
3015DF101	1.5L	Tier 1 Certified	Base Engine	3TNE84-EJ
3015DF002	1.5L	Non-Certified	Base Engine	3TNE84-JB
3015DF102	1.5L	Tier 1 Certified	Base Engine	3TNE84-EJB
3015DF005	1.5L	Non-Certified	Industrial Power Unit	3TNE84-JS
3015DF105	1.5L	Tier 1 Certified	Industrial Power Unit	3TNE84-EJS
3015DF006	1.5L	Non-Certified	Generator Drive Power Unit	3TNE84-JG1
3016DF270	1.6L	Tier 2 Certified	Industrial Power Unit	3TNV88
3016DF271	1.6L	Tier 2 Certified	Generator Drive Power Unit	3TNV88
4020DF001	2.0L	Non-Certified	Base Engine	4TNE84-J
4020DF101	2.0L	Tier 1 Certified	Base Engine	4TNE84-EJ
4020DF005	2.0L	Non-Certified	Industrial Power Unit	4TNE84-JS
4020DF105	2.0L	Tier 1 Certified	Industrial Power Unit	4TNE84-EJS
4020DF006	2.0L	Non-Certified	Generator Drive Power Unit	4TNE84-JG1
4020DF106	2.0L	Tier 1 Certified	Generator Drive Power Unit	4TNE84-EJG1
Turbocharged				
Engine Model	**Size**	**Emission Certification**	**Application**	**Yanmar Model No.**
4020TF001	2.0L	Non-Certified	Base Engine	4TNE84T-J
4020TF101	2.0L	Tier 1 Certified	Base Engine	4TNE84T-EJ
4020TF005	2.0L	Non-Certified	Industrial Power Unit	4TNE84T-JS
4020TF105	2.0L	Tier 1 Certified	Industrial Power Unit	4TNE84T-EJS
4020TF006	2.0L	Non-Certified	Generator Drive Power Unit	4TNE84T-JG1
4020TF106	2.0L	Tier 1 Certified	Generator Drive Power Unit	4TNE84T-EJG1

Continued on next page OUO1030,0000753 –19–01APR04–1/2

JOHN DEERE CONSTRUCTION AND FORESTRY EQUIPMENT	
Machine Model	**Engine Model (Emission Certification)**
304H Loader	CH4033D001 (Non—Certified)
244H Loader	CH4033D001 (Non—Certified)

OUO1030,0000753 –19–01APR04–2/2

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.

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

Cetane number of 40 minimum. Cetane number greater than 50 is preferred, especially for temperatures below -20°C (-4°F) or elevations above 1500 m (5000 ft).

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

Fuel lubricity should pass a minimum of 3100 gram load level as measured by the BOCLE scuffing test.

Sulfur content:

- Sulfur content should not exceed 0.5%. Sulfur content less than 0.05% is preferred.
- If diesel fuel with sulfur content greater than 0.5% sulfur content is used, reduce the service interval for engine oil and filter by 50%.
- DO NOT use diesel fuel with sulfur content greater than 1.0%.

Bio-diesel fuels may be used ONLY if the fuel properties meet DIN 51606 or equivalent specification.

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

DX,FUEL1 –19–19DEC03–1/1

Lubricity of Diesel Fuel

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

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

Sulfur content of diesel fuel for highway use is less than 0.05% (500 ppm) in the United States and Canada, and less than 0.035% (350 ppm) in the European Union.

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

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

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

If fuel of low or unknown lubricity is used, add John Deere PREMIUM DIESEL FUEL CONDITIONER (or equivalent) at the specified concentration.

DX,FUEL5 –19–19DEC03–1/1

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

Dieselscan Fuel Analysis

DIESELSCAN™ is a John Deere fuel sampling program to help you monitor the quality of your fuel source. It verifies fuel type, cleanliness, water content, suitability for cold weather operation, and if fuel is within ASTM specifications. Check with your John Deere dealer for availability of DIESELSCAN kits.

DIESELSCAN is a trademark of Deere & Company

DX,FUEL6 –19–06DEC00–1/1

Bio-Diesel Fuel

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

Bio-diesel fuels may be used ONLY if the bio-diesel fuel properties meet the latest edition of ASTM D6751, EN 14214, or equivalent specification.

The maximum allowable bio-diesel concentration is a 5% blend (also known as B5) in petroleum diesel fuel. It has been found that bio-diesel fuels may improve lubricity in concentrations up to this 5% blend.

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

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

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

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

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

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

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

Consult your fuel supplier for additives to improve storage and performance of bio-diesel fuels.

DX,FUEL7 –19–08MAR04–1/1

Minimizing the Effect of Cold Weather on Diesel Engines

John Deere diesel engines are designed to operate effectively in cold weather.

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

Use Grade No. 1-D Fuel

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

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

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

Coolant Heaters

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

Seasonal Viscosity Oil and Proper Coolant Concentration

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

Diesel Fuel Flow Additive

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.

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

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.

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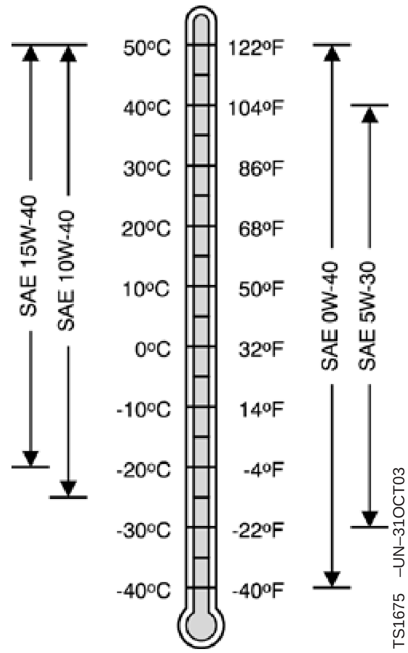
Diesel Engine Oil



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 E5
- ACEA Oil Sequence E4

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

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

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

Multi-viscosity diesel engine oils are preferred. Diesel fuel quality and fuel sulfur content must comply with all existing emissions regulations for the area in which the engine operates.

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

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

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

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TORQ-GARD SUPREME is a trademark of Deere & Company

DX,ENOIL7 –19–07NOV03–1/1

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.

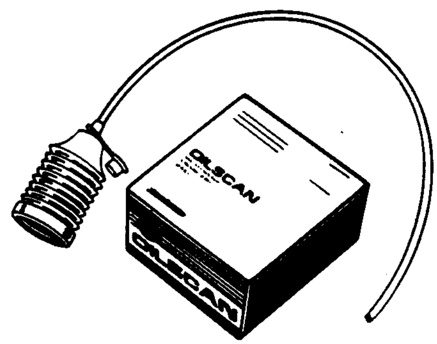
DX,LUBMIX –19–18MAR96–1/1

OILSCAN™ and COOLSCAN™

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

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

Check with your John Deere dealer for the availability of OILSCAN™ and COOLSCAN™ kits.



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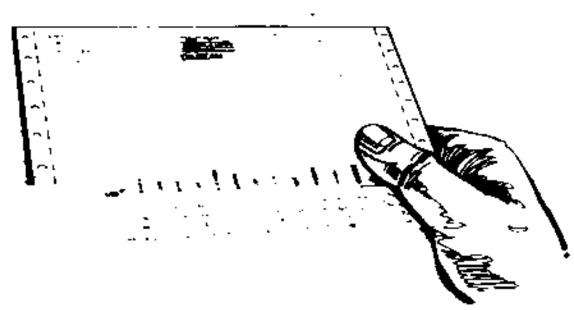

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COOLSCAN is a trademark of Deere & Company.

DX,OILSCAN –19–02DEC02–1/1

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

Grease

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

John Deere SD POLYUREA GREASE is preferred.

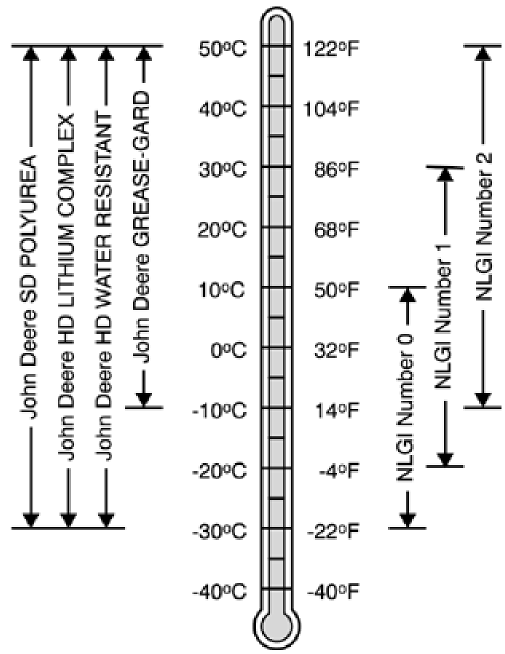
The following greases are also recommended

- John Deere HD LITHIUM COMPLEX GREASE
- John Deere HD WATER RESISTANT GREASE
- John Deere GREASE-GARD™

Other greases may be used if they meet the following:

NLGI Performance Classification GC-LB

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



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GREASE-GARD is a trademark of Deere & Company

DX,GREA1 –19–07NOV03–1/1

Diesel Engine Coolant

The engine cooling system is filled to provide year-round protection against corrosion and cylinder liner pitting, and winter freeze protection to -37°C (-34°F). If protection at lower temperatures is required, consult your John Deere dealer for recommendations.

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

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

If a coolant known to meet the requirements of coolant specifications shown in this manual is not available, use either:

- 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

The coolant concentrate or prediluted coolant shall be of a quality that provides cavitation protection to cast iron and aluminum parts in the 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.

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Continued on next page

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 –19–19DEC03–2/2

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 Deere COOL-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

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.

DX,COOL9 –19–19DEC03–1/1

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.

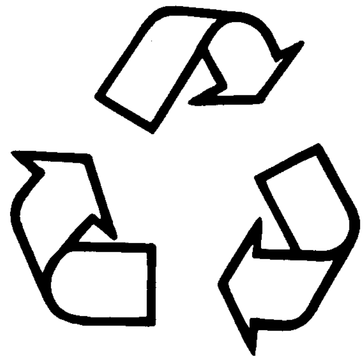
IMPORTANT: Water may be used as coolant *in emergency situations only.*

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

Disposing of Coolant



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

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

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

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

RG,RG34710,7543 –19–30JUN97–1/1

Section 02
Repair and Adjustments

Contents

Continued on next page

Continued on next page

Group 100—Starting and Charging Systems

Continued on next page

Preliminary Engine Testing

Before tuning up an engine, determine if a tune-up will restore operating efficiency. If in doubt, the following preliminary tests will help determine if the engine can be tuned up. Choose from the following procedures only those necessary to restore the unit.

1. After engine has stopped for several hours, loosen crankcase drain plug and watch for any water to seep out. A few drops could be due to condensation, but any more than this would indicate problems which require engine repairs rather than just a tune-up.

2. With engine stopped, inspect engine coolant for oil film. With engine running, inspect coolant for air bubbles. Either condition would indicate problems which require engine repairs rather than just a tune-up.

3. Perform a dynamometer test and record power output. (See DYNAMOMETER TEST SPECIFICATIONS in Group 210.) Repeat dynamometer test after tune-up. Compare power output before and after tune-up.

4. Perform compression test. (See TEST CYLINDER COMPRESSION PRESSURE—3009 or TEST CYLINDER COMPRESSION PRESSURE—3011, 3012, 3013, 3015, 3016, 4020 AND 4TNE98 in Group 150.)

OUO1032,000140B –19–29MAR04–1/1

General Tune-Up Recommendations

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

Operation	Detailed Reference
Change engine oil and filter.	Operator’s Manual
Replace fuel filter.	Group 090
Check crankcase ventilation system.	Group 150
Check air intake system. Replace air cleaner elements.	Group 150
Check exhaust system.	Group 150
Check and service engine cooling system.	Group 150
Check and adjust fan and alternator belts. Replace if necessary.	Group 150
Check electrical system.	Group 150
Inspect turbocharger and check turbocharger boost pressure (4020T).	Group 150
Check engine/injection pump timing.	Group 150
Check and adjust speed advance.	Group 150
Clean injection nozzles, and adjust opening pressure.	Group 150
Check engine oil pressure.	Group 150
Check and adjust engine valve clearance.	Group 020
Check engine speeds. Correct as necessary.	Group 150
Check engine performance on dynamometer.	Group 150

RG,RG34710,8324 –19–15APR97–1/1

Engine Lifting Procedure

CAUTION: 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.

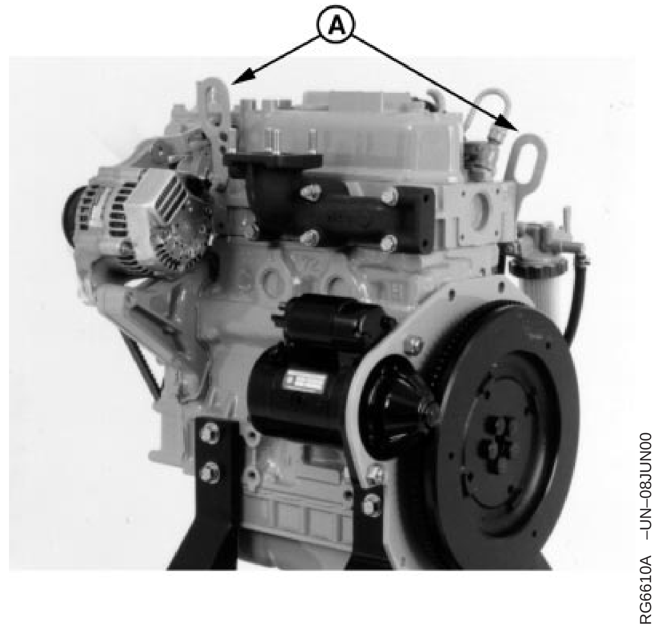
1. Attach JDG23 Engine Lifting Sling to engine lifting straps (A) and overhead hoist or floor crane.

NOTE: If engine does not have lifting straps, they can be procured through service parts. Use of an engine lifting sling is the ONLY APPROVED method for lifting engine.

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 PTOs, transmissions, generators or air compressors, are attached to other locations on the engine, the lifting 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.

NOTE: Use of an engine lifting sling is the ONLY APPROVED method for lifting engine.

2. Carefully lift engine and slowly lower to desired location.



Lifting Engine

A—Lifting Straps

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Clean Engine

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

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

IMPORTANT: Never steam clean or pour cold water on an injection pump while it is still warm. To do so may cause seizure of pump parts. Avoid fuel pumps, injectors, bearings, belts and hoses, etc.

3. Steam-clean engine thoroughly.

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Disconnect Turbocharger Oil Inlet Line—4020T

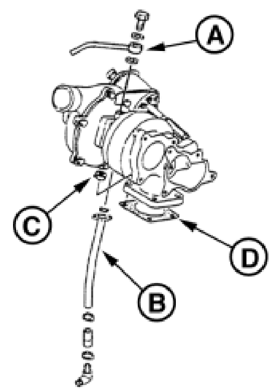
1. Drain all engine oil and coolant, if not previously done.

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

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

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

2. Disconnect turbocharger oil inlet line (A).



Remove Oil Inlet Line

A—Oil Inlet Line
B—Oil Drain Line
C—Nut and Washer (4 used)
D—Gasket

RG,RG34710,8050 –19–15APR97–1/1

Engine Disassembly Sequence

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

Continued on next page

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ENGINE DISASSEMBLY SEQUENCE	
Procedure	**Reference**
Mount engine on a safety approved repair stand	
Drain coolant and oil. Perform John Deere OILSCAN® and COOLSCAN® analysis.	See MIXING OF LUBRICANTS in Section 01, Group 002.
Remove fan belts, fan, belt tensioner, and alternator.	See: •REPLACE AND ADJUST FAN/ALTERNATOR BELT in Group 070. •REMOVE AND INSTALL COOLING FAN in Group 070. •REMOVE AND INSTALL ALTERNATOR in Group 100.
Remove turbocharger (if equipped). Remove exhaust manifold.	See: •REMOVE TURBOCHARGER—4020T in Group 080 •REMOVE AND INSTALL EXHAUST MANIFOLD in Group 080.
Remove rocker arm cover and vent tube. If option code label is located on rocker arm cover, be careful not to damage label.	See in Group 020: •REMOVE AND INSTALL ROCKER ARM COVER—3009, 4020 AND 4TNE98 or •REMOVE AND INSTALL ROCKER ARM COVER—3011, 3012 AND 3015 or •REMOVE AND INSTALL ROCKER ARM COVER—3013 AND 3016
Remove thermostat and thermostat housing.	See in Group 070: •REMOVE AND INSTALL THERMOSTAT—3009, 3011, 3012, 3013, 3015, 3016, AND 4020 or •REMOVE AND INSTALL THERMOSTAT AND HOUSING—4TNE98
Remove oil cooler piping (if equipped) and coolant pump.	See: •REMOVE, INSPECT AND INSTALL OIL COOLER—3016 AND 4020T in Group 060. •REMOVE, INSPECT AND INSTALL COOLANT PUMP—3009, 3011, 3012, 3013, 3015, 3016 AND 4020 or •REMOVE, INSPECT AND INSTALL COOLANT PUMP—4TNE98 in Group 070.
Remove dipstick, oil filter, oil cooler, and adapter housing (if equipped).	See REMOVE, INSPECT AND INSTALL OIL COOLER—3016 AND 4020T in Group 060.
Remove fuel filter and water separator. Remove fuel supply pump, and fuel line.	See in Group 090: •FUEL FILTER—3009 or •FUEL FILTER—3011, 3012, 3015 AND 4020 or •FUEL FILTER AND WATER SEPARATOR—3013 AND 3016 or •FUEL FILTER—4TNE98 See in Group 090: •REPLACE FUEL SUPPLY PUMP—3009 or •REPLACE FUEL SUPPLY PUMP—3011, 3012, 3015 AND 4020 or •REPLACE FUEL SUPPLY PUMP—3013 AND 3016 or •REPLACE FUEL SUPPLY PUMP—4TNE98

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COOLSCAN is a trademark of Deere & Company

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ENGINE DISASSEMBLY SEQUENCE	
Procedure	**Reference**
Remove injection lines and injection nozzles. Remove intake manifold. Remove injection pump.	See REMOVE AND INSTALL INTAKE MANIFOLD in Group 080. See in Group 090: REMOVE AND INSTALL FUEL INJECTION NOZZLES (PINTLE TYPE)—3009 or •REMOVE AND INSTALL FUEL INJECTION NOZZLES (HOLE TYPE)—3011, 3012, 3013, 3015, 3016, 4020 AND 4TNE98 •REMOVE FUEL INJECTION PUMP—3009 or •REMOVE FUEL INJECTION PUMP—3011, 3012, 3015 AND 4020 or •REMOVE FUEL INJECTION PUMP—3013 AND 3016 or •REMOVE FUEL INJECTION PUMP—4TNE98
Remove starting motor.	See REMOVE AND INSTALL STARTER in Group 100.
Remove rocker arm assembly and push rods. Keep push rods in order. Check for bent push rods and condition of wear pad contact surfaces on rockers.	See DISASSEMBLE AND ASSEMBLE ROCKER ARM SHAFT ASSEMBLY in Group 020. See INSPECT ROCKER ARM SHAFT ASSEMBLY COMPONENTS in Group 020.
Remove cylinder head. Check piston-to-cylinder head clearance.	See REMOVE CYLINDER HEAD in Group 020. See MEASURE PISTON-TO-CYLINDER HEAD CLEARANCE in Group 030.
Remove cam followers (3009). Keep followers in order.	
Remove flywheel and flywheel housing.	See REMOVE AND INSTALL FLYWHEEL HOUSING in Group 040.
Remove oil pan.	See REMOVE AND INSTALL OIL PAN AND STRAINER in Group 060.
Remove crankcase extension housing.	See REMOVE AND INSTALL CRANKCASE EXTENSION HOUSING in Group 040.
Remove crankshaft pulley and timing gear cover.	See REMOVE AND INSTALL TIMING GEAR COVER in Group 050.
Remove oil pump (3009, 3011, 3012, 3015, 4020 and 4TNE98). *NOTE: Oil pump on 3013 and 3016 is attached to the timing gear cover.*	See REMOVE AND INSTALL ENGINE OIL PUMP—3009, 3011, 3012, 3015, 4020 AND 4TNE98 in Group 060.
Check timing gear backlash. Remove timing gears and camshaft. Remove cam followers (3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98). Perform wear checks.	See in Group 050: •CHECK TIMING GEAR BACKLASH •CHECK CAMSHAFT END PLAY •REMOVE CAMSHAFT •INSPECT CAM FOLLOWERS
Remove timing cover mounting plate or housing.	See in Group 050: •REMOVE AND INSTALL TIMING GEAR HOUSING—3009 or •REMOVE AND INSTALL TIMING GEAR COVER MOUNTING PLATE—3011, 3012, 3013, 3015, 3016 AND 4020 or •REMOVE AND INSTALL TIMING GEAR HOUSING—4TNE98
Stamp cylinder number on connecting rod. Perform wear checks with PLASTIGAGE®. Remove pistons and rods.	See in Group 030: •MEASURE PISTON-TO-CYLINDER HEAD CLEARANCE •MEASURE CONNECTING ROD SIDE PLAY •MEASURE CONNECTING ROD BEARING CLEARANCE •REMOVE PISTONS AND CONNECTING RODS

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ENGINE DISASSEMBLY SEQUENCE	
Procedure	**Reference**
Perform crankshaft wear checks with PLASTIGAGE®. Remove crankshaft and main bearings.	See in Group 040: •MEASURE CRANKSHAFT END PLAY •MEASURE CRANKSHAFT MAIN BEARING CLEARANCE •REMOVE CRANKSHAFT AND MAIN BEARINGS
Remove piston cooling nozzles—4020T.	See REPLACE PISTON COOLING NOZZLES—4020T in Group 060.
Measure and remove camshaft bushing.	See MEASURE CAMSHAFT BUSHING AND BORES IN BLOCK in Group 030.
If cylinder block is to be put in a “hot tank”, remove cylinder block plugs.	See COMPLETE DISASSEMBLY OF CYLINDER BLOCK (IF REQUIRED) in Group 030.
Clean cylinder bores with nylon brush. Measure cylinder bores.	See INSPECT AND MEASURE CYLINDER BORE in Group 030.
Measure cylinder block. Disassemble and measure oil pump.	See Groups 030, 040, 050, and 060.

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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 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 when oil residue is present. Oil residues must be cleaned from surfaces before applying gasket material.

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

TY9370, 6 ml tube/T43512, 50 ml tube

- Oil galley plugs.
- Oil pump cover cap screws.
- Fan-to-fan spacer cap screws.
- Turbocharger thrust bearing mounting screws and seal plate screws.

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

TY9374, 6 ml tube/TY9375, 50 ml tube

- Pipe plugs in thermostat housing and water pump.
- Temperature sending unit.
- Oil pan drain fitting elbow.
- Heater hose fittings.

LOCTITE® 515 Flexible Form-In-Place Gasket (General Purpose) (Purple):

PM38655, 50 ml bottle

- Camshaft plug in cylinder block.
- Oil pan mating surfaces and crankcase extension housing.
- Timing gear cover mounting plate, timing gear housing and timing gear cover mating surfaces.
- Flywheel housing.
- Rear crankshaft seal case.
- Turbocharger seal plate and turbocharger compressor housing-to-center housing.

LOCTITE® 21348 Clean and Cure Primer

TY6305 6 oz can

- Clean mating surfaces of turbocharger center housing, compressor, and seal plate assembly.

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

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Engine Assembly Sequence

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

Continued on next page RG,RG34710,8052 –19–15APR97–1/4

ENGINE ASSEMBLY SEQUENCE	
Procedure	**Reference**
Install all plugs in cylinder block (if removed).	
Install piston cooling orifices—4020T.	See REPLACE PISTON COOLING NOZZLES—4020T in Group 060.
Install new camshaft bushing.	See MEASURE CAMSHAFT BUSHING AND BORES IN BLOCK in Group 030.
Install main bearings and crankshaft. Check bearing clearance using PLASTIGAGE®. Check crankshaft end play.	See in Group 040: •MEASURE CRANKSHAFT MAIN BEARING CLEARANCE •INSTALL CRANKSHAFT AND MAIN BEARINGS •MEASURE CRANKSHAFT END PLAY
Install flywheel housing, rear oil seal, and flywheel.	See in Group 040: •REMOVE AND INSTALL FLYWHEEL HOUSING •REPLACE CRANKSHAFT REAR OIL SEAL
Measure piston ring gap and piston-to-cylinder clearance. Install pistons and rods. Measure rod bearing clearance using PLASTIGAGE®.	See in Group 030: •MEASURE PISTON RING END GAP •INSTALL PISTON AND CONNECTING ROD ASSEMBLY •MEASURE CONNECTING ROD BEARING CLEARANCE
Install crankcase extension housing.	See REMOVE AND INSTALL CRANKCASE EXTENSION HOUSING in Group 040.
Install timing cover mounting plate or housing.	See in Group 050: •REMOVE AND INSTALL TIMING GEAR HOUSING—3009 or •REMOVE AND INSTALL TIMING GEAR COVER MOUNTING PLATE—3011, 3012, 3013, 3015, 3016 AND 4020 or •REMOVE AND INSTALL TIMING GEAR HOUSING—4TNE98
Install oil pump (3009, 3011, 3012, 3015, 4020 and 4TNE98). *NOTE: Oil pump on 3013 and 3016 is attached to the timing gear cover.*	See REMOVE AND INSTALL ENGINE OIL PUMP—3009, 3011, 3012, 3015, 4020 AND 4TNE98 in Group 060.
Install fuel injection pump. Install intake manifold.	See in Group 090: •INSTALL FUEL INJECTION PUMP—3009 or •INSTALL FUEL INJECTION PUMP—3011, 3012, 3015 AND 4020 or •INSTALL FUEL INJECTION PUMP—3013 AND 3016 or •INSTALL FUEL INJECTION PUMP—4TNE98 See REMOVE AND INSTALL INTAKE MANIFOLD in Group 080.
Install cam followers in same order as removed (3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98). Install camshaft and timing gears. Time all gears with No. 1 cylinder at TDC compression stroke.	See INSTALL CAMSHAFT in Group 050.
Install oil pump in timing cover (3013 and 3016). Install timing gear cover with new front seal. Install crankshaft pulley.	See DISASSEMBLE, INSPECT AND ASSEMBLE OIL PUMP—3013 AND 3016 in Group 060. See in Group 050: •REMOVE AND INSTALL TIMING GEAR HOUSING—3009 •REMOVE AND INSTALL TIMING GEAR COVER MOUNTING PLATE—3011, 3012, 3013, 3015, 3016 AND 4020 •REMOVE AND INSTALL TIMING GEAR HOUSING—4TNE98
Install oil pan and strainer.	See REMOVE AND INSTALL OIL PAN AND STRAINER in Group 060.

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ENGINE ASSEMBLY SEQUENCE	
Procedure	**Reference**
Install oil pressure regulating valve and oil filter housing (3009, 3011 and 3012).	See REMOVE AND INSTALL OIL PRESSURE REGULATING VALVE in Group 060.
Install cam followers in same order as removed (3009). Install cylinder head gasket, cylinder head, push rods, and rocker arm assembly.	See INSTALL CYLINDER HEAD in Group 020.
Install starting motor.	See REMOVE AND INSTALL STARTER in Group 100.
Install injection nozzles (with new seals) and injection lines.	See in Group 090: •REMOVE AND INSTALL FUEL INJECTION NOZZLES (PINTLE TYPE)—3009 or •REMOVE AND INSTALL FUEL INJECTION NOZZLES (HOLE TYPE)—3011, 3012, 3013, 3015, 3016, 4020 AND 4TNE98
Install fuel filter and water separator. Install fuel supply pump, and fuel lines.	See in Group 090: •FUEL FILTER—3009 or •FUEL FILTER—3011, 3012, 3015 AND 4020 or •FUEL FILTER AND WATER SEPARATOR—3013 AND 3016 or •FUEL FILTER—4TNE98 •REPLACE FUEL SUPPLY PUMP—3009 or •REPLACE FUEL SUPPLY PUMP—3011, 3012, 3015 AND 4020 or •REPLACE FUEL SUPPLY PUMP—3013 AND 3016 or •REPLACE FUEL SUPPLY PUMP—4TNE98
Install oil cooler (if equipped), new oil filter, and dipstick.	See REMOVE, INSPECT AND INSTALL OIL COOLER—3016 AND 4020T in Group 060.
Install thermostat housing and thermostat.	See in Group 070: •REMOVE AND INSTALL THERMOSTAT—3009, 3011, 3012, 3013, 3015, 3016, AND 4020 or •REMOVE AND INSTALL THERMOSTAT AND HOUSING—4TNE98
Install exhaust manifold and turbocharger (if equipped). Prelube the turbocharger.	See in Group 080: •REMOVE AND INSTALL EXHAUST MANIFOLD •INSTALL TURBOCHARGER—4020T
Install coolant pump, oil cooler tubes, and hoses.	See in Group 070: •REMOVE, INSPECT AND INSTALL COOLANT PUMP—3009, 3011, 3012, 3013, 3015, 3016 AND 4020 or •REMOVE, INSPECT AND INSTALL COOLANT PUMP—4TNE98
Install alternator, belt tensioner, fan, and fan belts.	See: •REMOVE AND INSTALL ALTERNATOR in Group 100. •REPLACE AND ADJUST FAN/ALTERNATOR BELT in Group 070. •REMOVE AND INSTALL COOLING FAN in Group 070.
Adjust valves and install rocker arm cover and vent tube.	See in Group 020: •CHECK AND ADJUST VALVE CLEARANCE •REMOVE AND INSTALL ROCKER ARM COVER—3009, 4020 AND 4TNE98 or •REMOVE AND INSTALL ROCKER ARM COVER—3011, 3012 AND 3015 or •REMOVE AND INSTALL ROCKER ARM COVER—3013 AND 3016

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RG,RG34710,8052 –19–15APR97–3/4

ENGINE ASSEMBLY SEQUENCE	
Procedure	**Reference**
Fill engine with clean oil and proper coolant.	See DIESEL ENGINE OIL and DIESEL ENGINE COOLANT in Section 01, Group 002.
Perform engine break-in and standard performance checks.	See ENGINE BREAK-IN GUIDELINES and PRELIMINARY ENGINE TESTING in this group.

RG,RG34710,8052 –19–15APR97–4/4

Engine Break-In Guidelines

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

- Main bearings, rod bearings, crankshaft, or any combination of these parts have been replaced.
- Pistons or rings have been replaced.
- Rear crankshaft oil seal has been replaced. (Primary objective is to see if oil seal still leaks.)
- Cylinder head has been removed.
- Injection pump has been removed or critical adjustments have been made while it is on the engine. (Primary objective is to check power.)

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Perform Engine Break-In

IMPORTANT: John Deere PLUS-50® oil is preferred. Engine oils meeting ACEA E5, ACEA E4 are also recommended. John Deere TORQ-GARD SUPREME® oil or oils meeting API CI-4, API CH-4, or ACEA E3 performance levels may also be used during break-in period of an engine that has had a major overhaul.

1. Fill engine crankcase to proper level with the recommended oil viscosity for expected operating temperatures. (See DIESEL ENGINE OIL in Section 01, Group 002.)

2. Check and readjust valve clearance as necessary. Cylinder head retorque is not required.

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

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.

3. Allow the engine to warm to operating temperature and operate the engine at normal loads with minimal idling during the break-in period.

IMPORTANT: Do not add makeup oil until the oil level is BELOW the add mark.

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

4. Check the oil daily or every 10 hours of operation during break-in. If oil must be added during this period, use seasonal viscosity grade oil.

After 50 hours operation, drain oil and change oil filter. Fill crankcase with John Deere PLUS-50® or other oil as recommended. (See DIESEL ENGINE OIL in Section 01, Group 002.)

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.

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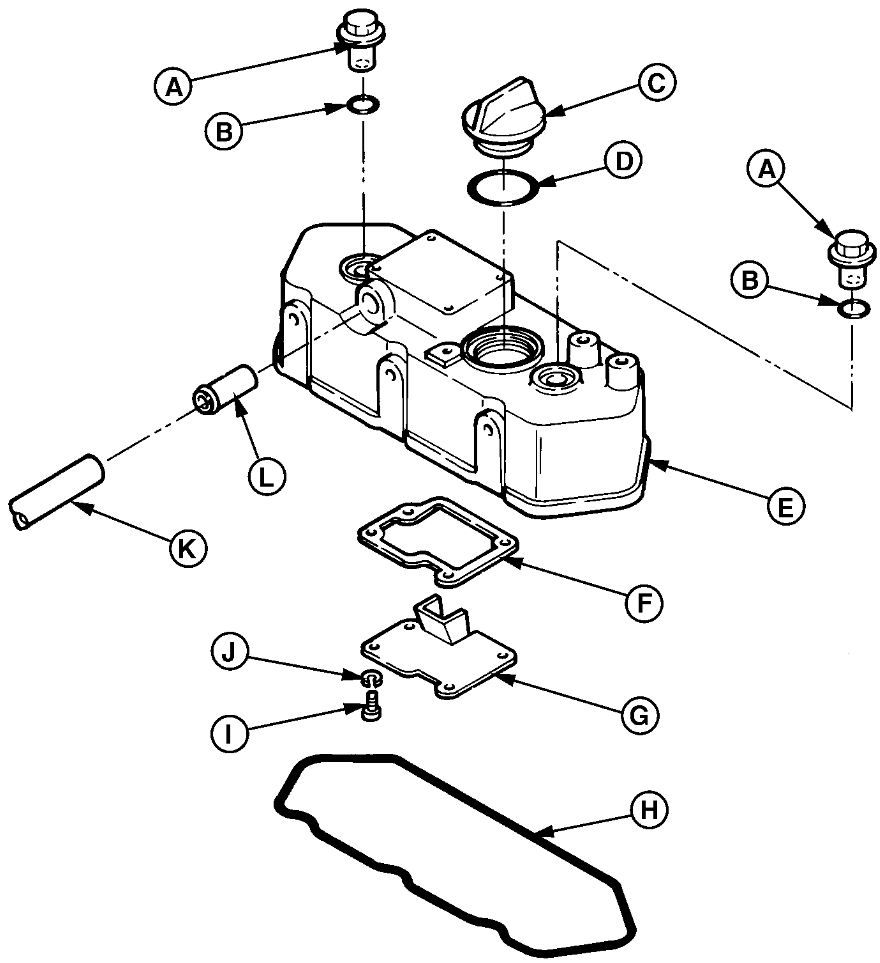
Remove and Install Rocker Arm Cover—3009, 4020 and 4TNE98



Model 3009 (Models 4020 and 4TNE98 are Similar.)

A—Special Nut
B—O-Ring
C—Oil Filler Cap
D—O-Ring
E—Rocker Arm Cover
F—Gasket
G—Baffle Breather Deflector
H—O-Ring Seal
I—Screw
J—Lock Washer
K—Crankcase Breather Tube
L—Breather Fitting

1. Remove special nuts (A).
2. If present, remove crankcase breather tube (K).
3. Remove rocker arm cover (E) from cylinder head.
4. If present, clean the crankcase breather filter.
5. If present, wash filter in a safe solvent and blow dry with air pressure. If filter is deteriorated, replace it.
6. Remove baffle breather deflector (G). Inspect gasket (F) and replace if deteriorated
7. If present, install clean and dry breather filter.
8. Install baffle breather deflector and gasket.
9. Inspect O-ring seal (H) before installing rocker arm cover. Replace if damaged.
10. Clean cylinder head surface and install rocker arm cover on cylinder head. Install special nuts and tighten to specification.

Specification

Rocker Arm Cover Special
Nuts—Torque.. 18 N•m (156 lb-in.)

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Remove and Install Rocker Arm Cover—3011, 3012 and 3015

1. Remove special nuts (A).

2. If present, remove crankcase breather tube (K).

NOTE: For Models 3011 and 3015, bend the hydraulic reservoir fill tube slightly upward to remove and install rocker arm cover. DO NOT bend so far that the reservoir is damaged.

3. Remove rocker arm cover (L) from cylinder head.

4. Remove crankcase breather cover (E), screen (I) and filter (B).

5. If present, wash filter in a safe solvent and blow dry with air pressure. If filter is deteriorated, replace it.

6. If present, install clean and dry breather filter.

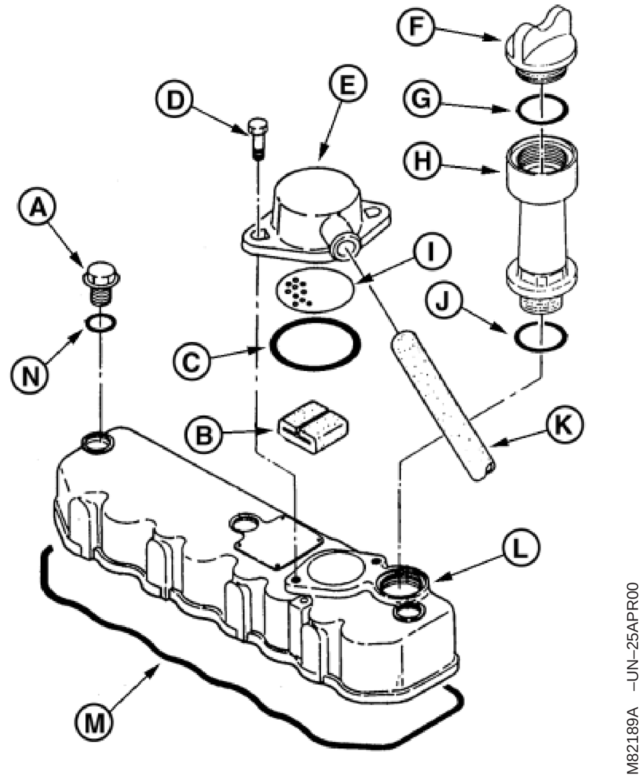
7. Install filter, screen and a new O-ring before replacing breather cover. Tighten to specification.

8. Inspect O-ring seal (M) before reinstalling rocker arm cover. Replace if damaged.

9. Clean cylinder head surface and install rocker arm cover on cylinder head. Install special nuts and tighten to specification.

Specification

Breather Cover Screws—3011, 3012 and 3015—Torque	22 N•m (192 lb-in.)
Rocker Arm Cover Special Nuts—Torque	18 N•m (156 lb-in.)



Models 3011, 3012 and 3015

A—Special Nut
B—Filter
C—O-Ring
D—Cap Screw
E—Crankcase Breather Cover
F—Oil Filler Cap
G—O-Ring
H—Extension
I—Screen
J—O-Ring
K—Crankcase Breather Tube
L—Rocker Arm Cover
M—O-Ring Seal
N—O-Ring

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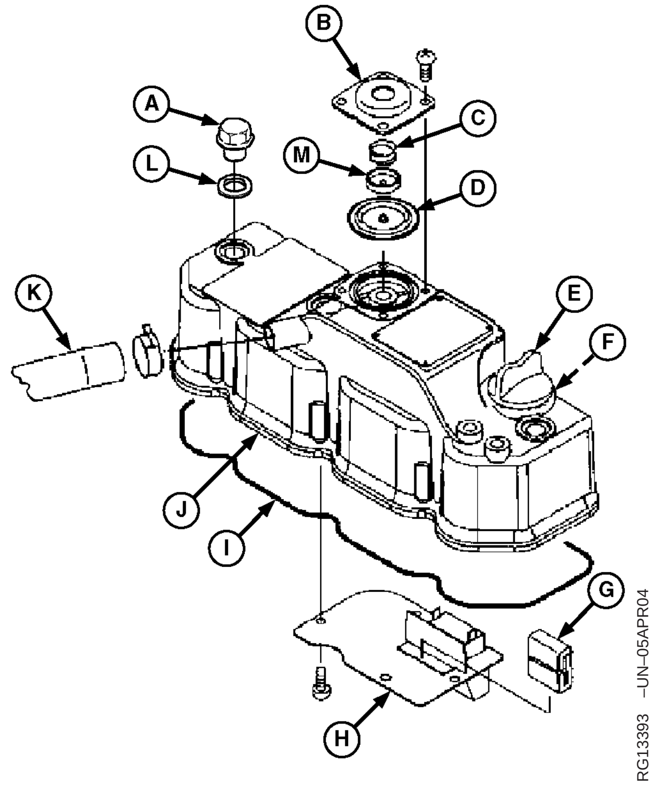
Remove and Install Rocker Arm Cover—3013 and 3016

1. Remove the special nuts (A).
2. If present, pull crankcase breather tube (K) from side of engine.
3. Remove rocker arm cover (J) from cylinder head.
4. Remove diaphragm cover (B).
5. Remove and inspect spring (C) and diaphragm (D). Replace if damaged or deteriorated.
6. Remove baffle plate (H) and baffle (G).
7. Wash baffle in solvent and blow dry with compressed air. Replace baffle if it is damaged or deteriorated.
8. Install baffle and baffle plate.
9. Install diaphragm, spring plate (M), spring and diaphragm cover.
10. Inspect gasket (I) and O-rings (L) before reinstalling rocker arm cover. Replace if damaged.
11. Clean cylinder head surface and install rocker arm cover on cylinder head. Install special nuts and tighten to specification.

Specification

Rocker Arm Cover Special
Nuts—Torque .... 18 N•m (156 lb-in.)



Models 3013 and 3016

A—Special Nut
B—Diaphragm Cover
C—Spring
D—Diaphragm
E—Oil Filler Cap
F—Gasket
G—Baffle
H—Baffle Plate
I—Gasket
J—Rocker Arm Cover
K—Crankcase Breather Tube
L—O-Ring
M—Spring Plate

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Check and Adjust Valve Clearance

NOTE: Location of the index mark will be different as a result of the various engine applications.

The index mark (A) appears on the following:

NOTE: "Top Dead Center" (TDC) is the piston at its highest point.

- 3009, 3015DF001,005 006 OEM and 4020: Flywheel housing.
- 3011DF001, 3012 and 3015DF001 OEM: Flywheel plate.
- 3013 and 3016: Bottom edge of engine back plate.
- 4TNE98: Set the piston in the cylinder to be adjusted to TDC.

1. Remove rocker arm cover.

2. Remove plug from timing hole in flywheel housing/cover, if equipped.

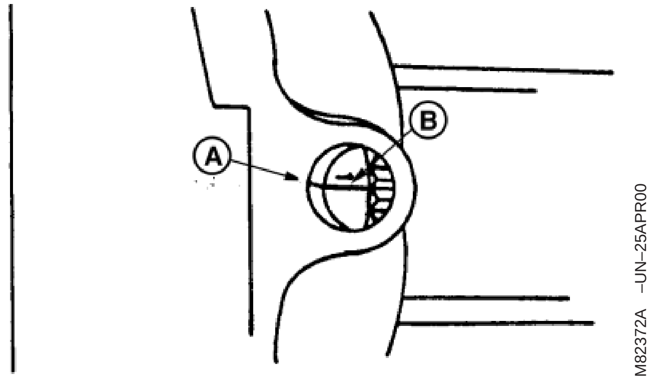
3. Turn crankshaft pulley clockwise until No.1 cylinder TDC mark on flywheel aligns with index mark on flywheel housing/cover (B) or plate.

NOTE: No. 1 cylinder is the closest to the flywheel.

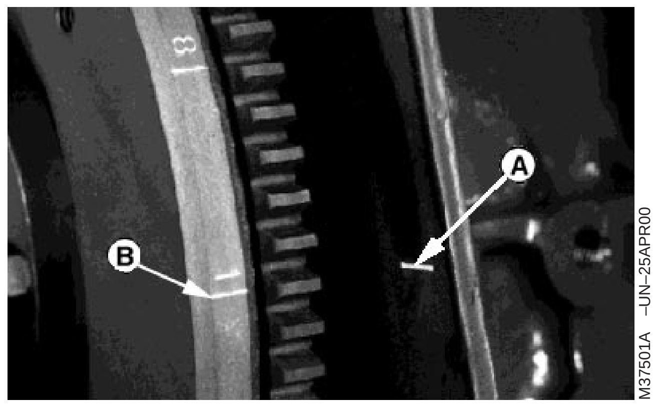
4. Try to move both No. 1 cylinder rocker arms or push rods.

   If rocker arm push rods are not loose, rotate flywheel one revolution (360°). If both rocker arm push rods are loose, the piston is at TDC on compression stroke.

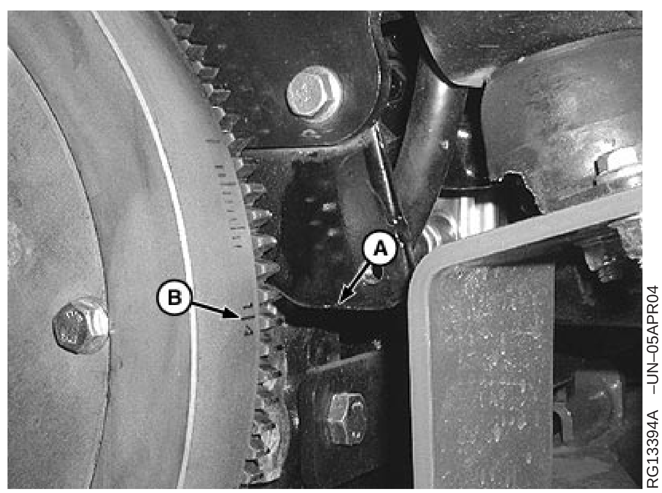
A—Timing Index Mark
B—Flywheel Timing Mark



3009, 3011, 3012, 3015 and 4020



3011DF001 and 3015DF001 OEM



3013 and 3016

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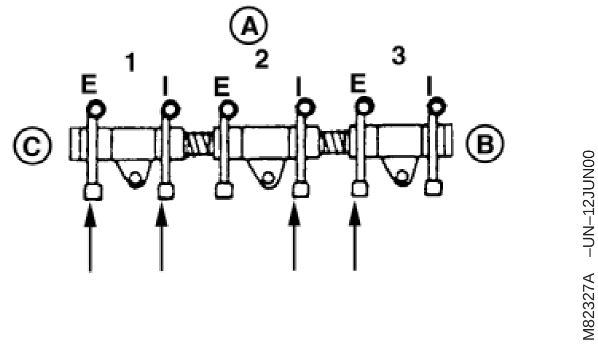
5. Measure and adjust valve clearance on the valves (arrows) with No. 1 piston at TDC.

   To adjust valves, loosen nut and turn adjusting screw until clearance is in specification. Hold screw while tightening nut. Measure with a feeler gauge (D).

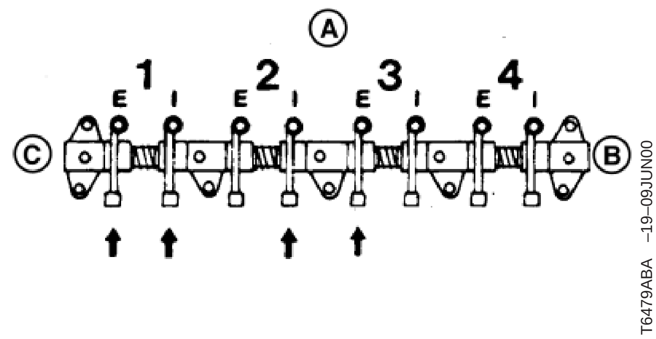
Specification

Valve—Intake and Exhaust—
Clearance .... 0.20 mm (0.008 in.)

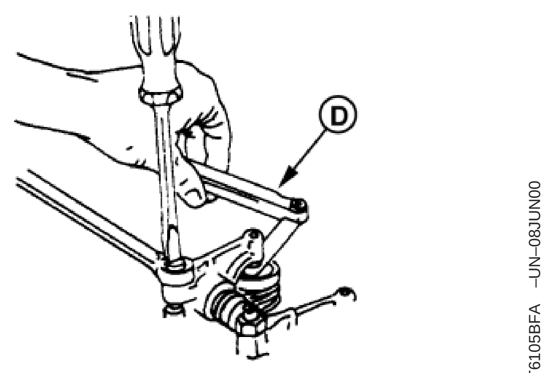
A—Cylinders
B—Fan End
C—Flywheel End
D—Feeler Gauge



3009, 3011, 3012, 3013, 3015 and 3016 No. 1 Piston at TDC



4020 and 4TNE98 No. 1 Piston at TDC



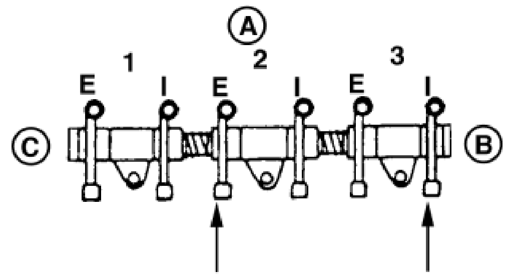
Adjusting Valve Clearance

Continued on next page RG,RG34710,8073 –19–15APR97–2/3

6. Turn crankshaft pulley one revolution (360°). This puts the piston in No. 2 cylinder for 3009, 3011, 3012, 3013, 3015 and 3016 engines or No. 4 cylinder for 4020 and 4TNE98 engines at TDC compression stroke.

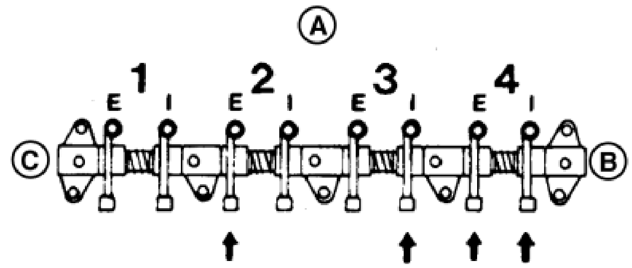
7. Measure and adjust valve clearance on the remaining valves (arrows) with No. 2 or 4 piston at TDC.

A—Cylinders
B—Fan End
C—Flywheel End



M82327B –UN–25APR00

3009, 3011, 3012, 3013, 3015 and 3016 No. 2 Piston at TDC



T6479ABB –19–09JUN00

4020 and 4TNE98 No. 4 Piston at TDC

RG,RG34710,8073 –19–15APR97–3/3

Measure Valve Lift

1. Remove rocker arm cover.

2. Adjust valve clearance. (See CHECK AND ADJUST VALVE CLEARANCE in this group.)

Continued on next page OUO1032,000140C –19–29MAR04–1/2

3. Fasten dial indicator (A) to engine and position indicator tip on valve spring retainer (B). Valve must be fully closed and rocker arm must move freely.

4. Zero the dial indicator.

5. Manually turn crankshaft pulley clockwise (from fan end).

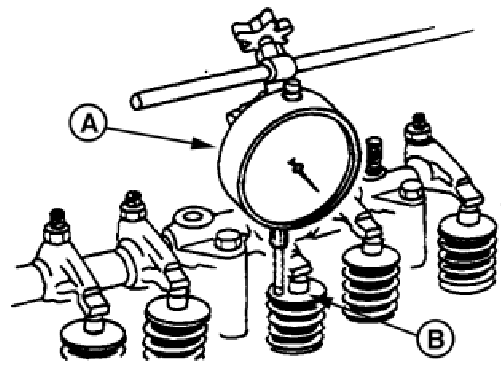
6. Observe dial indicator as valve is moved to the full open position.

Specification

Intake and Exhaust Valve—
3009—Lift .... 7.5 mm (0.300 in.) minimum
Intake and Exhaust Valve—3011,
3012, 3015, 4020 and 4TNE98—
Lift.. 8.8 mm (0.350 in.) minimum
Intake and Exhaust Valve—3013
and 3016—Lift .... 5.1 mm (0.201 in.) minimum

7. Repeat for each valve.

   If valve lift is less than specification, remove and inspect camshaft, followers and push rods. (See REMOVE CAMSHAFT in Group 050.)



T6333DTA –UN–12JUN00

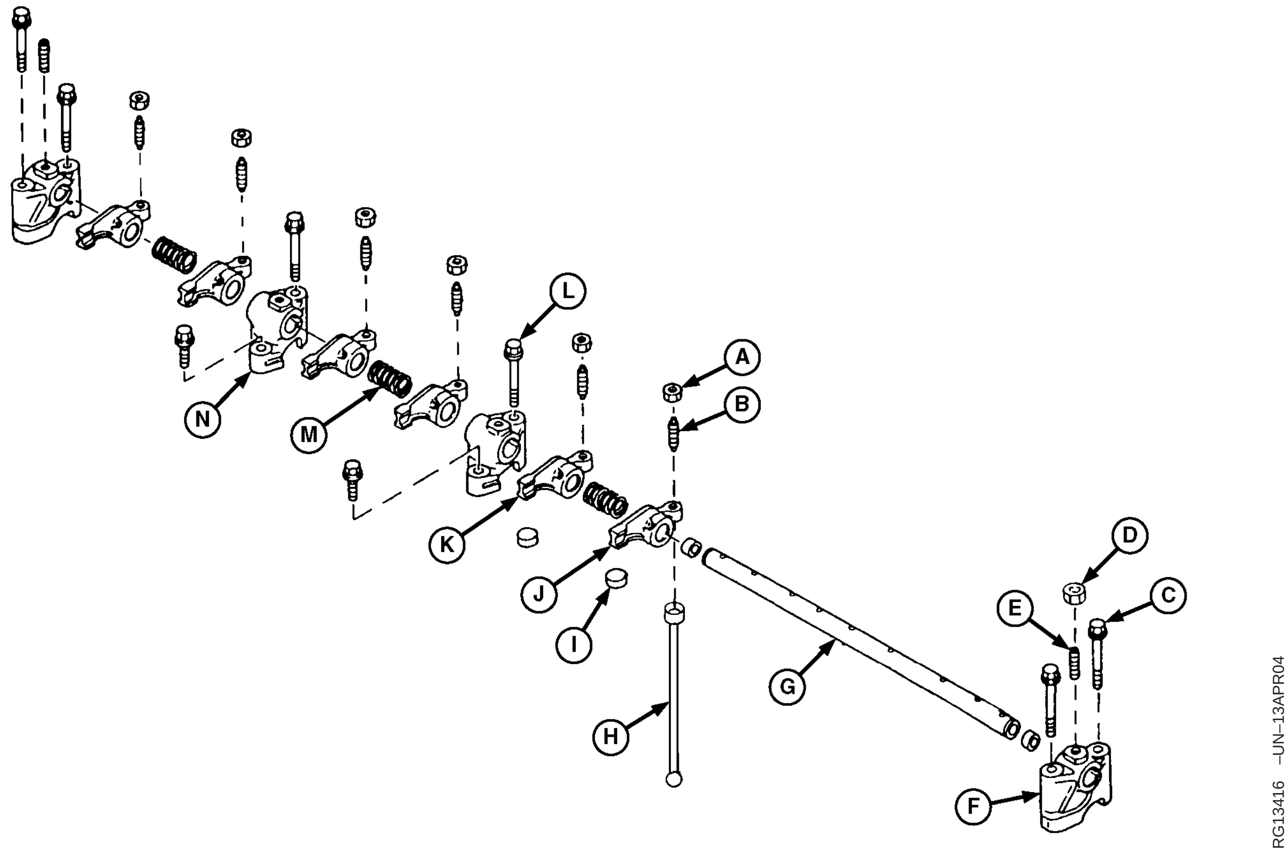
Measuring Valve Lift

A—Dial Indicator
B—Valve Spring Retainer

02
020
7

OUO1032,000140C –19–29MAR04–2/2

Disassemble and Assemble Rocker Arm Shaft Assembly



A—Nut
B—Adjusting Screw
C—Mounting Cap Screw
D—Nut
E—Stud
F—Rocker Arm End Support
G—Rocker Arm Shaft
H—Push Rod
I—Valve Cap
J—Intake Valve Rocker Arm
K—Exhaust Valve Rocker Arm
L—Mounting Cap Screw
M—Rocker Arm Shaft Spring
N—Rocker Arm Center Support

NOTE: Model 3015 is shown. Other models are similar.

1. Remove rocker arm cover.
2. Remove rocker arm end support mounting cap screws (C).
3. Remove rocker arm center support mounting cap screws (L).
4. Lift rocker arm assembly from cylinder head and set on bench.

NOTE: When disassembling the rocker arm assembly, replace components in same location on rocker arm shaft they were removed from.

5. Slide rocker arm assembly components off rocker arm shaft while noting positions for reassembly.
6. Lift push rods (H) from cylinder head and note order of removal for reassembly in same positions in head.
7. Inspect rocker arm components and push rods. (See INSPECT ROCKER ARM SHAFT ASSEMBLY COMPONENTS in this group.)

NOTE: Lubricate all parts with clean oil during assembly.

8. Install push rods in cylinder head with ball-shaped end down in head. Push rods should be in same locations they were removed from.

Continued on next page RG,RG34710,8076 –19–29MAR04–1/2

9. Assemble rocker arm assembly components in the reverse order of removal.

10. Place rocker arm assembly on cylinder head. Align rocker arms with valves and push rods. Align rocker arm end supports and center supports with corresponding holes in head.

11. Install rocker arm support mounting cap screws and torque to specification.

Specification

Rocker Arm Support Cap Screws—Torque	26 N•m (230 lb-in.)

12. Adjust valve clearance. (See CHECK AND ADJUST VALVE CLEARANCE in this group.)

RG,RG34710,8076 –19–29MAR04–2/2

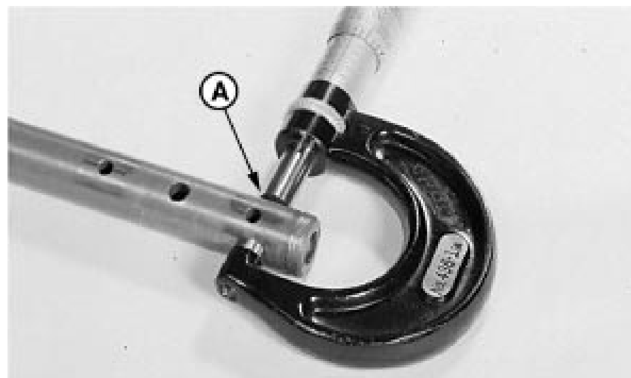
Inspect Rocker Arm Shaft Assembly Components

1. Measure outer diameter of rocker arm shaft (A) at each rocker arm location.

Specification

Rocker Arm Shaft—3009—OD	11.96—11.98 mm (0.4711—0.4718 in.)
Wear Limit	11.95 mm (0.4706 in.)
Rocker Arm Shaft—3011, 3012, 3013, 3015, 3016 and 4020—OD	15.97—15.98 mm (0.6286—0.6293 in.)
Wear Limit	15.95 mm (0.6280 in.)
Rocker Arm Shaft—4TNE98—OD	18.47—18.49 mm (0.7272—0.7280 in.)
Wear Limit	18.44 mm (0.7260 in.)

Replace rocker arm shaft if less than wear limit.



M35262A –UN–09JUN00

Measure Rocker Arm Shaft Outer Diameter

A—Rocker Arm Shaft

Continued on next page

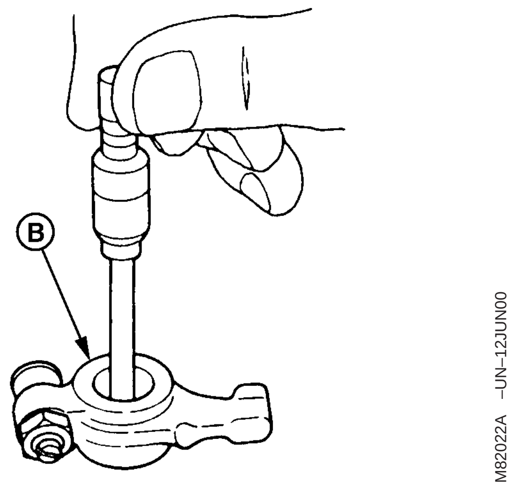
RG,RG34710,8077 –19–15APR97–1/3

2. Measure inner diameters of rocker arms (B) and supports.

Specification

Rocker Arm Shaft Support—
3009—ID.. 12.00—12.02 mm (0.4724—0.4732 in.)
Wear Limit .... 12.09 mm (0.4759 in.)
Rocker Arm Shaft-to-Rocker Arm and Shaft Support Clearance—
3009—Wear Limit.. 0.14 mm (0.006 in.)
Rocker Arm Shaft Support—
3011, 3012, 3013, 3015, 3016 and 4020—ID .... 16.00—16.02 mm (0.630—0.631 in.)
Wear Limit .... 16.09 mm (0.633 in.)
Rocker Arm Shaft-to-Rocker Arm and Shaft Support Clearance—
3011, 3012, 3013, 3015, 3016 and 4020—Wear Limit .... 0.14 mm (0.006 in.)
Rocker Arm Shaft Support—
4TNE98—ID .... 18.50—18.52 mm (0.7311—0.7291 in.)
Wear Limit .... 18.57 mm (0.7311 in.)
Rocker Arm Shaft-to-Rocker Arm and Shaft Support Clearance—
4TNE98—Wear Limit... 0.13 mm (0.005 in.)

Replace rocker arms or supports if ID is more than wear limit.



Measuring Rocker Arm ID

B—Rocker Arm

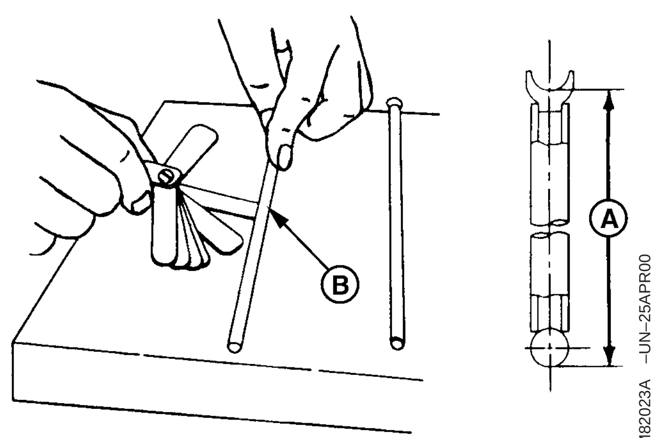
RG,RG34710,8077 –19–15APR97–2/3

3. Measure length (A) and bending (B) of push rod.

Specification

Push Rod—3009—Length .... 141—142 mm (5.550—5.590 in.)
Push Rod—3011, 3012, 3015, 3016 and 4020—Length... 178.2—178.75 mm (7.018—7.037 in.)
Push Rod—3013—Length .... 146.5—147 mm (5.767—5.787 in.)
Push Rod—4TNE98—Length .... 209.75—210.25 mm (8.258—8.278 in.)
Push Rod Bend—All Engines—
Wear Limit .... 0.03 mm (0.001 in.)

Replace push rod if not within specifications.



Measure Length and Bending of Push Rod

A—Push Rod Length
B—Push Rod Bend

RG,RG34710,8077 –19–15APR97–3/3

Remove Cylinder Head

NOTE: Model 4020 is illustrated. Other models are similar.

1. Remove rocker arm cover, rocker arm assembly, push rods and valve caps. (See DISASSEMBLE AND ASSEMBLE ROCKER ARM SHAFT ASSEMBLY in this group.)

2. Remove exhaust and intake manifolds. (See REMOVE AND INSTALL EXHAUST MANIFOLD and REMOVE AND INSTALL INTAKE MANIFOLD in Group 080.)

3. Remove coolant pump. (See REMOVE, INSPECT AND INSTALL COOLANT PUMP—3009, 3011, 3012, 3013, 3015, 3016 AND 4020 or REMOVE, INSPECT AND INSTALL COOLANT PUMP—4TNE98 in Group 070.)

4. Remove fuel injection nozzles. (See REMOVE AND INSTALL FUEL INJECTION NOZZLES (PINTLE TYPE)—3009 or REMOVE AND INSTALL FUEL INJECTION NOZZLES (HOLE TYPE)—3011, 3012, 3013, 3015, 3016, 4020 AND 4TNE98 in Group 90.)

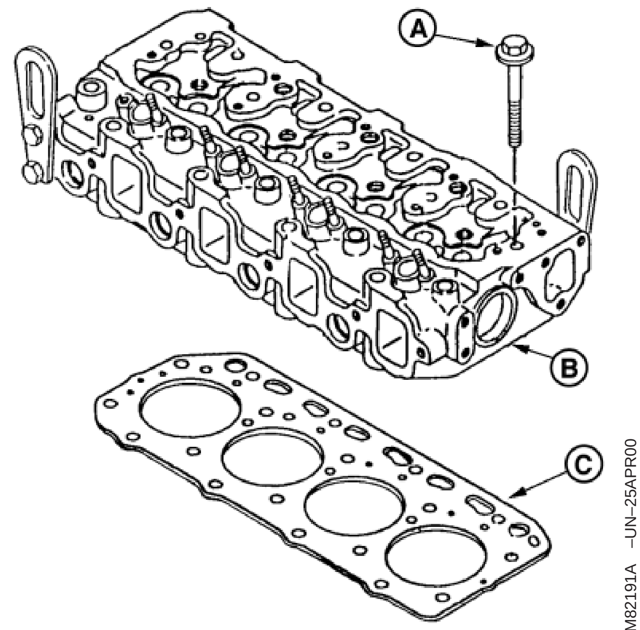
NOTE: See diagram for order of loosening mounting cap screws for Model 4TNE98.

Loosen cap screws in two steps. First, loosen all cap screws to 54 N•m (40 lb-ft). Then, loosen again to remove.

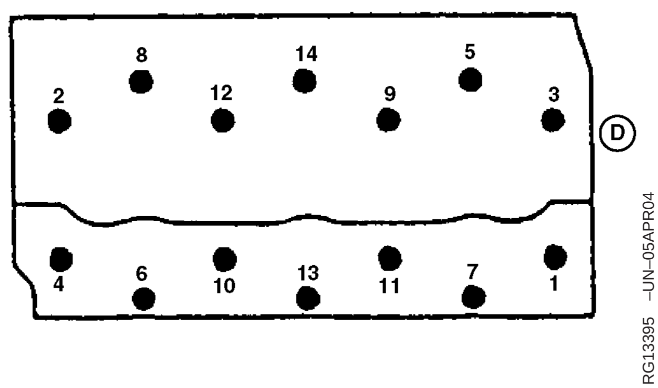
5. Remove all mounting cap screws.

6. Disassemble cylinder head and valves. (See DISASSEMBLE CYLINDER HEAD AND VALVES in this group.)

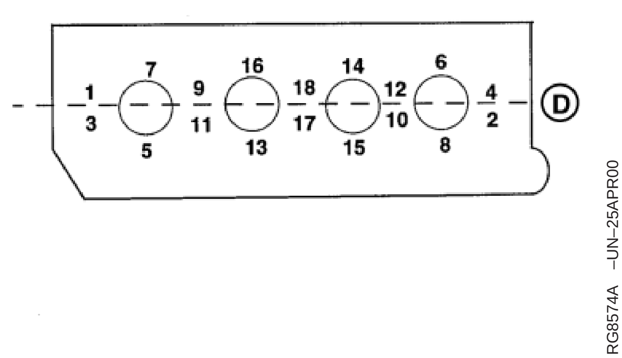
A—Mounting Cap Screw
B—Cylinder Head
C—Gasket
D—Fan End of Engine



Model 4020



Models 3009, 3011, 3012, 3013, 3015 and 3016 Cap Screw Loosening Sequence



Models 4020 and 4TNE98 Cap Screw Loosening Sequence

Continued on next page

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

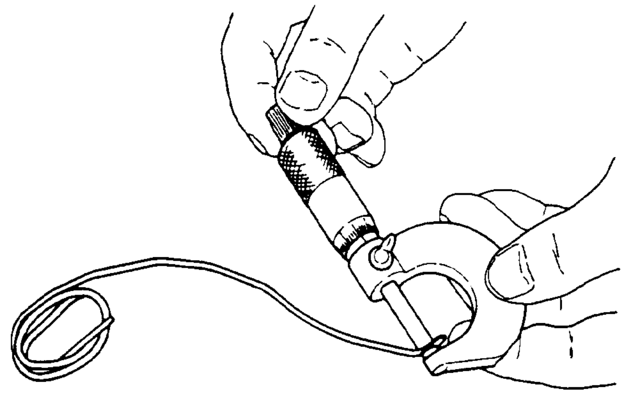
7. Lift cylinder head from the block.

8. Remove cylinder head gasket. Inspect for possible oil, coolant, or combustion chamber leaks.

9. 3009: Remove and inspect cam followers. (See INSPECT CAM FOLLOWERS in Group 050.)

RG,RG34710,8078 –19–15APR97–2/2

Measure Piston-to-Cylinder Head Clearance



M82042A –UN–25APR00

Measure Piston-to-Cylinder Head Clearance

1. Remove cylinder head. (See REMOVE CYLINDER HEAD in this group.)

2. Place three 10 mm (0.400 in.) long pieces of 1.50 mm (0.060 in.) diameter soft wire in three positions on the flat part of the piston head.

3. Install cylinder head and old gasket. Install cylinder head cap screws and tighten in proper sequence to specified torque. (See INSTALL CYLINDER HEAD in this group.)

4. Slowly turn crankshaft one complete revolution.

5. Remove cylinder head and gasket.

6. Measure thickness of flattened section of each piece of wire. Calculate average thickness of wires to obtain piston-to-cylinder head clearance specification.

Specification

Piston-to-Cylinder Head—3009—Clearance	0.61—0.79 mm (0.024—0.031 in.)
Piston-to-Cylinder Head—3011, 3012, 3015 and 4020—Clearance	0.64—0.82 mm (0.025—0.032 in.)
Piston-to-Cylinder Head—3013 and 3016—Clearance	0.66—0.78 mm (0.026—0.031 in.)
Piston-to-Cylinder Head—4TNE98—Clearance	0.737—0.869 mm (0.0290—0.0342 in.)

If clearance is less than specifications, replace cylinder head.

OUO1032,000140D –19–29MAR04–1/1

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

Worn or Broken Valve Seats:

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

Burned, Pitted, Worn, or Broken Valves:

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

Improper Valve Clearance:

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

Excessive Recession:

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

RG,05,DT7367 –19–13APR04–1/1

Disassemble Cylinder Head and Valves

NOTE: Size and shape of lifting brackets will vary due to numerous engine applications.

Model 4020 is illustrated. Other models are similar.

1. Remove valve caps from valves. Valve caps should be installed on the valves they were removed from.

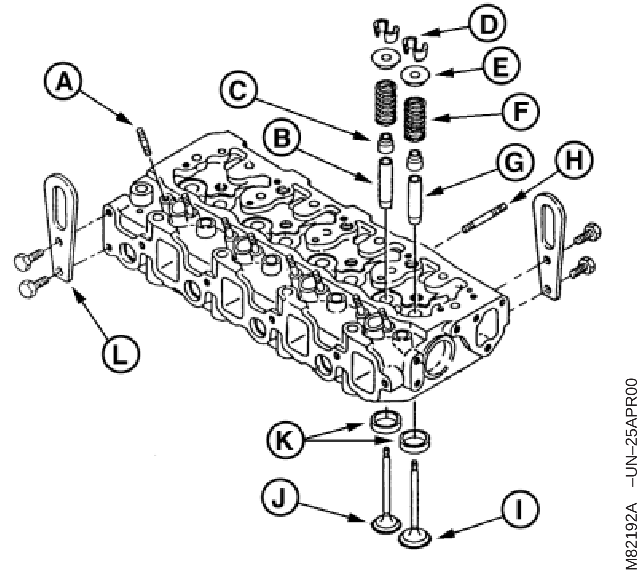
2. Compress valve spring using a valve spring compressor and remove the collet halves, retainer, valve spring and valve stem seal for each valve.

3. Intake and exhaust valve guides are press fit. Replace guides only if replacement is necessary.

4. Intake and exhaust valve seat inserts are not replacable. If inspection of cylinder head reveals worn or damaged valve seats that grinding will not repair, cylinder head must be replaced. (See INSPECT VALVE SEATS and GRIND VALVE SEATS in this group.)

5. Inspect all remaining parts for wear or damage. See the following procedures in this group:

- PRELIMINARY CYLINDER HEAD AND VALVE CHECKS
- CHECK CYLINDER HEAD FLATNESS
- INSPECT VALVE SEATS
- INSPECT AND MEASURE VALVES
- CHECK VALVE RECESS IN CYLINDER HEAD
- INSPECT AND MEASURE VALVE GUIDES
- INSPECT VALVE SPRINGS



A—Short Stud
B—Exhaust Valve Guide
C—Stem Seal
D—Collet Halves
E—Retainer
F—Valve Spring
G—Intake Valve Guide
H—Exhaust Manifold Mounting Stud
I—Intake Valve
J—Exhaust Valve
K—Valve Seat Inserts
L—Lifting Bracket

RG,RG34710,8079 –19–29MAR04–1/1

Check Cylinder Head Flatness

Before inspection, thoroughly clean all components of carbon or dirt.

Measure cylinder head distortion.

Place D05012ST Precision “Bevelled Edge” Straightedge (A) along each of the four sides and each diagonal. Measure clearance between straightedge and combustion surface with a feeler gauge (B).

Specification

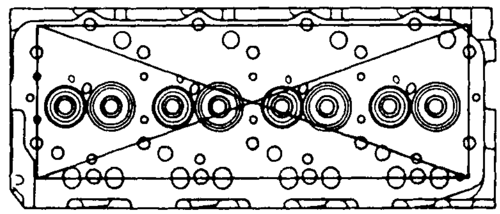
Cylinder Head—Out-of-Flat	0.05 mm (0.002 in.) maximum
Wear Limit	0.15 mm (0.006 in.)

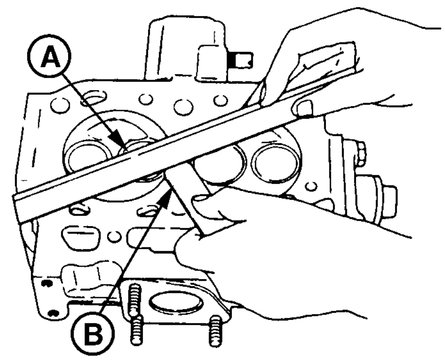
If distortion exceeds the wear limit, resurface or replace cylinder head. Remove only enough metal to make cylinder head flat, but do not remove more than 0.20 mm (0.008 in.).

Specification

Maximum Material Removal for Flattening Head—Quantity	0.20 mm (0.008 in.) maximum

M82027A –UN–12JUN00





M82028A –UN–12JUN00

Measuring Cylinder Head Flatness

A—Straightedge
B—Feeler Gauge

OUO1083,0000608 –19–13APR04–1/1

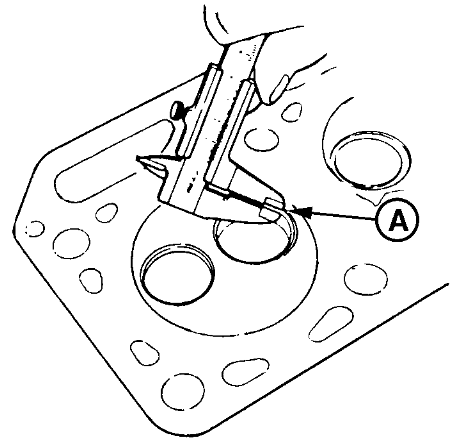
Inspect Valve Seats

Measure valve seat width (A).

If necessary, grind valve seats to meet specifications. (See GRIND VALVE SEATS in this group.)

Specification

Intake Valve Seat—3009, 3011 and 3012—Width	1.36—1.53 mm (0.054—0.060 in.)
Wear Limit	1.98 mm (0.078 in.)
Exhaust Valve Seat—3009, 3011 and 3012—Width	1.66—1.87 mm (0.065—0.074 in.)
Wear Limit	2.27 mm (0.089 in.)
Intake Valve Seat—3013—Width	1.44 mm (0.057 in.)
Wear Limit	1.94 mm (0.076 in.)
Exhaust Valve Seat—3013—Width	1.15 mm (0.045 in.)
Wear Limit	1.65 mm (0.065 in.)
Intake Valve Seat—3016—Width	1.77 mm (0.070 in.)
Wear Limit	2.27 mm (0.089 in.)
Exhaust Valve Seat—3016—Width	1.34 mm (0.053 in.)
Wear Limit	1.84 mm (0.072 in.)
Intake Valve Seat—3015 and 4020—Width	1.07—1.24 mm (0.042—0.049 in.)
Wear Limit	1.74 mm (0.069 in.)
Exhaust Valve Seat—3015 and 4020—Width	1.24—1.45 mm (0.049—0.057 in.)
Wear Limit	1.94 mm (0.076 in.)
Intake Valve Seat—4TNE98—Width	1.30 mm (0.051 in.)
Wear Limit	2.0 mm (0.079 in.)
Exhaust Valve Seat—4TNE98—Width	2.20 mm (0.086 in.)
Wear Limit	3.0 mm (0.118 in.)



M82029A –UN–12JUN00

Measure Valve Seat Width

A—Valve Seat Width

02
020
17

OUO1083,0000607 –19–13APR04–1/1

Grind Valve Seats

IMPORTANT: Valve seats should never be cut. Cutting a valve seat can damage its sealing surface, which may result in leaks or valve, seat failure. Valve seats should be ground and lapped.

NOTE: LIGHTLY grind valve seats for a few seconds only to avoid excessive valve seat width.

1. Grind valve seats (C) using a seat grinder (A). For intake valve seats use a 30° seat grinder. For exhaust valve seats use a 45° grinder. Follow tool manufacturers instructions.

2. Measure valve seat width (D) after grinding.

3. If seat is too wide after grinding, grind lower seat surface (B) using a 70° seat grinder until seat width is close to specifications.

Specification	
Lower Valve Seat Surface—Angle	70°

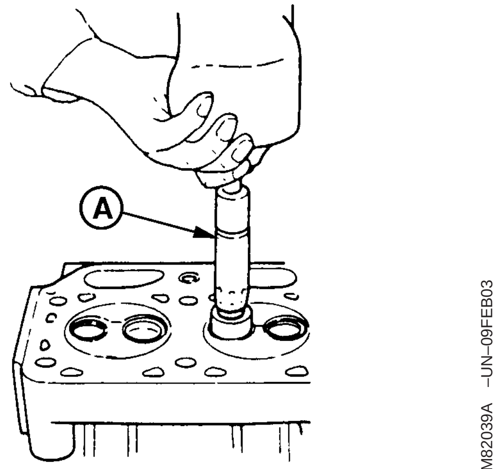
4. Grind upper seat surface (E) using a 15° seat grinder until seat width is narrowed to specifications.

Specification	
Upper Seat Surface—Angle	15°

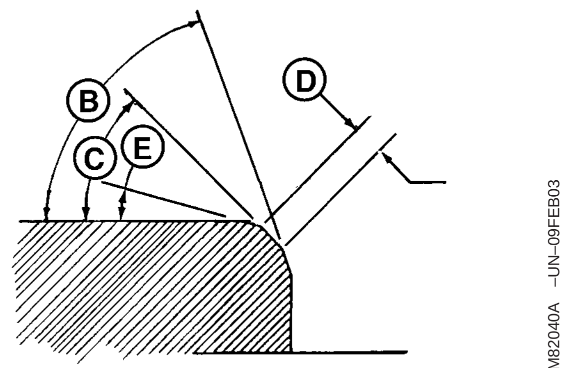
5. If valve seats are ground, measure valve recession and check contact pattern between the seat and valve with bluing dye.

6. Lap valves. (See LAP VALVES in this group.)

   If valve recession exceeds maximum specifications or seats cannot be reconditioned, replace valves, valve seats (if equipped) and/or cylinder head.



Grinding Valve Seat



Valve Seat Angles

A—Seat Grinder
B—Lower Seat Surface (70°)
C—Valve Seat Surface (45°)
D—Seat Width
E—Upper Seat Surface (15°)

RG,RG34710,8080 –19–30MAR04–1/1

Clean Valves

1. Hold each valve firmly against a soft 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.

RG,05,DT7363 –19–13APR04–1/1

Inspect and Measure Valves

1. Check valve for out-of-round, bent or warped condition using a valve inspection center. Replace valve if necessary.

2. If valve faces are worn, burned or pitted, grind valves to proper face angle. If valve face margin (A) is less than 0.51 mm (0.020 in.) after grinding, replace valve.

Valve Face—Specification

Intake and Exhaust Valve Face Margin—3009, 3011, 3012, 3015, 4020 and 4TNE98—Width	0.51 mm (0.020 in.) minimum

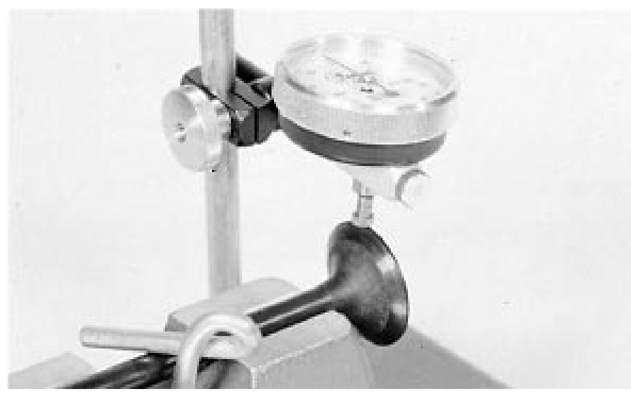
Valve Face—Specification

Intake Valve Face Margin—3013 and 3016—Width	1.24—1.44 mm (0.049—0.057 in.)
Wear Limit	0.50 mm (0.020 in.) minimum
Exhaust Valve Face Margin—3013 and 3016—Width	1.35—1.55 mm (0.053—0.061 in.)
Wear Limit	0.50 mm (0.020 in.) minimum

3. Measure valve face angles (B).

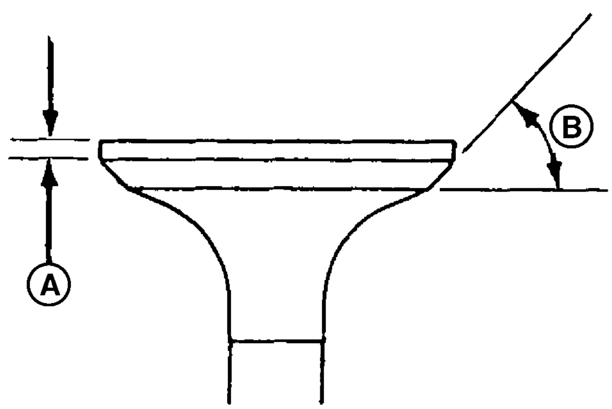
Specification

Intake Valve Face——Angle	30°
Exhaust Valve Face——Angle	45°



M35307 –UN–29AUG88

Measuring Valve for Bend



M82030A –UN–25APR00

Valve Face Margin and Angles

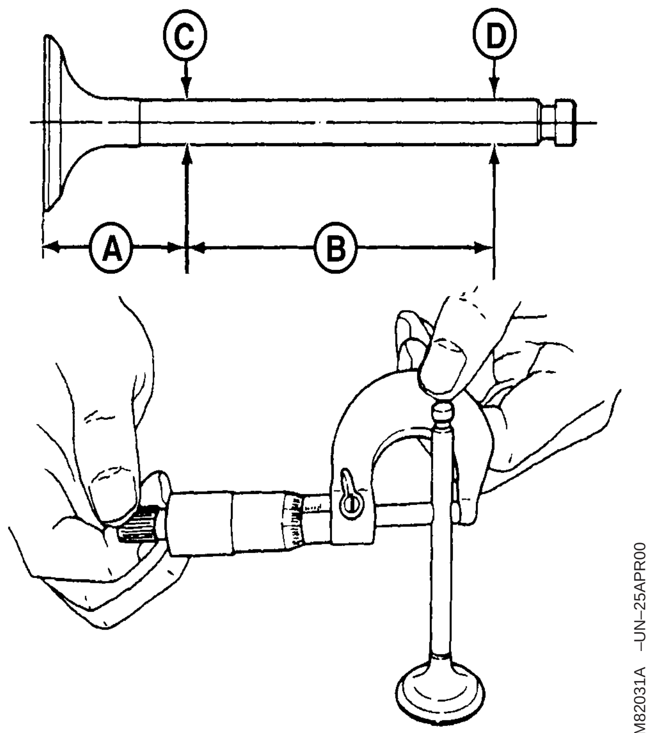
A—Valve Face Margin
B—Valve Face Angles

Continued on next page OUO1083,0000606 –19–13APR04–1/2

4. Measure valve stem diameter at the two locations (C) and (D) at the points shown as (A) and (B). Replace valve if measurement exceeds wear limit.

Specification

First Valve Stem Measure Point—3009 and 3013—Distance	25 mm (0.984 in.)
Second Valve Stem Measure Point—3009 and 3013—Distance	45 mm (1.772 in.)
Intake and Exhaust Valve Stem—3009 and 3013—OD	6.945—6.960 mm (0.2732—0.2740 in.)
Wear Limit	6.90 mm (0.2717 in.)
First Valve Stem Measure Point—3011 and 3012—Distance	30 mm (1.181 in.)
Second Valve Stem Measure Point—3011 and 3012—Distance	50 mm (1.969 in.)
Intake and Exhaust Valve Stem—3011 and 3012—OD	7.96—7.98 mm (0.3134—0.3142 in.)
Wear Limit	7.90 mm (0.3110 in.)
First Valve Stem Measure Point—3015, 3016 and 4020—Distance	43 mm (1.693 in.)
Second Valve Stem Measure Point—3015, 3016 and 4020—Distance	60 mm (2.360 in.)
Intake Valve Stem—3015, 3016 and 4020—OD	7.96—7.98 mm (0.3134—0.3142 in.)
Wear Limit	7.90 mm (0.3110 in.)
Exhaust Valve Stem—3015, 3016 and 4020—OD	7.96—7.97 mm (0.3134—0.3138 in.)
Wear Limit	7.90 mm (0.3110 in.)
First Valve Stem Measure Point—4TNE98—Distance	43 mm (1.693 in.)
Second Valve Stem Measure Point—4TNE98—Distance	60 mm (2.360 in.)
Intake Valve Stem—4TNE98—OD	7.965—7.98 mm (0.3134—0.3142 in.)
Wear Limit	7.915 mm (0.3116 in.)
Exhaust Valve Stem—4TNE98—OD	7.955—7.970 mm (0.3134—0.3138 in.)
Wear Limit	7.90 5 mm (0.3112 in.)



Measure Valve Stem Diameter

A—Distance from Valve Face to Measure Point C
B—Distance from Measure Point C to Measure Point D
C—First Valve Stem Diameter Measure Point
D—Second Valve Stem Diameter Measure Point

OUO1083,0000606 –19–13APR04–2/2

Lap Valves

NOTE: Use a rubber suction-cup type lapping tool for valves without a lapping tool groove slit.

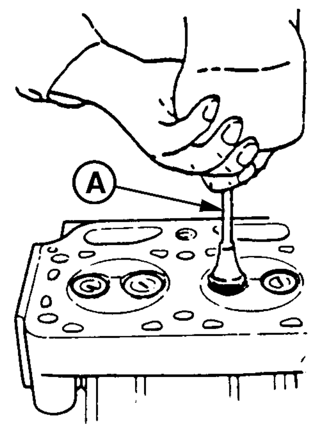
If seat does not make proper contact, lap the valve into the seat:

1. Apply small amount of fine lapping compound to face of valve.

RG,RG34710,8081 –19–15APR97–1/2

2. Turn valve lapping tool (A) to lap valve to seat.
3. Lift valve from seat every 8 to 10 strokes. Lap until a uniform ring appears around the surface of the valve face.
4. Wash all parts in solvent to remove lapping compound. Dry parts.
5. Check position of lap mark on valve face. Lap mark must be on or near center of valve face. If not, grind valve seat to relocate contact area. (See GRIND VALVE SEATS in this group.)

A—Valve Lapping Tool



M82041A –UN–12JUN00

Lap Valves

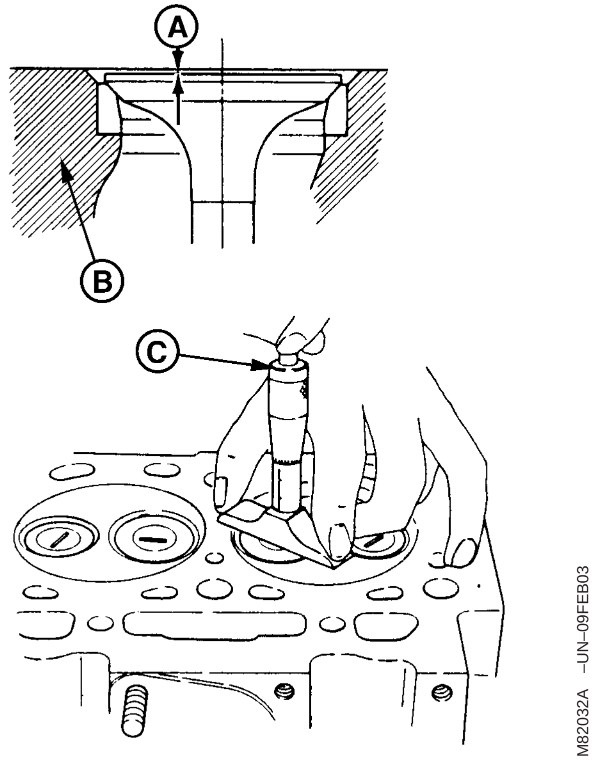
RG,RG34710,8081 –19–15APR97–2/2

Check Valve Recess in Cylinder Head

Measure valve recession (A) using a depth gauge (C). Replace valve or cylinder head (B) if measurement exceeds specification.

Specification

Intake Valve Recession—3009—Depth	0.40 mm (0.016 in.)
Exhaust Valve Recession—3009—Depth	0.85 mm (0.033 in.)
Intake and Exhaust Valve Recession—3011, 3012, 3015 and 4020—Depth	0.30—0.50 mm (0.012—0.020 in.)
Wear Limit	1.00 mm (0.039 in.)
Intake Valve Recession—3013—Depth	0.35—0.55 mm (0.014—0.021 in.)
Wear Limit	0.80 mm (0.031 in.)
Exhaust Valve Recession—3013—Depth	0.30—0.50 mm (0.012—0.020 in.)
Wear Limit	0.80 mm (0.031 in.)
Intake and Exhaust Valve Recession—3016—Depth	0.30—0.50 mm (0.012—0.020 in.)
Wear Limit	0.80 mm (0.031 in.)
Intake Valve Recession—4TNE98—Depth	0.50—0.70 mm (0.019—0.028 in.)
Wear Limit	1.00 mm (0.039 in.)
Exhaust Valve Recession—4TNE98—Depth	0.60—0.80 mm (0.0236—0.0314 in.)
Wear Limit	1.10 mm (0.043 in.)



Measuring Valve Recession

A—Valve Recession
B—Cylinder Head
C—Depth Gauge

OUO1083,0000605 –19–13APR04–1/1

Inspect and Measure Valve Guides

1. Clean valve guides with a plastic brush before inspection or repair.

NOTE: A few drops of light oil or kerosene will help clean the guides.

2. Measure valve guide inside diameter.

Specification

Valve Guide—3009 and 3013—
ID-Intake and Exhaust .... 7.00—7.02 mm (0.275—0.276 in.)
Wear Limit .... 7.08 mm (0.279 in.)
Valve Stem-to-Valve Guide—
3009 and 3013—
Clearance-Intake and Exhaust
(3009) .... 0.030—0.060 mm (0.0012—0.0024 in.)
Clearance-Intake (3013) .... 0.040—0.070 mm (0.0016—0.0028 in.)
Clearance-Exhaust (3013) .... 0.045—0.075 mm (0.0018—0.0030 in.)
Wear Limit (3009 and 3013) .... 0.18 mm (0.279 in.)
Valve Guide—3016—ID-Intake .... 8.010—8.025 mm (0.3154—0.3159 in.)
Wear Limit .... 8.10 mm (0.319 in.)
Valve Guide—3016—ID-Exhaust .... 8.015—8.030 mm (0.3156—0.3161 in.)
Wear Limit .... 8.10 mm (0.319 in.)
Valve Stem-to-Valve Guide—
3016—Clearance-Intake .... 0.035—0.070 mm (0.0014—0.0028 in.)
Clearance-Exhaust .... 0.045—0.075 mm (0.0018—0.0030 in.)
Wear Limit-Intake and Exhaust .... 0.18 mm (0.279 in.)
Valve Guide—3011, 3012, 3015
and 4020—ID-Intake and Exhaust .... 8.010—8.025 mm (0.315—0.316 in.)
Wear Limit .... 8.10 mm (0.318 in.)
Valve Stem-to-Valve Guide—
3011, 3012, 3015 and 4020—
Clearance-Intake and Exhaust .... 0.035—0.070 mm (0.001—0.003 in.)
Wear Limit .... 0.20 mm (0.0078 in.)
Valve Guide—4TNE98—ID-Intake
and Exhaust .... 8.015—8.030 mm (0.315—0.316 in.)
Wear Limit .... 8.10 mm (0.318 in.)
Valve Stem-to-Valve Guide—
4TNE98—Clearance-Intake .... 0.035—0.065 mm (0.0014—0.0026 in.)
Wear Limit .... 0.185 mm (0.0073 in.)

Continued on next page

Specification

Valve Stem-to-Valve Guide—4TNE98—Clearance-Exhaust	0.045—0.075 mm (0.0018—0.003 in.)
Wear Limit	0.195 mm (0.0077 in.)

If diameter exceeds wear limit, knurl or replace guide.

If diameter is less than wear limit, determine guide-to-stem clearance (guide diameter minus stem diameter).

If clearance exceeds 0.15 mm (0.006 in.) but is less than 0.20 mm (0.008 in.), knurl valve guides.

If clearance exceeds 0.20 mm (0.008 in.) replace valve guides. (See REPLACE VALVE GUIDES in this group.)

Knurl valve guides using:

- 3009 and 3013: D-20018WI Valve Guide Knurler
- 3011, 3012, 3015, 3016 and 4020: D-20019WI Valve Guide Knurler

Ream inside diameter of valve guides using:

- 3009 and 3013: D-20020WI Valve Guide Reamer
- 3011, 3012, 3015, 3016 and 4020: D-20021WI Valve Guide Reamer

OUO1083,0000604 –19–13APR04–2/2

Replace Valve Guides

Replace valve guides using:

- 3009, 3011, 3012, 3013, 3015, 3016 and 4020: JDE118 Valve Guide Driver
- Knurl and ream guides. (See INSPECT AND MEASURE VALVE GUIDES in this group.)

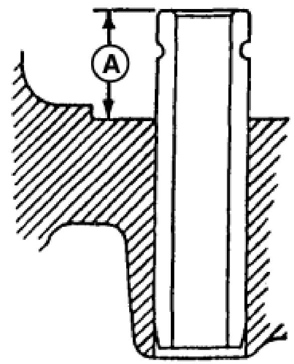
Continued on next page OUO1083,0000603 –19–13APR04–1/2

NOTE: For 4TNE98 engines, a valve guide driver tool can be fabricated. See VALVE GUIDE TOOL FOR 4TNE98 ENGINE in Group 190.

Intake and exhaust valve guides are different. The exhaust valve guide has one groove and the intake valve guide has none. Install valve guides with tapered ends down. Push valve guides down until top of valve guides are a specified distance (A) from top of cylinder head.

Specification

Valve Guide—3009—Height	9 mm (0.354 in.)
Valve Guide—3011 and 3012—Height	12 mm (0.472 in.)
Valve Guide—3013—Height	11.7—12 mm (0.461—0.472 in.)
Valve Guide—3015 and 4020—Height	15 mm (0.591 in.)
Valve Guide—3016 and 4TNE98—Height	14.7—15.0 mm (0.578—0.590 in.)



M82193A –UN–12JUN00

A—Distance from Top of Cylinder Head

OUO1083,0000603 –19–13APR04–2/2

Inspect Valve Springs

NOTE: Free length may vary slightly between valve springs.

1. Measure spring free length (C). Replace spring if measurement is less than specification.

Specification

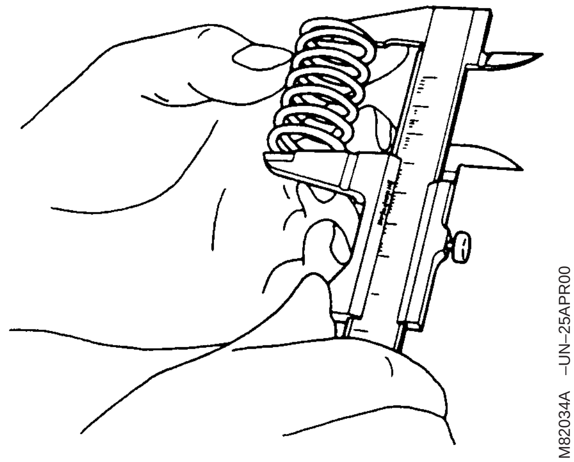
Valve Spring—3009—Free Length	37.40 mm (1.472 in.)
Valve Spring—3011, 3012 and 3013—Free Length	42.0 mm (1.654 in.)
Valve Spring—3015 and 4020—Free Length	40.0 mm (1.575 in.)
Valve Spring—3016—Free Length	44.4 mm (1.870 in.)
Vlave Spring—4TNE98—Free Length	47.5 mm (1.748 in.)

2. Measure spring inclination (B). Replace spring if measurement exceeds specification.

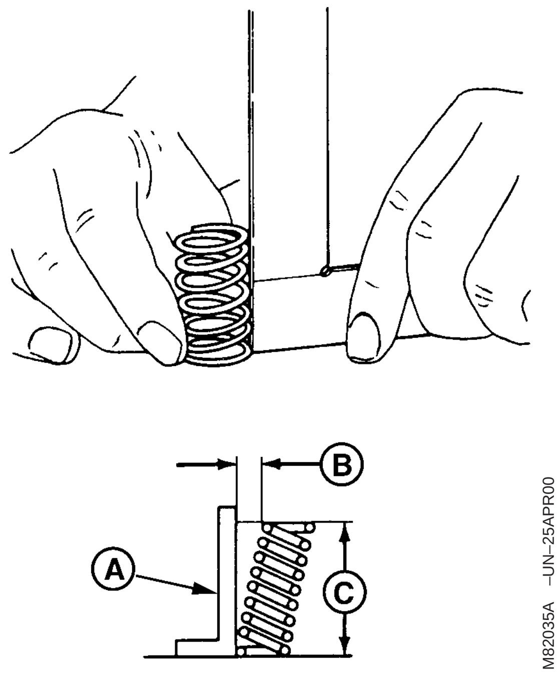
Specification

Valve Spring—3009—Inclination	1.0 mm (0.040 in.)
Valve Spring—3011, 3012, 3015 and 4020—Inclination	1.1 mm (0.044 in.)
Valve Spring—3013, 3016 and 4TNE98—Inclination	1.2 mm (0.047 in.)

A—Square Gauge
B—Spring Inclination
C—Free Length



Measure Spring Free Length



Measuring Valve Spring Inclination

OUO1083,0000602 –19–13APR04–1/1

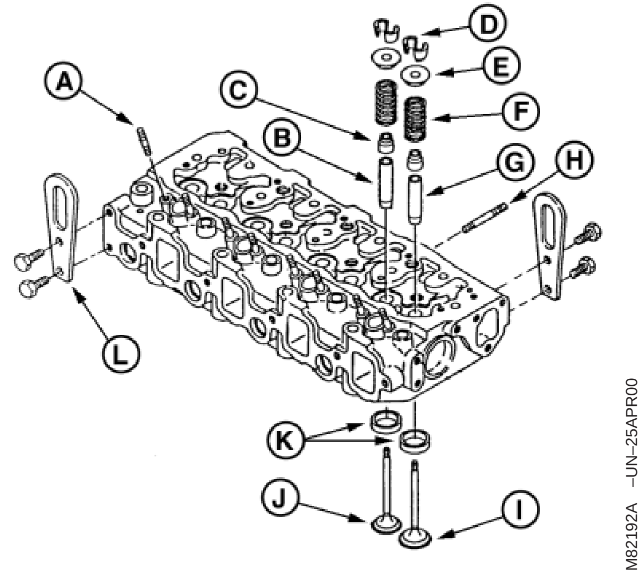
Assemble Cylinder Head and Valves

NOTE: Size and shape of lifting brackets will vary due to numerous engine applications.

Model 4020 is illustrated. Other models are similar.

IMPORTANT: Do not reuse stem seals if removed. Used seals will leak.

1. Install new valve stem seals over valve guides.
2. Apply clean engine oil on intake and exhaust valve stems during assembly.
3. Install springs with smaller pitch end or paint mark toward cylinder head.
4. Compress valve springs and retainer until collet halves are able to be installed in grooves of valve stem.
5. Carefully release tension on spring compressor.
6. Tap on end of valve with a plastic hammer to ensure collet halves have seated properly on valve stem.
7. Repeat for remaining valves.
8. Measure valve recession if new valves were installed. (See INSPECT INTAKE AND EXHAUST VALVES in this group.)



A—Short Stud
B—Exhaust Valve Guide
C—Stem Seal
D—Collet Halves
E—Retainer
F—Valve Spring
G—Intake Valve Guide
H—Exhaust Manifold Mounting Stud
I—Intake Valve
J—Exhaust Valve
K—Valve Seat Inserts
L—Lifting Bracket

RG,RG34710,8082 –19–15APR97–1/1

Install Cylinder Head

NOTE: Model 4020 is illustrated. Other models are similar.

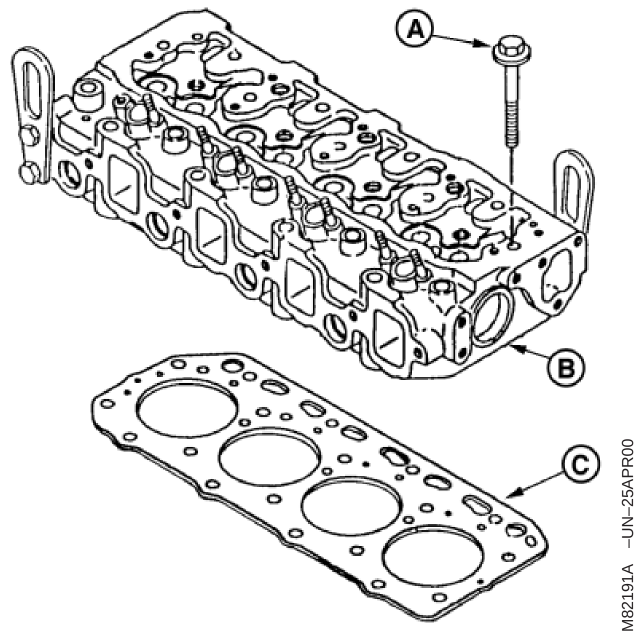
1. Reassemble cylinder head and valves. (See ASSEMBLE CYLINDER HEAD AND VALVES in this group.)

2. 3009: If removed, install cam followers in same locations as removed.

IMPORTANT: Oil passage in gasket must be located over oil passage in cylinder block.

3. Place cylinder head gasket (C) on engine block. Dowels in engine block will assist in aligning gasket.

4. Place cylinder head (B) on engine block. Dowels in engine block will again assist in alignment.



Model 4020

A—Mounting Cap Screw
B—Cylinder Head
C—Gasket

Continued on next page RG,RG34710,8084 –19–30MAR04–1/2

IMPORTANT: Cylinder head mounting cap screws must be checked for proper torque after 50 hours of engine operation.

5. Dip mounting cap screws in oil. Install and tighten cap screws in the sequence shown, in stages of gradually-increasing torque. See torque specifications below.

3009 Cylinder Head —Specification

Cap Screw—First—Torque	19 N•m (168 lb-in.)
Cap Screw—Second—Torque	38 N•m (28 lb-ft)
Cap Screw—Final—Torque	61 N•m (45 lb-ft)

3011, 3012 and 3013 Cylinder Head—Specification

Cap Screw—First—Torque	21 N•m (186 lb-in.)
Cap Screw—Second—Torque	42 N•m (31 lb-ft)
Cap Screw—Final (3011 and 3012)—Torque	69 N•m (51 lb-ft)
Cap Screw—Final (3013)—Torque	64 N•m (47 lb-ft)

3015, 3016 and 4020 Cylinder Head—Specification

Cap Screw—First—Torque	24 N•m (212 lb-in.)
Cap Screw—Second—Torque	48 N•m (36 lb-ft)
Cap Screw—Final—Torque	88 N•m (65 lb-ft)

4TNE98 Cylinder Head—Specification

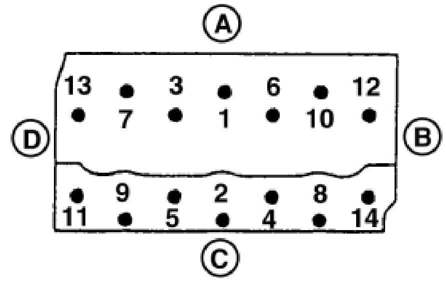
Cap Screw—First—Torque	54 N•m (40 lb-ft)
Cap Screw—Final—Torque	107 N•m (79 lb-ft)

6. Install coolant pump. (See REMOVE, INSPECT AND INSTALL COOLANT PUMP—3009, 3011, 3012, 3013, 3015, 3016 AND 4020 or REMOVE, INSPECT AND INSTALL COOLANT PUMP—4TNE98 in Group 070.)

7. Install exhaust and intake manifolds. (See REMOVE AND INSTALL EXHAUST MANIFOLD and REMOVE AND INSTALL INTAKE MANIFOLD in Group 080.)

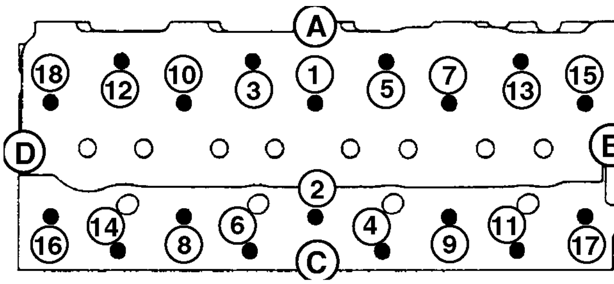
8. Install rocker arm assembly, push rods and valve caps. (See DISASSEMBLE AND ASSEMBLE ROCKER ARM SHAFT ASSEMBLY in this group.)

9. Install fuel injectors. (See REMOVE AND INSTALL FUEL INJECTION NOZZLES (PINTLE TYPE)—3009 or REMOVE AND INSTALL FUEL INJECTION NOZZLES (HOLE TYPE)—3011, 3012, 3013, 3015, 3016, 4020 AND 4TNE98 in Group 90.)



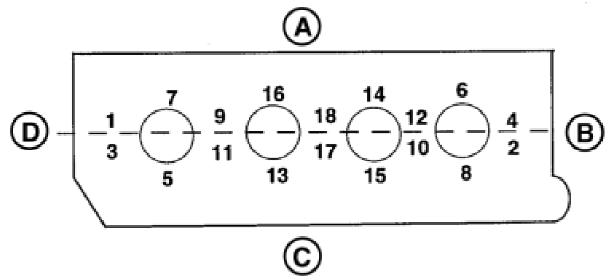
M82260A –UN–12JUN00

Models 3009, 3011, 3012, 3013, 3015 and 3016 Cap Screw Sequence



M82025A –UN–25APR00

Model 4020 Cap Screw Sequence



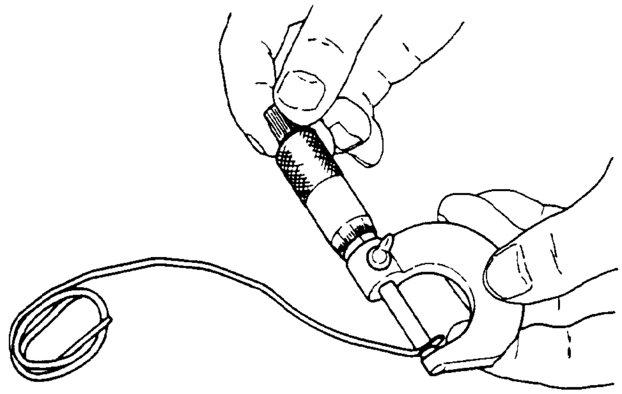
RG8574B –UN–25APR00

Model 4TNE98 Cap Screw Sequence

A—Exhaust Manifold Side
B—Timing Gear Case Side
C—Intake Manifold Side
D—Flywheel Side

RG,RG34710,8084 –19–30MAR04–2/2

Measure Piston-to-Cylinder Head Clearance



Measure Piston-to-Cylinder Head Clearance

1. Place three 10 mm (0.400 in.) long pieces of 1.50 mm (0.060 in.) diameter soft wire in three positions on the flat part of the piston head.
2. Install cylinder head and old gasket. Install cylinder head cap screws and tighten in proper sequence to specified torque. (See INSTALL CYLINDER HEAD in Group 020.)
3. Slowly turn crankshaft one complete revolution.
4. Remove cylinder head and gasket.
5. Measure thickness of flattened section of each piece of wire. Calculate average thickness of wires to obtain piston-to-cylinder head clearance specification.

Specification

Piston-to-Cylinder Head—3009—Clearance	0.61—0.79 mm (0.024—0.031 in.)
Piston-to-Cylinder Head—3011, 3012, 3015, 4020—Clearance	0.64—0.82 mm (0.025—0.032 in.)
Piston-to-Cylinder Head—3013, 3016—Clearance	0.66—0.78 mm (0.026—0.031 in.)
Piston-to-Cylinder Head—4TNE98—Clearance	0.74—0.87 mm (0.029—0.034 in.)

If clearance is less than specifications, replace cylinder head.

OUO1032,000140D –19–07APR04–1/1

Measure Connecting Rod Side Play

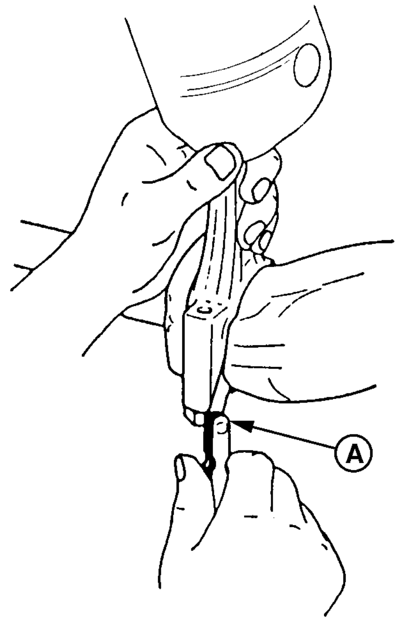
Use a feeler gauge (A) to measure clearance between connecting rod and crankshaft.

If side play exceeds wear limit, replace connecting rod and connecting rod cap.

Specification

Connecting Rod Side Play—All Engines—Clearance............................. 0.20—0.40 mm (0.0079—0.0157 in.)
Wear Limit .... 0.55 mm (0.022 in.)

A—Feeler Gauge



M82116A –UN–12JUN00

Checking Connecting Rod Side Play

RG,RG34710,8099 –19–07APR04–1/1

Measure Connecting Rod Bearing Clearance

IMPORTANT: Connecting rod caps must be installed on the same connecting rod and in the same direction to prevent crankshaft and connecting rod damage.

1. Remove connecting rod cap.

2. Wipe oil from bearing insert and crankshaft journal.

Continued on next page

RG,RG34710,8101 –19–07APR04–1/3

3. Put a piece of PLASTIGAGE® (A), or an equivalent, along the full width of the bearing insert approximately 6 mm (0.250 in.) off center.

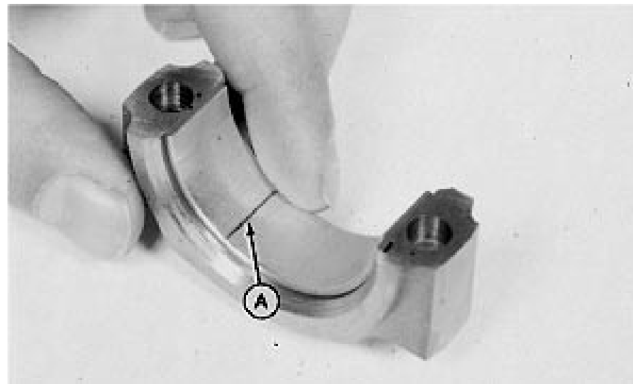
4. Turn crankshaft approximately 30° from bottom dead center.

IMPORTANT: Do not rotate crankshaft while PLASTIGAGE is installed. Doing so will result in a false reading.

5. Install connecting rod end cap and original cap screws. Tighten cap screws to specifications.

Specification

Connecting Rod Cap Screw—3009—Torque	23 N•m (203 lb-in.)
Connecting Rod Cap Screw—3011, 3012, 3013—Torque	39 N•m (29 lb-ft)
Connecting Rod Cap Screw—3015, 3016, 4020—Torque	47 N•m (35 lb-ft)
Connecting Rod Cap Screw—4TNE98—Torque	54 N•m (40 lb-ft)



Apply PLASTIGAGE® to Rod Bearing Insert

A—PLASTIGAGE®

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RG,RG34710,8101 –19–07APR04–2/3

6. Remove cap screws and connecting rod cap.

NOTE: The flattened PLASTIGAGE® will be found on either the bearing insert or crankshaft journal.

7. Use the graduation marks on the envelope (B) to compare the width of the flattened PLASTIGAGE® (A) at its widest point.

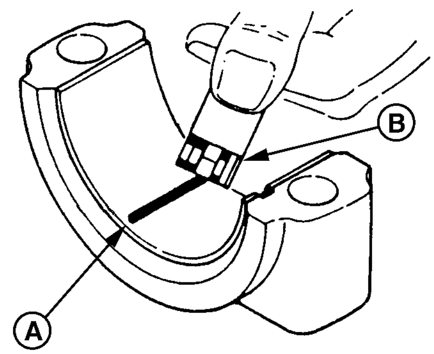
8. Determine bearing clearance. The number within the graduation marks indicates the bearing clearance in inches or millimeters, depending on which side of the envelope is used.

9. Remove PLASTIGAGE®.

Specification

Connecting Rod Bearing-to-Crankshaft—3009—Oil Clearance	0.020—0.072 mm (0.0008—0.0028 in.)
Wear Limit	0.15 mm (0.0059 in.)
Connecting Rod Bearing-to-Crankshaft—3011, 3012, 3013—Oil Clearance	0.038—0.090 mm (0.0015—0.0035 in.)
Wear Limit (3011, 3012)	0.16 mm (0.0063 in.)
Wear Limit (3013)	0.15 mm (0.0059 in.)
Connecting Rod Bearing-to-Crankshaft—3015, 3016, 4020, 4TNE98—Oil Clearance	0.038—0.074 mm (0.0015—0.0029 in.)
Wear Limit (3015, 4020, 4TNE98)	0.16 mm (0.0062 in.)
Wear Limit (3016)	0.15 mm (0.0059 in.)

If clearance is not within specification, replace bearing inserts, repair crankshaft, or both.



Measure Width of PLASTIGAGE®

A—PLASTIGAGE®
B—Envelope

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RG,RG34710,8101 –19–07APR04–3/3

Remove Pistons and Connecting Rods

If engine is to be removed from the machine, see your machine technical manual.

CAUTION: Do not drain engine coolant until it cools below operating temperature. Then slowly loosen cylinder block drain valve to relieve any pressure.

1. Drain coolant and engine oil.

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

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

3. Remove camshaft followers and keep in order for reassembly in same position.

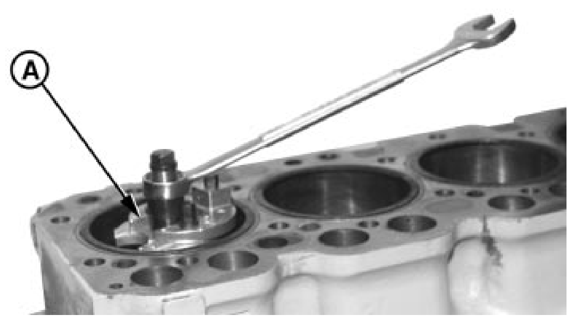
4. Clean all foreign material from cylinder block top deck.

RG,RG34710,8102 –19–15APR97–1/3

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

5. Remove carbon from cylinder bore with a scraper or ridge reamer (A). Use compressed air to remove loose material from cylinders.

A—Ridge Reamer



RG7455 –UN–04NOV97

Remove Ridge Using Ridge Reamer

Continued on next page RG,RG34710,8102 –19–15APR97–2/3

6. Remove oil pan and strainer tube.

7. Measure connecting rod side play. (See MEASURE CONNECTING ROD SIDE PLAY in this group.)

8. Measure crankshaft end play. (See MEASURE CRANKSHAFT END PLAY in Group 040.)

9. Measure connecting rod bearing clearance. (See MEASURE CONNECTING ROD BEARING CLEARANCE in this group.)

IMPORTANT: Pistons and rings, connecting rods, and bearings must be installed in the cylinders from which they were removed.

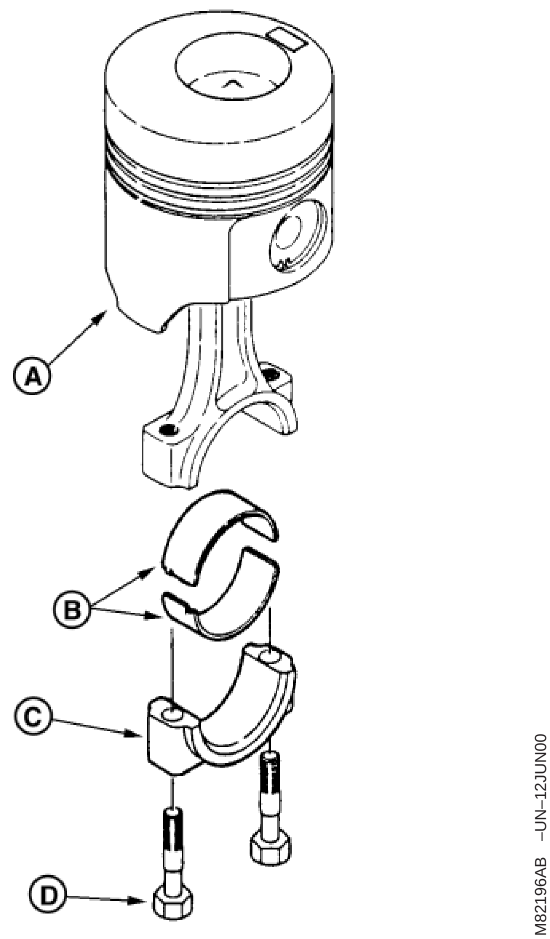
10. Mark rods, pistons, and caps to ensure correct assembly in the same location.

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

11. Remove all rod caps (C) with bearing inserts (B).

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

12. Push piston and connecting rod out of cylinder bore using a wooden dowel.



Piston, Connecting Rod, and Bearings

A—Piston and Connecting Rod
B—Bearing Inserts
C—Connecting Rod Cap
D—Connecting Rod Cap Screws

RG,RG34710,8102 –19–15APR97–3/3

Measure Crankshaft Connecting Rod Journals

Measure crankshaft connecting rod journals. Measure at several places around journal.

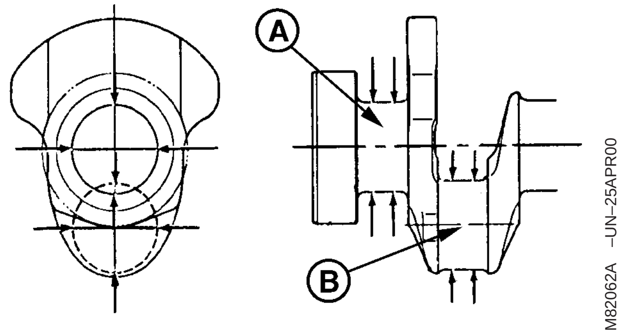
NOTE: If engine has had a previous major overhaul, journals may have been ground and undersized bearing inserts installed.

If journal diameter is less than wear limit, replace crankshaft or have journals ground undersize by a qualified machine shop.

If journals are ground, undersize bearing inserts must be installed. Bearing inserts are available in 0.25 mm (0.010 in.) undersize.

Specification

Crankshaft Connecting Rod Journal—3009—OD	39.97—39.98 mm (1.5736—1.5740 in.)
Wear Limit	39.92 mm (1.572 in.)
Connecting Rod Bearing-to-Crankshaft Journal—3009—Oil Clearance	0.020—0.072 mm (0.0008—0.0028 in.)
Wear Limit	0.15 mm (0.0059 in.)
Crankshaft Connecting Rod Journal—3011, 3012, 3013—OD	42.952—42.962 mm (1.6910—1.6914 in.)
Wear Limit	42.902 mm (1.6891 in.)
Connecting Rod Bearing-to-Crankshaft Journal—3011, 3012, 3013—Oil Clearance	0.038—0.090 mm (0.0015—0.0035 in.)
Wear Limit (3011, 3012)	0.16 mm (0.0063 in.)
Wear Limit (3013)	0.15 mm (0.0059 in.)
Crankshaft Connecting Rod Journal—3015, 3016, 4020—OD	47.952—47.962 mm (1.8879—1.8883 in.)
Wear Limit	47.902 mm (1.8859 in.)
Connecting Rod Bearing-to-Crankshaft Journal—3015, 3016, 4020—Oil Clearance	0.038—0.074 mm (0.0015—0.0029 in.)
Wear Limit (3015, 4020)	0.16 mm (0.0063 in.)
Wear Limit (3016)	0.15 mm (0.0059 in.)
Crankshaft Connecting Rod Journal—4TNE98—OD	57.952—57.962 mm (2.2816—2.2820 in.)
Wear Limit	57.902 mm (2.2796 in.)



A—Main Bearing Journal
B—Connecting Rod Journal

Continued on next page

RG,RG34710,8116 –19–15APR97–1/2

Specification

Connecting Rod
Bearing-to-Crankshaft Journal—
4TNE98—Oil Clearance .... 0.038—0.074 mm
(0.0015—0.0029 in.)
Wear Limit .... 0.15 mm (0.0059 in.)

RG,RG34710,8116 –19–15APR97–2/2

Complete Disassembly of Cylinder Block (If Required)

If not previously removed, also remove:

1. Timing gear cover, timing gears, and camshaft. (See REMOVE CAMSHAFT in Group 050.)
2. Camshaft bushing and rear plug. (See MEASURE CAMSHAFT BUSHING AND BORES IN BLOCK in this group.)
3. Front plate or housing. (See REMOVE AND INSTALL TIMING GEAR HOUSING—3009 or REMOVE AND INSTALL TIMING GEAR COVER MOUNTING PLATE—3011, 3012, 3013, 3015, 3016 AND 4020 or REMOVE AND INSTALL TIMING GEAR HOUSING—4TNE98 in Group 050.)
4. Piston cooling orifices (4020T only). (See REPLACE PISTON COOLING NOZZLES—4020T in Group 060.)
5. Crankshaft and main bearings. (See REMOVE CRANKSHAFT AND MAIN BEARINGS in Group 040.)
6. Coolant gallery plugs.
7. If necessary to “hot tank” the block, also remove screw-in-type oil galley plugs.

RG,RG34710,8103 –19–15APR97–1/1

Preliminary Piston and Rod Checks

Scuffed or Scored Pistons:

- Insufficient lubrication.
- Insufficient cooling.
- Improper piston-to-cylinder bore clearance.
- Coolant leakage in 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 break-in.
- Worn piston.
- Contaminated oil.

Worn or Broken Compression Rings:

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

Clogged Oil Control Ring:

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

Dull Satin Finish and Fine Vertical Scratches on Rings:

- Dirt and abrasive in air intake system.

Stuck Rings:

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

Cylinder Wear and Distortion:

- Incorrectly installed compression rings.
- Insufficient lubrication.
- Uneven cooling around cylinder bore.
- Improper piston-to-cylinder bore clearance.
- Cylinder bore damage.

Warped Cylinder Block:

- Insufficient cooling.

Broken Connecting Rod:

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

Piston Pin and Snap Ring Failure:

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

Mottled, Grayish or Pitted Compression Rings:

- Internal coolant leaks.

RG,RG34710,8104 –19–15APR97–1/1

Disassemble Pistons and Connecting Rods

1. Remove piston rings using the JDE135, JDE85, or KJD10140 Piston Ring Expander.

IMPORTANT: Pistons must be installed on the same connecting rod they were removed from.

2. Put a mark on each piston and connecting rod to aid in assembly.

3. Remove and discard piston pin snap rings and separate piston from connecting rod.

4. Piston pin bushing is press fit in connecting rod. Remove bushing only if replacement is necessary. (See MEASURE PISTON PIN BUSHINGS in this group.)

RG,RG34710,8105 –19–15APR97–1/1

Clean Pistons

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

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

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

DO NOT bead blast ring groove areas.

2. Clean pistons by any of the following methods:

- Immersion-Solvent "D-Part".
- Hydra-Jet Rinse Gun.
- Hot water with liquid detergent soap.

If cleaning with hot water and liquid detergent, soak pistons in a 50 percent solution of liquid household detergent and hot water for 30 to 60 minutes. Use a stiff bristle brush—NOT A WIRE BRUSH—to loosen carbon residue. Dry with compressed air.


RG7465 –UN–23NOV97

Cleaning Piston Ring Grooves

RG,RG34710,8107 –19–15APR97–1/1

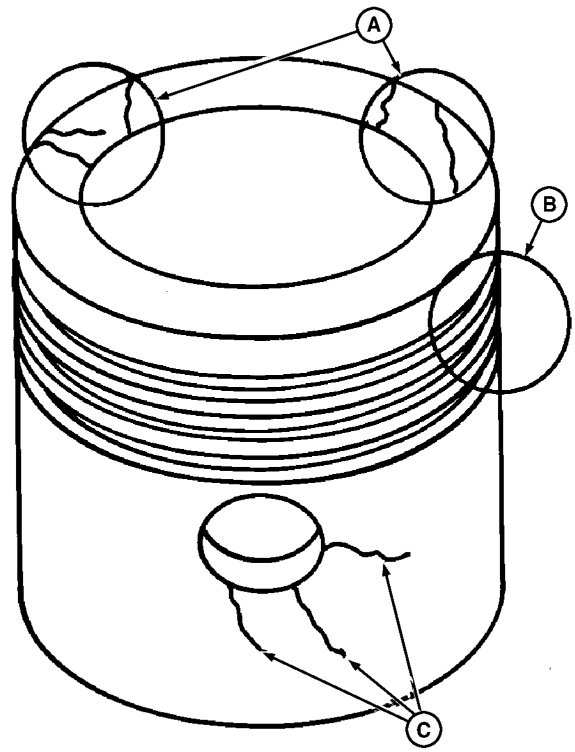
Visually Inspect Pistons

Carefully inspect pistons under magnification. Check for:

- signs of fatigue
- fine cracks in the piston head (A)
- bent or broken ring lands (B)
- cracks in the skirt (C) at inner and outer ends of piston pin bore
- excessive piston skirt wear (original machining marks must be visible)

If any imperfections are found, replace the piston.

A—Fine Cracks in Piston Head
B—Bent or Broken Ring Lands
C—Cracks in the Skirt



RG3326

(Defects Exaggerated)

RG,RG34710,8108 –19–15APR97–1/1

Check Piston Ring Groove Wear

Measure Piston Ring Groove Clearance

With rings installed on piston, measure piston ring groove clearance. Measure several places around each piston.

Piston Ring-to-Groove—3009—Specification

Top Compression Ring Groove—
Clearance .... 0.75—0.110 mm (0.0030—0.0043 in.)
Wear Limit .... 0.20 mm (0.0079 in.)
Second Compression Ring—
Clearance .... 0.030—0.065 mm (0.0012—0.0026 in.)
Wear Limit .... 0.20 mm (0.0079 in.)
Oil Ring—Clearance........ 0.020—0.055 mm (0.0008—0.0022 in.)
Wear Limit .... 0.20 mm (0.0079 in.)

Piston Ring-to-Groove—3011, 3012, 3016—Specification

Top Compression Ring—
Clearance .... 0.70—0.105 mm (0.0028—0.0041 in.)
Wear Limit (3011, 3012)........ 0.25 mm (0.0098 in.)
Wear Limit (3016)........ Can not be accurately measured due to design
Second Compression Ring—
Clearance .... 0.035—0.070 mm (0.0014—0.0028 in.)
Wear Limit (3011, 3012)........ 0.25 mm (0.0098 in.)
Wear Limit (3016)........ 0.190 mm (0.0075 in.)
Oil Ring—Clearance........ 0.030—0.060 mm (0.0012—0.0024 in.)
Wear Limit (3011, 3012)........ 0.20 mm (0.0079 in.)
Wear Limit (3016)........ 0.180 mm (0.0071 in.)

Piston Ring-to-Groove—3013, 3015, 4020—Specification

Top Compression Ring—
Clearance .... 0.75—0.110 mm (0.0030—0.0043 in.)
Wear Limit (3015, 4020)........ 0.25 mm (0.0098 in.)
Wear Limit (3013)........ Can not be accurately measured due to design
Second Compression Ring—
Clearance .... 0.045—0.080 mm (0.0018—0.0031 in.)
Wear Limit (3015, 4020)........ 0.25 mm (0.0098 in.)
Wear Limit (3013)........ 0.200 mm (0.0079 in.)
Oil Ring—Clearance........ 0.025—0.060 mm (0.0010—0.0024 in.)
Wear Limit (3015, 4020)........ 0.20 mm (0.0079 in.)
Wear Limit (3013)........ 0.180 mm (0.0071 in.)

Continued on next page
RG,RG34710,8106 –19–15APR97–1/2

Piston Ring-to-Groove—4TNE98—Specification

Top Compression Ring—Clearance	0.60—0.100 mm (0.0023—0.0039 in.)
Second Compression Ring—Clearance	0.090—0.125 mm (0.0035—0.0049 in.)
Wear Limit	0.245 mm (0.0096 in.)
Oil Ring—Clearance	0.025—0.060 mm (0.0010—0.0024 in.)
Wear Limit	0.180 mm (0.0070 in.)

RG,RG34710,8106 –19–15APR97–2/2

Measure Piston Ring End Gap

Push loose piston ring (C) into cylinder bore, using a piston, until ring is approximately 30 mm (1.181 in.) from bottom of cylinder bore.

Measure piston ring end gap (A) and compare to specifications.

If end gap exceeds wear limit, replace piston rings.

Piston Ring End Gap—3009—Specification

Top Compression Ring—Gap	0.10—0.25 mm (0.004—0.010 in.)
Wear Limit	1.50 mm (0.0591 in.)
Second Compression Ring—Gap	0.25—0.40 mm (0.010—0.016 in.)
Wear Limit	1.50 mm (0.0591 in.)
Oil Ring—Gap	0.15—0.35 mm (0.006—0.014 in.)
Wear Limit	1.50 mm (0.0591 in.)

Piston Ring End Gap—3011, 3012—Specification

Compression Rings—Gap	0.25—0.40 mm (0.010—0.016 in.)
Wear Limit	1.50 mm (0.0591 in.)
Oil Ring—Gap	0.02—0.04 mm (0.008—0.016 in.)
Wear Limit	1.50 mm (0.0591 in.)

Piston Ring End Gap—3013, 3016 —Specification

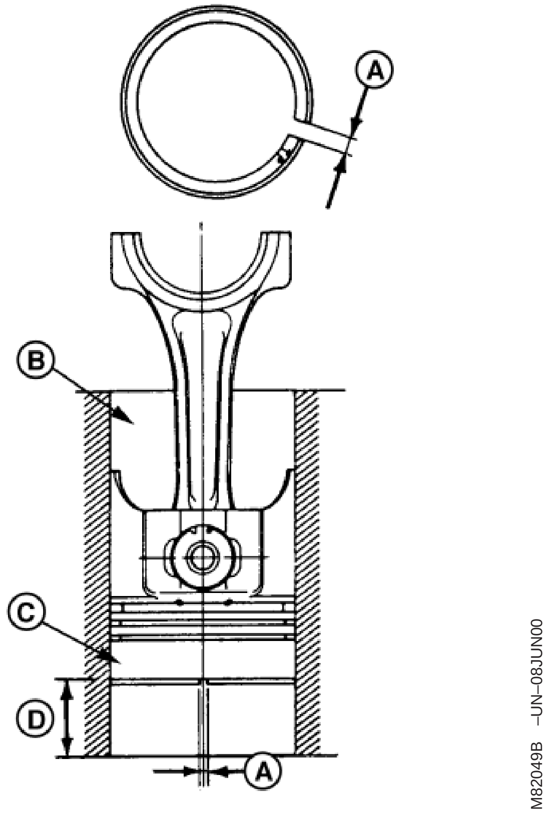
All Rings—Gap	0.20—0.40 mm (0.008—0.016 in.)
Wear Limit	0.490 mm (0.019 in.)

Piston Ring End Gap—3015, 4020 —Specification

All Rings—Gap	0.20—0.40 mm (0.008—0.016 in.)
Wear Limit	1.50 mm (0.0591 in.)

Piston Ring End Gap—4TNE98 —Specification

Top Compression Ring—Gap	0.25—0.45 mm (0.0098—0.0177 in.)
Second Compression Ring—Gap	0.450—0.650 mm (0.0177—0.0256 in.)
Wear Limit	0.730 mm (0.0287 in.)
Oil Ring—Gap	0.25—0.45 mm (0.0098—0.0177 in.)
Wear Limit	0.550 mm (0.0217 in.)



A—End Gap
B—Cylinder Bore
C—Piston Ring
D—Approx. 30 mm (1.181 in.)

RG,RG34710,8111 –19–15APR97–1/1

Measure Piston Pin Bore

Measure piston pin bore diameter in piston.

If piston pin bore is not within specification, replace piston.

If bore clearance (bore ID minus pin OD) exceeds specification, replace piston, piston pin or both.

Measure Piston Pin Bore

Specification

Piston Pin Bore—3009—Diameter .... 21.00—21.009 mm (0.8268—0.8271 in.)
Wear Limit .... 21.02 mm (0.828 in.)
Piston Pin-to-Piston Pin Bore—3009—Oil Clearance .... 0.045 mm (0.0018 in.)
Piston Pin Bore—3011, 3012, 3013—Diameter .... 23.00—23.009 mm (0.9055—0.9059 in.)
Wear Limit (3011, 3012) .... 23.02 mm (0.906 in.)
Wear Limit (3013) .... 23.039 mm (0.9070 in.)
Piston Pin-to-Piston Pin Bore—3011, 3012, 3013—Oil Clearance (3011, 3012) .... 0.000—0.017 mm (0.0000—0.0007 in.)
Wear Limit .... 0.120 mm (0.0047 in.)
Oil Clearance (3013) .... 0.000—0.014 mm (0.0000—0.0006 in.)
Wear Limit .... 0.074 mm (0.0029 in.)
Piston Pin Bore—3015, 3016, 4020—Diameter .... 26.00—26.009 mm (1.0236—1.0240 in.)
Wear Limit (3015, 4020) .... 26.02 mm (1.024 in.)
Wear Limit (3016) .... 26.039 mm (1.0252 in.)
Piston Pin-to-Piston Pin Bore—3015, 3016, 4020—Oil Clearance (3015, 4020) .... 0.000—0.022 mm (0.0000—0.0009 in.)
Wear Limit .... 0.120 mm (0.0047 in.)
Oil Clearance (3016) .... 0.000—0.014 mm (0.0000—0.0006 in.)
Wear Limit .... 0.074 mm (0.0029 in.)
Piston Pin Bore—4TNE98—Diameter .... 30.000—30.009 mm (1.1811—1.1815 in.)
Wear Limit .... 30.039 mm (1.1826 in.)
Piston Pin-to-Piston Pin Bore—4TNE98—Oil Clearance .... 0.00—0.020 mm (0.00—0.0008 in.)

RG,RG34710,8110 –19–15APR97–1/1

Measure Piston Diameter

1. Measure piston diameter perpendicular (90°) to piston pin bore at distance (A).

   If piston diameter is less than wear limit, install a new piston.

Piston Diameter—3009—Specification

Measurement Location (A)—Distance	8 mm (0.135 in.)
Standard Piston—Diameter	71.922—71.952 mm (2.832—2.833 in.)
Wear Limit	71.81 mm (2.827 in.)
0.25 mm (0.010 in.) Oversize Piston—Diameter	72.172—72.202 mm (2.8714—2.8426 in.)
Wear Limit	72.06 mm (2.837 in.)
Piston-to-Cylinder Bore—Clearance	0.105 mm (0.004 in.)

Piston Diameter—3011, 3012—Specification

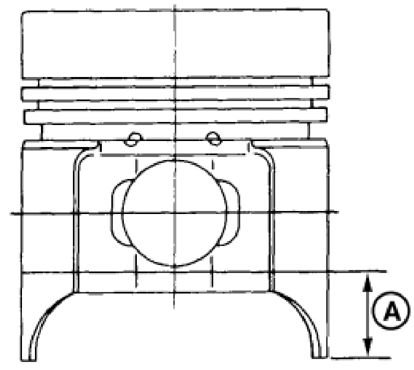
Measurement Location (A)—Distance	23 mm (0.905 in.)
Standard Piston—Diameter	77.895—77.925 mm (3.067—3.068 in.)
Wear Limit	77.80 mm (3.063 in.)
0.25 mm (0.010 in.) Oversize Piston—Diameter	78.150—78.165 mm (3.0768—3.0774 in.)
Wear Limit	78.05 mm (3.053 in.)
Piston-to-Cylinder Bore—Clearance	0.105 mm (0.004 in.)

Piston Diameter—3013—Specification

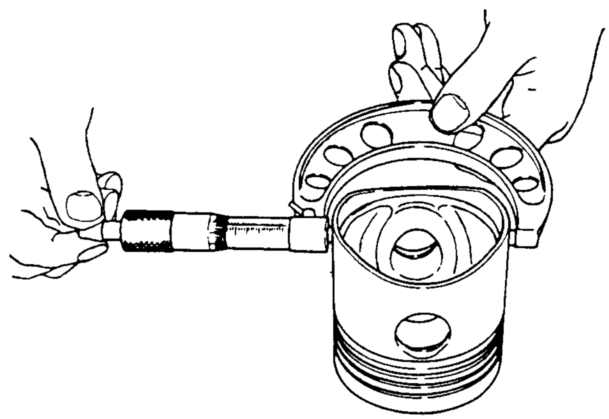
Measurement Location (A)—Distance	16 mm (0.630 in.)
Standard Piston—Diameter	81.950—81.980 mm (3.2264—3.2275 in.)
Wear Limit	81.905 mm (3.2246 in.)
0.25 mm (0.010 in.) Oversize Piston—Diameter	82.200—82.230 mm (3.2362—3.2374 in.)
Wear Limit	82.155 mm (3.2344 in.)
Piston-to-Cylinder Bore—Clearance	0.035—0.065 mm (0.0014—0.0026 in.)

Piston Diameter—3015, 4020—Specification

Measurement Location (A)—Distance	24 mm (0.945 in.)
Standard Piston—Diameter	83.945—83.975 mm (3.305—3.306 in.)
Wear Limit	83.90 mm (3.303 in.)



Piston Diameter Measurement Height



Measure Piston Diameter Perpendicular to Piston Pin Bore

A—Piston Measure Point

Continued on next page

RG,RG34710,8109 –19–15APR97–1/2

0.25 mm (0.010 in.) Oversize
Piston—Diameter........ 84.195—84.225 mm (3.315—3.316 in.)
Wear Limit .... 84.15 mm (3.313 in.)
Piston-to-Cylinder Bore—
Clearance .... 0.055 mm (0.002 in.)

Piston Diameter—3016—Specification

Measurement Location (A)—
Distance........ 24 mm (0.945 in.)
Standard Piston—Diameter........ 87.945—87.975 mm (3.4624—3.4636 in.)
Wear Limit .... 87.900 mm (3.4606 in.)
0.25 mm (0.010 in.) Oversize
Piston—Diameter........ 88.195—88.225 mm (3.4722—3.4734 in.)
Wear Limit .... 88.150 mm (3.4705 in.)
Piston-to-Cylinder Bore—
Clearance .... 0.040—0.070 mm (0.0016—0.0028 in.)

Piston Diameter—4TNE98—Specification

Measurement Location (A)—
Distance........ 22 mm (0.866 in.)
Standard Piston—Diameter........ 97.945—97.955 mm (3.38561—3.8565 in.)
Wear Limit .... 97.90 mm (3.8543 in.)
0.25 mm (0.010 in.) Oversize
Piston—Diameter........ 98.195—98.205 mm (3.38659—3.8663 in.)
Wear Limit .... 98.15 mm (3.8642 in.)
Piston-to-Cylinder Bore—
Clearance .... 0.050—0.080 mm (0.0019—0.0031 in.)

NOTE: If engine has had a previous major overhaul, oversize pistons and rings may have been installed. Pistons and rings are available in 0.25 mm (0.010 in.) oversize for all engines.

2. Measure cylinder bore diameter and compare with piston diameter to determine piston-to-cylinder bore clearance. (See INSPECT AND MEASURE CYLINDER BORE in this group.)

   If clearance exceeds wear limit, cylinders must be bored oversize.

RG,RG34710,8109 –19–15APR97–2/2

Inspect Piston Pins and Bushings

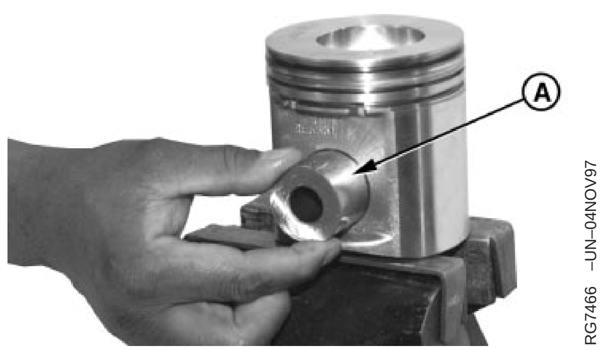
1. Visually inspect piston pin. Pin must be in good condition with no visible wear.

IMPORTANT: Do not attempt to polish or refinish piston pin. Pin has a highly polished surface.

2. Dip piston pin in clean engine oil.

3. Install pin (A) through piston. Pin should pass through piston using only light thumb pressure.

4. Insert pin from both sides. If pin enters freely, but binds in the center, the bore could be tapered. Pin should not “click” or need to be forced into bore on opposite side.



Inspect Piston Pins and Bushings

A—Pin

RG,RG34710,8112 –19–15APR97–1/1

Measure Piston Pins

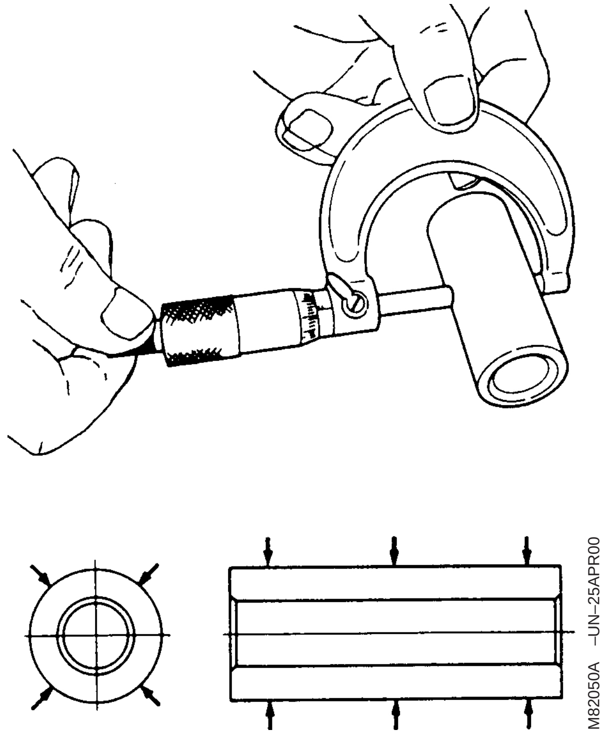
Measure piston pin diameter. Measure diameter at six places.

If pin diameter is less than wear limit, replace pin.

If bore clearance (bore ID minus pin OD) exceeds specification, replace piston pin, piston, or both.

Specification

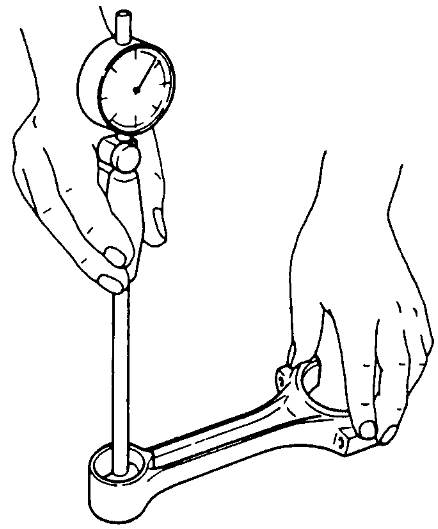
Piston Pin—3009—Diameter	20.991—21.00 mm (0.826—0.827 in.)
Wear Limit	20.975 mm (0.825 in.)
Piston Pin-to-Piston Pin Bore—3009—Oil Clearance	0.045 mm (0.0018 in.)
Piston Pin—3011, 3012—Diameter	22.991—23.00 mm (0.905—0.906 in.)
Wear Limit	22.90 mm (0.902 in.)
Piston Pin-to-Piston Pin Bore—3011, 3012—Oil Clearance	0.045 mm (0.0018 in.)
Piston Pin—3013—Diameter	22.995—23.000 mm (0.9053—0.9055 in.)
Wear Limit	22.965 mm (0.9041 in.)
Piston Pin-to-Piston Pin Bore—3013—Oil Clearance	0.000—0.014 mm (0.0000—0.0006 in.)
Wear Limit	0.074 mm (0.0029 in.)
Piston Pin—3016—Diameter	25.995—26.000 mm (1.0234—1.0236 in.)
Wear Limit	25.965 mm (1.0222 in.)
Piston Pin-to-Piston Pin Bore—3016—Oil Clearance	0.000—0.014 mm (0.0000—0.0006 in.)
Wear Limit	0.074 mm (0.0029 in.)
Piston Pin—3015, 4020—Diameter	25.987—26.000 mm (1.023—1.024 in.)
Wear Limit	25.90 mm (1.020 in.)
Piston Pin-to-Piston Pin Bore—3015, 4020—Oil Clearance	0.022 mm (0.0009 in.)
Piston Pin—4TNE98—Diameter	29.989—30.000 mm (1.1807—1.1811 in.)
Wear Limit	29.959 mm (1.1795 in.)
Piston Pin-to-Piston Pin Bore—4TNE98—Oil Clearance	0.00—0.020 mm (0.00—0.0008 in.)



Measure Piston Pins

RG,RG34710,8113 –19–15APR97–1/1

Measure Piston Pin Bushings



Measure Piston Pin Bushings

Measure piston pin bushing diameter in connecting rod.

If bushing diameter exceeds specification, replace bushing.

NOTE: When pressing in new bushings in connecting rod end, be sure oil holes are aligned.

If bushing clearance (bushing ID minus pin OD) exceeds specification, replace bushing, piston pin or both.

Specification

Piston Pin Bushing In Connecting Rod—3009—ID	21.025—21.038 mm (0.8278—0.8282 in.)
Wear Limit	21.10 mm (0.831 in.)
Piston Pin-to-Piston Pin Bushing—3009—Oil Clearance	0.110 mm (0.0043 in.)
Piston Pin Bushing In Connecting Rod—3011, 3012—ID	23.025—23.038 mm (0.9065—0.9070 in.)
Wear Limit	23.10 mm (0.909 in.)
Piston Pin-to-Piston Pin Bushing—3011, 3012—Oil Clearance	0.110 mm (0.0043 in.)
Piston Pin Bushing In Connecting Rod—3013—ID	23.025—23.038 mm (0.9065—0.9070 in.)
Wear Limit	23.068 mm (0.9082 in.)
Piston Pin-to-Piston Pin Bushing—3013—Oil Clearance	0.025—0.043 mm (0.0010—0.0017 in.)
Piston Pin Bushing In Connecting Rod—3015, 4020—ID	26.080—26.160 mm (1.0268—1.0299 in.)
Piston Pin-to-Piston Pin Bushing—3015, 4020—Oil Clearance	0.025—0.051 mm (0.0010—0.0020 in.)
Piston Pin Bushing In Connecting Rod—3016—ID	25.025—26.038 mm (0.9852—1.0251 in.)
Wear Limit	26.068 mm (0.9082 in.)
Piston Pin-to-Piston Pin Bushing—3016—Oil Clearance	0.025—0.043 mm (0.0010—0.0017 in.)
Piston Pin Bushing In Connecting Rod—4TNE98—ID	30.025—30.038 mm (1.1821—1.1826 in.)
Wear Limit	30.068 mm (1.1838 in.)

Continued on next page

RG,RG34710,8114 –19–15APR97–1/2

Specification

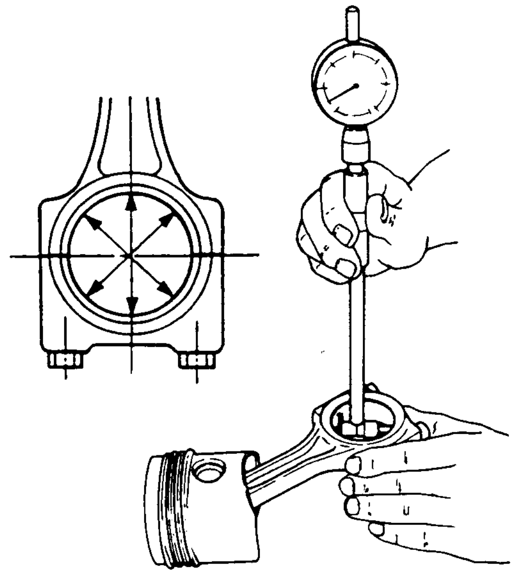
Piston Pin-to-Piston Pin
Bushing—4TNE98—Oil
Clearance .... 0.025—0.051 mm
(0.0010—0.0020 in.)
Wear Limit .... 0.109 mm (0.0043 in.)

RG,RG34710,8114 –19–15APR97–2/2

Measure Connecting Rod Bearings

Install connecting rod cap and bearing inserts on connecting rod. Install old connecting rod cap screws and tighten to specifications.

Specification	
Connecting Rod Cap Screw—3009—Torque	83 N•m (61 lb-ft)
Connecting Rod Cap Screw—3011, 3012, 3013—Torque	39 N•m (29 lb-ft)
Connecting Rod Cap Screw—3015, 4020—Torque	49—59 N•m (36—43 lb-ft)
Connecting Rod Cap Screw—3016—Torque	47 N•m (35 lb-ft)
Connecting Rod Cap Screw—4TNE98—Torque	54 N•m (35 lb-ft)



Measuring Connecting Rod Bearings

Measure inside diameter of bearing at three places as shown.

If bearing diameter exceeds wear limit, replace bearing inserts.

If bearing clearance with new bearing inserts (bearing ID minus crankshaft journal OD) exceeds specification, grind crankshaft connecting rod journals and install undersized bearing inserts, or replace bearing inserts and crankshaft.

Specification	
Connecting Rod Bearing—3009—ID	40.00—40.042 mm (1.575—1.577 in.)
Wear Limit	40.07 mm (1.578 in.)
Connecting Rod Bearing—3011, 3012, 3013—ID	43.00—43.042 mm (1.693—1.695 in.)
Wear Limit (3011, 3012)	43.07 mm (1.696 in.)
Connecting Rod Bearing—3015, 3016, 4020—ID	48.00—48.028 mm (1.888—1.891 in.)
Wear Limit	48.07 mm (1.893 in.)
Connecting Rod Bearing—4TNE98—ID	58.018—58.028 mm (2.2842—2.2846 in.)
Wear Limit	58.070 mm (2.286 in.)

RG,RG34710,8115 –19–15APR97–1/1

Inspect and Clean Cylinder Block

Before inspecting and cleaning cylinder block, remove all of the following:

- Soft plugs
- Oil galley plugs
- All internal and external mounted components. (Refer to the proper group for removal procedures.)

IMPORTANT: If block is cleaned in a hot tank, remove any aluminum parts (such as gallery plugs) which can be damaged by hot tank solutions.

1. Clean block thoroughly using cleaning solvent, pressure steam or a hot tank.

2. All passages and crevices must be clear of sludge and grease.

3. All coolant passages must be free of lime deposits and scale.

RG,RG34710,8120 –19–15APR97–1/1

Measure Camshaft Follower Bores in Block

Measure camshaft follower bores at all bore locations in block.

If any one camshaft follower bore ID or cam follower-to-follower bore clearance exceeds specification, install a new cylinder block.

Inspect and measure cam followers. (See INSPECT CAM FOLLOWERS in Group 050.)

Specification	
Camshaft Follower Bore—3009—ID	21.00—21.021 mm (0.8268—0.8276 in.)
Wear Limit	21.05 mm (0.829 in.)
Camshaft Follower-to-Bore—3009—Oil Clearance	0.040—0.094 mm (0.0016—0.0037 in.)
Camshaft Follower Bore—3011, 3012, 3015, 4020, 4TNE98—ID	12.00—12.018 mm (0.472—0.473 in.)
Wear Limit	12.05 mm (0.474 in.)
Camshaft Follower-to-Bore—3011, 3012, 3015, 4020, 4TNE98—Oil Clearance	0.010 (0.0004 in.)
Camshaft Follower Bore—3013, 3016—ID	12.00—12.025 mm (0.4724—0.4734 in.)
Wear Limit	12.045 mm (0.4742 in.)
Camshaft Follower-to-Bore—3013, 3016—Oil Clearance	0.010—0.050 (0.0004—0.0019 in.)
Wear Limit	0.090 (0.0035 in.)

RG,RG34710,8121 –19–15APR97–1/1

Measure Camshaft Bushing and Bores in Block

NOTE: Replaceable bushing (A) is installed in front camshaft bore only. Remaining bores in cylinder block act as camshaft bushings.

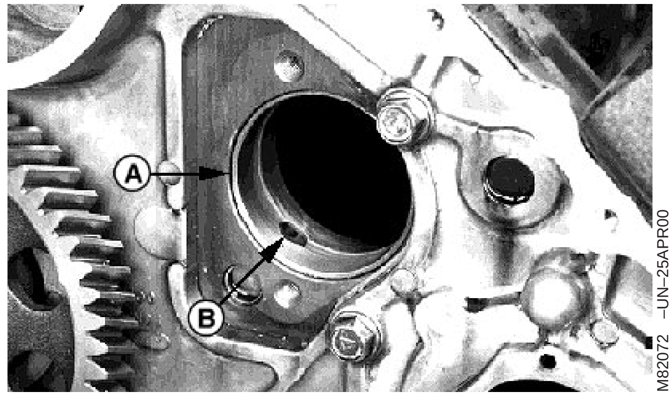
1. Measure camshaft bushing diameter at gear housing end.

   If bushing diameter is not within specification, replace bushing.

2. To replace bushing:

   a. Remove bushing using a chisel. Be careful not to push bushing inside of engine.

   b. Align oil holes in new bushing and cylinder block. Install bushing using a driver set.



Camshaft Bushing at Gear Housing End

A—Camshaft Bushing
B—Oil Hole

Continued on next page RG,RG34710,8122 –19–15APR97–1/3

3. Remove flywheel housing/plate. (See REMOVE AND INSTALL FLYWHEEL HOUSING in Group 040.)

4. Remove plug (A) using a long wooden dowel. Insert wooden dowel through gear housing side.

5. Measure intermediate (B) and flywheel end (C) camshaft bore diameters. If bore diameter exceeds specification, replace cylinder block.

6. Apply LOCTITE® 515 (PM38655) Flexible Form-In-Place Gasket on outer edge of plug. Install plug until it bottoms in bore.

   Install flywheel housing. (See REMOVE AND INSTALL FLYWHEEL HOUSING in Group 040.)

Camshaft Bore—3009—Specification

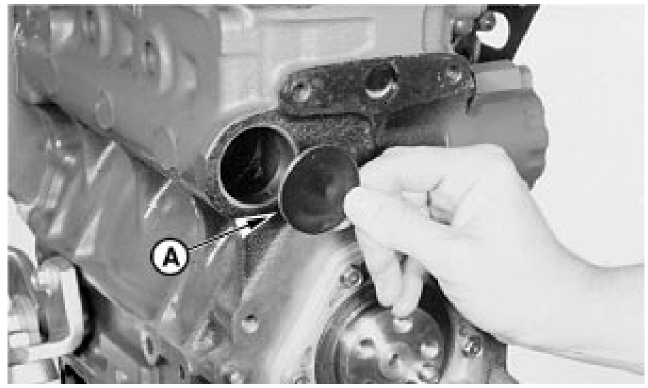
Gear Housing End (Bushing)—ID	40.00—40.025 mm (1.575—1.576 in.)
Wear Limit	40.10 mm (1.579 in.)
Intermediate and Flywheel-End Bores—ID	40.00—40.025 mm (1.575—1.576 in.)
Wear Limit	40.10 mm (1.579 in.)
Camshaft Journal-to-Bushing or Block—Oil Clearance	0.18 mm (0.007 in.)

Camshaft Bore—3011, 3012, 3015, 4020—Specification

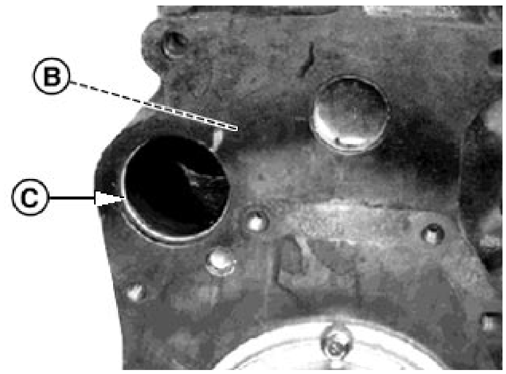
Gear Housing End (Bushing)—ID	44.990—45.055 mm (1.771—1.774 in.)
Wear Limit	45.10 mm (1.776 in.)
Intermediate and Flywheel-End Bores—ID	45.00—45.025 mm (1.772—1.773 in.)
Wear Limit	45.10 mm (1.776 in.)
Camshaft Journal-to-Bushing or Block—Oil Clearance	0.20 mm (0.0078 in.)

Camshaft Bore—3013, 3016—Specification

Gear Housing End (Bushing)—ID	44.990—45.055 mm (1.771—1.774 in.)
Wear Limit	45.13 mm (1.777 in.)
Intermediate and Flywheel-End Bores—ID	45.00—45.025 mm (1.772—1.773 in.)
Wear Limit	45.10 mm (1.776 in.)



Flywheel End Plug



Intermediate and Flywheel Bores

A—Plug
B—Intermediate Bores
C—Flywheel-End Bore

Continued on next page

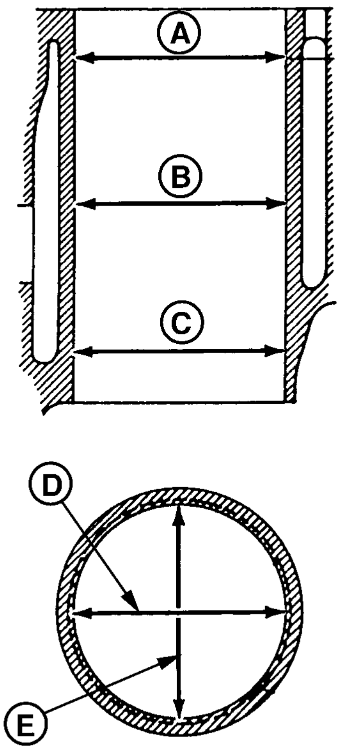
Camshaft Journal-to-Bushing—
Gear Housing End—Oil
Clearance .... 0.040—0.130 mm
(0.0016—0.0051 in.)
Wear Limit .... 0.240 mm (0.0094 in.)
Camshaft Journal-to-Block—
Intermediate—Oil Clearance .... 0.065—0.115 mm
(0.0026—0.0045 in.)
Wear Limit .... 0.225 mm (0.0089 in.)
Camshaft Journal-to-Block—
Flywheel End—Oil Clearance .... 0.050—0.100 mm
(0.0020—0.0039 in.)
Wear Limit .... 0.210 mm (0.0083 in.)

Camshaft Bore—4TNE98—Specification

Gear Housing End (Bushing)—ID............................ 49.990—50.055 mm
(1.9681—1.9706 in.)
Wear Limit .... 50.130 mm (1.9736 in.)
Intermediate and Flywheel-End
Bores—ID .... 50.00—50.025 mm
(1.9685—1.9694 in.)
Wear Limit .... 50.10 mm (1.972 in.)
Camshaft Journal-to-Bushing—
Gear Housing End—Oil
Clearance .... 0.040—0.130 mm
(0.0016—0.0051 in.)
Wear Limit .... 0.240 mm (0.0094 in.)
Camshaft Journal-to-Block Oil—
Intermediate—Oil Clearance .... 0.065—0.115 mm
(0.0025—0.0045 in.)
Wear Limit .... 0.225 mm (0.0088 in.)
Camshaft Journal-to-Block—
Flywheel End—Oil Clearance .... 0.050—0.100 mm
(0.0019—0.0039 in.)
Wear Limit .... 0.210 mm (0.0082 in.)

RG,RG34710,8122 –19–15APR97–3/3

Inspect and Measure Cylinder Bore



A—Top Position
B—Middle Position
C—Bottom Position
D—Direction of Crankshaft Rotation
E—Direction of Crankshaft Centerline

Measure cylinder bore diameter at three positions: top, middle and bottom. At these three positions, measure in both directions: along crankshaft centerline and in direction of crankshaft rotation.

NOTE: If engine has had a previous major overhaul, oversize pistons and rings may have been installed.

Slight uneven wear, flaws, or minor damage may be corrected by deglazing. (See DEGLAZE CYLINDER BORES in this group.)

If cylinder bore exceeds wear limit, replace cylinder block or have cylinder rebored. (See REBORE CYLINDER BORES later in this group.)

If cylinder is rebored, oversize pistons and rings must be installed. Pistons and rings are available in 0.25 mm (0.010 in.) oversize.

If clearance (cylinder bore ID minus piston OD) exceeds specification, replace cylinder block, piston or both; or rebore cylinder and install oversize piston and rings.

Cylinder Bore—3009—Specification

Standard Bore—Diameter	72.00—72.03 mm (2.835—2.836 in.)
Wear Limit	72.20 mm (2.843 in.)
0.25 mm (0.010 in.) Oversize Bore—Diameter	72.25—72.28 mm (2.845—2.846 in.)
Wear Limit	72.45 mm (2.852 in.)
Piston-to-Cylinder Bore—Clearance	0.078 mm (0.003 in.)

Cylinder Bore—3011, 3012—Specification

Standard Bore—Diameter	78.00—78.03 mm (3.071—3.072 in.)
Wear Limit	78.20 mm (3.079 in.)
0.25 mm (0.010 in.) Oversize Bore—Diameter	78.25—78.28 mm (3.081—3.082 in.)
Wear Limit	78.45 mm (3.089 in.)
Piston-to-Cylinder Bore—Clearance	0.035—0.065 mm (0.0014—0.0026 in.)

Continued on next page

Cylinder Bore—3013—Specification

Standard Bore—Diameter	82.00—82.03 mm (3.228—3.2295 in.)
Wear Limit	82.20 mm (3.236 in.)
0.25 mm (0.010 in.) Oversize Bore—Diameter	82.25—82.28 mm (3.238—3.239 in.)
Wear Limit	82.45 mm (3.245 in.)
Piston-to-Cylinder Bore—Clearance	0.035—0.065 mm (0.0014—0.0026 in.)

Cylinder Bore—3015, 4020—Specification

Standard Bore—Diameter	84.00—84.03 mm (3.307—3.308 in.)
Wear Limit	84.20 mm (3.315 in.)
0.25 mm (0.010 in.) Oversize Bore—Diameter	84.25—84.28 mm (3.317—3.318 in.)
Wear Limit	84.45 mm (3.325 in.)
Piston-to-Cylinder Bore—Clearance	0.055 mm (0.002 in.)

Cylinder Bore—3016—Specification

Standard Bore—Diameter	88.00—88.03 mm (3.4646—3.4657 in.)
Wear Limit	88.20 mm (3.472 in.)
0.25 mm (0.010 in.) Oversize Bore—Diameter	88.25—88.28 mm (3.4744—3.4756 in.)
Wear Limit	88.45 mm (3.482 in.)
Piston-to-Cylinder Bore—Clearance	0.040—0.070 mm (0.0016—0.0028 in.)

Cylinder Bore—4TNE98—Specification

Standard Bore—Diameter	98.00—98.03 mm (3.858—3.859 in.)
Wear Limit	98.13 mm (3.863 in.)
0.25 mm (0.010 in.) Oversize Bore—Diameter	98.25—98.28 mm (3.868—3.869 in.)
Wear Limit	98.38 mm (3.873 in.)
Piston-to-Cylinder Bore—Clearance	0.050—0.080 mm (0.0019—0.0031 in.)

Cylinder Bore—All Models—Specification

Cylinder—Out-of-Round	0.01 mm (0.0004 in.)
Wear Limit	0.03 mm (0.0012 in.)
Cylinder—Taper	0.01 mm (0.0004 in.)
Wear Limit	0.03 mm (0.0012 in.)

RG,RG34710,8117 –19–15APR97–2/2

Deglaze Cylinder Bores

If cylinder bores have slight uneven wear, or minor flaws or damage, they can possibly be corrected by deglazing.

IMPORTANT: If cylinder bores are to be deglazed with crankshaft installed in engine, put clean shop towels over crankshaft to protect journal and bearing surfaces from any abrasives.

1. Deglaze cylinder bores using a flex-hone with 300 grit stones.

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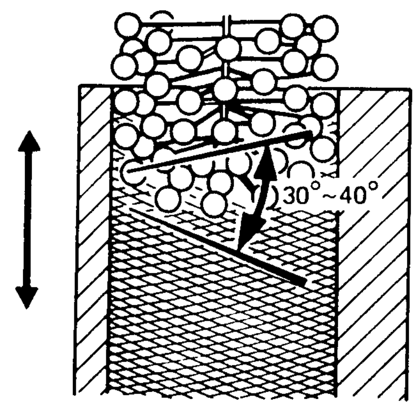
030
31

RG,RG34710,8118 –19–15APR97–1/2

2. Use flex-hone as instructed by manufacturer to obtain a **30—40° crosshatch pattern** as shown.

IMPORTANT: Do not use gasoline, kerosene or commercial solvents to clean cylinder bores. Solvents will not remove all abrasives from cylinder walls.

3. Remove excess abrasive residue from cylinder walls using a clean dry rag. Clean cylinder walls using clean white rags and warm soapy water. Continue to clean cylinder until white rags show no discoloration.



M82054A –UN–12JUN00

30—40° Crosshatch Pattern

RG,RG34710,8118 –19–15APR97–2/2

Rebore Cylinder Bores

NOTE: The cylinder block can be rebored to use oversize pistons and rings. Pistons and rings are available in 0.25 mm (0.010 in.) oversize for all engines. (See INSPECT AND MEASURE CYLINDER BORE earlier in this group.)

1. Align center of bore to drill press center.

IMPORTANT: Check stone for wear or damage. Use a rigid hone with 180 grit stones.

2. Adjust hone so lower end is even with lower end of cylinder bore.

3. Adjust rigid hone stones until they contact narrowest point of cylinder.

4. Coat cylinder with honing oil. Hone should turn by hand. Adjust if too tight.

Continued on next page RG,RG34710,8119 –19–15APR97–1/2

5. Run drill press at about 250 rpm. Move hone up and down in order to obtain a **30—40° crosshatch pattern.**

NOTE: Measure bore when cylinder is cool.

6. Stop press and check cylinder diameter.

NOTE: Finish should not be smooth. It should have a 30—40° crosshatch pattern.

7. Remove rigid hone when cylinder is within 0.03 mm (0.001 in.) of desired size.

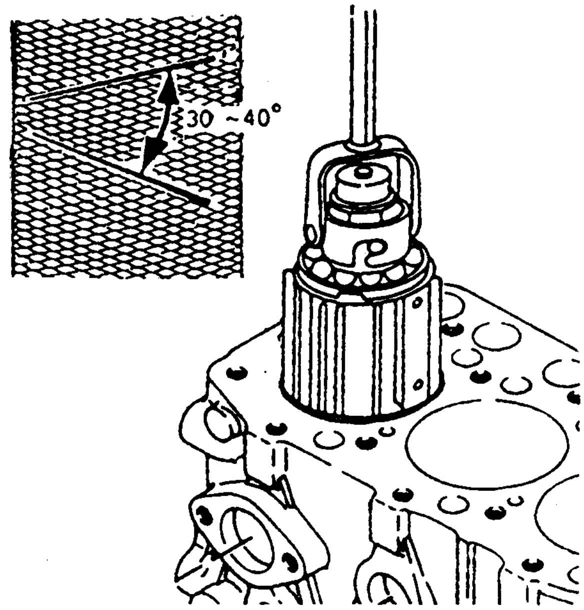
8. Use a flex hone with 300 grit stones for honing to final size.

9. Check bore for size, taper and out-of-round. (See INSPECT AND MEASURE CYLINDER BORE in this group.)

IMPORTANT: Do not use solvents to clean cylinder bore. Solvents will not remove all metal particles and abrasives produced during honing.

10. Clean cylinder thoroughly using warm soapy water until clean white rags show no discoloration.

11. Dry cylinder and apply engine oil.



M52959 –UN–05APR89

Using Rigid Hone

RG,RG34710,8119 –19–15APR97–2/2

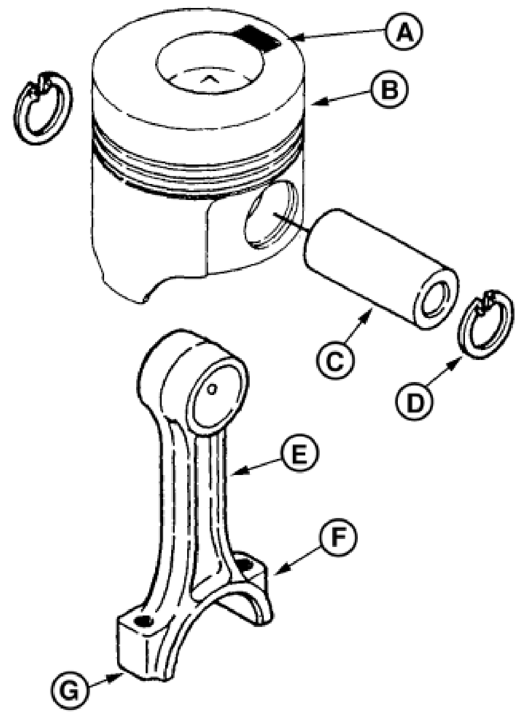
Assemble Piston and Connecting Rod

IMPORTANT: Pistons must be installed on the same connecting rod they were removed from, and new piston pin snap rings must be used.

NOTE: Apply clean engine oil to all parts during assembly.

1. Assemble piston to connecting rod with piston identification mark “M” (A) on same side as connecting rod stamped mark (F). If a new connecting rod is used, assemble piston to connecting rod with piston mark “M” opposite connecting rod bearing insert groove (G). Be sure oil hole in piston pin bushing is aligned with hole in connecting rod.

2. Install piston pin and new snap rings.

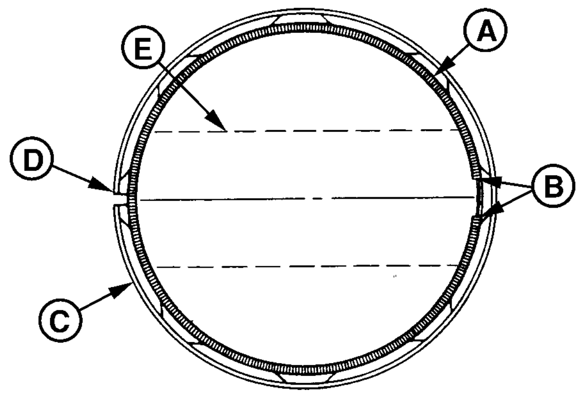


Assemble Piston and Connecting Rod

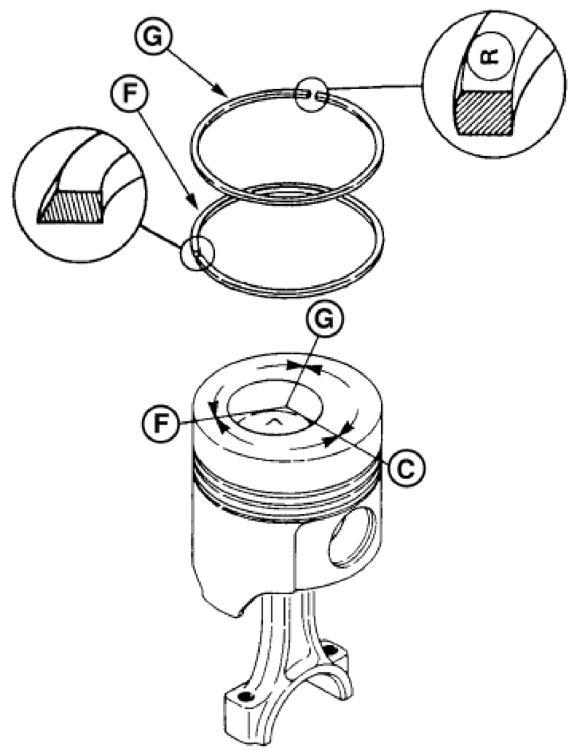
A—Piston Mark “M”
B—Piston
C—Piston Pin
D—Snap Ring
E—Connecting Rod
F—Stamped Mark
G—Bearing Insert Groove

RG,RG34710,8123 –19–15APR97–1/1

Install Piston Rings



Oil Ring Components



Piston Assembly

1. Install oil ring expander (A) in bottom ring groove of piston with ends above either end of piston pin (E).

2. Install oil ring over expander with ring gap (D) opposite (180°) of expander ends (B).

3. Install second compression ring, with manufacturer's mark (near ring gap) toward top of piston, in middle groove. Turn ring until gap is 120° away from oil ring gap.

4. Install first compression ring (chrome plated), with manufacturer's mark "R", "T" or "RN" (near ring gap) toward top of piston, in top groove. Turn ring until gap is 120° away from second ring gap and oil ring gap.

A—Oil Ring Expander
B—Oil Ring Expander Ends
C—Oil Ring
D—Oil Ring Gap
E—Piston Pin
F—Second Compression Ring
G—First Compression Ring

RG,RG34710,8124 –19–15APR97–1/1

Install Piston and Connecting Rod Assembly

IMPORTANT: Pistons must be installed in cylinders from which they were removed and in the same direction. Be careful not to damage crankshaft rod journal while installing piston.

NOTE: Apply clean engine oil on all parts during installation.

Never reuse connecting rod cap screws; replace with new.

1. Coat piston, cylinder bore, and piston ring compressor with clean engine oil.
2. Rotate crankshaft so that connecting rod journal for the cylinder you working on is at bottom dead center.

IMPORTANT: Ensure rings are correctly staggered before installing ring compressor.

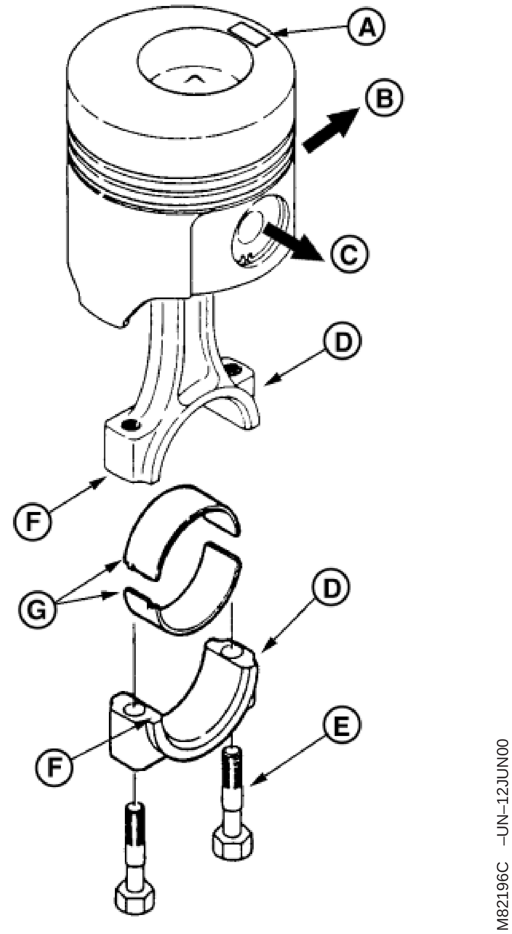
3. Install piston ring compressor over piston and rings, and tighten.
4. Install piston and connecting rod into the cylinder from which it was removed, with alignment mark (D) on connecting rod and/or with piston size mark (A) on top of piston toward fuel injection pump side of engine.

IMPORTANT: Do not touch bearing insert surfaces. Oil and acid from your finger will corrode the bearing surface.

5. Install bearing insert on connecting rod and rod cap, aligning tangs with grooves.
6. Apply clean engine oil to both bearing inserts and crankshaft journal. Carefully pull rod against crankshaft journal.

IMPORTANT: Connecting rod caps must be installed on the same connecting rods they were removed from.

7. Install cap on connecting rod with match marks on same side.



A—Piston Mark "M"
B—Fuel Injection Pump Side
C—Flywheel Side
D—Connecting Rod Alignment Mark
E—Connecting Rod Cap Screw
F—Groove
G—Tangs

Continued on next page

RG,RG34710,8125 –19–15APR97–1/2

8. Dip new connecting rod cap screws in clean engine oil. Install cap screws and tighten to specifications.

9. Repeat with remaining cylinders.

Specification

Connecting Rod Cap Screw—3009—Torque	23 N•m (203 lb-in.)
Connecting Rod Cap Screw—3011, 3012, 3013—Torque	39 N•m (29 lb-ft)
Connecting Rod Cap Screw—3015, 3016, 4020—Torque	47 N•m (35 lb-ft)
Connecting Rod Cap Screw—4TNE98—Torque	54 N•m (40 lb-ft)

10. If a new piston and connecting rod were installed, stamp a number corresponding to the cylinder number on the connecting rod cap and connecting rod.

11. Install cylinder head. (See INSTALL CYLINDER HEAD in Group 020.)

12. Install oil pan and strainer tube. (See REMOVE AND INSTALL OIL PAN AND STRAINER in Group 060.)

RG,RG34710,8125 –19–15APR97–2/2

Check Engine Rotation for Excessive Tightness

1. Rotate crankshaft several revolutions to be sure engine rotates without excessive tightness.

2. Check cylinder bores for deep scratches caused by an improperly installed or broken piston ring.

3. Check side clearance of connecting rods. (See MEASURE CONNECTING ROD SIDE PLAY in this group.)

RG,RG34710,8126 –19–15APR97–1/1

Complete Final Assembly

1. Install all coolant and oil galley plugs

2. Install piston cooling orifices (4020T only). (See REPLACE PISTON COOLING NOZZLES—4020T in Group 060.)

3. Install camshaft bushing and rear plug. (See MEASURE CAMSHAFT BUSHING AND BORES IN BLOCK in this group.)

4. Install crankshaft and main bearings. (See INSTALL CRANKSHAFT AND MAIN BEARINGS in Group 050.)

5. Install front plate or housing. (See REMOVE AND INSTALL TIMING GEAR HOUSING—3009 or REMOVE AND INSTALL TIMING GEAR COVER MOUNTING PLATE—3011, 3012, 3013, 3015, 3016 & 4020 or REMOVE AND INSTALL TIMING GEAR HOUSING—4TNE98 in Group 050.)

6. Install oil pump, strainer, and oil pan. (See REMOVE AND INSTALL ENGINE OIL PUMP—3009, 3011, 3012, 3015, 4020 AND 4TNE98 or REMOVE AND INSTALL ENGINE OIL PUMP—3013 AND 3016 and REMOVE AND INSTALL OIL PAN AND STRAINER in Group 060.)

7. Install timing gear cover, timing gears, camshaft followers, and camshaft. (See REMOVE AND INSTALL TIMING GEAR COVER and INSTALL CAMSHAFT in Group 050.)

8. Install oil pressure regulating plug, valve, and spring in oil filter housing (3009, 3011, 3012). Install oil filter housing. (See REMOVE AND INSTALL OIL PRESSURE REGULATING VALVE in Group 060.)

9. Install cylinder head, rocker arm components, and rocker arm cover. (See INSTALL CYLINDER HEAD in Group 020.)

10. Install intake and exhaust manifolds. (See REMOVE AND INSTALL INTAKE MANIFOLD and REMOVE AND INSTALL EXHAUST MANIFOLD in Group 080.)

RG,10,DT7383 –19–07APR04–1/1

Crankshaft and Main Bearing Failure Analysis

Scored Main Bearing: (Diagnosis also applies to connecting rod bearing.)

- Oil starvation.
- Contaminated oil.
- Engine parts failure.
- Excessive heat.
- Poor periodic service.

Galled or “Wiped” Bearings:

- Fuel in lubricating oil (incomplete combustion).
- Coolant in lubrication system (cracked block).
- Leaking water pump. (Seal with plugged hole).
- Insufficient bearing oil clearance.
- Parts not lubricated prior to engine operation.
- Wrong bearing size.

Inconsistent Wear Pattern

- Misaligned or bent connecting rod.
- Warped or bowed crankshaft.
- Distorted cylinder block.

Broken Main Bearing Caps:

- Improper installation.
- Dirt between bearing and crankshaft journal.
- Low oil pressure.
- Oil pump failure.

Cracked, Chipped or Broken Bearings:

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

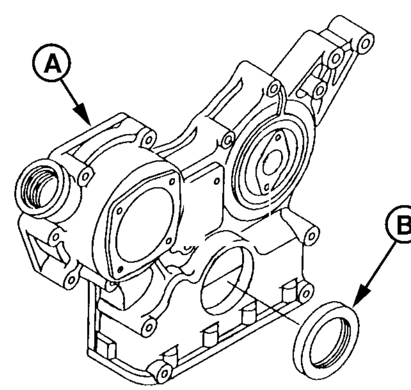
RG,RG34710,8138 –19–15APR97–1/1

Replace Crankshaft Front Oil Seal

1. Remove timing gear cover (A). (See REMOVE AND INSTALL TIMING GEAR HOUSING—3009, REMOVE AND INSTALL TIMING GEAR COVER MOUNTING PLATE—3011, 3012, 3013, 3015, 3016 AND 4020, or REMOVE AND INSTALL TIMING GEAR HOUSING—4TNE98 in Group 050.)

2. Replace oil seal (B) using a driver set. Install seal with lip toward inside of gear housing cover. Install seal flush with surface of cover.

A—Timing Gear Cover
B—Oil Seal



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Timing Gear Cover and Oil Seal

RG,RG34710,8139 –19–15APR97–1/1

Measure Crankshaft End Play

NOTE: Crankshaft end play can be measured at front end or rear end of crankshaft. Procedure shown is performed from the rear end. The flywheel is removed to show detail.

1. Fasten dial indicator (A) to engine and position indicator tip on end of crankshaft.

IMPORTANT: Do not use excessive force when moving crankshaft to avoid damaging bearings.

2. Push crankshaft (B) toward rear as far as possible.

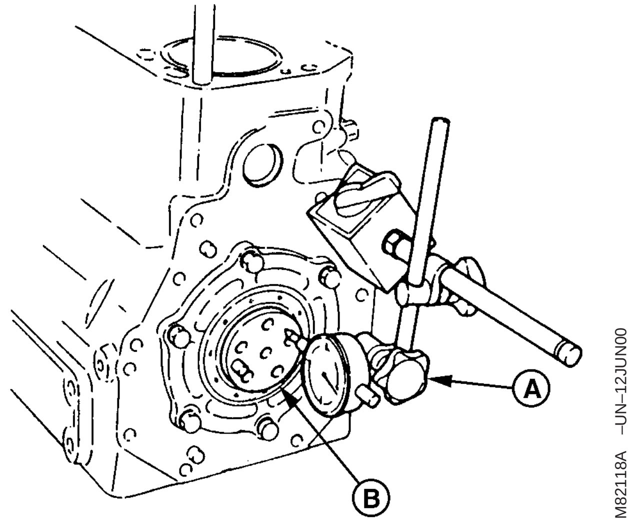
3. Zero the dial indicator.

4. Using a bar, gently pry the crankshaft as far forward as possible.

Specification

Crankshaft—3009—End Play	0.05—0.20 mm (0.002—0.008 in.)
Wear Limit	0.40 mm (0.016 in.)
Crankshaft—3011, 3012, 3015 and 4020—End Play	0.090—0.271 mm (0.004—0.011 in.)
Wear Limit	0.33 mm (0.0129 in.)
Crankshaft—3013 and 3016—End Play	0.13—0.23 mm (0.005—0.009 in.)
Wear Limit	0.28 mm (0.011 in.)
Crankshaft—4TNE98—End Play	0.11—0.21 mm (0.004—0.008 in.)

If end play exceeds wear limit, replace thrust bearings.



Measure Crankshaft End Play

A—Dial Indicator
B—Crankshaft

RG,RG34710,8140 –19–15APR97–1/1

Inspect Flywheel

1. Inspect the clutch contact face for scoring, overheating, or cracks. Replace or resurface flywheel if defective.

2. Examine flywheel ring gear for worn or broken teeth. Replace flywheel if defective.

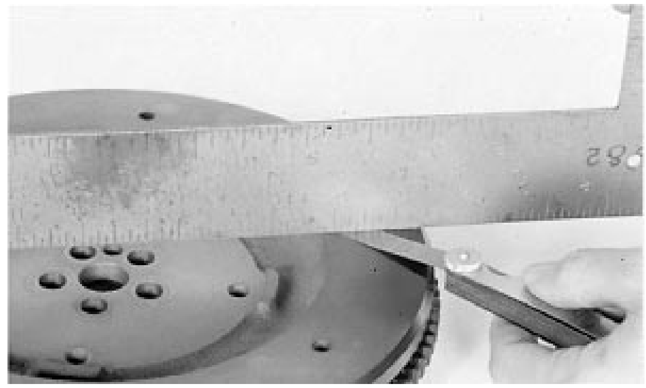
RG,RG34710,8141 –19–15APR97–1/1

Check Flywheel Face Flatness

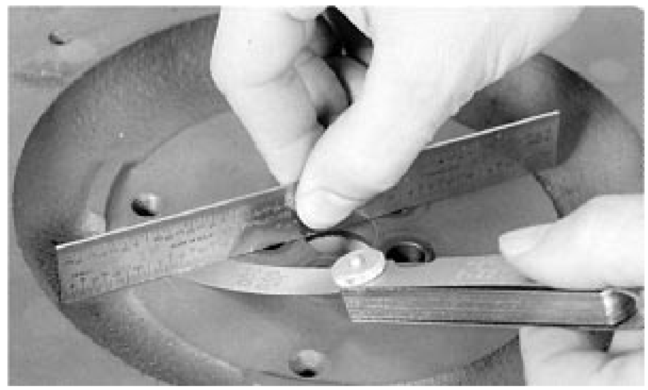
Measure flywheel flatness. Place a straightedge across flywheel surface opposite of ring gear. Measure clearance between straightedge and flywheel surface with a feeler gauge. If clearance exceeds specification, replace flywheel.

Specification

Flywheel—Out-of-Flatness .... 0.02 mm (0.0007 in.) maximum


M35337 –UN–29AUG88

Measuring Flywheel Face Flatness


M35336 –UN–29AUG88

RG,RG34710,8142 –19–15APR97–1/1

Remove and Install Flywheel

NOTE: Model 3009 is shown. Other models are similar.

1. For Model 3009, remove bearing housing (C).

2. Remove mounting cap screws (D) and flywheel (E).

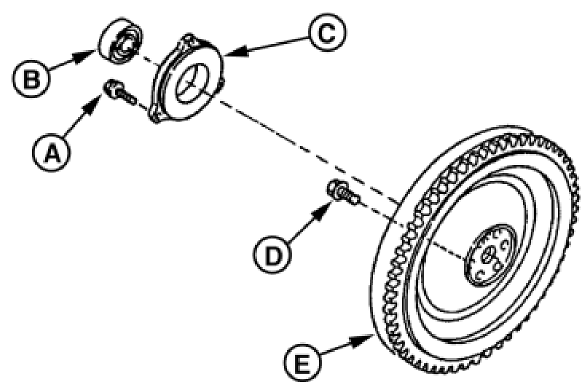
IMPORTANT: Never reuse flywheel mounting cap screws. Always install new cap screws.

3. Apply clean engine oil to flywheel mounting cap screws and tighten to specification.

Specification

Flywheel Cap Screw—Torque.. 83 N•m (61 lb-ft)

4. For 3009, install bearing housing (C).



RG11085A –UN–12JUN00

A—Cap Screw (3009 Only)
B—Bearing (3009 Only)
C—Bearing Housing (3009 Only)
D—Flywheel Mounting Cap Screws
E—Flywheel

RG,RG34710,8143 –19–15APR97–1/1

Replace Crankshaft Rear Oil Seal

1. Remove flywheel. (See REMOVE AND INSTALL FLYWHEEL in this group.)

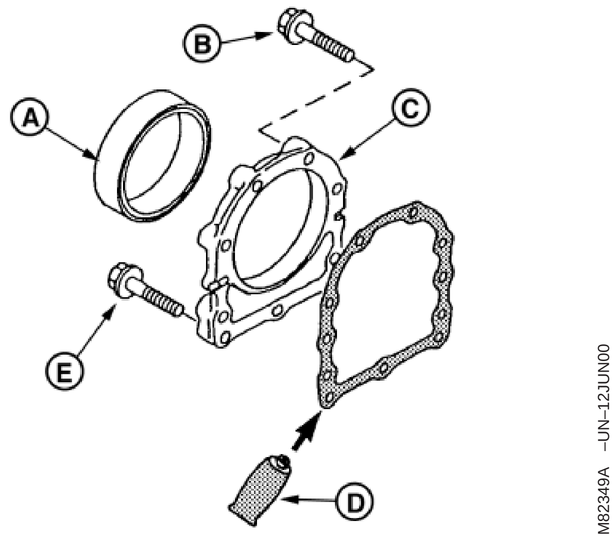
2. Remove rear oil seal case (C).

3. Replace oil seal (A) using a driver set. Install seal, with lip toward cylinder block. Install seal flush with surface of oil seal case.

NOTE: If crankshaft is grooved at oil seal contact point, seal can be installed 3 mm (0.120 in.) farther into oil seal case.

4. Apply LOCTITE® 515 (PM38655) Flexible Form-In-Place Gasket to oil seal case mounting surface.

5. Install rear oil seal case and tighten cap screws securely.



Crankshaft Rear Oil Seal Components

A—Rear Oil Seal
B—Oil Seal Case-to-Cylinder Block Cap Screw
C—Oil Seal Case
D—Flexible Form-In-Place Gasket
E—Oil Seal Case-to-Crankcase Extension Cap Screw

LOCTITE is a trademark of Loctite Corp.

RG,RG34710,8144 –19–15APR97–1/1

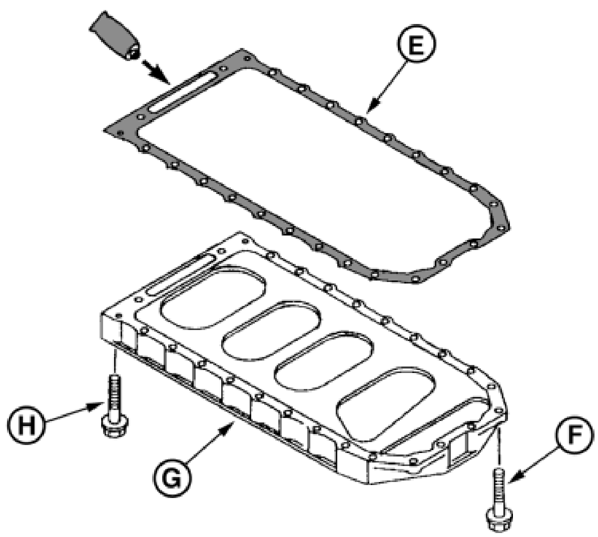
Remove and Install Crankcase Extension Housing

NOTE: Model 3015 is pictured. Other models are similar.

1. Remove flywheel. (See REMOVE AND INSTALL FLYWHEEL in this group.)
2. Remove oil pan. (See REMOVE AND INSTALL OIL PAN AND STRAINER in Group 060.)
3. Remove rear oil seal case-to-crankcase extension housing cap screws (D) and flywheel housing-to-crankcase extension housing cap screws. (C).
4. Remove crankcase extension housing cap screws (F and H) and crankcase extension housing (G).
5. Inspect crankcase extension housing for cracks.
6. Apply LOCTITE® 515 (PM38655) Flexible Form-In-Place Gasket in a continuous 2—4 mm (0.080—0.157 in.) bead to crankcase extension housing.
7. Install extension housing and tighten cap screws to specification.

Specification	
Rear Oil Seal Case-to-Crankcase Extension Housing Cap Screws—3009—Torque	9 N•m (78 lb-in.)
Flywheel Housing-to-Crankcase Extension Housing Cap Screws—3009—Torque	49 N•m (36 lb-ft)
Crankcase Extension Housing-to-Cylinder Block Cap Screws—3009—Torque	27 N•m (20 lb-ft)
Crankcase Extension Housing-to-Timing Gear Cover Cap Screws—3009—Torque	22 N•m (195 lb-in.)
Rear Oil Seal Case-to-Crankcase Extension Housing Cap Screws—3011, 3012, 3013, 3015 and 3016—Torque	21 N•m (186 lb-in.)

M82056 –UN–25APR00



RG10855A –UN–25APR00

A—Flywheel Housing
B—Rear Oil Seal Case
C—Cap Screw (Flywheel Housing-to-Crankcase Extension Housing)
D—Cap Screw (Rear Oil Seal Case-to-Crankcase Extension Housing)
E—Flexible Form-In-Place Gasket
F—Cap Screw (Crankcase Extension Housing-to-Timing Gear Cover)
G—Crankcase Extension Housing
H—Cap Screw (Crankcase Extension Housing-to-Cylinder Block)

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RG,RG34710,8145 –19–15APR97–1/2

Specification

Flywheel Housing-to-Crankcase Extension Housing Cap Screws—3011, 3012, 3013, 3015 and 3016—Torque.. 49 N•m (36 lb-ft)

Crankcase Extension Housing-to-Cylinder Block Cap Screws—3011, 3012, 3013, 3015 and 3016—Torque.. 27 N•m (20 lb-ft)

Crankcase Extension Housing-to-Timing Gear Cover Cap Screws—3011, 3012, 3013, 3015 and 3016—Torque .... 22 N•m (195 lb-in.)

Rear Oil Seal Case-to-Crankcase Extension Housing Cap Screws—4020—Torque.. 26 N•m (230 lb-in.)

Flywheel Housing-to-Crankcase Extension Housing Cap Screws—4020—Torque.. 49 N•m (36 lb-ft)

Crankcase Extension Housing-to-Cylinder Block Cap Screws—4020—Torque .... 27 N•m (20 lb-ft)

Crankcase Extension Housing-to-Timing Gear Cover Cap Screws—4020—Torque....................................... 22 N•m (195 lb-in.)

Flywheel Housing-to-Crankcase Extension Housing Cap Screws—4TNE98—Torque.. 27 N•m (20 lb-ft)

Crankcase Extension Housing-to-Cylinder Block Cap Screws—4TNE98—Torque .... 27 N•m (20 lb-ft)

Crankcase Extension Housing-to-Timing Gear Cover Cap Screws—4TNE98—Torque .... 27 N•m (20 lb-ft)

RG,RG34710,8145 –19–15APR97–2/2

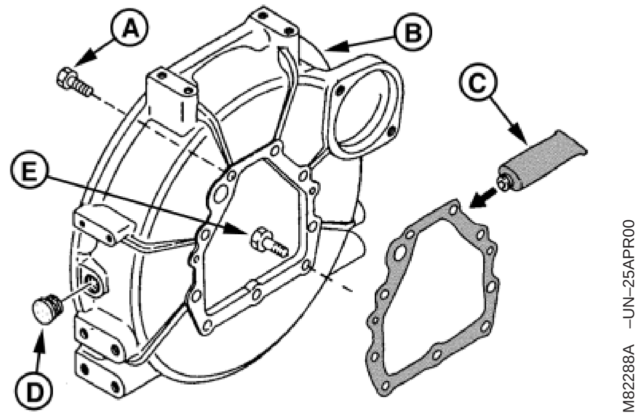
Remove and Install Flywheel Housing

NOTE: Model 3009 shown. Other models are similar.

1. Remove flywheel. (See REMOVE AND INSTALL FLYWHEEL in this group.)
2. Remove starting motor.
3. Remove cap screws (A and E) and remove flywheel housing.
4. When installing, apply a bead of LOCTITE® 515 (PM38655) Flexible Form-In-Place Gasket to mounting flange of flywheel housing.
5. Tighten cap screws (A and E) to specification.

Specification

Flywheel Housing-to-Cylinder Block Cap Screw—3009, 3011, 3012, 3013, 3015, 3016 and 4022—Torque	49 N•m (36 lb-ft)
Flywheel Housing-to-Crankcase Extension Cap Screw—3009, 3011, 3012, 3013, 3015, 3016 and 4022—Torque	49 N•m (36 lb-ft)
Flywheel Housing-to-Cylinder Block Cap Screw—4TNE98—Torque	49 N•m (36 lb-ft)
Flywheel Housing-to-Crankcase Extension Cap Screw—4TNE98—Torque	27 N•m (20 lb-ft)



Model 3009

A—Flywheel Housing-to-Cylinder Block Cap Screw
B—Flywheel Housing
C—Flexible Form-In-Place Gasket
D—Plug
E—Flywheel Housing-to-Crankcase Extension Cap Screw

RG,RG34710,8146 –19–15APR97–1/1

Remove and Install Flywheel Plate

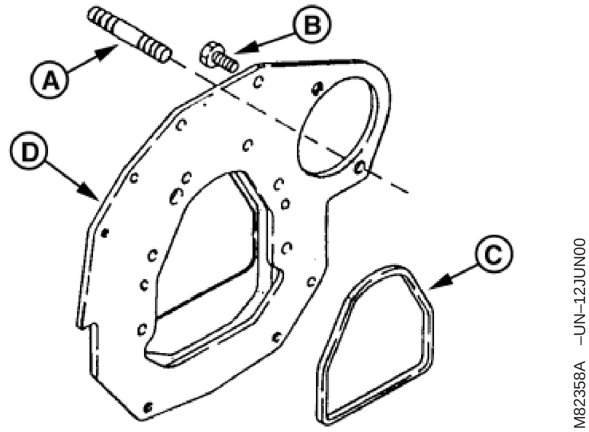
NOTE: Model 3009 is shown. Other models are similar.

1. Remove flywheel. (See REMOVE AND INSTALL FLYWHEEL in this group.)

2. Remove starter.

3. Remove flywheel plate (D) and foam seal (C).

4. Install in reverse order of removal. Install a new foam seal (C).



Model 3009

A—Stud
B—Mounting Cap Screw
C—Foam Seal
D—Flywheel Plate

RG,RG34710,8147 –19–15APR97–1/1

Remove Crankshaft and Main Bearings

1. Drain oil for crankcase.

2. Check crankshaft end play. (See MEASURE CRANKSHAFT END PLAY in this group.)

3. Remove rear oil seal. (See REPLACE CRANKSHAFT REAR OIL SEAL in this group.)

4. Remove flywheel housing. (See REMOVE AND INSTALL FLYWHEEL HOUSING in this group.)

5. Remove oil pan and crankcase extension housing. (See REMOVE AND INSTALL CRANKCASE EXTENSION HOUSING in this group.)

6. Remove timing gear cover and mounting plate or housing. (See REMOVE AND INSTALL TIMING GEAR HOUSING—3009 or REMOVE AND INSTALL TIMING GEAR COVER MOUNTING PLATE—3011, 3012, 3013, 3015, 3016 AND 4020 or REMOVE AND INSTALL TIMING GEAR HOUSING—4TNE98 in Group 050.)

7. Check crankshaft main bearing clearance. (See MEASURE CRANKSHAFT MAIN BEARING CLEARANCE in this group.)

IMPORTANT: Connecting rod caps must be installed on the same connecting rods from which they were removed. Note alignment marks on caps and rods.

8. Remove connecting rod cap screws and caps. (See REMOVE PISTONS AND CONNECTING RODS in Group 030.)

9. Push pistons and connecting rods away from crankshaft.

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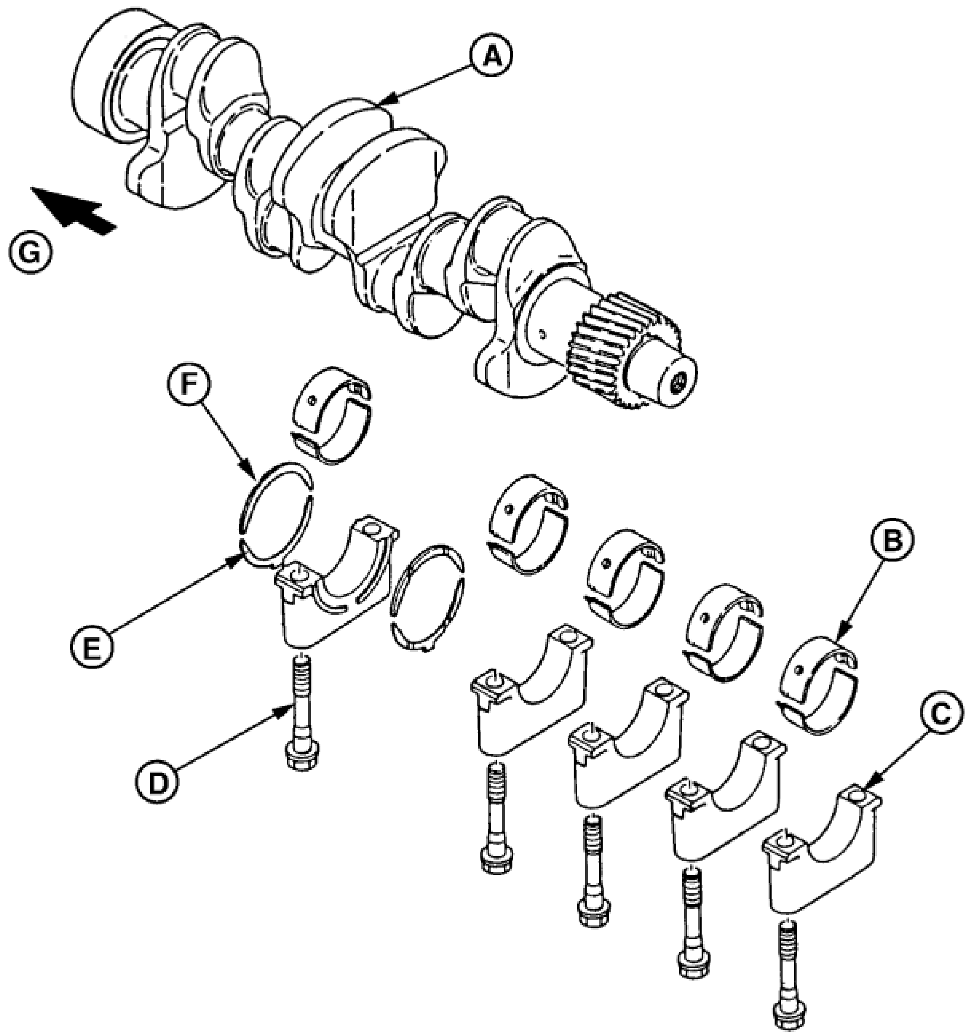
RG,RG34710,8148 –19–15APR97–1/2



A—Crankshaft
B—Main Bearing Inserts
C—Main Bearing Cap
D—Main Bearing Cap Screw
E—Bearing Cap Thrust Bearing
F—Cylinder Block Thrust Bearing
G—Flywheel End of Crankshaft

IMPORTANT: Main bearing caps must be installed on the same main bearings from which they were removed.

NOTE: Model 4020 is pictured. Other models are similar.

10. Remove main bearing cap screws (D), caps (C) and cap thrust bearings (E). Visually inspect condition of bearing inserts and crankshaft journals as bearing caps are removed.

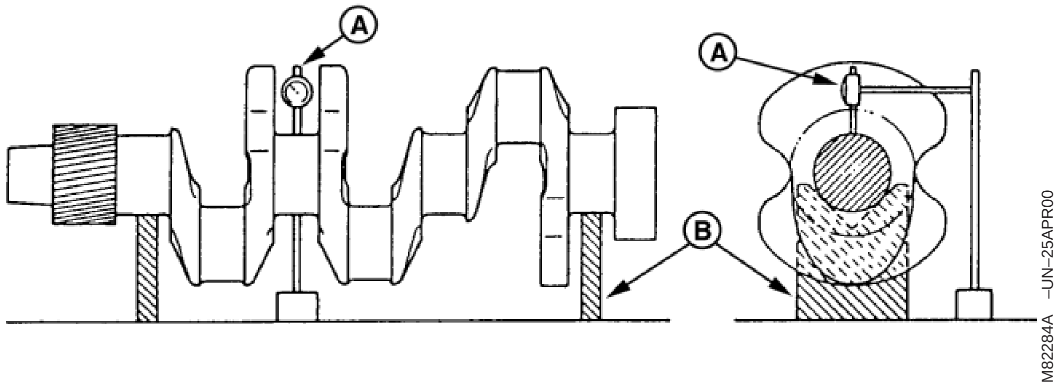
11. Remove crankshaft (A).

12. Remove cylinder block thrust bearing (F) and main bearing inserts (B).

13. Inspect all parts for wear or damage. (See INSPECT CRANKSHAFT AND MAIN BEARINGS in this group.)

RG,RG34710,8148 –19–15APR97–2/2

Inspect Crankshaft and Main Bearings



Measure Crankshaft Bend

1. Inspect crankshaft gear for chipped or broken teeth. Replace if necessary.

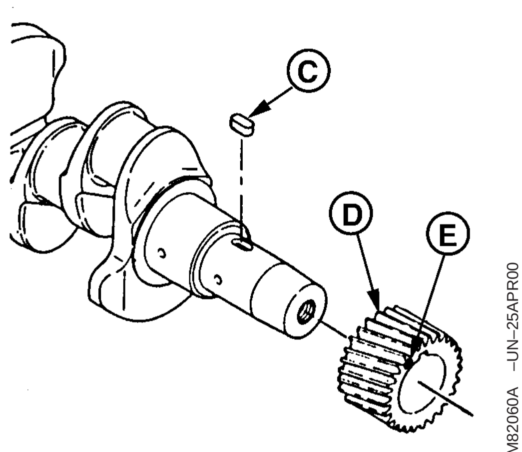
2. If necessary, remove crankshaft gear from crankshaft using a knife-edge puller and a press.

3. To install crankshaft gear, heat new gear to approximately 150°C (300°F). Install gear (D) with timing mark “A” (E) toward end of crankshaft. Align slot in gear with key (C) in shaft. Press crankshaft into gear until gear is tight against crankshaft shoulder.

4. Inspect crankshaft for bend using V-blocks (B) and a dial indicator (A). Turn crankshaft slowly and read runout on indicator. If runout is greater than specification, replace crankshaft.

Specification

Crankshaft—Radial Runout...................... 0.02 mm (0.0007 in.) maximum

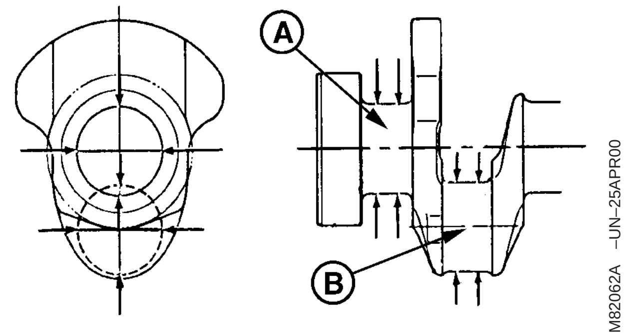


A—Dial Indicator
B—V-Blocks
C—Key
D—Crankshaft Gear
E—Timing Mark “A”

Continued on next page RG,RG34710,8150 –19–15APR97–1/5

5. Measure crankshaft connecting rod journal (B) and main bearing journal (A) diameters. Measure several places around each journal.

NOTE: If engine has had a previous major overhaul, journals may have been ground and undersized bearing inserts installed.



A—Main Bearing Journal
B—Crankshaft Connecting Rod Journal

Specification

Connecting Rod Journal—3009—OD	39.97—39.98 mm (1.5736—1.5740 in.)
Wear Limit	39.92 mm (1.572 in.)
Main Bearing Journal—3009—OD	43.97—43.98 mm (1.7311—1.7315 in.)
Wear Limit	43.92 mm (1.729 in.)
Connecting Rod Journal—3011, 3012 and 3013—OD	42.952—42.962 mm (1.6910—1.6914 in.)
Wear Limit	42.902 mm (1.6891 in.)
Main Bearing Journal—3011, 3012 and 3013—OD	46.952—46.962 mm (1.8485—1.8489 in.)
Wear Limit (3011 and 3012)	46.91 mm (1.847 in.)
Wear Limit (3013)	46.902 mm (1.8465 in.)
Connecting Rod Journal—3015 and 4020—OD	47.952—47.962 mm (1.8879—1.8883 in.)
Wear Limit	47.902 mm (1.8859 in.)
Main Bearing Journal—3015 and 4020—OD	49.952—49.962 mm (1.9666—1.9670 in.)
Wear Limit	49.91 mm (1.9650 in.)
Connecting Rod Journal—3016—OD	47.952—47.962 mm (1.8879—1.8883 in.)
Wear Limit	47.902 mm (1.8859 in.)
Main Bearing Journal—3016—OD	53.952—53.962 (2.1241—2.1245 in.)
Wear Limit	53.902 (2.1221 in.)
Connecting Rod Journal—4TNE98—OD	57.952—57.962 mm (2.2816—2.2820 in.)
Wear Limit	57.902 mm (2.2796 in.)
Main Bearing Journal—4TNE98—OD	64.952—64.962 mm (2.5571—2.5575 in.)
Wear Limit	64.902 mm (2.5551 in.)

If journal diameter is less than wear limit, replace crankshaft or have journals ground undersize by a qualified machine shop.

Continued on next page

If journals are ground, undersize bearing inserts must be installed. Bearing inserts are available in 0.25 mm (0.010 in.) undersize.

Continued on next page RG,RG34710,8150 –19–15APR97–3/5

6. Install bearing inserts and main bearing cap on main bearing. Tighten main bearing cap screws to specifications.

Specification

Main Bearing Cap Screw—3009, 3011, 3012 and 3013—Torque .... 79 N•m (58 lb-ft)
Main Bearing Cap Screw—3015, 3016 and 4020—Torque .... 98 N•m (72 lb-ft)
Main Bearing Cap Screw—4TNE98—Torque....... 108—118 N•m (80—87 lb-ft)

7. Measure main bearing inner diameter as shown.

Specification

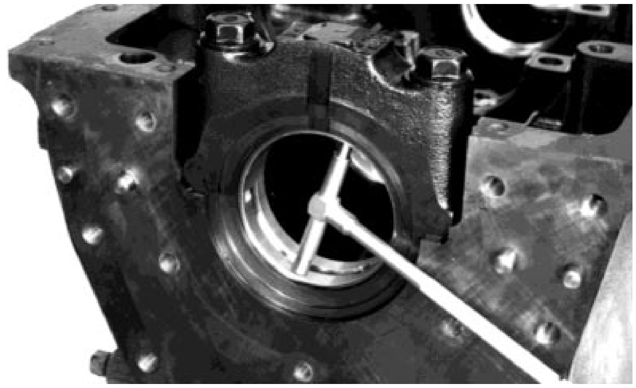
Main Bearing Insert—3009—ID .... 44.00—44.042 mm (1.732—1.734 in.)
Wear Limit .... 44.07 mm (1.735 in.)
Main Bearing Insert—3011 and 3012—ID....... 47.00—47.045 mm (1.850—1.852 in.)
Wear Limit .... 47.10 mm (1.8541 in.)
Main Bearing Insert—3013—ID .... 47.000—47.032 mm (1.8504—1.8516 in.)
Main Bearing Insert—3015 and 4020—ID....... 50.00—50.020 mm (1.9685—1.9693 in.)
Wear Limit .... 50.10 mm (1.9724 in.)
Main Bearing Insert—3016—ID .... 54.000—54.020 mm (2.1260—2.1268 in.)
Main Bearing Insert—4TNE98—ID .... 64.99—65.03 mm (2.5587—2.5602 in.)
Wear Limit .... 65.074 mm (2.5620 in.)

If bearing diameter exceeds wear limit, replace bearing inserts.

If bearing clearance (bearing ID minus crankshaft main bearing journal OD) exceeds specification, replace bearing inserts and crankshaft or have crankshaft journals ground undersize by a qualified machine shop and install undersized bearing inserts.

Specification

Main Bearing-to-Crankshaft—3009, 3011 and 3012—Clearance .... 0.038—0.093 mm (0.0015—0.0037 in.)
Wear Limit .... 0.15 mm (0.0059 in.)
Main Bearing-to-Crankshaft—3013—Clearance....... 0.038—0.080 mm (0.0015—0.0031 in.)
Wear Limit .... 0.150 mm (0.0059 in.)



Measure Main Bearing Inner Diameter

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RG,RG34710,8150 –19–15APR97–4/5

Specification

Main Bearing-to-Crankshaft—
3015, 3016, 4020 and 4TNE98—
Clearance .... 0.038—0.068 mm
(0.0015—0.0027 in.)
Wear Limit .... 0.150 mm (0.0059 in.)

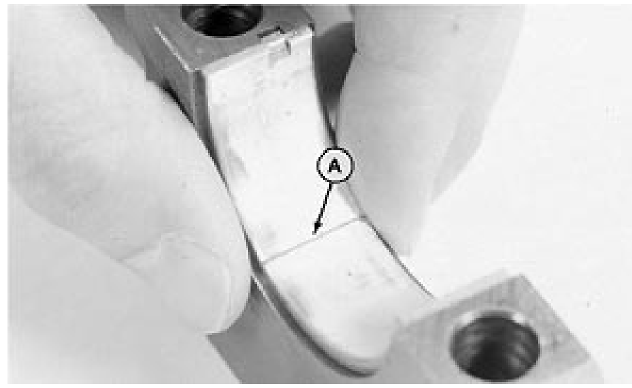
Bearing inserts are available in 0.25 mm (0.010 in.) undersize.

8. Clean and inspect oil passages in main bearing journals, connecting rod journals and main bearing bores in cylinder block.

9. Inspect crankshaft for cracks or damage. Replace if necessary.

RG,RG34710,8150 –19–15APR97–5/5

Measure Crankshaft Main Bearing Clearance



A—PLASTIGAGE®

IMPORTANT: Main bearing caps must be installed on the same main bearing and in the same direction to prevent crankshaft and main bearing damage.

1. Remove main bearing cap.

2. Wipe oil from bearing insert and crankshaft journal.

3. Put a piece of PLASTIGAGE® (A), or an equivalent, along the full width of the bearing insert approximately 6 mm (0.250 in.) off center.

IMPORTANT: Do not rotate crankshaft while PLASTIGAGE® is installed. Doing so will result in a false reading.

4. Install main bearing cap and cap screws. Tighten cap screws to specifications.

Specification	
Main Bearing Cap Screw—3009, 3011, 3012 and 3013—Torque	79 N•m (58 lb-ft)
Main Bearing Cap Screw—3015, 3016 and 4020—Torque	98 N•m (72 lb-ft)
Main Bearing Cap Screw—4TNE98—Torque	108—118 N•m (80—87 lb-ft)

5. Remove cap screws and main bearing cap.

NOTE: The flattened PLASTIGAGE® will be found on either the bearing insert or crankshaft journal.

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RG,RG34710,8151 –19–15APR97–1/2

6. Use the graduation marks (A) on the envelope to compare the width of the flattened PLASTIGAGE® (B) at its widest point.

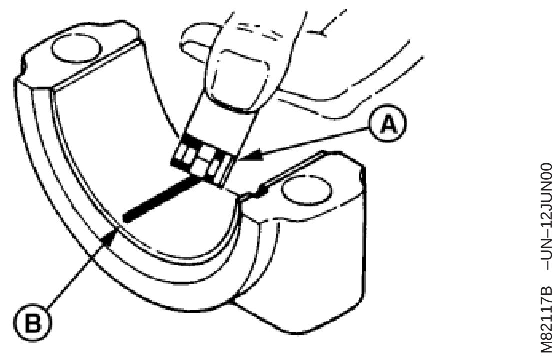
7. Determine main bearing clearance. The number within the graduation marks indicates the bearing clearance in inches or millimeters, depending on which side of the envelope is used.

8. Remove PLASTIGAGE®.

Specification

Main Bearing—3009, 3011 and 3012—Clearance .... 0.038—0.093 mm (0.0015—0.0037 in.)
Wear Limit .... 0.15 mm (0.0059 in.)
Main Bearing—3013—Clearance .... 0.038—0.080 mm (0.0015—0.0031 in.)
Wear Limit .... 0.150 mm (0.0059 in.)
Main Bearing—3015, 3016, 4020 and 4TNE98—Clearance .... 0.038—0.068 mm (0.0015—0.0027 in.)
Wear Limit .... 0.150 mm (0.0059 in.)

If clearance exceeds specification, replace bearing inserts.



A—Graduation Marks
B—PLASTIGAGE®

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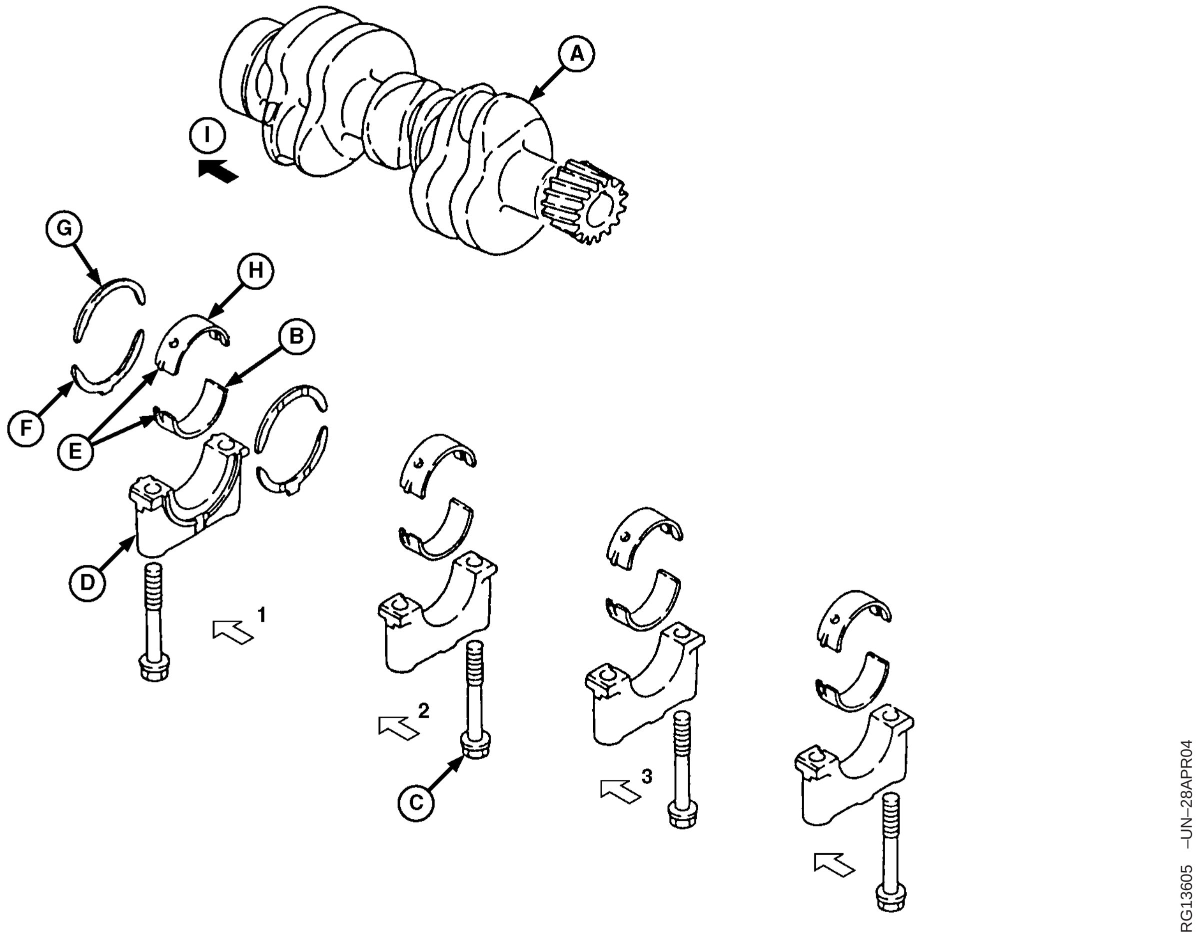
RG,RG34710,8151 –19–15APR97–2/2

Install Crankshaft and Main Bearings



Model 3009, 3011, 3012, 3013, 3015 and 3016

A—Crankshaft
B—Smooth Bearing Inserts
C—Main Bearing Cap Screw
D—Main Bearing Cap
E—Tangs
F—Bearing Cap Thrust Bearing
G—Cylinder Block Thrust Bearing
H—Grooved Bearing Insert
I—Flywheel End of Crankshaft

1. Apply clean engine oil on all parts during installation.

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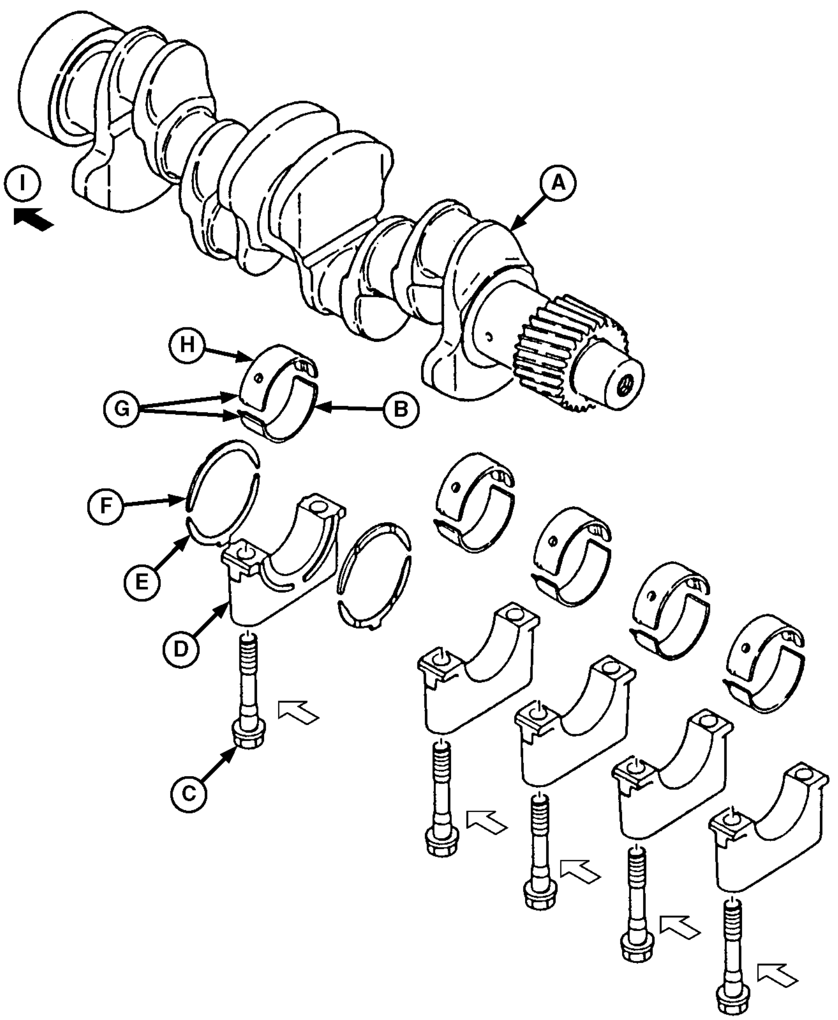


Model 4020 and 4TNE98

A—Crankshaft
B—Smooth Bearing Inserts
C—Main Bearing Cap Screw
D—Main Bearing Cap
E—Bearing Cap Thrust Bearing
F—Cylinder Block Thrust Bearing
G—Tangs
H—Grooved Bearing Insert
I—Flywheel End of Crankshaft

IMPORTANT: Do not touch bearing insert surfaces. Oil and acid from your finger will corrode the bearing surface.

2. Install grooved bearing inserts (H) in crankshaft bearing bores, aligning tangs with slots in bores. Ensure oil holes align with oil passages in cylinder block.

3. Install cylinder block thrust bearings with oil grooves facing away from engine block.

4. Install crankshaft.

5. Install smooth bearing inserts (B) in main bearing caps, aligning tangs with slots in caps.

Continued on next page

NOTE: Main bearing caps have "raised arrows" that are stamped with numbers. Both correspond to their location on the engine block. Install all bearing caps with the "arrow" toward the flywheel end. Install bearing caps beginning with thrust bearing cap (no number), number 1, then 2, etc. (See drawing) The main bearing cap at gear train end does not have a number.

6. Install bearing cap thrust bearings, with oil grooves facing away from cap, in the number "1" main bearing cap.

IMPORTANT: DO NOT use high-speed power tools or air wrenches to tighten main bearing cap screws.

7. Install main bearing caps (D) in their original locations with arrows pointing toward flywheel side of engine.

8. Dip entire main bearing cap screws in clean engine oil. Install cap screws and tighten. DO NOT tighten to specifications.

9. Using a soft-faced hammer, tap the front end of the crankshaft then the rear end of the crankshaft to align the thrust bearings.

10. Tighten main bearing cap screws to specifications. When tightening, start at center main bearing cap and work your way out, alternating to the ends. Turn crankshaft by hand. If it does not turn easily, disassemble the parts and find the cause.

Specification

Main Bearing Cap Screw—
3009, 3011, 3012 and 3013—
Torque........................ 79 N•m (58 lb-ft)
Main Bearing Cap Screw—
3015, 3016 and 4020—Torque .... 98 N•m (72 lb-ft)
Main Bearing Cap Screw—
4TNE98—Torque........................ 108—118 N•m (80—87 lb-ft)

IMPORTANT: Connecting rod caps must be installed on the same connecting rods they were removed from.

Never reuse connecting rod cap screws, replace with new.

11. Match the connecting rod caps to the rods, using alignment marks. Install caps.

12. Dip entire connecting rod cap screws in clean engine oil. Install new cap screws and tighten to specifications.

Specification

Connecting Rod Cap Screw—
3009—Torque........................ 23 N•m (203 lb-in.)
Connecting Rod Cap Screw—
3011, 3012 and 3013—Torque .... 39 N•m (29 lb-ft)
Connecting Rod Cap Screw—
3015, 3016 and 4020—Torque .... 47 N•m (35 lb-ft)
Connecting Rod Cap Screw—
4TNE98—Torque........................ 54 N•m (40 lb-ft)

RG,RG34710,8152 –19–15APR97–3/3

Complete Final Assembly

1. Install all coolant and oil galley plugs

2. Install piston cooling orifices (4020T only). (See REPLACE PISTON COOLING NOZZLES—4020T in Group 060.)

3. Install camshaft bushing and rear plug. (See MEASURE CAMSHAFT BUSHING AND BORES IN BLOCK in Group 030.)

4. Install front plate or housing. (See REMOVE AND INSTALL TIMING GEAR HOUSING—3009 or REMOVE AND INSTALL TIMING GEAR COVER MOUNTING PLATE—3011, 3012, 3013, 3015, 3016 AND 4020 or REMOVE AND INSTALL TIMING GEAR HOUSING—4TNE98 in Group 050.)

5. Install oil pump, strainer, and oil pan. (See REMOVE AND INSTALL ENGINE OIL PUMP—3009, 3011, 3012, 3015, 4020 AND 4TNE98 or REMOVE AND INSTALL ENGINE OIL PUMP—3013 AND 3016 and REMOVE AND INSTALL OIL PAN AND STRAINER in Group 060.)

6. Install timing gear cover, timing gears, camshaft followers, and camshaft. (See REMOVE AND INSTALL TIMING GEAR COVER and INSTALL CAMSHAFT in Group 050.)

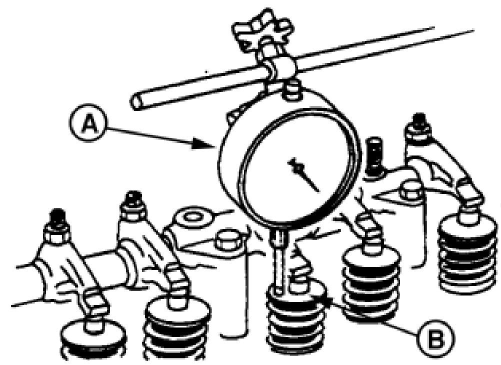
7. Install oil pressure regulating plug, valve, and spring in oil filter housing (3009, 3011, 3012). Install oil filter housing. (See REMOVE AND INSTALL OIL PRESSURE REGULATING VALVE in Group 060.)

8. Install cylinder head, rocker arm components, and rocker arm cover. (See INSTALL CYLINDER HEAD in Group 020.)

9. Install intake and exhaust manifolds. (See REMOVE AND INSTALL INTAKE MANIFOLD and REMOVE AND INSTALL EXHAUST MANIFOLD in Group 020.)

OUO1083,0000698 –19–21MAY04–1/1

Measure Valve Lift



T6333DTA –UN–12JUN00

Measuring Valve Lift

A—Dial Indicator
B—Valve Spring Retainer

1. Remove rocker arm cover.

2. Adjust valve clearance. (See CHECK AND ADJUST VALVE CLEARANCE in Group 020.)

3. Fasten dial indicator (A) to engine and position indicator tip on valve spring retainer (B). Valve must be fully closed and rocker arm must move freely.

4. Zero the dial indicator.

5. Manually turn crankshaft pulley clockwise (from fan end).

6. Observe dial indicator as valve is moved to the full open position.

Specification

Intake and Exhaust Valve—3009—Lift	7.5 mm (0.300 in.) minimum
Intake and Exhaust Valve—3011, 3012, 3015, 4020 and 4TNE98—Lift	8.8 mm (0.350 in.) minimum
Intake and Exhaust Valve—3013 and 3016—Lift	5.1 mm (0.201 in.) minimum

7. Repeat for each valve.

OUO1032,000140C –19–29MAR04–1/1

Remove and Install Timing Gear Cover

NOTE: Refer to parts illustrated on the following pages.

1. Remove alternator and belt.

2. Remove fan, spacer plate (if equipped), and pulley.

3. Remove cap screw and washer securing crankshaft pulley.

4. Remove crankshaft pulley using puller.

5. Remove tachometer (if equipped).

NOTE: When removing timing gear cover, it is not necessary to remove auxiliary drive cover and gasket, end cover and O-ring, or fuel injection pump gear cover. These items may be optional on some engines.

6. Remove mounting cap screws and timing gear cover.

7. Apply LOCTITE® 515 Flexible Form-In-Place Gasket where indicated on illustrations.

8. Install timing gear cover.

9. Tighten cap screws to specification.

10. Install crankshaft pulley and tighten to specification.

11. Install fan, spacer plate, fan pulley, alternator and belt.

Timing Gear Cover—3009—Specification

Timing Gear Cover-to-Gear Housing—Torque .... 9 N•m (80 lb-in.)
End Cover-to-Timing Gear Cover—Torque .... 9 N•m (80 lb-in.)
Auxiliary Drive Cover-to-Timing Gear Cover—Torque .... 9 N•m (80 lb-in.)
Crankshaft Pulley-to-Crankshaft—Torque .... 115 N•m (85 lb-ft)

Timing Gear Cover—3011, 3012, 3013, 3015 and 3016—Specification

Timing Gear Cover-to-Front Plate—Torque .... 26 N•m (229 lb-in.)
Tachometer-to-Timing Gear Cover—Torque .... 26 N•m (229 lb-in.)
End Cover-to-Timing Gear Cover—Torque .... 26 N•m (229 lb-in.)
Injection Pump Gear Cover-to-Timing Gear Cover—Torque .... 26 N•m (229 lb-in.)
Oil Pan-to-Timing Gear Cover—Torque .... 22 N•m (192 lb-in.)
Crankshaft Pulley-to-Crankshaft—Torque .... 115 N•m (85 lb-ft)

Timing Gear Cover—4020—Specification

Timing Gear Cover-to-Front Plate—Torque .... 26 N•m (229 lb-in.)
Tachometer-to-Timing Gear Cover—Torque .... 26 N•m (229 lb-in.)
Injection Pump Gear Cover-to-Timing Gear Cover—Torque .... 26 N•m (229 lb-in.)
Crankcase Extension-to-Timing Gear Cover—Torque .... 26 N•m (229 lb-in.)
Crankcase Oil Pan-to-Timing Gear Cover—Torque .... 22 N•m (192 lb-in.)
Crankshaft Pulley-to-Crankshaft—Torque .... 115 N•m (85 lb-ft)

Timing Gear Cover—4TNE98—Specification

Timing Gear Cover-to-Gear Housing—Torque .... 20 N•m (180 lb-in.)
Tachometer-to-Timing Gear Cover—Torque .... 20 N•m (180 lb-in.)
End Cover-to-Timing Gear Cover—Torque .... 20 N•m (180 lb-in.)
Injection Pump Gear Cover-to-Timing Gear Cover—Torque .... 20 N•m (180 lb-in.)

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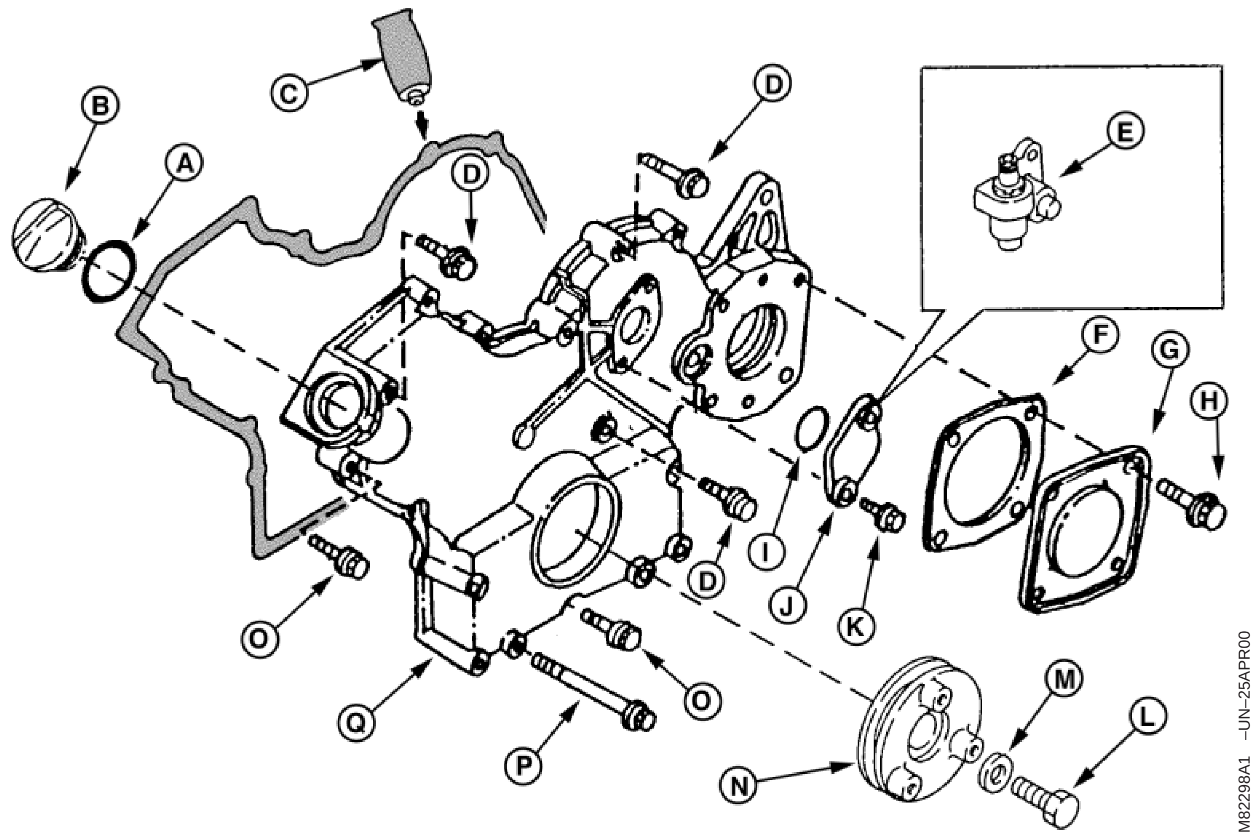

Model 3009

A—O-Ring
B—Cap
C—Form-in-Place Gasket
D—Cap Screw, Timing Gear Cover-to-Housing
E—Tachometer Drive
F—Gasket
G—Auxiliary Drive Cover
H—Cap Screw, Auxiliary Drive Cover Mounting
I—O-Ring
J—End Cover
K—Cap Screw, End Cover Mounting
L—Cap Screw, Crankshaft Pulley Mounting
M—Washer
N—Crankshaft Pulley
O—Cap Screw, Timing Gear Cover-to-Housing
P—Cap Screw, Timing Gear Cover-to-Housing
Q—Timing Gear Cover

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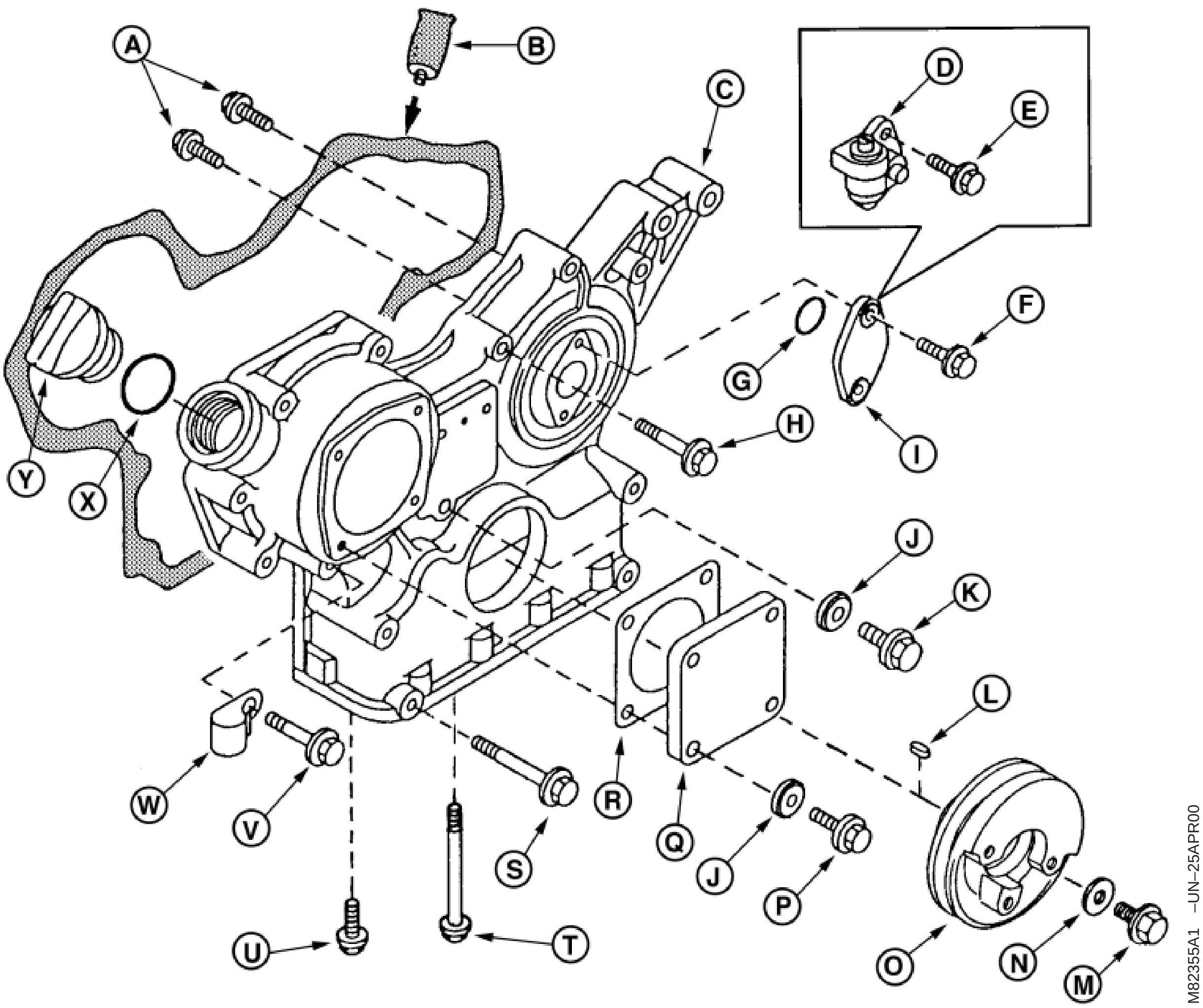
RG,RG34710,8166 –19–15APR97–2/6



Models 3011, 3012 and 3015

A—Cap Screw, Front Plate-to-Timing Gear Cover
B—Form-in-Place Gasket
C—Timing Gear Cover
D—Tachometer Drive
E—Cap Screw, Tachometer Drive Mounting
F—Cap Screw, End Cover Mounting
G—O-Ring
H—Cap Screw, Timing Gear Cover-to-Front Plate
I—End Cover
J—Seal Washer
K—Cap Screw, Timing Gear Cover-to-Front Plate
L—Key (Not on All Models)
M—Cap Screw, Crankshaft Pulley
N—Washer
O—Crankshaft Pulley
P—Cap Screw, Injection Pump Cover Mounting
Q—Injection Pump Gear Cover
R—Gasket
S—Cap Screw, Timing Gear Cover-to-Front Plate
T—Cap Screw, Oil Pan-to-Cover
U—Cap Screw, Crankcase Extension-to-Cover
V—Cap Screw, Timing Gear Cover-to-Front Plate
W—Clamp
X—O-Ring
Y—Cap

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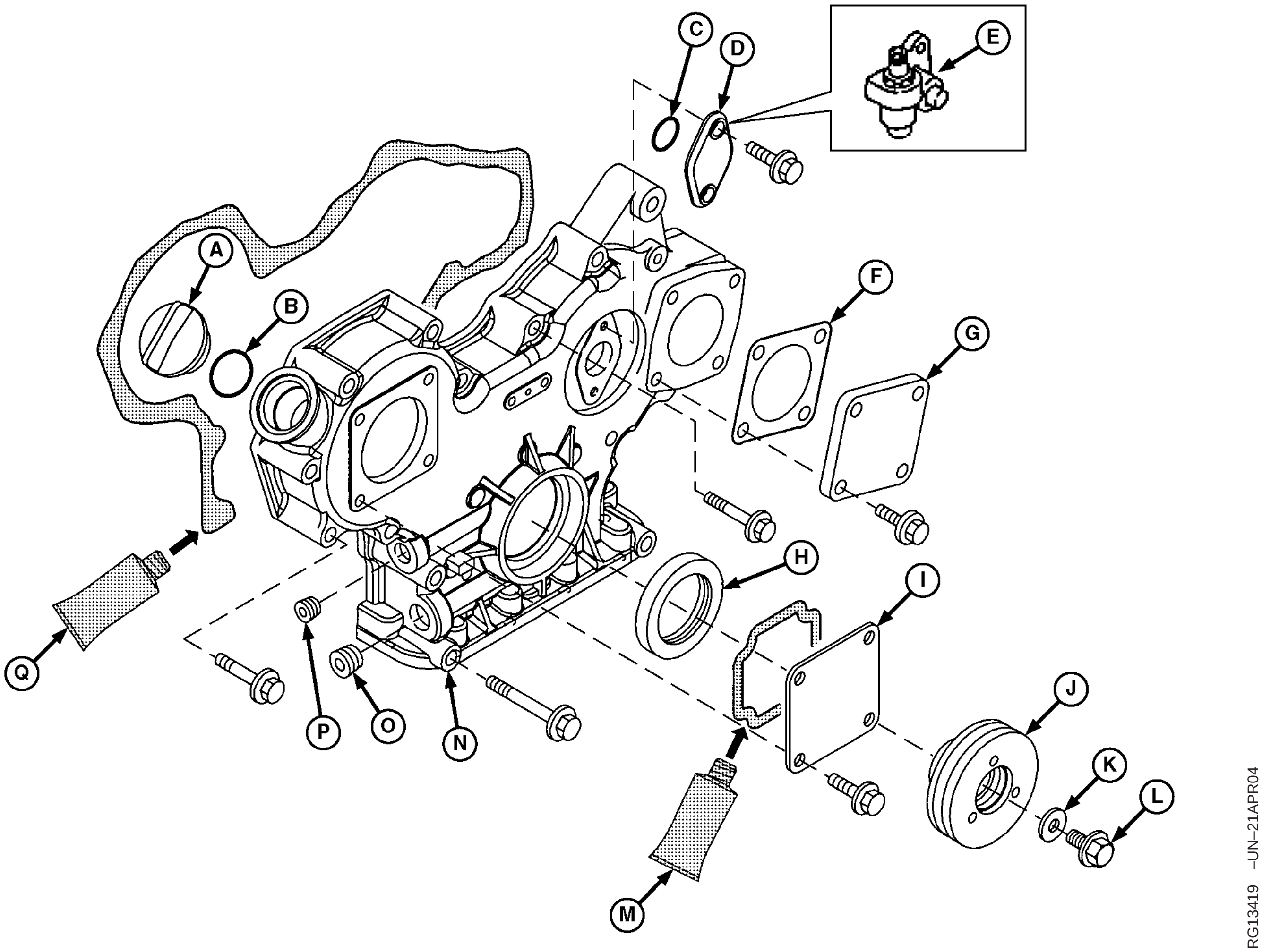
RG,RG34710,8166 –19–15APR97–3/6



Model 3013 and 3016

A—Oil Fill Cap
B—O-Ring
C—O-Ring
D—Cover
E—Tachometer Drive
F—Gasket
G—Auxiliary Drive Cover
H—Front Crankshaft Oil Seal
I—Injection Pump Gear Cover
J—Crankshaft Pulley
K—Washer
L—Cap Screw, Crankshaft Pulley
M—Form-in-Place Gasket
N—Timing Gear Cover
O—Pipe Plug
P—Pipe Plug
Q—Form-in-Place Gasket

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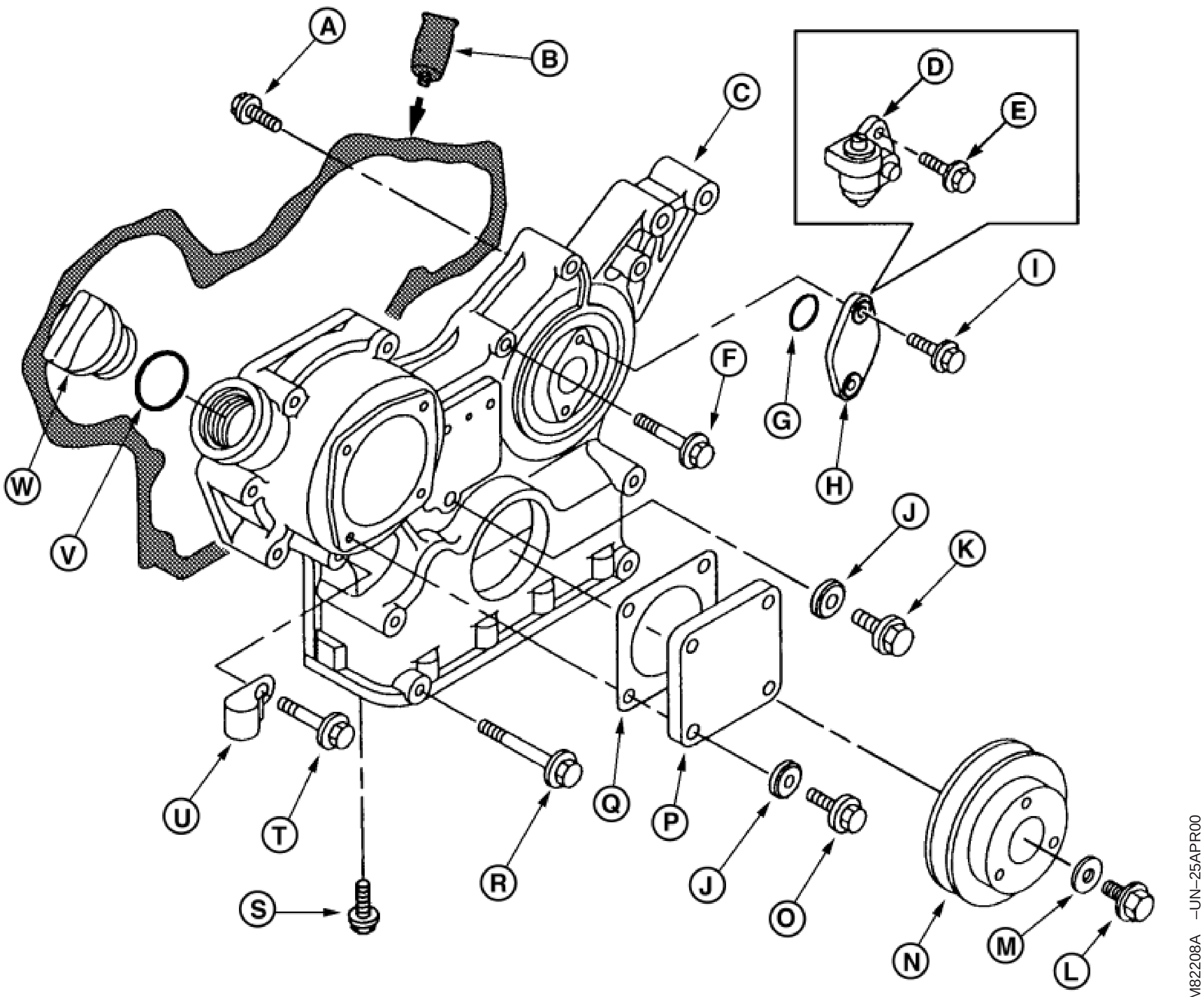

Model 4020

A—Cap Screw, Mounting Plate-to-Cover
B—Form-in-Place Gasket
C—Timing Gear Cover
D—Tachometer Drive
E—Cap Screw, Tachometer Drive Mounting
F—Cap Screw, Timing Gear Cover-to-Front Plate
G—O-Ring
H—End Cover
I—Cap Screw, End Cover Mounting
J—Seal Washer
K—Cap Screw, Timing Gear Cover-to-Front Plate
L—Cap Screw, Crankshaft Pulley
M—Washer
N—Crankshaft Pulley
O—Cap Screw, Injection Pump Cover Mounting
P—Injection Pump Gear Cover
Q—Gasket
R—Cap Screw, Timing Gear Cover-to-Front Plate
S—Cap Screw, Oil Pan-to-Cover
T—Cap Screw, Crankcase Extension-to-Timing Gear Cover
U—Clamp
V—O-Ring
W—Cap

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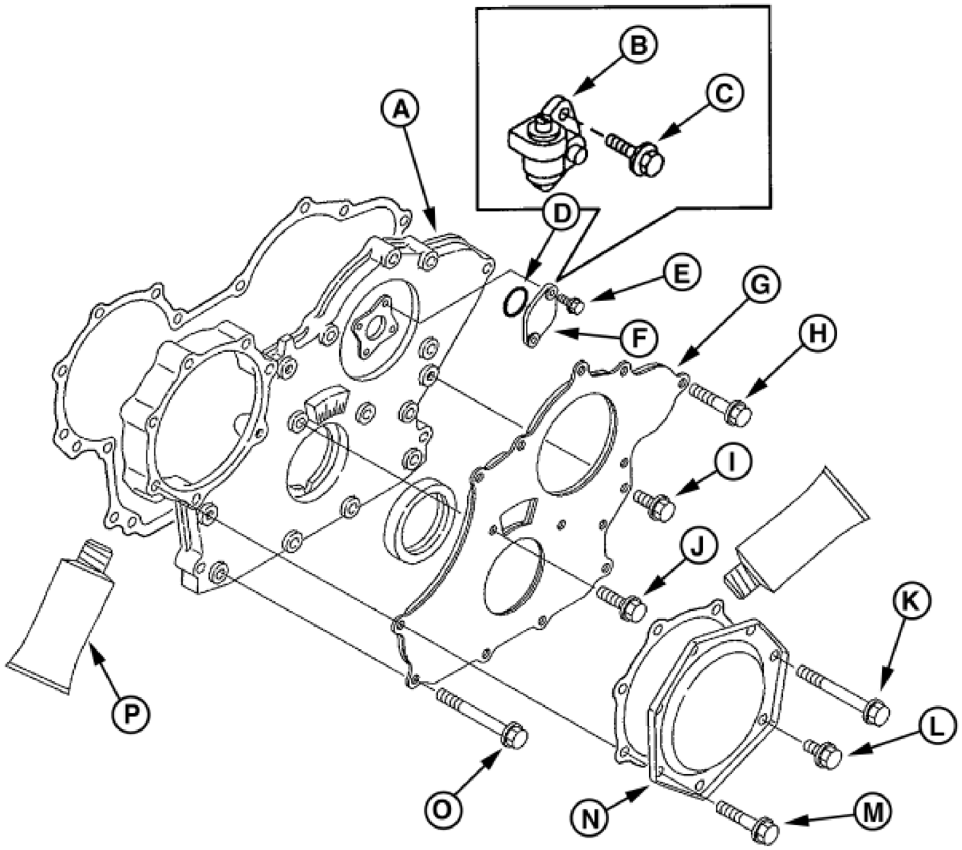


Model 4TNE98

A—Timing Gear Cover
B—Tachometer Drive
C—Cap Screw, Tachometer Drive Mounting
D—O-Ring
E—Cap Screw, End Cover Mounting
F—Cover
G—Cover Plate
H—Cap Screw, Timing Gear Cover-to-Gear Housing
I—Cap Screw, Timing Gear Cover-to-Gear Housing
J—Cap Screw, Timing Gear Cover-to-Gear Housing
K—Cap Screw, Injection Pump Gear Cover Mounting
L—Cap Screw, Injection Pump Gear Cover Mounting
M—Cap Screw, Injection Pump Gear Cover Mounting
N—Cover
O—Cap Screw, Timing Gear Cover-to-Gear Housing
P—Form-in-Place Gasket

RG,RG34710,8166 –19–15APR97–6/6

Check Camshaft End Play

1. Remove timing gear cover. (See REMOVE AND INSTALL TIMING GEAR COVER in this group.)

2. Fasten dial indicator to engine and position indicator tip on end of camshaft.

3. Push camshaft toward the rear as far as possible.

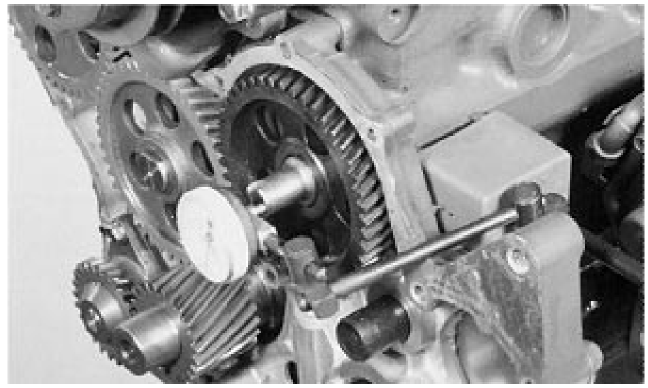
4. Zero the dial indicator.

5. Pull camshaft forward as far as possible.

   If end play exceeds wear limit, remove camshaft and replace thrust plate. (See REMOVE CAMSHAFT and INSTALL CAMSHAFT in this group.)

Specification

Camshaft—All Engines—End Play	0.05—0.20 mm (0.002—0.008 in.)
Wear Limit (3009, 3011, 3012, 3015 and 4020)	0.40 mm (0.016 in.)
Wear Limit (3013, 3016 and 4TNE98)	0.30 mm (0.012 in.)



Check Camshaft End Play

RG,RG34710,8172 –19–15APR97–1/1

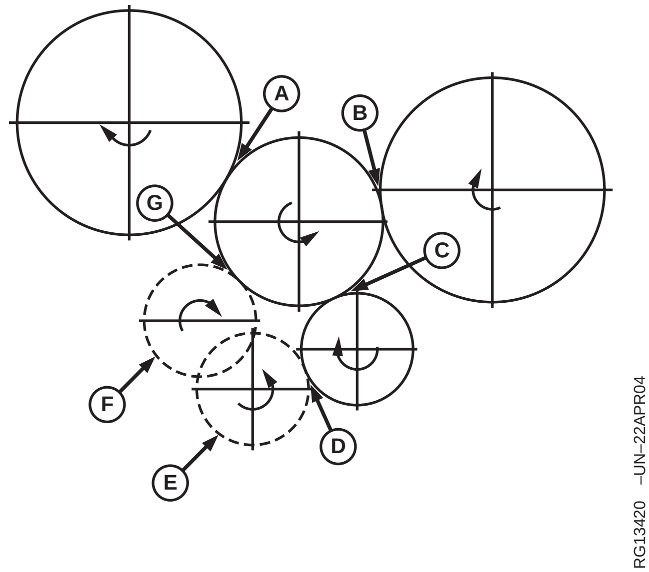
Check Timing Gear Backlash

NOTE: Oil pump on 3013 and 3016 is driven directly from the crankshaft and requires no oil pump gear backlash check.

Measure backlash between meshing gears at points (A—D and G). If backlash exceeds wear limit, replace meshing gears as a set.

Specification

Timing Gear Backlash Crankshaft Gear-to-Oil Pump Gear—3009, 3011, 3012, 3015 and 4020—Backlash .... 0.11—0.19 mm (0.0043—0.0075 in.)
Wear Limit .... 0.20 mm (0.0079 in.)
Timing Gear Backlash—All Except Crankshaft Gear-to-Oil Pump Gear—3009, 3011, 3012, 3015 and 4020—Backlash .... 0.04—0.12 mm (0.0016—0.0047 in.)
Wear Limit .... 0.20 mm (0.0079 in.)
Timing Gear Backlash—3013 and 3016—Backlash .... 0.07—0.15 mm (0.002—0.006 in.)
Wear Limit .... 0.17 mm (0.007 in.)
Timing Gear Backlash Crankshaft Gear-to-Oil Pump Gear—4TNE98—Backlash .... 0.09—0.15 mm (0.0035—0.0059 in.)
Wear Limit .... 0.17 mm (0.0067 in.)
Timing Gear Backlash—All Except Crankshaft Gear-to-Oil Pump Gear—4TNE98—Backlash .... 0.08—0.14 mm (0.0031—0.0055 in.)
Wear Limit .... 0.16 mm (0.0063 in.)

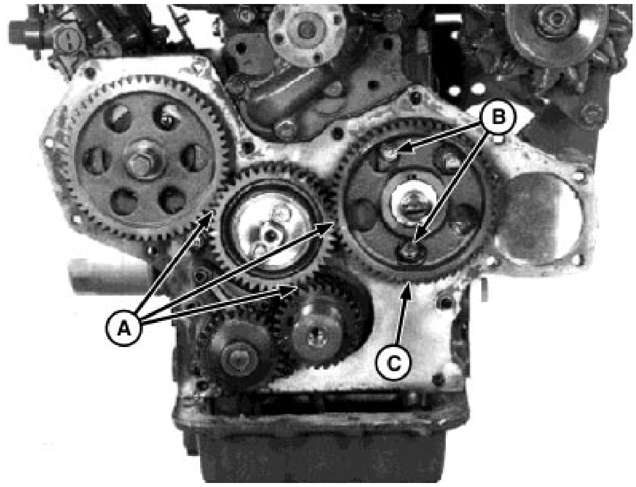


Timing Gear Arrangement

A—Fuel Injection Pump Gear-to-Idler Gear
B—Camshaft Gear-to-Idler Gear
C—Idler Gear-to-Crankshaft Gear
D—Crankshaft Gear-to-Oil Pump Gear (3009, 3011, 3012, 3015, 4020)
E—Oil Pump Gear (3009, 3011, 3012, 3015, 4020)
F—Oil Pump Gear (4TNE98)
G—Idler Gear-to-Oil Pump Gear (4TNE98)

RG,RG34710,8173 –19–15APR97–1/1

Remove Camshaft



RG13594A –UN–22APR04

4020 Shown

A—Timing Marks
B—Camshaft Mounting Cap Screws
C—Camshaft and Gear

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

2. Remove rocker arm assembly and push rods. (See REMOVE AND INSTALL ROCKER ARM COVER—3009, 4020 AND 4TNE98, REMOVE AND INSTALL ROCKER ARM COVER—3011, 3012 AND 3015, or REMOVE AND INSTALL ROCKER ARM COVER—3013 AND 3016 in Group 020.)

3. Remove timing gear cover. (See REMOVE AND INSTALL TIMING GEAR COVER in this group.)

4. Check camshaft end play. (See CHECK CAMSHAFT END PLAY in this group.)

5. Check backlash of timing gears. (See CHECK TIMING GEAR BACKLASH in this group.)

NOTE: If a magnetic follower holder kit is not available, turn engine until oil pan is upward, to hold cam followers away from camshaft.

6. Hold cam followers away from camshaft using a magnetic follower holder kit such as D15001NU.

NOTE: Due to the odd number of teeth on the idler gear, timing marks will only align periodically.

7. Rotate crankshaft and align timing marks (A).

IMPORTANT: DO NOT allow camshaft lobes to hit bearing surfaces while removing camshaft. Machined surfaces can be damaged.

8. Remove two cap screws (B) and remove camshaft with gear.

9. Inspect camshaft for wear or damage. (See INSPECT CAMSHAFT in this group.)

10. Inspect camshaft followers. (See INSPECT CAM FOLLOWERS in this group.)

Continued on next page

RG,RG34710,8174 –19–15APR97–1/2

11. Inspect camshaft follower bores in block and inspect camshaft bushing and bores in block. (See MEASURE CAMSHAFT FOLLOWER BORES IN BLOCK and MEASURE CAMSHAFT BUSHING AND BORES IN BLOCK in Group 030.)

RG,RG34710,8174 –19–15APR97–2/2

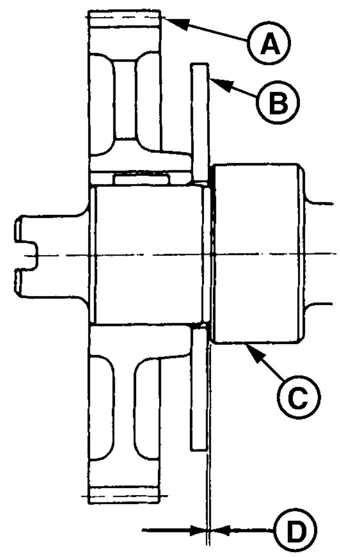
Inspect Camshaft

1. If camshaft end play was not checked before removing camshaft, check clearance (side gap) between camshaft and camshaft thrust plate using a feeler gauge.

   If side gap exceeds wear limit, remove camshaft gear and replace thrust plate.

Specification

Camshaft-to-Thrust Plate—Clearance	0.05—0.20 mm (0.002—0.008 in.)
Wear Limit (3009, 3011, 3012, 3015 and 4020)	0.40 mm (0.016 in.)
Wear Limit (3013, 3016 and 4TNE98)	0.30 mm (0.012 in.)



Measure Camshaft Side Play

A—Camshaft Gear
B—Thrust Plate
C—Camshaft
D—Side Gap

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RG,RG34710,8175 –19–15APR97–1/5

2. Inspect gear (A) for chipped or broken teeth. Replace if necessary.

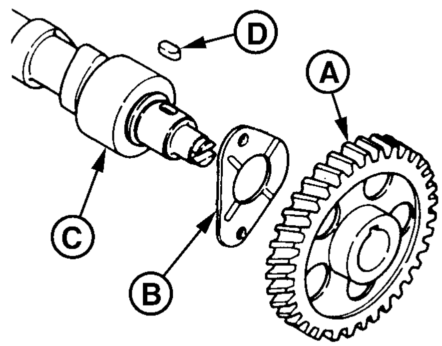
3. If nessesary, remove gear (A) and thrust plate (B) from camshaft (C) using a knife-edge puller and a press.

CAUTION: DO NOT heat oil over 182°C (360°F). Oil fumes or oil can ignite above 193°C (380°F). Use a thermometer. Do not allow a flame or heating element to come in direct contact with the oil. Heat the oil in a well-ventilated area. Plan a safe handling procedure to avoid burns.

4. Heat gear in oil to approximately 150°C (300°F).

IMPORTANT: Be sure thrust plate is not between camshaft gear and camshaft shoulder while installing gear. Thrust plate must spin freely on camshaft after installation of gear.

5. Install thrust plate (B) if removed. Install gear with timing mark “C” facing away from end of camshaft. Align slot in gear with key (D) in shaft. Press camshaft into gear until gear is tight against camshaft shoulder.



Camshaft Components

A—Camshaft Gear
B—Thrust Plate
C—Camshaft
D—Key

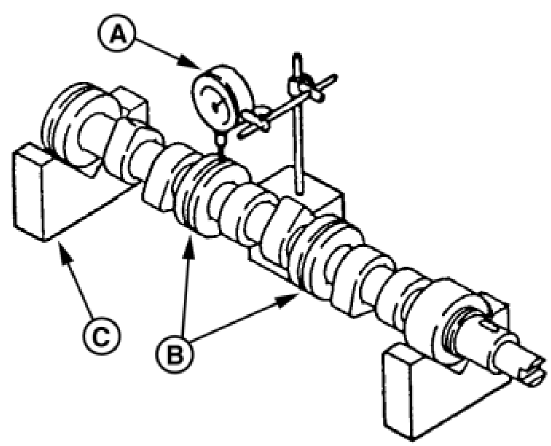
RG,RG34710,8175 –19–15APR97–2/5

6. Measure camshaft bend using V-blocks and a dial indicator (A). Turn camshaft slowly and read variation on indicator. If variation exceeds wear limit, replace camshaft.

Specification

Camshaft Bend—Radial Runout	0.02 mm (0.0008 in.) maximum
Wear Limit	0.05 mm (0.0020 in.)

A—Dial Indicator
B—Camshaft Central Bearing Areas
C—V-Block



Measure Camshaft Bend

Continued on next page

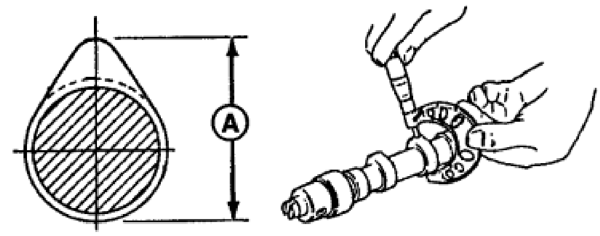
RG,RG34710,8175 –19–15APR97–3/5

7. Measure camshaft lobe height (A).

   If lobe height is less than wear limit, replace camshaft.

Specification

Camshaft Lobe—3009—Height	33.950—34.050 mm (1.3366—1.3406 in.)
Wear Limit	33.75 mm (1.3287 in.)
Camshaft Lobe—3011, 3012, 3015 and 4020—Height	38.635—38.765 mm (1.5211—1.5262 in.)
Wear Limit	38.40 mm (1.5118 in.)
Camshaft Lobe—3013 and 3016—Height	38.600—38.800 mm (1.5197—1.5276 in.)
Wear Limit	38.35 mm (1.5098 in.)
Camshaft Lobe—4TNE98—Height	42.435—42.565 mm (1.6707—1.6758 in.)
Wear Limit	42.185 mm (1.6608 in.)



RG11086A —UN—08JUN00

Measure Camshaft Lobe Height

A—Camshaft Lobe Height

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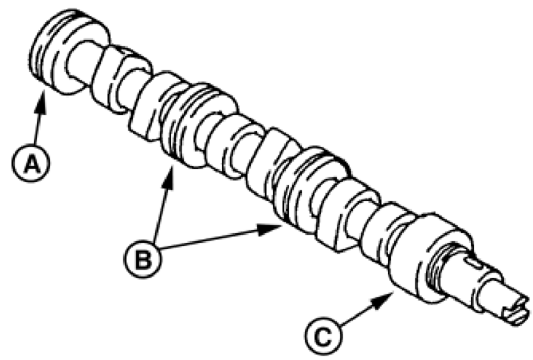
RG,RG34710,8175 –19–15APR97–4/5

8. Measure camshaft journal OD at both flywheel- and gear-end journals (A and C), and at intermediate journals (B).

   If journal diameter is less than wear limit, replace camshaft.

Specification

Camshaft End Journals—3009—OD	39.94—39.96 mm (1.5724—1.5732 in.)
Wear Limit	39.85 mm (1.5689 in.)
Intermediate Journal—3009—OD	39.91—39.94 mm (1.5713—1.5724 in.)
Wear Limit	39.85 mm (1.5689 in.)
End Journals—3011, 3012, 3013, 3015, 3016 and 4020—OD	44.925—44.950 mm (1.7687—1.7697 in.)
Wear Limit (3011, 3012, 3015, 4020)	44.85 mm (1.7657 in.)
Wear Limit (3013, 3016)	44.890 mm (1.7673 in.)
Intermediate Journal—3011, 3012, 3013, 3015, 3016 and 4020—OD	44.910—44.935 mm (1.7681—1.7691 in.)
Wear Limit (3011, 3012, 3015, 4020)	44.85 mm (1.7657 in.)
Wear Limit (3013, 3016)	44.875 mm (1.7667 in.)
End Journals—4TNE98—OD	49.925—49.950 mm (1.9656—1.9665 in.)
Wear Limit	49.89 mm (1.9642 in.)
Intermediate Journal—OD	49.910—49.935 mm (1.9650—1.9659 in.)
Wear Limit	49.875 mm (1.9636 in.)



Measure Camshaft Journal OD

A—Flywheel-End Journal
B—Intermediate Journals
C—Gear-End Journal

9. Measure camshaft bushing and camshaft bores in cylinder block. (See MEASURE CAMSHAFT BUSHING AND BORES IN BLOCK in Group 030.)

10. Inspect cam followers. (See INSPECT CAM FOLLOWERS in this group.)

11. Inspect cam follower bores in cylinder block. (See MEASURE CAMSHAFT FOLLOWER BORES IN BLOCK in Group 030.)

RG,RG34710,8175 –19–15APR97–5/5

Inspect Cam Followers

1. 3009: Remove cylinder head. (See REMOVE CYLINDER HEAD in Group 020.)

2. 3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98: Remove oil pan. (See REMOVE AND INSTALL OIL PAN AND STRAINER in Group 060.)

IMPORTANT: Cam followers must be installed in the same bores from which they were removed.

3. Put a mark on each cam follower and cylinder block bore to aid in installation.

4. Remove cam followers.

5. Inspect all parts for wear or damage.

Continued on next page RG,RG34710,8083 –19–15APR97–1/2

6. Inspect cam follower contact surface for abnormal wear (A). Replace if necessary. A normal contact surface is shown in (B).

7. Measure cam follower diameter.

Specification

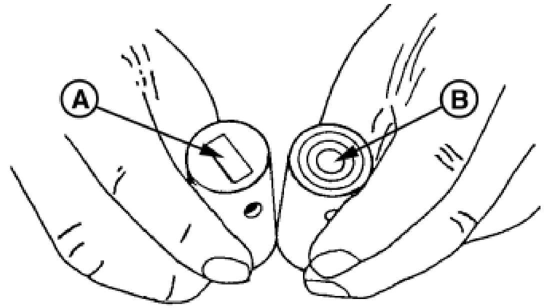
Cam Follower—3009—OD	20.927—20.960 mm (0.8239—0.8252 in.)
Wear Limit	20.93 mm (0.824 in.)
Cam Follower—3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98—OD	11.975—11.990 mm (0.471—0.472 in.)
Wear Limit (3011, 3012, 3015, 4020 and 4TNE98)	11.93 mm (0.470 in.)
Wear Limit (3013 and 3016)	11.955 mm (0.4707 in.)

If diameter is less than wear limit, replace cam follower.

8. Measure cam follower bore diameter in cylinder block and determine if clearance is within specification. (See MEASURE CAMSHAFT FOLLOWER BORES IN BLOCK in Group 030.)

   If cam follower bore diameter exceeds wear limit, replace cylinder block.

   If bore clearance (bore ID minus follower OD) exceeds specification, replace cam follower, cylinder block or both.



M82293A –UN–12JUN00

M35268 –UN–29AUG88

3009 Engine Shown

A—Abnormal Wear Surface
B—Normal Contact Surface

RG,RG34710,8083 –19–15APR97–2/2

Install Camshaft

NOTE: Apply clean engine oil on all parts during installation.

Due to the odd number of teeth on the idler gear, timing marks will only align periodically.

1. Rotate crankshaft to align timing marks (A).

IMPORTANT: DO NOT allow camshaft lobes to hit bearing surfaces while installing camshaft. Machined surfaces can be damaged.

2. Install camshaft (C).

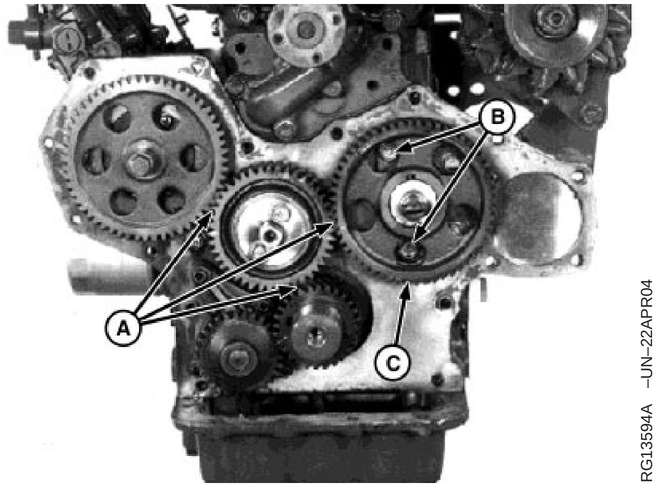
3. Install and tighten cap screws (B) to specification.

Specification

Camshaft Mounting Cap Screw—
3009—Torque .... 11 N•m (97 lb-in.)
Camshaft Mounting Cap Screw—
3011, 3012, 3013, 3015, 3016,
4020 and 4TNE98—Torque .... 26 N•m (228 lb-in.)

4. Install timing gear cover. (See REMOVE AND INSTALL TIMING GEAR COVER in this group.)

5. Install push rods and rocker arm assembly. (See REMOVE AND INSTALL ROCKER ARM COVER—3009, 4020 AND 4TNE98, REMOVE AND INSTALL ROCKER ARM COVER—3011, 3012 AND 3015, or REMOVE AND INSTALL ROCKER ARM COVER—3013 AND 3016 in Group 020.)



4020 Shown

A—Timing Marks
B—Camshaft Mounting Cap Screws
C—Camshaft and Gear

RG,RG34710,8176 –19–15APR97–1/1

Remove and Install Idler Gear

1. Remove timing gear cover. (See REMOVE AND INSTALL TIMING GEAR COVER in this group.)

2. Check backlash of timing gears. (See CHECK TIMING GEAR BACKLASH in this group.)

NOTE: Due to the odd number of teeth on the idler gear, timing marks will only align periodically. When all timing marks on gears align, the piston closest to the coolant pump is at TDC on compression stroke. No. 1 cylinder is closest to the flywheel.

3. Rotate crankshaft and align timing marks.

4. For model 3009, remove snap ring (A), washer (B) and idler gear (C).

   For models 3011, 3012, 3015, 4020 and 4TNE98, remove two cap screws (D), shaft (E) and gear (C).

   For models 3013 and 3016, remove three cap screws (D), shaft (E) and gear (C).

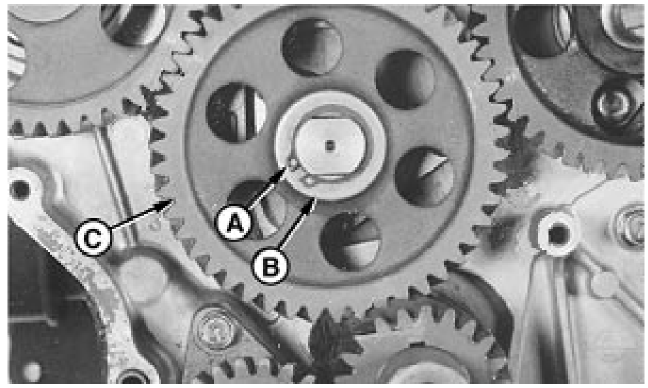
5. Inspect all parts for wear or damage.

6. Install idler gear and ensure all timing marks are aligned.

7. Install snap ring (3009) or cap screws (all except 3009).

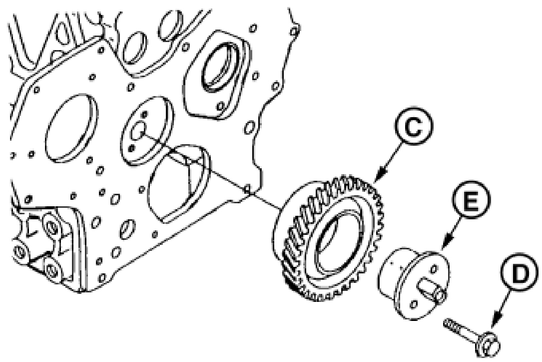
8. Install timing gear cover and crankshaft pulley. (See REMOVE AND INSTALL TIMING GEAR COVER in this group.)

A—Snap Ring
B—Washer
C—Idler Gear
D—Cap Screw
E—Idler Gear Shaft



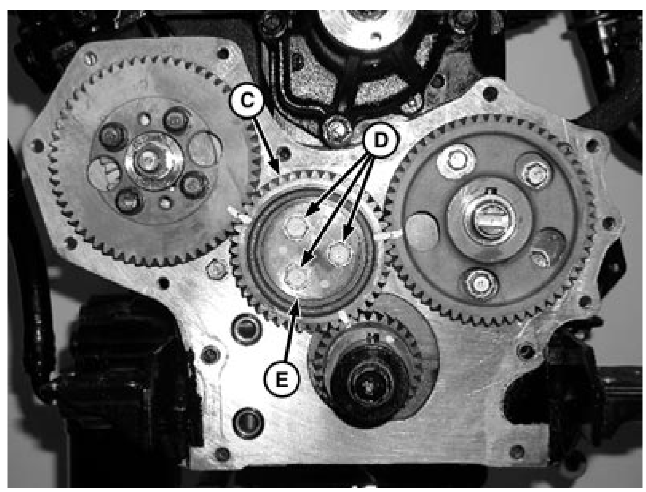
RG11101A –UN–08JUN00

Model 3009



M82209A –UN–12JUN00

Models 3011, 3012, 3015, 4020 and 4TNE98



RG13595A –UN–22APR04

Models 3013 and 3016

RG,RG34710,8177 –19–15APR97–1/1

Inspect Idler Gear—3009

1. Inspect gear for chipped or broken teeth. Replace if necessary.

2. Measure diameter of idler gear shaft (A).

   If shaft diameter is less than wear limit, remove three cap screws (B) and replace idler gear shaft.

Specification

Idler Gear Shaft—3009—OD	19.959—19.980 mm (0.786—0.787 in.)
Wear Limit	19.93 mm (0.785 in.)

3. Measure idler gear bushing diameter.

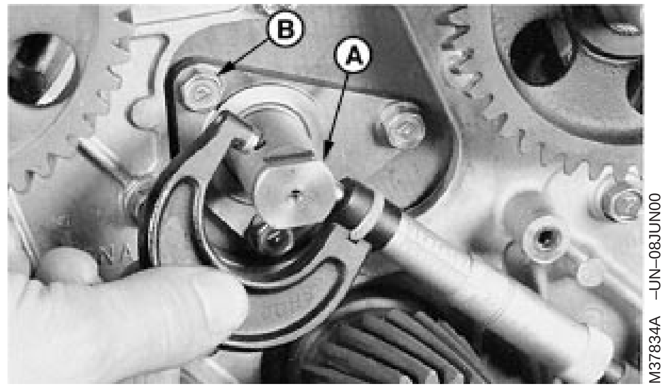
   If bushing diameter exceeds wear limit, replace bushing.

Specification

Idler Gear Bushing—3009—ID	20.00—20.021 mm (0.787—0.788 in.)
Wear Limit	20.08 mm (0.791 in.)
Oil Clearance	0.15 mm (0.0059 in.) maximum

If bushing oil clearance (bushing ID minus shaft OD) exceeds specification, replace bushing, shaft or both.

Replace bushing using a Universal Driver Set. Align oil holes in bushing and idler gear. Install bushing flush with surface of idler gear.



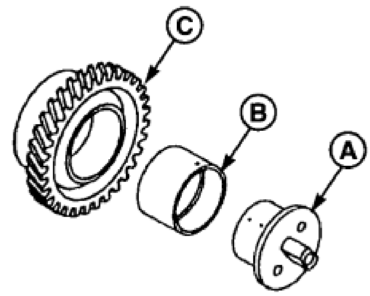
Idler Gear Shaft

Measure Idler Gear Bushing

A—Idler Shaft
B—Cap Screw

RG,RG34710,8178 –19–15APR97–1/1

Inspect Idler Gear—3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98



3011, 3012, 3015, 4020 and 4TNE98 Shown. 3013 and 3016 Are Similar.

A—Idler Gear Shaft
B—Idler Gear Bushing
C—Idler Gear

1. Inspect gear (C) for chipped or broken teeth. Replace if necessary.

2. Measure outside diameter of idler gear shaft (A).

   If shaft diameter is less than wear limit, replace idler gear shaft.

Specification

Idler Gear Shaft—3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98—OD	45.950—45.975 mm (1.809—1.810 in.)
Wear Limit	45.93 mm (1.808 in.)

3. Measure idler gear bushing (B) inside diameter.

   If bushing diameter exceeds wear limit, replace bushing.

Specification

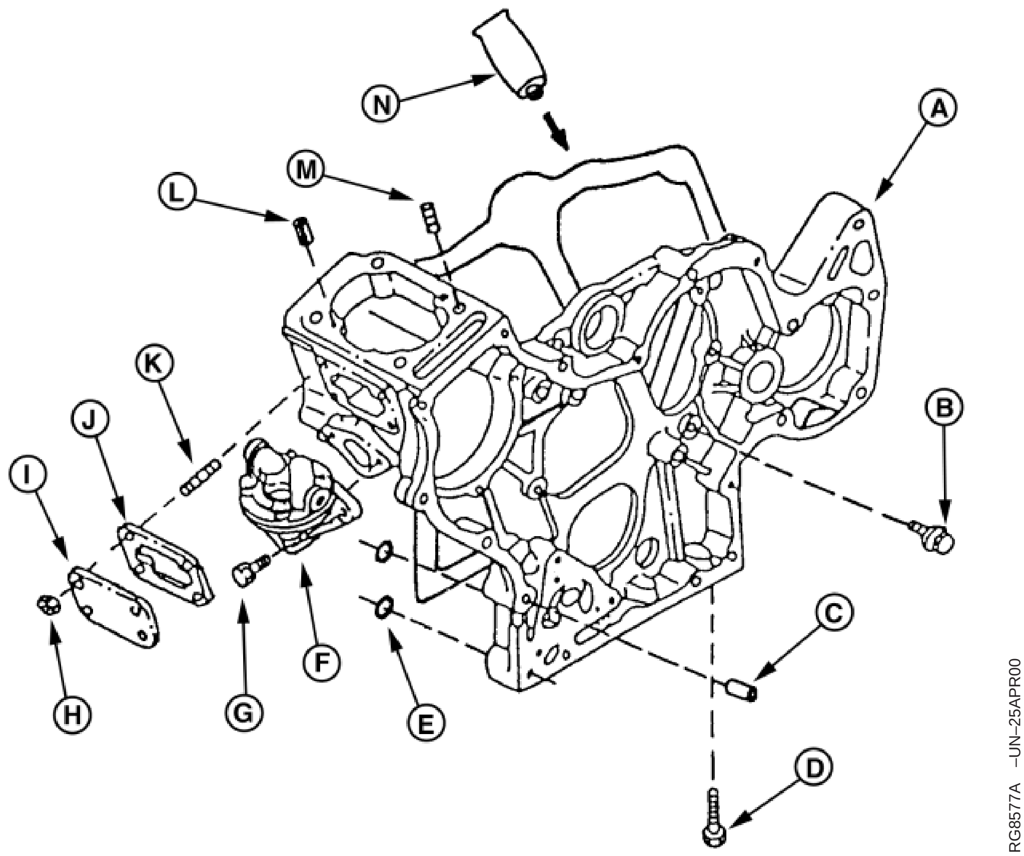
Idler Gear Bushing—3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98—ID	46.00—46.025 mm (1.811—1.812 in.)
Wear Limit	46.08 mm (1.814 in.)
Oil Clearance	0.025—0.075 mm (0.001—0.003 in.)
Wear Limit	0.18 mm (0.007 in.)

If bushing oil clearance (bushing ID minus shaft OD) exceeds specification, replace bushing, shaft or both.

Replace bushing using a Universal Driver Set. Align oil holes in bushing and idler gear. Install bushing flush with surface of idler gear.

RG,RG34710,8180 –19–15APR97–1/1

Remove and Install Timing Gear Housing—3009



A—Timing Gear Housing
B—Cap Screw
C—Dowel Pin
D—Cap Screw
E—O-Ring
F—Fuel Pump
G—Cap Screw
H—Nut
I—Cover
J—Gasket
K—Stud
L—Dowel Pin
M—Stud
N—Form-in-Place Gasket

1. Remove idler gear. (See REMOVE AND INSTALL IDLER GEAR in this group.)
2. Remove fuel supply pump. (See REPLACE FUEL SUPPLY PUMP—3009 in Group 090.)
3. Remove fuel injection pump camshaft. (See FUEL INJECTION PUMP CAMSHAFT—3009 in Group 090.)
4. Remove engine camshaft. (See REMOVE CAMSHAFT in this group.)
5. Remove oil pump. (See REMOVE AND INSTALL ENGINE OIL PUMP—3009, 3011, 3012, 3015, 4020 AND 4TNE98 in Group 060.)
6. Remove coolant pump. (See REMOVE, INSPECT AND INSTALL COOLANT PUMP—3009, 3011, 3012, 3013, 3015, 3016 AND 4020 in Group 070.)
7. Remove mounting cap screws (B and D) and housing (A).
8. Install new O-rings (E).
9. Apply a bead of LOCTITE® 515 Flexible Form-In-Place Gasket to the cylinder block and timing gear housing mating surfaces.
10. Install housing (A) and tighten cap screws to specification.

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RG,RG34710,8181 –19–15APR97–1/2

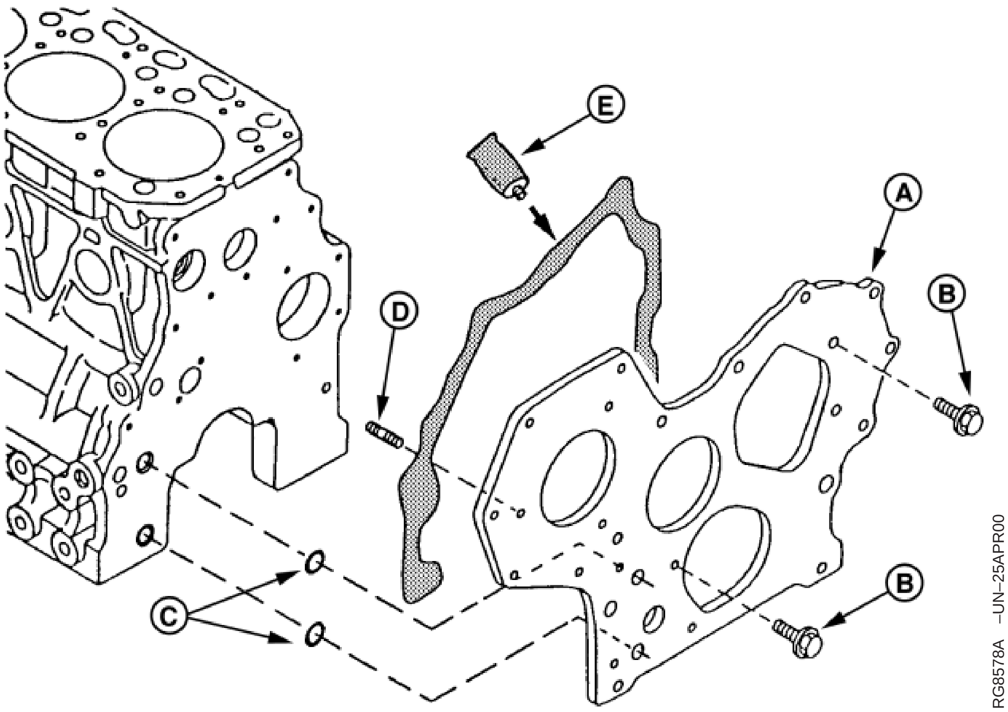
Timing Gear Housing—3009—Specification

Mounting Cap Screws—Cast
Iron Threads—Torque .... 11 N•m (97 lb-in.)
Mounting Cap Screws—
Aluminum Threads—Torque..................................... 9 N•m (80 lb-in.)
Crankcase Extension-to-Timing
Gear Housing Cap Screw—
Torque.. 22 N•m (192 lb-in.)

11. Install camshaft, idler gear, oil pump, fuel injection pump, fuel supply pump, and coolant pump . (See appropriate procedures in this group and Groups 060, 070 and 090.)

RG,RG34710,8181 –19–15APR97–2/2

Remove and Install Timing Gear Cover Mounting Plate—3011, 3012, 3013, 3015, 3016 and 4020



A—Timing Gear Cover Mounting Plate
B—Cap Screw
C—O-Rings
D—Stud
E—Form-in-Place Gasket

1. Remove camshaft. (See REMOVE CAMSHAFT in this group.)
2. Remove idler gear. (See REMOVE AND INSTALL IDLER GEAR in this group.)
3. Remove fuel injection pump. (See REMOVE FUEL INJECTION PUMP—3011, 3012, 3015 AND 4020 or REMOVE FUEL INJECTION PUMP—3013 AND 3016 in Group 090.)
4. Remove oil pump on 3011, 3012, 3015, 4020 and 4TNE98 engines. (See REMOVE AND INSTALL ENGINE OIL PUMP—3009, 3011, 3012, 3015, 4020 AND 4TNE98 in Group 060.)
5. Remove mounting cap screws (B) and plate (A).
6. Install new O-rings (C).
7. Apply a bead of LOCTITE® 515 Flexible Form-In-Place Gasket to the cylinder block and plate mating surfaces.
8. Install plate (A) and tighten cap screws (B) to specification.

Timing Gear Cover Mounting Plate—3011, 3012, 3013, 3015, 3016 and 4020—Specification
Mounting Cap Screws—Torque .... 25 N•m (221 lb-in.)

9. Install camshaft, idler gear, oil pump, fuel injection pump, fuel supply pump, and coolant pump . (See appropriate procedures in this group and Groups 060, 070 and 090.)

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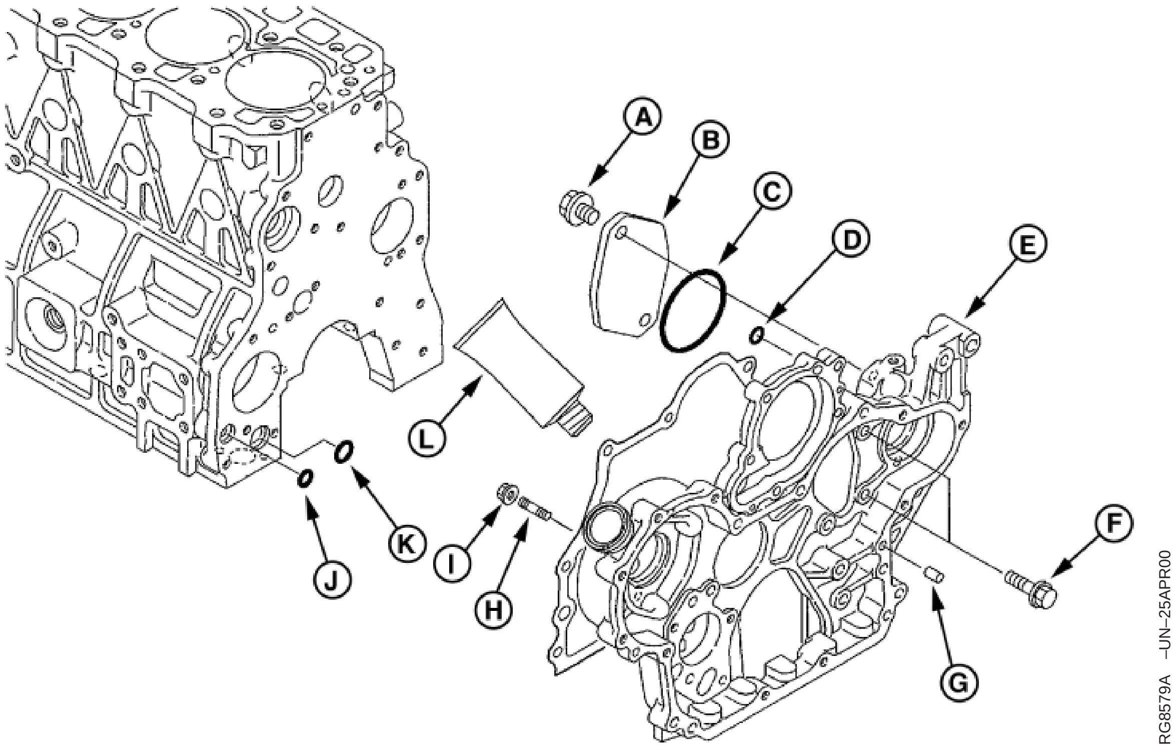
RG,RG34710,8182 –19–15APR97–1/1

Remove and Install Timing Gear Housing—4TNE98



A—Cap Screw
B—Cover
C—O-Ring
D—O-Ring
E—Timing Gear Housing
F—Cap Screw
G—Dowel Pin
H—Stud
I—Nut
J—O-Ring
K—O-Ring
L—Form-in-Place Gasket

1. Remove idler gear. (See REMOVE AND INSTALL IDLER GEAR in this group.)

2. Remove fuel injection pump camshaft. (See REMOVE FUEL INJECTION PUMP—4TNE98 in Group 090.)

3. Remove engine camshaft. (See REMOVE CAMSHAFT in this group.)

4. Remove oil pump. (See REMOVE AND INSTALL ENGINE OIL PUMP—3009, 3011, 3012, 3015, 4020 AND 4THN98 in Group 060.)

5. Remove coolant pump. (See REMOVE, INSPECT AND INSTALL COOLANT PUMP—4TNE98 in Group 070.)

6. Remove mounting cap screws and housing.

7. Install new O-rings (C and J).

8. Apply a bead of LOCTITE® 515 Flexible Form-In-Place Gasket to the cylinder block and timing gear housing mating surfaces.

9. Install housing (E) and tighten cap screws (F) to specification.

Timing Gear Housing—4TNE98—Specification
Mounting Cap Screws—Torque .... 25 N•m (221 lb-in.)

10. Install camshaft, idler gear, oil pump, fuel injection pump, fuel supply pump, and coolant pump . (See appropriate procedures in this group and Groups 060, 070 and 090.)

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RG,RG34710,8184 –19–15APR97–1/1

Remove and Install Oil Pan and Strainer

NOTE: Model 3015 is shown. Other models are similar.

1. Drain engine oil from crankcase.
2. Remove cap screws (F) and oil pan (E).
3. Remove oil strainer (B). Discard gasket or O-ring.
4. Replace O-ring or gasket on oil strainer.
5. Install oil strainer and tighten cap screws (C) to specification.

Specification

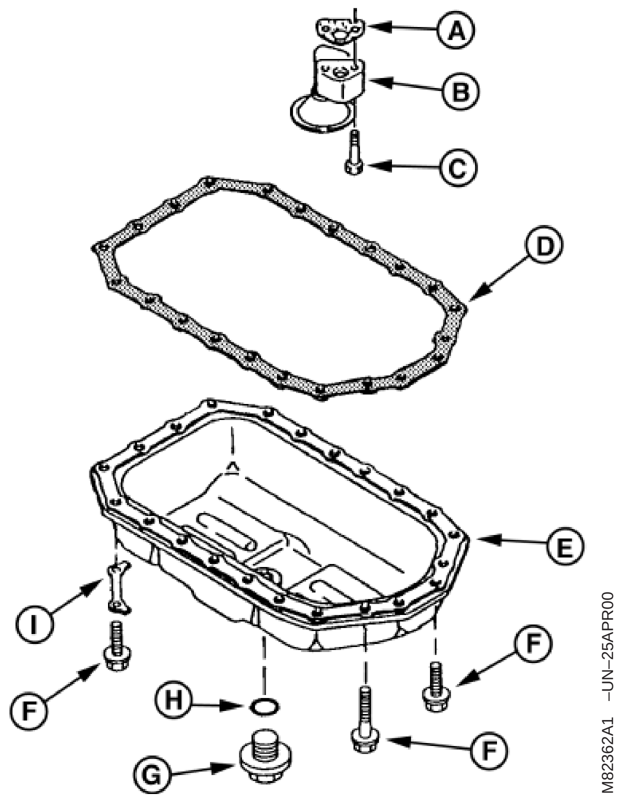
Oil Strainer Cap Screw—3009—
Torque .... 11 N•m (97 lb-in.)
Oil Strainer Cap Screw—3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98—Torque .... 26 N•m (230 lb-in.)

6. Apply LOCTITE® 515 Flexible Form-In-Place Gasket to oil pan rail.
7. Install oil pan (E) and spacer plate (I) (if equipped), and tighten cap screws to specification.

Specification

Oil Pan Cap Screw—3009—
Torque .... 11 N•m (97 lb-in.)
Oil Pan Cap Screw—3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98—Torque.. 26 N•m (230 lb-in.)

8. Replace drain plug O-ring or washers as necessary.



Typical Oil Pan Installation

A—Gasket
B—Oil Strainer
C—Cap Screw
D—Form-in-Place Gasket
E—Oil Pan
F—Cap Screw
G—Drain Plug
H—O-Ring
I—Spacer Plate (if equipped)

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RG,RG34710,8196 –19–15APR97–1/2

NOTE: If drain plug is equipped with aluminum or copper washer, install washer with raised center against plug.

If equipped with elbow drain fittings, the threads and sealing surfaces must be free of oil film to ensure an effective seal. Apply LOCTITE® 592 Pipe Sealant With TEFLON® to fittings, except for leading two threads.

9. Fill engine crankcase with correct grade and viscosity of engine oil. (See DIESEL ENGINE OIL in Section 01, Group 002.)

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TEFLON is a trademark of Du Pont Co.

RG,RG34710,8196 –19–15APR97–2/2

Remove and Install Engine Oil Pump—3009, 3011, 3012, 3015, 4020 and 4TNE98

1. Remove timing gear cover. (See REMOVE AND INSTALL TIMING GEAR COVER in Group 050.)

2. Check oil pump gear backlash. Replace entire oil pump assembly if backlash is more than specification.

Specification

Oil Pump Gear—3009—Backlash .... 0.25 mm (0.010 in) Maximum
Oil Pump Gear—3011, 3012,
3015 and 4020—Backlash .... 0.11—0.19 mm (0.0043—0.0074 in.)
Oil Pump Gear—4TNE98—
Backlash .... 0.09—0.15 mm (0.0035—0.0059 in.)

3. Remove mounting cap screws, oil pump and gasket.

4. Inspect all parts for wear or damage. (See DISASSEMBLE, INSPECT AND ASSEMBLE OIL PUMP—3009, 3011, 3012, 3015, 4020 and 4TNE98 in this group.)

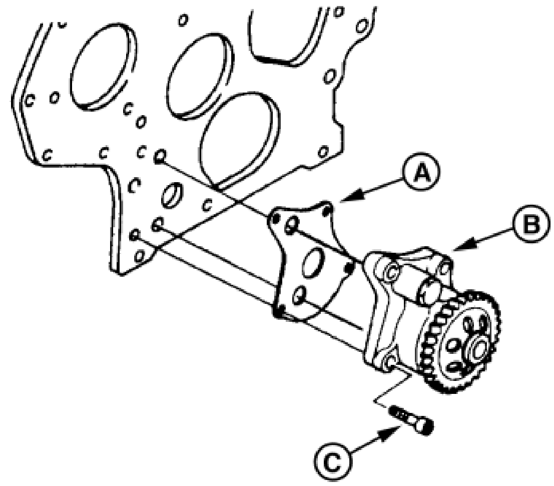
5. For Models 3015, 4020 and 4TNE98, inspect oil pressure regulating valve (located in oil pump). (See REMOVE AND INSTALL OIL PRESSURE REGULATING VALVE in this group.)

6. Replace gasket.

7. Install oil pump and tighten cap screws to specification.

Specification

Oil Pump Mounting Cap Screw—
Torque .... 25 N•m (221 lb-in.)



RG10856A –UN–12JUN00

Engine Oil Pump

A—Oil Pump Gasket
B—Oil Pump
C—Cap Screw

RG,RG34710,8197 –19–15APR97–1/1

Remove and Install Engine Oil Pump—3013 and 3016

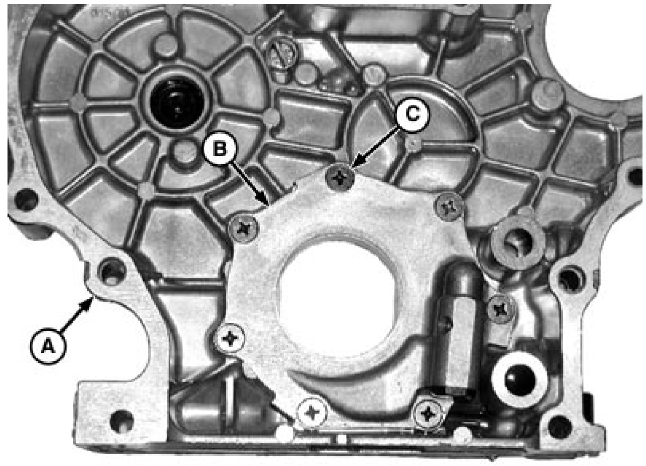
1. Remove timing gear cover. (See REMOVE AND INSTALL TIMING GEAR COVER in Group 050.)

2. Remove oil pressure regulating valve. (See REMOVE AND INSTALL OIL PRESSURE REGULATING VALVE in this group.)

3. Remove oil pump cover mounting cap screws (C) and remove oil pump cover (B).

4. Inspect all parts for wear or damage. (See DISASSEMBLE, INSPECT AND ASSEMBLE OIL PUMP—3013 and 3016 in this group.)

5. Install timing gear cover. (See REMOVE AND INSTALL TIMING GEAR COVER in Group 050.)



RG13414A –UN–12APR04

Oil Pump Mounting Screw

A—Timing Gear Cover
B—Oil Pump Cover
C—Cap Screw (7 used)

OUO1082,000029E –19–08APR04–1/1

Disassemble, Inspect and Assemble Oil Pump—3009, 3011, 3012, 3015, 4020 and 4TNE98

NOTE: Oil pump gear is press fit on rotor shaft. Remove gear using a suitable puller and a press.

Inspect oil pump components for excessive wear. Replace parts or oil pump assembly, as necessary.

1. Measure rotor shaft outside diameter and measure shaft hole diameter in backing plate. If clearance is more than wear limit, replace the entire assembly.

Specification

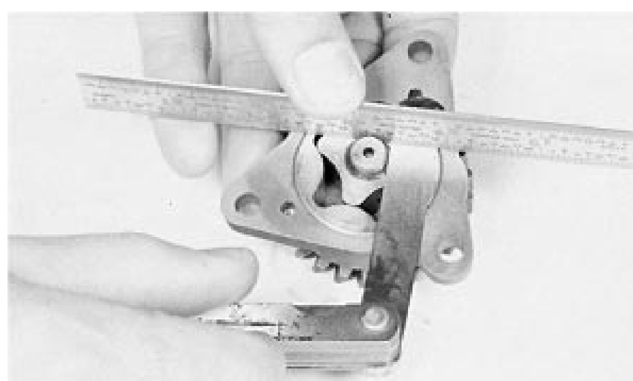
Oil Pump Rotor Shaft and Plate—
3009, 3011 and 3012—Clearance .... 0.015—0.048 mm (0.0006—0.0019 in.)
Wear Limit .... 0.20 mm (0.0079 in.)
Oil Pump Rotor Shaft and Plate—
3015 and 4020—Clearance .... 0.013—0.043 mm (0.0005—0.0017 in.)
Wear Limit .... 0.20 mm (0.0079 in.)
Oil Pump Rotor Shaft and Plate—
4TNE98—Clearance.. 0.010—0.065 mm (0.0004—0.0026 in.)
Wear Limit .... 0.20 mm (0.0079 in.)

RG,RG34710,8198 –19–15APR97–1/4

2. Check rotor recess. If rotors are below face of pump housing more than specification, replace rotor assembly.

Specification

Oil Pump Rotor—3009, 3011,
3012, 3015 and 4020—Recess .... 0.15 mm (0.0059 in.)
Oil Pump Rotor—4TNE98—
Recess.. 0.10 mm (0.0039 in.)



M37775 –UN–29AUG88

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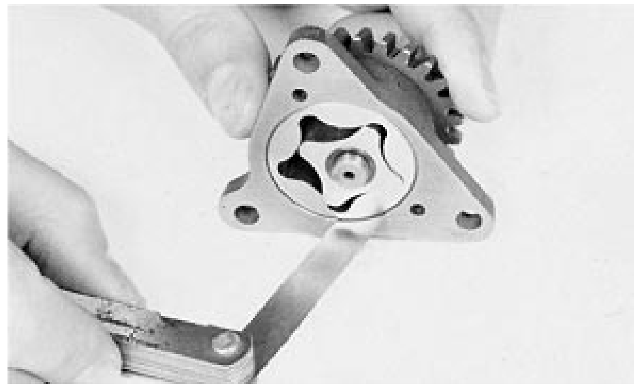
3. Check outer rotor-to-pump body clearance. If clearance is more than wear limit, replace entire assembly.

Specification

Outer Rotor-to-Pump Body—
3009—Clearance .... 0.03—0.09 mm
(0.0011—0.0035 in.)
Wear Limit .... 0.13 mm (0.0051 in.)
Outer Rotor-to-Pump Body—
3011, 3012 and 3015—Clearance .... 0.09—0.16 mm
(0.0035—0.0063 in.)
Wear Limit .... 0.25 mm (0.0098 in.)
Outer Rotor-to-Pump Body—
4020—Clearance .... 0.010—0.017 mm
(0.0039—0.0067 in.)
Wear Limit .... 0.25 mm (0.0098 in.)
Outer Rotor-to-Pump Body—
4TNE98—Clearance .... 0.10—0.155 mm
(0.0039—0.0061 in.)
Wear Limit .... 0.25 mm (0.0098 in.)



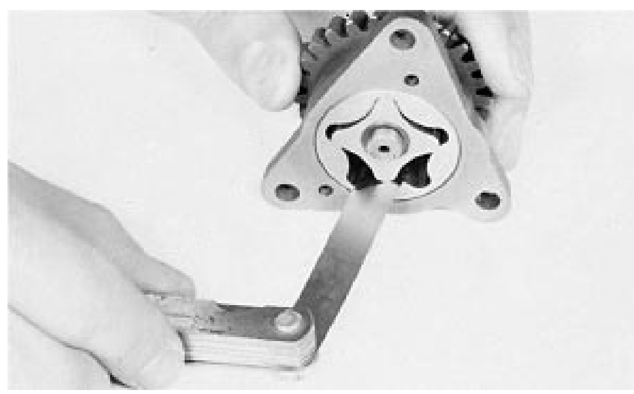
M37776 –UN–29AUG88

RG,RG34710,8198 –19–15APR97–3/4

4. Check inner-to-outer rotor clearance. If clearance is more than specification, replace rotor assembly.

Specification

Inner-to-Outer Rotor—3009,
3011, 3012, 3015, 4020 and
4TNE98—Clearance .... 0.15 mm (0.0059 in)



M37777 –UN–29AUG88

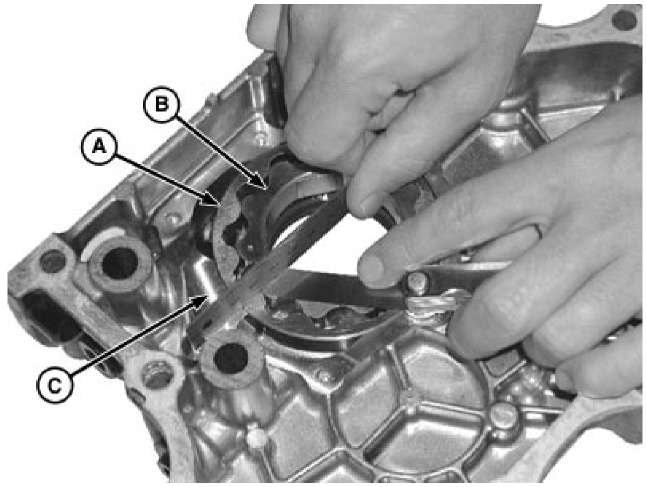
RG,RG34710,8198 –19–15APR97–4/4

Disassemble, Inspect and Assemble Oil Pump—3013 and 3016

1. Check rotor recess. If rotors are below face of pump housing more than specification, replace rotor assembly.

Specification

Oil Pump Rotor—3013 and 3016—Recess	0.02—0.07 mm (0.001—0.003 in.)
Wear Limit	0.12 mm (0.005 in.)

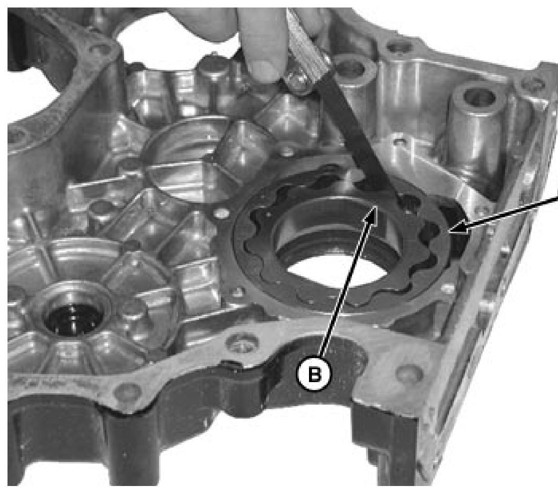


Rotor Recess

2. Check inner-to-outer rotor clearance. If clearance is more than specification, replace rotor assembly.

Specification

Inner-to-Outer Rotor—3013 and 3016—Clearance	0.16 mm (0.006 in.) Maximum

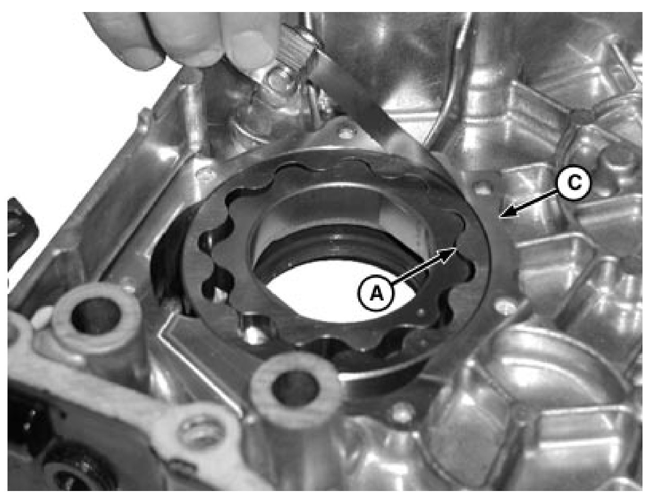


Rotor-to-Rotor Clearance

3. Check outer rotor-to-pump body clearance. If clearance is more than wear limit, replace entire assembly.

Specification

Outer Rotor-to-Housing—Clearance	0.12—0.21 mm (0.005—0.008 in.)
Wear Limit	0.30 mm (0.012 in.)



Rotor-to-Housing Clearance

A—Outer Rotor
B—Inner Rotor
C—Pump Housing

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4. Measure inner rotor diameter (A). If measurement is less than specification, replace rotor assembly.

Specification

Inner Rotor Inner Diameter—Diameter	53.05—53.15 mm (2.088—2.093 in.)

5. Measure distance between flats (B) of inner rotor. If measurement is less than specification, replace rotor assembly.

Specification

Inner Rotor Flat-to-Flat—Distance	49.95—50.05 mm (1.967—1.974 in.)

6. Measure crankshaft gear outer diameter (C). If measurement is less than specification, replace crankshaft gear.

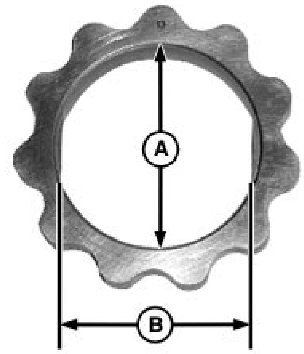
Specification

Crankshaft Gear Outer Diameter—Diameter	53.45—53.55 mm (2.104—2.108 in.)

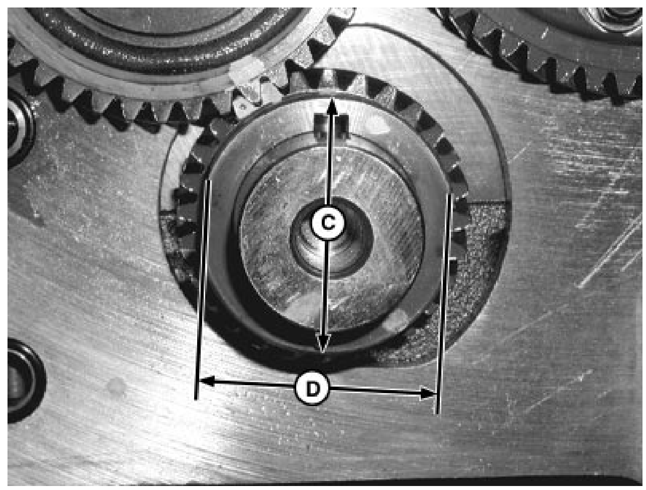
7. Measure distance between flats (D) of crankshaft gear. If measurement is less than specification, replace crankshaft gear.

Specification

Crankshaft Gear Flat-to-Flat—Distance	49.45—49.75 mm (1.947—1.959 in.)



Inner Rotor Flats



Crankshaft Gear

A—Inner Rotor Diameter
B—Inner Rotor Flat-to-Flat
C—Crankshaft Gear Diameter
D—Crankshaft Gear Flat-to-Flat

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8. Install rotors with alignment marks (A) facing out.

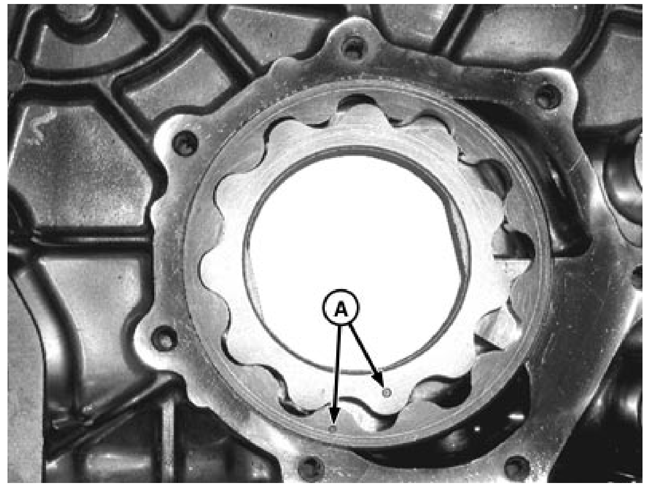
9. Apply LOCTITE® 242 Thread Lock and Sealer (Medium Strength) to pump cover mounting cap screws. Install cap screws and tighten to specification.

Specification

Oil Pump Cover Mounting Cap Screw—Torque.. 7 N•m (61 lb-in.)

10. Install oil pump. (See REMOVE AND INSTALL ENGINE OIL PUMP—3013 AND 3016 in this group.)

A—Alignment Marks



Oil Pump Rotor Installation

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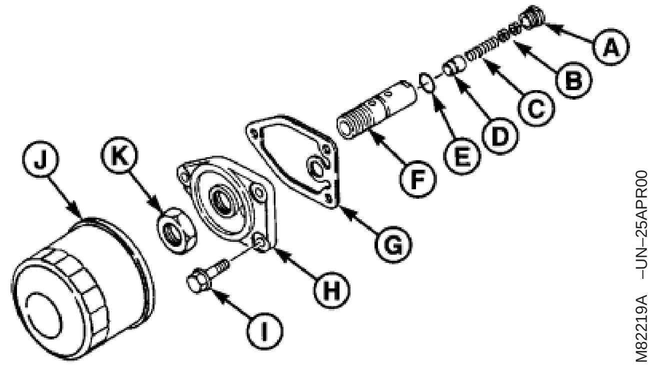
OUO1082,000029D –19–08APR04–3/3

Remove and Install Oil Pressure Regulating Valve

NOTE: On Models 3009, 3011, and 3012, the oil pressure regulating valve is located in the oil filter base.

On Models 3013, 3015, 3016, 4020, and 4TNE98 the oil pressure regulating valve is located in the oil pump.

Items (A—E) are similar in all installations.

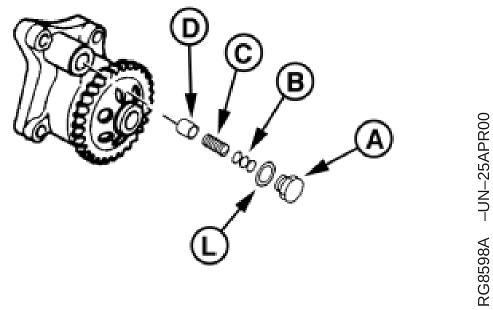


Oil Pressure Regulating Valve (3009, 3011 and 3012)

Remove parts as follows:

1. If adjusting oil pressure only, retaining nut (K) need not be removed. Remove cap (A) and add shims (B). Each 1 mm (0.039 in) of shim thickness increases oil pressure 10.9 kPa (1.6 psi).

NOTE: Valve components are not serviced individually. Replace complete regulating valve if any components are defective.



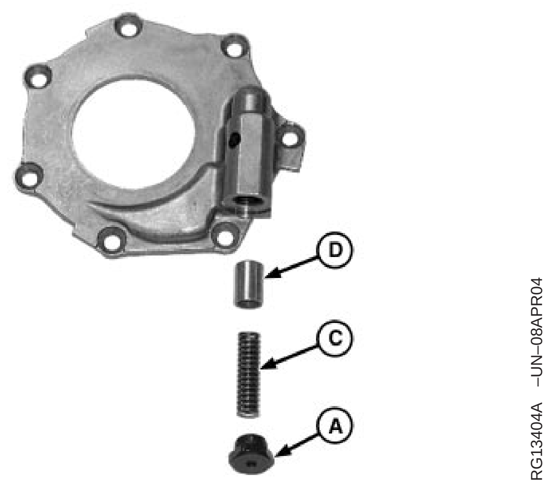
Oil Pressure Regulating Valve (3015, 4020 and 4TNE98)

2. Inspect all parts for wear or damage and replace parts or complete valve as needed. On models 4020D/T, replace the copper washer under the cap. A used washer may leak.

Installation is done in the reverse order of removal.

1. Stake valve cap to valve body

2. When installing oil filter base, tighten cap screws (I) and retaining nut (K) to specification.



Oil Pressure Regulating Valve (3013 and 3016)

A—Valve Cap
B—Shims
C—Spring
D—Valve
E—O-Ring
F—Valve Body
G—Gasket
H—Housing
I—Cap Screw
J—Oil Filter
K—Retaining Nut
L—Copper Washer

Continued on next page

RG,RG34710,8199 –19–15APR97–1/2

Specification	
Oil Pressure Regulating Valve Filter Housing Cap Screws—Torque	27 N•m (20 lb-ft)
Oil Pressure Regulating Valve Body Retaining Nut—Torque	30 N•m (22 lb-ft)

RG,RG34710,8199 –19–15APR97–2/2

Remove, Inspect and Install Oil Cooler—3016 and 4020T

1. Drain cooling system.

2. Remove oil filter (E).

3. Disconnect coolant hoses.

4. Remove mounting bolt or nut (I), oil cooler (G), and O-rings (if equipped) (H, J, and K).

5. Remove three cap screws (F), oil filter mounting block (B), and gasket (A).

6. Inspect all parts for physical damage, plugging, or leakage which may allow mixing of oil and coolant. Replace as necessary. DO NOT attempt to repair oil cooler.

7. Pressure test oil cooler:

    a. Plug one end of coolant inlet or outlet passage.

    b. Apply regulated air pressure of 206—483 kPa (30—70 psi) to other end.

    c. Dip oil cooler into water and check for leaks.

    d. Optional test: If a leak did not appear, use a hot water bath to attempt to open crack(s).

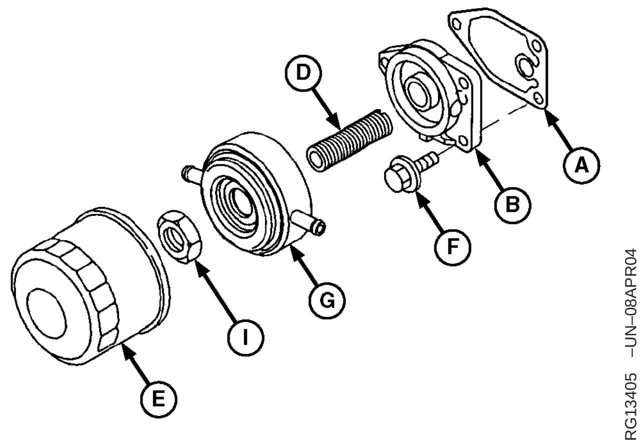
    e. Replace oil cooler if necessary.

Installation is done in reverse order of removal.

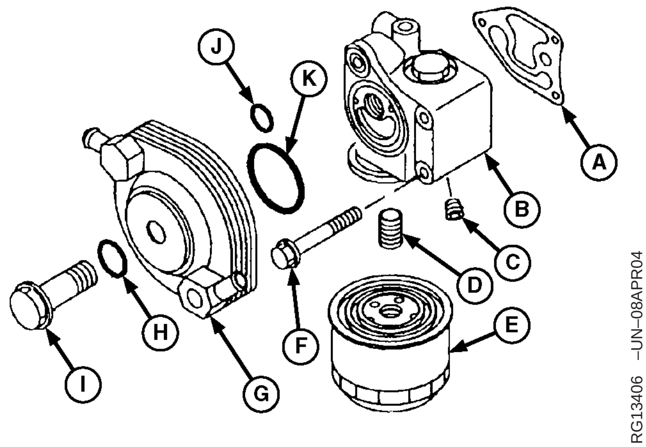
1. Lubricate new O-rings (if equipped) with clean engine oil.

2. Tighten cap screws to specification.

Specification	
Oil Cooler Mounting Block Cap Screws—Torque	27 N•m (20 lb-ft)



Oil Cooler—3016



Oil Cooler—4020T

A—Gasket
B—Mounting Block
C—Plug
D—Oil Filter Mounting Stud
E—Oil Filter
F—Cap Screw
G—Oil Cooler
H—O-Ring
I—Mounting Bolt or Nut
J—O-Ring
K—O-Ring

Continued on next page RG,RG34710,8200 –19–15APR97–1/2

3. Tighten mounting bolt or nut to specification.

Specification	
Oil Cooler Mounting Bolt or Nut—Torque	30 N•m (22 lb-ft)

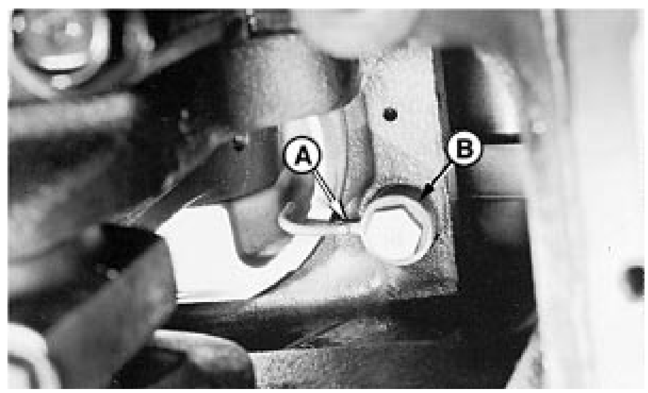
4. Apply LOCTITE® 592 Pipe Sealant with TEFLON® to oil cooler drain plug (if equipped).

5. Close drain valve and fill radiator with proper coolant. (See DIESEL ENGINE COOLANT in Section 01, Group 002.)

LOCTITE is a trademark of Loctite Corp.
TEFLON is a trademark of Du Pont Co.

RG,RG34710,8200 –19–15APR97–2/2

Replace Piston Cooling Nozzles—4020T



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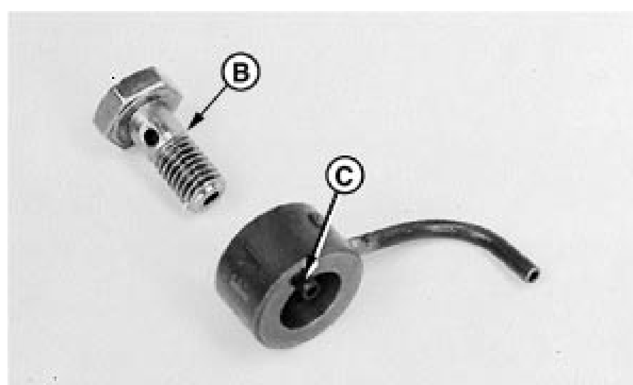


M51581A –UN–09JUN00

1. Remove oil pan and strainer. (See REMOVE AND INSTALL OIL PAN AND STRAINER earlier in this group.)

2. Inspect nozzle (A) for wear or blockage. Clean or replace as needed.

3. Install nozzle with locating pin (C) in locating hole of cylinder block.

4. Tighten mounting bolt to specification.

Specification	
Cooling Nozzle Mounting Bolt—4020T—Torque	15 N•m (133 lb-in.)

A—Piston Cooling Nozzle
B—Mounting Bolt
C—Locating Pin

RG,RG34710,8201 –19–15APR97–1/1

Remove and Install Coolant Temperature Sensor or Switch

NOTE: *Some engines may also be equipped with a coolant temperature switch. Switch is located opposite of sensor in coolant pump housing. Replacement procedures are the same.*

Model 3009 coolant pump housing is shown. Other models are similar.

1. Disconnect wiring lead, if equipped.

2. Open engine drain valve to drain coolant.

3. Remove sensor and washer.

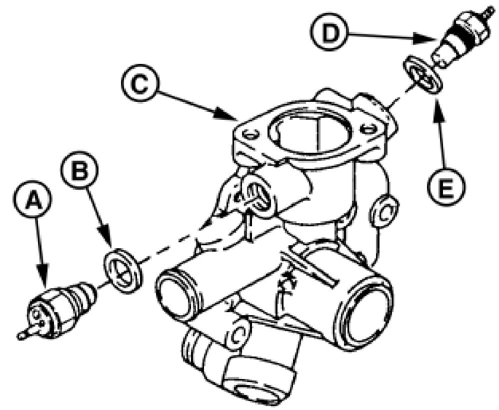
4. Test sensor. (See TEST COOLANT TEMPERATURE SWITCH in Section 04, Group 150.)

IMPORTANT: At installation, always replace copper washers with new.

5. Installation is done in reverse order of removal.

IMPORTANT: Air must be expelled from cooling system when system is filled. Loosen coolant temperature sender or plug in thermostat housing to allow air to escape when filling system. Retighten sender or plug when all the air has been expelled.

6. Close drain valve and remove coolant temperature sender from engine. Fill radiator with proper coolant until coolant is present at temperature sender hole. Install temperature sender and continue to fill radiator to top of filler neck.



M82313A –UN–12JUN00

A—Coolant Temperature Switch
B—Copper Washer
C—Coolant Pump Housing
D—Coolant Temperature Sensor
E—Copper Washer

RG,RG34710,8214 –19–13APR04–1/1

Remove and Install Thermostat—3009, 3011, 3012, 3013, 3015, 3016, and 4020

NOTE: Model 3009 is shown. Other models are similar.

1. Remove cap screws (A).

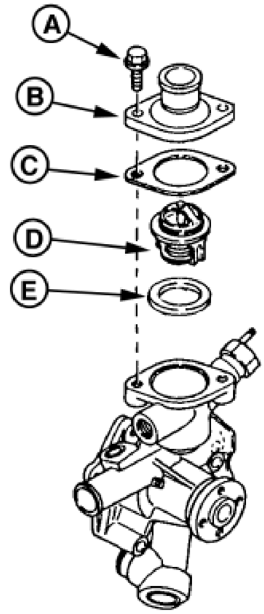
2. Remove cover (B), cover gasket (C), thermostat (D), and gasket (E).

3. Test thermostat. (See TEST THERMOSTAT OPENING in Section 04, Group 150.)

4. At installation, replace gaskets.

Specification

Thermostat Cover Cap Screw—
3009, 3011, 3012, 3013, 3015,
3016, and 4020—Torque .... 20 N•m (15 lb-ft)

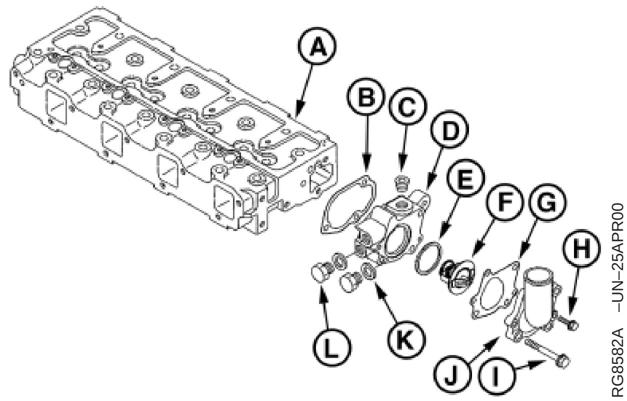


M82315A –UN–12JUN00

A—Cap Screw
B—Cover
C—Cover Gasket
D—Thermostat
E—Gasket

OUO1020,00013E1 –19–12APR04–1/1

Remove and Install Thermostat and Housing—4TNE98



A—Cylinder Head
B—Gasket
C—Plug
D—Housing
E—Gasket
F—Thermostat
G—Gasket
H—Cap Screw
I—Cap Screw
J—Cover
K—Gasket
L—Plug

1. Drain engine coolant.

2. Remove cap screws (H and I). Remove cover (J), gasket (G), thermostat (F), gasket (E), housing (D) and gasket (B).

3. Inspect all parts for wear or damage.

4. Test thermostat. (See TEST THERMOSTAT OPENING in Section 04, Group 150.)

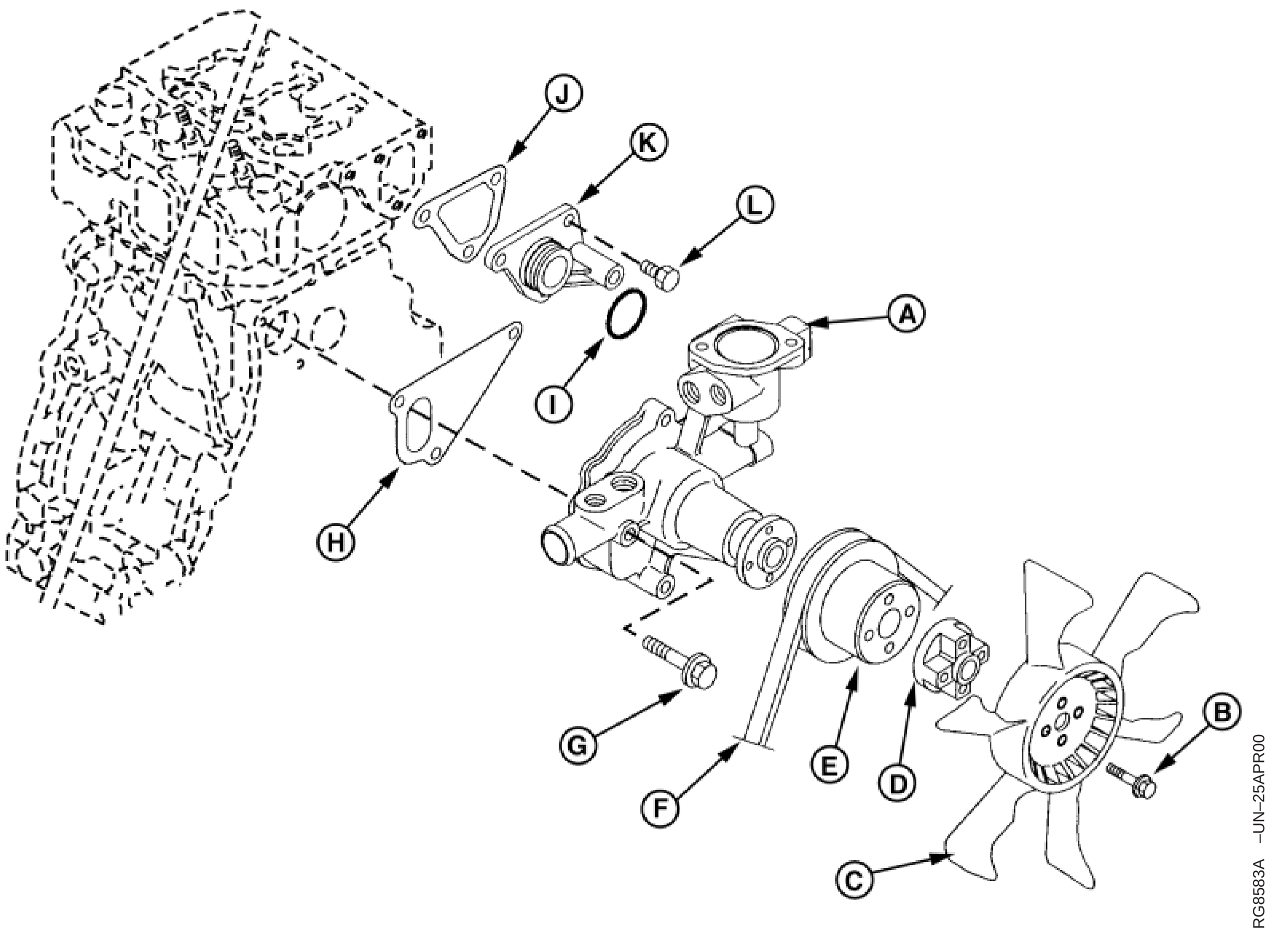
5. At installation, replace gaskets.

IMPORTANT: Air must be expelled from cooling system when system is filled. Loosen coolant temperature sender or plug in thermostat housing to allow air to escape when filling system. Retighten sender or plug when all the air has been expelled.

6. Close drain valve and remove coolant temperature sender from engine. Fill radiator with proper coolant until coolant is present at temperature sender hole. Install temperature sender and continue to fill radiator to top of filler neck. (See COOLING SYSTEM SPECIFICATIONS in Section 06, Group 200.)

RG,RG34710,8217 –19–13APR04–1/1

Remove, Inspect and Install Coolant Pump—3009, 3011, 3012, 3013, 3015, 3016 and 4020



A—Coolant Pump
B—Fan-to-Coolant Pump Cap Screw
C—Fan
D—Spacer (if equipped)
E—Pulley
F—Fan Belt
G—Coolant Pump-to-Cylinder Head Cap Screws
H—Gasket
I—O-Ring (3013, 3015, 3016, and 4020)
J—Gasket (3013, 3015, 3016, and 4020)
K—Ball Joint (3013, 3015, 3016, and 4020)
L—Cap Screw (3013, 3015, 3016, and 4020)

NOTE: Models 3015 and 4020 are shown. Other models are similar.

1. Open engine drain valve to drain coolant.
2. Disconnect coolant temperature sensor lead, if equipped.
3. Disconnect upper and lower radiator hoses.
4. If equipped, loosen clamps and remove thermostat housing-to-coolant pump hose.
5. Remove fan belt (F).
6. Remove cap screws (B), fan (C), spacer (D), and pulley (E).
7. Remove mounting cap screws (G), coolant pump (A), and gasket (H).
8. If equipped, remove cap screws (L), ball joint (K), gasket (J) and O-ring (I).
9. Inspect coolant pump for coolant leakage. If origin of leak cannot be determined, perform PRESSURE TEST COOLING SYSTEM AND RADIATOR CAP in Section 04, Group 150.

Continued on next page

10. If coolant is leaking at pulley flange, shaft seal is defective. Replace coolant pump.

11. If coolant is leaking between plate and pump housing, gasket between plate and pump housing is defective. Remove plate and replace gasket.

12. If coolant is leaking between plate and engine block, remove coolant pump and replace gasket.

13. Inspect coolant pump for worn bearing shaft by removing fan belt and checking for excessive movement of fan. Replace coolant pump if excessive movement is noticed.

14. If bearing shaft is making noise when operating, check fan belt tension. (See REPLACE AND ADJUST FAN/ALTERNATOR BELT in this group.) If adjustment does not relieve the noise, bearing shaft is defective. Replace coolant pump.

15. Test thermostat for proper operation. (See TEST THERMOSTAT OPENING in Section 04, Group 150.)

16. Installation is done in the reverse order of removal.

IMPORTANT: At installation, replace all O-rings and copper washers.

Specification

Coolant Pump Mounting Cap Screws—3009, 3011, 3012, 3013, 3015, 3016, and 4020—Torque.. 26 N•m (230 lb-in.)
Fan-to-Coolant Pump Mounting Cap Screws-—3009, 3011, 3012, 3013, 3015, 3016, and 4020—Torque... 11 N•m (97 lb-in.)
Coolant Pump Plug (If Equipped)-—3009, 3011, 3012, 3013, 3015, 3016, and 4020—Torque.. 15 N•m (132 lb-in.)

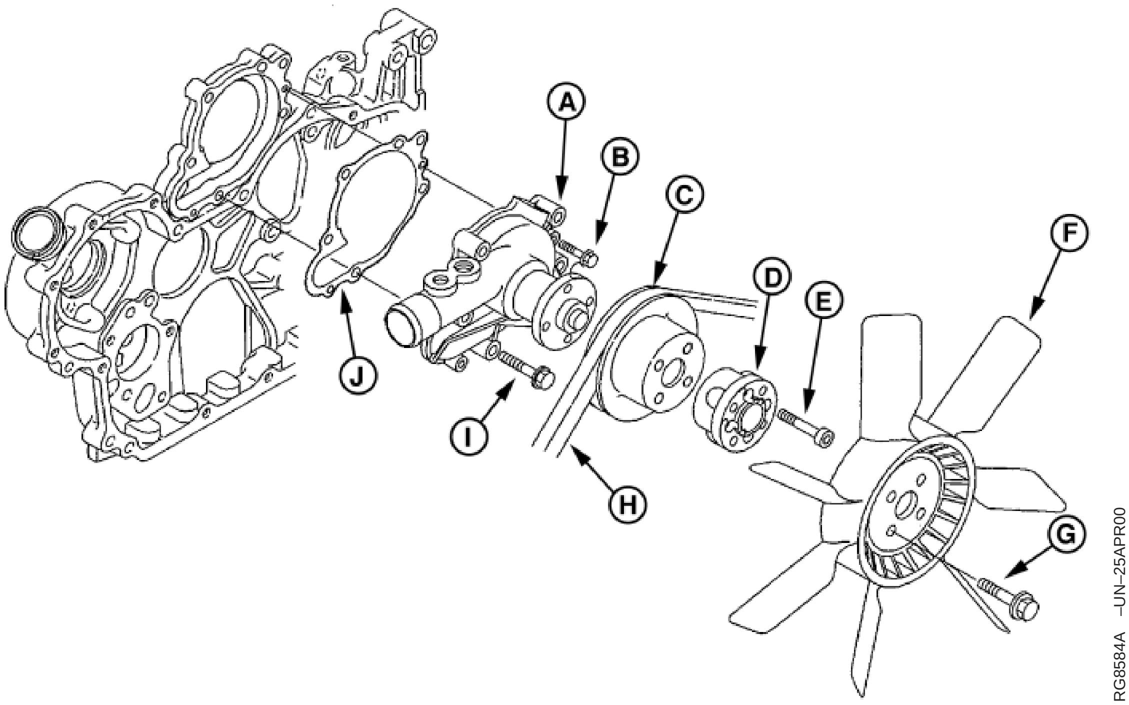
17. Adjust fan belt tension. (See REPLACE AND ADJUST FAN/ALTERNATOR BELT in this group.)

IMPORTANT: Air must be expelled from cooling system when system is filled. Loosen coolant temperature sender or plug in thermostat housing to allow air to escape when filling system. Retighten sender or plug when all the air has been expelled.

18. Close drain valve and remove coolant temperature sender from engine. Fill radiator with proper coolant until coolant is present at temperature sender hole. Install temperature sender and continue to fill radiator to top of filler neck.

OUO1020,00013E2 –19–12APR04–2/2

Remove, Inspect and Install Coolant Pump—4TNE98



A—Coolant Pump
B—Cap Screw
C—Pulley
D—Spacer (if equipped)
E—Cap Screw
F—Fan
G—Cap Screw
H—Fan Belt
I—Cap Screw
J—Gasket

1. Open engine drain valve to drain coolant.

2. Disconnect coolant temperature sensor lead, if equipped.

3. Disconnect upper and lower radiator hoses.

4. Remove fan belt (H).

5. Remove cap screws (G) and fan (F). Remove cap screws (E), spacer (D), and pulley (C).

6. Remove mounting cap screws (B and I), coolant pump (A) and gasket (J).

7. Inspect coolant pump for coolant leakage. If origin of leak cannot be determined, perform PRESSURE TEST COOLING SYSTEM AND RADIATOR CAP in Section 04, Group 150.

8. If coolant is leaking at pulley flange, shaft seal is defective. Replace coolant pump.

9. If coolant is leaking between pump and engine block, remove coolant pump and replace gasket.

10. Inspect coolant pump for worn bearing shaft by removing fan belt and checking for excessive movement of fan. Replace coolant pump if excessive movement is noticed.

11. If bearing shaft is making noise when operating, check fan belt tension. (See REPLACE AND ADJUST FAN/ALTERNATOR BELT in this group.) If adjustment does not relieve the noise, bearing shaft is defective. Replace coolant pump.

NOTE: Model 4TNE98 coolant pump has no replacement parts. Replace the coolant pump assembly.

12. Test thermostat for proper operation. (See TEST THERMOSTAT OPENING in Section 04, Group 150.)

Continued on next page

RG,RG34710,8221 –19–15APR97–1/2

13. Installation is done in the reverse order of removal.

IMPORTANT: At installation, replace all O-rings and copper washers.

Specification	
Coolant Pump Mounting Cap Screw—4TNE98—Torque	26 N•m (230 lb-in.)
Fan-to-Coolant Pump Cap Screw—4TNE98—Torque	20 N•m (177 lb-in.)

14. Adjust fan belt tension. (See REPLACE AND ADJUST FAN/ALTERNATOR BELT in this group.)

IMPORTANT: Air must be expelled from cooling system when system is filled. Loosen coolant temperature sender or plug in thermostat housing to allow air to escape when filling system. Retighten sender or plug when all the air has been expelled.

15. Close drain valve and remove coolant temperature sender from engine. Fill radiator with proper coolant until coolant is present at temperature sender hole. Install temperature sender and continue to fill radiator to top of filler neck.

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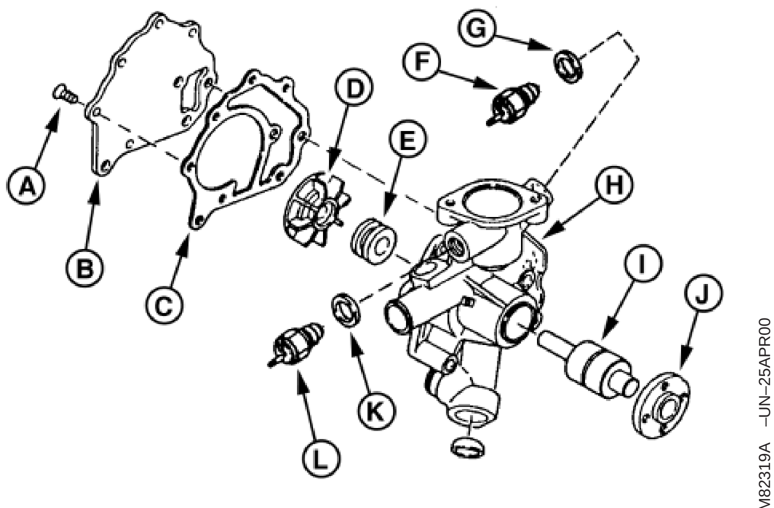
RG,RG34710,8221 –19–15APR97–2/2

Disassemble Coolant Pump—3009, 3011, and 3012



Model 3009

A—Plate-to-Housing Screw
B—Plate
C—Gasket
D—Impeller
E—Shaft Seal Assembly
F—Temperature Sensor
G—Gasket
H—Coolant Pump Housing
I—Bearing Shaft
J—Pulley Flange
K—Gasket
L—Temperature Switch

NOTE: Coolant pumps on 3013, 3015, 3016, 4020, and 4TNE98 engines are not servicable. Replace complete coolant pump if necessary.

NOTE: Model 3009 is shown. Other models are similar.

1. Apply heat to plate-to-housing screws (A). Remove screws, plate (B) and gasket (C).

Continued on next page

OUO1020,00013E3 –19–12APR04–1/2

2. Apply heat to pulley flange (A). Remove flange using a knife-edge puller set (B) and two small nuts (C).

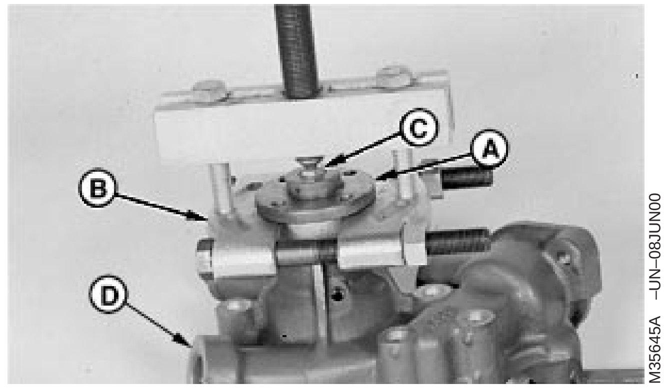
3. Place coolant pump assembly on a press table. Install supports under coolant pump housing (D), staying clear of impeller. Press bearing shaft assembly through coolant pump housing using a piece of pipe or a deep socket.

IMPORTANT: Impeller bore is tapered. When pressing bearing shaft from impeller, allow enough clearance between cap screw and impeller bore to prevent cap screw from binding.

4. Remove impeller from bearing shaft using a knife-edge puller, a 3/8 in. cap screw and a press.

5. Remove shaft seal, ceramic seal and seal cup.

6. Inspect all parts for wear or damage. Replace as necessary.

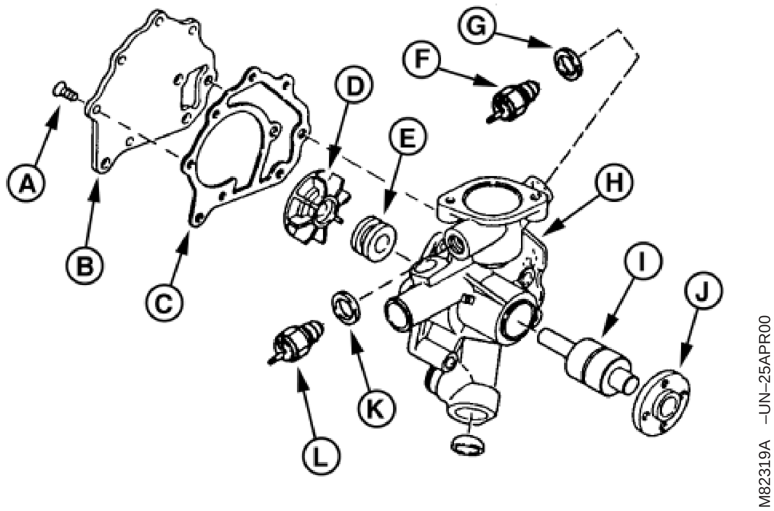


Removing Pulley Flange

A—Pulley Flange
B—Puller Set
C—Nuts
D—Coolant Pump Housing

OUO1020,00013E3 –19–12APR04–2/2

Assemble Coolant Pump—3009, 3011, and 3012



Model 3009

A—Plate-to-Housing Screw	**D—Impeller**	**G—Gasket**	**J—Pulley Flange**
B—Plate	**E—Shaft Seal Assembly**	**H—Coolant Pump Housing**	**K—Gasket**
C—Gasket	**F—Temperature Sensor**	**I—Bearing Shaft**	**L—Temperature Switch**

1. Install bearing shaft into pump housing, long end down, using a piece of pipe or deep socket and a press. Press shaft into pump housing until bearing surface is flush with pump housing surface.

2. Install new shaft seal over impeller side of bearing shaft, rubber seal side away from pump housing. Push shaft seal into pump housing, until it stops, using a 25 mm or 1.0 inch socket and a press.

IMPORTANT: Support pump housing on bearing shaft only. DO NOT support on housing or damage to housing will occur.

3. Place coolant pump housing on a press table. Support housing on bearing shaft using a driver disk. Install pulley flange onto shaft with straight hub facing away from housing.

   For 3009, press pulley flange onto bearing shaft until flange is flush with end of shaft.

   For 3011 and 3012 press pulley flange onto bearing shaft until bottom of flange is 17 mm (0.670 in.) from top of housing.

IMPORTANT: DO NOT touch lapped sealing surface of ceramic seal with bare hands. It must be clean and dry.

4. Install seal cup and ceramic seal in impeller.

5. Install a knife-edge puller around bearing shaft, between pulley flange and pump housing. Place pump housing, with knife-edge puller down, on a press table.

6. Install impeller with ceramic seal toward shaft seal.

   For 3009, press impeller on bearing shaft until top of impeller is even with end of shaft.

   For 3011, 3012, press impeller on bearing shaft until top of impeller is 2 mm (0.080 in.) below housing.

7. Install new gasket, plate, and cap screws. Tighten cap screws to specification.

Continued on next page

Specification

Coolant Pump Housing Cap Screw—3009, 3011, and 3012—Torque .... 9 N•m (79 lb-in.)

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8. Install coolant temperature sensor. (See TEST COOLANT TEMPERATURE SWITCH in Section 04, Group 150.)

9. Install thermostat. (See REMOVE AND INSTALL THERMOSTAT—3009, 3011, 3012, 3013, 3015, 3016, and 4020 in this group.)

RG,RG34710,8225 –19–08APR04–2/2

Remove and Inspect Radiator

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.

1. Remove radiator cap and open drain valve to drain cooling system.

Specification

Cooling System (Approximate)—3009—Capacity	3.5 L (3.7 qt)
Cooling System (Approximate)—3011, 3012 and 3013—Capacity	3.7 L (3.79 qt)
Cooling System (Approximate)—3015 and 3016—Capacity	4.0 L (4.2 qt)
Cooling System (Approximate)—4020—Capacity	4.7 L (4.9 qt)
Cooling System (Approximate)—4TNE98—Capacity	4.2 L (4.4 qt)

2. Remove fan guard (A).

3. Remove fan shroud mounting cap screws, and place shroud (C) over fan.

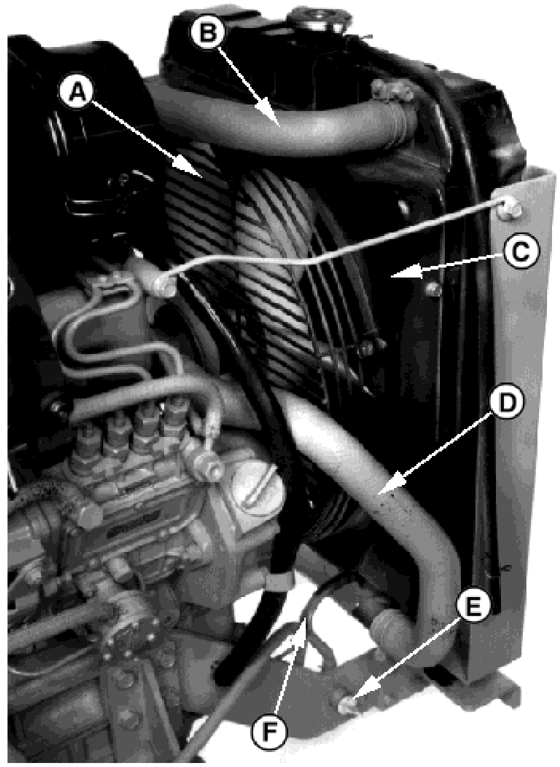
4. Remove upper and lower radiator hoses (B and D).

5. Disconnect drain hose (F).

6. Support bottom of radiator and remove radiator mounting cap screws (G).

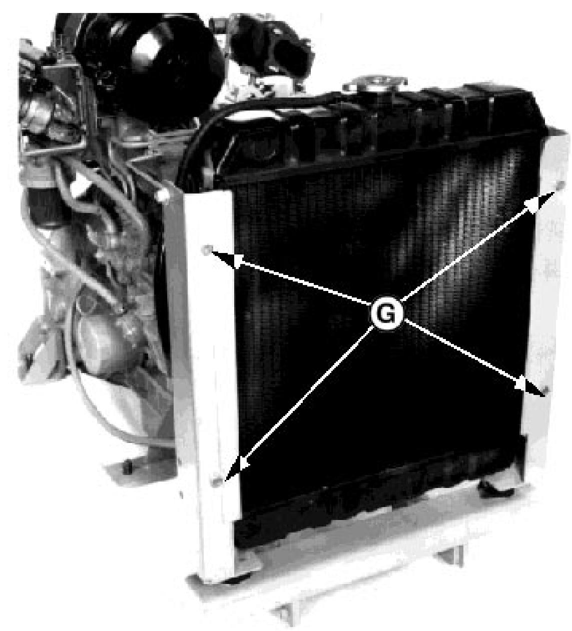
7. Remove radiator.

A—Fan Guard
B—Upper Radiator Hose
C—Fan Shroud
D—Lower Radiator Hose
E—Drain Valve
F—Drain Hose
G—Radiator Mounting Cap Screws



M82129 –UN–25APR00

Radiator Components



M82130 –UN–25APR00

Radiator Components

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CAUTION: Reduce compressed air to less than 210 kPa (30 psi) when using for cleaning purposes. Clear area of bystanders, guard against flying chips, and wear personal protection equipment including eye protection.

8. Check radiator for bent fins, cracks and damaged seams. Clean and repair as necessary.

   Installation is done in the reverse order of removal.

IMPORTANT: Air must be expelled from cooling system when system is filled. Loosen coolant temperature sender or plug in thermostat housing to allow air to escape when filling system. Retighten sender or plug when all the air has been expelled.

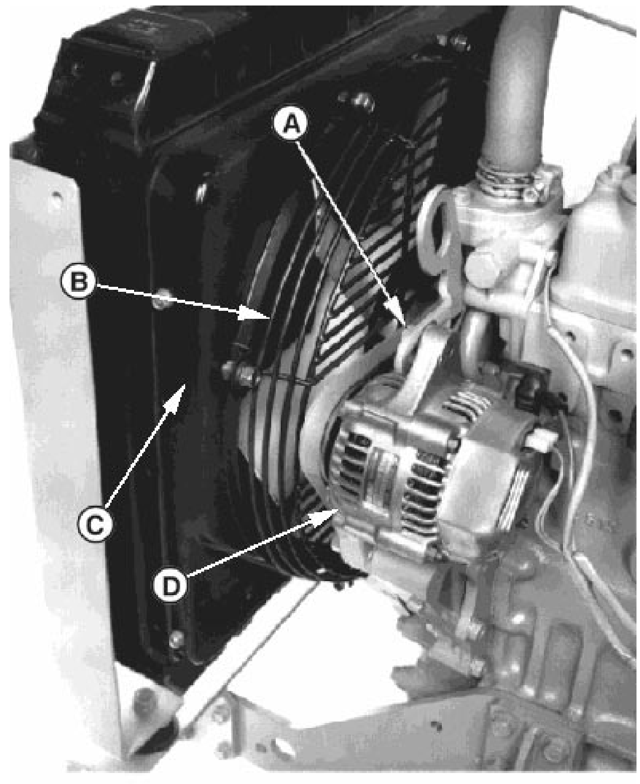
9. Close drain valve and remove coolant temperature sender from engine. Fill radiator with proper coolant until coolant is present at temperature sender hole. Install temperature sender and continue to fill radiator to top of filler neck.

10. Start engine and allow it to reach proper operating temperature. Check radiator, hoses and connections for leaks. Adjust coolant level in recovery tank.

RG,RG34710,8226 –19–12APR04–2/2

Remove and Install Cooling Fan

1. Remove fan guard (B).
2. Loosen alternator bracket cap screw (A) and flange nut (D).
3. Remove fan shroud (C) mounting cap screws, if equipped, and move shroud toward engine.
4. Remove cap screws, fan and spacer, if equipped.



M82131 –UN–29APR04

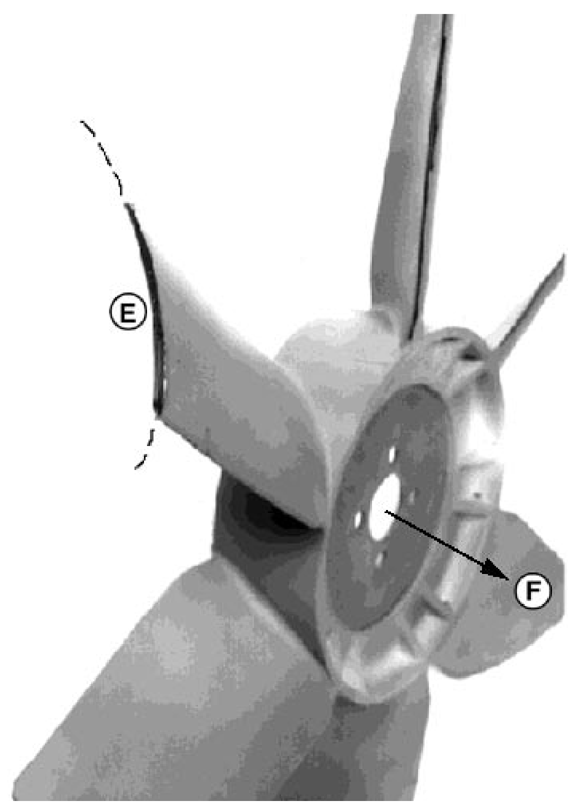
A—Cap Screw
B—Fan Guard
C—Fan Shroud
D—Flange Nut

RG,RG34710,8227 –19–15APR97–1/2

5. Installation is done in the reverse order of removal.

   Install fan with blade inward curve (E) facing AWAY from engine (F).

6. Adjust belt tension. (See REPLACE AND ADJUST FAN/ALTERNATOR BELT in this group.)



M82132 –UN–12JUN00

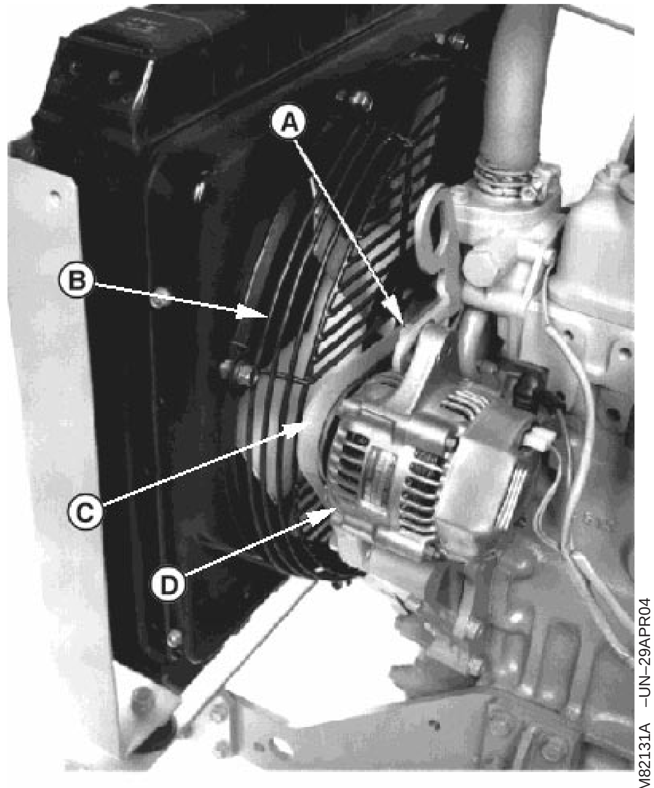
Blade Inward Curve Facing Away from Engine

E—Inward Curve
F—Engine

RG,RG34710,8227 –19–15APR97–2/2

Replace and Adjust Fan/Alternator Belt

1. Remove fan guard (B).
2. Loosen alternator bracket cap screw (A) and flange nut (D).
3. Replace fan/alternator belt (C).



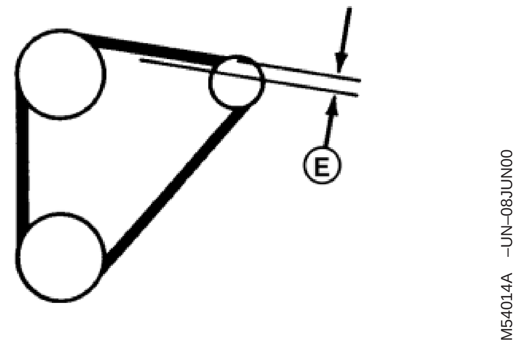
A—Cap Screw
B—Fan Guard
C—Fan/Alternator Belt
D—Flange Nut

Continued on next page RG,RG34710,8228 –19–15APR97–1/2

4. Adjust belt tension. Use JDG529 belt tension gauge and a straightedge to check belt deflection (E) between fan and alternator pulleys.

Specification

Belt Tension @ 98 N (22 lb) Applied Force (Used)—3009, 3011, 3012, 3015, and 4020—Deflection	10—14 mm (0.494—0.551 in.)
Belt Tension @ 98 N (22 lb) Applied Force (Used)—3013 and 3016—Deflection	7—10 mm (0.276—0.394 in.)
Belt Tension @ 98 N (22 lb) Applied Force (New)—3013 and 3016—Deflection	5—8 mm (0.197—0.315 in.)
Belt Tension @ 98 N (22 lb) Applied Force (New)—4TNE98—Deflection	7—9 mm (0.276—0.354 in.)



Belt Deflection

E—Belt Deflection

5. If deflection is not according to specifications:

   Loosen alternator mounting cap screws and nut.

6. Apply force to FRONT alternator housing only (near the belt) until tension is correct.

7. Tighten cap screws and nut.

RG,RG34710,8228 –19–15APR97–2/2

Extending Turbocharger Life—4020T

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:

- Lack of lube oil (quick starts and hot shutdowns)
- Oil contamination
- Ingestion of foreign objects
- Restricted oil drainage
- Low oil level
- Operation on excessive side slopes
- Abnormally high exhaust temperatures

Lack of Lube Oil

Oil not only lubricates the turbocharger’s spinning shaft and bearings, it also carries away heat. When oil flow stops or is reduced, heat is immediately transferred from the hot turbine wheel to the bearings, which are also heating up because of the increased friction due to the lack of oil. This combination causes the turbocharger shaft temperature to increase rapidly.

If oil flow does not increase and the process continues, bearings will fail. Once the bearings fail (which can happen in just seconds) seals, shaft, turbine and compressor wheels can also be damaged.

The principle causes of turbocharger bearing lubrication problems are low oil pressure, a bent, plugged or undersized oil lube supply line, plugged or restricted oil galleries in the turbocharger, or improper machine start-up and shutdown procedure.

Oil levels and pressure should always be closely monitored and all worn hoses and lines should be replaced. The turbocharger oil supply line should be checked frequently to make sure it is not kinked or bent and it should always be replaced with a line of equal size, length and strength.

The easiest way to damage a turbocharger is through improper start-up and shutdown procedures. Always idle the engine for at least 30 seconds (no load) after start-up and before shutdown. Warming the engine up before applying a load allows oil pressure to build up and lines to fill with oil.

Idling the engine before shutdown allows the engine and turbocharger to cool. “Hot” shutdowns can cause the turbocharger to fail because after high-speed operation the turbocharger will continue to rotate long after the engine has been shut off and oil pressure has dropped to zero. This will cause heat to build up and possible bearing damage. It can also cause carbon and varnish deposits to form.

Oil Contamination

Contamination can be caused by a worn or damaged oil filter or not changing the lube oil at recommended intervals. Expecting the oil filter to remove dirt, sand, metal chips, etc., from the oil before they reach the engine or turbocharger can be a costly mistake because contaminated oil may completely bypass the engine oil filter if the oil filter or oil cooler is clogged, if the filter element is improperly installed, or if the oil is thick during cold weather.

Four good ways of avoiding oil contamination are:

- Always inspect the engine thoroughly during major overhaul. Look especially for any sludge or debris left in lube oil galleries.
- Change lube oil at recommended intervals. Analysis of oil samples at filter change periods can help identify potentially harmful contaminants in the oil.
- Clean the area around the oil fill cap before adding oil.
- Use a clean container when adding oil.

Ingestion of Foreign Objects

Foreign objects or particles can be ingested and cause damage to the turbocharger on both compressor and turbine sides. This is easy to avoid.

Continued on next page

On the compressor side, foreign objects usually take the form of dust, sand, or shreds of air cleaner element that enter through improperly installed air cleaner elements. Leaky air inlet piping (loose clamps or torn rubber joints) or torn pleats in dry-type air cleaner elements also create problems.

The result is erosion of compressor blades that can cause the delicately balanced wheel to wobble.

IMPORTANT: Whenever an internal engine failure (valve, valve seat, piston) occurs, a thorough inspection of the turbocharger MUST BE performed before returning engine to service.

Restricted Oil Drainage

The lubricating oil carries away heat generated by friction of the bearings and from the hot exhaust gases. If drainage back to the sump is impeded, the bearings will overheat with damage that will ultimately lead to failure.

There are two primary reasons for restricted drainage:

- A blocked drain tube, due to either damage or a buildup of sludged oil.
- High crankcase pressure, due to restricted crankcase breather or excessive engine blowby.

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.

Low Oil Level

Check engine oil lever periodically according to your operator's manual. Proper oil level will prevent turbocharger failure.

Operation on Excessive Side Slopes

Operating equipment on excessive side slopes will prevent engine oil from being transferred up to the turbocharger, causing overheating wear of moving parts

Abnormally High Exhaust Temperatures

This can cause coking of oil which can lead to bearing failure. Extreme over-temperature operation can case wheel burst.

There are two basic causes of over-temperature:

- Restricted air flow
- 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.

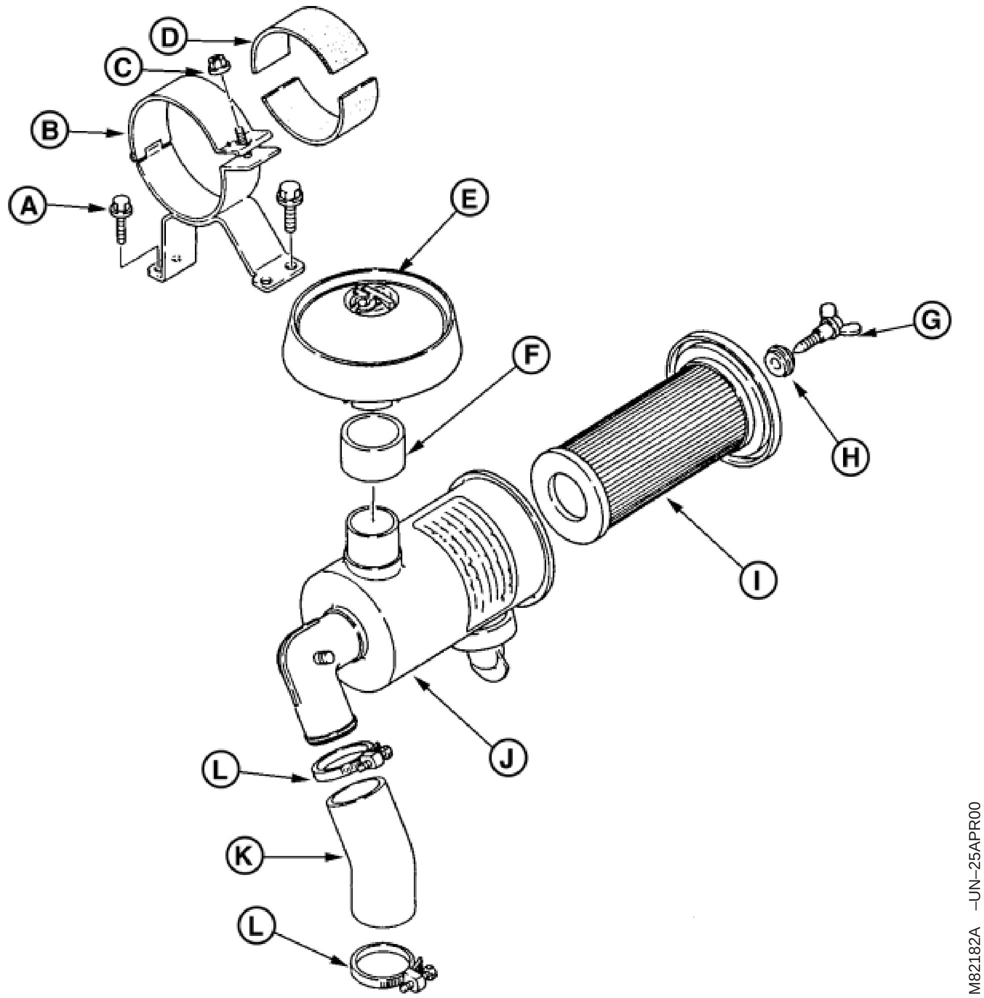
Causes of restricted air flow can include:

- Damaged inlet piping.
- Clogged air filters.
- Excessive exhaust restriction.
- Operation at extreme altitudes.

Overpowering generally is due to improper fuel delivery or injection timing. If over-temperature operation has been identified, an inspection of the air inlet and exhaust systems should be performed. Also, check the fuel delivery and timing.

RG,RG34710,8238 –19–15APR97–2/2

Inspect Air Cleaner—3009



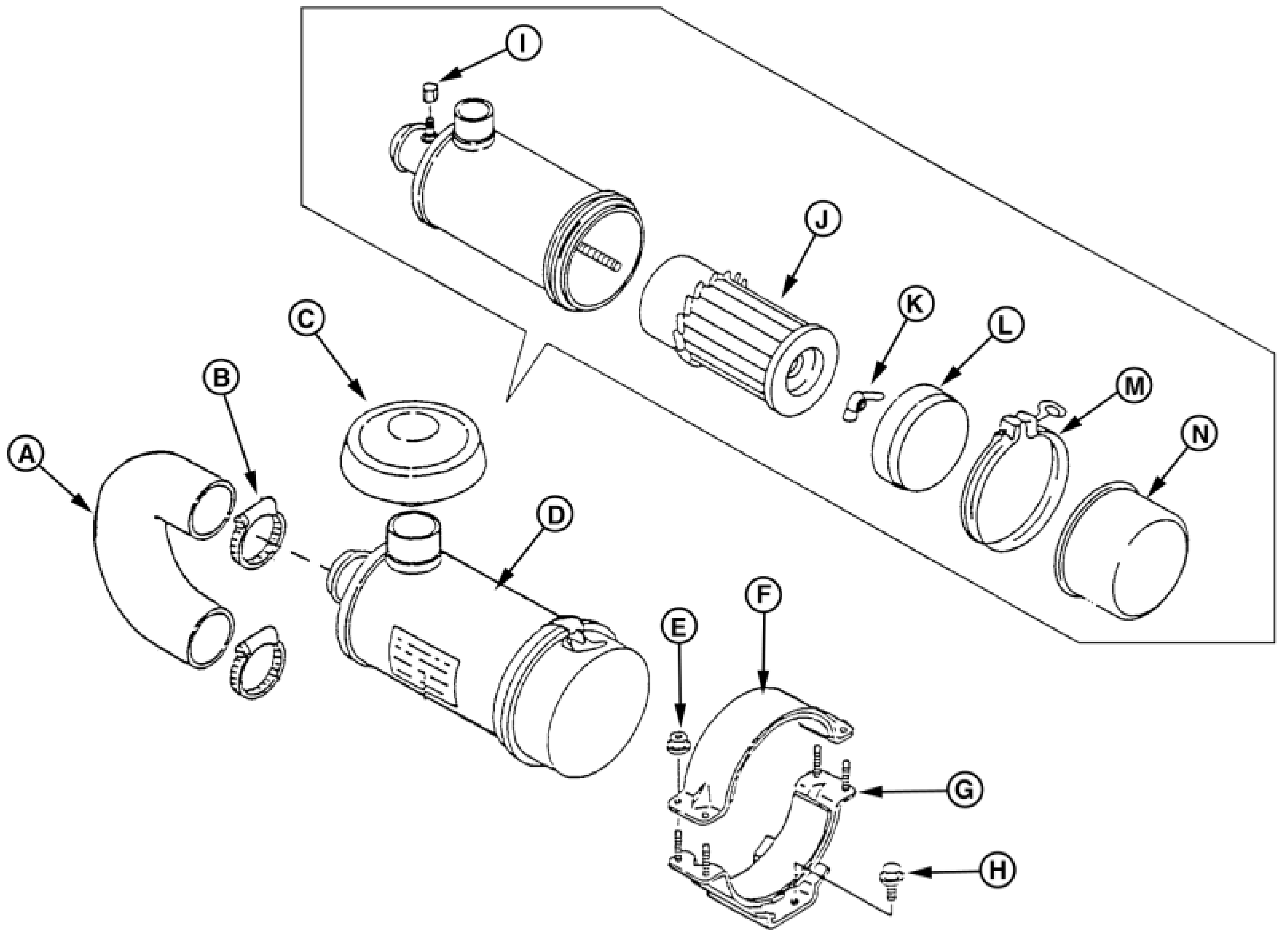
A—Cap Screw	**D—Isolator Pad**	**G—Wing Nut**	**J—Air Cleaner Housing**
B—Mounting Bracket	**E—Rain Cap**	**H—Seal Washer**	**K—Hose**
C—Flange Nut	**F—Collar**	**I—Element**	**L—Clamp**

NOTE: Inspect parts (D, I, and K) for wear or damage. Replace if necessary.

During inspection, check hose clamps (L). Tighten if necessary.

RG,RG34710,8235 –19–15APR97–1/1

Inspect Air Cleaner—3011, 3012 and 3013



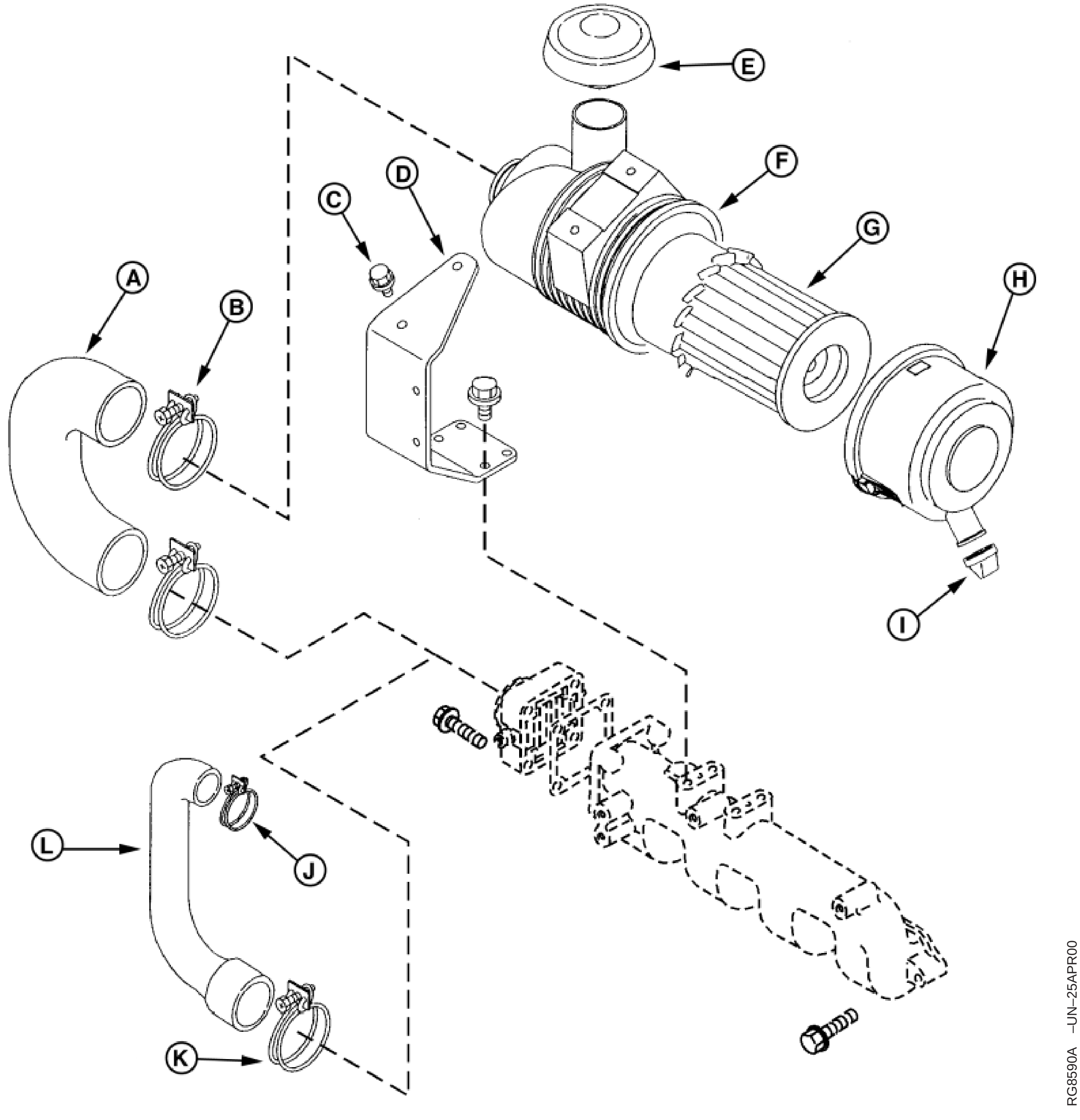
RG8591A –UN–12JUN00

A—Hose
B—Clamp
C—Rain Cap
D—Air Cleaner
E—Flange Nut
F—Upper Bracket
G—Lower Bracket
H—Bolt
I—Air Filter Restriction Indicator
J—Filter Element
K—Wing Nut
L—Deflector
M—Clamp
N—Cover

NOTE: Inspect parts (A and J) for wear or damage. Replace if necessary. During inspection, check hose clamps (B). Tighten if necessary.

DPSG,OUOE003,208 –19–30JUN99–1/1

Inspect Air Cleaner—3015, 3016, 4020D and 4020T



A—Hose (3015, 3016 and 4020D)
B—Clamp
C—Bolt
D—Bracket
E—Rain Cap
F—Air Filter Housing
G—Filter Element
H—Cover
I—Valve
J—Clamp (4020T)
K—Clamp (4020T)
L—Hose (4020T)

Continued on next page DPSG,OUOE003,207 –19–30JUN99–1/2

NOTE: Inspect parts (A,G, I, and L) for wear or damage. Replace if necessary.

During inspection, check hose clamps (B) on 3015 and 4020D engines or (J and K) on 4020T engines. Tighten if necessary.

DPSG,OUOE003,207 –19–30JUN99–2/2

Remove and Install Muffler—3009, 3011, 3012, 3013, 3015 and 3016

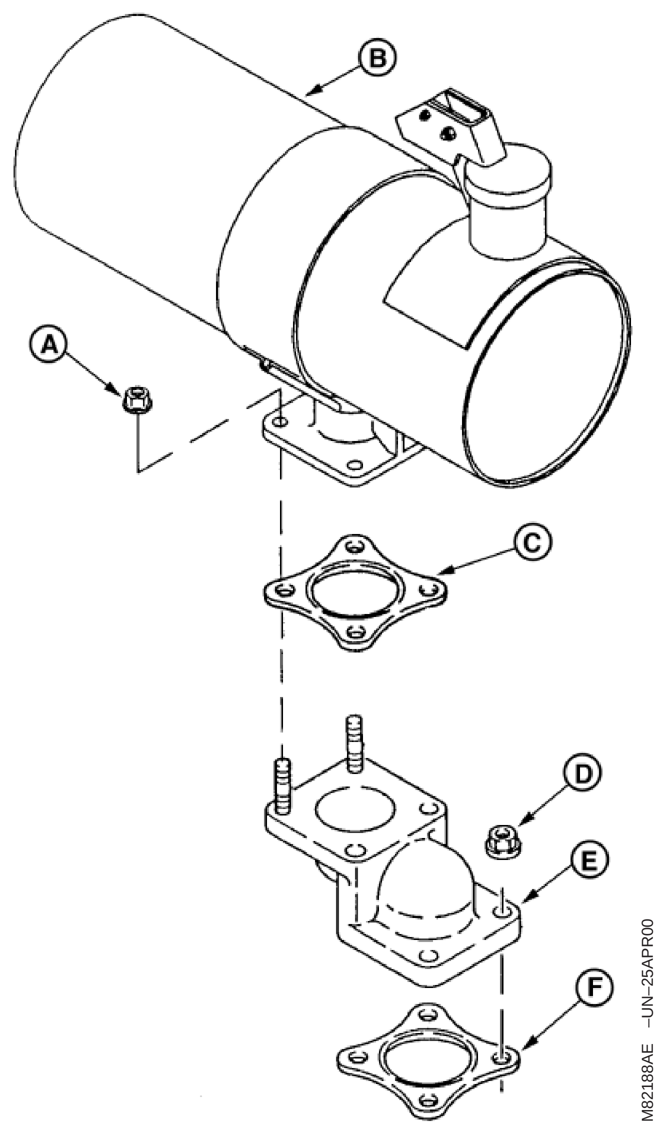
CAUTION: Muffler may be hot. Allow muffler to cool before removing. A hot muffler can cause serious burns.

NOTE: Parts (D, E, and F) are used on 3009 engines only.

1. Remove parts (A—F). Inspect gaskets (C and F) for wear or damage. Replace if necessary.
2. Install parts (D, E and F). Tighten nuts (D) to specifications.
3. Install Parts (A, B and C) and tighten nuts (A) securely.

Specification

3009 Muffler Adapter-to-Engine Nut—Torque .... 47 N•m (35 lb-ft)



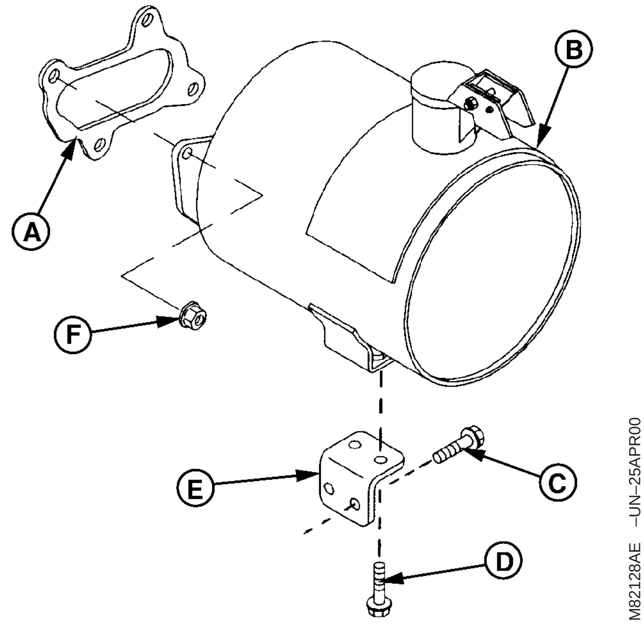
A—Nut
B—Muffler
C—Gasket
D—Nut (3009 Only)
E—Adapter (3009 Only)
F—Gasket (3009 Only)

RG,RG34710,8236 –19–15APR97–1/1

Remove and Install Muffler—4020T

CAUTION: Muffler may be hot. Allow muffler to cool before removing. A hot muffler can cause serious burns.

1. Remove cap screws (D) and nuts (F).
2. Remove muffler (B) and gasket (A).
3. Install all parts and tighten nuts (F) and cap screws (D) securely.



A—Gasket
B—Muffler
C—Cap Screw
D—Cap Screw
E—Support Bracket
F—Nut

RG,RG34710,8237 –19–15APR97–1/1

Remove Turbocharger—4020T

NOTE: Turbocharger model number RHB5 is equipped with a waste gate system and the RHB3 does not. Removal and installation procedures are the same for both.

CAUTION: Avoid injury! Muffler may be hot. Allow muffler to cool before removing. A hot muffler can cause serious burns.

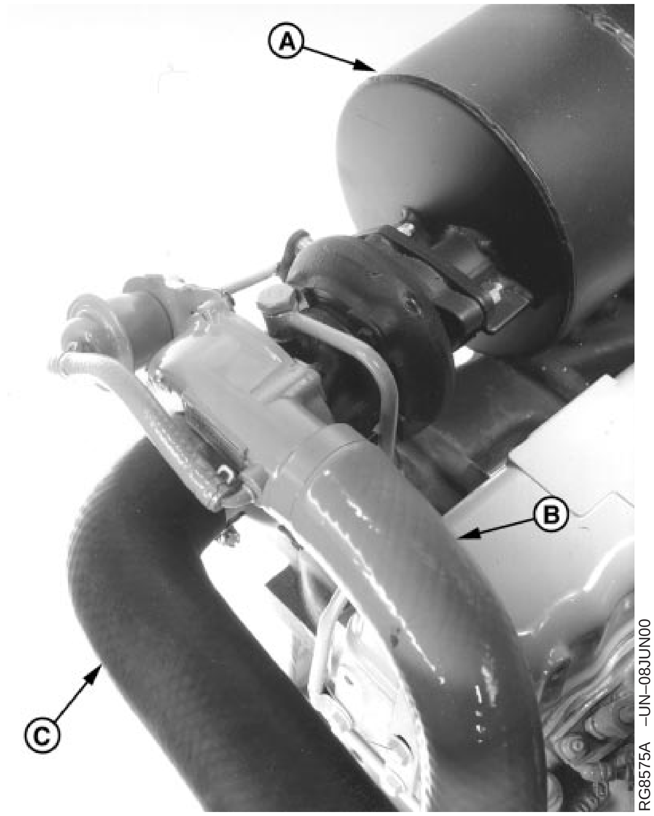
IMPORTANT: When cleaning turbocharger, do not spray directly into compressor or turbine housing. If inspection is required of turbocharger, do not clean exterior prior to removal. Doing so may wash away evidence of a potential failure mode. (See TURBOCHARGER INSPECTION in this group.)

If inspection is not required, thoroughly clean exterior of turbocharger and surrounding area to prevent entry of dirt into the air intake system during removal.

1. Remove muffler (A).

2. Remove turbocharger-to-intake manifold hose (B).

3. Remove air cleaner-to-turbocharger hose (C).



Model RHB5 Turbocharger shown.

A—Muffler
B—Turbocharger-to-Intake Manifold Hose
C—Air Cleaner-to-Turbocharger Hose

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RG,RG34710,8239 –19–15APR04–1/3

4. Remove oil inlet line (A).

CAUTION: Avoid injury! The following steps MUST be read and understood before continuing procedure.

5. Remove oil drain line (B)

CAUTION: Avoid injury! Gasket between the turbocharger and exhaust manifold contains asbestos fibers.

Avoid creating and inhaling dust.

Asbestos is a cancer and lung disease hazard.

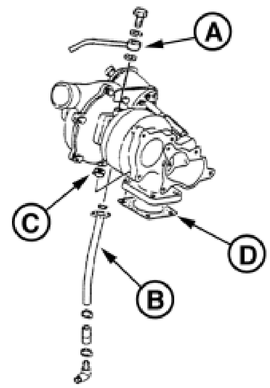
Follow all federal and state occupational safety and health and environmental regulations regarding the removal and disposal of asbestos-containing material.

6. Remove four nuts and washers (C).

CAUTION: Avoid injury! These steps MUST be followed when attempting to remove the gasket between the turbocharger and exhaust manifold. These steps are from the U.S. Department of Labor Occupational Safety and Health Administration (OSHA) Standard 1910.1001 App. F "Wet Method" in regard to work practices around asbestos.

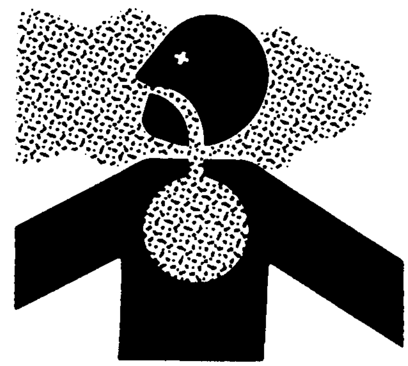
7. Thoroughly wet the gasket area using a spray bottle capable of delivering a fine mist of water. Keep gasket area moist throughout removal process.

8. Remove turbocharger while misting gasket area with water. Close all openings of the turbocharger using caps and plugs to prevent contamination.



RG11050A –UN–12JUN00

Remove Oil and Drain Lines



TS220 –UN–23AUG88

Avoid Creating and Inhaling Asbestos Dust

A—Oil Inlet Line
B—Oil Drain Line
C—Nut and Washer (4 used)
D—Gasket

Continued on next page

RG,RG34710,8239 –19–15APR04–2/3

CAUTION: Avoid injury! Gasket can separate and adhere to both the turbocharger and exhaust manifold.

Spray and clean both surfaces with water.

Place asbestos material and cloth in an impermeable bag upon removal.

DO NOT use compressed air or power tools to remove gasket.

9. Remove gasket (D) and place it in an impermeable bag. Wipe manifold and turbocharger gasket area clean with a cloth and place cloth in the impermeable bag. Any spills of water or gasket material should be cleaned up immediately. Seal and dispose of the impermeable bag in normal trash.

10. Place turbocharger on a clean flat surface.

11. Diagnose the cause of failure, if necessary. (See TURBOCHARGER FAILURE ANALYSIS—4020T in this group.)

12. Inspect turbocharger. (See TURBOCHARGER INSPECTION in this group.)

13. Check rotor shaft axial play. (See CHECK TURBOCHARGER BEARING AXIAL END PLAY in this group.)

14. Check rotor shaft radial play. (See CHECK TURBOCHARGER BEARING RADIAL PLAY in this group.)

15. Disassemble and inspect all parts for wear or damage. Replace if necessary. (See DISASSEMBLE TURBOCHARGER—4020T in this group.)

RG,RG34710,8239 –19–15APR04–3/3

Turbocharger Failure Analysis—4020T

The following is a guide for diagnosing the cause of turbocharger failures after removal from the engine.

COMPRESSOR HOUSING INLET DEFECTS

Problem	Possible Cause	Suggested Remedy
Foreign Object Damage	Objects left in intake system.	Disassemble and inspect intake system for foreign objects. Inspect engine for internal damage.
	Leaking and/or defective intake system.	Inspect air intake system connections, including air filter; repair as required. 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. Check injection pump timing.

Continued on next page RG,RG34710,8240 –19–15APR97–1/2

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.
Foreign Object Damage	Internal engine failure.	Inspect and repair engine as required.
	Objects left in intake system.	Disassemble and inspect air intake system.
	Leaking air intake system.	Correct as required.
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.	Verify with 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. (See REMOVE TURBOCHARGER—4020T in this group and INSTALL TURBOCHARGER—4020T in this group.)
	Defective gasket.	Verify that leaks are not occurring at gasket joints.
Leaks from Joints	Loose attaching screws.	Tighten to specifications. (See AIR INTAKE AND EXHAUST SYSTEM SPECIFICATIONS in Section 06, Group 200.)
	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 mis-timed 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.

RG,RG34710,8240 –19–15APR97–2/2

Turbocharger Inspection

The following inspection procedure is recommended for systematic failure analysis of a suspected failed turbocharger. This procedure will help to identify when a turbocharger has failed, and why it has failed, so the primary cause of the failure can be corrected.

Proper diagnosis of a non-failed turbocharger is important for two reasons.

1. Identification of a non-failed turbocharger will lead to further investigation and repair of the cause of a performance complaint.

2. Proper diagnosis eliminates the unnecessary expense incurred when a non-failed turbocharger is replaced.

The recommended inspection steps, which are explained in detail on following pages, are:

- Compressor Housing Inlet and Compressor Wheel.
- Compressor Housing Outlet.
- Turbine Housing Inlet.
- Turbine Housing Outlet and Turbine Wheel.
- External Center Housing and Joints.
- Internal Center Housing.
- Turocharger Bench Check

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.*

OUO1020,00013F0 –19–30APR04–1/13

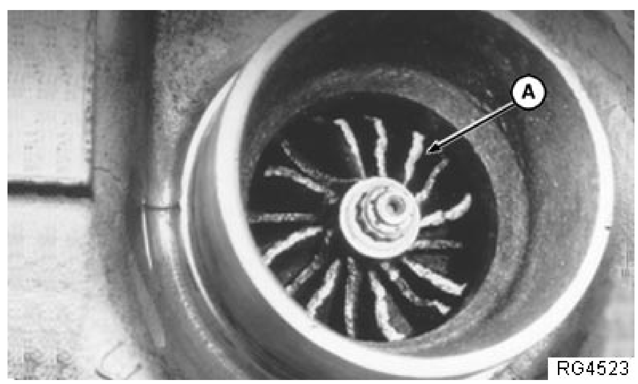
Compressor Housing Inlet and Compressor Wheel

1. Check compressor inlet and 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



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Check Compressor Inlet and Wheel

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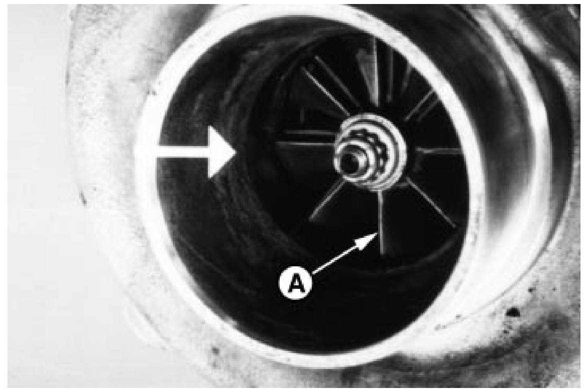
OUO1020,00013F0 –19–30APR04–2/13

NOTE: Use 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 (A) for damage.

A—Compressor Wheel Blades



Check Compressor Inlet for Wheel Rub

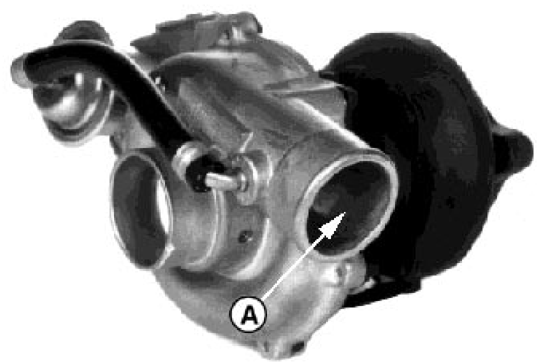
OUO1020,00013F0 –19–30APR04–3/13

Compressor Housing Outlet

1. Check compressor housing outlet (A). The outlet should be clean and free of dirt or oil.

2. Mark the checklist if dirt or oil is found and continue the inspection.

A—Compressor Housing Outlet



Check Compressor Housing Outlet

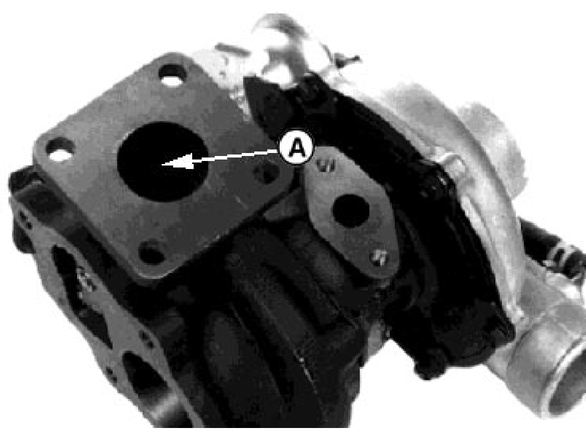
OUO1020,00013F0 –19–30APR04–4/13

Turbine Housing Inlet

Check the turbine housing inlet port (A) for oil in housing, excessive carbon deposit or erosion of walls.

NOTE: If the inlet is wet with oil or has excessive carbon deposits, an engine problem is likely. Wall erosion (cracking or missing pieces), indicate excessive exhaust temperature.

A—Turbine Housing Inlet Port



Check Turbine Housing Inlet Port

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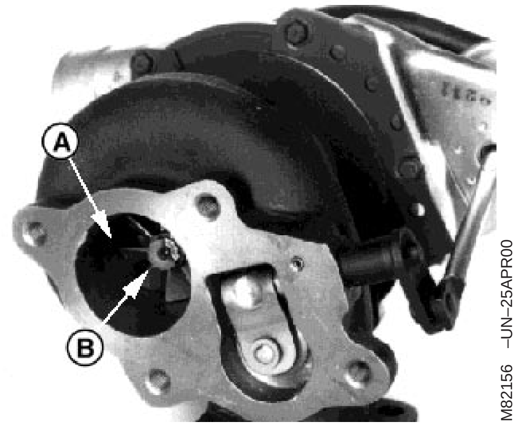
OUO1020,00013F0 –19–30APR04–5/13

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.

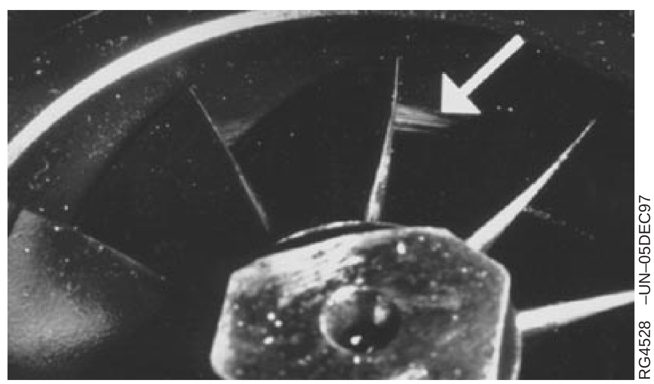
A—Turbine Housing Outlet
B—Turbine Wheel Blades



Check Turbine Housing Outlet Blades

OUO1020,00013F0 –19–30APR04–6/13

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.



Check Wheel Blades and Housing for Wheel Rub

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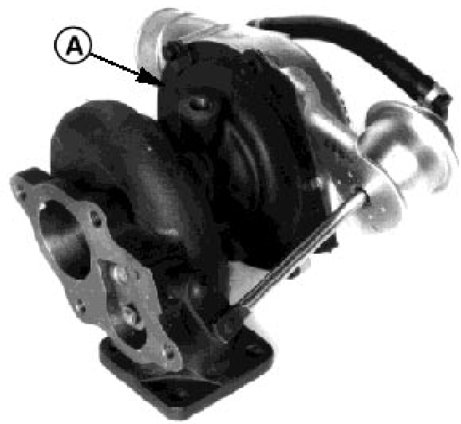
OUO1020,00013F0 –19–30APR04–7/13

External Center Housing and Joints

Visually check the outside of the center housing (A), all connections to the compressor housing, 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.

A—Center Housing



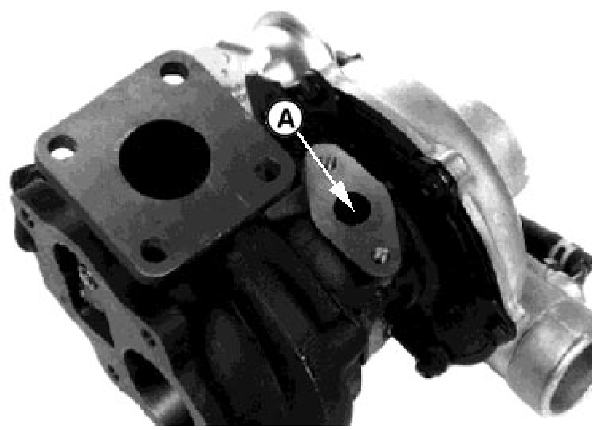
Check Center Housing

OUO1020,00013F0 –19–30APR04–8/13

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



Check Oil Return Hole

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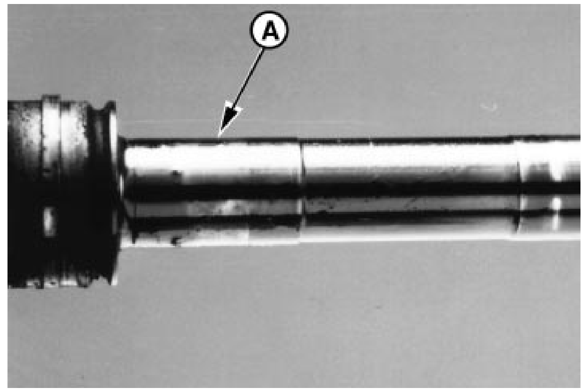
OUO1020,00013F0 –19–30APR04–9/13

2. Excessive “blueing” or “coking” of oil along the complete length of the shaft (A) indicates a possible lack of lubrication caused by an engine failure, or improper operation, such as hot shutdowns.

A—Shaft



Check Shaft

OUO1020,00013F0 –19–30APR04–10/13

Turbocharger Bench Check

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.

A—Shaft Rotation Direction

Rotate Shaft

Continued on next page

OUO1020,00013F0 –19–30APR04–11/13

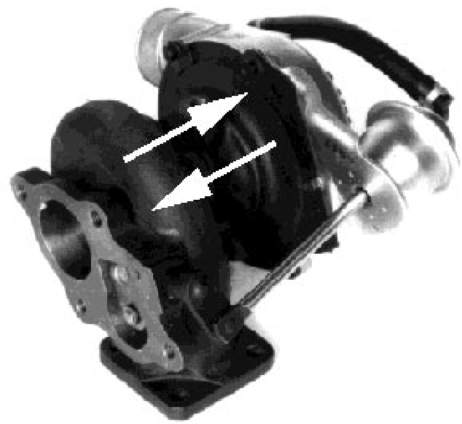
3. Pull up on the compressor end of the shaft and press down on the turbine end while rotating shaft. Neither the compressor wheel nor the turbine wheel should contact the housing at any point.

Check Shaft End Play

Continued on next page OUO1020,00013F0 –19–30APR04–12/13

NOTE: There will be some "play" because the bearings inside the center housing are free floating.

4. 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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Check Shaft End Play

IMPORTANT: Before you finalize your conclusion that the turbocharger has not failed, it is strongly recommended to check rotor shaft axial and radial play. (See CHECK TURBOCHARGER BEARING AXIAL END PLAY and CHECK TURBOCHARGER BEARING RADIAL PLAY in this group.) These procedures are not required if a failure mode has already been identified.

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—4020T 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.

OUO1020,00013F0 –19–30APR04–13/13

Check Turbocharger Bearing Axial End Play

This check will give an indication of the condition of the bearing within the center housing and rotating assembly.

1. Mount magnetic base (C) so that indicator tip rests on end of shaft (A). Preload indicator tip and zero dial on indicator (B).

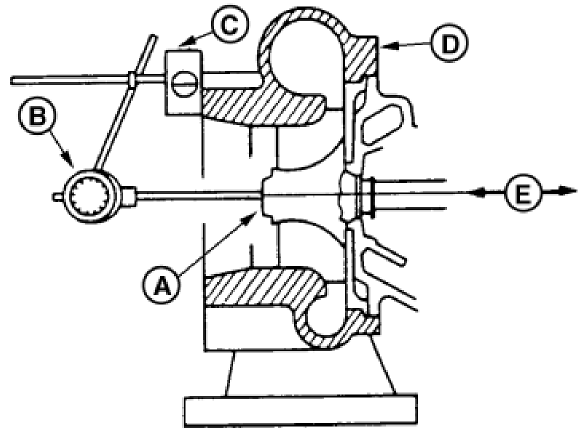
2. Move shaft axially back and forth by hand.

3. Observe and record total dial indicator movement.

Specification

Turbocharger Bearing Axial
Without Waste Gate—RHB3—
End Play .... 0.022—0.053 mm
(0.0008—0.0021 in.)
Wear Limit .... 0.07 mm (0.0028 in.)
Turbocharger Bearing Axial With
Waste Gate—RHB5—End Play .... 0.03—0.06 mm
(0.0012—0.0024 in.)
Wear Limit .... 0.09 mm (0.0035 in.)

If axial play is not within specifications, disassemble and inspect all components for wear or damage. (See DISASSEMBLE TURBOCHARGER—4020T in this group.)



M82186A –UN–12JUN00

Check Bearing Axial End Play

A—Shaft End
B—Dial Indicator
C—Magnetic Base
D—Turbine Housing
E—Axial Direction

OUO1020,00013EE –19–29APR04–1/1

Check Turbocharger Bearing Radial Play

This check will give an indication of the condition of the bearing within the center housing and rotation assembly.

NOTE: Prelube center housing bearings prior to performing radial play test.

Extension adapter (C) can be modified (bent) for this check. (See DFRG1 EXTENSION ADAPTER TIP (FOR RHB3 TURBOCHARGERS) or DFRG2 EXTENSION ADAPTER TIP (FOR RHB5 TURBOCHARGERS) in Section 05, Group 190.)

1. Position dial indicator (D) with correct extension adapter (C) onto turbocharger mounting flange (F), so that tip rests on shaft by extending through oil return cavity (B).

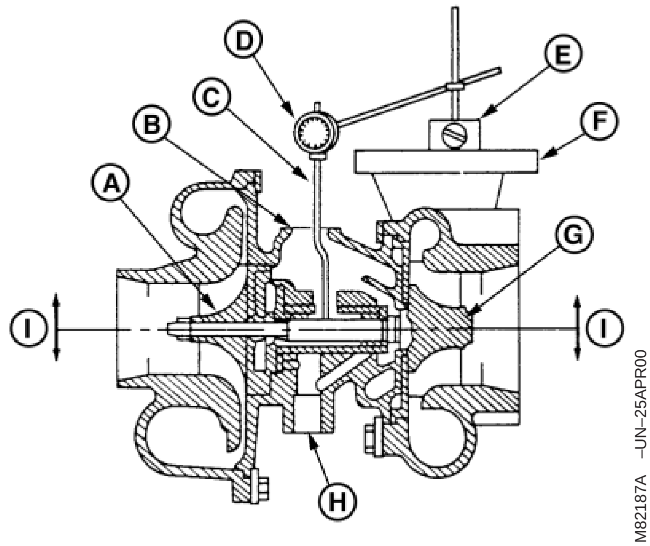
2. Grasp rotation shaft at both ends and move the shaft toward the indicator, then away from the indicator (arrows) by applying moderate force.

3. Observe and record total indicator movement. (See specification below.)

Specification

Turbocharger Bearing Radial Without Waste Gate—RHB3—Side Play	0.061—0.093 mm (0.0024—0.0037 in.)
Wear Limit	0.12 mm (0.0047 in.)
Turbocharger Bearing Radial With Waste Gate—RHB5—Side Play	0.08—0.13 mm (0.0031—0.0051 in.)
Wear Limit	0.17 mm (0.0067 in.)

If radial play is not within specifications, disassemble and inspect all components for wear or damage. (See DISASSEMBLE TURBOCHARGER—4020T in this group.)



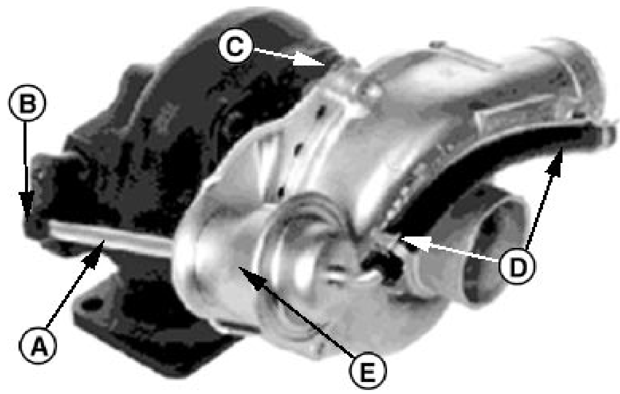
Check Bearing Radial End Play

A—Compressor Wheel
B—Oil Return Cavity
C—Extension Adapter
D—Dial Indicator
E—Magnetic Base
F—Turbocharger Mounting Flange
G—Turbine Wheel
H—Oil Inlet
I—Radial Direction

OUO1020,00013EF –19–29APR04–1/1

Disassemble Turbocharger—4020T

1. Remove turbocharger. (See REMOVE TURBOCHARGER—4020T in this group.)
2. Remove circlip (B) and disconnect rod (A).
3. Remove clamps and hose (D).
4. Remove two cap screws (C) and waste gate actuator (E).



Turbocharger—4020T

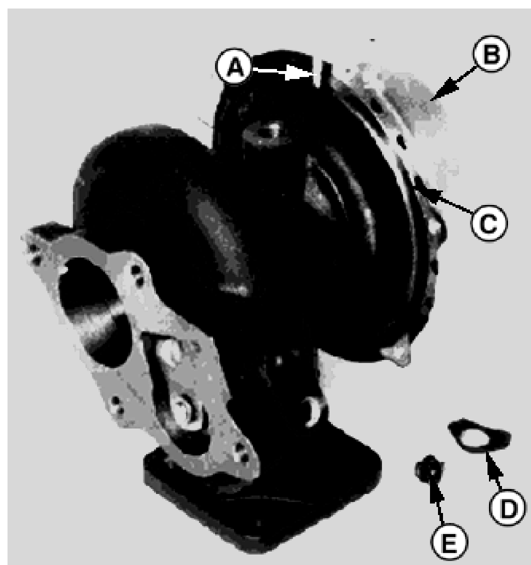
A—Actuator Rod
B—Circlip
C—Cap Screw
D—Clamps and Hose
E—Waste Gate Actuator

RG,RG34710,8247 –19–14APR04–1/8

5. Scribe alignment mark (A) across compressor housing (B) and center housing (C) to aid in assembly.
6. Remove four cap screws (E) and lock plates (D).

IMPORTANT: Be careful when removing compressor housing. Damage to compressor wheel blades can occur.

7. Tap on compressor housing with a plastic hammer to remove from center housing.



Remove Compressor Housing

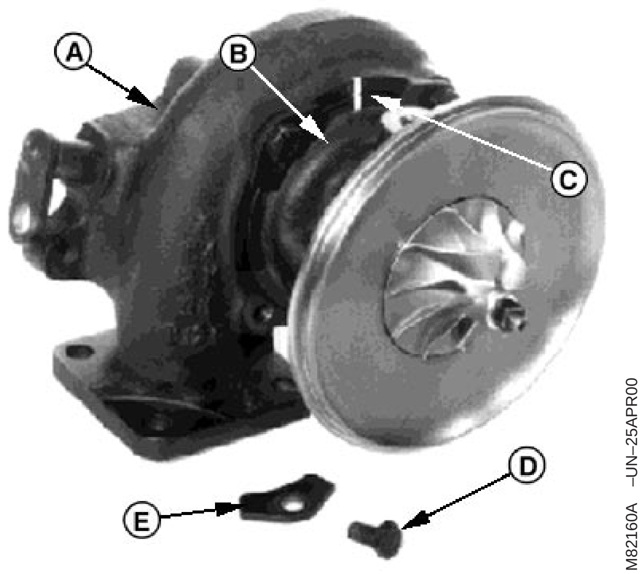
A—Alignment Mark
B—Compressor Housing
C—Center Housing
D—Lock Plate
E—Cap Screw

Continued on next page RG,RG34710,8247 –19–14APR04–2/8

8. Scribe alignment mark (C) across turbine housing (A) and center housing (B) to aid in assembly.

9. Remove four cap screws (D), lock plates (E) and turbine housing.

A—Turbine Housing
B—Center Housing
C—Alignment Mark
D—Cap Screw
E—Lock Plate



Remove Turbine Housing

Continued on next page

RG,RG34710,8247 –19–14APR04–3/8

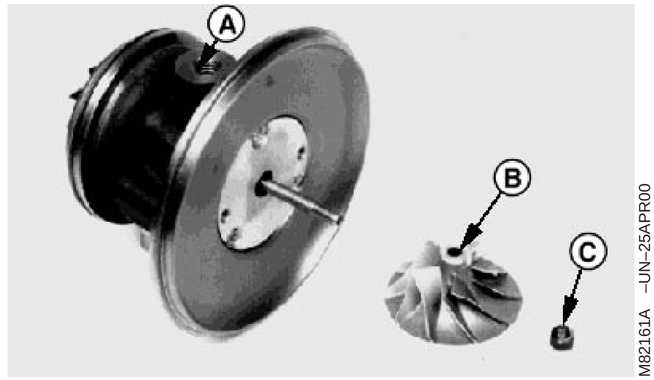
NOTE: Lock nut has left-hand threads.

10. Remove lock nut (C) and compressor wheel (B).

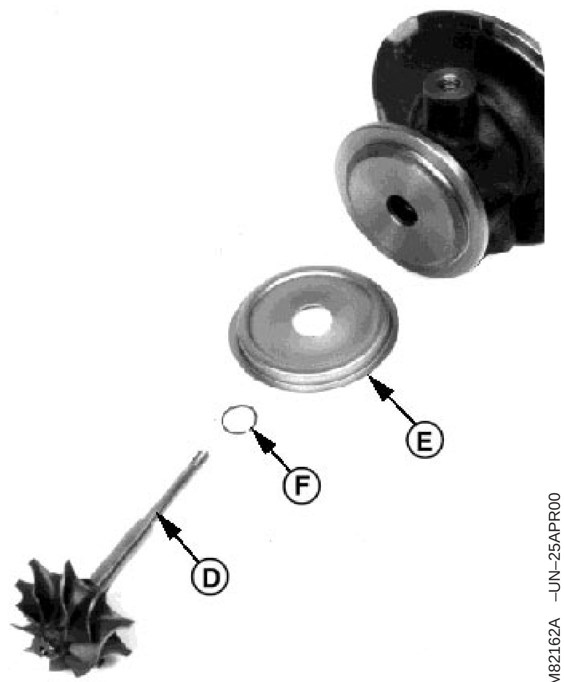
11. Remove turbine wheel/shaft (D) and heat protector (E).

12. Remove seal ring (F).

NOTE: Do not reuse seal ring (F). Install new seal ring supplied in turbocharger repair kit. (See PC2370 for kit number.)



Remove Lock Nut and Compressor Wheel



Turbine Wheel/Shaft Components

A—Center Housing
B—Compressor Wheel
C—Lock Nut
D—Turbine Wheel/Shaft
E—Heat Protector
F—Seal

Continued on next page RG,RG34710,8247 –19–14APR04–4/8

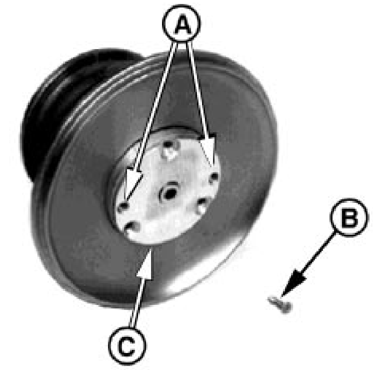
13. Model RHB3: Tap two holes (A) in seal plate (C) using a 5 mm, 0.80 thread tap.

NOTE: Do not reuse screws (B). Install new screws supplied in turbocharger repair kit. (See PC2370 for kit number.)

14. Remove seal plate mounting screws (B).

IMPORTANT: DO NOT overtighten M5 cap screws. Damage to seal plate could occur.

15. Using a slide hammer puller and two existing M5 cap screws (compressor housing-to-center housing cap screws) into threaded holes (A), remove seal plate (C).



Seal Plate Components

A—Tapped Holes
B—Screw
C—Seal Plate

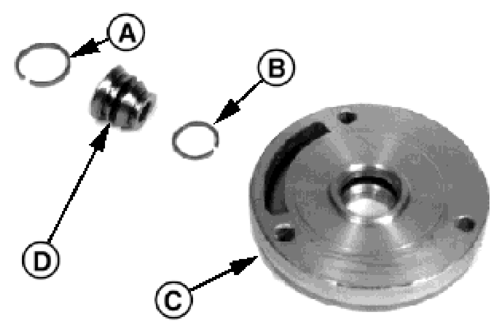
RG,RG34710,8247 –19–14APR04–5/8

NOTE: Do not reuse seal rings (A and B). Install new seal rings supplied in turbocharger repair kit. (See PC2370 for kit number.)

16. Remove seal rings (A and B).

17. Remove oil thrower (D) from seal plate (C).

A—Large Seal Ring
B—Small Seal Ring
C—Seal Plate
D—Oil Thrower



Remove Oil Thrower from Seal Plate

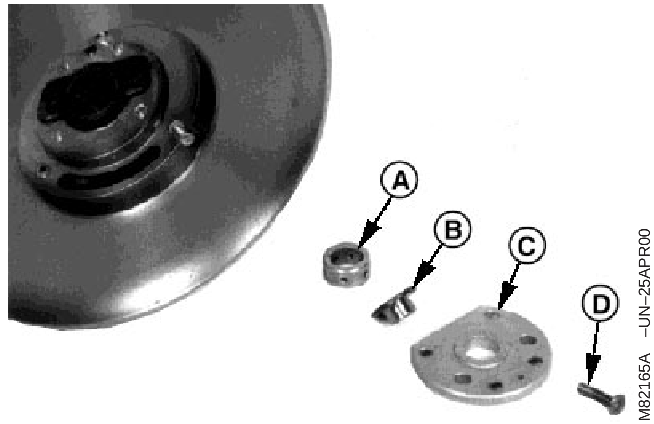
Continued on next page RG,RG34710,8247 –19–14APR04–6/8

NOTE: Do not reuse screws (D). Install new screws supplied in turbocharger repair kit. (See PC2370 for kit number.)

18. Using an impact driver, remove thrust bearing mounting screws (D).

19. Remove thrust bearing (C), thrust bushing (B) and journal bearing (A).

A—Journal Bearing
B—Thrust Bushing
C—Thrust Bearing
D—Screw



Remove Thrust Bearing

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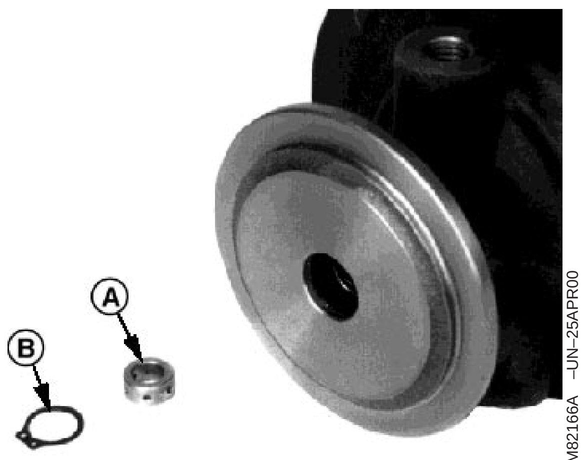
20. Remove retaining ring (B) and journal bearing (A) from turbine side of center housing.

NOTE: There are two more retaining rings inside center housing. Remove only if replacement is necessary.

21. Inspect all parts for wear or damage. Replace as necessary. (See INSPECT TURBOCHARGER in this group.)

A—Journal Bearing
B—Retaining Ring



Remove Retaining Ring and Journal Bearing

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Inspect Turbocharger

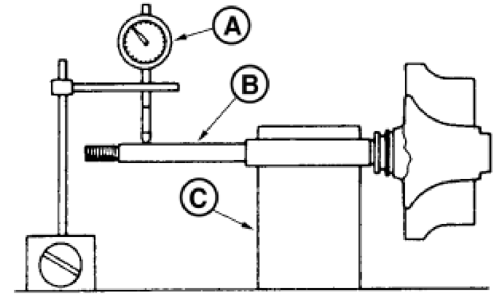
1. Inspect all parts for wear or damage. Replace as necessary.

2. Inspect turbine wheel/shaft (B) for bend using V-block (C) and a dial indicator (A). Turn wheel/shaft slowly and read variation on indicator.

Specification

Turbine Wheel/Shaft—RHB3—	
Deflection	0.002 mm (00008 in.)
Wear Limit	0.005 mm (.00019 in.)
Turbine Wheel/Shaft—RHB5—	
Deflection	0.010 mm (0.00039 in.)
Wear Limit	0.011 mm (0.00043 in.)

If variation is more than wear limit, replace wheel/shaft.



M82171A –UN–12JUN00

A—Dial Indicator
B—Turbine Wheel/Shaft
C—V-Block

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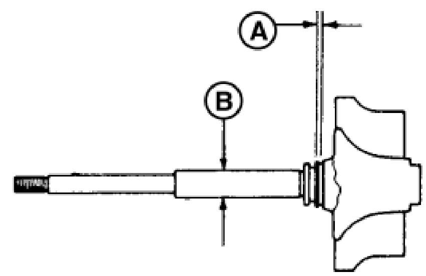
3. Measure turbine shaft diameter (B) and seal ring groove width (A).

Specification

Turbine Shaft—RHB3—OD	6.257—6.263 mm (0.2463—0.2466 in.)
Wear Limit	06.250 mm (0.2461 in.)
Turbine Shaft—RHB5—OD	7.99—8.00 mm (0.3146—0.3150 in.)
Wear Limit	7.980 mm (0.3142 in.)
Shaft Seal Ring Groove—	
RHB3—Width	1.038—1.062 mm (0.0409—0.0418 in.)
Wear Limit	1.070 mm (0.0421 in.)
Shaft Seal Ring Groove—	
RHB5—Width	1.250—1.280 mm (0.0492—0.0504 in.)
Wear Limit	1.290 mm (0.0508 in.)

If turbine shaft diameter is less than wear limit, replace turbine wheel/shaft and journal bearings.

If ring groove width is greater than wear limit, replace turbine wheel/shaft.



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A—Seal Ring Groove Width
B—Turbine Shaft Diameter

Continued on next page

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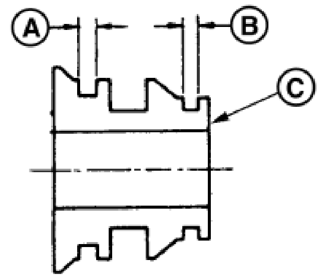
4. Measure seal ring groove (A and B) width in oil thrower (C).

Specification

Oil Thrower Seal Ring Groove
(Small End)—RHB3—Width... 0.82—0.83 mm
(0.0323—0.0327 in.)
Wear Limit .... 0.84 mm (0.0331 in.)
Oil Thrower Seal Ring Groove
(Small End)—RHB5—Width... 1.02—1.03 mm
(0.0402—0.0406 in.)
Wear Limit .... 1.11 mm (0.0437 in.)
Oil Thrower Seal Ring Groove
(Large End)—RHB3—Width... 1.02—1.03 mm
(0.0402—0.0406 in.)
Wear Limit .... 1.04 mm (0.0409 in.)
Oil Thrower Seal Ring Groove
(Large End)—RHB5—Width... 1.22—1.23 mm
(0.0480—0.0484 in.)
Wear Limit .... 1.31 mm (0.0516 in.)

If either ring groove width is greater than wear limit, replace oil thrower.



Oil Thrower

A—Seal Ring Groove (Large End)
B—Seal ring Groove (Small End)
C—Oil Thrower

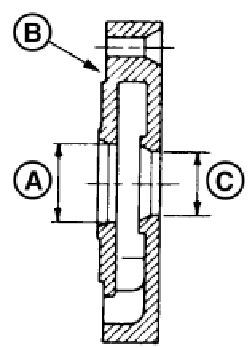
RG,RG34710,8249 –19–15APR97–3/7

5. Measure inside diameters of seal ring surfaces (A and C) on seal plate (B).

Specification

Seal Ring Surface (Larger)—
RHB3—ID.. 9.987—10.025 mm
(0.3932—0.3947 in.)
Wear Limit .... 10.04 mm (0.3953 in.)
Seal Ring Surface (Larger)—
RHB5—ID... 12.40—12.42 mm
(0.4882—0.4890 in.)
Wear Limit .... 12.45 mm (0.4902 in.)
Seal Ring Surface (Smaller)—
RHB3—ID... 7.968—8.0 mm
(0.3137—0.3150 in.)
Wear Limit .... 8.015 mm (0.3156 in.)
Seal Ring Surface (Smaller)—
RHB5—ID... 10.00—10.02 mm
(0.3937—0.3945 in.)
Wear Limit .... 10.05 mm (0.3957 in.)

If either inside diameter is less than wear limit, replace seal plate.



Seal Plate

A—Seal Ring Surface (Larger)
B—Seal Plate
C—Seal Ring Surface (Smaller)

Continued on next page

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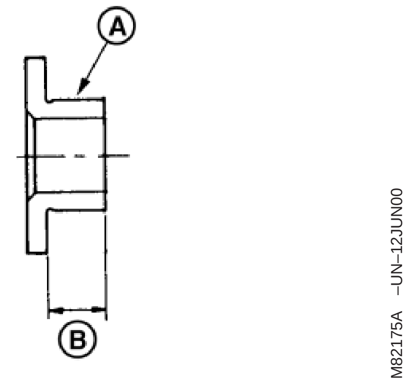
6. Measure length of shoulder (B) on thrust bushing (A).

Specification

Thrust Bushing Shoulder—
RHB3—Length.. 3.632—3.642 mm (0.1430—0.1434 in.)
Wear Limit .... 3.650 mm (0.1437 in.)
Thrust Bushing Shoulder—
RHB5—Length.. 4.04—4.05 mm (0.1591—0.1594 in.)
Wear Limit .... 4.07 mm (0.1602 in.)

If shoulder length is more than wear limit, replace thrust bushing.



Thrust Bushing

A—Thrust Bushing
B—Length of Shoulder

7. Measure thrust bearing thickness.

Specification

Thrust Bushing—RHB3—
Thickness.. 3.59—3.61 mm (0.1413—0.1421 in.)
Wear Limit .... 3.58 mm (0.1409 in.)
Thrust Bushing—RHB5—
Thickness.. 3.99—4.01 mm (0.1571—0.1579 in.)
Wear Limit .... 3.98 mm (0.1567 in.)

If bearing thickness is less than wear limit, replace thrust bearing.

8. Measure inside and outside diameters of journal bearings.

Specification

Journal Bearing—RHB3—ID.. 6.275—6.285 mm (0.2470—0.2474 in.)
Wear Limit .... 6.290 mm (0.2476 in.)
Journal Bearing—RHB5—ID.. 8.01—8.03 mm (0.3154—0.3161 in.)
Wear Limit .... 8.04 mm (0.3165 in.)

If inside diameter is more than wear limit, replace both journal bearings and turbine wheel/shaft.

Specification

Journal Bearing—RHB3—OD .... 9.940—9.946 mm (0.3913—0.3916 in.)
Wear Limit .... 9.930 mm (0.3909 in.)
Journal Bearing—RHB5—OD .... 12.32—12.33 mm (0.4850—0.4854 in.)
Wear Limit .... 12.31 mm (0.4846 in.)

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If outside diameter is less than wear limit, replace both journal bearings, turbine wheel/shaft and center housing.

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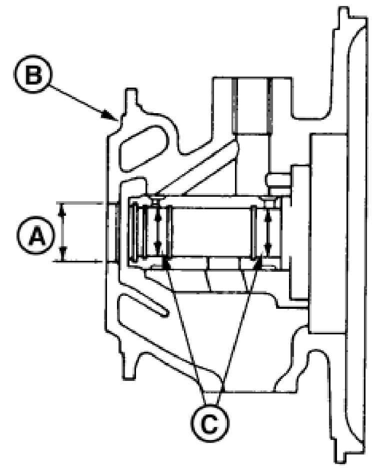
9. Inspect center housing for cracks or damage. Measure inside diameters of seal ring surface (A) and journal bearing surfaces (C) of center housing (B).

Specification

Seal Ring Surface—RHB3—ID	11.00—11.018 mm (0.4331—0.4338 in.)
Wear Limit	11.03 mm (0.4343 in.)
Seal Ring Surface—RHB5—ID	15.00—15.02 mm (0.5906—0.5913 in.)
Wear Limit	15.05 mm (0.5925 in.)
Journal Bearing Surface—RHB3—ID	9.995—10.005 mm (0.3935—0.3939 in.)
Wear Limit	10.01 mm (0.3941 in.)
Journal Bearing Surface—RHB5—ID	12.40—12.41 mm (0.4882—0.4886 in.)
Wear Limit	12.42 mm (0.4890 in.)

If seal ring surface is more than wear limit, replace center housing.

If journal bearing surface diameters are more than wear limit, replace center housing, journal bearings and turbine wheel/shaft.



M82176A –UN–12JUN00

Center Housing

A—Seal Ring Surface
B—Center Housing
C—Journal Bearing Surface

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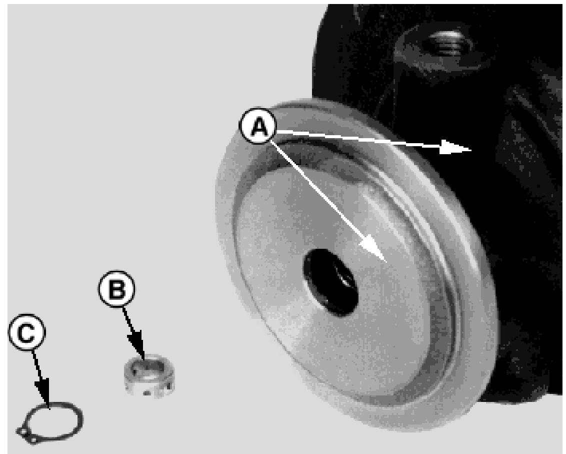
Assemble Turbocharger

1. If removed, install two new retaining rings (A) into center housing with “open end” of rings facing toward oil outlet port and beveled edges toward bearings.

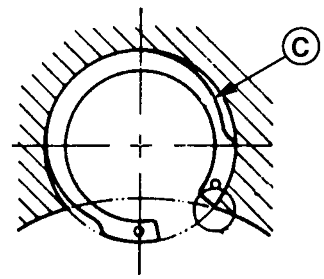
2. Coat journal bearing (B) with clean engine oil and install in center housing.

3. Install turbine side retaining ring (C) with beveled edge toward journal bearing and with “open end” in direction shown.

A—Retaining Ring
B—Journal Bearing
C—Retaining Ring



Install Journal Bearing and Retainer



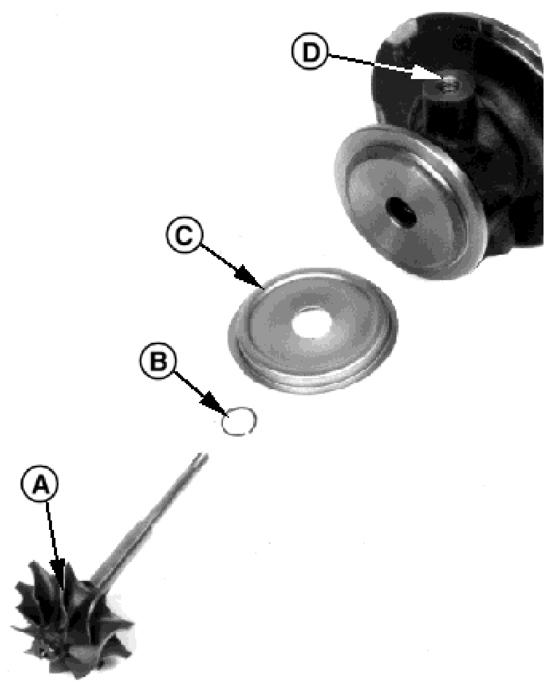
Viewed from Compressor Side (RBH3)
Viewed from Turbine Side (RBH5)

RG,RG34710,8250 –19–14APR04–1/9

4. Install new seal ring on turbine wheel/shaft (A).

5. Install heat protector (C) and turbine wheel/shaft (A) with “open end” of seal ring facing toward oil inlet port (D). Turbine wheel/shaft should “snap” into place.

A—Turbine Wheel/Shaft
B—Seal Ring
C—Heat Protector
D—Oil Inlet Port



Turbine Shaft

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6. Coat journal bearing (E) and thrust bushing (D) with clean engine oil and install in center housing (A).

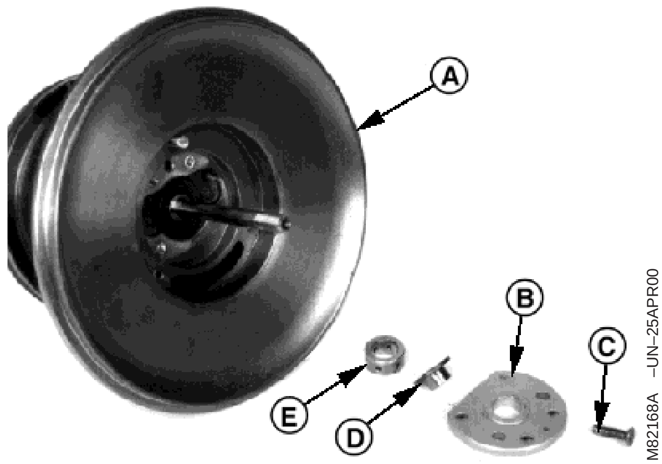
7. Apply LOCTITE® 242 Thread Lock and Sealer (Medium Strength) to screws (C).

8. Install thrust bearing (B) and screws (C). Tighten screws to specification.

Specification

Turbocharger Thrust Bearing
Screws—Torque .... 1 N•m (9 lb-in.)

A—Center Housing
B—Thrust Bearing
C—Screw
D—Thrust Bushing
E—Journal Bearing



Install Journal Bearing and Thrust Bushing

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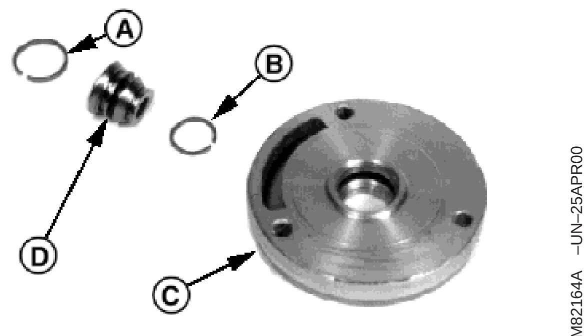
9. Install new seal rings (A and B) on oil thrower (D).

10. Position seal rings on oil thrower as shown and insert thrower into seal plate (C). Oil thrower should "snap" into place.

A—Seal Ring (Large)
B—Seal Ring (Small)
C—Seal Plate
D—Oil Thrower



Install New Seal Rings on Oil Thrower

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11. Apply LOCTITE® 7649 Cure Primer to mating surfaces of center housing (A) and seal plate assembly (C).

12. Apply LOCTITE® 515 Flexible Form-in-Place Gasket (E) around outer edge of seal plate assembly (C).

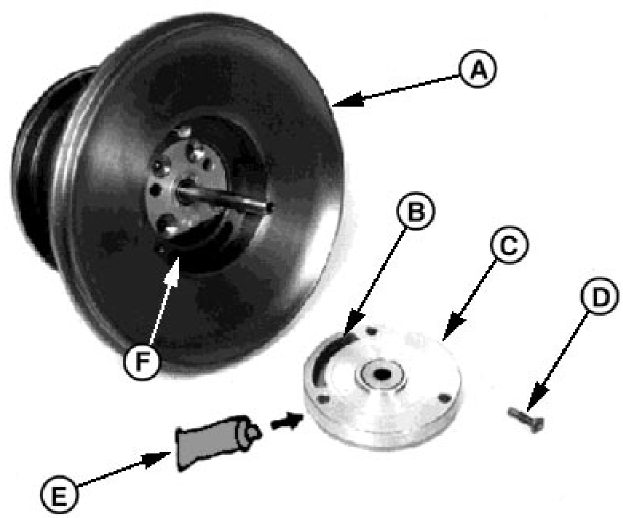
13. Install seal plate assembly with slot (B) toward oil outlet port (F).

14. Apply LOCTITE® 242 Thread Lock and Sealer (Medium Strength) to threads of screws (D) and install screws.

15. Tighten screws to specifications.

Specification

Turbocharger Seal Plate
Assembly Screws—Torque .... 1 N•m (9 lb-in.)



Install Seal Plate Assembly

A—Center Housing
B—Slot
C—Seal Plate Assembly
D—Screw
E—Form-in-Place Gasket
F—Oil Outlet Port

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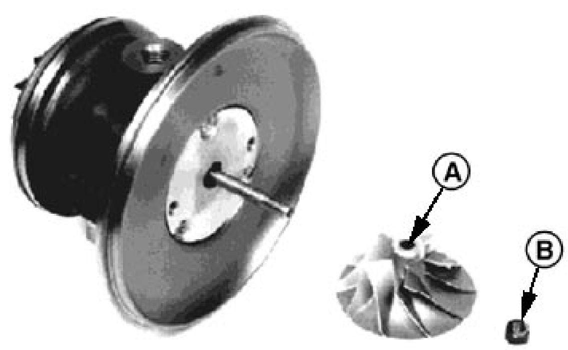
RG,RG34710,8250 –19–14APR04–5/9

NOTE: Lock nut has left-hand threads. Do not over tighten.

16. Install compressor wheel (A) and lock nut (B). Tighten nut to specifications.

Specification

Turbocharger Compressor Wheel
Lock Nut—RHB3—Torque .... 1 N•m (9 lb-in.)
Turbocharger Compressor Wheel
Lock Nut—RHB5—Torque .... 2 N•m (18 lb-in.)



Install Compressor Wheel and Lock Nut

A—Compressor Wheel
B—Lock Nut

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RG,RG34710,8250 –19–14APR04–6/9

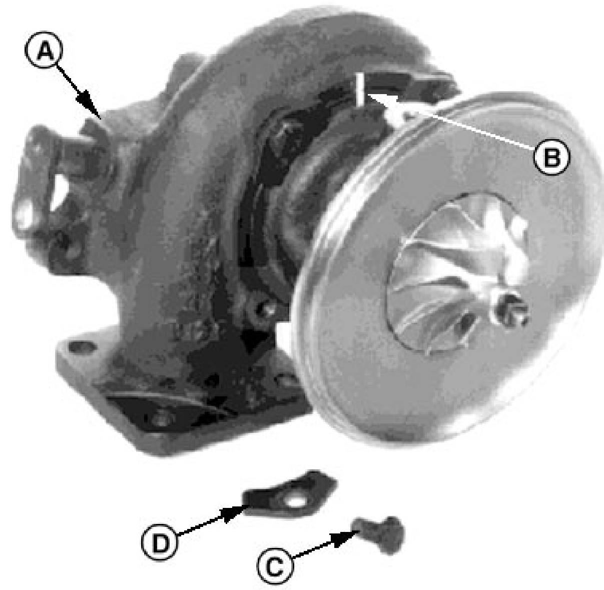
17. Install turbine housing (A).

18. Align marks (B) made during disassembly and install lock plates (D) and cap screws (C). Tighten cap screws to specifications.

Specification

Turbocharger Lock Plate Cap Screw—RHB3—Torque.. 12 N•m (106 lb-in.)
Turbocharger Lock Plate Cap Screw—RHB5—Torque... 28 N•m (21 lb-ft)

A—Turbine Housing
B—Alignment Marks
C—Cap Screw
D—Lock Plate



M82160B –UN–25APR00

Install Turbine Housing and Align Marks

RG,RG34710,8250 –19–14APR04–7/9

19. Apply LOCTITE® 7649 Cure Primer to mating surfaces of center housing and compressor housing (B). Apply LOCTITE® 515 Flexible Form-in-Place Gasket on compressor housing.

20. Install compressor housing

21. Align marks (A) made during disassembly and install lock plates (C) and cap screws (D).

Specification

Turbocharger Center Housing Lock Plate Cap Screw—Torque...................................... 4 N•m (36 lb-in.)

A—Alignment Marks
B—Compressor Housing
C—Lock Plates
D—Cap Screws

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Clean Mating Surfaces of Center Housing and Compressor Housing

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22. Install waste gate actuator (D) and two cap screws (B) Tighten cap screws to specification.

Specification

Turbocharger Waste Gate
Actuator Cap Screws—Torque .... 4 N•m (36 lb-in.)

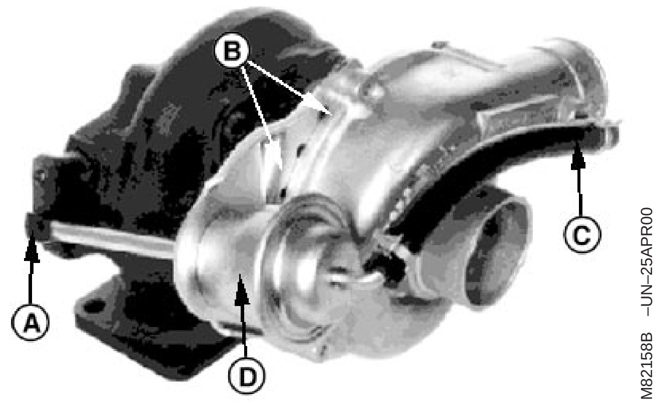
23. Install hose and clamps (C).

24. Connect rod and install circlip (A).

IMPORTANT: DO NOT spin the rotor assembly with compressed air. Damage to bearings can occur, when using compressed air.

25. Prelube turbocharger: Fill oil inlet or drain port with clean engine oil and turn rotating assembly (by hand) to properly lubricate bearings.

NOTE: If turbocharger is to be stored for an extended period of time, lubricate internally and install protective covers on all openings.



Install Waste Gate Actuator and Cap Screws

A—Circlip
B—Cap Screw
C—Hose and Clamps
D—Waste Gate Actuator

02
080
35

RG,RG34710,8250 –19–14APR04–9/9

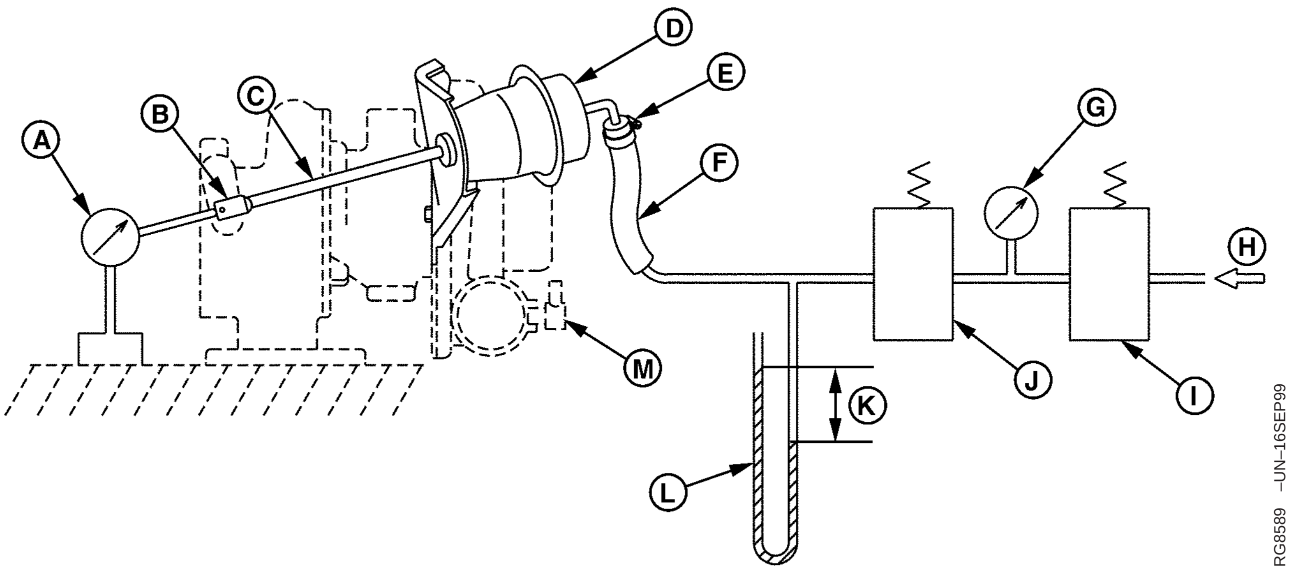
Check Turbocharger Waste Gate Valve—4020T with RHB5 Turbocharger

ESSENTIAL TOOLS
0—1500 mmHg (0—60 in.HG) Manometer (Mercury Column)
0—10 mm (0—0.3937 in.) Dial Indicator
0—2 kg/cm^2 (0—30 psi) Pressure Regulating Valve
5 kg/cm^2 (70 psi) or less Pressure Reducing Valve
0—10 kg/cm^2 (0—150 psi) Pressure Gauge

NOTE: This procedure is done on a flat surface or workbench.

Since RHB5 turbochargers for VM and VH applications are provided with a waste gate valve, adjustment of the waste gate valve opening pressure and lift is required at time of overhaul or inner parts replacement. Omission of this adjustment will adversely affect the engine performance.

Continued on next page RG,RG34710,8251 –19–15APR97–1/3



A—Dial Indicator
B—Waste Gate Valve
C—Rod
D—Waste Gate Actuator
E—Clip
F—Hose
G—Pressure Gauge
H—Compressed Air
I—Pressure Reducing Valve
J—Pressure Regulating Valve
K—Pc (Control Pressure)
L—Manometer
M—Adapter

NOTE: If the adjustment is impossible, do not replace inner parts, but replace the whole turbocharger assembly.

IMPORTANT: Set the dial indicator on the extension line of the actuator rod.

Piping and joints must be free from leaks.

Fix the turbocharger and the dial indicator securely.

A mercury column type manometer is recommended for calibration and daily checks.

Use a very slow increasing or decreasing adjustment speed when adjusting the pressure regulating valve near the measuring point. If the 2 mm position is exceeded, restart from the beginning.

Do not apply over 5 kg/cm^2 (70 psi) to the actuator.

Waste Gate Check

1. Set the manometer control pressure (K) applied to the waste gate actuator to 0 and set the dial indicator (A) to the zero point.

2. Gradually open the pressure regulating valve (J) and measure the control pressure (Pc) value when the actuator is operated by 2 mm (0.078 in.)

3. Let the rod move to 3 mm (0.118 in.) first, then gradually close the pressure regulation valve. Measure the control pressure (Pc) when the rod is moved to 2 mm (0.078 in.) and obtain the difference from the pressure in step 2. Control pressure (Pc) should be to specification , and will vary with the set output.

Specification

Turbocharger Waste Gate
Control (Pc)—Pressure............................. 600—750 mmHG (24—30 in.HG)

Continued on next page

RG,RG34710,8251 –19–15APR97–2/3

Waste Gate Actuator Leak Test

Apply 1.2 kg/cm^2 (17 psi) to the actuator for one minute. After one minute, the pressure should be to specification.

Specification

Turbocharger Waste Gate
Actuator (After One Minute)
Minimum—Pressure .... 1.1 kg/cm^2 (16 psi)

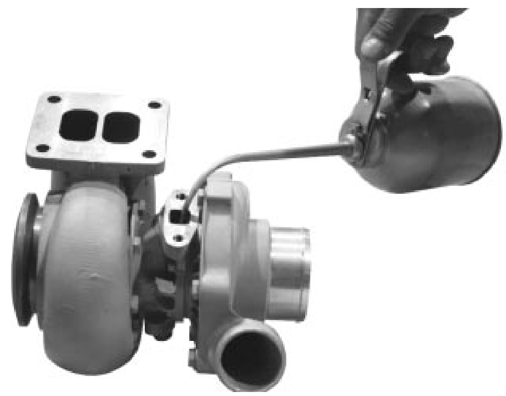
RG,RG34710,8251 –19–15APR97–3/3

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.



RG7624 –UN–23NOV97

Turbocharger Pre-Lubrication

RG,30,JW7570 –19–20NOV97–1/1

Install Turbocharger—4020T

1. Prelube turbocharger: Fill oil inlet or drain port with clean engine oil and turn rotating assembly (by hand) to properly lubricate bearings. (See PRELUBE TURBOCHARGER in this group.)

CAUTION: Avoid injury! A new (non-asbestos) RG61150 Gasket MUST be used.

2. Install new gasket (D) and turbocharger.

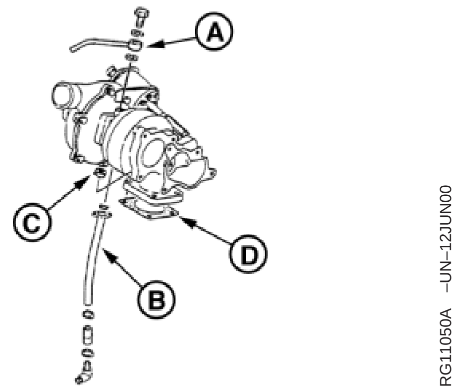
3. Install four lock washers and nuts (C). Tighten nuts to specification.

Specification

Turbocharger-to-Exhaust Manifold
Nuts—Torque .... 20 N•m (177 lb-in.)

4. Install new O-ring and connect oil drain line (B).

5. Install new copper washers and connect oil inlet line (A).



Turbocharger—4020T

A—Oil Inlet Line
B—Oil Drain Line
C—Nut And Washer
D—Gasket

Continued on next page RG,RG34710,8252 –19–15APR97–1/2

6. Install turbocharger-to-intake manifold hose (B) and tighten clamps.

7. Install air cleaner-to-turbocharger hose (C) and tighten clamps.

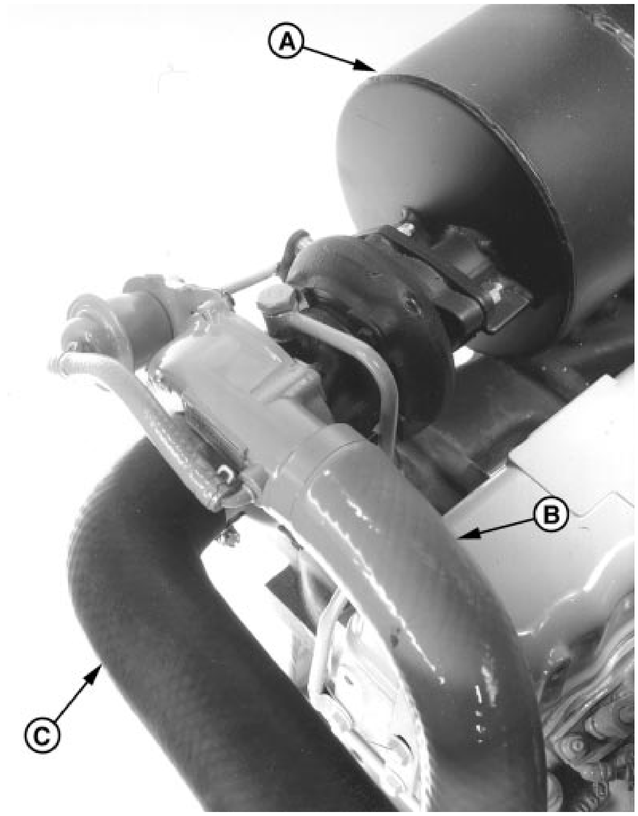
8. Install muffler (A).

IMPORTANT: A new or repaired turbocharger does not have an adequate oil supply for immediate start-up of engine. Perform the following steps to prevent damage to turbocharger bearings.

9. Push the throttle lever to the “STOP” position or disconnect fuel shutoff solenoid connector, if equipped.

10. Crank engine over with starter until oil pressure gauge needle registers within the “GREEN” zone of pressure gauge. DO NOT crank engine longer than 30 seconds at a time to avoid damaging the starter.

A—Muffler
B—Turbocharger-to-Intake Manifold Hose
C—Air Cleaner-to-Turbocharger Hose



Turbocharger-to-Intake Manifold Hose

RG,RG34710,8252 –19–15APR97–2/2

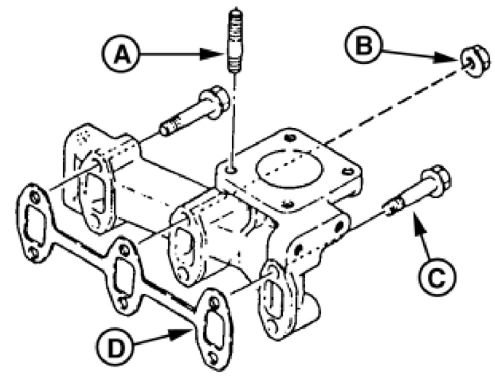
Remove and Install Exhaust Manifold

NOTE: Model 3009 is shown. Other models are similar.

1. Remove muffler and gasket, if equipped.
2. Remove extension/elbow and gasket, if equipped.
3. Remove cap screws (C) and/or nuts (B).
4. Remove manifold.
5. When installing, tighten all mounting hardware to specification.

Specification

Exhaust Manifold Cap Screw—
Torque .... 26 N•m (19 lb-ft)



Model 3009

A—Stud (4 used)
B—Nut and Lock Washer
C—Cap Screw
D—Gasket

RG,RG34710,8085 –19–15APR97–1/1

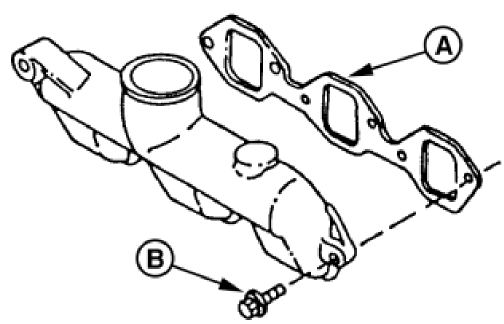
Remove and Install Intake Manifold

NOTE: Model 3009 is shown. Other models are similar.

1. Remove fuel filter assembly mounting cap screw(s), if equipped.
2. Remove fuel injection lines. (See REMOVE AND INSTALL FUEL INJECTION NOZZLES (PINTLE TYPE)—3009 or REMOVE AND INSTALL FUEL INJECTION NOZZLES (HOLE TYPE)—3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98 in Group 90.)
3. When installing, tighten all mounting cap screws to specification.

Specification

Intake Manifold Cap Screw—
Torque .... 11 N•m (97 lb-in.)



Model 3009

A—Gasket
B—Cap Screw

RG,RG34710,8086 –19–15APR97–1/1

Replace Fuel Supply Pump—3009

1. Disconnect fuel lines. Cap connections on fuel supply pump and fuel lines to keep debris out of fuel system.

2. Remove cap screws and remove fuel supply pump assembly.

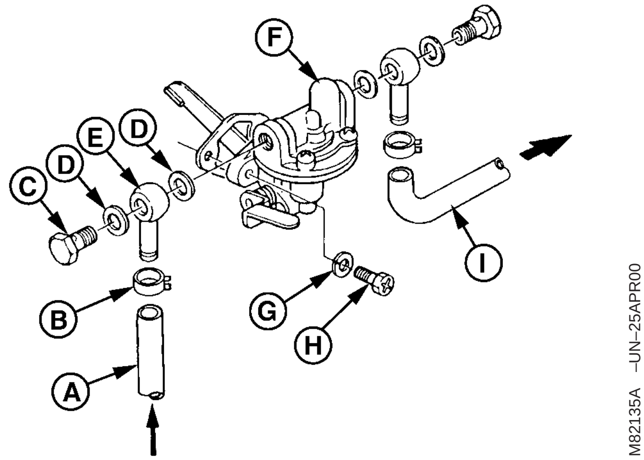
3. Cover opening on engine to prevent entry of dirt.

4. Inspect face of pump lever for wear. If lever face is worn flat or concave, replace pump.

IMPORTANT: Replace all copper washers. Damaged or used washers may leak.

5. Tighten mounting cap screws to specification.

Specification	
Fuel Supply Pump Mounting Cap Screws—3009—Torque	11 N•m (97 lb-in)



Fuel Supply Pump—3009

A—Hose (Supply-to-Fuel Pump)
B—Clamp
C—Fitting
D—Copper Washer
E—Fitting
F—Fuel Supply Pump
G—Washer
H—Cap Screw
I—Hose (Fuel Pump-to-Fuel Filter)

RG,RG34710,8260 –19–15APR97–1/1

Replace Fuel Supply Pump—3011, 3012, 3015 and 4020

1. Thoroughly clean pump body and surrounding area.

2. Disconnect fuel supply hose (A).

NOTE: Oil will leak out of fuel injection pump housing when supply pump is removed.

3. Remove cap screws and washers (E—F) and remove pump.

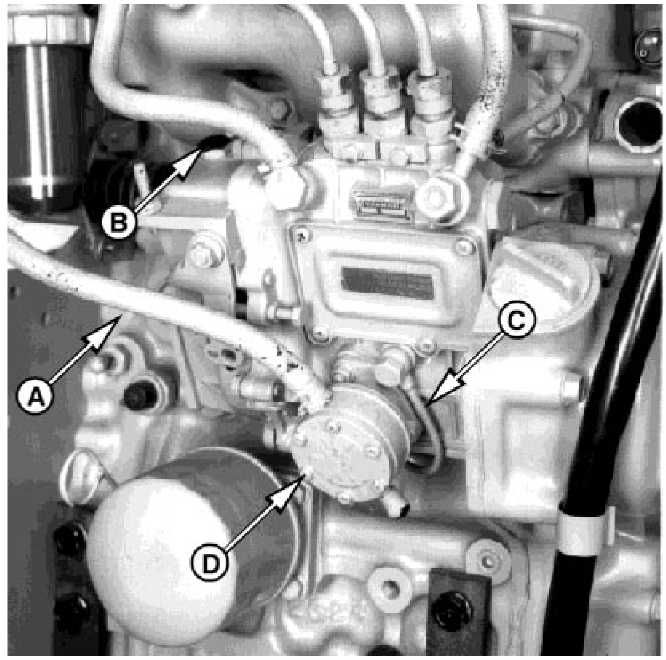
4. Install pump with new packing (G). Tighten mounting nuts to specification.

Specification
Fuel Supply Pump Mounting Cap Screws—3011, 3012, 3015 and 4020—Torque.. 11 N•m (97 lb-in)

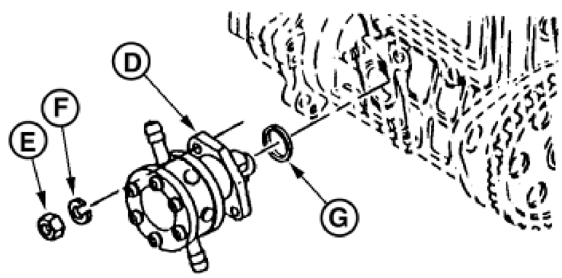
IMPORTANT: Fuel injection pump can become damaged if operated dry or without proper amount of oil.

5. Disconnect external lube line (C) from fuel injection pump. Remove fill plug (B) and add clean engine oil to housing. Add until oil begins to drip out of lube line hole. Tighten lube line fitting to specification.

Specification
Lube Line Fitting—3011, 3012, 3015, and 4020—Torque .... 15 N•m (132 lb-in.)



Fuel Supply Pump—3011, 3012, 3015, & 4020

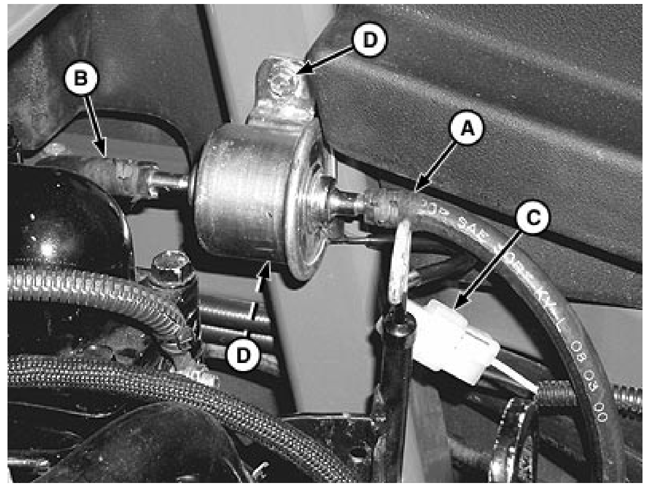


A—Hose (Fuel Pump-to-Fuel Filter)
B—Fill Plug
C—External Lube Line
D—Fuel Supply Pump
E—Mounting Nut
F—Washer
G—Packing

OUO1017,0000B1C –19–06APR04–1/1

Replace Fuel Supply Pump—3013 and 3016

1. Thoroughly clean pump and surrounding area.
2. Loosen clamps and remove inlet line (A) and outlet line (B).
3. Disconnect wire connector (C).
4. Remove cap screws (D) and remove pump.
5. Install new pump using cap screws (D).
6. Connect fuel inlet and outlet lines.
7. Connect wire connector.



Fuel Supply Pump—3013 and 3016

A—Pump Inlet Line
B—Pump Outlet Line
C—Pump Wire Connector
D—Cap Screw (2 used)

OUO1017,0000B24 –19–15APR04–1/1

Replace Fuel Supply Pump—4TNE98

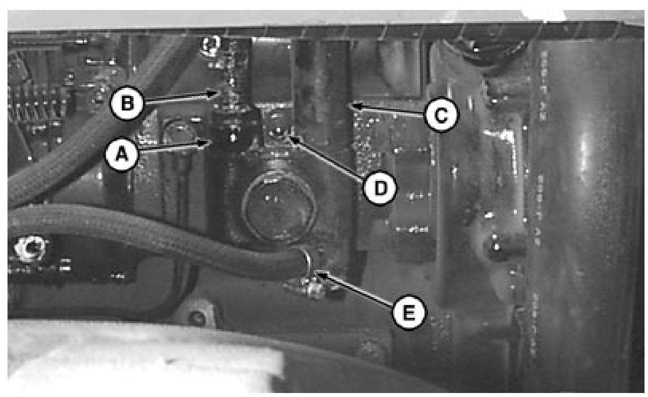
1. Thoroughly clean pump body and surrounding area.
2. Remove fuel supply lines (B and E), fitting (A), and hand primer (C).

NOTE: Oil will leak out of fuel injection pump housing when supply pump is removed.

3. Remove three nuts (D) and remove pump.
4. Replace parts as necessary.
5. Install pump and tighten nuts to specification.

Specification

Fuel Supply Pump Mounting Nuts—4TNE98—Torque.. 11 N•m (97 lb-in)



Fuel Supply Pump—4TNE98

A—Fitting
B—Fuel Filter In Port-to-Transfer Pump Top Port Line
C—Hand Primer
D—Nut (3 used)
E—Fuel Transfer Pump Bottom Port-to-Fuel Tank Bottom Return Port Line

Continued on next page

RG,RG34710,8262 –19–15APR97–1/2

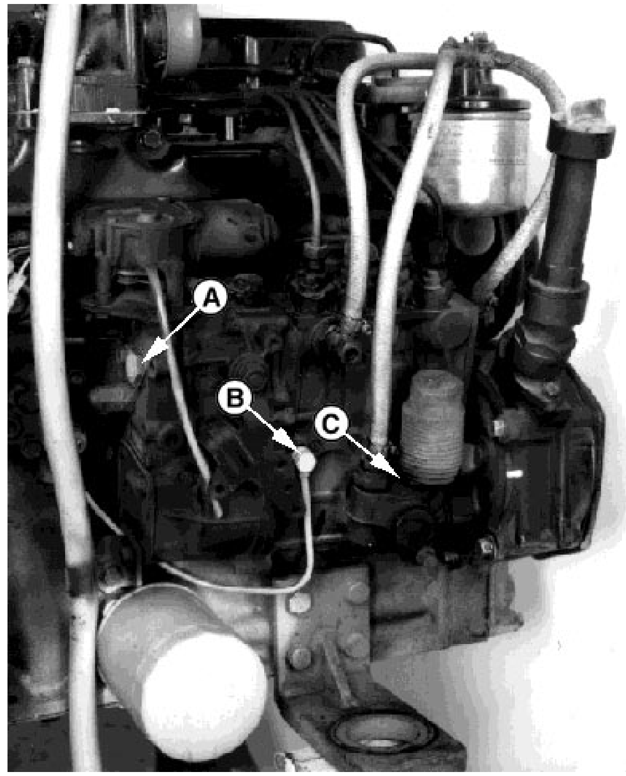
IMPORTANT: Fuel injection pump can become damaged if operated dry or without proper amount of oil.

6. Disconnect external lube line (B) from fuel injection pump housing. Remove fill plug (A) and add clean engine oil to housing. Add until oil begins to drip out of lube line hole. Tighten lube line fitting to specification.

Specification

Lube Line Fitting—3011, 3012,
3015, and 4020—Torque .... 15 N•m (132 lb-in.)

A—Fill Plug
B—External Lube Line
C—Fuel Supply Pump

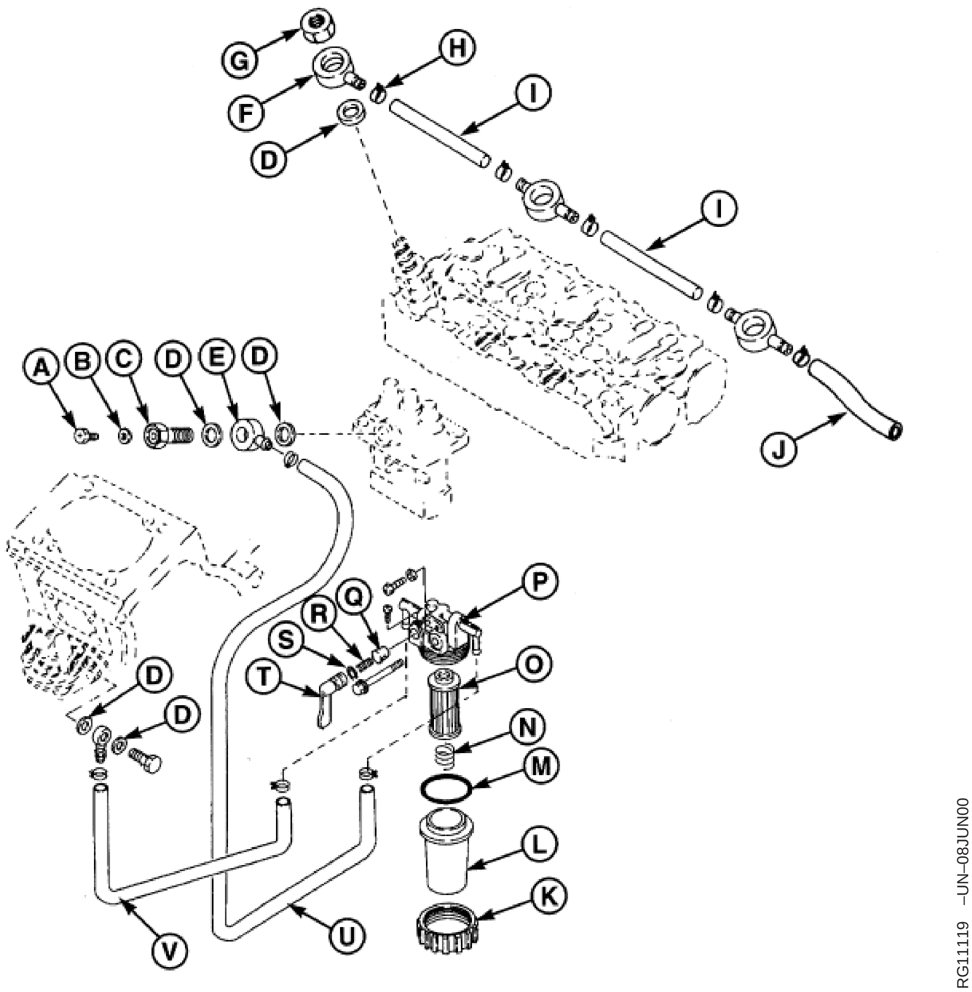


M82089 –UN–25APR00

Fuel Supply Pump

RG,RG34710,8262 –19–15APR97–2/2

Fuel Filter—3009



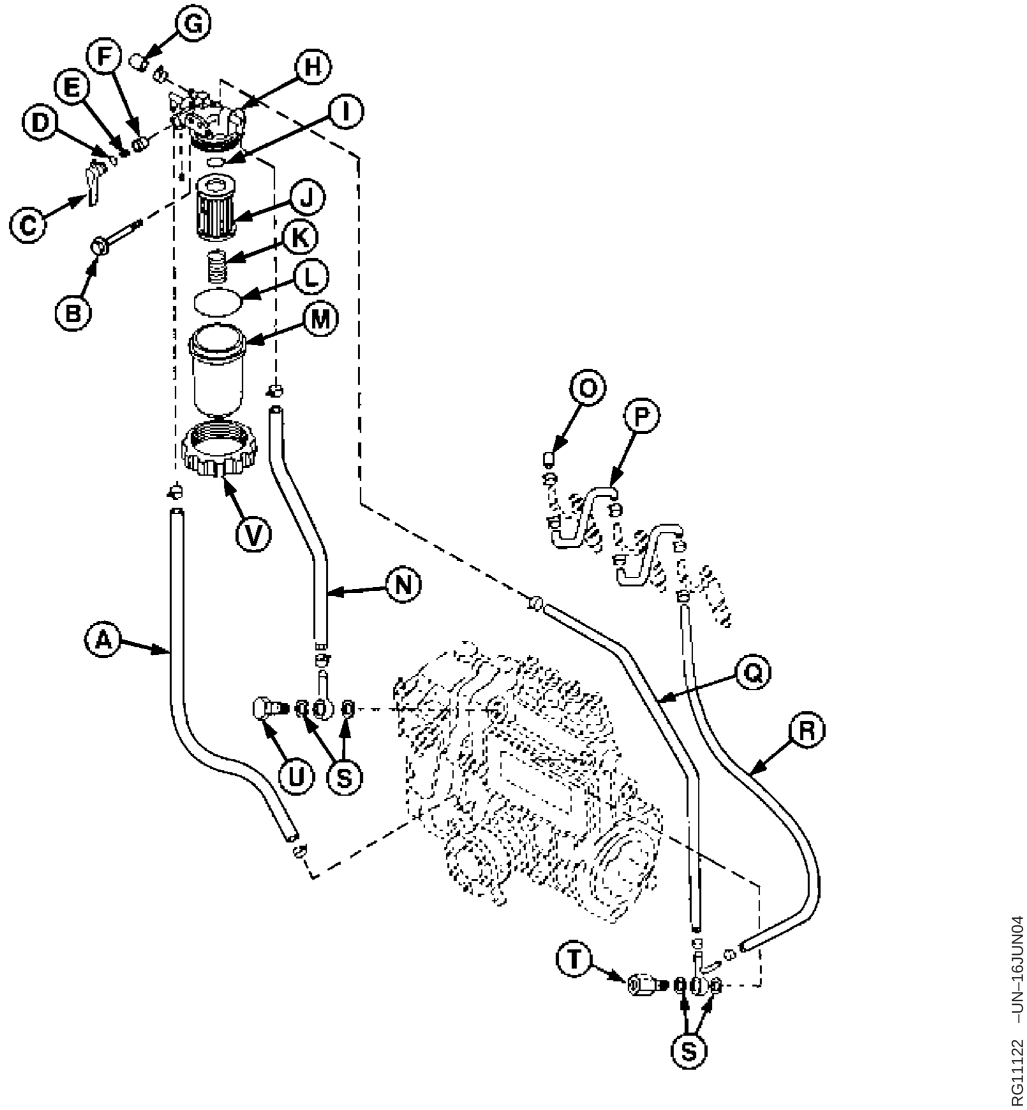
Fuel Filter

A—Bleed Screw
B—Rubber Washer
C—Bleed Valve
D—Copper Washer
E—Fitting
F—Fitting
G—Nut
H—Clamp
I—Nozzle Leak-Off Hose (Short)
J—Nozzle Leak-Off Hose (Long)
K—Retaining Ring
L—Filter Cover
M—O-Ring
N—Spring
O—Filter Element
P—Mounting Base
Q—Shutoff Valve
R—Spring
S—O-Ring
T—Shutoff Lever
U—Hose (Fuel Filter-to-Injection Pump)
V—Hose (Fuel Supply Pump-to-Filter)

IMPORTANT: Replace all copper washers and O-rings. Damaged or used washers may leak.

RG,RG34710,8264 –19–15APR97–1/1

Fuel Filter—3011, 3012, 3015 and 4020



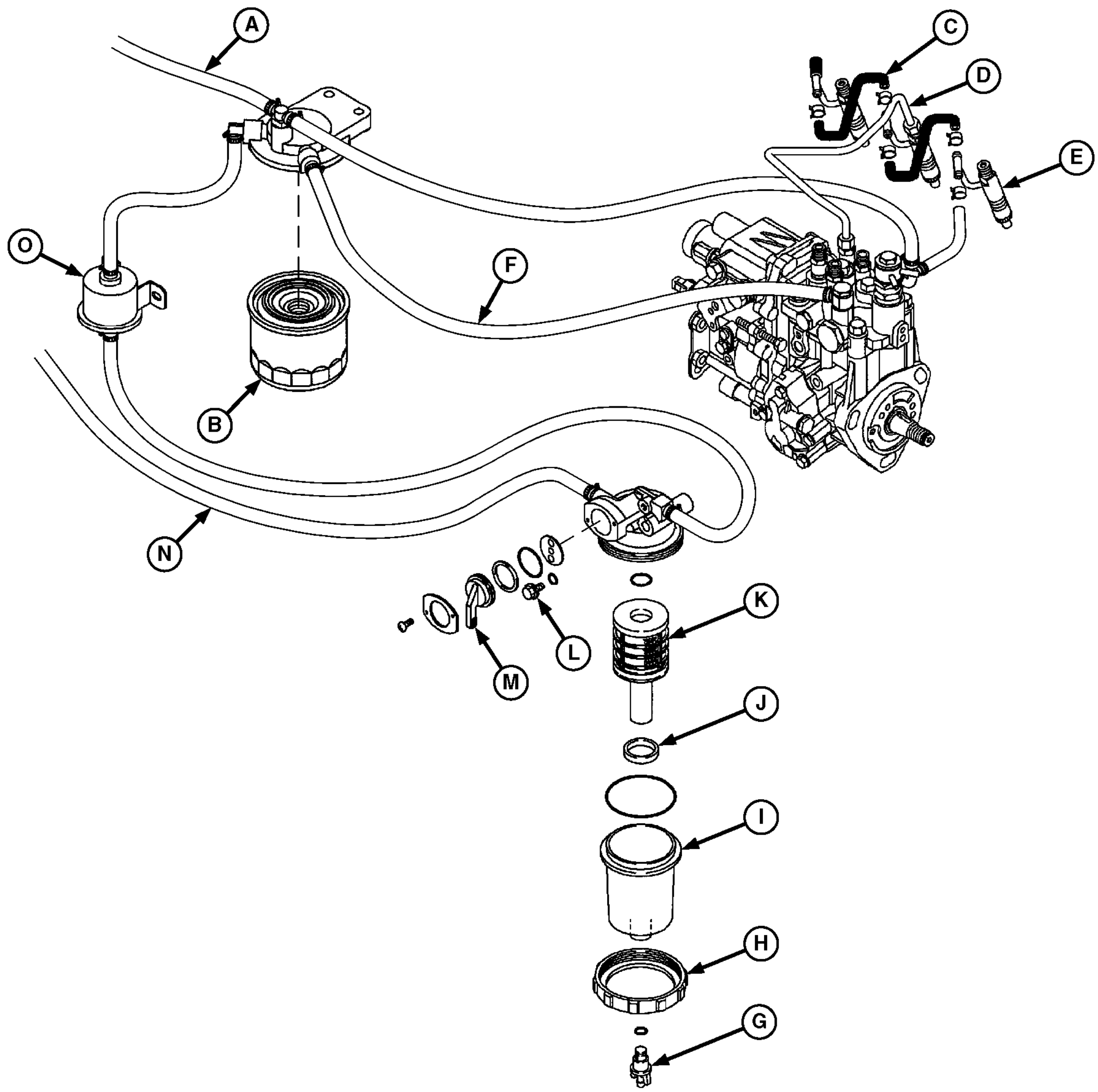
Fuel Filter

A—Hose (Fuel Supply Pump-to-Filter)
B—Cap Screw
C—Shutoff Lever
D—O-Ring
E—Spring
F—Shutoff Valve
G—End Cap
H—Mounting Base
I—O-Ring
J—Filter Element
K—Spring
L—O-Ring
M—Filter Cover
N—Hose (Fuel Filter-to-Injection Pump)
O—End Cap
P—Nozzle Leak-Off Hose (Short)
Q—Hose (Injection Pump Leak-Off)
R—Nozzle Leak-Off Hose (Long)
S—Copper Washer
T—Air Vent Check Valve
U—Fitting
V—Retaining Ring

IMPORTANT: Replace all copper washers and O-rings. Damaged or used washers may leak.

OUO1017,0000B1D –19–06APR04–1/1

Fuel Filter and Water Separator—3013 and 3016



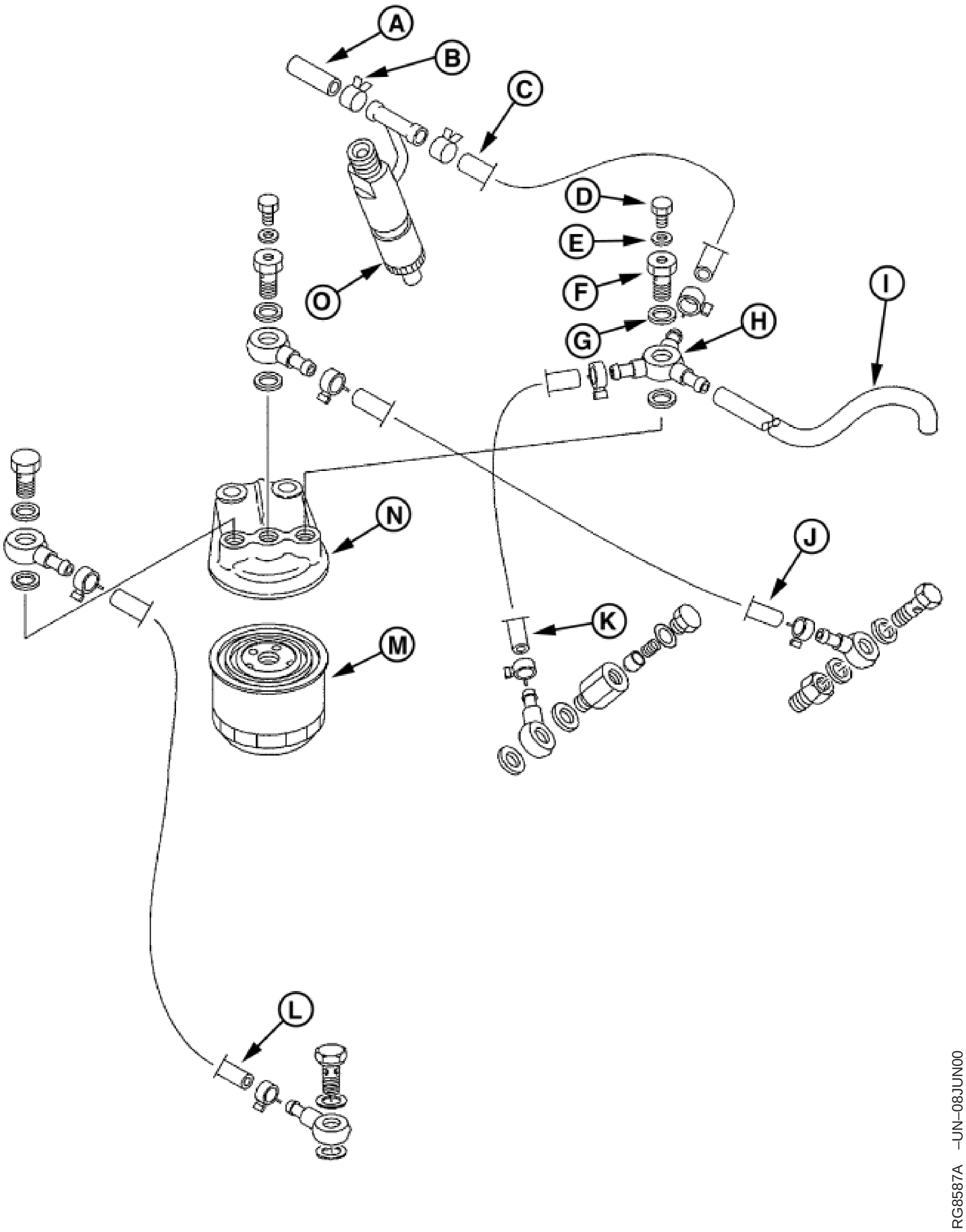
Fuel Filter and Water Separator—3013 and 3016

A—Fuel Return Line to Tank
B—Fuel Filter
C—Injector Leak-Off-Line
D—Injection Line
E—Injector
F—Injection Pump Inlet Line
G—Water Separator Drain Valve
H—Threaded Retaining Ring
I—Sediment Bowl
J—Float Ring
K—Water Separator
L—Air Bleed Screw
M—Shutoff Lever
N—Fuel Inlet from Tank
O—Fuel Supply Pump

IMPORTANT: Replace all copper washers and O-rings. Damaged or used washers may leak.

OUO1017,0000B26 –19–15APR04–1/1

Fuel Filter—4TNE98



Fuel Filter

A—Nozzle Leak-Off Hose (Short)
B—Hose Clamp
C—Hose (Nozzle Leak-Off-to-Fuel Filter)
D—Bolt
E—Washer
F—Fitting
G—Copper Washer
H—Joint Fitting
I—Hose (To Fuel Tank)
J—Hose (Fuel Filter-to-Injection Pump)
K—Hose (Injection Pump Leak-Off)
L—Hose (Supply Pump-to-Fuel Filter)
M—Filter Element Canister
N—Filter Base
O—Fuel Injection Nozzle

Continued on next page

IMPORTANT: Replace all copper washers and O-rings. Damaged or used washers may leak.

RG,RG34710,8266 –19–15APR97–2/2

Slow Idle Speed Adjustment—3009, 3011, 3012, 3015, 4020 and 4TNE98

1. Start engine and run for five minutes.

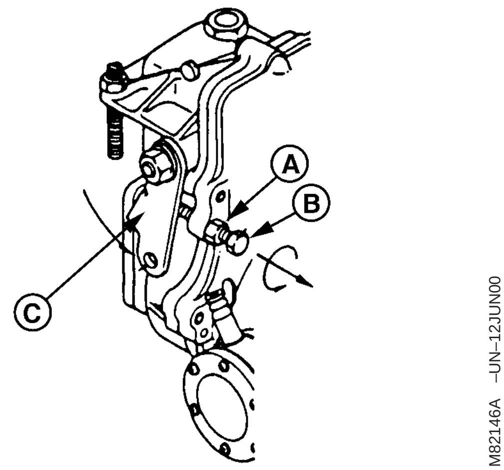
2. Visually check that injection pump throttle lever (C) is against slow idle stop screw (B).

NOTE: Follow manufacturer's instructions for operation of tachometer.

3. Check engine speed at flywheel using JT05719 Hand-Held Digital Tachometer.

If slow idle rpm is not according to specifications, loosen nut (A) and turn screw (B). After adjustment, tighten nut.

Specification	
Base/Ind. Engines Slow Idle—3009, 3011, 3012, 3015, and 4020—Speed	800 rpm
Gen. Set Engines Slow Idle—3011, 3012, 3015, and 4020—Speed	1200 rpm
Gen. Set Engines Slow Idle—3009—Speed	1300 rpm
Base/Ind. Engines Slow Idle—4TNE98—Speed	900 rpm

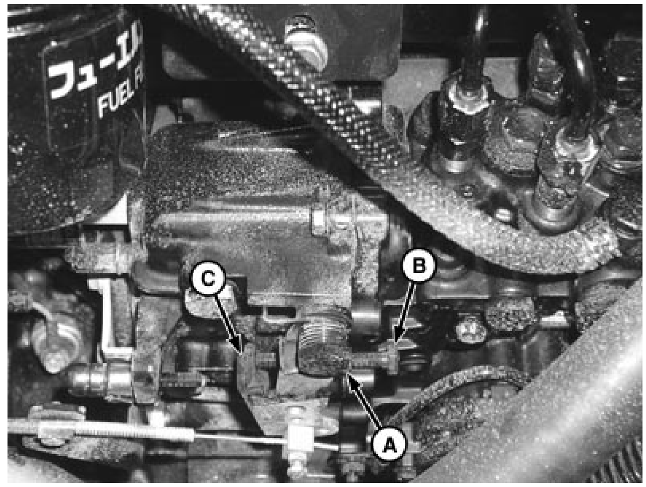


Slow Idle Speed Adjustment—3009, 3011, 3012, 3015, 4020 and 4TNE98

A—Nut
B—Slow Idle Adjustment Screw
C—Throttle Lever

OUO1017,0000B2C –19–28APR04–1/1

Slow Idle Speed Adjustment—3013 and 3016



Slow Idle Speed Adjustment 3013 and 3016

A—Nut
B—Slow Idle Adjustment Screw
C—Throttle Lever

1. Start engine and run for five minutes.

2. Visually check that injection pump throttle lever (C) is against slow idle stop screw (B).

NOTE: Follow manufacturer's instructions for operation of tachometer.

3. Check engine speed at flywheel using JT05719 Hand-Held Digital Tachometer.

If slow idle rpm is not according to specifications, loosen nut (A) and turn screw (B). After adjustment, tighten nut.

Specification

Base/Ind. Engines Slow Idle—3013 and 3016—Speed	800 rpm
Gen. Set Engines Slow Idle—3013 and 3016—Speed	1200 rpm

OUO1017,0000B2B –19–28APR04–1/1

Fast Idle Speed Adjustment—3009, 3011, 3012, 3015, 4020 and 4TNE98

IMPORTANT: Earlier engines MUST NOT be operated continuously at less than 2400 rpm.

If these engines are operated at less than 2400 rpm, rocker arm failures due to inadequate lubrication can occur. To operate continuously at 2300 rpm or less, special low-speed rocker arms are required. Consult your Parts Catalog.

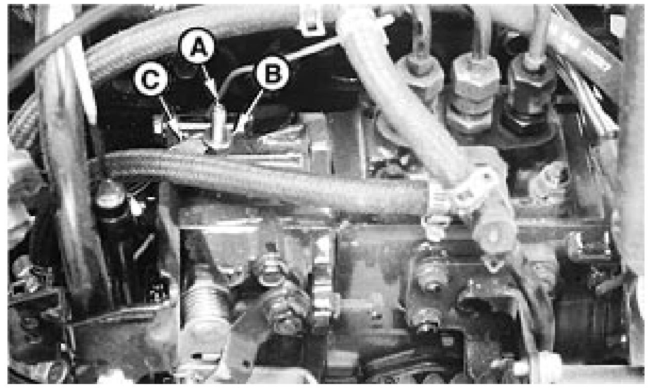
NOTE: On later engines, rocker arms have been modified to allow adequate lubrication at all operating speeds. This change was made at the following serial numbers (in 1996):

- *3009DF001 — (000247—)*
- *3009DF005 — (000186—)*
- *3009DF007 — (000368—)*
- *3011DF001 — (000389—)*
- *3011DF005 — (000387—)*
- *3011DF006 — (000388—)*
- *3012DF001 — (All)*
- *3015DF001 — (All)*
- *3015DF005 — (000247—)*
- *3015DF006 — (000230—)*
- *4020DF001 — (000424—)*
- *4020DF005 — (000212—)*
- *4020DF006 — (000376—)*
- *4020TF001 — (000348—)*
- *4020TF005 — (000417—)*
- *4020TF006 — (000339—)*
- *CH4033D001 [4TNE98] —- (All)*

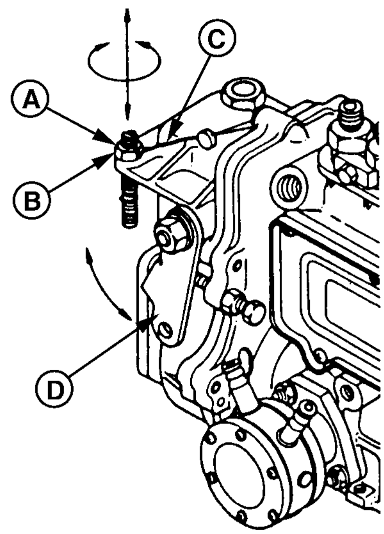
NOTE: Make sure air cleaner is clean and not restricted. Clean or replace air cleaner element(s) as necessary.

1. Start engine and run for five minutes.

2. Push against injection pump throttle lever (D) to ensure it is against fast idle stop screw (A).



Model 3009



Models—3011, 3012, 3015, 4020 and 4TNE98

A—Fast Idle Adjusting Screw
B—Nut
C—Sealing Wire
D—Throttle Lever

Continued on next page

OUO1017,0000B29 –19–28APR04–1/2

NOTE: Follow manufacturer's instructions for operation of tachometer.

3. Check engine speed at flywheel using JT05719 Hand-Held Digital Tachometer.

Specification	
Base/Ind. Engines Fast Idle—3009, 3011, 3012, 3015, and 4020—Speed	3225 rpm
Gen. Set Engines Fast Idle—3009—Speed	3800 rpm
Gen. Set Engines Fast Idle—3011, 3012, 3015, and 4020—Speed	1900 rpm
244H Loader Application Fast Idle—4TNE98—Speed	2375 rpm

Results:

NOTE: Some adjustment can be made without removing sealed wire on pump. Attempt to make the adjustment before removing wire.

If fast idle rpm is not according to specifications, loosen nut (B) and turn screw (A) until fast idle speed is correct. After adjustment, tighten nut.

If engine still does not meet fast idle specifications, have pump inspected by a diesel injection service.

OUO1017,0000B29 –19–28APR04–2/2

Fast Idle Speed Adjustment—3013 and 3016

NOTE: Make sure air cleaner is clean and not restricted. Clean or replace air cleaner element(s) as necessary.

1. Start engine and run for five minutes.

2. Visually check that injection pump throttle lever (A) is against fast idle stop screw (B).

NOTE: Follow manufacturer's instructions for operation of tachometer.

3. Check engine speed at flywheel using JT05719 Hand-Held Digital Tachometer.

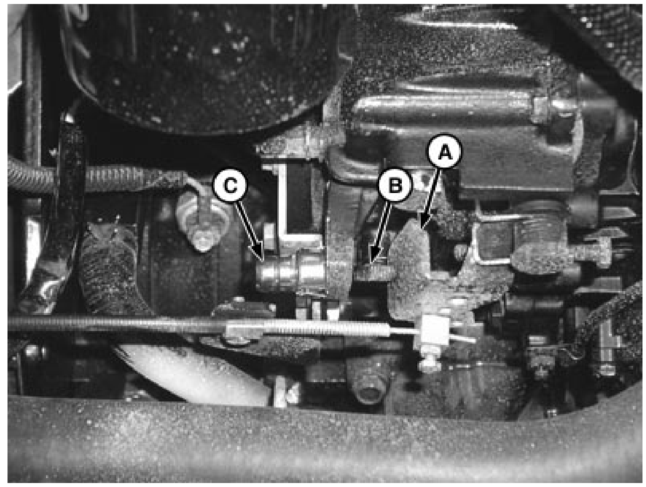
Specification

Base/Ind. Engines Fast Idle— 3013 and 3016—Speed	3225 rpm
Gen. Set Engines Fast Idle— 3013 and 3016—Speed	1900 rpm

NOTE: Tamper-resistant cap (C) must be replaced if removed for adjustment

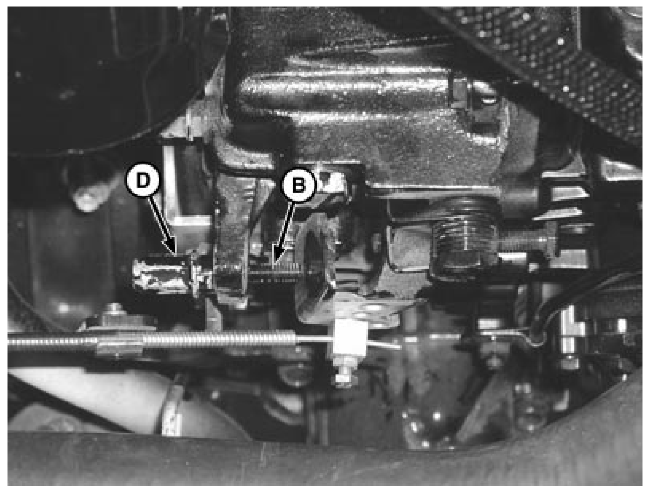
If fast idle rpm is not according to specifications, remove cap (C) and loosen nut (D) and turn screw (B) until fast idle speed is correct. After adjustment, tighten nut.

If engine still does not meet fast idle specifications, have pump inspected by a diesel injection service.



RG13610A –UN–29APR04

Fast Idle Speed Adjustment 3013 and 3016



RG13611A –UN–29APR04

Fast Idle Speed Adjustment—3013 and 3016

A—Throttle Lever
B—Fast Idle Adjusting Screw
C—Tamper-Resistant Cap
D—Jam Nut

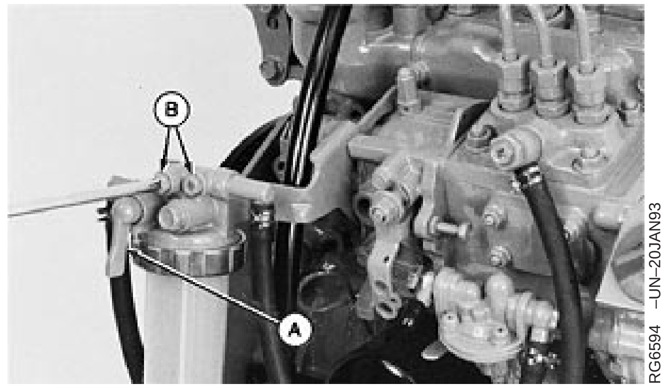
OUO1017,0000B2A –19–28APR04–1/1

Bleed Fuel System—3009

Any time the fuel system has been opened up for service (lines disconnected or filters removed), it will be necessary to bleed air from the system.

IMPORTANT: Modification or alteration of the injection pump, pump timing, or the injection nozzles in any way not approved by the manufacturer will terminate the warranty obligation.

1. Turn fuel filter shutoff valve (A) to OPEN position.
2. Loosen both air bleed screws (B) on fuel filter base.

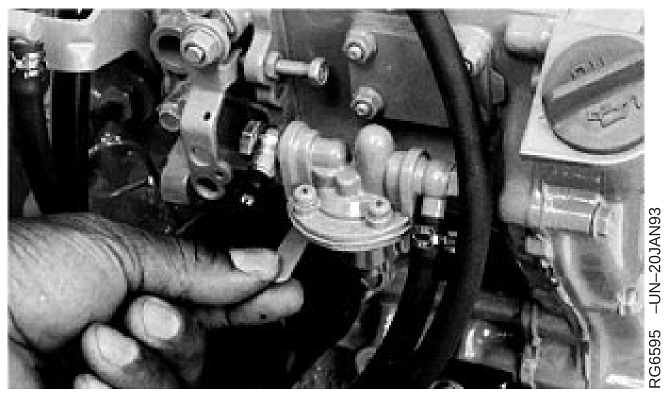


Bleed Fuel System—3009

A—Fuel Filter Shutoff Valve
B—Air Bleed Screw (2 used)

RG,RG34710,8394 –19–15APR97–1/4

3. Turn ignition switch to ON position.
4. Operate hand primer lever of fuel supply pump, if equipped, until fuel flows free of air bubbles. Tighten bleed screws.

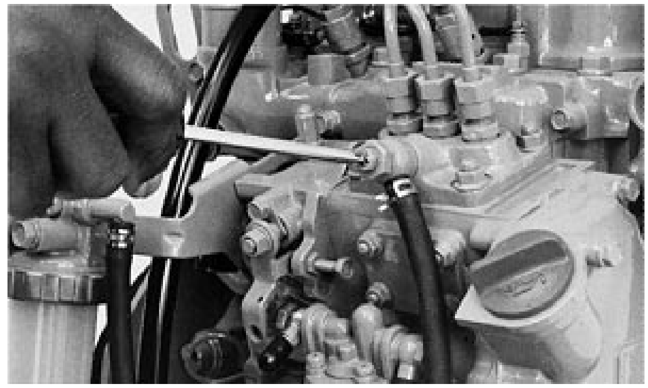


Operate Fuel Supply Pump Hand Primer, Remove Air Bubbles

Continued on next page RG,RG34710,8394 –19–15APR97–2/4

5. Loosen bleed screw on injection pump. Operate hand primer, if equipped, and tighten bleed screw when fuel flows free of air bubbles.

6. Start engine. If engine does not start after several attempts, proceed with steps 7—10.


RG6596 –UN–20JAN93

Remove Air Bubbles from Fuel

RG,RG34710,8394 –19–15APR97–3/4

7. Loosen all three injector line nuts using a 17 mm wrench. Be sure not to loosen bottom nut of injector.

8. Crank engine over with starter.

9. When fuel appears at injectors, tighten line nuts.

10. Start engine. If engine does not start, repeat bleed procedure.


RG6597 –UN–20JAN93

Loosen Injector Line Nuts

RG,RG34710,8394 –19–15APR97–4/4

Bleed Fuel System—3011, 3012, 3015, 4020 and 4TNE98

IMPORTANT: Modification or alteration of the injection pump, pump timing, or the injection nozzles in any way not approved by the manufacturer will terminate the warranty obligation.

All engines are equipped with an automatic air venting system which makes the fuel system self-bleeding.

Ensure that all fuel line connections are securely tightened.

Add fuel to fuel tank.

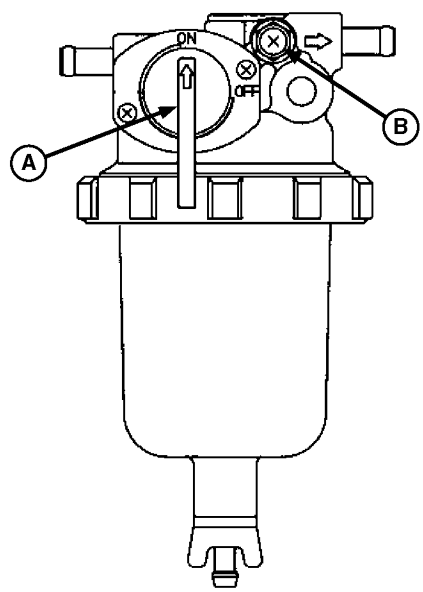
Crank engine to allow fuel system to bleed itself.

RG,RG34710,8395 –19–15APR97–1/1

Bleed Fuel System—3013 and 3016

1. Turn fuel shutoff valve (A) to the ON position.
2. Turn key or switch to the ON position to activate the electric fuel supply pump.
3. Loosen the air bleeding screw (B) on the water separator 2—3 turns.
4. When the fuel coming out of the bleeder screw is clear and not mixed with any air bubbles, tighten the air bleeding screw
5. Run supply pump for 10—15 seconds to fill fuel filter and bleed supply lines.

A—Fuel Shutoff Valve
B—Air Bleed Screw

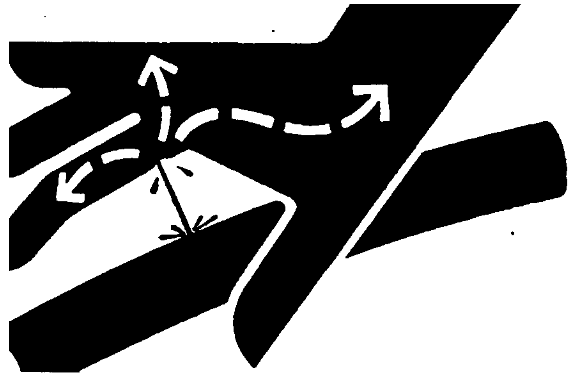


RG13612 –UN–29APR04

Water Separator Bleed Screw

OUO1017,0000B2D –19–28APR04–1/1

Remove Fuel Injection Pump—3009



X9811 –UN–23AUG88

High-Pressure Fluid

CAUTION: Escaping diesel fuel under pressure can have sufficient force to penetrate the skin, causing serious injury. Before disconnecting lines, be sure to relieve pressure. Before applying pressure to the system, be sure ALL connections are tight and lines, pipes and hoses are not damaged. Keep hands and body away from pinholes and nozzles which eject fluid under pressure. Use a piece of cardboard or wood, rather than hands, to search for suspected leaks.

If ANY fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type injury or gangrene may result. Doctors unfamiliar with this type of injury may call the Deere & Company Medical Department in Moline, Illinois, or other knowledgeable medical source.

IMPORTANT: Never steam clean or pour cold water on injection pump while the pump is running or warm. Doing so can damage the pump.

1. Any time the fuel system has been opened up for service (lines disconnected or filters removed), it will be necessary to bleed air from the system. (See BLEED FUEL SYSTEM—3009, BLEED FUEL SYSTEM—3011, 3012, 3015, 4020 AND 4TNE98, or BLEED FUEL SYSTEM—3013 AND 3016 in this group.)

2. Clean the injection pump lines and area around the pump using a parts cleaning solvent or steam cleaner.

Continued on next page

RG,RG34710,8267 –19–15APR97–1/4

IMPORTANT: When removing injection lines, DO NOT turn pump delivery valve fittings. Turning fittings may damage pump internally.

3. Loosen fuel injection line connectors slightly to release pressure in the fuel system. When loosening connectors, use another wrench to keep delivery valves from loosening.

4. Loosen line clamp and remove fuel injection lines.

5. Disconnect hose from fuel filter or supply pump, if equipped.

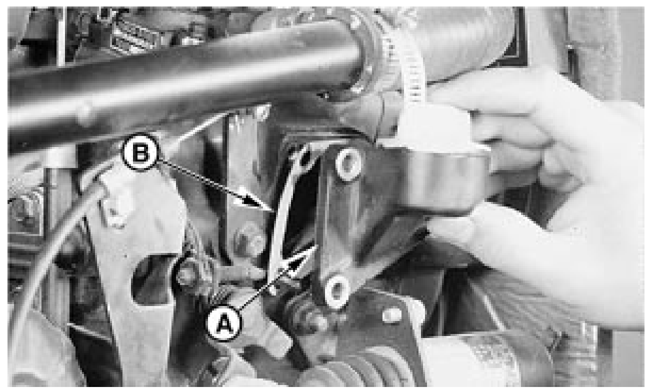
6. Disconnect leak-off hoses to/from injection pump.

7. Remove four nuts, oil fill cover (A) and gasket (B).

A—Oil Fill Cover
B—Gasket


M37785 –UN–29AUG88

Loosen Fuel Injection Line Connectors



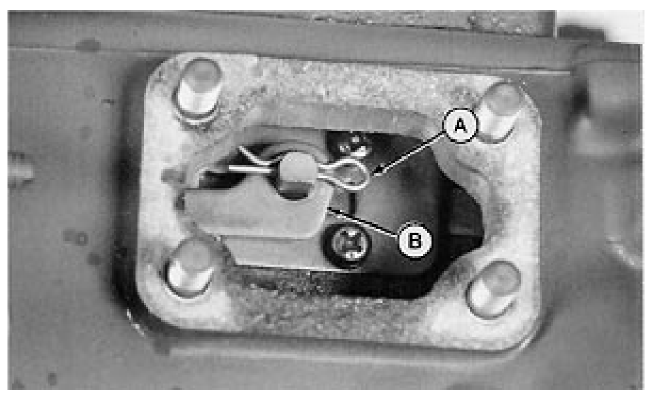
M35890A –UN–08JUN00

Oil Filter Cover and Gasket

RG,RG34710,8267 –19–15APR97–2/4

8. Remove pin (A) and washer, if equipped. Disconnect governor linkage (B).

A—Pin
B—Governor Linkage



M37787 –UN–29AUG88

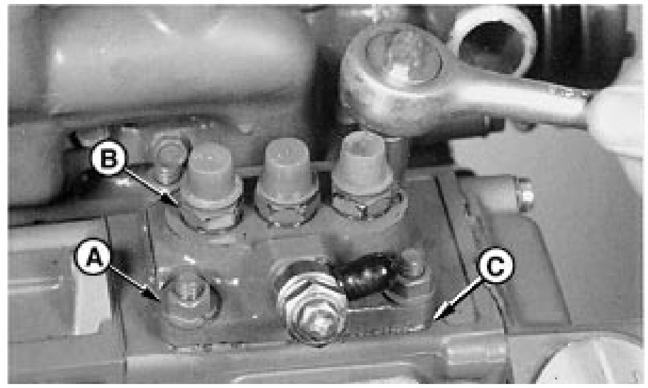
Pin and Governor Linkage

Continued on next page RG,RG34710,8267 –19–15APR97–3/4

IMPORTANT: If injection pump is being removed to be serviced or replaced, the same number and thickness of new shims must be installed when pump is assembled.

9. Remove four nuts (A) to remove fuel injection pump (B) and shims (C).

   DO NOT attempt to service the injection pump except for fuel delivery valves. If unit is in need of repair, it must be serviced by a qualified fuel injection repair shop. If replacement is necessary, replace entire unit.



Remove Fuel Injection Pump and Shims

A—Nuts
B—Fuel Injection Pump
C—Shims

RG,RG34710,8267 –19–15APR97–4/4

Install Fuel Injection Pump—3009

Installation is done in the reverse order of removal. Tighten mounting nuts to specification.

Specification

Fuel Injection Pump Mounting
Nuts 3009—Torque .... 20 N•m (180 lb-in.))

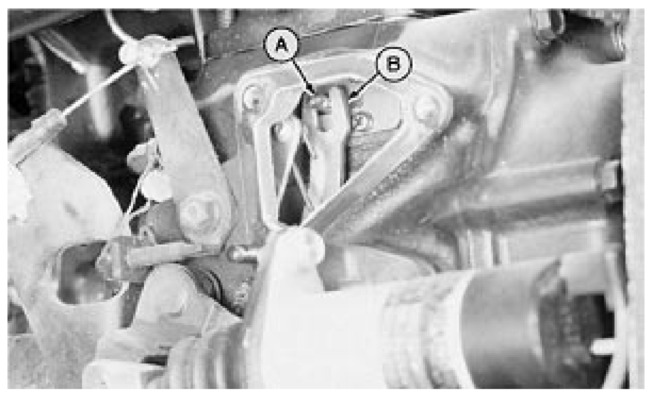
IMPORTANT: If a serviced or replacement fuel injection pump is installed, measure old shim thickness and install new shims of the same thickness.

NOTE: Governor linkage may have two holes. Connect governor linkage to injection pump rack using hole closest to injection pump gear.

When connecting governor linkage to injection pump rack, attach link to rack (A) at hole closest to injection pump gear.

Bleed the fuel system. (See BLEED FUEL SYSTEM—3009 in this group.)

If new injection pump is being installed, check and adjust injection pump timing. (See FUEL INJECTION PUMP STATIC TIMING ADJUSTMENT—3009 in this group.)



Fuel Injection Pump—3009

A—Controller Rack
B—Governor Linkage Fork

RG,RG34710,8269 –19–15APR97–1/1

Fuel Injection Pump Static Timing Adjustment—3009

IMPORTANT: Injection pump timing should be correct. Once timing is set, it will not normally change during the life of the engine, unless it was altered.

Check and adjust timing only as the last option. Check fuel, fuel supply system, injectors, air intake system and cylinder compression before continuing.

NOTE: The flywheel turns counterclockwise (as viewed from the flywheel end). The No. 1 fuel injection line is toward the flywheel.

1. Remove the No. 1 fuel injection line and delivery valve fitting (A).

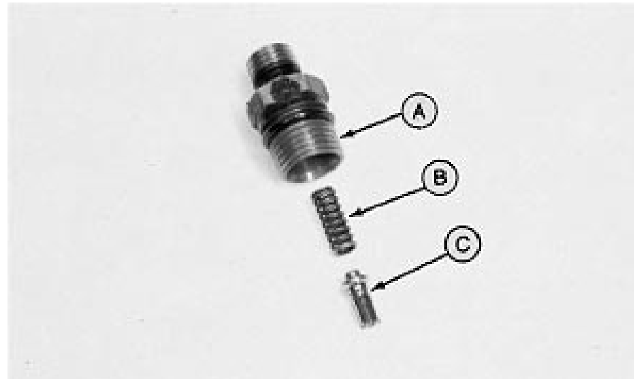
2. Remove spring (B) and delivery valve (C). Do not remove delivery valve seat.

3. Install delivery valve fitting (A) and tighten to specification.

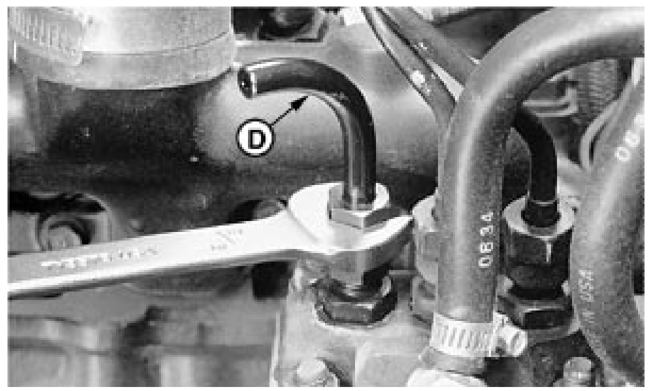
Specification

Fuel Injection Delivery Valve—
3009—Torque.. 42 N•m (31 lb-ft)

4. Cut a spare fuel injection line off at the first bend (D) and install on delivery valve fitting (A).



Delivery Valve Fitting, Spring, Delivery Valve



Timing Tool

A—Delivery Valve Fitting
B—Spring
C—Delivery Valve
D—Timing Tool

Continued on next page RG,RG34710,8388 –19–15APR97–1/4

5. Remove glow plugs to aid turning crankshaft pulley.

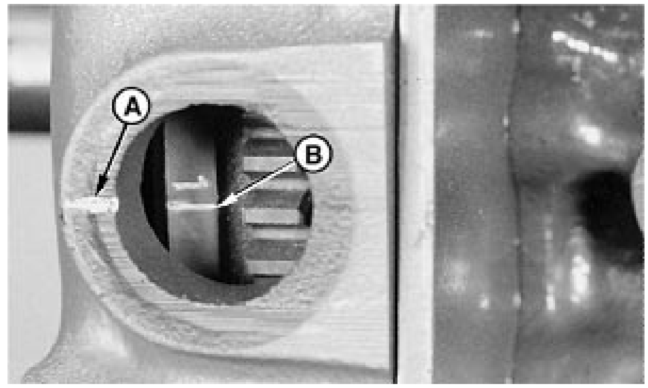
6. Remove plug from flywheel housing/cover, if equipped.

7. Turn crankshaft pulley in either direction until the No. 1 cylinder top dead center (TDC) mark (B) aligns with the index mark (A) on the flywheel housing/cover or plate.

8. Put a container under timing tool to collect any fuel.

9. Connect a pressurized fuel supply to the injection pump inlet.

10. Turn key switch to ON position. DO NOT start engine. Push fuel shutoff solenoid plunger to HOLD position.



M37500A –UN–08JUN00

Align Marks on Flywheel Housing Cover/Flywheel

A—Index Mark on Flywheel Housing/Cover
B—No. 1 TDC Mark on Flywheel

Continued on next page RG,RG34710,8388 –19–15APR97–2/4

11. Turn flywheel clockwise (as viewed from the flywheel end) until fuel flows in a stream.

NOTE: If the fuel flow does not stop, the No. 1 piston is on the exhaust stroke instead of the compression stroke. Turn flywheel one revolution and repeat steps 7—11.

12. Slowly turn flywheel counterclockwise until fuel flow changes from a stream and then stops completely. This is the point of injection timing at which the pump is set.

NOTE: Generator set engines should be set at 18° BTDC.

13. Check timing mark on flywheel. The index mark (C) must line up with 16° before top dead center (BTDC) (D) on flywheel.

NOTE: Each 1° of flywheel rotation is equal to a distance of 2.62 mm (0.100 in.) on the outer surface of the flywheel.

Specification

Injection Pump Timing—3009—Position	16° BTDC (Before Top Dead Center)
Engine Crankshaft—3009—Position	No. 1 Cylinder Near Top Dead Center of Compression Stroke

14. If timing is according to specifications, proceed to step 17.

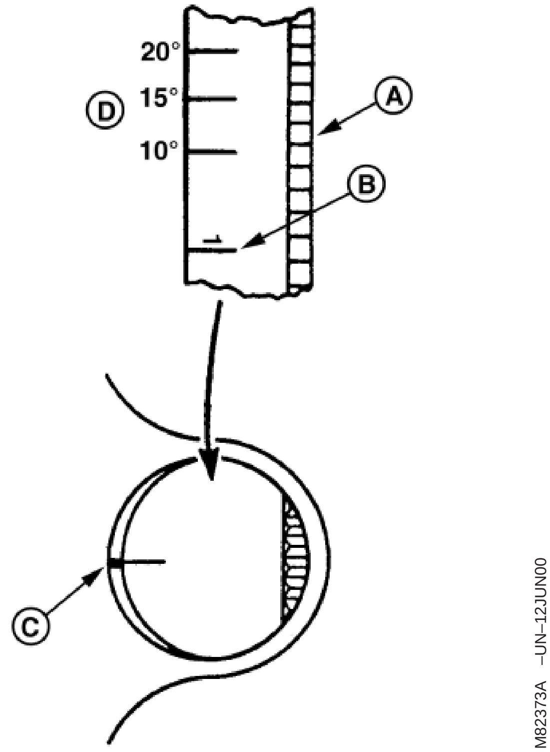
15. If timing is not according to specifications:

    a. Remove injection pump and shims. (See REMOVE FUEL INJECTION PUMP—3009 in this group.)

    b. Install new shim(s) with a total shim pack thickness of 0.5 mm (0.020 in.).

    c. Install injection pump and recheck timing.

16. If engine performance is poor, check air cleaners, fuel filter, fuel supply, injectors and cylinder compression before removing pump for service. Check all timing gears for wear. Retest performance.



Flywheel Components

A—Flywheel
B—Top Dead Center (TDC) Mark on Flywheel
C—Index Mark on Flywheel Housing
D—Timing Marks on Flywheel

Continued on next page

17. If performance did not change, have pump tested by a diesel injection service. When reinstalling injection pump, use same thickness of shim pack removed. If shim pack thickness is unknown or new pump is installed, replace with 0.5 mm (0.020 in.) shim pack thickness.

18. If timing is OK:

    a. Install rubber plug in flywheel housing/cover, if equipped.

    b. Remove timing tool.

    c. Remove delivery valve fitting.

    d. Install delivery valve and spring.

    e. Install new O-ring and delivery valve fitting. Tighten to specification.

Specification

Delivery Valve Fitting—3009—
Torque .... 42 N•m (31 lb-ft)

    f. Install No. 1 injection line.

RG,RG34710,8388 –19–15APR97–4/4

Fuel Injection Pump Camshaft—3009

Removal

1. Remove fuel injection pump. (See REMOVE FUEL INJECTION PUMP—3009 in this group.)

2. Remove fuel supply pump. (See REPLACE FUEL SUPPLY PUMP—3009 in this group.)

3. Remove fuel control and governor linkage. (See FUEL CONTROL AND GOVERNOR LINKAGE—3009 in this group.)

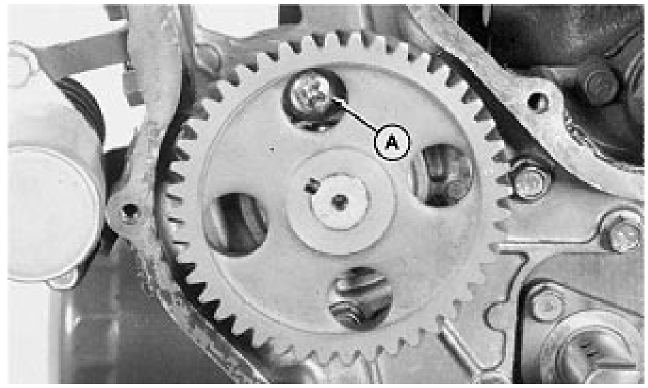
4. Remove idler gear. (See REMOVE AND INSTALL IDLER GEAR in Group 050.)

5. Remove bearing retaining screw (A).

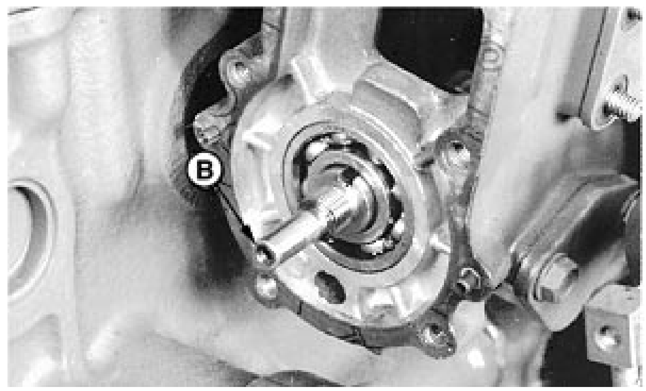
IMPORTANT: DO NOT allow fuel injection pump camshaft lobes to hit bearing surfaces while removing camshaft. Machined surfaces may be damaged.

6. Tap the rear of camshaft (B) with plastic hammer to remove from housing.

7. Disassemble and inspect all parts for wear or damage.



Bearing Retaining Screw



Fuel Injection Pump Camshaft

A—Bearing Retaining Screw
B—Fuel Injection Pump Camshaft

RG,RG34710,8270 –19–15APR97–1/4

Disassembly

IMPORTANT: Hold camshaft while removing gear and bearings. Shaft can be damaged if dropped.

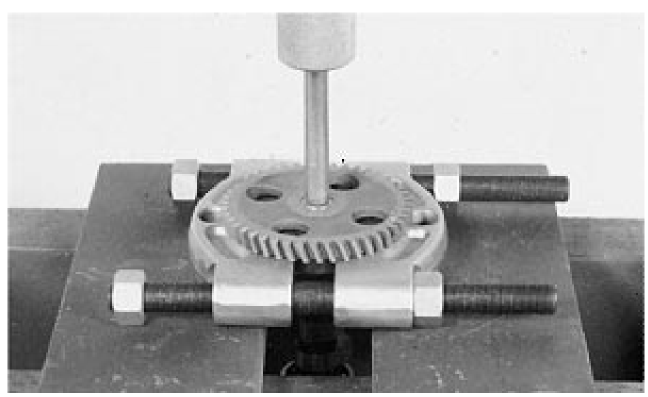
NOTE: Gear and bearings are press fit on shaft.

1. Remove gear using knife-edge puller and a press.

2. Remove key.

3. Remove bearings using a knife edge puller and a press.

4. Inspect all parts for wear or damage.



Disassembly

Continued on next page

RG,RG34710,8270 –19–15APR97–2/4

Inspection

1. Measure height of each camshaft lobe. Replace camshaft if lobe height is less than specification.

Specification

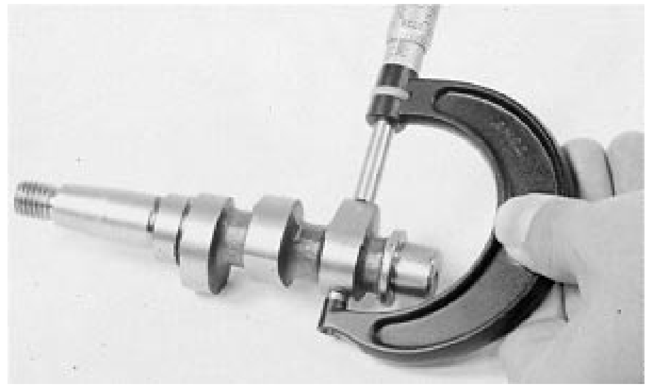
Fuel Injection Pump Camshaft
Lobe—3009—Height .... 30.90 mm (1.217 in.) minimum

2. Inspect camshaft bearing supports in timing gear housing. Check for cracks, damage or indications that bearings have spun in support.

   If rear bearing bore is damaged, replace timing gear housing. (See REMOVE AND INSTALL TIMING GEAR HOUSING—3009 in Group 050.)

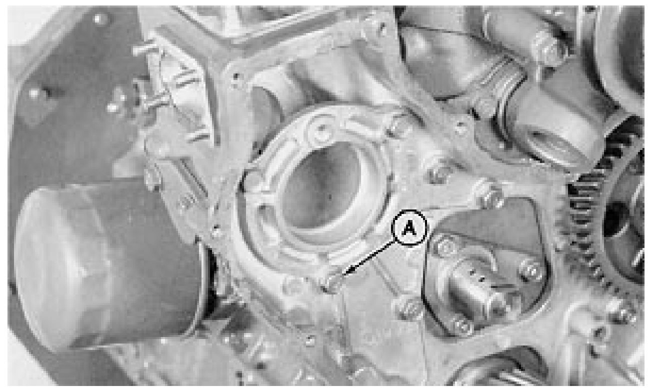
   If front bearing bore is damaged, remove three cap screws (A) and replace bearing support.

3. Inspect all parts for wear or damage. Replace as necessary.



M35905 –UN–26AUG88

Measure Height of Camshaft Lobe



M37803 –UN–29AUG88

Bearing Support

A—Cap Screw (3 used)

Assembly

NOTE: Install large bearing on gear end.

1. Install bearings on ends of camshaft using a 3/4 in. deep well socket and a press. Press until bearing races bottom on camshaft shoulders.

2. Install key.

3. Put camshaft gear on a flat surface and press camshaft assembly into gear. Press until gear face is flush with end of shaft.

Installation

IMPORTANT: DO NOT allow fuel injection pump camshaft lobes to hit bearing surfaces while installing camshaft. Machined surfaces may be damaged.

1. Install camshaft in housing.

Continued on next page

RG,RG34710,8270 –19–15APR97–3/4

2. Tighten screws (A) to specification.

Specification

Camshaft Bearing Retaining Screw—3009—Torque .... 20 N•m (180 lb-in.)

3. Tap on the end of the camshaft gear with a plastic hammer to seat bearings in bores.

4. Install idler gear. (See REMOVE AND INSTALL IDLER GEAR in Group 050.)

5. Install fuel control and governor linkage. (See FUEL CONTROL AND GOVERNOR LINKAGE—3009 in this group.)

6. Install fuel supply pump. (See REPLACE FUEL SUPPLY PUMP—3009 in this group.)

7. Install fuel injection pump. (See INSTALL FUEL INJECTION PUMP—3009 in this group.)

RG,RG34710,8270 –19–15APR97–4/4

Fuel Control and Governor Linkage—3009

Removal

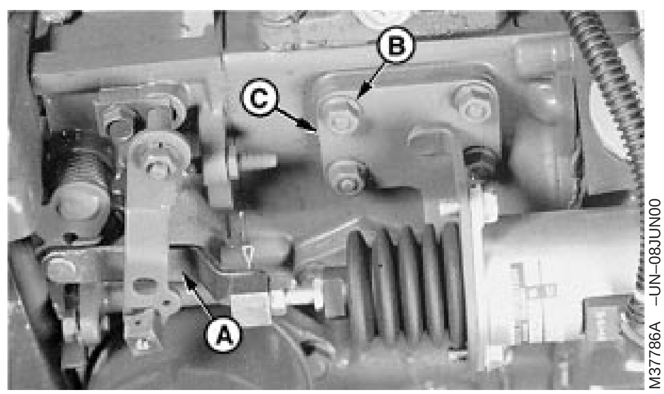
1. If equipped, disconnect fuel shutoff solenoid link (A).

2. Remove four nuts (B) and shutoff solenoid bracket (C) with gasket.

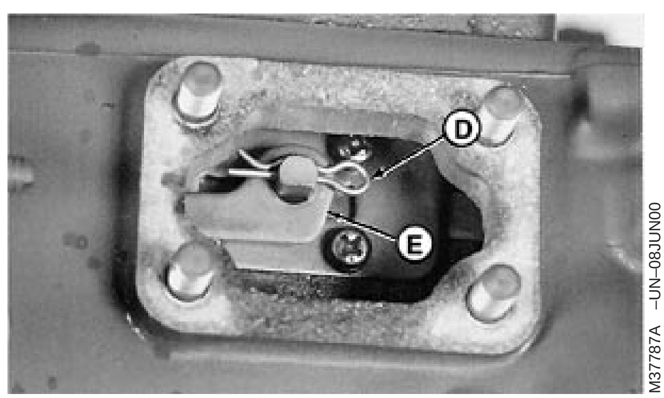
3. Remove pin (D) (and washer, if equipped), to disconnect governor linkage (E).

4. Remove dipstick tube.

A—Fuel Shutoff Solenoid Link
B—Nuts
C—Fuel Shutoff Solenoid Bracket
D—Pin
E—Governor Linkage



Fuel Shutoff Solenoid Link, Bracket, Nuts



Pin, Governor Linkage

Continued on next page RG,RG34710,8272 –19–15APR97–1/11

5. If equipped, remove throttle cable bracket (A).

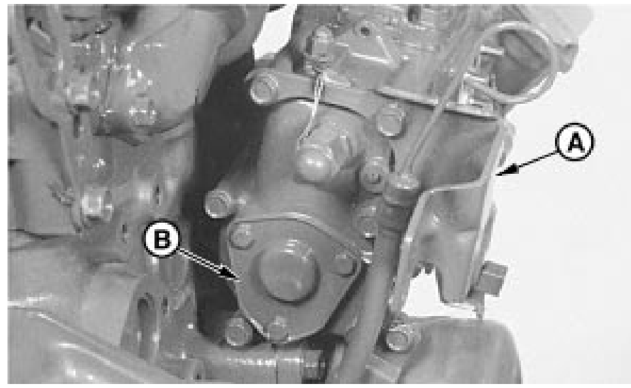
6. Remove six cap screws, linkage housing (B) and gasket.

7. Remove sleeve (C).

8. Remove nut (D) and governor weights (E).

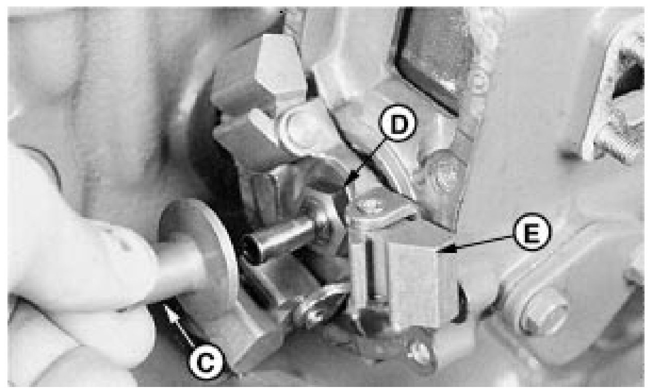
9. Disassemble and inspect all parts for wear or damage.

A—Throttle Cable Bracket (if equipped)
B—Linkage Housing
C—Sleeve
D—Nut
E—Governor Weights



M37754A –UN–08JUN00

Throttle Cable Bracket, Linkage Housing



M37755A –UN–08JUN00

Sleeve, Nut, Governor Weights

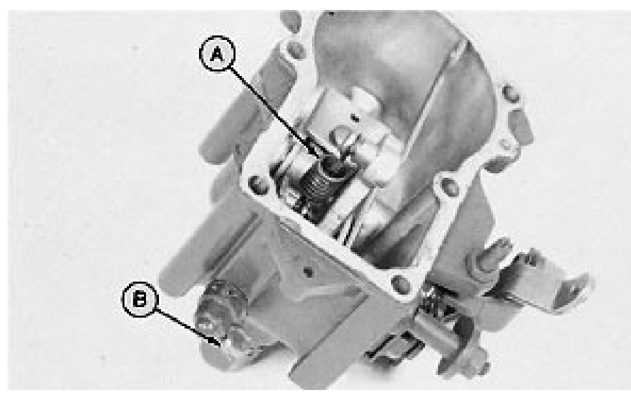
RG,RG34710,8272 –19–15APR97–2/11

Disassembly

1. Remove spring (A).

2. Remove seal and sealing wire (B).

A—Spring
B—Seal and Sealing Wire



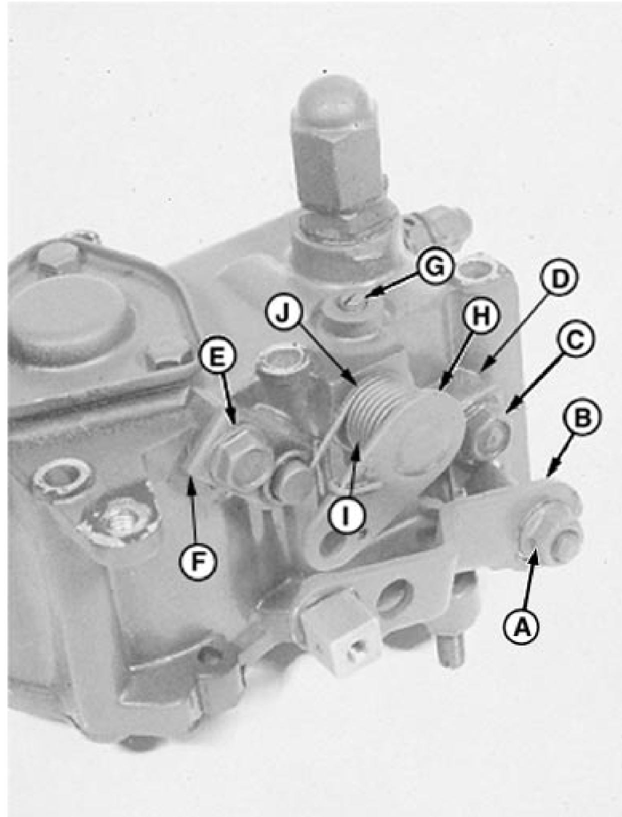
M37759 –UN–29AUG88

Remove Spring, Seal and Sealing Wire

Continued on next page RG,RG34710,8272 –19–15APR97–3/11

3. Remove nut and washer (A), and throttle lever (B).
4. Remove cap screw (C) and throttle shaft retaining plate (D).
5. Remove cap screw (E) and governor shaft retaining plate (F).
6. Remove set screw (G), fuel shutoff lever (H), spring (I) and O-ring (J).

A—Nut and Washer
B—Throttle Lever
C—Cap Screw
D—Throttle Shaft Retaining Plate
E—Cap Screw
F—Governor Shaft Retaining Plate
G—Set Screw
H—Fuel Shutoff Lever
I—Spring
J—O-Ring



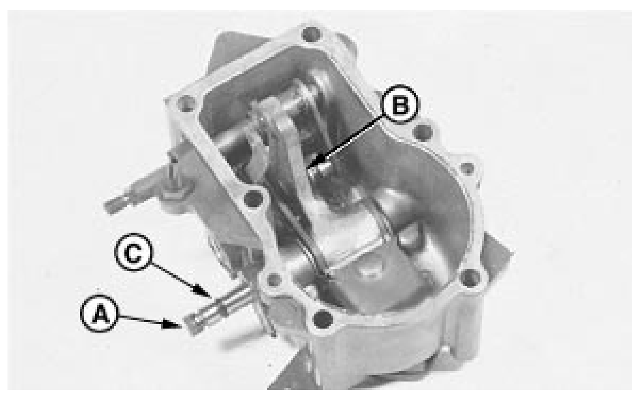
RG13603 –UN–27APR04

Fuel Control and Governor Assembly

RG,RG34710,8272 –19–15APR97–4/11

7. Remove governor shaft (A), governor linkage assembly (B) and O-ring (C).

A—Governor Shaft
B—Governor Linkage Assembly
C—O-Ring



M37762A –UN–08JUN00

Governor Assembly

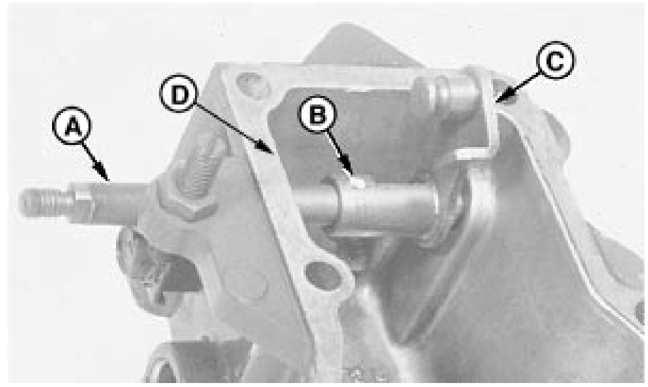
Continued on next page RG,RG34710,8272 –19–15APR97–5/11

8. Rotate throttle shaft assembly (A) as shown.

9. Remove tapered pin (B) from tapered hole using a punch.

10. Remove throttle shaft, shaft lever (C) and O-ring (D).

A—Throttle Shaft Assembly
B—Tapered Pin
C—Shaft Lever
D—O-Ring

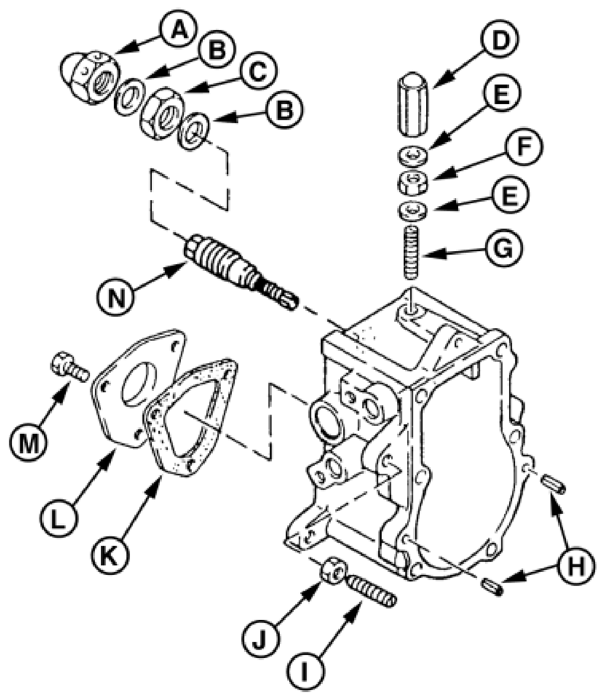


Rotate Throttle Shaft Assembly

RG,RG34710,8272 –19–15APR97–6/11

11. Remove cover (L), gasket (K), fuel controller assembly (N), fast idle stop (I) and slow idle stop (G).

A—Cap Nut
B—Seal
C—Lock Nut
D—Cap Nut
E—Seal
F—Lock Nut
G—Slow Idle Stop
H—Spring Pin
I—Fast Idle Stop
J—Lock Nut
K—Gasket
L—Cover
M—Cap Screw
N—Fuel Controller Assembly



Remove Idle Stops and Fuel Controller Assembly

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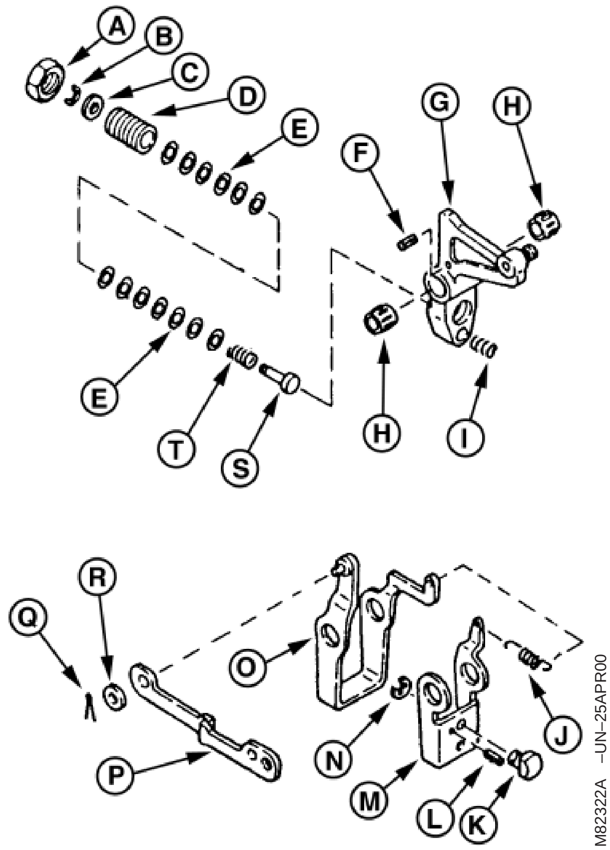
RG,RG34710,8272 –19–15APR97–7/11

12. Disassemble governor linkage assembly.

13. Inspect all parts for wear or damage. Replace as necessary.

A—Nut
B—Clip
C—Washer
D—Stud
E—Shims
F—Spring Pin
G—Tension Lever
H—Needle Bearing
I—Spring
J—Spring
K—Pin
L—Spring Pin
M—Governor Lever
N—E-Clip
O—Bracket
P—Governor Link
Q—Pin
R—Washer
S—Pin
T—Spring



Disassemble Governor Linkage Assembly

Continued on next page RG,RG34710,8272 –19–15APR97–8/11

Inspection

1. Measure governor shaft (A) diameter. If OD is less than specification, replace governor shaft.

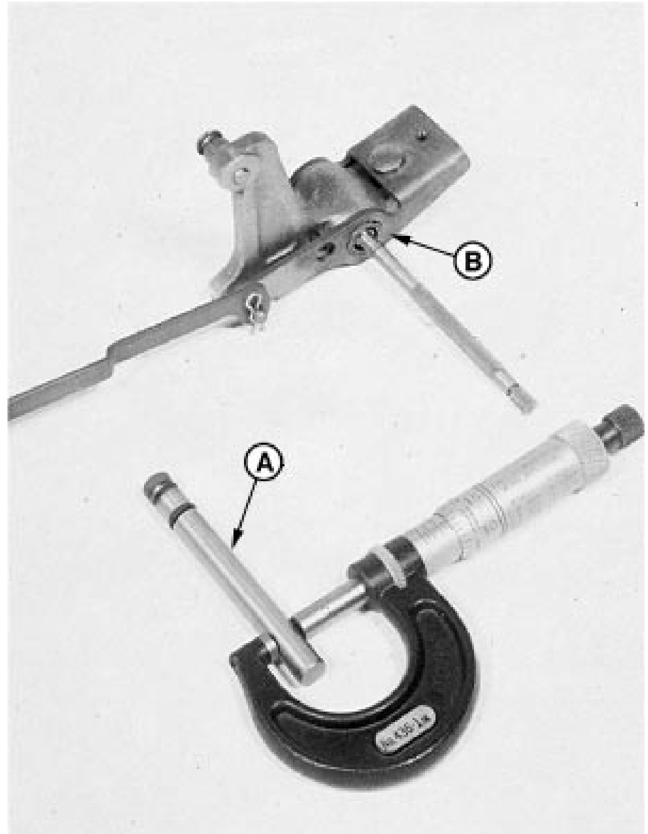
2. Measure governor shaft bore (B) diameter in governor linkage.

Specification

Governor Shaft and Bore—
3009—OD .... 7.90 mm (0.311 in.)
Governor Shaft Bore ID—3009—
Wear Limit .... 8.15 mm (0.321 in.)
Clearance .... 0.18 mm (0.007 in.) maximum

- If shaft bore exceeds wear limit, replace governor linkage.
- If bore clearance (bore ID minus shaft OD) exceeds specification, replace governor shaft, governor linkage or both.

A—Governor Shaft
B—Governor Shaft Bore



Measure Shaft Bore Diameter, Governor Shaft

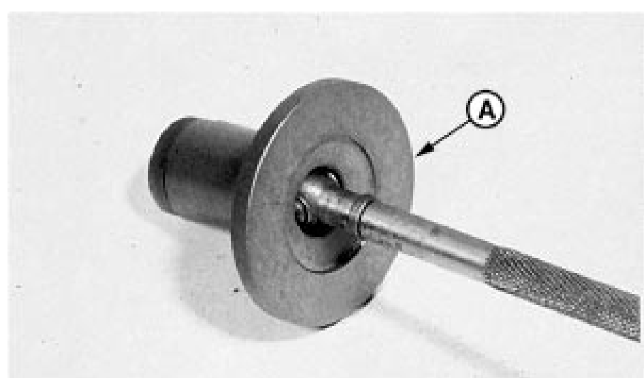
RG,RG34710,8272 –19–15APR97–9/11

3. Measure inside diameter of injection pump camshaft sleeve (A). If ID is more than specification, replace sleeve.

Specification

Injection Pump Camshaft
Sleeve—3009—ID .... 8.20 mm (0.323 in.)

A—Injection Pump Camshaft Sleeve



Injection Pump Camshaft Sleeve

Continued on next page

RG,RG34710,8272 –19–15APR97–10/11

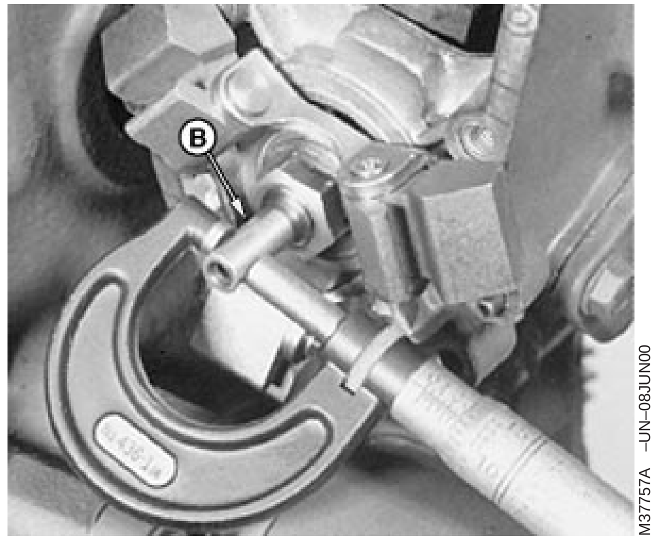
4. Measure injection pump camshaft (B) diameter.

   If camshaft diameter is less than wear limit, replace injection pump camshaft. (See FUEL INJECTION PUMP CAMSHAFT—3009 in this group.)

   If clearance (sleeve ID minus camshaft OD) exceeds specification, replace sleeve, injection pump camshaft or both.

Specification

Injection Pump Camshaft—3009—OD Wear Limit	7.90 mm (0.311 in.)
Clearance	0.15 mm (0.006 in.) maximum



Injection Pump Camshaft Diameter

B—Injection Pump Camshaft

5. Inspect all parts for wear or damage. Replace as necessary.

Assembly

Assembly is done in the reverse order of disassembly.

Apply clean engine oil on all internal parts.

When installing throttle shaft:

- Install new O-ring, throttle shaft and shaft lever. Rotate shaft until rounded side of shaft is facing toward hole
- Position shaft lever as shown and install tapered pin in tapered hole.

Installation

Installation is done in the reverse order of removal.

Governor linkage may have two holes. Connect governor linkage to injection pump rack using hole closest to injection pump gear.

Check and adjust slow and fast idle settings. (See SLOW IDLE SPEED ADJUSTMENT—3009, 3011, 3012, 3015, 4020 AND 4TNE98 and FAST IDLE SPEED ADJUSTMENT 3009, 3011, 3012, 3015, 4020 AND 4TNE98 in this group.)

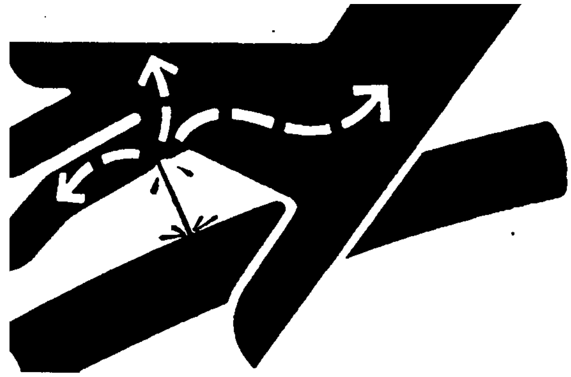
RG,RG34710,8272 –19–15APR97–11/11

Remove Fuel Injection Pump—3011, 3012, 3015 and 4020

Relieve Fuel System Pressure

CAUTION: Escaping diesel fuel under pressure can have sufficient force to penetrate the skin, causing serious injury. Before disconnecting lines, be sure to relieve pressure. Before applying pressure to the system, be sure ALL connections are tight and lines, pipes and hoses are not damaged. Keep hands and body away from pinholes and nozzles which eject fluid under pressure. Use a piece of cardboard or wood, rather than hands, to search for suspected leaks.

If ANY fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type injury or gangrene may result. Doctors unfamiliar with this type of injury may call the Deere & Company Medical Department in Moline, Illinois, or other knowledgeable medical source.


X9811 –UN–23AUG88

High-Pressure Fluid

Any time the fuel system has been opened up for service (lines disconnected or filters removed), it will be necessary to bleed air from the system. (See BLEED FUEL SYSTEM—3011, 3012, 3015, 4020 & 4TNE98 in this group.)

Continued on next page

OUO1017,0000B1E –19–06APR04–1/7

IMPORTANT: Never steam clean or pour cold water on injection pump while the pump is running or warm. Doing so can damage the pump.

1. Clean the injection pump lines and area around the pump using a parts cleaning solvent or steam cleaner.

IMPORTANT: When removing injection lines, DO NOT turn pump delivery valve fittings. Turning fittings may damage pump internally.

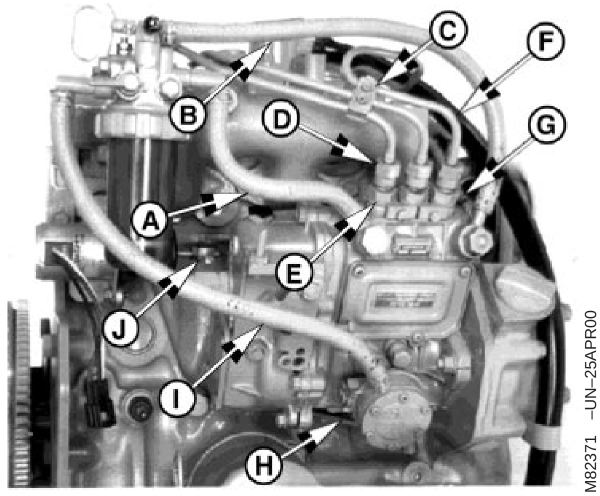
2. Loosen fuel injection line connectors (D) slightly to release pressure in the fuel system. When loosening connectors, use another wrench to keep delivery valves from loosening.

3. Loosen line clamp (C) and remove fuel injection lines (F).

4. Disconnect hose from fuel filter or supply pump, if equipped.

5. Remove external lube line (H).

6. Disconnect fuel shutoff solenoid link (J).



Models 3011, 3012, 3015 and 4020

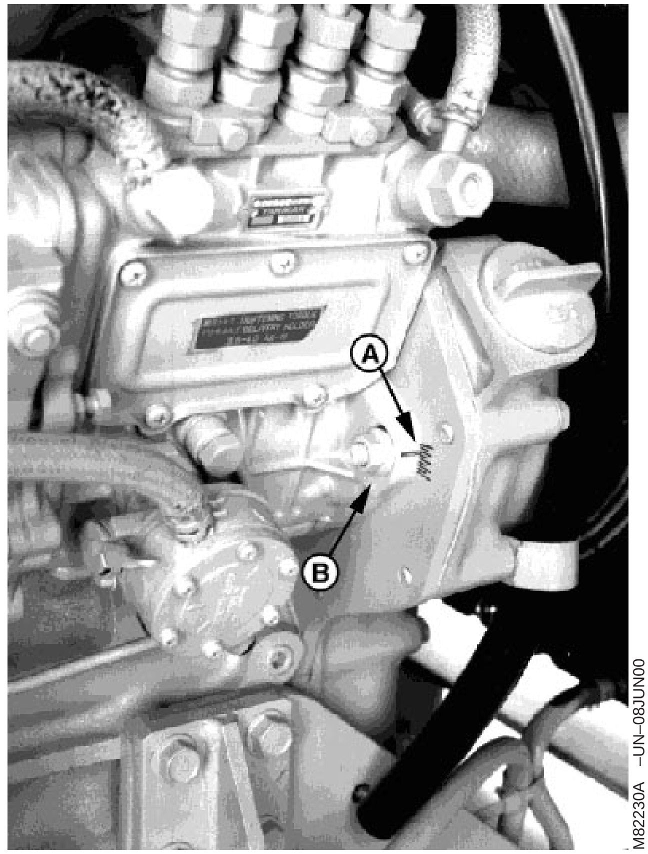
A—Hose, Fuel Filter-to-Injection Pump
B—Hose, Injection Pump Bleed-Off-to-Filter
C—Line Clamp
D—Fuel Injection Line Connectors
E—Delivery Valves
F—Fuel Injection Lines
G—Nozzle Leak-Off Hose
H—External Lube Line
I—Hose, Fuel Supply Pump-to-Filter
J—Fuel Shutoff Solenoid Link

Continued on next page OUO1017,0000B1E –19–06APR04–2/7

7. Mark position of timing marks (A) on injection pump and gear cover mounting plate.

8. Remove three mounting nuts (B).

A—Timing Marks
B—Mounting Nuts (3 used)



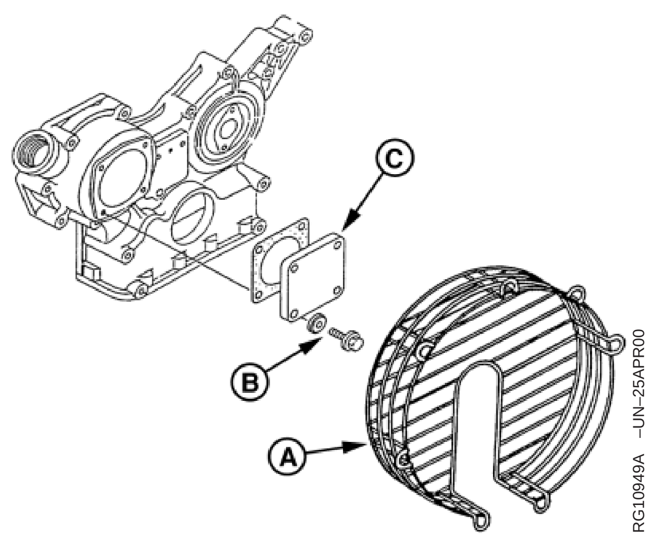
Timing Marks and Mounting Nuts

OUO1017,0000B1E –19–06APR04–3/7

9. Remove fan guard (A), if equipped.

10. Remove four cap screws and washers (B). Remove cover (C) and gasket from front of pump.

A—Fan Guard
B—Cap Screws and Washers (4 used)
C—Cover



Remove Fan Guard

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OUO1017,0000B1E –19–06APR04–4/7

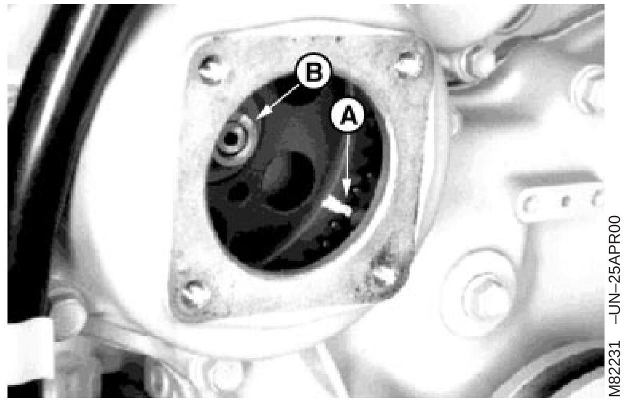
11. Remove injection pump gear.

Earlier 3011 and 3012, and All 3015 and 4020

a. Use chalk or paint to make a mark, (A) on injection pump gear and idler gear.

b. Remove nut and lock washer (B).

A—Chalk or Paint Mark
B—Nut and Lock Washer



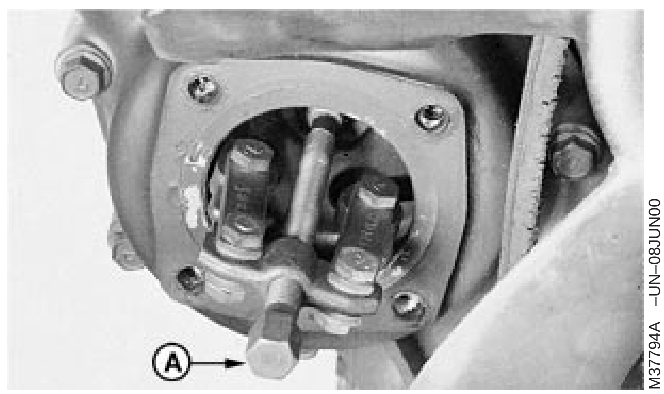
Earlier 3011 and 3012, and All 3015 and 4020

OUO1017,0000B1E –19–06APR04–5/7

c. Pull gear from injection pump shaft using a two-jaw puller (A).

Later 3011 and 3012

A—Two-Jaw Puller



Pull Gear from Injection Pump Shaft

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OUO1017,0000B1E –19–06APR04–6/7

IMPORTANT: Do not loosen or disturb cap screws (B) securing gear to the hub unless injection pump is to be replaced with a new or recalibrated unit. Gear to hub adjustment is pre-set to comply with strict EPA emissions requirements and is not adjustable. This procedure is done at the pump manufacturer and cannot be duplicated in the field.

a. Remove gear retaining nut and washer (A).

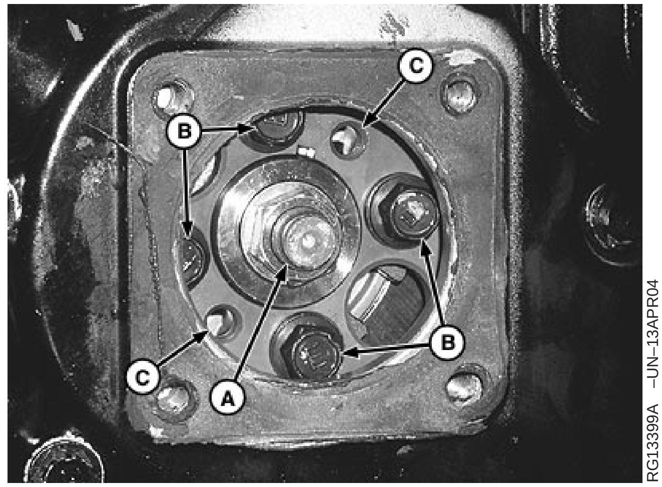
b. Install puller (E) into threaded holes (C) on gear using cap screws (D)

IMPORTANT: Engine must not be rotated when timing gear is removed from injection pump shaft. Engine can only be rotated when timing gear is securely fastened to pump or engine damage could result.

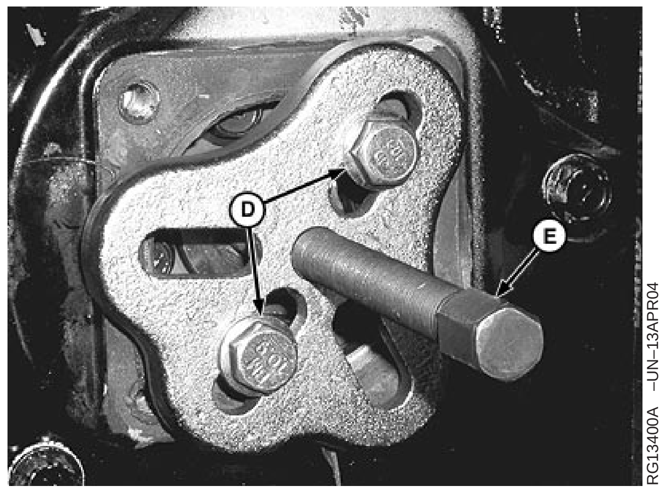
c. Remove gear and hub assembly from injection pump shaft. Gear will stay inside timing cover.

IMPORTANT: DO NOT attempt to service the injection pump or governor. If unit is in need of repair, it must be serviced by a qualified fuel injection repair shop. If replacement is necessary, replace entire unit.

12. Remove injection pump and O-ring.



Injection Pump Timing Gear— later 3011 and 3012



Injection Pump Timing Gear Puller

A—Timing Gear Nut and Washer
B—Cap Screw (4 used)
C—Threaded Puller Holes
D—Puller Cap Screws
E—Gear puller

OUO1017,0000B1E –19–06APR04–7/7

Install Fuel Injection Pump—3011, 3012, 3015 and 4020

NOTE: Earlier models shown. Later models are similar.

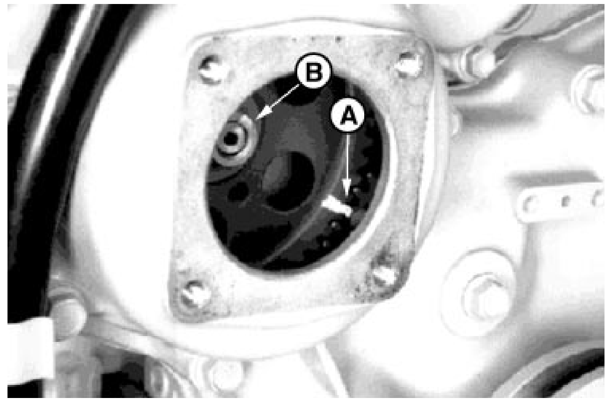
1. Install new O-ring on injection pump.

2. Put injection pump onto back of gear cover mounting plate. Align key on shaft with keyway in gear. Be sure to align marks (A) on gears made during removal. Install gear.

3. Install lock washer and nut (B). Tighten to specification.

Specification

Fuel Injection Pump Drive Gear Mounting Nut—3011, 3012, 3015, and 4020—Torque.. 90 N•m (66 lb-ft)



Align Marks on Shaft

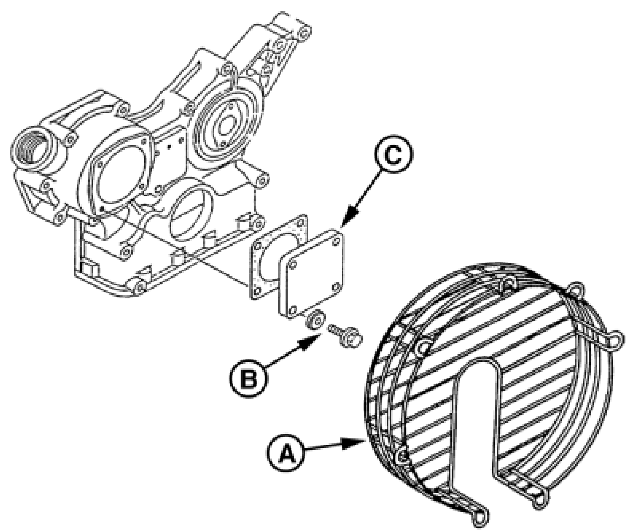
A—Chalk or Paint Mark
B—Nut and Lock Washer

OUO1017,0000B1F –19–06APR04–1/4

4. Install new gasket and cover (C). Install four washers and cap screws (B).

5. Install fan guard (A), if equipped.

A—Fan Guard
B—Cap Screws and Washers (4 used)
C—Cover



Install Gasket, Cover and Fan Guard

Continued on next page OUO1017,0000B1F –19–06APR04–2/4

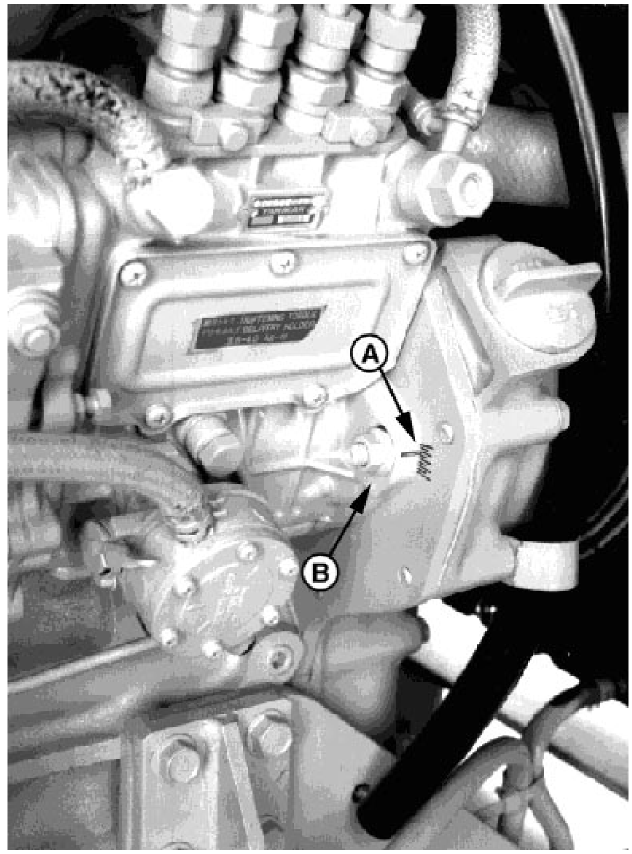
6. Install three mounting nuts (B). Do not tighten.

7. Align marks (A) on mounting plate and injection pump, to same place as when removed. Tighten mounting nuts to specifications.

Specification

Fuel Injection Pump Mounting Nut—3011, 3012, 3015, and 4020—Torque... 26 N•m (228 lb-in.)

A—Marks
B—Mounting Nuts (3 used)



Install Mounting Nuts, Align Marks

Continued on next page OUO1017,0000B1F –19–06APR04–3/4

8. Connect fuel shutoff solenoid link (J).

9. Connect hoses to/from fuel filter.

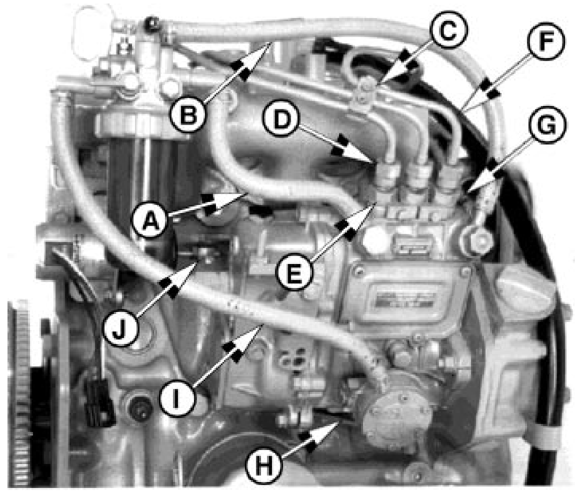
10. Install fuel injection lines (F) and tighten line clamp (C) cap screws.

IMPORTANT: If oil has been drained out of fuel injection pump housing, add oil as necessary. Fuel injection pump can become damaged if operated dry or without proper amount of oil.

11. Remove fill plug and add clean engine oil to housing. Add until oil begins to drip out of external lube line (H) inlet.

12. Install external lube line (H). When installing line, put one copper washer between mounting bolt head and lube line and the other between lube line and housing.

    If new injection pump is being installed, check and adjust injection pump static timing. (See FUEL INJECTION PUMP STATIC TIMING ADJUSTMENT —3011, 3012, 3015 AND 4020 in this group.)



M82371 –UN–25APR00

Models 3011, 3012, 3015 and 4020

A—Hose, Fuel Filter-to-Injection Pump
B—Hose, Injection Pump Bleed-Off-to-Filter
C—Line Clamp
D—Fuel Injection Line Connectors
E—Delivery Valves
F—Fuel Injection Lines
G—Nozzle Leak-Off Hose
H—External Lube Line
I—Hose, Fuel Supply Pump-to-Filter
J—Fuel Shutoff Solenoid Link

OUO1017,0000B1F –19–06APR04–4/4

Fuel Injection Pump Static Timing Adjustment—3011, 3012, 3015 and 4020

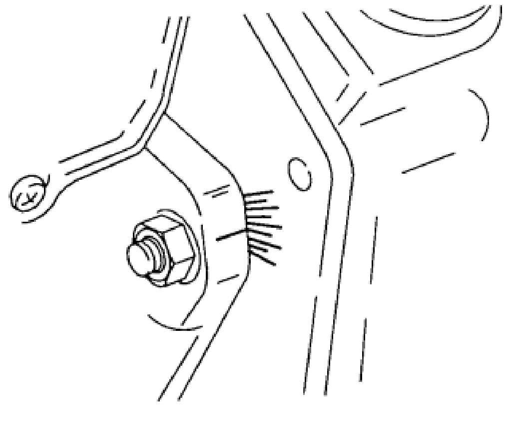
IMPORTANT: Injection pump timing should be correct. Once timing is set, it will not normally change during the life of the engine, unless it was altered.

Check and adjust timing only as the last option. Check fuel, fuel supply system, injectors, air intake system and cylinder compression before continuing.

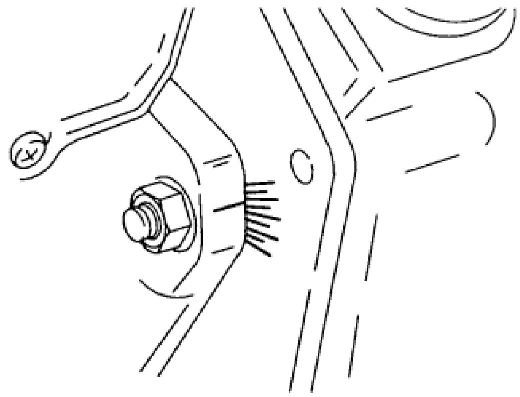
NOTE: If injection pump has been removed from engine without disturbing engine crankshaft and pump shaft, perform step 1 only. Otherwise, perform the entire timing procedure.

1. For Models 3011 and 3012 align arrow or line on injection pump flange with the sixth mark (line) on timing gear mounting plate.

   For Models 3015 and 4020, align arrow or line on injection pump flange between third and fourth marks (lines) on timing gear mounting plate.



Models 3011 and 3012



Models 3015 and 4020

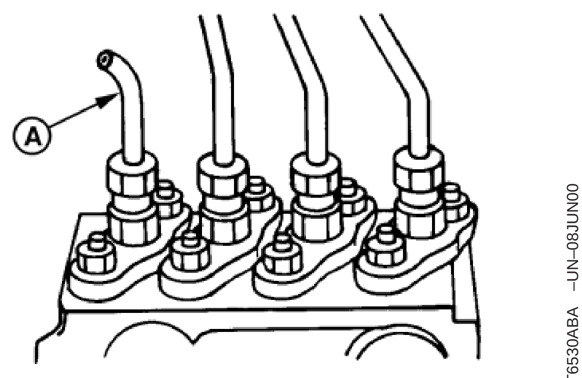
RG,RG34710,8389 –19–15APR97–1/4

NOTE: Normal rotation, as viewed from the flywheel end, is counterclockwise. The No. 1 fuel injection line is toward the flywheel.

2. Remove the number one fuel injection line.

3. Cut a spare fuel injection line (A) off at the first bend and install on delivery valve fitting.

A—Cut-Off Injection Line



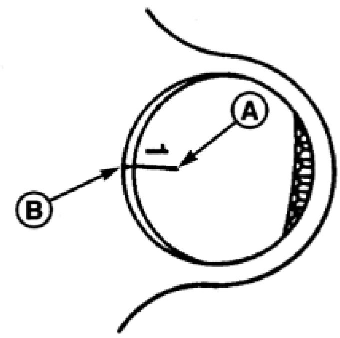
Fuel Injection Pump

Continued on next page RG,RG34710,8389 –19–15APR97–2/4

4. Remove rubber plug from flywheel housing, if equipped.

5. Turn crankshaft pulley in either direction until the No. 1 cylinder top dead center (TDC) mark (A) aligns with the index mark (B) on the flywheel housing/plate.

A—TDC Mark on Flywheel
B—Index Mark on Flywheel Housing/Plate



RG11099A –UN–08JUN00

Flywheel Alignment Marks

Continued on next page

RG,RG34710,8389 –19–15APR97–3/4

6. Prime pump to fill it with fuel. Approximately 1 L (1.06 qt) of fuel is sufficient.

7. Hold throttle lever in run position.

8. Turn flywheel clockwise (as viewed from the flywheel end) until tip of cut-off line has become **MOIST** with solid fuel.

9. Check timing mark on flywheel. The index mark (C) must line up with the injection pump timing mark (D) on flywheel as shown. See specifications.

Specification

Injection Pump—Base/Ind. Engines—3011, 3012, 3015 and 4020—Position	16°±1° BTDC (Before Top Dead Center)
Injection Pump—Gen. Set Engines—3011, 3012, 3015, 4020—Position	10°±1° BTDC

NOTE: 1° of flywheel rotation is equal to a distance of 2.62 mm (0.100 in.) on the outer surface of the flywheel.

10. If timing is not according to specifications, loosen pump mounting bolts and turn pump towards engine block to retard timing or away from block to advance timing. Recheck timing.

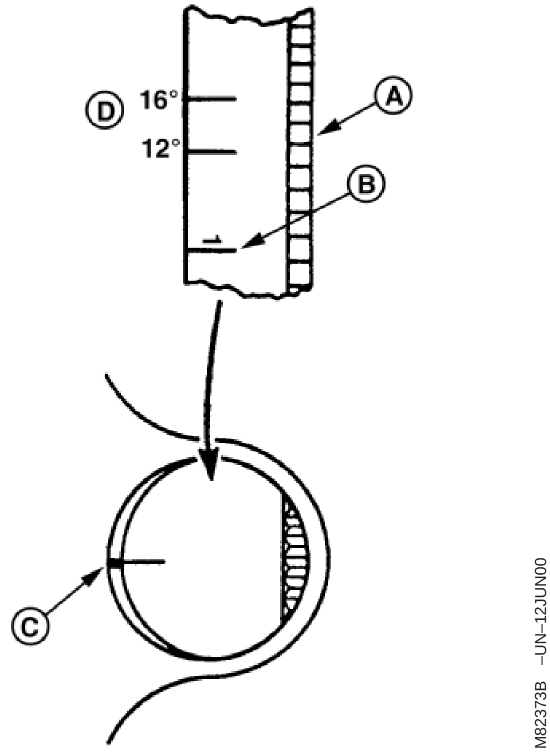
11. If timing did not change, remove pump and have tested by a diesel injection service shop.

12. If timing is OK:

    a. Install rubber plug in flywheel housing, if equipped.

    b. Remove timing tool.

    c. Install No. 1 injection line.



Timing Marks 3011, 3012, 3015 and 4020

A—Flywheel
B—TDC Mark on Flywheel
C—Index Mark on Flywheel Housing/Plate
D—Injection Pump Timing Marks on Flywheel

RG,RG34710,8389 –19–15APR97–4/4

Remove Fuel Injection Pump—3013 and 3016

IMPORTANT: Never steam clean or pour cold water on an injection pump while pump is running, or while it is still warm. To do so may cause seizure of pump parts.

1. Clean injection lines and area around the injection pump with cleaning solvent or a steam cleaner.

2. Drain engine coolant to level below injection pump.

3. Remove intake manifold. (See REMOVE AND INSTALL INTAKE MANIFOLD in Group 080.)

Continued on next page OUO1017,0000B20 –19–06APR04–1/4

4. Disconnect fuel inlet line (A) and fuel return line (B), and injector return line (C).

5. Disconnect coolant lines (D and E).

6. Disconnect fuel shutoff solenoid wire connector (F).

7. Remove foam spacer (G).

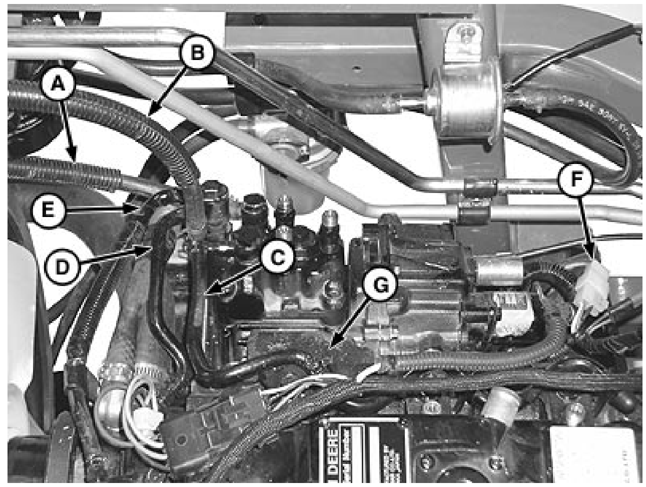
8. Remove cap screws (H) and remove injection pump gear access cover.

NOTE: For all the timing marks to become aligned, engine may need to be rotated up to fifty-two times.

Alignment marks (I) and (J) are both identified with a stamped letter "B".

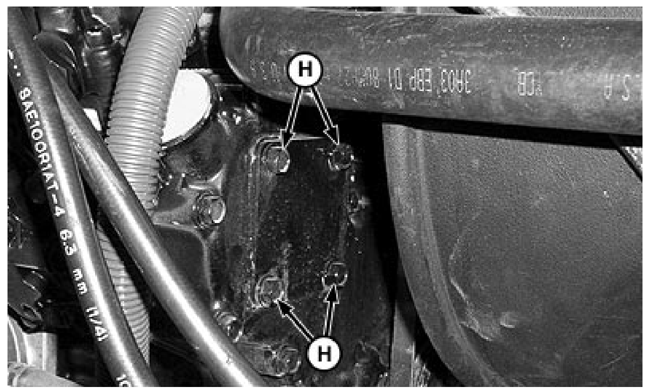
9. Rotate engine in the direction of rotation until mark (I) on pump gear aligns with mark on idler gear (J) (both identified by a stamped letter B). Use chalk or paint to mark injection pump gear to idler gear.

A—Fuel Inlet Line
B—Fuel Return Line
C—Injector Return Line
D—Coolant Line
E—Coolant Line
F—Fuel Shutoff Solenoid Wire Connector
G—Foam Spacer
H—Cap Screw (4 used)
I—Pump Gear Timing Mark
J—Idler Gear Timing Mark



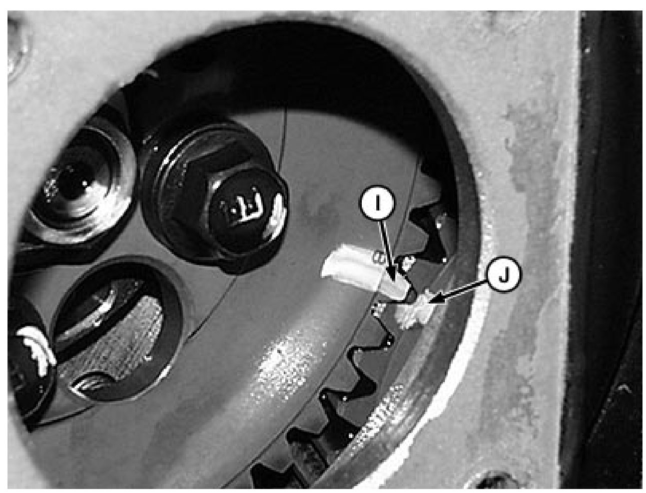
RG13396A –UN–13APR04

Remove Fuel Lines And Coolant Lines.



RG13397A –UN–13APR04

Injection Pump Gear Cover



RG13398A –UN–13APR04

Injection Pump Gear Timing Marks

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10. Remove gear retaining nut and washer (A).

IMPORTANT: Do not loosen or disturb cap screws (B) securing gear to the hub unless injection pump is to be replaced with a new or recalibrated unit. Gear to hub adjustment is pre-set to comply with strict EPA emissions requirements and is not adjustable. This procedure is done at the pump manufacturer and cannot be duplicated in the field.

11. Install puller (E) into threaded holes (C) on gear using cap screws (D)

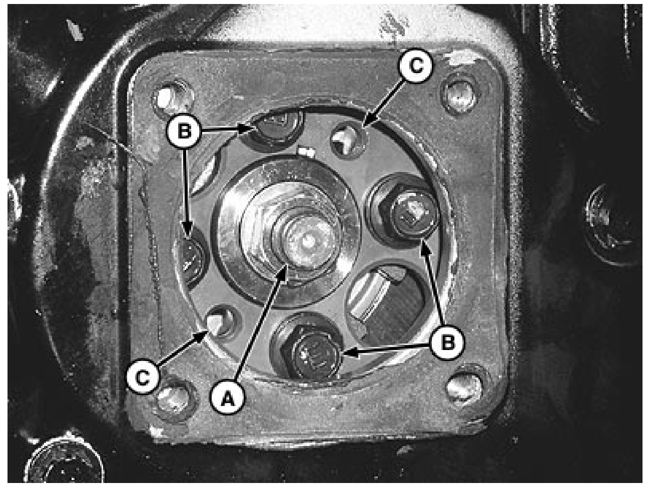
IMPORTANT: Engine must not be rotated when timing gear is removed from injection pump shaft. Engine can only be rotated when timing gear is securely fastened to pump or engine damage could result.

12. Remove gear and hub assembly from injection pump shaft. Gear will stay inside timing cover.

IMPORTANT: Marks must be made on the injection pump and the gear cover mounting plate to correctly install the pump. If marks are not made there will be no way to properly time the injection pump.

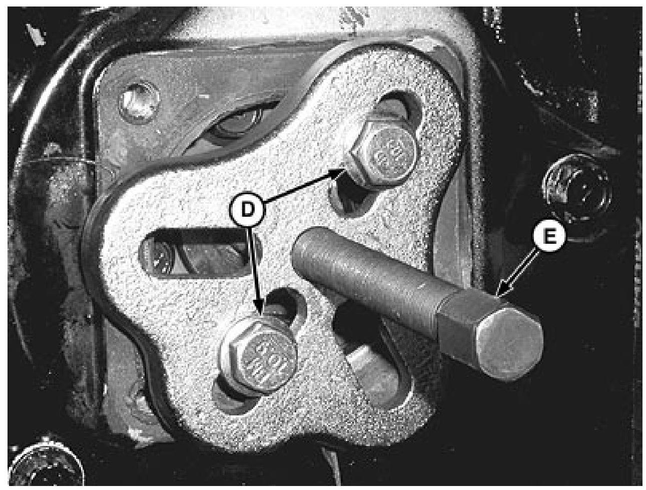
13. Note position of timing marks on gear cover mounting plate (G) and injection pump (F). Pump must be installed at the exact same timing mark as when removed. Scribe a line as accurately and straight as possible at the pump flange mark (F) onto the gear cover mounting plate.

A—Timing Gear Nut and Washer
B—Cap Screw (4 used)
C—Threaded Puller Holes
D—Puller Cap Screws
E—Gear puller
F—Injection Pump Timing Mark
G—Gear Cover Mounting Plate Timing Mark



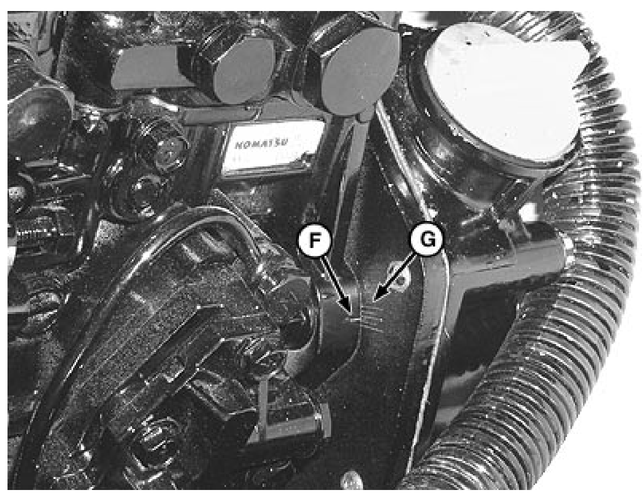
RG13399A –UN–13APR04

Injection Pump Timing Gear



RG13400A –UN–13APR04

Injection Pump Timing Gear Puller



RG13401A –UN–13APR04

Injection Pump Timing Marks

Continued on next page

OUO1017,0000B20 –19–06APR04–3/4

14. Remove external lube line (A) from pump.

15. Remove cap screw (B).

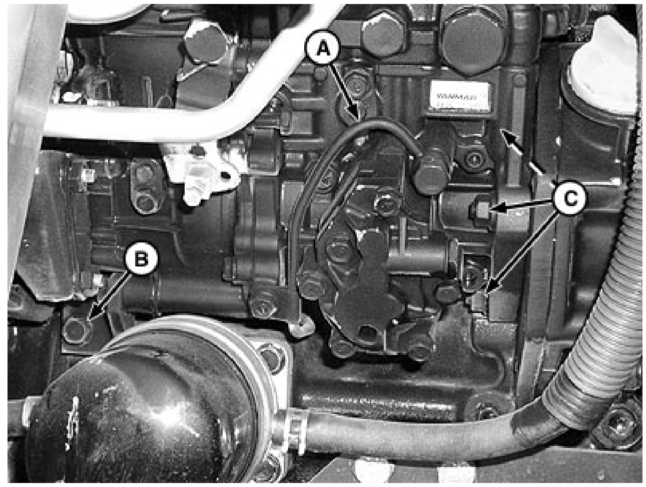
IMPORTANT: Marks must be made on the injection pump and the gear cover mounting plate to properly install pump. You must also record the injection pump timing number marked on the pump to correctly install the pump. If marks are not made and the timing number not recorded, there will be no way to properly time the injection pump.

16. Remove pump flange mounting nuts (C) and remove pump.

NOTE: The injection pump timing number is stamped into the top head assembly of the injection pump.

17. Find and record pump timing number stamped on pump. This number will be needed if pump is being replaced or recalibrated.

IMPORTANT: DO NOT attempt to service the injection pump or governor. If unit is in need of repair, it must be serviced by a qualified EPA/CARB certified fuel injection repair shop. If replacement is necessary, replace entire unit. Do not rotate engine while injection pump is removed. If engine is rotated the timing gear cover must be removed to ensure correct timing.



RG13402A –UN–13APR04

Injection Pump Mounting Points

A—External Lube Line
B—Cap Screw
C—Nut (3 used)

OUO1017,0000B20 –19–06APR04–4/4

Install Fuel Injection Pump—3013 and 3016

Installing Original Pump—3013 and 3016

NOTE: These instructions are for installing the same pump that was removed, and was NOT rebuilt or recalibrated. If you are installing a new, rebuilt, or recalibrated pump you must follow the instructions for Installing a New, Rebuilt or Recalibrated Pump later in this procedure.

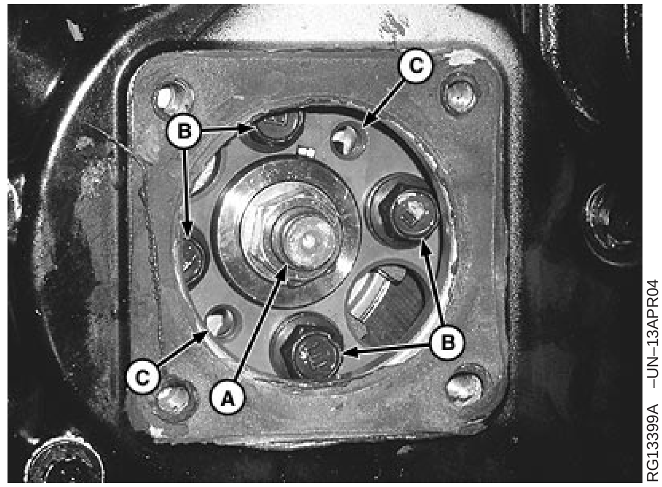
1. Install new O-ring on injection pump.

2. Put injection pump onto back of gear cover mounting plate. Install three mounting nuts. Do not tighten. Align key on shaft with keyway in gear hub. Ensure gear is still aligned to idler gear.

3. Install nut and washer on pump shaft. Tighten nut to specification.

Specification

Fuel Injection Pump Drive Gear
Hub-to-Shaft Retaining Nut—
3013 and 3016—Torque .... 78—88 N•m (58—65 lb-ft)



Injection Pump Timing Gear

A—Timing Gear Nut and Washer
B—Cap Screw (4 used)
C—Threaded Puller Holes

Continued on next page OUO1017,0000B21 –19–12APR04–1/7

4. Align timing mark on injection pump (A) with correct mark on gear cover mounting plate (B).

5. Tighten three pump mounting nuts (C) to specification.

Specification
Injection Pump Mounting Nuts—
3013 and 3016—Torque .... 26 N•m (228 lb-in.)

6. Install cap screw (D). Tighten to specification.

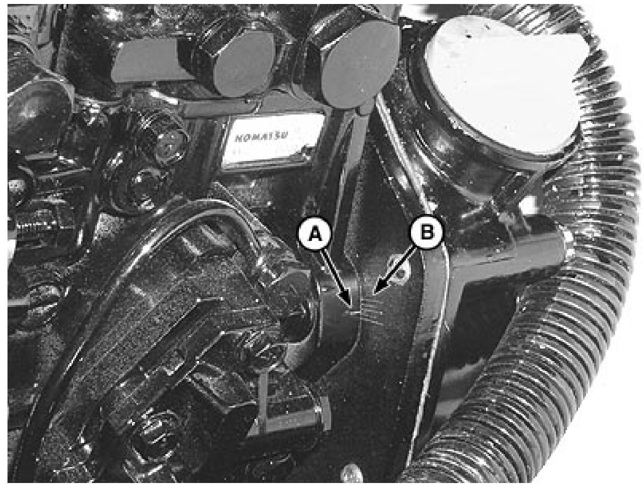
Specification
Injection Pump Mounting Cap
Screw—3013 and 3016—Torque................................. 26 N•m (228 lb-in.)

7. Fill pump with engine oil through external lube line port until oil runs out. Install external lube line. Tighten lube line fitting (E) to specification.

Specification
Injection Pump External Lube
Line Fitting—3013 and 3016—
Torque .... 15 N•m (133 lb-in.)

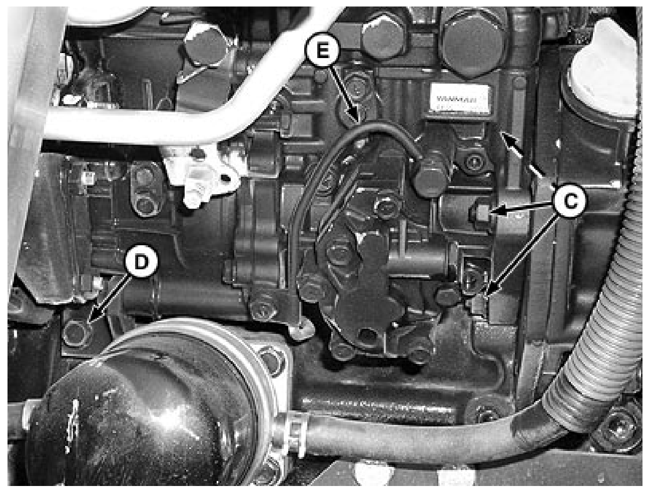
8. Install cover for injection pump timing gear.

A—Injection Pump Timing Mark
B—Gear Cover Mounting Plate Timing Mark
C—Pump Mounting Nut (3 used)
D—Cap Screw
E—External Lube Line



RG13403A –UN–13APR04

Injection Pump Timing Marks



RG13415A –UN–13APR04

Injection Pump Mounting

Continued on next page OUO1017,0000B21 –19–12APR04–2/7

9. Install foam spacer (G) between pump and engine block.

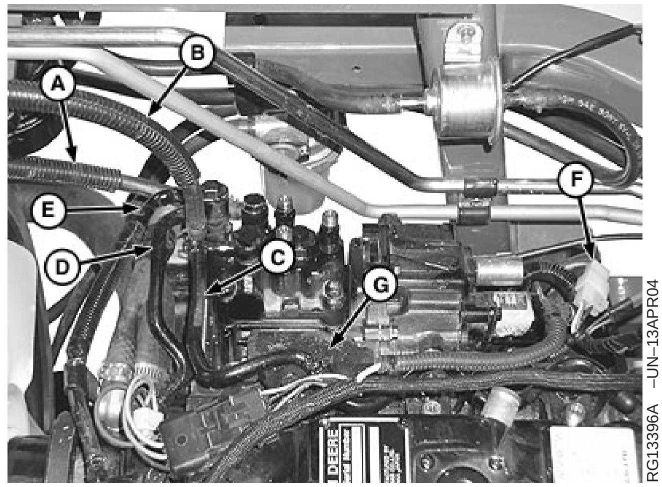
10. Connect fuel shutoff solenoid wire connector (F).

11. Connect fuel lines (A, B, and C).

12. Connect coolant lines (D and E).

13. Install intake manifold. (See REMOVE AND INSTALL INTAKE MANIFOLD in Group 080.)

14. Add coolant to engine.



Install Fuel and Coolant Lines

A—Fuel Inlet Line
B—Fuel Return Line
C—Injectors Return Line
D—Coolant Line
E—Coolant Line
F—Fuel Shutoff Solenoid Wire Connector
G—Foam Spacer

Continued on next page OUO1017,0000B21 –19–12APR04–3/7

Installing a New, Rebuilt, or Recalibrated Pump—3013 and 3016

NOTE: These instructions are for installing a NEW, REBUILT, OR RECALIBRATED pump. If you are installing the same pump that was removed and it was not rebuilt or recalibrated, you must follow the instructions for Installing Original Pump earlier in this procedure.

IMPORTANT: A new hub will be included with a replacement pump and must be used. The hub will be lock pin timed to the hub. Do not remove pin that locks hub to pump housing.

NOTE: The injection pump timing number is stamped into the top head assembly of the injection pump.

1. Find and record injection pump timing number that is marked on pump. Put this number with the timing number that was recorded at step 17 of REMOVE FUEL INJECTION PUMP—3013 AND 3016 instructions.

IMPORTANT: Be careful not to drop cap screws or the hub while removing the injection pump hub. Doing so will require the removal of the timing gear cover.

2. Remove the original hub from the pump drive gear.

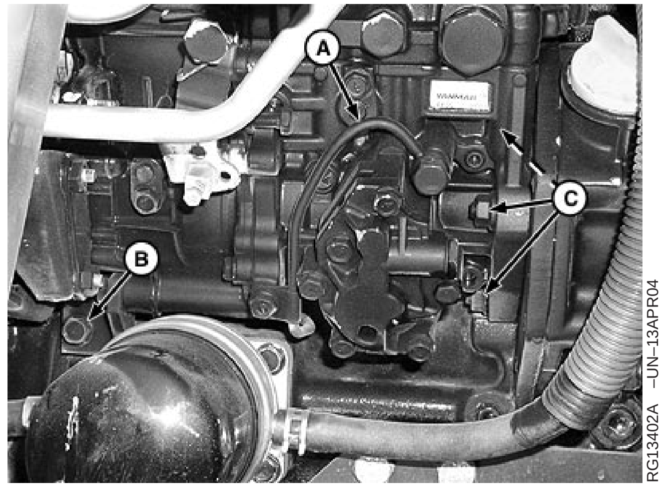
3. Install a new O-ring on injection pump.

4. Put injection pump onto back of gear cover mounting plate. Install three mounting nuts (C) and cap screw (B). Do not tighten.

5. Fill pump with oil through lube line port until oil runs out. Install external lube line (A). Tighten fitting to specification.

Specification

Injection Pump External Lube
Line Fitting—3013 and 3016—
Torque .... 15 N•m (133 lb-in.)



Install Injection Pump—3013 and 3016

A—External Lube Line
B—Cap Screw
C—Mounting Nuts

Continued on next page

6. Ensure that the timing mark (I) stamped B on the injection pump gear is aligned with a stamped B on the idler gear (J). If they are no longer aligned, or the injection pump was removed without first aligning the marks, the timing gear cover must be removed and gears aligned as follows:

   a. Remove timing cover (See REMOVE AND INSTALL TIMING GEAR COVER in Group 050).

NOTE: For all the timing marks to become aligned, engine may need to be rotated up to fifty-two times.

   b. Turn the engine in the direction of rotation and align timing marks (A and C). The idler gear will have an A, B and C stamped into it. Line up the A on idler gear with the A on the crankshaft gear and line up the C on idler gear with the C on the camshaft gear.

IMPORTANT: The new or recalibrated pump will come with a new hub installed. The hub is fixed in position by a removable alignment pin. The alignment pin must NOT be removed until the injection pump timing gear is fastened to the hub with the four cap screws (D).

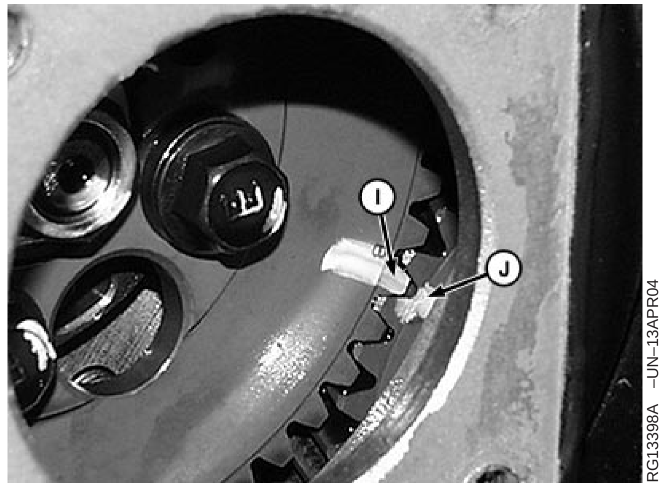
7. Install gear on hub of pump making sure the alignment pin in the hub aligns with the hole in the gear, and the timing marks (B) on gears are aligned. Install four cap screws (D) and tighten to specification.

Specification

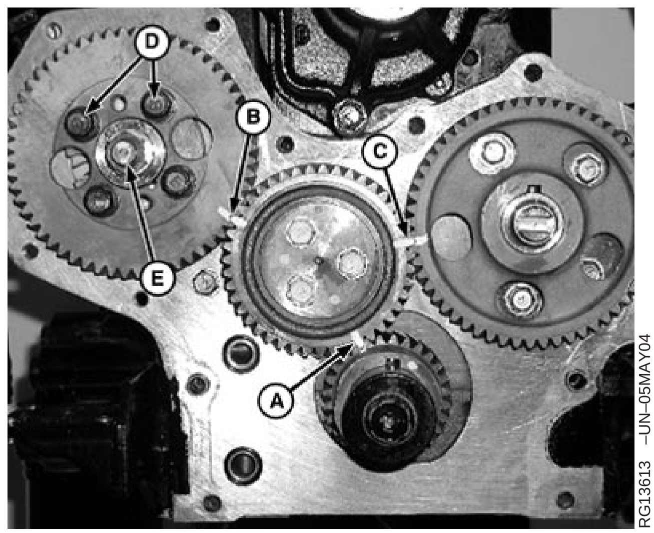
Injection Pump Timing Gear to Hub Cap Screws—3013 and 3016—Torque .... 34.3 N•m (25 lb-ft)

IMPORTANT: Alignment pin must be removed. Failure to do so will result in serious engine damage

8. Remove alignment pin from pump gear and hub.



Injection pump gear timing marks.



Timing Gear Alignment

A—Timing Marks – A
B—Timing Marks – B
C—Timing Marks – C
D—Cap Screw (4 used)
E—Nut and Washer

Continued on next page

9. Install timing mark sticker supplied with pump so that the (A) line is exactly in-line with the mark that was made on the gear cover mounting plate when the pump was removed.

IMPORTANT: You must have the injection pump timing numbers from the original and the replacement/recalibrated pumps. There is no way to properly install the injection pump without these numbers.

10. Calculate the difference between the timing numbers, recorded earlier, from the original and replacement/recalibrated pumps. This calculated number will be needed to correctly time the pump.

NOTE: Rotating the injection pump away from the cylinder block will retard the timing and rotating the injection pump towards the cylinder block will advance the timing.

11. Set the pump to the correct timing mark using the calculated number difference between the original and replacement pumps. Adjust timing accordingly using the new timing mark sticker.

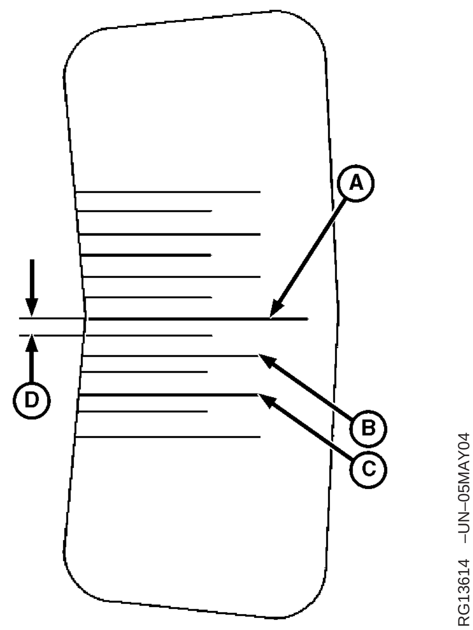
    Example: If the timing number on the original pump was -3, and the timing number on the replacement/recalibrated pump is -5, the replacement pump should be timed at the -2° (retarded) mark (C) on the new timing mark sticker.

12. Hold the pump at the correct timing mark and tighten three pump mounting nuts and cap screw to specification.

Specification

Injection Pump Mounting Nuts—3013 and 3016—Torque	26 N•m (228 lb-in.)
Injection Pump Mounting Cap Screw—3013 and 3016—Torque	26 N•m (228 lb-in.)

13. If removed, install timing cover. (See REMOVE AND INSTALL TIMING GEAR COVER in Group 050.)



Injection Pump Sticker

A—Middle 0° Line
B—1° Line
C—2° Line
D—0.5° Line

Continued on next page

14. Install foam spacer (G) between pump and engine block.

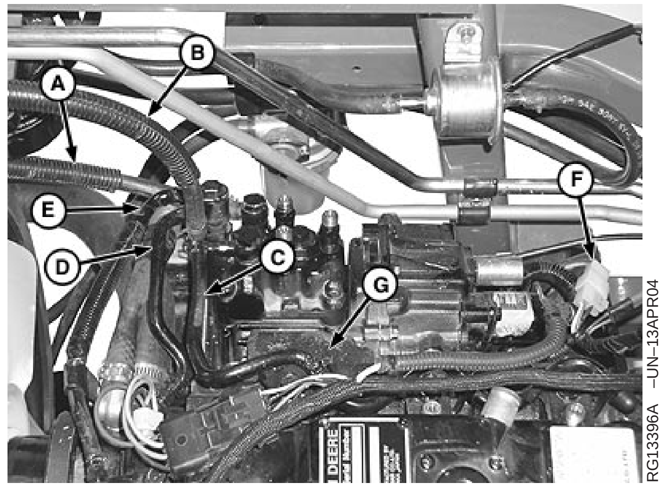
15. Connect fuel shutoff solenoid wire connector (F)

16. Connect fuel lines (A, B, and C).

17. Connect coolant lines (D and E).

18. Install intake manifold. (See REMOVE AND INSTALL INTAKE MANIFOLD in Group 080.)

19. Add coolant to engine.



Install Fuel And Coolant Lines

A—Fuel Inlet Line
B—Fuel Return Line
C—Injectors Return Line
D—Coolant Line
E—Coolant Line
F—Fuel Shutoff Solenoid Wire Connector
G—Foam Spacer

OUO1017,0000B21 –19–12APR04–7/7

Fuel Injection Pump Static Timing Adjustment—3013 and 3016

IMPORTANT: DO NOT attempt to adjust the fuel injection pump timing. For most engine problems, the fuel injection pump timing will not have to be adjusted. If the engine performed well at one time, then the performance dropped, the fuel injection timing is NOT the problem. Fuel injection timing, once set by the engine manufacturer, must NOT change during the life of the engine.

Fuel injection pump timing should not change during the life of the engine unless the pump has been altered illegally, or there is excessive wear to the camshaft injection pump cam lobes and lifters.

First check the fuel quality, fuel supply, fuel injection nozzles, air intake system and engine compression in all cylinders before considering fuel injection timing problems.

If all other possibilities have been ruled out and it is determined that the fuel injection pump and governor assembly are in need of repair, they must be repaired only by a EPA/CARB authorized diesel service facility. For removal or installation of injection pump, see REMOVE FUEL INJECTION PUMP—3013 AND 3016 or INSTALL FUEL INJECTION PUMP—3013 AND 3016 in this group.

OUO1017,0000B31 –19–06MAY04–1/1

Remove Fuel Injection Pump—4TNE98

IMPORTANT: Never steam clean or pour cold water on injection pump while the pump is running or warm. Doing so can damage the pump.

1. Clean the injection pump lines and area around the pump using a cleaning solvent or steam cleaner.

Continued on next page

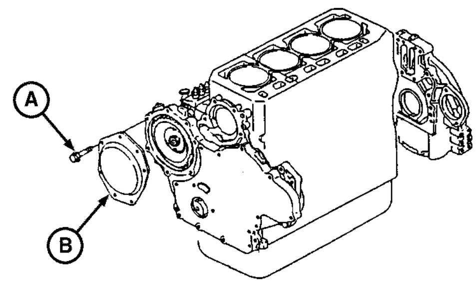
RG,RG34710,8277 –19–15APR97–1/4

2. Remove cap screws (A) and cover (B).

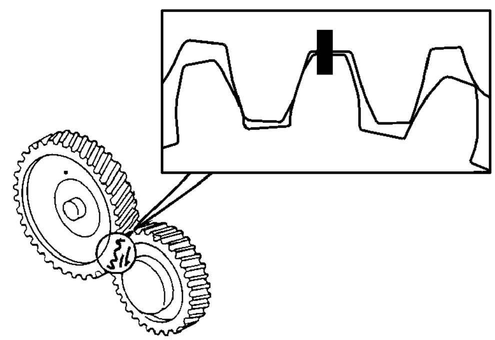
NOTE: Engine may have to be rotated up to fifty-two times to align injection pump gear and idler gear.

3. Turn engine in the direction of rotation and align timing marks on injection pump timing gear and idler gear. Mark gears using paint or chalk.

A—Cap Screw
B—Cover



Injection Pump Timing Gear Cover



Injection Pump Timing Gear and Idler Gear

RG,RG34710,8277 –19–15APR97–2/4

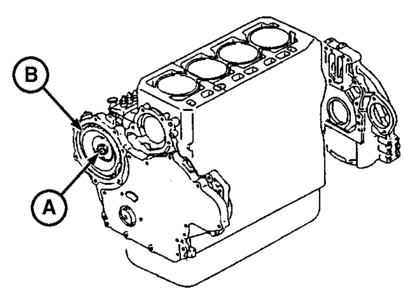
IMPORTANT: Do not rotate engine once injection pump timing gear is removed. Installation of pump will be much more difficult and internal engine damage could result.

4. Remove nut (A).

5. Use a puller to remove fuel injection pump gear (B).

6. Remove woodruff key.

A—Injection Pump Gear Retaining Nut
B—Injection Pump Timing Gear



Remove Injection Pump Timing Gear

Continued on next page

RG,RG34710,8277 –19–15APR97–3/4

7. Loosen fuel injection line connectors (B) slightly to release pressure in the fuel system. When loosening connectors, use another wrench to keep delivery valves from loosening.

8. Loosen line clamp (C) and remove fuel injection lines (D).

9. Disconnect hoses (E, F, and G) to/from fuel filter.

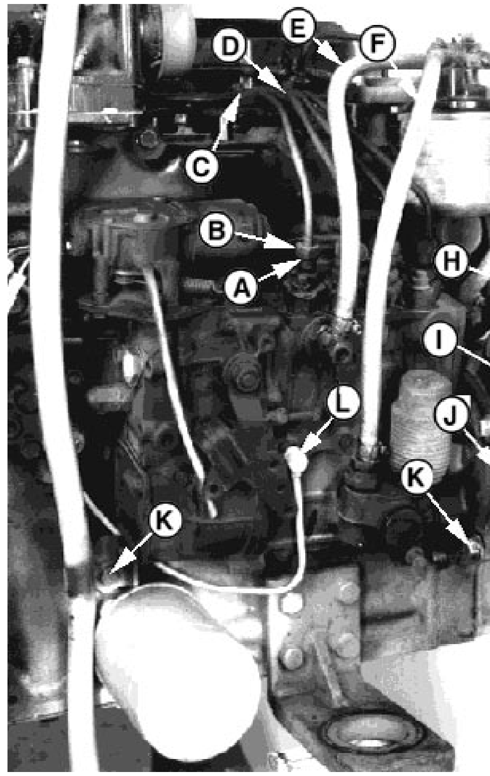
10. Remove external lube line (L).

11. Scribe an alignment mark (J) across injection pump and gear case housing.

12. Remove two cap screws (I), oil filler neck assembly (H), and gasket.

IMPORTANT: DO NOT attempt to service the injection pump or governor. If unit is in need of repair, it must be serviced by a qualified fuel injection repair shop. If replacement is necessary, replace entire unit.

13. Remove four mounting cap screws (K) (two screws not shown at front of injection pump). Remove injection pump and O-ring.



Injection Pump or Governor

A—Delivery Valves
B—Fuel Injection Line Connectors
C—Line Clamp
D—Fuel Injection Lines
E—Hose, Injection Pump Bleed-Off-to-Filter
F—Hose, Fuel Supply Pump-to-Filter
G—Hose, Fuel Filter-to-Injection Pump
H—Filler Neck
I—Filler Neck-to-Gear Case Cap Screws
J—Alignment Mark
K—Mounting Cap Screws
L—External Lube Line

RG,RG34710,8277 –19–15APR97–4/4

Install Fuel Injection Pump—4TNE98

1. Install new O-ring on injection pump.

2. Put injection pump onto gear case housing.

3. Install four mounting cap screws (K) (two cap screws not shown at front of injection pump). Do not tighten.

4. Align mark (J) on injection pump and gear case housing that was made during removal. Tighten mounting cap screws to specification.

Specification

Fuel Injection Pump Mounting
Cap Screws—4TNE98—Torque .... 27 N•m (20 lb-ft)

5. Install oil filler neck assembly (H) with new gasket and install two cap screws (I).

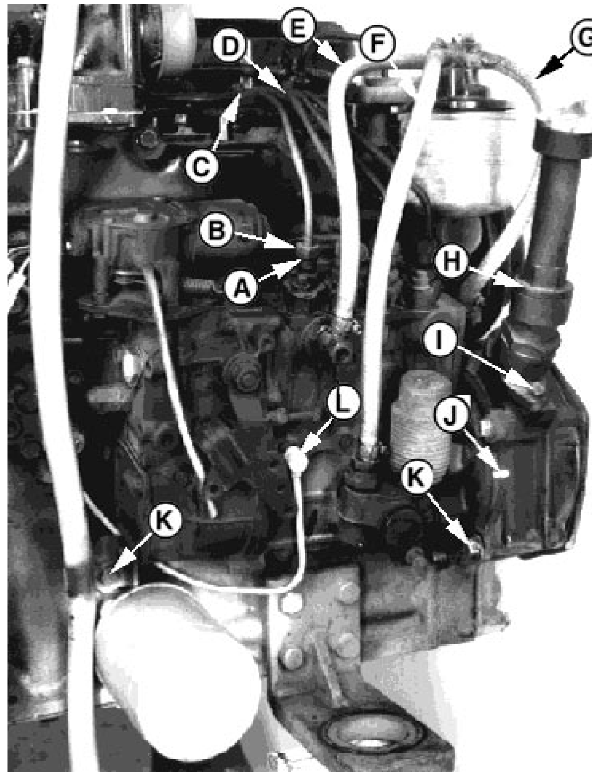
6. Connect hoses (E, F, and G) to/from fuel filter.

7. Install fuel injection lines (D) and tighten line clamp (C) cap screws.

IMPORTANT: If oil has been drained out of fuel injection pump housing, add oil as necessary. Fuel injection pump can become damaged if operated dry or without proper amount of oil.

8. Remove fill plug located at upper rear of injection pump, and add clean engine oil to housing. Add until oil begins to drip out of external lube line inlet.

9. Install external lube line (L). When installing line, put one copper washer between mounting bolt head and lube line and the other between lube line and housing.



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Install Fuel Injection Pump

A—Delivery Valves
B—Fuel Injection Line Connectors
C—Line Clamp
D—Fuel Injection Lines
E—Hose, Injection Pump Bleed-Off-to-Filter
F—Hose, Fuel Supply Pump-to-Filter
G—Hose, Fuel Filter-to-Injection Pump
H—Filler Neck
I—Filler Neck-to-Gear Case Cap Screws
J—Alignment Mark
K—Mounting Cap Screws
L—External Lube Line

Continued on next page RG,RG34710,8279 –19–15APR97–1/3

10. Install woodruff key on injection pump shaft.

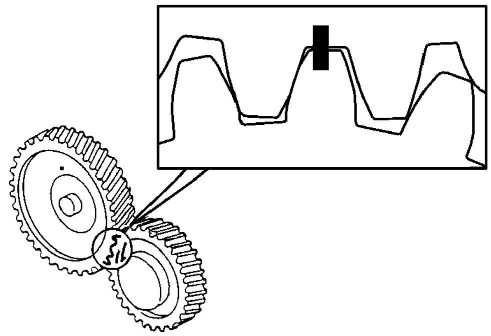
11. Install gear (B) on shaft and align marks on injection pump timing gear and idler gear.

12. Install injection pump timing gear nut (A) and tighten to specification.

Specification

Injection Pump Timing Gear Nut—4TNE98—Torque .... 85 N•m (63 lb-ft)

A—Nut
B—Injection Pump Timing Gear



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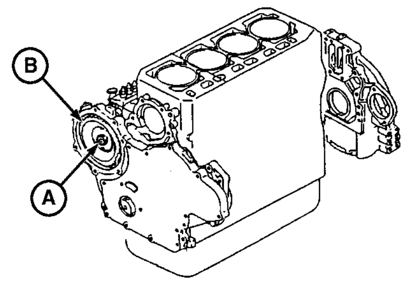
Align Injection Pump Gear and Idler Gear



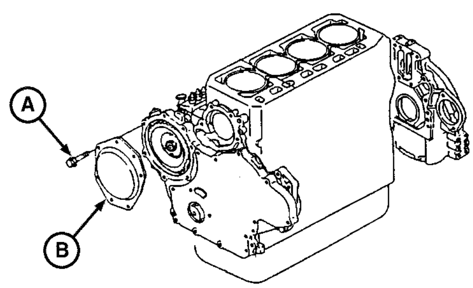
T107448 –UN–17FEB97

Install Injection Pump Timing Gear Nut

RG,RG34710,8279 –19–15APR97–2/3

13. Install cover (B) and cap screws (A).

A—Cap Screw
B—Cover



T107446 –UN–17FEB97

Install Gear Cover

RG,RG34710,8279 –19–15APR97–3/3

Injection Pump Static Timing Adjustment—4TNE98

NOTE: The flywheel turns counterclockwise (as viewed from the flywheel end). The number one fuel injection line is toward the flywheel.

1. Remove the number one fuel injection line and delivery valve fitting (A).

2. Remove spring (B) and delivery valve (C). Do not remove delivery valve seat.

IMPORTANT: Fingers must be coated with diesel fuel before handing precision injection pump parts.

3. Install delivery valve fitting back onto pump and tighten. Do not get dirt or paint in system.

4. Cut a spare injector line at the first bend (D) and install onto fuel delivery valve fitting.

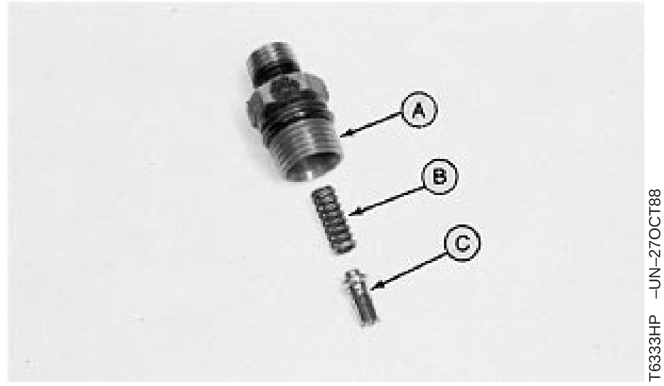
5. Remove timing hole plug from flywheel housing.

6. Turn crankshaft pulley cap screw in either direction until the number one cylinder top dead center mark (E) aligns with the timing mark on the flywheel housing (F).

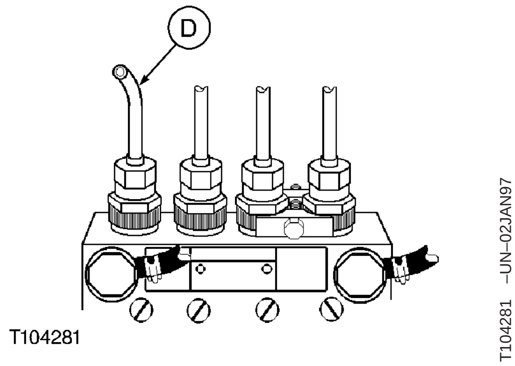
Specification

Injection Pump—4TNE98—Timing	11 ± 1° BTDC (Before top dead center)
Engine Crankshaft—4TNE98—Position	No. 1 Cylinder on TDC Compression Stroke
Outer Surface of Flywheel Per 1° of Rotation—4TNE98—Distance	3.5 mm (0.13 in.)
Lines on Pump Mounting Plate—4TNE98—Timing	2.0° apart

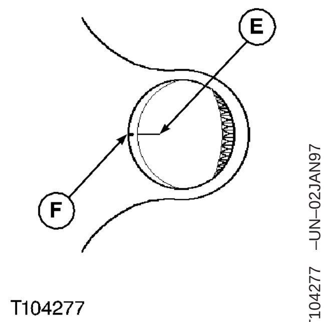
A—Delivery Valve Fitting
B—Spring
C—Delivery Valve
D—Cut-Off Injection Line
E—Crankshaft Timing Mark
F—Flywheel Housing Timing Mark



Injection Pump Parts



Timing Tool



Crankshaft & Flywheel Housing Timing Mark

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7. Put a container under timing tool to collect any fuel.

8. Operate hand operated primer pump and turn flywheel clockwise (as viewed from the flywheel end) until fuel flows in a stream.

9. Slowly turn flywheel counterclockwise until fuel flow changes from a stream to drops and then stops completely. This is the point of injection timing at which the pump is set.

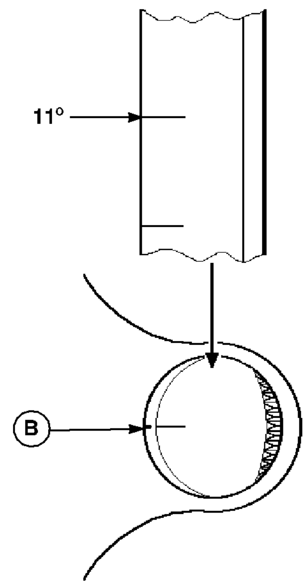
NOTE: If fuel flow does not stop, the number one piston is on the exhaust stroke instead of the compression stroke. Turn flywheel one revolution and repeat steps 6—9.

10. Check timing mark on flywheel.

    The timing mark on flywheel housing (B) must line up with 11° mark on flywheel.

Specification

Injection Pump—4TNE98—
Timing .... 11 ± 1° BTDC (Before top dead center)
Outer Surface of Flywheel Per 1°
of Rotation—4TNE98—Distance .... 3.5 mm (0.13 in.)



T104278

Timing Mark On Flywheel Housing

If timing is not correct, loosen pump mounting screws and rotate pump towards engine block to retard timing or away from block to advance timing.

11. Install flywheel housing plug.

12. Remove cut-off injection line.

13. Remove delivery valve fitting. Apply clean diesel fuel to the delivery valve. Install delivery valve, and spring.

14. Install new O-ring and delivery valve fitting.

15. Install and tighten delivery valve fitting to specification.

Specification

Fuel Injection Delivery Valve
Fitting—4TNE98—Torque .... 42 ± 3 N•m (31 ± 2 lb ft)

Continued on next page

OUO1017,0000B30 –19–04MAY04–2/3

16. Install number one cylinder injection line.

Specification

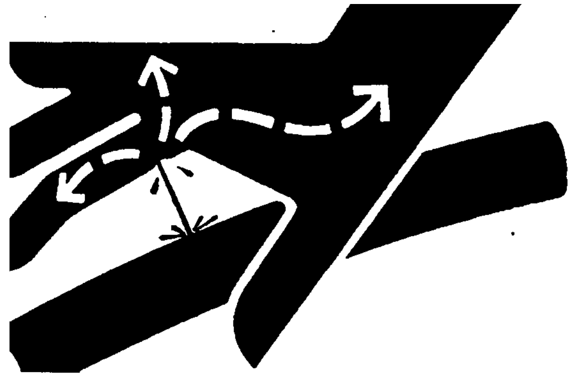
Engine Crankshaft—4TNE98—Position	No. 1 Cylinder on TDC Compression Stroke

17. Bleed fuel injection system if necessary. (See BLEED FUEL SYSTEM—3011, 3012, 3015, 4020 AND 4TNE98 in this group.)

OUO1017,0000B30 –19–04MAY04–3/3

Remove and Install Fuel Injection Nozzles (Pintle Type)—3009

Relieve Fuel System Pressure


X9811 –UN–23AUG88

High-Pressure Fluid

CAUTION: Escaping diesel fuel under pressure can have sufficient force to penetrate the skin, causing serious injury. Before disconnecting lines, be sure to relieve pressure. Before applying pressure to the system, be sure ALL connections are tight and lines, pipes and hoses are not damaged. Keep hands and body away from pinholes and nozzles which eject fluid under pressure. Use a piece of cardboard or wood, rather than hands, to search for suspected leaks.

If ANY fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type injury or gangrene may result. Doctors unfamiliar with this type of injury may call the Deere & Company Medical Department in Moline, Illinois, or other knowledgeable medical source.

Any time the fuel system has been opened up for service (lines disconnected or filters removed), it will be necessary to bleed air from the system. (See BLEED FUEL SYSTEM—3009, BLEED FUEL SYSTEM—3011, 3012, 3015, 4020 AND 4TNE98, or BLEED FUEL SYSTEM—3013 AND 3016 in this group.)

IMPORTANT: Never steam clean or pour cold water on injection pump while the pump is running or warm. Doing so can damage the pump.

1. Clean the injection pump lines and area around the pump using a parts cleaning solvent or steam cleaner.

Continued on next page

RG,RG34710,8280 –19–15APR97–1/2

IMPORTANT: When removing injection lines, DO NOT turn pump delivery valve fittings. Turning fittings may damage pump internally.

NOTE: Nozzles are matched to the cylinders. If removing more than one nozzle, tag nozzles, according to the cylinder from which it was removed.

2. Loosen fuel injection line connectors slightly to release pressure in the fuel system. When loosening connectors, use another wrench (as shown) to keep delivery valves from loosening.
3. Loosen line clamp and remove fuel injection lines.
4. Disconnect long leak-off hose (C).
5. Remove nuts (A) and leak-off hose assembly (B).
6. Remove bronze washers (E and I) and O-rings (H).
7. Remove injection nozzle (G). Remove and discard washers (E), and heat protector (F).
8. Test injection nozzles. (See TEST FUEL INJECTION NOZZLE in Group 150.)

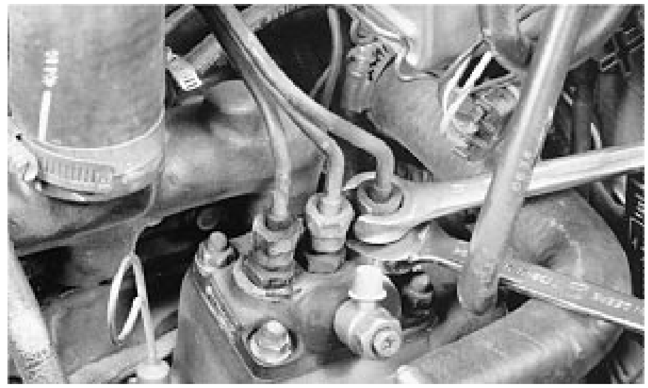
Installation is done in reverse order of removal.

Replace bronze washers (E and I), O-rings (H), and heat protector (F).

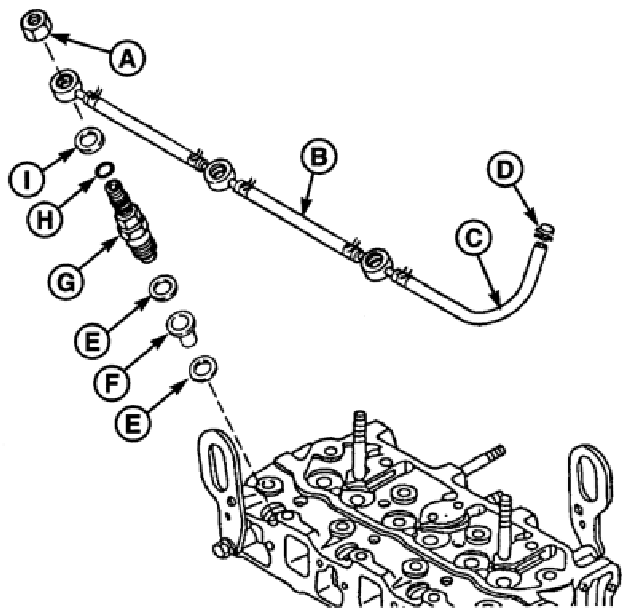
Tighten fuel injection nozzles to specification.

Tighten nuts (A) to specification.

Specification	
Fuel Injection Nozzle—3009—Torque	50 N•m (37 lb-ft)
Fuel Injection Nozzle Leak-Off Line Nuts—3009—Torque	40 N•m (30 lb-ft)



Fuel System



A—Nut
B—Leak-Off Hose Assembly
C—Leak-Off Hose (Long)
D—Hose Clamp
E—Bronze Washer
F—Heat Protector
G—Injection Nozzle
H—O-Ring
‘I—Bronze Washer

RG,RG34710,8280 –19–15APR97–2/2

Disassemble and Assemble Fuel Injection Nozzles (Pintle Type)—3009

NOTE: If servicing more than one nozzle, keep parts for each nozzle separate from one another.

1. Disassemble fuel injection nozzles.

IMPORTANT: If injection nozzles are disassembled to be cleaned, the same number and thickness of shims must be installed.

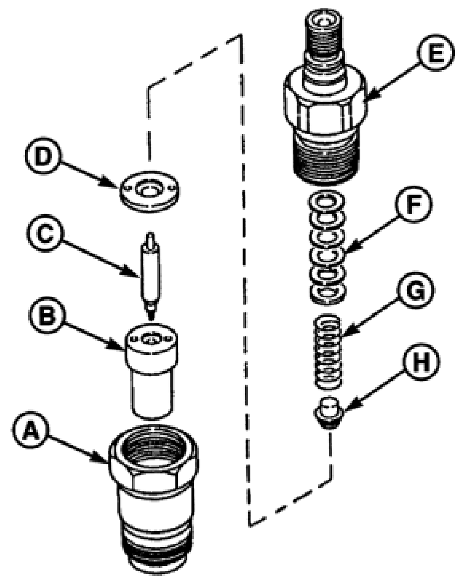
2. Clean and inspect nozzle components. (See CLEAN AND INSPECT FUEL INJECTION NOZZLES (PINTLE TYPE)—3009 in this group.)

3. Assembly is done in reverse order of disassembly.

   a. Tighten nozzle fitting (A) to specification.

Specification	
Fuel Injection Nozzle Fitting—3009—Torque	40 N•m (30 lb-ft)

   b. After assembly is complete, test injection nozzle. (See TEST FUEL INJECTION NOZZLE in Group 150.)



RG11095A —UN—08JUN00

Pintle-Type Nozzle—3009

A—Nozzle Fitting
B—Nozzle Body
C—Nozzle Valve
D—Separator Plate
E—Injector Body
F—Shims
G—Spring
H—Spring Seat

DPSG,OUOE003,210 –19–01JUL99–1/1

02
090
65

Clean and Inspect Fuel Injection Nozzles (Pintle Type)—3009

NOTE: To clean nozzles properly, JDF13B Nozzle Cleaning Kit is recommended. The cleaning kit is available through the John Deere SERVICEGARD™ Catalog.

1. Remove anti-corrosive grease from new or reconditioned nozzles by washing them thoroughly in diesel fuel.

IMPORTANT: Never use a steel brush to clean nozzles as this will distort the spray hole.

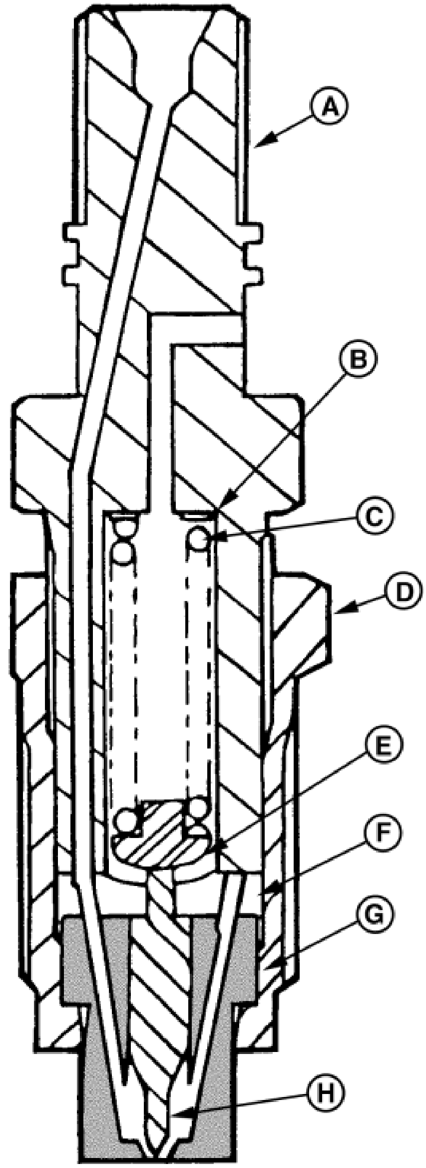
2. Remove carbon from used nozzles, and clean by washing in diesel fuel. If parts are coated with hardened carbon or lacquer, it may be necessary to use a brass wire brush (supplied in nozzle cleaning kit).

3. After removing carbon or lacquer from the exterior of nozzle, inspect sealing surfaces between separator plate and nozzle body for nicks or scratches.

4. Inspect condition of separator plate and nozzle body. Contact area of separator plate (both parts) must not be scored or pitted. Use an Inspection Magnifier (No. 16487 or equivalent) to aid in making the inspection.

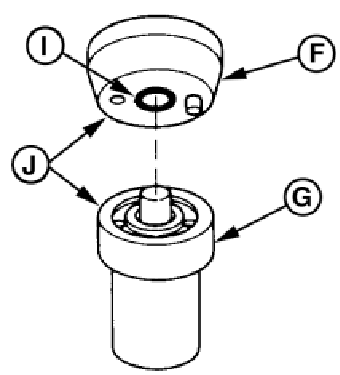
5. Check nozzle contact surface on separator plate for wear. If contact surface is more than specification, replace nozzle assembly.

A—Injector Body
B—Shims
C—Spring
D—Nozzle Fitting
E—Spring Seat
F—Separator Plate
G—Nozzle Body
H—Nozzle Valve
I—Nozzle Contact Surfaces
J—Sealing Surfaces



Fuel Injector Body—Cutaway

M82325A –UN–12JUN00



Fuel Injection Nozzles

M82326A –UN–12JUN00

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DPSG,OUOE003,209 –19–01JUL99–1/3

Specification

Fuel Injection Nozzle Contact Surface—3009—Size .... 0.10 mm (0.0039 in.) maximum

6. Inspect the piston (large) part of nozzle valve to see that it is not scratched or scored and that lower (tip) end of valve is not broken. If any of these conditions are present, replace the nozzle assembly.

DPSG,OUOE003,209 –19–01JUL99–2/3

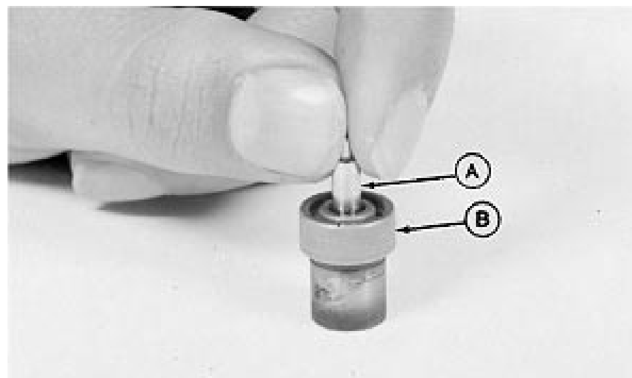
7. Further inspect the nozzle assembly by performing a slide test. Use the following procedure:

   a. Dip the nozzle valve in clean diesel fuel. Insert valve (A) in nozzle body (B).

   b. Hold nozzle vertical, and pull valve out about 1/3 of its engaged length as shown.

   c. Release valve. Valve should slide down to its seat by its own weight.

      Replace nozzle assembly if the valve does not slide freely to its seat.



M35919 –UN–26AUG88

Insert Valve in Nozzle Body

A—Nozzle Valve
B—Nozzle Body

DPSG,OUOE003,209 –19–01JUL99–3/3

Remove and Install Fuel Injection Nozzles (Hole Type)—3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98

General Nozzle Service Precautions

Before removal, thoroughly remove all dirt from the cylinder head around fuel injection nozzles. Clean with compressed air to prevent dirt from entering the cylinders. Plug the bore in the cylinder head after each nozzle has been removed. Cap fuel line openings as soon as they are disconnected.

Immediately fit protective caps over the nozzle tips and the line connections to avoid handling damage and getting debris in fuel system.

Do not bend the fuel delivery lines, as this may affect their durability. When loosening the fuel pressure lines, hold male union of nozzle line stationary with a backup wrench.

IMPORTANT: Never steam clean or pour cold water on injection pump while the pump is running or warm. Doing so can damage the pump.

1. Clean the injection pump lines and area around the nozzles using a parts cleaning solvent or steam cleaner.

NOTE: Nozzles are matched to the cylinders. If removing more than one nozzle, tag nozzles, according to the cylinder from which it was removed.

Continued on next page OUO1017,0000B22 –19–15APR04–1/3

2. Loosen fuel injection line connectors-to-nozzles slightly to release pressure in the fuel system.

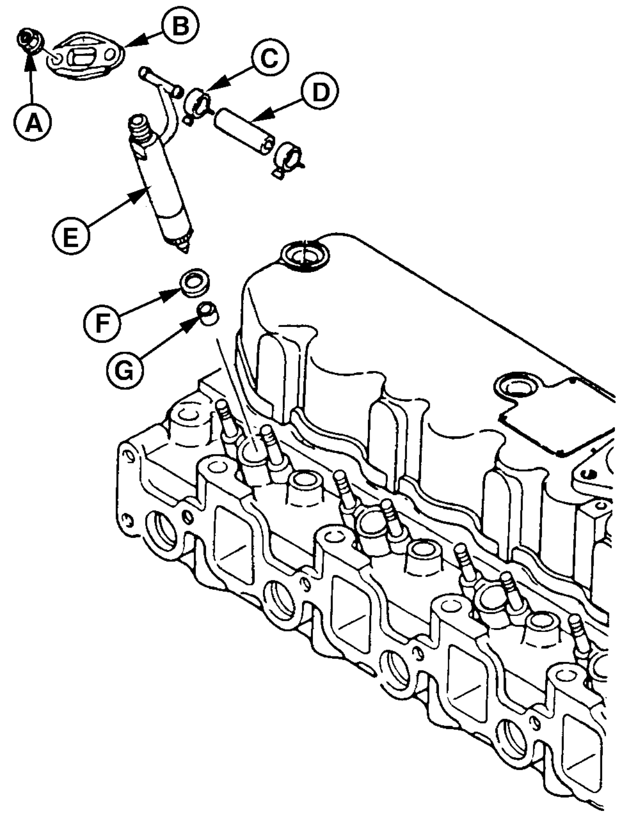
3. Loosen line clamp(s) and remove fuel injection lines.

4. Remove clamps (C) and leak-off hoses (D).

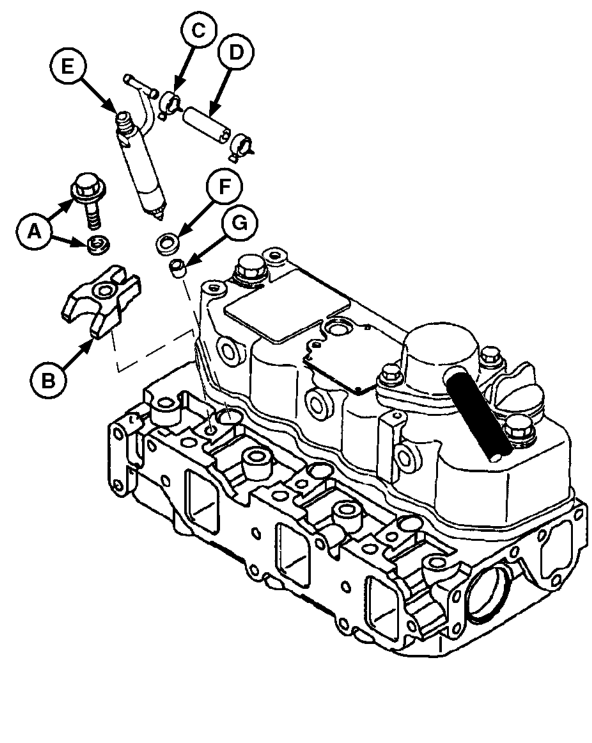
5. For 3011, 3012, 3015, 4020, and 4TNE98 remove nuts (A) and retaining plate (B). For 3013 and 3016 remove capscrew and washer (A) and retaining plate (B).

6. Remove injection nozzle (E), ring (F), and TEFLON® heat protector (G). If ring and protector stay in cylinder head, thread a cap screw into protector and pull from cylinder head.

A—Nut (3011, 3012, 3015, 4020, and 4TNE98)
Cap Screw and Washer (3013 and 3016)
B—Retaining Plate
C—Hose Clamp
D—Leak-Off Hose
E—Injection Nozzle
F—Ring
G—Heat Protector



Fuel Injector Components—3011, 3012, 3015, 4020, and 4TNE98



Fuel Injector Components—3013 and 3016

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OUO1017,0000B22 –19–15APR04–2/3

7. If nozzles are stuck in cylinder head:

   Grind the head of a cap screw (C) so it fits inside a nut from an old injection line (D).

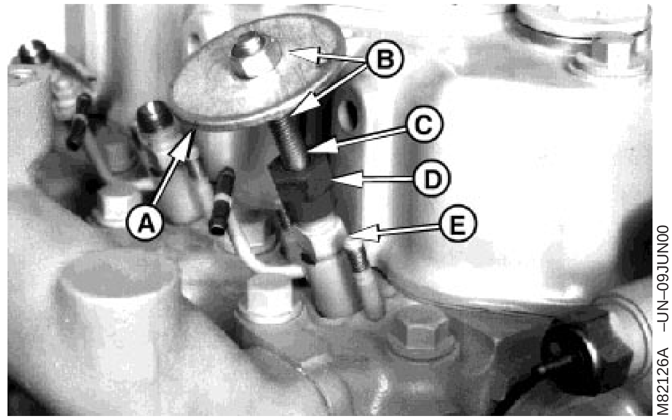
   Use two nuts (B) to attach a large flat washer (A) to the cap screw.

   Install assembly onto nozzle and use a puller and slide hammer to pull nozzle from cylinder head.

8. Test injection nozzles. (See TEST FUEL INJECTION NOZZLE in Group 150.)

9. Installation is done in reverse order of removal. Tighten retaining plate nuts for 3011, 3012, 3015, 4020 and 4TNE98, or cap screw and washer for 3013 and 3016, to specification.

Specification	
Fuel Injection Retaining Plate Nuts—3011, 3012, 3015, 4020, & 4TNE98—Torque	5 N•m (44 lb-in)
Fuel Injection Retaining Plate Cap Screw—3013 and 3016—Torque	24—28 N•m (212—248 lb-in)



If Nozzles Stick in Cylinder Head

A—Large Flat Washer
B—Nut (2 used)
C—Cap Screw
D—Old Injection Line Nut
E—Injection Nozzle

OUO1017,0000B22 –19–15APR04–3/3

Disassemble and Assemble Fuel Injection Nozzles (Hole Type)—3011, 3012, 3013, 3016, 3015, 4020 and 4TNE98

NOTE: If servicing more than one nozzle, keep parts for each nozzle separate from one another.

1. Disassemble fuel injection nozzles.

IMPORTANT: If injection nozzles are disassembled to be cleaned, the same number and thickness of shims must be installed.

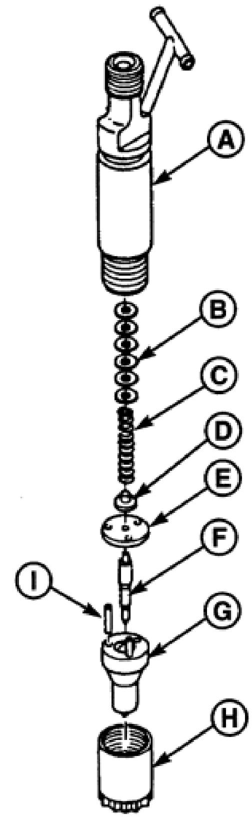
2. Clean and inspect nozzle components. (See CLEAN AND INSPECT FUEL INJECTION NOZZLES (HOLE TYPE)—3011, 3012, 3013, 3015, 3016, 4020, AND 4TNE98 in this group.)

3. Assembly is done in reverse order of disassembly.

   a. Tighten retaining nut (H) to specification.

Specification	
Fuel Injection Nozzle Retaining Nut—3011, 3012, 3013, 3015, 3016, 4020, and 4TNE98—Torque	43 N•m (31 lb-ft)

   b. After assembly is complete, test injection nozzle. (See TEST FUEL INJECTION NOZZLE in Group 150.)



RG11097A –UN–12JUN00

Hole-Type Nozzle—3011, 3012, 3013, 3015, 3016, 4020, and 4TNE98

A—Injector Body
B—Shims
C—Spring
D—Spring Seat
E—Separator Plate
F—Nozzle Valve
G—Nozzle Body
H—Retaining Nut
I—Index Pin (2 used)

OUO1017,0000B23 –19–15APR04–1/1

Clean and Inspect Fuel Injection Nozzles (Hole Type)—3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98

NOTE: To clean nozzles properly, JDF13B Nozzle Cleaning Kit is recommended. The Cleaning Kit is available through the John Deere SERVICEGARD™ Catalog.

1. Remove anti-corrosive grease from new or reconditioned nozzles by washing them thoroughly in diesel fuel.

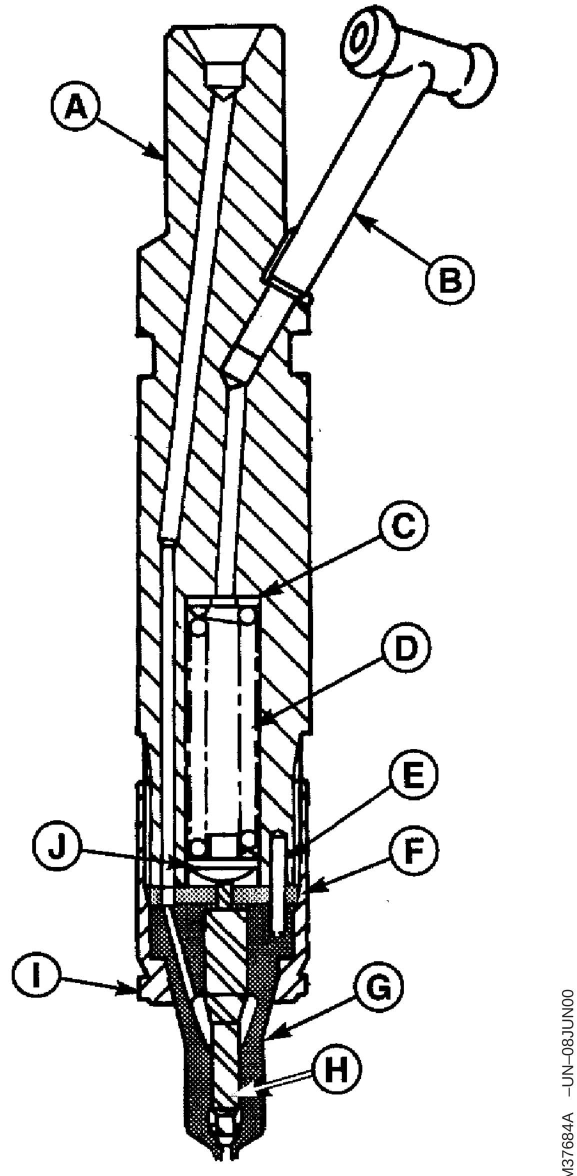
IMPORTANT: Never use a steel brush to clean nozzles as this will distort the spray hole.

2. Remove carbon from used nozzles, and clean by washing in diesel fuel. If parts are coated with hardened carbon or lacquer, it may be necessary to use a brass wire brush (supplied in nozzle cleaning kit).

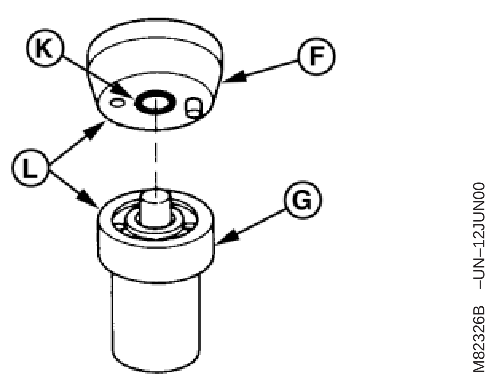
3. After removing carbon or lacquer from the exterior of nozzle, inspect sealing surfaces between separator plate and nozzle body for nicks or scratches.

4. Inspect condition of separator plate and nozzle body. Contact area of separator plate (both parts) must not be scored or pitted. Use an inspection magnifier (No. 16487 or equivalent) to aid in making the inspection.

A—Injector Body
B—Fuel Return Pipe
C—Shims
D—Spring
E—Index Pin
F—Separator Plate
G—Nozzle Body
H—Nozzle Valve
I—Retaining Nut
J—Spring Seat
K—Nozzle Contact Surfaces
L—Sealing Surfaces



Injection Nozzles (Hole Type)—3011, 3012, 3013, 3015, 3016, 4020, and 4TNE98



Nozzle Body, Separator Plate, Contact & Sealing Surfaces

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5. Check nozzle contact surface on separator plate for wear. If contact surface is more than specification, replace nozzle assembly.

Specification

Fuel Injection Nozzle Contact Surface—3011, 3012, 3013, 3015, 3016, 4020, and 4TNE98—Size........ 0.10 mm (0.0039 in.)

6. Inspect the piston (large) part of nozzle valve to see that it is not scratched or scored and that lower (tip) end of valve is not broken. If any of these conditions are present, replace the nozzle assembly.

RG,RG34710,8285 –19–15APR97–2/3

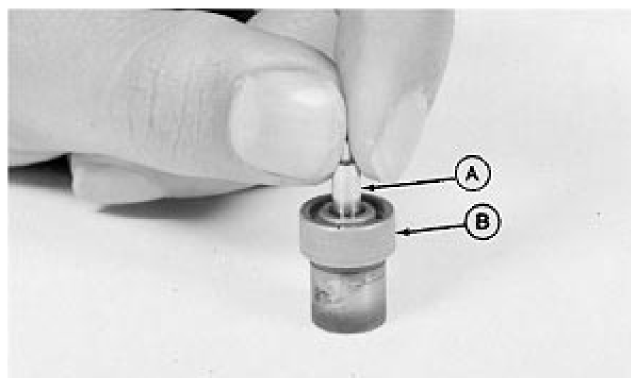
7. Further inspect the nozzle assembly by performing a slide test. Use the following procedure:

   a. Dip the nozzle valve in clean diesel fuel. Insert valve (A) in nozzle body (B).

   b. Hold nozzle vertical, and pull valve out about 1/3 of its engaged length as shown.

   c. Release valve. Valve should slide down to its seat by its own weight.

   Replace nozzle assembly if the valve does not slide freely to its seat.



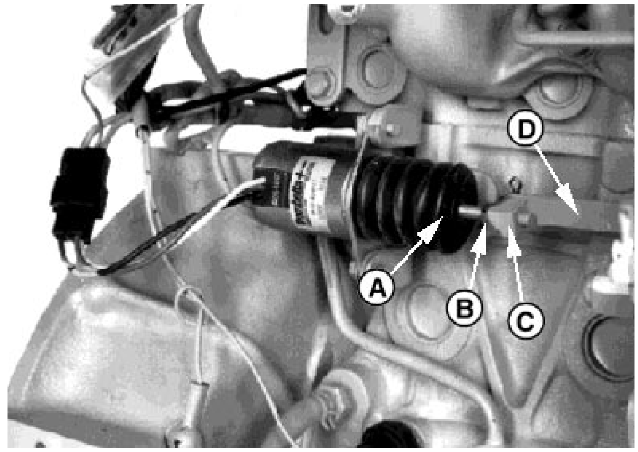
Nozzle Valve & Body

A—Nozzle Valve
B—Nozzle Body

RG,RG34710,8285 –19–15APR97–3/3

Fuel Shutoff Solenoid Adjustment—3011 and 3012

1. Loosen lock nut (A).
2. Disconnect link (B) from solenoid.
3. Hold solenoid plunger (C) bottomed in solenoid body.
4. Move link toward solenoid until it stops.
5. Turn plunger rod in or out of knuckle (D) until knuckle and link holes line up. Turn out two additional turns. The additional turns ensure that the solenoid bottoms out before the linkage.
6. Assemble and check for free movement when key switch is turned ON. Also check that linkage returns completely to the STOP position when key switch is turned OFF.



M82141A –UN–25APR00

Fuel Shutoff Solenoid Adjustment —3011 and 3012

A—Lock Nut
B—Link
C—Plunger
D—Knuckle

RG,RG34710,8369 –19–15APR97–1/1

About This Group

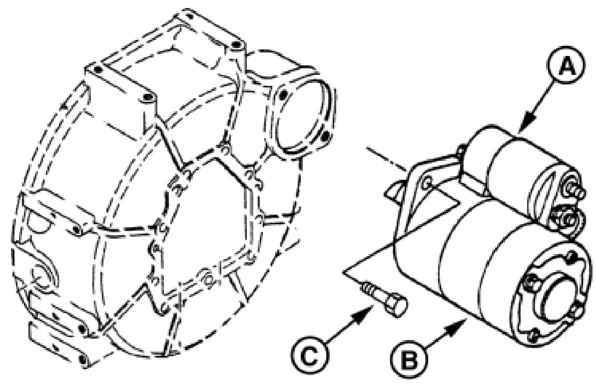
Starters and alternators for all engine models are covered in this group except 4TNE98 engines. Refer to CTM77 Alternators And Starter Motors for starter and alternator information for 4TNE98 engines.

OUO1083,0000660 –19–07MAY04–1/1

Remove and Install Starter

1. Disconnect battery cables, negative (—) cable first.
2. Disconnect all wiring leads from solenoid (A).
3. Remove two cap screws (C) and starter (B).
4. Inspect and repair starter motor, if necessary. (See appropriate procedures later in this group.)
5. Clean mating surfaces and install starter and cap screws. Tighten cap screws securely.
6. Connect all wiring leads to solenoid.
7. Connect battery cables, positive (+) cable first.

NOTE: After installing starter, perform starter amp draw/rpm test. (See TEST STARTER AMP DRAW/RPM in Section 04, Group 150.)



Typical Installation Shown

A—Solenoid
B—Starter
C—Cap Screw (2 used)

RG,RG34710,8291 –19–15APR97–1/1

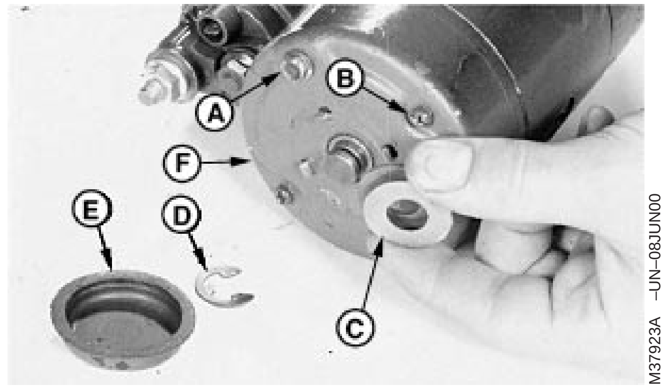
Disassemble and Inspect Starter—3009 (Hitachi 0.8 kW)

1. Remove starter. (See REMOVE AND INSTALL STARTER in this group.)

2. Remove two cap screws (A) and two screws (B) from rear cover (F).

3. Pry off plastic cap (E).

4. Remove E-clip (D), shims (C), and rear cover (F).



Starter—3009

A—Cap Screw (2 used)
B—Screw (2 used)
C—Shim
D—E-Clip
E—Plastic Cap
F—Rear Cover

RG,RG34710,8292 –19–15APR97–1/8

5. Inspect cover bushing (A) for wear or damage. Replace if necessary.

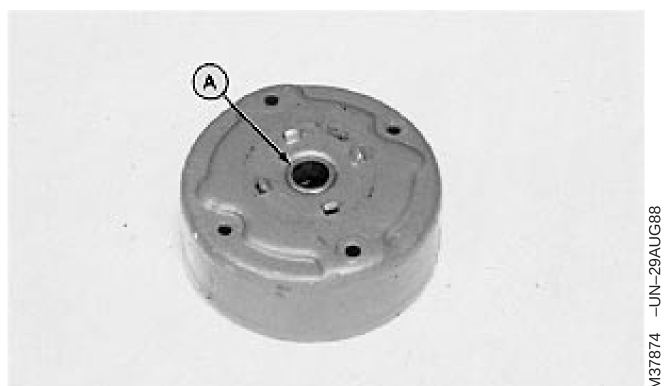
   To replace bushing:

   a. Remove bushing using a Blind-Hole Puller Set. Install new bushing until it bottoms in cover bore using a Universal Driver Set.

   b. Ream bushing to specification.

Specification

Starter Rear Cover Bushing Final Ream—3009—Size	12.50—12.53 mm (0.492—0.493 in.)



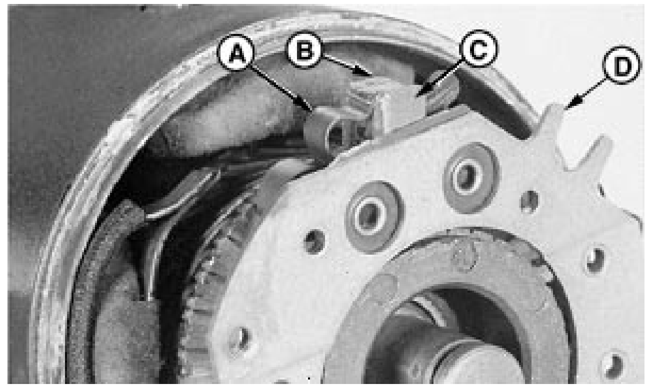
Inspect Cover Bushing

A—Cover Bushing

Continued on next page RG,RG34710,8292 –19–15APR97–2/8

6. Remove field coil brushes from brush holder.
7. Pry brush springs (A) away and pull negative brushes (B) up enough to allow spring to hold brush in place in brush holder (C).
8. Remove brush holder assembly.

A—Brush Spring
B—Field Coil Brush
C—Brush Holder
D—Brush Holder Assembly

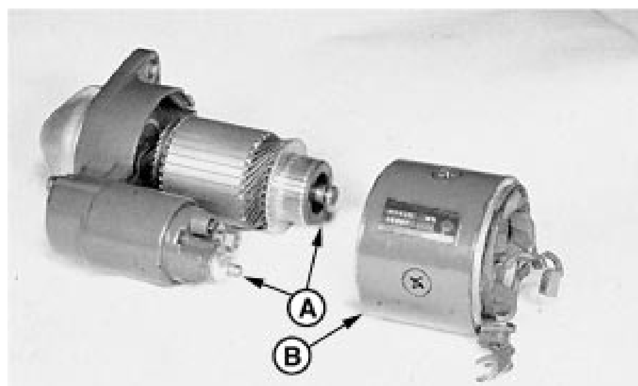


Remove Field Coil Brushes from Brush Holder

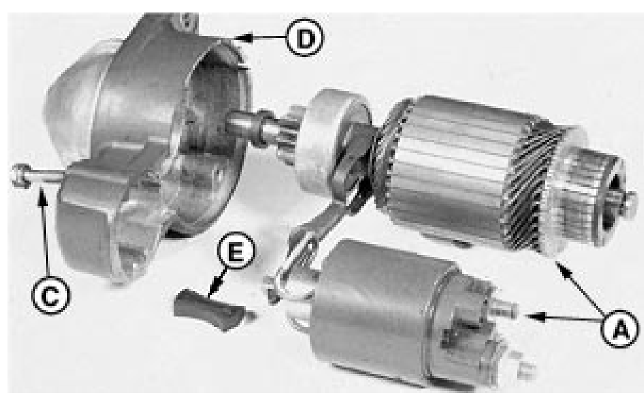
RG,RG34710,8292 –19–15APR97–3/8

9. Remove field coil housing (B) from armature/solenoid assembly.
10. Remove two cap screws (C).
11. Remove dust cover (E).
12. Remove end frame (D) from armature and solenoid.

A—Armature/Solenoid Assembly
B—Field Coil Housing
C—Cap Screw (2 used)
D—End Frame
E—Dust Cover



Armature/Solenoid Assembly



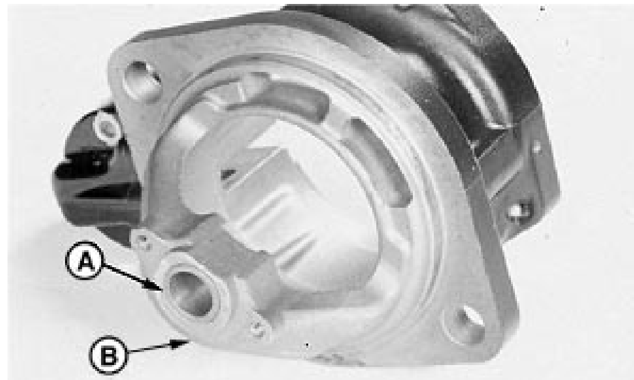
Remove Solenoid and Armature Assemblies

Continued on next page

RG,RG34710,8292 –19–15APR97–4/8

13. Inspect end frame bushing (A) for wear or damage. Replace if necessary. Install bushing flush with face of housing (B).

A—End Frame Bushing
B—Face of Housing



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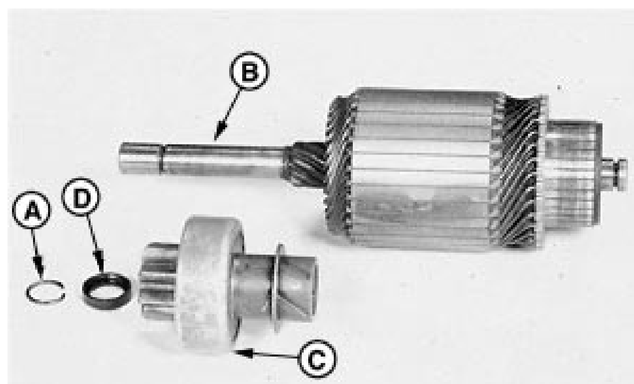
Inspect End Frame Bushing

RG,RG34710,8292 –19–15APR97–5/8

14. Slide pinion stopper (D) from retaining ring (A) using a piece of pipe or deep socket. Remove retaining ring, pinion stopper, and clutch assembly (C) from armature shaft (B).

15. Inspect clutch assembly (C) for wear or damage. Gear should rotate in one direction only. Replace if necessary.

A—Retaining Ring
B—Armature Shaft
C—Clutch Assembly
D—Pinion Stopper



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Clutch Assembly

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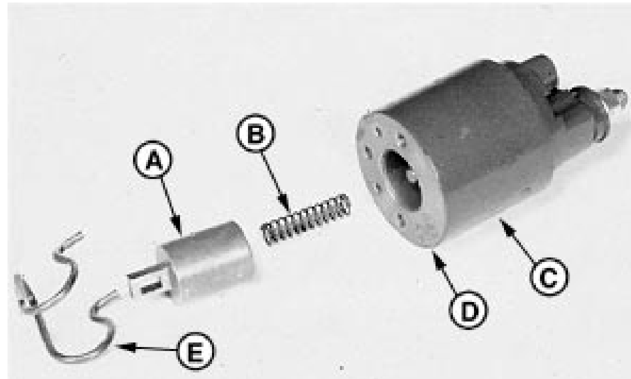
RG,RG34710,8292 –19–15APR97–6/8

16. Remove clutch fork pivot (E), plunger (A), spring (B) and shim(s) (D) from solenoid (C).

A—Plunger
B—Spring
C—Solenoid
D—Shim(s)
E—Clutch Fork Pivot



Remove Solenoid Components

Continued on next page RG,RG34710,8292 –19–15APR97–7/8

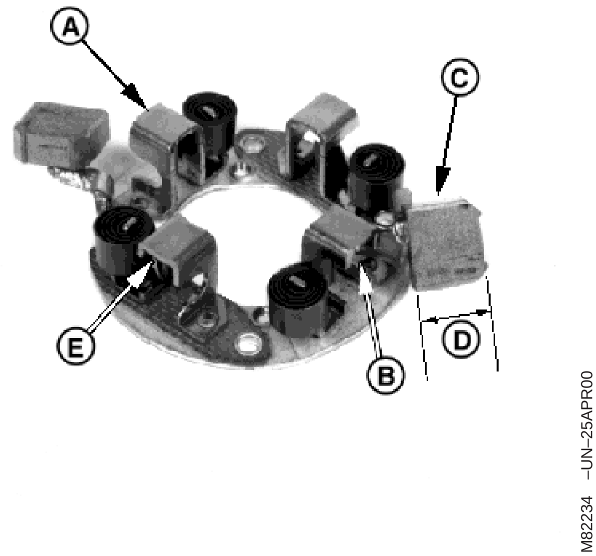
17. Measure negative brush (C) and field coil brush (F) lengths (D). Replace brush holder or field coil if brush length is below minimum specification.

Specification
Starter Brushes—3009—Length .... 7.70 mm (0.303 in.) minimum

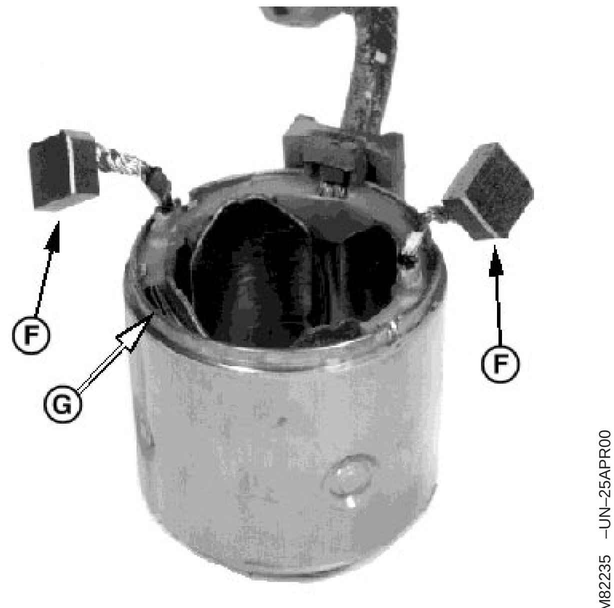
18. Inspect all parts for wear or damage. Replace as necessary.

19. Test brushes, holder, field coil and armature (See TEST STARTER—3009 (HITACHI 0.8 KW) in Section 04, Group 150.)

A—Spring
B—Negative Brush Holder
C—Negative Brush
D—Brush Length
E—Field Brush Holder
F—Field Coil Brush
G—Field Coil



Starter Components—3009



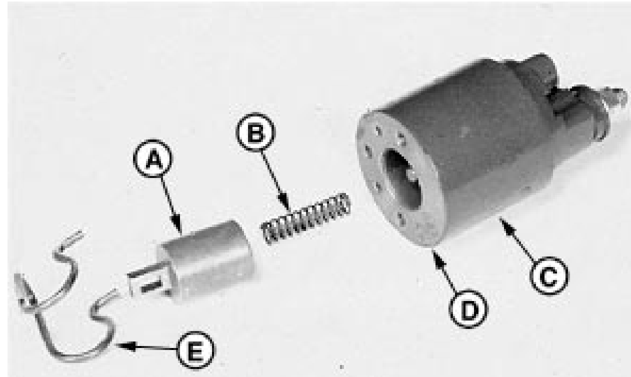
Field Coil Brush and Field Coil

RG,RG34710,8292 –19–15APR97–8/8

Assemble Starter—3009 (Hitachi 0.8 kW)

1. Install shims (D), spring (B), plunger (A) and clutch fork pivot (E).

A—Plunger
B—Spring
C—Solenoid
D—Shims
E—Clutch Fork Pivot

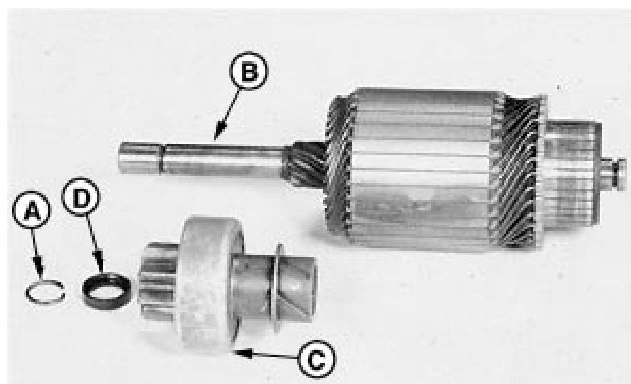


Install Shims, Spring, Plunger and Clutch Fork Pivot

RG,RG34710,8293 –19–15APR97–1/6

2. Install clutch (C), pinon stopper (D), and retaining ring (A) onto armature shaft (B).

A—Retaining Ring
B—Armature Shaft
C—Clutch Assembly
D—Pinion Stopper

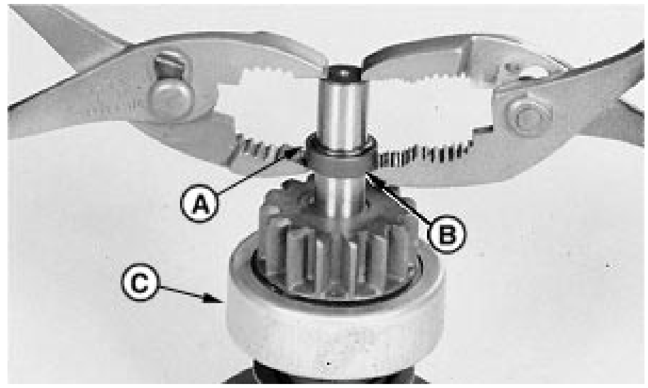


Install Clutch, Pinion Stopper, and Retaining Ring onto Armature

Continued on next page
RG,RG34710,8293 –19–15APR97–2/6

3. After installing clutch assembly (C), pinion stopper (B), and retaining ring (A) on armature shaft, use two pliers to press pinion stopper over retaining ring.

A—Retaining Ring
B—Pinion Stopper
C—Clutch Assembly



Install Clutch Assembly Components

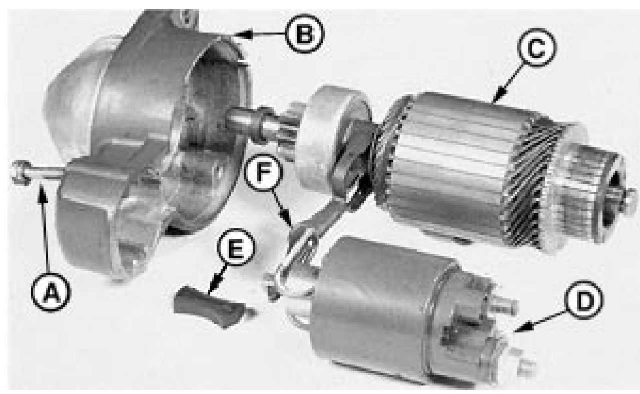
RG,RG34710,8293 –19–15APR97–3/6

NOTE: When installing armature and solenoid assemblies (C and D) in end frame (B), make sure fork pivot (G) seats in notch (H) on clutch fork.

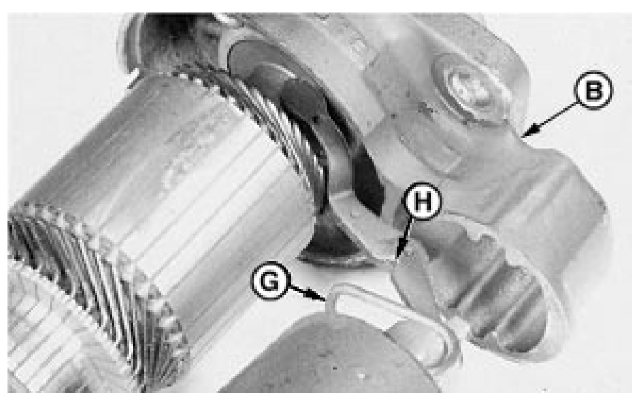
4. Install parts (A—F). Tighten cap screws (A) securely.

5. Install field coil housing and brush holder on armature assembly.

A—Cap Screw
B—End Frame
C—Armature Assembly
D—Solenoid Assembly
E—Dust Cover
F—Lever
G—Clutch Fork Pivot
H—Notch



Install Solenoid and Armature Assemblies



End Frame, Notch and Clutch Fork Pivot

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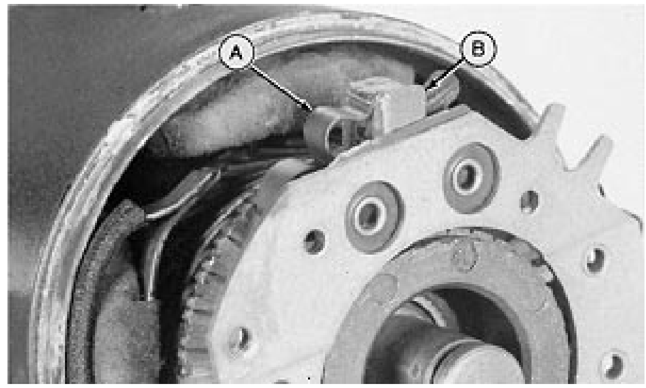
6. Pry brush springs (A) away and install brushes (B).

A—Brush Spring
B—Brush



Pry Brush Springs Away and Install Brushes

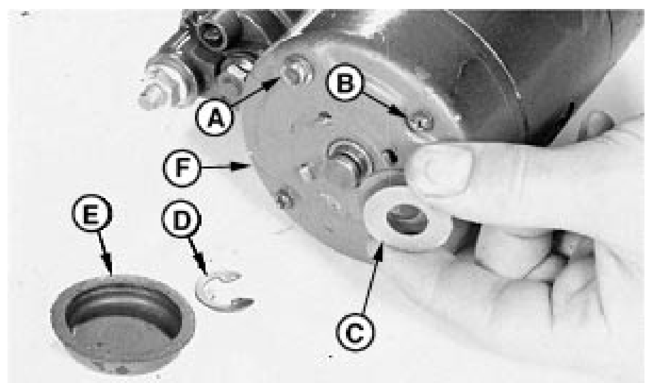
RG,RG34710,8293 –19–15APR97–5/6

IMPORTANT: When installing rear cover (F), be sure field coil brush wires do not touch cover. Turn brush holder slightly to take up slack in brush wires. Press wires inward to clear rear cover.

7. Install parts (A—F). Tighten screws securely.

8. Install starter. (See REMOVE AND INSTALL STARTER in this group.)

A—Cap Screw
B—Cap Screw
C—Shim
D—E-Clip
E—Cap
F—Rear Cover



Install Rear Cover

RG,RG34710,8293 –19–15APR97–6/6

Disassemble and Inspect Starter—3011, 3012, 3013, 3015, 3016 and 4020 (Denso 1.0 kW, 1.2 kW and 1.4 kW)

NOTE: This procedure covers the repair of the armature, field, and brushes.

If the clutch and drive mechanism is to be repaired, refer to DISASSEMBLE AND INSPECT STARTER GEAR AND OVERRUNNING CLUTCH— 3011, 3012, 3013, 3015, 3016 AND 4020 (Denso 1.0 KW, 1.2 KW AND 1.4 KW) in this group.

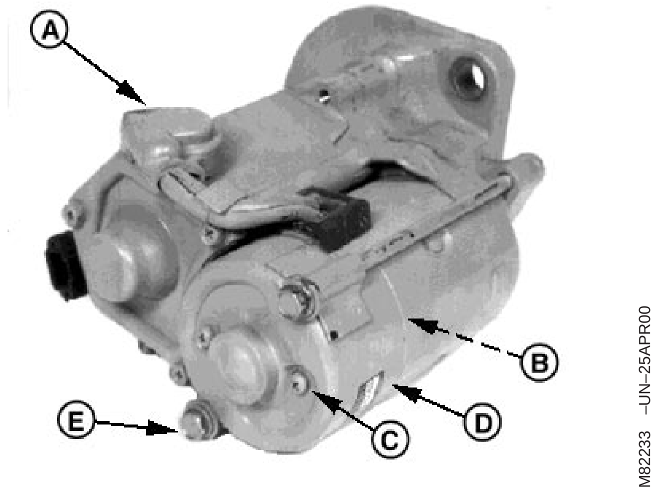
If the solenoid is to be repaired, refer to DISASSEMBLE, INSPECT AND ASSEMBLE STARTER SOLENOID—3011, 3012, 3013, 3015, 3016 AND 4020 (Denso 1.0 KW, 1.2 KW AND 1.4 KW) in this group.

1. Remove starter motor. (See REMOVE AND INSTALL STARTER in this group.)

2. Disconnect wiring leads (A).

3. Remove two cap screws (E) and two screws (C).

4. Remove rear cover (D) and O-ring (B).



Remove Cover

A—Wiring Leads
B—O-Ring
C—Screw (2 used)
D—Rear Cover
E—Cap Screw (2 used)

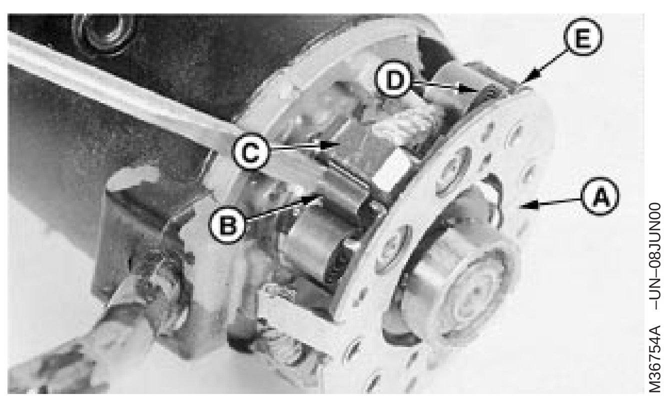
RG,RG34710,8294 –19–15APR97–1/4

5. Remove field coil brushes (C) from brush holder (A).

6. Pry negative brush spring (D) away and pull negative brush (E) up enough to allow spring (D) to hold brush in place. Repeat with other negative brush.

7. Remove brush holder (A).

A—Brush Holder
B—Field Coil Brush Spring
C—Field Coil Brush
D—Negative Brush Spring
E—Negative Brush



Remove Brush Holder

Continued on next page

RG,RG34710,8294 –19–15APR97–2/4

8. Remove armature (B) from field coil housing (C).

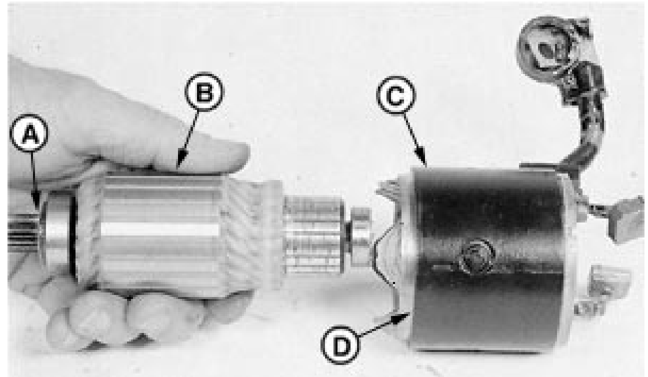
9. Remove felt washer (A) and O-ring (D).

10. Inspect all parts for wear or damage.

11. Measure length of brushes.

Specification
Starter Brushes—3011, 3012,
3013, 3015, 3016 and 4020—
Length.. 8.5 mm (0.355 in.) minimum

12. Test brushes, holder, field coil and armature. (See TEST STARTER—3011, 3012, 3013, 3015, 3016 and 4020 (Denso 1.0 KW, 1.2 KW AND 1.4 KW) in Section 04, Group 150.)



M36759A –UN–08JUN00

Remove and Inspect Armature and Field Coil Housing

A—Felt Washer
B—Armature
C—Field Coil Housing
D—O-Ring

RG,RG34710,8294 –19–15APR97–3/4

13. Inspect armature cover bearing (B) and housing bearing (A) for wear or damage. Replace if necessary.

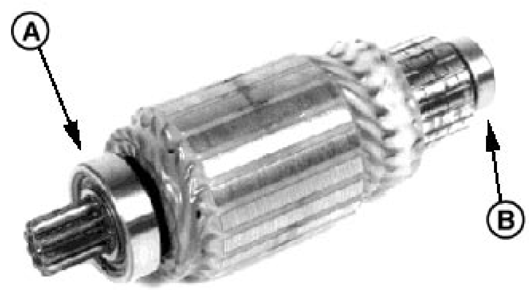
NOTE: Bearings are press fit. Use a knife-edge puller set.

14. Remove bearings (A and B).

IMPORTANT: Install both bearings with sealed side of bearing toward center of armature.

15. Install new bearings (A and B) tight against shoulder of shaft using a bushing, bearing, and seal driver set.

16. Assemble starter. (See ASSEMBLE STARTER—3011, 3012, 3013, 3015, 3016 AND 4020 (Denso 1.0 KW, 1.2 KW AND 1.4 KW) in this group.)



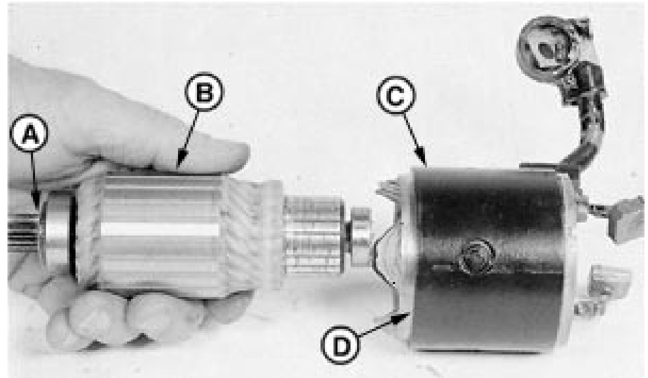
M82237 –UN–25APR00

Inspect Armature Bearings

A—Housing Bearing
B—Armature Cover Bearing

RG,RG34710,8294 –19–15APR97–4/4

Assemble Starter—3011, 3012, 3013, 3015, 3016 and 4020 (Denso 1.0 kW, 1.2 kW and 1.4 kW)



Install Armature into Field Coil Housing

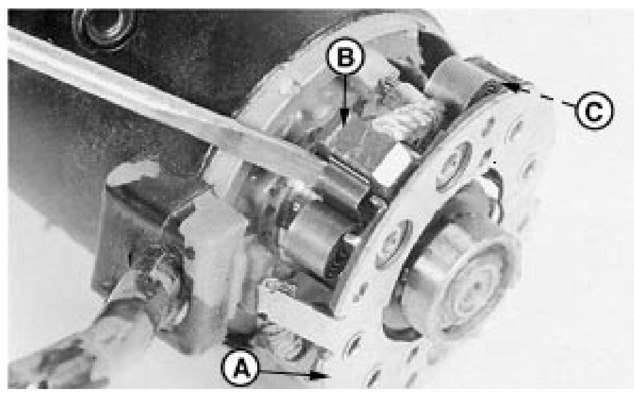
NOTE: Apply multipurpose grease during assembly to bearing cup inside rear cover and felt washer.

1. Install O-ring (D) and felt washer (A).

2. Install armature (B) into field coil housing (C).

A—Felt Washer
B—Armature
C—Field Coil Housing
D—O-Ring

RG,RG34710,8297 –19–15APR97–1/3



Install Brush Holder and Brushes

3. Install brush holder (A) onto armature.

4. Pry brush springs up and install field coil brushes, (B) and negative brushes (C).

A—Brush Holder
B—Field Coil Brush
C—Negative Brush

Continued on next page

RG,RG34710,8297 –19–15APR97–2/3

IMPORTANT: When installing rear cover (D), be sure field coil brush wires do not touch cover. Turn brush holder slightly to take up slack in brush wires. Press wires inward to clear rear cover.

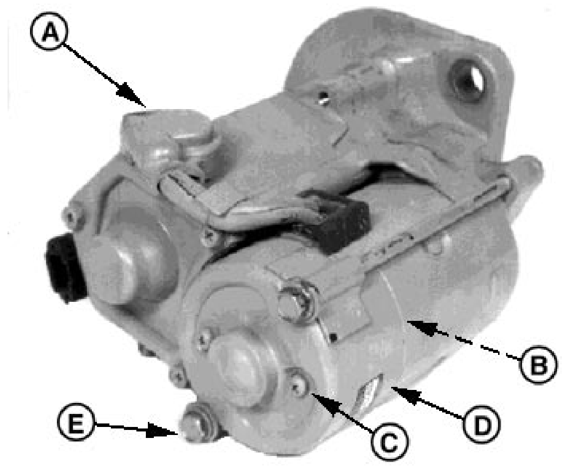
NOTE: Apply multipurpose grease to bearing cup inside rear cover (D).

5. Install O-ring (B) and rear cover (D).

6. Install cap screws (E) and screw (C). Tighten securely.

7. Connect wiring leads (A).

8. Install starter motor. (See REMOVE AND INSTALL STARTER in this group.)



M82233 –UN–25APR00

Install O-Ring and Rear Cover

A—Wiring Leads
B—O-Ring
C—Screw
D—Rear Cover
E—Cap Screw

RG,RG34710,8297 –19–15APR97–3/3

Disassemble and Inspect Starter Gear and Overrunning Clutch— 3011, 3012, 3013, 3015, 3016 and 4020 (Denso 1.0 kW, 1.2 kW and 1.4 kW)

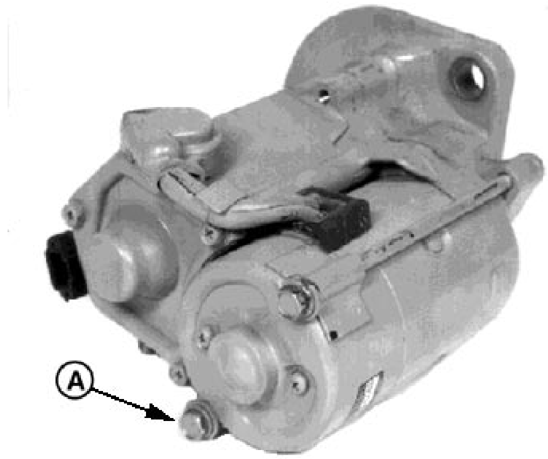
1. Remove starter motor from equipment. (See REMOVE AND INSTALL STARTER in this group.)

2. Remove cap screws (A) and screws (B).

3. Separate clutch housing (C) from starter assembly.

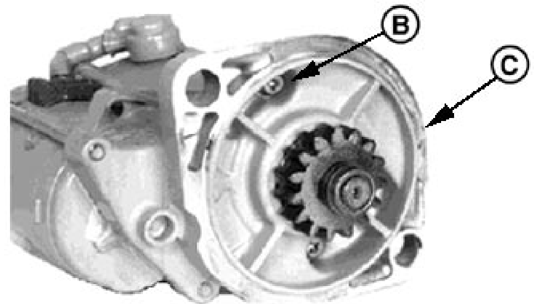
4. Remove plunger spring (E).

A—Cap Screw
B—Screw
C—Clutch Housing
D—Motor Shaft
E—Plunger Spring



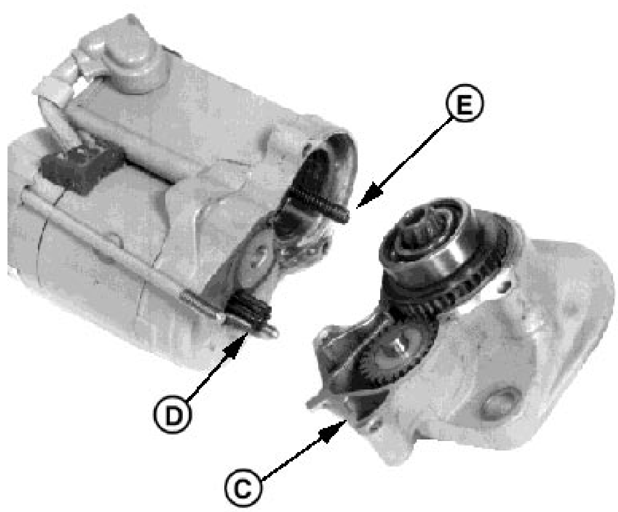
M82233A –UN–25APR00

Remove Cap Screws



M82238 –UN–25APR00

Remove Clutch Housing



M82239 –UN–25APR00

Remove Plunger Spring

Continued on next page RG,RG34710,8298 –19–15APR97–1/5

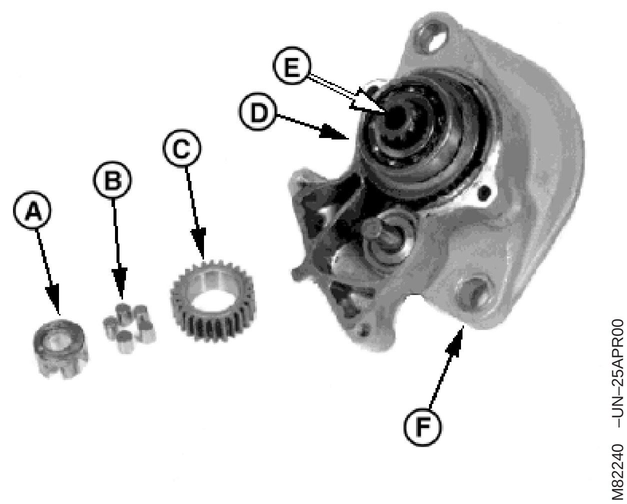
NOTE: Starter is equipped with either a 33 mm (1.299 in.), 44 mm (1.732 in.) or 44.5 mm (1.752 in.) drive gear on end of clutch shaft. Disassembly procedures are slightly different.

5. Starter with 33 mm (1.299 in.) drive gear: Remove clutch assembly (D) from housing (F).

6. Remove retainer (A), five rollers (B) and pinion gear (C).

7. Remove steel ball.

A—Retainer
B—Roller
C—Pinion Gear
D—Clutch Assembly
E—Steel Ball
F—Housing



Remove Clutch Assembly

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RG,RG34710,8298 –19–15APR97–2/5

CAUTION: Shaft could be propelled from clutch unit with considerable force if spring is not allowed to extend fully while in vise.

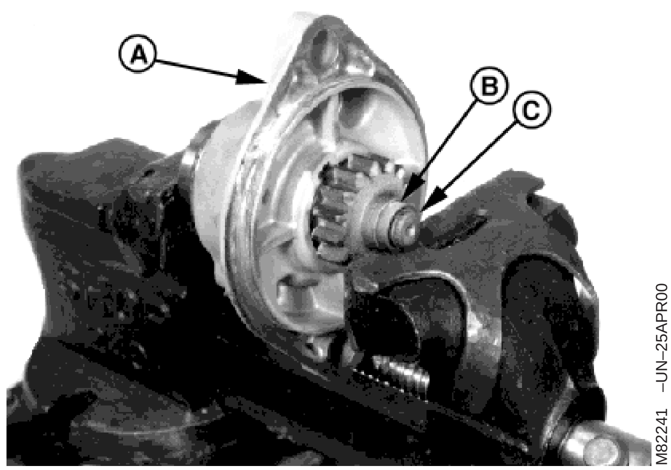
8. Put clutch housing (A) into a soft-jawed vise, as shown.

9. Tighten vise slowly, until drive gear compresses.

10. Remove retainer (B) and circlip (C).

11. While holding clutch housing, slowly open vise until all spring compression is relieved.

A—Clutch Housing Assembly
B—Retainer
C—Circlip



Starter with 44 or 44.5 mm (1.732 or 1.752 in.) Drive Gear Shown

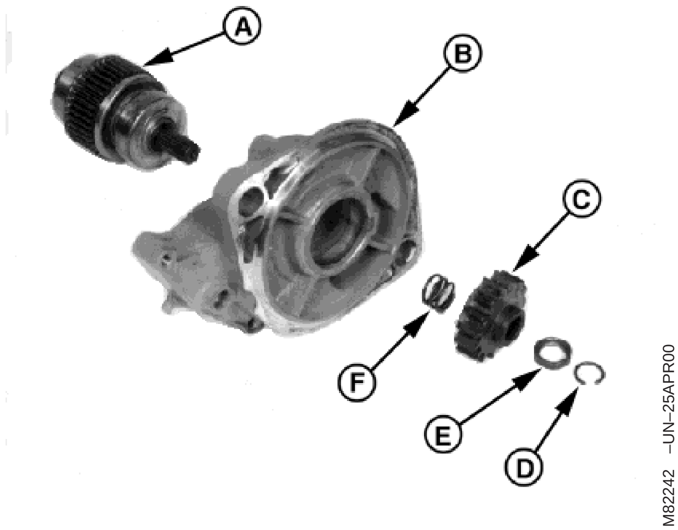
Continued on next page

RG,RG34710,8298 –19–15APR97–3/5

12. Remove drive gear (C) and spring (F).

13. Remove clutch assembly (A) from clutch housing (B).

A—Clutch Assembly
B—Clutch Housing
C—Drive Gear
D—Circlip
E—Retainer
F—Spring

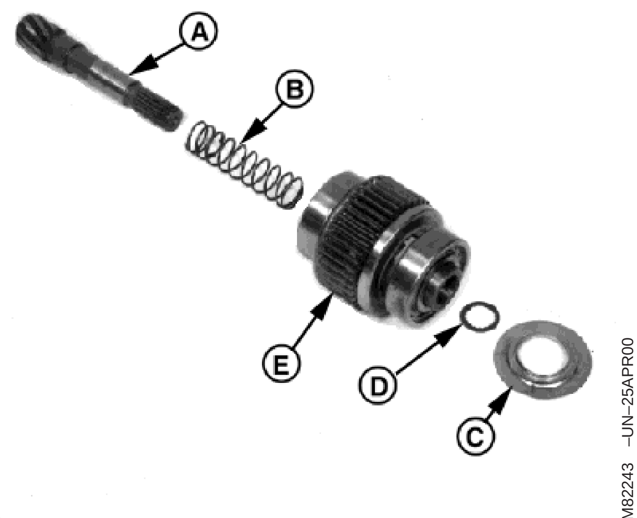


Starter with 44 or 44.5 mm (1.732 or 1.752 in.) Drive Gear Shown

RG,RG34710,8298 –19–15APR97–4/5

14. Remove parts (A—E). Inspect all parts for wear or damage. Replace as necessary.

A—Clutch Shaft
B—Spring
C—Washer
D—Toothed Washer
E—Clutch



Remove Parts, Inspect, Replace if Necessary

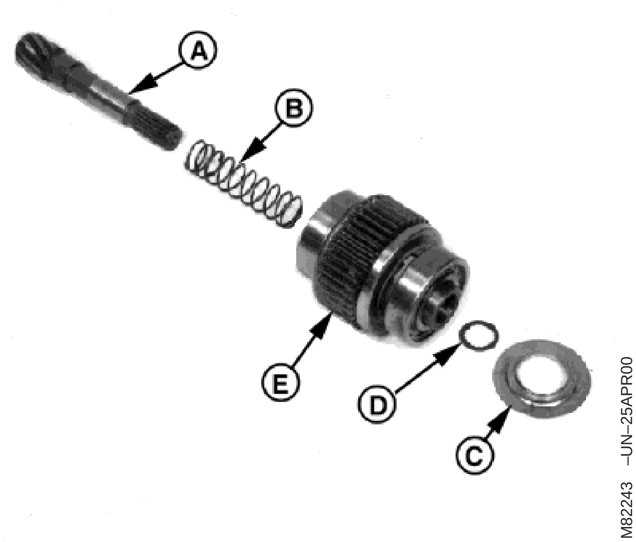
RG,RG34710,8298 –19–15APR97–5/5

Assemble Starter Gear and Overrunning Clutch—3011, 3012, 3013, 3015, 3016 and 4020 (Denso 1.0 kW, 1.2 kW and 1.4 kW)

NOTE: Apply multipurpose grease to clutch shaft (A) and spring (B). Make sure during installation of washer (C) that flat side is toward clutch (E).

1. Install parts (A—E).

A—Clutch Shaft
B—Spring
C—Washer
D—Toothed Washer
E—Clutch



Assemble Clutch Components

Continued on next page RG,RG34710,8299 –19–15APR97–1/5

NOTE: Apply multipurpose grease to spring (F). During installation of retainer (E), ensure that cupped side is facing away from clutch assembly.

2. Install clutch assembly (A) into clutch housing (B).

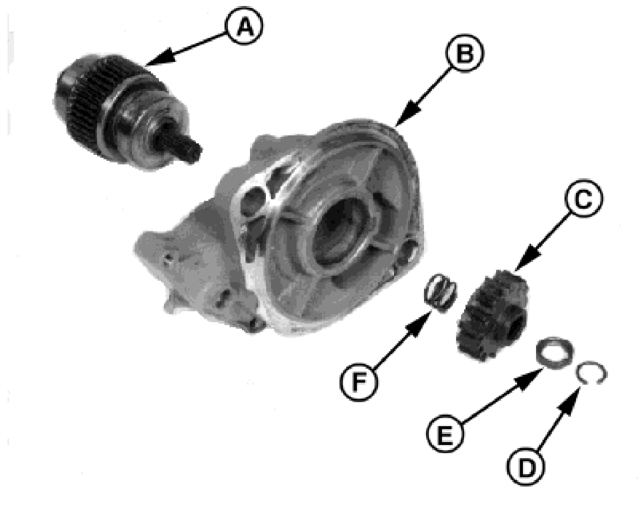
3. Install spring (F) and drive gear (C).

4. Place clutch housing in a soft-jawed vise, as shown. Tighten vise slowly, until drive gear compresses.

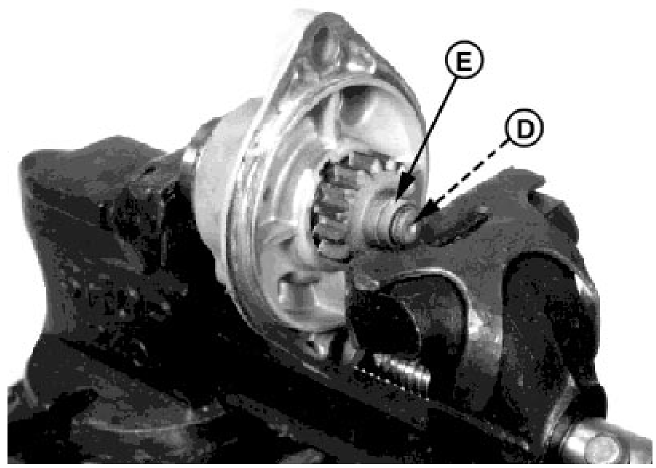
5. Install retainer (E) with cupped side away from clutch assembly and install circlip (D).

6. While holding clutch assembly, slowly open vise until all spring compression is relieved. Remove clutch housing from vise.

A—Clutch Assembly
B—Clutch Housing
C—Drive Gear
D—Circlip
E—Retainer
F—Spring



Install Clutch Assembly into Housing



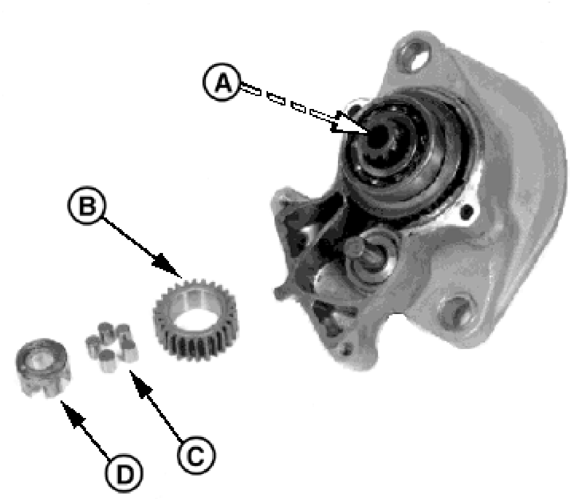
Install Retainer and Spring

Continued on next page RG,RG34710,8299 –19–15APR97–2/5

NOTE: Apply multipurpose grease to pinion gear (B), retainer (D), rollers (C), and steel ball (A).

7. Install parts (A—D).

A—Steel Ball
B—Pinion Gear
C—Roller
D—Retainer



M82240A —UN–25APR00

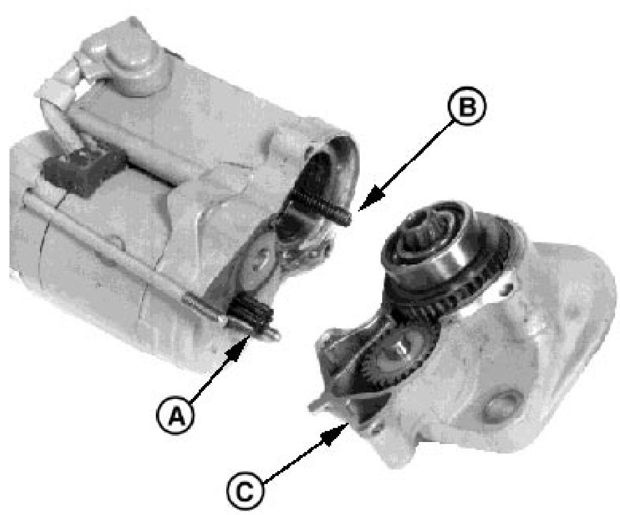
Install Pinion Gear, Steel Ball, Roller and Retainer

RG,RG34710,8299 –19–15APR97–3/5

8. Install plunger spring (B.

9. Install clutch housing (C).

A—Armature
B—Plunger Spring
C—Clutch Housing



M82239A —UN–25APR00

Install Plunger Spring

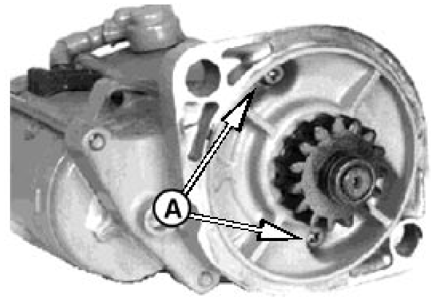
Continued on next page

RG,RG34710,8299 –19–15APR97–4/5

10. Install two screws (A) and two cap screws (B). Tighten securely.

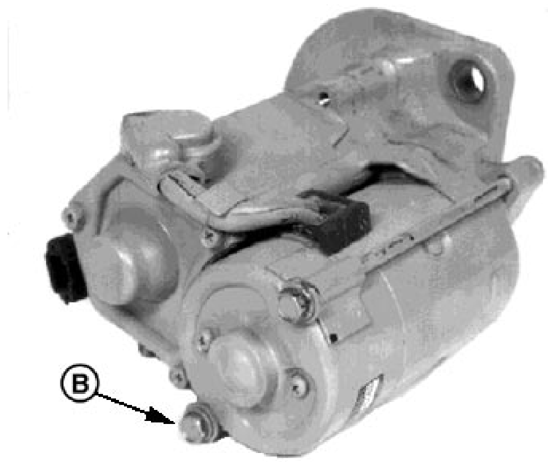
11. Install starter motor on engine. (See REMOVE AND INSTALL STARTER in this group.)

A—Screw (2 used)
B—Cap Screw (2 used)



M82238A –UN–25APR00

Install Two Screws



M82233B –UN–25APR00

Install Two Cap Screws

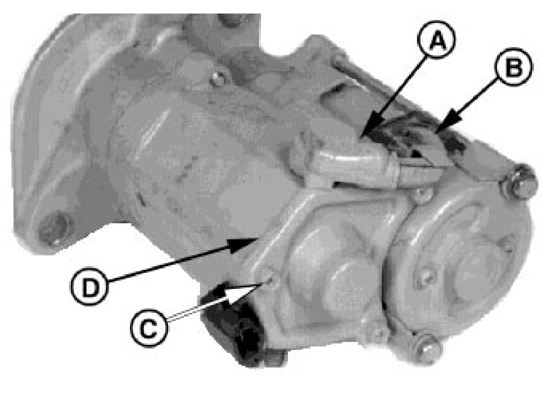
RG,RG34710,8299 –19–15APR97–5/5

Disassemble, Inspect and Assemble Starter Solenoid—3011, 3012, 3013, 3015, 3016 and 4020 (Denso 1.0 kW, 1.2 kW and 1.4 kW)

1. Remove starter motor from engine. (See REMOVE AND INSTALL STARTER in this group.)

2. Disconnect wiring lead (A). Remove clip (B), if equipped.

3. Remove three screws (C) and cover and gasket (D).



M82244 –UN–25APR00

Remove Cover

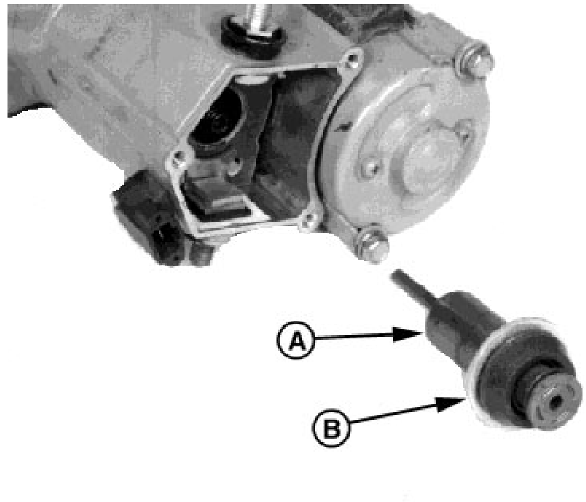
A—Wiring Lead
B—Clip
C—Screw (3 used)
D—Cover and Gasket

Continued on next page

RG,RG34710,8300 –19–15APR97–1/3

4. Remove plunger assembly (A). Inspect copper washer (B) for excessive burning or pitting. Clean burnt areas to improve electrical contact. Replace plunger assembly if necessary.

A—Plunger Assembly
B—Copper Washer



Remove and Inspect Plunger Assembly

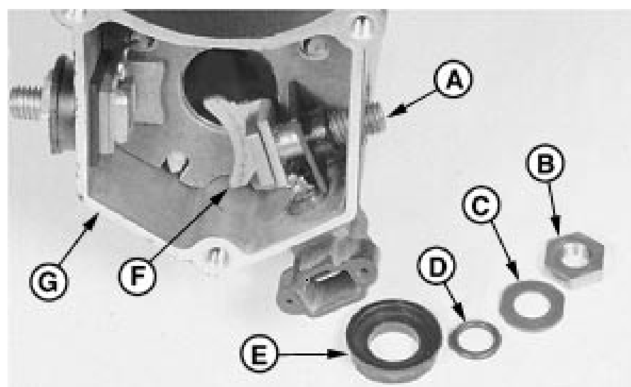
RG,RG34710,8300 –19–15APR97–2/3

5. Remove parts (A—F). Repeat step for other side of solenoid housing (G).

6. Inspect contact plates (F) for excessive burning or pitting. Clean burnt areas to improve electrical contact. Replace if necessary.

NOTE: *The assembly sequence of the left and right terminals is similar. Be sure solenoid terminal lead is installed between terminal bolt and contact plate. Also, be sure smaller contact plate is on the left side.*

7. Assemble all parts and install starter motor to engine. (See REMOVE AND INSTALL STARTER in this group.)



Remove and Inspect Solenoid Housing Assembly and Components

A—Terminal Bolt
B—Nut
C—Washer
D—O-Ring
E—Insulator
F—Contact Plate
G—Solenoid Housing Assembly

RG,RG34710,8300 –19–15APR97–3/3

Remove and Install Alternator

1. Disconnect battery, negative (—) cable first.

2. Disconnect all wiring leads and connectors on back of alternator.

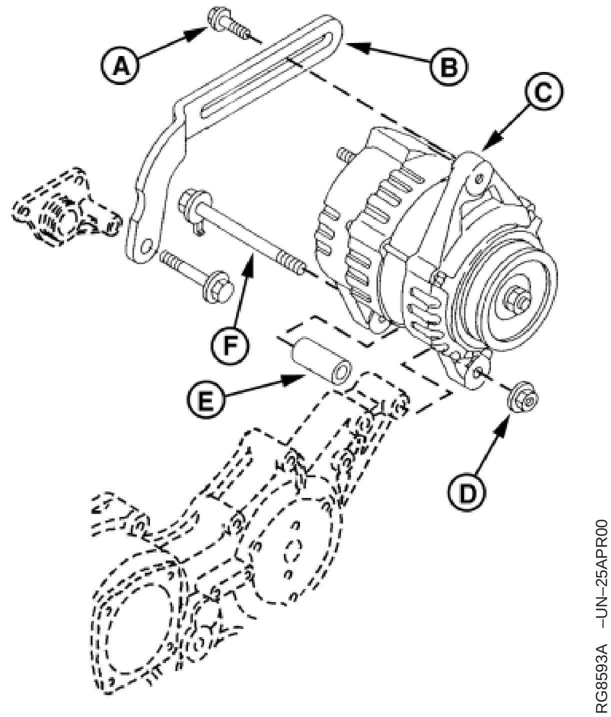
3. Remove nut (D) and cap screw (A).

4. Push alternator toward engine and remove belt from pulley.

NOTE: It is not necessary to remove adjustment bracket (B).

5. Support alternator (C). Remove cap screw (F), spacer (E) and alternator. Replace if necessary.

6. Disassemble, inspect and assemble alternator if necessary. (See DISASSEMBLE AND INSPECT ALTERNATOR—3009, 3011, 3013, 3015 AND 3016 (Denso 40-AMP) or DISASSEMBLE AND INSPECT ALTERNATOR—3012, 3015 AND 4020 (HITACHI 40-AMP) and ASSEMBLE ALTERNATOR—3012, 3015 AND 4020 (HITACHI 40-AMP)in this group.)



Typical Installation Shown

A—Cap Screw
B—Adjustment Bracket
C—Alternator
D—Nut
E—Spacer
F—Cap Screw

RG,RG34710,8306 –19–15APR97–1/1

Disassemble and Inspect Alternator—3009, 3011, 3013, 3015 and 3016 (Denso 40-Amp)

Disassembly

1. Remove alternator. (See REMOVE AND INSTALL ALTERNATOR in this group.)

2. Remove nut and insulator (A).

3. Remove three screws (B) and cover (C).

Remove Cover

A—Insulator
B—Screw (3 used)
C—Cover

Continued on next page

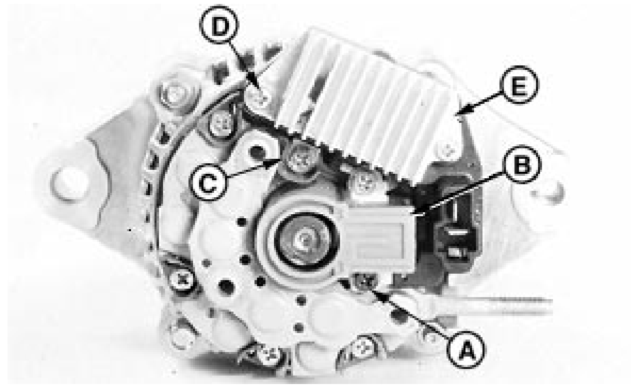
RG,RG34710,8307 –19–15APR97–1/6

4. Remove two screws (A), brush holder and cover (B).

NOTE: Note location of short screw (C) for proper installation.

5. Remove short screw (C) and two long screws (D). Remove voltage regulator (E).

A—Screw (2 used)
B—Brush Holder and Cover
C—Short Screw (1 used)
D—Long Screws (2 used)
E—Voltage Regulator



M52472A –UN–08JUN00

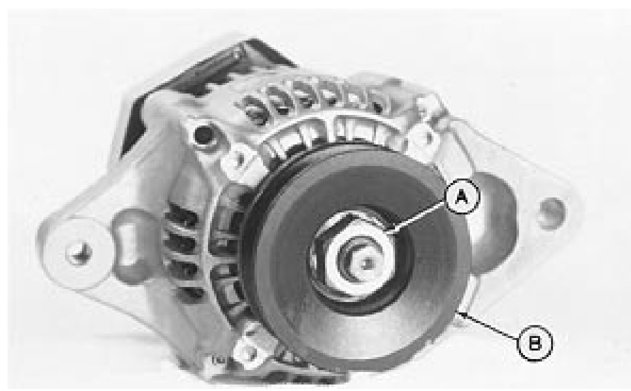
Remove Brush Holder and Voltage Regulator

RG,RG34710,8307 –19–15APR97–2/6

6. Remove nut (A).

7. Remove sheave (B) using a Universal Puller Set.

A—Nut
B—Sheave



M52469 –UN–29JAN90

Remove Nut and Sheave

Continued on next page RG,RG34710,8307 –19–15APR97–3/6

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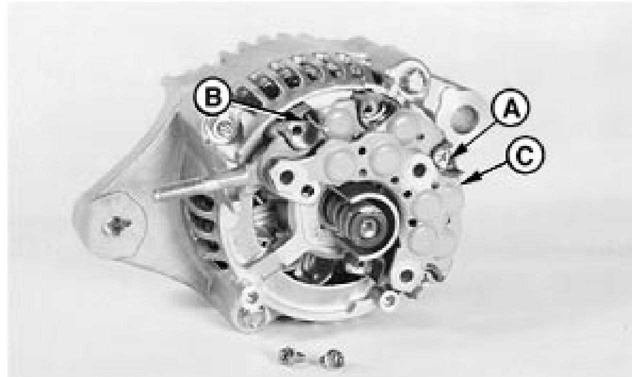
8. Remove four screws (A) and straighten stator wire leads (B).

9. Remove rectifier (C).

A—Screw (4 used)
B—Stator Wire Leads
C—Rectifier



Remove Rectifier

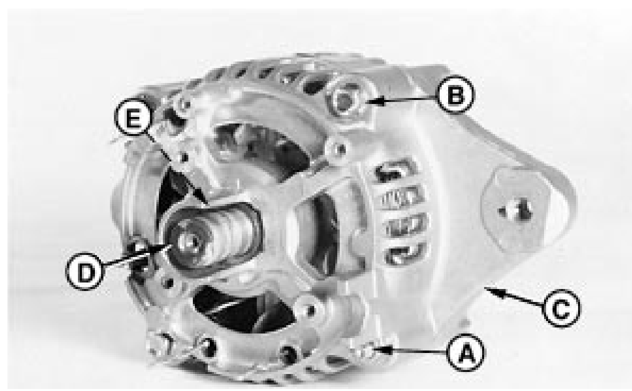
RG,RG34710,8307 –19–15APR97–4/6

10. Remove two nuts (A), two screws (B) and end frame assembly (C).

11. Press rotor shaft (D) from end frame.

12. Remove spring washer (E).

A—Nut (2 used)
B—Screw (2 used)
C—End Frame
D—Rotor Shaft
E—Spring Washer



Remove Rotor Shaft and Spring Washer

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RG,RG34710,8307 –19–15APR97–5/6

13. Remove four screws (A) and retainer (B).

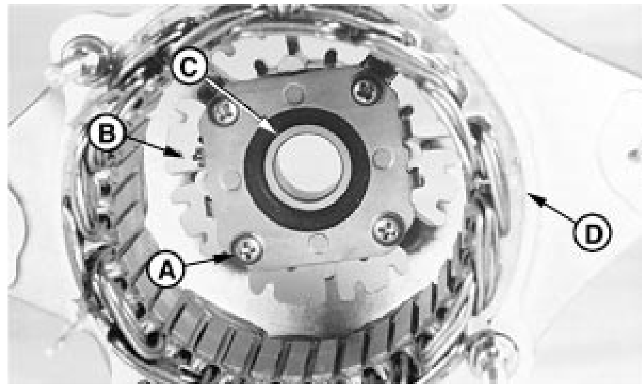
NOTE: Front bearing (C) is press fit in front frame (D). Remove bearing only if replacement is necessary.

14. Inspect bearing (C) in front frame (D) for wear or damage. Replace if necessary using a Universal Bushing, Bearing, and Driver Set and a press.

15. Measure length of brushes. Replace if less than minimum.

Specification

Alternator Brush—3009, 3011, 3013, 3015 and 3016 (Denso Equipped)—Length...................................... 4.50 mm (0.170 in.) minimum



Remove Retainer

A—Screw (4 used)
B—Retainer
C—Front Bearing
D—Front Frame

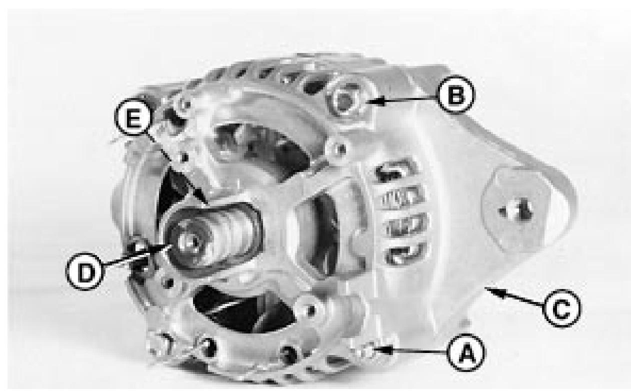
RG,RG34710,8307 –19–15APR97–6/6

Assemble Alternator—3009, 3011, 3013, 3015 and 3016 (Denso 40-Amp)

1. Install spring washer (E).

2. Press rotor shaft (D) into end frame.

3. Install end frame assembly (C) with two nuts (A), and two screws (B).



Install Spring Washer, Rotor Shaft and End Frame Assembly

A—Nut (2 used)
B—Screw (2 used)
C—End Frame
D—Rotor Shaft
E—Spring Washer

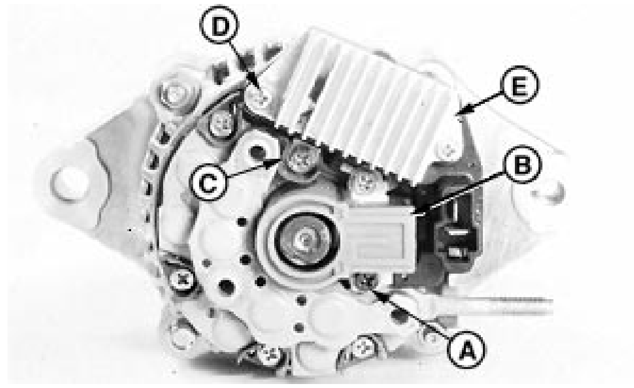
Continued on next page RG,RG34710,8309 –19–15APR97–1/3

IMPORTANT: Make sure to install short screw (C) at location shown. Longer screw will contact frame and cause damage to the charging system.

4. Install voltage regulator (E) with short screw (C) and two long screws (D).

5. Install brush holder and cover (B) with two screws (A).

A—Screw (2 used)
B—Brush Holder and Cover
C—Short Screw
D—Long Screw (2 used)
E—Voltage Regulator



M52472A –UN–08JUN00

Install Voltage Regulator and Brush Holder

RG,RG34710,8309 –19–15APR97–2/3

6. Install cover (C) with three screws (B).

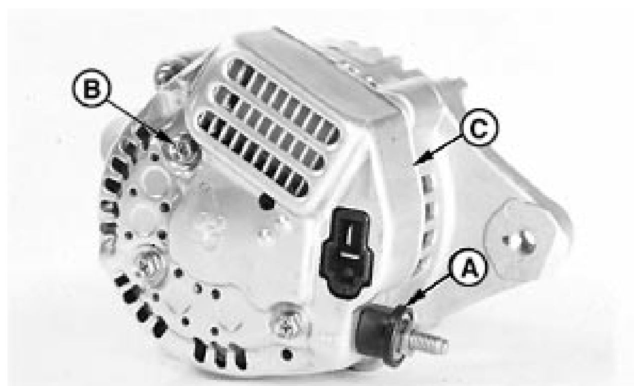
7. Install insulator and nut (A).

8. Install sheave (D) and nut (E). Tighten nut to specification.

Specification

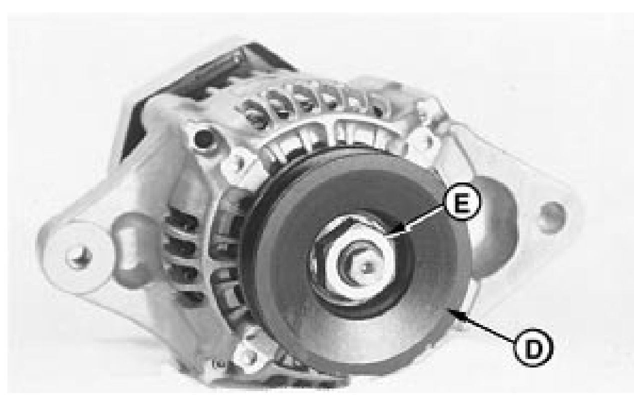
Alternator Sheave Nut—3009, 3011, 3013, 3015 and 3016 (Denso Equipped)—Torque.. 69 N•m (51 lb-ft)

A—Insulator and Nut
B—Screw (3)
C—Cover
D—Sheave
E—Nut



M52470A –UN–08JUN00

Install Cover



M52469A –UN–08JUN00

Install Sheave and Nut

RG,RG34710,8309 –19–15APR97–3/3

Disassemble and Inspect Alternator—3012, 3015 and 4020 (Hitachi 40-Amp)

1. Test regulator amperage output. (See TEST ALTERNATOR REGULATED AMPERAGE in Section 04, Group 150.)

2. Remove alternator from engine. (See REMOVE AND INSTALL ALTERNATOR in this group.)

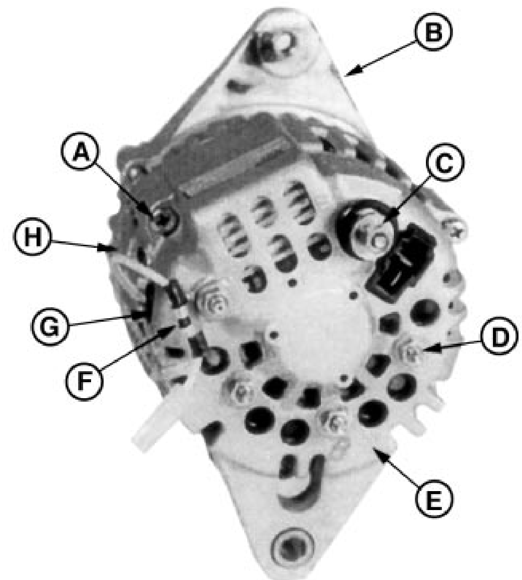
3. Place an alignment mark across the top of the front frame (B), stator (H) and end frame (E) to aid during assembly.

4. Remove three screws (A), nuts (D) and clamp (F).

5. Remove nut and insulator (C) from alternator.

IMPORTANT: Do not pry against stator wires.

6. Use a screwdriver to pry end frame from stator. Do not completely separate stator from front frame.



M76415 –UN–12JUN00

Disassemble Alternator

A—Screw (3 used)
B—Front Frame
C—Nut and Insulator
D—Nut
E—End Frame
F—Clamp
G—Grommet
H—Stator

Continued on next page RG,RG34710,8311 –19–15APR97–1/3

IMPORTANT: Do not heat connections longer than necessary to melt solder, as excess heat will damage rectifier assembly.

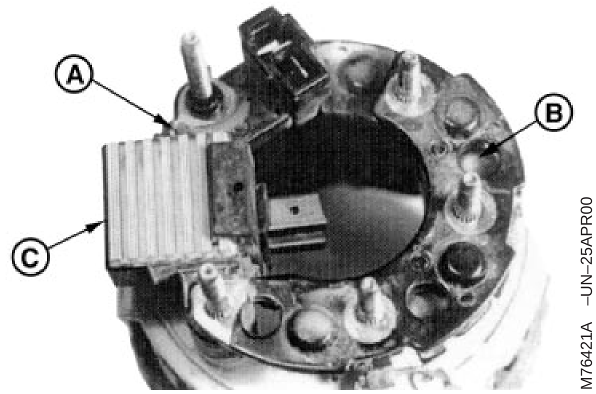
NOTE: Remove voltage regulator (C) only if replacement is necessary.

7. Use a soldering gun with at least 120 watt capacity to disconnect voltage regulator lead (A) from rectifier (B).

8. Use a screwdriver to separate stator from front frame.

NOTE: If additional solder is needed during installation of new voltage regulator, use only 60-40 rosin-core solder.

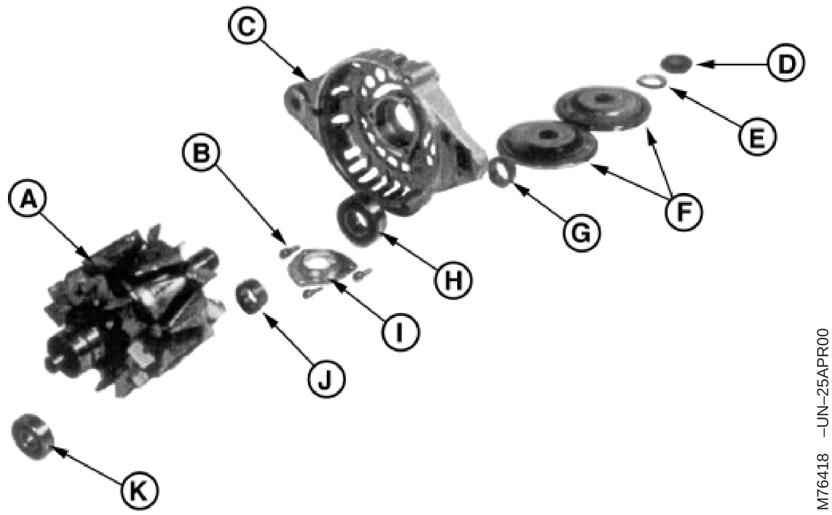
9. Install new voltage regulator using soldering gun with at least 120 watt capacity to connect three terminals.



Disconnect Voltage Regulator Lead from Rectifier

A—Regulator Wiring Lead
B—Rectifier
C—Voltage Regulator

Continued on next page RG,RG34710,8311 –19–15APR97–2/3



Disassemble Alternator

A—Rotor Assembly
B—Screw
C—Front Frame
D—Nut
E—Lock Washer
F—Sheave Halves
G—Spacer
H—Front Bearing
I—Retainer
J—Spacer
K—Rear Bearing

NOTE: Front bearing (H) and rear bearing (K) are press fit. Remove bearings only if necessary.

10. Disassemble and inspect parts (A—K). Replace as necessary.

11. If needed, remove bearing (H) using a Bushing, Bearing, and Seal Driver Set. Remove bearing (K) using a knife-edge puller.

12. Inspect the rotor slip rings for dirt build-up, rough spots, or out of roundness. If necessary, polish the surface of the slip rings using No. 00 sandpaper or 400-grit silicon carbide paper.

13. Inspect stator for defective insulation, discoloration or a burned odor. If any of these defects are found, replace stator.

14. Measure length of brushes. Replace if less than minimum.

Specification

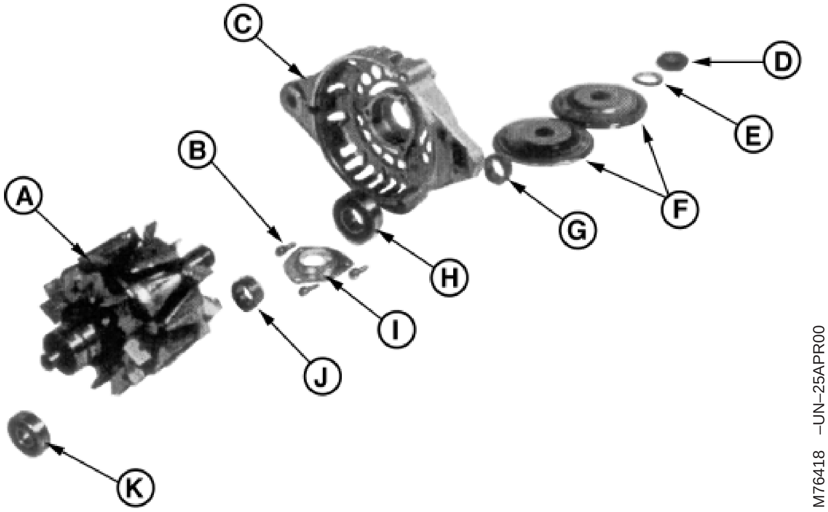
Alternator Brush—3012, 3015 and 4020 (Hitachi Equipped)—Length .... 5.50 mm (0.220 in.) minimum

15. Test components. (See TEST ALTERNATOR—3012, 3015 AND 4020 (HITACHI 40-AMP) in Section 04, Group 150.)

16. If stator is to be replaced, disconnect three stator wires from the rectifier using a soldering gun with at least 120 watt capacity.

RG,RG34710,8311 –19–15APR97–3/3

Assemble Alternator—3012, 3015 and 4020 (Hitachi 40-Amp)



Assemble Rotor Components

A—Rotor Assembly
B—Screw
C—Front Frame
D—Nut
E—Lock Washer
F—Sheave Halves
G—Spacer
H—Front Bearing
I—Retainer
J—Spacer
K—Rear Bearing

1. Assemble parts (A—K).

Continued on next page OUO1083,000068B –19–18MAY04–1/2

IMPORTANT: Be sure stator lead wires do not contact end frame (B) when installed.

NOTE: If additional solder is needed, use ONLY 60-40 rosin-core solder.

2. If stator was removed, bend the stator lead wires, as necessary, to obtain an approximate distance of 33.50 mm (1.300 in.) from stator to rectifier.

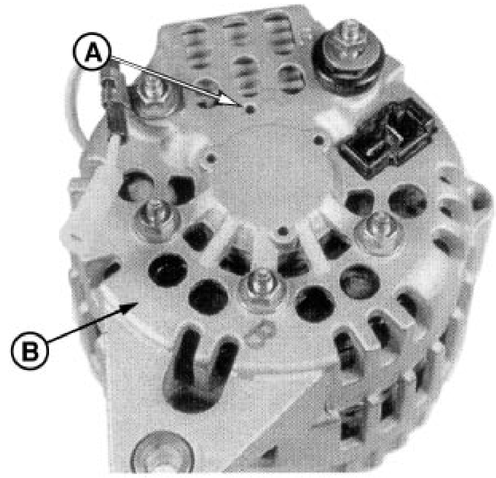
3. Connect the stator leads to rectifier using a soldering gun with at least 120 watt capacity.

4. Before assembling stator assembly to rotor assembly, push brushes into brush holder and insert a wire through access hole (A) to lock brushes in place.

5. Use alignment marks made on alternator during disassembly to aid in assembly.

6. Assemble rotor assembly to stator assembly and fasten with three attaching screws. Remove wire from access hole.

7. Install alternator to engine. (See REMOVE AND INSTALL ALTERNATOR in this group.)



M76420 –UN–25APR00

Assemble Alternator

A—Access Hole
B—End Frame

OUO1083,000068B –19–18MAY04–2/2

Replace Fuel Shut-Off Solenoid

1. Before replacing fuel shut-off solenoid, perform solenoid test. (See TEST FUEL SHUTOFF SOLENOID AMPERAGE—3011 AND 3012 in Section 04, Group 150.)

2. If replacement is necessary, disconnect wiring connector and remove mounting hardware.

3. On Model 4TNE98, disconnect breather tube on solenoid.

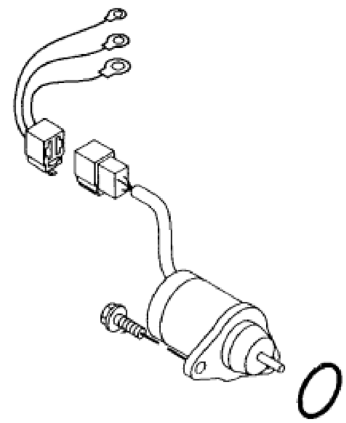
   On Models 3011 and 3012, disconnect linkage from solenoid.

4. If equipped with seal, replace seal. Install new solenoid.

5. Install mounting hardware and connect wiring connector.

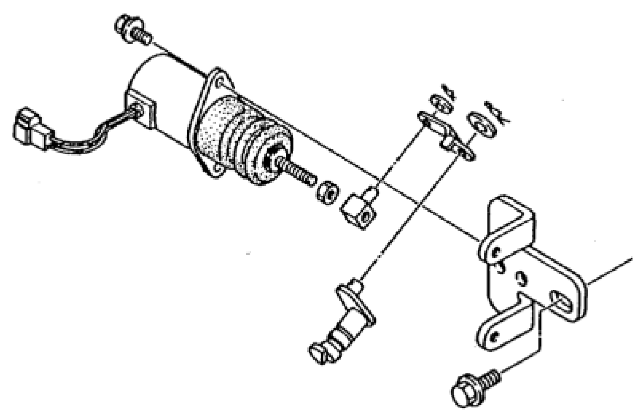
6. On Model 4TNE98, connect breather tube.

   On Models 3011 and 3012, connect linkage.



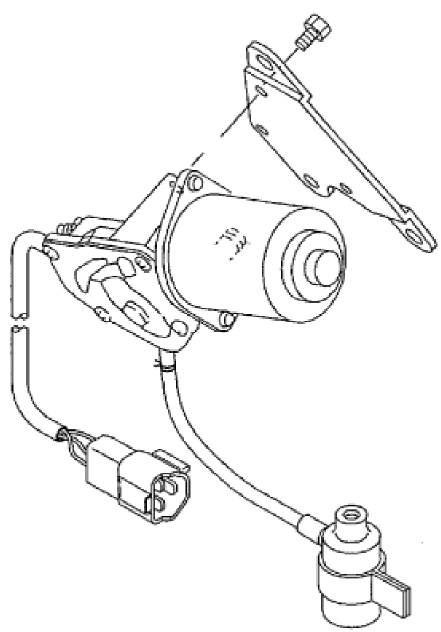
RG8594 –UN–12JUN00

Models 3009, 3013, 3015, 3016 and 4020



RG8595A –UN–08JUN00

Models 3011 and 3012



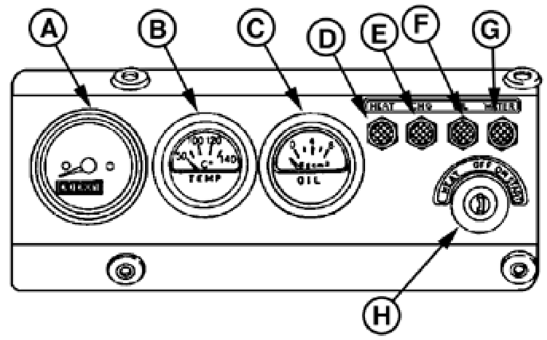
RG8596 –UN–12JUN00

Model 4TNE98

RG,RG34710,8312 –19–15APR97–1/1

Instrument Panel Components—3009, 3011, 3012, 3015 and 4020

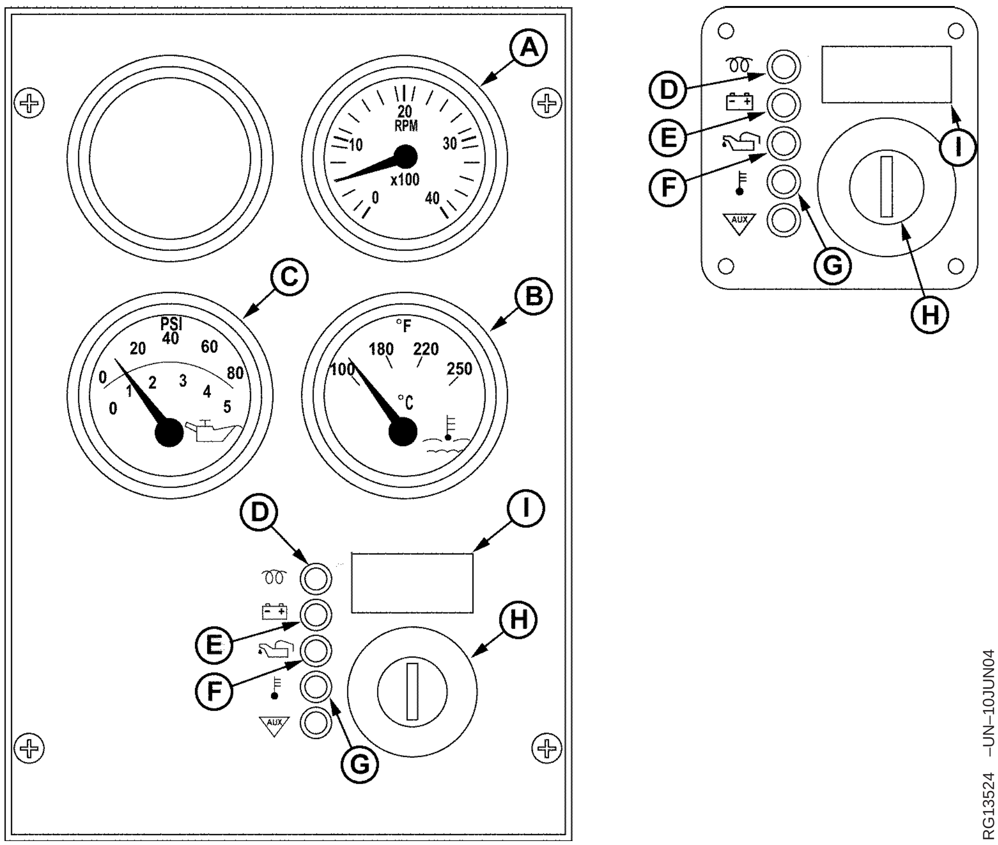
A—Tachometer/Hour Meter (Optional)
B—Coolant Temperature Gauge (Optional)
C—Oil Pressure Gauge (Optional)
D—Preheat Indicator
E—Charge Indicator
F—Oil Pressure Indicator
G—Coolant Temperature Indicator
H—Key Switch



Instrument Panel Components—3009, 3011, 3012, 3015 and 4020

RG,RG34710,8313 –19–15APR97–1/1

Instrument Panel Components—3013 and 3016

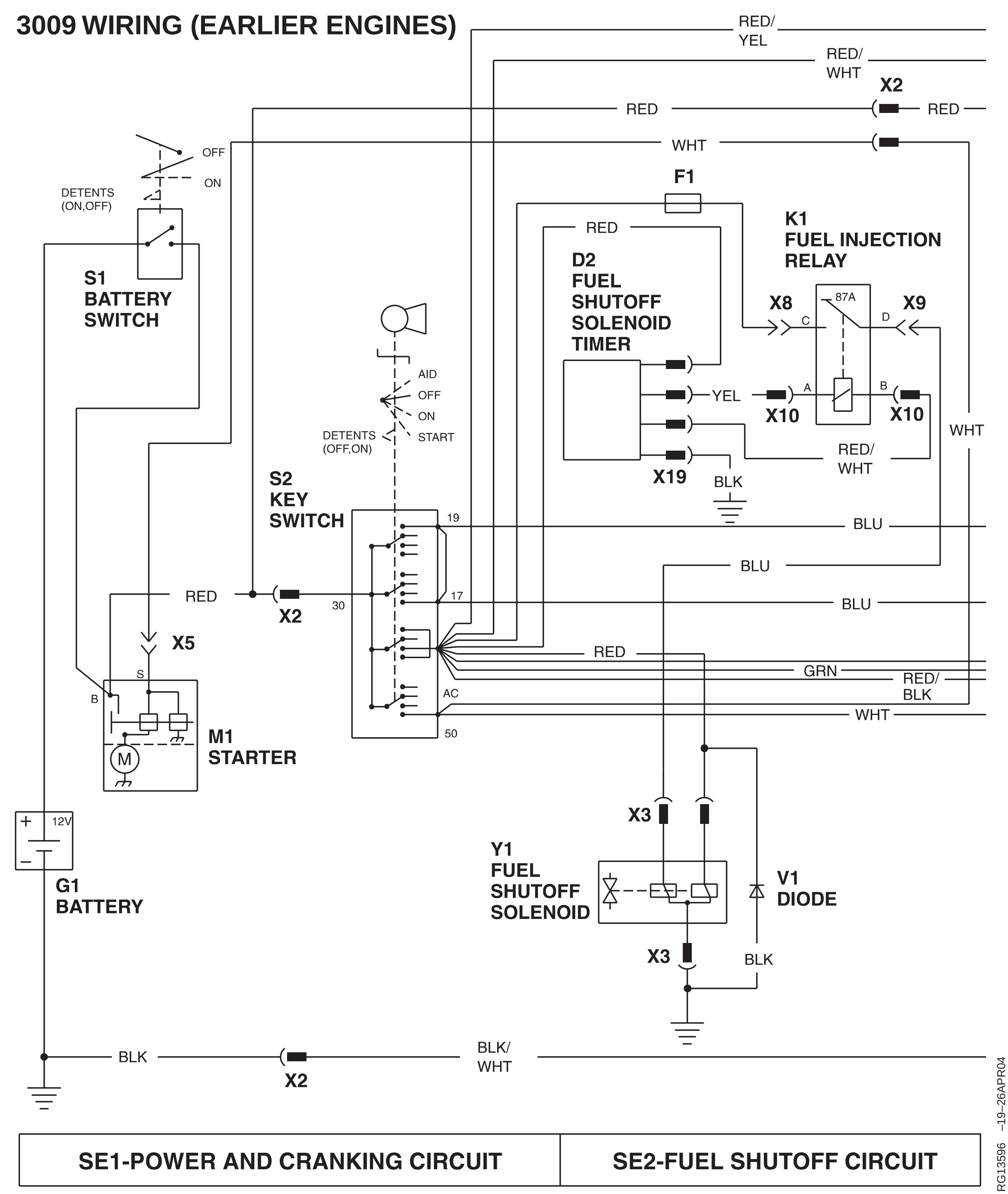


Instrument Panel Components—3013 and 3016—Full-Featured Panel on Left; Basic Panel on Right

A—Tachometer
B—Coolant Temperature Gauge
C—Oil Pressure Gauge
D—Preheat Indicator Lamp
E—Charge Indicator Lamp
F—Oil Pressure Indicator Lamp
G—Coolant Temperature Indicator Lamp
H—Key Switch
I—Hour Meter (Optional)

OUO1089,000029D –19–21APR04–1/1

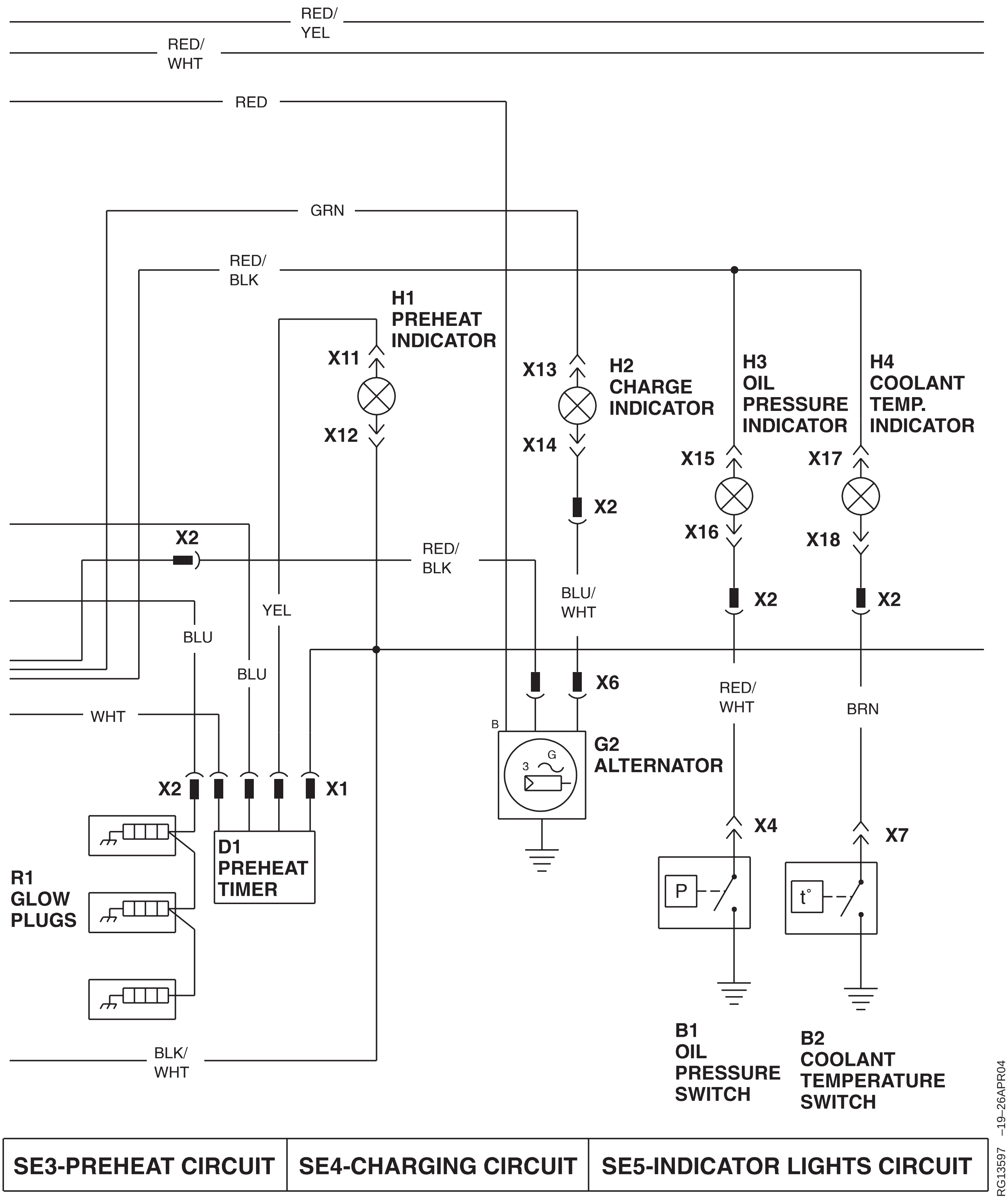
Electrical Schematic—3009 (Earlier Engines)



3009 Wiring—Earlier Engines (Page 1 of 3)

Continued on next page

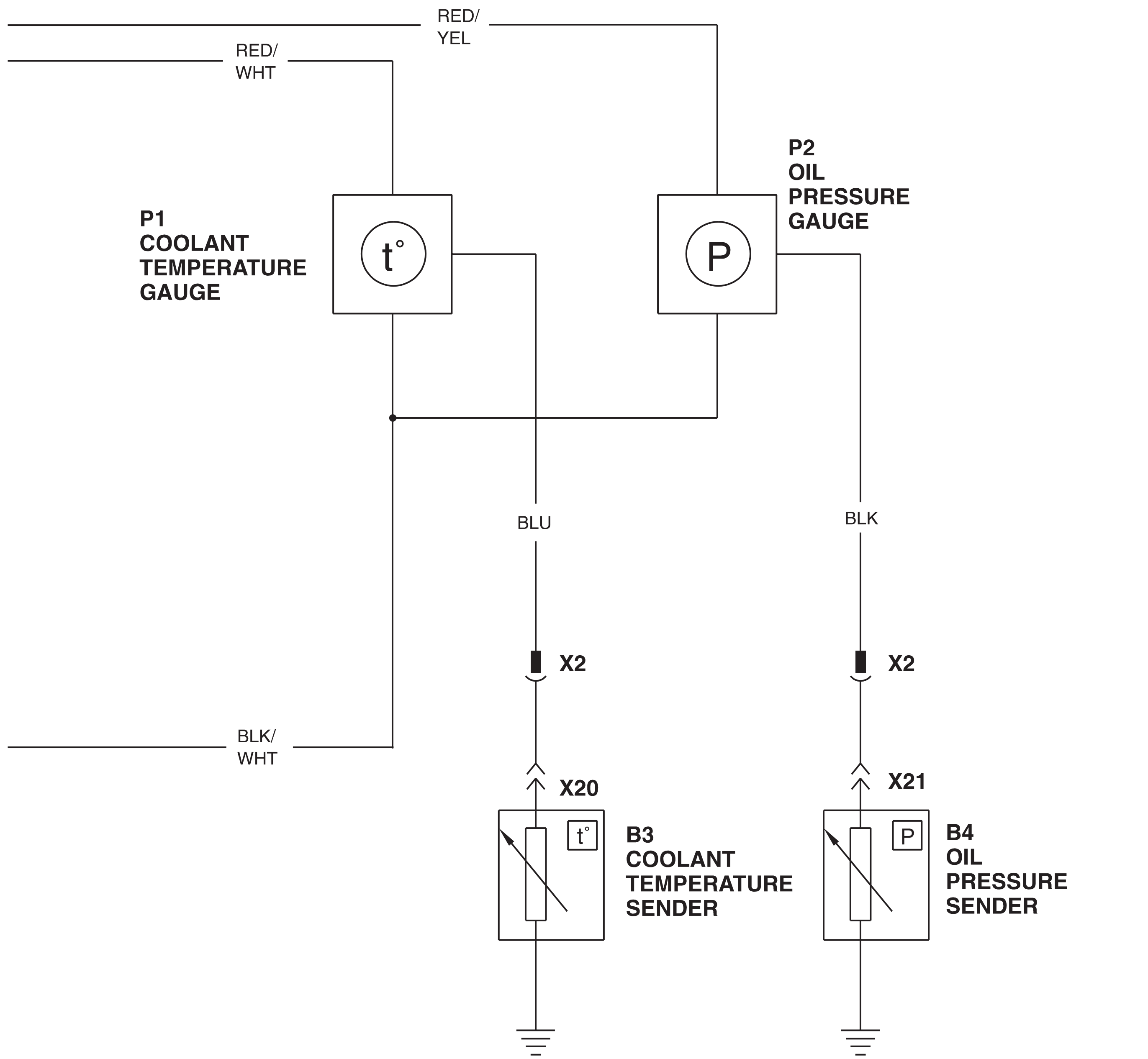
RG,RG34710,8314 –19–15APR97–1/3



3009 Wiring—Earlier Engines (Page 2 of 3)

Continued on next page

RG,RG34710,8314 –19–15APR97–2/3



SE6-OPTIONAL EQUIPMENT CIRCUITS

3009 Wiring—Earlier Engines (Page 3 of 3)

RG,RG34710,8314 –19–15APR97–3/3

Legend for Electrical Schematic—3009 (Earlier Engines)

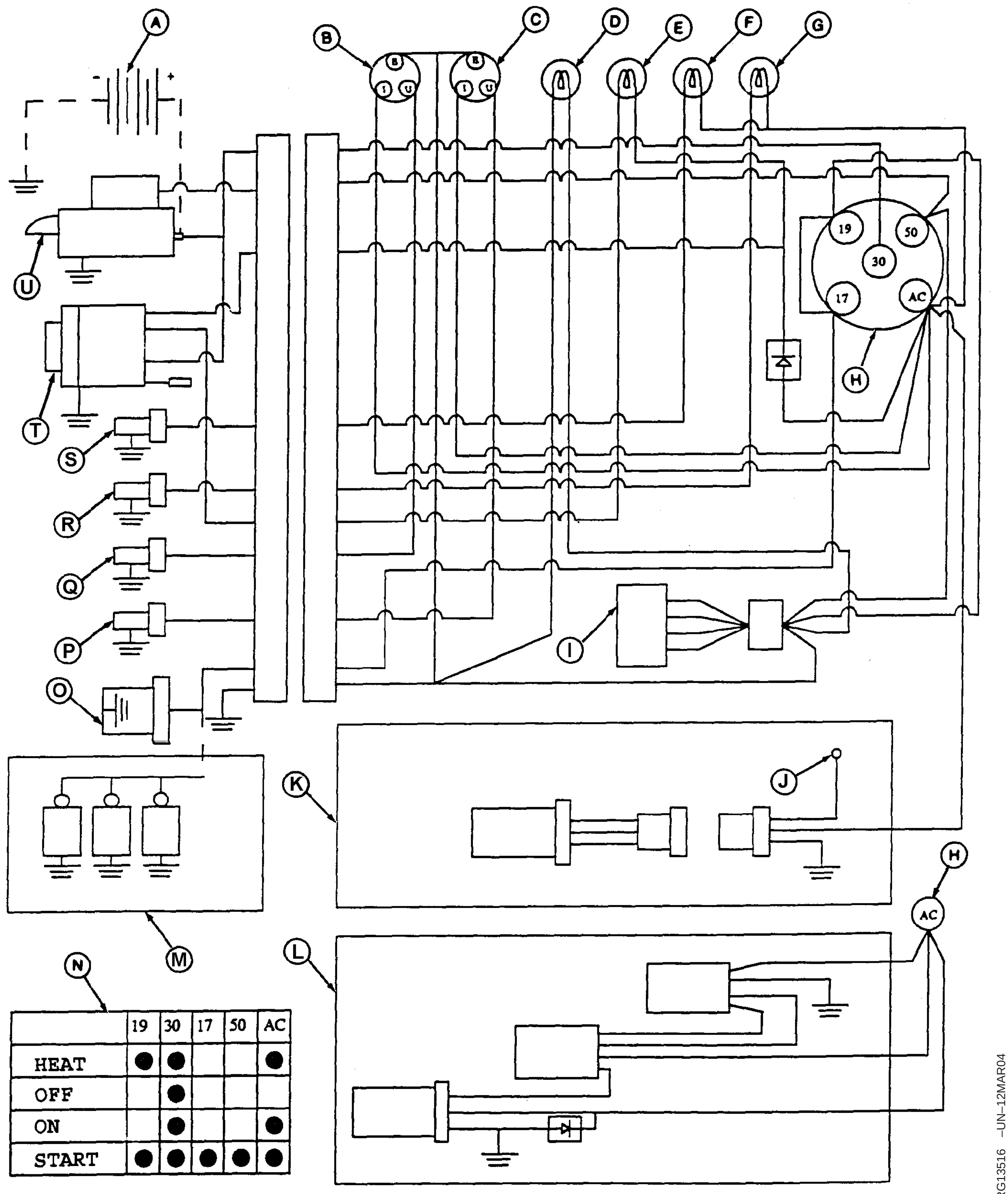
Legand for Electrical Schematic—3009 (Earlier Engines)

B1	Oil Pressure Switch	X1	4-Wire Connector, at Preheat Timer
B2	Coolant Temperature Switch	X2	10-Wire Connector, Main Harness-to-Instrument Panel
B3	Coolant Temperature Sender (Optional)	X3	3-Wire Connector, at Fuel Shutoff Solenoid
B4	Oil Pressure Sender (Optional)	X4	1-Wire Bullet Connector, at Oil Pressure Switch
D1	Preheat Timer	X5	1-Wire Connector, at Starter
D2	Fuel Shutoff Solenoid Timer	X6	2-Wire Connector, at Alternator
F1	30-amp Fuse	X7	1-Wire Bullet Connector, at Coolant Temperature Switch
G1	12-Volt Battery	X8	1-Wire Connector, Fuel Injection Relay-to-Fuse
G2	Alternator	X9	1-Wire Connector, at Fuel Injection Relay-to-Shutoff Solenoid
H1	Preheat Indicator	X10	2-Wire Connector, at Fuel Injection Relay
H2	Charge Indicator	X11	1-Wire Bullet Connector, Preheat Indicator Positive Lead
H3	Oil Pressure Indicator	X12	1-Wire Bullet Connector, Preheat Indicator Negative Lead
H4	Coolant Temperature Indicator	X13	1-Wire Bullet Connector, Charge Indicator Positive Lead
K1	Fuel Injection Relay	X14	1-Wire Bullet Connector, Charge Indicator Negative Lead
M1	Starter	X15	1-Wire Bullet Connector, Oil Pressure Indicator Positive Lead
P1	Coolant Temperature Gauge (Optional)	X16	1-Wire Bullet Connector, Oil Pressure Indicator Negative Lead
P2	Oil Pressure Gauge (Optional)	X17	1-Wire Bullet Connector, Coolant Temperature Indicator Positive Lead
R1	Glow Plugs	X18	1-Wire Bullet Connector, Coolant Temperature Indicator Negative Lead
S1	Battery Switch	X19	4-Wire Connector, at Fuel Shutoff Solenoid Timer
S2	Key Switch	X20	1-Wire Bullet Connector, at Coolant Temperature Sender (Optional)
V1	Diode	X21	1-Wire Bullet Connector, at Oil Pressure Sender (Optional)
		Y1	Fuel Shutoff Solenoid

NOTE: The schematic shows one diode. A second diode (not shown) is installed in the harness but is not currently used.

OUO1083,0000659 –19–06MAY04–1/1

Electrical Schematic—3009 (Later Engines), 3011, 3012, 3015 and 4020



	19	30	17	50	AC
HEAT	●	●			●
OFF		●			
ON		●			●
START	●	●	●	●	●

3009 (Later Engines), 3011, 3012, 3015 and 4020 Wiring

Continued on next page

DPSG,OUOE003,211 –19–06JUL99–1/2

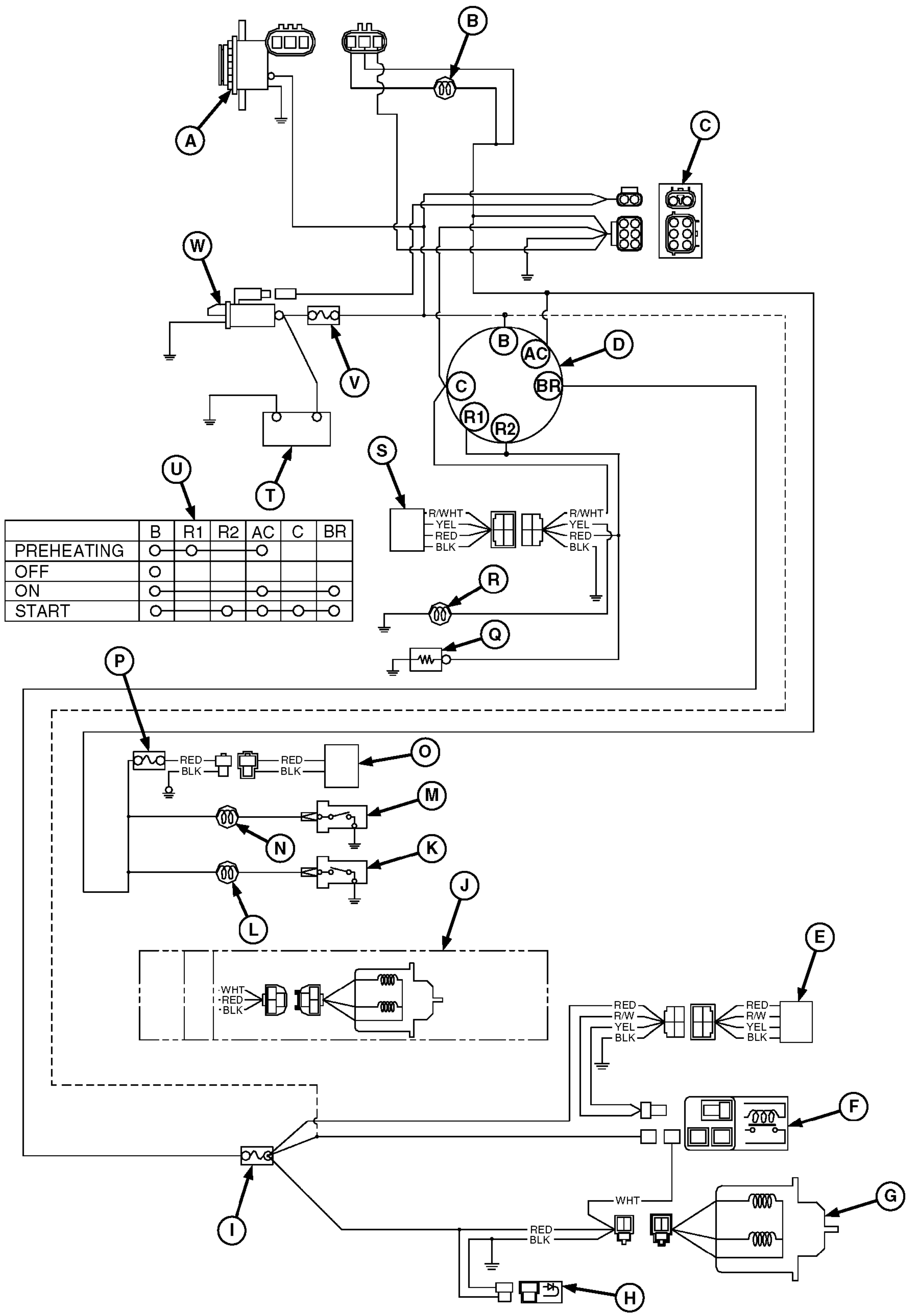
A—Battery
B—Coolant Temperature Gauge (Optional)
C—Oil Pressure Gauge (Optional)
D—Pre-Heat Lamp
E—Charge Lamp
F—Oil Pressure Lamp
G—Coolant Temperature Lamp
H—Key Switch
I—Pre-Heat Timer
J—Connect to Starter "M" Terminal
K—Shut-off Solenoid[1]
L—Shut-off Solenoid[2]
M—Glow Plugs[2]
N—Key Switch Connections
O—Air Heater[1]
P—Oil Pressure Sender (Optional)
Q—Coolant Temperature Sender (Optional)
R—Coolant Temperature Switch
S—Oil Pressure Switch
T—Alternator
U—Starter Motor

[1] *Used on all engines except 3009D.*

[2] *Used on 3009D engines only.*

DPSG,OUOE003,211 –19–06JUL99–2/2

Electrical Schematic—3013 and 3016



	B	R1	R2	AC	C	BR
PREHEATING	O	O		O		
OFF	O					
ON	O			O		O
START	O		O	O	O	O

RG13621 –UN–24MAY04

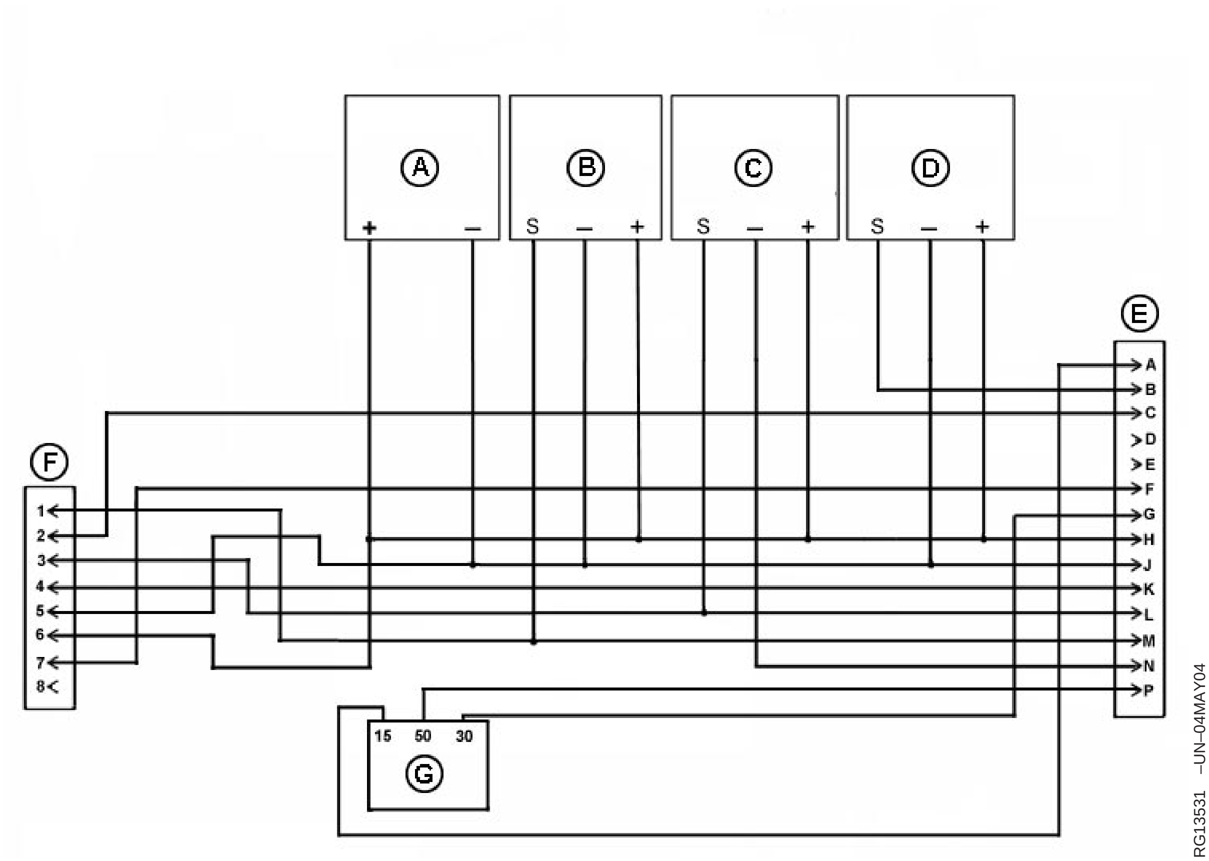
Electrical Schematic—3016 and 3016

Continued on next page OUO1083,0000686 –19–17MAY04–1/2

A—Alternator
B—Charge Lamp
C—Safety Relay
D—Key Switch
E—Timer, Fuel Solenoid
F—Relay, Fuel Solenoid
G—Fuel Solenoid (Standard)
H—Diode
I—Fuse, Fuel Solenoid (20 Amp)
J—Fuel Solenoid (Waterproof)
K—Switch, Engine Coolant Overheat
L—Pilot Lamp, Engine Coolant Overheat
M—Switch, Low Oil Pressure
N—Pilot Lamp, Low Oil Pressure
O—Fuel Supply Pump
P—Fuse, Fuel Pump (5 Amp)
Q—Preheater
R—Pilot Lamp, Preheater
S—Timer, Preheater
T—Battery, 12 V
U—Key Switch Positions
V—Fuse Link
W—Starter Motor

OUO1083,0000686 –19–17MAY04–2/2

Instrument Panel Schematic—3013 and 3016

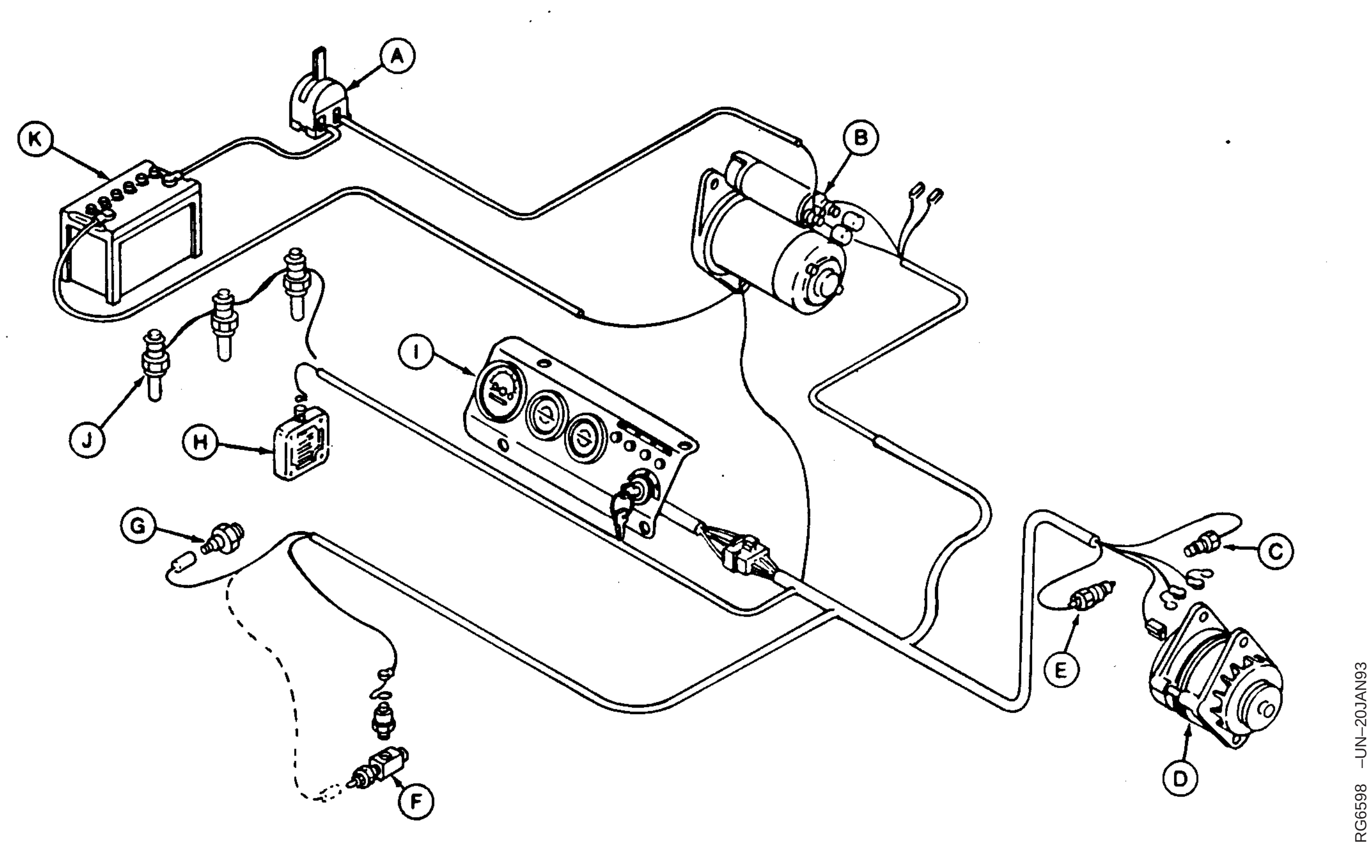


Instrument Panel (Full-Featured) Schematic—3013 and 3016

A—Voltmeter (Optional)
B—Oil Pressure Gauge
C—Coolant Temperature Gauge
D—Tachometer
E—Instrumet Panel-to-Engine Harness Connector
F—Circuit Board Connector
G—Key Switch

OUO1089,000029C –19–20APR04–1/1

Electrical System Wiring Diagram (Typical)—3009, 3011, 3012, 3015, 4020 and 4TNE98

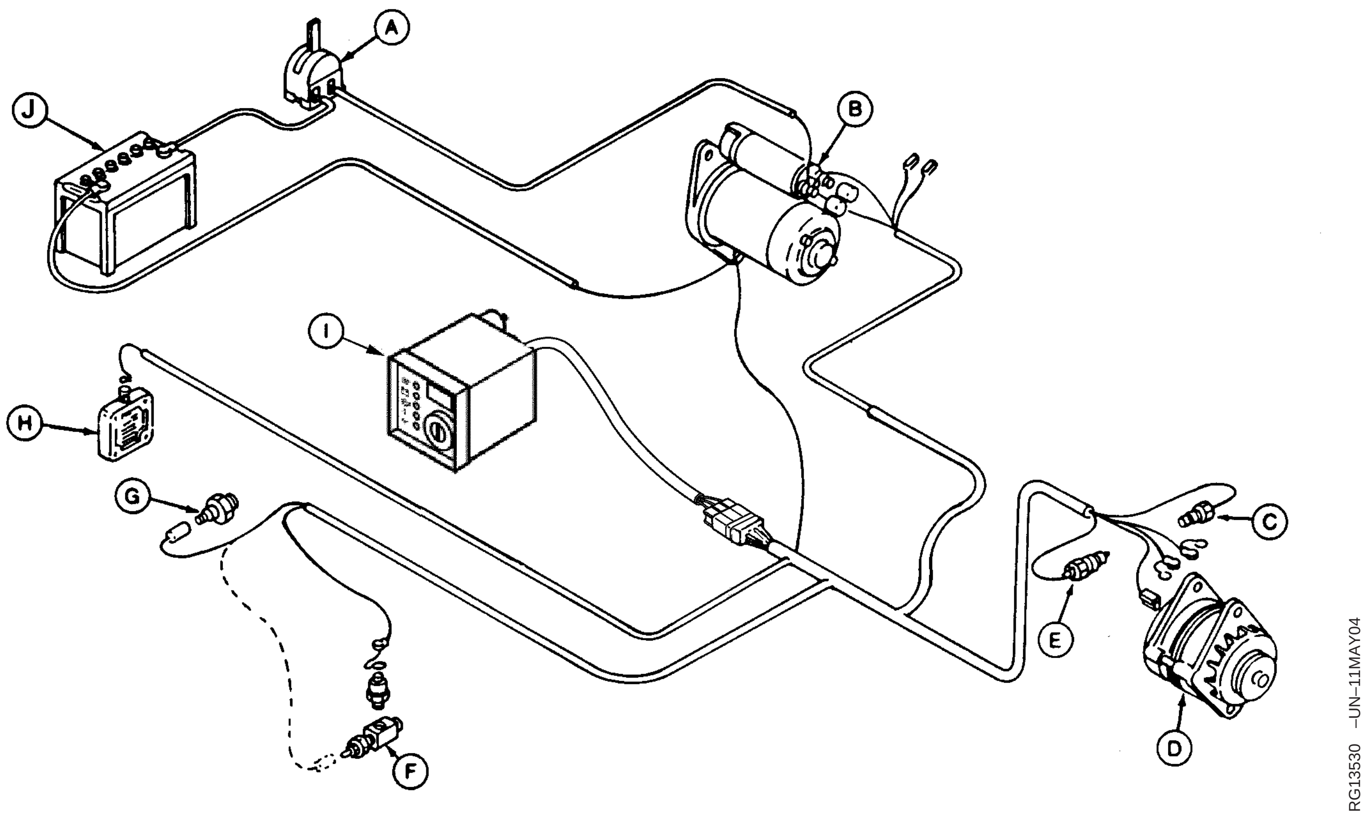


3009, 3011, 3012, 3015, 4020 and 4TNE98 (Typical)

A—Battery Disconnect Switch (Optional)
B—Starting Motor
C—Coolant Temperature Sender Unit (Optional)
D—Alternator
E—Coolant Temperature Switch
F—Oil Pressure Sender Unit (Optional)
G—Oil Pressure Switch
H—Air Heater (All except 3009)
I—Instrument (Gauge) Panel
J—Glow Plugs (3009 only)
K—Battery

RG,RG34710,8320 –19–15APR97–1/1

Electrical System Wiring Diagram (Typical)—3013 and 3016



3013 and 3016 (Typical)

A—Battery Disconnect Switch (Optional)
B—Starting Motor
C—Coolant Temperature Sensor (Optional)
D—Alterantor
E—Coolant Temperature Switch
F—Oil Pressure Sending Unit (Optional)
G—Oil Pressure Switch
H—Air Pre-Heater
I—Instrument Panel (Basic Panel Shown)
J—Battery

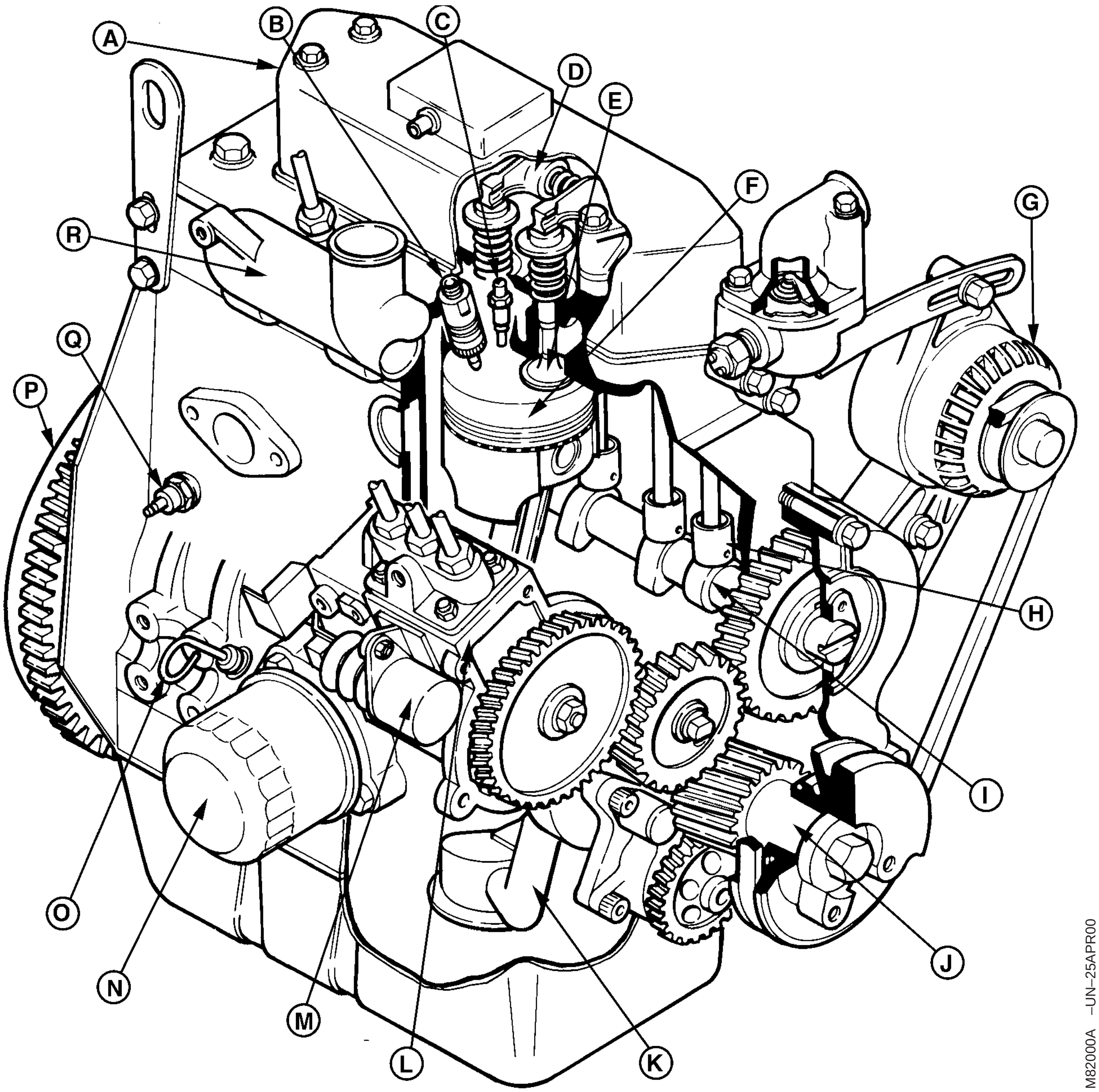
OUO1089,00002A4 –19–22APR04–1/1

Section 03
Theory of Operation

Contents

03

Component Location—3009



A—Rocker Arm Cover
B—Fuel Injector
C—Glow Plug
D—Rocker Arm
E—Valves
F—Piston
G—Alternator
H—Tappets
I—Camshaft
J—Crankshaft
K—Oil Sump
L—Fuel Injection Pump
M—Fuel Shutoff Solenoid
N—Oil Filter
O—Oil Dipstick
P—Flywheel
Q—Oil Pressure Switch
R—Intake Manifold

DPSG,OUOE003,212 –19–06JUL99–1/1

General Description—3009

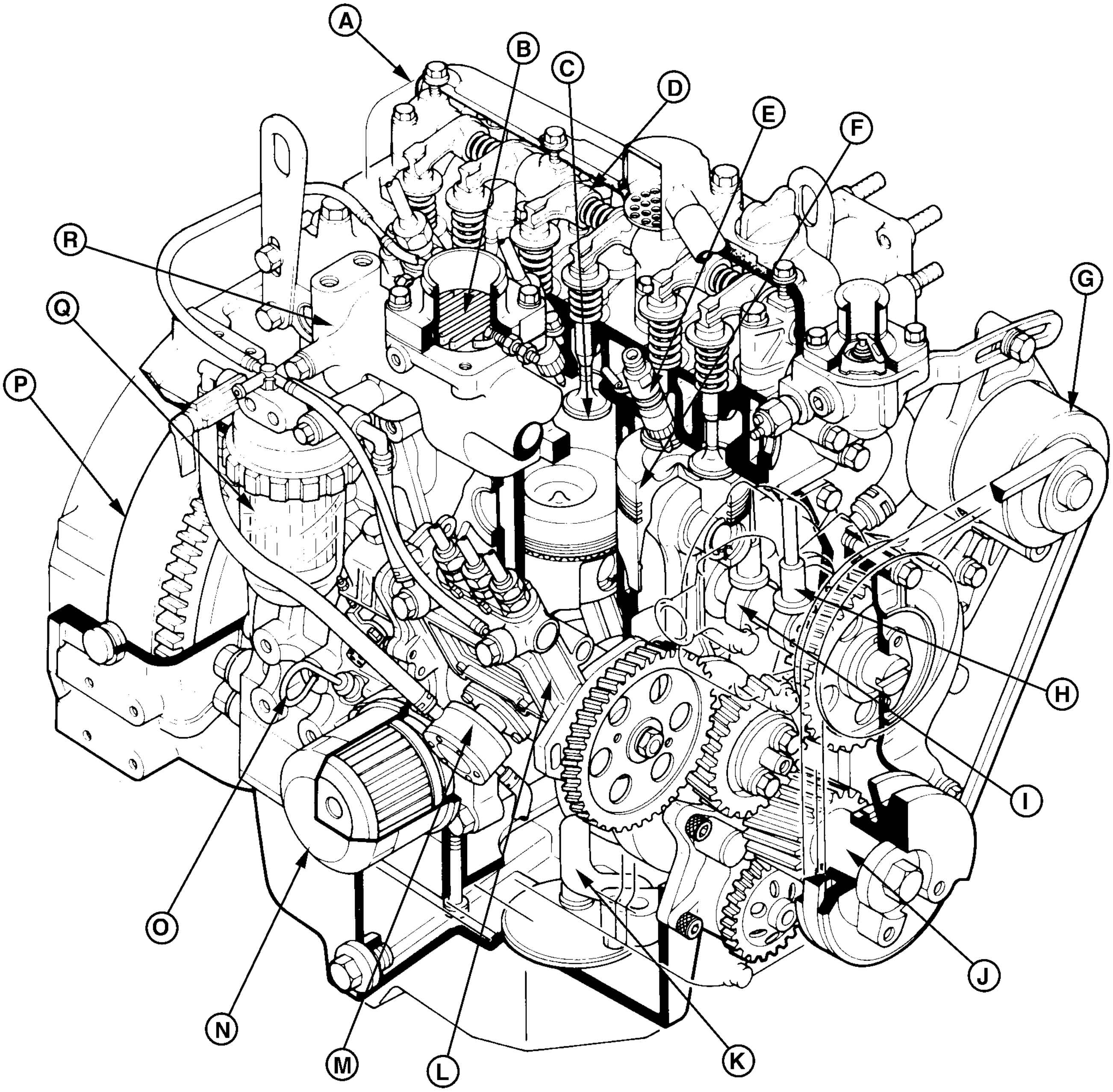
The 3009 engine is a compact 3-cylinder diesel. It is available as a base engine, an industrial power unit, or a generator drive power unit.

The major components of the 3009 engine are shown in the cutaway view.

The 3009 has an indirect fuel injection system with precombustion chambers.

RG,RG34710,8339 –19–15APR97–1/1

Component Location—3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98



M82001A –UN–23MAR00

A—Rocker Arm Cover
B—Heater Element
C—Valves
D—Rocker Arm
E—Fuel Injector
F—Piston
G—Alternator
H—Tappets
I—Camshaft
J—Crankshaft
K—Oil Sump
L—Fuel Injection Pump
M—Fuel Shutoff Solenoid
N—Oil Filter
O—Oil Dipstick
P—Flywheel
Q—Fuel Filter
R—Intake Manifold

DPSG,OUOE003,213 –19–22APR04–1/1

General Description—3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98

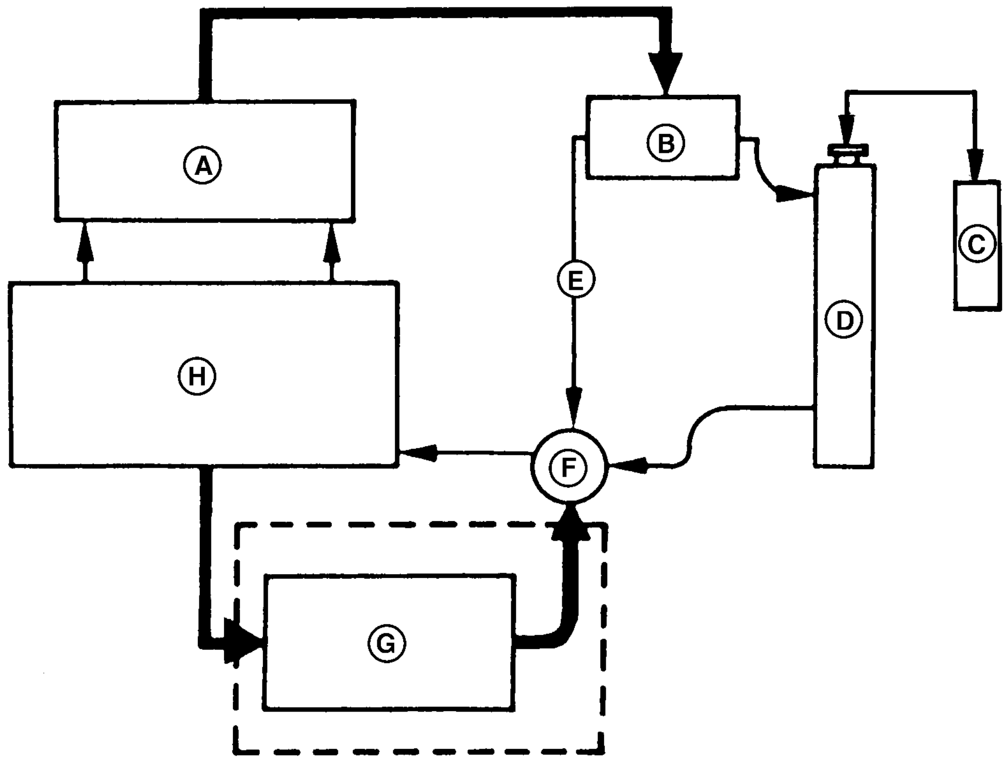
These engines are compact 3- and 4-cylinder in-line diesels. They are available as base engines, industrial power units, or generator drive power units. (4TNE98 is available only as a base engine.)

The major components of the engines are shown in the cutaway view.

These engines have a direct injection fuel system with the fuel injected into the cylinder head above the pistons.

RG,RG34710,8340 –19–15APR97–1/1

Cooling System Operation



M82003A –UN–25APR00

A—Cylinder Head
B—Thermostat Housing
C—Coolant Recovery Tank
D—Radiator
E—Bypass Tube
F—Coolant Pump
G—Oil Cooler (3016 and 4020T)
H—Cylinder Block

The coolant pump circulates coolant through the cooling system, drawing hot coolant from the engine block, circulating it through the radiator for cooling.

The pressurized cooling system includes the radiator, water pump, fan and thermostat.

During the warm-up period, the thermostat remains closed and coolant is directed through a bypass tube to the suction side of the coolant pump. The coolant circulates continuously through the cylinder block, cylinder head, thermostat housing, and water pump providing a fast warm-up period.

Once the engine has reached operating temperature, (82°C (180°F) the thermostat opens and coolant passes through the housing into the top of the radiator.

Coolant flows through the radiator to dissipate heat and is then pumped from the bottom of the radiator via the lower radiator hose into the cylinder block. Here it circulates through the block and around the cylinders.

From the block, coolant is then directed through the cylinder head, and into thermostat housing.

When coolant system pressure exceeds 48 kPa (7 psi), a valve in the radiator cap opens to allow coolant to discharge into the coolant recovery tank.

When temperature is reduced, a vacuum is produced in the radiator and coolant is drawn back out of the coolant recovery tank through a valve in the radiator cap.

Continued on next page

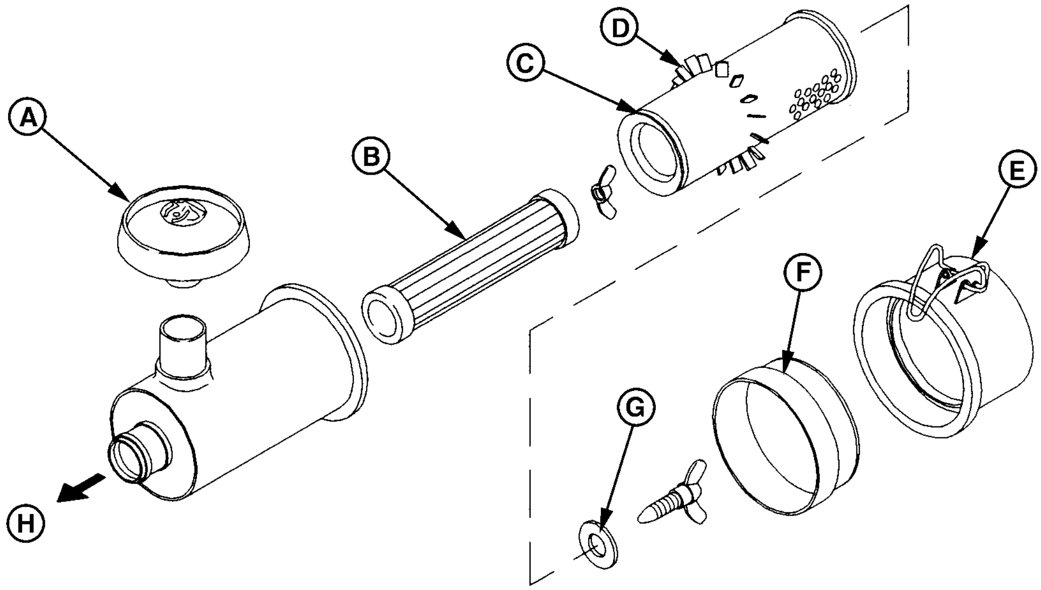
OUO1020,00013EA –19–22APR04–1/2

Models 3016 and 4020T are equipped with an oil cooler to help reduce the temperature of the engine oil. Pressurized oil enters the oil cooler and passes through a network of tubing surrounded by engine coolant. Heat transfers from the oil to the coolant, reducing oil temperature.

A coolant temperature sender senses critical coolant temperature and sends a signal to an indicator light and/or gauge on the instrument panel.

OUO1020,00013EA –19–22APR04–2/2

Air Cleaner Operation



M82007AE –UN–25APR00

Typical Air Cleaner Components

A—Rain Cap
B—Secondary Safety Element
C—Primary Element
D—Fins
E—Dust Pan Assembly
F—Baffle
G—Seal Washer
H—To Intake Manifold

The air cleaner filters the air needed for combustion.

Model 3009

Air enters the air cleaner inlet and is directed into the side of a metal shield. This starts a high-speed centrifugal motion of air which continues around the element until it reaches the far end of the air cleaner housing, to an unloader valve.

Most of the dust is separated from the air by centrifugal force that causes heavy dust particles to enter the opening at the top of the unloader valve. The remaining air enters the element.

The dirt that is deposited in the unloader valve is removed by the rubber diaphragm at the base of the unloader valve. When the engine is running, a pulsing action is created in the intake system by each intake stroke of the engine. This pulsing action causes the rubber diaphragm to open and close, thus emptying the unloader valve.

Models 3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98

Air enters the air cleaner inlet and is forced into a high-speed centrifugal motion by fins on the primary element. When the air reaches the end of the air cleaner housing, the dirt passes through a slot in the top of the dust pan assembly.

Most of the dust is separated from the air by centrifugal force that causes the heavy dust particles to enter the opening at the top of the dust pan assembly. The remaining air enters the primary element, then secondary safety element to cylinder head.

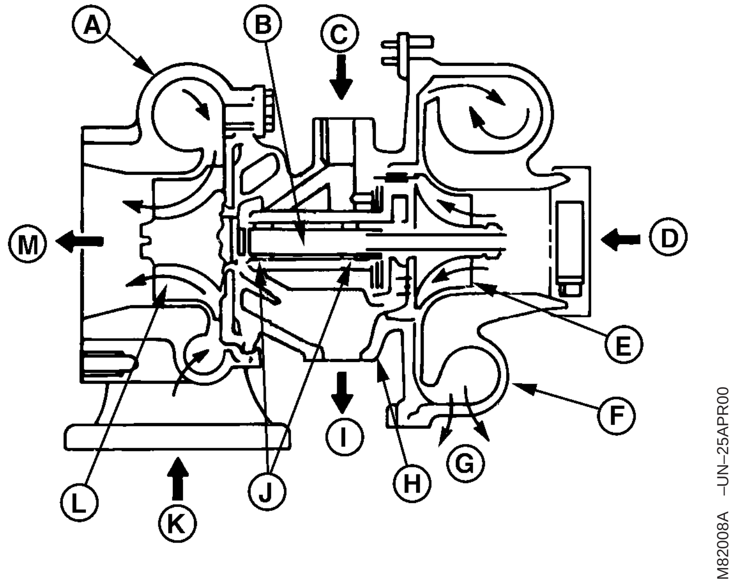
Continued on next page

RG,RG34710,8342 –19–22APR04–1/2

Remove the baffle to empty dust pan assembly. Dust pan should be emptied daily.

RG,RG34710,8342 –19–22APR04–2/2

Turbocharger Operation—4020T



A—Turbo Housing
B—Shaft
C—Oil Inlet
D—From Air Cleaner
E—Compressor Wheel
F—Compressor Housing
G—To Intake Manifold
H—Center Housing
I—Oil Outlet
J—Float Bearings
K—From Exhaust Manifold
L—Turbine Wheel
M—To Muffler

The turbocharger provides additional air to burn more fuel and produce more power without increasing the size of the engine. In the thinner air of high altitudes, the turbocharger turbine wheel may turn as fast as 186,000 rpm to maintain power.

Exhaust gases from the engine pass through a turbine housing, causing a shaft to rotate before the exhaust gas is discharged.

A compressor wheel, also mounted on the shaft, rotates in the compressor housing. Inlet air is drawn into the housing, where it is compressed and delivered to engine cylinders.

Engine oil under pressure from the engine lubrication system is pumped through passages in the bearing housing and directed to the bearings.

The turbocharger contains two floating bearings that have clearance between the bearing OD and housing ID as well as a clearance between the bearing ID and the shaft OD.

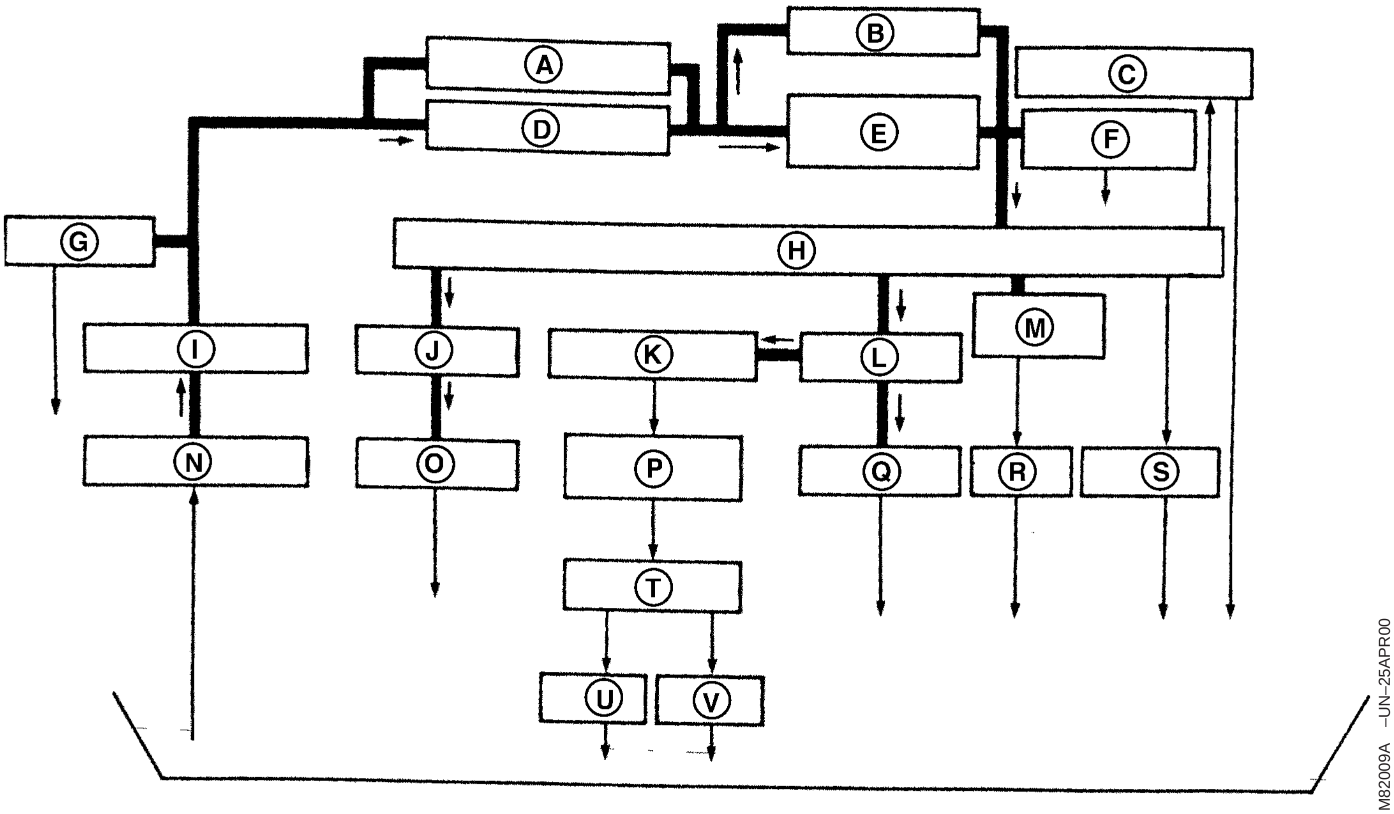
These clearances are lubricated by the oil supply and the bearings are protected by a cushion of oil.

The pressure-free oil drains by gravity from the center housing to the engine crankcase.

The turbocharger may be equipped with a waste gate. If the turbocharger boost pressure goes above specified pressure, a diaphragm sensing inlet pressure from the compressor, opens a waste gate valve to allow excess exhaust gases to bypass the turbine. The waste gate valve limits boost pressure at high rpm to prevent damage to the engine.

RG,RG34710,8344 –19–15APR97–1/1

Lubrication System Operation



A—Bypass Valve
B—Bypass Valve (3016 and 4020T)
C—Fuel Injection Pump
D—Oil Filter
E—Oil Cooler (3016 and 4020T)
F—Oil Pressure Regulating Valve
G—Safety Valve (4020T)
H—Engine Block Main Oil Galley
I—Oil Pump
J—Idler Gear Shaft
K—Camshaft Bearing
L—Crank Journal
M—Piston Cooling Nozzle (4020T)
N—Oil Strainer
O—Idler Gear Face
P—Valve Rocker Arm Shaft
Q—Crank Pin
R—Piston
S—Turbocharger (4020T)
T—Valve Rocker Arm
U—Tappet
V—Valve

The pressure lubrication system consists of a positive displacement gear-driven pump, oil strainer, full flow oil filter, oil pressure regulating valve and an electrical pressure warning switch. Models 3016 and 4020T are also equipped with an oil cooler. Model 4020T is also equipped with a safety valve and piston cooling nozzles.

The pump draws lubrication oil from the oil pan through a strainer and a suction tube. The oil is then pumped through an oil passage to the oil filter, oil cooler, if equipped, and through the engine block main oil galley.

From the main oil galley, oil is forwarded under pressure to the crankshaft main bearing journals, idler gear shaft and piston cooling nozzles, if equipped. Drilled cross-passages in the crankshaft distribute the oil from the main bearings to connecting rod bearings.

Lube oil holes in main bearing oil grooves are provided to direct oil to the camshaft bearings.

A drilled passage from the rear camshaft bearing through the cylinder block and cylinder head supplies lubricating oil to the rocker arm shaft. The hollow shaft distributes oil to the rocker arms, tappets and valves.

Continued on next page

Oil passages direct from the main oil galley, through external oil lines, route lubricating oil to the fuel injection pump and turbocharger, if equipped.

An oil pressure switch activates an indicator light to alert the operator to shut down the engine if oil pressure drops below a specification.

RG,RG34710,8346 –19–15APR97–2/2

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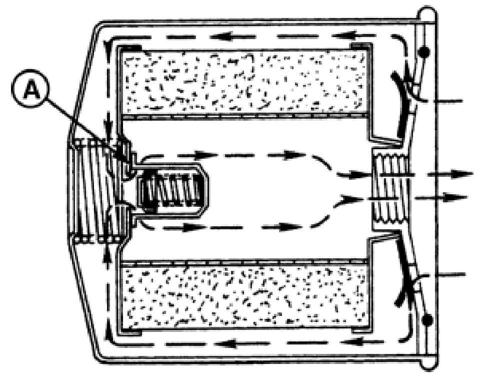
Oil Filter Operation

The replaceable spin-on oil filter screens out contaminants from the oil between oil/filter changes.

Pressurized oil is directed from the oil pump to the oil filter. Oil flows through the filter element to the main oil galley and to the engine components.

The oil filter is equipped with a bypass valve (A) to ensure adequate engine lubrication if the filter is clogged or oil viscosity is too heavy to properly flow through the filter. Bypass valve opens at 96 kPa (14 psi) pressure differential.



RG11114A –UN–08JUN00

Oil Filter Bypass Valve

A—Bypass Valve

RG,RG34710,8347 –19–15APR97–1/1

Oil Pressure Regulating Valve Operation

NOTE: On Models 3009, 3011, and 3012 the oil pressure regulating valve is located in the oil filter base.

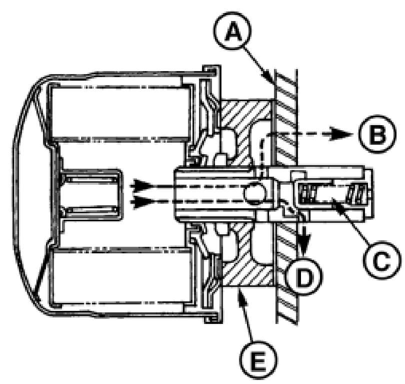
On Models 3013, 3015, 3016, 4020 and 4TNE98 the oil pressure regulating valve is located in the oil pump.

This valve regulates engine oil pressure.

Filtered oil passes through the pressure regulating valve to the main oil galley.

If oil pressure is higher than the valve is set for, a poppet spring is overcome, opening the relief valve. When opened, a passage is opened to route oil back to the crankcase.

The oil pressure regulating valve is set to maintain a pressure of 294—440 kPa (43—64 psi).



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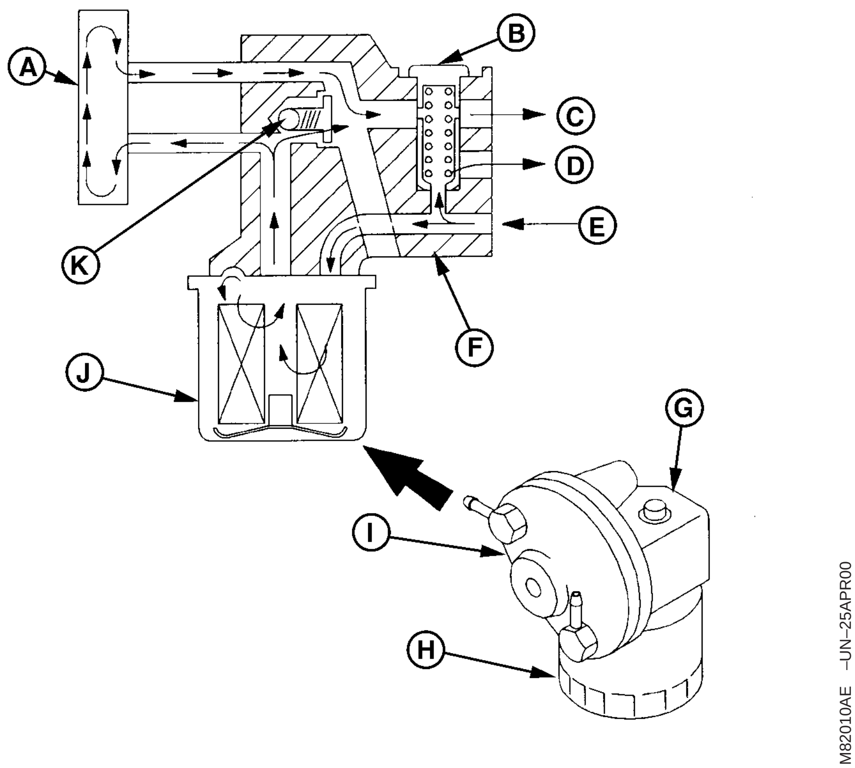
3009—3012 Shown

A—Engine
B—Filtered Oil-to-Main Galley
C—Poppet Spring
D—Filtered Oil-to-Crankcase
E—Filter Mounting Base

RG,RG34710,8348 –19–22APR04–1/1

Oil Cooler Operation—3016 and 4020T



A—Oil Cooler
B—Oil Pressure Regulating Valve
C—To Main Oil Galley
D—To Crankcase
E—From Oil Pump
F—Oil Filter Bracket
G—Oil Filter Bracket
H—Oil Filter
I—Oil Cooler
J—Oil Filter
K—Oil Cooler Bypass Valve

The oil coolers on 3016 and 4020T engines help reduce the temperature of the engine oil.

After passing through the oil filter, pressurized oil enters the oil cooler and passes through a network of tubing surrounded by engine coolant. Engine coolant from the cylinder block enters the oil cooler, where the heat from the engine oil is transferred to the engine coolant. The engine coolant is then returned to the coolant pump inlet where it is mixed with the cooler engine coolant from the radiator.

The now cooler engine oil, flows into the engine block main oil galley through the filter bracket.

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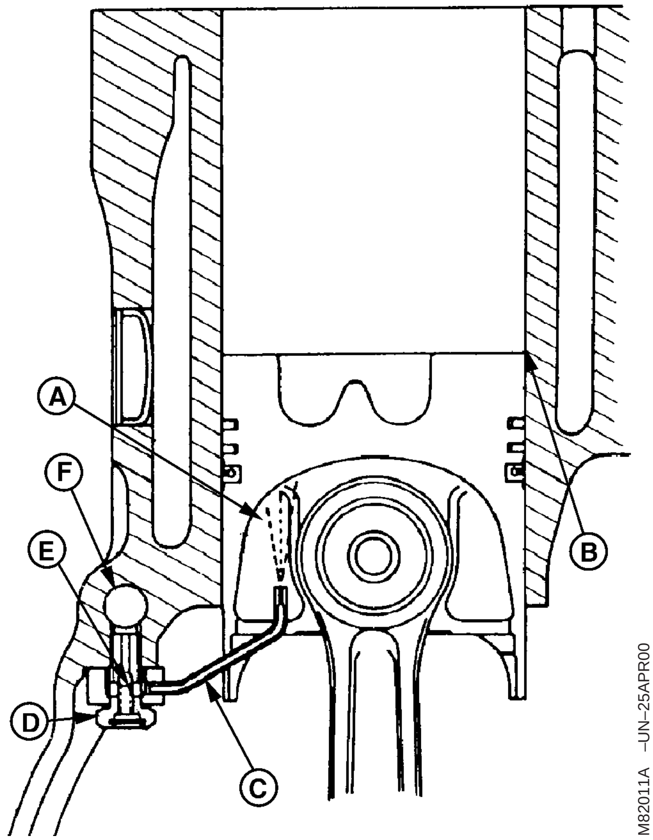
Piston Cooling Nozzle Operation—4020T



Cooling nozzles direct lube oil to underside of pistons to lower piston temperature and thermal load. Cooling the pistons also reduces thermal expansion and carbon deposits in the piston ring grooves.

Lube oil from the engine block main oil galley passes a check valve in the nozzle mounting bolt, then flows through a small steel pipe creating a jet spray. This jet spray coats the underside of the piston, cooling the piston as a whole.

The check valve's opening pressure is factory set at 148—245 kPa (21.5—35.5 psi).

The oil spray amount is 21.3 L/min (5.6 gal/min) at an oil pressure of 343 kPa (50 psi).

A—Jet Spray
B—Piston
C—Piston Cooling Nozzle
D—Nozzle Mounting Bolt
E—Check Valve
F—Engine Block Main Oil Galley

RG,RG34710,8350 –19–15APR97–1/1

Crankcase Breather Operation

The crankcase breather vents crankcase gases and water vapor out of the engine without losing engine oil, and controls the pressurization of the crankcase.

During normal engine operation, unburned fuel vapors and water vapors tend to contaminate the crankcase. Most of these vapors are expelled by the exchange of air which is controlled by the breather. The crankcase is slightly pressurized by the leakage of compression around the pistons. The air is circulated by the movement of the pistons.

3013 and 3016 engines use a spring-loaded diaphragm to maintain a pre-determined level of pressure within the crankcase. Vapors from the crankcase are routed into the intake manifold to be ingested and burned by the engine, thus reducing emissions.

When the crankcase breather assembly contains packing, wash the packing in a safe solvent and blow dry with air pressure. If packing comes apart or is deteriorated, replace it.

RG,RG34710,8351 –19–15APR97–1/1

Fuel System Operation

The fuel system supplies fuel to injection nozzles.

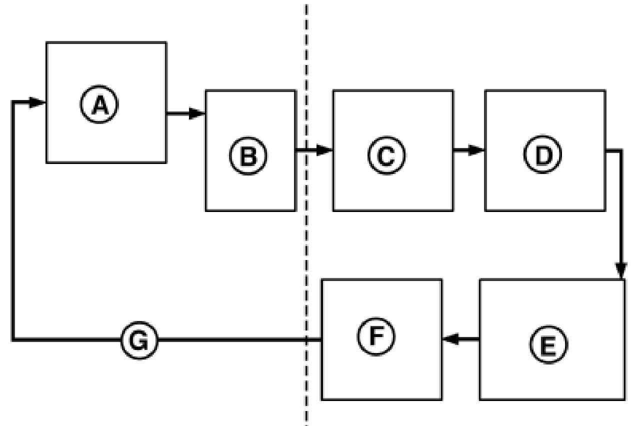
Fuel supply pump draws fuel from a vented fuel tank through a water separator and directs fuel through a fuel filter to the fuel galley of an injection pump. The injection pump meters fuel as determined by the governor and delivers it at high pressure to the injection nozzles.

The injection nozzle prevents flow until high pressure is reached, opening the valve and spraying atomized fuel into the combustion chamber. Injection lines have trapped fuel whenever injection is not taking place.

Model 3009 (Indirect Injection Engine): A small amount of fuel leaks past the nozzle valve to lubricate the fuel injection nozzle. This leakage is then returned to the fuel tank.

Models 3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98 (Direct Injection Engines): A small amount of fuel leaks past the nozzle valve to lubricate the fuel injection nozzle. This leakage combines with excess fuel from the injection pump and is returned to tank.

Any air in the fuel system is bled out with return fuel to the fuel tank.



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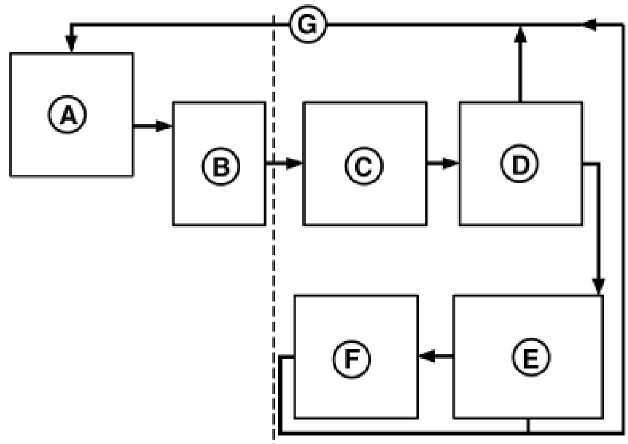
Fuel Supply (Indirect Injection)—3009



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Fuel Supply (Direct Injection)—3011, 3012, 3013, 3015, 3016, 4020, and 4TNE98

A—Fuel Tank
B—Water Trap
C—Feed Pump
D—Fuel Filter
E—Fuel Injection Pump
F—Fuel Injection Nozzle Valve
G—Return Fuel

RG,RG34710,8373 –19–15APR97–1/1

Fuel Injection Pump Operation—3009, 3011, 3012, 3015, 4020, and 4TNE98

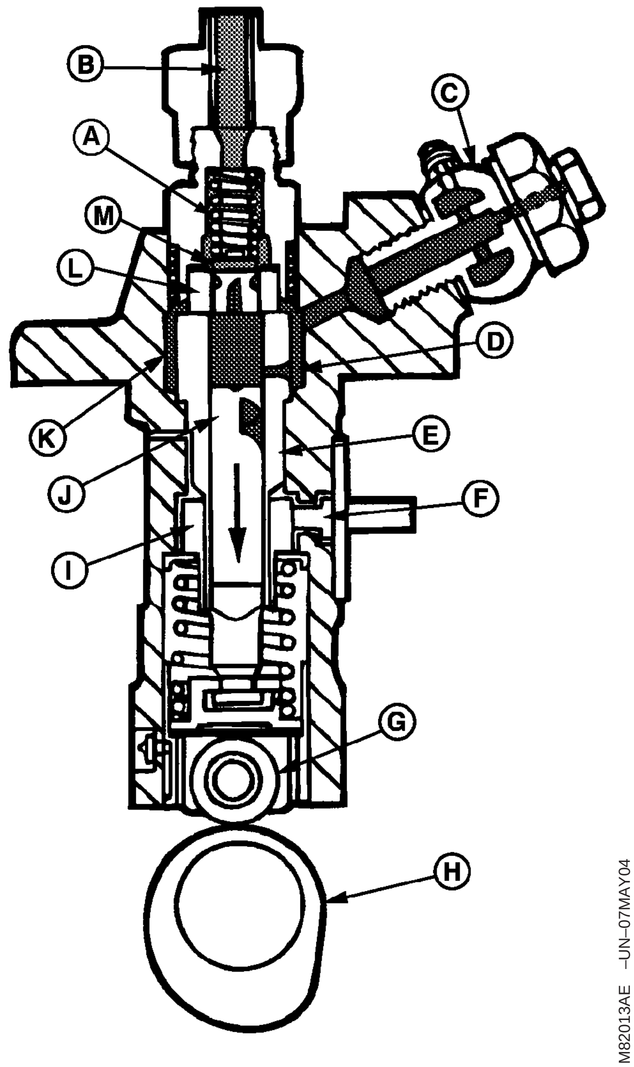
The injection pump regulates fuel flow from fuel supply pump to injectors.

Bottom of Plunger Stroke

The fuel injection pump is a variable-displacement, in-line plunger-type pump. It is located on the right side of the engine. The pump is driven by a camshaft which turns at one-half engine speed.

When the plunger is in the downward position, filtered medium-pressure fuel from the fuel supply pump flows through the fuel inlet fitting, to the fuel galley. Fuel flows from the fuel galley through the inlet orifice and fills the plunger area.

Whenever the plunger is in the downward position, the delivery valve is held closed against the valve seat, by spring pressure and trapped fuel pressure. In this position, fuel flow to the fuel injection line and nozzle is blocked.



A—Spring
B—Fuel Injection Line
C—Fuel Inlet Fitting
D—Inlet Orifice
E—Barrel
F—Control Rack
G—Roller Tappet
H—Camshaft
I—Control Sleeve
J—Plunger
K—Fuel Galley
L—Valve Seat
M—Delivery Valve

Continued on next page OUO1020,00013EB –19–23APR04–1/2

Top of Plunger Stroke

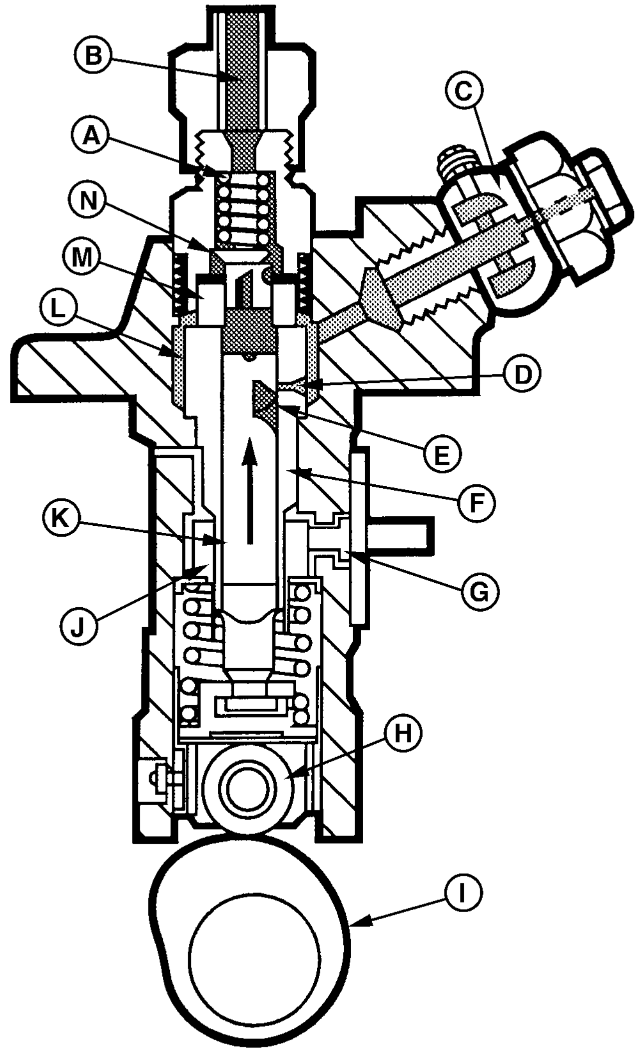
When the roller tappet is moved up by the camshaft, the inlet orifice is blocked by the plunger. Fuel in the plunger area is compressed and forced against the delivery valve.

When fuel pressure is high enough to overcome the spring, the delivery valve is lifted upward off the valve seat. High-pressure fuel flows past the delivery valve to the fuel injection line and then to the fuel injection nozzle. The delivery valve is held open only when the fuel pressure in the plunger area is greater than the delivery valve spring pressure.

As the plunger continues moving upward, the plunger helix aligns with the inlet orifice. The pressure in the plunger area is higher than the pressure in the fuel galley. This causes fuel to flow from the plunger area, through the plunger helix and inlet orifice to the fuel galley.

Fuel flow through the inlet orifice causes pressure in the plunger area to decrease. With pressure equal on both sides of the delivery valve, spring force closes the delivery valve and stops the fuel flow to injection nozzle.

A governor-operated control rack is connected to the control sleeve and plunger to regulate the quantity of fuel delivery to the nozzles. The control sleeve turns the plunger and increases or decreases the amount of plunger movement before the plunger helix and inlet orifice are aligned.



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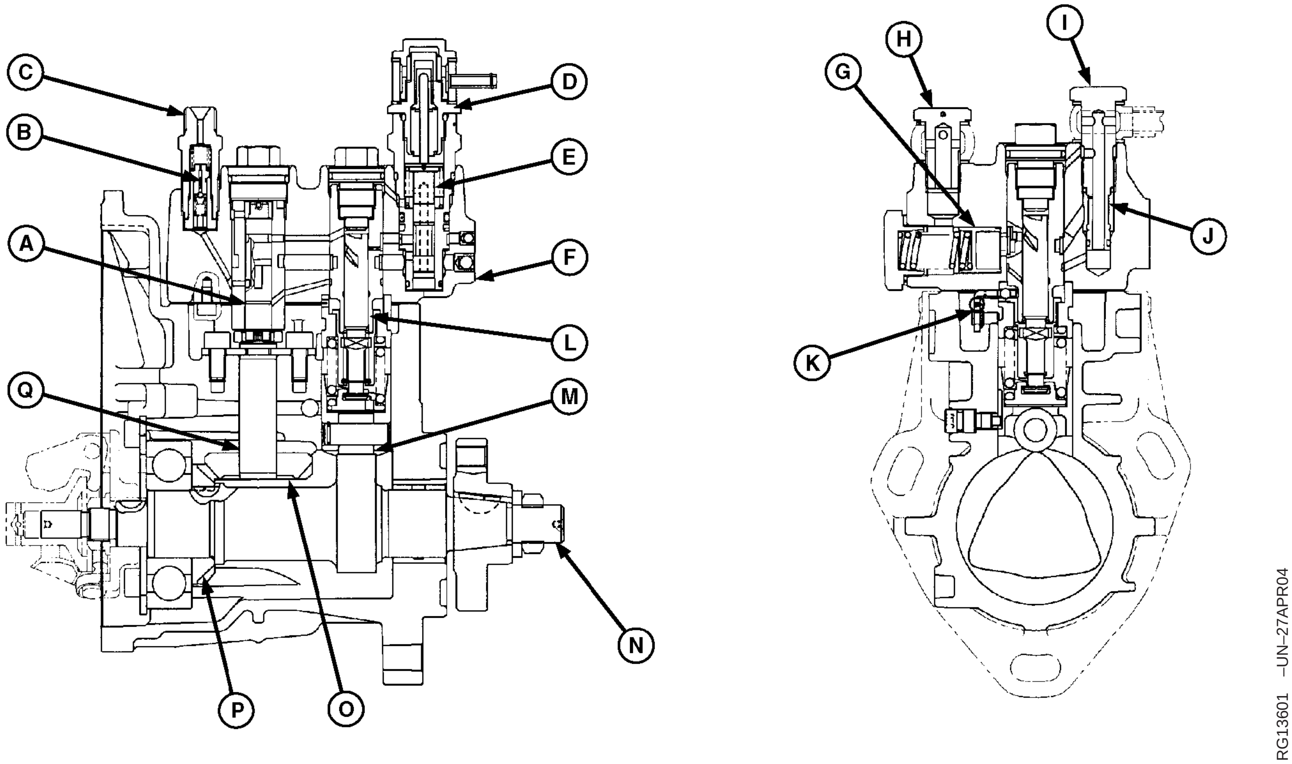
A—Spring
B—Fuel Injection Line
C—Fuel Inlet Fitting
D—Inlet Orifice
E—Plunger Helix
F—Barrel
G—Control Rack
H—Roller Tappet
I—Camshaft
J—Control Sleeve
K—Plunger
L—Fuel Galley
M—Valve Seat
N—Delivery Valve

OUO1020,00013EB –19–23APR04–2/2

Fuel Injection Pump Operation—3013 and 3016



Injection Pump Components—3013 and 3016

A—Distribution Shaft
B—Delivery Valve
C—Delivery Valve Housing
D—Thermo-Element
E—Piston
F—Head
G—Accumulator
H—Fuel Inlet
I—Fuel Return
J—Strainer
K—Control Rack
L—Plunger
M—Roller
N—Camshaft
O—Bevel Gear
P—Bevel Gear
Q—Transmission Shaft

The injection pump regulates fuel flow from fuel supply pump to injectors.

The fuel injection pump is located on the right side of the engine and is driven by the injection pump drive gear, which drives the fuel injection pump camshaft. The fuel injection pump is a single plunger-type pump which supplies fuel to each individual cylinder of the engine by means of a rotating distribution shaft.

The plunger is driven by the camshaft. As the plunger moves up and down, it feeds high-pressure fuel to the rotating distribution shaft that sends a measured amount of fuel to each cylinder delivery valve and then to each individual injection nozzle and cylinder.

For each revolution of the camshaft, three cycles (for three cylinder engines) of the fuel delivery process are completed. Each cycle consists of: medium-pressure fuel being changed to high-pressure fuel and sent to the distribution shaft by the plunger, high-pressure fuel from the distribution shaft being sent to one cylinder delivery valve, high-pressure fuel then being sent through the fuel injection line to the corresponding fuel injection nozzle and cylinder. This cycle is repeated for each engine cylinder.

A governor-operated control rack is connected to the control sleeve and plunger to regulate the quantity of fuel delivered to the nozzles under varying loads.

Continued on next page

There is also a mechanical timing controller to help optimize injection timing for performance, reduced engine noise, and exhaust gas emissions. There is also a cold start advancer that is used along with the timing controller to advance fuel injection timing during cold temperatures.

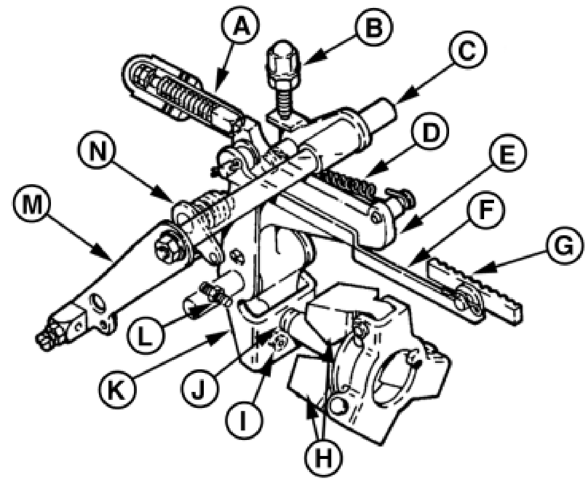
OUO1020,00013EC –19–23APR04–2/2

Governor Operation

The governor maintains a set engine speed under varying loads.

The injection pump governor is a mechanical centrifugal flyweight type. On Model 3009 (indirect injection engines), it is contained in a housing mounted to the timing gear case and is serviced separately from the injection pump. On all other engines, the governor is assembled to the injection pump and serviced with the pump. Governor internal components and operation are similar.

The flyweights are mounted on the injection pump camshaft. The flyweights move the thrust sleeve in and out with changes in engine rpm. The thrust sleeve works against a button on the governor lever. The governor lever is connected to the injection pump control rack by the fuel control link. The governor spring connects the tension lever assembly to the throttle lever.



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A—Torque Spring Capsule
B—Fast Idle Stop
C—Throttle Shaft
D—Governor Spring
E—Tension Lever
F—Fuel Control Link
G—Control Rack
H—Flyweights
I—Enrichment Spring
J—Thrust Sleeve
K—Governor Lever Assembly
L—Slow Idle Stop
M—Throttle Lever
N—Fuel Control Lever

Continued on next page RG,RG34710,8376 –19–15APR97–1/3

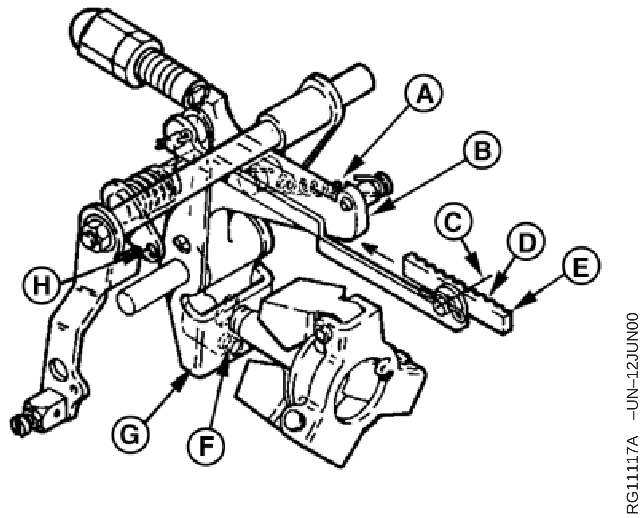
Starting

When the key switch is turned to “ON”, a fuel solenoid pulls the shutoff lever to the “RUN” position. This permits the governor spring to move the tension lever, pulling the control rack left. The enrichment spring extends, pulling the rack an additional amount to give starting fuel delivery.

After the engine starts, as speed increases, centrifugal force moves the flyweights outward forcing the thrust sleeve against the button on the governor lever. The enrichment spring compresses and remains compressed while the engine is running.

The forces generated by the flyweights against the governor lever overcome governor spring tension, pushing the rack to the right. This reduces fuel delivery to an amount that will maintain the rpm established by the speed control lever setting.

When the key is turned “OFF”, the fuel control solenoid is de-energized. The spring on the shutoff lever rotates the shaft so the high spot moves the governor lever to the right, pushing the rack to a “No Fuel” position, stopping the engine.



Starting

A—Governor Spring
B—Tension Spring
C—Starting Fuel Delivery
D—Maximum Fuel
E—Minimum Fuel
F—Enrichment Spring
G—Governor Lever
H—Shutoff Lever

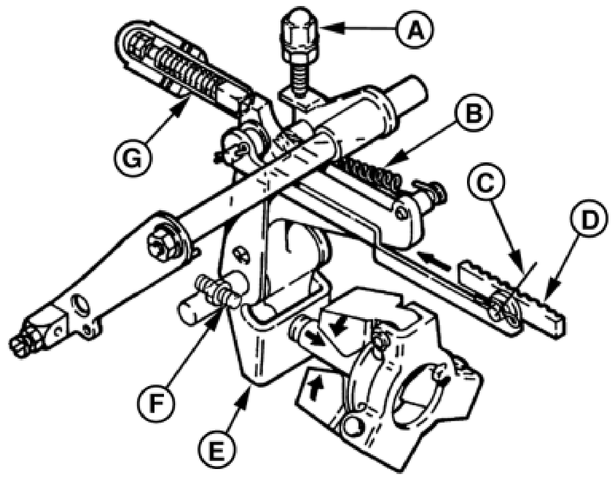
Continued on next page RG,RG34710,8376 –19–15APR97–2/3

Fast Idle, Maximum Torque

When a load is applied, decreasing engine speed, the flyweight force is reduced against the governor lever. The spring can then pull the lever assembly and the rack to increase fuel delivery and bring rpm back up to preset speed.

Additional load would further reduce the flyweight force, permitting the governor spring to pull tension lever against the torque spring, compressing it and moving the rack to the maximum torque fuel delivery.

A fast idle adjusting screw and slow idle screw, provide stops for the speed control lever.



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Fast Idle, Maximum Torque

A—Fast Idle Screw
B—Governor Spring
C—Maximum Fuel
D—Minimum Fuel
E—Governor Lever
F—Slow Idle Screw
G—Torque Spring

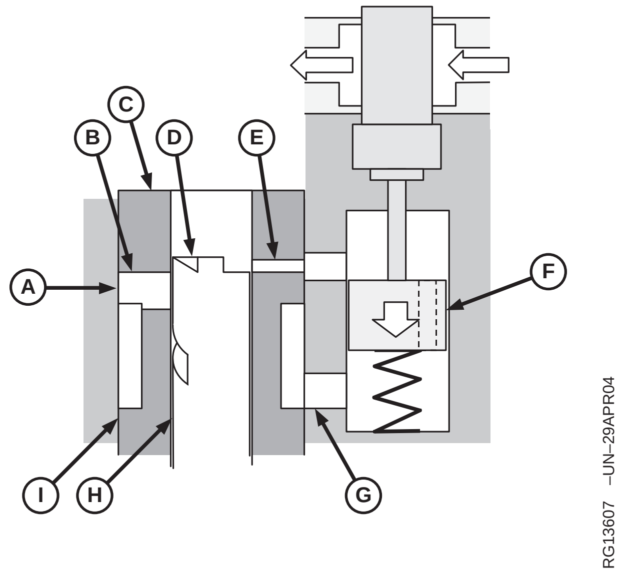
RG,RG34710,8376 –19–15APR97–3/3

Timing Controller and Cold Start Advancer Operation—3013 and 3016

Timing Controller

The timing controller adjusts fuel injection timing according to engine speed and load. The timing controller uses the fuel leakage from the small diameter sub-port located on the upper portion of the plunger barrel. With the engine running at high speed, as the plunger rises, the fuel pressure in the plunger barrel quickly rises, and high-pressure fuel is sent to the distribution shaft and delivery valve, thus advancing injection timing. But when the engine is running at low speed, more fuel is allowed to leak from the sub-port, and fuel pressure does not rise until the sub-port is blocked by the plunger, delaying the injection timing. The timing controller prevents the injection timing from advancing during low engine speeds, thus controlling engine noise and emissions.

During low or no-load conditions, the timing controller's sub-lead allows the main port to close earlier, advancing the injection timing. This feature helps to prevent misfire and emission of bluish white smoke during low load operation.



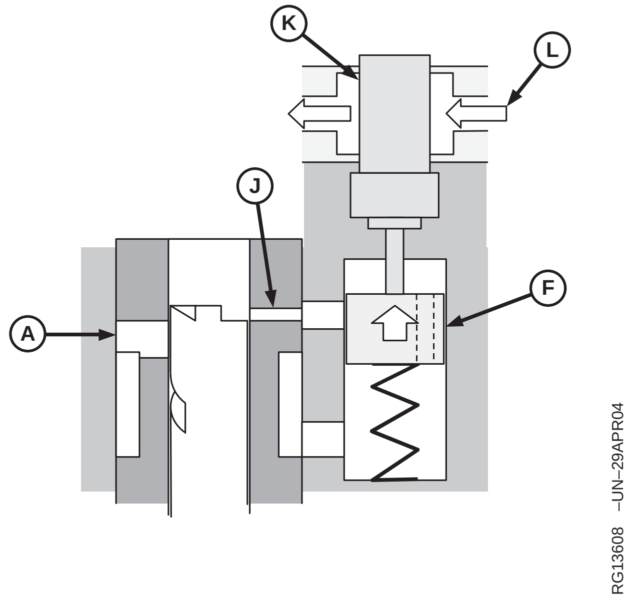
Normal Operation

A—Fuel Inlet
B—Main Port
C—Timing Controller
D—Sub-Lead
E—Sub-Port (Open)
F—Piston
G—Fuel Galley
H—Plunger
I—Plunger Barrel

Continued on next page OUO1020,00013ED –19–27APR04–1/2

Cold Start Advancer

The cold start advancer causes the sub-port to be blocked during cold temperatures, advancing injection timing and facilitating cold starting. The cold start advancer houses a thermo-element allowing engine coolant to circulate around the thermo-element's temperature sensor. When the engine coolant is below a set temperature the thermo-element piston is drawn into the element, blocking the sub-port and advancing the injection timing. As the engine coolant temperature increases the thermo-element piston is extended, opening the sub-port, allowing the timing controller to operate normally.



Cold Start Operation

A—Fuel Inlet
F—Piston
J—Sub-Port (Closed)
K—Thermo-Element
L—Engine Coolant

OUO1020,00013ED –19–27APR04–2/2

Indirect Injection Nozzle Operation (Pintle Type)—3009

The injection nozzle injects fuel in an atomized form into a precombustion chamber.

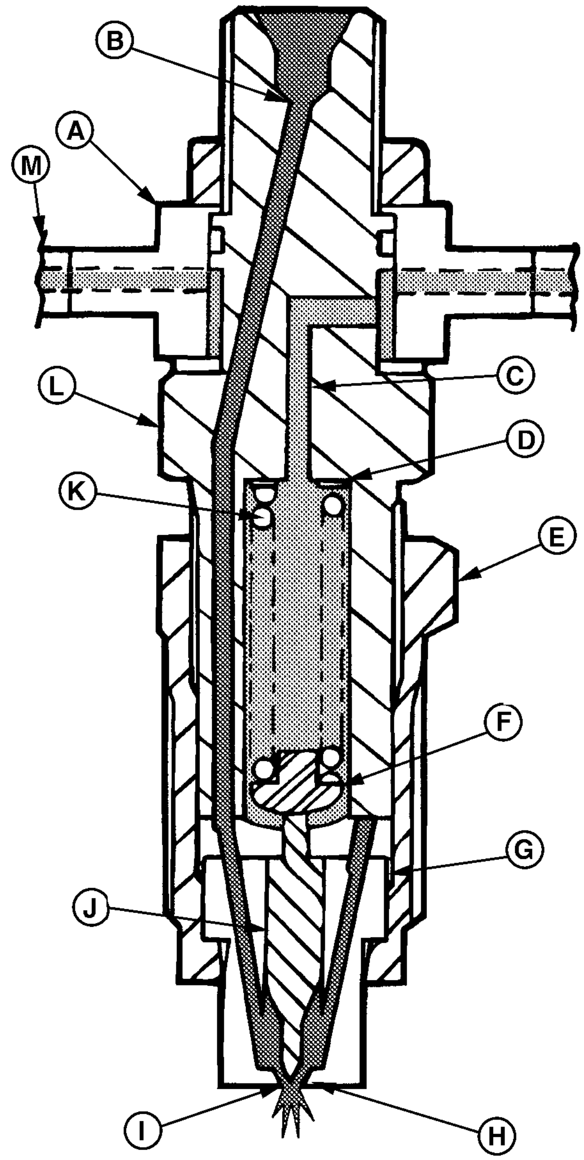
The pintle-type nozzle is used on 3009 indirect injection engines.

The fuel injection nozzle has an inward opening pintle-type valve.

High-pressure fuel from the pump flows through an inlet passage to the pintle valve. When pressure against the valve increases above spring tension, the valve is lifted off its seat, permitting fuel to be forced through a nozzle body orifice in an atomized form into the precombustion chamber.

A small amount of fuel leaks past the pintle valve to lubricate valve and body, then flows through a return passage to return lines and tank.

The pintle valve is shim adjustable to regulate the opening pressure.



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A—Return Connector
B—Fuel Inlet Passage
C—Fuel Return Passage
D—Shim
E—Nozzle Fitting
F—Spring Seat
G—Separator Plate
H—Valve Seat
I—Orifice
J—Pintle (Valve)
K—Spring
L—Injector Body
M—Return Line

RG,RG34710,8379 –19–15APR97–1/1

Direct Injection Nozzle Operation (Hole Type)—3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98

The injection nozzle injects fuel in an atomized form into the combustion chamber.

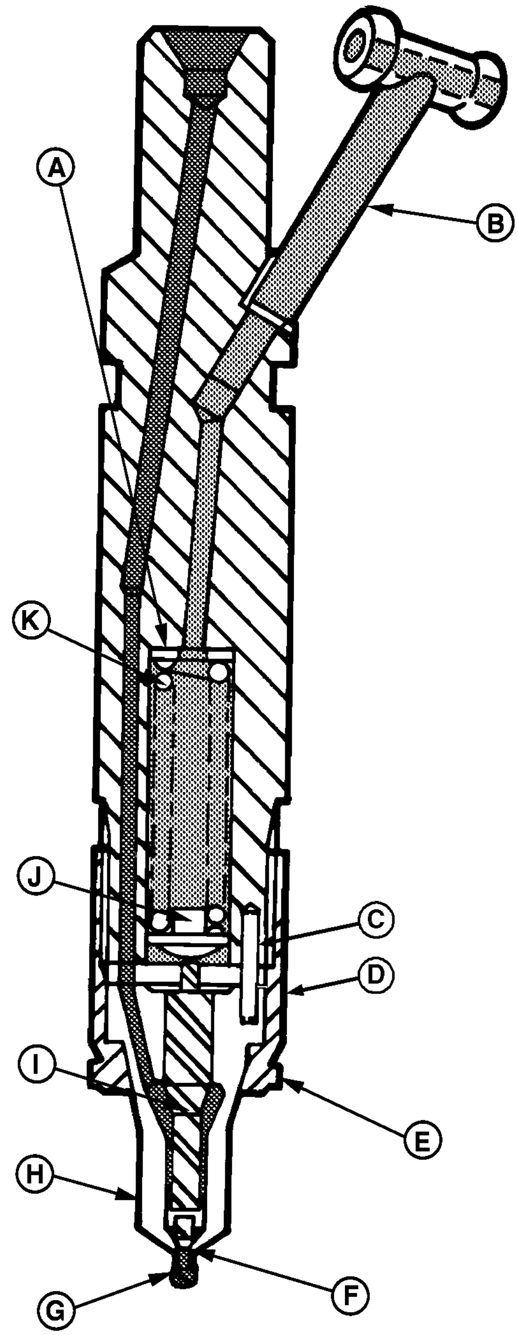
The hole-type nozzle is used on direct injection engines.

High-pressure fuel from the injection pump flows through a fuel inlet passage. Pressure builds beneath the nozzle valve. When the fuel pressure reaches specified pressure it overcomes the nozzle spring tension. The nozzle valve retracts into the nozzle body and fuel is injected into the engine.

The nozzle valve is automatically pushed down by the nozzle spring and closed after fuel is injected.

Leakage (return fuel) flows from between the nozzle valve and nozzle body to the hole on top of the nozzle spring, through the return pipe and back into the fuel tank.

The nozzle valve is shim adjustable to regulate the opening pressure.



A—Shim
B—Return Pipe
C—Dowel Pin
D—Seat
E—Nozzle Nut
F—Nozzle Valve Seat
G—Injection Holes
H—Nozzle Body
I—Nozzle Valve
J—Retainer
K—Spring

RG,RG34710,8380 –19–15APR97–1/1

Precombustion Chamber Operation (Indirect Injection)—3009

The precombustion chamber is a small turbulent area where the fuel is injected, mixed with a limited amount of air, and the start of ignition takes place.

A precombustion chamber is located in the cylinder head with a small opening into the cylinder.

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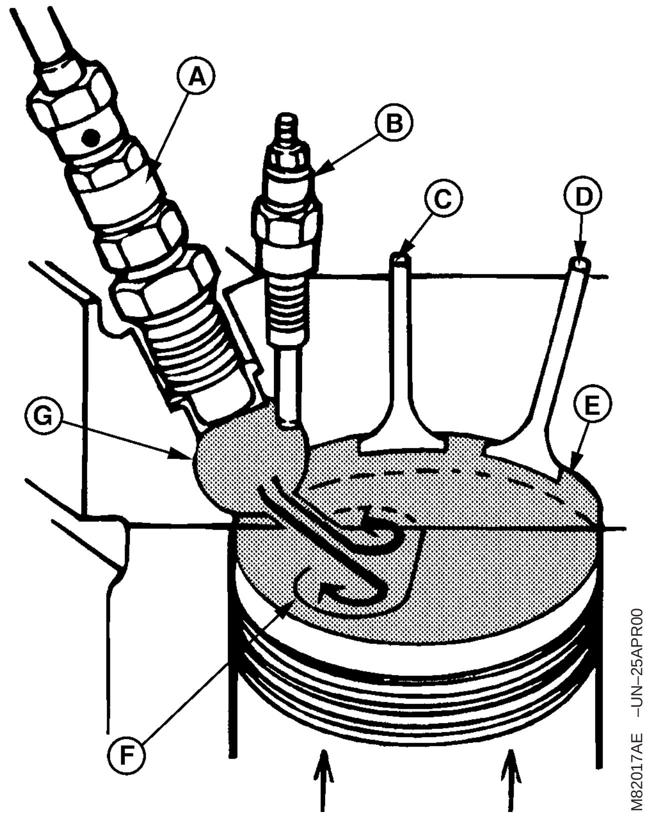
As the piston comes up on the compression stroke, some of the air is forced through the opening into the precombustion chamber. The opening is shaped to direct this air flow into a turbulent action as it is being compressed and heated.

At 16° BTDC[1] crankshaft rotation, injection of fuel begins. The injection nozzle sprays atomized fuel into the precombustion chamber turbulent air. Heat from the compressed air ignites the fuel, increasing pressure in the precombustion chamber and forcing the burning mixture into the cylinder where it mixes with the air in the piston swirl cup.

Expansion for the burning mixture forces the piston down on its power stroke.

When starting a cold engine, compression pressure may not provide enough heat to ignite the fuel when injected into a cold precombustion chamber. An electrically operated glow plug is installed into the precombustion chamber to provide added heat to ignite the fuel as it is injected. The glow plugs are energized during starting, and also may be pre-heated by turning the key switch counterclockwise and holding for up to 30 seconds.

NOTE: On 3009 generator set engines, fuel injection timing is 18° BTDC.



A—Injection Nozzle
B—Glow Plug
C—Intake Valve
D—Exhaust Valve
E—Engine Cylinder
F—Swirl Cup
G—Precombustion Chamber

[1]*BTDC = Before Top Dead Center.*

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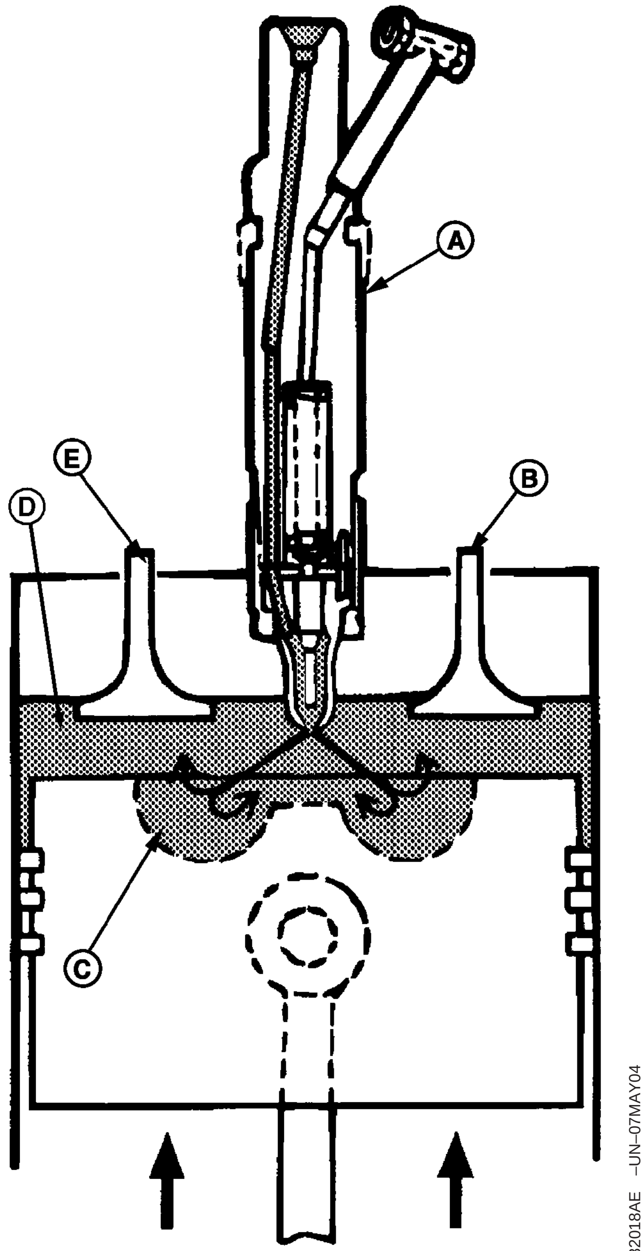
Combustion Chamber Operation (Direct Injection)—3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98

The combustion chamber is the area in the cylinder head where the fuel is injected, mixed with a limited amount of air, and the start of ignition takes place.

A swirl cup is formed in the head of the piston. As the piston travels upward on its compression stroke, the shape of the cup causes the air to swirl as it is compressed and heated.

At a certain pre-set point BTDC[1] crankshaft rotation, fuel is injected by the multi-hole injection nozzle. The swirling action of the air thoroughly mixes the atomized fuel and air for complete burning as the piston travels into the power stroke.

When starting a cold engine, compression of ambient temperature air may not provide enough heat for ignition. To aid cold temperature starting, an electrically operated heater element may be located at the intake manifold inlet. The heater is energized during starting and also may be pre-heated by turning the key switch counterclockwise and holding for up to 30 seconds.



A—Injection Nozzle
B—Exhaust Valve
C—Piston Swirl Cup
D—Combustion Chamber
E—Intake Valve

[1] *BTDC = Before Top Dead Center.*

RG,RG34710,8382 –19–15APR97–1/1

Section 04
Diagnostics

Contents

Specifications

OUO1083,00006AF –19–02JUN04–1/1

About This Section of the Manual

This section of the manual contains necessary information to diagnose some base engine, all lubrication system and all cooling system problems. Starters and alternators for all engine models are covered in this group except 4TNE98 engines. Refer to CTM77 Alternators and Starter Motors for starter and alternator information for 4TNE98 engines. This section is divided into two areas: diagnosing malfunctions and testing procedures. The diagnosing malfunctions area is further divided into the following headings, containing the following symptoms:

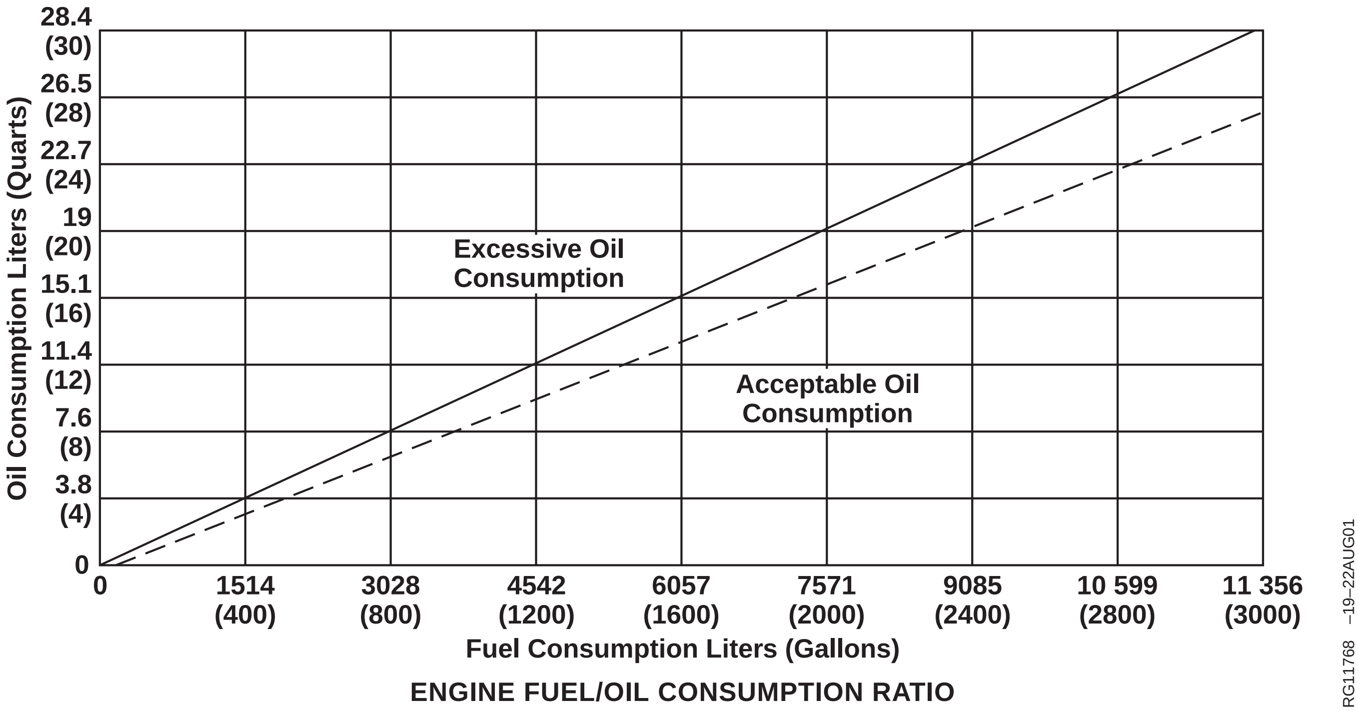
- **(L)** Diagnosing Lubrication System Malfunctions:
  - L1—Excessive Oil Consumption
  - L2—Engine Oil Pressure Low
  - L3—Engine Oil Pressure High
- **(C)** Diagnosing Cooling System Malfunctions:
  - C1—Coolant Temperature Above Normal
  - C2—Coolant Temperature Below Normal
  - C3—Coolant in Oil 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 with 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 contains the following testing procedures:

- Base Engine Testing Procedures:
  - Test Engine Compression Pressure
  - Test Engine Cranking Speed
  - Dynamometer Test
- Lubrications System Testing Procedures:
  - Engine Oil Consumption
  - 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
  - Check and Service Cooling System
- Air Supply and Exhaust Systems Testing Procedures:
  - Check Air Intake System
  - Measure Intake Manifold Pressure (Turbo Boost)
  - Check for Intake and Exhaust Restrictions
  - Test for Intake Air Leaks
  - Check for Exhaust Leaks (Turbocharged Engines)
  - Test Turbocharger Wastegate
  - Test Air Filter Restriction Indicator Switch

OUO1083,0000678 –19–14MAY04–1/1

Guideline for Acceptable Oil Consumption



ENGINE FUEL/OIL CONSUMPTION RATIO

Oil consumption complaints are usually reported as how many liters (quarts) are used per day. This information is not very specific. Two questions to consider are:

- How long is a day?
- How hard did the engine work in this day?

A much better method of checking oil consumption is based on oil usage compared to the amount of fuel burned (see chart). Long-term oil consumption (three oil drain intervals after engine break-in) should not exceed 0.95 L (1 qt) of oil for every 379 L (100 gal) of fuel burned.

IMPORTANT: If the engine fuel/oil consumption ratio falls below the dashed line, oil consumption is acceptable. If the ratio is between the solid and dashed line, oil consumption is still acceptable but the oil level and usage should be monitored closely. If the ratio is above the solid line, oil consumption is excessive and action should be taken to determine the cause.

For example, if an engine uses less than 0.95 L (1 qt) of oil for every 379 L (100 gal) of fuel burned, it is within acceptable operating parameters. If the engine begins to use 0.95 L (1 qt) of oil or more for every 379 L (100 gal) of fuel burned, you should investigate to determine the cause of the excess oil consumption.

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L1—Excessive Oil Consumption

OUO1083,000067A –19–14MAY04–1/1

L1—Excessive Oil Consumption

Before using this diagnostic procedure:

Check for too low or too high engine oil level.

Check for too low viscosity, or coolant- or fuel-diluted engine oil.

Check for excessive external oil leaks.

– – –1/1

❶ **Check Oil in Coolant**	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 **Check for Excessive Crankcase Pressure (Blow-By)**	Check for excessive crankcase pressure. See CHECK CRANKCASE VENTILATION SYSTEM later 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 (4020T):** Check the turbocharger, repair/replace as needed. See DIAGNOSING TURBOCHARGER MALFUNCTIONS—4020T in Group 080 in Section 02 of this manual. **Excessive fumes or dripping oil observed; does not appear to be caused by boost pressure:** Excessive blow-by, not caused by boost pressure, is most likely caused by faulty piston rings/cylinder bores not providing an adequate combustion seal. Perform a compression test to verify this is the case. See TEST CYLINDER COMPRESSION PRESSURE—3009 or TEST CYLINDER COMPRESSION PRESSURE—3011, 3012, 3013, 3015, 3016, 4020 AND 4TNE98 later in this group. – – –1/1

❸ **Turbocharger Oil Seal Leak Check—4020T**	*NOTE: This check is not needed for non-turbocharged engines. For these engines Go to 4.* Check for turbocharger oil seal leaks. See TURBOCHARGER INSPECTION in Section 02, Group 080.	**No signs of oil leakage:** Go to 4. **Signs of oil leakage present:** Investigate problems associated with oil leakage as outlined in the inspection procedure, perform necessary repairs, and retest. – – –1/1

❹ **Pistons, Rings, Cylinder Bores Check**	At this point, the most likely cause of excessive oil consumption is one of the following failures in the pistons, rings, and/or cylinder bores, or in the valve guides. Check the most likely items as needed. • Oil control rings worn or broken • Scored cylinder bores or pistons • Piston ring grooves excessively worn • Insufficient piston ring tension • Piston ring gaps not staggered • Cylinder bores glazed (insufficient load during engine break-in) • Worn valve guides or stems	Problem found with pistons, rings, and/or cylinder bores, or valve guides. Repair problem as necessary. – – –1/1

L2—Engine Oil Pressure Low

Symptom	Problem	Solution
L2—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, INSPECT AND INSTALL OIL COOLER—3016 AND 4020T in Group 060 in Section 02 of this manual. Replace oil filter.
	Excessive oil temperature	Remove and inspect oil cooler. See REMOVE, INSPECT AND INSTALL OIL COOLER—3016 AND 4020T in Group 060 in Section 02 of this manual.
	Defective oil pump	Remove and inspect oil pump. See REMOVE AND INSTALL ENGINE OIL PUMP—3009, 3011, 3012, 3015, 4020 AND 4TNE98 or REMOVE AND INSTALL ENGINE OIL PUMP—3013 AND 3016 in Group 060 in Section 02 of this manual.
	Incorrect oil	Drain crankcase and refill with correct oil.
	Oil pressure regulating valve failure	Inspect oil pressure regulating valve. See REMOVE AND INSTALL OIL PRESSURE REGULATING VALVE in Group 060 in Section 02 of this manual.
	Broken piston cooling nozzle	Replace piston cooling nozzle. See REPLACE PISTON COOLING NOZZLES—4020T in Group 060 in Section 02 of this manual.

Continued on next page OUO1083,000067B –19–14MAY04–1/2

Symptom	Problem	Solution
	Clogged oil pump screen or cracked pick-up tube	Remove oil pan and clean screen. Replace pick-up tube. See REMOVE AND INSTALL OIL PAN AND STRAINER in Group 060 in Section 02 of this manual.
	Excessive main or connecting rod bearing clearance	Determine bearing clearance. See CYLINDER BLOCK, PISTONS, AND RODS SPECIFICATIONS or CRANKSHAFT, MAIN BEARINGS, AND FLYWHEEL SPECIFICATIONS in Group 200 in Section 06 of this manual.

OUO1083,000067B –19–14MAY04–2/2

L3—Engine Oil Pressure High

Symptom	Problem	Solution
L3 - Engine Oil Pressure High	Improper oil classification	Drain crankcase and refill with correct oil.
	Improperly operating regulating valve	Remove and inspect oil pressure regulating valve. See REMOVE AND INSTALL OIL PRESSURE REGULATING VALVE in Group 060 in Section 02 of this manual.
	Plugged piston cooling nozzle	Replace piston cooling nozzle. See REPLACE PISTON COOLING NOZZLES—4020T in Group 060 in section 02 of this manual.
	Stuck or damaged bypass valve	Remove and inspect bypass valve. See DISASSEMBLE, INSPECT AND ASSEMBLE OIL PUMP—3009, 3011, 3012, 3015, 4020 AND 4TNE98 or DISASSEMBLE, INSPECT AND ASSEMBLE OIL PUMP—3013 AND 3016 in Group 060 in Section 02 of this manual.
	Stuck or damaged oil filter bypass valve	Replace oil filter.

OUO1083,000067C –19–14MAY04–1/1

C1—Engine Coolant Temperature Above Normal

Symptom	Problem	Solution
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 TEST THERMOSTAT OPENING later in this group.
	Damaged cylinder head gasket	Replace cylinder head gasket. See TEST CYLINDER COMPRESSION PRESSURE—3009 or TEST CYLINDER COMPRESSION PRESSURE—3011, 3012, 3013, 3015, 3016, 4020 AND 4TNE98 later in this group.
	Defective coolant pump	Replace coolant pump. See REMOVE, INSPECT AND INSTALL COOLANT PUMP—3009, 3011, 3012, 3013, 3015, 3016 AND 4020 or REMOVE, INSPECT AND INSTALL COOLANT PUMP—4TNE98 in Group 070 in Section 02 of this manual.
	Defective radiator cap	Replace radiator cap as required. See PRESSURE TEST COOLING SYSTEM AND RADIATOR CAP later in this group.

OUO1083,000067D –19–14MAY04–1/1

C2—Engine Coolant Temperature Below Normal

Symptom	Problem	Solution
C2—Engine Coolant Temperature Below Normal	Defective thermostat(s)	Test thermostat; replace thermostat as required. See TEST THERMOSTAT OPENING later in this group.

OUO1083,000067E –19–14MAY04–1/1

C3—Coolant in Oil or Oil in Coolant

Symptom	Problem	Solution
C3—Coolant in Oil or Oil in Coolant	Faulty cylinder head gasket	Look for signs of head gasket failure. See RADIATOR BUBBLE TEST later in this group.
	Faulty oil cooler	Remove and inspect engine oil cooler. See REMOVE, INSPECT AND INSTALL OIL COOLER—3016 AND 4020T in Group 060 in Section 02 of this manual.
	Cracked cylinder head or block	Locate crack; repair/replace components as required.

OUO1083,000067F –19–14MAY04–1/1

Check Fan/Alternator Belt

Check condition of fan/alternator belt and replace if cracked, frayed or excessively worn. Check belt tension and adjust as necessary. (See REPLACE AND ADJUST FAN/ALTERNATOR BELT in Group 070.)

RG,RG34710,8329 –19–15APR97–1/1

Check and Service Cooling System

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

2. Visually inspect entire cooling system and all components for leaks or damage. Repair or replace as necessary.

3. Inspect radiator hoses for signs of leakage or rot. Replace hoses as necessary.

4. Remove and check thermostat. (See REMOVE AND INSTALL THERMOSTAT—3009, 3011, 3012, 3013, 3015, 3016, and 4020 or REMOVE AND INSTALL THERMOSTAT AND HOUSING—4TNE98 in Group 070—Cooling System.)

CAUTION: Do not drain until the coolant temperature is below operation temperature. Always loosen drain cock slowly to relieve any excess pressure.

5. Drain cooling system by opening drain cocks on radiator and engine block.

6. Close drain cocks and fill cooling system with clean water.

7. Run engine until it reaches operating temperature (about 10 minutes) to stir up possible rust or sediment.

8. Stop engine and immediately drain the water before rust and sediment settle.

9. Close drain cocks and fill the cooling system with a good commercial radiator cleaner and water. Follow the instructions with the cleaner.

10. After cleaning the cooling system, fill with water to flush the system. Run the engine about 10 minutes, then drain out flushing water.

IMPORTANT: Air must be expelled from cooling system when system is filled. Loosen coolant temperature sender or plug in thermostat housing to allow air to escape when filling system. Retighten sender or plug when all the air has been expelled.

11. Fill cooling system with coolant. (See Group 200—Repair and General OEM Specifications.)

12. Run engine until it reaches operating temperature. This mixes solution uniformly and circulates it through the entire system. The normal engine coolant temperature range is 82°—94°C (180°—202°F).

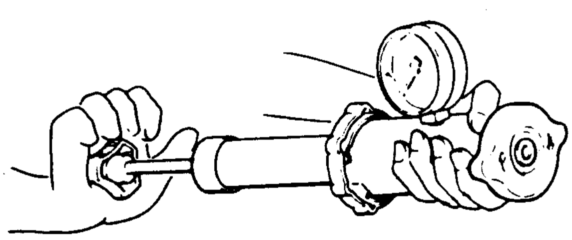
NOTE: Coolant level should be at bottom of radiator filler neck.

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

14. Check system for holding pressure. (See PRESSURE TEST COOLING SYSTEM AND RADIATOR CAP in this group.)

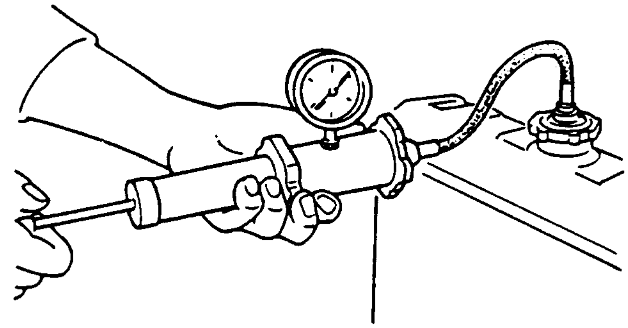
RG,RG34710,8330 –19–15APR97–1/1

Pressure Test Cooling System and Radiator Cap



RG6557 –UN–20JAN93

Pressure Testing Radiator Cap



RG6558 –UN–20JAN93

Pressure Testing Radiator

CAUTION: Explosive released 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 Pressure Pump as shown.

2. Pressurize cap to the following specification[1].

Specification	
Radiator Cap—Holding Pressure (10 Second Minimum Hold)	90 kPa (0.9 bar) (13 psi) minimum

Gauge should hold pressure for 10 seconds within the normal range if cap is acceptable.

If gauge does not hold pressure, replace radiator cap.

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

Test Cooling System

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

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

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

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 specification listed for radiator cap[1], using D05104ST Pressure Pump.

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.

[1]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.

RG,105,JW7649 –19–26NOV03–1/1

Test Coolant Temperature Switch

1. Connect lead wires from ohmmeter probes (A) to switch (B) terminal and body.

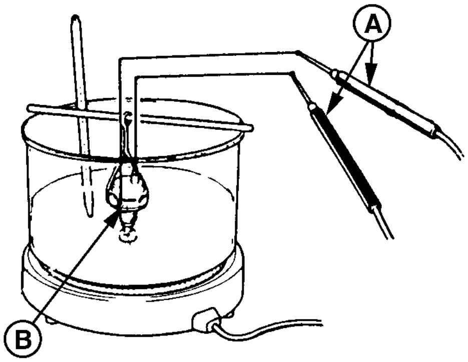
2. Suspend switch and a thermometer in a container of water.

3. Heat and stir the water. Observe water temperature when switch closes (continuity occurs).

4. Switch should close at specification. If switch does not close at specification, replace switch.

Specification

Coolant Temperature Switch,
Closing—Temperature..................................... 107—113°C (225—235°F)



M82123A –UN–12JUN00

Test Coolant Temperature Switch

A—Ohmmeter Probes
B—Temperature Switch

04
150
12

RG,RG34710,8215 –19–12APR04–1/1

Test Coolant Temperature Sensor

1. With sensor at room temperature, connect lead wires from ohmmeter probes (A) to switch (B) terminal and body.

2. Observe resistance on ohmmeter.

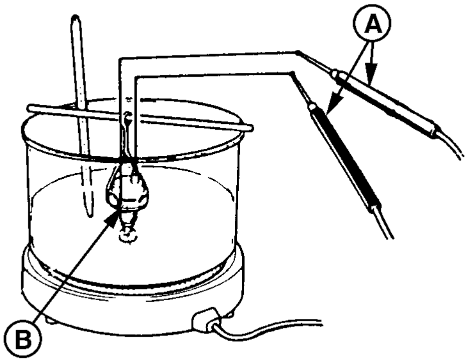
3. Suspend sensor and a thermometer in a container of water.

4. Heat and stir the water to approximately 96° C (205° F). Observe resistance on ohmmeter.

5. If sensor resistance range is not within specification, replace sensor.

Specification

Coolant Temperature Sensor—
Resistance.. 40—700 Ohms



M82123A –UN–12JUN00

Test Coolant Temperature Sensor

A—Ohmmeter Probes
B—Temperature Sensor

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Test Thermostat Opening

CAUTION: DO NOT allow thermostat (B) or thermometer (A) to rest against the side or bottom of glass container when heating water. Either may rupture if overheated

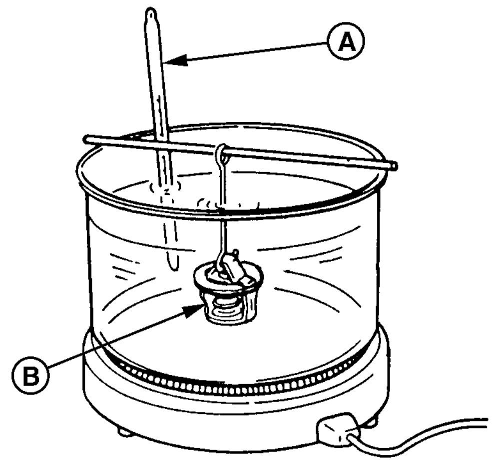
1. Suspend thermostat and a thermometer in a glass container of water.
2. Heat and stir the water. Observe opening action of thermostat and compare temperatures with specifications.
3. Remove thermostat and observe its closing action as it cools.

Specification

Thermostat—Begin Opening—Temperature	71°C (160°F)
Thermostat—Fully Open—Temperature	85°C (184°F)
Thermostat Opening (Minimum at Full Open)—Height	8 mm (0.310 in.)

If thermostat does not open according to specifications, replace.

If closing action is not smooth and slow, replace thermostat.



M82122A –UN–12JUN00

Test Thermostat

A—Thermometer
B—Thermostat

RG,RG34710,8218 –19–30APR04–1/1

Check Crankcase Ventilation System

1. Remove vent hose (A) from rocker cover.

2. Run engine at fast 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.

   Excessive blow-by coming out of the crankcase vent indicates that either the turbocharger (if equipped) seals are faulty or the piston rings and cylinder liners are not adequately sealing off the combustion chamber. This is a comparative check that requires some experience to determine when blow-by is excessive.

   If blow-by is excessive, perform cylinder compression test. (See TEST CYLINDER COMPRESSION PRESSURE—3009 or TEST CYLINDER COMPRESSION PRESSURE—3011, 3012, 3013, 3015, 3016, 4020 AND 4TNE98 in this group.)

3. Inspect crankcase ventilation system for restrictions. Lack of ventilation causes sludge to form in crankcase. This can lead to clogging of oil passages, filters, and screens, resulting in serious engine damage.

4. Clean crankcase vent tube or hose (A) with solvent and compressed air if restricted.

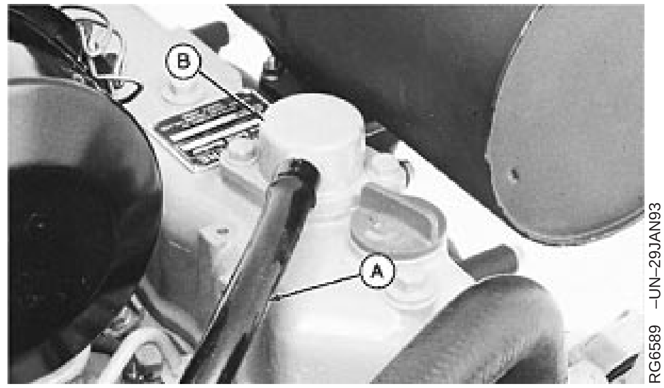
5. 3009, 4020 and 4TNE98: Remove rocker arm cover and clean crankcase ventilator.

   3011, 3012 and 3015: Remove and clean crankcase ventilator assembly (B).

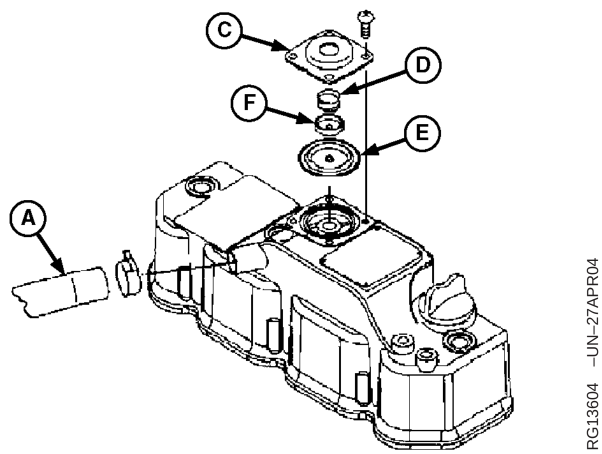
   3013 and 3016: Remove, inspect and clean crankcase ventilator assembly (C—F).

NOTE: **If excessive blow-by is observed, perform the following steps (6—8) to determine if the turbocharger (4020T) is causing the blow-by:**

6. Remove the turbocharger oil drain line where it connects to the engine block and run line into a bucket.



Models 3011, 3012 and 3015



Models 3013 and 3016

A—Vent Tube or Hose
B—Ventilator Assembly—3011, 3012 and 3015
C—Diaphragm Cover—3013 and 3016
D—Spring—3013 and 3016
E—Diaphragm—3013 and 3016
F—Spring Plate—3013 and 3016

Continued on next page

RG,RG34710,8326 –19–15APR97–1/2

7. Run engine at fast idle, slightly loaded, and determine if boost pressure is forcing oil through the drain line. Check crankcase breather tube to determine if blow-by has decreased.

8. If it appears that boost pressure is forcing oil through the drain line, and/or blow-by decreases with the drain line disconnected from block, replace the turbocharger, and retest.

RG,RG34710,8326 –19–15APR97–2/2

Dynamometer Test

IMPORTANT: Dynamometers should be periodically checked for accuracy and calibrated as necessary.

NOTE: High elevations may affect engine performance. (See EFFECTS OF ALTITUDE AND TEMPERATURE ON ENGINE PERFORMANCE in Section 06, Group 210.)

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 operating range.

3. Run engine at fast idle.

4. Gradually increase load on engine until speed is reduced to rated speed rpm.

NOTE: Refer to appropriate machine technical manual for average power ratings of specific applications. Allow ±5% for minimum and maximum power.

5. Read horsepower on dynamometer and record reading over a period of several minutes after engine stabilizes.

6. Compare readings taken with power rating level for your engine application, as listed in Section 06, Group 210.

RG,100,JW7644 –19–12NOV99–1/1

Test Fuel Supply Pump Pressure—3009, 3011, 3012, 3015, 4020 and 4TNE98

1. Disconnect supply pump-to-filter hose.

2. Assemble JT03274 Hose Fitting, JT01609 Female Quick Coupler, and JT03115 Gauge with Male Quick Coupler and connect to supply pump outlet.

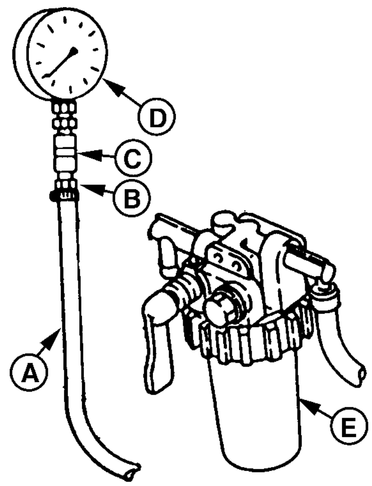
3. Disconnect fuel shutoff solenoid connector.

4. Crank engine using the starter. Do not run starter for more than 10 seconds at a time. Observe reading on gauge.

   If pressure is below specification, repair or replace fuel supply pump.

Specification

Fuel Supply Pump—3011, 3012, 3015, 4020 and 4TNE98—Pressure .... 29 kPa (4.3 psi) minimum



M82145B –UN–08JUN00

Fuel Supply Pump Pressure Test

A—Hose, Supply Pump-to-Fuel Filter
B—JT03274 Hose Fitting
C—JT01609 Female Quick Coupler
D—JT03115 Gauge with Male Quick Coupler
E—Fuel Filter

RG,RG34710,8383 –19–15APR97–1/1

Test Fuel Supply Pump Pressure—3013 and 3016

1. Verify fuel is within 15-25°C (59-77°F).

2. Disconnect hose (A) from outlet side of fuel pump (B).

3. Assemble JT03274 Hose Fitting, JT01609 Female Quick Coupler, and JT03115 Gauge with Male Quick Coupler and connect to supply pump outlet.

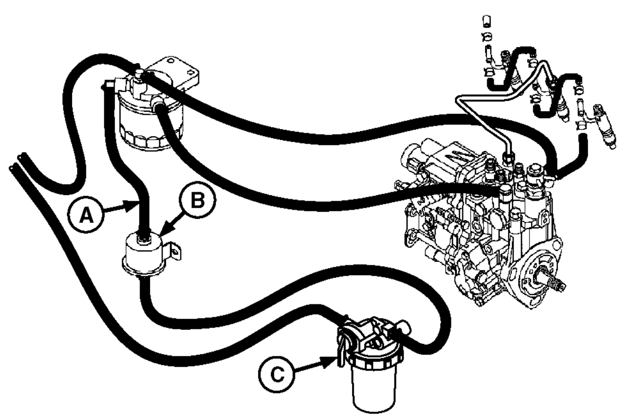
4. Ensure that valve (C) on the water separator is turned ON.

5. Turn key switch on for 15 seconds and observe reading on gauge.

   If pressure is below specification, replace fuel supply pump.

Specification

Fuel Supply Pump—3013 and 3016—Pressure.. 37 kPa (5.4 psi) minimum



RG13616 –UN–17MAY04

Typical Fuel System

A—Fuel Outlet Hose
B—Fuel Supply Pump
C—Fuel Shut-Off Valve

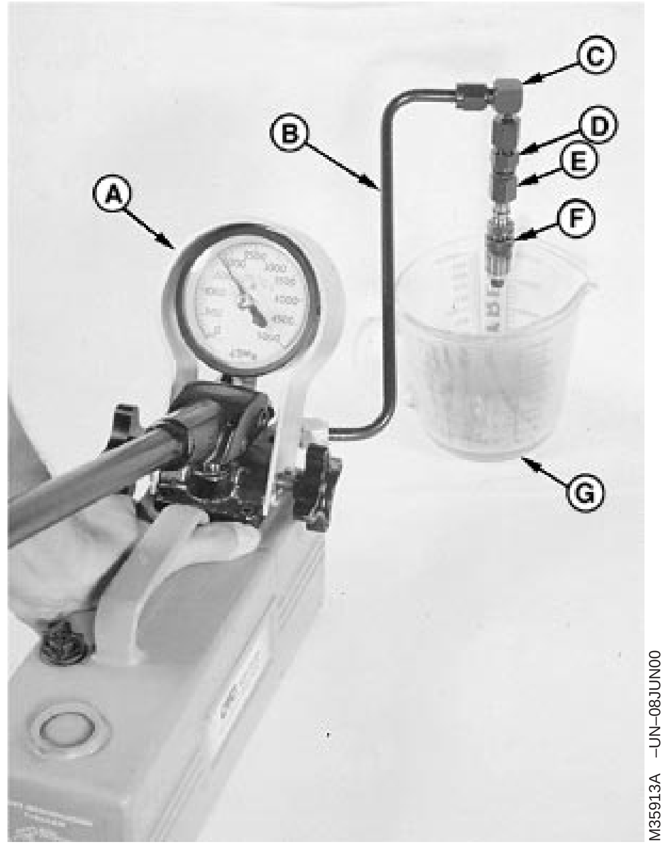
OUO1017,0000B2E –19–29APR04–1/1

Test Fuel Injection Nozzle

CAUTION: The nozzle tip should always be directed away from the operator. Fuel from the spray orifices can penetrate clothing and skin causing serious personal injury. Enclosing the nozzle in a clear glass beaker is recommended.

Before applying pressure to the nozzle tester, be sure that all connections are tight, and that the fittings are not damaged. Fluid escaping from a very small hole can be almost invisible. To search for suspected leaks, use a piece of cardboard or wood, rather than hands.

If ANY fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type injury or gangrene may result. Doctors unfamiliar with this type of injury may call the Deere & Company Medical Department in Moline, Illinois, U.S.A.



Test Fuel Injection Nozzles

A—D01109AA Fuel Injection Nozzle Tester
B—36352 Fuel Line Assembly
C—23617 90° Adapter
D—23621 Straight Adapter
E—23622 Straight Adapter
F—Fuel Injection Nozzle
G—Container

Test Opening Pressure

1. Connect fuel injection nozzle to D01109AA Diesel Fuel Injection Nozzle Tester (A) using parts from D01110AA Adapter Set and 23622 Straight Adapter (E).

2. Position tip of nozzle below top of container (G) and back out 30° from vertical. This is necessary to contain all spray in beaker, as nozzle spray pattern is at an angle to the nozzle centerline. Leave connections slightly loose.

NOTE: Rapid operation of pump handle will result in inaccurate cracking pressure readings and cause undue wear on gauge.

3. Pump handle several strokes to flush air from lines and to determine the pumping rate required for proper fuel atomization. Tighten all connections securely after all air has been expelled from nozzle and line.

Continued on next page

Test Injection Nozzle Opening Pressure

IMPORTANT: Use clean filtered diesel fuel when testing injection nozzles to get best test results.

1. Open gauge valve, actuate the tester and raise the pressure to a point where the gauge needle falls rapidly. This is the nozzle opening pressure, and should be as specified for a new or used nozzle.

2. Compare readings to the following specifications.

Injection Nozzle Opening Test—Specification

Opening—3009—Pressure	11 242—12 202 kPa (1630—1770 psi)
Opening—3011, 3012, 3013, 3015, 4020, and 4TNE98—Pressure	19 120—20 080 kPa (2773—2913 psi)
Opening—3013 and 3016—Pressure	21 600—22 600 kPa (3133—3278 psi)

IMPORTANT: If any of the nozzle opening pressures are not within specified range, add or subtract the number of shims to adjust pressure and valve lift BEFORE checking chatter and spray pattern. Otherwise, these characteristics may be affected. (See DISASSEMBLE AND ASSEMBLE FUEL INJECTION NOZZLES (PINTLE TYPE)—3009 or DISASSEMBLE AND ASSEMBLE FUEL INJECTION NOZZLES (HOLE TYPE)—3011, 3012, 3013, 3016, 3015, 4020 AND 4TNE98 in Section 020, Group 090.)

3. If pressure reading does not meet specification, disassemble injection nozzle and inspect nozzle assembly for contamination or stuck valve. If necessary, add or remove shims to change opening pressure.

Continued on next page

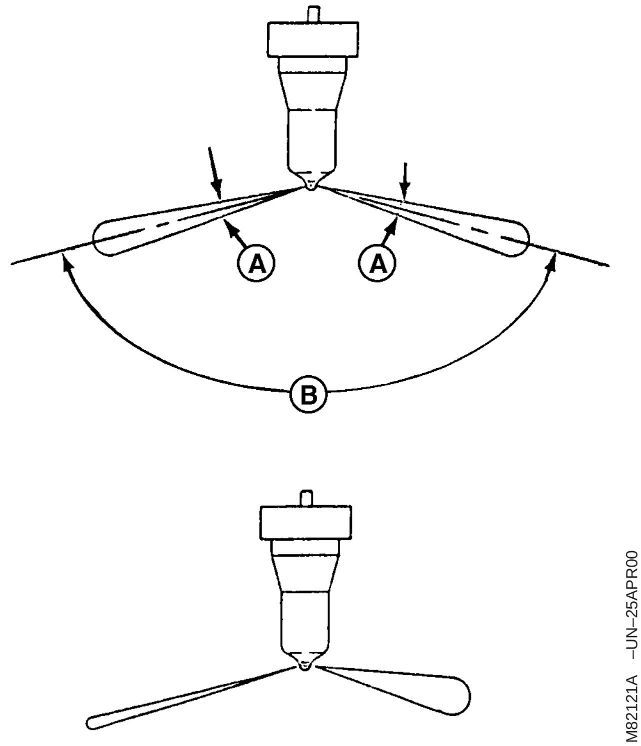
RG,RG34710,8384 –19–15APR97–2/4

Test Injection Nozzle Chatter and Spray Pattern

1. Pressurize nozzle to specification.

Injection Nozzle Spray Pattern Test—Specification

Opening—3009—Pressure.. 11 242—12 202 kPa (1630—1770 psi)
Opening—3011, 3012, 3015, 4020 and 4TNE98—Pressure .... 19 120—20 080 kPa (2773—2913 psi)
Opening—3013 and 3016—Pressure .... 20 000—21 600 kPa (2901—3133 psi)



Correct (Top) and Poor (Bottom) Spray Pattern

A—Proper Spray Angle
B—Correct Injection Angle

Continued on next page RG,RG34710,8384 –19–15APR97–3/4

2. Listen for “chatter” sound and watch spray pattern.

Injection Nozzle Chatter and Spray —Specification

Slow Hand Lever Movement—	Chatter sound
Slow Hand Lever Movement—	Fine stream spray pattern
Fast Hand Lever Movement—	Fine atomized spray pattern

If nozzle chatter or spray pattern does not meet specifications, disassemble injection nozzle and inspect nozzle assembly for contamination. Inspect valve seating surface. Replace nozzle assembly if necessary.

If there is excessive difference in spray angle or injection angle, incomplete atomization or sluggish starting/stopping of injection, disassemble injection nozzle and inspect nozzle assembly for contamination. Replace nozzle assembly if necessary.

Test Injection Nozzle Leakage

1. Dry nozzle completely using a lint-free cloth.

2. Pressurize nozzle to specification.

Injection Nozzle Leakage Test—Specification

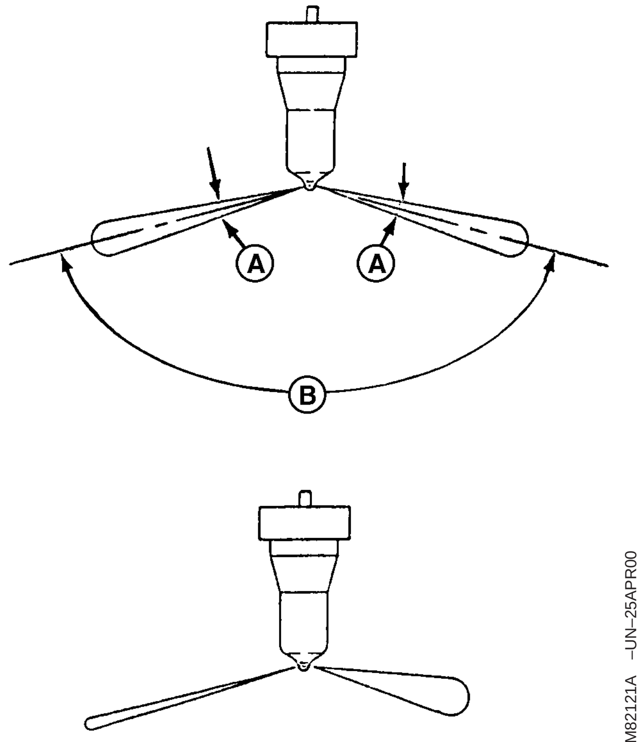
Leakage Test—3009—Pressure	11 032 kPa (1600 psi)
Leakage Test—3011, 3012, 3015 and 4020—Pressure	17 640 kPa (2558 psi)
Leakage Test—4TNE98—Pressure	18 100 kPa (2625 psi)
Leakage Test—3013 and 3016—Pressure	20 000 kPa (2901 psi)

3. Watch for leakage from nozzle spray orifice.

   3009 (Pintle-Type nozzles): leakage time should be a minimum of 10 seconds.

   3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98 (Hole-Type nozzles): leakage time should be a minimum of 5 seconds.

If leakage time does not meet specification, disassemble injection nozzle and inspect nozzle assembly for contamination. Inspect valve seating surface. Replace nozzle assembly if necessary.



Spray Pattern

A—Proper Spray Angle
B—Correct Injection Angle

RG,RG34710,8384 –19–15APR97–4/4

Test Fuel Drain-Back

1. Disconnect fuel supply line and return line at fuel tank.

IMPORTANT: Fuel return line MUST extend below fuel level in fuel tank before performing this test. Fill fuel tank if necessary.

2. Drain all fuel from the system, including fuel supply pump, injection pump, filter(s) and water separator, if equipped.

3. Plug end of fuel return hose.

4. Pressurize fuel system at fuel supply line, to a maximum pressure of 103 kPa (15 psi).

5. Apply liquid soap and water solution to all joints and connections in the fuel system and inspect for leaks.

   Repair or replace parts as necessary.

RG,RG34710,8393 –19–15APR97–1/1

Diagnosing Air Intake Malfunctions

Symptom	Problem	Solution
Engine Starts Hard or Won't Start	Air leak on suction side of system.	Check hose and pipe connections for tightness; repair as required. (See TEST AIR INTAKE SYSTEM LEAKAGE in this group.)
Erratic Engine Operation	Air leak on suction side of system.	Check hose and pipe connections for tightness; repair as required. (See TEST AIR INTAKE SYSTEM LEAKAGE in this group.)
Engine Emits Excessive Black Smoke	Air cleaner element restricted.	Clean or replace elements. (See operator's manual.)
	Turbocharger defective.	Repair or replace. (See REMOVE TURBOCHARGER—4020T and INSTALL TURBOCHARGER—4020T in Group 080.)
	Air leak in manifold.	Check hose and pipe connections for tightness; repair as required. (See TEST AIR INTAKE SYSTEM LEAKAGE in this group.)
Engine Idles Poorly	Air leak on suction side of system.	Check hose and pipe connections for tightness; repair as required. (See TEST AIR INTAKE SYSTEM LEAKAGE in this group.)

Continued on next page RG,RG34710,8343 –19–03MAY04–1/2

Symptom	Problem	Solution
Engine Does Not Develop Full Power	Air cleaner restricted.	Clean or replace elements. (See operator's manual.)
	Air leak on suction side of system.	Check hose and pipe connections for tightness; repair as required. (See TEST AIR INTAKE SYSTEM LEAKAGE in this group.)
	Turbocharger defective.	Repair or replace. (See REMOVE TURBOCHARGER—4020T and INSTALL TURBOCHARGER—4020T in Group 080.)
	Manifold pressure pipe to aneroid loose or broken.	Check hose and pipe connections for tightness; repair as required. (See TEST AIR INTAKE SYSTEM LEAKAGE in this group.)
Turbocharger "Screams" (4020T)	Air leak in manifold.	Check intake manifold gasket and manifold; repair as required. (See TEST AIR INTAKE SYSTEM LEAKAGE in this group or REMOVE AND INSTALL INTAKE MANIFOLD in Group 080.)

RG,RG34710,8343 –19–03MAY04–2/2

Check Air Intake System

1. Replace air cleaner primary filter element(s).

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.

RG,RG34710,8327 –19–15APR97–1/1

Test Air Intake System Leakage

Check for leaks in air intake system.

1. Remove air cleaner restriction indicator/switch, if equipped, and install test fitting.

2. Connect air pressure regulator to manifold using hose and fitting from air cleaner.

3. Remove air cleaner cover and main filter element.

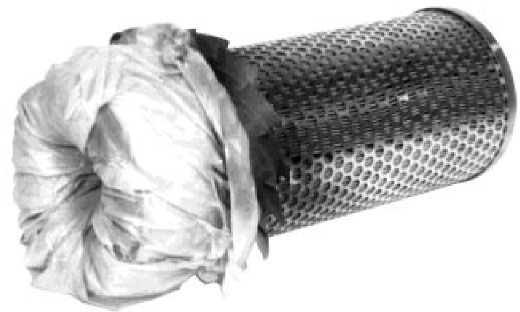
4. Put large plastic bag into and over end of main filter element. Install main filter element and cover.

5. Pressurize air intake system between 34—69 kPa (5—10 psi). If air intake system cannot be pressurized, turn engine slightly to close valves.

6. Apply soap solution over all connections from air cleaner to intake manifold or turbocharger, if equipped, and look for air bubbles. Repair or replace parts as necessary.

7. Repeat test until all leaks are found and repaired.

IMPORTANT: When reinstalling starting aid nozzle, position arrow on nozzle pointing against intake air flow.



M82124 –UN–12JUN00

Plastic Bag over Air Filter Element

RG,RG34710,8355 –19–03MAY04–1/1

Diagnosing Turbocharger Malfunctions—4020T

Before replacing the turbocharger, determine what caused the failure of the defective unit, and correct the condition. This will prevent an immediate repeat failure of the replacement unit. Refer to Air Intake and Exhaust System, Group 080, for repair information.

Symptom	Problem	Solution
Noise or Vibration:[1]	Bearings not lubricated (insufficient oil pressure).	See EXTENDING TURBOCHARGER LIFE—4020T in Group 080.
	Air leak in engine intake or exhaust manifold. Improper clearance between turbine wheel and turbine housing.	See TEST AIR INTAKE SYSTEM LEAKAGE in this group or TURBOCHARGER INSPECTION in Group 080.
	Broken blades (or other wheel failures).	See TURBOCHARGER INSPECTION in Group 080.
Engine Will Not Deliver Rated Power	Clogged manifold system.	See EXTENDING TURBOCHARGER LIFE—4020T in Group 080.
	Foreign material lodged in compressor, impeller, or turbine.	See TURBOCHARGER INSPECTION in Group 080.
	Excessive dirt build-up in compressor.	See TURBOCHARGER INSPECTION in Group 080.
	Leak in engine intake or exhaust manifold	See REMOVE AND INSTALL INTAKE MANIFOLD and REMOVE AND INSTALL EXHAUST MANIFOLD in Group 080.
	Leak in intake manifold-to-aneroid pipe.	See REMOVE AND INSTALL INTAKE MANIFOLD in Group 080.
	Rotating assembly bearing failure.	See TURBOCHARGER INSPECTION in Group 080.
	Damaged compressor or turbine blades.	See TURBOCHARGER INSPECTION in Group 080.

[1] *Do not confuse the whine heard during run down with noise which indicates a bearing failure.*

Continued on next page

Symptom	Problem	Solution
Oil on Compressor Wheel or in Compressor Housing (Oil Being Pushed or Pulled through Center Housing)	Excessive crankcase pressure.	See TURBOCHARGER INSPECTION in Group 080.
	Air intake restriction.	See TURBOCHARGER INSPECTION in Group 080.
	Drain tube restriction.	See EXTENDING TURBOCHARGER LIFE—4020T in Group 080.
Oil in Manifold or Dripping from Housing	Excessive crankcase pressure.	See TURBOCHARGER INSPECTION in Group 080.
	Air intake restriction.	See TURBOCHARGER INSPECTION in Group 080.
	Drain tube restriction.	See EXTENDING TURBOCHARGER LIFE—4020T in Group 080.
	Damaged or worn journal bearings.	See TURBOCHARGER INSPECTION in Group 080.
	Unbalanced rotating assembly due to damage to turbine or compressor wheel or blade.	See TURBOCHARGER INSPECTION in Group 080.
	Unbalanced rotating assembly due to dirt or carbon build-up on wheel or blade.	See TURBOCHARGER INSPECTION in Group 080.
	Bearing wear due to oil starvation or insufficient lubrication.	See EXTENDING TURBOCHARGER LIFE—4020T in Group 080.
	Shaft seals worn.	See TURBOCHARGER INSPECTION in Group 080.
Turbine Wheel Drag	Carbon build-up behind turbine wheel caused by coked oil or combustion deposits.	See TURBOCHARGER INSPECTION in Group 080.

Continued on next page

Symptom	Problem	Solution
	Dirt build-up behind compressor wheel caused by air intake leaks.	See EXTENDING TURBOCHARGER LIFE—4020T in Group 080.
	Bearing seizure or dirty, worn bearings caused by excessive temperatures, unbalanced wheel, dirty oil, oil starvation, or insufficient lubrication.	See EXTENDING TURBOCHARGER LIFE—4020T in Group 080.

RG,RG34710,8345 –19–15APR97–3/3

Check Exhaust System

1. Inspect exhaust system for leaks or restrictions. Check manifold for cracks. Repair or replace as necessary.

2. On turbocharged engines, check exhaust adapter to make sure it has end play and rotates freely. Correct as necessary.

RG,RG34710,8328 –19–15APR97–1/1

Test Engine Oil Pressure

1. Remove oil pressure sender.
2. Install JT03349 Connector.
3. Connect JT03017 Hose Assembly and JT05577 Pressure Gauge.

IMPORTANT: Do not run if no pressure is present.

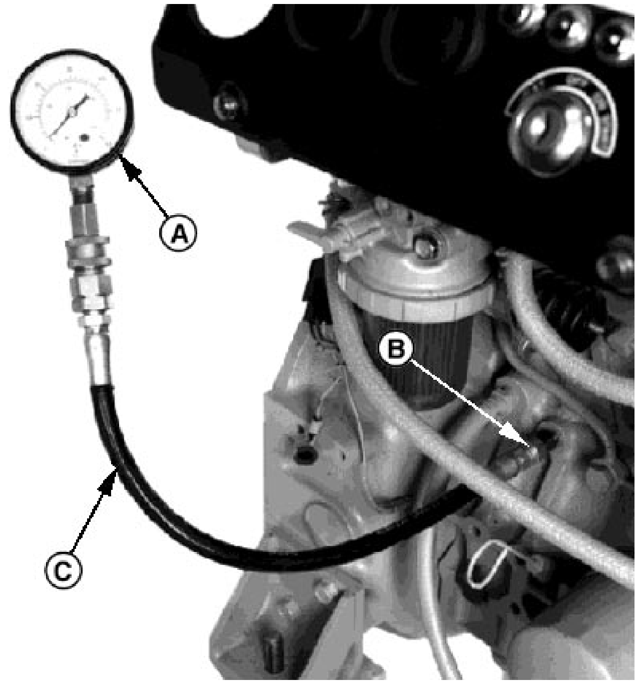
4. Start engine. If pressure reading is below 69 kPa (10 psi), STOP ENGINE.
5. Run engine approximately five minutes to heat oil, then check oil pressure at slow idle.

Specification

Engine Oil (At Slow Idle)—3009, 3011—Pressure	147 kPa (21 psi)
Engine Oil (At Slow Idle)—3012, 3015, 4020—Pressure	193 kPa (28 psi)
Engine Oil (At Slow Idle)—3013, 3016—Pressure	296 kPa (43 psi)
Engine Oil (At Slow Idle)—4TNE98—Pressure	59 kPa (8.5 psi)

If oil pressure is not within specifications, inspect oil pressure regulating valve parts for wear or damage. Add or remove shims as necessary. (See REMOVE AND INSTALL OIL PRESSURE REGULATING VALVE in Section 02, Group 60.)

If oil pressure does not increase, disassemble and inspect the oil pump. (See DISASSEMBLE, INSPECT AND ASSEMBLE OIL PUMP—3009, 3011, 3012, 3015, 4020 AND 4TNE98 or DISASSEMBLE, INSPECT AND ASSEMBLE OIL PUMP—3013 AND 3016 in Section 02, Group 060.)



M82144 –UN–25APR00

A—JT05577 Pressure Gauge
B—JT03349 Connector
C—JT03017 Hose Assembly

RG,RG34710,8356 –19–15APR97–1/1

Test Cylinder Compression Pressure—3009

IMPORTANT: Compression pressures are affected by the cranking speed of the engine. Before beginning test, ensure that batteries are fully charged and injection nozzle area is thoroughly cleaned.

NOTE: Pressure listed is for 300 m (1000 ft) above sea level. For naturally aspirated engines, reduce specification an additional 4% for each 300 m (1000 ft) of altitude.

1. Run engine until it is at operating temperature. Shut off engine.
2. Place throttle at slow idle.
3. Remove injection nozzles. (See REMOVE AND INSTALL FUEL INJECTION NOZZLES (PINTLE TYPE)—3009 in Group 090.)
4. Install JTG472 Adapter and JT01682 Compression Gauge Assembly in injector nozzle bore.
5. Disconnect fuel shut-off solenoid connector.
6. Crank engine for 10—15 seconds with starter (minimum cranking speed—250 rpm).
7. Record pressure reading for each cylinder.

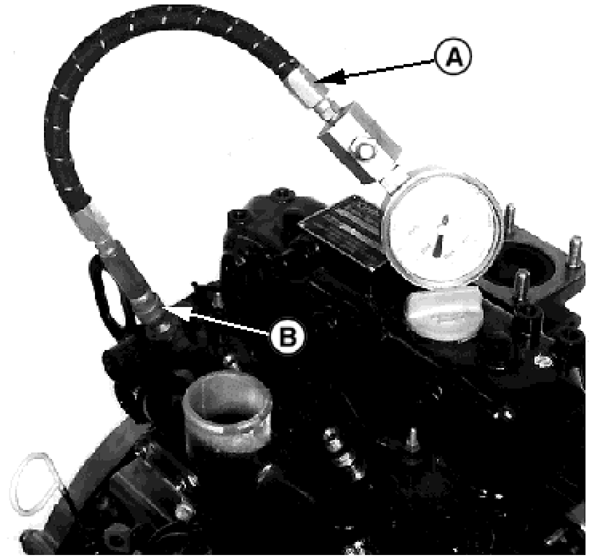
Specification

Cylinder Compression Pressure Test—3009—Compression Pressure	2455 kPa (356 psi)
Maximum Difference Between Cylinders	490 kPa (71 psi)

If pressure reading is below specification, squirt approximately two teaspoons of clean engine oil into cylinders through injector ports and repeat test.

If pressure increases significantly, check piston, rings and cylinder walls for wear or damage.

If pressure does not increase significantly after retest, check for leaking valves, valve seats or cylinder head gasket.



Cylinder Compression Test—3009

A—JT01682 Compression Gauge Assembly
B—JDG472 Adapter

Test Cylinder Compression Pressure—3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98

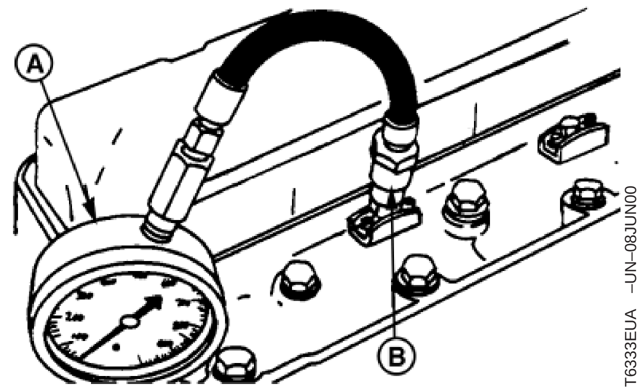
IMPORTANT: Compression pressures are affected by the cranking speed of the engine. Before beginning test, ensure that batteries are fully charged and injection nozzle area is thoroughly cleaned.

NOTE: Pressure listed is for 300 m (1000 ft) above sea level. For naturally aspirated engines, reduce specification an additional 4% for each 300 m (1000 ft) of altitude.

1. Run engine until it is at operating temperature. Shut off engine.
2. Move throttle to slow idle.
3. Remove injection nozzles. (See REMOVE AND INSTALL FUEL INJECTION NOZZLES (HOLE TYPE)—3011, 3012, 3013, 3015, 3016, 4020 AND 4TNE98 in Group 090.)
4. Remove heat protector from end of injector and install on Adapter (B).
5. Install JTG560 Adapter and JT01682 Compression Gauge Assembly in injector nozzle bore. Install retaining plate and tighten nuts/cap screw to specification.
6. Hold fuel shut-off knob in shut-off position.
7. Crank engine for 10—15 seconds with starter. Ensure minimum cranking speed is met.
8. Record pressure reading for each cylinder.

Specification

Cylinder Compression Pressure Test—3011, 3012, 3015 and 4020—Compression Pressure	2158 kPa (313 psi)
Maximum Difference Between Cylinders	490 kPa (71 psi)
Minimum Cranking Speed	300 rpm



Cylinder Compression Test—3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98

A—JT01682 Compression Gauge Assembly
B—JDG560 Adapter

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150
30

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RG,RG34710,8358 –19–29APR04–1/2

Specification

Cylinder Compression Pressure Test—3013—Compression Pressure	3055—3261 kPa (443—473 psi)
Minimum	2345 kPa (340 psi)
Maximum Difference Between Cylinders	250 kPa (26 psi)
Minimum Cranking Speed	250 rpm
Cylinder Compression Pressure Test—3016—Compression Pressure	3324—3530 kPa (482—512 psi)
Minimum	2648 kPa (384 psi)
Maximum Difference Between Cylinders	250 kPa (26 psi)
Minimum Cranking Speed	250 rpm
Cylinder Compression Pressure Test—4TNE98—Compression Pressure	3421 kPa (498 psi)
Minimum	2737 kPa (355 psi)
Maximum Difference Between Cylinders	195—293 kPa (28—43 psi)
Minimum Cranking Speed	250 rpm
Fuel Injection Retaining Plate Nuts—3011, 3012, 3015, 4020 and 4TNE98—Torque	5 N•m (44 lb-in.)
Fuel Injection Retaining Plate Cap Screw—3013 and 3016—Torque	24—28 N•m (212—248 lb-in.)

If pressure reading is below specification, squirt approximately two teaspoons of clean engine oil into cylinders through injector ports and repeat test.

If pressure increases significantly, check piston, rings and cylinder walls for wear or damage.

If pressure does not increase significantly after retest, check for leaking valves, valve seats or cylinder head gasket.

RG,RG34710,8358 –19–29APR04–2/2

Radiator Bubble Test

1. With coolant at proper level and radiator cap tight, run engine for five minutes to bring to operating temperature.

2. Remove cap from recovery tank.

3. Check for bubbles coming from overflow hose at bottom of tank.

If bubbles are present, isolate source of compression leak.(See TEST FOR CYLINDER LEAKAGE in this group.)

RG,RG34710,8361 –19–15APR97–1/1

Test for Cylinder Leakage

1. Remove injection nozzles.

2. Install JDG472 Adapter in injection port of cylinder to be tested.

3. Move piston to bottom of stroke with intake and exhaust valves closed.

4. Connect hose from compressed air source to adapter.

5. Apply the specified maximum air pressure into cylinder:

Cylinder Leakage Test Pressure—Specification

3009, 3011 and 4020—Maximum Air Pressure	2448 kPa (355 psi)
3015 and 4TNE98—Maximum Air Pressure	2158 kPa (313 psi)

6. Check for bubbles in recovery tank or air escaping from muffler, air cleaner or oil fill opening.

7. Repeat for each cylinder.

   If bubbles are present, check for cracks in cylinder head and block. Check for damaged head gasket.

   If air escapes from muffler, check for worn exhaust valve.

   If air escapes from air cleaner, check for worn intake valve.

   If air escapes from engine oil fill, check for worn piston rings.

OUO1083,00006A9 –19–28MAY04–1/1

Check Electrical System


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 (—) cable clamp from battery first and replace it last, when disconnecting and reconnecting battery.

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 fan/alternator drive belt. (See REPLACE AND ADJUST FAN/ALTERNATOR BELT in Group 070.)

7. Check operation of starting motor and gauges.

RG,RG34710,8331 –19–15APR97–1/1

Test Starter Amp Draw/RPM

IMPORTANT: Turn load knob of battery load tester fully counterclockwise before making connections.

NOTE: Engine should be at normal operating temperature when performing this test for an accurate amperage reading.

1. Turn load knob of battery load tester fully counterclockwise.

2. Connect JT05865 Battery Load Tester to battery.

3. Disconnect fuel shutoff solenoid connector.

4. Check system ground connections. Be sure battery is fully charged.

5. Crank engine. Read and record voltage at meter.

6. Use Hand-Held Digital Tachometer to read and record cranking rpm.

7. Turn key switch to OFF position. Adjust load knob until battery voltage is the same as when engine is cranking.

8. Read amperage on meter.

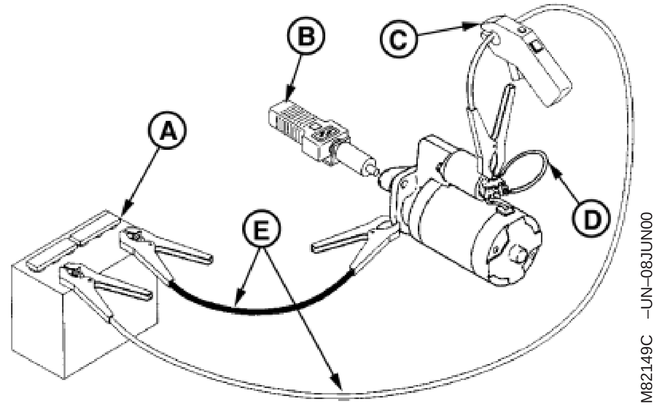
Specification

Starter Cranking Amp Draw/RPM—3009—Amperage (Maximum).. 200 amps @ 300 (minimum) rpm
Starter Cranking Amp Draw/RPM—3011, 3012, 3013, 3015, 3016 and 4020—Amperage (Maximum).. 230 amps @ 300 (minimum) rpm

9. Turn load knob of battery load tester fully counterclockwise.

   If amp reading is not to specification, or to specification but rpm is low, perform TEST STARTER NO-LOAD AMP DRAW/RPM later in this group.

Test Starter No-Load Amp Draw/RPM



A—12 Volt Battery
B—JT05719 Hand Held Digital Tachometer
C—JT05712 Current Gun
D—Jumper Wire
E—Jumper Cables

1. Mount starter in a vise.

NOTE: Check that battery is fully charged and of proper size to ensure accuracy of test.

2. Connect jumper cables (E) to a 12-volt battery (A).
    - Connect positive (+) cable to solenoid battery terminal on starter.
    - Connect negative (—) cable to starter body.

3. Attach JT05712 Current Gun (C) to positive cable.

IMPORTANT: Complete this test in 20 seconds or less to prevent starter damage.

4. Use a jumper wire (D) to briefly connect positive (+) starter terminal to solenoid terminal “S”. Starter should engage and run.

5. Read and record starter amperage and rpm using JT05712 Current Gun (C) and JT05719 Hand-Held Digital Tachometer (B).

Specification

Starter No-Load Amp Draw—3009—Amperage (Maximum)	60 amps @ 7000 (mimimum) rpm
Starter No-Load Amp Draw—3011, 3012, 3013, 3015 and 3016—Amperage (Maximum)	90 amps @ 3000 (mimimum) rpm
Starter No-Load Amp Draw—4020—Amperage (Maximum)	90 amps @ 3500 (mimimum) rpm
Starter No-Load Amp Draw—4TNE98—Amperage (Maximum)	19 amps @ 3500 (mimimum) rpm

6. If solenoid “clicks” or chatters and motor does not turn, replace solenoid.

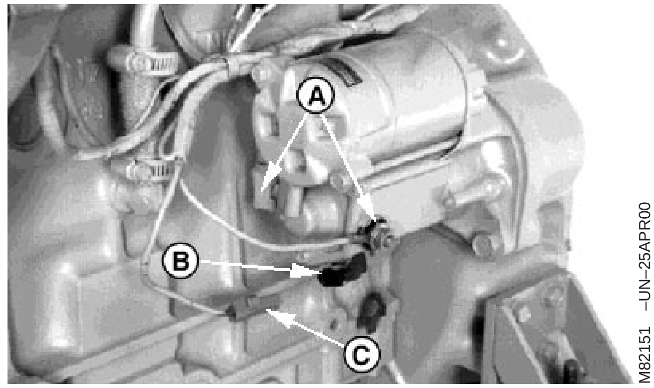
    If pinion gear engages and motor doesn’t turn, repair or replace starter motor.

    If starter engages and runs but amperage is more than specifications, repair or replace starter.

    If rpm is less than specification, with battery fully charged, repair or replace starter.

Test Starter Solenoid

1. Disconnect fuel shutoff solenoid connector (C).
2. Disconnect single wire connector from starter solenoid (B).
3. Connect jumper wire to positive (+) battery terminal and briefly jump to starter solenoid terminal (A).
4. If starter runs: Solenoid is good.
5. If starter does not run: Remove rubber boots from starter solenoid large terminals.
6. Connect jumper wire between terminals.
7. If starter runs: Replace solenoid.
8. If starter does not run: Check battery cables, then replace starter.



3011 and 4020 Shown

A—Starter Solenoid Terminal
B—Starter Solenoid Single Wire Connector
C—Fuel Shutoff Solenoid Connector

RG,RG34710,8364 –19–15APR97–1/1

Test Starter—3009 (Hitachi 0.8 kW)

Test Brush Holder

NOTE: Test brush holder using an ohmmeter or test light.

1. Touch one probe of tester to negative brush holder (A) and other probe to field brush holder (E). If there is continuity, replace the brush holder.

2. Inspect springs (B) for wear or damage. Replace if necessary.

3. Inspect brushes for abnormal wear or arching. Measure brush length (D). Replace if less than specification.

Specification
Starter Brushes—3009—Length .... 7.70 mm (0.303 in.) minimum

4. Test for grounded field winding:

   Touch one probe of tester to field coil brush (F) and other probe to field coil (G). Be sure the brush lead is not touching the frame. If there is continuity, the coil is grounded and the field coil assembly must be replaced.

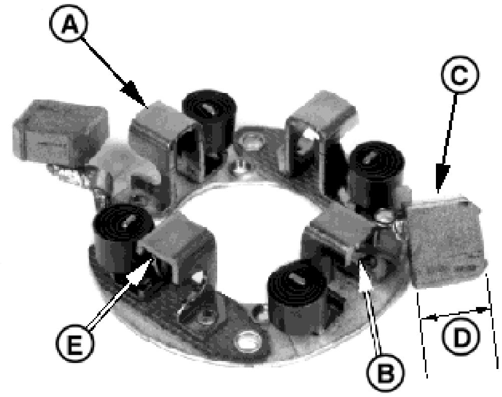
Test for Open Field Coil

1. Touch one probe of tester to each field coil brush (F). If there is no continuity, the field coil is open and the field coil assembly must be replaced.

IMPORTANT: Do not clean armature with solvent. Solvent can damage insulation on windings. Use only mineral spirits and a brush.

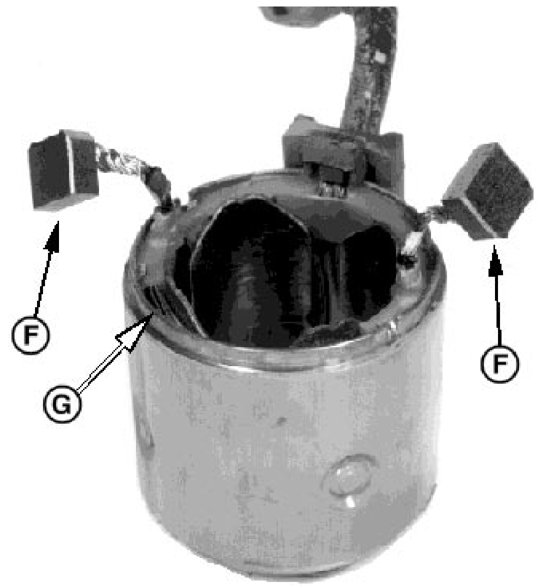
2. Inspect armature. Look for signs of armature rubbing against pole shoes.

3. Inspect commutator. Look for roughness, burned bars, or any material which might cause short circuits between bars. If necessary, clean and touch up with 400 grit sandpaper. Never use emery cloth. Clean all dust from armature when finished.



M82234 –UN–25APR00

Starter Components—3009



M82235 –UN–25APR00

Field Coil Brush and Field Coil

A—Negative Brush Holder
B—Spring
C—Negative Brush
D—Brush Length
E—Field Brush Holder
F—Field Coil Brush
G—Field Coil

Continued on next page

OUO1083,0000656 –19–06MAY04–1/3

Test for Grounded Windings

NOTE: Test armature windings using an ohmmeter or test light.

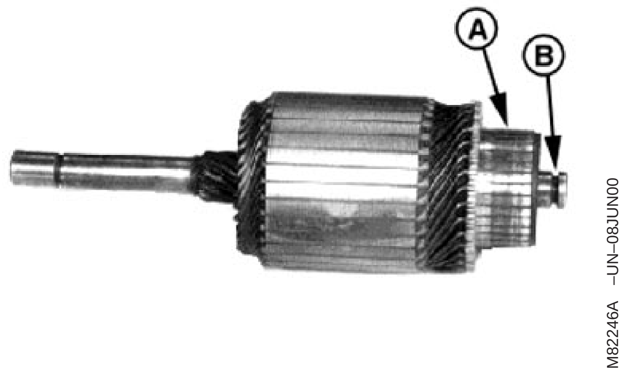
Touch probes on one commutator bar (A) and armature shaft (B). Armature windings are connected in series, so only one commutator needs to be checked.

If test shows continuity, a winding is grounded and the armature must be replaced.

Test for Open Circuit Windings

1. Touch probes on two different commutator bars.

   If test shows no continuity, there is an open circuit and the armature must be replaced.



Commutator Bar and Armature Shaft

A—Commutator Bar
B—Armature Shaft

04
150
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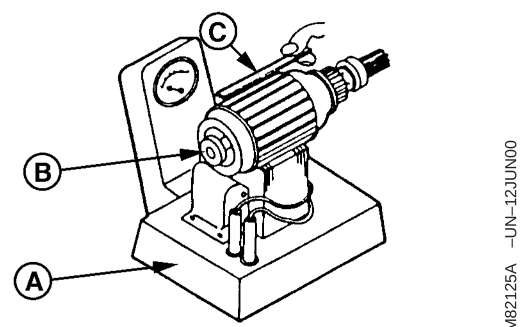
OUO1083,0000656 –19–06MAY04–2/3

2. Test for short circuit windings using a growler (A). Put armature (B) in a growler and hold a hacksaw blade (C) above each slot while slowly rotating armature.

   If coil is shorted, the blade will vibrate on the slot.

NOTE: A short circuit most often occurs because of copper dust or filings between two commutator segments.

3. If test indicates short circuit windings, clean the commutator of dust and filings. Check the armature again. If the test still indicates a short circuit, replace the armature.

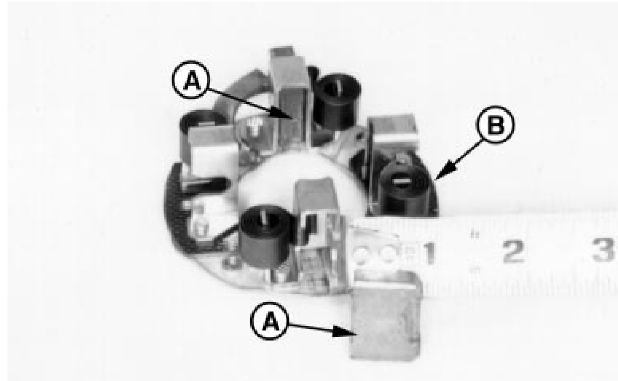


Test for Short Circuit Windings Using Growler

A—Growler
B—Armature
C—Hacksaw Blade

OUO1083,0000656 –19–06MAY04–3/3

Test Starter—3011, 3012, 3013, 3015, 3016 and 4020 (Denso 1.0 kW, 1.2 kW and 1.4 kW)



RW10072A –UN–08JUN00

Measure Length of Negative Brushes on Holder

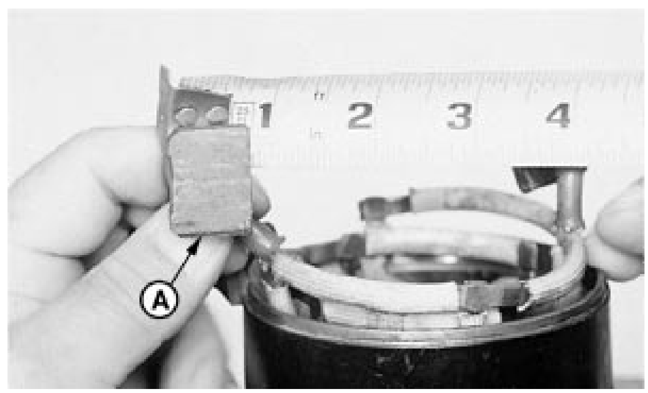
1. Measure length of negative brushes (A) mounted on brush holder (B). If worn below specification, replace the brush holder assembly.

Specification
Starter Negative Brushes—3011, 3012, 3013, 3015, 3016 and 4020—Length .... 8.5 mm (0.355 in.) minimum

A—Negative Brushes
B—Brush Holder

04
150
39

RG,RG34710,8296 –19–15APR97–1/9



RW10073A –UN–08JUN00

Measure the Field Coil Brushes

2. Measure the field coil brushes (A) attached to the field frame assembly. If worn below specification, replace the entire field frame assembly.

Specification
Starter Field Coil Brushes—3011, 3012, 3013, 3015, 3016 and 4020—Length .... 8.5 mm (0.355 in.) minimum

A—Field Coil Brushes

Continued on next page

RG,RG34710,8296 –19–15APR97–2/9

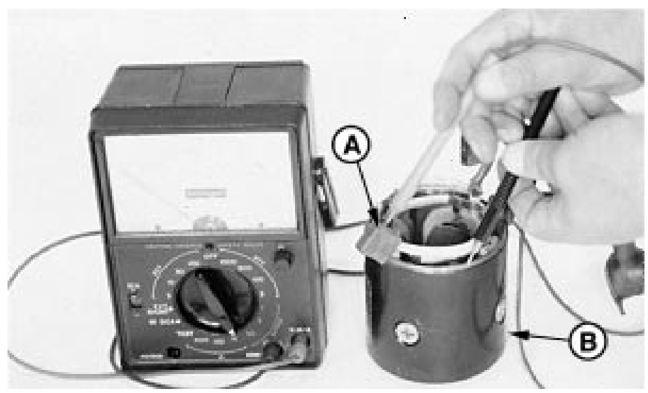
3. Test the brush holder using an ohmmeter, as shown, or a test light. Place one lead of tester to the negative brush holder and the other lead to the field brush holder. If there is continuity (needle movement), replace the brush holder.

Test Brush Holder

RG,RG34710,8296 –19–15APR97–3/9

4. Check for grounded field winding using an ohmmeter, as shown, or a test light. Touch one lead to a field coil brush (A) and the other lead to the field frame (B). Be sure the brush lead is not touching the frame. If there is continuity (needle movement) the coil is grounded and the field frame assembly must be replaced.

A—Field Coil Brush
B—Field Frame



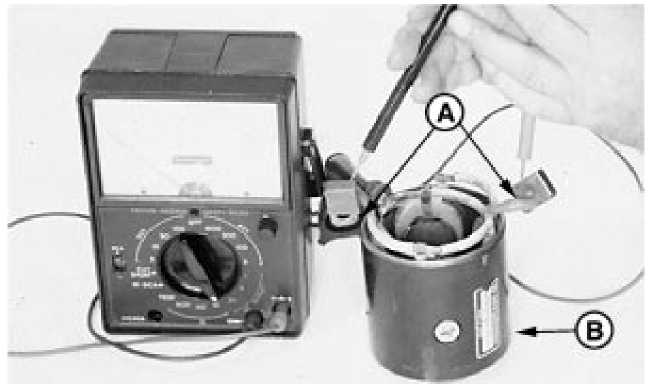
Check for Grounded Field Winding

Continued on next page

RG,RG34710,8296 –19–15APR97–4/9

5. Check for open field coil using an ohmmeter, as shown, or a test light. Touch a lead to each field coil brush (A). If there is no continuity (no needle movement) the field coil is open and the field frame assembly (B) must be replaced.

A—Field Coil Brush
B—Field Frame Assembly



RW10077A –UN–08JUN00

Check for Open Field Coil Winding

RG,RG34710,8296 –19–15APR97–5/9

IMPORTANT: Do not clean armature with solvent. Solvent could damage insulation on windings. Use only mineral spirits and a brush.

6. Visually inspect armature. Look for signs of dragging against pole shoes.

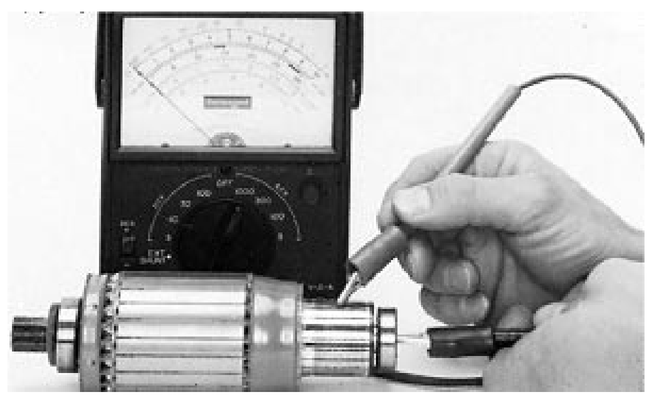

RW2166 –UN–06MAR90

Inspect Armature

RG,RG34710,8296 –19–15APR97–6/9

NOTE: Operating symptoms of grounded windings would be that the starting motor would have low armature speed and high current draw or fail to operate and have high current draw.

7. Check for grounded windings using an ohmmeter, as shown, or a test lamp. Place ohmmeter probes on commutator bar and armature shaft. If test shows continuity (needle movement) a winding is grounded and the armature must be replaced.


RW2167 –UN–26FEB93

Check for Grounded Windings on Armature

Continued on next page

RG,RG34710,8296 –19–15APR97–7/9

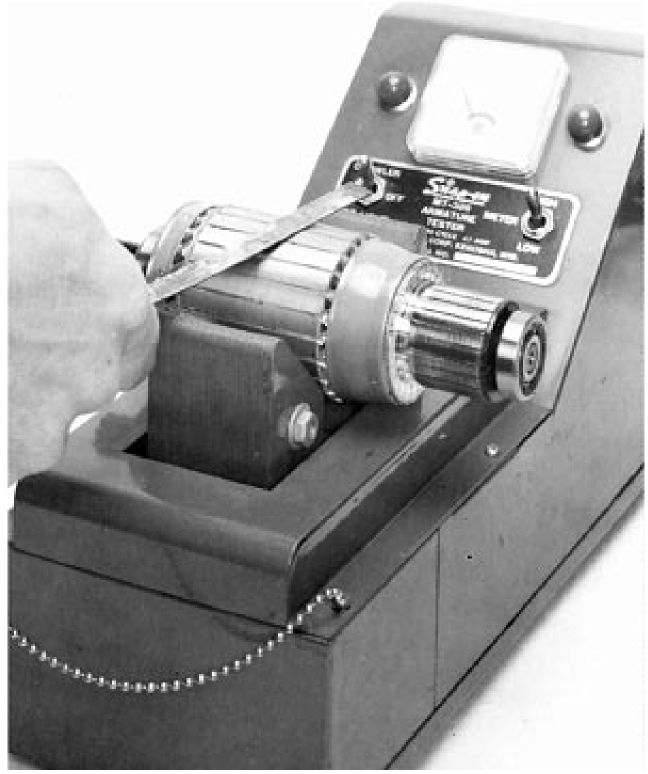
NOTE: Operating symptoms of short-circuited windings would be that the starting motor cranks engine slowly. On no-load test, motor has low armature speed and high current draw.

8. Check for short-circuited windings using a growler such as shown.

9. Place armature in growler and hold a hacksaw blade above each slot while slowly rotating the armature. The blade will be attracted to and repelled (vibrating motion) from the slot.

NOTE: A short circuit most often occurs because of copper dust or filings between two commutator segments.

10. If test indicates short-circuited windings, clean the commutator of dust and filings and recheck the armature. If test still indicates a short circuit, replace the armature.



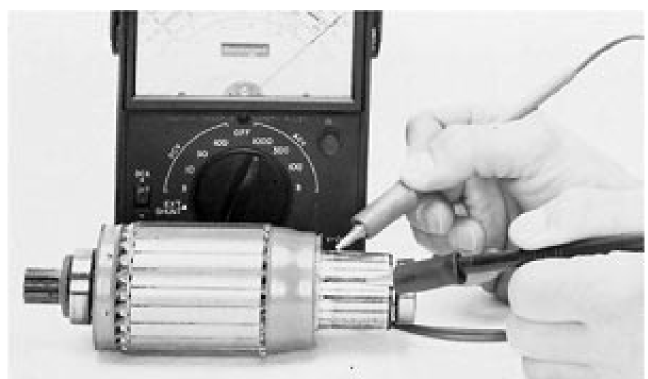
RW2168 –UN–01DEC88

Check for Shorted Armature Windings

RG,RG34710,8296 –19–15APR97–8/9

NOTE: Operating symptoms of open-circuited windings would be that the starting motor cranks engine slowly. On no-load test, motor has low armature speed and high current draw.

11. Check for open-circuited windings using an ohmmeter, as shown, or a test lamp. Place ohmmeter probes on two different commutator bars. If test shows no continuity (no needle movement), there is an open circuit and the armature must be replaced.



RW10060 –UN–10NOV89

Check for Open-Circuited Windings

RG,RG34710,8296 –19–15APR97–9/9

Test Alternator—3009, 3011, 3013, 3015 and 3016 (Denso 40-Amp)

Rotor

NOTE: Rear bearing (B) and rotor assembly are not serviced separately. Damaged parts require that rotor assembly and bearing be replaced as a unit.

1. Inspect bearing for wear or damage. Replace complete rotor if necessary.

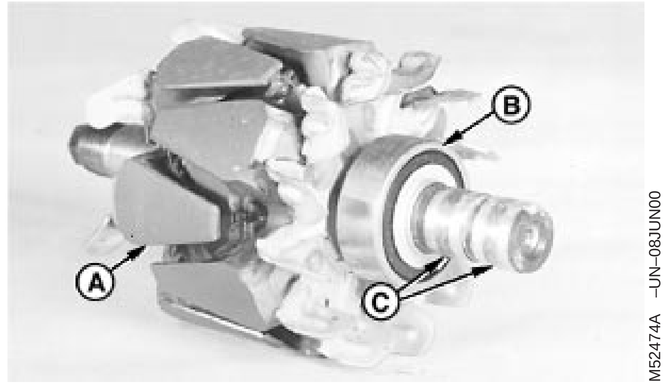
2. Inspect slip rings (C) for dirt build-up, rough spots or out-of-roundness. If necessary, polish the surface of the slip rings using No. 00 sandpaper or 400-grit silicone carbide paper. Measure outer diameter of slip rings. Replace rotor if less than specification.

Specification

Denso 40-Amp Alternator Rotor
Slip Ring—OD .... 14 mm (0.550 in.)

3. Touch the probes of an ohmmeter to slip rings (C). Replace rotor if test indicates no continuity (no needle movement).

4. Touch probes of ohmmeter to the rotor core (A) and one of the slip rings. Repeat for other slip ring. Replace rotor if test shows continuity (needle movement).



Rotor Assembly

A—Rotor Core
B—Rear Bearing
C—Slip Rings

Continued on next page

OUO1083,0000657 –19–06MAY04–1/5

Brushes

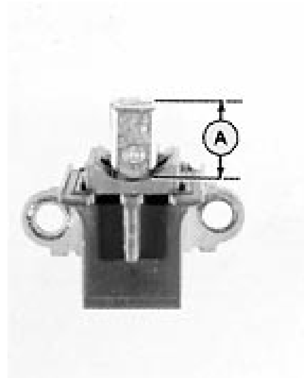
1. Inspect brush holder, brushes and springs for damage. Brushes must slide freely and springs must hold brushes firmly against the slip rings of the rotor.

2. Measure length (A) of brush protruding from holder. If length is less than wear limit, replace brushes.

Specification

Alternator Brush—3009, 3011,
3013, 3015 and 3016—Length .... 4.50 mm (0.170 in.) minimum

A—Measured Length



M52478 –UN–29JAN90

Measure Length of Brush

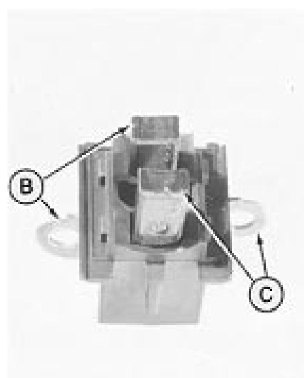
OUO1083,0000657 –19–06MAY04–2/5

3. Check continuity between brush and terminal B (B).

4. Check continuity between brush and terminal C (C).

5. There should be continuity only at these points.

B—Terminal B
C—Terminal C



M52479 –UN–29JAN90

Continuity Checkpoints

Continued on next page OUO1083,0000657 –19–06MAY04–3/5

Stator

1. Inspect stator for defective insulation, discoloration or a burned odor. If any of these defects are found, replace stator.

NOTE: Use an ohmmeter that is sensitive to resistance of 0 to 1 ohm.

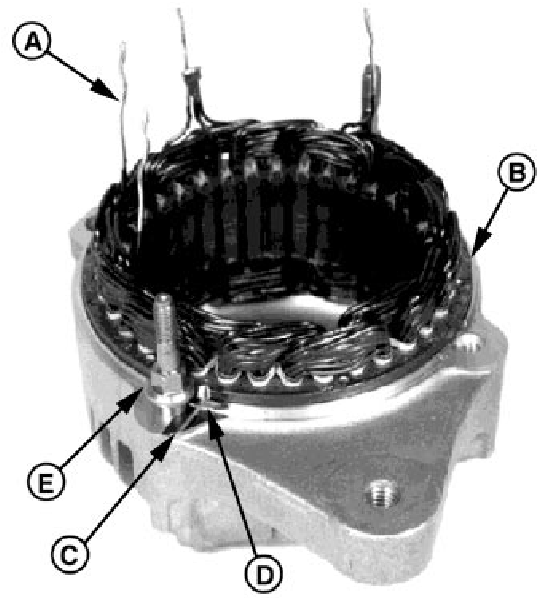
2. Check for continuity between each stator lead (A) and stator body (B). Replace stator if test indicates continuity.

3. To replace stator:

   a. Scribe a mark (C) on housing, at notch (D) in stator, to aid in installation of a new stator.

   b. Remove two studs (E).

   c. Replace stator using a punch and hammer.



M82251A –UN–12JUN00

Inspect Stator

A—Stator Leads (4 used)
B—Stator Body
C—Scribe Mark on Housing
D—Notch
E—Stud (2 used)

OUO1083,0000657 –19–06MAY04–4/5

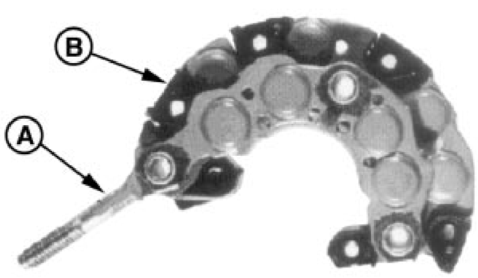
Rectifier

NOTE: Set the ohmmeter to the K-ohm range.

Check continuity between output post (A) and each diode lead (B). Reverse ohmmeter leads and recheck. There should be continuity in one direction, but not the other.

A shorted diode would have continuity in both directions. An open diode would have no continuity in either direction. Replace the rectifier if any of the four diodes are defective.

A—Output Post
B—Diode Lead



RG10854A –UN–12JUN00

Check Rectifier

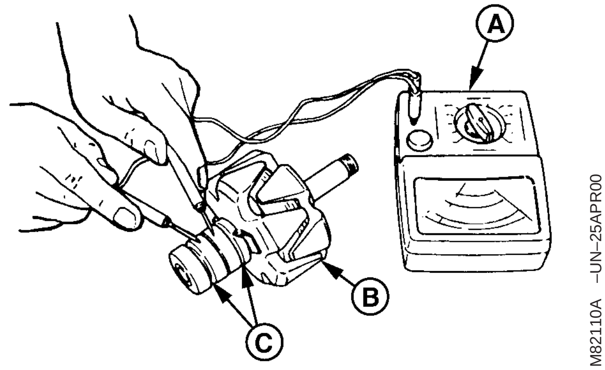
OUO1083,0000657 –19–06MAY04–5/5

Test Alternator—3012, 3015 and 4020 (Hitachi 40-Amp)

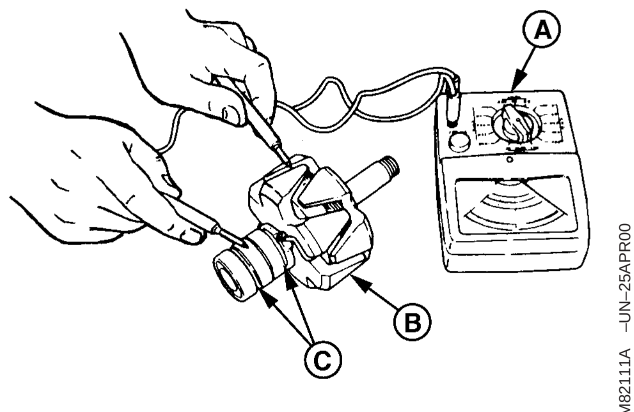
1. Touch the probes of an ohmmeter (A) to slip rings (C). Replace rotor assembly (B) if test indicates no continuity (no needle movement).

2. Touch the probes of the ohmmeter to the rotor (B) and to one of the slip rings (C). Repeat for other slip ring. Replace rotor assembly if test shows continuity (needle movement).

A—Ohmmeter
B—Rotor Assembly
C—Slip Rings



Test Rotor Continuity



Test Rotor Short Circuit

Continued on next page OUO1083,0000658 –19–06MAY04–1/3

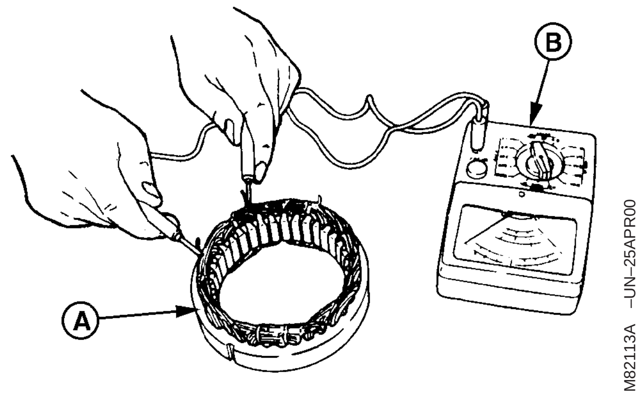
3. Inspect stator (A) for defective insulation, discoloration or a burned odor. If any of these defects are found, replace stator.

NOTE: Use an ohmmeter (B) that is sensitive to resistance of 0 to 1 ohm.

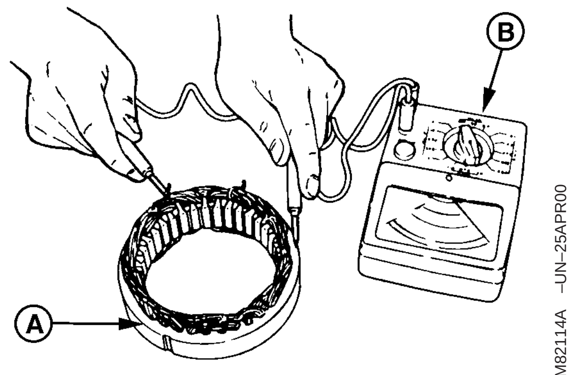
4. Touch probes of an ohmmeter (B) to lead wires of stator (A) in three possible combinations. Continuity should read approximately 0.26 ohms. If readings are not equal, replace stator.

5. Touch one probe of the ohmmeter to the bare metal surface of stator and the other probe to a bare stator lead wire. Repeat for each wire. Replace stator if test indicates continuity.

A—Stator
B—Ohmmeter



Test Stator Continuity



Test Stator Short Circuit

Continued on next page OUO1083,0000658 –19–06MAY04–2/3

6. Inspect rectifier/brush holder (C) and brushes (D) for damage. Brushes must slide freely and the springs must hold the brushes firmly against the slip rings of the rotor.

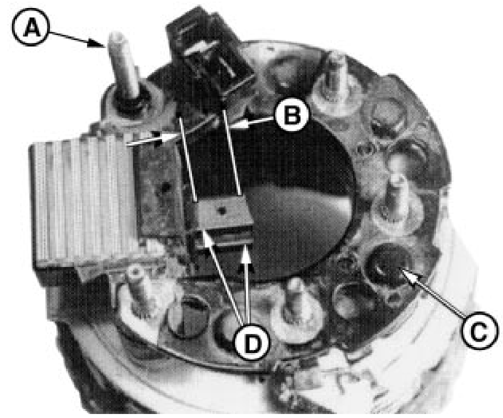
7. Measure brushes for wear. Replace brushes if length (B) is less than minimum.

Specification

Alternator Brush—3012, 3015 and 4020—Length...................................... 5.50 mm (0.220 in.) minimum

8. Use an ohmmeter or a test light to check for continuity. Check between the two brushes and between each brush and ground stud (A). There should be no continuity. Replace rectifier/brush holder assembly if there is continuity.

9. To replace brushes, melt solder from connections. Install new brushes.



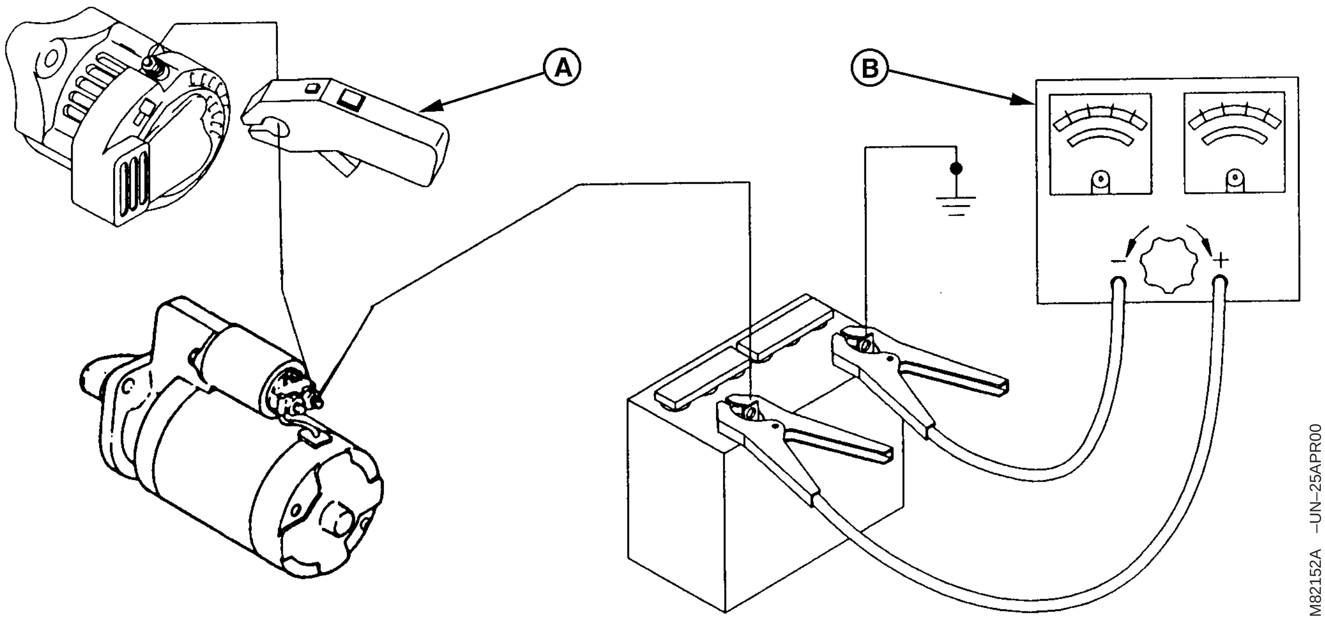
M76421B –UN–25APR00

Inspect Rectifier/Brush Holder and Brushes

A—Ground Stud
B—Brush Length
C—Rectifier/Brush Holder
D—Brushes

OUO1083,0000658 –19–06MAY04–3/3

Test Alternator Regulated Amperage



Alternator

A—JT05712 Current Gun **B—JT05865 Battery Load Tester**

1. Turn load knob of JT05865 Battery Load Tester (B) fully out (counterclockwise) before connecting to battery.

2. Connect load battery tester (B) to battery.

3. Attach JT05712 Current Gun (A) to alternator red wire. Set current gun for DC current.

IMPORTANT: Perform this test quickly to prevent damage to battery tester. DO NOT apply full load to battery for more than 10 seconds.

4. Start and run engine at fast idle (full throttle).

5. Turn load knob in until voltage read on the tester voltage scale is 11 volts and read amperage on current gun.

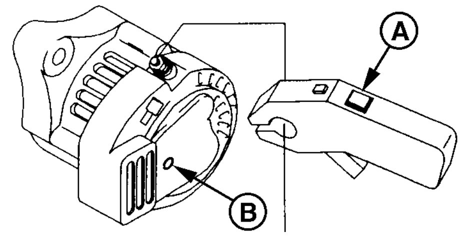
Specification

Minimum Regulated Amperage—Base/Industrial Applications—All Models except 4TNE98	35 Amps @ 3225 rpm
Minimum Regulated Amperage—Generator Set Applications—3009	35 Amps @ 3800 rpm
3011, 3012, 3013, 3015, 3016 and 4020	35 Amps @ 1900 rpm

If reading is less than specifications, verify voltage at the alternator regulator terminal and check for good alternator ground. If voltage and ground are OK, perform TEST ALTERNATOR UNREGULATED AMPERAGE later in this group to determine if alternator or voltage regulator is defective.

RG,RG34710,8365 –19–15APR97–1/1

Test Alternator Unregulated Amperage



Test Unregulated Amperage

A—JT05712 Current Gun
B—Hole

1. Attach JT05712 Current Gun (A) to alternator red wire. Set current gun for DC current.

IMPORTANT: Perform this test quickly to prevent damage to battery. DO NOT apply full load to battery for more than 10 seconds.

2. Start and run engine at fast idle (full throttle).

3. Insert a Phillips screwdriver through hole (B) in rear cover of alternator to ground the regulator to the rear cover. Read amperage on current gun.

04
150
50

Specification	
Minimum Unregulated Amperage—Base/Industrial Applications—All Models except 4TNE98	35 Amps @ 3225 rpm
Minimum Unregulated Amperage—Generator Set Applications—3009	35 Amps @ 3800 rpm
3011, 3012, 3013, 3015, 3016 and 4020	35 Amps @ 1900 rpm

If reading is less than specification, verify voltage at the alternator regulator terminal and good alternator ground. If voltage and ground are OK, replace the alternator.

If reading meets the specification, replace the regulator.

RG,RG34710,8366 –19–15APR97–1/1

Test Alternator Regulated Voltage

1. Remove surface charge from battery by placing a small load on the battery for 15 seconds.
2. Set voltmeter to DC volts scale.
3. Connect meter red lead to positive (+) battery terminal.
4. Connect meter black lead to negative (—) battery terminal.
5. Start and run engine at fast idle (full throttle).
6. Read meter several times during five minutes of running time.

Specification

Regulated Voltage Fast Idle Speed—Base/Industrial Applications—All Models except 4TNE98	12.2—14.7 VDC @ 3225 rpm
Regulated Voltage Fast Idle Speed—Generator Set Applications—3009	12.2—14.7 VDC @ 3800 rpm
3011, 3012, 3013, 3015, 3016 and 4020	12.2—14.7 VDC @ 1900 rpm

IMPORTANT: Do not allow the battery voltage to exceed 15.5 volts or the battery and charging system will be damaged.

If the DC voltage stays below the minimum specification, verify voltage at the alternator regulator terminal and good alternator ground. If voltage and ground are OK, perform TEST ALTERNATOR UNREGULATED AMPERAGE earlier in this group to determine if alternator or voltage regulator is defective.

If the DC voltage goes above the maximum specification, replace the regulator.

RG,RG34710,8367 –19–15APR97–1/1

Test Fuel Shutoff Solenoid Amperage—3011 and 3012

1. Test system ground connections and battery.

2. Perform circuit tests to ensure voltage at solenoid.

3. Attach JT05712 Current Gun (A) to white wire of fuel shutoff solenoid (B).

4. Set current gun for DC current.

NOTE: The high current required for pull-in will last only a short time.

5. Turn key switch ON. Compare pull-in amperage reading with specification.

Specification

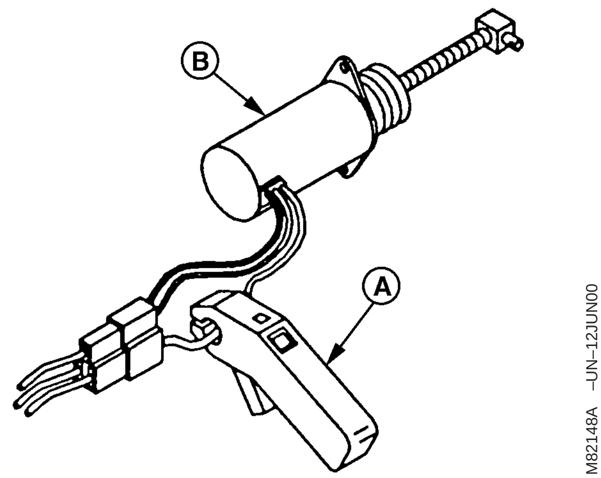
Fuel Shutoff Pull-In Amperage
(White Wire)—3011 and 3012—
Amperage .... 50 Amps (1/2 second)

6. Move current gun to red wire. Compare hold-in amperage reading with specification.

Specification

Fuel Shutoff Hold-In Amperage
(Red Wire)—3011 and 3012—
Amperage .... 1 Amp (continuous)

If readings do not meet specifications, check for binding linkage and adjust as needed or replace solenoid.



A—JT05712 Current Gun
B—Fuel Shutoff Solenoid

RG,RG34710,8368 –19–15APR97–1/1

Section 05
Tools and Other Materials

Contents

05

Engine Rebuild Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

Some of the SERVICEGARD™ tools listed in this manual may no longer be available for purchase. If you do not have the referenced tool, a suitable substitute may be available from a local supplier.

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OUO1083,000068F –19–19MAY04–1/2

Engine Lifting Sling JDG23

Lift engine.

OUO1083,000068F –19–19MAY04–2/2

Cylinder Head and Valves Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

Some of the SERVICEGARD™ tools listed in this manual may no longer be available for purchase. If you do not have the referenced tool, a suitable substitute may be available from a local supplier.

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OUO1083,0000637 –19–27APR04–1/4

Valve Guide Knurler. D-20018WI

Knurl valve guides

Continued on next page

OUO1083,0000637 –19–27APR04–2/4

Valve Guide Reamer D-20020WI

Used to ream ID of valve guides

OUO1083,0000637 –19–27APR04–3/4

Valve Guide Driver JDE118

Used to replace valve guides

OUO1083,0000637 –19–27APR04–4/4

Cylinder Head and Valves Service Equipment and Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC). Some tools may be available from a local supplier.

Some of the SERVICEGARD™ tools listed in this manual may no longer be available for purchase. If you do not have the referenced tool, a suitable substitute may be available from a local supplier.

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OUO1083,0000636 –19–27APR04–1/3

Plastic Brush

Clean valve guides.

OUO1083,0000636 –19–27APR04–2/3

Precision “Bevelled Edge” Straightedge D05012ST

Check cylinder head flatness.

OUO1083,0000636 –19–27APR04–3/3

Cylinder Block, Pistons, and Rods Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

Some of the SERVICEGARD™ tools listed in this manual may no longer be available for purchase. If you do not have the referenced tool, a suitable substitute may be available from a local supplier.

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OUO1083,000064D –19–03MAY04–1/2

Piston Ring Expander JDE85, JDE135, KJD10140

Remove and install piston rings.

OUO1083,000064D –19–03MAY04–2/2

Cylinder Block, Pistons, and Rods Other Material

Number	Name	Use
PM38655 (U.S.) TY9484 (Canadian) 515 (LOCTITE®)	Flexible Form-In-Place Gasket	Apply to camshaft bore plug.

LOCTITE is a trademark of Loctite Corp.

OUO1083,000064F –19–03MAY04–1/1

Crankshaft, Main Bearings, and Flywheel Service Equipment and Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC). Some tools may be available from a local supplier.

Some of the SERVICEGARD™ tools listed in this manual may no longer be available for purchase. If you do not have the referenced tool, a suitable substitute may be available from a local supplier.

SERVICEGARD is a trademark of Deere & Company

OUO1082,00002A9 –19–15JUN04–1/3

Universal Driver Set . . . . N/A

Used to remove and install crankshaft front oil seal.

OUO1082,00002A9 –19–15JUN04–2/3

Dial Indicator with Magnetic Base . . . . N/A

Used to measure crankshaft end play, and check crankshaft for bends.

OUO1082,00002A9 –19–15JUN04–3/3

Crankshaft, Main Bearings, and Flywheel Other Material

Number	Name	Use
PM38655 (U.S.) TY9484 (Canadian) 515 (LOCTITE®)	Flexible Form-In-Place Gasket	Apply to cylinder block front plate or housing, crankcase extension housing, rear crankshaft oil seal case and flywheel housing.

LOCTITE is a trademark of Loctite Corp.

OUO1083,000064A –19–29APR04–1/1

Camshaft and Timing Gear Train 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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OUO1083,0000652 –19–04MAY04–1/5

Dial Indicator with Magnetic Base . . . . N/A

Used to measure valve lift, check camshaft end play and check camshaft for bends.

OUO1083,0000652 –19–04MAY04–2/5

Magnetic Follower Holder Kit D15001NU

Hold camshaft followers when removing and installing camshaft.

OUO1083,0000652 –19–04MAY04–3/5

Knife Edge Puller . . . . N/A

Used to remove camshaft gear.

OUO1083,0000652 –19–04MAY04–4/5

Universal Driver Set . . . . N/A

Used to remove and install idler gear bushing.

OUO1083,0000652 –19–04MAY04–5/5

Camshaft and Timing Gear Train Other Material

Number	Name	Use
PM38655 (U.S.) TY9484 (Canadian) 515 (LOCTITE®)	Flexible Form-In-Place Gasket	Timing Gear Cover-to-Gear Housing/Front Plate, Timing Gear Housing/Front Plate-to-Cylinder Block

LOCTITE is a trademark of Loctite Corp.

OUO1083,0000653 –19–04MAY04–1/1

Lubrication System Other Material

Number	Name	Use
PM38655 (U.S.) TY9484 (Canadian) 515 (LOCTITE®)	Flexible Sealant	To seal oil pan gasket surfaces.
TY9375 (U.S.) TY9480 (Canadian) 592 (LOCTITE®)	Pipe Sealant	To seal oil pan drain fitting elbow (if equipped) and oil cooler drain plug (if equipped).
T43512 (U.S.) TY9473 (Canadian) 242 (LOCTITE®)	Thread Lock and Sealer (Medium Strength)	Apply to oil pump cover mounting cap screws.

LOCTITE is a trademark of Loctite Corp.

OUO1082,00002A1 –19–16APR04–1/1

Cooling System Service Equipment and Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC). Some tools may be available from a local supplier.

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Continued on next page

OUO1020,00013F5 –19–03MAY04–1/3

Knife Edge Puller . . . . N/A

Used to disassemble and assemble coolant pump.

OUO1020,00013F5 –19–03MAY04–2/3

Belt Tension Gauge. JDG529

Used to adjust fan/alternator belt tension.

OUO1020,00013F5 –19–03MAY04–3/3

Air Intake and Exhaust System Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

Some of the SERVICEGARD™ tools listed in this manual may no longer be available for purchase. If you do not have the referenced tool, a suitable substitute may be available from a local supplier.

OUO1083,0000664 –19–07MAY04–1/5

Manometer (Mercury Column) . . . 0—1500 mmHg (0—60 in.HG)

Used to measure control pressure in turbocharger waste gate test.

OUO1083,0000664 –19–07MAY04–2/5

Dial Indicator . . . . 0—10 mm (0—0.3937 in.)

Used to measure rod movement in turbocharger waste gate test.

Continued on next page

OUO1083,0000664 –19–07MAY04–3/5

Pressure Reducing Valve . . . . . 5 kg/cm² (70 psi) or less

Used to regulate air pressure in turbocharger waste gate test.

OUO1083,0000664 –19–07MAY04–4/5

Pressure Gauge . . . . 0—10 kg/cm² (0—150 psi)

Used to measure pressure in turbocharger waste gate test.

OUO1083,0000664 –19–07MAY04–5/5

Air Intake and Exhaust System 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.

Some of the SERVICEGARD™ tools listed in this manual may no longer be available for purchase. If you do not have the referenced tool, a suitable substitute may be available from a local supplier.

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OUO1083,0000663 –19–07MAY04–1/6

Dial Indicator with Magnetic Base . . . . N/A

Used to measure turbocharger shaft axial end play and radial side play.

OUO1083,0000663 –19–07MAY04–2/6

Extended Indicator Tip (RHB3). DFRG1

Used to measure turbocharger shaft radial side play.

Extended Indicator Tip (RHB5). DFRG2

Used to measure turbocharger shaft radial side play.

Continued on next page

OUO1083,0000663 –19–07MAY04–3/6

5 mm, 0.80 Thread Tap

Used to make threaded holes to remove turbocharger seal plate (RHB3)

OUO1083,0000663 –19–07MAY04–4/6

Universal Slide Hammer

Used to remove turbocharger seal plate.

OUO1083,0000663 –19–07MAY04–5/6

Impact Driver

Used to remove turbocharger thrust bearing mounting screws.

OUO1083,0000663 –19–07MAY04–6/6

Air Intake and Exhaust System Other Material

Number	Name	Use
TY16285 (U.S.) CXTY16285 (Canadian) 7649 (LOCTITE®)	Cure Primer	Apply to mating surfaces of turbocharger center housing and seal plate. Apply to mating surfaces of turbocharger center housing and compressor.
PM38655 (U.S.) TY9484 (Canadian) 515 (LOCTITE®)	Flexible Form-In-Place Gasket	Used to seal turbocharger seal plate. Apply to surface of turbocharger compressor housing.
T43512 (U.S.) TY9473 (Canadian) 242 (LOCTITE®)	Thread Lock and Sealer (Medium Strength)	Apply to threads of turbocharger seal plate screws.

LOCTITE is a trademark of Loctite Corp.

OUO1020,00013FA –19–03MAY04–1/1

Fuel System Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

Some of the SERVICEGARD™ tools listed in this manual may no longer be available for purchase. If you do not have the referenced tool, a suitable substitute may be available from a local supplier.

SERVICEGARD is a trademark of Deere & Company

OUO1083,0000674 –19–14MAY04–1/4

Hand-Held Digital Tachometer JT05719

Used to adjust slow idle and fast idle.

OUO1083,0000674 –19–14MAY04–2/4

Fast Idle Adjustment Socket (required for engines with recessed fast idle lock nut) JDG991

Used to adjust fast idle.

OUO1083,0000674 –19–14MAY04–3/4

Nozzle Cleaning Kit JDF13B

Cleaning fuel injection nozzles.

OUO1083,0000674 –19–14MAY04–4/4

Fuel System Service Equipment and Tools

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OUO1083,0000675 –19–14MAY04–1/4

Knife Edge Puller . . . . N/A

Used to disassemble fuel injection pump camshaft.

OUO1083,0000675 –19–14MAY04–2/4

Universal Puller Set . . . . N/A

Used to remove gear from injection pump.

OUO1083,0000675 –19–14MAY04–3/4

Inspection Magnifier 16487

Used to inspect the condition of fuel injector components.

OUO1083,0000675 –19–14MAY04–4/4

Fuel System Other Material

Number	Name	Use
JDF13B (U.S.)	Nozzle Cleaning Kit	Used to clean fuel injection nozzles.

OUO1083,0000676 –19–14MAY04–1/1

Starting and Charging Systems 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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SERVICEGARD is a trademark of Deere & Company

OUO1083,0000673 –19–11MAY04–1/6

Blind-Hole Puller Set . . . . N/A

Used to remove bushing from starter end cover (3009).

OUO1083,0000673 –19–11MAY04–2/6

Universal Driver Set. . . . . N/A

Used to install bushing in starter end cover (3009).

OUO1083,0000673 –19–11MAY04–3/6

Universal Puller Set . . . . N/A

Used to remove pulley from alternator.

OUO1083,0000673 –19–11MAY04–4/6

Universal Bushing, Bearing, and Seal Driver Set . . . . N/A

Used to remove front alternator bearing.

OUO1083,0000673 –19–11MAY04–5/6

Knife Edge Puller . . . . N/A

Used to remove rear alternator bearing (3015 and 4020 Hitachi equipped).

OUO1083,0000673 –19–11MAY04–6/6

Diagnostic Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

Some of the SERVICEGARD™ tools listed in this manual may no longer be available for purchase. If you do not have the referenced tool, a suitable substitute may be available from a local supplier.

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OUO1083,0000680 –19–14MAY04–1/14

Cooling System Pressure Pump D05104ST

Used to pressure test radiator cap and cooling system.

R26406N –UN–29NOV88

D05104ST

OUO1083,0000680 –19–14MAY04–2/14

Hose Fitting JT03274

Used to test fuel supply pump pressure.

Female Quick Coupler JT01609

Used to test fuel supply pump pressure.

Gauge w/Male Quick Coupler (0—150 psi) JT03274

Used to test fuel supply pump pressure.

Continued on next page

OUO1083,0000680 –19–14MAY04–3/14

Diesel Fuel Injection Nozzle Tester D01109AA

Used to test fuel injection nozzle.

Adapter Set D01110AA

Used to test fuel injection nozzle.

Straight Adapter 23622

Used to test fuel injection nozzle.

Container

Used to test fuel injection nozzle.

OUO1083,0000680 –19–14MAY04–4/14

Air Pressure Regulator

Used to regulate air pressure when pressurizing air intake system for test.

OUO1083,0000680 –19–14MAY04–5/14

Connector JT03349

Used to measure engine oil pressure.

OUO1083,0000680 –19–14MAY04–6/14

Hose Assembly. JT03017

Used to measure engine oil pressure.

OUO1083,0000680 –19–14MAY04–7/14

Pressure Gauge (100 psi) JT05577

Used to measure engine oil pressure.

Continued on next page OUO1083,0000680 –19–14MAY04–8/14

Adapter JTG472

Used to check cylinder compression pressure.

Compression Gauge Assembly JT01682

Used to check cylinder compression pressure.

OUO1083,0000680 –19–14MAY04–9/14

Adapter JTG560

Used to check cylinder compression pressure.

Compression Gauge Assembly JT01682

Used to check cylinder compression pressure.

OUO1083,0000680 –19–14MAY04–10/14

Battery Load Tester JT05685

Used to test starter and alternator output.

OUO1083,0000680 –19–14MAY04–11/14

Hand-Held Digital Tachometer JT05719

Used to test starter.

OUO1083,0000680 –19–14MAY04–12/14

Current Gun JT05712

Used to test starter, alternator output and fuel shutoff solenoid current draw.

OUO1083,0000680 –19–14MAY04–13/14

Voltmeter

Used to test alternator output voltage.

OUO1083,0000680 –19–14MAY04–14/14

Diagnostic 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.

Some of the SERVICEGARD™ tools listed in this manual may no longer be available for purchase. If you do not have the referenced tool, a suitable substitute may be available from a local supplier.

OUO1083,0000684 –19–14MAY04–1/2

Thermometer . . . . 0—93° C (0—200° F)

Used to measure water temperature for thermostat opening test and temperature switch test.

Glass Container

Used to contain water for thermostat opening test and temperature switch test.

Heating Unit

Used to heat water for thermostat opening test and temperature switch test.

OUO1083,0000684 –19–14MAY04–2/2

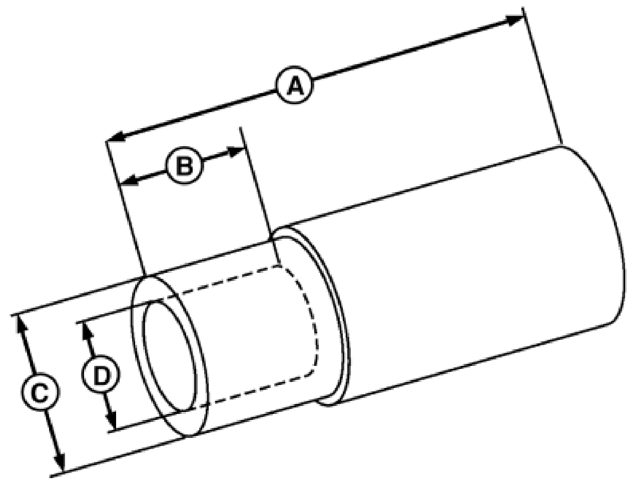
How To Make Tools

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

RG,RG34710,8396 –19–15APR97–1/1

Valve Guide Tool for 4TNE98 Engine

This tool is required for inserting valve guides into cylinder head on 4TNE98 engines.

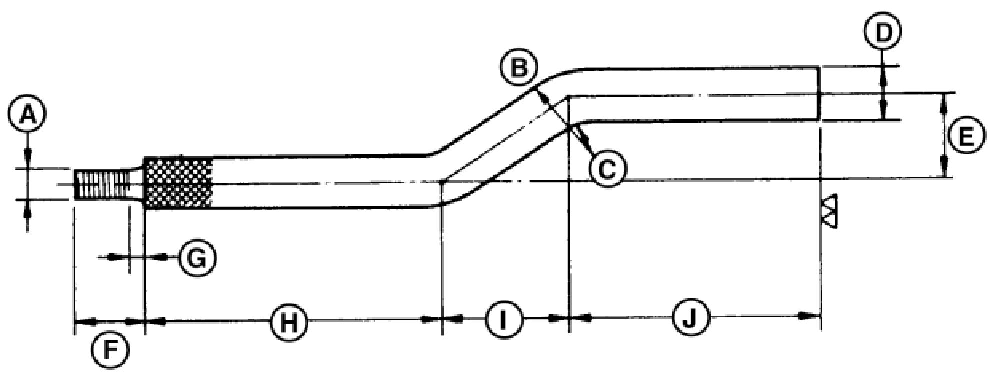


RG8592A –UN–25APR00

A—Length: 65 mm (2.56 in.)
B—Length: 15 mm (0.59 in.)
C—Diameter: 20 mm (0.787 in.)
D—Diameter: 14 mm (0.55 in.)

RG,RG34710,8397 –19–15APR97–1/1

DFRG1 Extension Adapter Tip (For RHB3 Turbochargers)



M82177A –UN–25APR00

A—M2.6, P0.45
B—Radius: 10 mm (0.3937 in.)
C—Radius: 5 mm (0.1968 in.)
D—Diameter: 3 mm 0.1181 in.)
E—Distance: 6 mm (0.236 in.)
F—Length: 8 mm (0.3149 in.)
G—Length: 1 mm (0.0393 in.)
H—Length: 30 mm (1.180 in.)
I—Length: 10 mm (0.3937 in.)
J—Length: 20 mm (0.787 in.)

This tool is used to check the radial play of the rotor shaft on RHB3 turbochargers on 4020T engines. Attach extended tip to a dial indicator. Purchase an extended indicator tip from a local supplier with the following approximate dimensions:

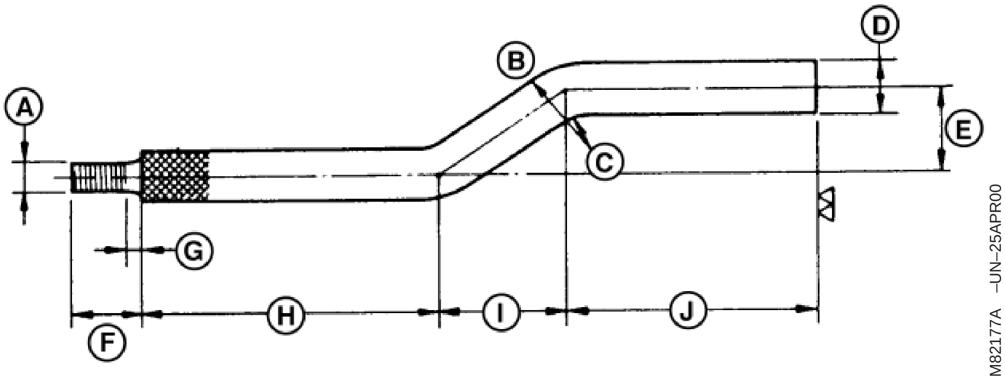
Length: 76 mm (3.0 in.)

Diameter: 3.0 mm (0.118 in.)

Heat and bend to size as shown.

RG,RG34710,8398 –19–15APR97–1/1

DFRG2 Extension Adapter Tip (For RHB5 Turbochargers)



A—M2.6, P0.45
B—Radius: 10 mm (0.3937 in.)
C—Radius: 5 mm (0.1968 in.)
D—Diameter: 5 mm 0.1968 in.)
E—Distance: 7 mm (0.2755 in.)
F—Length: 8 mm (0.3149 in.)
G—Length: 1 mm (0.0393 in.)
H—Length: 40 mm (1.5748 in.)
I—Length: 10 mm (0.3937 in.)
J—Length: 15 mm (0.5905 in.)

This tool is used to check the radial play of the rotor shaft on RHB5 turbochargers on 4020T engines. Attach extended tip to a dial indicator. Purchase an extended indicator tip from a local supplier with the following approximate dimensions:

Length: 76 mm (3.0 in.)

Diameter: 5.0 mm (0.197 in.)

Heat and bend to size as shown.

RG,RG34710,8399 –19–15APR97–1/1

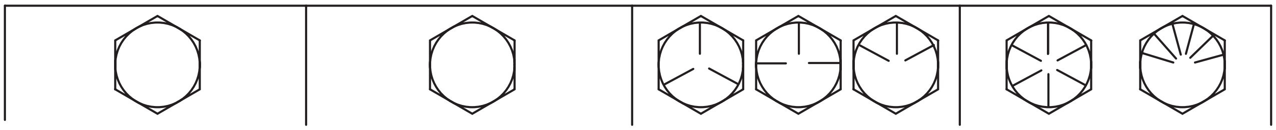
Section 06
Specifications

Contents

06

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.

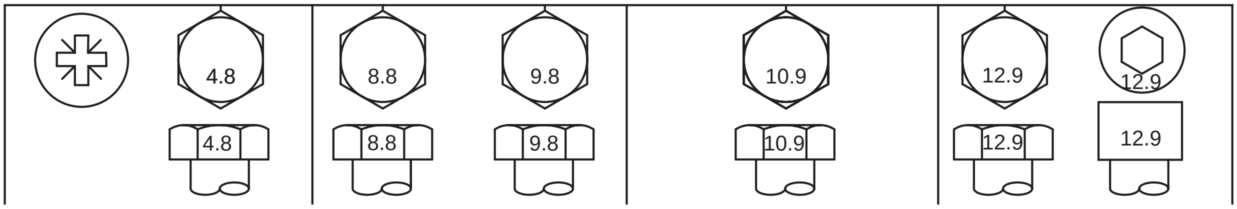
[a]Grade 2 applies for hex cap screws (not hex bolts) up to 6. in (152 mm) long. Grade 1 applies for hex cap screws over 6 in. (152 mm) long, and for all other types of bolts and screws of any length.

[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.

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

General OEM Engine Specifications

ITEM	3009 (3TNA72)	3011 (3TNC78)	3012 (3TNE78A)	3013 (3TNV82)	3015 (3TNE84)	3016 (3TNV88)	4020D (4TNE84)	4020T (4TNE84T)
Number of Cylinders	3	3	3	3	3	3	4	4
Bore	72 mm (2.83 in.)	78 mm (3.07 in.)	78 mm (3.07 in.)	82 mm (3.20 in.)	84 mm (3.31 in.)	88 mm (3.46 in.)	84 mm (3.31 in.)	84 mm (3.31 in.)
Stroke	72 mm (2.83 in.)	80 mm (3.15 in.)	84 mm (3.31 in.)	84 mm (3.30 in.)	90 mm (3.54 in.)	90 mm (3.54 in.)	90 mm (3.54 in.)	90 mm (3.54 in.)
Displacement	0.9 L (54 cu in.)	1.1 L (70 cu in.)	1.2 L (74 cu in.)	1.3 L (81 cu in.)	1.5 L (91 cu in.)	1.6 L (100 cu in.)	2.0 L (121 cu in.)	2.0 L (121 cu in.)
Compression	22.6:1	18.0:1	18.0:1	19.0:1	18.0:1	19.0:1	18.0:1	18.0:1
Max. Crank Pressure	0.5 kPa	0.5 kPa	0.5 kPa	0.5 kPa	0.5 kPa	0.5 kPa	0.5 kPa	0.5 kPa
Governor Regulation (Industrial)	5—8%	5—8%	5—8%	4—6%	5—8%	5—7%	5—8%	5—8%
Governor Regulation (Generator)	3—5%	3—5%	3—5%	3—5%	3—5%	3—5%	3—5%	3—5%
Oil Pressure Rated Speed	343 kPa (50 psi)	294 kPa (43 psi)	343 kPa (50 psi)	441 kPa (64 psi)	441 kPa (64 psi)	441 kPa (64 psi)	412 kPa (60 psi)	441 kPa (64 psi)
Oil Pressure Slow Idle	147 kPa (21 psi)	147 kPa (21 psi)	196 kPa (28 psi)	294 kPa (43 psi)	196 kPa (28 psi)	294 kPa (43 psi)	196 kPa (28 psi)	196 kPa (28 psi)
Length	640 mm (25.2 in)	670 mm (26.4 in)	690 mm (27.1 in)	574 mm (22.6 in)	728 mm (28.7 in)	609 mm (24.0 in)	819 mm (32.2 in)	819 mm (32.2 in)
Width	534 mm (21.0 in)	572 mm (22.5 in)	568 mm (22.3 in)	508 mm (20.0 in	615 mm (24.2 in)	509 mm (20.0 in)	615 mm (24.2 in)	618 mm (24.3 in)
Height	708 mm (27.9 in)	764 mm (30.1 in)	784 mm (30.9 in)	612 mm (24 in)	792 mm (31.2 in)	667 mm (26.3 in)	787 mm (31.0 in)	850 mm (33.5 in)
Weight (dry)	120 kg (265 lb)	160 kg (353 lb)	160 kg (353 lb)	135 kg (298 lb)	198 kg (436 lb)	163 kg (359 lb)	228 kg (502 lb)	233 kg (513 lb)

OUO1030,0000756 –19–07APR04–1/1

John Deere Construction and Forestry Equipment Engine Specifications

ITEM	4TNE98 (4033D)
Number of Cylinders	4
Bore	98 mm (3.86 in)
Stroke	mm (in.)
Displacement	3.3 L (202 cu in.)
Compression	18:1
Max. Crank Pressure	0.5 kPa
Governor Regulation	4—6%
Oil Pressure Rated Speed	345 ± 48 kPa (50 ± 7 psi)
Oil Pressure Slow Idle	59 kPa (8.5 psi)
Length	mm Not Available (in)
Width	mm Not Available (in)
Height	mm Not Available (in)
Weight (dry)	223 (491)

OUO1030,0000758 –19–13APR04–1/1

Cylinder Head and Valves Specifications

Item	Measurement	Specification
Rocker Arm Cover Special Nuts	Torque	18 N•m (156 lb-in.)
Breather Cover Screws—3011, 3012 and 3015	Torque	22 N•m (192 lb-in.)
Valve—Intake and Exhaust	Clearance	0.20 mm (0.008 in.)
Intake and Exhaust Valve—3009	Lift	7.5 mm (0.300 in.) minimum
Intake and Exhaust Valve—3011, 3012, 3015, 4020 and 4TNE98	Lift	8.8 mm (0.350 in.) minimum
Intake and Exhaust Valve—3013 and 3016	Lift	5.1 mm (0.201 in.) minimum
Rocker Arm Support Cap Screws	Torque	26 N•m (230 lb-in.)
Rocker Arm Shaft—3009	OD	11.96—11.98 mm (0.4711—0.4718 in.)
	Wear Limit	11.95 mm (0.4706 in.)
Rocker Arm Shaft—3011, 3012, 3013, 3015, 3016 and 4020	OD	15.97—15.98 mm (0.6286—0.6293 in.)
	Wear Limit	15.95 mm (0.6280 in.)
Rocker Arm Shaft—4TNE98	OD	18.47—18.49 mm (0.7272—0.7280 in.)
	Wear Limit	18.44 mm (0.7260 in.)
Rocker Arm Shaft Support—3009	ID	12.00—12.02 mm (0.4724—0.4732 in.)
	Wear Limit	12.09 mm (0.4759 in.)
Rocker Arm Shaft-to-Rocker Arm and Shaft Support Clearance—3009	Wear Limit	0.14 mm (0.006 in.)
Rocker Arm Shaft Support—3011, 3012, 3013, 3015, 3016 and 4020	ID	16.00—16.02 mm (0.630—0.631 in.)
	Wear Limit	16.09 mm (0.633 in.)
Rocker Arm Shaft-to-Rocker Arm and Shaft Support Clearance—3011, 3012, 3013, 3015, 3016 and 4020	Wear Limit	0.14 mm (0.006 in.)

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Item	Measurement	Specification
Rocker Arm Shaft Support—4TNE98	ID	18.50—18.52 mm (0.7311—0.7291 in.)
	Wear Limit	18.57 mm (0.7311 in.)
Rocker Arm Shaft-to-Rocker Arm and Shaft Support Clearance—4TNE98	Wear Limit	0.13 mm (0.005 in.)
Push Rod—3009	Length	141—142 mm (5.550—5.590 in.)
Push Rod—3011, 3012, 3015, 3016 and 4020	Length	178.2—178.75 mm (7.018—7.037 in.)
Push Rod—3013	Length	146.5—147 mm (5.767—5.787 in.)
Push Rod—4TNE98	Length	209.75—210.25 mm (8.258—8.278 in.)
Push Rod Bend—All Engines	Wear Limit	0.03 mm (0.001 in.)
Piston-to-Cylinder Head—3009	Clearance	0.61—0.79 mm (0.024—0.031 in.)
Piston-to-Cylinder Head—3011, 3012, 3015 and 4020	Clearance	0.64—0.82 mm (0.025—0.032 in.)
Piston-to-Cylinder Head—3013 and 3016	Clearance	0.66—0.78 mm (0.026—0.031 in.)
Piston-to-Cylinder Head—4TNE98	Clearance	0.737—0.869 mm (0.0290—0.0342 in.)
Cylinder Head	Out-of-Flat	0.05 mm (0.002 in.) maximum
	Wear Limit	0.15 mm (0.006 in.)
Maximum Material Removal for Flattening Head	Quantity	0.20 mm (0.008 in.) maximum
Intake Valve Seat—3009, 3011 and 3012	Width	1.36—1.53 mm (0.054—0.060 in.)
	Wear Limit	1.98 mm (0.078 in.)

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Item	Measurement	Specification
Exhaust Valve Seat—3009, 3011 and 3012	Width	1.66—1.87 mm (0.065—0.074 in.)
	Wear Limit	2.27 mm (0.089 in.)
Intake Valve Seat—3013	Width	1.44 mm (0.057 in.)
	Wear Limit	1.94 mm (0.076 in.)
Exhaust Valve Seat—3013	Width	1.15 mm (0.045 in.)
	Wear Limit	1.65 mm (0.065 in.)
Intake Valve Seat—3016	Width	1.77 mm (0.070 in.)
	Wear Limit	2.27 mm (0.089 in.)
Exhaust Valve Seat—3016	Width	1.34 mm (0.053 in.)
	Wear Limit	1.84 mm (0.072 in.)
Intake Valve Seat—3015 and 4020	Width	1.07—1.24 mm (0.042—0.049 in.)
	Wear Limit	1.74 mm (0.069 in.)
Exhaust Valve Seat—3015 and 4020	Width	1.24—1.45 mm (0.049—0.057 in.)
	Wear Limit	1.94 mm (0.076 in.)
Intake Valve Seat—4TNE98	Width	1.30 mm (0.051 in.)
	Wear Limit	2.0 mm (0.079 in.)
Exhaust Valve Seat—4TNE98	Width	2.20 mm (0.086 in.)
	Wear Limit	3.0 mm (0.118 in.)
Lower Valve Seat Surface	Angle	70°
Upper Seat Surface	Angle	15°
Valve Face		
Intake and Exhaust Valve Face Margin—3009, 3011, 3012, 3015, 4020 and 4TNE98	Width	0.51 mm (0.020 in.) minimum
Valve Face		
Intake Valve Face Margin—3013 and 3016	Width	1.24—1.44 mm (0.049—0.057 in.)
	Wear Limit	0.50 mm (0.020 in.) minimum

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Item	Measurement	Specification
Exhaust Valve Face Margin—3013 and 3016	Width	1.35—1.55 mm (0.053—0.061 in.)
	Wear Limit	0.50 mm (0.020 in.) minimum
Intake Valve Face—	Angle	30°
Exhaust Valve Face—	Angle	45°
First Valve Stem Measure Point—3009 and 3013	Distance	25 mm (0.984 in.)
Second Valve Stem Measure Point—3009 and 3013	Distance	45 mm (1.772 in.)
Intake and Exhaust Valve Stem—3009 and 3013	OD	6.945—6.960 mm (0.2732—0.2740 in.)
	Wear Limit	6.90 mm (0.2717 in.)
First Valve Stem Measure Point—3011 and 3012	Distance	30 mm (1.181 in.)
Second Valve Stem Measure Point—3011 and 3012	Distance	50 mm (1.969 in.)
Intake and Exhaust Valve Stem—3011 and 3012	OD	7.96—7.98 mm (0.3134—0.3142 in.)
	Wear Limit	7.90 mm (0.3110 in.)
First Valve Stem Measure Point—3015, 3016 and 4020	Distance	43 mm (1.693 in.)
Second Valve Stem Measure Point—3015, 3016 and 4020	Distance	60 mm (2.360 in.)
Intake Valve Stem—3015, 3016 and 4020	OD	7.96—7.98 mm (0.3134—0.3142 in.)
	Wear Limit	7.90 mm (0.3110 in.)
Exhaust Valve Stem—3015, 3016 and 4020	OD	7.96—7.97 mm (0.3134—0.3138 in.)
	Wear Limit	7.90 mm (0.3110 in.)
First Valve Stem Measure Point—4TNE98	Distance	43 mm (1.693 in.)

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Item	Measurement	Specification
Second Valve Stem Measure Point—4TNE98	Distance	60 mm (2.360 in.)
Intake Valve Stem—4TNE98	OD	7.965—7.98 mm (0.3134—0.3142 in.)
	Wear Limit	7.915 mm (0.3116 in.)
Exhaust Valve Stem—4TNE98	OD	7.955—7.970 mm (0.3134—0.3138 in.)
	Wear Limit	7.90 5 mm (0.3112 in.)
Intake Valve Recession—3009	Depth	0.40 mm (0.016 in.)
Exhaust Valve Recession—3009	Depth	0.85 mm (0.033 in.)
Intake and Exhaust Valve Recession—3011, 3012, 3015 and 4020	Depth	0.30—0.50 mm (0.012—0.020 in.)
	Wear Limit	1.00 mm (0.039 in.)
Intake Valve Recession—3013	Depth	0.35—0.55 mm (0.014—0.021 in.)
	Wear Limit	0.80 mm (0.031 in.)
Exhaust Valve Recession—3013	Depth	0.30—0.50 mm (0.012—0.020 in.)
	Wear Limit	0.80 mm (0.031 in.)
Intake and Exhaust Valve Recession—3016	Depth	0.30—0.50 mm (0.012—0.020 in.)
	Wear Limit	0.80 mm (0.031 in.)
Intake Valve Recession—4TNE98	Depth	0.50—0.70 mm (0.019—0.028 in.)
	Wear Limit	1.00 mm (0.039 in.)
Exhaust Valve Recession—4TNE98	Depth	0.60—0.80 mm (0.0236—0.0314 in.)
	Wear Limit	1.10 mm (0.043 in.)
Valve Guide—3009 and 3013	ID-Intake and Exhaust	7.00—7.02 mm (0.275—0.276 in.)
	Wear Limit	7.08 mm (0.279 in.)

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Item	Measurement	Specification
Valve Stem-to-Valve Guide—3009 and 3013	Clearance-Intake and Exhaust (3009)	0.030—0.060 mm (0.0012—0.0024 in.)
	Clearance-Intake (3013)	0.040—0.070 mm (0.0016—0.0028 in.)
	Clearance-Exhaust (3013)	0.045—0.075 mm (0.0018—0.0030 in.)
	Wear Limit (3009 and 3013)	0.18 mm (0.279 in.)
Valve Guide—3016	ID-Intake	8.010—8.025 mm (0.3154—0.3159 in.)
	Wear Limit	8.10 mm (0.319 in.)
Valve Guide—3016	ID-Exhaust	8.015—8.030 mm (0.3156—0.3161 in.)
	Wear Limit	8.10 mm (0.319 in.)
Valve Stem-to-Valve Guide—3016	Clearance-Intake	0.035—0.070 mm (0.0014—0.0028 in.)
	Clearance-Exhaust	0.045—0.075 mm (0.0018—0.0030 in.)
	Wear Limit-Intake and Exhaust	0.18 mm (0.279 in.)
Valve Guide—3011, 3012, 3015 and 4020	ID-Intake and Exhaust	8.010—8.025 mm (0.315—0.316 in.)
	Wear Limit	8.10 mm (0.318 in.)
Valve Stem-to-Valve Guide—3011, 3012, 3015 and 4020	Clearance-Intake and Exhaust	0.035—0.070 mm (0.001—0.003 in.)
	Wear Limit	0.20 mm (0.0078 in.)
Valve Guide—4TNE98	ID-Intake and Exhaust	8.015—8.030 mm (0.315—0.316 in.)
	Wear Limit	8.10 mm (0.318 in.)
Valve Stem-to-Valve Guide—4TNE98	Clearance-Intake	0.035—0.065 mm (0.0014—0.0026 in.)
	Wear Limit	0.185 mm (0.0073 in.)
Valve Stem-to-Valve Guide—4TNE98	Clearance-Exhaust	0.045—0.075 mm (0.0018—0.003 in.)
	Wear Limit	0.195 mm (0.0077 in.)
Valve Guide—3009	Height	9 mm (0.354 in.)
Valve Guide—3011 and 3012	Height	12 mm (0.472 in.)

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Item	Measurement	Specification
Valve Guide—3013	Height	11.7—12 mm (0.461—0.472 in.)
Valve Guide—3015 and 4020	Height	15 mm (0.591 in.)
Valve Guide—3016 and 4TNE98	Height	14.7—15.0 mm (0.578—0.590 in.)
Valve Spring—3009	Free Length	37.40 mm (1.472 in.)
Valve Spring—3011, 3012 and 3013	Free Length	42.0 mm (1.654 in.)
Valve Spring—3015 and 4020	Free Length	40.0 mm (1.575 in.)
Valve Spring—3016	Free Length	44.4 mm (1.870 in.)
Vlave Spring—4TNE98	Free Length	47.5 mm (1.748 in.)
Valve Spring—3009	Inclination	1.0 mm (0.040 in.)
Valve Spring—3011, 3012, 3015 and 4020	Inclination	1.1 mm (0.044 in.)
Valve Spring—3013, 3016 and 4TNE98	Inclination	1.2 mm (0.047 in.)
3009 Cylinder Head		
Cap Screw—First	Torque	19 N•m (168 lb-in.)
Cap Screw—Second	Torque	38 N•m (28 lb-ft)
Cap Screw—Final	Torque	61 N•m (45 lb-ft)
3011, 3012 and 3013 Cylinder Head		
Cap Screw—First	Torque	21 N•m (186 lb-in.)
Cap Screw—Second	Torque	42 N•m (31 lb-ft)
Cap Screw—Final (3011 and 3012)	Torque	69 N•m (51 lb-ft)
Cap Screw—Final (3013)	Torque	64 N•m (47 lb-ft)

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Item	Measurement	Specification
3015, 3016 and 4020 Cylinder Head		
Cap Screw—First	Torque	24 N•m (212 lb-in.)
Cap Screw—Second	Torque	48 N•m (36 lb-ft)
Cap Screw—Final	Torque	88 N•m (65 lb-ft)
4TNE98 Cylinder Head		
Cap Screw—First	Torque	54 N•m (40 lb-ft)
Cap Screw—Final	Torque	107 N•m (79 lb-ft)

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Cylinder Block, Pistons, and Rods Specifications

Item	Measurement	Specification
Piston-to-Cylinder Head—3009	Clearance	0.61—0.79 mm (0.024—0.031 in.)
Piston-to-Cylinder Head—3011, 3012, 3015, 4020	Clearance	0.64—0.82 mm (0.025—0.032 in.)
Piston-to-Cylinder Head—3013, 3016	Clearance	0.66—0.78 mm (0.026—0.031 in.)
Piston-to-Cylinder Head—4TNE98	Clearance	0.74—0.87 mm (0.029—0.034 in.)
Connecting Rod Side Play—All Engines	Clearance Wear Limit	0.20—0.40 mm (0.0079—0.0157 in.) 0.55 mm (0.022 in.)
Connecting Rod Cap Screw—3009	Torque	23 N•m (203 lb-in.)
Connecting Rod Cap Screw—3011, 3012, 3013	Torque	39 N•m (29 lb-ft)
Connecting Rod Cap Screw—3015, 3016, 4020	Torque	47 N•m (35 lb-ft)
Connecting Rod Cap Screw—4TNE98	Torque	54 N•m (40 lb-ft)
Connecting Rod Bearing-to-Crankshaft—3009	Oil Clearance Wear Limit	0.020—0.072 mm (0.0008—0.0028 in.) 0.15 mm (0.0059 in.)
Connecting Rod Bearing-to-Crankshaft—3011, 3012, 3013	Oil Clearance Wear Limit (3011, 3012) Wear Limit (3013)	0.038—0.090 mm (0.0015—0.0035 in.) 0.16 mm (0.0063 in.) 0.15 mm (0.0059 in.)
Connecting Rod Bearing-to-Crankshaft—3015, 3016, 4020, 4TNE98	Oil Clearance Wear Limit (3015, 4020, 4TNE98) Wear Limit (3016)	0.038—0.074 mm (0.0015—0.0029 in.) 0.16 mm (0.0062 in.) 0.15 mm (0.0059 in.)
Crankshaft Connecting Rod Journal—3009	OD Wear Limit	39.97—39.98 mm (1.5736—1.5740 in.) 39.92 mm (1.572 in.)

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Item	Measurement	Specification
Connecting Rod Bearing-to-Crankshaft Journal—3009	Oil Clearance	0.020—0.072 mm (0.0008—0.0028 in.)
	Wear Limit	0.15 mm (0.0059 in.)
Crankshaft Connecting Rod Journal—3011, 3012, 3013	OD	42.952—42.962 mm (1.6910—1.6914 in.)
	Wear Limit	42.902 mm (1.6891 in.)
Connecting Rod Bearing-to-Crankshaft Journal—3011, 3012, 3013	Oil Clearance	0.038—0.090 mm (0.0015—0.0035 in.)
	Wear Limit (3011, 3012)	0.16 mm (0.0063 in.)
	Wear Limit (3013)	0.15 mm (0.0059 in.)
Crankshaft Connecting Rod Journal—3015, 3016, 4020	OD	47.952—47.962 mm (1.8879—1.8883 in.)
	Wear Limit	47.902 mm (1.8859 in.)
Connecting Rod Bearing-to-Crankshaft Journal—3015, 3016, 4020	Oil Clearance	0.038—0.074 mm (0.0015—0.0029 in.)
	Wear Limit (3015, 4020)	0.16 mm (0.0063 in.)
	Wear Limit (3016)	0.15 mm (0.0059 in.)
Crankshaft Connecting Rod Journal—4TNE98	OD	57.952—57.962 mm (2.2816—2.2820 in.)
	Wear Limit	57.902 mm (2.2796 in.)
Connecting Rod Bearing-to-Crankshaft Journal—4TNE98	Oil Clearance	0.038—0.074 mm (0.0015—0.0029 in.)
	Wear Limit	0.15 mm (0.0059 in.)
Piston Ring-to-Groove—3009		
Top Compression Ring Groove	Clearance	0.75—0.110 mm (0.0030—0.0043 in.)
	Wear Limit	0.20 mm (0.0079 in.)
Second Compression Ring	Clearance	0.030—0.065 mm (0.0012—0.0026 in.)
	Wear Limit	0.20 mm (0.0079 in.)
Oil Ring	Clearance	0.020—0.055 mm (0.0008—0.0022 in.)
	Wear Limit	0.20 mm (0.0079 in.)

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Item	Measurement	Specification
Piston Ring-to-Groove—3011, 3012, 3016		
Top Compression Ring	Clearance	0.70—0.105 mm (0.0028—0.0041 in.)
	Wear Limit (3011, 3012)	0.25 mm (0.0098 in.)
	Wear Limit (3016)	Can not be accurately measured due to design
Second Compression Ring	Clearance	0.035—0.070 mm (0.0014—0.0028 in.)
	Wear Limit (3011, 3012)	0.25 mm (0.0098 in.)
	Wear Limit (3016)	0.190 mm (0.0075 in.)
Oil Ring	Clearance	0.030—0.060 mm (0.0012—0.0024 in.)
	Wear Limit (3011, 3012)	0.20 mm (0.0079 in.)
	Wear Limit (3016)	0.180 mm (0.0071 in.)
Piston Ring-to-Groove—3013, 3015, 4020		
Top Compression Ring	Clearance	0.75—0.110 mm (0.0030—0.0043 in.)
	Wear Limit (3015, 4020)	0.25 mm (0.0098 in.)
	Wear Limit (3013)	Can not be accurately measured due to design
Second Compression Ring	Clearance	0.045—0.080 mm (0.0018—0.0031 in.)
	Wear Limit (3015, 4020)	0.25 mm (0.0098 in.)
	Wear Limit (3013)	0.200 mm (0.0079 in.)
Oil Ring	Clearance	0.025—0.060 mm (0.0010—0.0024 in.)
	Wear Limit (3015, 4020)	0.20 mm (0.0079 in.)
	Wear Limit (3013)	0.180 mm (0.0071 in.)
Piston Ring-to-Groove—4TNE98		
Top Compression Ring	Clearance	0.60—0.100 mm (0.0023—0.0039 in.)

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Item	Measurement	Specification
Second Compression Ring	Clearance	0.090—0.125 mm (0.0035—0.0049 in.)
	Wear Limit	0.245 mm (0.0096 in.)
Oil Ring	Clearance	0.025—0.060 mm (0.0010—0.0024 in.)
	Wear Limit	0.180 mm (0.0070 in.)
Piston Ring End Gap—3009		
Top Compression Ring	Gap	0.10—0.25 mm (0.004—0.010 in.)
	Wear Limit	1.50 mm (0.0591 in.)
Second Compression Ring	Gap	0.25—0.40 mm (0.010—0.016 in.)
	Wear Limit	1.50 mm (0.0591 in.)
Oil Ring	Gap	0.15—0.35 mm (0.006—0.014 in.)
	Wear Limit	1.50 mm (0.0591 in.)
Piston Ring End Gap—3011, 3012		
Compression Rings	Gap	0.25—0.40 mm (0.010—0.016 in.)
	Wear Limit	1.50 mm (0.0591 in.)
Oil Ring	Gap	0.02—0.04 mm (0.008—0.016 in.)
	Wear Limit	1.50 mm (0.0591 in.)
Piston Ring End Gap—3013, 3016		
All Rings	Gap	0.20—0.40 mm (0.008—0.016 in.)
	Wear Limit	0.490 mm (0.019 in.)
Piston Ring End Gap—3015, 4020		
All Rings	Gap	0.20—0.40 mm (0.008—0.016 in.)
	Wear Limit	1.50 mm (0.0591 in.)

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Item	Measurement	Specification
Piston Ring End Gap—4TNE98		
Top Compression Ring	Gap	0.25—0.45 mm (0.0098—0.0177 in.)
Second Compression Ring	Gap	0.450—0.650 mm (0.0177—0.0256 in.)
	Wear Limit	0.730 mm (0.0287 in.)
Oil Ring	Gap	0.25—0.45 mm (0.0098—0.0177 in.)
	Wear Limit	0.550 mm (0.0217 in.)
Piston Pin Bore—3009	Diameter	21.00—21.009 mm (0.8268—0.8271 in.)
	Wear Limit	21.02 mm (0.828 in.)
Piston Pin-to-Piston Pin Bore—3009	Oil Clearance	0.045 mm (0.0018 in.)
Piston Pin Bore—3011, 3012, 3013	Diameter	23.00—23.009 mm (0.9055—0.9059 in.)
	Wear Limit (3011, 3012)	23.02 mm (0.906 in.)
	Wear Limit (3013)	23.039 mm (0.9070 in.)
Piston Pin-to-Piston Pin Bore—3011, 3012, 3013	Oil Clearance (3011, 3012)	0.000—0.017 mm (0.0000—0.0007 in.)
	Wear Limit	0.120 mm (0.0047 in.)
	Oil Clearance (3013)	0.000—0.014 mm (0.0000—0.0006 in.)
	Wear Limit	0.074 mm (0.0029 in.)
Piston Pin Bore—3015, 3016, 4020	Diameter	26.00—26.009 mm (1.0236—1.0240 in.)
	Wear Limit (3015, 4020)	26.02 mm (1.024 in.)
	Wear Limit (3016)	26.039 mm (1.0252 in.)
Piston Pin-to-Piston Pin Bore—3015, 3016, 4020	Oil Clearance (3015, 4020)	0.000—0.022 mm (0.0000—0.0009 in.)
	Wear Limit	0.120 mm (0.0047 in.)
	Oil Clearance (3016)	0.000—0.014 mm (0.0000—0.0006 in.)
	Wear Limit	0.074 mm (0.0029 in.)

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Item	Measurement	Specification
Piston Pin Bore—4TNE98	Diameter	30.000—30.009 mm (1.1811—1.1815 in.)
	Wear Limit	30.039 mm (1.1826 in.)
Piston Pin-to-Piston Pin Bore—4TNE98	Oil Clearance	0.00—0.020 mm (0.00—0.0008 in.)
Piston Diameter—3009		
Measurement Location (A)	Distance	8 mm (0.135 in.)
Standard Piston	Diameter	71.922—71.952 mm (2.832—2.833 in.)
	Wear Limit	71.81 mm (2.827 in.)
0.25 mm (0.010 in.) Oversize Piston	Diameter	72.172—72.202 mm (2.8714—2.8426 in.)
	Wear Limit	72.06 mm (2.837 in.)
Piston-to-Cylinder Bore	Clearance	0.105 mm (0.004 in.)
Piston Diameter—3011, 3012		
Measurement Location (A)	Distance	23 mm (0.905 in.)
Standard Piston	Diameter	77.895—77.925 mm (3.067—3.068 in.)
	Wear Limit	77.80 mm (3.063 in.)
0.25 mm (0.010 in.) Oversize Piston	Diameter	78.150—78.165 mm (3.0768—3.0774 in.)
	Wear Limit	78.05 mm (3.053 in.)
Piston-to-Cylinder Bore	Clearance	0.105 mm (0.004 in.)
Piston Diameter—3013		
Measurement Location (A)	Distance	16 mm (0.630 in.)
Standard Piston	Diameter	81.950—81.980 mm (3.2264—3.2275 in.)
	Wear Limit	81.905 mm (3.2246 in.)

Continued on next page

Item	Measurement	Specification
0.25 mm (0.010 in.) Oversize Piston	Diameter	82.200—82.230 mm (3.2362—3.2374 in.)
	Wear Limit	82.155 mm (3.2344 in.)
Piston-to-Cylinder Bore	Clearance	0.035—0.065 mm (0.0014—0.0026 in.)
Piston Diameter—3015, 4020		
Measurement Location (A)	Distance	24 mm (0.945 in.)
Standard Piston	Diameter	83.945—83.975 mm (3.305—3.306 in.)
	Wear Limit	83.90 mm (3.303 in.)
0.25 mm (0.010 in.) Oversize Piston	Diameter	84.195—84.225 mm (3.315—3.316 in.)
	Wear Limit	84.15 mm (3.313 in.)
Piston-to-Cylinder Bore	Clearance	0.055 mm (0.002 in.)
Piston Diameter—3016		
Measurement Location (A)	Distance	24 mm (0.945 in.)
Standard Piston	Diameter	87.945—87.975 mm (3.4624—3.4636 in.)
	Wear Limit	87.900 mm (3.4606 in.)
0.25 mm (0.010 in.) Oversize Piston	Diameter	88.195—88.225 mm (3.4722—3.4734 in.)
	Wear Limit	88.150 mm (3.4705 in.)
Piston-to-Cylinder Bore	Clearance	0.040—0.070 mm (0.0016—0.0028 in.)
Piston Diameter—4TNE98		
Measurement Location (A)	Distance	22 mm (0.866 in.)
Standard Piston	Diameter	97.945—97.955 mm (3.38561—3.8565 in.)
	Wear Limit	97.90 mm (3.8543 in.)

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Item	Measurement	Specification
0.25 mm (0.010 in.) Oversize Piston	Diameter	98.195—98.205 mm (3.38659—3.8663 in.)
	Wear Limit	98.15 mm (3.8642 in.)
Piston-to-Cylinder Bore	Clearance	0.050—0.080 mm (0.0019—0.0031 in.)
Piston Pin—3009	Diameter	20.991—21.00 mm (0.826—0.827 in.)
	Wear Limit	20.975 mm (0.825 in.)
Piston Pin-to-Piston Pin Bore—3009	Oil Clearance	0.045 mm (0.0018 in.)
Piston Pin—3011, 3012	Diameter	22.991—23.00 mm (0.905—0.906 in.)
	Wear Limit	22.90 mm (0.902 in.)
Piston Pin-to-Piston Pin Bore—3011, 3012	Oil Clearance	0.045 mm (0.0018 in.)
Piston Pin—3013	Diameter	22.995—23.000 mm (0.9053—0.9055 in.)
	Wear Limit	22.965 mm (0.9041 in.)
Piston Pin-to-Piston Pin Bore—3013	Oil Clearance	0.000—0.014 mm (0.0000—0.0006 in.)
	Wear Limit	0.074 mm (0.0029 in.)
Piston Pin—3016	Diameter	25.995—26.000 mm (1.0234—1.0236 in.)
	Wear Limit	25.965 mm (1.0222 in.)
Piston Pin-to-Piston Pin Bore—3016	Oil Clearance	0.000—0.014 mm (0.0000—0.0006 in.)
	Wear Limit	0.074 mm (0.0029 in.)
Piston Pin—3015, 4020	Diameter	25.987—26.000 mm (1.023—1.024 in.)
	Wear Limit	25.90 mm (1.020 in.)
Piston Pin-to-Piston Pin Bore—3015, 4020	Oil Clearance	0.022 mm (0.0009 in.)

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Item	Measurement	Specification
Piston Pin—4TNE98	Diameter	29.989—30.000 mm (1.1807—1.1811 in.)
	Wear Limit	29.959 mm (1.1795 in.)
Piston Pin-to-Piston Pin Bore—4TNE98	Oil Clearance	0.00—0.020 mm (0.00—0.0008 in.)
Piston Pin Bushing In Connecting Rod—3009	ID	21.025—21.038 mm (0.8278—0.8282 in.)
	Wear Limit	21.10 mm (0.831 in.)
Piston Pin-to-Piston Pin Bushing—3009	Oil Clearance	0.110 mm (0.0043 in.)
Piston Pin Bushing In Connecting Rod—3011, 3012	ID	23.025—23.038 mm (0.9065—0.9070 in.)
	Wear Limit	23.10 mm (0.909 in.)
Piston Pin-to-Piston Pin Bushing—3011, 3012	Oil Clearance	0.110 mm (0.0043 in.)
Piston Pin Bushing In Connecting Rod—3013	ID	23.025—23.038 mm (0.9065—0.9070 in.)
	Wear Limit	23.068 mm (0.9082 in.)
Piston Pin-to-Piston Pin Bushing—3013	Oil Clearance	0.025—0.043 mm (0.0010—0.0017 in.)
Piston Pin Bushing In Connecting Rod—3015, 4020	ID	26.080—26.160 mm (1.0268—1.0299 in.)
Piston Pin-to-Piston Pin Bushing—3015, 4020	Oil Clearance	0.025—0.051 mm (0.0010—0.0020 in.)
Piston Pin Bushing In Connecting Rod—3016	ID	25.025—26.038 mm (0.9852—1.0251 in.)
	Wear Limit	26.068 mm (0.9082 in.)
Piston Pin-to-Piston Pin Bushing—3016	Oil Clearance	0.025—0.043 mm (0.0010—0.0017 in.)
Piston Pin Bushing In Connecting Rod—4TNE98	ID	30.025—30.038 mm (1.1821—1.1826 in.)
	Wear Limit	30.068 mm (1.1838 in.)

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Item	Measurement	Specification
Piston Pin-to-Piston Pin Bushing—4TNE98	Oil Clearance	0.025—0.051 mm (0.0010—0.0020 in.)
	Wear Limit	0.109 mm (0.0043 in.)
Connecting Rod Cap Screw—3009	Torque	83 N•m (61 lb-ft)
Connecting Rod Cap Screw—3011, 3012, 3013	Torque	39 N•m (29 lb-ft)
Connecting Rod Cap Screw—3015, 4020	Torque	49—59 N•m (36—43 lb-ft)
Connecting Rod Cap Screw—3016	Torque	47 N•m (35 lb-ft)
Connecting Rod Cap Screw—4TNE98	Torque	54 N•m (35 lb-ft)
Connecting Rod Bearing—3009	ID	40.00—40.042 mm (1.575—1.577 in.)
	Wear Limit	40.07 mm (1.578 in.)
Connecting Rod Bearing—3011, 3012, 3013	ID	43.00—43.042 mm (1.693—1.695 in.)
	Wear Limit (3011, 3012)	43.07 mm (1.696 in.)
Connecting Rod Bearing—3015, 3016, 4020	ID	48.00—48.028 mm (1.888—1.891 in.)
	Wear Limit	48.07 mm (1.893 in.)
Connecting Rod Bearing—4TNE98	ID	58.018—58.028 mm (2.2842—2.2846 in.)
	Wear Limit	58.070 mm (2.286 in.)
Camshaft Follower Bore—3009	ID	21.00—21.021 mm (0.8268—0.8276 in.)
	Wear Limit	21.05 mm (0.829 in.)
Camshaft Follower-to-Bore—3009	Oil Clearance	0.040—0.094 mm (0.0016—0.0037 in.)
Camshaft Follower Bore—3011, 3012, 3015, 4020, 4TNE98	ID	12.00—12.018 mm (0.472—0.473 in.)
	Wear Limit	12.05 mm (0.474 in.)
Camshaft Follower-to-Bore—3011, 3012, 3015, 4020, 4TNE98	Oil Clearance	0.010 (0.0004 in.)

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Item	Measurement	Specification
Camshaft Follower Bore—3013, 3016	ID	12.00—12.025 mm (0.4724—0.4734 in.)
	Wear Limit	12.045 mm (0.4742 in.)
Camshaft Follower-to-Bore—3013, 3016	Oil Clearance	0.010—0.050 (0.0004—0.0019 in.)
	Wear Limit	0.090 (0.0035 in.)
Camshaft Bore—3009		
Gear Housing End (Bushing)	ID	40.00—40.025 mm (1.575—1.576 in.)
	Wear Limit	40.10 mm (1.579 in.)
Intermediate and Flywheel-End Bores	ID	40.00—40.025 mm (1.575—1.576 in.)
	Wear Limit	40.10 mm (1.579 in.)
Camshaft Journal-to-Bushing or Block	Oil Clearance	0.18 mm (0.007 in.)
Camshaft Bore—3011, 3012, 3015, 4020		
Gear Housing End (Bushing)	ID	44.990—45.055 mm (1.771—1.774 in.)
	Wear Limit	45.10 mm (1.776 in.)
Intermediate and Flywheel-End Bores	ID	45.00—45.025 mm (1.772—1.773 in.)
	Wear Limit	45.10 mm (1.776 in.)
Camshaft Journal-to-Bushing or Block	Oil Clearance	0.20 mm (0.0078 in.)
Camshaft Bore—3013, 3016		
Gear Housing End (Bushing)	ID	44.990—45.055 mm (1.771—1.774 in.)
	Wear Limit	45.13 mm (1.777 in.)
Intermediate and Flywheel-End Bores	ID	45.00—45.025 mm (1.772—1.773 in.)
	Wear Limit	45.10 mm (1.776 in.)

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Item	Measurement	Specification
Camshaft Journal-to-Bushing—Gear Housing End	Oil Clearance	0.040—0.130 mm (0.0016—0.0051 in.)
	Wear Limit	0.240 mm (0.0094 in.)
Camshaft Journal-to-Block—Intermediate	Oil Clearance	0.065—0.115 mm (0.0026—0.0045 in.)
	Wear Limit	0.225 mm (0.0089 in.)
Camshaft Journal-to-Block—Flywheel End	Oil Clearance	0.050—0.100 mm (0.0020—0.0039 in.)
	Wear Limit	0.210 mm (0.0083 in.)
Camshaft Bore—4TNE98		
Gear Housing End (Bushing)	ID	49.990—50.055 mm (1.9681—1.9706 in.)
	Wear Limit	50.130 mm (1.9736 in.)
Intermediate and Flywheel-End Bores	ID	50.00—50.025 mm (1.9685—1.9694 in.)
	Wear Limit	50.10 mm (1.972 in.)
Camshaft Journal-to-Bushing—Gear Housing End	Oil Clearance	0.040—0.130 mm (0.0016—0.0051 in.)
	Wear Limit	0.240 mm (0.0094 in.)
Camshaft Journal-to-Block Oil—Intermediate	Oil Clearance	0.065—0.115 mm (0.0025—0.0045 in.)
	Wear Limit	0.225 mm (0.0088 in.)
Camshaft Journal-to-Block—Flywheel End	Oil Clearance	0.050—0.100 mm (0.0019—0.0039 in.)
	Wear Limit	0.210 mm (0.0082 in.)
Cylinder Bore—3009		
Standard Bore	Diameter	72.00—72.03 mm (2.835—2.836 in.)
	Wear Limit	72.20 mm (2.843 in.)
0.25 mm (0.010 in.) Oversize Bore	Diameter	72.25—72.28 mm (2.845—2.846 in.)
	Wear Limit	72.45 mm (2.852 in.)

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Item	Measurement	Specification
Piston-to-Cylinder Bore	Clearance	0.078 mm (0.003 in.)
Cylinder Bore—3011, 3012		
Standard Bore	Diameter	78.00—78.03 mm (3.071—3.072 in.)
	Wear Limit	78.20 mm (3.079 in.)
0.25 mm (0.010 in.) Oversize Bore	Diameter	78.25—78.28 mm (3.081—3.082 in.)
	Wear Limit	78.45 mm (3.089 in.)
Piston-to-Cylinder Bore	Clearance	0.035—0.065 mm (0.0014—0.0026 in.)
Cylinder Bore—3013		
Standard Bore	Diameter	82.00—82.03 mm (3.228—3.2295 in.)
	Wear Limit	82.20 mm (3.236 in.)
0.25 mm (0.010 in.) Oversize Bore	Diameter	82.25—82.28 mm (3.238—3.239 in.)
	Wear Limit	82.45 mm (3.245 in.)
Piston-to-Cylinder Bore	Clearance	0.035—0.065 mm (0.0014—0.0026 in.)
Cylinder Bore—3015, 4020		
Standard Bore	Diameter	84.00—84.03 mm (3.307—3.308 in.)
	Wear Limit	84.20 mm (3.315 in.)
0.25 mm (0.010 in.) Oversize Bore	Diameter	84.25—84.28 mm (3.317—3.318 in.)
	Wear Limit	84.45 mm (3.325 in.)
Piston-to-Cylinder Bore	Clearance	0.055 mm (0.002 in.)

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Item	Measurement	Specification
Cylinder Bore—3016		
Standard Bore	Diameter	88.00—88.03 mm (3.4646—3.4657 in.)
	Wear Limit	88.20 mm (3.472 in.)
0.25 mm (0.010 in.) Oversize Bore	Diameter	88.25—88.28 mm (3.4744—3.4756 in.)
	Wear Limit	88.45 mm (3.482 in.)
Piston-to-Cylinder Bore	Clearance	0.040—0.070 mm (0.0016—0.0028 in.)
Cylinder Bore—4TNE98		
Standard Bore	Diameter	98.00—98.03 mm (3.858—3.859 in.)
	Wear Limit	98.13 mm (3.863 in.)
0.25 mm (0.010 in.) Oversize Bore	Diameter	98.25—98.28 mm (3.868—3.869 in.)
	Wear Limit	98.38 mm (3.873 in.)
Piston-to-Cylinder Bore	Clearance	0.050—0.080 mm (0.0019—0.0031 in.)
Cylinder Bore—All Models		
Cylinder	Out-of-Round	0.01 mm (0.0004 in.)
	Wear Limit	0.03 mm (0.0012 in.)
Cylinder	Taper	0.01 mm (0.0004 in.)
	Wear Limit	0.03 mm (0.0012 in.)
Connecting Rod Cap Screw—3009	Torque	23 N•m (203 lb-in.)
Connecting Rod Cap Screw—3011, 3012, 3013	Torque	39 N•m (29 lb-ft)
Connecting Rod Cap Screw—3015, 3016, 4020	Torque	47 N•m (35 lb-ft)
Connecting Rod Cap Screw—4TNE98	Torque	54 N•m (40 lb-ft)

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Crankshaft, Main Bearings, and Flywheel Specifications

Item	Measurement	Specification
Crankshaft—3009	End Play	0.05—0.20 mm (0.002—0.008 in.)
	Wear Limit	0.40 mm (0.016 in.)
Crankshaft—3011, 3012, 3015 and 4020	End Play	0.090—0.271 mm (0.004—0.011 in.)
	Wear Limit	0.33 mm (0.0129 in.)
Crankshaft—3013 and 3016	End Play	0.13—0.23 mm (0.005—0.009 in.)
	Wear Limit	0.28 mm (0.011 in.)
Crankshaft—4TNE98	End Play	0.11—0.21 mm (0.004—0.008 in.)
Flywheel	Out-of-Flatness	0.02 mm (0.0007 in.) maximum
Flywheel Cap Screw	Torque	83 N•m (61 lb-ft)
Rear Oil Seal Case-to-Crankcase Extension Housing Cap Screws—3009	Torque	9 N•m (78 lb-in.)
Flywheel Housing-to-Crankcase Extension Housing Cap Screws—3009	Torque	49 N•m (36 lb-ft)
Crankcase Extension Housing-to-Cylinder Block Cap Screws—3009	Torque	27 N•m (20 lb-ft)
Crankcase Extension Housing-to-Timing Gear Cover Cap Screws—3009	Torque	22 N•m (195 lb-in.)
Rear Oil Seal Case-to-Crankcase Extension Housing Cap Screws—3011, 3012, 3013, 3015 and 3016	Torque	21 N•m (186 lb-in.)
Flywheel Housing-to-Crankcase Extension Housing Cap Screws—3011, 3012, 3013, 3015 and 3016	Torque	49 N•m (36 lb-ft)

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Item	Measurement	Specification
Crankcase Extension Housing-to-Cylinder Block Cap Screws—3011, 3012, 3013, 3015 and 3016	Torque	27 N•m (20 lb-ft)
Crankcase Extension Housing-to-Timing Gear Cover Cap Screws—3011, 3012, 3013, 3015 and 3016	Torque	22 N•m (195 lb-in.)
Rear Oil Seal Case-to-Crankcase Extension Housing Cap Screws—4020	Torque	26 N•m (230 lb-in.)
Flywheel Housing-to-Crankcase Extension Housing Cap Screws—4020	Torque	49 N•m (36 lb-ft)
Crankcase Extension Housing-to-Cylinder Block Cap Screws—4020	Torque	27 N•m (20 lb-ft)
Crankcase Extension Housing-to-Timing Gear Cover Cap Screws—4020	Torque	22 N•m (195 lb-in.)
Flywheel Housing-to-Crankcase Extension Housing Cap Screws—4TNE98	Torque	27 N•m (20 lb-ft)
Crankcase Extension Housing-to-Cylinder Block Cap Screws—4TNE98	Torque	27 N•m (20 lb-ft)
Crankcase Extension Housing-to-Timing Gear Cover Cap Screws—4TNE98	Torque	27 N•m (20 lb-ft)
Flywheel Housing-to-Cylinder Block Cap Screw—3009, 3011, 3012, 3013, 3015, 3016 and 4022	Torque	49 N•m (36 lb-ft)
Flywheel Housing-to-Crankcase Extension Cap Screw—3009, 3011, 3012, 3013, 3015, 3016 and 4022	Torque	49 N•m (36 lb-ft)

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Item	Measurement	Specification
Flywheel Housing-to-Cylinder Block Cap Screw—4TNE98	Torque	49 N•m (36 lb-ft)
Flywheel Housing-to-Crankcase Extension Cap Screw—4TNE98	Torque	27 N•m (20 lb-ft)
Crankshaft	Radial Runout	0.02 mm (0.0007 in.) maximum
Connecting Rod Journal—3009	OD	39.97—39.98 mm (1.5736—1.5740 in.)
	Wear Limit	39.92 mm (1.572 in.)
Main Bearing Journal—3009	OD	43.97—43.98 mm (1.7311—1.7315 in.)
	Wear Limit	43.92 mm (1.729 in.)
Connecting Rod Journal—3011, 3012 and 3013	OD	42.952—42.962 mm (1.6910—1.6914 in.)
	Wear Limit	42.902 mm (1.6891 in.)
Main Bearing Journal—3011, 3012 and 3013	OD	46.952—46.962 mm (1.8485—1.8489 in.)
	Wear Limit (3011 and 3012)	46.91 mm (1.847 in.)
	Wear Limit (3013)	46.902 mm (1.8465 in.)
Connecting Rod Journal—3015 and 4020	OD	47.952—47.962 mm (1.8879—1.8883 in.)
	Wear Limit	47.902 mm (1.8859 in.)
Main Bearing Journal—3015 and 4020	OD	49.952—49.962 mm (1.9666—1.9670 in.)
	Wear Limit	49.91 mm (1.9650 in.)
Connecting Rod Journal—3016	OD	47.952—47.962 mm (1.8879—1.8883 in.)
	Wear Limit	47.902 mm (1.8859 in.)
Main Bearing Journal—3016	OD	53.952—53.962 (2.1241—2.1245 in.)
	Wear Limit	53.902 (2.1221 in.)
Connecting Rod Journal—4TNE98	OD	57.952—57.962 mm (2.2816—2.2820 in.)
	Wear Limit	57.902 mm (2.2796 in.)

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OUO1083,000064B –19–29APR04–3/5

Item	Measurement	Specification
Main Bearing Journal—4TNE98	OD	64.952—64.962 mm (2.5571—2.5575 in.)
	Wear Limit	64.902 mm (2.5551 in.)
Main Bearing Cap Screw—3009, 3011, 3012 and 3013	Torque	79 N•m (58 lb-ft)
Main Bearing Cap Screw—3015, 3016 and 4020	Torque	98 N•m (72 lb-ft)
Main Bearing Cap Screw—4TNE98	Torque	108—118 N•m (80—87 lb-ft)
Main Bearing Insert—3009	ID	44.00—44.042 mm (1.732—1.734 in.)
	Wear Limit	44.07 mm (1.735 in.)
Main Bearing Insert—3011 and 3012	ID	47.00—47.045 mm (1.850—1.852 in.)
	Wear Limit	47.10 mm (1.8541 in.)
Main Bearing Insert—3013	ID	47.000—47.032 mm (1.8504—1.8516 in.)
Main Bearing Insert—3015 and 4020	ID	50.00—50.020 mm (1.9685—1.9693 in.)
	Wear Limit	50.10 mm (1.9724 in.)
Main Bearing Insert—3016	ID	54.000—54.020 mm (2.1260—2.1268 in.)
Main Bearing Insert—4TNE98	ID	64.99—65.03 mm (2.5587—2.5602 in.)
	Wear Limit	65.074 mm (2.5620 in.)
Main Bearing-to-Crankshaft—3009, 3011 and 3012	Clearance	0.038—0.093 mm (0.0015—0.0037 in.)
	Wear Limit	0.15 mm (0.0059 in.)
Main Bearing-to-Crankshaft—3013	Clearance	0.038—0.080 mm (0.0015—0.0031 in.)
	Wear Limit	0.150 mm (0.0059 in.)
Main Bearing-to-Crankshaft—3015, 3016, 4020 and 4TNE98	Clearance	0.038—0.068 mm (0.0015—0.0027 in.)
	Wear Limit	0.150 mm (0.0059 in.)

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OUO1083,000064B –19–29APR04–4/5

Item	Measurement	Specification
Main Bearing Cap Screw—3009, 3011, 3012 and 3013	Torque	79 N•m (58 lb-ft)
Main Bearing Cap Screw—3015, 3016 and 4020	Torque	98 N•m (72 lb-ft)
Main Bearing Cap Screw—4TNE98	Torque	108—118 N•m (80—87 lb-ft)
Main Bearing—3009, 3011 and 3012	Clearance	0.038—0.093 mm (0.0015—0.0037 in.)
	Wear Limit	0.15 mm (0.0059 in.)
Main Bearing—3013	Clearance	0.038—0.080 mm (0.0015—0.0031 in.)
	Wear Limit	0.150 mm (0.0059 in.)
Main Bearing—3015, 3016, 4020 and 4TNE98	Clearance	0.038—0.068 mm (0.0015—0.0027 in.)
	Wear Limit	0.150 mm (0.0059 in.)
Main Bearing Cap Screw—3009, 3011, 3012 and 3013	Torque	79 N•m (58 lb-ft)
Main Bearing Cap Screw—3015, 3016 and 4020	Torque	98 N•m (72 lb-ft)
Main Bearing Cap Screw—4TNE98	Torque	108—118 N•m (80—87 lb-ft)
Connecting Rod Cap Screw—3009	Torque	23 N•m (203 lb-in.)
Connecting Rod Cap Screw—3011, 3012 and 3013	Torque	39 N•m (29 lb-ft)
Connecting Rod Cap Screw—3015, 3016 and 4020	Torque	47 N•m (35 lb-ft)
Connecting Rod Cap Screw—4TNE98	Torque	54 N•m (40 lb-ft)

OUO1083,000064B –19–29APR04–5/5

Camshaft and Timing Gear Train Specifications

Item	Measurement	Specification
Intake and Exhaust Valve—3009	Lift	7.5 mm (0.300 in.) minimum
Intake and Exhaust Valve—3011, 3012, 3015, 4020 and 4TNE98	Lift	8.8 mm (0.350 in.) minimum
Intake and Exhaust Valve—3013 and 3016	Lift	5.1 mm (0.201 in.) minimum
Timing Gear Cover—3009		
Timing Gear Cover-to-Gear Housing	Torque	9 N•m (80 lb-in.)
End Cover-to-Timing Gear Cover	Torque	9 N•m (80 lb-in.)
Auxiliary Drive Cover-to-Timing Gear Cover	Torque	9 N•m (80 lb-in.)
Crankshaft Pulley-to-Crankshaft	Torque	115 N•m (85 lb-ft)
Timing Gear Cover—3011, 3012, 3013, 3015 and 3016		
Timing Gear Cover-to-Front Plate	Torque	26 N•m (229 lb-in.)
Tachometer-to-Timing Gear Cover	Torque	26 N•m (229 lb-in.)
End Cover-to-Timing Gear Cover	Torque	26 N•m (229 lb-in.)
Injection Pump Gear Cover-to-Timing Gear Cover	Torque	26 N•m (229 lb-in.)
Oil Pan-to-Timing Gear Cover	Torque	22 N•m (192 lb-in.)
Crankshaft Pulley-to-Crankshaft	Torque	115 N•m (85 lb-ft)
Timing Gear Cover—4020		
Timing Gear Cover-to-Front Plate	Torque	26 N•m (229 lb-in.)
Tachometer-to-Timing Gear Cover	Torque	26 N•m (229 lb-in.)

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Item	Measurement	Specification
Injection Pump Gear Cover-to-Timing Gear Cover	Torque	26 N•m (229 lb-in.)
Crankcase Extension-to-Timing Gear Cover	Torque	26 N•m (229 lb-in.)
Crankcase Oil Pan-to-Timing Gear Cover	Torque	22 N•m (192 lb-in.)
Crankshaft Pulley-to-Crankshaft	Torque	115 N•m (85 lb-ft)
Timing Gear Cover—4TNE98		
Timing Gear Cover-to-Gear Housing	Torque	20 N•m (180 lb-in.)
Tachometer-to-Timing Gear Cover	Torque	20 N•m (180 lb-in.)
End Cover-to-Timing Gear Cover	Torque	20 N•m (180 lb-in.)
Injection Pump Gear Cover-to-Timing Gear Cover	Torque	20 N•m (180 lb-in.)
Camshaft—All Engines	End Play	0.05—0.20 mm (0.002—0.008 in.)
	Wear Limit (3009, 3011, 3012, 3015 and 4020)	0.40 mm (0.016 in.)
	Wear Limit (3013, 3016 and 4TNE98)	0.30 mm (0.012 in.)
Timing Gear Backlash Crankshaft Gear-to-Oil Pump Gear—3009, 3011, 3012, 3015 and 4020	Backlash	0.11—0.19 mm (0.0043—0.0075 in.)
	Wear Limit	0.20 mm (0.0079 in.)
Timing Gear Backlash—All Except Crankshaft Gear-to-Oil Pump Gear—3009, 3011, 3012, 3015 and 4020	Backlash	0.04—0.12 mm (0.0016—0.0047 in.)
	Wear Limit	0.20 mm (0.0079 in.)
Timing Gear Backlash—3013 and 3016	Backlash	0.07—0.15 mm (0.002—0.006 in.)
	Wear Limit	0.17 mm (0.007 in.)

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Item	Measurement	Specification
Timing Gear Backlash Crankshaft Gear-to-Oil Pump Gear—4TNE98	Backlash	0.09—0.15 mm (0.0035—0.0059 in.)
	Wear Limit	0.17 mm (0.0067 in.)
Timing Gear Backlash—All Except Crankshaft Gear-to-Oil Pump Gear—4TNE98	Backlash	0.08—0.14 mm (0.0031—0.0055 in.)
	Wear Limit	0.16 mm (0.0063 in.)
Camshaft-to-Thrust Plate	Clearance	0.05—0.20 mm (0.002—0.008 in.)
	Wear Limit (3009, 3011, 3012, 3015 and 4020)	0.40 mm (0.016 in.)
	Wear Limit (3013, 3016 and 4TNE98)	0.30 mm (0.012 in.)
Camshaft Bend	Radial Runout	0.02 mm (0.0008 in.) maximum
	Wear Limit	0.05 mm (0.0020 in.)
Camshaft Lobe—3009	Height	33.950—34.050 mm (1.3366—1.3406 in.)
	Wear Limit	33.75 mm (1.3287 in.)
Camshaft Lobe—3011, 3012, 3015 and 4020	Height	38.635—38.765 mm (1.5211—1.5262 in.)
	Wear Limit	38.40 mm (1.5118 in.)
Camshaft Lobe—3013 and 3016	Height	38.600—38.800 mm (1.5197—1.5276 in.)
	Wear Limit	38.35 mm (1.5098 in.)
Camshaft Lobe—4TNE98	Height	42.435—42.565 mm (1.6707—1.6758 in.)
	Wear Limit	42.185 mm (1.6608 in.)
Camshaft End Journals—3009	OD	39.94—39.96 mm (1.5724—1.5732 in.)
	Wear Limit	39.85 mm (1.5689 in.)
Intermediate Journal—3009	OD	39.91—39.94 mm (1.5713—1.5724 in.)
	Wear Limit	39.85 mm (1.5689 in.)
End Journals—3011, 3012, 3013, 3015, 3016 and 4020	OD	44.925—44.950 mm (1.7687—1.7697 in.)
	Wear Limit (3011, 3012, 3015, 4020)	44.85 mm (1.7657 in.)
	Wear Limit (3013, 3016)	44.890 mm (1.7673 in.)

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Item	Measurement	Specification
Intermediate Journal—3011, 3012, 3013, 3015, 3016 and 4020	OD	44.910—44.935 mm (1.7681—1.7691 in.)
	Wear Limit (3011, 3012, 3015, 4020)	44.85 mm (1.7657 in.)
	Wear Limit (3013, 3016)	44.875 mm (1.7667 in.)
End Journals—4TNE98	OD	49.925—49.950 mm (1.9656—1.9665 in.)
	Wear Limit	49.89 mm (1.9642 in.)
Intermediate Journal	OD	49.910—49.935 mm (1.9650—1.9659 in.)
	Wear Limit	49.875 mm (1.9636 in.)
Cam Follower—3009	OD	20.927—20.960 mm (0.8239—0.8252 in.)
	Wear Limit	20.93 mm (0.824 in.)
Cam Follower—3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98	OD	11.975—11.990 mm (0.471—0.472 in.)
	Wear Limit (3011, 3012, 3015, 4020 and 4TNE98)	11.93 mm (0.470 in.)
	Wear Limit (3013 and 3016)	11.955 mm (0.4707 in.)
Camshaft Mounting Cap Screw—3009	Torque	11 N•m (97 lb-in.)
Camshaft Mounting Cap Screw—3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98	Torque	26 N•m (228 lb-in.)
Idler Gear Shaft—3009	OD	19.959—19.980 mm (0.786—0.787 in.)
	Wear Limit	19.93 mm (0.785 in.)
Idler Gear Bushing—3009	ID	20.00—20.021 mm (0.787—0.788 in.)
	Wear Limit	20.08 mm (0.791 in.)
	Oil Clearance	0.15 mm (0.0059 in.) maximum
Idler Gear Shaft—3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98	OD	45.950—45.975 mm (1.809—1.810 in.)
	Wear Limit	45.93 mm (1.808 in.)

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Item	Measurement	Specification
Idler Gear Bushing—3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98	ID	46.00—46.025 mm (1.811—1.812 in.)
	Wear Limit	46.08 mm (1.814 in.)
	Oil Clearance	0.025—0.075 mm (0.001—0.003 in.)
	Wear Limit	0.18 mm (0.007 in.)
Timing Gear Housing—3009		
Mounting Cap Screws—Cast Iron Threads	Torque	11 N•m (97 lb-in.)
Mounting Cap Screws—Aluminum Threads	Torque	9 N•m (80 lb-in.)
Crankcase Extension-to-Timing Gear Housing Cap Screw	Torque	22 N•m (192 lb-in.)
Timing Gear Cover Mounting Plate—3011, 3012, 3013, 3015, 3016 and 4020		
Mounting Cap Screws	Torque	25 N•m (221 lb-in.)
Timing Gear Housing—4TNE98		
Mounting Cap Screws	Torque	25 N•m (221 lb-in.)

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Lubrication System Specifications

Item	Measurement	Specification
Oil Strainer Cap Screw—3009	Torque	11 N•m (97 lb-in.)
Oil Strainer Cap Screw—3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98	Torque	26 N•m (230 lb-in.)
Oil Pan Cap Screw—3009	Torque	11 N•m (97 lb-in.)
Oil Pan Cap Screw—3011, 3012, 3013, 3015, 3016, 4020 and 4TNE98	Torque	26 N•m (230 lb-in.)
Oil Pump Gear—3009	Backlash	0.25 mm (0.010 in) Maximum
Oil Pump Gear—3011, 3012, 3015 and 4020	Backlash	0.11—0.19 mm (0.0043—0.0074 in.)
Oil Pump Gear—4TNE98	Backlash	0.09—0.15 mm (0.0035—0.0059 in.)
Oil Pump Mounting Cap Screw	Torque	25 N•m (221 lb-in.)
Oil Pump Rotor Shaft and Plate—3009, 3011 and 3012	Clearance	0.015—0.048 mm (0.0006—0.0019 in.)
	Wear Limit	0.20 mm (0.0079 in.)
Oil Pump Rotor Shaft and Plate—3015 and 4020	Clearance	0.013—0.043 mm (0.0005—0.0017 in.)
	Wear Limit	0.20 mm (0.0079 in.)
Oil Pump Rotor Shaft and Plate—4TNE98	Clearance	0.010—0.065 mm (0.0004—0.0026 in.)
	Wear Limit	0.20 mm (0.0079 in.)
Oil Pump Rotor—3009, 3011, 3012, 3015 and 4020	Recess	0.15 mm (0.0059 in.)
Oil Pump Rotor—4TNE98	Recess	0.10 mm (0.0039 in.)
Outer Rotor-to-Pump Body—3009	Clearance	0.03—0.09 mm (0.0011—0.0035 in.)
	Wear Limit	0.13 mm (0.0051 in.)
Outer Rotor-to-Pump Body—3011, 3012 and 3015	Clearance	0.09—0.16 mm (0.0035—0.0063 in.)
	Wear Limit	0.25 mm (0.0098 in.)

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Item	Measurement	Specification
Outer Rotor-to-Pump Body—4020	Clearance	0.010—0.017 mm (0.0039—0.0067 in.)
	Wear Limit	0.25 mm (0.0098 in.)
Outer Rotor-to-Pump Body—4TNE98	Clearance	0.10—0.155 mm (0.0039—0.0061 in.)
	Wear Limit	0.25 mm (0.0098 in.)
Inner-to-Outer Rotor—3009, 3011, 3012, 3015, 4020 and 4TNE98	Clearance	0.15 mm (0.0059 in)
Oil Pump Rotor—3013 and 3016	Recess	0.02—0.07 mm (0.001—0.003 in.)
	Wear Limit	0.12 mm (0.005 in.)
Inner-to-Outer Rotor—3013 and 3016	Clearance	0.16 mm (0.006 in.) Maximum
Outer Rotor-to-Housing	Clearance	0.12—0.21 mm (0.005—0.008 in.)
	Wear Limit	0.30 mm (0.012 in.)
Inner Rotor Inner Diameter	Diameter	53.05—53.15 mm (2.088—2.093 in.)
Inner Rotor Flat-to-Flat	Distance	49.95—50.05 mm (1.967—1.974 in.)
Crankshaft Gear Outer Diameter	Diameter	53.45—53.55 mm (2.104—2.108 in.)
Crankshaft Gear Flat-to-Flat	Distance	49.45—49.75 mm (1.947—1.959 in.)
Oil Pump Cover Mounting Cap Screw	Torque	7 N•m (61 lb-in.)
Oil Pressure Regulating Valve Filter Housing Cap Screws	Torque	27 N•m (20 lb-ft)
Oil Pressure Regulating Valve Body Retaining Nut	Torque	30 N•m (22 lb-ft)
Oil Cooler Mounting Block Cap Screws	Torque	27 N•m (20 lb-ft)

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Item	Measurement	Specification
Oil Cooler Mounting Bolt or Nut	Torque	30 N•m (22 lb-ft)
Cooling Nozzle Mounting Bolt—4020T	Torque	15 N•m (133 lb-in.)

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Cooling System Specifications

Item	Measurement	Specification
Thermostat Cover Cap Screw—3009, 3011, 3012, 3013, 3015, 3016, and 4020	Torque	20 N•m (15 lb-ft)
Coolant Pump Mounting Cap Screws—3009, 3011, 3012, 3013, 3015, 3016, and 4020	Torque	26 N•m (230 lb-in.)
Fan-to-Coolant Pump Mounting Cap Screws-—3009, 3011, 3012, 3013, 3015, 3016, and 4020	Torque	11 N•m (97 lb-in.)
Coolant Pump Plug (If Equipped)-—3009, 3011, 3012, 3013, 3015, 3016, and 4020	Torque	15 N•m (132 lb-in.)
Coolant Pump Mounting Cap Screw—4TNE98	Torque	26 N•m (230 lb-in.)
Fan-to-Coolant Pump Cap Screw—4TNE98	Torque	20 N•m (177 lb-in.)
Coolant Pump Housing Cap Screw—3009, 3011, and 3012	Torque	9 N•m (79 lb-in.)
Cooling System (Approximate)—3009	Capacity	3.5 L (3.7 qt)
Cooling System (Approximate)—3011, 3012 and 3013	Capacity	3.7 L (3.79 qt)
Cooling System (Approximate)—3015 and 3016	Capacity	4.0 L (4.2 qt)
Cooling System (Approximate)—4020	Capacity	4.7 L (4.9 qt)
Cooling System (Approximate)—4TNE98	Capacity	4.2 L (4.4 qt)
Belt Tension @ 98 N (22 lb) Applied Force (Used)—3009, 3011, 3012, 3015, and 4020	Deflection	10—14 mm (0.494—0.551 in.)

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Item	Measurement	Specification
Belt Tension @ 98 N (22 lb) Applied Force (Used)—3013 and 3016	Deflection	7—10 mm (0.276—0.394 in.)
Belt Tension @ 98 N (22 lb) Applied Force (New)—3013 and 3016	Deflection	5—8 mm (0.197—0.315 in.)
Belt Tension @ 98 N (22 lb) Applied Force (New)—4TNE98	Deflection	7—9 mm (0.276—0.354 in.)

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Air Intake and Exhaust System Specifications

Item	Measurement	Specification
3009 Muffler Adapter-to-Engine Nut	Torque	47 N•m (35 lb-ft)
Turbocharger Bearing Axial Without Waste Gate—RHB3	End Play	0.022—0.053 mm (0.0008—0.0021 in.)
	Wear Limit	0.07 mm (0.0028 in.)
Turbocharger Bearing Axial With Waste Gate—RHB5	End Play	0.03—0.06 mm (0.0012—0.0024 in.)
	Wear Limit	0.09 mm (0.0035 in.)
Turbocharger Bearing Radial Without Waste Gate—RHB3	Side Play	0.061—0.093 mm (0.0024—0.0037 in.)
	Wear Limit	0.12 mm (0.0047 in.)
Turbocharger Bearing Radial With Waste Gate—RHB5	Side Play	0.08—0.13 mm (0.0031—0.0051 in.)
	Wear Limit	0.17 mm (0.0067 in.)
Turbine Wheel/Shaft—RHB3	Deflection	0.002 mm (00008 in.)
	Wear Limit	0.005 mm (.00019 in.)
Turbine Wheel/Shaft—RHB5	Deflection	0.010 mm (0.00039 in.)
	Wear Limit	0.011 mm (0.00043 in.)
Turbine Shaft—RHB3	OD	6.257—6.263 mm (0.2463—0.2466 in.)
	Wear Limit	06.250 mm (0.2461 in.)
Turbine Shaft—RHB5	OD	7.99—8.00 mm (0.3146—0.3150 in.)
	Wear Limit	7.980 mm (0.3142 in.)
Shaft Seal Ring Groove—RHB3	Width	1.038—1.062 mm (0.0409—0.0418 in.)
	Wear Limit	1.070 mm (0.0421 in.)
Shaft Seal Ring Groove—RHB5	Width	1.250—1.280 mm (0.0492—0.0504 in.)
	Wear Limit	1.290 mm (0.0508 in.)
Oil Thrower Seal Ring Groove (Small End)—RHB3	Width	0.82—0.83 mm (0.0323—0.0327 in.)
	Wear Limit	0.84 mm (0.0331 in.)

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Item	Measurement	Specification
Oil Thrower Seal Ring Groove (Small End)—RHB5	Width	1.02—1.03 mm (0.0402—0.0406 in.)
	Wear Limit	1.11 mm (0.0437 in.)
Oil Thrower Seal Ring Groove (Large End)—RHB3	Width	1.02—1.03 mm (0.0402—0.0406 in.)
	Wear Limit	1.04 mm (0.0409 in.)
Oil Thrower Seal Ring Groove (Large End)—RHB5	Width	1.22—1.23 mm (0.0480—0.0484 in.)
	Wear Limit	1.31 mm (0.0516 in.)
Seal Ring Surface (Larger)—RHB3	ID	9.987—10.025 mm (0.3932—0.3947 in.)
	Wear Limit	10.04 mm (0.3953 in.)
Seal Ring Surface (Larger)—RHB5	ID	12.40—12.42 mm (0.4882—0.4890 in.)
	Wear Limit	12.45 mm (0.4902 in.)
Seal Ring Surface (Smaller)—RHB3	ID	7.968—8.0 mm (0.3137—0.3150 in.)
	Wear Limit	8.015 mm (0.3156 in.)
Seal Ring Surface (Smaller)—RHB5	ID	10.00—10.02 mm (0.3937—0.3945 in.)
	Wear Limit	10.05 mm (0.3957 in.)
Thrust Bushing Shoulder—RHB3	Length	3.632—3.642 mm (0.1430—0.1434 in.)
	Wear Limit	3.650 mm (0.1437 in.)
Thrust Bushing Shoulder—RHB5	Length	4.04—4.05 mm (0.1591—0.1594 in.)
	Wear Limit	4.07 mm (0.1602 in.)
Thrust Bushing—RHB3	Thickness	3.59—3.61 mm (0.1413—0.1421 in.)
	Wear Limit	3.58 mm (0.1409 in.)
Thrust Bushing—RHB5	Thickness	3.99—4.01 mm (0.1571—0.1579 in.)
	Wear Limit	3.98 mm (0.1567 in.)

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Item	Measurement	Specification
Journal Bearing—RHB3	ID	6.275—6.285 mm (0.2470—0.2474 in.)
	Wear Limit	6.290 mm (0.2476 in.)
Journal Bearing—RHB5	ID	8.01—8.03 mm (0.3154—0.3161 in.)
	Wear Limit	8.04 mm (0.3165 in.)
Journal Bearing—RHB3	OD	9.940—9.946 mm (0.3913—0.3916 in.)
	Wear Limit	9.930 mm (0.3909 in.)
Journal Bearing—RHB5	OD	12.32—12.33 mm (0.4850—0.4854 in.)
	Wear Limit	12.31 mm (0.4846 in.)
Seal Ring Surface—RHB3	ID	11.00—11.018 mm (0.4331—0.4338 in.)
	Wear Limit	11.03 mm (0.4343 in.)
Seal Ring Surface—RHB5	ID	15.00—15.02 mm (0.5906—0.5913 in.)
	Wear Limit	15.05 mm (0.5925 in.)
Journal Bearing Surface—RHB3	ID	9.995—10.005 mm (0.3935—0.3939 in.)
	Wear Limit	10.01 mm (0.3941 in.)
Journal Bearing Surface—RHB5	ID	12.40—12.41 mm (0.4882—0.4886 in.)
	Wear Limit	12.42 mm (0.4890 in.)
Turbocharger Thrust Bearing Screws	Torque	1 N•m (9 lb-in.)
Turbocharger Seal Plate Assembly Screws	Torque	1 N•m (9 lb-in.)
Turbocharger Compressor Wheel Lock Nut—RHB3	Torque	1 N•m (9 lb-in.)
Turbocharger Compressor Wheel Lock Nut—RHB5	Torque	2 N•m (18 lb-in.)
Turbocharger Lock Plate Cap Screw—RHB3	Torque	12 N•m (106 lb-in.)

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Item	Measurement	Specification
Turbocharger Lock Plate Cap Screw—RHB5	Torque	28 N•m (21 lb-ft)
Turbocharger Center Housing Lock Plate Cap Screw	Torque	4 N•m (36 lb-in.)
Turbocharger Waste Gate Actuator Cap Screws	Torque	4 N•m (36 lb-in.)
Turbocharger Waste Gate Control (Pc)	Pressure	600—750 mmHG (24—30 in.HG)
Turbocharger Waste Gate Actuator (After One Minute) Minimum	Pressure	1.1 kg/cm^2 (16 psi)
Turbocharger-to-Exhaust Manifold Nuts	Torque	20 N•m (177 lb-in.)
Exhaust Manifold Cap Screw	Torque	26 N•m (19 lb-ft)
Intake Manifold Cap Screw	Torque	11 N•m (97 lb-in.)
3009 Muffler Adapter-to-Engine Nut	Torque	47 N•m (35 lb-ft)
Turbocharger Bearing Axial Without Waste Gate—RHB3	End Play	0.022—0.053 mm (0.0008—0.0021 in.)
	Wear Limit	0.07 mm (0.0028 in.)
Turbocharger Bearing Axial With Waste Gate—RHB5	End Play	0.03—0.06 mm (0.0012—0.0024 in.)
	Wear Limit	0.09 mm (0.0035 in.)
Turbocharger Bearing Radial Without Waste Gate—RHB3	Side Play	0.061—0.093 mm (0.0024—0.0037 in.)
	Wear Limit	0.12 mm (0.0047 in.)
Turbocharger Bearing Radial With Waste Gate—RHB5	Side Play	0.08—0.13 mm (0.0031—0.0051 in.)
	Wear Limit	0.17 mm (0.0067 in.)
Turbine Wheel/Shaft—RHB3	Deflection	0.002 mm (00008 in.)
	Wear Limit	0.005 mm (.00019 in.)
Turbine Wheel/Shaft—RHB5	Deflection	0.010 mm (0.00039 in.)
	Wear Limit	0.011 mm (0.00043 in.)

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Item	Measurement	Specification
Turbine Shaft—RHB3	OD	6.257—6.263 mm (0.2463—0.2466 in.)
	Wear Limit	06.250 mm (0.2461 in.)
Turbine Shaft—RHB5	OD	7.99—8.00 mm (0.3146—0.3150 in.)
	Wear Limit	7.980 mm (0.3142 in.)
Shaft Seal Ring Groove—RHB3	Width	1.038—1.062 mm (0.0409—0.0418 in.)
	Wear Limit	1.070 mm (0.0421 in.)
Shaft Seal Ring Groove—RHB5	Width	1.250—1.280 mm (0.0492—0.0504 in.)
	Wear Limit	1.290 mm (0.0508 in.)
Oil Thrower Seal Ring Groove (Small End)—RHB3	Width	0.82—0.83 mm (0.0323—0.0327 in.)
	Wear Limit	0.84 mm (0.0331 in.)
Oil Thrower Seal Ring Groove (Small End)—RHB5	Width	1.02—1.03 mm (0.0402—0.0406 in.)
	Wear Limit	1.11 mm (0.0437 in.)
Oil Thrower Seal Ring Groove (Large End)—RHB3	Width	1.02—1.03 mm (0.0402—0.0406 in.)
	Wear Limit	1.04 mm (0.0409 in.)
Oil Thrower Seal Ring Groove (Large End)—RHB5	Width	1.22—1.23 mm (0.0480—0.0484 in.)
	Wear Limit	1.31 mm (0.0516 in.)
Seal Ring Surface (Larger)—RHB3	ID	9.987—10.025 mm (0.3932—0.3947 in.)
	Wear Limit	10.04 mm (0.3953 in.)
Seal Ring Surface (Larger)—RHB5	ID	12.40—12.42 mm (0.4882—0.4890 in.)
	Wear Limit	12.45 mm (0.4902 in.)
Seal Ring Surface (Smaller)—RHB3	ID	7.968—8.0 mm (0.3137—0.3150 in.)
	Wear Limit	8.015 mm (0.3156 in.)

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Item	Measurement	Specification
Seal Ring Surface (Smaller)—RHB5	ID	10.00—10.02 mm (0.3937—0.3945 in.)
	Wear Limit	10.05 mm (0.3957 in.)
Thrust Bushing Shoulder—RHB3	Length	3.632—3.642 mm (0.1430—0.1434 in.)
	Wear Limit	3.650 mm (0.1437 in.)
Thrust Bushing Shoulder—RHB5	Length	4.04—4.05 mm (0.1591—0.1594 in.)
	Wear Limit	4.07 mm (0.1602 in.)
Thrust Bushing—RHB3	Thickness	3.59—3.61 mm (0.1413—0.1421 in.)
	Wear Limit	3.58 mm (0.1409 in.)
Thrust Bushing—RHB5	Thickness	3.99—4.01 mm (0.1571—0.1579 in.)
	Wear Limit	3.98 mm (0.1567 in.)
Journal Bearing—RHB3	ID	6.275—6.285 mm (0.2470—0.2474 in.)
	Wear Limit	6.290 mm (0.2476 in.)
Journal Bearing—RHB5	ID	8.01—8.03 mm (0.3154—0.3161 in.)
	Wear Limit	8.04 mm (0.3165 in.)
Journal Bearing—RHB3	OD	9.940—9.946 mm (0.3913—0.3916 in.)
	Wear Limit	9.930 mm (0.3909 in.)
Journal Bearing—RHB5	OD	12.32—12.33 mm (0.4850—0.4854 in.)
	Wear Limit	12.31 mm (0.4846 in.)
Seal Ring Surface—RHB3	ID	11.00—11.018 mm (0.4331—0.4338 in.)
	Wear Limit	11.03 mm (0.4343 in.)
Seal Ring Surface—RHB5	ID	15.00—15.02 mm (0.5906—0.5913 in.)
	Wear Limit	15.05 mm (0.5925 in.)

Continued on next page

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Item	Measurement	Specification
Journal Bearing Surface—RHB3	ID	9.995—10.005 mm (0.3935—0.3939 in.)
	Wear Limit	10.01 mm (0.3941 in.)
Journal Bearing Surface—RHB5	ID	12.40—12.41 mm (0.4882—0.4886 in.)
	Wear Limit	12.42 mm (0.4890 in.)
Turbocharger Thrust Bearing Screws	Torque	1 N•m (9 lb-in.)
Turbocharger Seal Plate Assembly Screws	Torque	1 N•m (9 lb-in.)
Turbocharger Compressor Wheel Lock Nut—RHB3	Torque	1 N•m (9 lb-in.)
Turbocharger Compressor Wheel Lock Nut—RHB5	Torque	2 N•m (18 lb-in.)
Turbocharger Lock Plate Cap Screw—RHB3	Torque	12 N•m (106 lb-in.)
Turbocharger Lock Plate Cap Screw—RHB5	Torque	28 N•m (21 lb-ft)
Turbocharger Center Housing Lock Plate Cap Screw	Torque	4 N•m (36 lb-in.)
Turbocharger Waste Gate Actuator Cap Screws	Torque	4 N•m (36 lb-in.)
Turbocharger Waste Gate Control (Pc)	Pressure	600—750 mmHG (24—30 in.HG)
Turbocharger Waste Gate Actuator (After One Minute) Minimum	Pressure	1.1 kg/cm^2 (16 psi)
Turbocharger-to-Exhaust Manifold Nuts	Torque	20 N•m (177 lb-in.)
Exhaust Manifold Cap Screw	Torque	26 N•m (19 lb-ft)
Intake Manifold Cap Screw	Torque	11 N•m (97 lb-in.)

OUO1083,0000697 –19–20MAY04–7/7

Fuel System Specifications

Item	Measurement	Specification
Fuel Supply Pump Mounting Cap Screws—3009	Torque	11 N•m (97 lb-in)
Fuel Supply Pump Mounting Cap Screws—3011, 3012, 3015 and 4020	Torque	11 N•m (97 lb-in)
Lube Line Fitting—3011, 3012, 3015, and 4020	Torque	15 N•m (132 lb-in.)
Fuel Supply Pump Mounting Nuts—4TNE98	Torque	11 N•m (97 lb-in)
Lube Line Fitting—3011, 3012, 3015, and 4020	Torque	15 N•m (132 lb-in.)
Base/Ind. Engines Slow Idle—3009, 3011, 3012, 3015, and 4020	Speed	800 rpm
Gen. Set Engines Slow Idle—3011, 3012, 3015, and 4020	Speed	1200 rpm
Gen. Set Engines Slow Idle—3009	Speed	1300 rpm
Base/Ind. Engines Slow Idle—4TNE98	Speed	900 rpm
Base/Ind. Engines Slow Idle—3013 and 3016	Speed	800 rpm
Gen. Set Engines Slow Idle—3013 and 3016	Speed	1200 rpm
Base/Ind. Engines Fast Idle—3009, 3011, 3012, 3015, and 4020	Speed	3225 rpm
Gen. Set Engines Fast Idle—3009	Speed	3800 rpm
Gen. Set Engines Fast Idle—3011, 3012, 3015, and 4020	Speed	1900 rpm
244H Loader Application Fast Idle—4TNE98	Speed	2375 rpm
Base/Ind. Engines Fast Idle—3013 and 3016	Speed	3225 rpm

Continued on next page

OUO1083,0000677 –19–14MAY04–1/4

Item	Measurement	Specification
Gen. Set Engines Fast Idle—3013 and 3016	Speed	1900 rpm
Fuel Injection Pump Mounting Nuts 3009	Torque	20 N•m (180 lb-in.))
Fuel Injection Delivery Valve—3009	Torque	42 N•m (31 lb-ft)
Injection Pump Timing—3009	Position	16° BTDC (Before Top Dead Center)
Engine Crankshaft—3009	Position	No. 1 Cylinder Near Top Dead Center of Compression Stroke
Delivery Valve Fitting—3009	Torque	42 N•m (31 lb-ft)
Fuel Injection Pump Camshaft Lobe—3009	Height	30.90 mm (1.217 in.) minimum
Camshaft Bearing Retaining Screw—3009	Torque	20 N•m (180 lb-in.)
Governor Shaft and Bore—3009	OD	7.90 mm (0.311 in.)
Governor Shaft Bore ID—3009	Wear Limit Clearance	8.15 mm (0.321 in.) 0.18 mm (0.007 in.) maximum
Injection Pump Camshaft Sleeve—3009	ID	8.20 mm (0.323 in.)
Injection Pump Camshaft—3009	OD Wear Limit Clearance	7.90 mm (0.311 in.) 0.15 mm (0.006 in.) maximum
Fuel Injection Pump Drive Gear Mounting Nut—3011, 3012, 3015, and 4020	Torque	90 N•m (66 lb-ft)
Fuel Injection Pump Mounting Nut—3011, 3012, 3015, and 4020	Torque	26 N•m (228 lb-in.)
Injection Pump—Base/Ind. Engines—3011, 3012, 3015 and 4020	Position	16°±1° BTDC (Before Top Dead Center)
Injection Pump—Gen. Set Engines—3011, 3012, 3015, 4020	Position	10°±1° BTDC

Continued on next page

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Item	Measurement	Specification
Fuel Injection Pump Drive Gear Hub-to-Shaft Retaining Nut—3013 and 3016	Torque	78—88 N•m (58—65 lb-ft)
Injection Pump Mounting Nuts—3013 and 3016	Torque	26 N•m (228 lb-in.)
Injection Pump Mounting Cap Screw—3013 and 3016	Torque	26 N•m (228 lb-in.)
Injection Pump External Lube Line Fitting—3013 and 3016	Torque	15 N•m (133 lb-in.)
Injection Pump External Lube Line Fitting—3013 and 3016	Torque	15 N•m (133 lb-in.)
Injection Pump Timing Gear to Hub Cap Screws—3013 and 3016	Torque	34.3 N•m (25 lb-ft)
Injection Pump Mounting Nuts—3013 and 3016	Torque	26 N•m (228 lb-in.)
Injection Pump Mounting Cap Screw—3013 and 3016	Torque	26 N•m (228 lb-in.)
Fuel Injection Pump Mounting Cap Screws—4TNE98	Torque	27 N•m (20 lb-ft)
Injection Pump Timing Gear Nut—4TNE98	Torque	85 N•m (63 lb-ft)
Injection Pump—4TNE98	Timing	11 ± 1° BTDC (Before top dead center)
Engine Crankshaft—4TNE98	Position	No. 1 Cylinder on TDC Compression Stroke
Outer Surface of Flywheel Per 1° of Rotation—4TNE98	Distance	3.5 mm (0.13 in.)
Lines on Pump Mounting Plate—4TNE98	Timing	2.0° apart
Injection Pump—4TNE98	Timing	11 ± 1° BTDC (Before top dead center)

Continued on next page

OUO1083,0000677 –19–14MAY04–3/4

Item	Measurement	Specification
Outer Surface of Flywheel Per 1° of Rotation—4TNE98	Distance	3.5 mm (0.13 in.)
Fuel Injection Delivery Valve Fitting—4TNE98	Torque	42 ± 3 N•m (31 ± 2 lb ft)
Engine Crankshaft—4TNE98	Position	No. 1 Cylinder on TDC Compression Stroke
Fuel Injection Nozzle—3009	Torque	50 N•m (37 lb-ft)
Fuel Injection Nozzle Leak-Off Line Nuts—3009	Torque	40 N•m (30 lb-ft)
Fuel Injection Nozzle Fitting—3009	Torque	40 N•m (30 lb-ft)
Fuel Injection Nozzle Contact Surface—3009	Size	0.10 mm (0.0039 in.) maximum
Fuel Injection Retaining Plate Nuts—3011, 3012, 3015, 4020, & 4TNE98	Torque	5 N•m (44 lb-in)
Fuel Injection Retaining Plate Cap Screw—3013 and 3016	Torque	24—28 N•m (212—248 lb-in)
Fuel Injection Nozzle Retaining Nut—3011, 3012, 3013, 3015, 3016, 4020, and 4TNE98	Torque	43 N•m (31 lb-ft)
Fuel Injection Nozzle Contact Surface—3011, 3012, 3013, 3015, 3016, 4020, and 4TNE98	Size	0.10 mm (0.0039 in.)

OUO1083,0000677 –19–14MAY04–4/4

Starting and Charging Systems Specifications

Item	Measurement	Specification
Starter Rear Cover Bushing Final Ream—3009	Size	12.50—12.53 mm (0.492—0.493 in.)
Starter Brushes—3009	Length	7.70 mm (0.303 in.) minimum
Starter Brushes—3011, 3012, 3013, 3015, 3016 and 4020	Length	8.5 mm (0.355 in.) minimum
Alternator Brush—3009, 3011, 3013, 3015 and 3016 (Denso Equipped)	Length	4.50 mm (0.170 in.) minimum
Alternator Sheave Nut—3009, 3011, 3013, 3015 and 3016 (Denso Equipped)	Torque	69 N•m (51 lb-ft)
Alternator Brush—3012, 3015 and 4020 (Hitachi Equipped)	Length	5.50 mm (0.220 in.) minimum

Item	Measurement	Specification
Starter Rear Cover Bushing Final Ream—3009	Size	12.50—12.53 mm (0.492—0.493 in.)
Starter Brushes—3009	Length	7.70 mm (0.303 in.) minimum
Starter Brushes—3011, 3012, 3013, 3015, 3016 and 4020	Length	8.5 mm (0.355 in.) minimum
Alternator Brush—3009, 3011, 3013, 3015 and 3016 (Denso Equipped)	Length	4.50 mm (0.170 in.) minimum
Alternator Sheave Nut—3009, 3011, 3013, 3015 and 3016 (Denso Equipped)	Torque	69 N•m (51 lb-ft)
Alternator Brush—3012, 3015 and 4020 (Hitachi Equipped)	Length	5.50 mm (0.220 in.) minimum

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Diagnostic Specifications

Item	Measurement	Specification
Radiator Cap	Holding Pressure (10 Second Minimum Hold)	90 kPa (0.9 bar) (13 psi) minimum
Coolant Temperature Switch, Closing	Temperature	107—113°C (225—235°F)
Coolant Temperature Sensor	Resistance	40—700 Ohms
Thermostat—Begin Opening	Temperature	71°C (160°F)
Thermostat—Fully Open	Temperature	85°C (184°F)
Thermostat Opening (Minimum at Full Open)	Height	8 mm (0.310 in.)
Fuel Supply Pump—3011, 3012, 3015, 4020 and 4TNE98	Pressure	29 kPa (4.3 psi) minimum
Fuel Supply Pump—3013 and 3016	Pressure	37 kPa (5.4 psi) minimum
Injection Nozzle Opening Test		
Opening—3009	Pressure	11 242—12 202 kPa (1630—1770 psi)
Opening—3011, 3012, 3013, 3015, 4020, and 4TNE98	Pressure	19 120—20 080 kPa (2773—2913 psi)
Opening—3013 and 3016	Pressure	21 600—22 600 kPa (3133—3278 psi)
Injection Nozzle Spray Pattern Test		
Opening—3009	Pressure	11 242—12 202 kPa (1630—1770 psi)
Opening—3011, 3012, 3015, 4020 and 4TNE98	Pressure	19 120—20 080 kPa (2773—2913 psi)
Opening—3013 and 3016	Pressure	20 000—21 600 kPa (2901—3133 psi)

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Item	Measurement	Specification
Injection Nozzle Chatter and Spray		
Slow Hand Lever Movement		Chatter sound
Slow Hand Lever Movement		Fine stream spray pattern
Fast Hand Lever Movement		Fine atomized spray pattern
Injection Nozzle Leakage Test		
Leakage Test—3009	Pressure	11 032 kPa (1600 psi)
Leakage Test—3011, 3012, 3015 and 4020	Pressure	17 640 kPa (2558 psi)
Leakage Test—4TNE98	Pressure	18 100 kPa (2625 psi)
Leakage Test—3013 and 3016	Pressure	20 000 kPa (2901 psi)
Engine Oil (At Slow Idle)—3009, 3011	Pressure	147 kPa (21 psi)
Engine Oil (At Slow Idle)—3012, 3015, 4020	Pressure	193 kPa (28 psi)
Engine Oil (At Slow Idle)—3013, 3016	Pressure	296 kPa (43 psi)
Engine Oil (At Slow Idle)—4TNE98	Pressure	59 kPa (8.5 psi)
Cylinder Compression Pressure Test—3009	Compression Pressure Maximum Difference Between Cylinders	2455 kPa (356 psi) 490 kPa (71 psi)
Cylinder Compression Pressure Test—3011, 3012, 3015 and 4020	Compression Pressure Maximum Difference Between Cylinders Minimum Cranking Speed	2158 kPa (313 psi) 490 kPa (71 psi) 300 rpm
Cylinder Compression Pressure Test—3013	Compression Pressure Minimum Maximum Difference Between Cylinders Minimum Cranking Speed	3055—3261 kPa (443—473 psi) 2345 kPa (340 psi) 250 kPa (26 psi) 250 rpm

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Item	Measurement	Specification
Cylinder Compression Pressure Test—3016	Compression Pressure	3324—3530 kPa (482—512 psi)
	Minimum	2648 kPa (384 psi)
	Maximum Difference Between Cylinders	250 kPa (26 psi)
	Minimum Cranking Speed	250 rpm
Cylinder Compression Pressure Test—4TNE98	Compression Pressure	3421 kPa (498 psi)
	Minimum	2737 kPa (355 psi)
	Maximum Difference Between Cylinders	195—293 kPa (28—43 psi)
	Minimum Cranking Speed	250 rpm
Fuel Injection Retaining Plate Nuts—3011, 3012, 3015, 4020 and 4TNE98	Torque	5 N•m (44 lb-in.)
Fuel Injection Retaining Plate Cap Screw—3013 and 3016	Torque	24—28 N•m (212—248 lb-in.)
Cylinder Leakage Test Pressure		
3009, 3011 and 4020	Maximum Air Pressure	2448 kPa (355 psi)
3015 and 4TNE98	Maximum Air Pressure	2158 kPa (313 psi)
Starter Cranking Amp Draw/RPM—3009	Amperage (Maximum)	200 amps @ 300 (minimum) rpm
Starter Cranking Amp Draw/RPM—3011, 3012, 3013, 3015, 3016 and 4020	Amperage (Maximum)	230 amps @ 300 (minimum) rpm
Starter No-Load Amp Draw—3009	Amperage (Maximum)	60 amps @ 7000 (mimimum) rpm
Starter No-Load Amp Draw—3011, 3012, 3013, 3015 and 3016	Amperage (Maximum)	90 amps @ 3000 (mimimum) rpm
Starter No-Load Amp Draw—4020	Amperage (Maximum)	90 amps @ 3500 (mimimum) rpm
Starter No-Load Amp Draw—4TNE98	Amperage (Maximum)	19 amps @ 3500 (mimimum) rpm
Starter Brushes—3009	Length	7.70 mm (0.303 in.) minimum

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OUO1083,000068C –19–18MAY04–3/4

Item	Measurement	Specification
Starter Negative Brushes—3011, 3012, 3013, 3015, 3016 and 4020	Length	8.5 mm (0.355 in.) minimum
Starter Field Coil Brushes—3011, 3012, 3013, 3015, 3016 and 4020	Length	8.5 mm (0.355 in.) minimum
Denso 40-Amp Alternator Rotor Slip Ring	OD	14 mm (0.550 in.)
Alternator Brush—3009, 3011, 3013, 3015 and 3016	Length	4.50 mm (0.170 in.) minimum
Alternator Brush—3012, 3015 and 4020	Length	5.50 mm (0.220 in.) minimum
Minimum Regulated Amperage—Base/Industrial Applications	All Models except 4TNE98	35 Amps @ 3225 rpm
Minimum Regulated Amperage—Generator Set Applications	3009 3011, 3012, 3013, 3015, 3016 and 4020	35 Amps @ 3800 rpm 35 Amps @ 1900 rpm
Minimum Unregulated Amperage—Base/Industrial Applications	All Models except 4TNE98	35 Amps @ 3225 rpm
Minimum Unregulated Amperage—Generator Set Applications	3009 3011, 3012, 3013, 3015, 3016 and 4020	35 Amps @ 3800 rpm 35 Amps @ 1900 rpm
Regulated Voltage Fast Idle Speed—Base/Industrial Applications	All Models except 4TNE98	12.2—14.7 VDC @ 3225 rpm
Regulated Voltage Fast Idle Speed—Generator Set Applications	3009 3011, 3012, 3013, 3015, 3016 and 4020	12.2—14.7 VDC @ 3800 rpm 12.2—14.7 VDC @ 1900 rpm
Fuel Shutoff Pull-In Amperage (White Wire)—3011 and 3012	Amperage	50 Amps (1/2 second)
Fuel Shutoff Hold-In Amperage (Red Wire)—3011 and 3012	Amperage	1 Amp (continuous)

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Dynamometer Test Specifications

NOTE: The power specifications shown below apply to Dubuque, Torreon and Saran-built OEM engines. Specifications are subject to change. Refer to factory DTAC for assistance.

Engine speeds listed are as preset to factory specification. In most cases, slow idle speed will be reset depending upon specific vehicle application requirements. Refer to your machine technical manual for engine speeds that are different from those preset at the factory.

Power ratings specify flywheel power for a bare engine without the drag effect of a cooling fan or other accessories like an air compressor.

Altitude, fuel temperature, air temperature, and humidity may affect engine performance. (See EFFECTS OF ALTITUDE AND TEMPERATURE ON ENGINE PERFORMANCE later in this group.)

POWER RATINGS ON DYNAMOMETER FOR OEM ENGINES[a]

Naturally Aspirated

Engine Model (Emission Certification)	Application	Injection Pump (Part No.)	Governor Regulation	Rated Speed at Full Load (rpm)[a]	Fast Idle (rpm)[a]	Power Rating kW (HP)[b]
3009DF001 (Non—Certified)	Base Engine	AM101403	5—8%	3000	3225	14 (19)
3009DF005 (Non—Certified)	Industrial Power Unit	AM101403	5—8%	3000	3225	14 (19)
3009DF007 (Non—Certified)	Generator Drive Power Unit	AM101403	3—5%	1800	1900	13 (17)
3011DF001 (Non—Certified)	Base Engine	RG60187	5—8%	3000	3225	19 (25)
3011DF005 (Non—Certified)	Industrial Power Unit	RG60187	5—8%	3000	3225	19 (25)
3011DF006 (Non—Certified)	Generator Drive Power Unit	RG60464	3—5%	1800	1900	17 (23)
3012DF101 (Tier 1)	Base Engine	—	5—8%	3000	3225	20 (27)
3012DF105 (Tier 1)	Industrial Power Unit	—	5—8%	3000	3225	20 (27)
3012DF006 (Tier 1)	Generator Drive Power Unit	—	5—8%	1800	1900	12 (16)
3013DF270 (Tier 2)	Industrial Power Unit	RG61149	4—6%	3000	3225	23 (30)
3013DF271 (Tier 2)	Generator Drive Power Unit	RG61149	3—5%	1800	1900	13 (18)
3015DF001 (Non—Certified)	Base Engine	RG60754	5—8%	3000	3225	25 (33)
3015DF101 (Tier 1)	Base Engine	AM880375	5—8%	3000	3225	25 (33)

[a]Engine speeds listed are preset to factory specifications. Slow idle speed may be reset depending upon specific vehicle application requirements. Refer to your machine operator’s manual for engine speeds that are different from those preset at the factory.

[b]Power ratings are for a bare engine without drag of cooling fan or accessories like air compressor. All power ratings are at full load at rated speed.

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OUO1030,0000754 –19–01APR04–1/3

POWER RATINGS ON DYNAMOMETER FOR OEM ENGINES[a]						
Naturally Aspirated						
Engine Model (Emission Certification)	**Application**	**Injection Pump (Part No.)**	**Governor Regulation**	**Rated Speed at Full Load (rpm)[a]**	**Fast Idle (rpm)[a]**	**Power Rating kW (HP)[b]**
3015DF002 (Non—Certified)	Base Engine	RG60754	5—8%	3000	3225	25 (33)
3015DF102 (Tier 1)	Base Engine	AM880375	5—8%	3000	3225	25 (33)
3015DF005 (Non—Certified)	Industrial Power Unit	RG60754	5—8%	3000	3225	25 (33)
3015DF105 (Tier 1)	Industrial Power Unit	AM880375	5—8%	3000	3225	25 (33)
3015DF006 (Non—Certified)	Generator Drive Power Unit	RG60771	3—5%	1800	1900	15 (20)
3016DF270 (Tier 2)	Industrial Power Unit	RG61127	5—7%	3000	3225	27 (36)
3016DF271 (Tier 2)	Generator Drive Power Unit	RG61127	3—5%	1800	1900	16 (22)
4020DF001 (Non—Certified)	Base Engine	RG60771	5—8%	3000	3225	33 (44)
4020DF101 (Tier 1)	Base Engine	AM880384	5—8%	3000	3225	33 (44)
4020DF005 (Non—Certified)	Industrial Power Unit	RG60771	5—8%	3000	3225	33 (44)
4020DF105 (Tier 1)	Industrial Power Unit	AM880384	5—8%	3000	3225	33 (44)
4020DF006 (Non—Certified)	Generator Drive Power Unit	RG60771	3—5%	1800	1900	20 (26)
4020DF106 (Tier 1)	Generator Drive Power Unit	AM880384	3—5%	1800	1900	20 (26)
Turbocharged						
4020TF001 (Non—Certified)	Base Engine	RG60771	5—8%	3000	3225	41 (55)
4020TF101 (Tier 1)	Base Engine	AM880405	5—8%	3000	3225	41 (55)
4020TF005 (Non—Certified)	Industrial Power Unit	RG60771	5—8%	3000	3225	41 (55)
4020TF105 (Tier 1)	Industrial Power Unit	AM880405	5—8%	3000	3225	41 (55)

[a]Engine speeds listed are preset to factory specifications. Slow idle speed may be reset depending upon specific vehicle application requirements. Refer to your machine operator's manual for engine speeds that are different from those preset at the factory.

[b]Power ratings are for a bare engine without drag of cooling fan or accessories like air compressor. All power ratings are at full load at rated speed.

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POWER RATINGS ON DYNAMOMETER FOR OEM ENGINES[a]						
Naturally Aspirated						
Engine Model (Emission Certification)	**Application**	**Injection Pump (Part No.)**	**Governor Regulation**	**Rated Speed at Full Load (rpm)[a]**	**Fast Idle (rpm)[a]**	**Power Rating kW (HP)[b]**
4020TF006 (Non—Certified)	Generator Drive Power Unit	RG60771	3—5%	1800	1900	27 (36)
4020TF106 (Tier 1)	Generator Drive Power Unit	AM880410	3—5%	1800	1900	27 (36)

[a]Engine speeds listed are preset to factory specifications. Slow idle speed may be reset depending upon specific vehicle application requirements. Refer to your machine operator’s manual for engine speeds that are different from those preset at the factory.

[b]Power ratings are for a bare engine without drag of cooling fan or accessories like air compressor. All power ratings are at full load at rated speed.

JOHN DEERE CONSTRUCTION AND FORESTRY EQUIPMENT[a]						
Model	**Engine Model (Emission Certification)**	**Injection Pump (Part No.)**	**Governor Regulation**	**Rated Speed at Full Load (rpm)[a]**	**Fast Idle (rpm)[a]**	**Power Rating kW (HP)[b]**
304H Loader	CH4033D001 (Non—Certified)	AT211785	4—6%	2400	2600	48 (65)
244H Loader	CH4033D001 (Non—Certified)	AT211785	4—6%	2200	2375	41 (55)

[a]Engine speeds listed are preset to factory specifications. Slow idle speed may be reset depending upon specific vehicle application requirements. Refer to your machine operator’s manual for engine speeds that are different from those preset at the factory.

[b]Power ratings are for a bare engine without drag of cooling fan or accessories like air compressor. All power ratings are at full load at rated speed.

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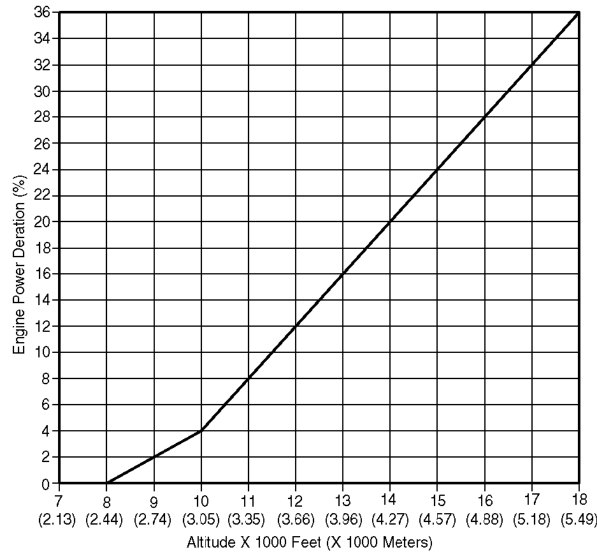
Effects of Altitude and Temperature on Engine Performance

Altitude, fuel temperature, air temperature, and humidity may affect engine performance. As a general rule, atmospheric changes will usually cause a decrease in engine power by the percentages shown in chart below.

ATMOSPHERIC CHANGE	% POWER DECREASE
Fuel Temperature Rise of 1°C (1.8°F) above 40°C (104°F)	
Naturally Aspirated Engines	0.19
Turbocharged Engines:	0.19
Air Temperature Rise of 5.5°C (10°F) above 25°C (77°F)	
Naturally Aspirated Engines	1.50
Turbocharged Engines:	0.50
Altitude Rise of 300 m (1000 ft) above 180 m (600 ft)	
Naturally Aspirated Engines	3.00
Turbocharged Engines:	4.00
Relative Humidity Rise of 10% above 0%	
Naturally Aspirated Engines	0.10
Turbocharged Engines:	0.07

NOTE: This data does not apply to engines with electronic fuel control systems. In these engines, the ECU compensates for changes in altitude and temperature and adjusts engine performance.



RG9094 –UN–27MAR98

Turbocharged Engines

RG,RG34710,1064 –19–27APR04–1/1

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Fuel Injection Pump Specifications

NOTE: Engine speeds listed are as preset to factory specification. In some cases, slow idle speed will be reset depending upon specific application requirements.

Engine Model	Application	Injection Pump (Part No.)	Slow Idle (rpm)	Rated Speed (rpm)	Fast Idle (rpm)	Fuel Injection Static Timing (DBTDC[a])
3009DF001	Base Engine	AM101403	800	3000	3225	16 ± 1
3009DF005	Industrial Power	AM101403	800	3000	3225	16 ± 1
3009DF007	Generator Set	AM101403	1300	3600	3800	18 ± 1
3011DF001	Base Engine	RG60187	800	3000	3225	16 ± 1
3011DF005	Industrial Power	RG60187	800	3000	3225	16 ± 1
3011DF006	Generator Set	RG60464	1200	1800	1900	10 ± 1
3015DF001	Base Engine	RG60754	800	3000	3225	16 ± 1
3015DF005	Industrial Power	RG60754	800	3000	3225	16 ± 1
3015DF006	Generator Set	RG60771	1200	1800	1900	10 ± 1
4020DF001	Base Engine	RG60771	800	3000	3225	16 ± 1
4020DF005	Industrial Power	RG60771	800	3000	3225	16 ± 1
4020DF006	Generator Set	RG60771	1200	1800	1900	10 ± 1
4020TF001	Base Engine	RG60771	800	3000	3225	16 ± 1
4020TF005	Industrial Power	RG60771	800	3000	3225	16 ± 1
4020TF006	Generator Set	RG60771	1200	1800	1900	10 ± 1
CH4033D001 (4TNE98)	244H Loader	AT211785	900	2200	2375	16 ± 1

[a]Degrees Before Top Dead Center

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