2.4L and 3.0L Diesel Engines

COMPONENT TECHNICAL MANUAL

2.4L and 3.0L Diesel Engines Component Technical Manual

CTM301 09NOV10 (ENGLISH)

For complete service information also see:

Alternators and Starting Motors	**CTM77**
OEM Engine Accessories (English Only).....	**CTM67**

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.

Technical manuals are divided in two parts: repair and operation and tests. Repair sections tell how to repair the components. Operation and tests sections help you identify the majority of routine failures quickly.

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

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.

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.

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

Engine Owner

John Deere Engine Owner:

Don't wait until you need warranty or other service to meet your local John Deere Engine Distributor or Service Dealer.

Learn who he is and where he is. At your first convenience, go meet him. He'll want to get to know you and to learn what your needs might be.

Aux Utilisateurs De Moteurs John Deere:

N'attendez pas d'être obligé d'avoir recours a votre concessionnaire John Deere ou point de service le plus proche pour vous adresser a lui.

Renseignez-vous des que possible pour l'identifier et le localiser. A la premiere occasion, prenez contact avec lui et faites-vous connaître. Il sera lui aussi heureux de faire votre connaissance et de vous proposer ses services le moment venu.

An Den Besitzer Des John Deere Motors:

Warten Sie nicht auf einen evt. Reparaturfall um den nächstgelegenen John Deere Händler kennen zu lernen.

Machen Sie sich bei ihm bekannt und nutzen Sie sein "Service Angebot".

Proprietario Del Motore John Deere:

Non aspetti fino a quando ha bisogno della garanzia o di un altro tipo di assistenza per incontrarsi con il Suo Concessionario che fornisce l'assistenza tecnica.

Impari a conoscere chi è e dove si trova. Alla Sua prima occasione cerchi d'incontrarlo. Egli desidera farsi conoscere e conoscere le Sue necessità.

Propietario De Equipo John Deere:

No espere hasta necesitar servicio de garantía o de otro tipo para conocer a su Distribuidor de Motores John Deere o al Concesionario de Servicio.

Entérese de quién es, y dónde está situado. Cuando tenga un momento, vaya a visitarlo. A él le gustará conocerlo, y saber cuáles podrían ser sus necesidades.

John Deere MotorÄgare:

Vänta inte med att besöka Din John Deere återförsäljare till dess att Du behöver service eller garanti reparation.

Bekanta Dig med var han är och vem han är. Tag första tillfälle att besöka honom. Han vill också träffa Dig för att få veta vad Du behöver och hur han kan hjälpa Dig.

DPSG,OUOE003,2736 -19-11JAN99-1/1

About This Manual

The changes listed below update your CTM. **Discard CTM301 dated 14Jul09 and replace with this manual. Also refer to the following manuals.**

SECTION 02—Group 090 (Fuel System)

- Added injection nozzle testing procedures

SECTION 05—Group 170 (Repair Tools)

- Added tools

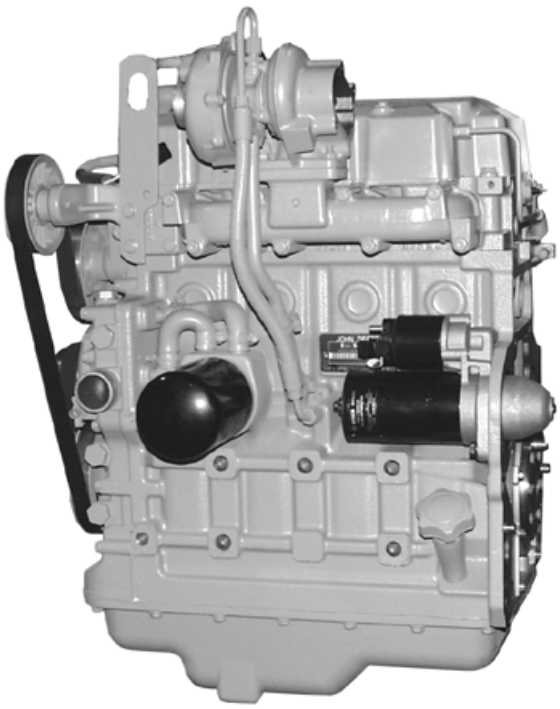
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2.4L and 3.0L Diesel Engines



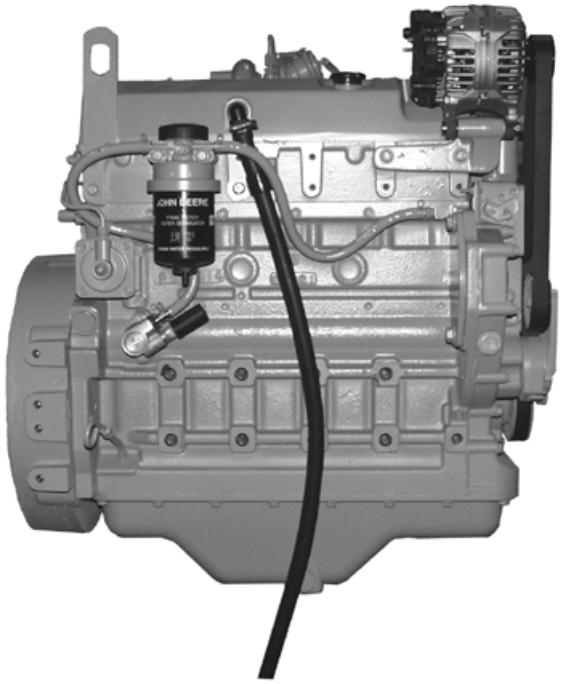
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2.4 L Right Side View



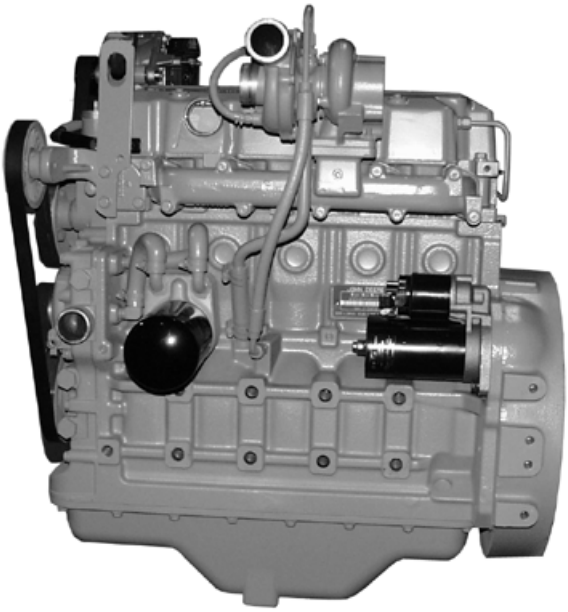
RG12960 —UN—03JUN03

2.4 L Left Side View



RG12962 —UN—03JUN03

3.0 L Right Side View



RG12963 —UN—03JUN03

3.0 L Left Side View

RG41183,000001D -19-08NOV10-1/1

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

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A John Deere ILLUSTRUCTION ® Manual
Previous Editions
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Section 01
General Information

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Handle Fluids Safely—Avoid Fires

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

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

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

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



TS227 —UN—23AUG88

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

Understand Signal Words

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

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



TS187 —19—30SEP88

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

Handle Chemical Products Safely

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

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

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

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



TS1132 —UN—26NOV90

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

Handle Starting Fluid Safely

Starting fluid is highly flammable.

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

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

Do not incinerate or puncture a starting fluid container.



TS1356 —UN—18MAR92

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

Prevent Bypass Starting

Avoid possible injury or death from engine runaway.

Do not start engine by shorting across starter terminal. Engine will start with PTO engaged if normal circuitry is bypassed.

Start engine only from operator's station with PTO disengaged or in neutral.



Prevent Bypass Starting

RG5419 —UN—28FEB89

RG,RG34710,7508 -19-09JAN07-1/1

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

DO NOT USE Starting Fluids

DO NOT USE ether starting fluids with these glow plug - equipped engines as it could cause an extreme explosion with possible personal injury.

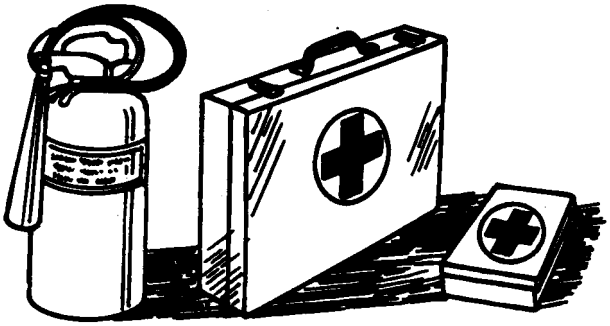
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Prepare for Emergencies

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

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

Prevent Acid Burns

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

Avoid the hazard by:

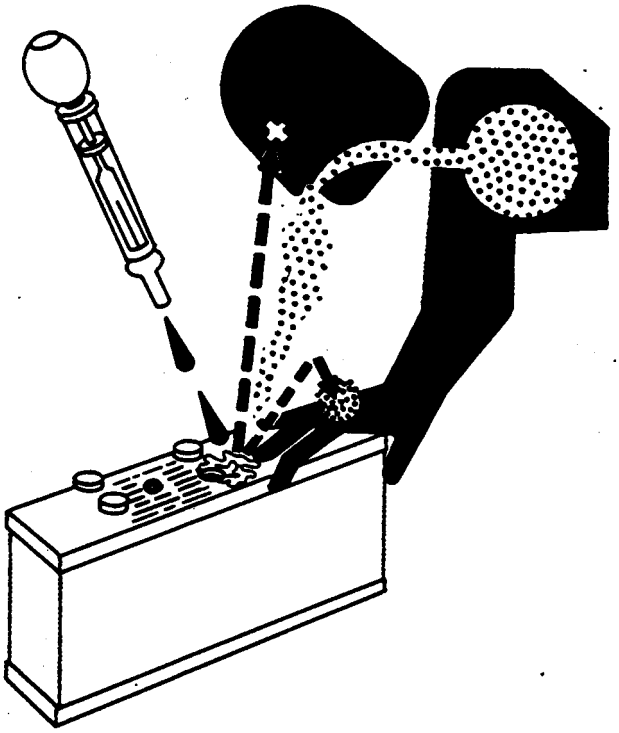
1. Filling batteries in a well-ventilated area.
2. Wearing eye protection and rubber gloves.
3. Avoiding breathing fumes when electrolyte is added.
4. Avoiding spilling or dripping electrolyte.
5. Use proper jump start procedure.

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.



TS203 —UN—23AUG88

DX,POISON -19-21APR93-1/1

Handling Batteries Safely

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.



TS204 —UN—23AUG88

Continued on next page

DPSG,OUO1004,2758 -19-09JAN07-1/2

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.**

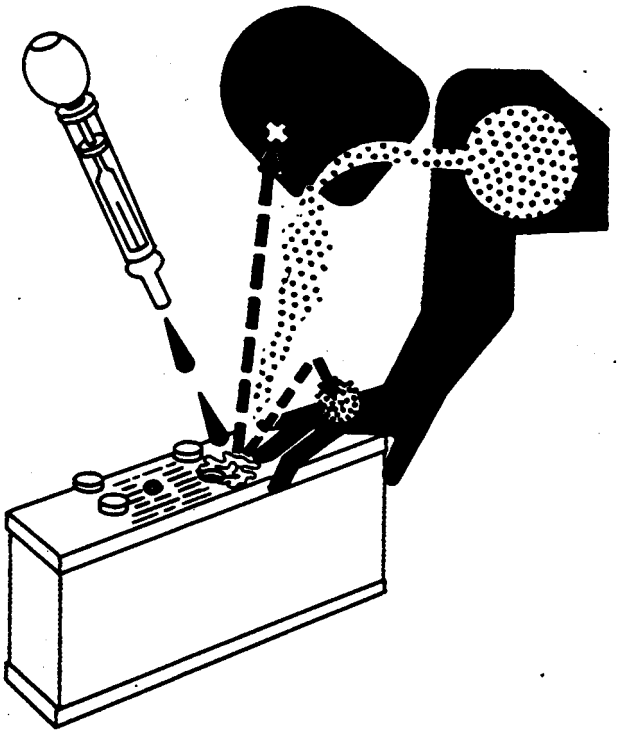
If you spill acid on yourself:

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.**



TS203 —UN—23AUG88

DPSG,OUO1004,2758 -19-09JAN07-2/2

Handle Fluids Safely—Avoid Fires

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

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

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

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



TS227 —UN—23AUG88

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

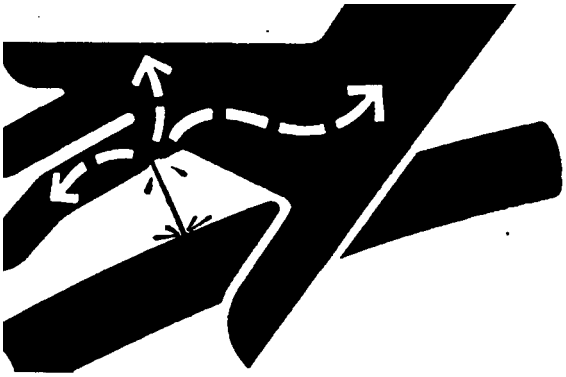
Avoid High-Pressure Fluids

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

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

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

If an accident occurs, see a doctor immediately. Any fluid injected into the skin must be surgically removed within a few hours or gangrene may result. Doctors unfamiliar with this type of injury should reference a knowledgeable medical source. Such information is available in English from Deere & Company Medical Department in Moline, Illinois, U.S.A., by calling 1-800-822-8262 or +1 309-748-5636.



X9811 —UN—23AUG88

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

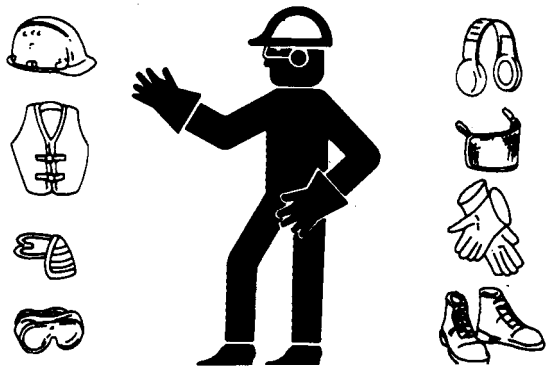
Wear Protective Clothing

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

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

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

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



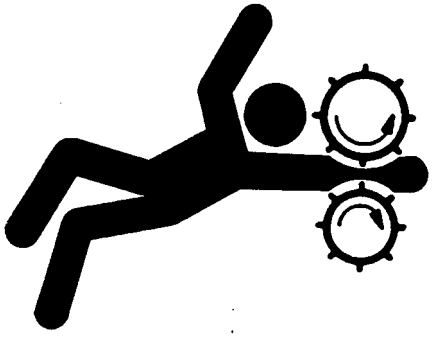
TS206 —UN—23AUG88

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

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.



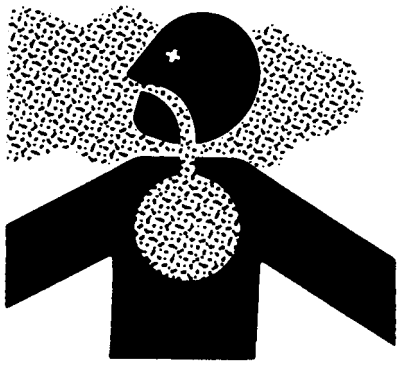
TS228 —UN—23AUG88

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.



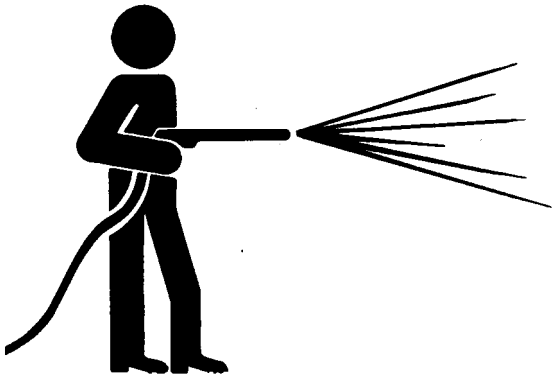
TS220 —UN—23AUG88

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

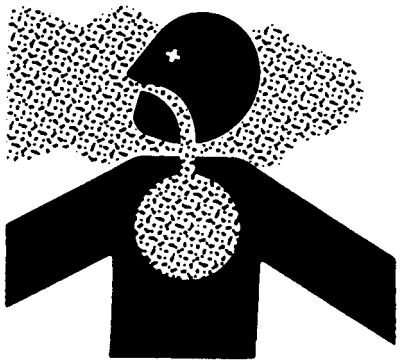
Avoid potentially toxic fumes and dust.

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

Remove paint before heating:

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

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



TS220 —UN—23AUG88

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

Dispose of paint and solvent properly.

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

Avoid Heating Near Pressurized Fluid Lines

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

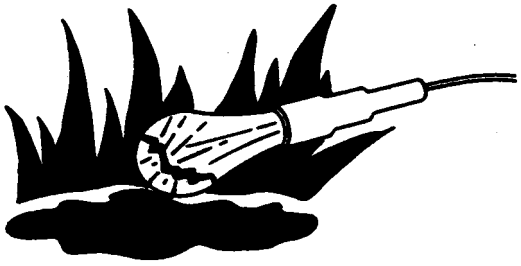


TS953 —UN—15MAY90

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

Illuminate Work Area Safely

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



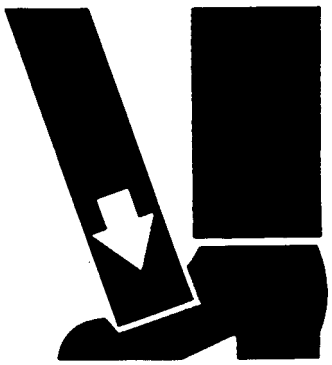
TS223 —UN—23AUG88

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

Use Proper Lifting Equipment

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

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



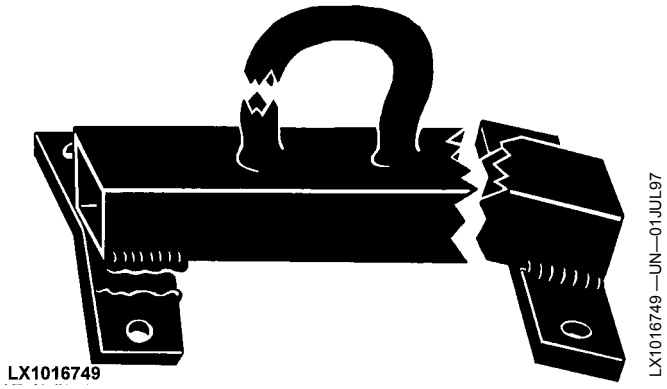
TS226 —UN—23AUG88

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

Construct Dealer-Made Tools Safely

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

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



Construct Dealer-Made Tools Safely

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.



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

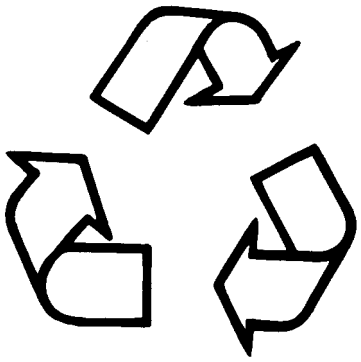
Improperly disposing of waste can threaten the environment and ecology. Potentially harmful waste used with John Deere equipment include such items as oil, fuel, coolant, brake fluid, filters, and batteries.

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.



TS1133 —UN—26NOV90

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

Live With Safety

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



TS231 —19—07OCT88

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

Engine Model Designation

JOHN DEERE ENGINE MODEL—4024

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

4024TF270 Engine

4 ..... Number of cylinders
2.4 ..... Liter designation
T ..... Aspiration code
F ..... User code
01 ..... Application Code

Aspiration Code

T ..... Turbocharged, no aftercooling
H ..... Turbocharged and air-to-air aftercooled

User Code

F ..... OEM

Application Code

001, etc. ..... See ENGINE APPLICATION CHART, later in this Group

RG41183,000001B -19-26JAN06-1/1

POWERTECH™ Medallion

A medallion is located on the rocker arm cover which identifies each engine as a John Deere ***POWERTECH***™ engine.



RG12685 —UN—12DEC02



RG12684 —UN—12DEC02

***POWERTECH** is a trademark of Deere & Company.*

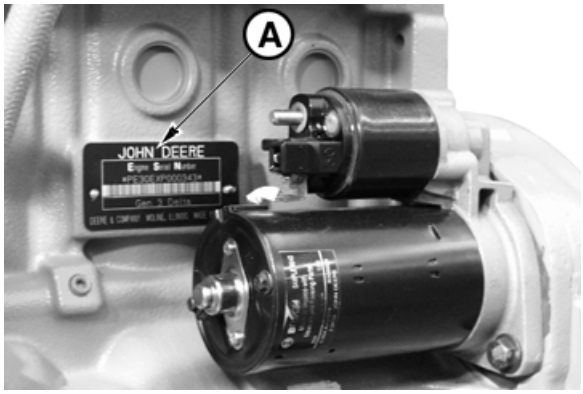
RG41183,0000022 -19-10DEC02-1/1

Engine Serial Number Plate

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

- "PE" indicates the engine was built in Torreon, Mexico

Your engine's serial number plate (A) is located on the left-hand side of cylinder block behind the starter motor.



RG12687 —UN—12DEC02

13-Digit Engine Serial Number Plate

RG41183,0000025 -19-11DEC02-1/1

Record Engine Serial Number

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

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

Engine Serial Number (B)

_____

Engine Model Number (C)

_____

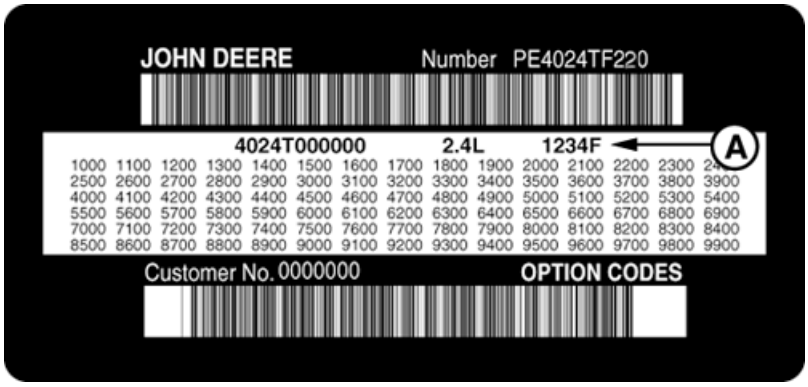


RG12688 —UN—09JUN04

Engine Serial Plate

RG41183,0000026 -19-11DEC02-1/1

OEM Engine Option Code Label



RG12689A —UN—09JUN04

Engine Option Codes

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

Always provide option code information and engine base code (A) when ordering repair parts. A listing of option codes is given in Parts Catalogs and Operator's Manuals.

NOTE: Before "hot tank" cleaning, ensure that option codes are recorded elsewhere.

RG41183,0000026 -19-16JUN03-1/1

Engine Application Chart

JOHN DEERE AGRICULTURAL EQUIPMENT	
Machine Model	**Engine Model**
5225 Tractor	PE5030TLV01
5325 Tractor	PE5030TLV02
JOHN DEERE COMMERCIAL and CONSUMER EQUIPMENT	
Machine Model	**Engine Model**
4120 Tractor	PE4024TLV04
4320 Tractor	PE4024TLV01
4520 Tractor	PE4024TLV02
4720 Tractor	PE4024TLV03
JOHN DEERE CONSTRUCTION and FORESTRY EQUIPMENT	
Machine Model	**Engine Model**
4WD Loader	
244J Loader	PE4024TT003
304J Loader	PE5030TT003
Skid Steer	
317 Skid Steer	PE4024TT001
320, CT322 Skid Steer	PE4024TT002
325 Skid Steer	PE5030TT001
328, CT332 Skid Steer	PE5030TT002
332 Skid Steer	PE5030HT001

John Deere OEM (Outside Equipment Manufacturers)			
Turbocharged		**Turbocharged, Air-to-Air Aftercooled**	
Engine Model	**Emission Certification**	**Engine Model**	**Emission Certification**
PE4024TF220	Non-Certified	PE5030HF220	Non-Certified
PE4024TF270	Tier 2 - Certified	PE5030HF270	Tier 2 - Certified
PE5030TF220	Non-Certified		
PE5030TF270	Tier 2 - Certified		

RG41183,000001C -19-24SEP04-1/1

Diesel Fuel

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

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

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

Required fuel properties

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

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

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

Fuel lubricity should pass a minimum load level of 3100 grams as measured by ASTM D6078 or, maximum scar diameter of 0.45 mm as measured by ASTM D6079 or ISO12156-1.

Sulfur content:

- Diesel fuel quality and fuel sulfur content must comply with all existing regulations for the area in which the engine operates.
- Sulfur content less than 0.05% (500 ppm) is preferred.
- If diesel fuel with sulfur content greater than 0.05% (500 ppm) is used, crankcase oil service intervals may be affected. (See recommendation for Diesel Engine Oil.)
- DO NOT use diesel fuel with sulfur content greater than 1.0%.

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

OUOD002,0000171 -19-27JAN06-1/1

Lubricity of Diesel Fuel

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

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

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

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

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

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

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

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

OUOD002,0000179 -19-18DEC01-1/1

Diesel Fuel Storage

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.

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

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

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

Avoid storing fuel over long periods of time. If fuel is stored for more than a month prior to use, or there is a slow turnover in fuel tank or supply tank, add a fuel conditioner such as John Deere PREMIUM DIESEL FUEL CONDITIONER or equivalent to stabilize the fuel and prevent water condensation. John Deere PREMIUM DIESEL FUEL CONDITIONER is available in winter and summer formulas. Fuel conditioner also reduces fuel gelling and controls wax separation during cold weather.

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

RG,RG34710,7526 -19-18DEC01-1/1

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, DIN 51606, EN14214 or equivalent specification.

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

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

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

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

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

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

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

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

RG41183,0000046 -19-05MAR04-1/1

Handling And Storing Bio-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.

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.

OUOD002,0000176 -19-18DEC01-1/1

Testing Diesel Fuel

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

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

DIESELSCAN is a trademark of Deere & Company

DX,FUEL6 -19-14NOV05-1/1

Filling Fuel Tank

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

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

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.

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



TS202 —UN—23AUG88

RG,RG34710,7527 -19-30JUN97-1/1

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 becomes 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.

Glow Plug starting Aids

Glow plugs in the cylinder head are standard equipment to aid in cold weather starting at temperatures below 0°C (32°F). (See Cold Weather Starting in section 15).

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.

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

For more information, see your John Deere engine distributor or servicing dealer.

RG,RG34710,7529 -19-30JUN97-1/1

Diesel Engine Break-In Oil

New engines should be filled at the factory with John DeerePLUS-50 ™oil. During the break-in period, add John DeerePLUS-50 ™15W-40 oil as needed to maintain the specified oil level. (Order TY6389.)

PLUS-50 is a trademark of Deere & Company.

RG39774,0000003 -19-27JAN06-1/1

Diesel Engine Oil

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

The following oil is preferred:

- John Deere PLUS-50 ®

The following oils are also recommended:

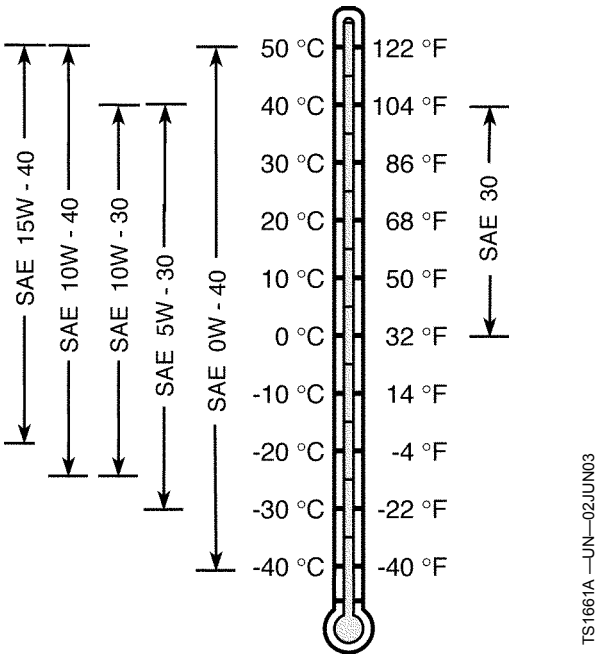
- John Deere TORQ-GARD SUPREME®
- ACEA Specification E4
- ACEA Specification E5
- ACEA Specification E6
- ACEA Specification E7

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

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

Multi-viscosity diesel engine oils are preferred.

NOTE: DO NOT use break-in oils in these engines.



Diesel Engine Oil Viscosity at Various Temperatures

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

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

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

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

Extended service intervals may apply when John Deere preferred engine oils are used. Consult your John Deere dealer for more information.

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TORQ-GARD SUPREME is a trademark of Deere & Company

RG41183,0000023 -19-09JUN03-1/1

Extended Diesel Engine Oil Service Intervals

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

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

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OUOD006,0000069 -19-27JAN06-1/1

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

Oil Filters

Filtration of oils is critical to proper operation and lubrication.

Always change filters regularly as specified in this manual.

Use filters meeting John Deere performance specifications.

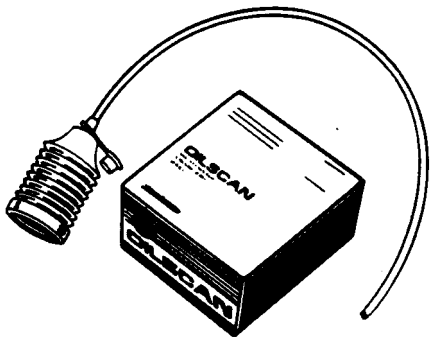
DX,FILT -19-18MAR96-1/1

OILSCAN ®and COOLSCAN ™

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

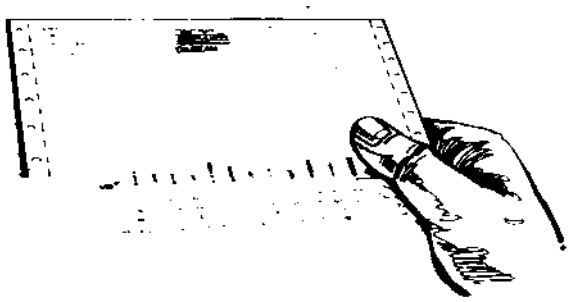
Oil and coolant samples should be taken from each system prior to its recommended change interval.

Check with your John Deere engine distributor or servicing dealer for the availability of OILSCAN, ® OILSCAN PLUS,® COOLSCAN ™ and, COOLSCAN PLUS™ kits.



T6828AB —UN—15JUN89

Sampling Programs



T6829AB —UN—18OCT88

Recommended Change Interval

OILSCAN is a registered trademark of Deere & Company.
COOLSCAN is a trademark of Deere & Company.
OILSCAN is a registered trademark of Deere & Company.
OILSCAN PLUS is a registered trademark of Deere & Company.
COOLSCAN PLUS is a trademark of Deere & Company.

OUOD002,0000173 -19-23NOV01-1/1

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.

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.

Avoid mixing different brands or types of oils. Oil manufacturers blend base stock and additives to create their oils and to meet certain specifications and performance requirements. Mixing different oils can interfere with proper functioning of these formulations and degrade lubricant performance.

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

DX,ALTER -19-11NOV09-1/1

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.

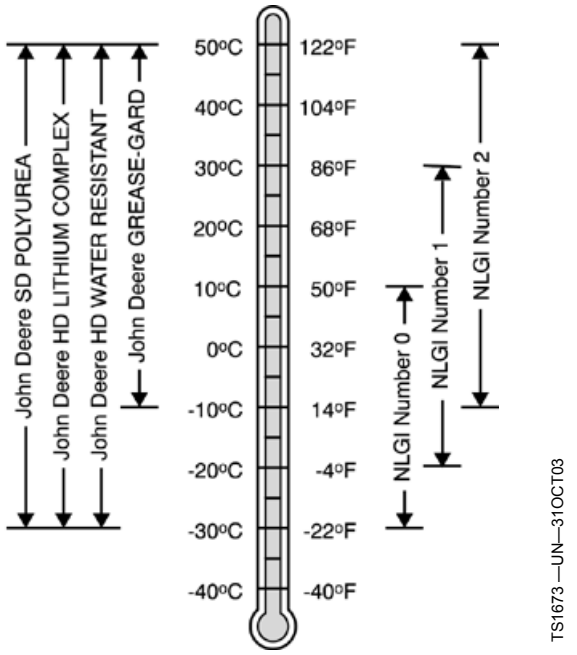
The following greases are also recommended

- 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.



GREASE-GARD is a trademark of Deere & Company

DX,GREA1 -19-07NOV03-1/1

Heavy Duty Diesel Engine Coolant

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

John Deere COOL-GARD™ II Premix Coolant is preferred.

John Deere COOL-GARD II Premix is available in a concentration of 50% ethylene glycol.

Additional Recommended Coolants

The following engine coolants are also recommended:

- John Deere COOL-GARD II Concentrate in a 40% to 60% mixture of concentrate with quality water.
- John Deere COOL-GARD Premix (available in a concentration of 50% ethylene glycol).
- John Deere COOL-GARD Concentrate in a 40% to 60% mixture of concentrate with quality water.
- John Deere COOL-GARD PG Premix (available in a concentration of 55% propylene glycol).

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

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

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

Other Coolants

It is possible that John Deere COOL-GARD II, COOL-GARD, and COOL-GARD PG coolants are unavailable in the geographical area where service is performed.

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

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

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

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

Water Quality

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

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

Do not mix ethylene glycol and propylene glycol base coolants.

Do not use coolants that contain nitrites.

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DX,COOL3 -19-03NOV08-1/1

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

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

Coolant Specifications

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

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

Replenish Coolant Additives

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

Why use John Deere LIQUID COOLANT CONDITIONER?

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

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

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Avoid Automotive-type Coolants

Never use automotive-type coolants (such as those meeting ASTM D3306). These coolants do not contain the correct additives to protect heavy-duty diesel engines. They often contain a high concentration of silicates and may damage the engine or cooling system. Do not treat an automotive engine coolant with a supplemental coolant additive because the high concentration of additives can result in additive fallout.

Water Quality

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

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

Freeze Protection

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

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

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

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

Testing Diesel Engine Coolant

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

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

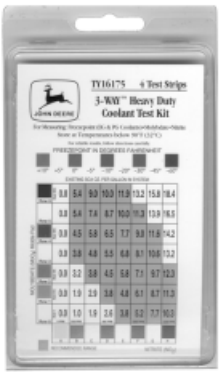
Coolant Test Strips

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. See your John Deere dealer for information.



RG7297 —UN—22SEP99

Coolant Test Strips



RG7397 —UN—05DEC97

CoolScan Bellows

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COOLSCAN PLUS is a trademark of Deere & Company.

OUOD002,0000174 -19-18DEC01-1/1

Supplemental Coolant Additives

Some coolant additives will gradually deplete during engine operation. For John Deere COOL-GARD™ Premix, COOL-GARD Concentrate, or John Deere COOL-GARD PG Premix, replenish coolant additives between drain intervals by adding a supplemental coolant additive as determined necessary by coolant testing.

John Deere LIQUID COOLANT CONDITIONER is recommended as a supplemental coolant additive for John Deere COOL-GARD Premix, COOL-GARD Concentrate, and COOL-GARD PG Premix.

John Deere LIQUID COOLANT CONDITIONER is not designed for use with COOL-GARD II Premix or COOL-GARD II Concentrate.

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

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

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

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

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

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DX,COOL4 -19-03NOV08-1/1

Operating in Warm Temperature Climates

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

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

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

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

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

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

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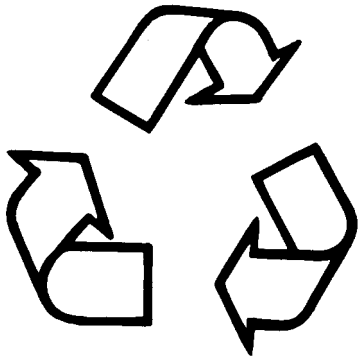
Disposing of Coolant

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.



TS1133 —UN—26NOV90

RG,RG34710,7543 -19-27JUL06-1/1

Section 02
Repair and Adjustments

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Engine Overhaul Guidelines

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

Consider installing a John Deere overhaul kit when:

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

Overhaul kits may be available for John Deere engines in your area.

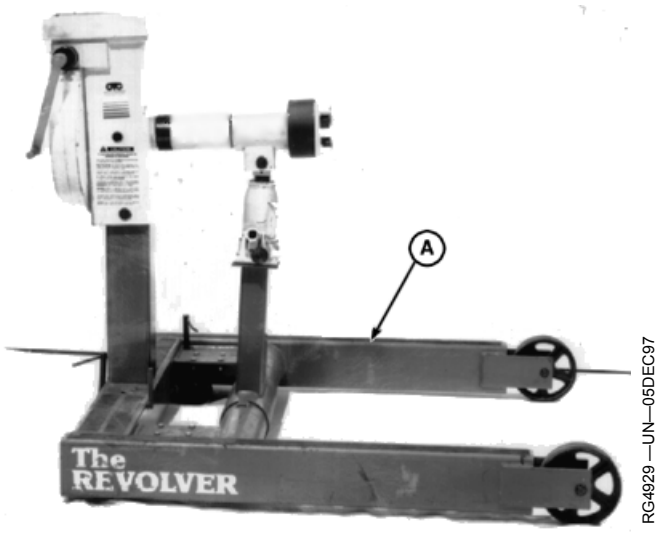
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Engine Repair Stand

NOTE: Only the 2722 kg (6000 lb) heavy duty engine repair stand (A) No. D05223ST manufactured by Owatonna Tool Co., Owatonna, Minnesota, is referenced in this manual. When any other repair stand is used, consult the manufacturer's instructions for mounting the engine.

Refer to machine technical manual for steps to remove engine from machine.

A—D05223ST Engine Repair Stand



Engine Repair Stand

RG,01,DT7044 -19-27SEP07-1/1

Engine Stand Safety Precautions

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

To maintain shear strength specifications, alloy steel Class 12.9 or SAE Grade 8 or higher cap screws must be used to mount adapters and engine to repair stand. Use LOCTITE® 242 Thread Lock and Sealer (Medium Strength) on cap screws when installing lifting straps on engine. Tighten cap screws to specifications given.

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

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

The center of balance of an engine must be located within 51 mm (2 in.) of the engine stand rotating shaft. Engine center of balance is generally located a few millimeters above the crankshaft.

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

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

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

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

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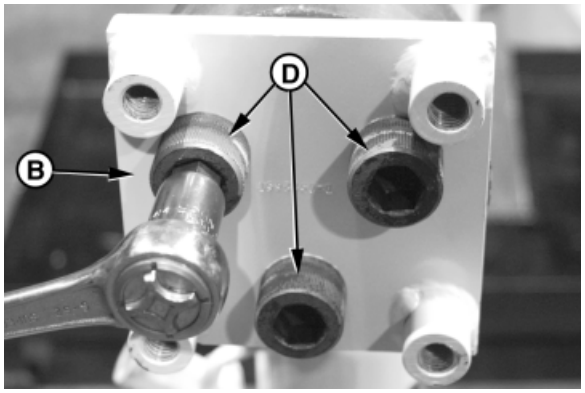
Install Adapters on Engine Repair Stand

1. Attach the D05226ST Special Adapter (B) to mounting hub (A) of the engine repair stand, using SAE Grade 8 socket head cap screws (D), to the following specifications.

Specification	
D05226ST Special Adapter-to-Mounting Hub SAE Grade 8 Socket Head Cap Screws. —Torque	600 N·m (450 lb-ft).

2. Attach the JDG1676 Engine Adapter (C) to the special adapter, using four SAE Grade 8 caps screws (E), to the following specifications.

Specification	
JDG1676 Engine Adapter-to-Special Adapter SAE Grade 8 Cap Screws.—Torque	135 N·m (100 lb-ft).



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Engine Repair Stand Adapters

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Engine Lifting Procedure

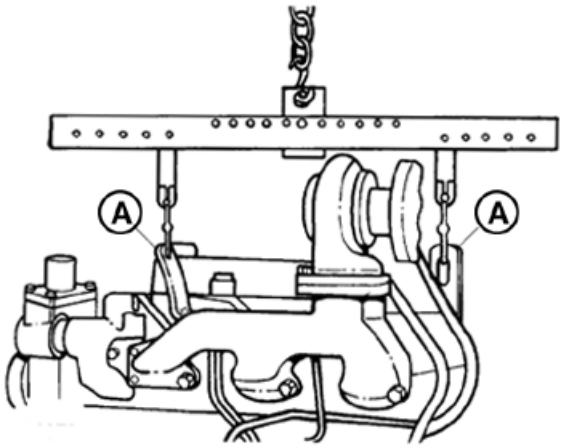
CAUTION: Use extreme caution when lifting and NEVER permit any part of the body to be lifted or suspended.

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

1. Attach JDG23 Engine Lifting Sling (or other suitable sling) to engine lifting straps (A) and overhead hoist on 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.

2. Carefully lift engine to desired location.



RG14502 —UN—21SEP05

Lifting Engine with Lifting Sling

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Clean Engine

1. Cap or plug all openings (air intake, exhaust, fuel, coolant, etc.).
2. Remove electrical components (starter, alternator, etc.). Cover electrical components that are not removed with plastic and tape securely to prevent moisture damage.
3. Thoroughly steam clean engine.

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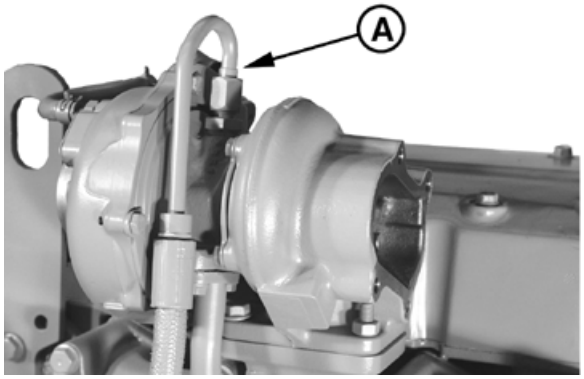
Disconnect Turbocharger Oil Inlet Line

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

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

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

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



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Turbocharger Oil Inlet Line

A—Oil Inlet Line

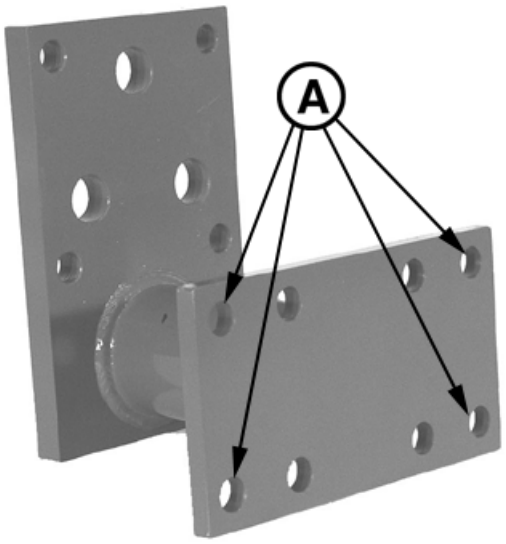
2. Disconnect turbocharger oil inlet line at turbocharger or oil filter housing.

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Mount Engine on Repair Stand

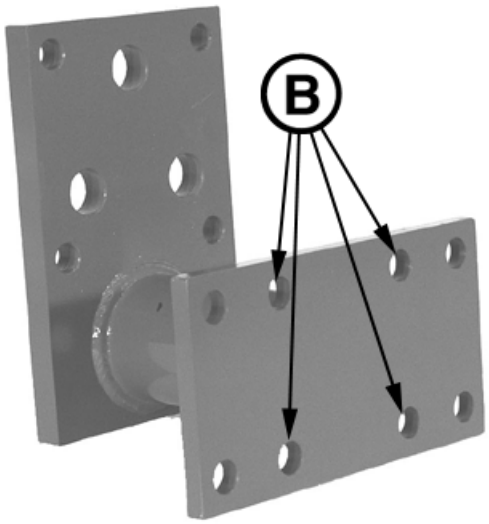
CAUTION: NEVER remove the overhead lifting equipment until the engine is securely mounted onto the repair stand and all mounting hardware is tightened to specified torque. Always release the overhead lifting equipment slowly.

Mount the engine to JDG1676 using M16 X 45mm (1.75 in.) cap screws.



RG12786 —UN—09FEB03

4024 Engine



RG12785 —UN—09FEB03

5030 Engine

RG41183,0000043 -19-27SEP07-1/1

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.

1. Mount engine on a safety approved repair stand.
2. Drain coolant and oil. Perform John Deere OILSCAN and COOLSCAN analysis. (Group 02)
3. Remove fan belt, fan, belt tensioner, and alternator. (Group 20)
4. Remove turbocharger (if equipped) and exhaust manifold. (Group 80)
5. Remove rocker arm cover and vent tube. If option code label is located on rocker arm cover, be careful not to damage label. (Group 20)
6. Remove oil cooler hoses and water pump. (Groups 60 and 70)
7. Remove dipstick, oil filter, oil cooler, and adapter housing (if equipped). (Group 60)
8. Remove fuel filter, fuel supply pump, and fuel line. (Group 90)
9. Remove starting motor. (Group 100)
10. Remove rocker arm assembly and push rods. Keep rods in order (Group 20). Check for bent push rods and condition of wear pad contact surfaces on rockers.
11. Remove Integrated Fuel System (IFS). (Group 90)
12. Remove cylinder head. Check piston-to-cylinder head clearance. (Group 20)
13. Remove cam followers. Keep followers in order. (Groups 20 and 90)
14. Remove flywheel and flywheel housing. (Group 40)
15. Remove oil pan. (Group 60)
16. Remove crankshaft pulley. (Group 40)
17. Remove timing gear cover. (Group 50)
18. Remove oil pressure regulating valve assembly. (Group 60)
19. Remove timing gears and camshaft. Perform wear checks. (Group 50)
20. Stamp cylinder number on connecting rod. Remove pistons and rods. (First, perform wear checks with PLASTIGAGE®.) (Group 30)
21. Remove crankshaft and main bearings. (First, perform wear checks with PLASTIGAGE®PLASTIGAGE.) (Group 40)
22. Remove piston cooling orifices. (Group 30)
23. Remove camshaft bushing. (Group 50)
24. Remove cylinder block plugs when block is to be put in a “hot tank”. (Group 30)
25. Clean cylinder bores with nylon brush. (Group 30)
26. Measure cylinder block. (Groups 30, 40, and 50)

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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.

1. Install all plugs and serial number plate in cylinder block (if removed). (Group 30)
2. Install piston cooling orifices. (Group 30)
3. Install new balancer shaft bushings and a new camshaft bushings. (Group 50)
4. Install main bearings and crankshaft. PLASTIGAGE® bearings. (Group 40)
5. Install flywheel housing, rear oil seal, and flywheel. (Group 40)
6. Install pistons and rods. Measure piston protrusion. (Group 30)
7. Install balancer shaft, if equipped. Check end play. (Group 50)
8. Install camshaft and governor assembly. (Group 50)
9. Install cylinder head gasket and cylinder head. (Group 20)
10. Install unit injection pumps and injector nozzles. (Group 90)
11. Install hydraulic lifters, push rods, and rocker arm assembly. (Group 20)
12. Install glow plugs and wire harness. (Group 20)
13. Install fuel supply pump. (Group 90)
14. Install fuel filter assembly. (Group 90)
15. Install oil cooler, new oil filter, and dipstick. (Group 60)
16. Install aneroid. (Group 70)
17. Install oil pressure regulating valve into timing gear cover. (Group 60)
18. Install timing gear cover and new front seal. (Group 50)
19. Install coolant pump and thermostat. (Group 70)
20. Install rocker arm cover. (Group 20)
21. Install oil pickup tube and oil pan. (Group 60)
22. Install exhaust manifold and turbocharger. (Group 80)
23. Fill engine with clean oil. (Group 02)
24. Flush cooling system and refill with proper coolant. (Group 150)
25. Perform engine break-in and standard performance checks. See PERFORM ENGINE BREAK-IN in this group.

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Engine Break-In Guidelines

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

- Main bearings, rod bearings, crankshaft, or any combination of these parts have been replaced.
- Pistons, rings have been replaced or cylinder bore has been honed.
- Rear crankshaft oil seal and wear sleeve have been replaced. (Primary objective is to see if oil seal still leaks.)
- Cylinder head has been removed.
- Unit Injection pump has been removed or critical adjustments have been made. (Primary objective is to check power.)

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Perform Engine Break-In

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

1. During the first 20 hours, avoid prolonged periods of engine idling or sustained maximum load operation. Warm-up engine carefully and operate at normal loads. If engine will idle longer than 5 minutes, stop engine.

IMPORTANT: Do not use break-in oil in this engine.

2. Check oil level daily or every 10 hours during engine break-in period. If oil must be added during this period, use John DeerePLUS-50 ™oil. (See DIESEL ENGINE OIL in Fuels, Lubricants, and Coolant section.)

PLUS-50 is a trademark of Deere & Company.

3. Watch coolant temperatures (A) closely during break-in period. Also check coolant level daily or every 10 hours and check for leaks.

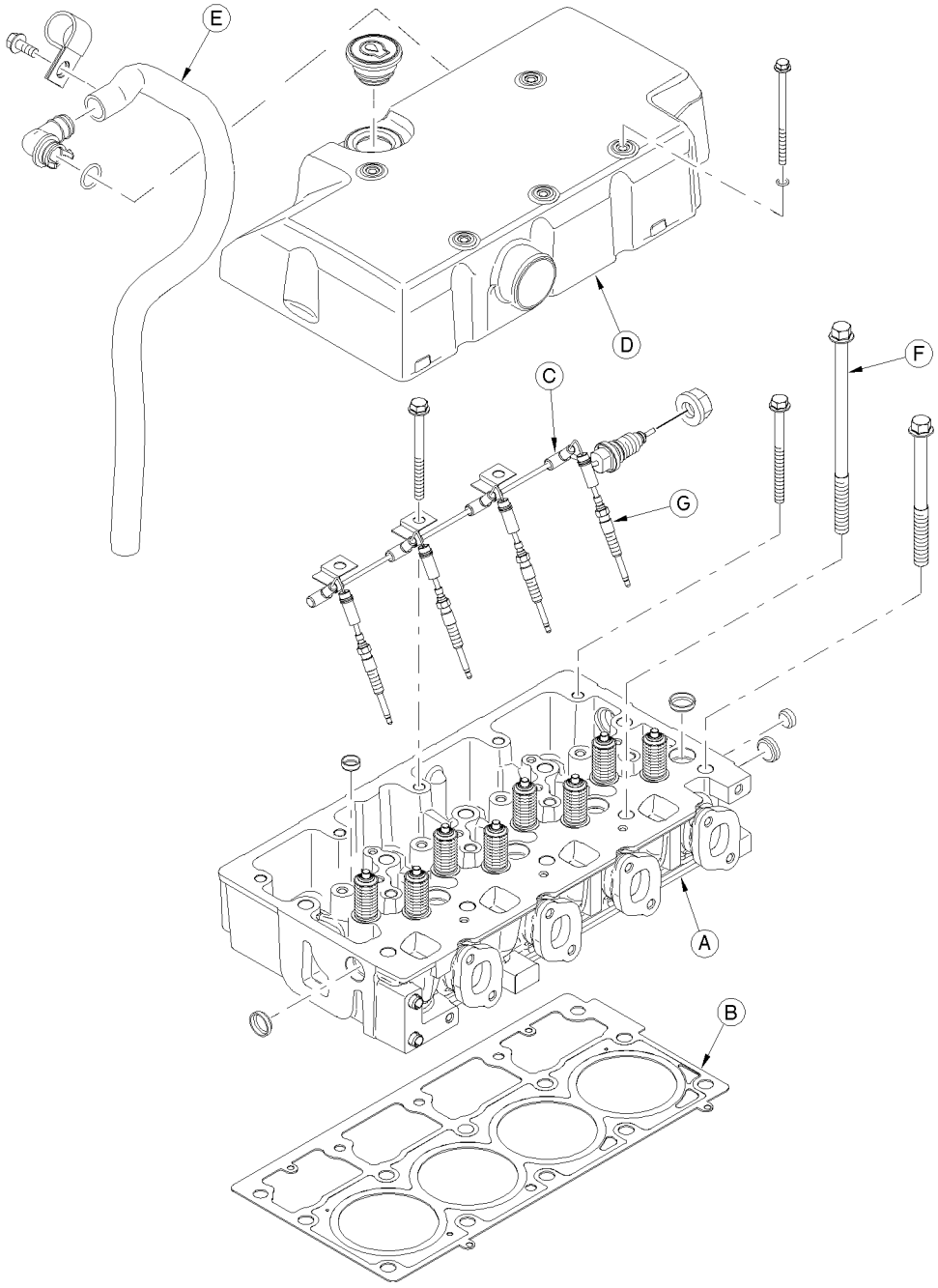
NOTE: The coolant temperature gauge is an (optional) orderable accessory.

4. Check poly-vee belt for proper alignment and seating in pulley grooves.
5. Change oil and filter every 250 hours/6 months. (See CHANGE ENGINE OIL AND FILTER in Lubrication and Maintenance/250 Hour Section.) Fill crankcase with seasonal viscosity grade oil. (See DIESEL ENGINE OIL, in Fuels, Lubricants, and Coolant Section.)

IMPORTANT: DO NOT operate engine when oil level is below ADD mark on dipstick. Check oil level before starting engine for the first time.

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Cylinder Head - Exploded View



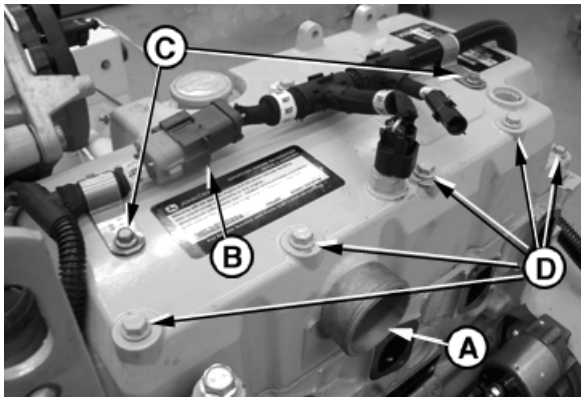
RG12251 —UN—06JUN03

A—Cylinder Head
B—Cylinder Head Gasket
C—Glow Plug Wire Harness
D—Rocker Arm Cover
E—Vent Tube
F—Cylinder Head Bolt
G—Glow Plug

RG41183,0000021 -19-06JUN03-1/1

Remove Rocker Arm Cover

1. .Remove air intake hose from turbocharger (shown removed).
2. Disconnect wiring harness sensor connectors (B). Remove engine wiring harness P-clamp cap screws (C) and engine wiring harness.
3. Remove poly-vee belt.
4. Remove alternator.
5. Remove rocker arm cover cap screws and O-rings (D). Inspect O-rings for nicks and cuts, replace as necessary. Remove rocker arm cover.
6. Clean surface of rocker arm cover of all gasket material and oil. Using a clean rag, cover intake ports on cylinder head and remove gasket material and oil from cylinder head.



RG15586 —UN—24SEP07

Remove Rocker Arm Cover

A—Turbocharger Intake Hose
B—Sensor Connector
C—Engine Wiring Harness Clamp Cap Screws
D—Rocker Arm Cover Cap Screws

RG41183,0000051 -19-24SEP07-1/1

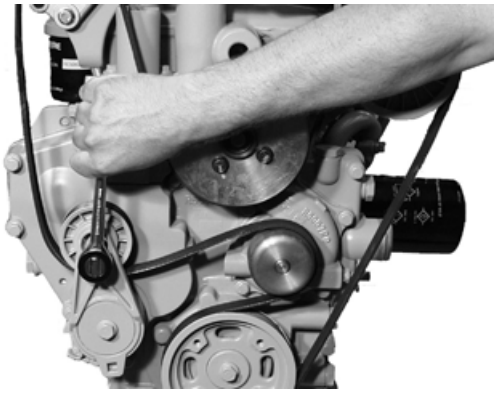
Remove Cylinder Head

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

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

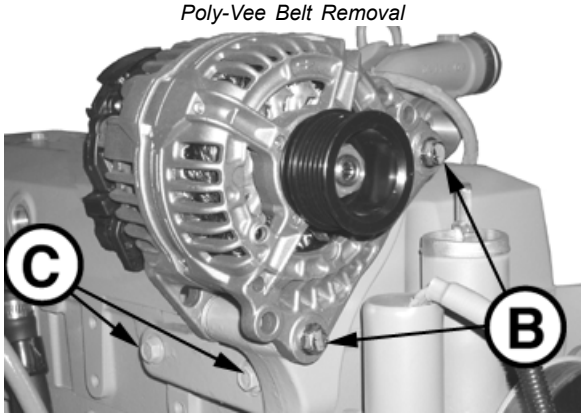
Do NOT drain coolant until the coolant temperature is below operating temperature. Remove radiator filler cap only when the cap is cool enough to touch with bare hands. Slowly loosen cap to first stop to relieve pressure before removing completely.

1. Drain engine oil and coolant.
2. Remove poly-vee belt.
3. Remove alternator (B) and bracket (C).
4. Remove vent hose (D) and P-clamp (E).
5. Disconnect fuel filter inlet line (F) from the fuel supply pump and the fuel filter outlet line (G). Cap connectors to prevent contamination



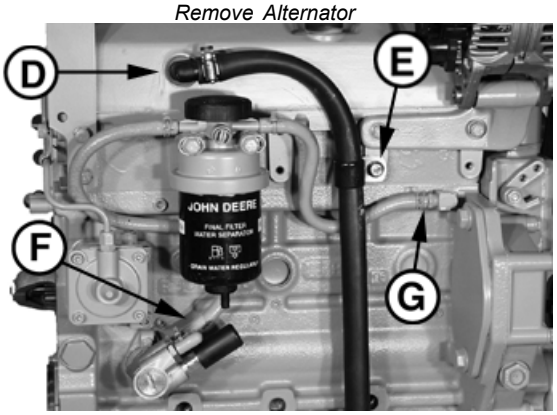
RG12502 —UN—12DEC02

Poly-Vee Belt Removal



RG12501 —UN—12DEC02

Remove Alternator



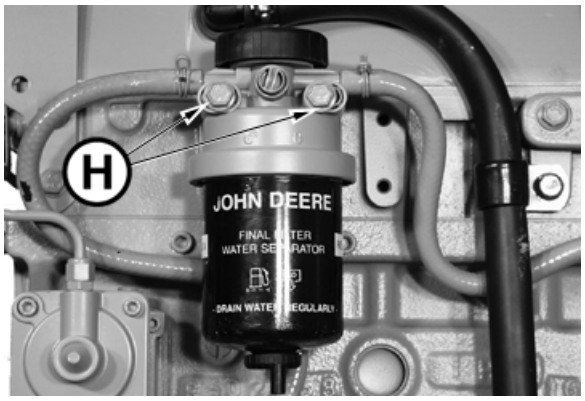
RG12503 —UN—12DEC02

Remove Vent Hose and Fuel Lines

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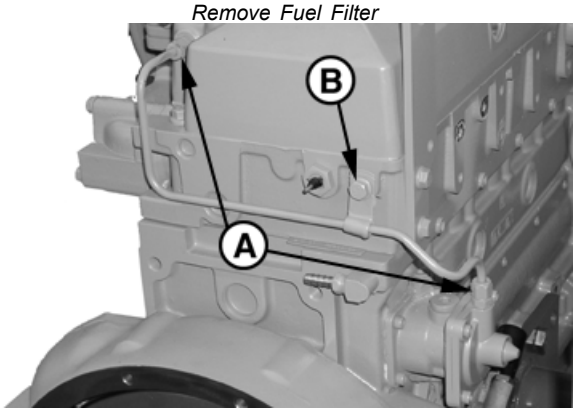
RG41183,0000002 -19-05MAR04-1/4

6. Remove filter element from filter header. Remove capscrews (H) from fuel filter header.
7. Remove aneroid line (A) and P-clamp (B).
8. Remove idler pulley cap screws (C) from cylinder head.



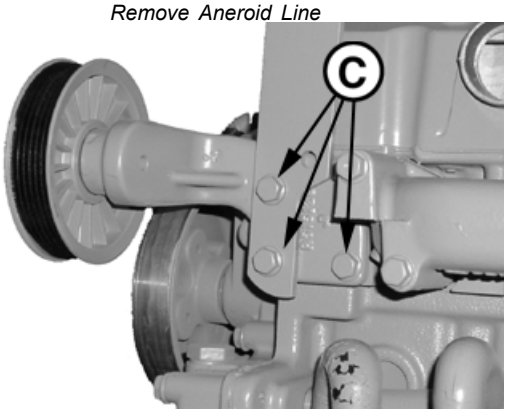
RG12504 —UN—12DEC02

Remove Fuel Filter



RG12505 —UN—12DEC02

Remove Aneroid Line



RG12506 —UN—12DEC02

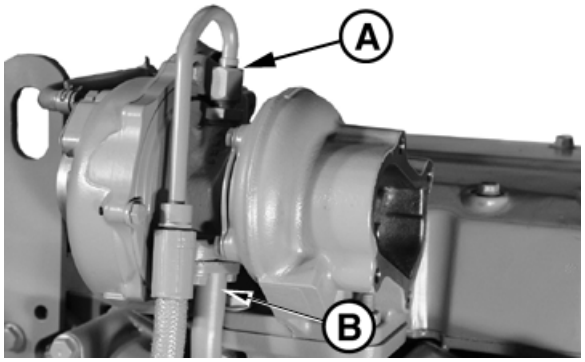
Remove Idler Pulley

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RG41183,0000002 -19-05MAR04-2/4

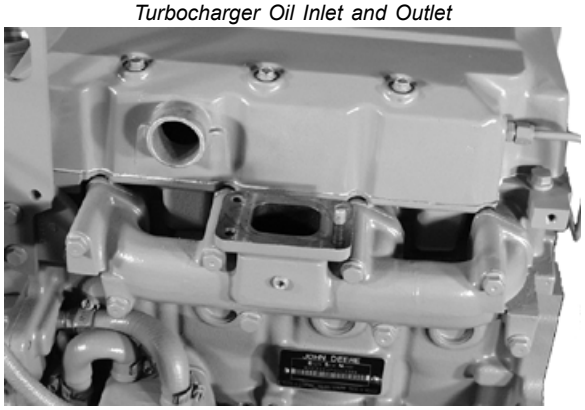
NOTE: Turbocharger may be removed from engine while assembled to the exhaust manifold, if desired.

9. Disconnect turbocharger oil inlet line (A) and oil outlet line (B) at turbocharger. Remove exhaust elbow (shown removed) and turbocharger. See REMOVE TURBOCHARGER in Group 80.
10. Remove exhaust manifold and gaskets. See REMOVE, INSPECT, AND INSTALL EXHAUST MANIFOLD in Group 80
11. Remove cap screws from rocker arm cover. Inspect cap screw O-rings, replace as necessary. Remove rocker arm cover.
12. Remove rocker arm cap screws and remove rocker arm assemblies. Identify each one for reassembly in the same location.
13. Remove all push rods and identify each for reassembly in the same location. Clean and inspect push rods.



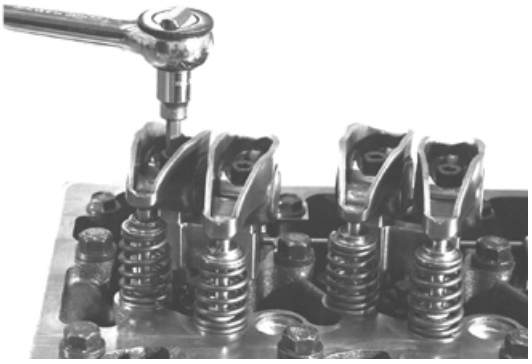
RG12507 —UN—12DEC02

Turbocharger Oil Inlet and Outlet



RG12508 —UN—12DEC02

Remove Exhaust Manifold



RG12509 —UN—12DEC02

Rocker Arm Assembly

Continued on next page

RG41183,0000002 -19-05MAR04-3/4

14. If a cylinder head gasket failure has occurred, check and record torque on each cylinder head cap screw before removing.

    To check cylinder head cap screw torque:

    a. Make a reference mark (in-line) on socket (A) and cylinder head surface (B).

    b. Loosen cap screw at least 1/2 turn.

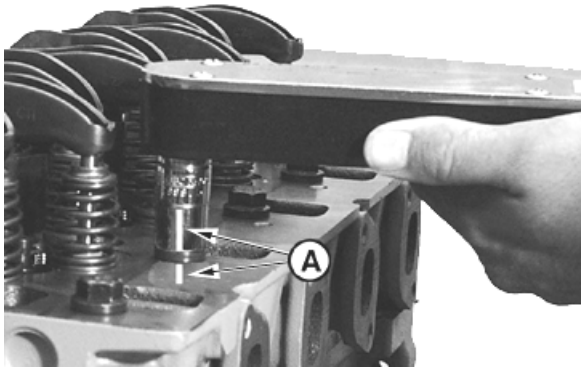
    c. Retighten cap screw (using a torque wrench) until reference marks align and record torque.

15. Remove glow plugs and wire harness. See INSPECT, REMOVE, AND INSTALL GLOW PLUGS AND WIRE HARNESS later in this group.

16. Remove unit pump injectors. Identify parts for reassembly in the same location. See REMOVE AND INSPECT INTEGRATED FUEL SYSTEM (IFS) in Group 90.

17. Remove all cylinder head cap screws.

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.



RG12510 —UN—12DEC02

Cylinder Head Torque Check

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

19. Remove cylinder head gasket (B). Inspect for possible oil, coolant, or combustion chamber leaks. Also, check for evidence of incorrect head gasket being used.

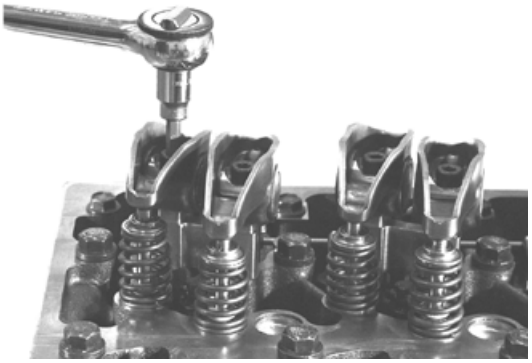
RG41183,0000002 -19-05MAR04-4/4

Disassemble and Inspect Rocker Arm Assembly

NOTE: Note location of parts as rocker arms are disassembled, to aid in assembly.

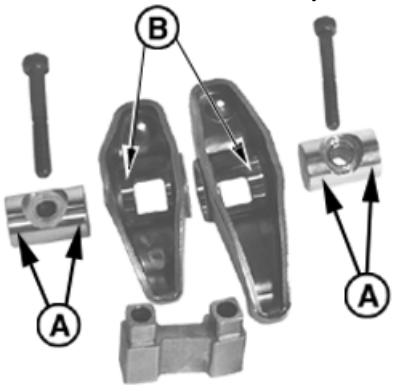
1. Remove rocker arm assembly from cylinder head.
2. Inspect rocker arm shaft (A) and rocker arm (B) for excessive wear. If excessive wear is present, replace complete assembly.

A—Rocker Arm Shaft **B—Rocker Arm**



RG12509 —UN—12DEC02

Remove Rocker Arm Assembly



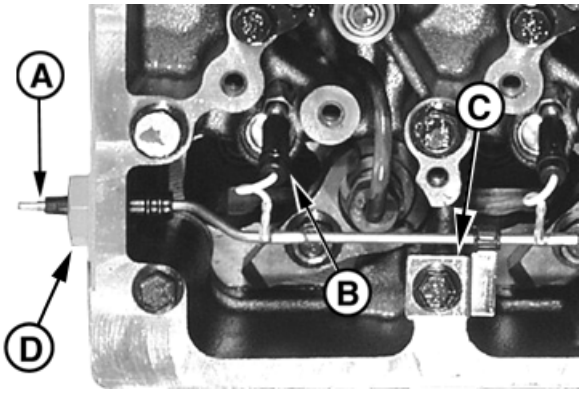
RG12809 —UN—09FEB03

Inspect Rocker Arm Assembly for Wear

RG41183,0000070 -19-23JAN03-1/1

Inspect, Remove, and Install Glow Plugs and Wire Harness

1. Disconnect connector from glow plug wire harness (A) *(shown removed)*.
2. Disconnect connectors from glow plugs (B).
3. Remove clamp cap screws (C) and nut (D). Remove wire harness from cylinder head.
4. Inspect the O-ring for cuts and wire harness connections for cracks or broken connections. Replace if necessary.



RG12810 —UN—09FEB03

Remove Glow Plug Wire Harness

RG41183,0000072 -19-23JAN03-1/2

5. Remove glow plugs (E) from cylinder head.
6. Install glow plugs and tighten to specification.

Specification

Glow Plug—Torque..... 13 N•m (9 lb-ft)

7. Lubricate O-ring with clean engine oil and install wire harness into rear of cylinder head.
8. Install nut (D) at rear of head and tighten to specification.

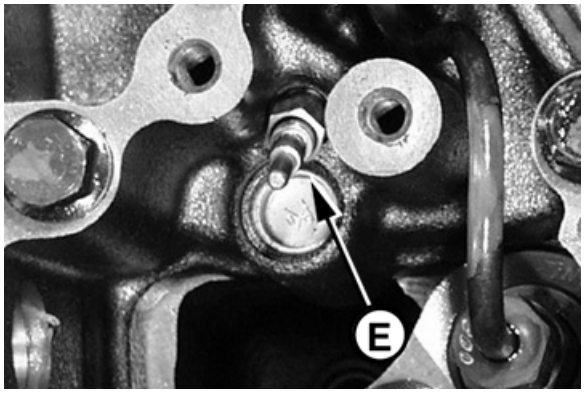
Specification

Glow Plug Wire Harness Nut—Torque..... 3.5 N•m (31 lb-in.)

9. Dip cylinder head cap screws (C) in clean engine oil and install into cylinder head to secure wire harness. Tighten cap screws to specification.

Specification

Cylinder Head Cap Screw/Glow Plug Wire Harness—Torque..... 28 N•m (21 lb-ft)



RG12811 —UN—09FEB03

Remove Glow Plugs

10. Install connectors (B) securely onto glow plugs.

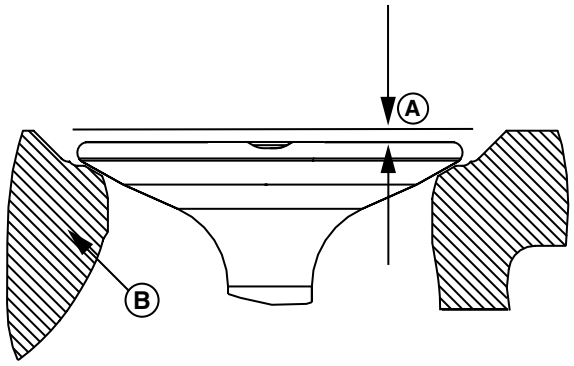
RG41183,0000072 -19-23JAN03-2/2

Measure Valve Recess in Cylinder Head

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

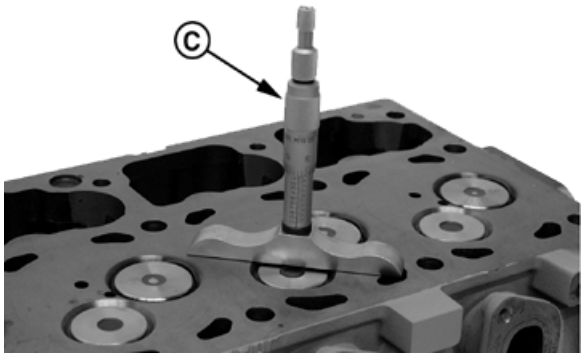
Specification	
Intake Valve—Recess in Cylinder Head	0.08—1.40 mm (0.031—0.055 in.)
Exhaust Valve—Recess in Cylinder Head	0.08—1.40 mm (0.031—0.055 in.)

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



RG12820 —UN—09FEB03

Valve Recess Measurement



RG12821 —UN—09FEB03

Valve Recess Measurement

RG41183,0000074 -19-13FEB07-1/1

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.
- Coolant leakage into cylinder causing hydraulic failure of gasket.
- Cracked cylinder head.
- Cracked cylinder bore.
- 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 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 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.

RG41183,0000075 -19-13FEB07-1/1

Remove Valve Assembly

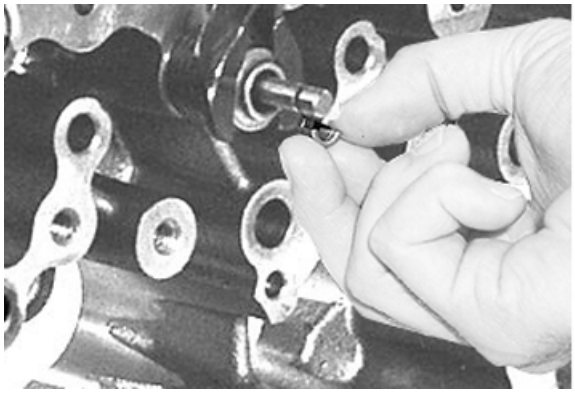
NOTE: A small magnet may be used to aid removal of valve retainer locks.

1. Using JDE138 Valve Spring Compressor, compress valve springs far enough to remove retainer locks (D).
2. Release spring tension and remove valve rotator (C) and valve spring (B).
3. Remove valves from cylinder head.

NOTE: Identify all parts for assembly in same location.

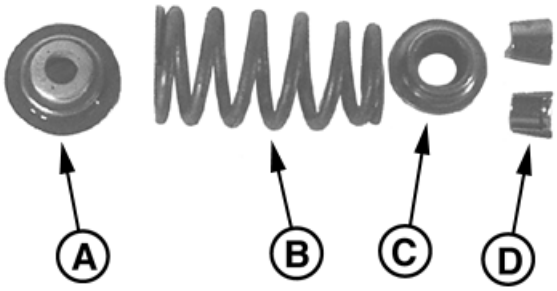
4. Remove valve stem seals (A) from valve guide tower.

A—Valve Stem Seal
B—Valve Spring
C—Valve Spring Cap
D—Retainer Locks



RG12812 —UN—09FEB03

Valve Spring Removal Tool



RG12813 —UN—09FEB03

Valve Spring and Components

RG41183,0000076 -19-13FEB07-1/1

Inspect and Measure Valve Springs

1. Inspect valve springs for alignment, wear, and damage.
2. Using D01168AA Spring Compression Tester, check valve spring tension. Compressed height must be within specification given below.

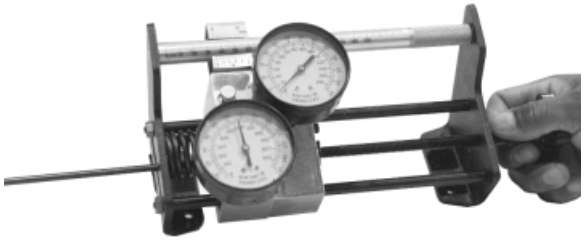
Valve Springs—Specification

Spring Free Length 0 N (0 lb-force)[1] —Height	46.2 mm (1.818 in.)
Spring Compressed 250 N (56 lb-force)—Height	35.8 mm (1.41 in.)
Spring Compressed 515 N (116 lb-force)—Height	25.6 mm (1.01 in.)



RG2732 —UN—28AUG09

Valve Spring



RG7427 —UN—21MAY98

Valve Spring Compression Tester

[1]Free length may vary slightly between valve springs.

RG41183,0000077 -19-30APR04-1/1

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.

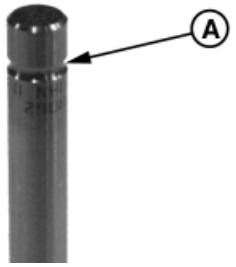
RG,05,DT7363 -19-13FEB07-1/1

Inspect and Measure Valves

1. Clean and inspect valves, valve stems, stem tips, and retainer lock groove (A). Replace valves that are worn or damaged.

Specification	
Intake Valve Head—OD	36.87—37.13 mm (1.452—1.462 in.)
Exhaust Valve Head—OD	33.87—34.13 mm (1.333—1.344 in.)

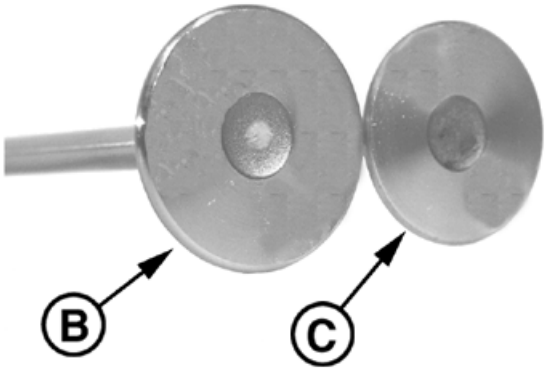
NOTE: Intake valve has a larger head OD (B).



RG7429 —UN—03NOV97

Valve Stem

A—Retainer Lock Groove
B—Intake Valve
C—Exhaust Valve



RG12814 —UN—12MAY03

Intake/Exhaust Valve Identification

RG41183,0000078 -19-13FEB07-1/3

2. Measure valve stem OD. Record measurements and compare with valve guide ID.

Specification	
Intake Valve Stem—OD	6.987—7.013 mm (0.2751—0.2761 in.)
Exhaust Valve Stem—OD	6.974—7.000 mm (0.2746—0.2755 in.)



RG7430 —UN—23NOV97

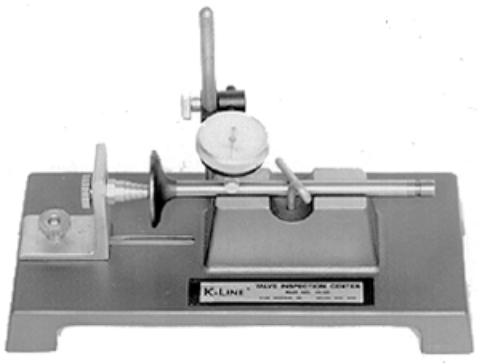
Valve Stem Measurement

Continued on next page

RG41183,0000078 -19-13FEB07-2/3

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

Specification	
Valve Face—Maximum Runout (Intake and Exhaust)	0.038 mm (0.0015 in.)



RG4234 —UN—05DEC97

Valve Inspection Center

RG41183,0000078 -19-13FEB07-3/3

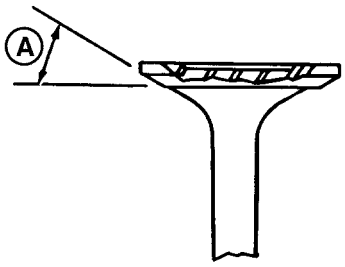
Grind Valves

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

Reface serviceable valves to specified angle (A).

Specification	
Valves—Face Angle	29.25° ± 0.25°

A—Valve Face Angle

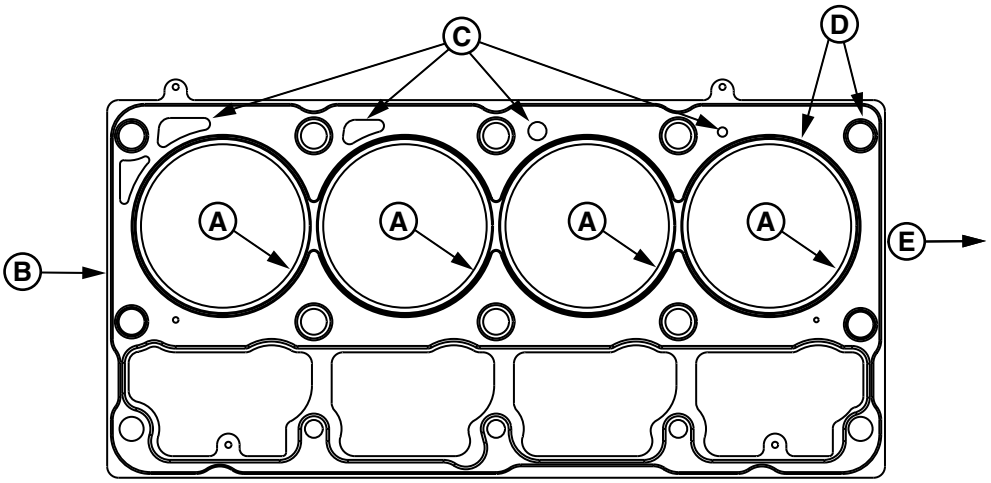


RG4755 —UN—31OCT97

Checking Valve Face Angle

RG41183,0000079 -19-13FEB07-1/1

Head Gasket Inspection and Repair Sequence



RG12815 —UN—09FEB03

Head Gasket Inspection

A—Combustion Seals (Flanges)
B—Gasket Body
C—Coolant Port
D—Polymer Beading Strip
E—Front of Engine

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

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

   Examine combustion seals (A) for the following:

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

   Examine gasket body (B) for the following:

   - Combustion gas erosion paths or soot deposits originating at combustion seals.
   - Extreme discoloration/hardening/embrittlement in localized areas.
   - Polymer missing/damaged in port area (D).
   - Oil or coolant paths from port areas.
   - Localized areas of low compression.
6. Before cleaning components, inspect head, block, and liners for evidence of combustion gas and fluid leakage. Inspect cylinders and valve ports for unusual deposits.
7. Clean block, head, liners, and cap screws. (See Groups 020 and 030.)
8. Proceed with the following dimensional checks and visual inspections:

   Cylinder Head (See Group 020.)

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

   Cylinder Block (See Group 030.)

   - Check surface flatness/finish.
   - Inspect for surface damage.
   - Check top deck to crankshaft centerline dimension.
   - Inspect cap screw bosses; must be clean/intact.

   Cylinder Head Cap Screws (See Group 020.)

   - Inspect for corrosion damage.
   - Inspect condition of threads.
   - Inspect for straightness.
   - Check length.
9. When inspections and measurements have been completed, determine most probable causes of joint failure. Make all necessary repairs to joint components, cooling system, and fuel injection system.
10. Reassemble the engine according to procedures and specifications in the repair groups of this manual.

RG41183,000007A -19-13FEB07-1/1

Inspect and Clean Cylinder Head

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

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

3. Clean cylinder head in a chemical hot tank, or with solvent and a brush.
4. Dry with compressed air and blow out all passages.

RG,05,DT7360 -19-13FEB07-1/1

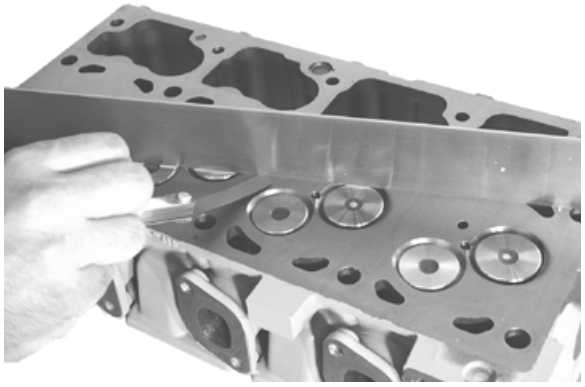
Check Cylinder Head Flatness

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

Specification

Cylinder Head Flatness—Maximum Acceptable Out-of-Flat for every 150 mm (6 in)..... 0.05 mm (0.002 in.)
Maximum Acceptable Out-of-Flat for every 25 mm (1 in) ..... 0.025 mm (0.001 in.)

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



RG12816 —UN—09FEB03

Cylinder Head Flatness Check

RG41183,000007B -19-25SEP07-1/1

Knurl Valve Guides

IMPORTANT: Valve guide knurling should only be done by experienced personnel familiar with equipment and capable of maintaining required specification.

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

1. Use JT05949 Valve Guide Knurler Kit to knurl valve guides. Use kit exactly as directed by the manufacturer.
2. After knurling, ream valve guide to finished size to provide specified stem-to-guide clearance.

Specification

Intake Valve Clearance—Clearance..... 0.028 —0.080 mm (0.0011—0.0032 in.)



RG12818 —UN—09FEB03

Knurling Valve Guides

Exhaust Valve Clearance—Clearance..... 0.041—0.093 mm (0.0016—0.0037 in.)

RG41183,000007D -19-24SEP07-1/1

Clean and Inspect Valve Seats

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



RG12819 —UN—09FEB03

Valve Seat Cleaning and Inspection

RG41183,000007E -19-13FEB07-1/1

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.

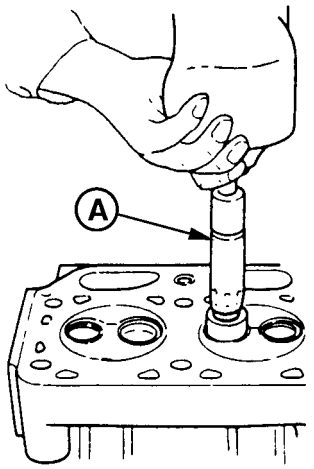
NOTE: LIGHTLY grind valve seats for a few seconds only to avoid excessive valve seat width.

1. Grind valve seats (C) using a seat grinder (A). For intake and exhaust valve seats use a 30° seat 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 45° seat grinder for intake and 30° seat grinder for exhaust until seat width is close to specifications.
4. Grind upper seat surface (E) using a 15° seat grinder until seat width is narrowed to specifications.
5. If valve seats are ground, measure valve recession and check contact pattern between the seat and valve with bluing dye. See Measure Valve Recess in Cylinder Head, in this section.

Valve Seat Grinding Specifications—Specification

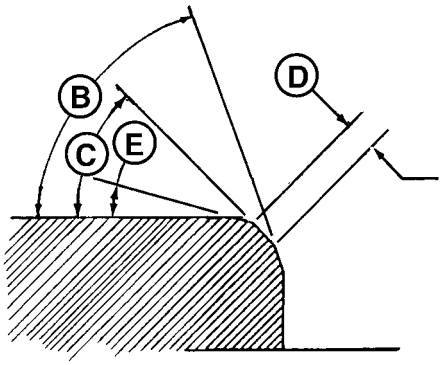
Lower Seat	
Surface—Intake	45°
Exhaust	30°
Valve Seat	
Surface—Intake and	
Exhaust	30°
Seat Width—Intake	1.96 mm (0.077 in.)
Exhaust	1.82 mm (0.072 in.)
Upper Seat	
Surface—Intake and	
Exhaust	15°

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



M82039A —UN—09FEB03

Valve Seat Grinder



M82040A —UN—09FEB03

Valve Seat Grinding Specifications

A—Seat Grinder
B—Lower Seat Surface
C—Valve Seat Surface
D—Seat Width
E—Upper Seat Surface

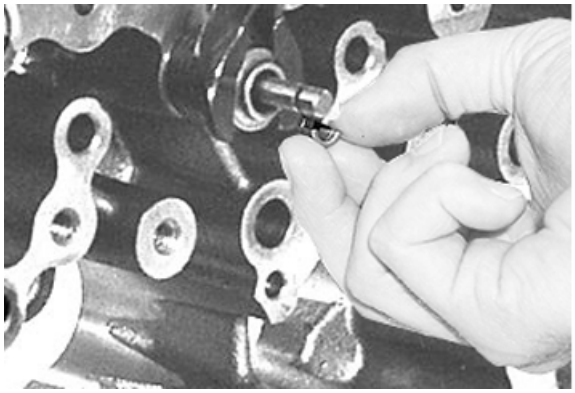
RG41183,000007F -19-13FEB07-1/1

Install Valves

1. Lubricate valve stems and guides with clean engine oil.

NOTE: Valves must move freely in guide and seat properly in head to form an effective seal.

2. Insert valves in head (if valves are reused, install in same location from which removed).
3. Install valve springs and spring caps.
4. Compress valve springs using JDE138 Valve Spring Compressor and install retainer locks on valve stems.
5. Strike end of each valve three or four times with a soft mallet (non-metallic) to insure proper positioning of the retainer locks.
6. Recheck valve recess. (See MEASURE VALVE RECESS IN CYLINDER HEAD, earlier in this group.)



RG12812 —UN—09FEB03

Valve spring Compressor and Retainer Locks

RG41183,0000080 -19-13FEB07-1/1

Inspect Cylinder Head Cap Screws

Inspect cap screws for corrosion, damage and overall condition of threads for indication of other problems. DO NOT RE-USE large diameter flange-head cap screws. The smaller diameter cap screws may be reused.



RG6319 —UN—23NOV97

Cylinder Head Cap Screw

RG,05,DT7348 -19-19JUN07-1/1

Inspect and Clean Exhaust Manifold

1. Thoroughly clean all passages and gasket surfaces in exhaust manifold.
2. Inspect entire exhaust manifold for cracks or damage. Replace parts as necessary.

RG41183,0000082 -19-31JAN03-1/1

Install Cylinder Head (4-Cylinder)

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

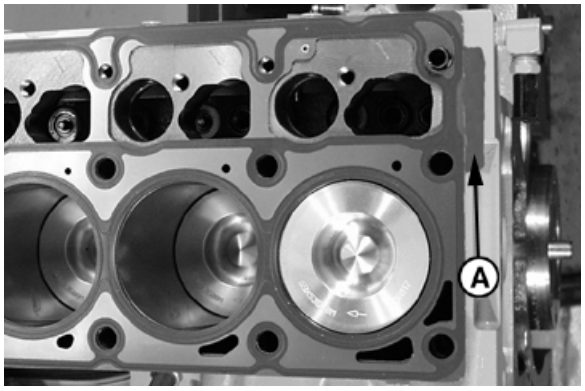
ALWAYS use NEW cap screws when installing cylinder head. Cap screws may be used only one time.

DO NOT use multi-viscosity oils to lubricate cap screws, SAE 30W is recommended.

1. Place new head gasket on cylinder block with part number tab to rear (A). Do not use sealant; install dry.
2. Position cylinder head over guide studs and lower onto cylinder block.
3. Dip entire cap screw in clean engine oil. Remove excess oil from screw.
4. Install flanged-head cylinder head cap screws hand tight.
5. Tighten cap screws No. 1 through 10 in order to initial torque specification.
6. Starting with No. 1 completely loosen the cap screw. Re-tighten to specification and torque-turn required. Repeat on each individual cap screw in the sequence for cap screws 2 - 8.
7. Completely loosen cap screw No. 9. Re-tighten to specification and torque-turn required. Repeat on cap screw No. 10.

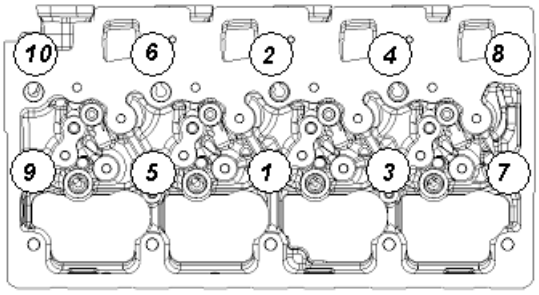
Specification

Initial Cylinder Head Cap Screw—Torque	110 N•m (81 ft-lb)
Final Cylinder Head Cap Screws No.1 - No.8—Torque	70 N•m (52 ft-lb) plus 150° +10/-0
Final Cylinder Head Cap Screws No.9 - No.10—Torque	70N•m (52 ft-lb) plus 120° +10°/-0°



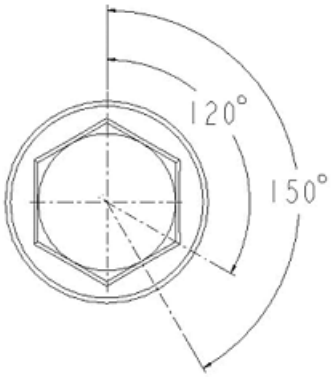
RG12514 —UN—12DEC02

Cylinder Head Gasket



RG12512 —UN—12DEC02

Torque Sequence - 4 Cylinder



RG12988 —UN—18JUN03

Torque Turn

RG41183,000000A -19-26FEB04-1/1

Install Cylinder Head (5-Cylinder)

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

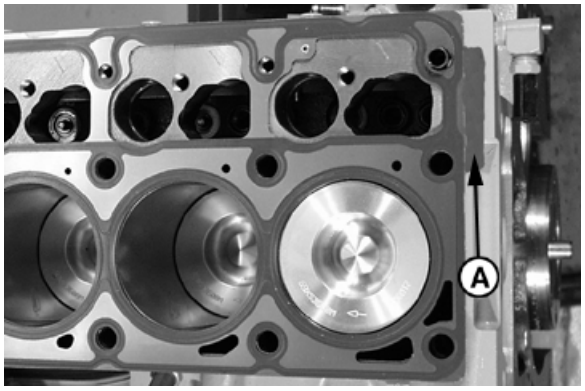
ALWAYS use NEW cap screws when installing cylinder head. Cap screws may be used only one time.

DO NOT use multi-viscosity oils to lubricate cap screws, SAE 30W is recommended.

1. Place new head gasket on cylinder block. Do not use sealant; install dry.
2. Position cylinder head over guide studs and lower onto cylinder block.
3. Dip entire cap screw in clean engine oil. Remove excess oil from screw.
4. Install flanged-head cylinder head cap screws.
5. Torque cap screws No. 1 through No. 12 in order to specification.
6. Starting with No. 1 completely loosen cap screw. Re-torque to specification and torque-turn required. Repeat on each individual cap screw (2-10) in the sequence.
7. Completely loosen cap screw No. 11. Re-torque to specification and torque-turn required. Repeat on cap screw No. 12.

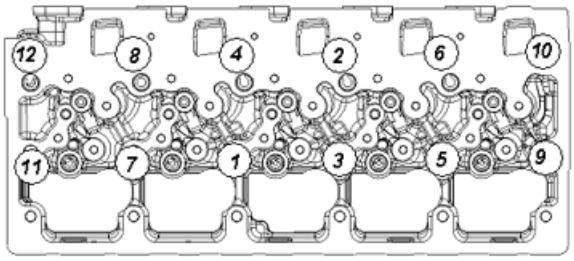
Specification

Initial Cylinder Head Cap Screw—Torque	110 N•m (81 ft-lb)
Final Cylinder Head Cap Screws No.1 - No.10—Torque	70 N•m (52 ft-lb) plus 150° +10°/-0°
Final Cylinder Head Cap Screws No.11 - No.12—Torque	70N•m (52 ft-lb) plus 120° +10°/-0°



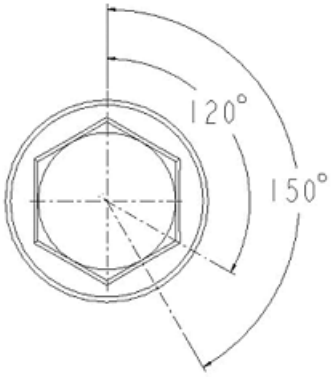
RG12514 —UN—12DEC02

Cylinder Head Gasket



RG12513 —UN—12DEC02

5 Cylinder Head Torque Sequence



RG12988 —UN—18JUN03

Torque Turn

RG41183,000002A -19-21SEP04-1/1

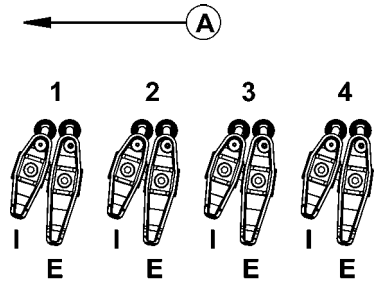
Install Rocker Arm Assembly

4-cylinder

NOTE: This procedure provides standardized assembly instructions for installing rocker arms, push rods and cam followers .

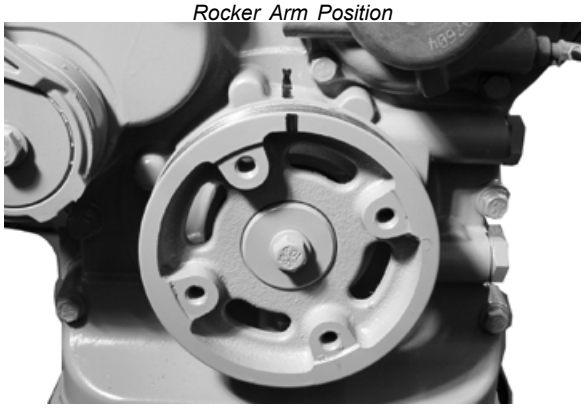
NOTE: Firing order is 1-3-4-2

1. Remove rocker arm cover and clean all sealing surfaces.
2. Remove glow plug wiring harness.
3. Find TDC end of compression stroke of No.1 piston.
   - Lock crankshaft at TDC with timing pin (cylinder block/flywheel).
   - Mark front of engine and pulley/damper at the 12 o'clock position.
4. Remove rocker arm assembly(s), push rods and hydraulic cam followers. Note parts for installation back in the original location.



RG12854 —UN—21FEB03

Rocker Arm Position



RG12851 —UN—24FEB03

Crankshaft Pulley

A— Front of Engine
E — Exhaust Rocker Arm
I — Intake Rocker Arm

Continued on next page

RG41183,00000B7 -19-12SEP07-1/8

IMPORTANT: Any time rocker arm cap screws are loosened, the cam followers for that cylinder must be bled down. Failure to remove engine oil from the follower will result in bent push rods.

5. Using JDG1678 Hydraulic Lifter Bleed-Down tool, **slowly** compress the cam follower piston. Alternate compressing each follower to provide additional time for the engine oil to escape through the top or the small hole in the follower.

IMPORTANT: Repeat as required to insure all engine oil has been expelled from the follower.

NOTE: If using new cam followers, expelling oil from the follower is not necessary..

6. Dip hydraulic cam follower head in TY6333 High-Temperature Grease and place one follower in each follower bore in the cylinder block.
7. Dip each end of the push rod in TY6333 High-Temperature Grease. Install push rod in each follower.

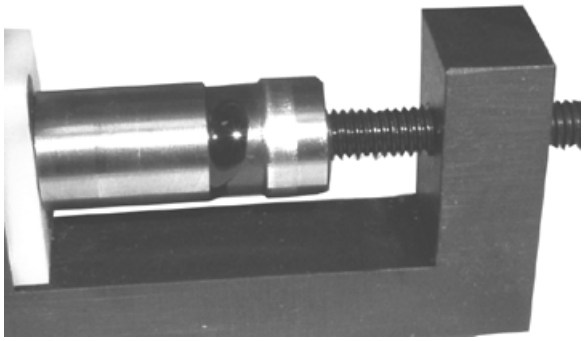
IMPORTANT: Install push rod with copper plated end up.

8. Apply LOCTITE 242® to the bottom 4 to 8 threads (A) of the rocker arm assembly capscrews. Install assembly in position in the cylinder head and engage the cap screws 2 to 4 threads.
9. Remove the timing pin and rotate the engine clockwise (viewed from the front) 90 degrees to insure valves of the first two cylinders in sequence do not contact pistons during assembly.

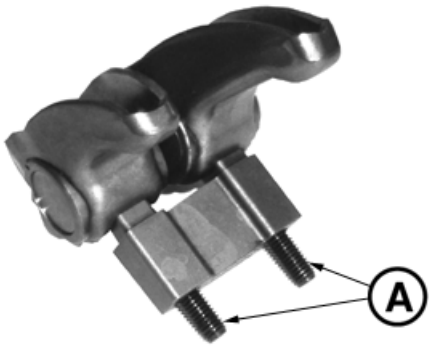


RG12858 —UN—08MAY03

JDG1678 Hydraulic Lifter Bleed-Down Tool

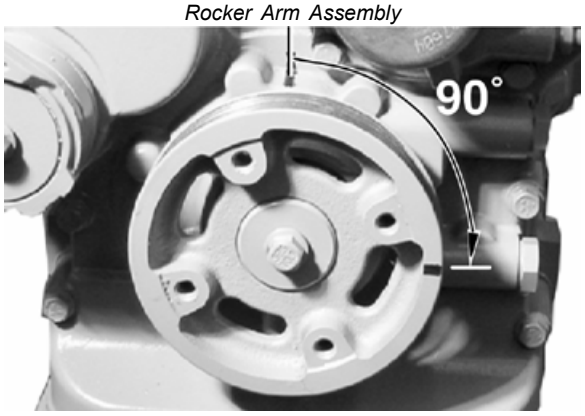


RG12859 —UN—24FEB03



RG12856 —UN—24FEB03

Rocker Arm Assembly



RG12852 —UN—21FEB03

LOCTITE is a trademark of Loctite Corp.

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RG41183,00000B7 -19-12SEP07-2/8

10. Slowly tighten both rocker arm cap screws on No. 1 and No. 3 cylinder to specifications. Insure rocker arm pad is aligned with valve stem.

Specification

Rocker Arm Alignment
—Torque..... 40 N·m (30 lb-ft)

IMPORTANT: Failure to have valves in the seated position will result in bent push rods when the engine is rotated.

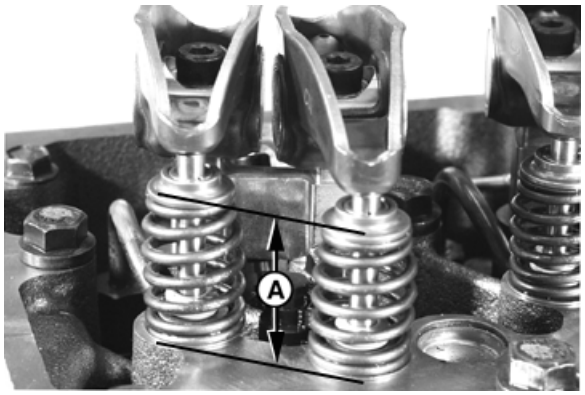
11. Insure the No. 1 and No. 3 cylinder valve springs have returned to seated valve position (A) before moving to the next step.

Specification

A – Top of valve spring retainer to cylinder head—Height..... 37.0 mm (1.46 in.) minimum

12. Rotate the engine clockwise (when viewed from the front) 315 degrees (45 degrees short of a full rotation) to insure valves for the No. 2 and No. 4 cylinder do not contact the piston. Engine should rotate freely. If there is resistance to rotation, **stop**, wait one minute and slowly resume rotation. Inspect all push rods for bending.

13. Slowly tighten both rocker arm cap screws on No. 2 and No. 4 cylinder to specifications. Insure rocker arm pad is aligned with valve stem.



RG12857 —UN—06MAR03



RG12853 —UN—21FEB03

Specification

Rocker Arm Capscrew
—Torque..... 40 N·m (30 lb-ft)

RG41183,00000B7 -19-12SEP07-3/8

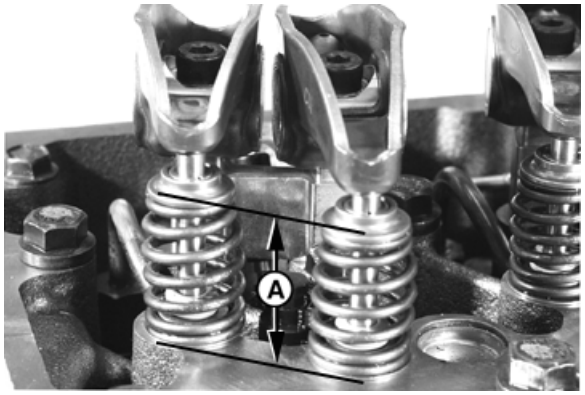
IMPORTANT: Failure to have valves in the seated position will result in bent push rods when the engine is rotated.

14. Insure the No. 2 and No. 4 cylinder valve springs have returned to seated valve position (A) before moving to the next step.

Specification

A – Top of valve spring retainer to cylinder head—Height..... 37.0 mm (1.46 in.) minimum

15. Rotate engine two complete revolutions in a clockwise direction (when viewed from the front). During engine rotation:
    - Inspect push rods for bending by aligning valves in the seated position and rotating the push rod. The rod should turn freely with the fingers.
    - Insure rocker arm pads are centered on the valve stems. If they are not, loosen capscrews slightly, realign rocker arm and tighten to specifications.



RG12857 —UN—06MAR03

Specification

Rocker Arm Capscrew
—Torque..... 40 N·m (30 lb-ft)

16. Install glow plug wiring harness.

17. Generously lubricate all rocker arm pedestal joints with clean engine oil.

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RG41183,00000B7 -19-12SEP07-4/8

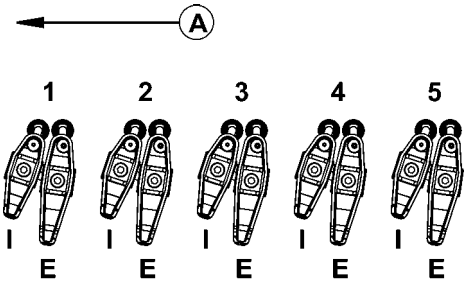
5-cylinder

NOTE: This procedure provides standardized assembly instructions for installing rocker arms, push rods and cam followers .

NOTE: Firing order is 1-2-4-5-3

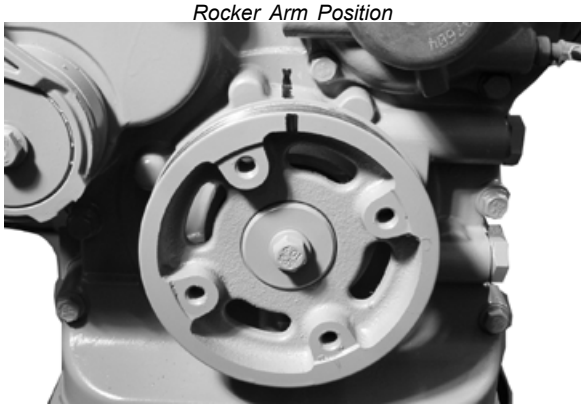
1. Remove rocker arm cover and clean all sealing surfaces.
2. Remove glow plug wiring harness.
3. Find TDC end of compression stroke of No. 1 piston.
   - Lock crankshaft at TDC with timing pin (cylinder block/flywheel).
   - Mark front of engine and pulley/damper at the 12 o'clock position.
4. Remove rocker arm assembly(s), push rods and hydraulic cam followers. Note parts for installation back in the original location.

A— Front of Engine
I — Intake Rocker Arm
E — Exhaust Rocker Arm



RG12855 —UN—21FEB03

Rocker Arm Position



RG12851 —UN—24FEB03

Crankshaft Pulley

Continued on next page

RG41183,00000B7 -19-12SEP07-5/8

IMPORTANT: Any time rocker arm cap screws are loosened, the cam followers for that cylinder must be bled down. Failure to remove engine oil from the follower will result in bent push rods.

5. Using JDG1678 Hydraulic Lifter Bleed-Down Tool, **slowly** compress the cam follower piston. Alternate compressing each follower to provide additional time for the engine oil to escape through the top or the small hole in the follower.

IMPORTANT: Repeat as required to insure all engine oil has been expelled from the follower.

6. Dip hydraulic cam follower head in TY6333 High-Temperature Grease and place one follower in each follower bore in the cylinder block.
7. Dip each end of the push rod in TY6333 High-Temperature Grease. Install push rod in each follower.

IMPORTANT: Install push rod with copper plated end up.

8. Apply LOCTITE 242®to the bottom 4 to 8 threads (A) of the rocker arm assembly capscrews. Install assembly in position in the cylinder head and engage the cap screws 2 to 4 threads.
9. Slowly tighten both rocker arm cap screws on No. 3 cylinder to specifications. Insure rocker arm pad is aligned with valve stem.

Specification	
Rocker Arm Alignment —Torque	40 N·m (30 lb-ft)

IMPORTANT: Failure to have valves in the seated position will result in bent push rods when the engine is rotated.

10. Insure the No. 3 cylinder valve springs have returned to seated valve position (A) before moving to the next step.

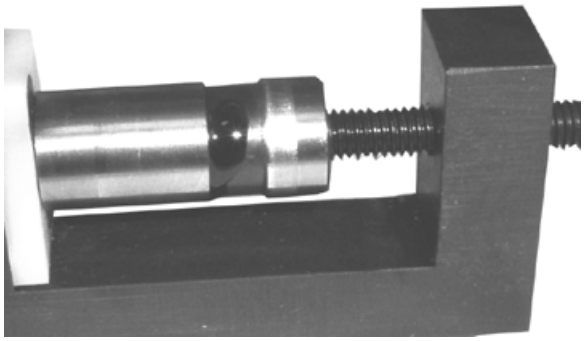
Specification	
A – Top of valve spring retainer to cylinder head—Height	37.0 mm (1.46 in.) minimum

11. Remove the timing pin and rotate the engine clockwise (viewed from the front) 90 degrees to insure valves for the No.1 and No. 2 cylinder do not contact the piston.

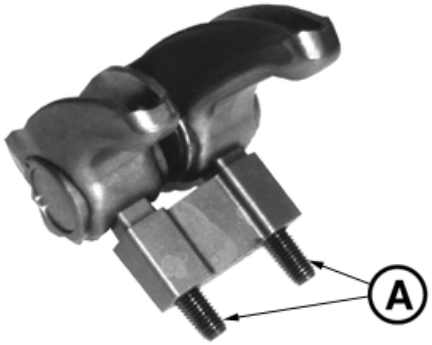


RG12858 —UN—08MAY03

JDG1678 Hydraulic Lifter Bleed-Down Tool

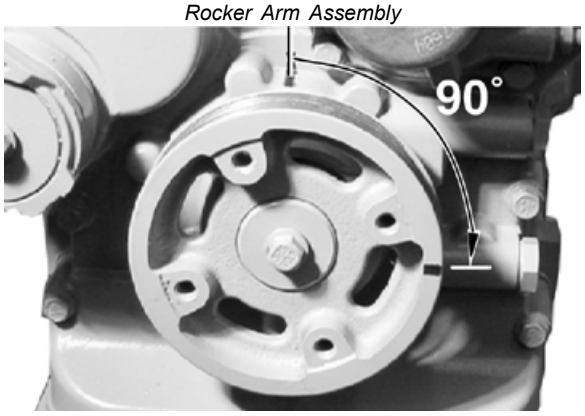


RG12859 —UN—24FEB03



RG12856 —UN—24FEB03

Rocker Arm Assembly



RG12852 —UN—21FEB03

LOCTITE is a trademark of Loctite Corp.

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RG41183,00000B7 -19-12SEP07-6/8

12. Slowly tighten both rocker arm cap screws on No. 1 and No. 2 cylinders to specifications. Insure rocker arm pad is aligned with valve stem.

Specification

Rocker Arm Alignment
—Torque.....40 N·m

IMPORTANT: Failure to have valves in the seated position will result in bent push rods when the engine is rotated.

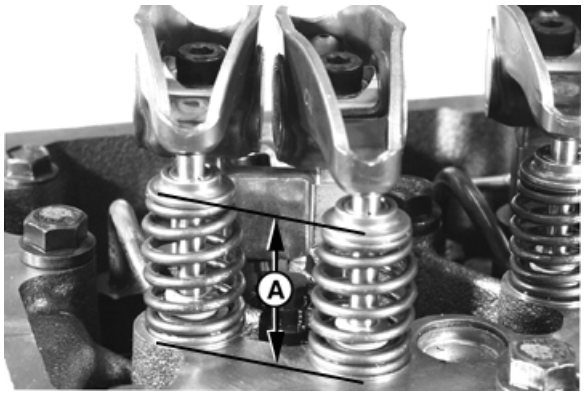
13. Insure the No. 1 and No. 2 cylinder valve springs have returned to seated valve position (A) before moving to the next step.

Specification

A – Top of valve spring retainer to cylinder head—Height..... 37.0 mm (1.46 in.) minimum

14. Rotate the engine clockwise (when viewed from the front) 315 degrees (45 degrees short of a full rotation) to insure valves for the No. 4 and No. 5 cylinder do not contact the piston. Engine should rotate freely. If there is resistance to rotation, **stop**, wait one minute and slowly resume rotation. Inspect all push rods for bending.

15. Slowly tighten both rocker arm cap screws on No. 4 and No. 5 cylinder to specifications. Insure rocker arm pad is aligned with valve stem.



RG12857 —UN—06MAR03



RG12853 —UN—21FEB03

Specification

Rocker Arm Capscrew
—Torque..... 40 N·m (30 lb-ft)

RG41183,00000B7 -19-12SEP07-7/8

IMPORTANT: Failure to have valves in the seated position will result in bent push rods when the engine is rotated.

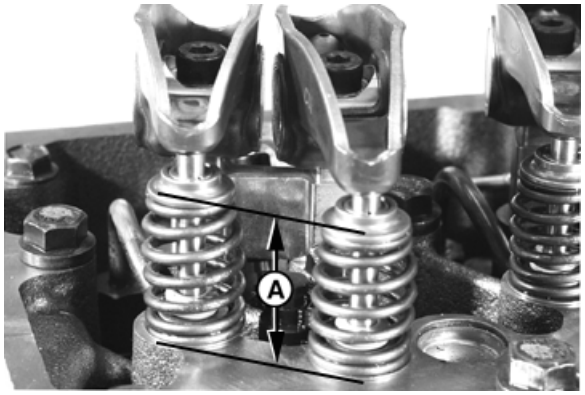
16. Insure the No. 4 and No. 5 cylinder valve springs have returned to seated valve position (A) before moving to the next step.

Specification

A – Top of valve spring retainer to cylinder head—Height..... 37.0 mm (1.46 in.) minimum

17. Rotate engine two complete revolutions in a clockwise direction (when viewed from the front). During engine rotation:

- Inspect push rods for bending by aligning valves in the seated position and rotating the push rod. The rod should turn freely with the fingers.
- Insure rocker arm pads are centered on the valve stems. If they are not, loosen capscrews slightly, realign rocker arm and tighten to specifications.



RG12857 —UN—06MAR03

Specification

Rocker Arm Capscrew
—Torque..... 40 N·m (30 lb-ft)

18. Install glow plug wiring harness.

19. Generously lubricate all rocker arm pedestal joints with clean engine oil.

RG41183,00000B7 -19-12SEP07-8/8

Connecting Rods—General Information

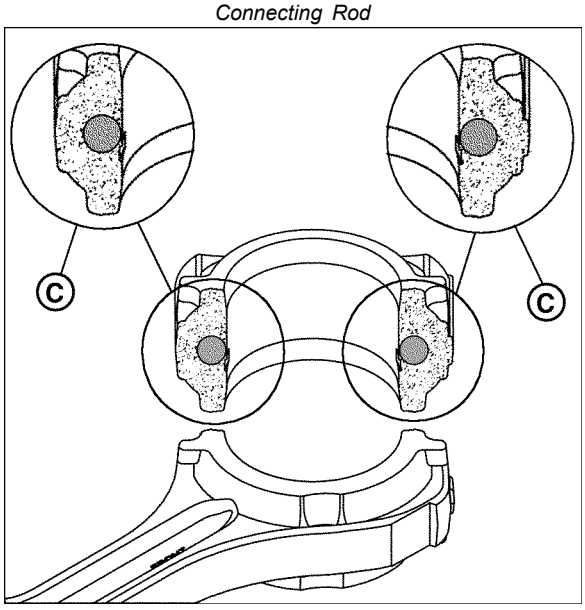
To create the PRECISION JOINT™, the connecting rod is notched with a laser beam. Then a precision mandrel in the rod bore is powered to separate the cap from the body at the joints (A) and (C).

- Care must be exercised when inspecting and handling the precision joint connecting rods. Do not nick the joint surfaces. Never scrape these surfaces with a wire brush or other tool. Cap MUST BE kept with the parent rod.
- Due to the machining process, PRECISION JOINT™ rod and cap have two grooves each, while the bearing inserts have a single tang. The extra grooves are not used. Install cap and rod with tangs to same side.
- Never use connecting rod bolts more than once for final engine assembly. Once bolts have been tightened to final torque, they must not be reused.



RG12533 —UN—03JUL09

Connecting Rod



RG9616 —UN—02DEC98

Precision Joint™ Rod

PRECISION JOINT is a trademark of Deere & Company

RG41183,000002F -19-09JAN07-1/1

Preliminary Cylinder Block, Pistons, and Rod Checks

Scuffed or Scored Pistons:

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

Worn or Broken Compression Rings:

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

Clogged Oil Control Ring:

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

Stuck Rings:

- Improper oil classification.
- Improper periodic service.
- Poor operating conditions.
- Coolant leakage into crankcase.
- Excessive cylinder bore taper.
- Insufficient Cooling
- Insufficient Lubrication

Mottled, Grayish or Pitted Compression Rings:

- Internal coolant leaks.

Dull Satin Finish and Fine Vertical Scratches on Rings:

- Dirt and abrasives in air intake system.

Piston Pin and Snap Ring Failure:

- Misaligned connecting rod.
- Excessive crankshaft end play.
- Incorrect snap rings.
- Snap ring not installed properly - not seated in groove.

Broken Connecting Rod:

- Inadequate piston-to-cylinder bore clearance.
- Worn connecting rod bearing.
- Distorted cylinder bore.
- Piston pin failure.
- Cap screws not tightened properly.
- Wrong cap with connecting rod.

Cylinder Wear and Distortion:

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

Warped Cylinder Block:

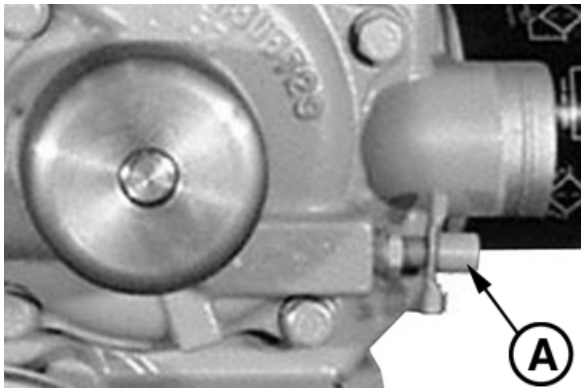
- Insufficient cooling.

RG41183,000002E -19-09JAN07-1/1

Remove Pistons and Connecting Rod Assembly

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

1. Drain all engine coolant (A) and engine oil.
2. Remove oil pan.
3. Remove cylinder head.



RG12534 —UN—12DEC02

Coolant Pump Drain Valve

Continued on next page

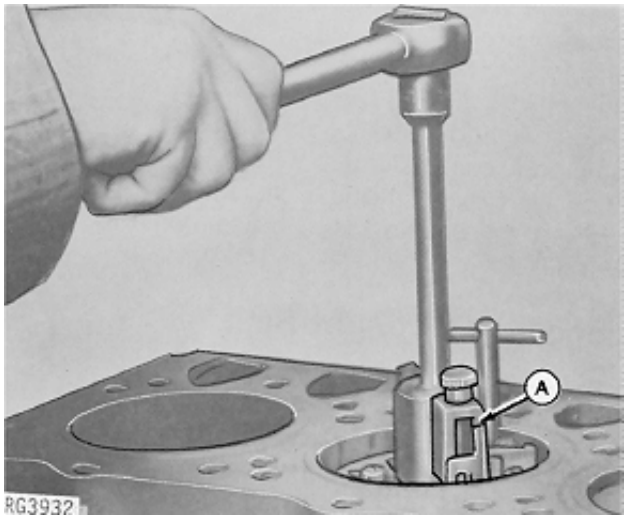
RG41183,0000030 -19-09JAN07-1/4

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

IMPORTANT: Do not disturb cylinder block parent material with ridge reamer.

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

A—Ridge Reamer



RG3932 —UN—07DEC88

Removing Carbon From Cylinder Bore

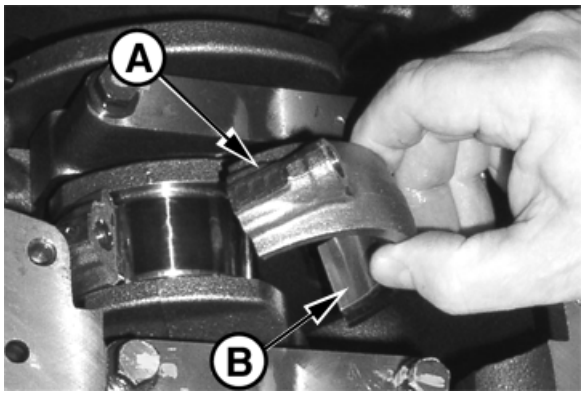
RG41183,0000030 -19-09JAN07-2/4

IMPORTANT: DO NOT use pneumatic wrenches on rod cap screws. Using pneumatic wrenches may cause thread damage.

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

5. Remove all rod caps (A) with bearings (B).

A—Rod Caps **B—Bearings**



RG12535 —UN—12DEC02

Removing Connecting Rod Caps

Continued on next page

RG41183,0000030 -19-09JAN07-3/4

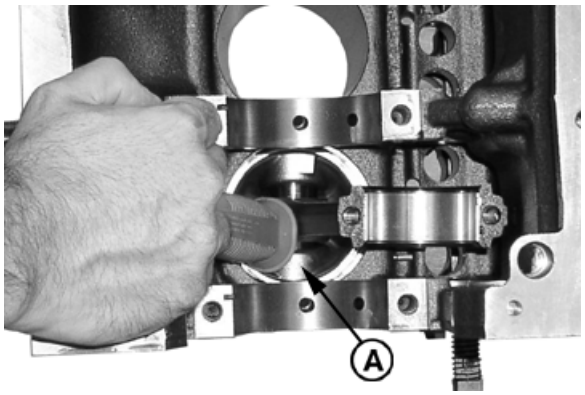
IMPORTANT: Be careful not to let rod nick crankshaft bearing surface as piston and rod assembly is removed.

Be extremely careful not to let connecting rod hit cylinder bore when removing piston and rod assembly.

Piston/connecting rod assemblies and cylinders are matched. Pistons must be installed in the cylinders from which they are removed.

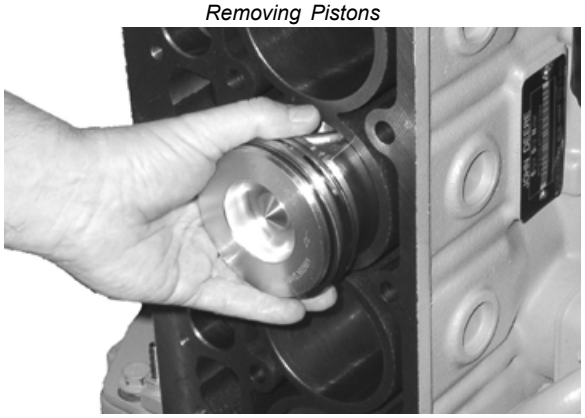
NOTE: Crankshaft is shown removed for picture purposes. Piston and rod assembly can be removed with crankshaft installed.

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



RG12536 —UN—12DEC02

Removing Pistons



RG12537 —UN—12DEC02

Holding Piston

RG41183,0000030 -19-09JAN07-4/4

Disassemble Piston and Rod Assembly

IMPORTANT: Do NOT reuse piston rings.

1. Remove piston rings using JDG135 Piston Ring Expander.



RG12538 —UN—12DEC02

Removing Piston Rings

Continued on next page

RG41183,0000031 -19-09JAN07-1/2

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

NOTE: Discard snap rings, DO NOT reuse.



RG12539 —UN—12DEC02

Removing Piston Pin Snap Ring

RG41183,0000031 -19-09JAN07-2/2

Clean Pistons

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

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

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

DO NOT bead blast ring groove areas.

2. Clean pistons by any of the following methods:

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

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



RG7465 —UN—23NOV97

Cleaning Piston Ring Grooves

RG41183,0000032 -19-09JAN07-1/1

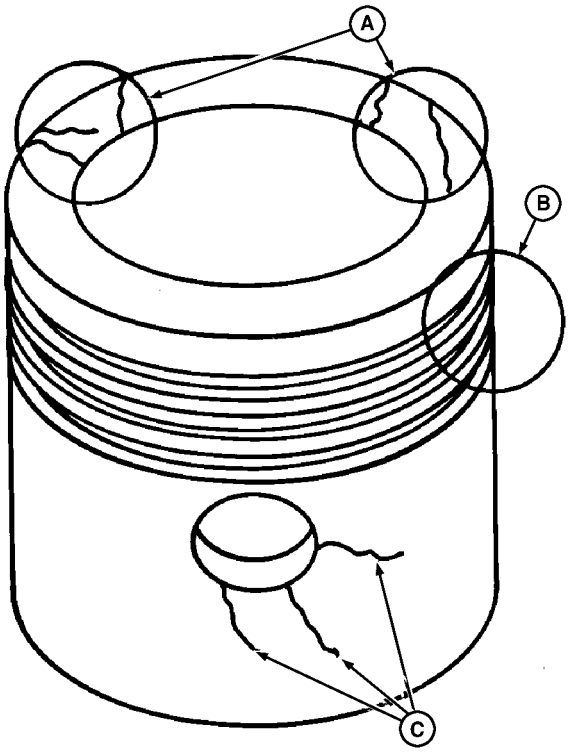
Visually Inspect Pistons

Carefully inspect pistons under magnification. Check for:

- Signs of fatigue
- Fine cracks in the piston head (A)
- Bent or broken ring lands (B)
- Cracks in the skirt (C) at inner and outer ends of piston pin bore
- Excessive piston skirt wear. (Original machining marks must be visible.)

If any imperfections are found, replace the piston.

A—Piston Head
B—Ring Lands
C—Skirt



RG3326 —UN—04DEC97

RG3326

Piston Defects (Exaggerated)

RG,RG34710,1120 -19-09JAN07-1/1

Check Piston Ring Groove Wear

1. Check ring grooves using a new piston ring and a feeler gauge. Measure clearance at several points. Compare measurements with specifications.

Specification	
Piston Ring-to-Groove Clearance—New Piston Ring (First Compression Ring Groove)—Maximum Clearance	0.12 mm (0.005 in.)
Piston Ring-to-Groove Clearance—New Piston Ring (Second Compression Ring Groove)—Maximum Clearance	0.098 mm (0.004 in.)
Piston Ring-to-Groove Clearance—New Piston Ring (Third Oil Control Ring Groove, Standard Ring)—Maximum Clearance	0.09 mm (0.004 in.)



RG12540 —UN—01MAY03

Piston Ring Groove Wear

2. Need step 2 completed

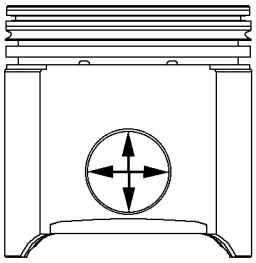
RG41183,0000033 -19-09JAN07-1/1

Measure Piston Pin Bore

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

Specification

Piston Pin Bore—ID.....30.003—30.009 mm (1.1812—1.1815 in.)



RG7402 —UN—23NOV97

Piston Pin Bore

RG41183,0000034 -19-09JAN07-1/1

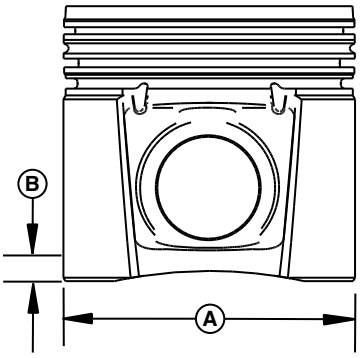
Measure Piston Skirt

1. Measure piston Skirt (A) 90° to piston pin bore and 12 mm (0.5 in.) from bottom of piston (B). Record measurement.

Specification

Piston Skirt (Measurement Taken at Bottom of Skirt 12 mm (0.5 in.) from Bottom of Piston)—Diameter.....85.876—85.908 mm (3.381—3.382 in.)

2. Measure cylinder bore as directed later in this group and compare with piston measurement.



RG12698 —UN—07JAN03

Piston Skirt Wear

RG41183,0000035 -19-09JAN07-1/1

Measure Piston Height

Measure piston height from center of piston pin bore to top of piston.

Specification

Piston — Turbocharged Engines—Height.....53.415—53.465 mm (2.103—2.105 in.)

RG41183,0000036 -19-09JAN07-1/1

Determine Piston-to-Cylinder Bore Clearance

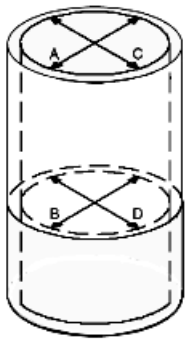
1. Measure piston OD.
2. Record measurement and compare measurement obtained from matching cylinder bore.

Specification

Piston —Piston OD.....85.876—85.908 mm (3.381—3.382 in.)
Cylinder Bore—ID.....85.987—86.013 mm (3.385—3.386 in.)

IMPORTANT: ALWAYS measure cylinder bore at room temperature.

3. Measure cylinder bore parallel to piston pin at top end of ring travel (A).
4. Measure bore in same position at bottom end of ring travel (B).
5. Measure bore at right angle to piston pin at top end of ring travel (C).
6. Measure bore in same position at bottom end of ring travel (D).
7. Compare measurements A, B, C, and D to determine if cylinder bore is tapered or out-of-round.



RG12699 —UN—13APR04

8. Compare cylinder bore ID with matched piston OD. Replace piston and cylinder block if they exceed wear specifications given.

Specification

Cylinder Bore—ID.....85.987—86.013 mm (3.385—3.386 in.)
Piston-to-Cylinder Bore Clearance (Measured at Bottom of Piston Skirt) —Clearance.....0.095—0.153 mm (0.003—0.006 in.)

RG41183,0000037 -19-09JAN07-1/1

Deglaze Cylinder Bores

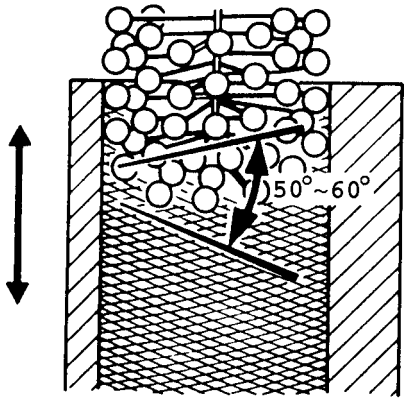
If cylinder bores have slight uneven wear, or minor flaws or damage, they can possibly be corrected by deglazing.

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 180 grit stones.
2. Use flex-hone as instructed by manufacture to obtain a **50 - 60° cross-hatch 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 until white rags show no discoloration.



M82054B —UN—13APR04

Deglazing Cylinder Bore

RG41183,0000039 -19-09JAN07-1/1

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.) and 0.50 mm (0.020 in.) oversizes 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 280 silicone carbide grit stones.

2. Adjust hone so lower end is 193.5 mm (7.62 in.) from top of the cylinder deck.
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.
5. Run drill press at about 250 rpm. Move hone up and down in order to obtain a **50—60° 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 50—60° crosshatch pattern.

7. Remove rigid hone when cylinder is within 0.12 mm (0.004 in.) of desired size.
8. Use a flex hone with 180 grit stones for honing to final size. Recommeded surface finish is Rpk 0.42 max, Rvk 1.5-2.5, Rk 0.5-1.5, MR2 65-85%.
9. Check bore for size, taper and out-of-round. (See INSPECT AND MEASURE CYLINDER BORE in this group.) Maximum lead-in chamfer diameter is 88.0 mm (3.464 in.)

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.

RG,RG34710,8119 -19-09JAN07-1/1

Inspect and Measure Connecting Rod Bearings (Rods Removed from Engine)

1. Inspect rod bearings for damage or wear.
2. Measure crankshaft rod journal OD at several points.

Specification

Crankshaft
Journal—OD.....59.987—60.013 mm (2.361—2.363 in.)

3. Assemble connecting rod, cap, and bearings with OLD cap screws. Tighten cap screws to 35 N•m (18 ft-lb). Tighten cap screw an additional 90° (See Torque-Turn Connecting Rod Cap Screws later in this group).
4. Measure assembled rod bearing ID.

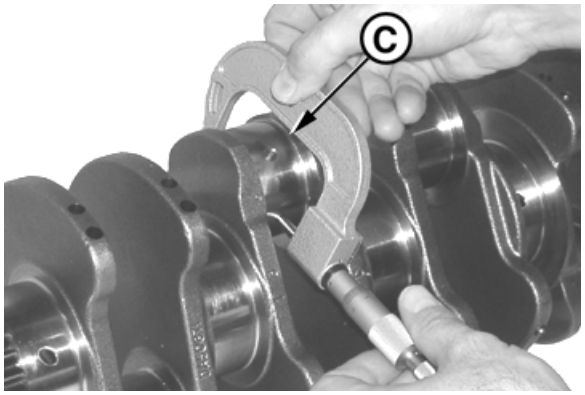
Specification

Assembled Rod
Bearing—ID.....60.030—60.073 mm (2.363—2.365 in.)

5. Subtract crankshaft journal OD from rod bearing ID to determine oil clearance. Replace bearing if oil clearance is out of specification.

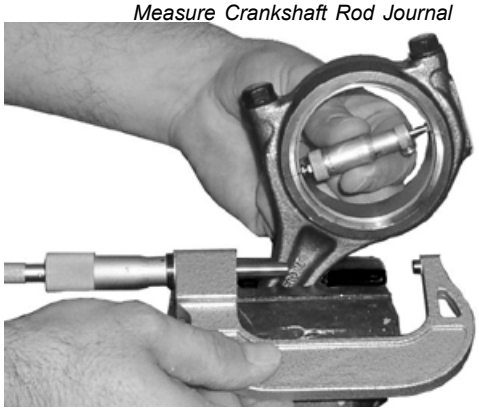
Specification

Connecting Rod
Bearing-to-Journal
Minimum—Clearance.....0.017 mm (0.001 in.)
Maximum—Clearance.....0.086 mm (0.003 in.)



RG12777 —UN—04JUN03

Measure Crankshaft Rod Journal



RG12778 —UN—07JAN03

Measuring Rod Bearing ID

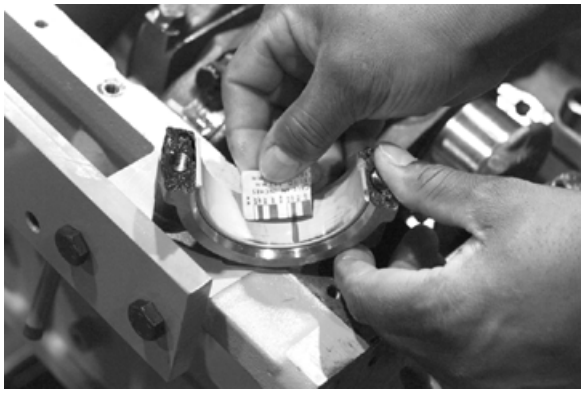
RG41183,000003A -19-09JAN07-1/1

Inspect and Measure Connecting Rod Bearings (Rod and Crankshaft in Engine)

IMPORTANT: Use hand wrenches. Pneumatic wrenches may cause thread damage.

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

1. Remove rod cap. Place a piece of PLASTIGAGE® in enter of bearing. Install rod cap using OLD cap screws. Tighten cap screws to 35 N•m (18 ft-lb). Tighten cap screw an additional 90° (See Torque-Turn Connecting Rod Cap Screws later in this group).
2. Remove rod cap. Compare width of PLASTIGAGE® with scale provided on package to determine clearance. Replace bearings if oil clearance is out of specification.


RG12700 —UN—07JAN03

Measure Rod Oil Clearance

PLASTIGAGE is a trademark of DANA Corp.

RG41183,000003B -19-09JAN07-1/1

Inspect Rod and Cap

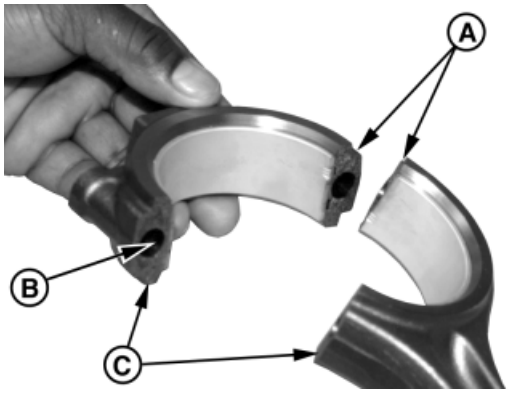
1. Inspect rod and cap for wear or damage, such as chips or nicks in the joint area (A).

IMPORTANT: Do not nick the joint surfaces of the rod and cap. This is very critical on PRECISION JOINT™ rods to ensure proper seating. Never scrape these surfaces (C) with a wire brush or other tool. The interlocking mating surfaces must be preserved.

2. Inspect in and around cap screw holes (B) in cap. If any imperfections are found, replace rod and cap.
3. Carefully clamp rod in a soft-jawed vise (cap end upward).

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

4. Install cap WITHOUT bearing inserts. Use old cap screws.



RG9555 —UN—02JUL98

Precision Joint™ Rod and Cap

5. Tighten cap screws to 35 N•m (18 ft-lb). Tighten cap screw an additional 90° (See Torque-Turn Connecting Rod Cap Screws later in this group).

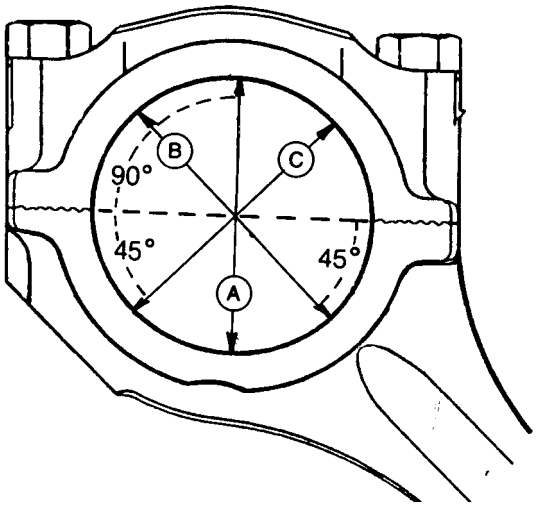
PRECISION JOINT is a trademark of Deere & Company

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RG41183,000003C -19-09JAN07-1/2

6. Using an inside micrometer, measure rod bore at center of bore and record measurements as follows:
   - At right angle to rod-to-cap joint (A).
   - At 45 degrees left of measurement step “A” (B).
   - At 45 degrees right of measurement step “A” (C).
7. Compare measurements to specifications.

Specification	
Connecting Rod Bore (Without Bearing Inserts)—ID	63.437—63.463 mm (2.498—2.499 in.)



RG7140A —UN—12DEC02

Measuring Rod Bearing ID

RG41183,000003C -19-09JAN07-2/2

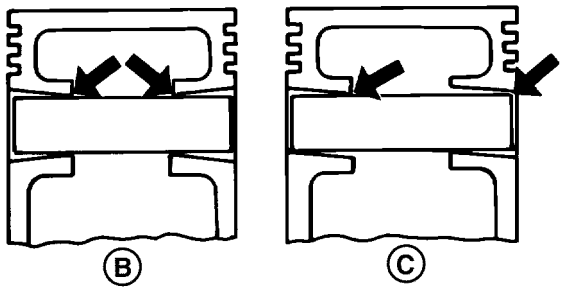
Inspect Piston Pins and Bushings

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.

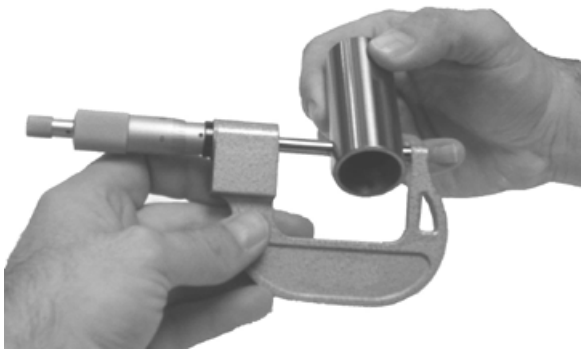
2. Dip piston pin in clean engine oil.
3. Install pin (A) through piston. Pin should pass through piston using only light thumb pressure.
4. Insert pin from both sides. If pin enters freely, but binds in the center, the bore could be tapered (B).
5. Insert pin to check for bore alignment (C). Pin should not “click” or need to be forced into bore on opposite side.
6. Measure piston pin OD. Replace if not within specification.

Specification	
Piston Pin—OD	29.994—30.000 mm (1.1809—1.1811 in.)
Wear Limit	29.980 mm (1.1803 in.)
Piston Pin—Length	67.75—68.00 mm (2.667—2.677 in.)



RG4747 —UN—31OCT97

Piston Pin Wear Points



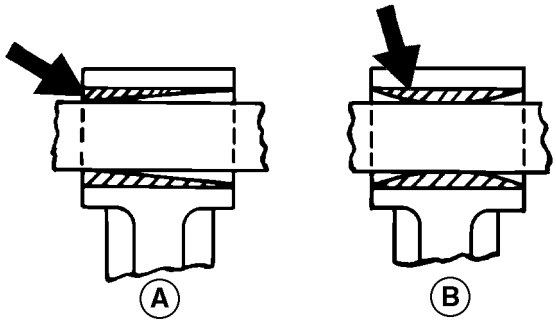
RG12672 —UN—12DEC02

Measuring Piston Pin OD

Continued on next page

RG41183,000003D -19-09JAN07-1/2

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



Piston Pin Wear Points in Connecting Rod

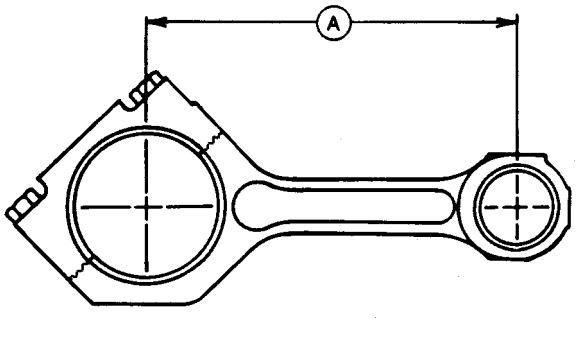
RG41183,000003D -19-09JAN07-2/2

Measure Rod Center-to-Center Bores

Measure rod center-to-center bores (A). Compare to specifications given below. Replace rod if necessary.

	Specification
Rod Bearing Bore-to-Piston Pin Bushing Bore (Center-to-Center) —Measurement	169.975 — 170.025 mm (6.692— 6.694 in.)

A—Center-to-Center Measurement



Measure Rod Center-to-Center Bores

RG41183,0000042 -19-09JAN07-1/1

Inspect and Clean Cylinder Block

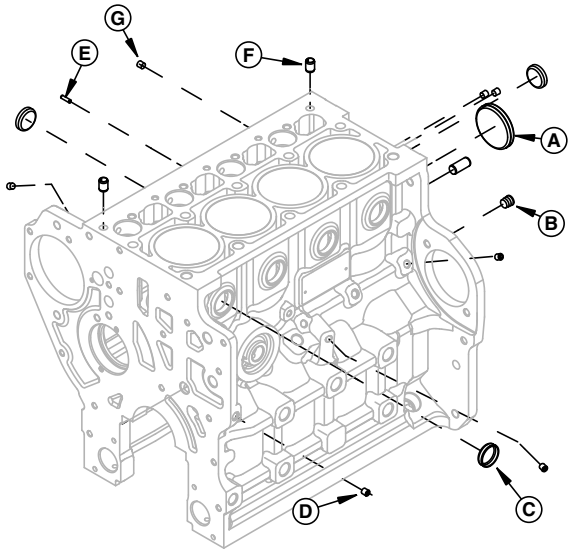
Before inspecting and cleaning cylinder block, remove all of the following:

- piston cooling orifices (A) (see REMOVE, INSPECT AND INSTALL PISTON COOLING ORIFICES later in this group)
- soft plugs (B)
- oil gallery plugs (C)
- all external and internal mounted components (refer to the proper group for removal procedures)

IMPORTANT: If block is cleaned in a hot tank, be sure to remove any aluminum parts such as nameplates (D). Aluminum parts can be damaged or destroyed 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 clear of lime deposits and scale.
4. Carefully inspect block for cracks or damage. If a cracked block is suspected, pressure-test the block. A procedure for pressure testing is outlined in FOS (Fundamentals of Service) Manual—ENGINES. Replace cracked or damaged blocks.
5. If cylinder block is serviceable, clean out all threaded holes for cylinder head mounting cap screws in top deck of cylinder block, using an M12 tap. Remove debris or fluid from tapped holes with compressed air.
6. After service of cylinder block, reinstall piston cooling orifices. (See REMOVE, INSPECT AND INSTALL PISTON COOLING ORIFICES later in this group.)
7. Apply LOCTITE® 277 to steel caps/soft plugs and install caps in block.
8. Apply LOCTITE® 592 Pipe Sealant with TEFLON® to coolant gallery plugs. Install plugs and tighten to specifications.

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



RG12694 —UN—17DEC02

Cylinder Block Plugs and Caps

A—Camshaft Bore Cap
B—Plug (Oil Gallery)
C—Cap
D—Plug (Oil Gallery)
E—Roller Follower Guide Pin
F—Guide Stud
G—Plug (Fuel Gallery)

Cylinder Block Oil and Coolant Gallery Plugs—Specification

Plug (Oil Gallery)—Torque	15 N·m (11 lb-ft)

RG41183,0000041 -19-09JAN07-1/1

Measure Cylinder Block Main Bearing Bore

Measure main bearing bore diameter.

Specification

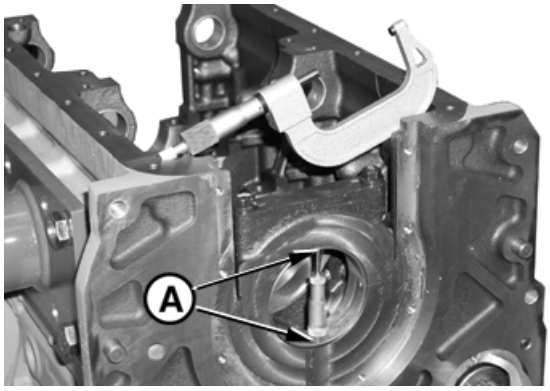
Cylinder Block Main Bearing Bore—ID.....79.892 - 79.918 mm (3.145 - 3.146 in.)

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 ID Clearance—Clearance.....0.021—0.090 mm (0.0008—0.0035 in.)



RG12674 —UN—03JUN03

Measure Main Bearing Bore

RG41183,0000043 -19-09JAN07-1/1

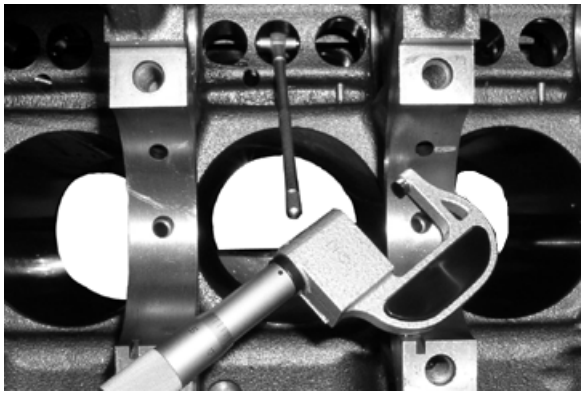
Measure Camshaft Follower Machined Bore

Measure camshaft follower bore diameter at all bore locations.

Specification

Camshaft Follower Bore in Block—ID.....21.428—21.454 mm (0.8436—0.8446 in.)
Camshaft Follower (New)—OD.....21.392—21.404 mm (0.8422—0.8427 in.)

If any one camshaft follower bore ID and follower-to-bore clearance exceeds specified maximum, install a new cylinder block.



RG12675 —UN—12DEC02

Measuring Camshaft Follower Bore

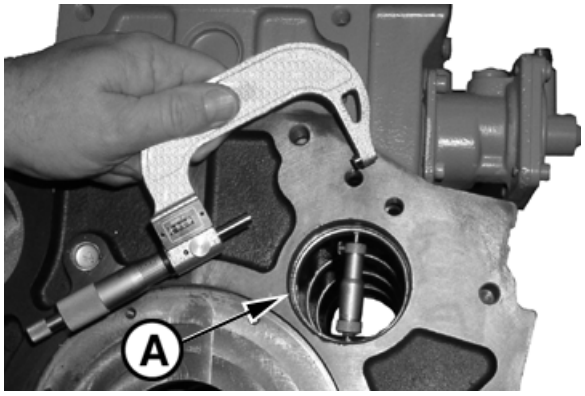
RG41183,0000045 -19-12OCT09-1/1

Measure Camshaft Bushing Bores in Block

Replaceable bushings (A) are installed in all camshaft bores with the exception of the front camshaft bore.

1. Visually inspect and measure camshaft bushing ID. If bushing is worn or not within specification, install new bushings. (See REMOVE AND INSTALL CAMSHAFT BUSHING in Group 050.)

A—Bushings



RG12676 —UN—12DEC02

Measuring Camshaft Bushing Bores

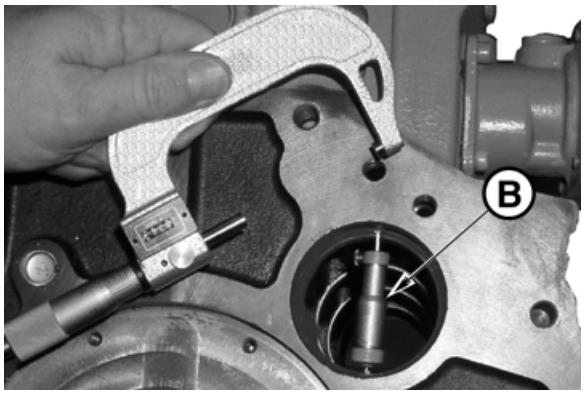
Continued on next page

RG41183,0000046 -19-09JAN07-1/2

2. If necessary to replace bushing, remove bushing and measure bore diameter in block. If bushing bore (B) in block is not within specification, repair or replace cylinder block as required.
3. Measure remaining camshaft bores in block and compare with specification given. Replace cylinder block as needed.

Specification	
Camshaft Bore In Block (With Bushing)—ID	60.05 - 60.102 mm (2.364 - 2.366 in.)
Camshaft Journal-to-Bushing—Oil—Clearance	0.037 - 0.115 mm (0.001 - 0.004 in.)

B—Bushing Bore



RG12677 —UN—12DEC02

Measuring Camshaft Bores

RG41183,0000046 -19-09JAN07-2/2

Inspect and Measure Cylinder Bore

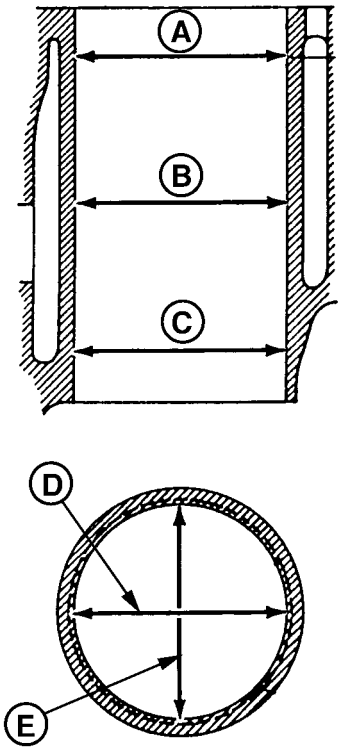
Measure cylinder bore diameter at three positions; top, middle and bottom. At these three positions, measure in both directions; along crankshaft center line and in direction of crankshaft rotation.

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 BORE later 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.) and 0.50 mm (0.020 in.) oversizes.
- If clearance (cylinder bore I.D. minus piston O.D.) exceeds specification, replace cylinder block, piston or both.

CYLINDER BORE SPECIFICATIONS

4024 and 5030	Standard	Wear Limit
Standard Size	85.987—86.013 3.385—3.386 in.)	86.130 mm (3.391 in.)
0.25 mm (0.010 in) Oversize Bore	86.237—86.263 mm (3.395—3.396 in.)	86.380 mm (3.401 in.)
0.50 mm (0.020 in) Oversize Bore	86.487—86.513 mm (3.405—3.406 in.)	86.630 mm (3.411 in.)
Piston-to-Cylinder Bore Clearance	0.079—0.137 mm (0.003—0.005 in.)	— —



M82053A —UN—25APR00

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

RG41183,0000048 -19-09JAN07-1/1

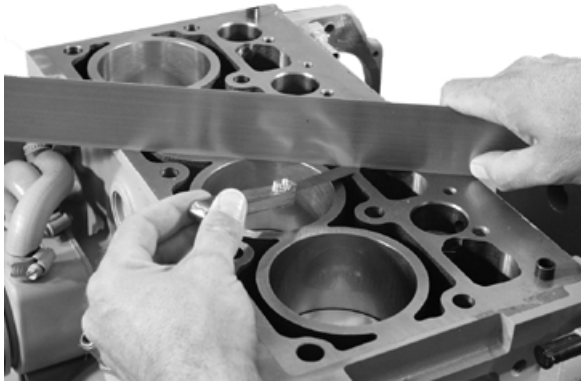
Measure Cylinder Block Top Deck Flatness

IMPORTANT: When cylinder block top deck or main bearing bores are machined, the dimension from crankshaft centerline to top deck will be changed. Make sure this dimension is within specifications, otherwise piston may contact cylinder head.

Measure cylinder block top deck flatness using D05012ST Precision Straightedge and feeler gauge. If flatness is not as specified, clean up top deck of cylinder block.

Cylinder Block Top Deck—Specification

Cylinder Block Flatness—Maximum Acceptable Out-of-Flat for every 150 mm (6 in)	0.05 mm (0.002 in.)
Maximum Acceptable Out-of-Flat for every 25 mm (1 in)	0.025 mm (0.001 in.)



RG12680 —UN—12DEC02

Measuring Cylinder Block Top Deck Flatness

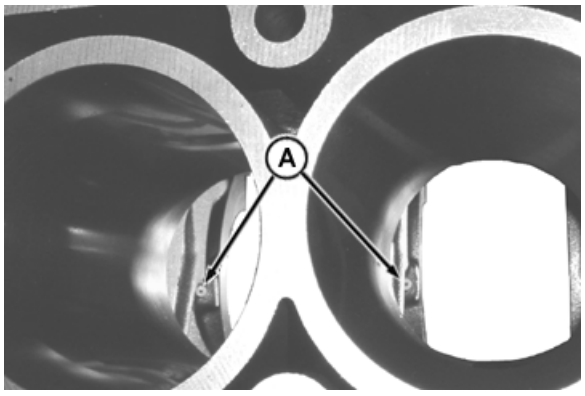
Main Bearing Bore Centerline-to-Cylinder Block Top Deck —Distance	274.96—275.04 mm (10.825—10.828 in.)

RG41183,000001F -19-25SEP07-1/1

Remove, Inspect, and Install Piston Cooling Orifices

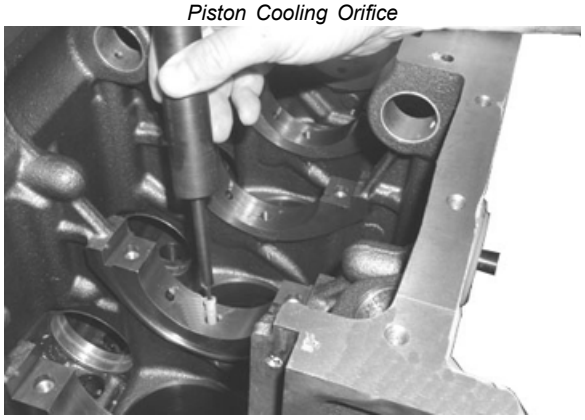
IMPORTANT: A piston cooling orifice failure could cause damage to pistons, piston pins, rod pin bushings and liners. If a piston cooling orifice is left out, low or no oil pressure will result. New spray jets are recommended during engine overhaul.

1. Remove and clean each piston cooling orifice (A) to make sure it is not plugged or damaged. The cooling orfice diameter should not exceed 1.7 mm (0.07 in.). Replace if damaged, plugged or if it does not remain securely in position.
2. Install orifices using JDG1697 Installer.



RG12682 —UN—03JUL09

Piston Cooling Orifice



RG12681 —UN—12DEC02

Installing Piston Cooling Orifice

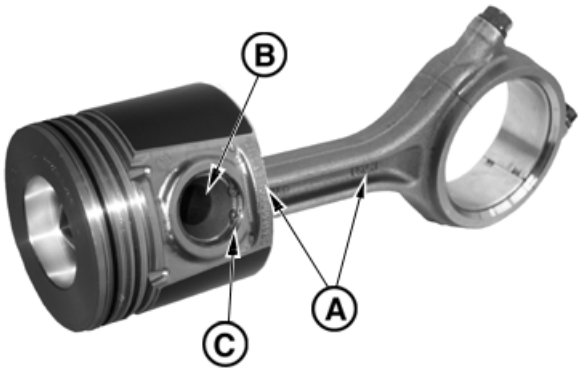
RG41183,0000020 -19-09JAN07-1/1

Assemble Piston and Connecting Rod

1. Lubricate piston pin and bushing with clean engine oil.

NOTE: Pistons are marked with an arrow on top of piston. Arrow must point to side marked "FRONT" on connecting rod when assembled.

2. Assemble pistons and connecting rods, making sure the word "FRONT" (A) on side of piston and side of connecting rod are facing same direction.
3. Insert piston pin (B) into piston pin bore.
4. Install NEW piston pin snap rings with ring gap (C) facing down to the 6 o'clock position at bottom of piston (viewed from rod end) and square edge of ring facing away from piston pin. Make sure snap rings are seated in grooves of piston pin bore.



RG12683 —UN—12DEC02

Assembly Piston and Connecting Rod

A—Marked "Front"
B—Piston Pin
C—Snap Ring Gap

RG41183,0000021 -19-09JAN07-1/1

Install Piston Rings

IMPORTANT: Piston rings can be damaged if expanded too far. Expand piston rings only as far as necessary to install rings on piston.

1. Use JDE135 or any other suitable piston ring expander for a proper installation and to prevent any damage to the piston and piston rings. Install oil ring expander in bottom ring groove. Position end gap toward either side of piston pin.
2. Install oil control ring (C) in bottom ring groove over ring expander. Install with end gap on opposite side of piston from ring expander gap.

NOTE: Identify ring top as follows:

If rings are marked with depression ("pip"), mark should be on top as shown (A). Ring with two depression marks goes in the second groove.

If ring is marked with paint strip, hold ring with gap facing you and turn ring so that paint strip is to the left side of gap.

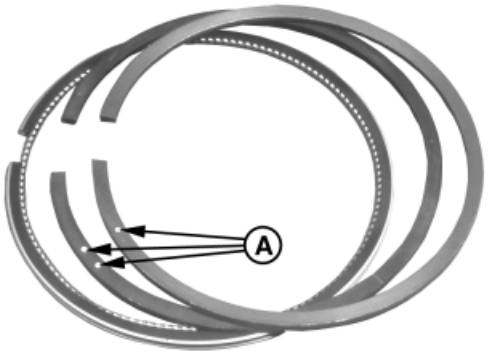
3. Identify top side of compression rings. Top side of compression rings will be identified by marks on the top side of two rings.
4. Install compression ring (B) in center ring groove with top of ring toward top of piston.
5. Position gap in compression ring (B) on opposite side (180°) of piston from oil control ring (C) gap.
6. Install compression ring (D) in top ring groove with top of ring toward top of piston.

A—Depression Marks
B—Rectangular Compression Ring
C—Oil Control Ring
D—Keystone Compression Ring



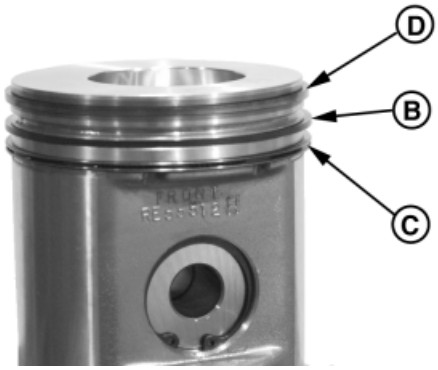
RG7499 —UN—04NOV97

Piston Ring Expander Tool



RG7797 —UN—11NOV97

Compression Rings



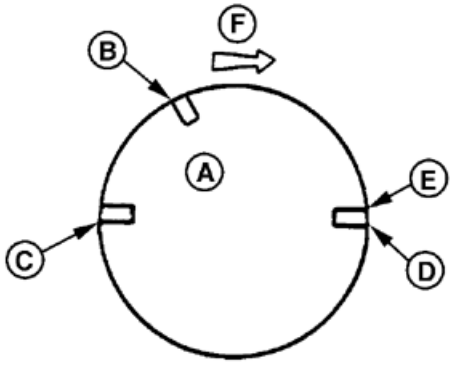
RG7500 —UN—04NOV97

Piston Ring Locations

RG41183,0000023 -19-09JAN07-1/2

7. Position gap in compression ring (D) 120° from compression ring (B) gap.
8. Coat pistons, cylinder bores, and inside of with clean engine oil.

A—Piston Head
B—Top Compression Ring
C—Oil Control Ring Gap
D—Expander ring Gap
E—Bottom Compression Ring Gap
F—Front of Engine



RGCD5781B —UN—12DEC02

RG41183,0000023 -19-09JAN07-2/2

Install Piston and Connecting Rod Assembly

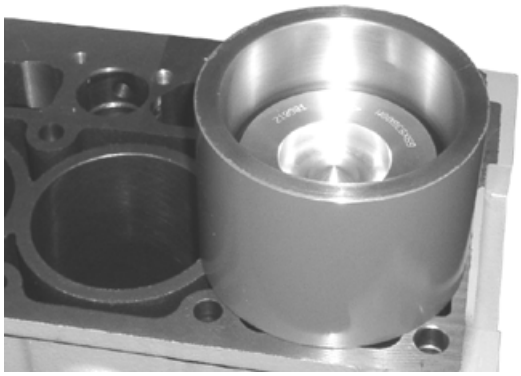
IMPORTANT: Be careful so crankshaft journals and cylinder block bore walls are not damaged by connecting rod when installing piston and connecting rod assembly.

1. Coat cylinder block bore, pistons and inside of piston ring compressor with clean engine oil.
2. Carefully place Piston Ring Compressor with piston and rod over cylinder bore so the word “FRONT” on side of rod and on the piston faces toward the front of the engine.

NOTE: Be sure the word “FRONT” on connecting rod faces toward the front of the engine.

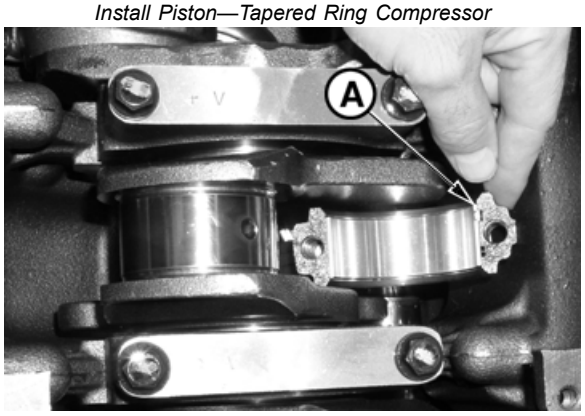
If arrow indicating “FRONT” is not visible on top of pistons, refer to the side of the piston by the piston pin for the word “FRONT”.

3. With piston centered in ring compressor and rings staggered correctly, push piston down until top ring is into the cylinder block bore.
4. Install bearing insert in connecting rod with tang in groove (A).
5. Apply clean engine oil on insert and crankshaft journal. Carefully pull connecting rod and insert against crankshaft journal.



RG12695 —UN—07JAN03

Install Piston—Tapered Ring Compressor



RG12686 —UN—12DEC02

Tang Groove on PRECISION JOINT™ Connecting Rod

Continued on next page

RG41183,0000024 -19-09JAN07-1/2

NOTE: Due to the manufacturing process, the PRECISION JOINT™ rod and cap both have two grooves, while the bearing insert has a single tang. Only the one groove in the rod and cap is used for the bearing tang.

6. Install bearing insert in connecting rod cap with tang (A) in groove (B).

IMPORTANT: On PRECISION JOINT™ connecting rods, make sure cap is properly aligned on rod with edges flush and interlocking surfaces sealed tightly. The flat on the side of the cap should align with the connecting rod. The cylinder number stamped on the rod and cap must be the same.

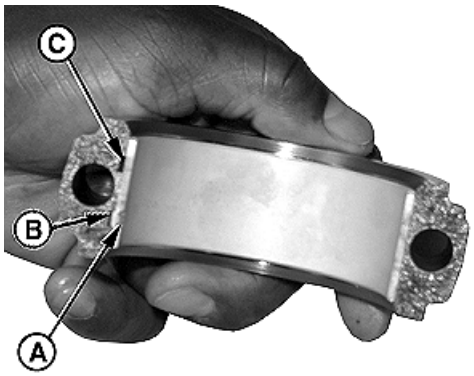
7. Apply clean engine oil to bearing insert. Install cap on connecting rod with tangs to same side.

IMPORTANT: NEVER use connecting rod cap screws more than once for final engine assembly. Once rod cap screws have been tightened to final torque-turn specification, they must not be reused for another final assembly.

8. Dip NEW connecting rod cap screws in clean oil and install.

9. Tighten cap screws alternately to initial torque specification.

PRECISION JOINT is a trademark of Deere & Company



RG9448 —UN—27JUL98

PRECISION JOINT™ Rod

A—Tang
B—Groove
C—Extra Groove (Not Used)

Specification

Connecting Rod Cap Screws—Initial Torque..... 35 N·m (18 lb-ft)

10. Torque-turn all cap screws to 90—100 degrees. (See TORQUE-TURN CONNECTING ROD CAP SCREWS next in this group.)

RG41183,0000024 -19-09JAN07-2/2

Torque-Turn Connecting Rod Cap Screws

Using Engine Axis Method to Torque-Turn Connecting Rod Cap Screws

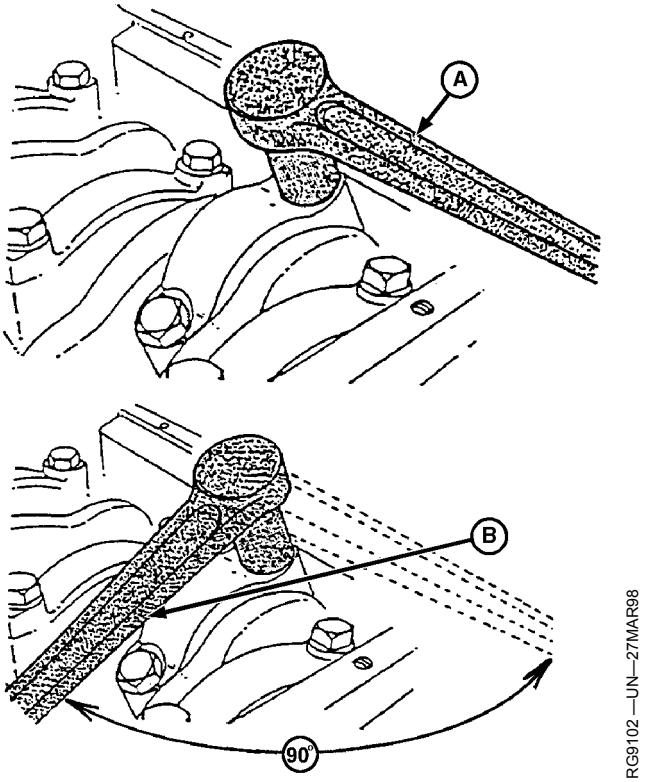
1. After tightening cap screws to initial torque values, mark connecting rod cap and socket.
2. Position handle of wrench parallel to centerline of engine crankshaft axis (A).
3. Tighten 1/4 turn (90—100°) clockwise until handle of wrench is perpendicular to centerline of engine crankshaft axis (B) as shown.

Specification

Connecting Rod Cap Screws—Torque-Turn.....1/4 Turn (90—100°) After Initial Torque

A—Parallel to Centerline Crankshaft

B—Perpendicular to Centerline Crankshaft



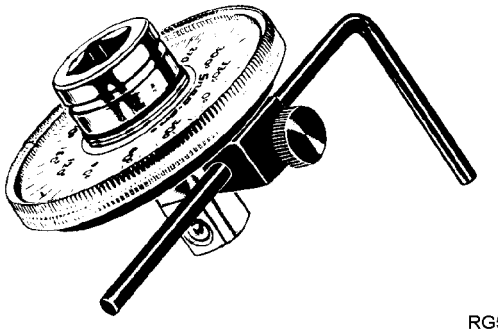
RG9102 —UN—27MAR98

Torque-Turn Rod Caps

RG,10,DT7386 -19-09JAN07-1/2

Using JT05993 Torque Angle Gauge to Torque-Turn Connecting Rod Cap Screws

After tightening cap screws to initial torque values provided earlier, follow directions provided with JT05993 Gauge and torque-turn each cap screw 90°—100°.



RG5698

RG5698 —UN—05DEC97

Torque Angle Gauge

RG,10,DT7386 -19-09JAN07-2/2

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 rods. Must have less than 0.574 mm (0.022 in.) side-to-side movement.

RG,10,DT7385 -19-09JAN07-1/1

Measure Piston Protrusion - Locate TDC

1. Press down on top of piston to remove oil clearances before measuring piston protrusion.

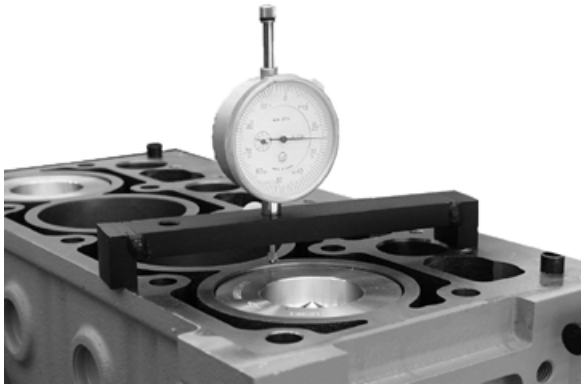
NOTE: If JDG451 is not available, a dial indicator with magnetic base can be used to measure piston protrusion.

Use JDG451 Height Gauge (or use a magnetic base dial indicator) to measure piston protrusion. Place gauge on top of cylinder block so dial indicator can be set to "zero" with top of block.

2. Position gauge across piston as close to centerline of piston pin as possible. While pressing gauge downward, rotate crankshaft until piston is at TDC position. Measure piston height over the piston pin axis at the front and rear outermost diameter of the piston.
3. Piston protrusion must be within specifications to prevent piston-to-exhaust valve contact.
4. Measure piston protrusion and compare to the following specifications. If protrusion does not meet specifications, check dimensions of piston, connecting rod, cylinder block, crankshaft, and bearings to determine the cause.

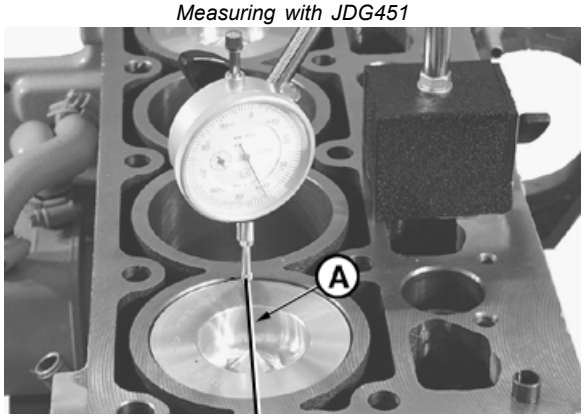
Piston Protrusion—Specification

Asperation Type: T and H—Piston Protrusion.....0.765—0.953 mm (0.03—0.038 in.)



RG12696 —UN—07JAN03

Measuring with JDG451



RG12697 —UN—07JAN03

Magnetic Base Indicator

RG41183,0000028 -19-09JAN07-1/1

Complete Final Assembly

1. Install balancer shaft bushings (4-cylinder engines). (See REMOVE AND INSTALL BALANCER SHAFT BUSHINGS in Group 050.)
2. Install camshaft bushings. (See REMOVE AND INSTALL CAMSHAFT BUSHINGS in Group 050.)
3. Install balancer shafts (if equipped). (See INSTALL AND TIME BALANCER SHAFTS in Group 050.)
4. Install camshaft and timing gears. (See INSTALL CAMSHAFT in Group 050.)
5. Install cylinder head with new gasket. (See INSTALL CYLINDER HEAD in Group 020 for two valve head or INSTALL CYLINDER HEAD in Group 021 for four valve head.)
6. Install turbocharger. (See INSTALL TURBOCHARGER in group 080.)
7. Install timing gear cover. (See INSTALL TIMING GEAR COVER in Group 050.)
8. Install oil pan. (See INSTALL OIL PAN in Group 060.)
9. Install oil cooler and filter.
10. Install crankshaft pulley. (See INSTALL PULLEY OR VIBRATION DAMPER PULLEY in Group 040.)
11. Fill engine with clean oil and proper coolant.
12. Perform engine break-in. (See PERFORM ENGINE BREAK-IN in Group 010.)

RG41183,0000029 -19-12DEC02-1/1

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.
- 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.

RG19661,0000003 -19-09JAN07-1/1

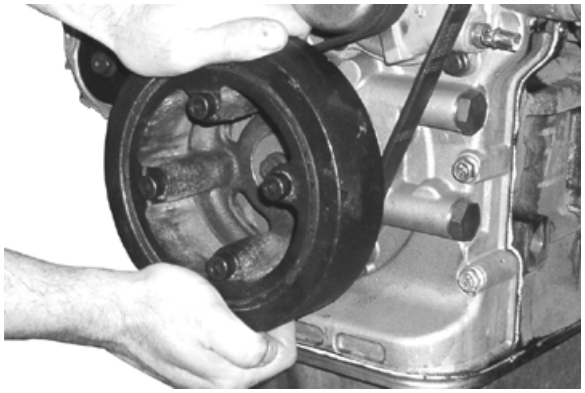
Inspect Vibration Damper (If Equipped)

IMPORTANT: Do not immerse the vibration damper in cleaning solvent or any petroleum product. Rubber portion of damper may be damaged. Use a steam cleaner, soap solution or water only.

Never apply thrust on outer ring. Damper is sensitive to impact damage, such as being dropped or struck with a hammer.

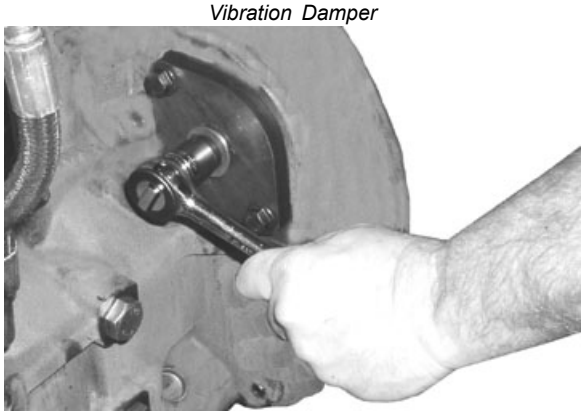
The damper assembly is not repairable. Replace damper every 5 years or 4500 hours, whichever occurs first. Also, replace damper whenever crankshaft is replaced or after major engine overhaul.

1. Grasp outer ring of damper and attempt to turn it in both directions. If rotation is felt, damper is defective and should be replaced. Also, if rubber is separated, partially missing, or displaced, replace damper.



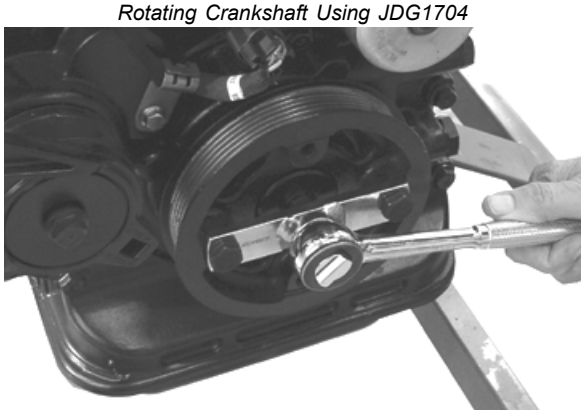
RG12917 —UN—16MAY03

Vibration Damper



RG12788 —UN—21JAN03

Rotating Crankshaft Using JDG1704



RG15114 —UN—26SEP06

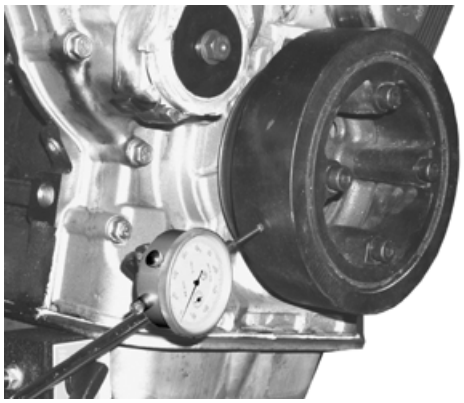
Rotating Crankshaft Using JDG10221

Continued on next page

RG19661,0000004 -19-09JAN07-1/3

2. Check vibration damper radial runout (concentricity) by positioning D17526CI (English, in.) or D17527CI (Metric, mm) dial indicator so probe contacts damper OD.
3. Remove starting motor.
4. Rotate crankshaft using JDG1704 or JDG10221 Turning Tool.
5. Note dial indicator reading. If runout (concentricity) exceeds specifications given below, replace vibration damper.

Specification	
Damper—Maximum Radial Runout (Concentricity)	1.00 mm (0.040 in.)



RG12918 —UN—16MAY03

Vibration Damper Radial (Concentricity)

RG19661,0000004 -19-09JAN07-2/3

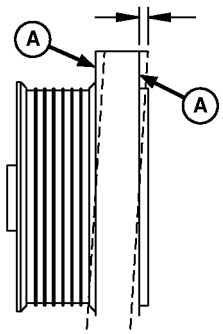
6. Check vibration damper wobble using a dial indicator. Measure wobble at the outer edges of damper face (A).
7. Rotate crankshaft one complete revolution using flywheel rotation tool and note total dial indicator movement. Compare readings with specifications below.

Specification	
Damper Pulley Outer Ring—Wobble (Maximum)	1.50 mm (0.060 in.)
Damper Pulley Inner Ring—Wobble (Maximum)	0.5 mm (0.020 in.)

IMPORTANT: Replace damper after 4500 hours or every five years, whichever occurs first.

8. Remove engine rotation tool and install starting motor. Connect wiring and tighten mounting cap screws to specification.

Specification	
Starter Motor Mounting Cap Screws—Torque	80 N·m (59 lb-ft)



RG9053 —UN—16MAR98

Damper Wobble

A—Vibration Damper Wobble

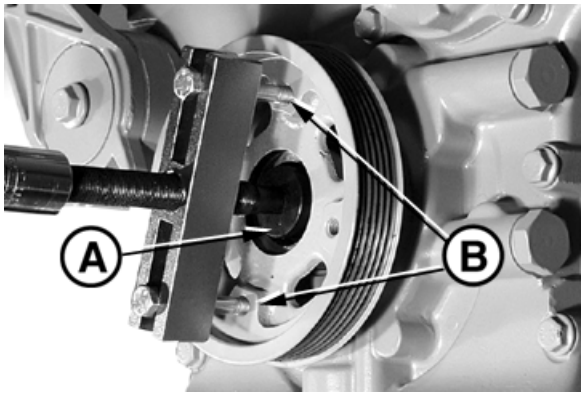
RG19661,0000004 -19-09JAN07-3/3

Remove Crankshaft Pulley/Damper

IMPORTANT: Never apply thrust on outer ring of damper. Use of heavy duty puller mounted to auxiliary mounting holes is preferred method for removal. Do not drop or hammer on damper.

1. Install JDG1571 Timing Pin to prevent crankshaft rotation.
2. Remove damper from pulley, if equipped (shown removed).
3. Remove cap screw and washer securing pulley from crankshaft.
4. Install a thread protector (A) in nose of crankshaft and secure a heavy duty puller to pulley using the auxiliary mounting holes (B).

CAUTION: Crankshaft pulley may suddenly release from crankshaft. Plan a safe handling procedure to avoid personal injury or damage to pulley.



RG12919 —UN—04JUN03

Remove Crankshaft Pulley

A—Crankshaft Pulley Washer B—Auxiliary Mounting Holes

5. Remove pulley from crankshaft.
6. Remove friction washer and o-ring.

RG19661,0000005 -19-09JAN07-1/1

Inspect Pulley and Wear Sleeve

NOTE: Front oil seal wear sleeve is not a service part. If sleeve is worn, replace with new pulley assembly.

1. Inspect front pulley wear sleeve for grooves and damage.
2. Clean wear sleeve and smooth any surface imperfections with polishing cloth.
3. Protect belt pulley grooves, pilot bore and threads from paint.



RG12920 —UN—23MAY03

Crankshaft Pulley with Wear Sleeve

RG19661,0000039 -19-09JAN07-1/1

Replace Front Crankshaft Oil Seal (Without Removing Timing Gear Cover)

NOTE: If timing gear cover is to be removed, remove seal after cover is removed.

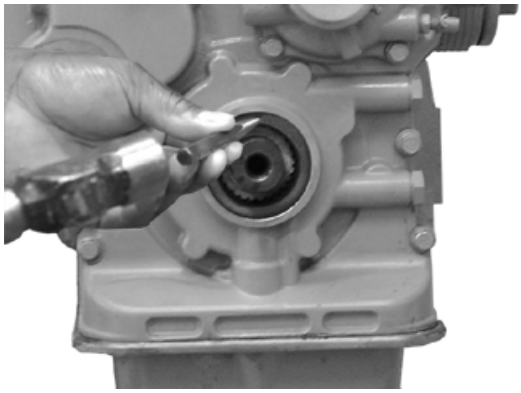
Remove Front Crankshaft Oil Seal

1. Remove poly-vee belt.
2. Remove vibration damper/pulley or pulley from crankshaft as previously instructed in this group.
3. Check oil seal for wear, damage, or leakage.

IMPORTANT: On unitized oil seal applications, holes must be drilled at outer edge of seal case. Screws will pull seal against wear ring, removing both pieces.

4. Center punch seal casing at 12 o'clock position and drill 1/8 in. hole in casing.

   Remove seal from timing gear cover using JDG22 Seal Remover or JDG719 Seal Puller Adapter along with JDE38-2 Shank and JDE38-3 Slide Hammer. Be careful not to damage seal bore in timing gear cover.



RG12966 —UN—04JUN03

Crankshaft Oil Seal/Wear Sleeve



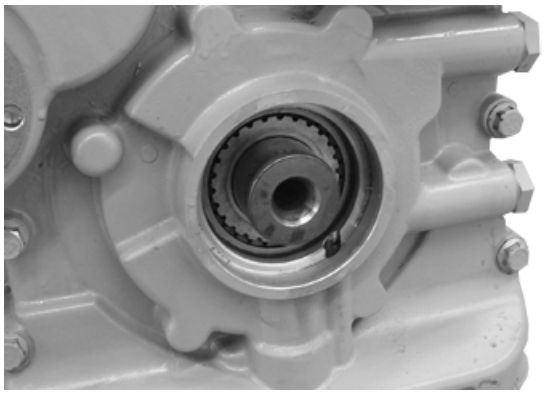
RG12967 —UN—04JUN03

Slide Hammer Installed in Oil Seal

RG19661,0000007 -19-09JAN07-1/2

Install Front Crankshaft Oil Seal

1. Inspect and clean ID of timing gear cover.
2. Apply light coat of lithium grease to ID of seal.
3. Install oil seal using JDG1660 Timing Gear Cover Alignment tool. Carefully drive the oil seal into the cover until the until the seal bottoms on the timing gear cover flange.



RG12909 —UN—23MAY03

Clean Seal Bore



RG12921 —UN—23MAY03

RG19661,0000007 -19-09JAN07-2/2

Install Crankshaft Pulley/Damper

IMPORTANT: Never apply thrust on outer ring of damper or pulley. Do not drop or hammer on damper.

1. Install JDG1571 Timing Pin to prevent engine rotation.
2. Inspect and clean nose of crankshaft using LOCTITE® 7649 (TY16285) clean and cure primer.

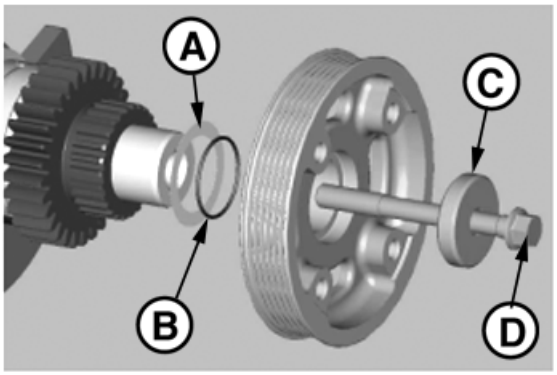
IMPORTANT: ALWAYS use a new cap screw, friction washer and o-ring. A friction washer is not specified for all engine applications.

3. Install friction washer (A) against the front face of the crankshaft gear.
4. Lightly lubricate o-ring (B) with soap and slide into position against crank gear.
5. Apply a thin coat of lithium grease to the lead-in area of the O.D. wear sleeve surface on the crankshaft pulley. The flat leading edge of the crankshaft pulley contacting the crankshaft gear must remain clean and dry.
6. Position pulley on crankshaft.
7. Dip cap screw in clean SAE30 engine oil.
8. Install pulley on crankshaft using the washer (C) and cap screw (D). Tighten cap screw to specification.

Specification

Initial Pulley Mounting Cap Screw—Torque ..... 100 N·m (74 lb-ft)

LOCTITE is a registered trademark of Loctite Corp.



RG12910 —UN—23MAY03

Front Pulley Installation

A—Friction Washer
B—O-Ring
C—Crankshaft Pulley Washer
D—Crankshaft Pulley Cap Screw

9. Loosen cap screw completely. Retighten cap screw to specification.

Specification

Final Pulley Mounting Cap Screw—Torque Turn ..... 50 N·m + 90° (37 lb-ft + 90°)

10. Install damper, if equipped to specifications.

Specification

Damper Cap Screws—Torque ..... 64 N·m (48 lb-ft)

RG19661,0000006 -19-09JAN07-1/1

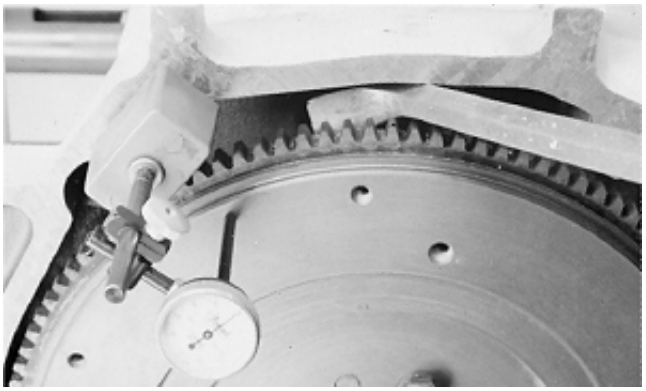
Check Crankshaft End Play

Measure end play prior to removing crankshaft to determine condition of thrust bearings.

1. Position dial indicator to contact face of flywheel, on front crankshaft nose, on damper, or front pulley assembly, if installed.
2. Using a pry bar, gently push crankshaft as far to rear of engine as possible.
3. Zero the dial indicator.
4. Gently pry the crankshaft as far forward as possible. Note indicator reading. If end play is not within specifications, install new thrust bearings.

Specification

Crankshaft—End Play ..... 0.089—0.396 mm (0.004—0.016 in.)



T88331 —UN—14OCT88

Check Crankshaft End Play w/Dial Indicator

RG19661,0000008 -19-09JAN07-1/1

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 ring gear if defective, as described later in this group.

RG19661,0000009 -19-09JAN07-1/1

Check Flywheel Face Flatness

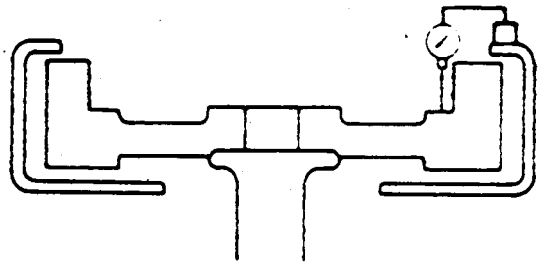
1. Mount dial indicator base on flywheel housing. Position pointer to contact driving ring mounting surface. Do not allow pointer to contact driving ring mounting holes.

IMPORTANT: Maintain constant end pressure on crankshaft to hold shaft against thrust bearing when measuring flywheel face runout.

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

Specification

Flywheel Face Flatness—Maximum Variation	0.23 mm (0.009 in.)
	0.013 mm (0.0005 in.)



Flywheel Face Flatness Check

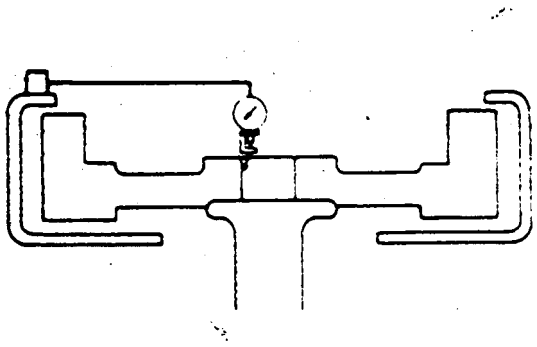
RG19661,000000A -19-09JAN07-1/1

Check Pilot Bearing Bore Concentricity

1. Mount dial indicator on flywheel housing face and position pointer to contact ID of pilot bearing bore in flywheel.
2. Rotate flywheel by turning crankshaft. Read total dial indicator movement.

Specification

Flywheel Bearing Bore Concentricity—Maximum Variation	0.127 mm (0.005 in.)



Flywheel Bearing Bore Concentricity

RG19661,000000B -19-09JAN07-1/1

Flywheel—Removal

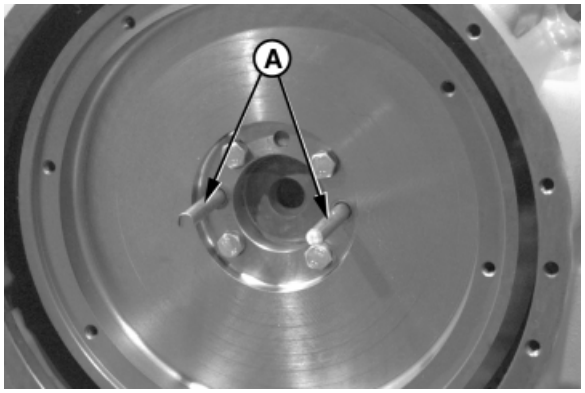
Tools:
• JDG1571 Timing Pin

Consumables:
• No consumables required

CAUTION: Flywheel is heavy. Plan a proper lifting procedure to avoid personal injury.

1. Insert JDG1571 Timing Pin to prevent crankshaft rotation. Remove two cap screws and install guide studs (A) in their place. Remove the remaining cap screws.
2. Pry flywheel off of crankshaft.

NOTE: If flywheel to housing clearance will not allow use of a pry bar, install a punch through timing pin hole or remove starting motor and tap on flywheel face to drive from crankshaft.



RG7518A —UN—05NOV97

Remove Flywheel

A—Guide Studs

RG19661,000000C -19-20MAY10-1/1

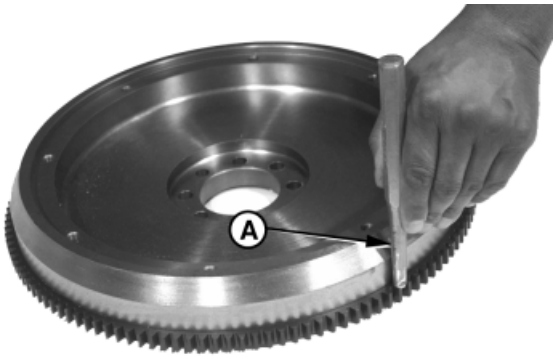
Replace Flywheel Ring Gear

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

1. Place the flywheel on a solid flat surface.
2. Drive ring gear off with a brass drift (A) and hammer.

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

3. Heat new ring gear to 148°C (300°F) using either heated oil, oven heat, or flame heat.



RG7519 —UN—05NOV97

A—Brass Drift

4. Install ring gear against shoulder of flywheel.

RG19661,000000D -19-09JAN07-1/1

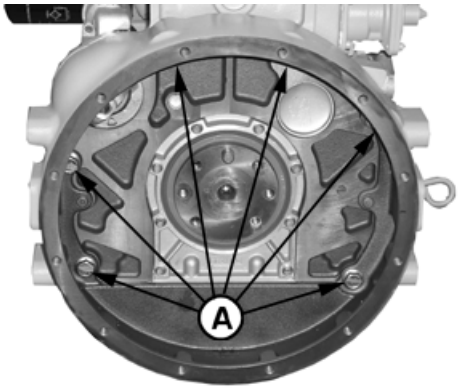
Remove Flywheel Housing

1. Remove flywheel.
2. Remove starting motor if desired. Starting motor and flywheel housing may be removed as an assembly.

CAUTION: The flywheel housing is heavy. Plan a proper handling procedure to avoid injuries.

3. Remove flywheel housing-to-cylinder block cap screws (A). Remove flywheel housing from block.

A—Cap Screws



RG12826 —UN—03JUN03

Flywheel Housing

RG19661,0000013 -19-09JAN07-1/1

Crankshaft Rear Oil Seal and Wear Sleeve Handling Precautions

Use the following precautions for handling seal and wear sleeve assembly (A):

- Always install seal and wear sleeve assembly immediately after removal from plastic bag to avoid possible dirt contamination.
- No lubrication of any kind is to contact seal when installing. Use of a lubricant may result in premature seal failure.
- Install oil seal/wear sleeve assembly with the open side of seal and wear sleeve ID chamfer toward the engine. If seal is reversed, engine oil may be lost because grooves in oil seal lip would be incorrect with respect to direction of crankshaft rotation.



RG5640A —UN—31OCT97

Crankshaft Rear Oil Seal

A—Wear Sleeve

RG19661,000000F -19-09JAN07-1/1

Remove Crankshaft Rear Oil Seal and Housing

The crankshaft rear oil seal (A) and wear sleeve (B) are fabricated as a non-separable part.

A—Oil Seal **B—Wear Sleeve**



RG9083 —UN—16MAR98

Crankshaft Rear Oil Seal and Wear Sleeve

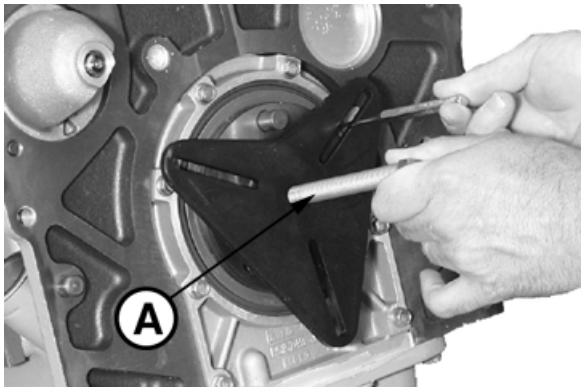
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RG19661,0000010 -19-09JAN07-1/4

Remove Rear Oil Seal Using JDG698A

1. Adjust forcing screw (A) on JDG698A Seal and Wear Sleeve Remover and position screw so it centers tool on crankshaft flange.
2. Using the slots in JDG698A Remover as a template, mark three locations on seal casing where screws should be installed for removal purposes. Remove tool from crankshaft flange.

A—Forcing Screw



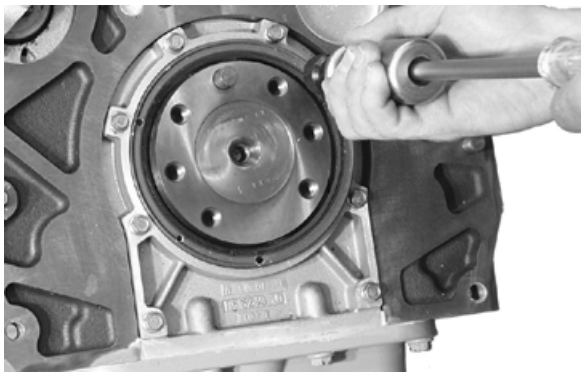
RG12923 —UN—27MAY03

Unitized Crankshaft Rear Oil Seal/Wear Sleeve Puller

RG19661,0000010 -19-09JAN07-2/4

IMPORTANT: Holes must be drilled at outer edge of seal case. Screws will pull seal against wear ring, thereby removing both pieces.

3. Drill a 3/16 in. hole through wear sleeve lip and seal casing at the three marked locations.
4. Position JDG698A Remover on end of crankshaft.



RG12925 —UN—27MAY03

Setting Puller Removal Screws

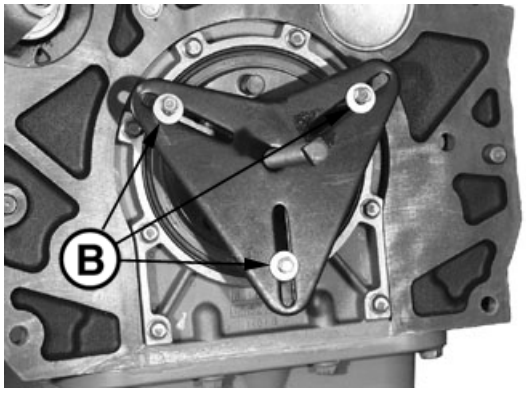
RG19661,0000010 -19-09JAN07-3/4

5. Install three 2-1/2 in. (approximate) sheet metal screws with washers (B) into slots of removal tool and thread screws into holes in seal casing. Evenly tighten screws until plate is flush with rear face of crankshaft.
6. Tighten forcing screw (plate should pull evenly against the three screws) until seal assembly is removed from engine

Remove Rear Oil Seal Housing

1. Remove rear oil seal housing cap screws.
2. Inspect seal housing for any damage and replace if required.

B—Sheet Metal Screws



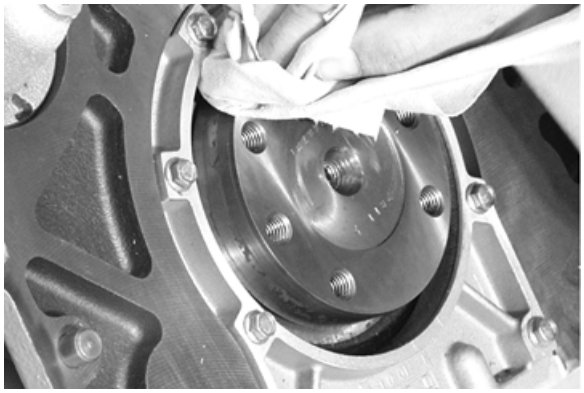
RG12924 —UN—27MAY03

Puller in Position

RG19661,0000010 -19-09JAN07-4/4

Clean and Inspect Crankshaft Flange

1. Look for nicks or burrs on wear ring surface and bore in flywheel housing. If necessary, use polishing cloth to remove nicks or burrs.
2. Clean OD of crankshaft flange and ID of flywheel housing with cleaning solvent, acetone, or any other suitable cleaner that will remove sealant, if previously applied. (Brake Kleen, Ignition Cleaner and Drier are examples of commercially available solvents that will remove sealant from flange.)



RG12922 —UN—05JUN03

Clean Crankshaft Flange

RG19661,0000011 -19-09JAN07-1/1

Install Crankshaft Rear Oil Seal Housing

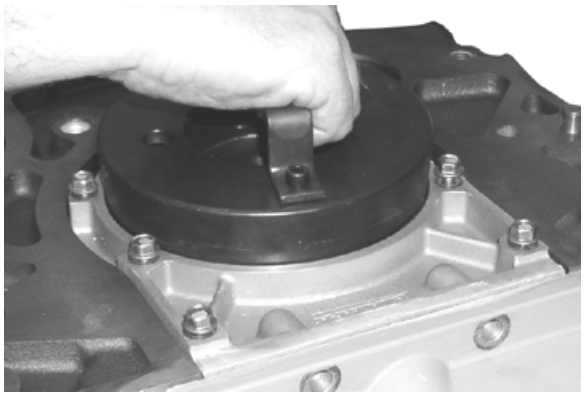
1. Look for nicks or burrs in seal housing bore. If necessary, use polishing cloth to remove nicks or burrs.
2. Clean sealing surfaces of the cylinder block and seal housing with cleaning solvent, acetone, or any other suitable cleaner that will remove sealant. (Brake Kleen, Ignition Cleaner and Drier are examples of commercially available solvents that will remove sealant from flange)
3. Apply a continuous 2.0—4.0 mm (0.08—0.16 in.) bead of LOCTITE 5910® (PM37512) silicone sealant to the mounting surface of the seal housing and place in position.

   Install all seal housing cap screws and tighten finger-tight.
4. Place JDG1703 Rear Oil Seal Housing Aligner into the seal housing bore and over the crankshaft flange to center the housing.
5. Tighten cap screws to specifications in sequence as shown.

Specification

Rear Oil Seal Housing
Cap Screws—Torque..... 17 N·m (13 lb-ft)

LOCTITE is a trademark of Loctite Corp.



RG12926 —UN—27MAY03

Rear Oil Seal Housing Aligner



RG12935 —UN—05JUN03

Rear Oil Seal Torque Sequence

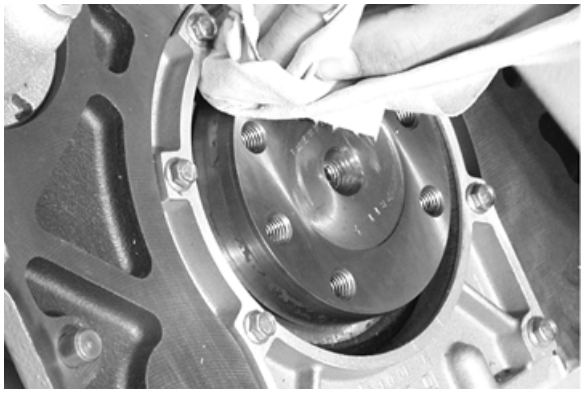
RG19661,0000035 -19-23JUL09-1/1

Install Crankshaft Rear Oil Seal

IMPORTANT: No lubrication of any kind is to contact seal when installing. Use of a lubricant may result in premature seal failure. Install seal and wear sleeve assembly immediately after removal from plastic bag to avoid possible dirt contamination.

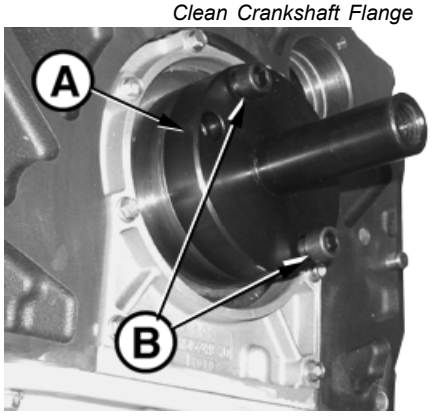
1. Clean OD of crankshaft flange and ID of seal housing with cleaning solvent, acetone, or any other suitable cleaner that will remove sealant, if previously applied. (Brake Kleen, Ignition Cleaner and Drier are examples of commercially available solvents that will remove sealant from flange.) Make sure that OD of crankshaft flange and ID of seal housing bore are free from nicks or burrs.
2. Install JT30041A Pilot (A) from the JT30040B Seal/Wear Sleeve Installer Set on end of crankshaft using two 38 mm (1-1/2 in.) socket-head cap screws. Tighten both cap screws until they touch base of pilot, then back them off approximately 1/2 turn.

A—Pilot **B—Cap Screws**



RG12922 —UN—05JUN03

Clean Crankshaft Flange



RG12928 —UN—27MAY03

Rear Oil Seal Pilot Tool

RG19661,0000012 -19-09JAN07-1/3

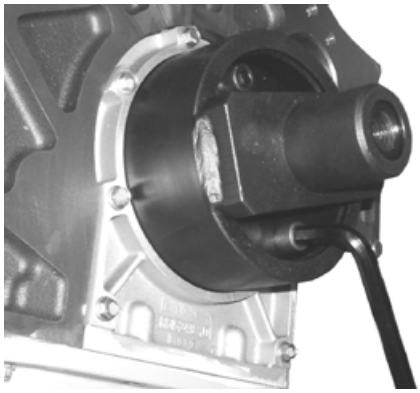
3. Install JT30042 Driver over JT30041A Pilot until driver cross-plate bottoms on pilot. This will properly center pilot with crankshaft flange.

NOTE: It may be necessary to lift up on pilot to install driver to full depth over pilot and crankshaft flange.

Tighten two pilot socket head cap screws securely. Remove driver from pilot.

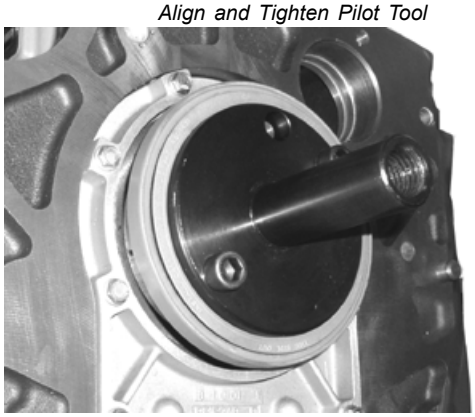
IMPORTANT: Handle the rear oil seal assembly carefully. If wear sleeve surface is scratched, gouged or any sealant (liquid) is present, order a new seal assembly.

4. Carefully start oil seal over pilot and crankshaft flange with open side of seal toward engine.



RG12929 —UN—27MAY03

Align and Tighten Pilot Tool



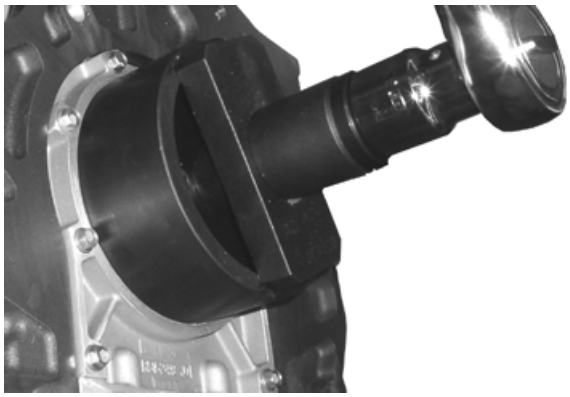
RG12930 —UN—27MAY03

Install Seal

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RG19661,0000012 -19-09JAN07-2/3

5. Attach JT30042 Driver and thrust washer to the guide plate with cap screw. Tighten the cap screw until driver bottoms on pilot.
6. Remove seal driver and pilot plate. Check that seal assembly is properly positioned on crankshaft flange and installed square in rear seal housing bore.



RG12947 —UN—05JUN03

Rear Seal Driver Tool

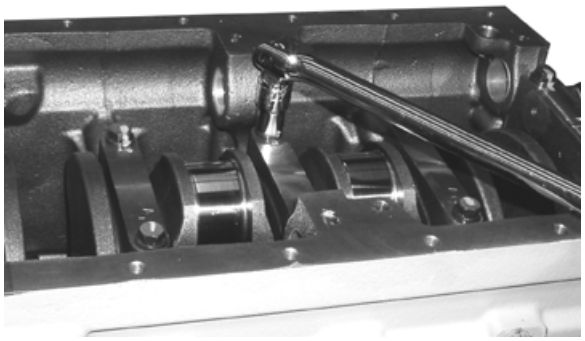


RG12944 —UN—04JUN03

RG19661,0000012 -19-09JAN07-3/3

Remove Crankshaft Main Bearings

1. Drain oil from engine crankcase and remove oil pan and oil pump pick-up tube.
2. Remove timing gear cover.
3. Remove connecting rods from crankshaft.



RG12933 —UN—03JUN03

Checking Main Bearing Cap Screw Torque

Continued on next page

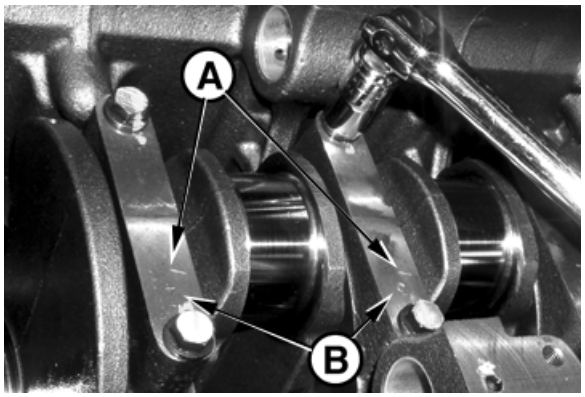
RG19661,0000014 -19-09JAN07-1/3

IMPORTANT: Before removing main bearing caps, check for proper torque on all main bearings.

NOTE: When crankshaft is to be removed, leave front and rear main bearing caps installed until all connecting rod caps have been removed.

4. Check main bearing caps for arrows (A) stamped in main bearing cap, and numbers (B) stamped on cap and oil pan rail. Arrow points toward the front of engine.

   If there are no numbers, stamp corresponding numbers on cap and oil pan rail to ensure correct placement of bearing caps during reassembly.



RG12932 —UN—03JUN03

Crankshaft Main Bearing Caps

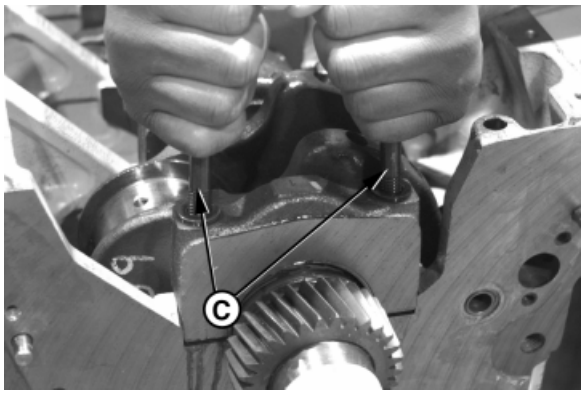
A—Stamped Arrows **B—Stamped Numbers**

RG19661,0000014 -19-09JAN07-2/3

5. Remove main bearing caps by extending cap screws (C) and forcing heads of screws together. Wiggle bearing cap back and forth while applying an upward force with cap screws until free from main bearing cap support.

IMPORTANT: Keep matched bearings with their respective main bearing cap for comparison with crankshaft journal (surface wear) from which removed.

6. Visually inspect condition of bearing inserts and crankshaft main journals as bearing caps are removed.



RG7526 —UN—05NOV97

Crankshaft Main Bearing Cap Screws

C—Cap Screws

RG19661,0000014 -19-09JAN07-3/3

Check Main Bearing Oil Clearance

NOTE: The use of PLASTIGAGE ® will determine wear (crankshaft-to-bearing oil clearance) but will not determine condition of either bearing or journal surface.

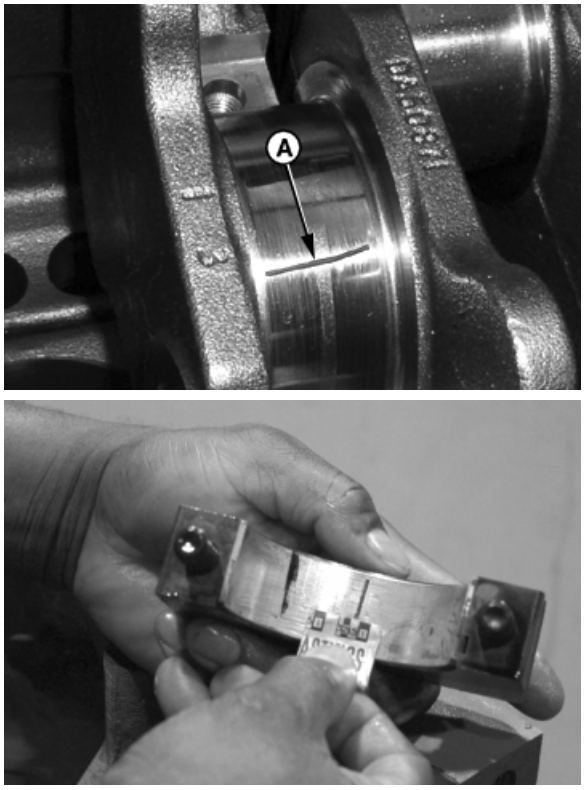
1. Place a strip of PLASTIGAGE ® (A) in the center of the main bearing cap (with insert) about three-fourths of the width of the bearing or on crankshaft journal to measure oil clearance.
2. Use clean (SAE30) oil on PLASTIGAGE ® to prevent smearing.
3. Install cap and tighten cap screws to specifications.

Specification	
Crankshaft Main Bearing Cap Screws—Torque	80 N·m (59 lb-ft)

4. Remove cap and compare width of PLASTIGAGE ® with scale provided on wrapper to determine clearance.

Specification	
Crankshaft Main Bearing-to-Journal—Oil Clearance	0.020—0.090 mm (0.0008—0.0035 in.)

PLASTIGAGE is a registered trademark of the DANA Corp.



RG12946 —UN—05JUN03

RG7528 —UN—23NOV97

Using PLASTIGAGE

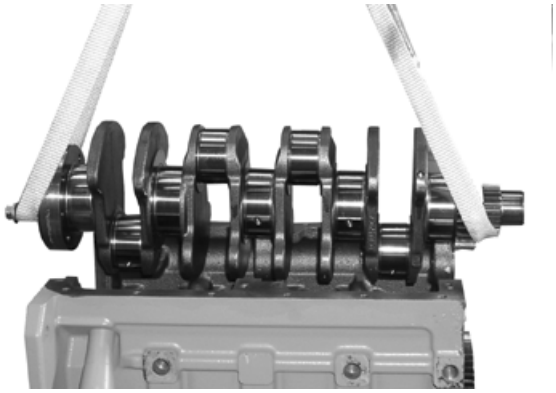
RG19661,0000015 -19-09JAN07-1/1

Remove Crankshaft

1. Remove main bearing caps and connecting rod caps, as described earlier in this group.

⚠ CAUTION: Crankshaft is heavy. Plan a proper handling procedure to avoid injury. Do not use lifting sling on connecting rod or main journals.

2. Attach a lifting sling to crankshaft. Using proper lifting equipment, carefully raise crankshaft out of cylinder block.
3. Clean crankshaft, especially oil passages, using solvent and compressed air.
4. Place crankshaft on clean V-blocks.
5. If main bearing inserts are to be replaced, remove inserts from cylinder block. Otherwise, leave bearing inserts in block until assembled ID has been measured.



RG12931 —UN—03JUN03

Remove Crankshaft from Cylinder Block

RG19661,0000016 -19-09JAN07-1/1

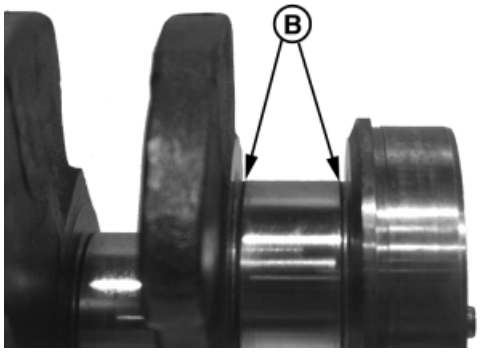
Inspect Crankshaft

NOTE: If vibration damper damage was discovered during tear down, it is recommended that the crankshaft be magna-fluxed. This will verify whether of not it has microscopic cracks or fissures. .

1. Thoroughly clean crankshaft. Clear restrictions from all oil passages.

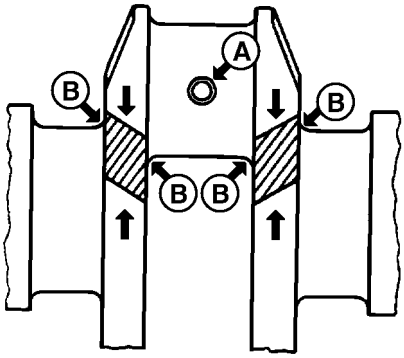
IMPORTANT: Small cracks may not be visible to the eye. Use a method such as the Fluorescent Magnetic Particle Method. This method magnetizes the crank, employing magnetic particles which are fluorescent and glow under "black light". The crankshaft must be de-magnetized after inspection.

2. Inspect crankshaft for signs of load stress, cracks, scoring, or journal scratches. Replace crankshaft if cracks are found.
3. Check each journal for evidence of excessive overheating or discoloration. If either condition exists, replace crankshaft since heat treatment has probably been destroyed.
4. Inspect front crankshaft gear for cracks, chipped teeth, or excess wear. Replace crankshaft as required.
5. Carefully inspect the rear hub of the crankshaft in the area of the wear sleeve contact surface for evidence of a rough or grooved condition. Any imperfections in this area will result in oil leakage. Slight ridges may be cleaned up with emery cloth or crocus cloth.
6. Carefully check the crankshaft for cracks in the area of rod journal holes (A) and at journal fillets (B). Replace crankshaft if any cracks are found.



RG7536B —UN—05NOV97

Crankshaft Main Bearing Journal Fillets



RGCD7147 —UN—30OCT97

Crankshaft Rod Bearing Journal Holes/Fillets

A—Rod Journal Hole **B—Journal Fillets**

RG19661,0000017 -19-09JAN07-1/1

Measure Crankshaft Journals and Main Bearing ID

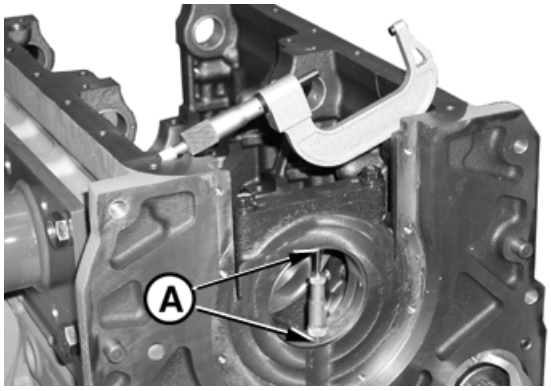
1. With crankshaft removed from engine, assemble main bearing caps with bearing inserts. Be sure inserts are installed correctly.
2. Tighten main bearing cap screws to specifications.

Specification	
Main Bearing Cap Screws—Torque	80 N·m (59 lb-ft)

3. Measure and record main bearing assembled ID (A) at several points with an inside micrometer.
4. Measure and record crankshaft main journal OD (B) and rod journal OD (C) at several points around each journal.
5. Compare measurements with specifications given below.

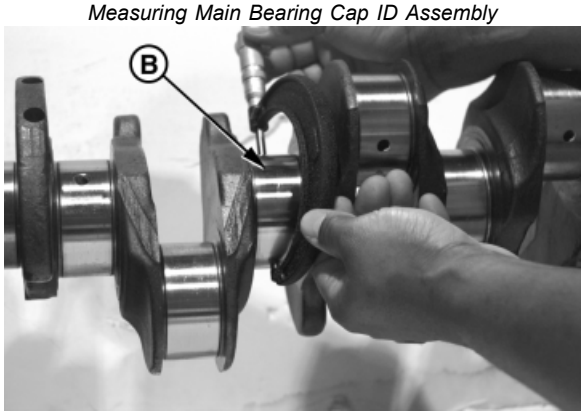
Specification	
Crankshaft Main Bearing—ID	75.034—75.077 mm (2.9541—2.9558 in.)
Crankshaft Main Journal—OD	74.987—75.013 mm (2.9522—2.9533 in.)
Crankshaft Rod Journal—OD	59.987—60.013 mm (2.36170—2.3627 in.)
Crankshaft Main Bearing-to-Journal—Oil Clearance	0.021—0.090 mm (0.0008—0.0035 in.)
Crankshaft Main or Rod Journal—Maximum Taper	0.010 mm (0.0004 in.)
Crankshaft Main or Rod Journal—Maximum Out-of-Round	0.008 mm (0.0003 in.)

Replace crankshaft if it does not fall within above specifications.



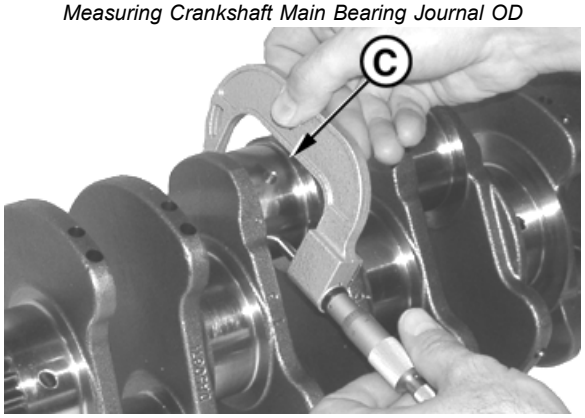
RG12674 —UN—03JUN03

Measuring Main Bearing Cap ID Assembly



RG7538 —UN—05NOV97

Measuring Crankshaft Main Bearing Journal OD



RG12777 —UN—04JUN03

Measuring Crankshaft Rod Bearing Journal OD

A—Main Bearing ID
B—Main Journal OD
C—Rod Journal OD

RG19661,0000018 -19-09JAN07-1/1

Crankshaft Grinding Guidelines

IMPORTANT: Crankshaft grinding should be done ONLY by experienced personnel on equipment capable of maintaining crankshaft size and finish specifications. Undercut and rolled fillets (A) have taken the place of ground (tangential) fillets. DO NOT grind within this undercut area when undersize bearings are used.

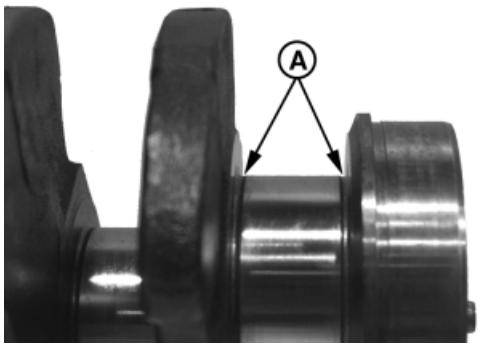
Crankshafts have micro-finished journal surfaces.

IMPORTANT: If undersize bearings are installed, recheck bearing-to-journal clearance. If oil clearance is not within specifications, premature wear of bearings and journals will result.

If the crankshaft is to be reground, use the following recommended guidelines:

1. Compare the crankshaft journal measurements taken during inspection and determine the size which the journals are to be reground.
2. Grind all main journals or all connecting rod journals to the same required size.

IMPORTANT: Care must be taken to avoid localized heating which often produces grinding cracks. Use coolant generously to cool the crankshaft while grinding. DO NOT crowd the grinding wheel into the work. Grind crankshaft with journals turning counterclockwise, as viewed from the front end of the crankshaft. Lap or polish journals in opposite direction of grinding.



RG7536A —UN—23NOV97

Crankshaft Main Bearing Journal Fillets

A—Fillets

3. Polish or lap the ground surfaces to the specified finish to prevent excessive wear of the journals.
4. Stone the edge of all oil holes in the journal surfaces smooth to provide a radius of approximately 1.50 mm (0.060 in.).
5. When finished grinding, inspect the crankshaft by the fluorescent magnetic particle method, or other similar method to determine if cracks have originated due to the grinding operation.
6. De-magnetize the crankshaft after inspection.
7. Thoroughly clean the crankshaft and oil passages with solvent. Dry with compressed air.

RG,15,DT7437 -19-09JAN07-1/1

Crankshaft Grinding Specifications

Bearing Size	Crankshaft Main Journal OD	Crankshaft Rod Journal OD
Standard	74.987—75.013 mm (2.952—2.953 in.)	59.987—60.013 mm (2.3616—2.3627 in.)
0.25 mm (0.010 in.) Undersize	74.733—74.759 mm (2.9422—2.9433 in.)	59.733—59.759 mm (2.3516—2.3527 in.)

Main and Connecting Rod Journal Surface Finish (AA)	Lap 0.20 µm (8 AA)
Thrust Surface Finish (AA)	Lap 0.40 µm (16 AA)
Thrust Bearing Journal Width	31.302—31.378 mm (1.2324—1.2353 in.)
Direction of Crankshaft Rotation (viewed from flywheel end):	
Grinding	Clockwise
Lapping	Counterclockwise
Engine Stroke	105 mm (4.1338 in.)
Main Journal Maximum Runout (Concentricity) Relative to End Journals	0.080 mm (0.0034 in.)
Main Journal Maximum Runout (Concentricity) Between Adjacent Journals	0.050 (mm (0.0020 in.)

RG,15,DT7435 -19-09JAN07-1/1

Measure Main Thrust Journal Width and Thrust Washers

1. Inspect thrust surfaces of the thrust washers and the thrust bearing journal on crankshaft and replace as necessary.

   Measure and record crankshaft main thrust journal width.

   If crankshaft thrust journal width is not within specifications, replace crankshaft.

2. Measure and record thickness of main thrust washer.



RG12792 —UN—05JUN03

Measuring Main Thrust Journal Width

Specification

Crankshaft Main Thrust Bearing Journal Width—Width.....31.302—31.378 mm (1.2340—1.2350 in.)

Crankshaft Main Thrust Washer—Overall Thickness.....2.95—3.05 mm (0.120—0.116 in.)

RG19661,0000019 -19-09JAN07-1/1

Measure Assembled ID of Main Bearing Caps

1. Remove bearing inserts from caps and cylinder block. Keep inserts in correct order if they are to be reused.
2. Clean and inspect caps for damage. Small burrs or nicks on flat surfaces may be removed with a file. Use a medium-grit polishing cloth to dress curved bearing surfaces.
3. Install bearing caps (without bearings) in cylinder block. Tighten cap screws to specifications.

Specification

Main Bearing Cap Screws—Torque..... 80 N·m (59 lb-ft)

4. Measure ID of bearing cap bores.

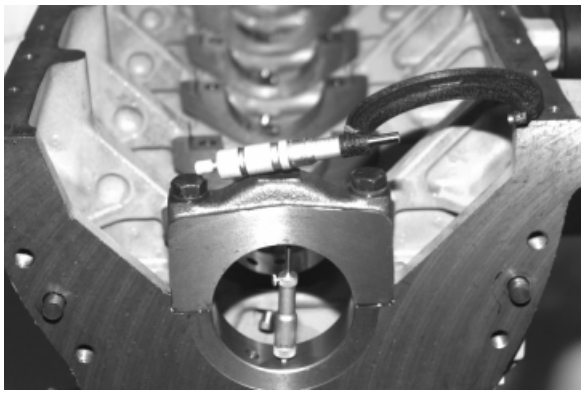
Specification

Crankshaft Main Bearing Bore (Without Bearings)—ID.....79.892—79.918 mm (3.1454—3.1464 in.)

Crankshaft Main Bearing Bore Centerline-to-Top Deck—Distance.....274.960—275.040 mm (10.8252—10.8283 in.)

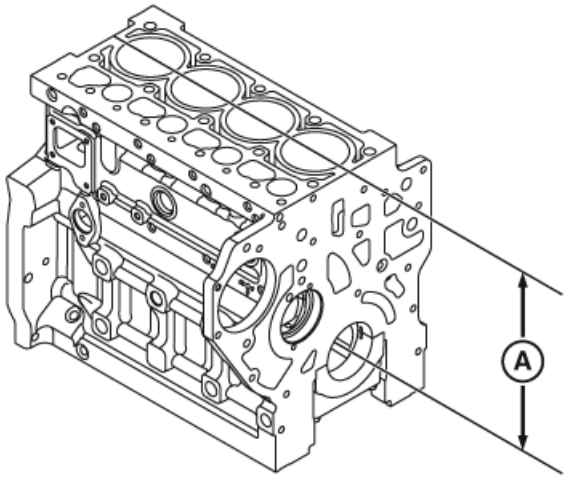
5. If bearing caps are damaged or bore is not within specification, replace cylinder block.

A—Top Deck-to-Centerline Bearing Bore



RG7537 —UN—23NOV97

Measuring Assembled Main Bearing Cap ID



RG16329 —UN—22JUL09

Cylinder Block to Crankshaft Centerline

RG19661,000001C -19-23FEB09-1/1

Install Main Bearings, Thrust Washers and Crankshaft

IMPORTANT: If new main bearings or thrust washers are installed, they must be installed as a matched set.

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

- All main bearing webs in block
- Both sides of main bearings and thrust washers
- Entire O.D. of crankshaft main bearing journals

1. Install upper main bearing inserts in block. Be sure locating tabs (A) on inserts are properly positioned with slot in block web and that holes in the main bearing web are aligned with oil holes in the bearing inserts.

CAUTION: Crankshaft is heavy. Plan a proper lifting procedure to avoid injuries. Do not use lifting sling on connecting rod or main journals.

2. Carefully position crankshaft onto main bearing inserts using a hoist and lift sling.
3. Lubricate the thrust washers with clean engine oil. Install the front and rear thrust washers (C) into the thrust cavity between the cylinder block upper web and the crankshaft with the profiled surfaces facing the crankshaft.

NOTE: Thrust bearing must be installed with slots facing crankshaft flanges in the upper cylinder block web.

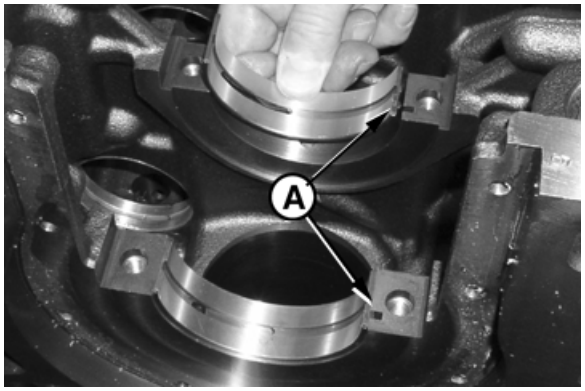
IMPORTANT: Always use new main bearing cap screws.

4. Dip entire main bearing cap screws in clean engine oil and position them in main bearing caps. Apply a liberal amount of oil to bearing inserts in caps.
5. Install each bearing cap (B), bearings, and cap screws (E) with the recesses and tabs aligned in matching order. Make sure bearing tabs also match up before tightening cap screws.

NOTE: Make sure main bearing caps are installed on the bearing bosses from which they were removed. The numbers stamped on the caps are in numerical order from the front of the engine. The arrow should point to the front of the engine (D).

IMPORTANT: Do not use pneumatic wrench to install main bearing cap screws, as damage may occur to threads.

6. Before tightening cap screws on main bearing caps, insure the thrust bearings are retained by the thrust bearing cap.
7. Tighten all main bearing cap screws to specified torque.



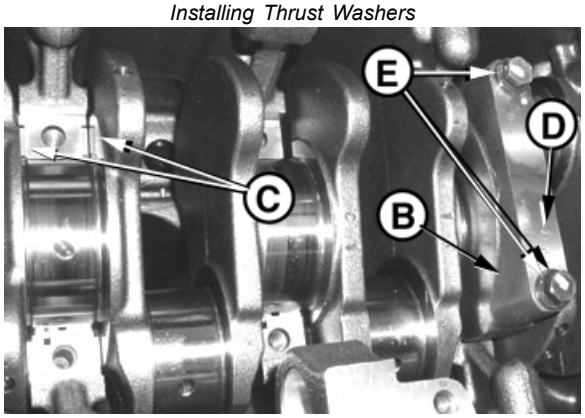
RG12794 —UN—03JUN03

Installing Main Thrust Bearings



RG12796 —UN—04JUN03

Installing Thrust Washers



RG12934 —UN—04JUN03

Installing Main Bearing Caps



RG12797 —UN—04JUN03

Tighten Main Bearing Cap Screws

A—Locating Tabs
B—Bearing Cap
C—Thrust Washer
D—Stamped Number and Direction Arrow Location
E—Cap Screws

Continued on next page

RG,RG34710,1181 -19-09JAN07-1/2

Specification

Crankshaft Main Bearing
Cap Screws—Torque..... 80 N·m (59 lb-ft)

8. Turn crankshaft by hand. If it does not turn easily, disassemble parts and determine the cause.
9. Check crankshaft for specified end play.

Specification

Crankshaft—End Play.....0.089—.396 mm (0.004—0.016 in.)

RG,RG34710,1181 -19-09JAN07-2/2

Install Flywheel Housing

1. Inspect and clean cylinder block and flywheel housing and mating surfaces.

CAUTION: The flywheel housing is heavy. Plan a proper handling procedure to avoid injuries.

2. Install flywheel housing on cylinder block and tighten cap screws (A) to specifications.

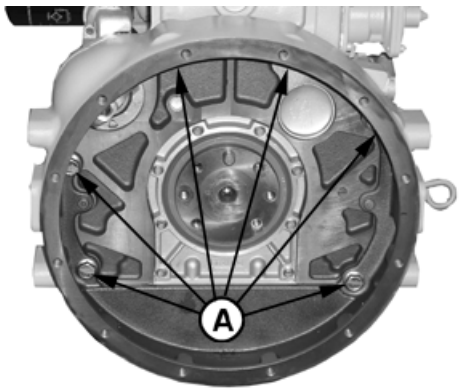
Specification

Initial Flywheel Housing
Cap Screws—Torque..... 35 N·m (26 lb-ft)

Specification

Final Flywheel Housing
Cap Screws—Torque..... 140 N·m (105 lb-ft)

NOTE: Some flywheel housings may use a sheet metal plate as part of the enclosure, install as necessary.



RG12826 —UN—03JUN03

Flywheel Housing

A—Cap Screws

RG19661,000001F -19-09JAN07-1/1

Install Flywheel

CAUTION: Flywheel is heavy. Plan a proper handling procedure to avoid injuries.

IMPORTANT: Flywheel MUST BE clean and free of any oil, grease or debris.

1. Install two guide studs (A) in crankshaft cap screw threaded holes. Place flywheel on studs and slide into position against crankshaft.

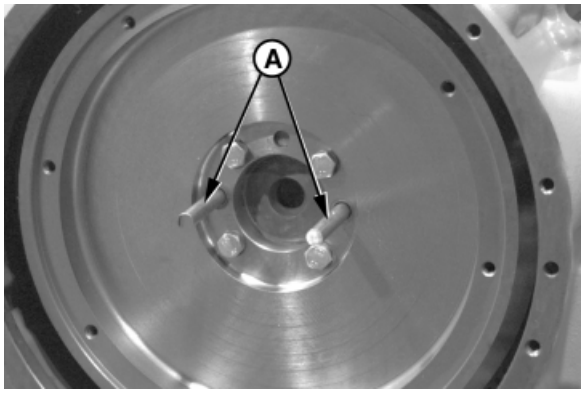
IMPORTANT: ALWAYS use new flywheel cap screws when flywheel has been removed. Inspect cap screws to insure they have sealant. If required, apply LOCTITE 242® Thread Lock and Sealer (Medium Strength) to cap screws threads.

2. Start cap screws in crankshaft. Do not tighten until guide studs are removed and all cap screws are started. Insert JDG1571 Timing Pin to prevent crankshaft rotation. Tighten cap screws in a cross-shaped sequence to specifications.

Specification

Initial Flywheel Mounting
Cap Screws—Torque..... 30 N·m (20 lb-ft)

LOCTITE is a trademark of Loctite Corp.



RG7518A —UN—05NOV97

Flywheel and Guide Studs

A—Guide Studs

Specification

Final Flywheel Mounting
Cap Screws—Torque.....110 N·m (80 lb-ft)

RG19661,000000E -19-26APR07-1/1

Remove Timing Gear Cover

IMPORTANT: Whenever the aluminum timing gear cover or water pump are replaced, the cooling system should be flushed and serviced. Ensure system, including radiator, is completely drained.

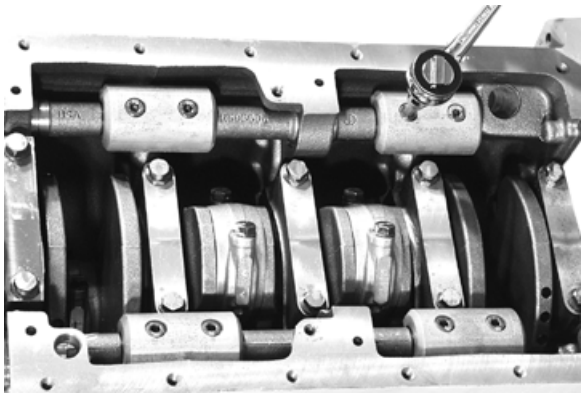
1. Drain coolant from cooling system.
2. Drain oil from engine crankcase.
3. Remove fan.
4. Release fan belt tensioner and remove fan belt.
5. Remove fan belt tensioner.
6. Remove alternator and alternator mounting bracket.
7. Remove fan pulley.
8. Remove water pump.
9. Remove crankshaft pulley/damper.
10. Remove oil pan.
11. Remove oil pump pick-up tube.
12. Remove timing gear cover.

RG19661,0000002 -19-09JAN07-1/1

Remove Balancer Shafts (If Equipped)

1. Rotate crankshaft until balancer weight cap screws point straight down into the oil pan.
2. Remove weights from balancer shafts.

IMPORTANT: Identify left and right balancer shafts for correct assembly. Permanently mark a letter "R" or letter "L" on the thrust plate for identification.



RG13037 —UN—16JUL03

Remove Balancer Weights

RG19661,0000011 -19-09JAN07-1/2

3. Remove two cap screws from balancer shaft thrust plate.

NOTE: When removing balancer shafts, use caution to insure shaft journals and bushings are not damaged.

4. Carefully remove balancer shafts.



RG13039 —UN—16JUL03

Remove Balancer Shaft

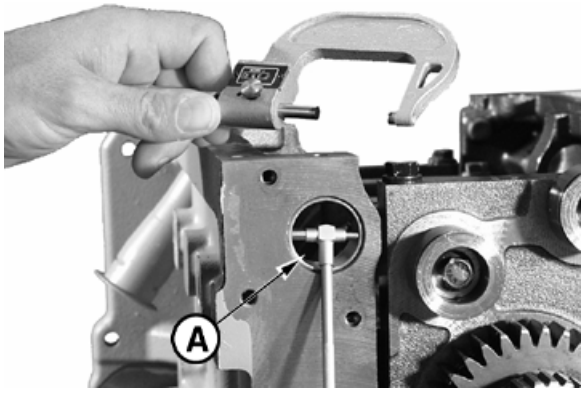
RG19661,0000011 -19-09JAN07-2/2

Inspect and Measure Balancer Shaft Bushings and Journals

1. Inspect, measure and record bushing ID (A) at all locations.
2. Measure balancer shaft journal OD (B). Difference between journal OD and bushing ID is oil clearance.

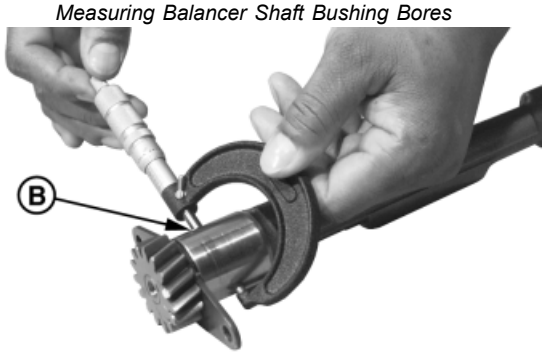
   If oil clearance is not within specification, install new bushings and, if necessary, new balancer shaft.

Specification	
Balancer Shaft Bushing (New)—ID	30.038—30.104 mm (1.1826—1.1852 in.)
Balancer Shaft Journal —OD	29.987—30.013 mm (1.1806—1.1816 in.)
Balancer Shaft Journal-to-Bushing —Oil Clearance	0.025—0.117 mm (0.0009—0.0046 in.)
Cylinder Block Bore for Balancer Shaft Bushing—ID	33.500—33.526 mm (1.3189—1.3199 in.)



RG13626 —UN—19MAY04

Measuring Balancer Shaft Bushing Bores



RG7706 —UN—07NOV97

Measuring Balance Shaft Journal OD

A—Bushing ID **B—Journal OD**

RG19661,0000012 -19-09JAN07-1/1

Inspect Balancer Shaft Gears and Thrust Plates

1. Inspect for broken, cracked or excessively worn gears. Replace balancer shaft assembly if defects are found.
2. Inspect thrust plate (A) for scoring, excessive wear and cracks. Replace balancer shaft assembly if defects are found.

Specification	
Balancer Shaft Thrust Plate (New)—End Play	Not to exceed 0.45 mm (0.02 in.)

RG7708 —UN—07NOV97



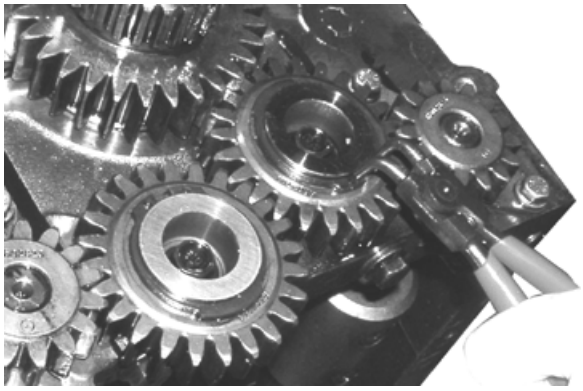
Balancer Shaft Thrust Plate

A—Thrust Plate

RG19661,0000014 -19-09JAN07-1/1

Remove, Inspect and Install Balancer Idler Gears and Shafts (If Equipped)

1. Remove snap ring.



Remove Balancer Idler Gear

RG19661,0000015 -19-09JAN07-1/2

2. Remove idler gears and inspect for worn bushings, chipped or cracked gear teeth and worn or scored idler shafts.
3. If the idler gear shaft does not meet specifications, remove from the main bearing cap. Idler shaft cap screw may be reused if the screw and main bearing cap threads are free of oil and debris. Install new idler shaft, apply LOCTITE 242® to cap screw and tighten to specification.

Specification

Idler Shaft Cap Screw—Torque..... 40 N·m (30 lb-ft)

4. Apply TY6333 High-Temperature Grease to the idler shaft, assemble idler gear on the balancer idler shaft and install snap ring.

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Balancer Idler Gear

RG19661,0000015 -19-09JAN07-2/2

Measure Idler Gear Bushing and Shaft

Measure idler gear bushing ID and shaft OD to determine oil clearance. Replace worn parts if measurements exceed specifications.

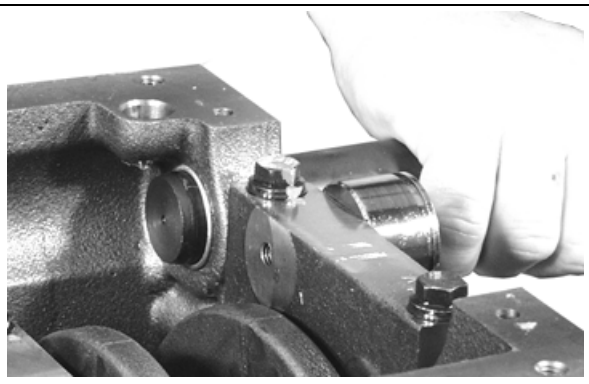
Specification

Idler Gear Bushing —ID..... 38.586—38.662 mm (1.5191—1.5221 in.)
Idler Gear Shaft —OD..... 38.517—38.543 mm (1.5164—1.5174 in.)

RG19661,0000017 -19-09JAN07-1/1

Remove Balancer Bushings

1. Using JDG1691-3 Driver, remove the front balancer shaft bushing from the cylinder block.

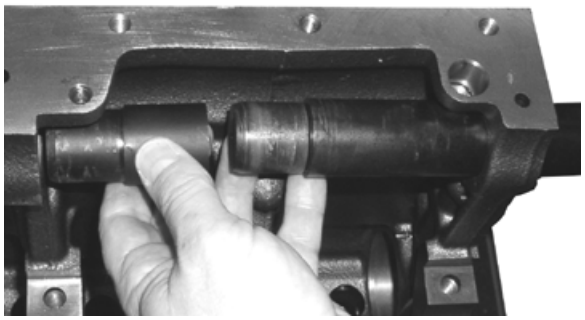


Remove Front Balancer Shaft Bushing

Continued on next page

RG19661,0000036 -19-09JAN07-1/3

2. Remove bushing from driver and place JDG1691-2 Driver Extension on JDG1691-1 Driver.

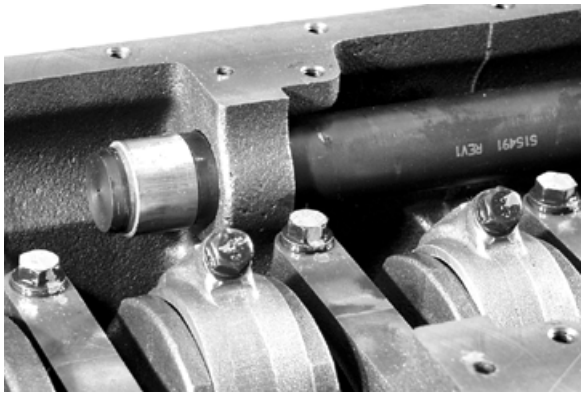


RG13043 —UN—16JUL03

Rear Balancer Bushing Driver Extension

RG19661,0000036 -19-09JAN07-2/3

3. Remove the rear balancer bushing with JDG1691-3 Driver and JDG1691-2 Driver Extension.



RG13042 —UN—16JUL03

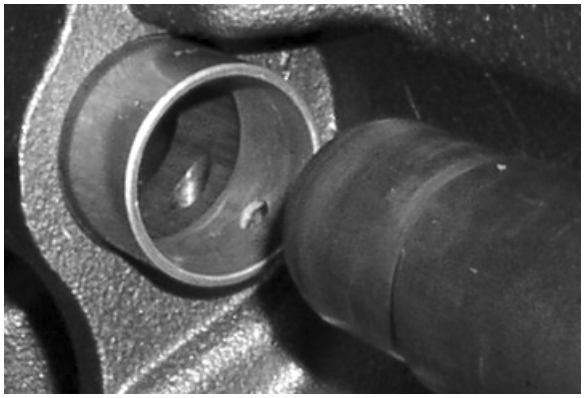
Remover Rear Balancer Bushing

RG19661,0000036 -19-09JAN07-3/3

Install Balancer Bushings

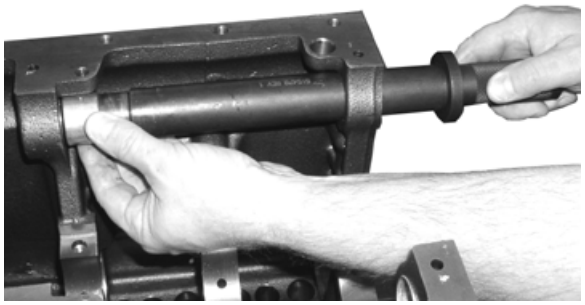
IMPORTANT: On balancer shaft equipped engines, make sure oil holes in bushing and block are aligned for proper bushing and journal lubrication.

1. Lubricate rear balancer bushing with clean engine oil and install with JDG1691-3 Driver until the tool shoulder hits the front face of the cylinder block.
2. Lubricate the front balancer bushing with clean engine oil and install with JDG1691-1 Driver until the tool shoulder hits the front face of the cylinder block.
3. Inspect bushings to insure oil holes are in alignment.



RG13046 —UN—16JUL03

Align Oil Supply Holes



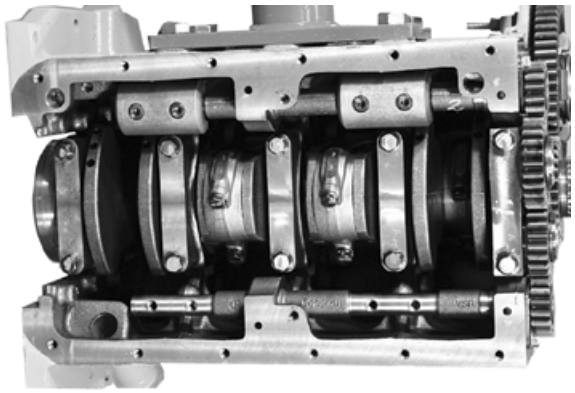
RG13044 —UN—16JUL03

Install Rear Balancer Shaft Bushing

RG19661,0000046 -19-09JAN07-1/1

Install Balancer Shafts (If Equipped)

1. Using JDG1571 Timing Pin, lock No. 1 piston at TDC compression stroke.



RG13625 —UN—16APR04

Orient Balancer Weights

Continued on next page

RG19661,000001B -19-09JAN07-1/2

2. Lubricate balancer shaft bushings and journals with TY6333 High-Temperature Grease.

NOTE: When installing balancer shafts, use caution to insure shaft journals and bushings are not damaged.

IMPORTANT: The counterbore cap screw holes for the balancer weights should be orientated directly down in to the oil pan with the crankshaft at the TDC position.

3. Install balancer shafts assemblies by engaging the balancer gear with the idler gear.
4. Tighten thrust plate cap screws to specifications.

Specification	
Balancer Shaft Thrust Plate Cap Screws—Torque	16 N·m (12 lb-ft)

5. Install balancer weights and tighten cap screws to specifications.



RG13039 —UN—16JUL03

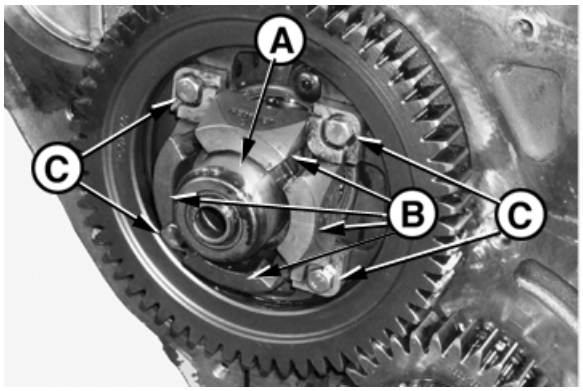
Install Balancer Shafts

Specification	
Balancer Shaft Weight Cap Screws—Torque	33 N·m (25 lb-ft)

RG19661,000001B -19-09JAN07-2/2

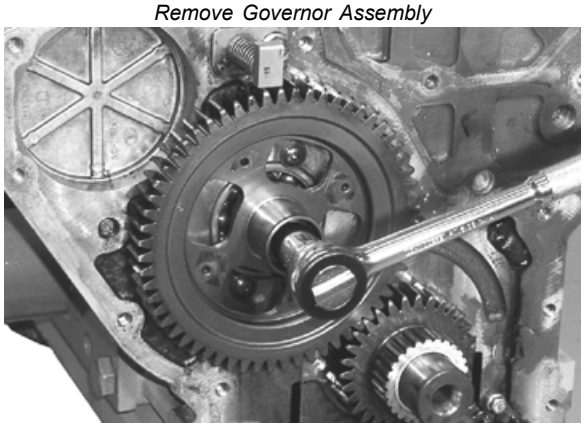
Remove Governor Assembly and Camshaft Drive Gear

1. Rotate crankshaft to set the No. 1 piston at TDC and pin the flywheel using JDG1571 Timing Pin.
2. Before removing the governor assembly, check for proper operation. Governor control collar (A) should slide without binding and flyweights (B) should rotate freely.
3. Remove governor assembly cap screws (C) and remove governor assembly.
4. Remove cam gear cap screw, cam gear and friction washer from camshaft.



RG13056 —UN—29JUL03

Remove Governor Assembly



RG13050 —UN—22JUL03

Remove Camshaft Gear

RG19661,0000037 -19-21MAR03-1/1

Remove Camshaft

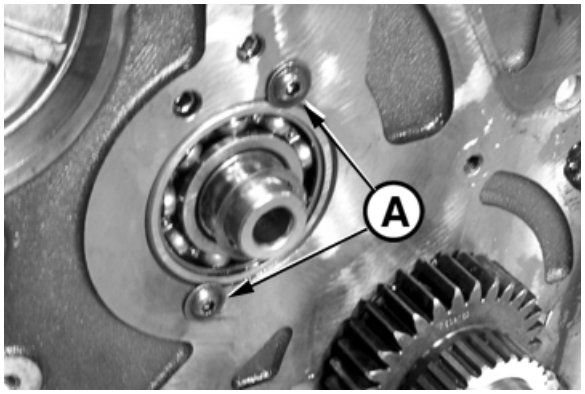
1. Remove rocker arm assemblies, push rods and camshaft followers. Note parts location for installation back to original position.

   Remove fuel transfer pump and push rod.

2. Remove two special screws (A) holding the front camshaft bearing assembly in place.

IMPORTANT: DO NOT allow camshaft lobes to drag in bushing or honed bores by rotating camshaft.

3. Carefully remove camshaft with front bearing assembly from cylinder block.



RG13051 —UN—23JUL03

Camshaft Bearing Retaining Screws

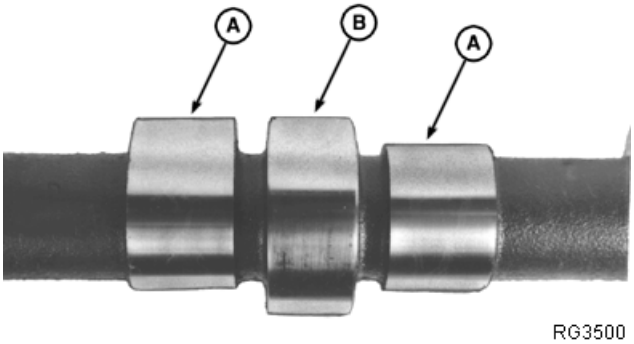
RG19661,0000009 -19-12SEP07-1/1

Inspect Camshaft

1. Clean camshaft in solvent. Dry with compressed air.
2. Inspect all camshaft lobes (A) and journals (B) for wear or damage. Replace camshaft, if required.
3. Inspect camshaft gear for broken, cracked or excessively worn teeth. Replace camshaft, if required.

IMPORTANT: New camshaft followers can be used with old camshaft. DO NOT reuse old camshaft followers with a new camshaft.

NOTE: Very light score marks are acceptable if valve lift is within specification. If pitting or galling exists, replace camshaft.



RG3500 —UN—03NOV97

Camshaft Lobe Inspection

A—Lobes **B—Journal**

RG19661,000000A -19-09JAN07-1/1

Inspect and Measure Camshaft Bushing ID and Journal OD

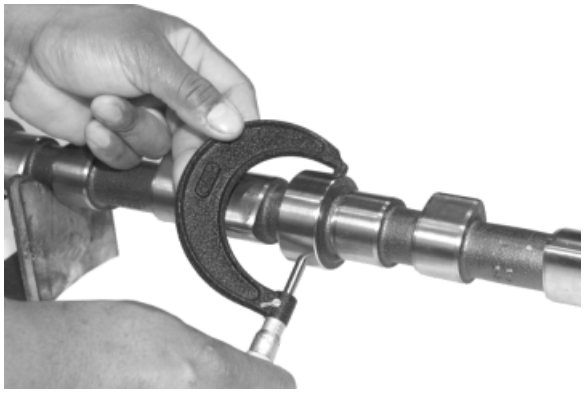
All engine camshafts have a (replaceable) bushing installed in No. 1 (front) camshaft bore.

1. Measure camshaft journals. If a camshaft journal is damaged or does not meet specification, install a new camshaft.
2. Measure camshaft bushing ID and remaining bores in cylinder block. If camshaft bore is damaged or is not within specification, have a qualified machine shop install new bushings.

   If No. 1 camshaft bushing ID does not meet specifications, replace camshaft bushing.

Camshaft Bearing Bores and Journals—Specification

Camshaft Journals—OD	59.987—60.013 mm (2.3617—2.3627 in.)
Camshaft Journal, Front No. 1 (Ball Bearing)—OD	35.004—35.020 mm (2.2031—2.2042 in.)
Camshaft Bushings—ID	60.051—60.127 mm (2.3642—2.3672 in.)
Camshaft Journal-to-Bushing—Oil Clearance	0.038—0.140 mm (0.0015—0.0055 in.)



RG7566 —UN—23NOV97

Measuring Camshaft Journal OD

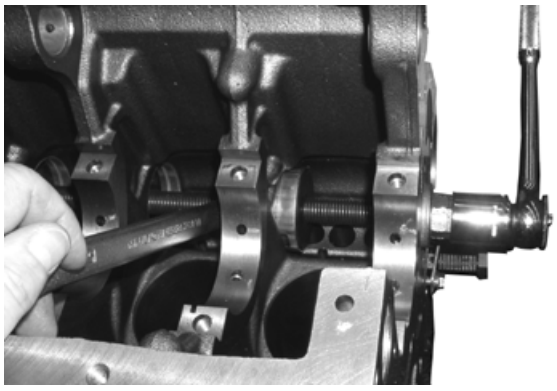
RG19661,000000C -19-09JAN07-1/1

Remove and Install Camshaft Bushings

Remove Camshaft Bushings

IMPORTANT: Block must be replaced if camshaft bore is damaged. Be careful when removing or installing bushing. Cylinder block bore may be damaged if puller is not properly piloted in bushing. Be sure puller is properly piloted before pulling bushing.

1. Using JDG1694 Cam Bushing tools, insert 313793 Forcing Screw through JDG1694-3 Front Guide Bushing and first bearing.
2. Install JDG1694-2 Installer, washer and hex nut. Tighten hex nut until bushing is free of block bore. Remove puller and discard bushing.
3. Repeat procedure for the remaining bearings, moving the tool from bore-to-bore. JDG1694-2 Rear Guide can be used to remove the last bearing.



RG13562 —UN—25FEB04

Remove Cam Bushings

4. Clean and inspect bores in cylinder block. If bore is damaged, replace cylinder block.

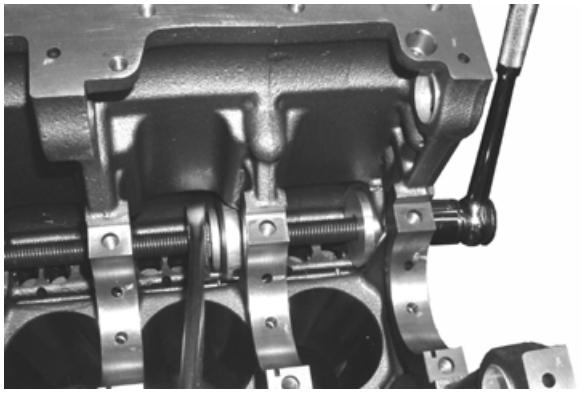
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RG19661,0000003 -19-09JAN07-1/2

Install Camshaft Bushings

IMPORTANT: Bushings must be installed so oil supply hole in bushing aligns with oil drilling in block bore.

1. Mark orientation of oil supply hole on front face of block and on bushing to help with bushing alignment during installation.
2. Apply TY6333 High-Temperature Grease to ID and OD of new bushing and to ID of bushing bore. Slide bushing onto JDG1694 Bushing Installer so notched end of bushing will be toward front end of engine when installed.
3. Thread JDG1694 Bushing Installer on 313793 Forcing Screw. With bushing started, square in bore and oil hole aligned, tighten nut until flange of bushing driver bottoms against face of block.
4. Remove bushing tool and forcing screw from cylinder block and check oil supply hole for correct alignment.



RG13561 —UN—25FEB04

Install Cam Bushings

If holes are not aligned, remove and discard bushing. Install a new bushing.

5. Repeat for remaining bushings, and insure that oil supply holes are aligned.

RG19661,0000003 -19-09JAN07-2/2

Measure Camshaft Lobe Height

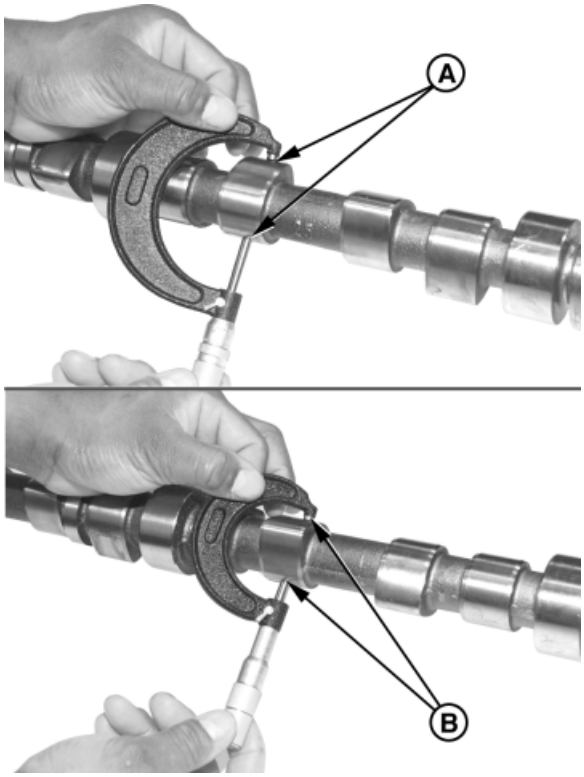
1. Measure each camshaft lobe at highest point (A) and at narrowest point (B). The difference between these dimensions is camshaft lobe height. If height is not within specification on any lobe, install a new camshaft.

Specification	
Camshaft Intake Lobe—Height	7.05—7.31 mm (0.278—0.288 in.)
Camshaft Exhaust Lobe—Height	6.89—7.15 mm (0.271—0.281 in.)

2. Measure fuel supply pump camshaft lobe diameter. If diameter is not within specification or lobe surface is grooved, install a new camshaft.

Specification	
Fuel Supply Pump Camshaft Lobe —Diameter	42.67—42.93 mm (1.68—1.69 in.)

A—High Point **B—Narrow Point**



RG7567 —UN—05NOV97

Measuring Camshaft Lobe Height

RG19661,000000D -19-09JAN07-1/1

Inspect Camshaft Followers

1. Inspect followers for uneven wear or damage. Also inspect corresponding camshaft lobe for wear or damage. Replace as necessary.
2. Remove oil from followers using JDG1678 Hydraulic Lifter Bleed-down Tool. Insure the push rod seat will compress smoothly without binding.
3. Measure follower OD and follower bore ID in cylinder block.

Specification

Camshaft Follower—OD	21.387—21.405 mm (0.8420—0.8427 in.)
Camshaft Follower Bore—ID	21.428—21.454 mm (0.8436—0.8446 in.)
Camshaft Follower-to-Bore—Clearance	0.023—0.067 mm (0.0009—0.0026 in.)

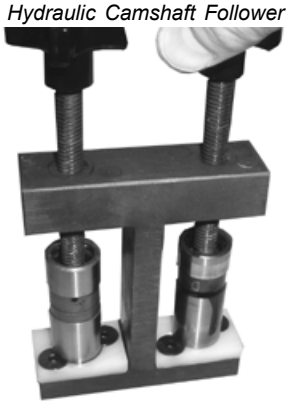
Replace camshaft followers that are not within specification.

Replace cylinder block if any one camshaft follower bore is not within specification.



RG13048 —UN—22JUL03

Hydraulic Camshaft Follower



RG12858 —UN—08MAY03

JDG1678 Hydraulic Bleed-Down Tool

RG19661,000000F -19-09JAN07-1/1

Install Camshaft

1. Lubricate camshaft bearing journals, lobes, and followers with TY6333 High-Temperature Grease.

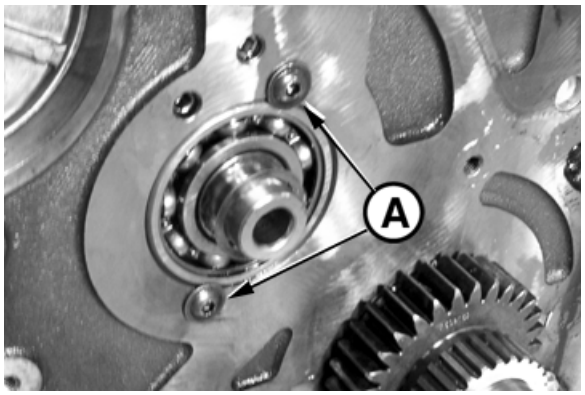
IMPORTANT: DO NOT allow camshaft lobes to drag on camshaft bore or bushing surfaces while installing camshaft. Bearing surfaces may become scratched or scored. Rotate camshaft during installation to avoid obstruction in any bore.

2. Install camshaft and bearing assembly in cylinder block. Insure bearing is seated completely in the cylinder block.
3. Apply LOCTITE 242® to special camshaft retaining screws and tighten to specifications.

Specification

Camshaft Retaining Screws—Torque	15 N·m (11 lb-ft)

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LOCTITE is a trademark of Loctite Corp.



RG13051 —UN—23JUL03

Camshaft Bearing Retaining Screws

4. Apply LOCTITE 277® to cup plug and install in the cylinder block rear flange.

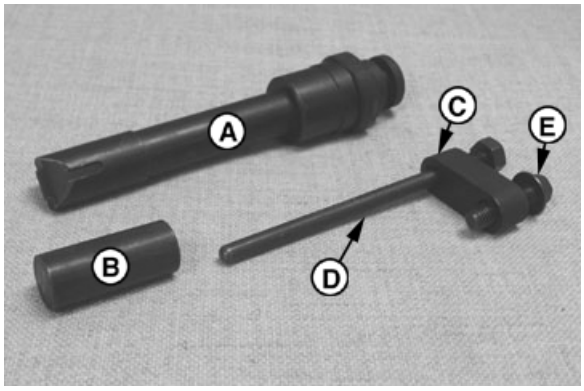
RG19661,000001C -19-09JAN07-1/1

Time Camshaft

1. Locate true TDC of the No. 1 piston by using a dial indicator and/or timing wheel. See MEASURE PISTON PROTRUSION - LOCATE TDC in Section 03, Group 030. Secure flywheel to cylinder block rear flange with a large C-clamp to prevent crankshaft rotation.

IMPORTANT: JDG1700-5-1 Gauge is a precision tool machined to duplicate the injection pump and follower position for start of fuel injection. It should be handled with care to avoid damage.

2. Install JDG1700-5-1 Timing Gauge (A) in the Number 1 injection pump bore in the cylinder bloc. Secure gauge in the cylinder block using the injection pump hold-down clamp and cap screw.
3. Rotate the camshaft **counter-clockwise**, viewed from the front of the engine, until the camshaft stops against the timing tool.
4. Place JDG1700-5-2 (B) Cam Follower in the last **exhaust** camshaft follower bore (Number 4 or Number 5) in the cylinder block.
5. Install JDG1700-3 (C) Lock Plate on the cylinder block for the last (Number 4 or Number 5) cylinder using the injection pump clamp cap screw hole. Do not tighten lock plate cap screw at this time.
6. Assemble JDG1700-2 (B) Forcing Screw through JDG1700-3 Lock Plate until it contacts JDG1700-5-2 Cam Follower. Tighten lock plate cap screw. Slowly tighten the forcing screw down on the follower tool. The camshaft will now be prevented from rotation in either direction.



RG13560 —UN—25FEB04

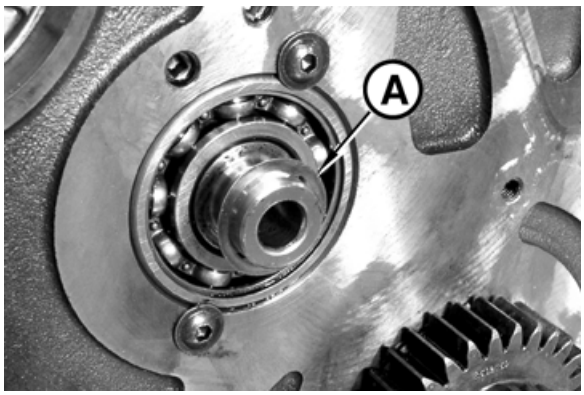
JDG1700 Camshaft Timing Tools

A—JDG1700-5-1 Timing Gauge
B—JDG1700-5-2 Cam Follower
C—JDG1700-3 Lock Plate
D—JDG1700-2 Forcing Screw
E—Lock Plate Cap Screw

IMPORTANT: Always use a new friction washer and cap screw when installing camshaft gear.

RG19661,0000038 -19-24SEP04-1/3

7. Install friction washer (A) on camshaft nose.
8. Assemble camshaft gear on the camshaft while engaging the crankshaft gear teeth



RG13692 —UN—08SEP04

A - Friction Washer

Continued on next page

RG19661,0000038 -19-24SEP04-2/3

9. Lubricate the camshaft gear cap screw with clean engine oil and tighten to specification.

Specification

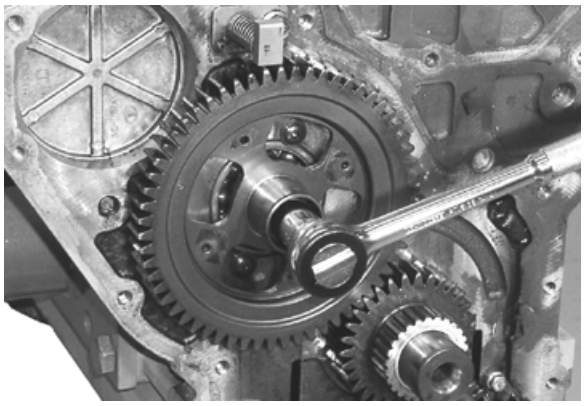
Camshaft Gear Cap Screw—Torque ..... 90 N·m (68 lb-ft)

10. Loosen camshaft gear cap screw and retighten to specification.

Specification

Camshaft Gear Cap Screw—Torque Turn ..... 30 N·m + 90° (23 lb-ft + 90°)

11. Remove C-clamp and timing tools.



RG13050 —UN—22JUL03

Install Camshaft Gear

RG19661,0000038 -19-24SEP04-3/3

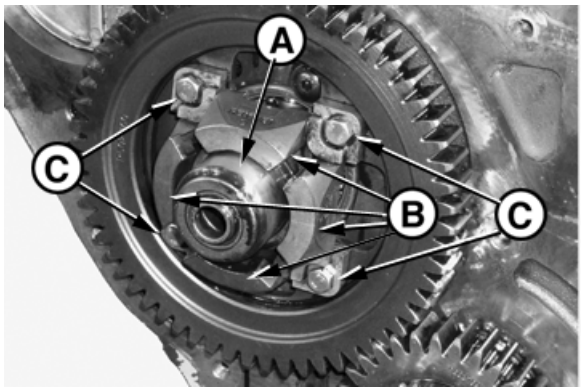
Install Governor Assembly

1. Insure weights (B) move freely on the pivot supports
2. Install governor control collar (A).
3. Carefully slide the governor assembly into position on the front face of the camshaft gear, while locating the flyweight control levers into the governor collar groove. Governor control collar (A) should move without binding and flyweights (B) should rotate freely.
4. Apply LOCTITE 242® to governor cap screws (C) and tighten to specifications.

Specification

Governor Cap Screws—Torque ..... 16 N·m (12 lb-ft)

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RG13056 —UN—29JUL03

Install Governor Assembly

RG19661,000003A -19-10SEP04-1/1

Clean and Inspect Timing Gear Cover

1. Drive crankshaft front oil seal out of cover.
2. Remove old sealant from cylinder block and timing gear cover gasket surfaces.
3. Clean timing gear cover in solvent. Dry with compressed air.
4. Inspect cover for cracks or damage. Make sure seal bore is clean and free of nicks and burrs.
5. Insure all sealing surfaces are clean and free of grease and oil.

RG19661,000001D -19-13FEB07-1/1

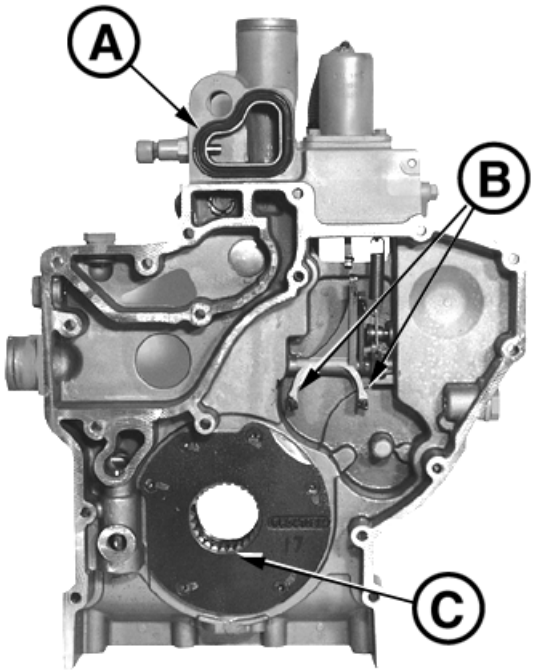
Install Timing Gear Cover

1. Install “L” shaped coolant gasket (A).
2. Apply thin layer of TY6333 High-Temperature Grease to the governor lever fork ends (B).
3. Apply a continuous 2—4 mm (0.08—0.16 in.) bead of PM710XX280 Silicone Sealant to machined sealing surfaces.
4. Align oil pump spline (C) in timing gear cover to spline on crankshaft and install timing gear cover using JDG1660 Alignment tool. Secure timing gear cover to cylinder block with the cap screw at location number 4.
5. Apply a continuous 2—4 mm (0.08—0.16 in.) bead of Hylomar 3400 Silicone Sealant on water pump flange and install cap screws at locations 1, 13, 15, 16 and 17.
6. Apply LOCTITE 242®to cap screw and install in location 9.
7. Install remaining cap screws and tighten all cap screws to specifications as shown in the tightening sequence.

Specification	
Timing Gear Cover-to-Cylinder Block Cap Screws - Initial—Torque	20 N·m (16 lb-ft)

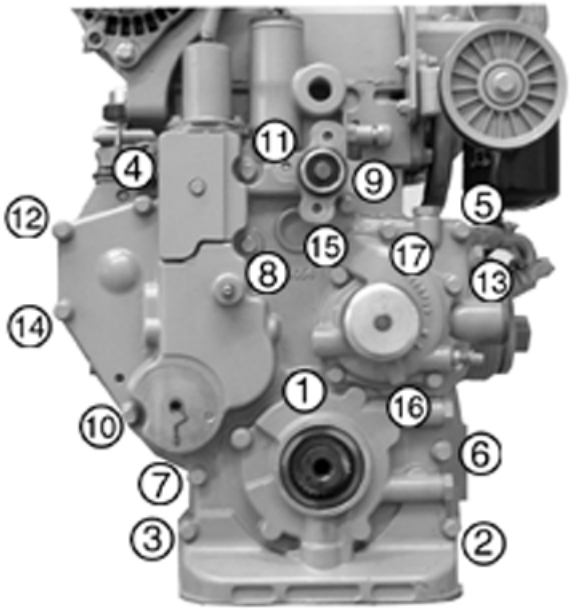
Specification	
Timing Gear Cover-to-Cylinder Block Cap Screws - Final—Torque	40 N·m (30 lb-ft)

8. Apply a continuous 2—4 mm (0.08—0.16 in.) bead of PM710XX280 Silicone Sealant to the timing gear cover sealing surface and install governor cover.
9. Install oil pan.
10. Install front seal.
11. Install front pulley.
12. Install belt tensioner and fan belt.



RG13049 —UN—22JUL03

Install Timing Gear Cover



RG13047 —UN—21JUL03

Timing Gear Cover Cap Screw Tightening Sequence

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RG19661,000001E -19-06MAY04-1/1

General Lubrication System Information

The oil filter is located on the left side of the engine. The oil filter may be located horizontally directly connected to the oil cooler or positioned vertically with the vertical oil filter header mounted near the idler pulley.

Dipsticks and oil fill locations can be located on either side of the engine. The oil fill can also be located on the rocker arm cover.

The pressure regulating valve is located in the front timing gear cover next to the oil pump. There is a bypass valve located in the oil cooler and will open if the oil filter is clogged. Oil coolers are full-flow, plate-type coolers.

The oil pump is a gerotor pump located in the front timing gear cover and is used in both 4- and 6-cylinder engines.

For flow diagram and more information on the lubrication system, see LUBRICATION SYSTEM OPERATION in Section 03, Group 120.

NOTE: For Lubrication system diagnostics, see L1 - EXCESSIVE OIL CONSUMPTION in Section 04, Group 150

RG41183,0000027 -19-05MAR04-1/1

Remove and Install Cold Start Advance Valve

NOTE: Insure the adapter tool is fully engaged in the 5-sided plug hole.

1. Locate cold start advance plug on the rear, right-hand side of the engine block flange. Carefully remove the tamper-proof plug (A) using JDG1755 Socket Adapter tool.
2. Remove spring and valve assembly. The spring should be attached to the valve. Inspect the valve tip and cylinder block drilled passage to insure there is no debris.
3. Install cold start advance assembly and engage plug in position. Using JDG1755 Socket Adapter tool, carefully tighten plug to specifications.

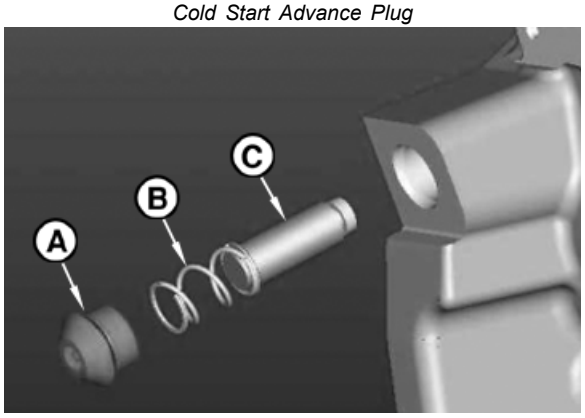
Specification	
Cold Start Advance Plug—Torque	45 N·m (33 lb-ft)

A—Tamper-proof Plug
B—Spring
C—Cold Start Advance Valve



RG13754 —UN—28SEP04

Cold Start Advance Plug



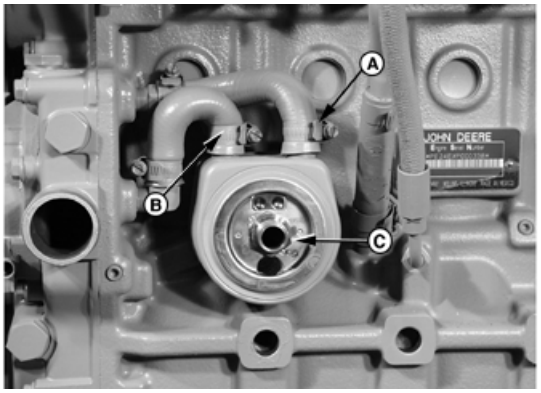
RG13755 —UN—28SEP04

Cold Start Advance

RG19661,0000080 -19-28SEP04-1/1

Remove Oil Cooler

1. Drain coolant from system.
2. Remove oil filter from oil cooler.
3. Disconnect inlet line (A) and outlet line (B) at oil cooler.
4. Remove nipple (C) and lift out oil cooler.
5. Discard packing.



RG12986 —UN—16JUN03

Oil Cooler Removal

RG41183,000001E -19-05MAR04-1/1

Install Oil Cooler

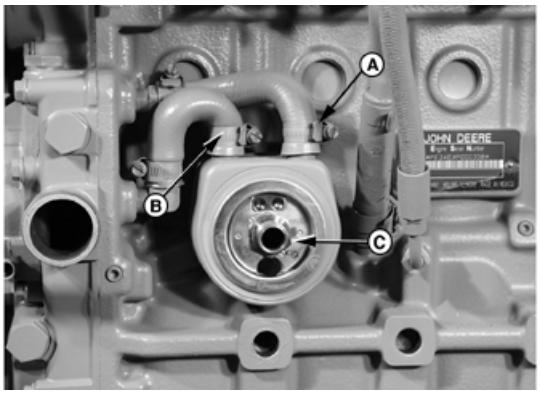
Horizontal Oil Filter

1. Install new packing between oil cooler and cylinder block.
2. Attach oil cooler with nipple (C). Tighten to specification.

Specification

Oil Cooler
Nipple—Torque.....37 N•m (27 lb-ft)

3. Connect coolant inlet line (A) and outlet line (B) to the oil cooler.
4. Apply a thin coating of clean engine oil to the oil filter gasket.
5. Install oil filter until gasket contacts the oil cooler. Tighten oil filter an additional 3/4 to 1-1/4 turns.



RG12986 —UN—16JUN03

Install Oil Cooler

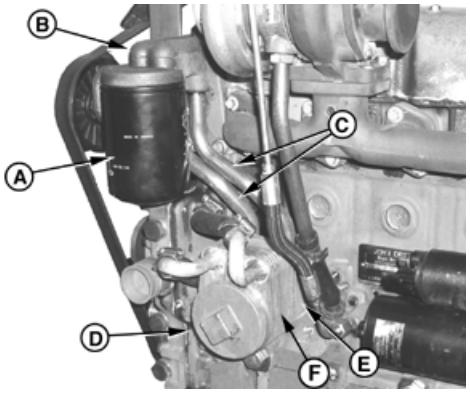
Continued on next page

RG41183,0000029 -19-01SEP04-1/2

Vertical Oil Filter

1. Install oil filter header (B) to cylinder head and tighten to specification.
2. Install idler pulley to oil filter header (B) and tighten to specification.
3. Install new O-rings into the bottom of the oil filter header and install header inlet and outlet lines (C).
4. Install new O-rings into oil cooler adapter (E). Install new seal between cylinder block and oil cooler adapter. Connect to the header inlet and outlet lines (C).
5. Install the oil cooler (F) to the oil cooler adapter (E). Insert the threaded nipple through the oil cooler and tighten to specification.
6. Connect coolant lines to the oil cooler adapter and tighten clamps.
7. Install the oil cooler cover (D) with a new seal and tighten to specification.
8. Apply a thin coating of clean engine oil to the oil filter gasket. Install oil filter until gasket contacts the oil filter header. Tighten oil filter (A) an additional 3/4 to 1-1/4 turns.

Specification	
Oil Filter Header Cap Screw—Torque	34 N·m (25 lb-ft)
Idler Pulley Cap Screw—Torque	63 N·m (46 lb-ft)
Threaded Nipple—Torque	37 N·m (27 lb-ft)
Oil Cooler Cover Plate—Torque	37 N·m (27 lb-ft)



RG13032 —UN—02JUL03

Vertical Oil Filter Configuration

A—Oil Filter
B—Oil Filter Header
C—Header Inlet and Outlet Lines
D—Oil Cooler Cover
E—Oil Cooler Adapter
F—Oil Cooler

RG41183,0000029 -19-01SEP04-2/2

Remove and Install Oil Pan

1. Drain engine oil.

NOTE: Observe position of oil pan, cap screws, and drain plug for reassembly.

2. Remove all cap screws and remove oil pan.
3. Remove all gasket material from oil rail and cylinder block mounting surfaces. Clean surfaces from oil, grease, and dirt.
4. Apply a continuous 2—4 mm (0.08—0.16 in.) bead of LOCTITE 5910® (PM37512) silicone sealant to mounting surface on the cylinder block (A).

NOTE: Guide pins (M8 x 1.25) may be used while installing oil pan.

5. Carefully install oil pan on cylinder block and tighten all oil pan-to-cylinder block cap screws as follows:

4-Cylinder Engines

a. Tighten cap screws 1-10 and 15-16 to specification.

Specification	
Oil Pan Cap Screws —Torque	32 N·m (24 lb-ft)

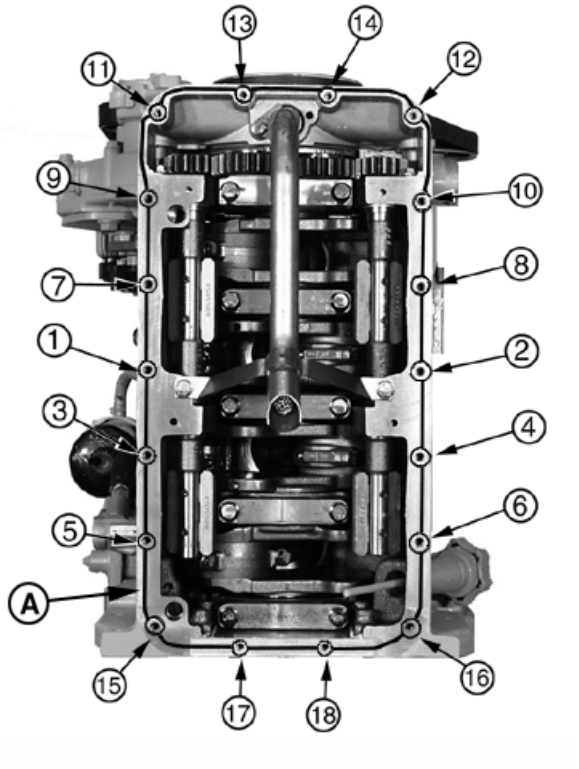
b. Tighten cap screws 11-14 and 17-18 to specification.

Specification	
Oil Pan Cap Screws —Torque	25 N·m (18 lb-ft)

c. Re-torque all cap screws to specifications listed above.

IMPORTANT: Allow sealant to cure for a minimum of 8 hours before operating engine.

d. Install drain plug with new O-ring and tighten to specification.



RG12992 —UN—23JUN03

Torque Sequence for 4-Cylinder Engine

A—Sealant Path

Specification	
Oil Pan Drain Plug—Torque	35 N·m (26 lb-ft)

5-Cylinder Engines

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Continued on next page

RG41183,000002B -19-23JUL09-1/2

a. Tighten cap screws 1-12 and 17-18 to specification.

Specification

Oil Pan Cap Screws
—Torque..... 32 N·m (24 lb-ft)

b. Tighten cap screws 13-16 and 19-20 to specification.

Specification

Oil Pan Cap Screws
—Torque..... 25 N·m (18 lb-ft)

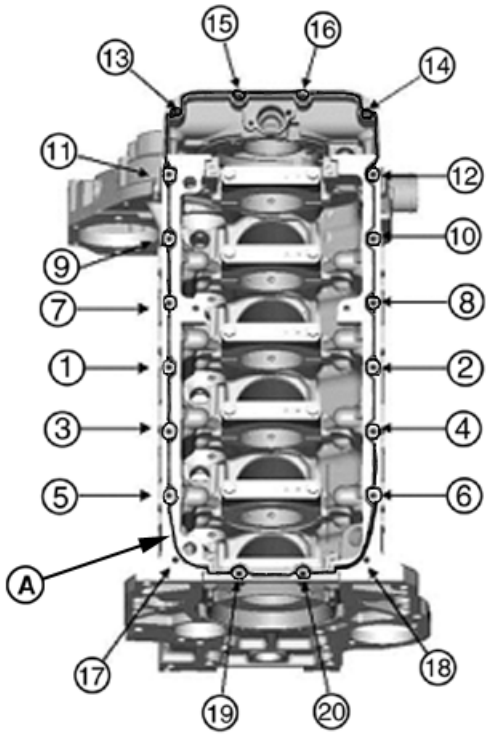
c. Re-torque all cap screws to specifications listed above.

IMPORTANT: Allow sealant to cure for a minimum of 8 hours before operating engine.

d. Install drain plug with new O-ring and tighten to specification.

Specification

Oil Pan Drain
Plug—Torque..... 35 N·m (26 lb-ft)



RG12993 —UN—23JUN03

Torque Sequence for 5-Cylinder Engine

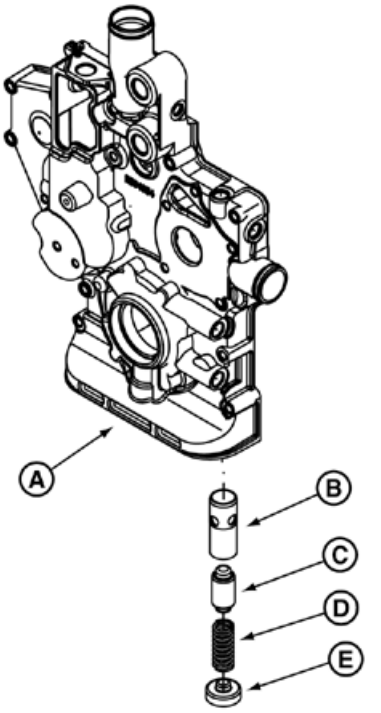
RG41183,000002B -19-23JUL09-2/2

Remove and Install Oil Pressure Regulating Valve

1. Drain engine oil.
2. Remove oil pan. Clean all gasket material from surfaces.

NOTE: The timing gear cover only needs to be removed from 4-cylinder engines that are equipped balancer shafts.

3. Remove timing gear cover (A). See REMOVE TIMING GEAR COVER in Group 50.
4. Remove plug (E) from timing gear cover.
5. Remove valve (C), compression spring (D) and valve seat (B). Inspect parts for excessive wear or damage. Replace as necessary.
6. Install valve seat (B) using JDG1721-2 to proper positioning.
7. Install valve (C) and compression spring (D) into valve seat (B).
8. Install plug (E) into bore. Using JDG1721-1, tap plug to proper depth. This tool also stakes the bore to ensure plug installation.
9. Install Timing gear cover if removed. See INSTALL TIMING GEAR COVER in Group 50.



RG12989 —UN—19JUN03

Oil Pressure Regulating Valve

A—Timing Gear Cover
B—Valve Seat
C—Valve
D—Compression Spring
E—Plug

RG41183,000001F -19-09JAN07-1/1

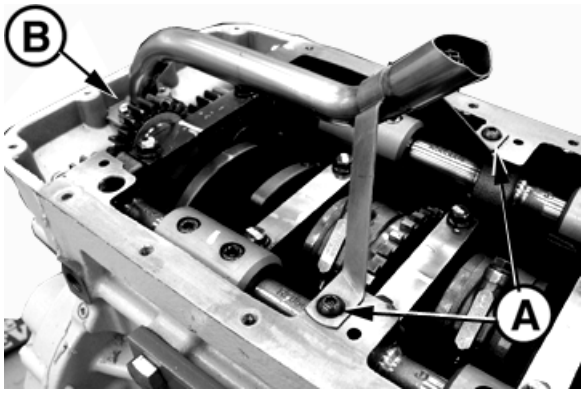
Remove, Inspect, and Install Oil Pick-Up Tube Assembly

1. Drain engine oil.
2. Remove oil pan. Clean all gasket material from surfaces.
3. Remove screws (A) and cap screw with clamp (B).
4. Remove oil pick-up tube and inspect O-rings (C), replace as necessary.
5. Clean any debris from oil pick-up tube screen (D) and inspect. If screen is damaged, replace oil pick-up tube.
6. Lubricate O-rings with clean engine oil and install oil pick-up tube into timing gear cover.
7. Apply LOCTITE® 242 to screws (A) and install. Tighten to specification.

Specification	
Oil Pick-up Tube Support Bracket Screws—Torque	28 N·m (21 lb-ft)

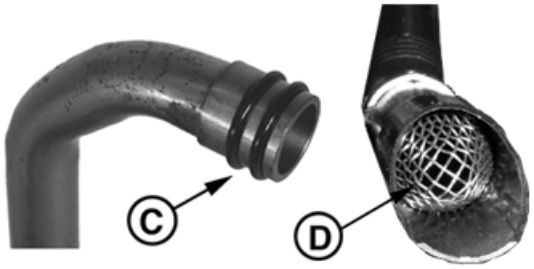
8. Install cap screw with clam and tighten to specification.

Specification	
Oil Pick-up Tube Hold Down Clamp Cap Screw—Torque	16.5 N·m (12 lb-ft)



RG15558 —UN—10SEP07

Oil Pick-Up Tube Removal



RG12991 —UN—19JUN03

Inspect O-rings and Pick-Up tube Screen

A—Cap Screws
B—Clamp
C—O-rings
D—Pick-Up Tube Screen

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RG41183,0000020 -19-09JAN07-1/1

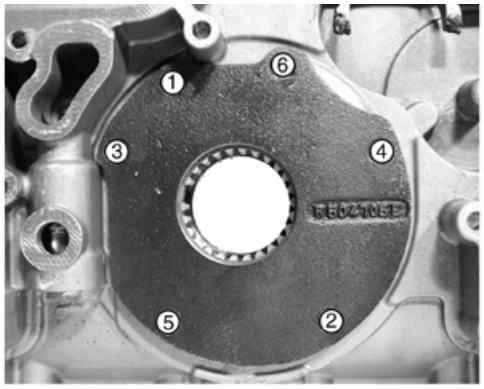
Remove and Inspect Oil Pump

1. Remove timing gear cover. See REMOVE TIMING GEAR COVER in Group 50.
2. Remove cap screws from oil pump cover.
3. Inspect oil pump cover (A) and gerotor gear (B) for excessive wear.
4. Measure clearance at point (C). If not within specification replace oil pump.

Specification

Oil Pump
Rotor—Clearance.....0.05 — 0.195 mm (0.0019 — 0.0077 in.)

5. Remove rotors from pump housing.
6. Inspect pump housing for excessive wear and replace as necessary.



RG13027 —UN—27JUN03

Oil Pump Cover Plate



RG13028 —UN—07JUL03

Inspect Gerotor in Oil Pump Housing

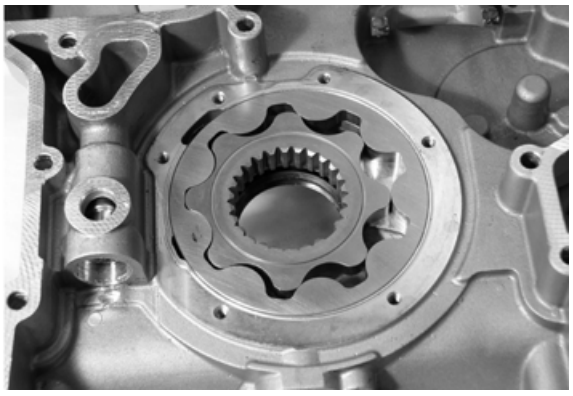
RG41183,0000042 -19-23JAN07-1/1

Install Oil Pump

1. Apply a thin coat of clean engine oil to oil pump housing area in the timing gear cover and to the gerotor.
2. Install gerotor assembly into pump housing. Check that the gerotor assembly spins freely.
3. Apply a thin coat of clean engine oil to oil pump cover.
4. Apply Loctite 242 to cap screws and install oil pump cover. Tighten cap screws in sequence to specification.

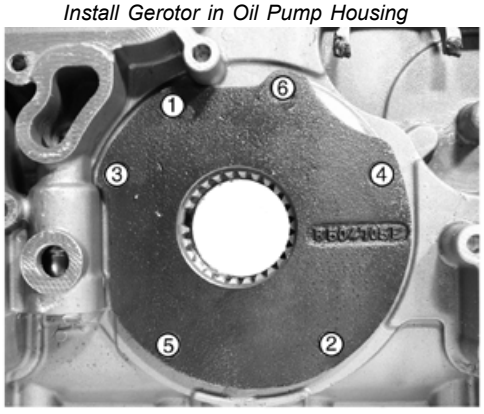
Specification

Oil Pump Cover Cap
Screws—Torque.....11.5 N·m (8 lb-ft)



RG13028 —UN—07JUL03

Install Gerotor in Oil Pump Housing



RG13027 —UN—27JUN03

Oil Pump Cover Plate Torque Sequence

RG41183,0000043 -19-23JAN07-1/1

Remove and Install Oil Dipstick Tube with Oil Pan Installed

1. Remove dipstick.
2. Using JT01724 (5/16 in.) Collet, JT01720 Actuator Pin, and JT01718 Slide Hammer, remove dipstick tube from block.
3. Coat end of new dipstick tube with LOCTITE® 609.
4. Using JDG1658 Dipstick Tube Driver, Install dipstick tube until shoulder bottoms.
5. Install dipstick.

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RG41183,000003F -19-09JAN07-1/1

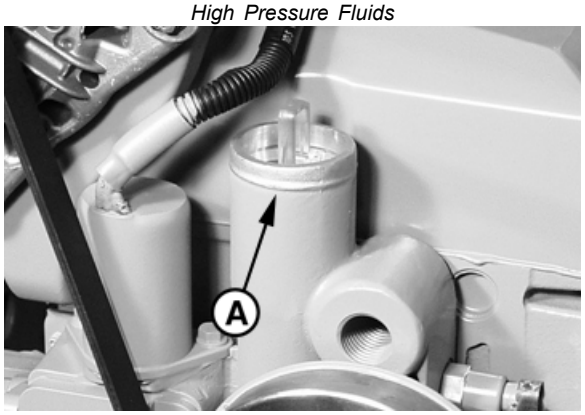
Remove and Install Thermostat

A—Thermostat Hose Connection



TS281 —UN—23AUG88

High Pressure Fluids



RG12789 —UN—21JAN03

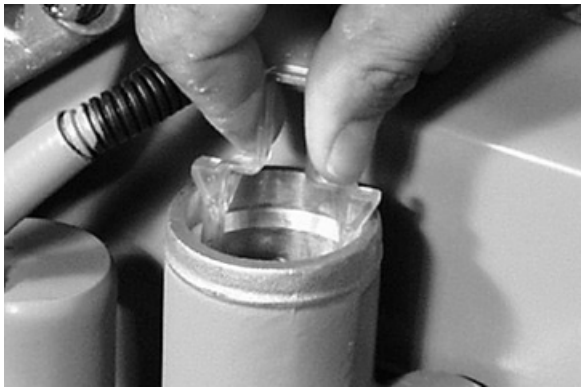
Coolant Hose to Thermostat Housing

RG41183,0000050 -19-14JAN03-1/3

To Remove Thermostat

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

1. Visually inspect area around thermostat housing on top of engine timing gear cover for leaks.
2. Remove radiator pressure cap and partially drain cooling system.
3. Remove coolant hose (shown removed) from thermostat housing.
4. Remove thermostat from thermostat housing by squeezing handle to release from grooves inside bore and pull out.



RG12790 —UN—21JAN03

Removing Thermostat from Housing

5. Clean and check thermostat housing for cracks or damage.

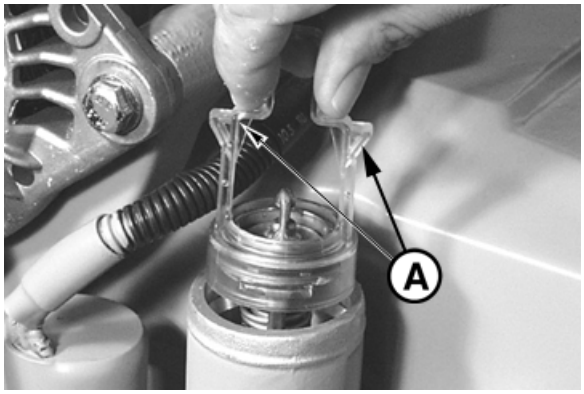
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RG41183,0000050 -19-14JAN03-2/3

To Install Thermostats

1. Insert thermostat in housing as shown until both tabs (A) are fully engaged in the groove in the housing bore.
2. Install coolant hose to thermostat cover. Tighten clamp.
3. If not already done, fill cooling system and check for leaks.

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



RG12791 —UN—21JAN03

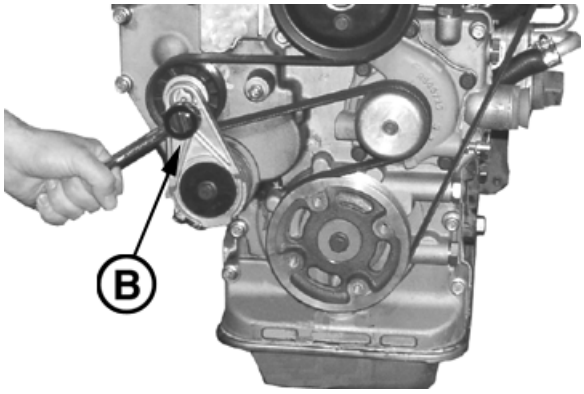
Installing Thermostat

RG41183,0000050 -19-14JAN03-3/3

Replacing Fan and Alternator Belt

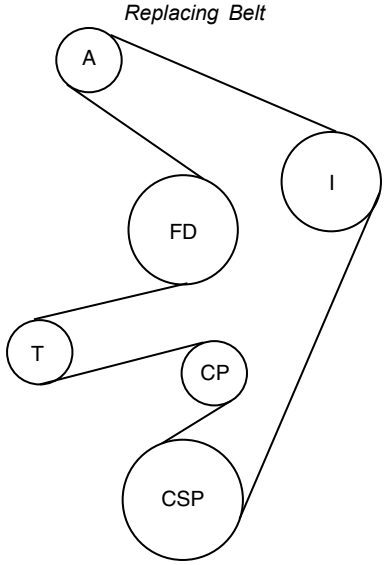
1. Inspect belts for cracks, fraying, or stretched out areas. Replace if necessary.
2. To replace belt, release tension on belt using a 3/8-inch drive arm (B) on tension arm.
3. Remove poly-vee belt from pulleys and discard belt.
4. Install new belt, making sure belt is correctly seated in all pulley grooves. Refer to belt routing at right for your application.
5. Best method to install belt is:
   Back-wrap it around the fan pulley (FD), route it over the alternator (A), over top of the idler pulley (I), then down and around the crankshaft pulley (CSP). Finally, use a 3/8-inch drive arm to rotate the tensioner (T) to the tensioned position and slip the belt (back-wrap) over the coolant pump pulley (CP), then release the tensioner.
6. Apply tension to belt with tensioner. Remove drive arm.
7. Start engine and check belt alignment.

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



RG12800 —UN—21JAN03

Replacing Belt



RG12799 —UN—21JAN03

Belt Routing

RG41183,0000056 -19-16JAN03-1/1

Remove and Install Automatic (Spring) Belt Tensioner

IMPORTANT: Belt tensioner cap screw is left-hand threaded.

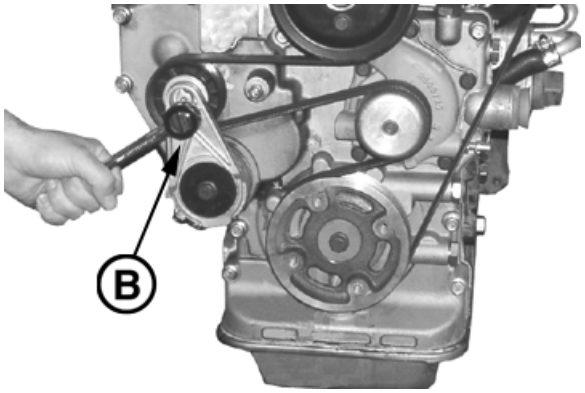
1. Release tension on belts using a breaker bar and socket.
2. Remove poly-vee belts from pulleys.
3. Remove belt tensioner.
4. Inspect sheave (A).

IMPORTANT: If belt tensioner mounting plate was removed, tighten cap screws to timing gear cover first and then tighten cap screws to engine.

5. Install belt tensioner and tighten cap screws to specifications.

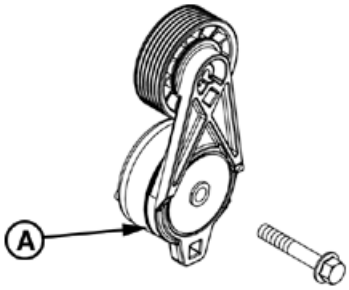
Specification	
Belt Tensioner-to-Timing Cover and Engine Cap Screws—Torque	50 N·m (37 lb-ft)
Belt Tensioner Pulley Cap Screw—Torque	35 N·m (26 lb-ft)

6. Install poly-vee belts. Be sure that belt is correctly seated in all pulley grooves.



RG12800 —UN—21JAN03

Automatic Belt Tensioner and Belt



RG13034 —UN—02JUL03

Tensioner Sheave Inspection

A—Sheave **B—Belt Tensioner**

RG19661,000002A -19-09JAN07-1/1

Checking Belt Tensioner Spring Tension and Belt Wear

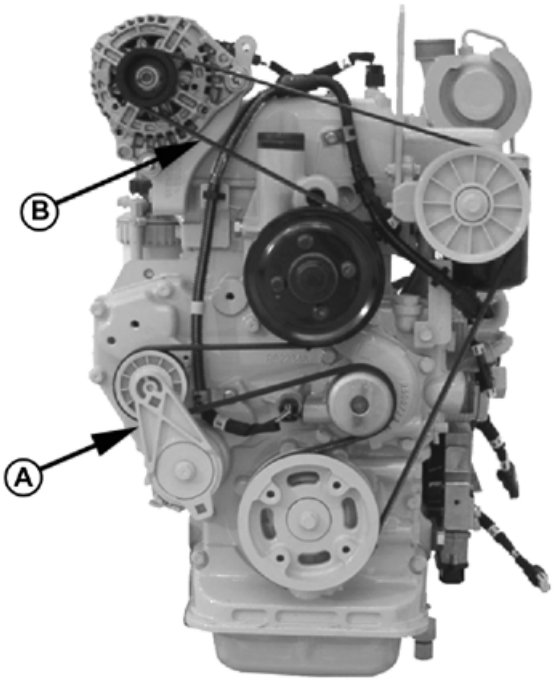
Belt drive systems equipped with an automatic (spring) belt tensioner cannot be adjusted or repaired. The automatic belt tensioner is designed to maintain proper belt tension over the life of the belt. If tensioner spring tension is not within specification, replace tensioner assembly.

Checking Belt Wear

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

Visually inspect poly-vee belt (B) for excessive wear and cracks. See Replacing Fan and Alternator Belt in Section 45.

A—Belt Tensioner **B—Poly-Vee Belt**



RG15339 —UN—04OCT07

Belt Wear Inspection

Continued on next page

OUOD006,000010E -19-10OCT07-1/2

Checking Tensioner Spring Tension

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

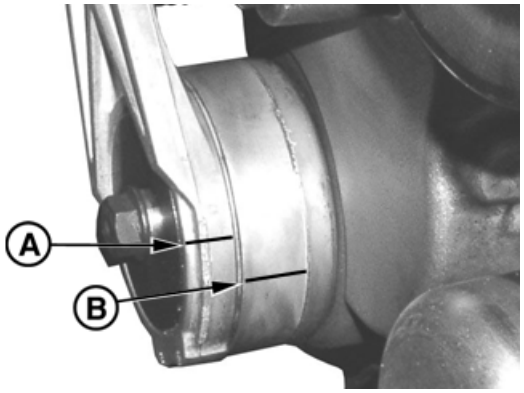
1. Release tension on belt using a breaker bar and socket on tension arm. Remove belt from pulleys.
2. Release tension on tension arm and remove breaker bar.
3. Put a mark (A) on swing arm of tensioner as shown.
4. Measure 21 mm (0.83 in.) from (A) and put a mark (B) on tensioner mounting base.
5. Install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

Specification

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

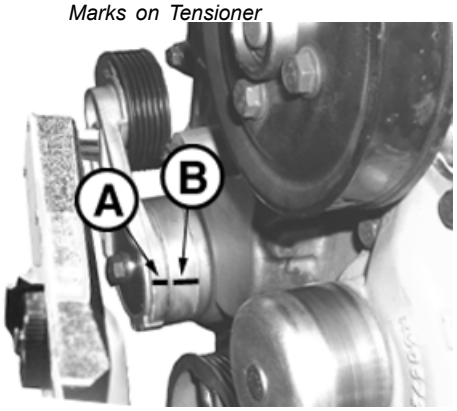
NOTE: Threads on belt tensioner roller cap screw are LEFT-HAND threads

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



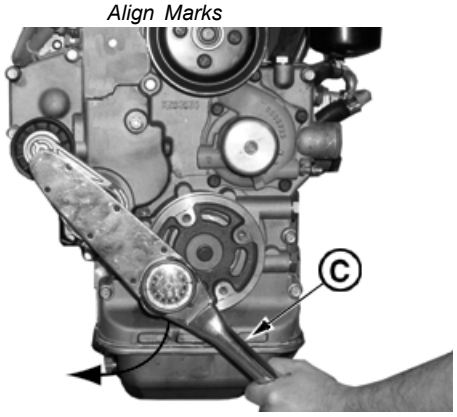
RG12825 —UN—19FEB03

Marks on Tensioner



RG12824 —UN—19FEB03

Align Marks



RG12971 —UN—04JUN03

Align Torque Wrench With Pulley And Tensioner

OUOD006,000010E -19-10OCT07-2/2

Remove Coolant Pump

CAUTION: Explosive release of fluids from pressurized cooling system can cause serious burns. Do not drain coolant until the coolant temperature is below operating temperature. Always loosen cooling system filler cap, radiator cap, or drain valve slowly to relieve pressure.

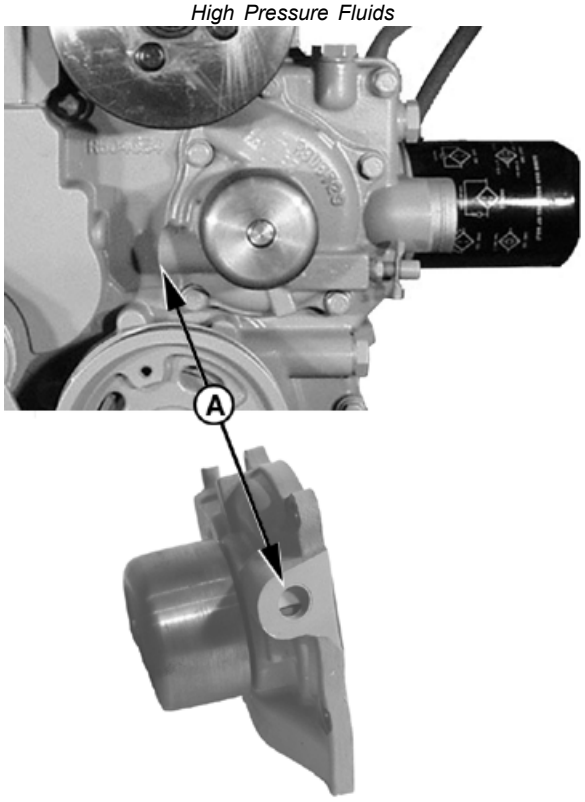
IMPORTANT: Whenever the aluminum timing gear cover or coolant pump is replaced, the cooling system must be flushed and serviced, regardless of time/hours since last coolant change. Ensure system, including radiator, is completely drained.

1. Inspect weep hole (A) for oil or coolant leakage.
   - Oil leakage indicates a damaged sealed bearing .
   - Coolant leakage indicates a damaged housing seal.
2. Drain coolant.
3. Remove fan.
4. Release tension on belt using a breaker bar and remove poly-vee belt from pulleys.
5. Remove coolant pump.
6. Clean mounting surfaces of pump and timing gear cover. Surfaces should be free of defects and old gasket sealing material.



TS281 —UN—23AUG88

High Pressure Fluids



RG12663 —UN—09JUN03

Coolant Pump Weep Hole Location



RG12949 —UN—09JUN03

Clean Coolant Pump Gasket Surface

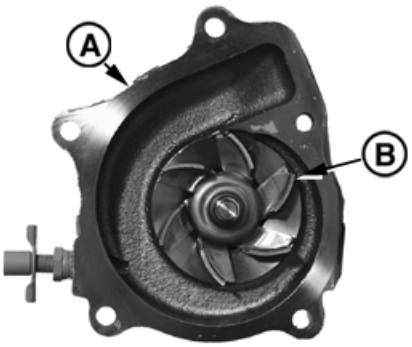
RG19661,0000024 -19-09JAN07-1/1

Inspect and Clean Coolant Pump Parts

1. Inspect coolant pump housing (A) for cracks or damage. Replace coolant pump if defects are found.
2. Inspect coolant pump impeller (B) for worn or damaged vanes. Rotate impeller to insure it turns freely without binding. Replace coolant pump if defects are found.

NOTE: Coolant pumps are available with different diameter impellers to insure adequate coolant flow for a given engine application. Be sure to replace the coolant pump with the same size impeller.

Specification	
Standard Flow Coolant Pump Impeller Diameter—Diameter	56 mm (2.20 in.)
High Flow Coolant Pump Impeller Diameter—Diameter	70 mm (2.75 in.)



RG12950 —UN—10JUN03

Inspect Coolant Pump

RG19661,0000026 -19-09JAN07-1/1

Install Coolant Pump

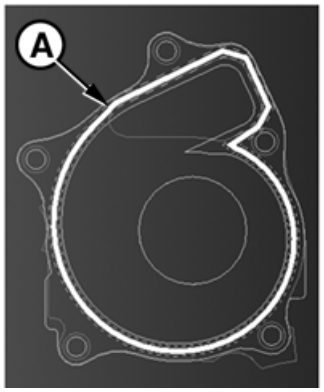
1. Clean sealing surfaces of the coolant pump housing and timing gear cover with cleaning solvent, acetone, or any other suitable cleaner that will remove sealant. (Brake Kleen, Ignition Cleaner and Drier are examples of commercially available solvents)
2. Apply a continuous 3—4 mm (0.12—0.16 in.) bead of LOCTITE 5127® (PM38657) silicone sealant (A) to the mounting surface of the coolant pump and place in position using two cap screws as guides.
3. Install remaining cap screws and tighten all cap screws finger tight. Tighten cap screws to specifications in sequence as shown.

Specification	
Coolant Pump-to-Timing Cover Cap Screws—Torque	40 N·m (30 lb-ft)

4. Install poly-vee belt. Be sure that belt is correctly seated in all pulley grooves.

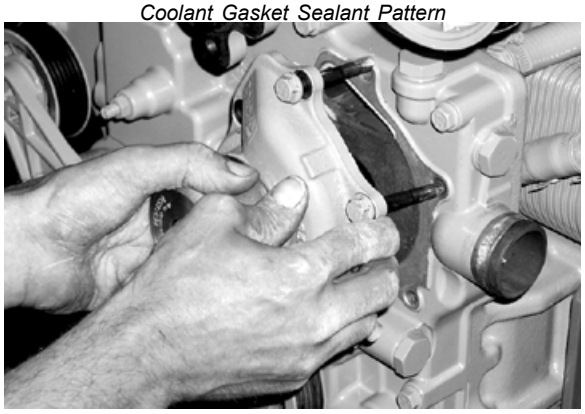
IMPORTANT: Air must be expelled from cooling system when refilled. Loosen temperature sending unit fitting in the timing gear cover to allow air to escape when filling system. Tighten fitting when all the air has been expelled.

5. Fill cooling system with proper coolant.



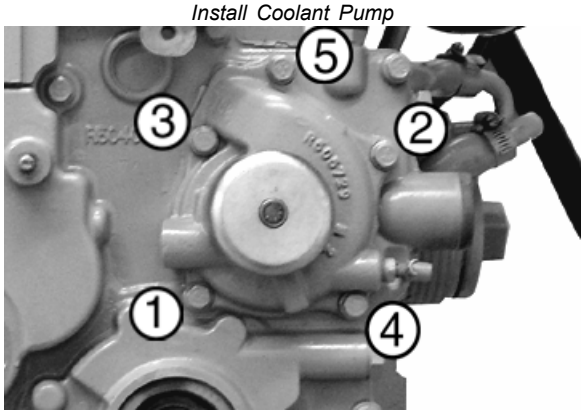
RG12953 —UN—12JUN03

Coolant Gasket Sealant Pattern



RG12981 —UN—12JUN03

Install Coolant Pump



RG12951 —UN—11JUN03

Coolant Pump Torque Sequence

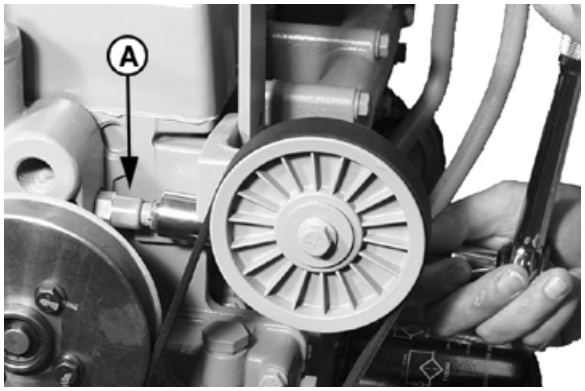
LOCTITE is a trademark of Loctite Corp.

RG19661,0000028 -19-23JUL09-1/1

Cooling System Deaeration

Deaeration is normally accomplished by the jiggle pin or notch in the thermostat flange. However, a pocket of air can stay on the top rear of the engine. When refilling the cooling system, loosen the coolant temperature sensor (A) or a coolant line at the highest point of the system to allow air to escape.

A—Coolant Temperature Sensor



RG12982 —UN—12JUN03

Cooling System Deaeration

RG19661,0000029 -19-09JAN07-1/1

Inspect and Install Fan Assembly

Several fan drive ratios are available, allowing a closer matching of fan speed to application.

1. Inspect fan blades for bent or damaged condition. Bent blades reduce cooling system efficiency and throw the fan out of balance. Replace fan if blades are bent or damaged.

NOTE: Engines may be equipped with either suction-type fan or a blower-type fan, depending on application. Take care to install the fan correctly. Refer to illustrations to identify fan type and corresponding installation.

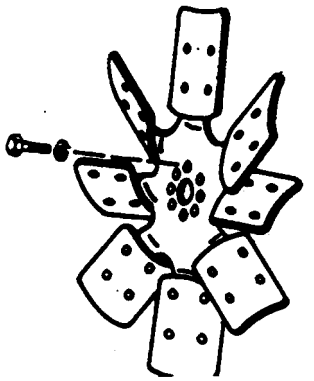
2. Install fan on pulley or pulley hub.

   Install blower-type fan with concave side of blade toward radiator.

   Install suction-type fan with concave side of blade toward engine.

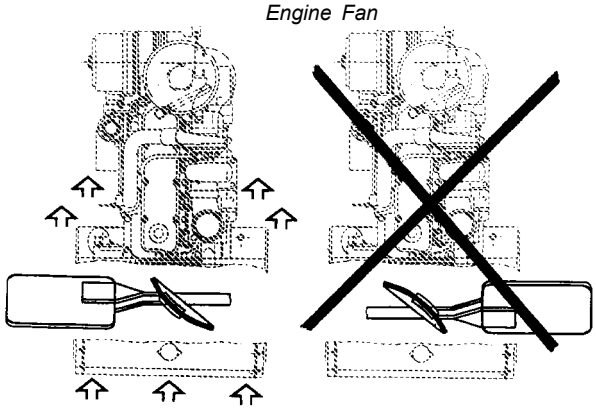
   Tighten cap screws (with lock washers) to specifications.

Specification	
Fan-to-Pulley Hub M8	
Cap Screws—Torque	35 N·m (26 lb-ft)
Fan-to-Pulley Hub M10	
Cap Screws—Torque	70 N·m (52 lb-ft)



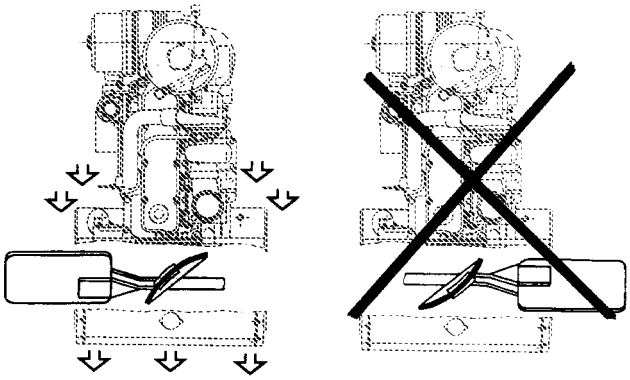
RG4797 —UN—14DEC88

Engine Fan



CD30648 —UN—16JUN98

Suction Fan (Top View)



CD30649 —UN—16JUN98

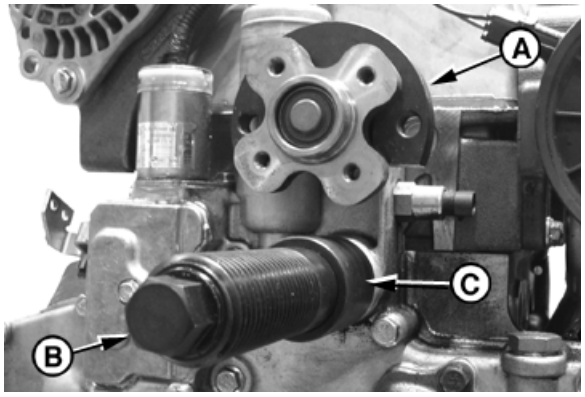
Blower Fan (Top View)

RG19661,000002D -19-09JAN07-1/1

Remove Standard-Duty Fan Bearing

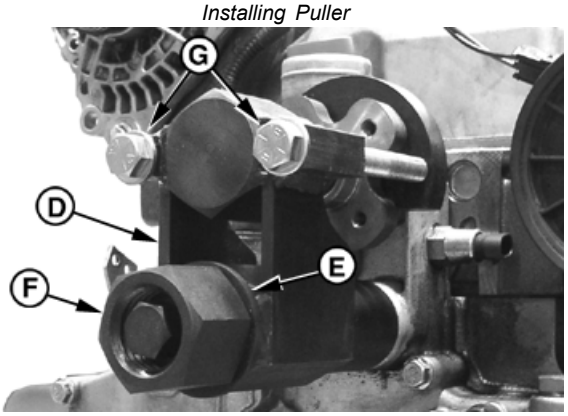
1. Remove fan and fan belt.
2. Remove fan drive pulley.
3. Position JDG1679-7 Puller (A) behind the fan hub/bearing assembly. Install JDG1679-1 Forcing Screw (B) in the open alternate fan height position machined hole.
4. Slide JDG1679-6 Spacer (C), JDG1679-2 Base (D) and JDG1679-3 Washer (E) over the forcing screw. Install JDG1679-4 Special Nut (F) on forcing screw and tighten.
5. Slide long cap screws (G) through JDG1679-2 Base and thread into JDG1679-7 Puller.
6. Pull fan hub/bearing assembly from the fan bushing by alternately turning each cap screw approximately one revolution.
7. Carefully remove fan bearing bushing (I) from the timing gear cover using JDG1679-5 Insert Wrench (H), a thin profile 32 mm (1-1/4 in.) open-end wrench or JDG10409 Wrench Adapter.

A—JDG1679-7 Puller
B—JDG1679-1 Forcing Screw
C—JDG1679-6 Spacer
D—JDG1679-2 Base
E—JDG1679-3 Washer
F—JDG1679-4 Special Nut
G—Cap Screws
H—JDG1679-5 Insert Wrench
I— Fan Bearing Bushing



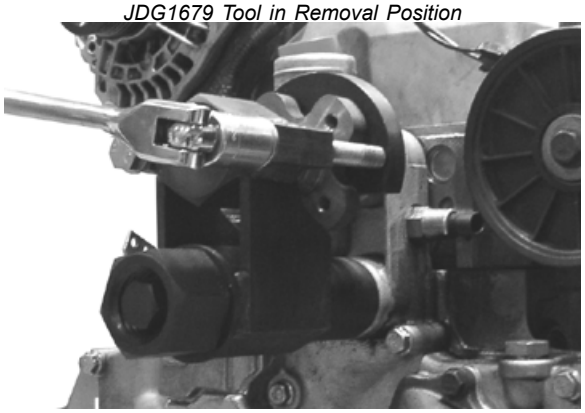
RG13018 —UN—26JUN03

Installing Puller

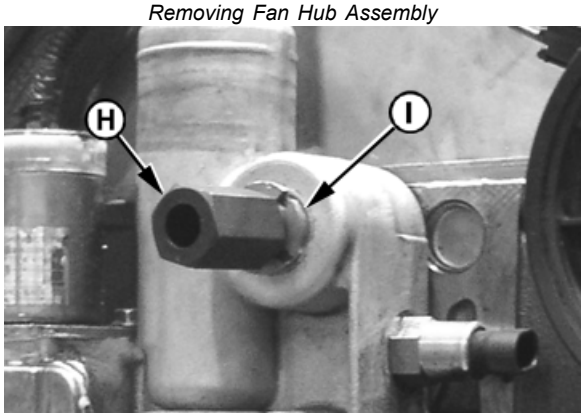


RG13019 —UN—26JUN03

JDG1679 Tool in Removal Position


RG13020 —UN—26JUN03

Removing Fan Hub Assembly



RG13021 —UN—27JUN03

Fan Bearing Bushing

RG19661,000002F -19-23JUL09-1/1

Install Standard-Duty Fan Bearing

1. Install fan bearing bushing (I) in the timing gear cover upper or lower fan mount boss. Tighten to specifications using JDG1679-5 Insert Wrench (H), a thin profile 32 mm (1-1/4 in.) open-end wrench or JDG10409 Wrench Adapter.

Specification

Fan Bushing—Torque..... 87 N·m (75 lb-ft)

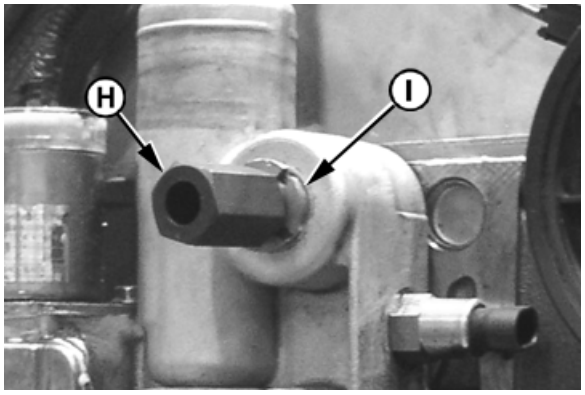
2. Install JDG1679-1 Forcing Screw (B) in the open alternate fan height position machined hole.
3. Slide JDG1679-2 Installer Tool (D) over forcing screw while holding the fan hub/bearing assembly (C) in position.
4. Install JDG1679-3 Washer (E) and JDG1679-4 Special Nut (F).
5. Slowly turn nut , forcing the fan hub/bearing assembly into the fan bushing. Turn nut until the tool body contacts the forcing screw collar.
6. Remove tools, install fan pulley and tighten cap screws to specifications.

Specification

Fan Pulley Cap Screws—Torque..... 32 N·m (24 lb-ft)

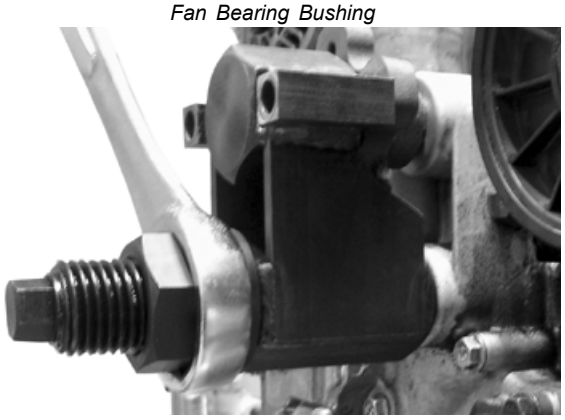
7. Check fan pulley alignment with alternator and upper idler pulleys using a straight edge. Remove fan pulley and readjust hub position, if required.
8. Install fan belt and fan.

B—JDG1679-1 Forcing Screw
C—Fan Hub/Bearing Assembly
D—JDG1679-2 Base
E—JDG1679-3 Washer
F—JDG1679-4 Special Nut

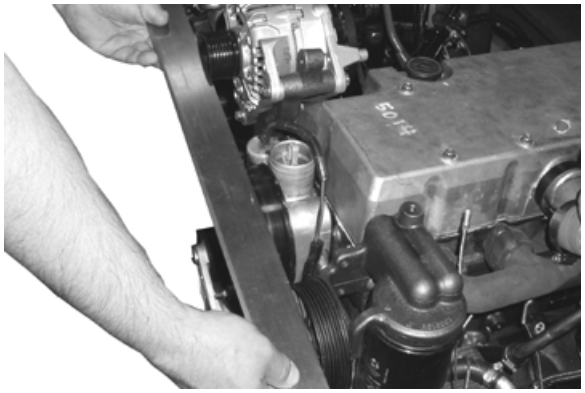


RG13021 —UN—27JUN03

Fan Bearing Bushing



RG13022 —UN—26JUN03



RG13024 —UN—26JUN03

Checking Fan Belt Alignment

RG41183,0000046 -19-23JUL09-1/1

Remove and Install Fan Bearing Serial Number (0010609 —)

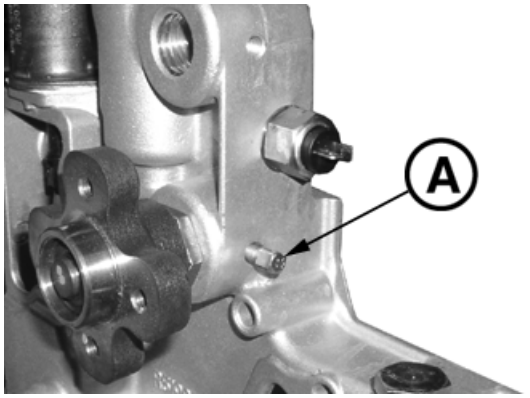
1. Remove fan hub assembly retaining set screw (A).
2. Remove the fan hub assembly (B) using a thin profile 32 mm (1-1/4 in.) open-end wrench or JDG10409 Wrench Adapter.
3. Apply LOCTITE® 242 Thread Lock and Sealer to new fan hub assembly and install at the desired fan height location. Tighten fan hub assembly to specifications using JDG10409 Wrench Adapter (C) with a standard length (12 in.) 3/8-in.drive torque wrench. Actual installed fan hub assembly torque is 100 N·m (75 lb-ft).

Specification	
Fan Hub Assembly Torque with JDG10409 Wrench Adapter—Torque	68 N·m (50 lb-ft)

4. Apply LOCTITE® 242 Thread Lock and Sealer to fan hub assembly retaining set screw (A). Install and tighten to specifications.

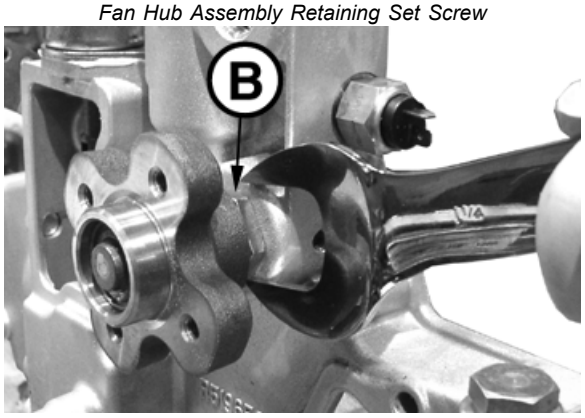
Specification	
Fan Bushing Set Screw—Torque	15 N·m (10 lb-ft)

A—Fan Hub Retaining Set Screw
B—Fan Hub Assembly
C—JDG10409 Wrench Adapter



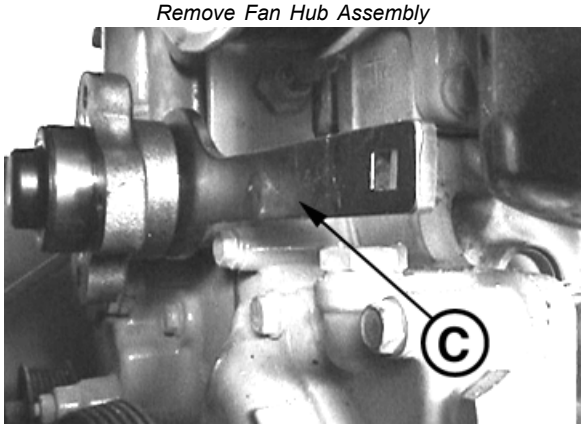
RG13634 —UN—01SEP04

Fan Hub Assembly Retaining Set Screw



RG13635 —UN—01SEP04

Remove Fan Hub Assembly



RG14951 —UN—11JUL06

Tighten Fan Bushing

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RG19661,0000065 -19-27SEP06-1/1

Extending Turbocharger Life

Turbochargers are designed to last the life of the engine, but, because they operate at such high speeds (100,000 rpm or more); a moment's carelessness can cause them to fail in seconds.

The major causes of turbocharger failures are:

- **Lack of Lube Oil (Quick Starts and Hot Shutdowns)**
- **Oil Contamination**
- **Ingestion of Foreign Objects**
- **Restricted Oil Drainage**
- **Low Oil Level**
- **Operation on Excessive Side Slopes**
- **Abnormally High Exhaust Temperatures**

Lack of Lube Oil

Oil not only lubricates the turbocharger's spinning shaft and bearings, it also carries away heat. When oil flow stops or is reduced, heat is immediately transferred from the hot turbine wheel to the bearings, which are also heating up because of the increased friction due to the lack of oil. This combination causes the turbocharger shaft temperature to increase rapidly.

If oil flow does not increase and the process continues, bearings will fail. Once the bearings fail (which can happen in just seconds) seals, shaft, turbine and compressor wheels can also be damaged.

The principle causes of turbocharger bearing lubrication problems are low oil pressure, a bent, plugged or undersized oil lube supply line, plugged or restricted oil galleries in the turbocharger, or improper machine start-up and shutdown procedure.

Oil levels and pressure should always be closely monitored and all worn hoses and lines should be replaced. The turbocharger oil supply line should be checked frequently to make sure it is not kinked or bent and it should always be replaced with a line of equal size, length and strength.

The easiest way to damage a turbocharger is through improper start-up and shutdown procedures. Always idle the engine for at least 30 seconds (no load) after start-up and before shutdown. Warming the engine up before applying a load allows oil pressure to build up and lines to fill with oil.

Idling the engine before shutdown allows the engine and turbocharger to cool. "Hot" shutdowns can cause the turbocharger to fail because after high-speed operation the turbocharger will continue to rotate long after the engine has been shut off and oil pressure has dropped to zero. This will cause heat to build up and possibly damage bearings. It can also cause carbon and varnish deposits to form.

Oil Contamination

A second cause of turbocharger failures is contaminated oil. It can be caused by a worn or damaged oil filter or not changing the lube oil at recommended intervals. Expecting the oil filter to remove dirt, sand, metal chips, etc. from the oil before they reach the engine or turbocharger can be a costly mistake because contaminated oil may completely bypass the engine oil filter if the oil filter or oil cooler is clogged, if the filter element is improperly installed, or if the oil is thick during cold weather.

Four good ways of avoiding oil contamination are:

- Always inspect the engine thoroughly during major overhaul. Look especially for any sludge or debris left in lube oil galleries.
- Change lube oil at recommended intervals. Analysis of oil samples at filter change periods can help identify potentially harmful contaminants in the oil.
- Clean the area around the oil fill cap before adding oil.
- Use a clean container when adding oil.

Ingestion of Foreign Objects

The third cause of turbocharger damage is the ingestion of foreign objects. These particles can be ingested and cause damage to the turbocharger on both compressor and turbine sides. This is easy to avoid.

On the compressor side, foreign objects usually take the form of dust, sand, or shreds of air cleaner element that enter through improperly installed air cleaner elements. Leaky air inlet piping (loose clamps or torn rubber joints) or torn pleats in dry-type air cleaner elements also create problems.

The result is erosion of compressor blades that can cause the delicately balanced wheel to wobble.

IMPORTANT: Whenever an internal engine failure (valve, valve seat, piston) occurs, a thorough inspection of the turbocharger MUST BE performed before returning engine to service.

Restricted Oil Drainage

A fourth cause of turbocharger damage is restricted lube oil drainage. The lubricating oil carries away heat generated by friction of the bearings and from the hot exhaust gases. If drainage back to the sump is impeded, the bearings will overheat with damage that will ultimately lead to failure.

There are two primary reasons for restricted drainage. A blocked drain tube, due to either damage or a buildup of sludged oil, or high crankcase pressure, which can be due to restricted crankcase breather or excessive engine blow-by.

Periodically check both the turbocharger oil drain tube and engine breather tube for damage or restriction. Correction of these conditions leads to longer turbocharger life.

Continued on next page

RG,RG34710,1256 -19-05MAR04-1/2

Abnormally High Exhaust Temperatures

A fifth cause of turbocharger damage is abnormally high exhaust temperatures. Elevated exhaust temperatures cause coking of oil which can lead to bearing failure. Extreme over-temperature operation can cause wheel burst.

There are two basic causes of over-temperature. The first is restricted air flow and the second is overpowering the engine. In either case the engine has more fuel than available air for proper combustion; this over-fueled condition leads to elevated exhaust temperatures.

Causes of restricted air flow can include damaged inlet piping, clogged air filters, excessive exhaust restriction, or operation at extreme altitudes. Overpowering generally is due to improper fuel delivery or injection timing. If over temperature operation has been identified, an inspection of the air inlet and exhaust systems should be performed. Also, check the fuel delivery and timing.

RG,RG34710,1256 -19-05MAR04-2/2

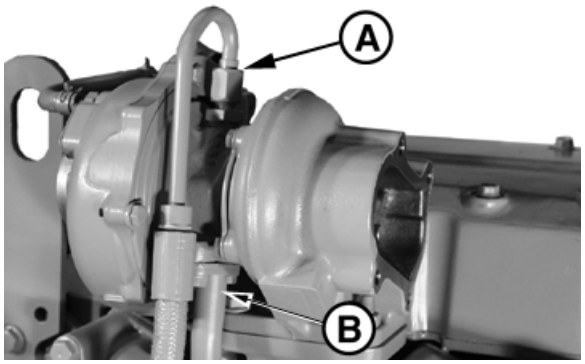
Remove Turbocharger

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

IMPORTANT: When cleaning turbocharger, do not spray directly into compressor cover or turbine housing. If turbocharger inspection is required, do not clean exterior prior to removal. Doing so may wash away evidence of a potential failure mode. See TURBOCHARGER INSPECTION later in this group.

Thoroughly clean exterior of turbocharger and surrounding area to prevent entry of dirt into the air intake system during removal.

1. Disconnect air intake and exhaust piping from turbocharger (shown disconnected).
2. Disconnect turbocharger oil inlet line (A) from elbow adapter.
3. Disconnect turbocharger oil return (drain) tube (B). Remove and discard gasket.
4. Remove four turbocharger mounting cap screws securing turbocharger to exhaust manifold and remove turbocharger.



RG12507 —UN—12DEC02

Removing Turbocharger

A—Oil Inlet Line **B—Oil Return Line**

5. Cap or plug all openings on engine (exhaust and intake manifold related) and place turbocharger on a clean flat table for inspection.
6. Perform turbocharger seven-step inspection, as described later, if failure mode has not been determined. See TURBOCHARGER INSPECTION later in this group.

RG41183,000002C -19-18OCT02-1/1

Turbocharger Failure Analysis

The following is a guide for diagnosing the cause of turbocharger failures after removal from the engine.

Problem	Possible Cause	Suggested Remedy
COMPRESSOR HOUSING INLET DEFECTS		
Foreign Object Damage	Objects left in intake system.	Disassemble and inspect intake system for foreign objects (this group).
		Inspect engine for internal damage.
	Leaking and/or defective intake system.	Inspect air intake system connections including air filter; repair as required (this group).
		Inspect air intake related engine components.
Compressor Wheel Rub	Bearing failure.	Determine if engine and/or operator contributed to lack of lubrication, contaminated lubrication, excessive temperature, or debris generating engine failure in progress. Correct as required.
	Manufacturing defects.	Correct as required.
COMPRESSOR HOUSING OUTLET DEFECTS		
Oil and/or Dirt in Housing	Restricted air intake system.	Inspect and clean air cleaner.
	Prolonged periods of low rpm engine idling.	Check with operator to confirm conditions. (See Operator's Manual.)
	Defective oil seal ring.	Repair as required (this group).
	Restricted oil drain line.	Inspect and clear oil drain line as required.
TURBINE HOUSING INLET DEFECTS		
Oil in Housing	Internal engine failure.	Inspect and repair engine as required. **Make certain to check all ail lines/hoses for oil residue. If oil is found, it is ABSOLUTELY NECESSARY to make certain the lines and Charge Air Cooler or Heat Exchanger have been thoroughly cleaned out. Failure to do so can result in engine failure. Remove CAC and use John Deere Coolant System Cleaner PMCC2638, or equivalent. Dry the components with compressed air and BE CERTAIN all water is removed.**
	Oil leaking from compressor housing seal.	Verify that oil is in compressor housing and refer to "Compressor Housing Outlet Defects" as listed earlier in this chart.
Center Wall Deteriorated	Excessive operating temperature.	Check for restricted air intake.
		Check engine for overfueling.
		Check injection pump timing.
TURBINE HOUSING OUTLET DEFECTS		
Turbine Wheel Rub	Bearing failure.	Determine if engine and/or operator contributed to lack of lubrication, contaminated lubrication, excessive temperature, or debris generating engine failure in progress. Correct as required.
	Manufacturing defect.	Correct as required (this group).
Foreign Object Damage	Internal engine failure.	Inspect and repair engine as required.
	Objects left in intake system.	Disassemble and inspect air intake system (this group).

Continued on next page

RE38635,000002E -19-13SEP07-1/2

TURBINE HOUSING OUTLET DEFECTS

	Leaking air intake system.	Correct as required (this group).
Oil and/or Excessive Carbon	Internal engine failure.	Verified by oil in turbine housing.
	Turbine seal failure.	Inspect for excessive heat from overfueling and/or restricted air intake.
	Prolonged periods of low rpm engine idling.	Ask operator to run engine under load or at a higher rpm (See Operator's Manual).
	Restricted oil drain line.	Inspect and clear oil drain line as required.

EXTERNAL CENTER HOUSING AND JOINT DEFECTS

Leaks from Casting	Defective casting.	Replace turbocharger (this group).
	Defective gasket.	Verify if leaks are occurring at gasket joints.
Leaks from Joints	Loose attaching screws.	Tighten to specifications in CTM (this group).
	Defective gasket.	Inspect and repair as required.

INTERNAL CENTER HOUSING DEFECTS

Excessive Carbon Build-Up in Housing or on Shaft	Hot engine shutdown.	Review proper operation with operator as shown in operator's manual.
	Excessive operating temperature.	Restricted air intake; overfueling or mistimed engine.
	Restricted oil drain line.	Inspect and clean oil drain lines as required.
	Operating engine at high speeds and loads immediately after start-up.	Idle engine for a few minutes to allow oil to reach bearings before applying heavy loads.

RE38635,000002E -19-13SEP07-2/2

Turbocharger Inspection

The following inspection procedure is recommended for systematic failure analysis of a suspected failed turbocharger. This procedure will help to identify when a turbocharger has failed, and why it has failed so the primary cause of the failure can be corrected.

Proper diagnosis of a non-failed turbocharger is important for two reasons. First, identification of a non-failed turbocharger will lead to further investigation and repair of the cause of a performance complaint.

Second, proper diagnosis eliminates the unnecessary expense incurred when a non-failed turbocharger is replaced.

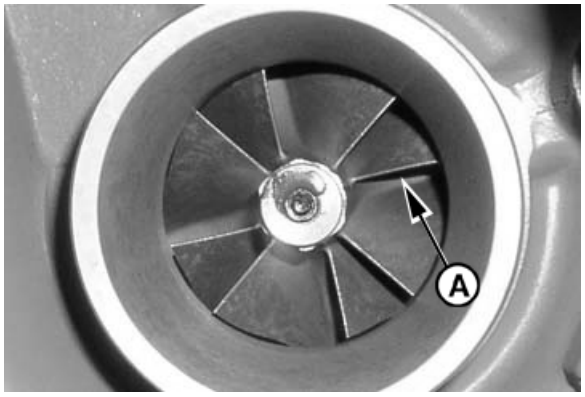
The recommended inspection steps, which are explained in detail on following pages, are:

- Compressor Housing Inlet and Compressor Wheel.
- Compressor Housing Outlet.
- Turbine Housing Inlet.
- Turbine Housing Outlet and Turbine Wheel.
- External Center Housing and Joints.
- Perform Axial End Play Test

NOTE: To enhance the turbocharger inspection, an inspection sheet (Form No. DF-2280 available from Distribution Service Center—English only) can be used that lists the inspection steps in the proper order and shows potential failure modes for each step. Check off each step as you complete the inspection and record any details or problems obtained during inspection. Retain this with the work order for future reference.

Compressor Housing Inlet and Compressor Wheel

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



RG12517 —UN—12DEC02

Checking Inlet and Compressor Wheel

A—Compressor Wheel

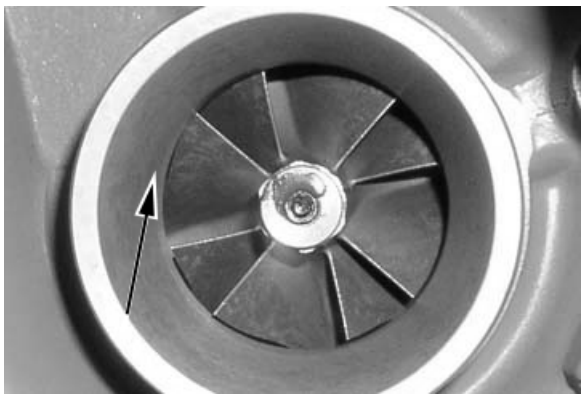
NOTE: Foreign object damage may be extensive or minor. In either case, the source of the foreign object must be found and corrected to eliminate further damage.

2. Mark findings on your checklist and continue the inspection.

RG41183,0000029 -19-16OCT02-1/11

NOTE: You will need a good light source for this check.

3. Check compressor inlet for wheel rub on the housing (arrow). Look very closely for any score marks on the housing itself and check the tips of the compressor wheel blades for damage.



RG12518 —UN—12DEC02

Checking Compressor Inlet

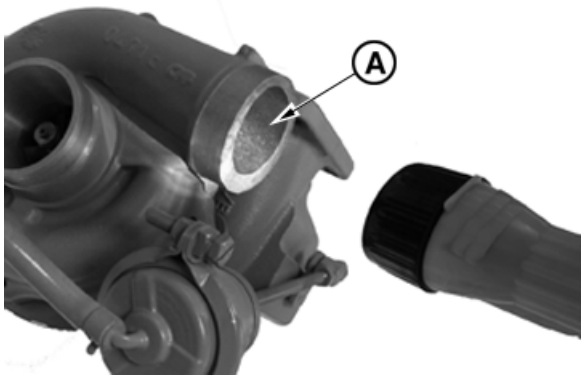
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RG41183,0000029 -19-16OCT02-2/11

Compressor Housing Outlet

1. Check compressor housing outlet (A). The outlet should be clean and free of dirt or oil.
2. Mark it on your checklist if dirt or oil is found and continue the inspection.

A—Compressor Housing Outlet



RG12519 —UN—12DEC02

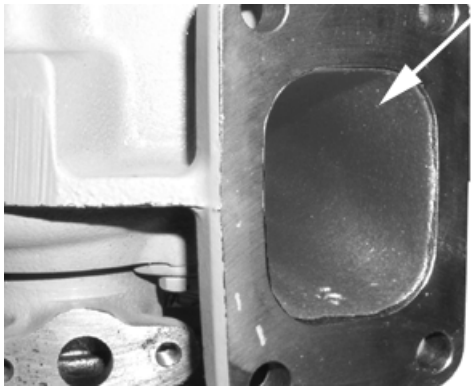
Compressor Housing Outlet

RG41183,0000029 -19-16OCT02-3/11

Turbine Housing Inlet

Check the turbine housing inlet (arrow) for oil in housing, excessive carbon deposit.

NOTE: If the inlet is wet with oil, or has excessive carbon deposits, an engine problem is likely.



RG12523 —UN—12DEC02

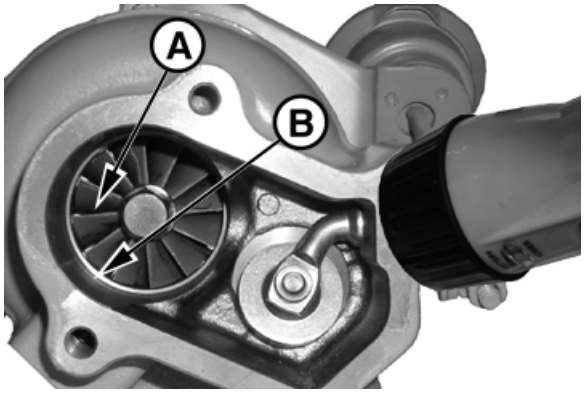
Checking Turbine Housing Inlet

RG41183,0000029 -19-16OCT02-4/11

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—Blades **B—Turbine Housing Outlet**



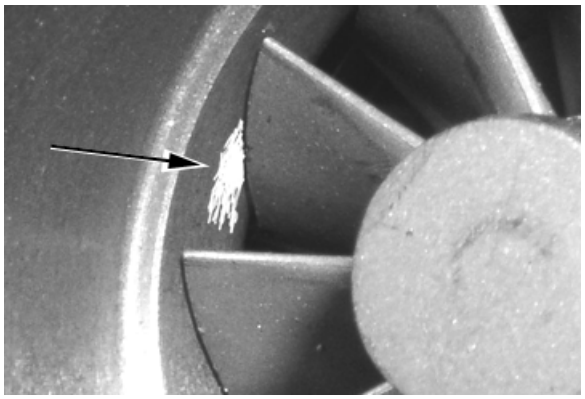
RG12521 —UN—12DEC02

Checking Turbine Wheel and Outlet

Continued on next page

RG41183,0000029 -19-16OCT02-5/11

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.

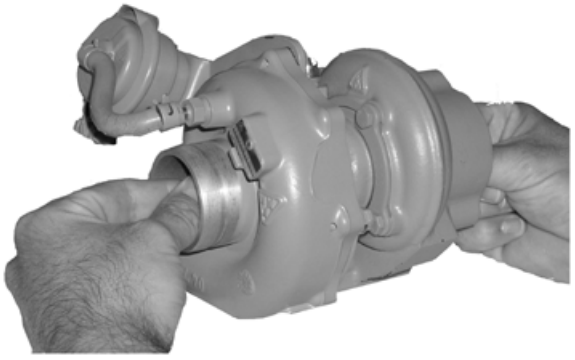


RG12524 —UN—12DEC02

Checking Turbine Wheel Blades

RG41183,0000029 -19-16OCT02-6/11

3. Rotate the shaft, using both hands, to check rotation and clearance. The shaft should turn freely, however, there may be a slight amount of drag.



RG12525 —UN—12DEC02

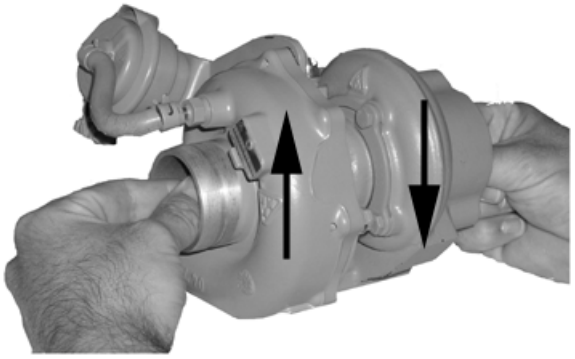
Checking Shaft Rotation and Clearance

RG41183,0000029 -19-16OCT02-7/11

IMPORTANT: Use only moderate hand force (3-4 pounds) on each end of shaft.

4. Next, pull up on the compressor end of the shaft and press down on the turbine end while rotating shaft. Neither the compressor wheel nor the turbine wheel should contact the housing at any point.

NOTE: There will be some "play" because the bearings inside the center housing are free floating.



RG12526 —UN—12DEC02

Checking for Contact of Compressor and Turbine Wheels

Continued on next page

RG41183,0000029 -19-16OCT02-8/11

External Center Housing and Joints

Visually check the outside of the center housing, all connections to the compressor, and turbine housing for oil.

NOTE: If oil is present, make sure it is not coming from a leak at the oil supply or return line.

IMPORTANT: Before you finalize your conclusion that the turbocharger has not failed, it is strongly recommended that the following procedures of checking radial bearing clearance and axial bearing endplay with a dial indicator be performed. These procedures are not required if a failure mode has already been identified.



RG12520 —UN—12DEC02

Checking Center Housing

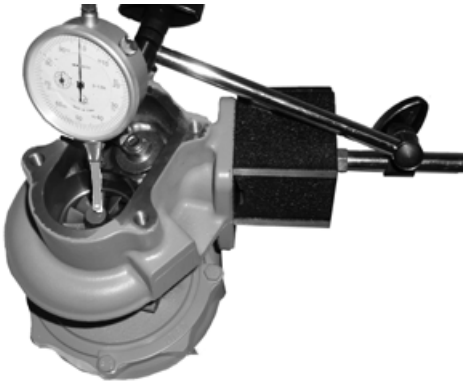
RG41183,0000029 -19-16OCT02-9/11

Perform Axial Bearing End Play Test

This test will give an indication of the condition of the thrust bearing within the center housing and rotating assembly.

1. Mount magnetic base dial indicator so that indicator tip rests on flat surface on turbine end of shaft. Preload indicator tip and zero dial on indicator.
2. Move shaft axially back and forth by hand.
3. Observe and record total dial indicator movement.

Specification	
Turbocharger Shaft—Axial Bearing End Play	0.064—0.114 mm (0.0025—0.0045 in.)



RG12527 —UN—12DEC02

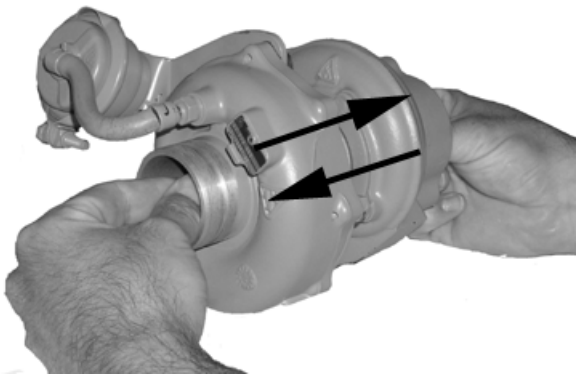
Checking Axial Bearing End Play

If bearing end play is not within specification, install a replacement turbocharger.

RG41183,0000029 -19-16OCT02-10/11

4. Next, check shaft endplay by moving the shaft back and forth (arrows) while rotating. There will be some endplay but not to the extent that the wheels contact the housings.

NOTE: These diagnostic procedures will allow you to determine the condition of the turbocharger. If the turbocharger has failed, analysis of your inspection notes should direct you to the specific areas of the engine to correct the problems causing the turbocharger failure. It is not unusual to find that a turbocharger has not failed. If your turbocharger passes all the inspections, the problem lies somewhere else.



RG12528 —UN—12DEC02

Checking Shaft End Play

RG41183,0000029 -19-16OCT02-11/11

Repair Turbocharger

Turbochargers used on the engines covered in this manual are available through service parts as a complete remanufactured assembly only. Individual components for repair are not available.

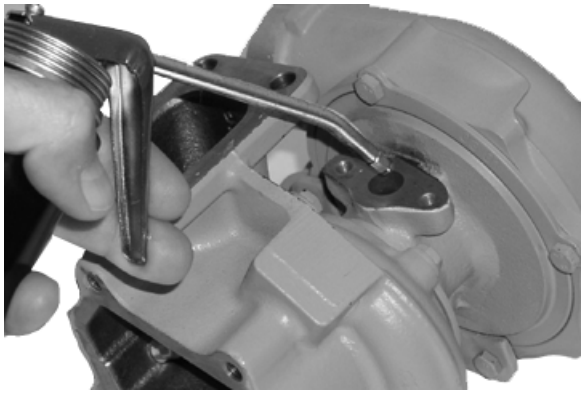
RG,30,JW7571 -19-20NOV97-1/1

Prelube Turbocharger

IMPORTANT: DO NOT spin the rotor assembly with compressed air. Damage to bearings can occur when using compressed air.

Fill oil return (drain) port with clean engine oil and spin rotating assembly by hand to properly lubricate bearings.

If turbocharger is to be stored for an extended period of time, lubricate internally and install protective covers on all openings.



RG12516 —UN—12DEC02

Prelubing Turbocharger

RG41183,0000028 -19-15OCT02-1/1

Install Turbocharger

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

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

1. Put a new gasket on turbocharger-to-exhaust manifold mounting surface (not shown).
2. Position turbocharger against gasket on exhaust manifold.
3. Apply PT569 NEVER-SEEZ® Compound to all turbocharger mounting cap screws. Install cap screws and tighten to specifications.

Specification	
Turbocharger-to-Exhaust Manifold Cap Screws—Torque	32 N·m (22 lb-ft)

NOTE: Remove all caps or plugs from turbocharger openings.

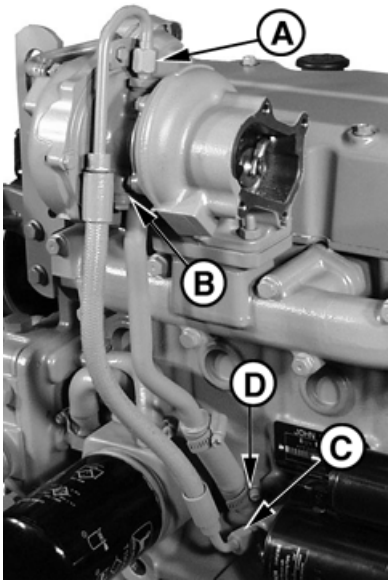
4. Install turbocharger oil return (drain) tube (B) using a new gasket. Tighten cap screws to specifications. If not already installed, install oil return fitting (D) into the engine block. Tighten 2-3 turns beyond hand tight. Install turbocharger drain hose between turbocharger drain line and turbocharger hose fitting on engine block. Tighten each end with hose clamps.

Specification	
Turbocharger Oil Return Line (Turbocharger End)—Torque	36 N·m (26 lb-ft)
Oil Return Line (Block End)—Turns	2-3 Beyond Hand Tight

5. Connect oil line (A) (C) to fittings and tighten to specification.

Specification	
Turbocharger Oil Inlet Line (Turbocharger End)—Torque	19 N•m (14 lb-ft)

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



RG12529 —UN—12DEC02

Installing Turbocharger

A—Oil Supply Line (Turbocharger End)
B—Oil Return Line (Turbocharger End)
C—Oil Supply Line (Block End)
D—Oil Return Line (Block End)

Turbocharger Oil Inlet Line (Block End)—Torque	16 N•m (12 lb-ft)

6. If equipped, connect wastegate diaphragm hose.
7. Connect air intake and exhaust piping to turbocharger. Tighten all connections securely. (For vehicle engines, refer to machine Technical Manual.)

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

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

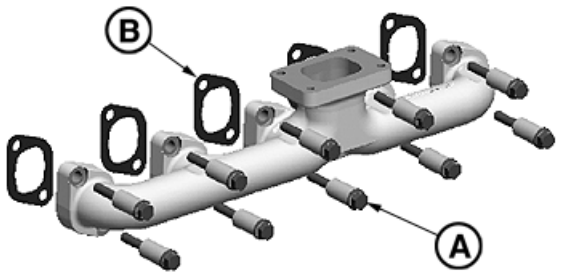
RG41183,000002A -19-16OCT02-1/1

Remove, Inspect, and Install Exhaust Manifold

1. Remove cap screws and spacers (A) and remove exhaust manifold. Remove manifold gaskets (B) and discard.
2. Remove all residue and gasket material from all gasket surfaces.
3. Thoroughly clean passages in exhaust manifold.
4. Inspect exhaust manifold for cracks or damage. Inspect machined mounting surfaces for burrs or other defects which might prevent gaskets from sealing properly. Replace parts as needed.
5. To install exhaust manifold, align new gaskets on exhaust manifold and exhaust ports. Install all cap screws with spacers finger tight to maintain gasket alignment.
6. Tighten cap screws on No. 2 and No. 3 cylinders to specification.

Specification

Exhaust Manifold Cap Screw—Torque.....32 N•m (24 lb-ft)



RG15559 —UN—26SEP07

Exhaust Manifold Assembly

A—Cap Screws with Spacers B—Gaskets

7. Tighten cap screws on No. 1 and No. 4 cylinders to specification.

   For 5-Cylinder engines tighten No. 1, No. 4, and No. 5 cylinders to specification.

Specification

Exhaust Manifold Cap Screw—Torque.....32 N•m (24 lb-ft)

RG41183,000002B -19-26SEP07-1/1

Remove, Inspect, and Install Intake Manifold

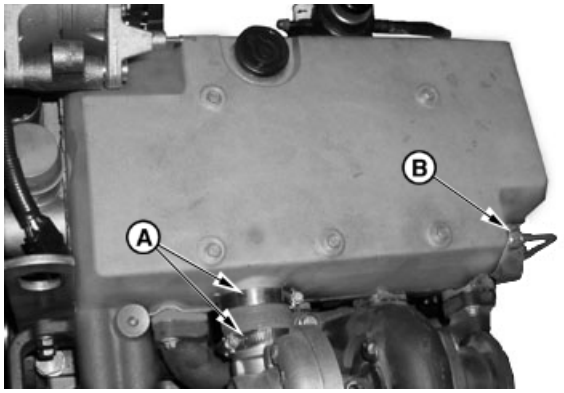
IMPORTANT: All intake manifold connections at the turbocharger and engine cylinder head must be tight to prevent loss of power resulting from lack of intake manifold pressure.

The intake manifold is an integral part of the rocker arm cover.

Intake manifold hose and rocker arm cover cap screws should be inspected periodically for tightness.

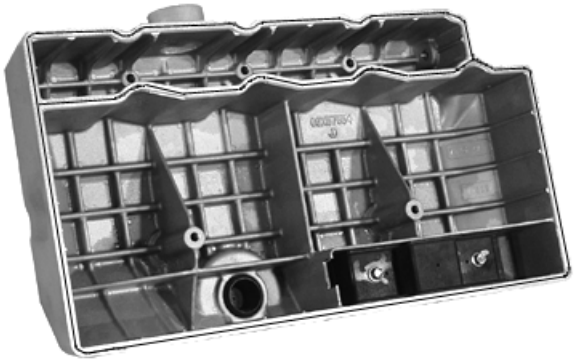
Whenever a tune-up has been performed on the engine, or whenever it is suspected that the horsepower output might be low, the intake manifold pressure (turbo-boost) should be checked.

1. Remove air intake hose clamps (A).
2. Disconnect aneroid line (B).
3. Remove cap screws and inspect O-rings, replace as necessary. Remove rocker arm cover.
4. Clean sealant from surfaces.
5. Inspect rocker arm cover for serviceability. Replace if cracked or otherwise damaged.
6. Apply a continuous 2—4 mm (0.08 in.) bead of PM710XX280 Silicone Sealant to mounting surface of rocker arm cover.
7. Install rocker arm cover onto cylinder head.



RG12531 —UN—06JUN03

Removing Intake Manifold



RG12530 —UN—12DEC02

Ensure Proper Application of Sealant

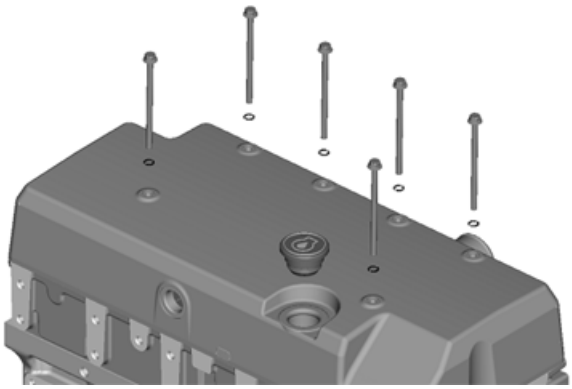
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RG41183,000002D -19-04MAY04-1/3

8. Install rocker arm cover O-rings and cap screws and tighten to specification.

Specification	
Rocker Arm Cover Cap Screws—Torque	12 N•m (9 lb-ft)

IMPORTANT: Allow sealant to cure for a minimum of 8 hours before operating engine.



RG12532 —UN—12DEC02

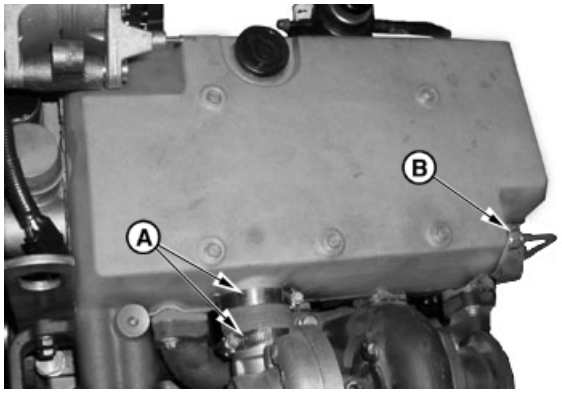
Installing Rocker Arm Cover O-ring and Cap Screws

RG41183,000002D -19-04MAY04-2/3

9. Install aneroid line (B) and tighten to specification.

Specification	
Aneroid line to Intake Manifold—Torque	15 N•m (11 lb-ft)

10. Install air inlet hose and tighten hose clamps (A).



RG12531 —UN—06JUN03

RG41183,000002D -19-04MAY04-3/3

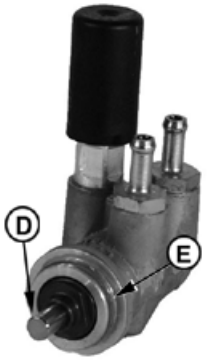
Remove and Install Fuel Supply Pump

1. Disconnect fuel outlet (A) and inlet (B) lines (shown removed).
2. Remove cap screws and clamps and remove fuel supply pump.
3. Clean and inspect push rod (D) for excessive wear and O-ring (E) for damage. Replace O-ring as needed.
4. Apply clean engine oil to push rod.
5. Apply AR54749 Soap Lubricant to O-ring.
6. Install fuel supply pump in a upright position at approximately 20° angle (C) as illustrated and tighten to specification.
7. Install fuel supply pump inlet and outlet lines.

Specification

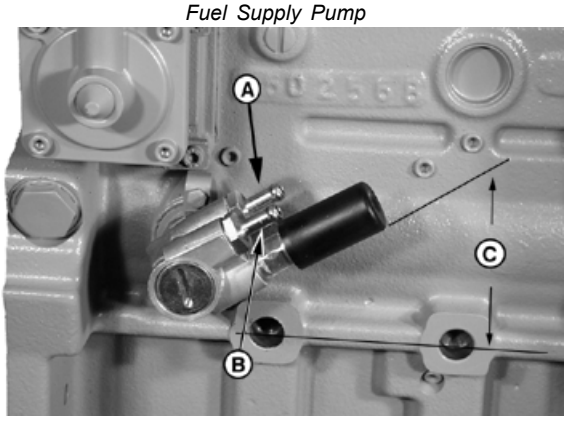
Fuel Supply Pump—Torque..... 15 N•m (11 lb-ft)

A—Fuel Outlet
B—Fuel Inlet
C—20° Angle
D—Supply Pump Push Rod
E—O-ring



RG12965 —UN—03JUN03

Fuel Supply Pump



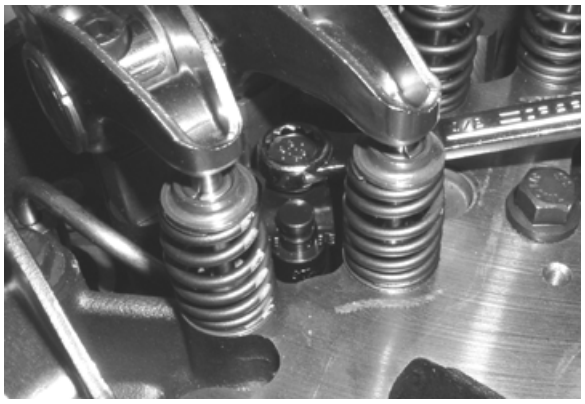
RG12964 —UN—03JUN03

Installation of Fuel Supply Pump

RG41183,0000003 -19-21JUN02-1/1

Remove and Install Injection Nozzles

1. Remove the injection nozzle hold-down clamp cap screw.



RG13630 —UN—20MAY04

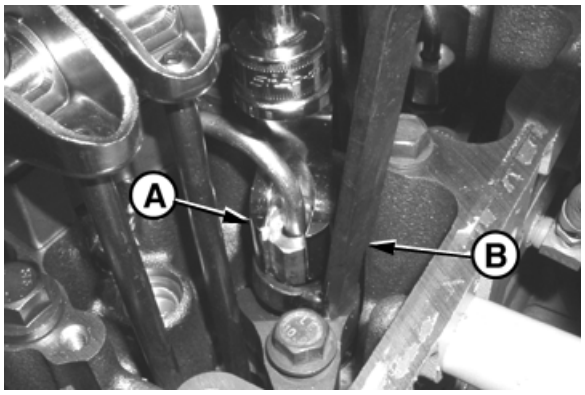
Remove Injection Nozzle Hold-Down Clamp Screw

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RG19661,000005C -19-28OCT04-1/4

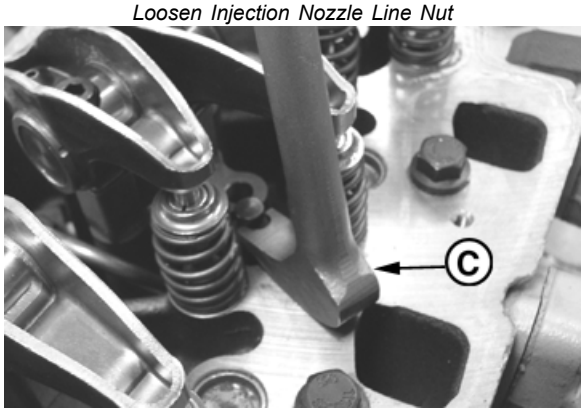
2. Loosen the injection nozzle line nut from the pressure relief valve on the pump unit with a 17 mm flare nut socket (A). To insure the injection pump unit does not move, use JDG1854 Wrench (B) to hold the pressure relief fitting while turning the injection nut. Remove injection nozzle from cylinder head using JDG1822 Injector Puller (C).

A—17 mm Flare Nut Socket
B—JDG1854 Wrench
C—JDG1822 Injection Nozzle Puller



RG13631 —UN—20MAY04

Loosen Injection Nozzle Line Nut



RG13632 —UN—20MAY04

Remove Injection Nozzle

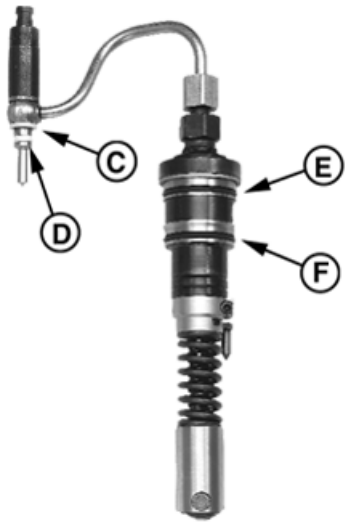
RG19661,000005C -19-28OCT04-2/4

NOTE: Anytime the nozzle is removed from the cylinder head, the washer and carbon seal must be replaced.

3. Remove carbon stop seal (D) and washer (C) from nozzle and discard. Install new carbon seal and washer.
4. Insert injection nozzle into cylinder head bore using thumb pressure only while aligning the end of the line with the pump pressure relief fitting. **Do not drive the nozzle into the bore by tapping or hammering - it will be seated properly when the clamp is tightened**. Start injection nozzle line nut on the injection pump pressure relief fitting.
5. Apply clean engine oil to the nozzle hold down clamp cap screw and tighten to specifications.

Specification	
Nozzle Clamp Cap Screw—Torque	27 N·m (20 lb-ft)

C—Washer
D—Carbon Stop Seal
E—O-ring Seal (Upper - Brown)
F—O-ring Seal (Lower - Black)



RG12976 —UN—11JUN03

Integrated Fuel System (IFS)

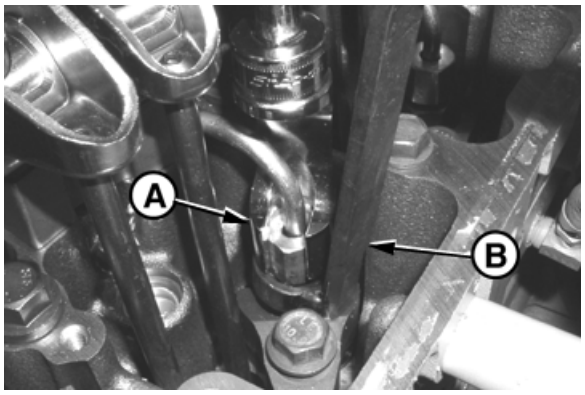
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RG19661,000005C -19-28OCT04-3/4

6. Hold the injection pump in position with JDG1854 (B) Wrench to prevent rotation and tighten the injection nozzle line nut using a 17 mm flare nut socket (A) to specifications.

Specification	
Injection Nozzle Nut—Torque	30 N·m (23 lb-ft)

A—17 mm Flare Nut Socket **B—JDG1854 Line Wrench**



RG13631 —UN—20MAY04

Tightening Injection Nozzle Line Nut

RG19661,000005C -19-28OCT04-4/4

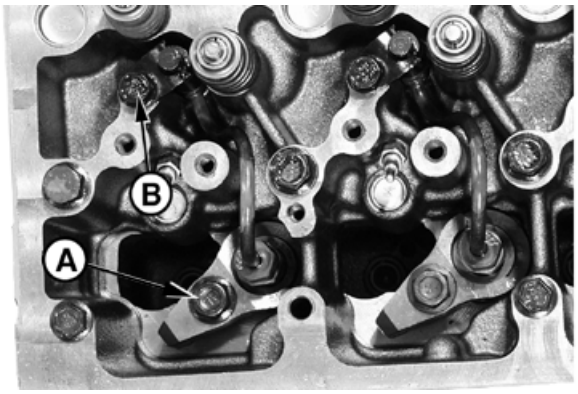
Remove and Inspect Injection Pump Units

NOTE: Place parts on a clean bench and identify parts for reassembly.

IMPORTANT: Never remove shims from unit pump body. Shims must stay on pump unit to ensure correct timing.

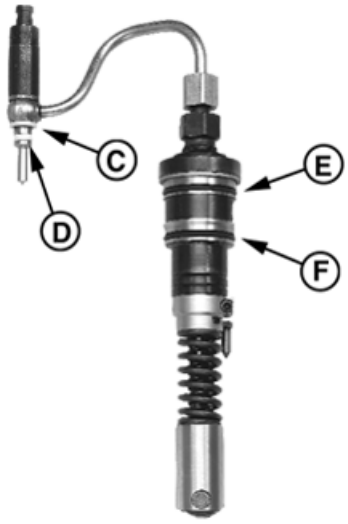
1. Remove injection pump clamp cap screw.
2. Carefully remove the pump unit. To prevent damage to the fuel control arm, do not rotate pump during removal. If the pump is difficult to remove, rotate the crankshaft two revolutions.
3. Remove cam follower/cold advance plunger assembly with a magnet. Inspect cam roller for excessive wear. Replace injection unit assembly if necessary.
4. Inspect O-ring rings (E) and (F) for nicks and cuts. Replace damaged O-rings.

C—Washer **E—O-ring Seal (Upper - Brown)**
D—Carbon Stop Seal **F—O-ring Seal (Lower - Black)**



RG12975 —UN—11JUN03

Unit Pump and Nozzle Hold Down Clamps



RG12976 —UN—11JUN03

Integrated Fuel System (IFS)

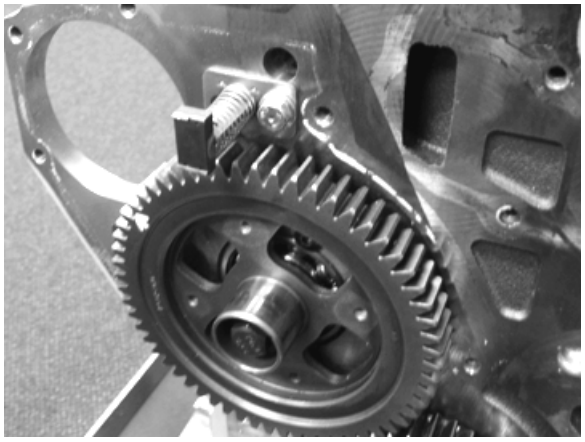
RG19661,000005D -19-08FEB05-1/1

Remove, Inspect and Install Fuel Control Rack

NOTE: Fuel injection pump units and electronic governor coupler (if equipped) must be removed before removing fuel control rack. Insure the aneroid control arm is not engaging the fuel control rack.

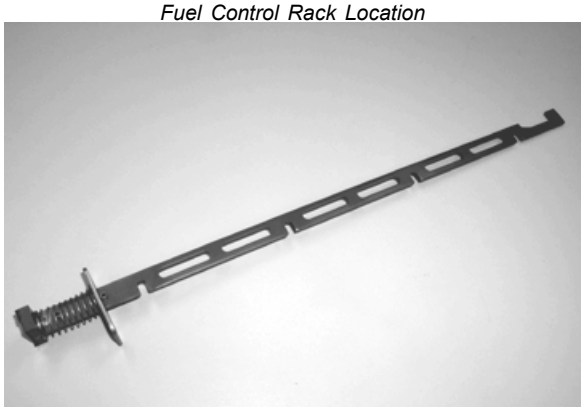
1. Remove fuel rack cap screw.
2. Carefully remove rack by pulling it forward out of the cylinder block.
3. Inspect fuel control rack for wear in the fuel control arm notches or rack face plate, a broken spring or bent spring pins. Fuel control rod should be straight and flat.

   Replace rack if worn or bent.



RG15134 —UN—29SEP06

Fuel Control Rack Location



RG15135 —UN—29SEP06

Fuel Control Rack



RG15136 —UN—29SEP06

Fuel Control Rack Plate

Continued on next page

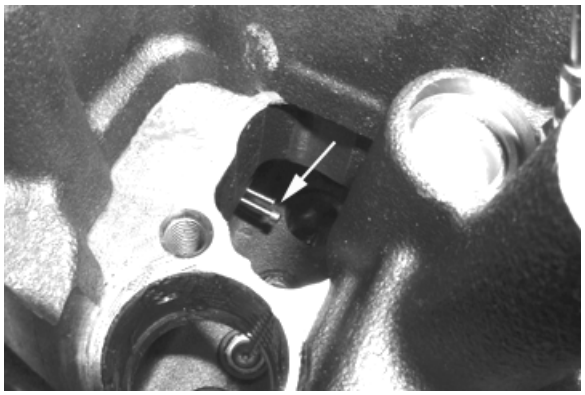
RG19661,0000183 -19-02OCT06-1/2

4. Carefully install fuel control rack into the cylinder block. Insure the rack is inserted through the guide at the rear of the cylinder block.
5. Locate fuel control attaching plate through cylinder block guide pin and install cap screw. Tighten to specifications.

Specification

Fuel Control Rack Cap Screw—Torque.....15 N·m (11 lb-ft)

6. Check rack travel to insure rack moves without binding in a smooth motion. See Measure Rack Travel in this section.



RG15137 —UN—02OCT06

Cylinder Block Fuel Control Rack Guide

RG19661,0000183 -19-02OCT06-2/2

Measure Fuel Control Rack Travel

NOTE: This measurement is used to ensure fuel control rack travel, without the fuel pump units installed, is within specifications. This step will be repeated after the fuel pump units are installed to verify complete rack travel.

1. Install JDG2073 Base (A) across the governor opening using the governor cover cap screw (C). The notch (N) in the top of the base will position the base with Pin Bushing (B) to guide the pin on the fuel control rack plate.

   Tighten cap screw to specifications. For consistent measurements, this cap screw must be tightened to the same torque value each time the base is installed.

   Specification

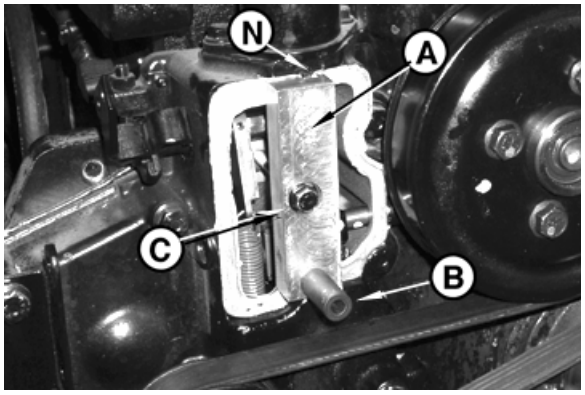
   Base Cap Screw—Torque..... 3.4 N·m (30 lb-in.)

2. Insert JDG2073 Pin (D) through the pin bushing and push the rack back (into the cylinder block) until it stops. Lock the collar in position on the pin. Withdraw the pin and measure this distance using a vernier caliper.
3. Allow the rack to move forward (out of the cylinder block) until it stops. Make sure the electric shut-off lever is not contacting the rack plate. With the rack in the forward position, gently insert the pin through the bushing until it contacts the rack plate. Measure this distance with the pin, locking collar and vernier caliper.
4. Calculate total rack travel by subtracting the smaller dimension from the larger one. Record this distance and compare to specification.

   Specification

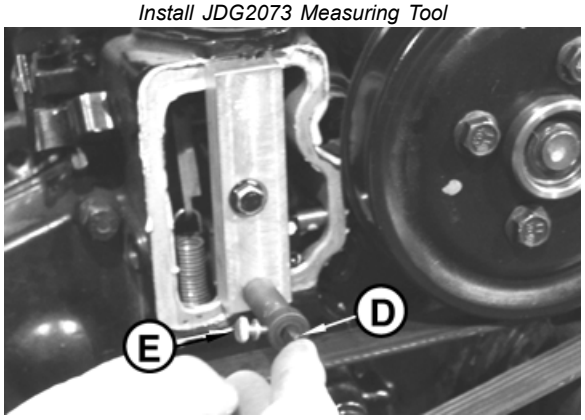
   Fuel Control Rack Travel - Pumps Not Installed—Distance.....21.00—21.75 mm (0.827—0.856 in.)

   If the measurement is not within this range, additional investigation is required to determine if the aneroid actuating lever, damaged fuel rack guide or debris are preventing full travel. Remove JDG2073 Measuring Tool.



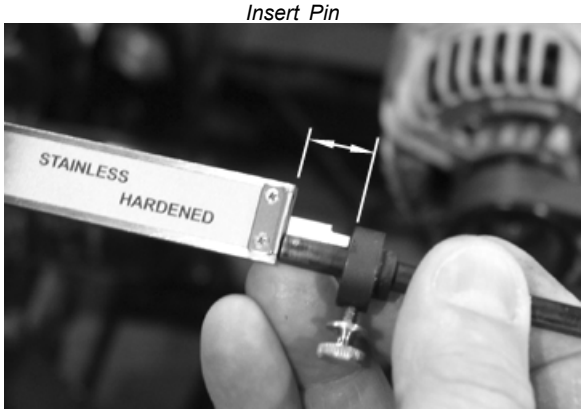
RG14494 —UN—20SEP05

Install JDG2073 Measuring Tool



RG14495 —UN—20SEP05

Insert Pin



RG14496 —UN—20SEP05

Measure and Record Distance

A—Base
B—Pin Bushing
C—Cap Screw
D—Pin
E—Locking Collar
N—Notch in Base

RG19661,0000132 -19-02DEC05-1/1

Install and Synchronize Injection Pumps

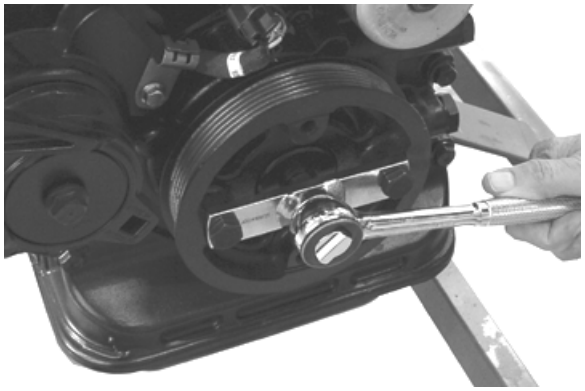
IMPORTANT: If rocker arm assembly was removed, the hydraulic lifters will need to be bled down. Refer to the valve train instructions to insure cam followers and valve train components are properly installed when the rocker arm supports have been removed. See INSTALL ROCKER ARM ASSEMBLY in Section 02, Group 20 in CTM 301 manual.

The following procedure must be followed to properly install each injection pump. Each individual pump fuel control lever must be set in the same relative position in the fuel control rack. **The injection pump, camshaft follower and nozzle are calibrated and installed as a matched set.** Mixing components will result in excessive variation in fuel delivery and injection timing. Install a complete pump before moving to the next cylinder to avoid mixing components.

1. Using JDG1704 or JDG10221 Turning Tool, rotate engine crankshaft in running direction (clockwise as viewed from front) until the No. 1 piston is at TDC on the exhaust stroke. The No. 1 cylinder is defined as the cylinder closest to the engine-mounted fan.

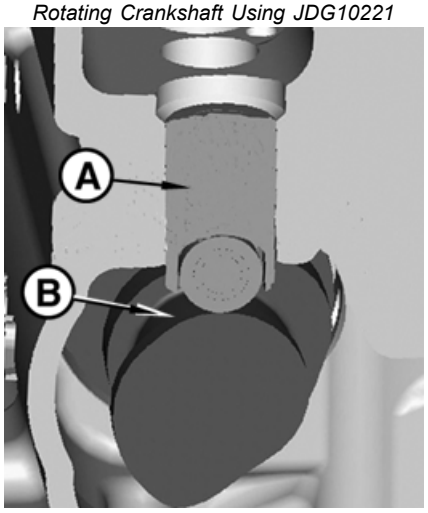
   Install the JDE81-4 Timing Pin at the rear, right-hand side of the cylinder block and observe the No. 1 intake and exhaust valves will be partially open. The injection pump must be installed when the camshaft pump follower (A) is at the lowest position on the camshaft base circle (B) and seated properly in the follower bore. This can be visually confirmed by observing the movement of the camshaft follower with relation to the cylinder block casting as the crankshaft is turned.

A—Camshaft Pump Follower **B—Camshaft Injection Lobe**



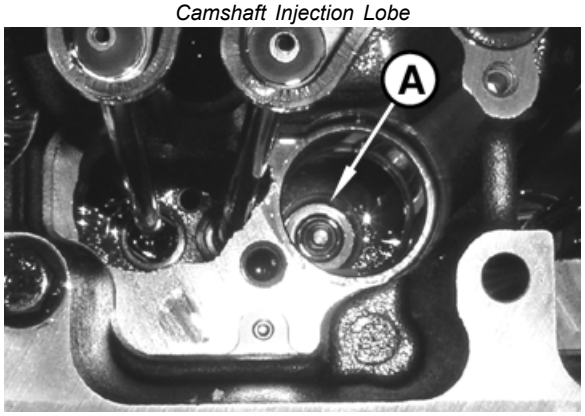
RG15114 —UN—26SEP06

Rotating Crankshaft Using JDG10221



RG14053 —UN—07DEC05

Camshaft Injection Lobe



RG14001 —UN—01MAR05

Camshaft Pump Follower in Cylinder Block

Continued on next page

RG19661,0000137 -19-27SEP06-1/5

IMPORTANT: When installing injection pump into cylinder block, the control arm pin (F) must be aligned into the fuel rack groove. Do not apply excessive pressure to force engagement.

2. Lubricate O-rings (C) and (D) for the No. 1 pump with Parker O Lube™. Avoid getting excess lubricant on fuel inlet screen (E).

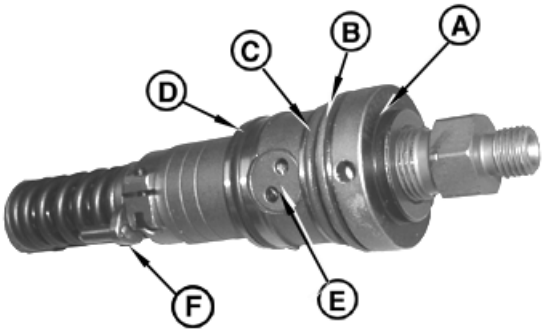
NOTE: When installing the No. 1 pump, the fuel control rack should be positioned to the rear (into the cylinder block) as far as it will travel to allow visual inspection of the injection pump fuel control arm engagement in the fuel control rack notch. All other pumps will be installed with the fuel control rack in the forward position (out of the cylinder block).

   Install pump into the engine block. Visually verify fuel control arm engagement in fuel control rack notch (H).

   Apply clean engine oil to the new pump clamp cap screw and tighten finger-tight to insure pump is properly seated.

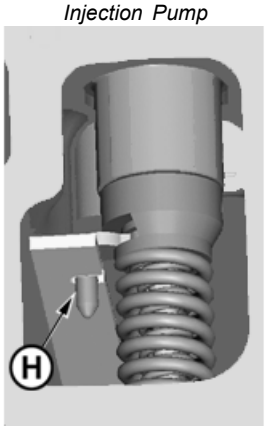
3. Slowly rotate the pump counter-clockwise (as viewed from the top of the engine) using the torque wrench until the fuel control rack visually stops moving forward (out of the cylinder block) and a value of 3.4 N·m (30 lb-in.) is indicated.

A—Pump Part Number and Serial Number Location
B—Timing Shim
C—O-Ring (Upper - Brown)
D—O-Ring (Lower - Black)
E—Inlet Screen
F—Fuel Control Arm
H—Fuel Control Rack Notch



RG13996 —UN—24FEB05

Injection Pump



RG12983 —UN—12JUN03

Pump Fuel Control Arm Pin in Fuel Rack Notch



RG13992 —UN—19FEB05

Pump Installation - Initial

Continued on next page

RG19661,0000137 -19-27SEP06-2/5

4. Install JDG10245 Rack Retaining Pin (C) into the fuel control rack spring pin. It is not necessary to push the rack spring back to insert the tool in the spring pin. The tool can be engaged through the rack spring.
5. Install JDG10245 Base (A) across the governor opening using the governor cover cap screw (H). The notch in the top of the base will position the Gauge Bushing (B) to guide the dial indicator extension onto the fuel control rack plate and allow the threaded retaining pin to protrude through the hole in the base.

   Tighten to specifications. For consistent measurements, this cap screw must be tightened to the same torque value each time the base is installed.

Specification

Base Cap Screw—Torque ..... 3.4 N·m (30 lb-in.)

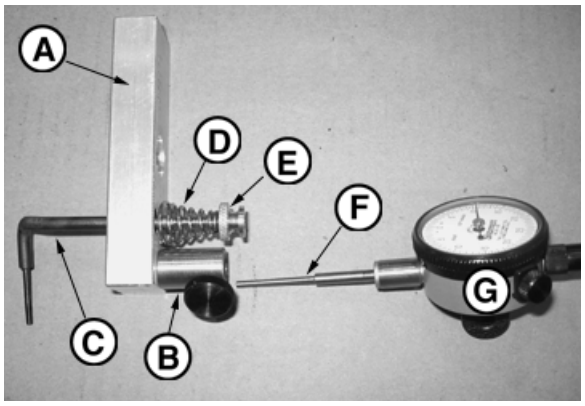
CAUTION: Ensure the rack retaining pin (C) is slowly pulled straight forward and without rotation so a bending or twisting force is not applied to the rack.

6. Place the tapered spring (D) over pin with the larger diameter against the base and install the knurled nut (E). Tighten knurled nut until spring is compressed to approximately 1/2 the original spring length.
7. Install Indicator Bushing (B) into the base.

   Install dial indicator extension (F) to dial indicator (G).

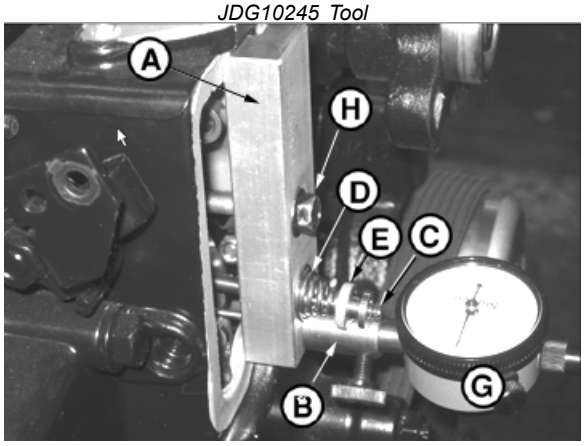
   Slide dial indicator into bushing until the indicator extension contacts the fuel control rack plate. Continue to slide the indicator into the bushing for 1/2 - 3/4 turns of the pointer and tighten thumbscrew. Visually confirm the indicator extension is contacting **below** the rack plate lip and moves freely.

   Rotate the No. 1 pump clockwise approximately 10°—15° and stop. The No. 1 pump **will not** be clocked at this time.



RG14615 —UN—30NOV05

JDG10245 Tool



RG14614 —UN—30NOV05

Install JDG10245 Tool

A—Base
B—Gauge Bushing
C—Retaining Pin
D—Tapered Spring
E—Knurled Nut
F—Dial Indicator Extension
G—Dial Indicator
H—Governor Cover Cap Screw

Turn the indicator dial face until the pointer is on “0”.

Continued on next page

RG19661,0000137 -19-27SEP06-3/5

IMPORTANT: To minimize fuel control rack deflection, injection pumps are synchronized in sequence from the rear-to-front of the engine.

8. Lubricate O-rings for the rear pump with Parker O Lube™. Avoid getting excess lubricant on fuel inlet screen. Install pump into the engine block. Visually verify fuel control arm engagement in fuel control rack notch.

   Apply clean engine oil to the new pump clamp cap screw and tighten to specification to insure pump is properly seated.

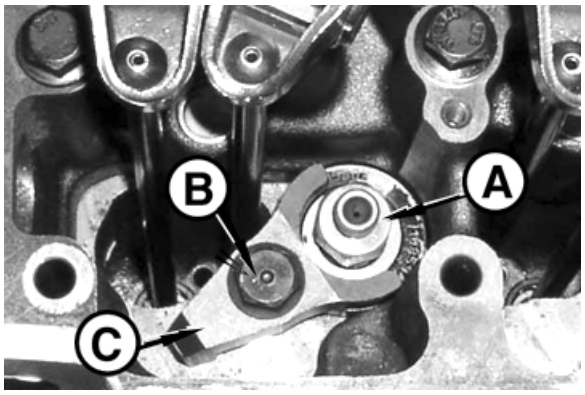
Specification

Pump Clamp Cap Screw
- Initial—Torque..... 50 N·m (37 lb-ft)

   Loosen pump clamp cap screw and retighten to specification to take-up shim pack clearance and ensure pump remains fully seated while allowing pump rotation without excess friction.

Specification

Pump Clamp Cap Screw
- Intermediate—Torque..... 6.2 N·m (55 lb-in.)



RG13997 —UN—24FEB05

Install Injection Pump

A—Injection Pump
B—Injection Pump Clamp Cap Screw
C—Injection Pump Clamp

Dial indicator pointer should be at “0”. If not, reset dial face position so the pointer is at “0”.

Continued on next page

RG19661,0000137 -19-27SEP06-4/5

9. Slowly rotate the injection pump clockwise (as viewed from the top of the engine) until the indicator pointer moves off “0” approximately 0.38—0.25 mm (0.010—0.015 in.). Slowly rotate pump in both directions and observe dial indicator to insure unrestricted smooth indicator pointer movement. If movement is restricted or irregular, check dial indicator extension for binding.

   Slowly rotate the pump counter-clockwise until the pointer stops moving. The pointer should now be at “0”. If not, reset indicator dial face until the pointer is on “0”.

10. Slowly rotate the pump clockwise until the dial indicator pointer has moved 0.025 mm (0.001 in.).

    If the indicator moves more than this distance, slowly rotate the pump back (counter-clockwise) until the pointer is at “0”. Reset the pump by slowly rotating the pump clockwise until the pointer has moved 0.025 mm (0.001 in.).

11. Tighten injection pump clamp cap screw to specifications.

Specification

Pump Clamp Cap Screw
- Final—Torque..... 50 N·m (37 lb-ft)

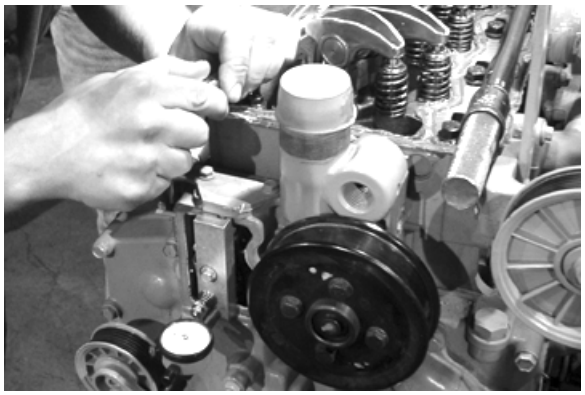
    Observe dial indicator pointer while tightening the clamp cap screw. Rack movement of 0.0127 mm (0.0005 in.) in either direction is acceptable.

    If the rack movement is greater than 0.0127 mm (0.0005 in.), loosen the pump clamp cap screw to 6.2 N·m (55 lb-in.) and repeat steps 9—11.

    Reset dial indicator face to “0”.

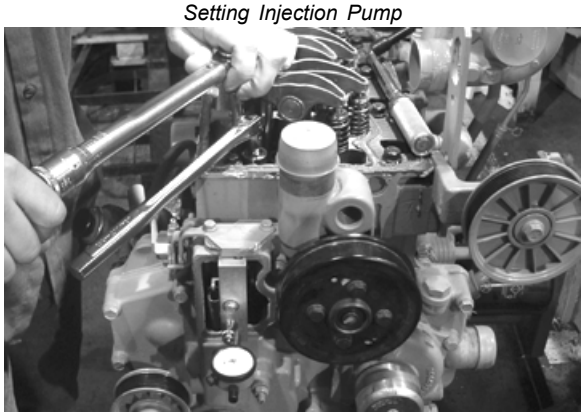
12. To ensure each injection pump camshaft follower will be on the base circle (Step 1) during pump installation , remove the timing pin and rotate the crankshaft as follows:

    - 4-Cylinder engine: With the No. 1 pump in place, rotate the crankshaft 360° in the direction of engine rotation. Install and synchronize No. 4 and No. 3 pumps. Rotate the crankshaft another 360°. Install the No. 2 pump and synchronize the No. 2 and No. 1 pumps.
    - 5-Cylinder engine: With the No. 1 pump in place, rotate the crankshaft 540° (360° + 180°) in the direction of engine rotation. Install and synchronize No. 5, No. 4 and No. 3 pumps. Rotate the crankshaft another 360°. Install the No. 2 pump and synchronize No. 2 and No. 1 pumps.



RG14617 —UN—30NOV05

Setting Injection Pump



RG14616 —UN—30NOV05

Tightening Injection Pump Clamp Cap Screw

13. Move forward to the next cylinder and repeat Steps 8 — 11 to install and synchronize the remaining injection pumps, rotating the crankshaft per Step 12.

14. Remove JDG10251 Rack Measuring tools. Pull the electric shut-off solenoid lever forward and check to ensure free rack movement.

RG19661,0000137 -19-27SEP06-5/5

Remeasure Fuel Control Rack Travel

1. Install JDG2073 Base with bushing across the governor opening using the governor cover cap screw.

   Tighten cap screw to specifications. For consistent measurements, this cap screw must be tightened to the same torque value each time the base is installed.

Specification

Base Cap
Screw—Torque..... 3.4 N·m (30 lb-in.)

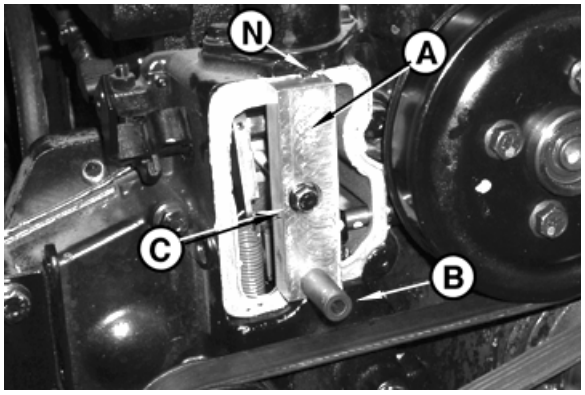
2. Measure distance to the rack in the front and rear positions with the electric shut-off lever pulled forward (see Measure Fuel Control Rack Travel instruction). Record these measurements and subtract to determine the total rack travel. Record this measurement.
3. Compare this measurement with pumps installed to the previous measurement recorded with pumps not installed . The difference between the two total rack travel measurements should be within specifications.

Specification

Fuel Control Rack
Measurement
Difference—Distance..... 0.203 mm (0.008 in.)

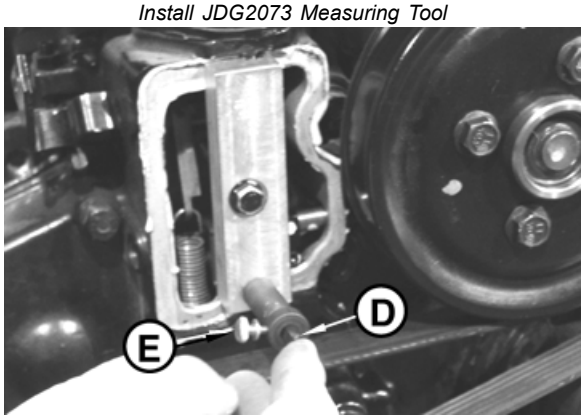
   If the measurement difference is greater than this value, the pumps will need to be reset as follows.

   - Loosen all injection pump clamp cap screws the minimum amount to allow pump rotation (6.2 N·m or 55 lb-in.). **Do not remove injection pumps**.
   - Rotate all pumps 20°—30° counter-clockwise (as viewed from the top of the engine).
   - Synchronize the pumps per Step 9 — 11, after positioning No. 1 piston at TDC (compression stroke). This position can be verified by installing JDE84-1 Timing Pin and observing No. 1 intake and exhaust valves are closed. Remove timing pin and rotate the engine as follows:
     - 4-cylinder: Synchronize No. 4 pump and No. 3 pump; rotate crankshaft 360°; synchronize No. 2 pump and No. 1 pump.
     - 5-cylinder: Rotate crankshaft 180°; synchronize No. 5 pump, No, 4 pump and No. 3 pump; rotate crankshaft 360°; synchronize No. 2 pump and No. 1 pump.
4. Apply a continuous 2—4 mm (0.08—0.16 in.) bead of PM710XX280 Silicone Sealant to mounting surface of the governor cover and install. All sealing surfaces must be clean and free of oil. Tighten cap screw to specifications.



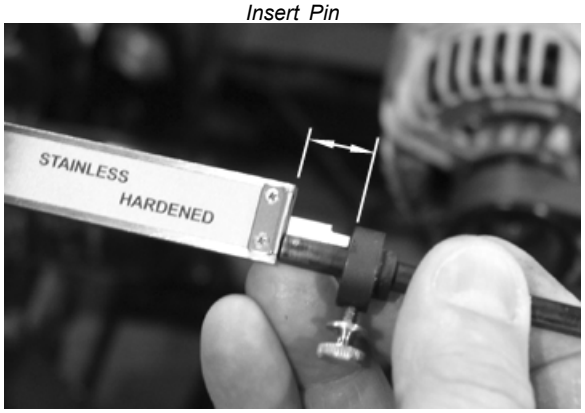
RG14494 —UN—20SEP05

Install JDG2073 Measuring Tool



RG14495 —UN—20SEP05

Insert Pin



RG14496 —UN—20SEP05

Measure and Record Distance

A—Base
B—Pin Bushing
C—Cap Screw
D—Pin
E—Locking Collar
N—Notch in Base

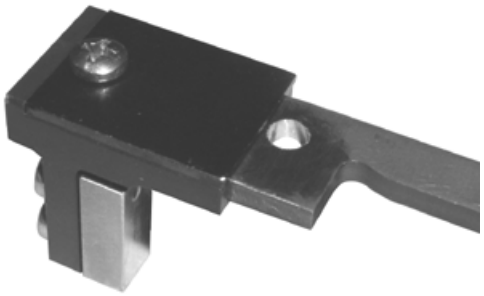
Specification

Governor Cover Cap
Screw—Torque..... 14 N·m (10 lb-ft)

RG19661,0000133 -19-07DEC05-1/1

Install Electronic Governor Coupler

1. Move the fuel control rack forward in the cylinder block and place the governor coupler on the rack end. Push the coupler onto the rack using enough force to engage the retaining ball in the rack.
2. Ensure the coupler is in place by trying to pull the coupler off the rack using 2—3 Kg (4—7 lbs) force.
3. Check movement of the coupler on the rack. It should fit securely yet have slight movement.



RG13551 —UN—13FEB04

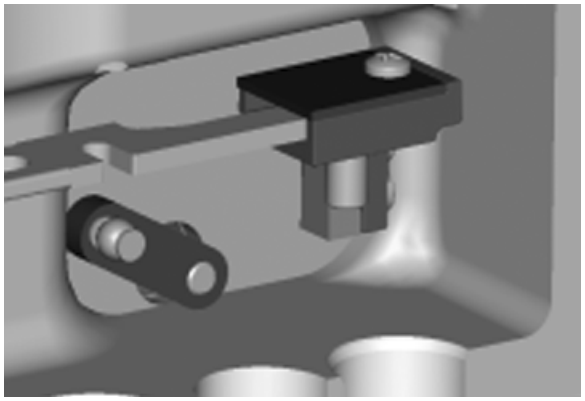
Coupler Installation

RG19661,0000054 -19-20JAN04-1/1

Install Electronic Governor

IMPORTANT: Do not install the plastic actuator cover on the actuator assembly at this time. Plastic tabs in the cover engage square holes in the actuator body and will be broken when the cover is removed.

1. Apply a continuous 3—4 mm (0.12—0.16 in.) bead of PM710XX280 Silicone Sealant to the mounting plate surface of the actuator.



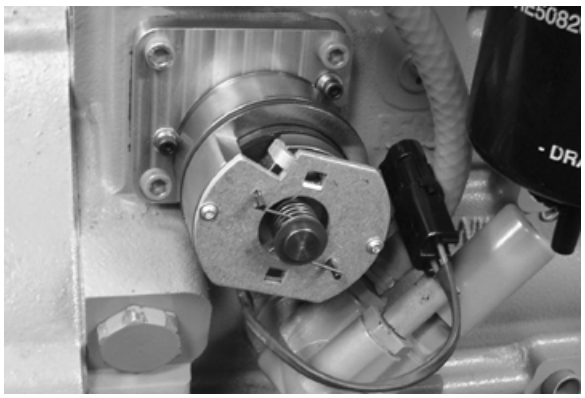
RG13556 —UN—13FEB04

Coupler - Governor Actuator Lever Position (Inside View)

RG19661,0000055 -19-20JAN04-1/2

2. Ensure the actuator lever is in front of the rack coupler and the O-ring for the oil passage is in place. Install the actuator on the cylinder block. Tighten the mounting screws to specifications.

Specification	
Actuator Mounting Screw—Torque	15 N·m (11 lb-ft)



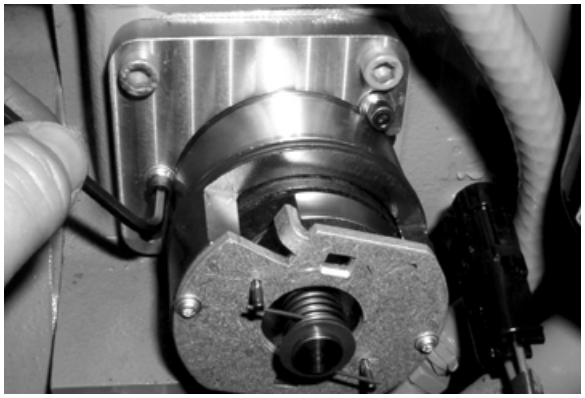
RG13552 —UN—13FEB04

Install Electronic Governor

RG19661,0000055 -19-20JAN04-2/2

Adjust Electronic Governor Actuator Arm

1. Loosen the three screws that retain the actuator to the mounting plate.
2. Rotate the actuator counter-clockwise until the rack is to the end of the travel to the back of the cylinder block (zero rack position). The rack will be in this position when the engine shut-off solenoid is in the “stop” position.



RG13555 —UN—13FEB04

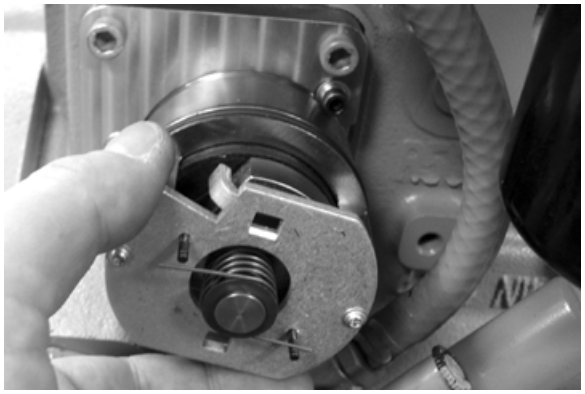
Actuator Mounting Screws

RG19661,0000056 -19-20JAN04-1/4

3. Rotate the actuator in a clockwise position to obtain the specified clearance gap between the actuator stop and the rotor.

Specification

Actuator Clearance—Clearance ..... 0.13—0.25 mm (0.005—0.010 in.)



RG13559 —UN—13FEB04

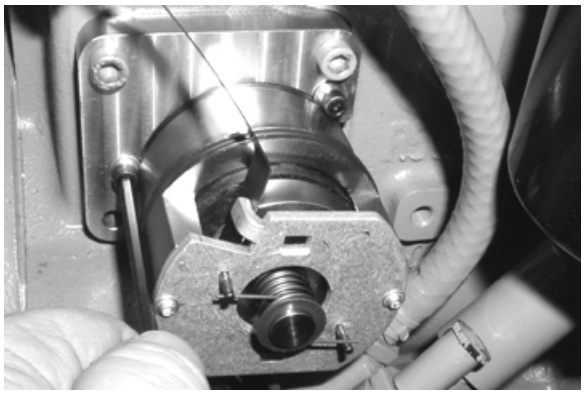
Adjust Actuator Rotor

RG19661,0000056 -19-20JAN04-2/4

4. Tighten the three actuator retaining screws to specifications.

Specification

Actuator Retaining Screw—Torque ..... 2—3 N·m (0.5—0.6 lb-ft)



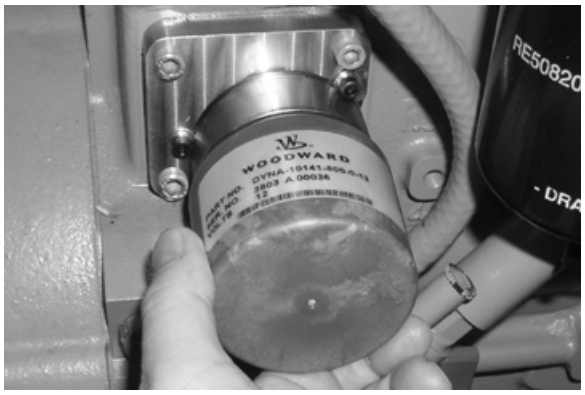
RG13553 —UN—13FEB04

Setting Actuator Rotor Position

Continued on next page

RG19661,0000056 -19-20JAN04-3/4

5. Install plastic cap on actuator. Plastic tabs on the inside of the cover will snap into holes in the actuator.
6. Connect wiring lead to control box.



RG13554 —UN—16FEB04

Install Governor Cover

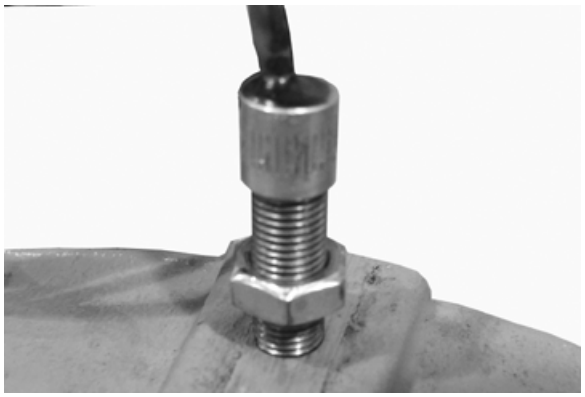
RG19661,0000056 -19-20JAN04-4/4

Install Speed Sensor

Speed Sensor in Flywheel

The speed sensor is located on the flywheel housing. The center of the ring gear tooth must be aligned with the centerline of the speed sensor hole to properly set the air gap.

1. Install speed sensor and tighten until it contacts a ring gear tooth. Identify this position by placing a mark on the top of the sensor.



RG13557 —UN—13FEB04

Install and Position Speed Sensor

RG19661,0000057 -19-05MAR04-1/3

2. Loosen the sensor between 3/4 and 1 turn. This will provide the proper gap of 0.5—1.0 mm (0.02—0.04 in.) between the sensor and the ring gear teeth. Tighten speed sensor lock nut to specification.

Specification	
Speed Sensor Lock Nut—Torque	14—19 N·m (10—14 lb-ft)



RG13558 —UN—13FEB04

Speed Sensor

Continued on next page

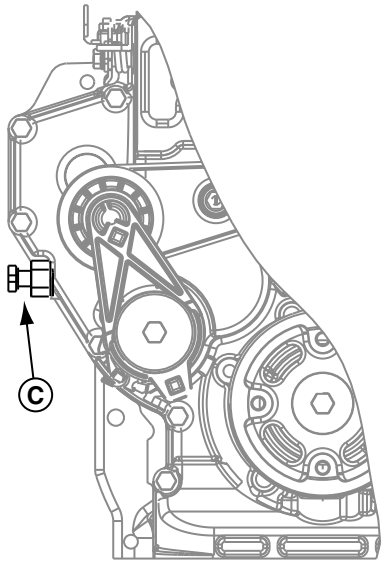
RG19661,0000057 -19-05MAR04-2/3

Speed Sensor in Timing Gear Cover

1. Install speed sensor (C) with O-ring into timing gear cover.
2. Tighten to specification.

Specification

Speed Sensor (TGC)—Torque..... 20 N·m (15 lb-ft)



RG13583 —UN—05MAR04

Speed Sensor in Timing Gear Cover

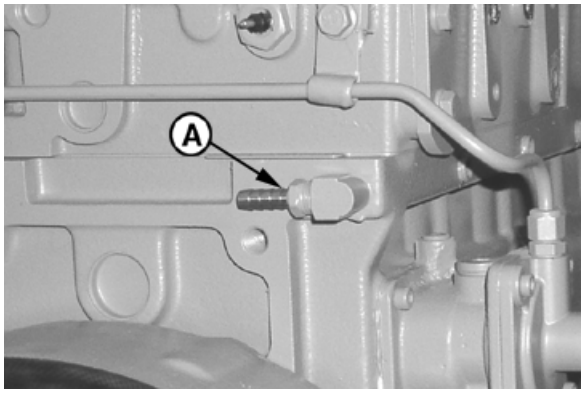
RG19661,0000057 -19-05MAR04-3/3

Remove and Install Fuel Rail Check Valve

1. Remove fuel return line from check valve (shown removed).
2. Remove check valve (A) from 90° fitting and clean threads.
3. Check operation of check valve using 15 - 20 psi air. Replace as necessary.
4. Apply LOCTITE® 592 to threads, install into 90° fitting and tighten.

A—Fuel Drain Back Check Valve

LOCTITE is a trademark of Loctite Corp.



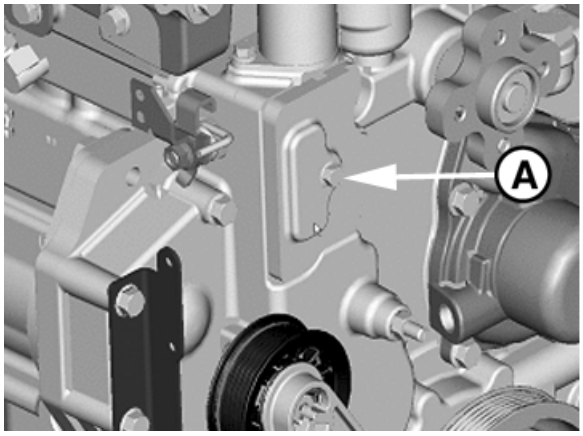
RG12890 —UN—06MAY03

Fuel Drain Back Check Valve

RG41183,0000044 -19-30JUN03-1/1

Change Main Governor Spring

1. Loosen and remove hex screw (A) and remove governor access cover from the front cover of the engine.



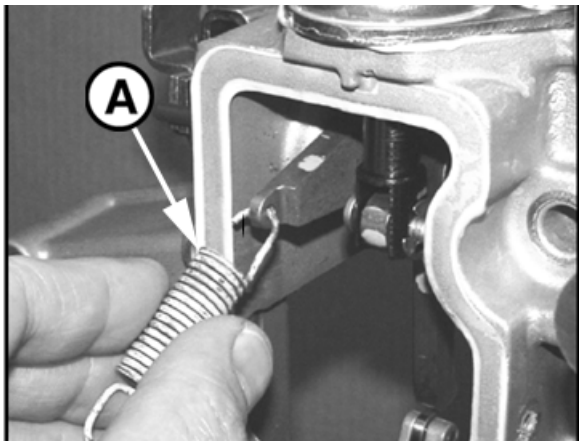
RG13693 —UN—08SEP04

Governor Access Cover

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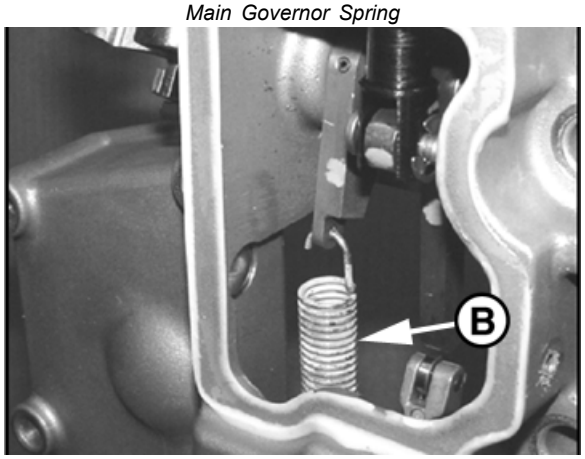
RG19661,0000079 -19-21SEP04-1/4

2. Remove the main governor spring (A).
3. Install new main governor spring provided in same position (A). Position the spring inside the governor housing and allow to hang vertically as shown (B).



RG13694 —UN—08SEP04

Main Governor Spring



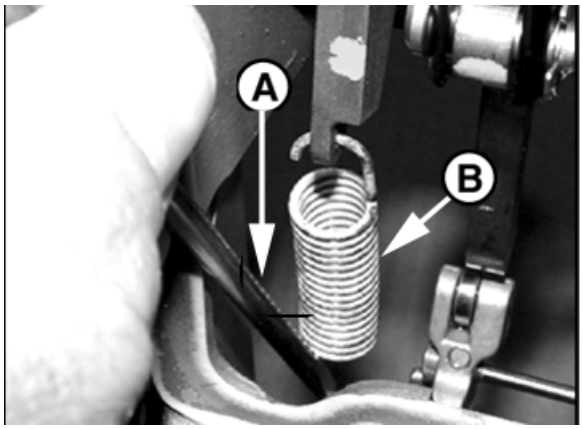
RG13695 —UN—08SEP04

Main Governor Spring Position

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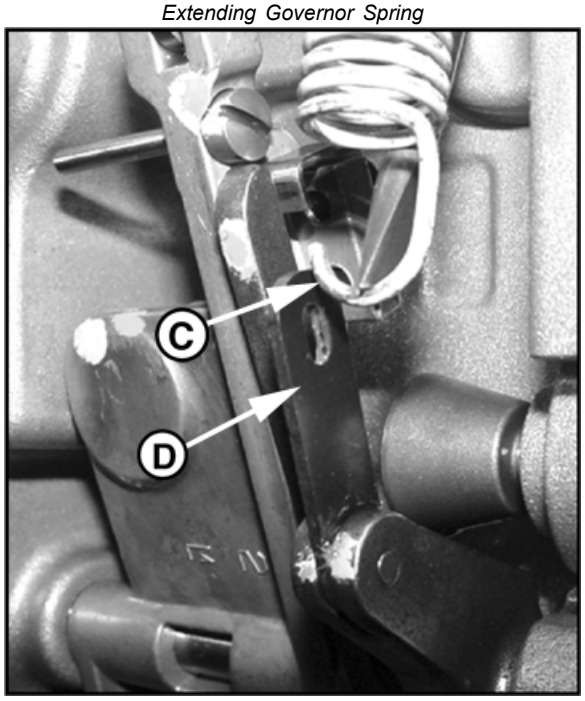
RG19661,0000079 -19-21SEP04-2/4

4. Using spring tool or fabricated screwdriver (A), push the spring (B) downward to install the end of spring (C) into governor linkage arm (D). The end of the notched screwdriver is visible in the photo below, showing position on the end of the spring. See DEALER FABRICATED TOOLS, Group 190.



RG13696 —UN—08SEP04

Extending Governor Spring

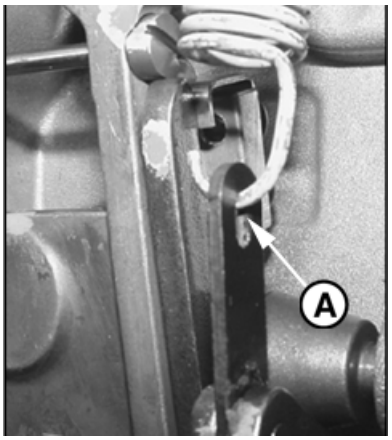


RG13697 —UN—13JUL05

Attaching End of Governor Spring

RG19661,0000079 -19-21SEP04-3/4

5. When the spring is assembled correctly, the end loop of the spring is installed in the linkage arm notch, as shown (A).



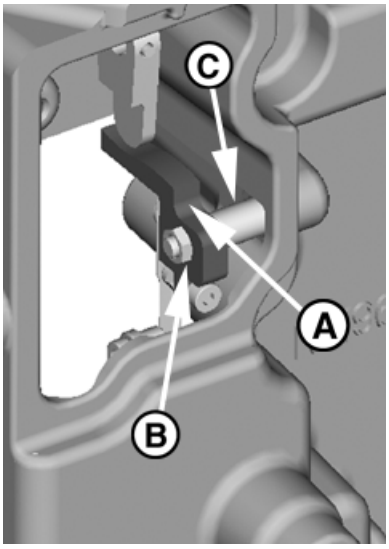
RG13698 —UN—08SEP04

Assembled Governor Spring

RG19661,0000079 -19-21SEP04-4/4

Change Low Idle Bumper Spring

1. Locate the low idle bumper (LIB) lever assembly (A) at the lower right hand side of the governor access opening.
2. Remove the nut (B) that secures the LIB lever assembly on to the shaft (C).
3. Clean the shaft and hex nut threads to remove thread locking compound.



RG13699 —UN—08SEP04

Low Idle Bumper Assembly

RG19661,000007B -19-21SEP04-1/3

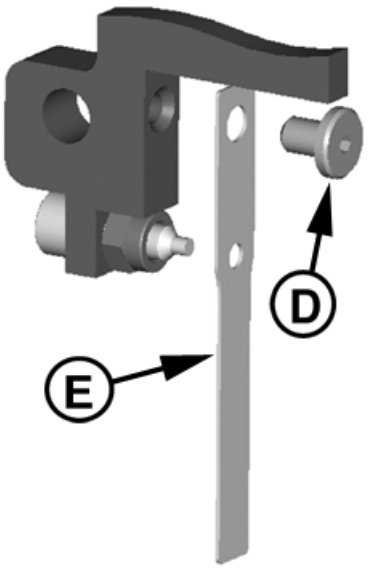
4. Remove the small screw (D) that attaches the LIB leaf spring (E) to the lever.

NOTE: Apply a light duty thread locking compound (such as LOCTITE®242) on the external threads of the new attaching screw.

5. Attach the new leaf spring to the lever in the same position.

Specification

Leaf Spring Attaching Screw—Torque.....2-3 N·m (1.5-2.0 lb-ft)



RG13700 —UN—08SEP04

LIB Attaching Screw and Leaf Spring

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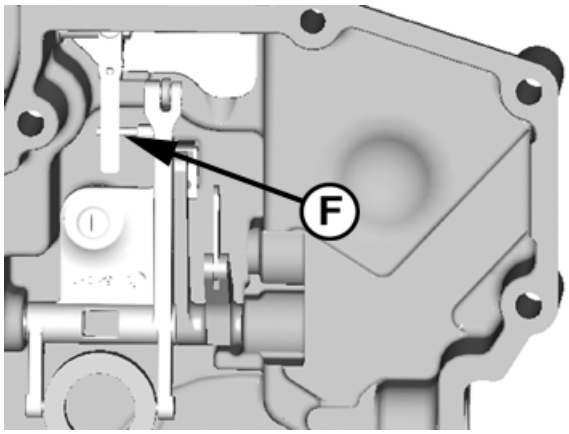
RG19661,000007B -19-21SEP04-2/3

IMPORTANT: Insure leaf spring position is on the cylinder block side of the governor lever rest pin (F).

NOTE: Apply a light duty thread locking compound (such as LOCTITE®242) on the external threads of the stub shaft. Exercise caution to not get compound into the LIB lever to shaft joint.

6. Assemble the LIB lever assembly back onto the shaft. Secure the shaft with the hex nut.

Specification	
Lever Assembly Hex Nut to Stub Shaft—Torque	3-4 N·m (2.0-3.0 lb-ft)



RG13701 —UN—08SEP04

LIB Lever Assembly Position

7. Apply a continuous 2—4 mm (0.08—0.16 in.) bead of PM710XX280 Silicone Sealant to clean sealing surface of the governor access opening and install cover with hex screw.

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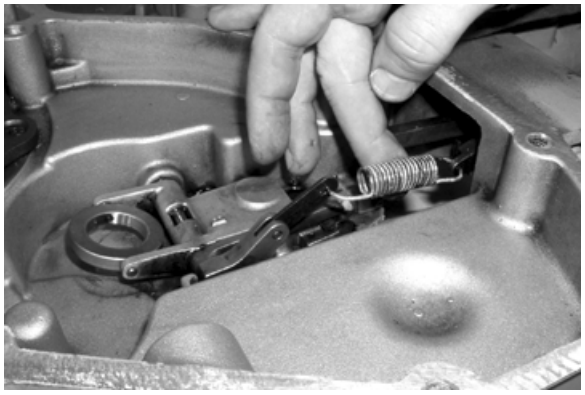
RG19661,000007B -19-21SEP04-3/3

Remove and Install Governor Lever Assembly

Remove Governor Lever Assembly

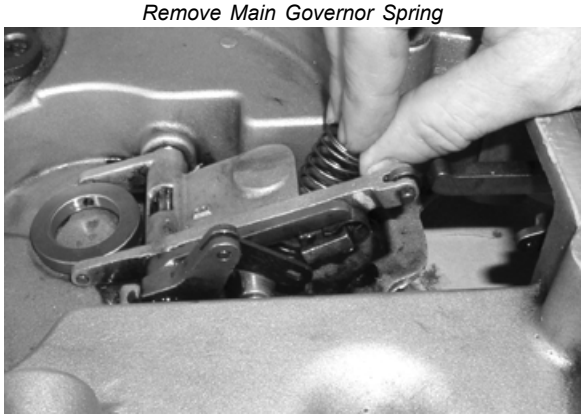
NOTE: To avoid damaging the spring, pliers or similar tools should not be used.

1. Disconnect main governor spring from throttle control lever link and throttle spring lever.
2. Remove idle bias spring.
3. Drill 1/8 in. hole in the governor shaft cup plug and remove from the timing gear cover using JDG22 Seal Remover.



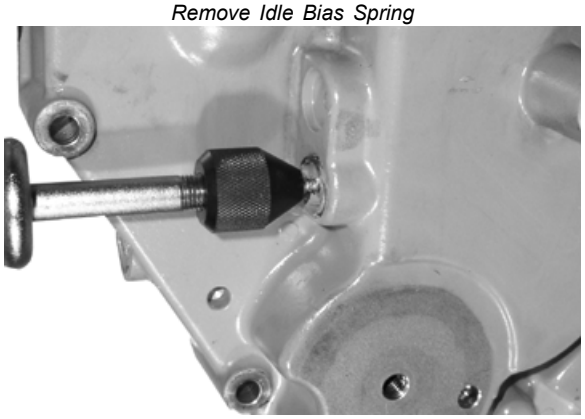
RG12863 —UN—01MAY03

Remove Main Governor Spring



RG12864 —UN—28APR03

Remove Idle Bias Spring



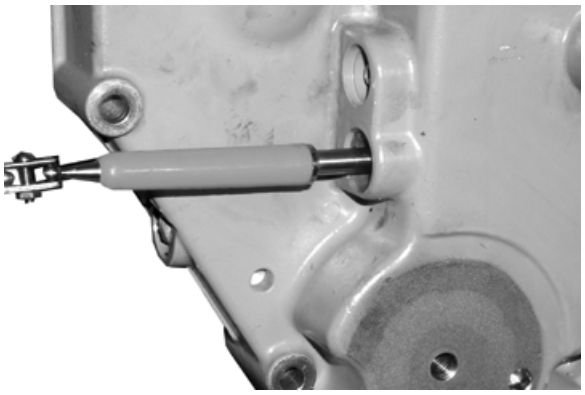
RG12865 —UN—01MAY03

Remove Governor Shaft Cup Plug

Continued on next page

RG19661,000003B -19-21SEP04-1/6

4. Remove governor shaft with a magnetic tool. The throttle control lever and governor lever can now be removed. Inspect shaft, governor lever and thrust ring for wear and defects. Replace assembly, if required.



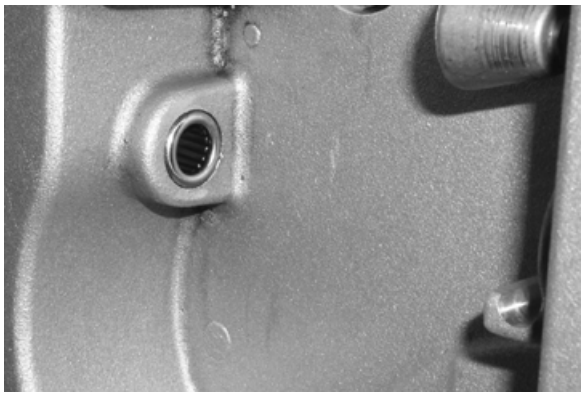
RG12866 —UN—02MAY03

Remove Governor Shaft

RG19661,000003B -19-21SEP04-2/6

Install Governor Lever Assembly

1. The inner governor shaft bearing should protrude 1—2 mm (0.04—0.08 in) from the timing gear cover surface.



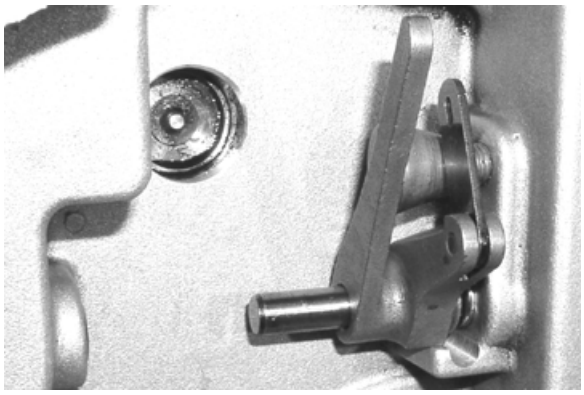
RG12870 —UN—05MAY03

Inner Bearing Location

Continued on next page

RG19661,000003B -19-21SEP04-3/6

2. Insert governor lever shaft through the timing gear cover and install the throttle lever and governor lever assembly. Throttle tension lever on the is inside the governor lever arm spring.



RG12867 —UN—05MAY03

Install Throttle Lever



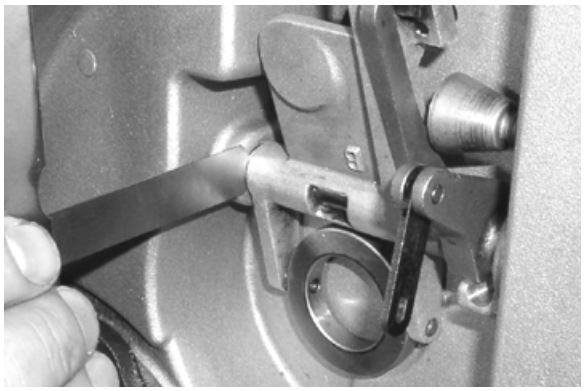
RG12868 —UN—05MAY03

Install Governor Lever

RG19661,000003B -19-21SEP04-4/6

3. Place a 0.13 mm (.005 in) shim between the inner governor shaft bearing and the governor lever assembly. Install the outer governor shaft bearing until it contacts the throttle lever assembly. Remove the feeler gauge and insure the governor lever, throttle lever and thrust plate move freely.
4. Apply LOCTITE 609® to the OD of the governor shaft cup plug and install in timing gear cover. Recheck clearance to verify 0.13 mm (.005 in) lash between the governor lever and the timing gear cover.
5. Compress and install the idle bias spring between the timing gear cover and the governor lever assembly. The spring should seat firmly in the governor and timing gear cover recesses. Check levers to ensure they rotate freely and the spring does not bind.

NOTE: To avoid damaging the spring, pliers or similar tools should not be used.



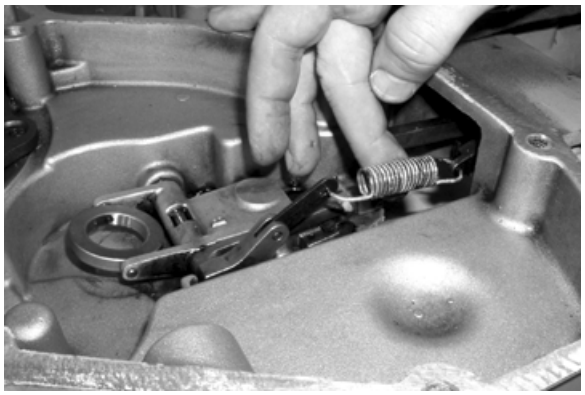
RG12869 —UN—05MAY03

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RG19661,000003B -19-21SEP04-5/6

6. Carefully attach main governor spring to throttle control lever link and throttle spring lever by bending in the middle of the coil body to loop spring ends into the holes.



RG12863 —UN—01MAY03

Install Governor Spring

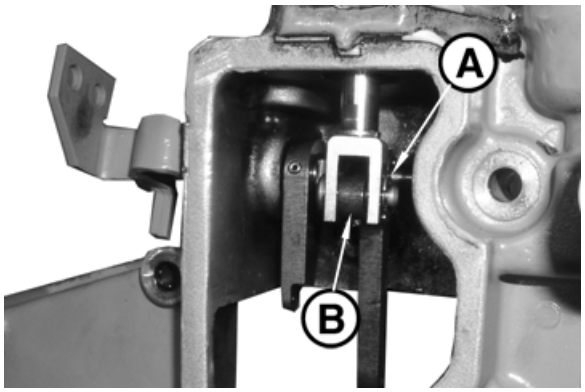
RG19661,000003B -19-21SEP04-6/6

Remove and Install Throttle Control Assembly

Remove Throttle Assembly

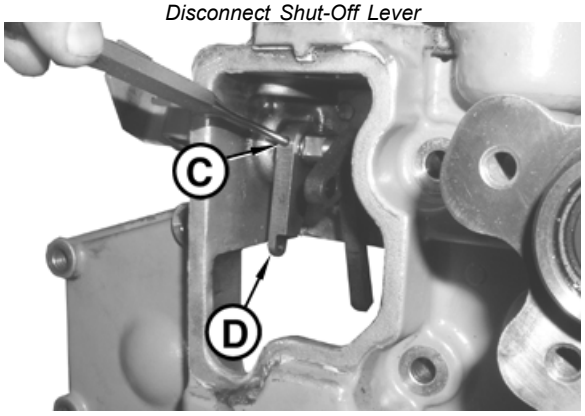
1. Disconnect electric shut-off solenoid from throttle shut-off lever by removing retaining ring (A) and link pin (B).
2. Rotate throttle shaft assembly until spring pin (C) is accessible. Remove spring pin from spring lever (D) with a punch.
3. Remove throttle shaft assembly, spring lever and shut-off lever from timing gear cover. Inspect parts for wear and replace if required.

A—Retaining Ring
B—Link Pin
C—Spring Pin
D—Spring Lever



RG12872 —UN—27SEP04

Disconnect Shut-Off Lever



RG12873 —UN—27SEP04

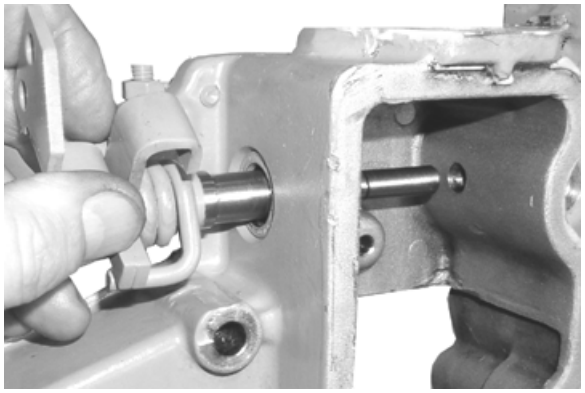
Remove Spring Pin

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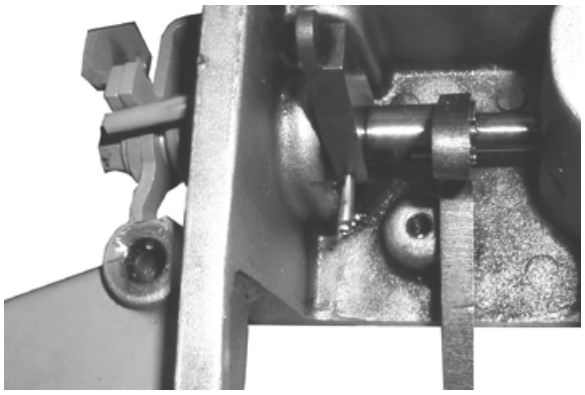
RG19661,000003C -19-24SEP04-1/3

Install Throttle Assembly

1. Insert throttle shaft assembly through the outer timing gear cover wall. Slide spring lever and shut-off lever on the shaft. Continue to insert assembly until the shaft bottoms in housing bore.
2. Install spring pin in spring lever. Notch in spring lever is on the inside of the engine.
3. Connect electric shut-off solenoid to throttle shut-off lever with pin and retaining ring.



RG12874 —UN—05MAY03



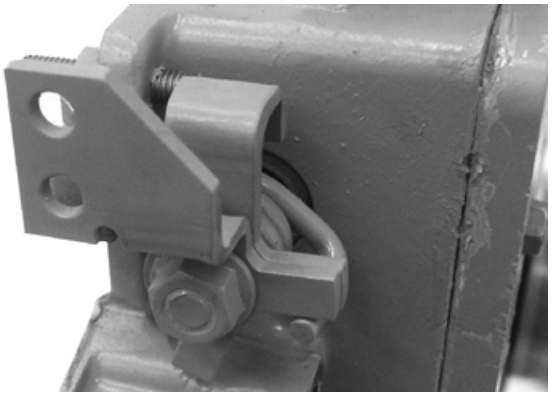
RG12875 —UN—05MAY03

RG19661,000003C -19-24SEP04-2/3

Throttle Assembly Adjustments

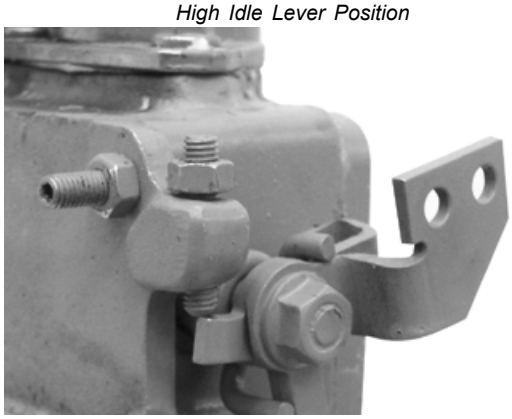
NOTE: These settings will be approximate. Final idle speed adjustments will need to be made when engine is installed.

1. Adjust high idle set screw until throttle lever bearing surface is vertical.
2. Adjust low idle set screw until throttle lever bearing surface is horizontal.



RG12879 —UN—07MAY03

High Idle Lever Position



RG12880 —UN—07MAY03

Low Idle Lever Position

RG19661,000003C -19-24SEP04-3/3

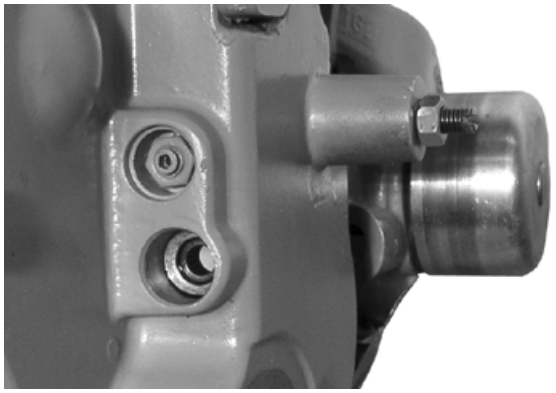
Remove and Install Full Load Stop Screw

Remove Full Load Stop Screw

1. Drill 1/8 in. hole in full load screw cup plug and remove using JDG22 Seal Remover.
2. Remove jam nut using JDG10038 Full Load Socket Wrench.
3. From inside the timing gear cover, remove the full load stop screw.

Install Full Load Stop Screw

1. Install full load stop screw from inside the cover and tighten until it stops against the timing gear cover wall.
2. Assemble jam nut onto the screw from outside the timing gear cover. Insure all threads of the jam nut are engaged.
3. Adjust using JDG1791 Socket Adapter with a 1/4 in. drive extension and tighten jam nut with JDG10038 Full Load Socket Wrench. See ADJUST ENGINE POWER, Section 04, Group 151.
4. Apply a bead of LOCTITE 277®on inverted cup plug and install in the timing gear cover.



RG12905 —UN—07MAY03

Full Load Screw and Jam Nut



RG12871 —UN—05MAY03

Full Load Stop Screw

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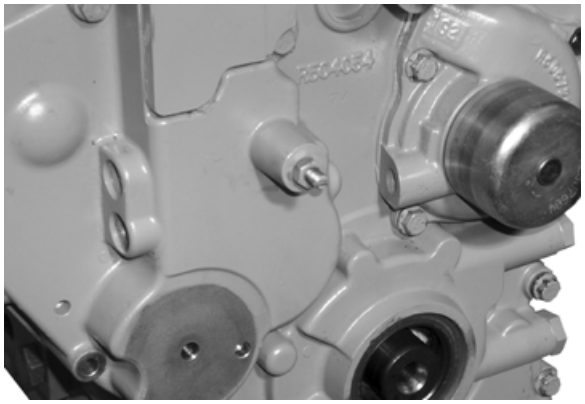
RG19661,000003B -19-20SEP05-1/1

Remove and Install Idle Bias Adjustment Screw

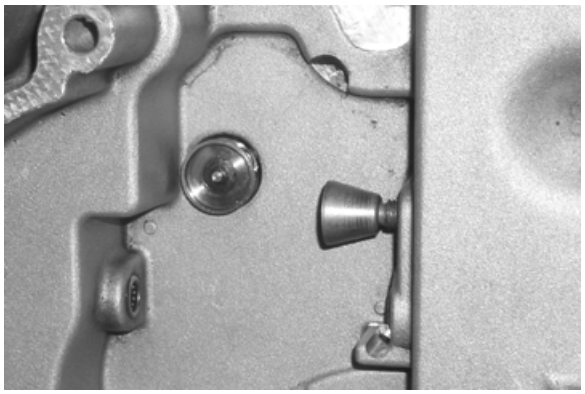
1. Remove jam nut.
2. Remove idle bias screw from cover by turning it into the timing gear cover and remove from the inside.
3. Inspect screw and o-ring for damage. Replace if required.

NOTE: This setting will be approximate. Final idle adjustments will need to be made when engine is installed.

4. Install the idle adjustment screw from the inside of the timing gear cover. Turn until the end of the screw is approximately 10 mm (.39 in.) past the timing gear cover exterior boss.
5. Install jam nut.



RG12876 —UN—06MAY03



RG12877 —UN—06MAY03



RG12878 —UN—06MAY03

Idle Bias Adjustment Screw

RG19661,000003D -19-05MAY03-1/1

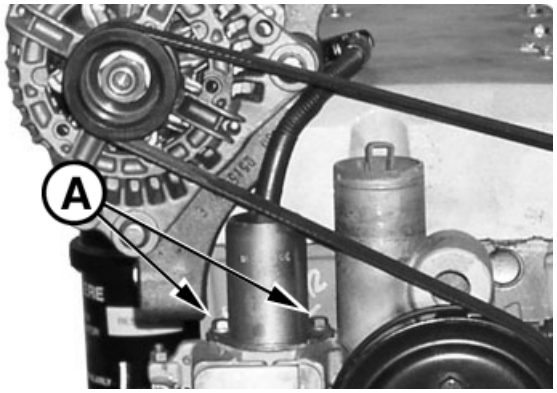
Remove and Install Fuel Shut-Off Solenoid

1. Disconnect wire harness connection from fuel shut-off solenoid.
2. Remove timing gear cover access cover. Carefully remove retaining ring from throttle shaft.
3. Remove cap screws (A) and remove solenoid. Clean sealant from mounting surface.
4. Apply a continuous 2—4 mm (0.08—0.16 in.) bead of PM710XX280 Silicone Sealant to mounting surface of solenoid and install solenoid by sliding it onto the throttle shaft.
5. Tighten solenoid cap screws to specification.

Specification

Fuel Shut-Off Solenoid—Torque.....15 N·m (11 lb-ft)

6. Carefully install solenoid retaining ring on throttle shaft.



RG13016 —UN—24JUN03

Fuel Shut-Off Solenoid

7. Apply a continuous 2—4 mm (0.08—0.16 in.) bead of PM710XX280 Silicone Sealant to mounting surface of the access cover and assemble on timing gear cover.
8. Connect wire harness connector.

RG41183,0000041 -19-05MAR04-1/1

Remove and Install Aneroid

1. Remove cap screw (A) from clamp.
2. Disconnect aneroid line (B).
3. Remove four cap screws (C) noting location for reassembly and remove aneroid.
4. Clean sealant material from mating surfaces.
5. Install new O-ring (D).
6. Apply a continuous 2—4 mm (0.08—0.16 in.) bead of PM710XX280 Silicone Sealant to around the perimeter of the opening on the cylinder block mounting surface.
7. Apply LOCTITE 242® to cap screws and install aneroid to cylinder block. Tighten cap screws to specification.

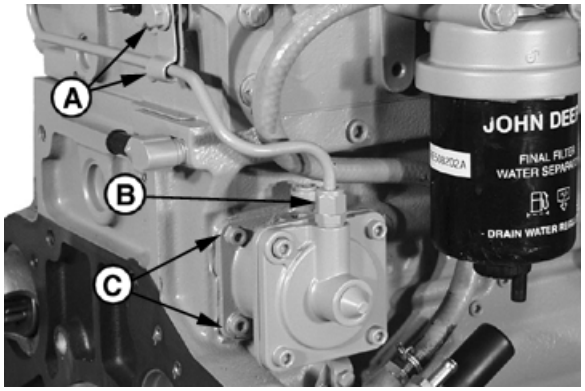
Specification

Aneroid Cap Screws—Torque..... 10 N·m (7 lb-ft)

8. Install aneroid line (B) and clamp cap screw (C) and tighten to specification.

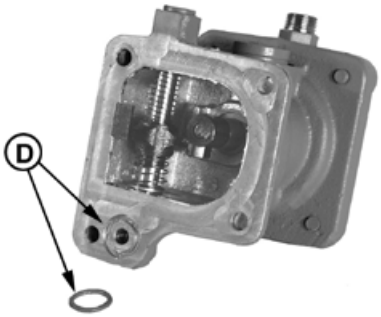
Specification

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



RG12901 —UN—07MAY03

Aneroid Removal and Install



RG13029 —UN—01JUL03

Aneroid O-ring

A—Clamp Cap Screw
B—Aneroid Line
C—Mounting Cap Screws
D—O-ring

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RG41183,0000045 -19-21SEP04-1/1

Clean Fuel Injection Nozzle Bore

IMPORTANT: Always turn tool clockwise in bore to prevent dulling of cutting edges, even when removing tool from bore.

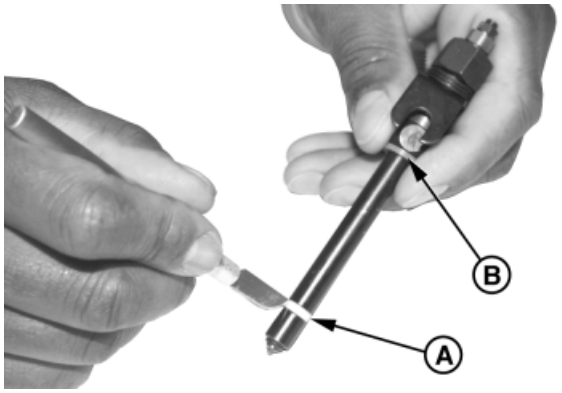
Clean injection nozzle bore using JDE39 Nozzle Bore Cleaning Tool (A). Blow debris from bore using compressed air, and plug the bore to prevent entry of foreign material.

RG19661,00002F0 -19-21DEC09-1/1

Clean Fuel Injection Nozzle

1. Remove carbon stop seal (A) from groove in nozzle body using razor blade or sharp knife and remove upper sealing washer (B). Discard seal and washer.
2. Place nozzle in solvent or clean diesel fuel, so carbon stop seal groove is submerged, and soak for a while.
3. After soaking, clean nozzle tip with brass wire brush. Never use a steel wire brush or scraper.

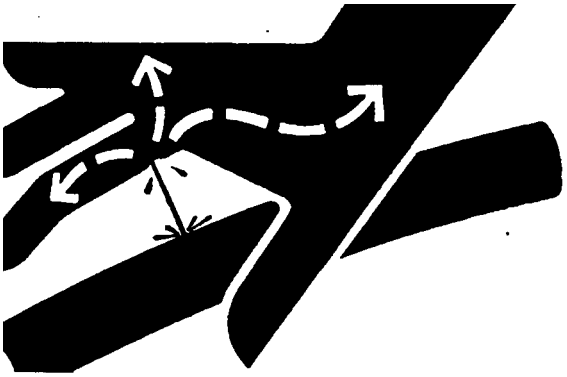
A—Carbon Stop Seal **B—Upper Sealing Washer**



Clean Fuel Injection Nozzle

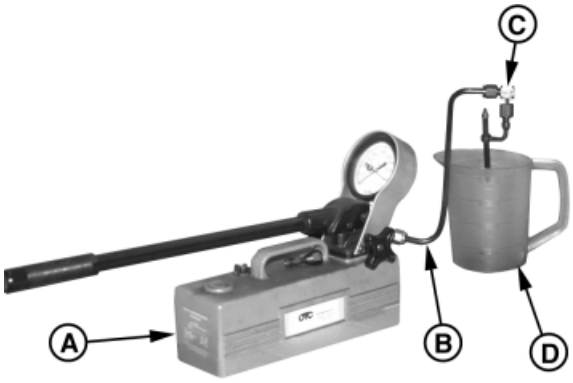
RG19661,00002F1 -19-21DEC09-1/1

Test Fuel Injection Nozzles



X9811 —UN—23AUG88

High Pressure Fluid



RG7799 —UN—11NOV97

Injection Nozzle Tester

A—Nozzle Tester **B—Fuel Line** **C—Adapters** **D—Beaker**

IMPORTANT: The compact injection nozzle used in these engines does not provide for return fuel so there is no reduction in line pressure on the nozzle tester. This will eventually cause the pressure in the injector cap nut area to fill with high pressure fuel and balance pressure in the nozzle body preventing the valve from lifting off the seat. This hydraulic lock will cause non-repeatable readings and eventually an inoperable injector. If these symptoms occur during testing, remove the nozzle from the tester and drain the cap nut per the following procedure later in this group.

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.

1. Connect injection nozzle to nozzle tester.

NOTE: When using the JT25510 Bosch Bench Mounted Nozzle Tester, use the KJD10109 Fuel Line and connect line to tester and nozzle.

2. Use 23617 and 23621 Adapters (C) and 36352 Fuel Line (B) from D01110AA Fuel Injection Nozzle Tester Adapter Set to connect nozzles to D01109AA OTC Portable Nozzle Tester (A).
3. Position tip of nozzle below top of beaker (D) 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.

4. 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.

IMPORTANT: Make sure that nozzle tester is in good condition and that gauge works properly. Service nozzle tester as recommended in the operating instructions provided with tester.

Opening Pressure Test

1. Actuate the nozzle tester rapidly several times to allow the valve to seat rapidly.
2. Open the nozzle tester 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 230—240 bar (3340—3480 PSI). Repeat this test several times. If large variations are noted, disconnect the nozzle from the tester and drain the cap nut.

Chatter and Spray Pattern Test

1. Close tester gauge valve and operate nozzle tester rapidly. The nozzle should chatter which is the audible sound of the rapid opening and closing of the nozzle valve as fuel is pumped through the nozzle.
2. Check the quality of the spray pattern for a finely atomized plume from each spray orfice.

Continued on next page

RG19661,00002F2 -19-21DEC09-1/2

Seat Condition

1. With the nozzle tip pointed down and the gauge closed, operated the tester rapidly to firmly seat the valve,
2. Thoroughly dry the nozzle tip.
3. Open the gauge valve and raise the pressure to 17—24 bar (250—350 PSI) below the noted opening pressure.
4. Maintain this pressure for 10 seconds. No droplet should separate from the nozzle tip. Slight dampness or a drop forming is permissible with a used nozzle.

Return Oil

1. Slowly raise the test gauge pressure to at least 179 bar (2600 PSI).
2. Release the nozzle tester lever and note the time it takes for the pressure to drop from 172 bar (2500 PSI) to 138 bar (2000 PSI). This time interval should be a minimum of five seconds.

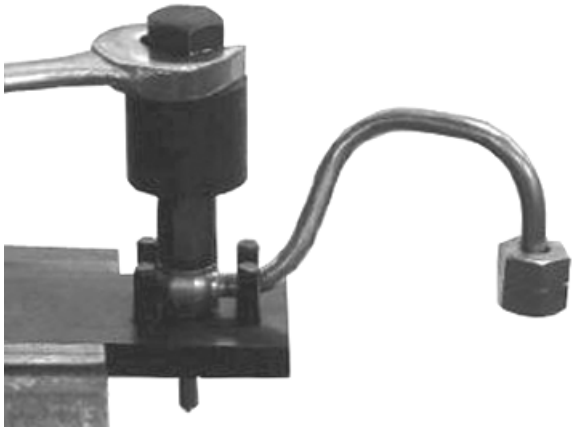
RG19661,00002F2 -19-21DEC09-2/2

Drain Injection Nozzle

1. Place JDG11042P3 Injection Nozzle Holding Plate in a vise and insert nozzle.
2. Loosen cap nut.
3. Remove the nozzle from the nozzle plate and hold at an angle so the spring and shim will not fall out of the cap nut when removed. Carefully tip the cap to drain the trapped fuel and not allow the spring, shim and spring seat to fall out of the cap.
4. Apply clean calibrating fluid to the nozzle o-ring seal and hand-tighten the cap.
5. Place injection nozzle in the holding plate and tighten cap nut to specifications using JDG11042P1 Injection Nozzle Cap wrench.

Specification

Injection Nozzle Cap Nut—Torque..... 12.4 - 13.6 N·m (110 - 120 lb.-in.)



RG15988 —UN—13JAN10

Remove Injection Nozzle Cap Nut



RG15985 —UN—08JAN10

Drain Injection Nozzle Cap



RG15984 —UN—08JAN10

Tighten Injection Nozzle Cap Nut

RG19661,00002F4 -19-12JAN10-1/1

Install Seals on Fuel Injection Nozzle

NOTE: Anytime the nozzle is removed from the cylinder head, the washer and carbon seal must be replaced.

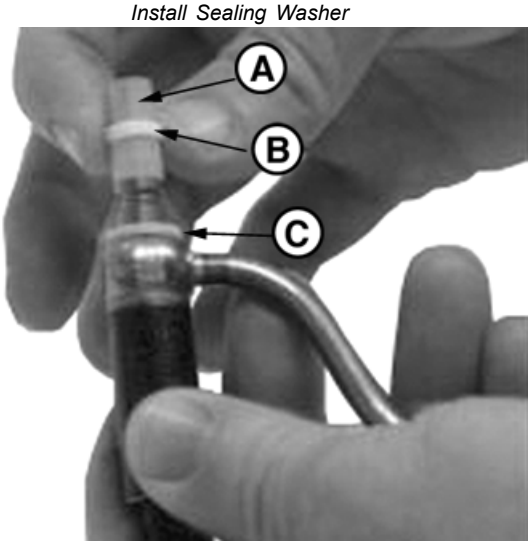
1. Install a new seal washer (C) on to injection nozzle body.
2. Position R518614 Nozzle Carbon Stop Seal Installer (A) over nozzle tip. Place a new carbon stop seal (B) on seal installer. Slide the carbon seal over the seal installer until it seats in its groove on the injection nozzle body. Remove and discard installation tool.
3. The new seal will not immediately return to the proper size. Using a gentle rocking motion, install the JDG11042P2 Carbon Seal Sizing tool over the end of the nozzle body assembly.

NOTE: If nozzle is not going to be installed at this time, install a No. 16189 Nozzle Protector Cap over nozzle tip. Plug all other openings in nozzle to prevent contamination.



RG15986 —UN—08JAN10

Install Sealing Washer



RG15990 —UN—14JAN10

Install Carbon Seal



RG15989 —UN—13JAN10

Re-size Carbon Seal

RG19661,00002F3 -19-21DEC09-1/1

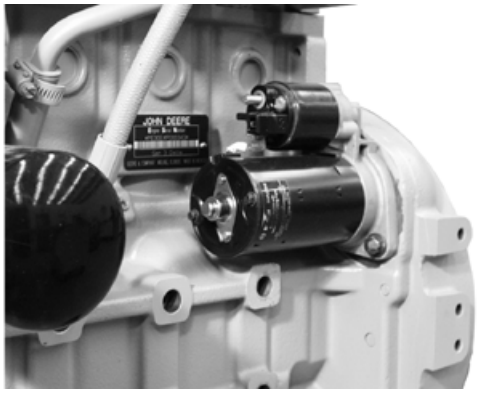
Remove and Install Starter

CAUTION: Disconnect battery ground strap or serious injury could result if tools ground electrical system.

1. Disconnect ground strap from battery.
2. Disconnect wiring to starter motor.
3. Remove mounting cap screws and/or nuts.
4. Remove starter motor.
5. Install starter motor and tighten cap screws and/or nuts to specification.

Specification

Starter Motor—Torque ..... 80 Ṅn (59 lb-ft)



RG12969 —UN—04JUN03

Starter Motor

6. Connect starter wiring and ground strap.

RG41183,0000012 -19-09JAN07-1/1

Remove and Install Alternator

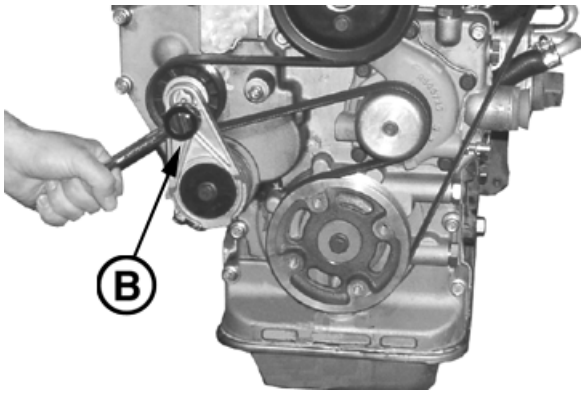
IMPORTANT: Always disconnect battery negative (—) cables before removing alternator or a short circuit could result.

1. Disconnect battery ground (—) cable.
2. Disconnect positive (+) red wire and regulator connector.
3. Remove alternator belt by relieving the tension on belt tensioner (B).
4. Remove cap screws (A) and remove alternator.
5. Install alternator on bracket and tighten to specification.

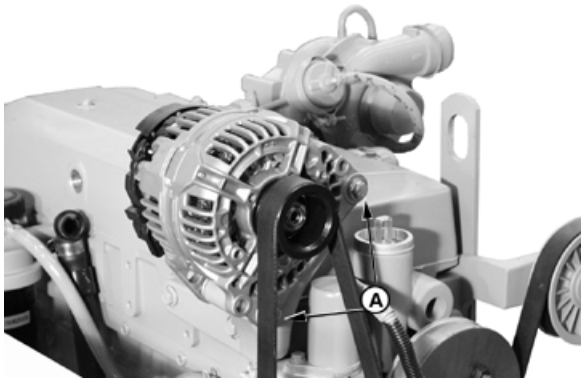
Specification

Alternator Cap Screws—Torque ..... 40 Ṅn (29.5 lb-ft)

6. Reconnect positive (+) red wire and regulator connector.



RG12800 —UN—21JAN03



RG12970 —UN—04JUN03

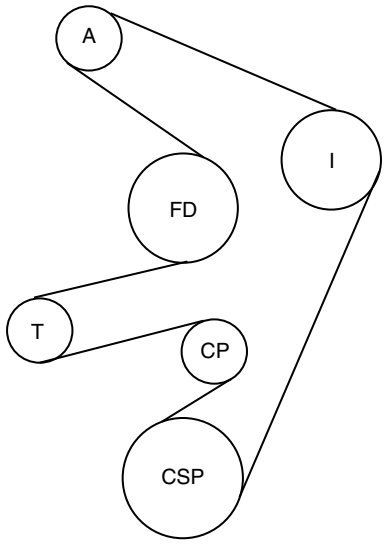
Alternator

Continued on next page

RG41183,0000013 -19-02JUN03-1/2

7. Install alternator belt.

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



RG12799 —UN—21JAN03

Belt Routing

RG41183,0000013 -19-02JUN03-2/2

Section 03
Theory of Operation

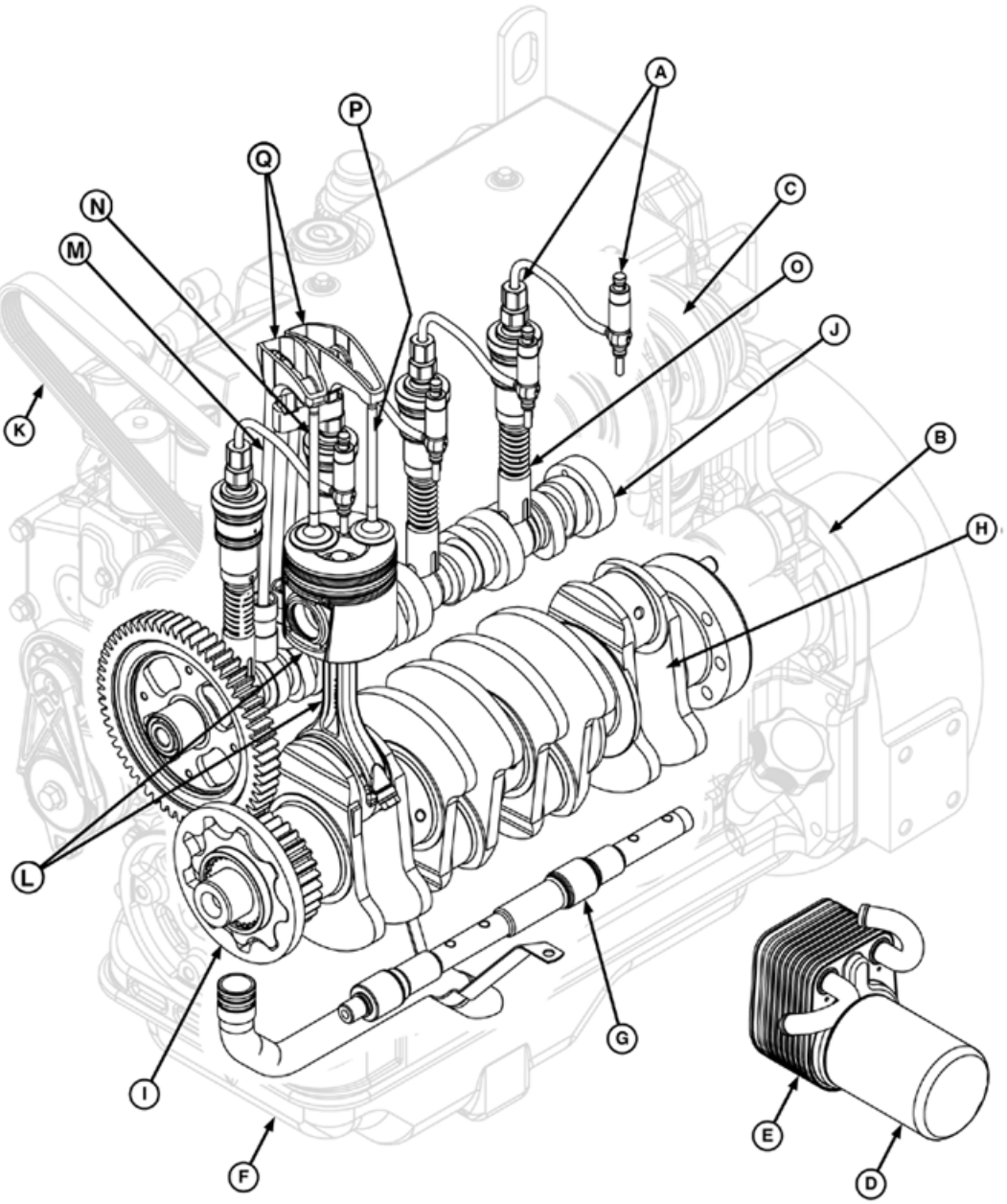
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General Engine Operation



RG12915 —UN—24JUN03

General Engine Operation

A—Unit Injector Pump and Nozzle
B—Cylinder Block
C—Turbocharger
D—Oil Filter
E—Oil Cooler
F—Oil Pan
G—Balancer Shaft
H—Crankshaft
I— Oil Pump
J—Camshaft
K—Poly Vee Belt
L—Piston and Connecting Rod
M—Push Rod
N—Intake Valve
O—Hydraulic Cam Followers
P—Exhaust Valve
Q—Rocker Arm

The Series 250 engines are vertical, inline, two valve in head, four cycle (stroke) diesel engines. The 2.4 L engine (shown) has four cylinders. The 3.0 L version of the Series 250 engine is a five cylinder design

The fuel system utilized in the Series 250 is a new design for Deere Power. Direct fuel injection is provided by an integral pumping unit and compact nozzle assembly, and a roller hydraulic camshaft follower (lifter), (A) for each cylinder. A fuel transfer pump draws fuel from the tank and provides pressure to and through the fuel filter and cylinder block fuel galley. The fuel galley, integral with the cylinder block to avoid external fuel lines, supplies fuel to the pumping units and nozzles. The quantity of fuel delivered to each pumping unit is controlled by a mechanical governor and throttle assembly, located in the timing gear cover, and a rack assembly, located in the cylinder block. The fuel rack, similar to those used in inline injection pumps used on Series 350 and 450 engines, is located in the block and is parallel to the fuel galley. The pumping units, driven by hydraulic cam followers, pressurizes and delivers the fuel to the nozzle.

Continued on next page

Glow plugs for each cylinder are included in the design as standard equipment to aid during cold weather starts. The cold start advance (CSA) feature is also included as standard equipment to aid in cold starts. This feature is regulated by the lubrication system, and advances unit pump injection timing to reduce white smoke present during a cold start. Both cold start aids are addressed in more detail in the Fuel System Operation Section.

Most Series 250 engines are equipped with a turbocharger (C). The turbocharger uses energy from exhaust gases to compress and deliver intake air to the intake manifold and, subsequently, the combustion chambers. The compressed air means additional air is being delivered to the cylinders. The additional air results in a higher power output by the engine, as well as cleaner emissions.

The cylinder block (B) is a one piece casting with integral cylinder bores.

The camshaft (J) is timed to the crankshaft through the timing gear train. The camshaft rotates in honed bores in the cylinder block. The Series 250 engines use a bearing in the number one camshaft bore, with bushings in the other journals. The camshaft lobe design controls not only the lift and duration of each intake and exhaust valve opening and closing, but they also actuate the pumping and injection of fuel within the pumping units and nozzles for each bore. The camshaft followers, or lifters (O), for both the valves and pumping units, are a hydraulic design. This eliminates the need for regular valve lash adjustment intervals.

Intake (N) and exhaust (P) valves are actuated by the hydraulic cam followers, or lifters (O), running off the camshaft lobes. Push rods (M) and rocker arms (Q) complete the camshaft-to-valve actuation assembly.

The crankshaft (H), is a one piece, nodular iron forging. The crankshaft is dynamically balanced, and the journals are machined with undercut and rolled fillets for additional strength. Each crankshaft journal is encased in a two piece, replaceable, main or rod bearing assembly. Additional two piece main journal thrust bearing inserts are used to control crankshaft end play.

Cylinder liners are a cast-in, integral with the block design. This is a major change from the traditional, Deere replaceable cylinder liner design.

Pistons (L) are manufactured from a high grade, cast aluminum alloy, with internal ribbing. The piston skirt is cam ground to allow for heat expansion during the combustion process. The piston crown has a cut out combustion bowl with a truncated cone center. All piston rings are located above the piston pin. Two compression rings and one oil control ring are utilized. The top compression ring is a rectangular, steel, 2 mm thick, barrel face shaped design, and is located close to the top of the piston, by design, for improved starting and engine performance.

The hardened, fully floating piston pins are held in place in the piston bore by snap rings. Piston spray jets, located in the cylinder block, spray pressurized oil to the underside of the piston to lubricate the pins, and cool the piston.

The forged steel connection rods have replaceable bushing inserts to support the piston pin during the combustion process. Rods and caps are manufactured with an angled PRECISION JOINT™

Series 250 engines are designed with a crankshaft driven, gerotor oil pump (I) and a full flow oil filter (D). The oil filter has an internal bypass valve, which opens if the filter element becomes restricted. The filter is mounted on a “donut style” oil cooler (E), which is located on the side of the cylinder block. The Series 250 engines are also designed with a pressure regulating valve, located in the front timing gear cover, to relieve excessive oil pressure that may build up in the lubrication system.

Balancer shafts (G) are used on four cylinder engines to reduce the natural vibration that exists with four cylinder four stroke diesel engine designs. The two shafts, located in integral bores on each side of the crankshaft in the cylinder block, are counter rotating to each other and rotate at twice the engine speed.

The engine has a pressurized cooling system, consisting of a radiator, water pump, multi blade fan, and a thermostat housing.

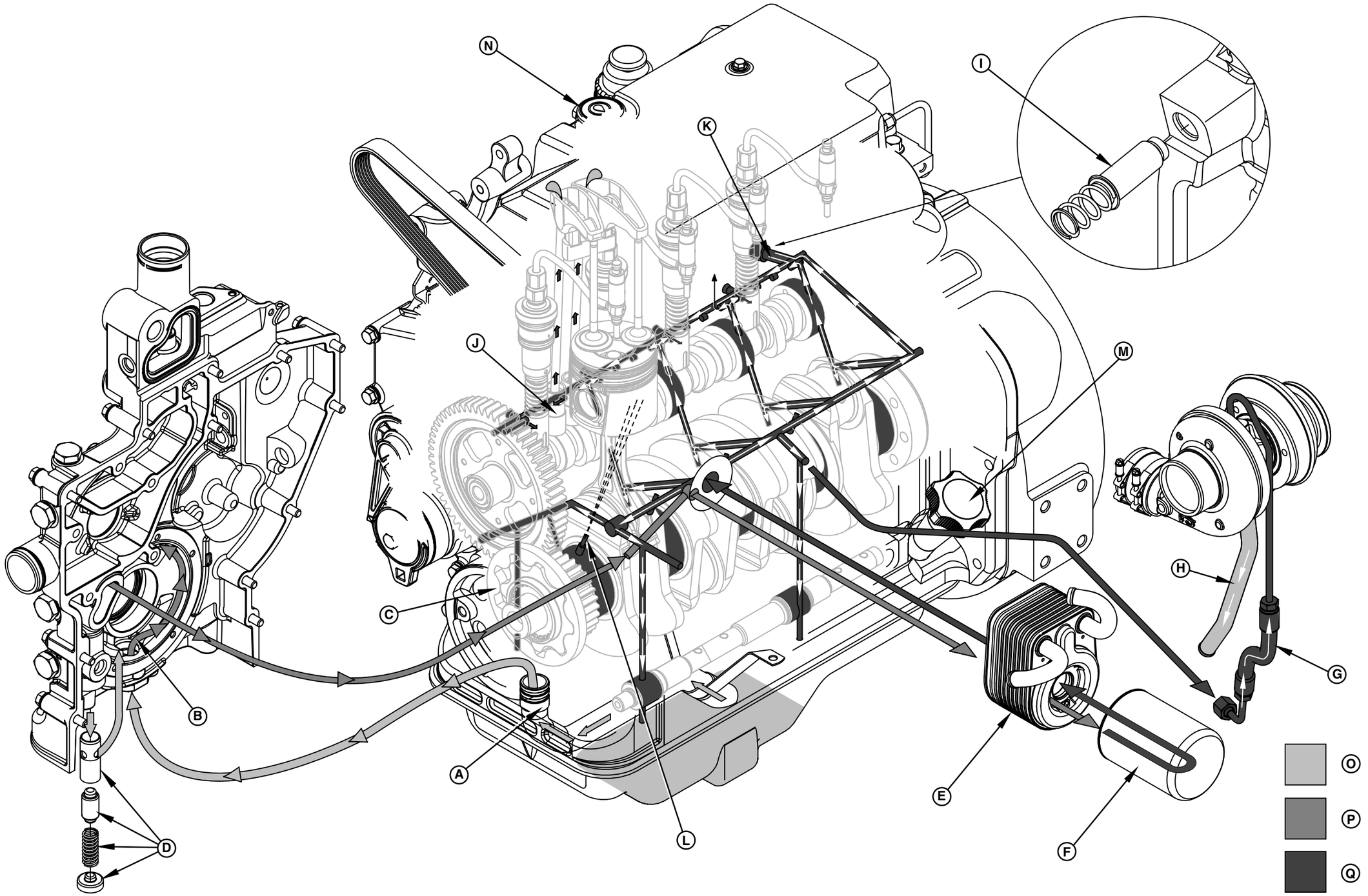
For additional details on fuel, lubrication, cooling, and air systems, see later in this section.

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RE38635,000000C -19-23AUG07-2/2

Lubrication System Operation

RG12776 —UN—28SEP06



Lubrication System (2.4 L Engine Shown)

Continued on next page

RE38635,000000E -19-23AUG07-1/2

A—Oil Suction Line
B—Oil Pump Housing
C—Oil Pump
D—Oil Pressure Regulating Valve
E—Oil Cooler
F—Oil Filter
G—Turbocharger Oil Supply Line
H—Turbocharger Drain Line
I— Cold Start Advance Valve
J—Hydraulic Lifter
K—Cold Start Oil Inlet
L—Piston Cooling Orifice
M—Oil Fill/Dipstick
N—Rocker Arm Cover Oil Fill
O—Pressure Free Oil
P—Pressurized, Unfiltered Oil
Q—Pressurized, Filtered Oil

NOTE: The 2.4 L engine is shown. Lubrication of the 3.0 L engine is similar.

The engine lubrication system consists of a crankshaft driven, gerotor design oil pump (C), a full flow oil filter (F), oil cooler (E), oil pressure regulating valve (D), and a cold start advance valve (I).

The gerotor oil pump draws oil from the oil pan sump through a strainer and suction line (A). The oil pump forces pressurized oil to the main oil galley in the cylinder block through a separate drilled passage. Oil is then routed through the oil cooler and filter, and back into the main oil galley, to be fed to the remainder of the engine.

The main oil galley runs the length of the cylinder block and delivers oil to cross-drilled oil passages that feed oil to the camshaft journals, and main bearing bushings. Additional cross-drilled passages intersect with cam and crank oil passages and provide lube oil to the balancer shaft bushings (when equipped).

Oil flows past the camshaft journals to the cold start advance galley. This galley provides oil for the hydraulic valve lifters (J), to activate the cold start advance feature, and the push rods. The push rods are hollow and allow oil to flow up to the rocker arm area.

From the main bearings, oil flows to the connecting rod bearings through drilled passages in the crankshaft. Oil from the main bearings also supply the piston cooling orifices (L).

The piston cooling orifice (L) sprays oil to the underside of the piston to keep the piston crown cool during combustion. The oil spray also provides splash lubrication for the piston pin and bushing via a drilled hole through the top end of the connecting rod.

At the front of the cylinder block, oil flows from the oil passage into a machined groove in the front face of the block. This groove connects with the idler gear shaft to provide oil to the idler gear bushing.

The turbocharger oil supply line (G) supplies oil from the main oil galley to the turbocharger housing to cool and lubricate the turbocharger shaft and bearings. The oil returns to the crankcase from the turbocharger through a separate drain line (H). Turbocharger components operate at extremely high speeds, so a constant oil supply and an unrestricted return to sump is critical.

Oil pressure is regulated by a valve assembly (D) located in the front timing gear cover. Excessive oil is returned to the engine crankcase.

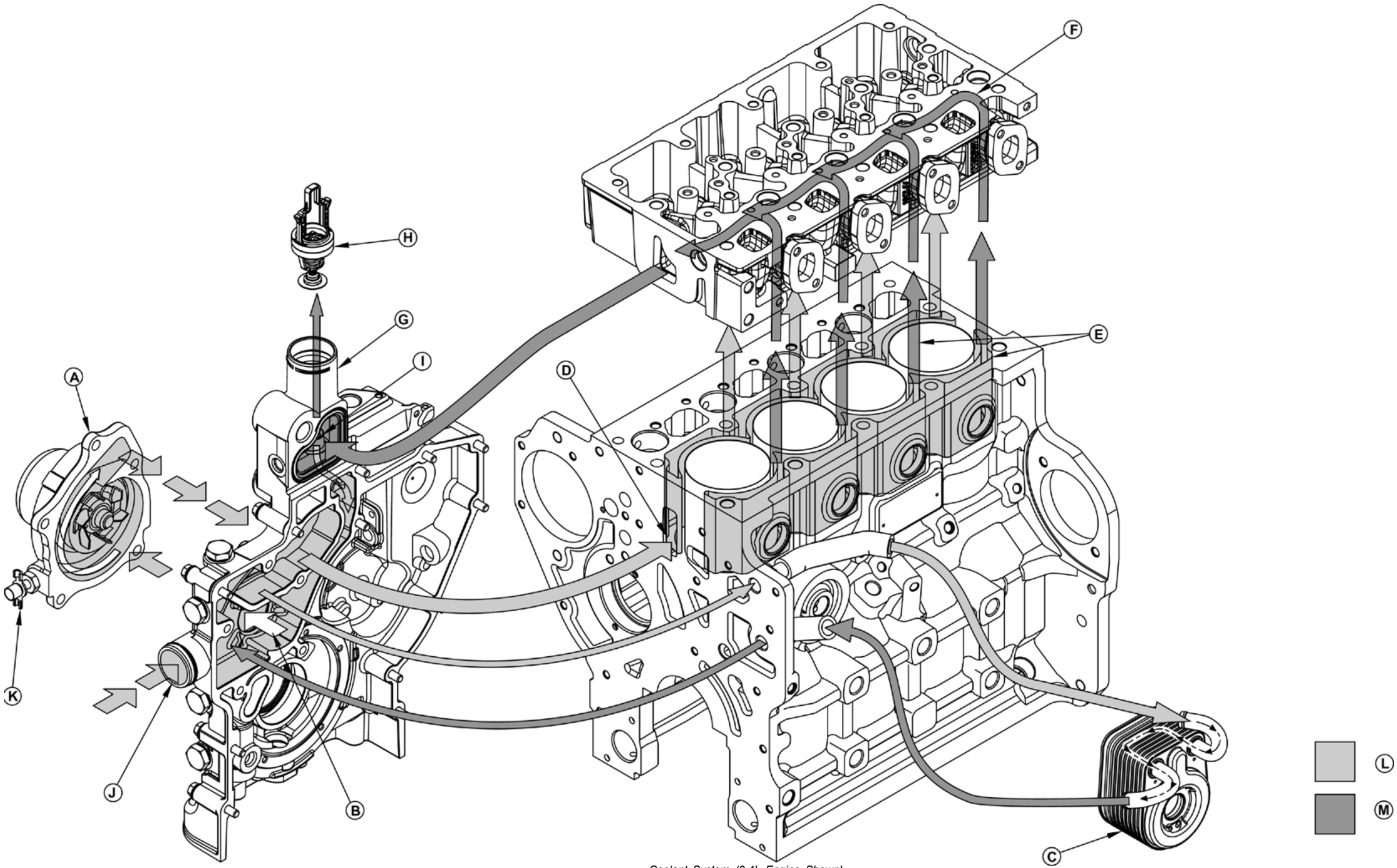
The oil fill locations are on left side of the engine, with right side fill optional. Oil can be added through either the oil dipstick location (M), or through the top of the rocker arm cover (N).

A cold start advance (I), activated by oil pressure, is located at the rear of the block. When the engine is cold, oil pressure expands the cold advance piston in the unit pump follower. This, in effect, makes the hydraulic follower “longer” . This moves the plunger higher in the pump barrel, advancing timing. The advanced timing helps smooth out the engine at cold start idle, and reduces the white smoke present at cold starts.

RE38635,000000E -19-23AUG07-2/2

Coolant System Operation

RG12267 —UN—03JUN03



Coolant System (2.4L Engine Shown)

Continued on next page

RE38635,000000F -19-31AUG07-1/2

A—Water Pump
B—Coolant Flow to Water Pump (Suction Side)
C—Oil Cooler
D—Coolant Flow to Block
E—Coolant Flow - Block to Cylinder Head
F—Coolant Flow in Cylinder Head
G—Thermostat Housing
H—Thermostat
I— Thermostat Bypass Port
J— Coolant Return from Radiator
K—Drain Valve
L— Low Temperature Coolant
M—High Temperature Coolant

NOTE: The 2.4L engine is shown. Cooling of the 3.0L engine is similar

The coolant system includes the radiator, water pump, thermostat and housing, and coolant passages.

When the engine is cold, the water pump (A) forces coolant through the engine block, around the cylinders (E), and into the cylinder head (F).

From the cylinder head, the coolant routes to the thermostat housing (G) and back to the bypass port (I). Regardless of engine temperature, the water pump also forces coolant through the oil cooler (C).

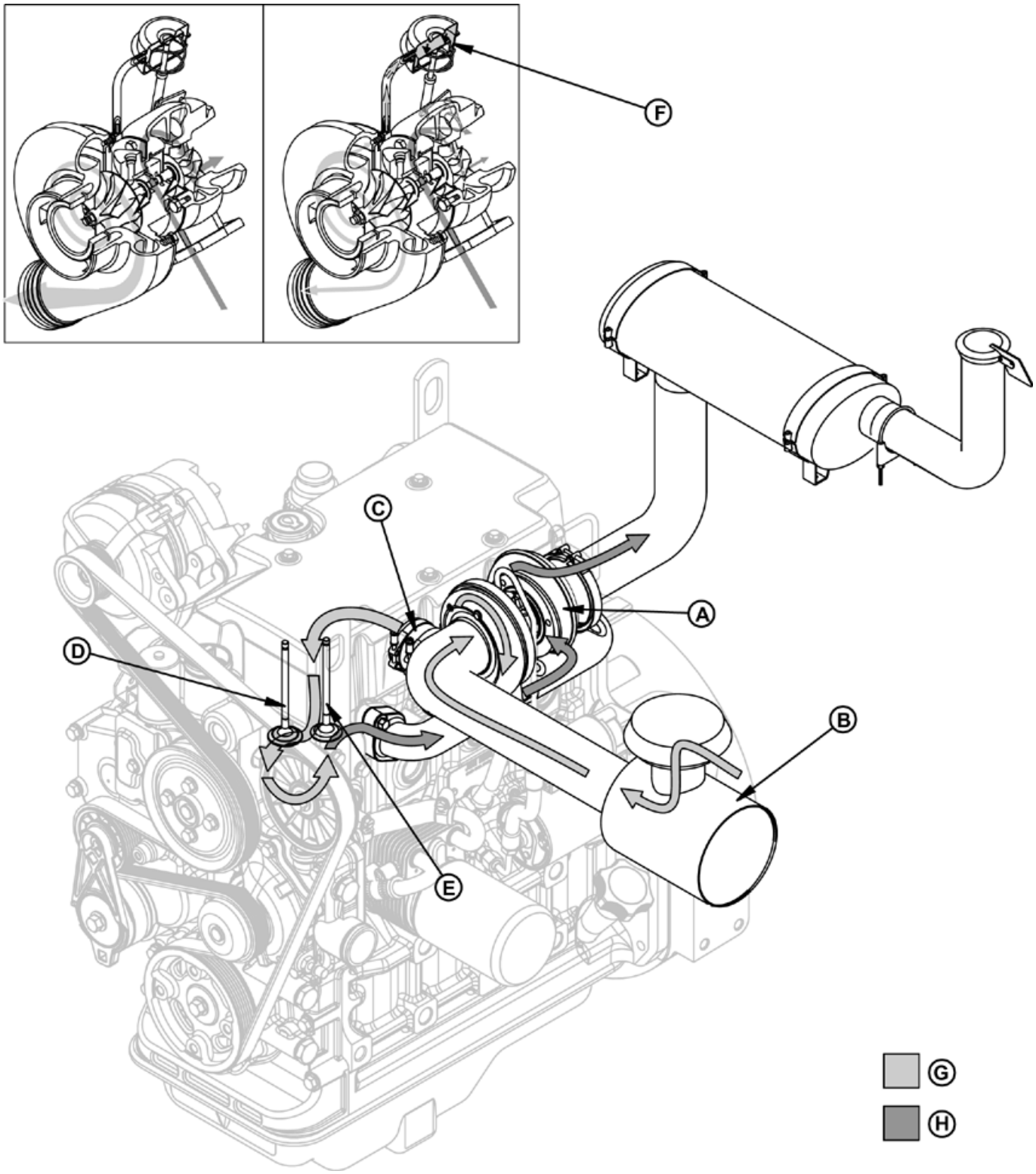
When the engine is warm, the coolant partially opens the thermostat (H) and the coolant is routed through the radiator and back to the coolant inlet, located in the front timing gear housing.

When the engine is at operating temperature, the coolant fully opens the thermostat, increasing coolant flow through the radiator. Under operating temperature conditions, the bypass port (I) is closed. All of the coolant circulates through both the radiator and oil cooler assembly, and back to the water pump inlet (B).

Coolant continues flowing through the radiator circuit until the coolant temperature drops below the thermostat opening temperature.

RE38635,000000F -19-31AUG07-2/2

Air Intake and Exhaust System Operation



Air Intake and Exhaust System

A—Turbocharger Turbine Housing (exhaust side)
B—Air Cleaner
C—Clean Air Intake
D—Intake Valve/Combustion Chambers
E—Exhaust Valve/Gases
F—Turbocharger Wastegate
G—Intake Air
H—Exhaust Air

NOTE: The 2.4 L four cylinder engine is shown. The air intake and exhaust of the 3.0 L five cylinder engine is similar

Continued on next page

RE38635,0000010 -19-23AUG07-1/2

Engine suction draws dust laden outside air through an air inlet stack into the air cleaner (B). Air is filtered through dry type primary and secondary (safety) filter elements in the air cleaner canister. Clean air travels through the air intake hose to the turbocharger and into the air intake side of the cylinder head (C).

Exhaust gases (E) drive the turbocharger turbine (A), which in turn drives the turbocharger compressor to compress the intake air and thus deliver a larger quantity of air to the combustion cylinders (D). The quantity of air delivered to an engine intake by a turbocharger is not possible with naturally aspirated, or non-turbocharged, applications.

Some applications of the Series 250 engine have a wastegate actuator (bypass) valve to help control turbine speed and boost at high engine rpm operation. This device is integral to the turbine housing (F) and is diaphragm activated.

The wastegate actuator is precisely calibrated, and opens a valve to direct some (excess) exhaust gas flow around the turbine wheel to be released from the turbine housing. This “dumping” of exhaust gases limits the turbocharger shaft speed, which in turn controls engine boost pressure.

The valve allows the system to develop peak charge air pressures for maximum engine boost response, while eliminating the chance of excessive manifold pressure (boost) at high speeds or loads.

RE38635,0000010 -19-23AUG07-2/2

Air Cleaner Operation

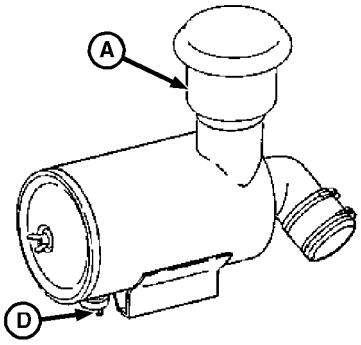
Under suction generated by the engine, unfiltered air flows through the air inlet tube (A) and is forced into a high speed centrifugal motion by tilted fins in the element. By this circulating action, most of the dust and dirt particles are separated from the air and collected in the dust unloading tube (D).

The remaining dirt is removed as the air flows through the primary element (C) and the secondary (safety) filter (B), before being drawn into the engine.

The secondary (safety) filter ensures that, should the primary element fail, no unfiltered air is drawn into the engine.

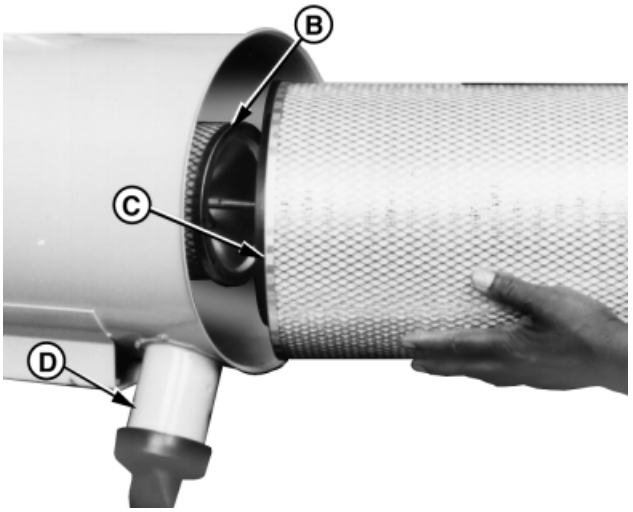
Under normal operating conditions, maximum air intake restriction is 6.25 kPa (0.06 bar) (1.0 psi) (25 in. water). However, a clogged air cleaner element will cause excessive intake restriction and a reduced air supply to the engine. An optional air restriction indicator aides the operator to know when an air cleaner needs servicing.

A—Air Inlet Tube
B—Secondary, or Safety, Filter Element
C—Primary Air Filter Element
D—Dust Unloading Tube



RG9097 —UN—27MAR98

Air Cleaner Assembly



RG7766B —UN—10NOV97

Air Cleaner Primary and Secondary Elements

RE38635,0000011 -19-23AUG07-1/1

Turbocharger Operation

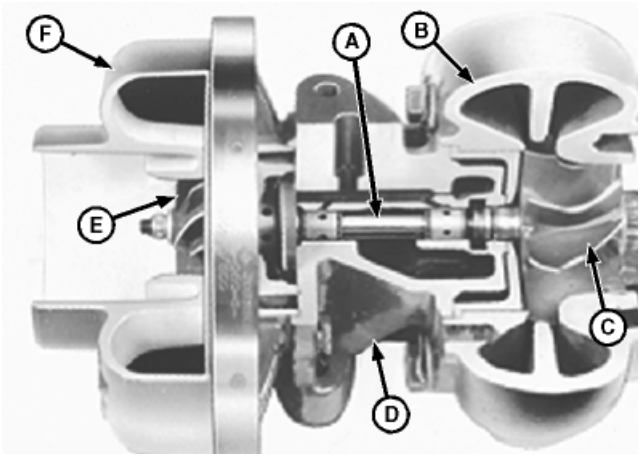
The turbocharger, which is basically an air pump that is driven by exhaust gases, allows the engine to produce added power without increasing displacement. Turbochargers are specially matched to the engine for the power ratio requirements of each specific application.

The turbine wheel (C) is driven by the hot engine exhaust gases. These gases flowing through the turbine housing (B) act on the turbine wheel, causing the shaft (A) to turn.

The compressor wheel (E) draws in filtered air and discharges the compressed air into the intake manifold, where it is then delivered to the engine combustion cylinders.

Since exhaust gas pressure varies with engine speed and load, the power available to operate the turbocharger also varies.

Engine oil, under pressure from the engine lubricating system, is provided to the turbocharger center housing (D) to lubricate and cool the shaft and bearings.



Turbocharger Components

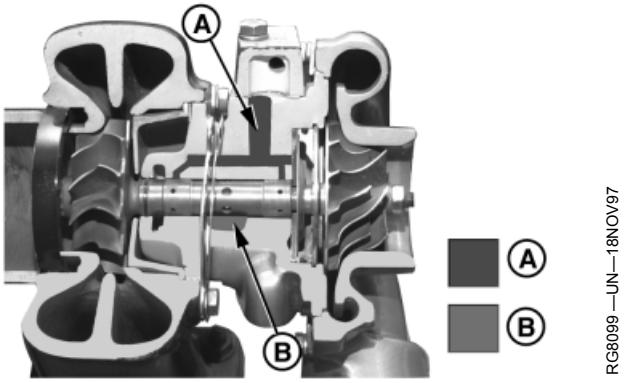
A—Shaft
B—Turbine Housing
C—Turbine Wheel
D—Center Housing
E—Compressor Wheel
F—Compressor Housing

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Turbocharger Lubrication

Engine oil, under pressure from the lubricating system, is pumped through a passage in the bearing housing and directed to the bearings, thrust plate, and thrust sleeve. Oil is sealed from the compressor and turbine by a piston ring at both ends of the bearing (center) housing.

The turbocharger contains two floating bearings. These bearings have clearance between the bearing OD and the housing bore, as well as clearance between the bearing ID and shaft OD. These clearances are lubricated by the oil supply pressure oil (A), and the bearings are protected by a cushion of oil. Discharge oil (B) drains by gravity from the bearing, or center, housing to the engine crankcase.



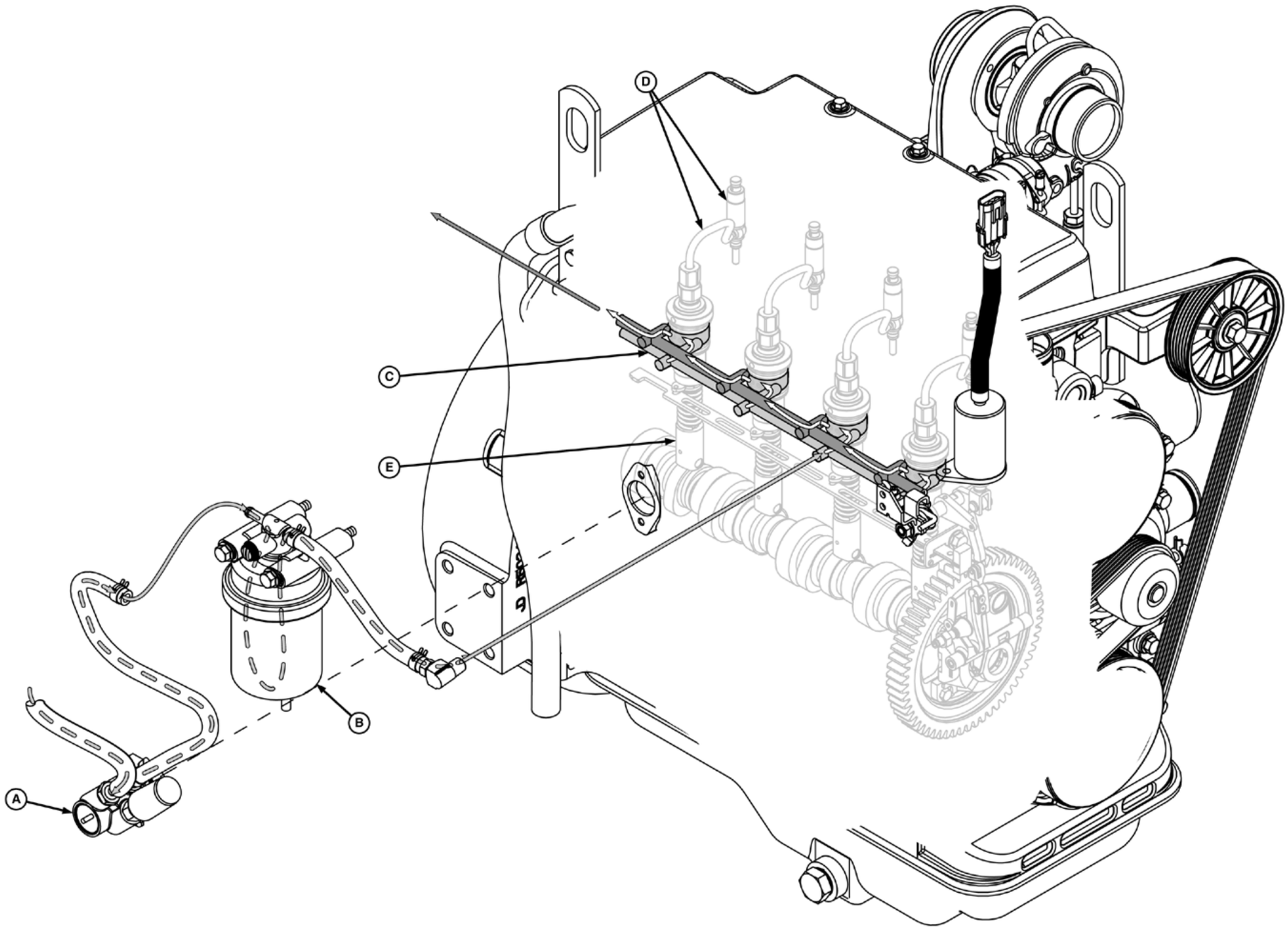
Turbocharger Pressure and Discharge Oil

A—Pressure Oil
B—Discharge Oil

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Fuel System Operation

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Fuel System

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RE38635,0000014 -19-13MAY03-1/2

The fuel system utilized in the Series 250 is a new design for Deere Power. Direct fuel injection is provided by an integral pumping unit and compact nozzle assembly for each cylinder. A fuel transfer pump (A) draws fuel from the tank and provides pressure to and through the fuel filter (B) and cylinder block fuel galley (C). The fuel galley, integral with the cylinder block to avoid external fuel lines, supplies fuel to the pumping units and nozzles (D). The quantity of fuel delivered to each pumping unit is controlled by a mechanical governor and throttle assembly, located in the timing gear cover, and a rack assembly, located in the cylinder block. The fuel rack, similar to those used in inline injection pumps used on Series 350 and 450 engines, is located in the block and is parallel to the fuel galley. The pumping units, driven by hydraulic cam followers (E), pressurizes and delivers the fuel to the nozzle.

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Fuel Supply Pump

The fuel supply pump (A) is a mechanical pump, driven off a lobe on the camshaft. The pump draws fuel from the vented fuel tank and directs and maintains pressurized flow through the fuel filter and the fuel galley within the cylinder block. It also contains an optional plunger (B) for bleeding air from and priming the fuel system.

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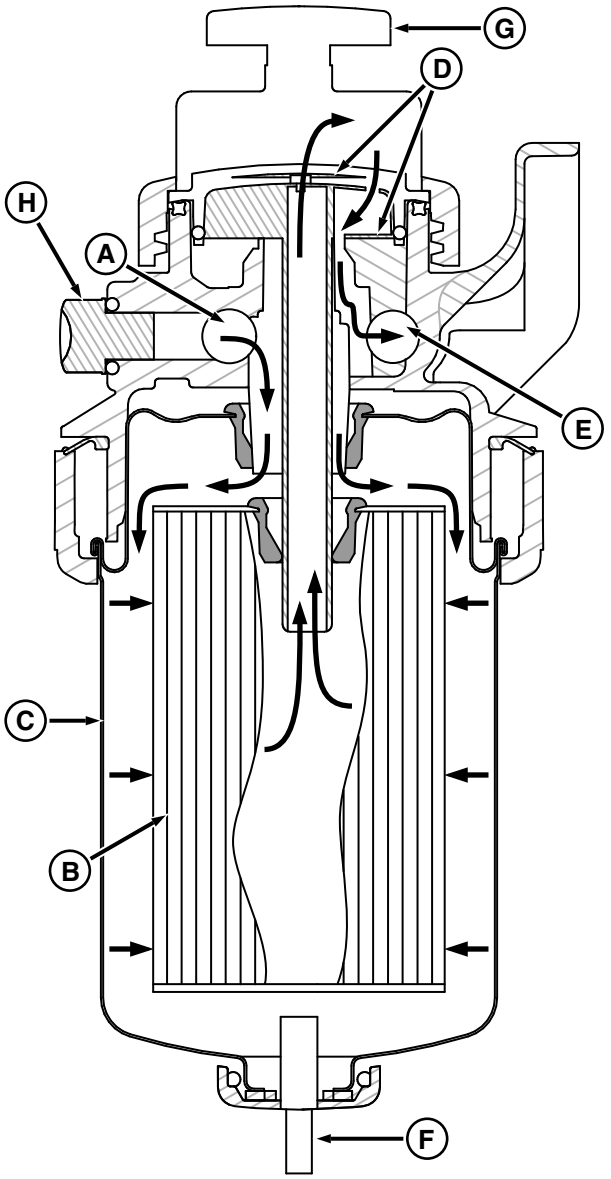
Fuel Filter/Water Separator Operation

Fuel under pressure from the low pressure fuel pump enters the fuel filter header inlet port (A). Fuel then flows through the five micron filter element (B) contained in a disposable housing (C) and passes through the check valve (D) exits through the fuel filter header outlet port (E) to the fuel supply gallery in the engine block. The check valve prevents filtered fuel from draining back into the fuel tank with the engine not running.

A fuel drain (F) on the bottom of the fuel filter housing permit water and contaminants to be drained from the unfiltered fuel. An optional water-in-fuel sensor is also located on the bottom of the fuel filter housing.

The hand primer pump (G) and bleeder screw (H) provide a means to pre-fill the filter housing following fuel system service.

A—Fuel Filter Header Inlet Port
B—Filter Element
C—Fuel Filter Element Housing
D—Check Valve
E—Fuel Filter Header Outlet Port
F—Fuel Drain
G—Hand Primer Pump
H—Bleeder Screw



Fuel Filter Assembly

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Governor Operation

The purpose of the governor is to maintain and limit maximum engine speed. The governor system in the Series 250 engine is located as part if the camshaft gear assembly. Flyweights and springs are mounted to the camshaft gear and are used to detect the speed of the engine.

To maintain engine speed, the flyweights are positioned in a manner that holds the fuel rack in a constant position. This holds the throttle control lever (plunger) of each pumping unit in the same position so that fuel delivery is neither increased, nor decreased.

As the engine load increases, engine speed decreases. Fuel delivery must increase to maintain engine speed. As engine speed decreases, the flyweights move inward and the rack rotates the throttle control lever (plunger) to increase fuel delivery.

As the engine load decreases, engine speed increases. Fuel delivery must decrease to maintain engine speed. As engine speed increases, the flyweights move out and the rack rotates the pump plunger control lever to decrease fuel delivery.

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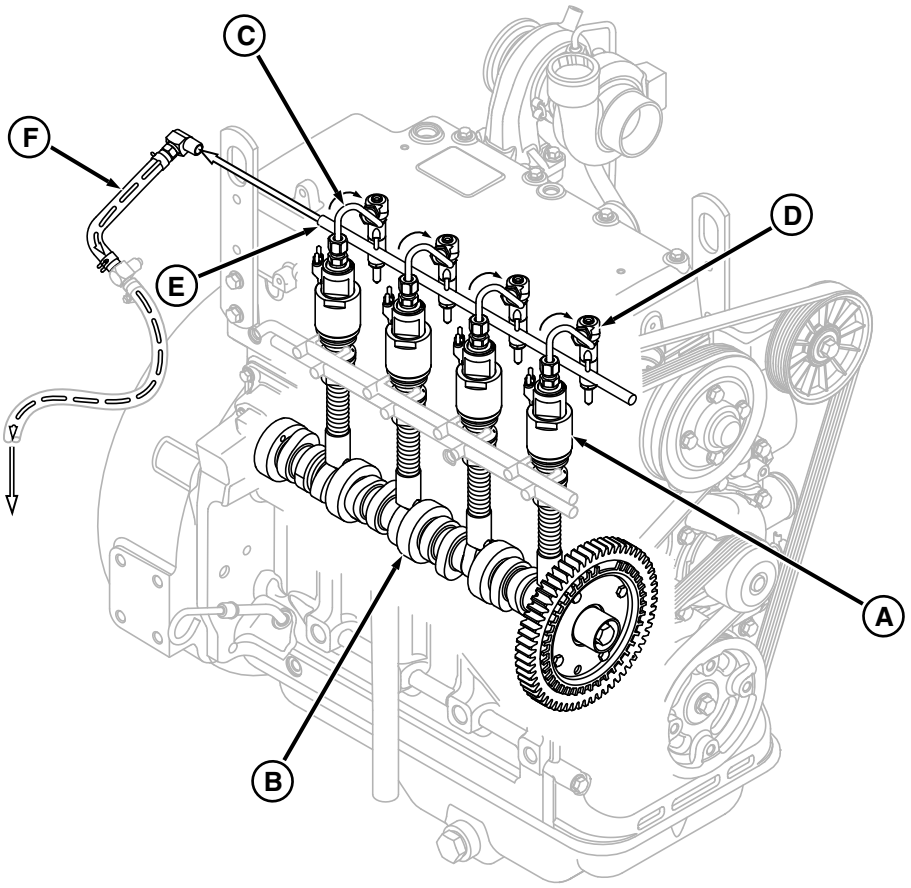
Electronic Governor

The electronically controlled governor consists of a engine control unit (ECU), magnetic speed sensor, and actuator. The ECU monitors the input pulses from the magnetic speed sensor and converting it to an output controlling the amount of travel the actuator moves the fuel rack.

The ECU is set to control the engine speed at specific speed and maintain that speed during engine operation. When changes to the load occur the ECU will adjust the amount of fuel being delivered to maintain the proper engine speed.

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Electronic Unit Pump and Injector Nozzle Operation



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Figure 1 - Electronic Unit Pump and Injector Nozzle System

A—Electronic Unit Pumps
B—Camshaft
C—High Pressure Fuel Lines
D—Injector Nozzles
E—Injector Nozzle Leak-Off Gallery
F—Injector Nozzle Leak-Off Hose

Basic System Operation

The 2.4L/3.0L electronic unit pump and injector nozzle together are very similar in operation to the 13.5L electronic unit injector. An electronic unit pump (A) for each cylinder is mounted in the engine block and held in place by a hold-down clamp. A roller follower with spring on lower end of the unit pump follows a lobe on the camshaft (B). Camshaft rotation causes the follower and a plunger inside the unit pump to move up and down to produce a pumping action. An electric solenoid inside the unit pump is controlled by the ECU. When the ECU determines that fuel is to be injected, the solenoid is energized. The energized solenoid causes a spill valve inside the unit pump to close resulting in the plunger upward motion applying a high pressure to the fuel. The fuel under high pressure flows through rigid high pressure fuel lines (C) to the injector nozzles (D) mounted in the cylinder head. The tip of the injector nozzle is located in the combustion chamber. When fuel under pressure exceeds the nozzle opening pressure, a needle in the injector nozzle lifts to inject fuel into the combustion chamber. Injection continues until the ECU de-energizes the unit pump solenoid. The injector nozzles are plumbed to a leak-off gallery (E). Leak-off fuel returns to the fuel tank through the injector nozzle leak-off hose (F).

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Electronic Unit Pump Details

The roller camshaft follower (G) on the unit pump is a mechanical follower. A return spring (H) keeps the follower in contact with the camshaft. The unit pump is contained in the engine block (I). A cavity (J) surrounding each unit pump is plumbed to the fuel supply gallery (K) and the fuel return gallery (L). O-rings (M) on the unit pump seal the fuel cavity. There are three openings (N) on the unit pump in area of the fuel cavity which supply fuel to the unit pump and return fuel that has not been injected to the fuel cavity or fuel that leaks past the internal pump components.

Two studded electrical terminals are located at the top of the unit pump (O). The terminals are internally connected to the electric solenoid, which is used to control injection.

The high pressure fuel outlet port (P) is located at the upper end of the unit pump. The high pressure fuel lines are threaded into the fuel outlet port.

The electronic unit pumps are marked with a six digit hexadecimal calibration code which identifies unique characteristics of the unit pump. The calibration code must be entered into the ECU using Service ADVISOR if a unit pump is replaced or moved to another cylinder. The electronic unit pump is independent of the injector nozzle. The electronic unit pump or corresponding injector nozzle can be replaced without replacing the other component.

G—Roller Follower
H—Return Spring
I— Engine Block
J— Fuel Cavity
K—Fuel Supply Gallery
L— Fuel Return Gallery
M—O-Rings
N—Fuel Supply and Return Openings
O—Electrical Connections
P—High Pressure Fuel Outlet Port

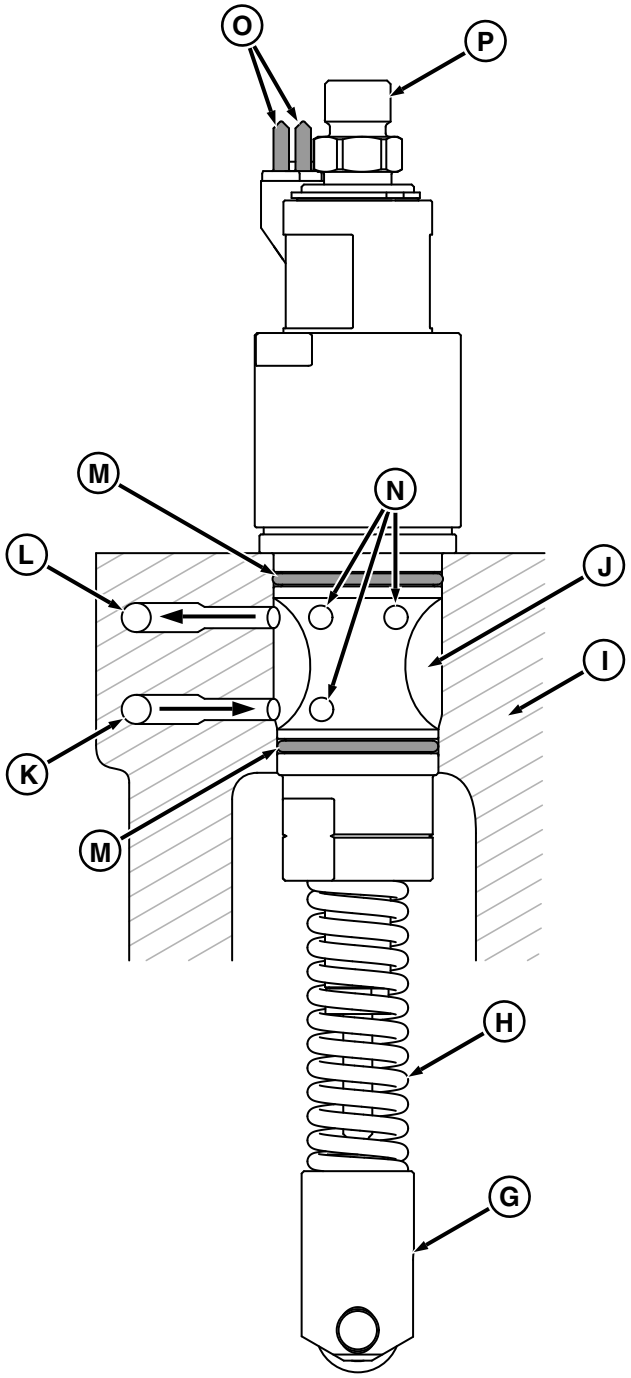


Figure 2 - Electronic Unit Pump

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Injector Nozzle Details

The injector nozzles are mounted in the cylinder head (Q). The fuel inlet port (R) is located at the upper end of the injector nozzle. The high pressure fuel lines are threaded onto the fuel inlet port. A fuel leak-off cavity (S) in the cylinder head surrounds each injector nozzle. The leak-off cavity is plumbed to the leak-off gallery (T). An O-ring (U) at the top of each injector nozzle seals the upper end of the leak-off cavity. A sealing washer (V) at the bottom of each injector nozzle seals the leak-off cavity from the combustion chamber.

Injector nozzles do not have a calibration code but there are two different injector nozzle part numbers with different flow rates. Installing the wrong nozzles in an engine will result in excessive or insufficient fueling. The injector nozzle part number (W) is stamped on the side of the injector nozzle body and can only be viewed with the injector nozzle removed from the cylinder head.

Fuel Control Details

The electronic unit pump and injector nozzle operation is divided into three cycles. The Fill Cycle, the Pump Cycle, and the Injection Cycle. The Injection Cycle is broken down into the Start of Injection and End of Injection.

Q—Cylinder Head
R—Fuel Inlet Port
S—Leak-Off Cavity
T—Leak-Off Gallery
U—O-Ring
V—Sealing Washer
W—Part Number Location

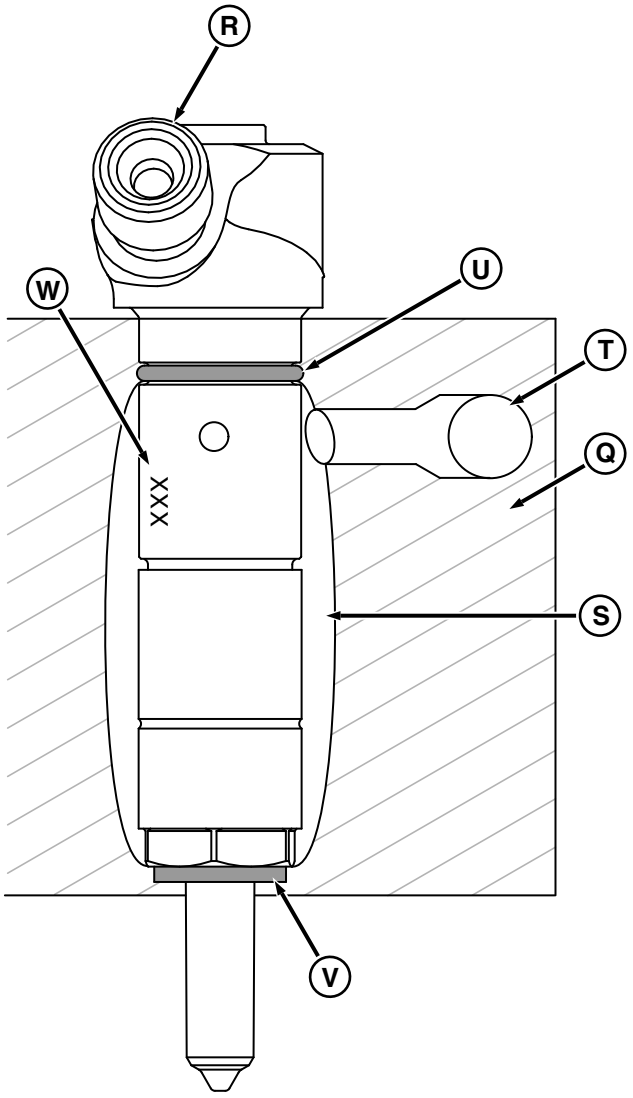


Figure 3 - Injector Nozzle

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Electronic Unit Pump Fill Cycle

The Fill Cycle begins when the plunger (A) shown in Figure 4 is pulled downward by the return spring (B) as the roller follower (C) follows the camshaft lobe off of the ramp towards the base circle. The downward motion of the plunger causes fuel from the fuel supply gallery to be drawn into the unit pump plunger cylinder (D). The unit pump solenoid (E) is not energized during the fill cycle, so the normally-open spill valve (F) is open. Plunger downward motion ceases when the follower reaches the base circle of the camshaft lobe.

A—Plunger
B—Return Spring
C—Roller Follower
D—Plunger Cylinder
E—Solenoid
F—Spill Valve

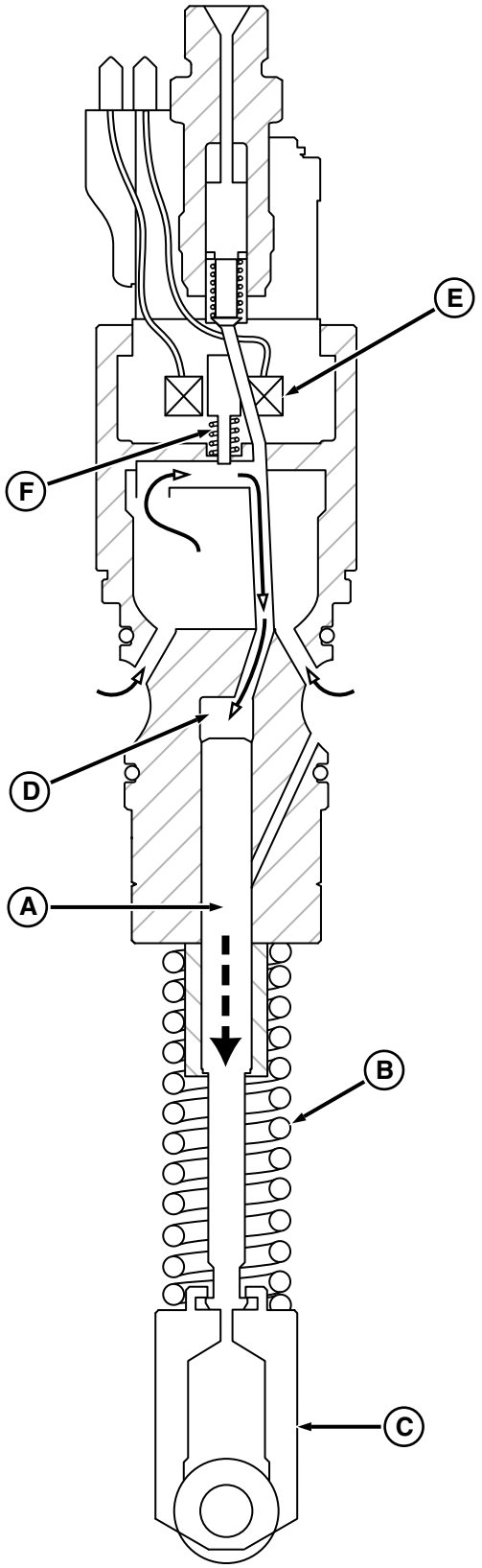


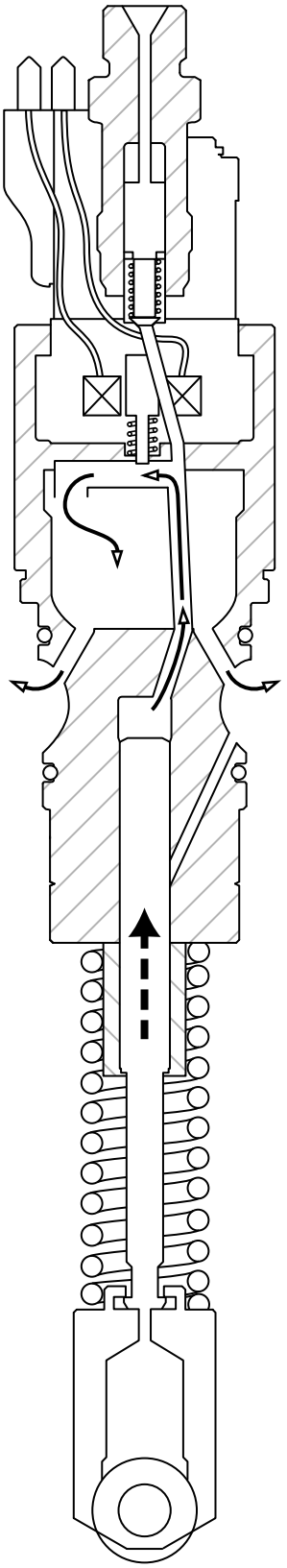
Figure 4 - Electronic Unit Pump Fill Cycle

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Pump Cycle

The Pump Cycle (Figure 5) begins when the camshaft lobe begins lifting the unit pump follower as the corresponding piston is approximately 90 degrees before top dead center of the compression stroke. The upward motion of the follower causes the plunger to also move upwardly . With the spill valve open, fuel in the plunger cylinder is pumped back into the fuel cavity around the unit pump resulting in relatively no pressure being applied to the fuel in the plunger cylinder.



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Figure 5 - Pump Cycle with Spill Valve Open

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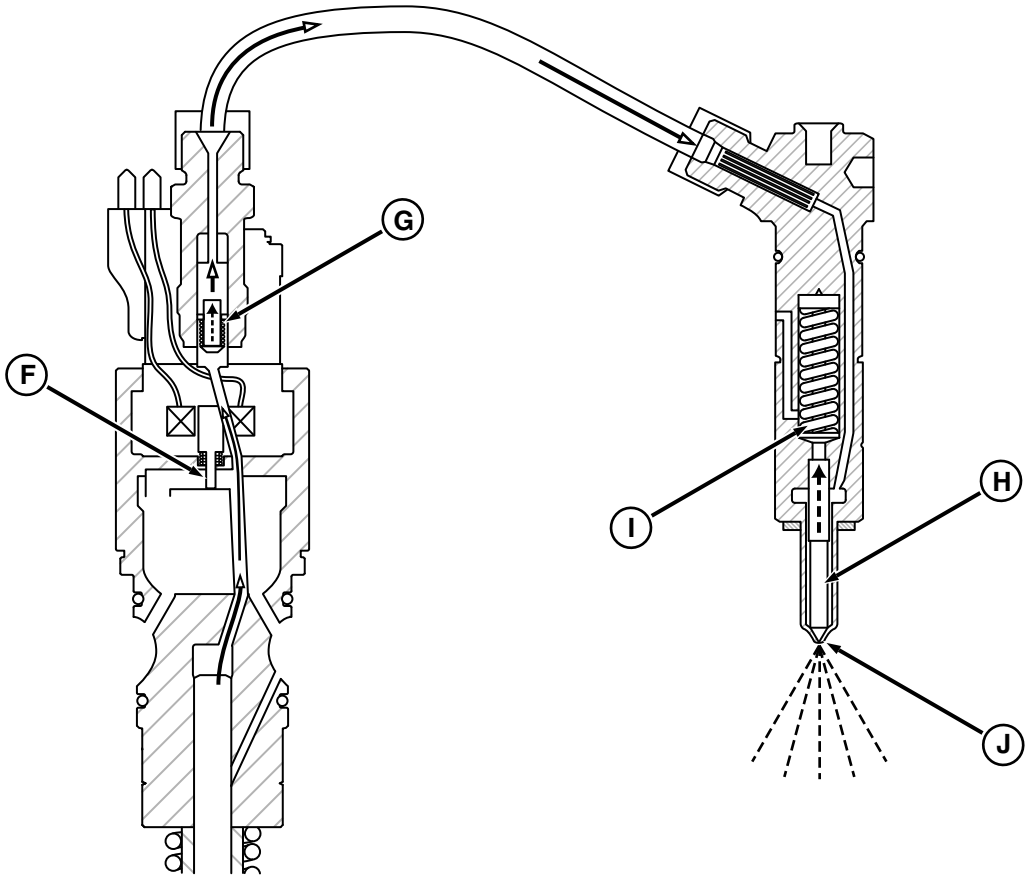


Figure 6 - Injection Cycle, Spill Valve Closed

F—Spill Valve
G—Check Valve
H—Injector Needle
I— Injector Spring
J— Injector Nozzle Tip

Start of Injection Cycle

When the ECU determines that fuel should be injected, the ECU provides +90V and ground to the unit pump solenoid coil which causes a strong magnetic field to be developed around the coil. The magnetic field causes the spill valve (F) to be pulled closed as shown in Figure 6. With the spill valve closed, pressure is rapidly applied to the fuel in the plunger cylinder. When the pressure exceeds 4 MPa (580 psi) a check-valve (G) in the unit pump outlet port opens which causes fuel under pressure to flow through the high pressure fuel line to the injector nozzle. As the plunger continues its upward movement, the pressure applied to the fuel in the injector nozzle increases. When the pressure in the injector nozzle exceeds 25 MPa (3625 psi), the normally-closed injector needle (H) overcomes the injector spring (I). The injector needle lifts and fuel is injected through the tip of the injector nozzle (J) into the combustion chamber. The pressure applied to the fuel in the injector nozzle rapidly rises as high as 160 MPa (23,200 psi) as the plunger upward movement continues.

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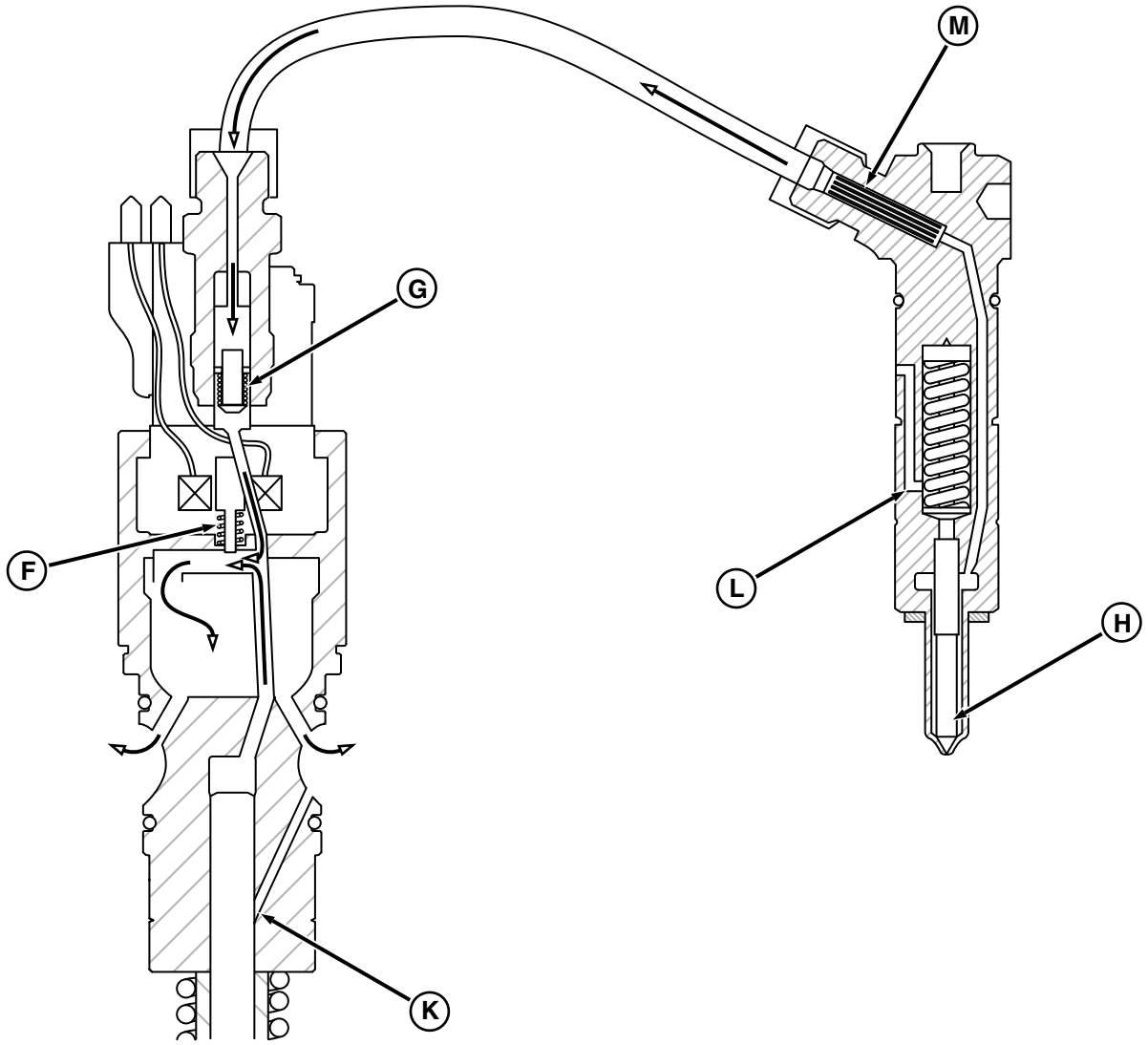


Figure 7 - End of Injection Cycle

F—Spill Valve
G—Check Valve
H—Needle
K—Unit Pump Leak-Off
L—Injector Nozzle Leak-Off
M—Edge Filter

End of Injection Cycle

The start of injection is determined by when the solenoid is energized in relationship to piston position, based on information from the crankshaft position sensor. The length of time that the electronic unit pump solenoid is energized determines the quantity of fuel injected. When the ECU calculates that the prescribed quantity of fuel has been injected, the ECU de-energizes the solenoid (Figure 7). The magnetic field around the solenoid collapses and the normally-open spill valve (F) is opened. The open spill valve vents the fuel under pressure in the unit pump and injector nozzle into the fuel cavity surrounding the unit pump. The pressure in the injector nozzle rapidly drops which causes the normally-closed injector needle (H) to close and injection ceases. The check valve (G) at the unit pump outlet closes when pressure drops below 4 MPa (580 psi) to maintain fuel under pressure in the high pressure fuel line and injector nozzle. This reduces the time necessary for pressure in the injector nozzle and high pressure line to rise during the next injection event.

Other Details

The unit pump and injector nozzle have internal leak-off ports (Figure 7). The unit pump leak off (K) returns any fuel that leaks between the plunger and cylinder to the fuel return system. The injector nozzle leak-off (L) returns any fuel that leaks between the injector needle and guide. The injector nozzle inlet also contains a non-servicable edge filter (M).

The fuel system performs pilot injection during engine start-up. The ECU energizes the unit pump solenoid briefly to inject a small amount of fuel prior to main injection. Pilot injection ceases after the engine starts.

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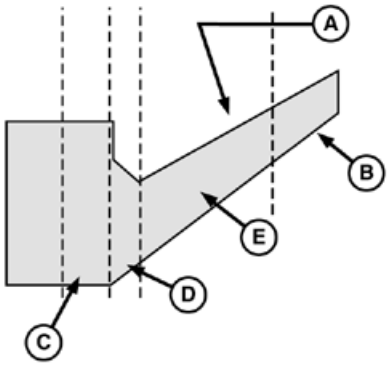
Light Load and Speed Advance Operation

The upper edge of the helix (A) controls start of pumping (timing). The lower ramp (B) controls fuel quantity delivered. The starting, or cranking zone (C) of the helix produces an advance in timing and a delivery of a large quantity of fuel, both of which aid starting.

The full load zone (D) provides less advance timing (lower upper ramp location), and less fuel, than the starting zone of the helix.

When the engine is run at no, to light load conditions, the governor rotates the plunger so that the light load zone of the helix (E) controls the covering and uncovering of the charging port as follows: With a decrease in load, engine speed increases, causing the governor to turn the plunger which in turn will cause a decrease in fuel with a corresponding increase in timing. As load increases, engine speed drops. The governor moves the plunger in the opposite direction, increasing fuel and decreasing timing advance.

IMPORTANT: The helix is specially designed to advance fuel timing under light engine loads to improve combustion efficiency, especially during warm-up.



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Plunger Helix

A—Upper Ramp
B—Lower Ramp
C—Starting (Cranking) Zone
D—Full Load Zone
E—Light Load Zone

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Cold Start Advance Operation

IMPORTANT: By slightly advancing the injection event (pump timing), the injected fuel is provided more time to heat during the compression stroke and burn more cleanly in the combustion chamber when ignited. Without cold start advance (CSA), fuel injected into a cool or cold combustion chamber at cold startup takes longer to heat up and ignite. If this delay in ignition is too great, it results in unburned fuel (white smoke and "slobber") and rough running or misfire until the combustion chamber warms.

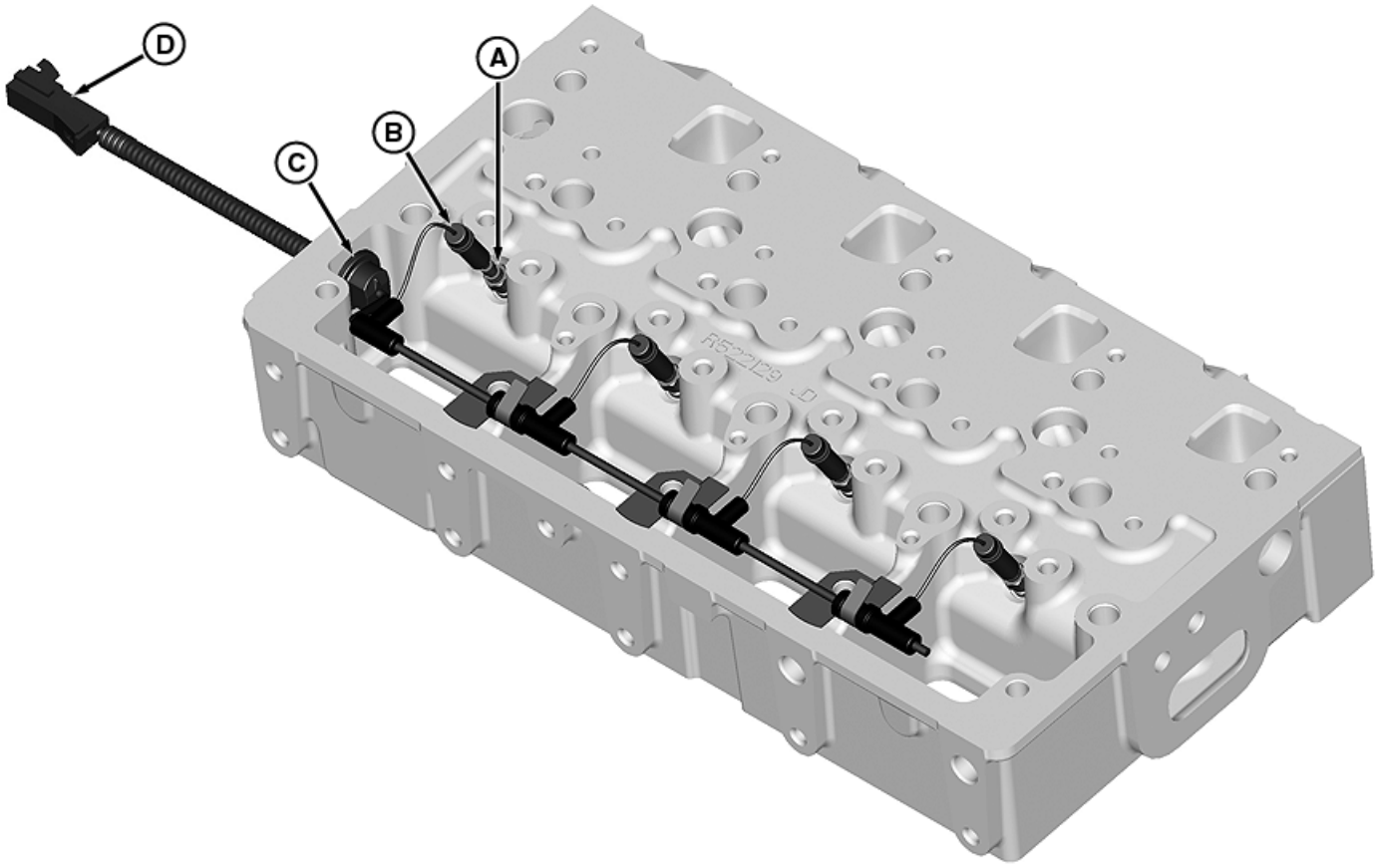
The cold start advance on the Series 250 engine is controlled by oil pressure in the hydraulic roller cam followers, or lifters, for the unit pumps. During cold starting, engine oil is sent by the cold advance thermostat to the cold advance piston in the cam follower via the cold advance oil gallery. The oil pressure lifts the piston 1.5 mm, thus increasing the overall travel length, or stroke, of the unit pump plunger. This advances the pump timing. The increase in stroke of the plunger causes the cam to raise the plunger sooner. This change results in the injection timing to be advanced approximately ten degrees. The oil pressure needed to provide full cold start advance is about 35 psi. A ball check at the base of the piston prevents pumping forces from collapsing the advance.

The cold start advance thermostat begins to block the oil flow when oil temperatures reach approximately 80°C (176°F). When the oil supply port to the roller cam followers is fully blocked, residual oil in the piston cup bleeds out through a drain orifice located in the cup end of the follower. At approximately 15 psi oil pressure, the cold start advance is fully disabled. The follower piston returns to the lower position, returning timing advance to the optimum performance level for an engine at normal operating temperatures.

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Glow Plug Operation

CAUTION: Do NOT use flammable starting aids such as ether on engines equipped with glow plugs.



Glow Plugs (2.4L Shown)

A—Glow Plugs (4) **B—Glow Plug Connectors (4)** **C—Hole in Cylinder Head with Grommet** **D—Glow Plug Harness Connector**

Glow Plugs

Glow plugs are high-power electric heating elements located in each cylinder's combustion chamber. An application-supplied glow plug relay, controlled by the ECU, provides the voltage supply to the parallel connected glow plugs. The ECU supplies a high side output to the glow plug relay coil to energize the glow plug relay.

Glow plugs (A) are installed into a threaded hole in the cylinder head beneath the rocker cover. The tip of each glow plug extends into the corresponding combustion chamber. An engine-supplied glow plug wire harness located beneath the rocker cover is connected (B) to each glow plug. The glow plug wire harness exits the cylinder head through a hole (C) at the rear of the engine as a single cable and a grommet on the glow plug harness acts as a seal. A connector (D) on the glow plug harness is mated with the application's wire harness.

The glow plugs are internally grounded to the cylinder head through the threaded mounting hole in the cylinder head. Normal resistance to ground of each glow plug is less than 1 ohm with the glow plug at room temperature. The resistance increases significantly when the glow plug is heated.

Preheat Cycle

The ECU uses coolant temperature to determine if the glow plug relay should be energized to preheat the combustion chamber prior to the engine being cranked. Coolant temperature must be below 0°C (32°F) for the ECU to energize the glow plug relay. The length of time that the ECU energizes the glow plug relay to preheat the combustion chamber increases to a programmed maximum value as coolant temperature decreases.

Wait to Start Lamp

An application-supplied wait to start lamp controlled by the ECU is illuminated to signal the operator to not crank the engine until the ECU has completed the preheating cycle. If the engine does not start, the key switch must be cycled OFF and back ON again to cause the ECU to reset the glow plug preheat cycle and re-energize the glow plug relay for the next attempt to start the engine.

Continued on next page

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Reheat and Reheat Cycle

After the engine starts, the ECU may re-energize the glow plug relay for several seconds to reheat the combustion chamber to reduce white smoke and stabilize the engine speed. After the reheat period expires, the ECU may energize the glow plug relay again for a minute or more (reheat cycle) to help stabilize engine speed, if engine speed is fluctuating excessively.

System Diagnostics

The ECU monitors the output of the glow plug relay to determine if the relay is energized for diagnostic purposes. The ECU will generate DTC 000676.05 if the glow plug relay is detected as NOT being energized when commanded and DTC 000675.03 if the glow plug relay is energized when NOT commanded.

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Section 04
Diagnostics

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About This Group of the Manual

This Group of the manual contains necessary information to diagnose some base engine, all lubrication system and all cooling system problems. This section is divided into two areas: diagnosing malfunctions and testing procedures. The diagnosing malfunction areas are further divided into the following headings, containing the following symptoms:

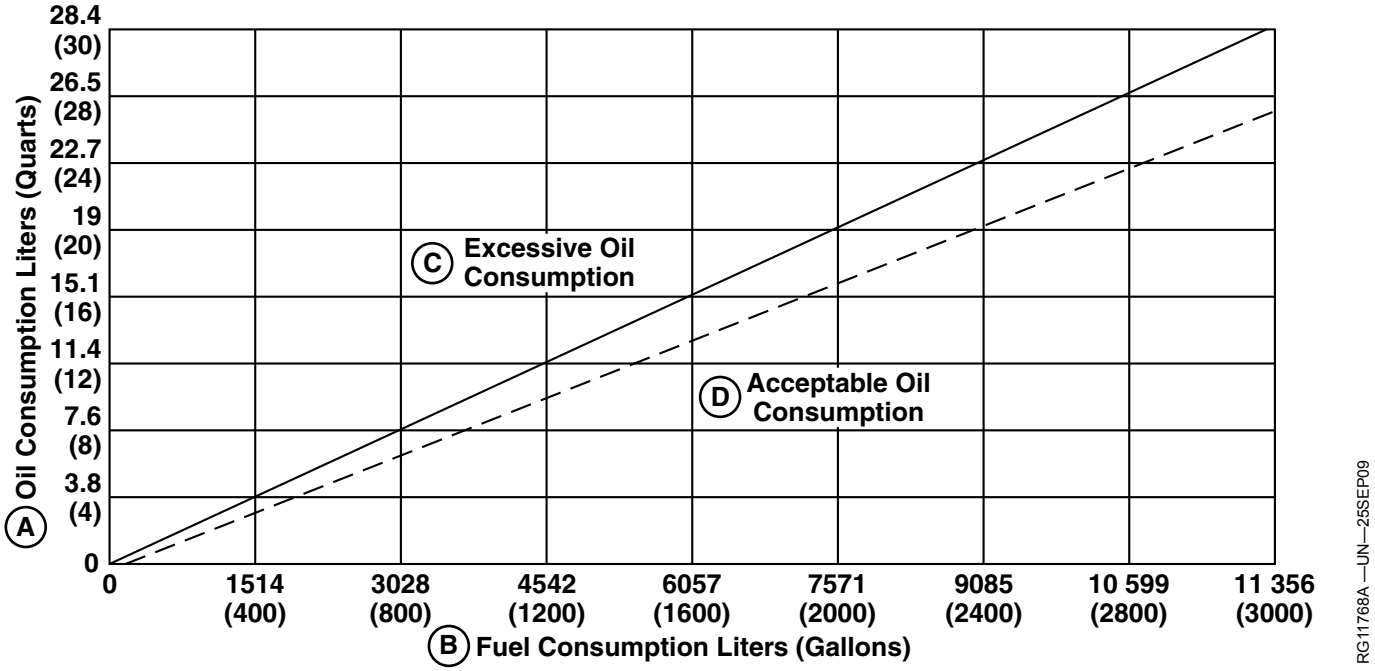
- **(L)** Diagnosing Lubrication System Malfunctions:
  - L1 - Excessive Oil Consumption
  - L2 - Engine Oil Pressure Low
  - L3 - Engine Oil Pressure High
- **(C)** Diagnosing Cooling System Malfunctions:
  - C1 - Coolant Temperature Above Normal
  - C2 - Coolant Temperature Below Normal
  - C3 - Coolant 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 in the most likely or easiest to check first. Symptoms arranged in both formats refer to testing procedures in the second part of this section. The second part of this section 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 (Turbocharger Engines)
  - Test Turbocharger Wastegate
  - Test Air Filter Restriction Indicator Switch

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Guideline for Acceptable Oil Consumption



Engine Oil/Fuel Consumption Ratio

A—Oil Consumption Liters (Quarts) **B—Fuel Consumption Liters (Gallons)** **C—Excessive Oil Consumption** **D—Acceptable Oil Consumption**

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

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L1 - Excessive Oil Consumption

RG41183,0000008 -19-29MAY03-2/7

❶ **L1 - Preliminary Check**	1. Check for too low or too high engine oil level. 2. Check for too low viscosity, or coolant- or fuel-diluted engine oil. 3. Check for excessive external oil leaks.	**No problems found:** GO TO ❷ **Problem found:** Repair and retest.

RG41183,0000008 -19-29MAY03-3/7

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

Continued on next page

RG41183,0000008 -19-29MAY03-4/7

❸ **Check for Excessive Crankcase Pressure (Blow-By)**	Check for excessive crankcase pressure. See CHECK FOR EXCESSIVE ENGINE CRANKCASE PRESSURE (BLOW-BY) later in this Group.	**No fumes and no dripping oil observed:** GO TO ❹ **Excessive fumes or dripping oil observed; appears to be caused by boost pressure (if equipped with turbocharger):** Check the turbocharger, repair/replace as needed. See TURBOCHARGER FAILURE ANALYSIS in Section 02, Group 080 of this manual. **Excessive fumes or dripping oil observed; does not appear to be caused by boost pressure (if equipped with turbocharger):** 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 ENGINE COMPRESSION PRESSURE later in this Group.

RG41183,0000008 -19-29MAY03-5/7

❹ **Turbocharger Oil Seal Leak Check**	*NOTE: This check is not needed for non-turbocharged (“D” engines).* *For these engines, GO TO* ❺ Check for turbocharger oil seal leaks. See CHECK FOR TURBOCHARGER OIL SEAL LEAK later in this group.	**No signs of oil leakage:** GO TO ❺ **Signs of oil leakage present:** Investigate problems associated with oil leakage as outlined in the test procedure, perform necessary repairs, and retest.

Continued on next page

RG41183,0000008 -19-29MAY03-6/7

5 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 bores or valve guides. Repair problem as necessary.

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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 in Section 02, Group 060 of this manual. Replace oil filter.
	Excessive oil temperature	Remove and inspect oil cooler. See REMOVE, INSPECT, AND INSTALL OIL COOLER in Section 02, Group 060 of this manual.
	Incorrect oil	Drain crankcase and refill with correct oil.
	Defective oil pump	Remove and inspect oil pump. See REMOVE ENGINE OIL PUMP in Section 02, Group 060 of this manual.
	Oil pressure regulating valve failure	Inspect oil pressure regulating valve. See REMOVE AND INSTALL OIL PRESSURE REGULATING VALVE in Section 02, Group 060 of this manual.
	Broken piston spray jet	Replace piston spray jet. See REMOVE, INSPECT, AND INSTALL PISTON COOLING ORIFICES in Section 02, Group 030 of this manual.
	Clogged oil pump screen or cracked pick-up tube	Remove oil pan and clean screen. Replace pick-up tube. See REMOVE, INSPECT, AND INSTALL OIL PICK-UP TUBE ASSEMBLY in Section 02, Group 060 of this manual.
	Excessive main or connecting rod bearing clearance	Determine bearing clearance. See CYLINDER BLOCK, CYLINDER BORES, PISTONS, AND RODS SPECIFICATIONS in Section 06, Group 200 or CRANKSHAFT, MAIN BEARINGS, AND FLYWHEEL SPECIFICATIONS in Section 06, Group 200 of this manual.

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L3 - Engine Oil Pressure High

Symptom	Problem	Solution
L3 - Engine Oil Pressure High	Improper oil classification	Drain crankcase and refill with correct oil.
	Oil pressure regulating valve body loose (wanders)	Remove and inspect oil pressure regulating valve. See REMOVE AND INSTALL OIL PRESSURE REGULATING VALVE in Section 02, Group 060 of this manual.
	Improperly operating regulating valve	Remove and inspect oil pressure regulating valve. See REMOVE AND INSTALL OIL PRESSURE REGULATING VALVE in Section 02, Group 060 of this manual.
	Plugged piston spray jet	Replace piston spray jet. See REMOVE, INSPECT, AND INSTALL PISTON COOLING ORIFICES in Section 02, Group 030 of this manual. Inspect cylinder bore for damage.

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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.
	Premature belt wear or belt flies off pulley	Check pulley alignment.
	Defective thermostat(s)	Test thermostat opening temperature; replace thermostat as required. See INSPECT THERMOSTAT AND TEST OPENING TEMPERATURE later in this Group.
	Damaged cylinder head gasket	Replace cylinder head gasket. See CHECK FOR HEAD GASKET FAILURES later in this Group.
	Defective coolant pump	Replace coolant pump. See REMOVE COOLANT PUMP in Section 02, Group 070 of this manual.
	Defective radiator cap	Replace radiator cap as required. See PRESSURE TEST COOLING SYSTEM AND RADIATOR CAP later in this Group.

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C2 - Engine Coolant Temperature Below Normal

Symptom	Problem	Solution
C2 - Engine Coolant Temperature Below Normal	Defective thermostat(s)	Test thermostats; replace thermostats as required. See INSPECT THERMOSTAT AND TEST OPENING TEMPERATURE later in this Group.

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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 CHECK FOR HEAD GASKET FAILURES later in this Group.
	Faulty oil cooler	Remove and inspect engine oil cooler. See REMOVE, INSPECT, AND INSTALL OIL COOLER in Section 02, Group 060 of this manual.
	Cracked cylinder bore(s)	Locate crack; repair/replace components as required.
	Cracked cylinder head or block	Locate crack; repair/replace components as required.

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A2 - Glow Plug Check

RG41183,00000EC -19-14MAY03-1/7

A2 - Glow Plug Check

RG41183,00000EC -19-14MAY03-2/7

1 A2 - Preliminary Check	**IMPORTANT: Do not force probes into connector terminals or damage will result. Use JT07328 Connector Adapter Test Kit to make measurements in connectors. This will ensure that terminal damage does not occur.** Perform a preliminary inspection of the glow plug connectors , and any connectors between them looking for dirty, damaged, or poorly positioned terminals. Ensure connection	**No faulty connection(s):** GO TO 2 **Faulty connection(s):** Repair faulty connection(s).

RG41183,00000EC -19-14MAY03-3/7

2 Pre-Heat Indicator Lamp	1. Activate glow plug switch. 2. Verify that the Pre-Heat Indicator Lamp is working.	**Lamp is working:** GO TO 3 **Lamp does not work:** Faulty pre-heat indicator lamp wiring OR Faulty pre-heat indicator lamp

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3 Voltage at Air Heater Check	1. Ignition OFF 2. Disconnect all glow plug connectors 3. Using a multimeter, measure the voltage between each glow plug connector and a good chassis ground while turning ignition ON (engine OFF). *NOTE: Voltage must be read as ignition is turned ON*	**At or near battery voltage:** GO TO 4 **No voltage detected:** GO TO 5

RG41183,00000EC -19-14MAY03-5/7

4 Glow Plugs Check	1. Ignition OFF 2. Remove glow plugs from engine. 3. Using a multimeter, check the continuity of the glow plug(s)	**Good continuity through glow plug(s):** No glow plug related problem found **Poor continuity through glow plug(s):** Faulty glow plug(s)

Continued on next page

RG41183,00000EC -19-14MAY03-6/7

5 Glow Plug Wire Check	1. Check fuse 2. Using a multimeter, check the continuity of the wire from activation switch to glow plug wire harness connector and each glow plug connector.	**Good continuity:** No glow plug related problem found **Poor continuity:** Replace wire and/or glow plug wire harness

RG41183,00000EC -19-14MAY03-7/7

Test Engine Compression Pressure

IMPORTANT: Compression pressures are affected by the cranking speed of the engine. Before beginning test, ensure that batteries are fully charged.

1. Start engine and run at rated speed until it warms up to normal operating temperature. (From a cold start, operate engine 10—15 minutes at slow idle.)
2. Shut off engine and remove the rocker arm cover. See Rocker Arm Cover Installation and Removal in Group 20.
3. Shut off fuel supply and remove glow plugs. See Glow Plug Installation and Removal in Section 20.
4. Install JDG1687 into glow plug bore in the cylinder head and tighten to specification. Attach 45° quick disconnect fitting to compression adapter and install compression gauge to adapter. Do not tighten adapter to more than glow plug torque specification.

Specification	
Glow Plug—Torque	13 N·m (10 lb-ft)

5. Set rocker arm cover on top of cylinder head to reduce oil spray from push rods.

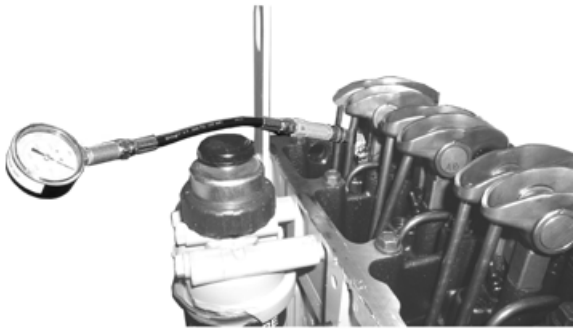
Compression Test

1. Push throttle lever to “STOP” position. Turn crankshaft for 10—15 seconds with starter motor (minimum cranking speed—150 rpm cold/200 rpm hot).
2. Compare readings from all cylinders. Compression pressure must be within specification.

Specification	
Engine Compression Pressure Test—Engine Compression Pressure	2379—2792 kPa (24—28 bar) (345—405 psi)
Maximum Difference between Cylinders	350 kPa (3.5 bar) (50 psi)

NOTE: Pressure given was taken at 183 m (600 ft) above sea level. A 3.6 percent reduction in gauge pressure will result for each additional 300 m (1000 ft) rise in altitude.

All cylinders within an engine should have approximately the same pressure. There should be less than 340 kPa (3.4 bar) (50 psi) difference between cylinders.



RG13030 —UN—01JUL03

Engine Compression Test

3. If pressure is much lower than shown, remove gauge and apply oil to ring area of piston through injection nozzle or glow plug bore. Do not use too much oil. Do not get oil on the valves.
4. Test compression pressure again.

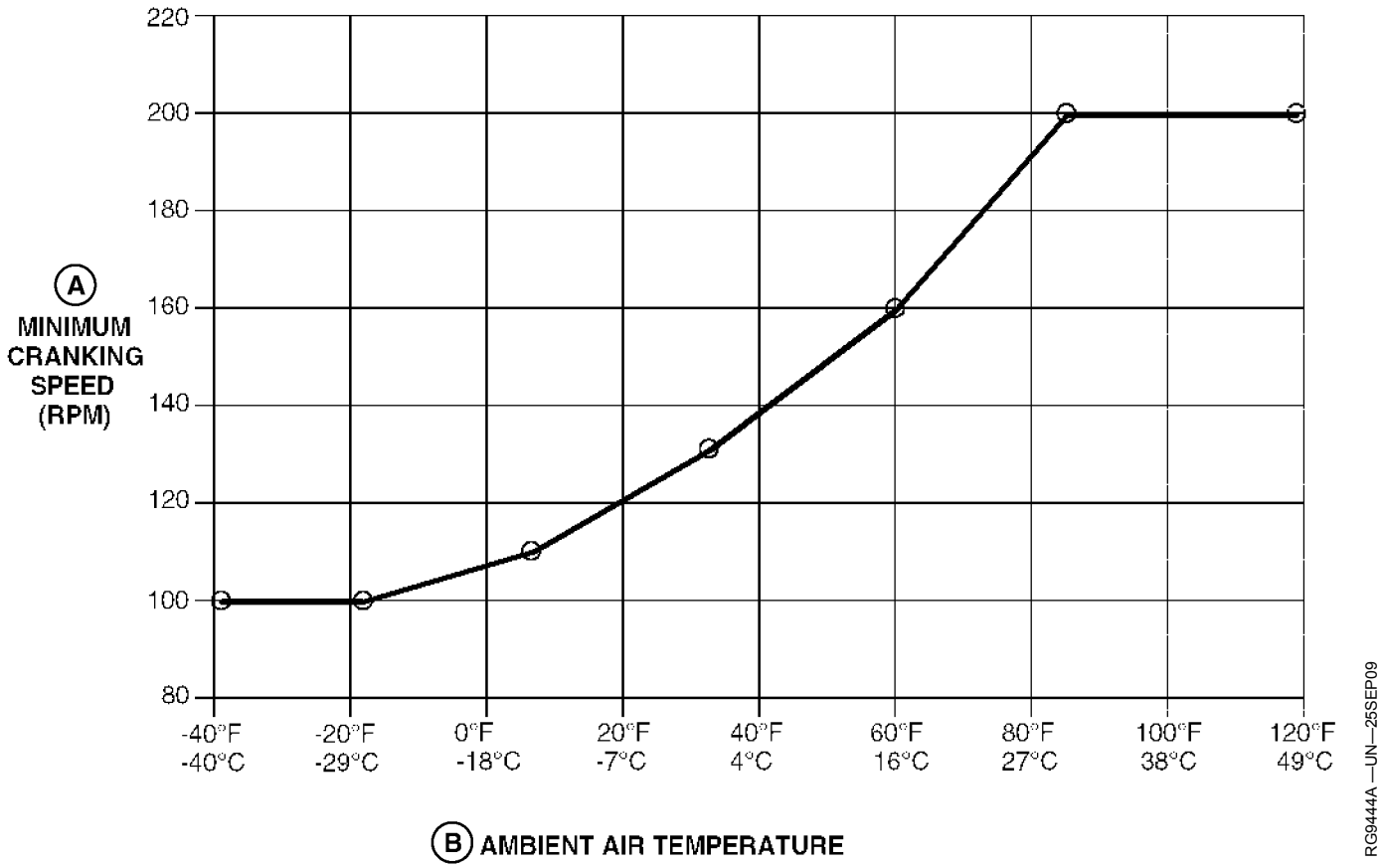
   If pressure is high, worn or stuck rings are indicated, replace piston rings or install new piston set as needed. (See Section 02, Group 030.)

   If pressure is low, valves could be worn or sticking. Recondition cylinder head as required. (See Section 02, Group 020.)
5. Measure compression pressure in all remaining cylinders and compare readings. Recondition cylinders and valves as required.

IMPORTANT: When testing is completed, use a clean lint free rag to clean all oil from intake manifold ports.

RG41183,00000E3 -19-06MAY03-1/1

Test Engine Cranking Speed



Engine Cranking Speed Test

A—Minimum Cranking Speed (RPM) **B—Ambient Air Temperature**

IMPORTANT: Cranking speed specifications above are for OEM engines only. See Machine Technical Manual for other applications.

Make sure that batteries are fully charged before performing this test.

1. Disable the fuel supply system at the injection pump so fuel delivery is in the OFF position.
2. If not using the machine tachometer, install a photo tach.
3. Crank the engine for 15 seconds and record engine speed.
4. Compare recorded engine speed to chart above.

   Cranking speed should meet or exceed specified engine rpm for a given ambient air temperature. For example, at 29°C (85°F) ambient air temperature, cranking speed should be at least 200 rpm.

   If cranking speed is below specifications, check the following:

   - Starting system problems (low battery, loose or defective wiring, defective starter, etc.).
   - Excessive engine loads (hydraulic pumps/thick oil, thick engine oil, etc.).

RG41183,00000E7 -19-25SEP09-1/1

Dynamometer Test

IMPORTANT: Dynamometers should be periodically checked for accuracy and calibrated as necessary.

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 200.

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Engine Oil Consumption

All engines consume some oil. The consumption rate depends on loading, design of key parts and engine condition. Since fuel consumption is an indicator of operating power levels, fuel used versus oil consumed is a critical factor in analyzing oil consumption. Oil consumption should be measured over a 100-hour period.

Long-term oil consumption (three oil drain intervals after the engine is broken in) with consumption rates poorer than 400:1 (100 gallons of fuel and 1 quart of oil) indicates a need to monitor/investigate. Suggested steps would be:

- Check for signs of ingested dust or perform an OILSCAN® test to check for silicon.
- Check for proper crankcase oil fill level.
- Perform compression test to find low compression cylinders.
- Remove head and inspect for glazed or worn cylinder bores.
- Inspect pistons for carbon deposits in the ring land grooves.
- Measure valve stem OD and valve guide ID to determine clearance.

NOTE: Ring gap alignment does not identify the leak source.

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

When changing to a premium oil such as TORQ-GARD SUPREME® PLUS-50®, little oil consumption change is expected, although a small percentage of engines may experience a noticeable change in consumption rates. This may be due to the following:

- The previous oil may have left deposits on internal components. Use of PLUS-50® oil will cause different chemical reactions in those deposits. The time required for the engine to regain the previous oil consumption rate will vary from one to three normal drain intervals.
- TORQ-GARD SUPREME® PLUS-50® contains a high-performance anti-oxidant along with other additives resulting in the oil remaining in the specified viscosity grade throughout the recommended drain interval. API oil grades CD, CE, and CF-4 universal engine oils do not provide this oxidation resistance which results in more rapid thickening. Increased oil viscosity can reduce oil consumption.

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

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Check Engine Oil Pressure

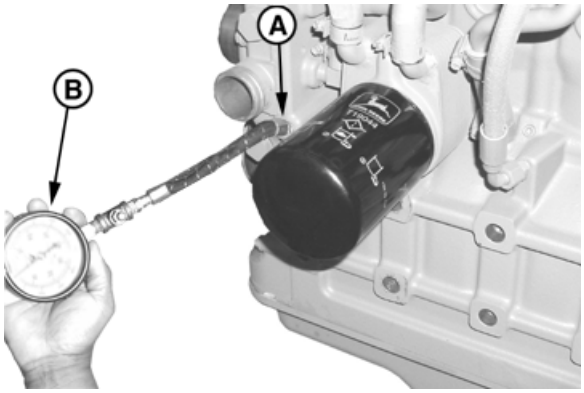
CAUTION: Engine oil pressure MUST be taken from the left side of the engine. The oil gallery on the right side is for cold start advance and will give false readings when engine reached operating temperature.

1. Remove main oil gallery plug from left side of engine.
2. Attach pressure gauge (B) from JT05470 Universal Pressure Test Kit to oil gallery.

IMPORTANT: To achieve an accurate oil pressure reading, warm up engine crankcase oil to 105°C (220°F) or high oil pressure readings will occur.

3. Start engine and run at speeds given below.
4. Measure oil pressure and compare readings.

Specification	
Minimum Oil Pressure—No Load at Slow Idle and 93°C (200°F) Oil Temperature—Minimum Pressure	105 kPa (1.05 bar) (15 psi)
Minimum Oil Pressure—Full Load at Rated Speed and 105°C (220°F) Oil Temperature—Minimum Pressure	275 kPa (2.75 bar) (40 psi)



RG13033 —UN—02JUL03

Oil Gallery Plug

A—Oil Gallery Port **B—Pressure Gauge**

NOTE: Tolerance extremes and gauge fluctuations can result in the gauge reading up to 586 kPa (5.86 bar) 85 psi. This is not detrimental to the engine.

The oil pressure regulating valve is designed so that adjustment of oil pressure should not be required.

5. Replace oil pressure regulating valve if oil pressure is not within specified range.

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Check for Excessive Engine Crankcase Pressure (Blow-By)

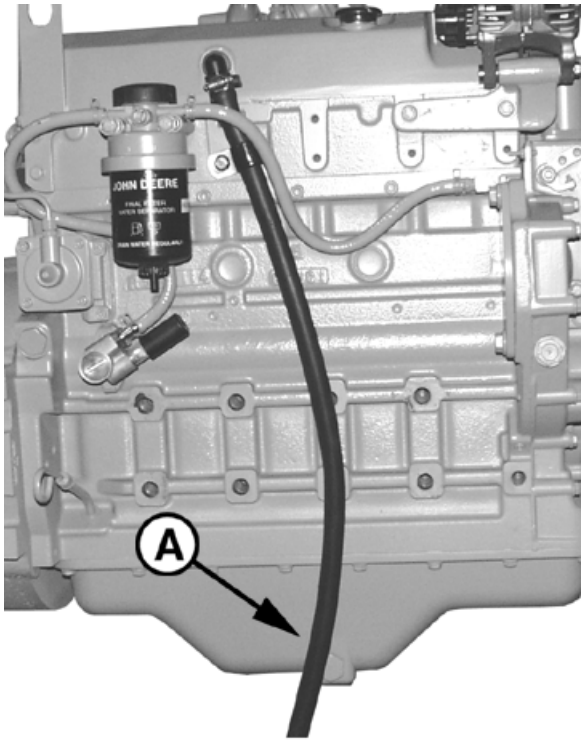
Excessive blow-by coming out of the crankcase breather tube (A) indicates that either the turbocharger (if equipped) seals are faulty or the piston rings and cylinder bores are not adequately sealing off the combustion chamber. This is a comparative check that requires some experience to determine when blow-by is excessive.

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

If excessive blow-by is observed, perform the following to determine if the turbocharger (if equipped) is causing the blow-by:

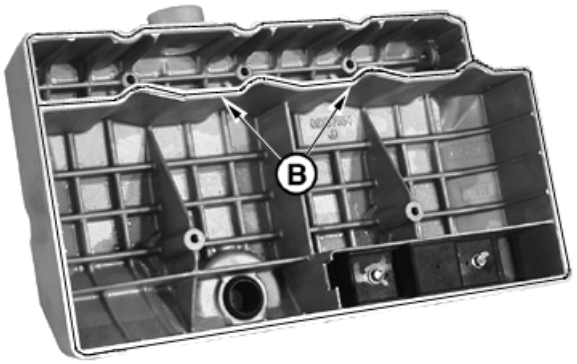
1. Remove the turbocharger oil drain line where it connects to the engine block and run line into a bucket.
2. Run engine at high idle, slightly loaded, and determine if boost pressure is forcing oil through the drain line. Check crankcase breather tube to determine if blow-by has decreased.
3. If it appears that boost pressure is forcing oil through the drain line, and/or blow-by decreases with the drain line disconnected from block, replace the turbocharger, and retest.
4. Remove rocker arm cover and inspect sealant path (B) for areas showing possible blow-by. Clean ssurface and apply sealant as shown and and reinstall. Allow sealant to completely cure. Run engine at high idle and check crankcase breather tube.

A—Breather Tube **B—Sealant Path**



RG12659 —UN—29MAY03

Blow-By Check



RG12530B —UN—13APR04

Sealant Path

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Check for Turbocharger Oil Seal Leak

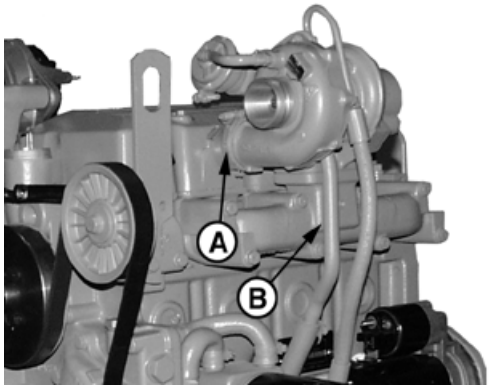
Seals are used on both sides of the turbocharger rotor assembly. The seals are used to prevent exhaust gasses and air from entering the turbocharger housing. Oil leakage past the seals is uncommon but can occur.

A restricted or damaged turbocharger oil return line can cause the housing to pressurize, causing oil to leak by the seals. Additionally, intake or exhaust restrictions can cause a vacuum between the compressor and turbocharger housing, causing oil to leak by the seals.

1. Remove exhaust pipe (shown removed) and inlet hose (A).
2. Inspect the turbine casing and inlet hose for evidence of oil leakage.

   If oil leakage is present, perform the following:

   - Inspect turbocharger oil return line (B) for kinks or damage. Replace if necessary.
   - Check the air intake filter, hoses, and inlet hose for restrictions.
   - Check the exhaust system for restrictions to include position of exhaust outlet.
3. Perform necessary repairs and repeat test.



RG12656 —UN—29MAY03

Turbocharger Oil Seal Leak Test

A—Inlet Hose **B—Oil Return Line**

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Inspect Thermostat and Test Opening Temperature

Visually inspect thermostat for corrosion or damage. Replace as necessary.

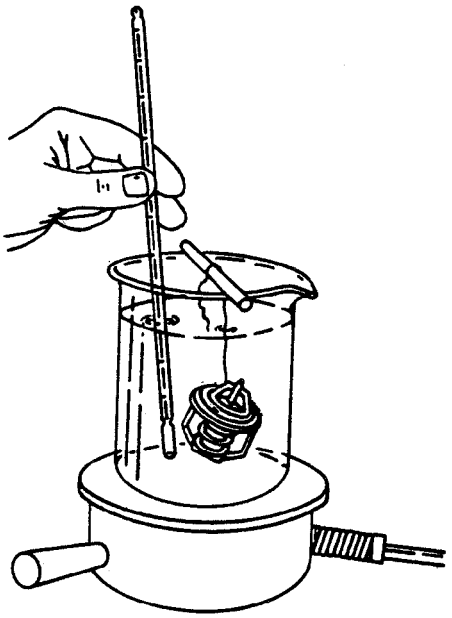
Test thermostat as follows:

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

1. Remove thermostats. (See procedure in Section 02, Group 070.)
2. Suspend thermostat and a thermometer in a container of water.
3. Stir the water as it heats. Observe opening action of thermostat and compare temperatures with specification given in chart below.

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

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



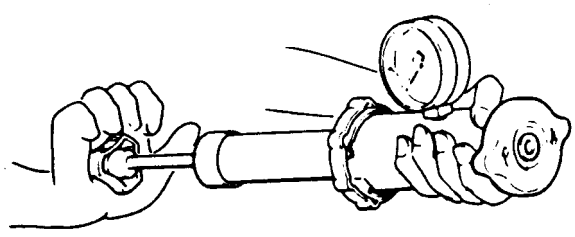
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Test Thermostat Opening Temperature

4. Remove thermostat and observe its closing action as it cools. In ambient air the thermostat should close completely. Closing action should be smooth and slow.
5. If thermostat is defective, replace thermostat.

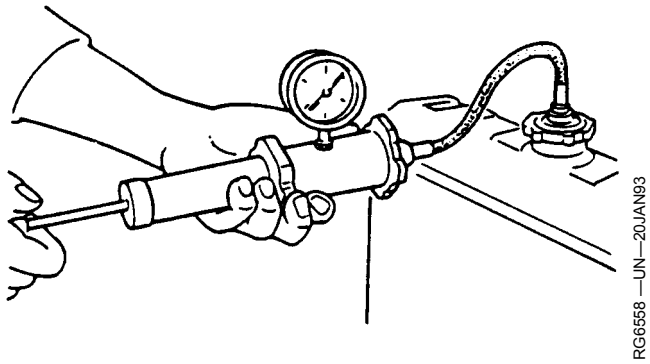
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Pressure Test Cooling System and Radiator Cap



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].

2.4 L & 3.0 L Diesel Engines—Specification

Radiator Cap—Holding Pressure (10 Second Minimum Hold).....70 kPa (0.7 bar) (10 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.

[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.

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.[2], 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.

[2] Test pressures recommended are for all Deere OEM cooling systems. On specific vehicle applications, test cooling system and pressure cap according to the recommended pressure for that vehicle.

RG,105,JW7649 -19-21NOV97-1/1

Check for Head Gasket Failures

Head gasket failures generally fall into three categories:

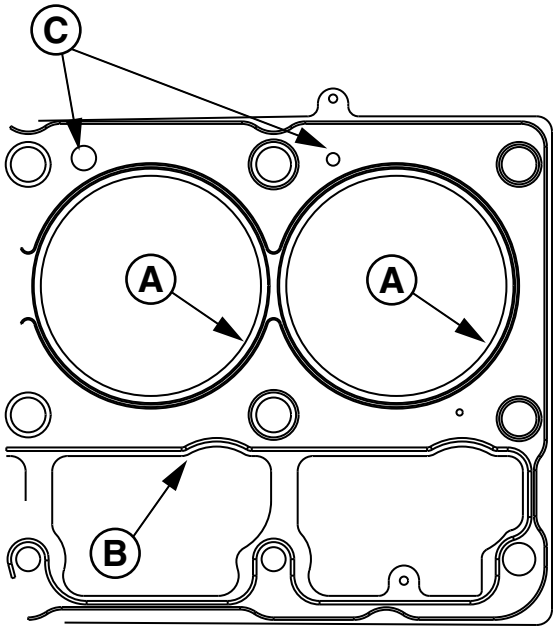
- Combustion seal failures.
- Coolant seal failures.
- Oil seal failures.

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

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

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

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



RG12815A —UN—12MAY03

Diagnosing Head Gasket Joint Failures

A—Combustion Sealing Area **C—Coolant Sealing Areas**
B—Oil Sealing Areas

4. Shut engine down. Recheck crankcase, radiator, and overflow tank for any significant differences in fluid levels, viscosity, or appearance.
5. Compare your observations from above steps with the diagnostic charts earlier in this group. If diagnostic evaluations provide conclusive evidence of combustion gas, coolant, or oil leakage from head gasket joint, the cylinder head must be removed for inspection and repair of gasket joint components.

COMBUSTION SEAL LEAKAGE

Symptoms:

- Exhaust from head gasket crevice
- Air bubbles in radiator/overflow tank
- Coolant discharge from overflow tube
- Engine overheating
- Power loss
- Engine runs rough
- White exhaust smoke
- Loss of cab heat
- Gasket section dislodged, missing (blown)
- Coolant in cylinder
- Coolant in crankcase oil
- Low coolant level

Possible Causes:

- Low head bolt clamping loads
- Cracked/deformed gasket combustion flange
- Out-of-flat/damaged/rough cylinder head surface
- Missing/mislocated gasket fire ring
- Excessive fuel delivery
- Advanced injection pump timing

Continued on next page

RG41183,00000E9 -19-07MAY03-1/2

- Hydraulic or mechanical disturbance of combustion seal

NOTE: Cracked cylinder head or cylinder bores may also allow combustion gas leakage into coolant.

COOLANT SEAL LEAKAGE

Symptoms:

- Coolant discharge from head gasket crevice
- Coolant in crankcase oil
- Low coolant level
- High oil level
- Coolant discharge from crankcase vent

Possible Causes:

- Low head bolt clamping loads
- Out-of-flat/damaged/rough block surface
- Out-of-flat/damaged/rough cylinder head surface
- Oil or coolant overheating
- Cracks/creases in gasket body surfaces
- Damage/voids in elastomer beading

OIL SEAL LEAKAGE

Symptoms:

- Oil discharge from head gasket crevice
- Oil in coolant
- Low crankcase oil level
- Reduced oil to rocker arms (noisy)

Possible Causes:

- Low head bolt clamping loads
- Out-of-flat/damaged/rough block surface
- Out-of-flat/damaged/rough cylinder head surface
- Oil or coolant overheating
- Cracks/creases in gasket body surfaces
- Damage/voids in elastomer beading

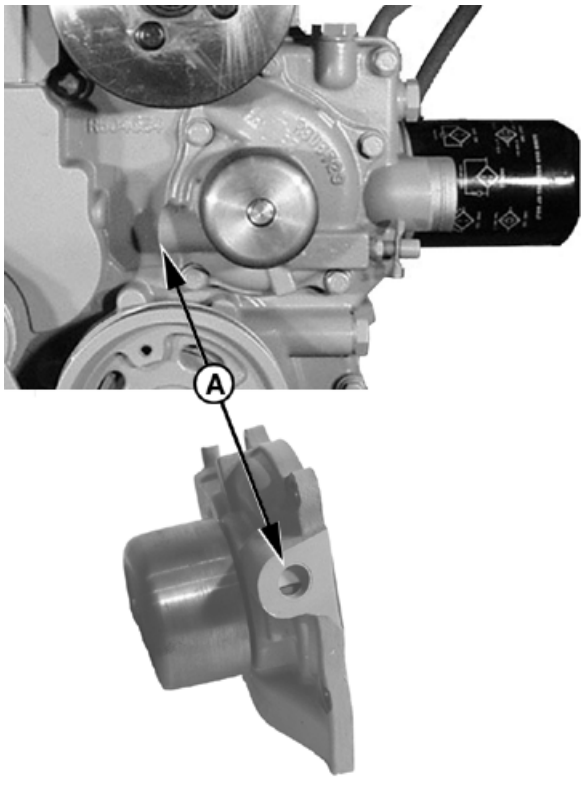
NOTE: Defective oil cooler may also allow oil leakage into coolant.

RG41183,00000E9 -19-07MAY03-2/2

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. (Belt removed for illustration)
3. Inspect radiator hoses for signs of leakage or rot. Replace hoses as necessary.
4. Inspect the coolant pump weep hole (A) for any restrictions.
5. Insert a heavy gauge wire deep into weep hole to make sure hole is open.

A—Weep Hole



RG12663 —UN—09JUN03

Weep Hole

Continued on next page

RG41183,00000EA -19-07MAY03-1/2

CAUTION: Do not drain coolant until it has cooled below operating temperature. Always loosen pump drain valve slowly to relieve any excess pressure.

6. Remove and check thermostat (B). (See TEST THERMOSTATS in Section 02, Group 070.)

IMPORTANT: Whenever the aluminum timing gear cover or coolant pump are replaced, the radiator should be completely drained by opening the radiator petcock and removing the lower radiator hose.

When removing the coolant pump, inspect the coolant pump cavity in the timing gear cover for excessive cavitation.

7. Drain coolant at drain valve (A) and flush cooling system. (See FLUSH AND SERVICE COOLING SYSTEM in Section 01, Group 002.)

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

8. Fill cooling system with recommended concentration of coolant, clean soft water, and inhibitors. (See DIESEL ENGINE COOLANT in Section 01, Group 002.)
9. Run engine until it reaches operating temperature. Check entire cooling system for leaks.
10. After engine cools, check coolant level.

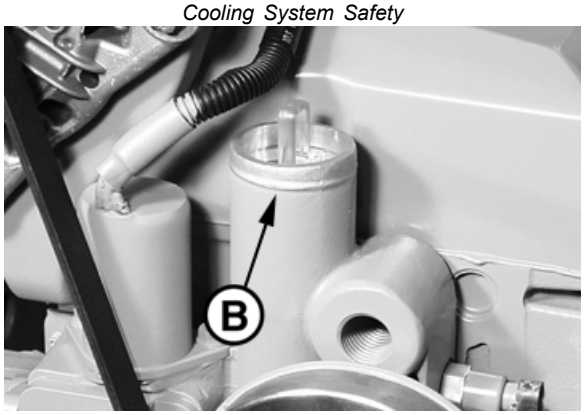
NOTE: Coolant level should be even with bottom of radiator filler neck.

11. Check system for holding pressure. (See PRESSURE TEST COOLING SYSTEM AND RADIATOR CAP in this group.)



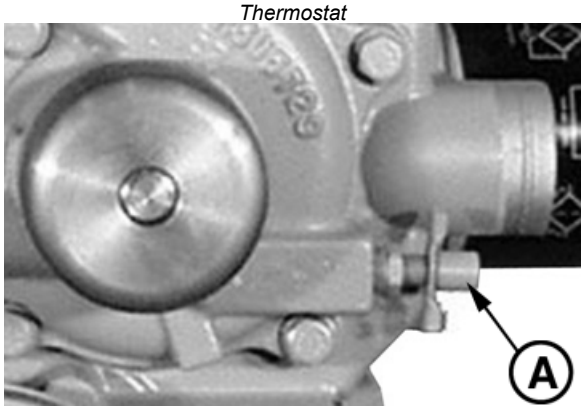
TS281 —UN—23AUG88

Cooling System Safety



RG12789A —UN—07MAY03

Thermostat



RG12534 —UN—12DEC02

Drain Valve

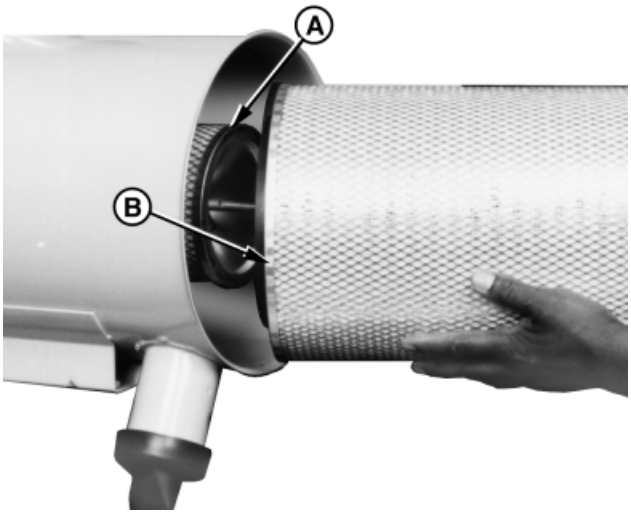
A—Drain Valve **B—Thermostat**

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Check Air Intake System

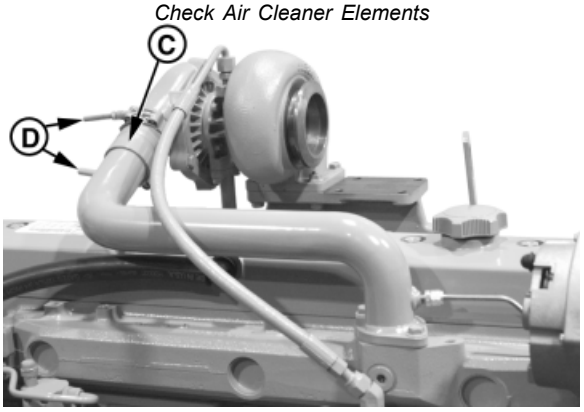
1. Replace air cleaner primary filter element (B). Replace secondary element (A) if primary element has holes in it.
2. Check condition of air intake hose(s) (C). Replace hoses that are cracked, split, or otherwise in poor condition.
3. Check hose clamps (D) for tightness. Replace clamps that cannot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

A—Secondary Filter Element
B—Primary Filter Element
C—Air Intake Hose(s)
D—Hose Clamps



RG7766A —UN—10NOV97

Check Air Cleaner Elements



RG7618C —UN—06NOV97

Check Turbocharger Air Intake Hoses

RG41183,000000A -19-29MAY03-1/1

Measure Intake Manifold Pressure (Turbocharger Boost)

This test of turbocharger boost is also a good indicator of whether the engine is performing at full rated power.

IMPORTANT: If testing the engine with the air filter system removed, install JDG576 Turbocharger Shield to inlet of turbocharger.

1. Disconnect line (A) from intake manifold and install the appropriate fitting from JDE147 Manifold Pressure Test Kit or FKM10002 Universal Pressure Test Kit.

   Connect gauge (B) and hose assembly to fitting. Be sure all connections are tight.

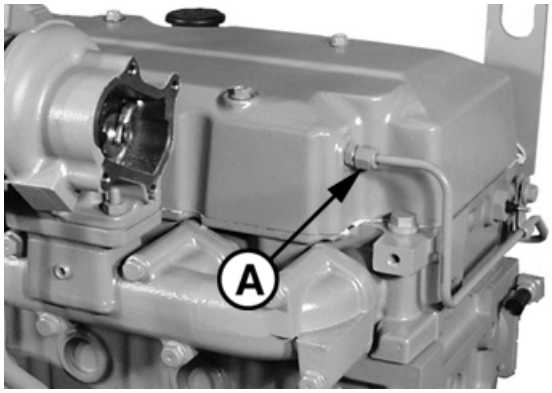
IMPORTANT: Engine speed and load should be stabilized before taking a gauge reading. Be sure that gauge works properly and familiarize yourself with the use of the gauge.

Turbo-boost pressure checks are only a guide to determine if there is an engine problem (valve leakage, faulty nozzles, etc.).

2. Before checking boost pressure, warm up engine to allow the lubricating oil to reach operating temperature.

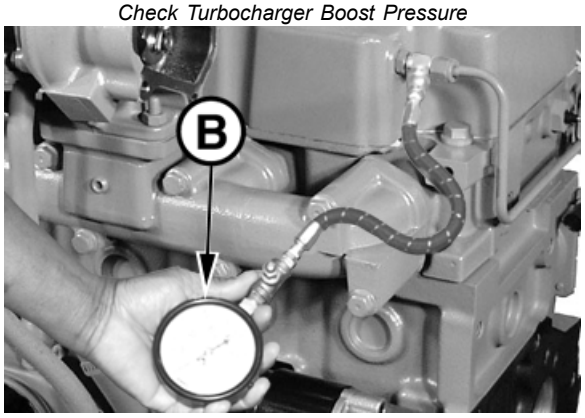
IMPORTANT: In some applications, it may not be possible to meet the turbo boost pressure due to inability to get full load rated speed. In these cases, see Machine Operation and Test Manual for the appropriate test method and pressure.

3. Place engine under full load at rated speed to make test.
4. Observe pressure reading on gauge. Compare readings with charts in Section 06, Group 210. Boost pressure should be within ranges shown in charts when engine is developing rated power at full load rated speed.
5. If boost pressure is too low, check the following:
   - Restricted air filter elements.
   - Restricted fuel filter elements.
   - Incorrect fast idle adjustment.
   - Exhaust manifold leaks.
   - Intake manifold leaks.
   - Faulty fuel supply pump.
   - Low compression pressure.
   - Faulty fuel injection nozzles.
   - Carbon build-up in turbocharger.
   - Turbocharger compressor or turbine wheel rubbing housing.
   - Faulty unit injection pump.
   - Restricted exhaust.
6. After completing test, remove test equipment and fitting and reconnect line to intake manifold. Tighten securely.



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Check Turbocharger Boost Pressure



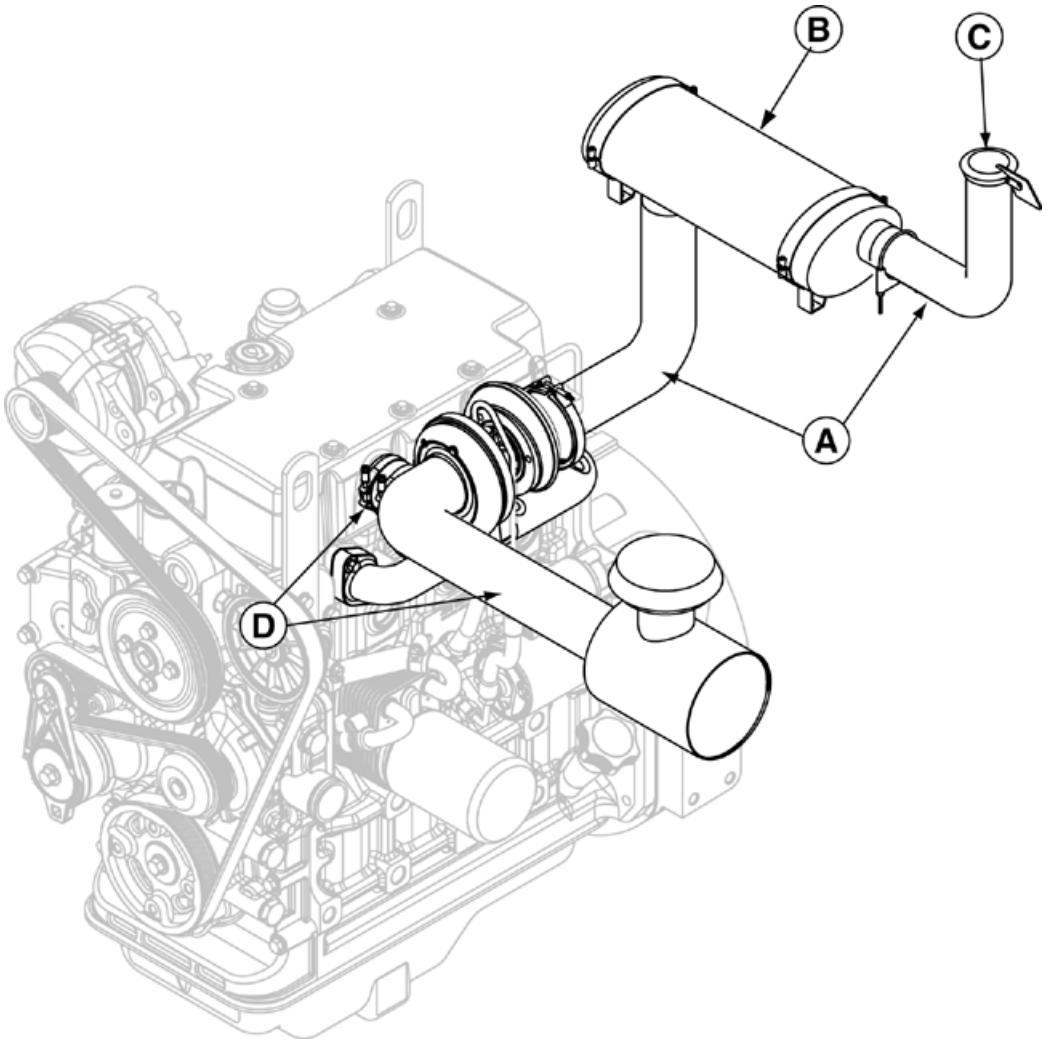
RG12665 —UN—23JUN03

Check Turbocharger Boost Pressure

A—Intake Manifold Line **B—Pressure Gauge**

RG41183,0000010 -19-01JUN03-1/1

Check for Intake and Exhaust Restrictions



RG12912 —UN—28MAY03

Intake/Exhaust Restriction Check

A—Exhaust Piping **B—Muffler** **C—Rain Cap** **D—Intake Piping**

Low power, low boost pressure, and excessive black exhaust smoke can be caused by an intake air or exhaust restriction.

1. Inspect the exhaust piping (A), the muffler (B), and the rain cap (C) for damage or any possible restrictions.
2. Inspect the intake piping (D). Look for collapsed pipes, dented pipes, cracked hose, and loose connections. Replace components as needed.

RG41183,000000B -19-29MAY03-1/1

Test for Intake Air Leaks

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

Air leaking from loose connections or cracks on the pressure side of the turbocharger can cause excessive smoke and low power.

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

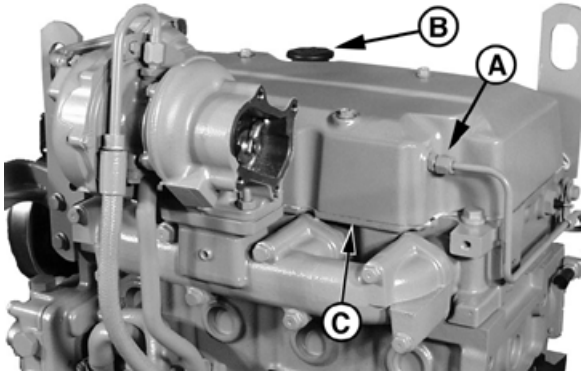
⚠ CAUTION: Do not start engine during this test procedure. Plastic bag (or whatever material/object used to seal intake) can be sucked into the engine.

1. Remove air cleaner cover and main filter element.
2. Put a plastic bag over secondary filter element and install main element and cover.
3. Remove aneroid line (A) from the intake manifold.
4. Using a adapter, connect a regulated air source.
5. Pressurize air intake system to 13.8—20.7 kPa (0.13-0.21 bar) (2—3 psi).
6. Remove oil fill cap (B) and feel for air passing through the rocker arm cover.
7. Spray soap and water solution over all connections from the air cleaner to the turbocharger or air inlet, and rocker arm cover (C) to check for leaks. Repair all leaks.



T5906AP —UN—23FEB89

Air Intake Leak Test



RG12667 —UN—29MAY03

Air Intake Leak Test

A—Aneroid Line

8. Reconnect aneroid line (A).
9. Remove plastic bag from filter element and reinstall element and cover.

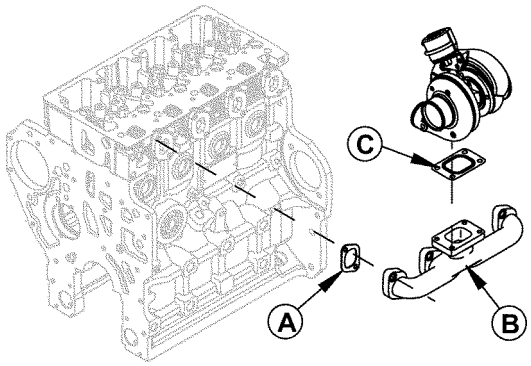
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Check for Exhaust Air Leaks (Turbocharged Engines)

Exhaust leaks, upstream of the turbocharger, will cause the turbocharger turbine to rotate at a reduced speed resulting in low boost pressure, low power, and excessive black smoke.

Inspect the exhaust manifold gasket (A), the exhaust manifold (B), and the turbocharger gasket (C) for damage and any signs of leakage. Replace components as needed.

A—Exhaust Manifold Gasket
B—Exhaust Manifold
C—Turbocharger Gasket



RG12911 —UN—09MAY03

Exhaust Leak Check

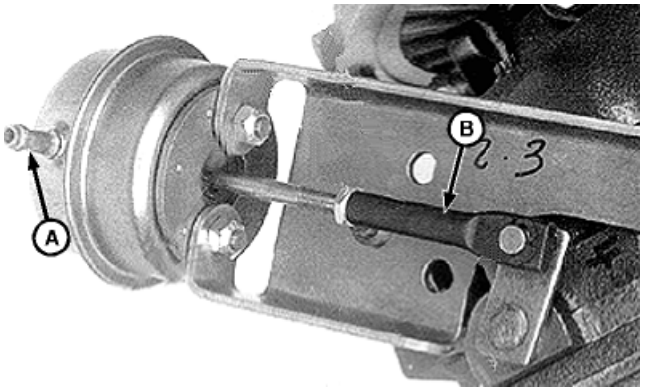
RG41183,000000D -19-29MAY03-1/1

Test Turbocharger Wastegate

1. Check hose to wastegate actuator for kinks or cracks. Replace if damaged.
2. Disconnect hose from wastegate actuator.
3. Connect a regulated air source to actuator fitting (A).
4. Vary pressure to wastegate actuator from 83—103 kPa (.83—1.03 bar) (12—15 psi).

   Actuator rod (B) should move in and out freely as pressure is varied.

   If rod does not move freely, check wastegate adjustment. (See ADJUST TURBOCHARGER WASTEGATE ACTUATOR in Section 02, Group 080.)



Wastegate Check

A—Actuator Fitting **B—Actuator Rod**

RG41183,000000E -19-29MAY03-1/1

Glow Plug Operation

The glow plug heaters are used to increase intake manifold air temperature to improve cold starting. When the operator turns the key switch from “OFF” to “HEAT”, the “Pre-Heat Indicator Lamp” on the dash turns on, and energizes the glow plug relay. The glow plug relay will in turn energize the glow plugs located above each cylinder. The pre-heat indicator lamp will stay on for 15 seconds and then turn off. When the indicator lamp turns off, turn the key switch to the “START” position . Release the key once engine starts; key automatically returns to the “ON” position.

Anytime the engine cranks but does not start, a key-off/key-on cycle will be required before preheating is allowed again.

IMPORTANT: Do not operate the starter for more than 15 seconds at a time. To do so may overheat the starter.

RG41183,00000EB -19-14MAY03-1/1

Test Fuel Shutoff Solenoid

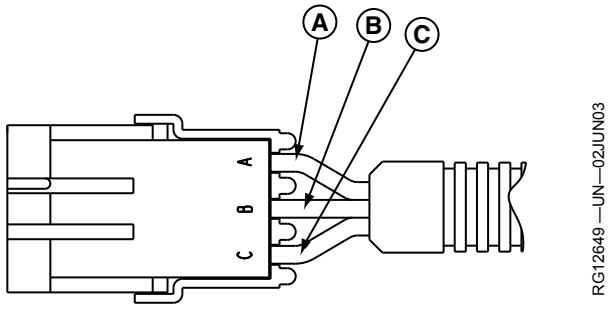
Disconnect shut-of solenoid 3-way WEATHER PACK™ connector.

1. Measure “PULL” coil resistance between black lead wire (C) and white lead wire (B).
2. Measure “HOLD” coil resistance between black lead wire (C) and red lead wire (A).

Replace solenoid if resistance is not within specification.

Specification	
Pull Coil—Resistance	5 Ohms
Hold Coil—Resistance	14 Ohms

WEATHER PACK is a trademark of Packard Electric



Fuel Shut-Off Solenoid Resistance Check

A—Hold Coil - Red
B—Pull Coil - White
C—Common Ground - Black

RG41183,00000ED -19-19MAY03-1/1

Cylinder Misfire Test

1. With engine running and at normal operating temperature use a noncontact thermometer, inspect the temperature of each exhaust port.
2. Compare readings and investigate cylinders that are low or high from other cylinders.

RG41183,00000EE -19-20MAY03-1/1

About This Group of the Manual

This section of the manual contains necessary information to diagnose general engine and fuel system observable symptoms for 2.4L/3.0L engines with electronic unit pumps. This group is divided into two areas: diagnosing observable malfunctions and testing procedures. The observable diagnostic section is divided into the following symptoms:

- Diagnosing General Engine Malfunctions:
  - Engine Cranks/Won't Start
  - Engine Misfires/Runs Irregularly
  - Engine Does Not Develop Full Power
  - Engine Emits Excessive White Exhaust Smoke
  - Engine Emits Excessive Black or Gray Exhaust Smoke
  - Engine Will Not Crank
  - Abnormal Engine Noise
  - Primary Analog Throttle Will Not Respond
  - Secondary Analog Throttle Will Not Respond
- Diagnosing Fuel System Malfunctions
  - Low Pressure Fuel System Check
  - Excessive Fuel Consumption
  - Fuel in Oil

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. For these symptoms, the problems are arranged in the most likely or easiest to check problems first. Symptoms arranged in both formats refer to testing procedures in the second part of this section. The second part of this section of the manual contains the following testing procedures:

- Fuel System Testing Procedures:
  - Check Fuel Supply Quality
  - Check for Air in Fuel
  - Bleed the Fuel System
  - Check for Restricted Fuel Return Line
  - Restarting an Engine that has Ran Out of Fuel
  - Charge Air System Diagnostic

RG40854,0000001 -19-26SEP07-1/1

Engine Cranks/Won't Start

RG40854,000000C -19-26SEP07-1/17

Engine Cranks/Won't Start Diagnostic Procedure

Additional References:

NOTE: This procedure should be followed if engine cranks, but will not start. If the engine will not crank, see ENGINE WILL NOT CRANK to diagnose the cranking system.

IMPORTANT: When directed to run the HARNESS DIAGNOSTIC MODE TEST the engine temperature should be above freezing. It is recommended that the engine temperature be at least room temperature 20° C (68° F). This test is located in Service ADVISOR.

RG40854,000000C -19-26SEP07-2/17

❶ **Preliminary Checks**	1. Verify sufficient fuel in fuel tank. 2. Verify that any remote switch used to shut down engine is in the RUN position. 3. Check for major intake air restriction. 4. Check for major exhaust restriction. 5. Check battery state of charge. 6. Verify engine cranking speed is adequate to start engine. 7. Verify glow plugs are functional if temperature is below 0°C (32°F). Does engine start?	**YES:** Problem fixed. **NO:** GO TO ❷

RG40854,000000C -19-26SEP07-3/17

❷ **Attempt to Connect to ECU with Service ADVISOR**	1. Ignition ON, engine OFF. 2. Attempt to connect to ECU with Service ADVISOR. Were you able to connect to ECU with Service ADVISOR?	**YES:** GO TO ❸ **NO:** Discontinue this test and perform procedure ECU DOES NOT COMMUNICATE WITH SERVICE ADVISOR.

RG40854,000000C -19-26SEP07-4/17

❸ **Check for Active DTCs**	Are there any active DTCs?	**YES:** Discontinue this test and perform test for the active DTC. **NO:** GO TO ❹

Continued on next page

RG40854,000000C -19-26SEP07-5/17

4 Read DTCs and Store Snapshot Information	1. Write down any stored DTCs and their occurrence count. If any DTCs have snapshot capture or snapshot recording information, save the information. For instructions on saving and using snapshot information, see SNAPSHOT INSTRUCTIONS earlier in this Group. *NOTE: When DTCs are cleared Snapshot information for ALL DTCs will also be cleared.* 2. Clear stored DTCs. 3. Crank engine for 15 seconds. Are there any stored or active DTCs after cranking engine?	**YES:** Discontinue this test and perform test for the stored or active DTC. **NO:** GO TO 5

RG40854,000000C -19-26SEP07-6/17

5 Harness Diagnostic Mode Test	1. Ignition ON, engine OFF. 2. Perform HARNESS DIAGNOSTIC MODE TEST in Service ADVISOR. Were any DTCs generated during Harness Diagnostic Mode Test?	**YES:** Discontinue this test and perform test for the DTC. **NO:** GO TO 6

RG40854,000000C -19-26SEP07-7/17

6 Low Pressure Fuel System Test	Perform LOW PRESSURE FUEL SYSTEM TEST, found later in this group. Did engine start?	**YES:** Problem fixed. **NO:** GO TO 7

RG40854,000000C -19-26SEP07-8/17

7 Check Fuel Quality	Perform procedure CHECK FUEL SUPPLY QUALITY, found later in this group. Did engine start?	**YES:** Problem fixed. **NO:** GO TO 8

Continued on next page

RG40854,000000C -19-26SEP07-9/17

8 Camshaft Position and Crankshaft Position Signal Test

NOTE: See DTC procedures 000636.02 and 000637.02 in Section 04, Group 160 later in this manual for more information on position sensor data points.

1. Monitor and record the following data points in Service ADVISOR:
   - Crankshaft Position Status
   - Camshaft Position Status
   - Crankshaft Position Speed
   - Camshaft Position Speed
   - Crankshaft Position Improper Pattern Indicator
   - Camshaft Position Improper Pattern Indicator
   - Crankshaft Position Noise Indicator
   - Camshaft Position Noise Indicator
2. Crank engine for 15 seconds.
3. Replay recording and review the recorded data points.

Did the data points indicate the following while the engine is cranking at a steady speed?

NOTE: When engine first begins cranking, the data points may not indicate these values. Ignore data point values until engine has rotated at least two full revolutions.

- Crankshaft Position Status – 63 for speeds below 400 rpm, 47 for speeds above 400 rpm.
- Camshaft Position Status – 63 for speeds below 400 rpm, 47 for speeds above 400 rpm.
- Crankshaft Position Speed - The actual cranking speed (nearly same as camshaft position sensor speed).
- Camshaft Position Speed - The actual cranking speed (nearly same as crankshaft position sensor speed).
- Crankshaft Position Improper Pattern Indicator - 0
- Camshaft Position Improper Pattern Indicator - 0
- Crankshaft Position Noise Indicator - 0
- Camshaft Position Noise Indicator - 0

YES: GO TO 11

NO: GO TO 9

RG40854,000000C -19-26SEP07-10/17

9 Check for Crankshaft Position Signal Problem

1. Ignition OFF, engine OFF.
2. Disconnect crankshaft position sensor and secure connector away from rotating components.

NOTE: Ignore DTC 000637.08 which may be set due to the disconnected sensor.

3. Ignition ON, engine OFF.
4. Crank engine for 20 seconds.
5. Ignition OFF, engine OFF.
6. Reconnect crankshaft position sensor.

Did engine start?

YES: Perform diagnostic procedure for 000637.02 as though DTC were active.

NO: GO TO 10

Continued on next page

RG40854,000000C -19-26SEP07-11/17

10 Check for Camshaft Position Signal Problem

1. Verify crankshaft position sensor is reconnected.
2. Disconnect camshaft position sensor and secure connector away from rotating components.

NOTE: Ignore DTC 000636.08 which may be set due to the disconnected sensor.

3. Ignition ON, engine OFF.
4. Crank engine for 20 seconds.
5. Clear DTCs.
6. Ignition OFF, engine OFF.
7. Reconnect camshaft position sensor.

Did engine start?

YES: Perform diagnostic procedure for 000636.02 as though DTC were active.

NO: GO TO 11

RG40854,000000C -19-26SEP07-12/17

11 Check Engine Oil Pressure

NOTE: Camshaft followers for valves are hydraulic. A lack of oil pressure can cause inadequate valve opening.

With oil pressure sensor:

1. Monitor Engine Oil Pressure data point in Service ADVISOR.
2. Crank engine for 15 seconds.

Without oil pressure sensor:

3. Remove oil pressure switch or oil gallery plug.
4. Install pressure gauge.
5. Crank engine for 15 seconds.

Is engine oil pressure at least 6 psi with engine cranking?

YES: GO TO 12

NO: Determine cause of low oil pressure.

RG40854,000000C -19-26SEP07-13/17

12 Reprogram ECU

1. Ignition OFF, engine OFF.
2. Download latest ECU payload and reprogram ECU.

Did engine start?

YES: Problem fixed.

NO: GO TO 13

RG40854,000000C -19-26SEP07-14/17

13 Inspect Valve Train

1. Ignition OFF, engine OFF.
2. Remove rocker arm cover.
3. Inspect valve train for damage.
4. Rotate engine using JDG1704 or JDG10221 Engine Turning Tool while observing valve train for proper operation.

Were any problems found?

YES: Fix problem. Attempt to start engine.

NO: GO TO 14

Continued on next page

RG40854,000000C -19-26SEP07-15/17

14 Check Compression and Approximate Camshaft Timing	*NOTE: This step verifies that camshaft timing is close enough for engine to start. The camshaft timing procedure in Section 02, Group 050 should be followed for precise camshaft timing adjustment.* 1. Perform procedure TEST ENGINE COMPRESSION PRESSURE found in Section 04, Group 150. Ignore requirement for engine to be at operating temperature for the test. 2. Remove #1 cylinder rocker arms and electronic unit pump. 3. Install JDG1700-5-1 Timing Gauge in #1 unit pump bore and secure gauge in the cylinder block using the injection pump hold-down clamp and cap screw. 4. Slowly rotate engine using JDG1704 or JDG10221 Engine Turning Tool until significant turning resistance is met indicating the timing gauge is contacting camshaft lobe. 5. Determine if crankshaft is near TDC #1 by attempting to insert JDE81-4 Timing Pin. Is compression pressure at least 1700 kPa (250 psi) in each cylinder and can timing pin be inserted?	**YES:** Reassemble engine. GO TO **15** **NO:** Fix mechanical problem.

RG40854,000000C -19-26SEP07-16/17

15 Replace ECU	Replace ECU. Did engine start?	**YES:** Problem fixed. **NO:** Open DTAC case.

RG40854,000000C -19-26SEP07-17/17

Engine Misfires/Runs Irregularly

Additional References:

NOTE: The wiring diagrams provided are for a typical John Deere supplied OEM harness. Wire number, colors, and jumper connectors do not apply to all applications.

For wiring information see 2.4L ECU WIRING DIAGRAM 1 or 3.0L ECU WIRING DIAGRAM 2 located in Section 06, Group 210 later in this manual.

RG40854,0000004 -19-26SEP07-1/15

Engine Misfires/Runs Irregularly Diagnostic Procedure

RG40854,0000004 -19-26SEP07-2/15

1 Check for Active DTCs	Were you referred to this test while performing the diagnostic procedures for a diagnostic trouble code (DTC)?	**YES:** GO TO 2 **NO:** Check for and resolve any active DTCs prior to performing this test, then GO TO 2

RG40854,0000004 -19-26SEP07-3/15

2 Items Possibly Mistaken As Misfire or Irregular Running Engine	Check for the following items which may be mistaken for a misfire: • Engine accessories such as A/C clutch or fan drives cycling on and off. • Alterations to the engine and/or machine harness such as radios or non-John Deere accessories. Does disabling or switching off these devices temporarily restore engine performance?	**YES:** Problem fixed. **NO:** GO TO 3

RG40854,0000004 -19-26SEP07-4/15

3 Misfire and Cut-Out Test	1. Perform Cylinder Misfire Test in Service ADVISOR. 2. Perform Cylinder Cut-Out Test in Service ADVISOR with engine at low idle. Is each cylinder's contribution within 10 percent of the others during the Cylinder Misfire Test and does the sound of the engine change equally when each injector is disabled during the Cylinder Cut-Out Test?	**YES:** GO TO 5 **NO:** Only one cylinder has low contribution. GO TO 4 **NO:** Two or more cylinders have low contribution. GO TO 13

RG40854,0000004 -19-26SEP07-5/15

4 Check Compression Pressure	Perform procedure TEST ENGINE COMPRESSION PRESSURE found in Section 04, Group 150. Is compression pressure and variation between cylinders within specification?	**YES:** Replace electronic unit pump and injector nozzle in the cylinders with low contribution identified in previous step. GO TO 16 **NO:** Fix cause of low compression in the affected cylinder. GO TO 16

Continued on next page

RG40854,0000004 -19-26SEP07-6/15

5 Check for Air in Fuel	Perform TEST FOR AIR IN FUEL procedure, found later in this group. Is engine performance restored?	**YES:** Problem fixed. **NO:** GO TO 6

RG40854,0000004 -19-26SEP07-7/15

6 Low Pressure Fuel Supply System Test	Perform LOW PRESSURE FUEL SUPPLY SYSTEM TEST, found later in this group. Is engine performance restored?	**YES:** Problem fixed. **NO:** GO TO 7

RG40854,0000004 -19-26SEP07-8/15

7 Check Fuel Quality	Perform procedure CHECK FUEL SUPPLY QUALITY, found later in this group. Is engine performance restored?	**YES:** Problem fixed. **NO:** GO TO 8

RG40854,0000004 -19-26SEP07-9/15

8 Camshaft Position and Crankshaft Position Signal Test

NOTE: See DTC procedures 000636.02 and 000637.02 in Group 04, Section 160 later in this manual for more information on speed sensor data points.

1. Monitor and record the following data points in Service ADVISOR:
   - Crankshaft Position Status
   - Camshaft Position Status
   - Crankshaft Position Speed
   - Camshaft Position Speed
   - Crankshaft Position Improper Pattern Indicator
   - Camshaft Position Improper Pattern Indicator
   - Crankshaft Position Noise Indicator
   - Camshaft Position Noise Indicator
2. Operate engine at speed and load where problem occurs.
3. Replay recording and review the recorded data points.

Did the data points indicate the following with engine running?

- Crankshaft Position Status – 47 for speeds above 400 rpm.
- Camshaft Position Status – 47 for speeds above 400 rpm.
- Crankshaft Position Speed - The actual engine speed (nearly same as camshaft position sensor speed).
- Camshaft Position Speed - The actual engine speed (nearly same as crankshaft position sensor speed).
- Crankshaft Position Improper Pattern Indicator - 0
- Camshaft Position Improper Pattern Indicator - 0
- Crankshaft Position Noise Indicator - 0
- Camshaft Position Noise Indicator - 0

YES: GO TO 11

NO: GO TO 9

Continued on next page

RG40854,0000004 -19-26SEP07-10/15

9 Check for Crankshaft Position Signal Problem	1. Ignition OFF, engine OFF. 2. Disconnect crankshaft position sensor and secure connector away from rotating components. *NOTE: Ignore DTC 000637.08 which may be set due to the disconnected sensor.* 3. Ignition ON, engine OFF. 4. Operate engine at speed and load where problem occurs. 5. Ignition OFF, engine OFF. 6. Reconnect crankshaft position sensor. Was engine performance restored?	**YES:** Perform diagnostic procedure for 000637.02 as though DTC were active. **NO:** GO TO 10

RG40854,0000004 -19-26SEP07-11/15

10 Check for Camshaft Position Signal Problem	1. Verify crankshaft position sensor is reconnected. 2. Disconnect camshaft position sensor and secure connector away from rotating components. *NOTE: Ignore DTC 000636.08 which may be set due to the disconnected sensor.* 3. Ignition ON, engine OFF. 4. Operate engine at speed and load where problem occurs. 5. Clear DTCs. 6. Ignition OFF, engine OFF. 7. Reconnect camshaft position sensor. Was engine performance restored?	**YES:** Perform diagnostic procedure for 000636.02 as though DTC were active. **NO:** GO TO 11

RG40854,0000004 -19-26SEP07-12/15

11 Check Throttle	1. Engine running at speed where misfire or irregular running occurs. 2. Throttle held at a steady position. 3. Monitor Throttle Position data point in Service ADVISOR. Does Throttle Position data point indicate throttle signal is changing by more than 3 percent?	**YES:** Check for throttle circuit problem. **NO:** GO TO 12

RG40854,0000004 -19-26SEP07-13/15

12 Reprogram ECU	Download latest payload and reprogram ECU. Is engine performance restored?	**YES:** Problem fixed. **NO:** Open DTAC case.

Continued on next page

RG40854,0000004 -19-26SEP07-14/15

13 Check Unit Pump Circuits for Swapped Terminals	Using 2.4L ECU WIRING DIAGRAM 1 or 3.0L ECU WIRING DIAGRAM 2, verify wire harness continuity for unit pumps in cylinders with low contribution (verify terminals are not swapped in one of the connectors). Are all unit pump circuits wired correctly?	**YES:** GO TO 4 **NO:** Correct wiring problem and retest engine performance.

RG40854,0000004 -19-26SEP07-15/15

Engine Does Not Develop Full Power

RG40854,000000E -19-27SEP07-1/18

Engine Does Not Develop Full Power Diagnostic Procedure

Additional References:

IMPORTANT: When directed to run the HARNESS DIAGNOSTIC MODE TEST the engine temperature should be above freezing. It is recommended that the engine temperature be at least room temperature 20° C (68° F). This test is located in Service ADVISOR.

RG40854,000000E -19-27SEP07-2/18

1 Check for Active DTCs	Were you referred to this test while performing the diagnostic procedures for a diagnostic trouble code (DTC)?	**YES:** GO TO 2 **NO:** Check for and resolve any active DTCs prior to performing this test.

RG40854,000000E -19-27SEP07-3/18

2 Harness Diagnostic Mode Test	1. Write down any stored DTCs and their occurrence count. If any DTCs have snapshot capture or snapshot recording information, save the information. For instructions on saving and using snapshot information, see SNAPSHOT INSTRUCTIONS earlier in this Group. *NOTE: When DTCs are cleared Snapshot information for ALL DTCs will also be cleared.* 2. Perform Harness Diagnostic Mode Test in Service ADVISOR. Were any active DTCs generated during Harness Diagnostic Mode Test?	**YES:** Discontinue this test and perform test for the active DTC. **NO:** GO TO 3

RG40854,000000E -19-27SEP07-4/18

3 Preliminary Checks	*NOTE: Low engine power complaints are often due to the operator's expectations, rather than the engine not actually developing rated power. Compare the suspect engine's performance to another identical application, if possible.* Check for the following, if applicable, on the application. • Air filter element restricted. • Large amount of contamination present in fuel drained from fuel filter drain indicated a restricted fuel filter. • Transmission problems, overheating or slipping. • Driven load has changed. • Auxiliary drives with abnormally high loads. • Hydraulic system problems causing high engine loads. • Engine is otherwise overloaded. Is engine performance restored?	**YES:** Problem fixed. **NO:** GO TO 4

Continued on next page

RG40854,000000E -19-27SEP07-5/18

4 Exhaust Check	Operate engine under the conditions where the low power complaint occurs. Does the engine produce excessive blue, white, or black exhaust smoke?	**YES:** Blue smoke - Check for internal engine damage. Perform CHECK FOR EXCESSIVE ENGINE CRANKCASE PRESSURE (BLOW-BY) TEST. **YES:** White smoke - Perform procedure ENGINE EMITS EXCESSIVE WHITE SMOKE. **YES:** Black smoke - Perform procedure ENGINE EMITS EXCESSIVE BLACK OR GRAY SMOKE. **NO:** GO TO 5

RG40854,000000E -19-27SEP07-6/18

5 Check for Misfire	Does engine misfire or run irregularly?	**YES:** Perform procedure ENGINE MISFIRES-RUNS IRREGULARLY **NO:** GO TO 6

RG40854,000000E -19-27SEP07-7/18

6 Throttle Test	*NOTE: Some applications may have a limit on maximum throttle percentage by design. Consult engine distributor for more information.* 1. Ignition ON, engine OFF. 2. Monitor Throttle Position data point in Service ADVISOR. 3. Fully advance throttle lever. Is Throttle Position 97% or higher?	**YES:** GO TO 7 **NO:** Check for throttle circuit problem.

RG40854,000000E -19-27SEP07-8/18

7 Low Pressure Fuel Supply System Test	Perform procedure LOW PRESSURE FUEL SUPPLY SYSTEM TEST, found later in this group. Is engine performance restored?	**YES:** Problem fixed. **NO:** GO TO 8

RG40854,000000E -19-27SEP07-9/18

8 Check Fuel Quality	Perform procedure CHECK FUEL SUPPLY QUALITY, found later in this group. Is engine performance restored?	**YES:** Problem fixed. **NO:** GO TO 9

Continued on next page

RG40854,000000E -19-27SEP07-10/18

9 **Check for Air in Fuel**	Perform procedure CHECK FOR AIR IN FUEL found late in this group. Is engine performance restored?	**YES:** Problem fixed. **NO:** GO TO **10**

RG40854,000000E -19-27SEP07-11/18

10 **Charge Air System Analysis**	Perform CHARGE AIR SYSTEM DIAGNOSTIC PROCEDURE found later in this group. Is engine performance restored?	**YES:** Problem fixed. **NO:** GO TO **11**

RG40854,000000E -19-27SEP07-12/18

11 **Intake and Exhaust Restriction and Air Leak Test**	Check for intake and exhaust restrictions and leaks. See CHECK FOR INTAKE AND EXHAUST RESTRICTIONS and CHECK FOR EXHAUST AIR LEAKS in Section 04 of the base engine manual. Was a problem found?	**YES:** Fix problem, recheck engine performance. **NO:** GO TO **12**

RG40854,000000E -19-27SEP07-13/18

12 **Check Manifold Pressure**	Check intake manifold pressure with engine under load. See MEASURE INTAKE MANIFOLD PRESSURE in Section 04, Group 150. Is manifold pressure within specification?	**YES:** Fix problem. Recheck engine performance. **NO:** GO TO **13**

RG40854,000000E -19-27SEP07-14/18

13 **Reprogram ECU**	1. Download latest ECU payload. 2. Modify Custom Performance trimmable options to values specified by the engine distributor, if applicable. 3. Reprogram ECU. Is engine performance restored?	**YES:** Problem fixed. **NO:** GO TO **14**

RG40854,000000E -19-27SEP07-15/18

14 **Check Engine Load**	1. Monitor Engine Load at Current Speed data point in Service ADVISOR. 2. Operate engine at speed and load where low power complaint occurs. Does Engine Load at Current Speed data point indicate a value of 95 percent or more?	**YES:** GO TO **15** **NO:** ECU is limiting engine power. Open DTAC case.

Continued on next page

RG40854,000000E -19-27SEP07-16/18

15 Check on Dynamometer	Check engine power on a certified dynamometer, if possible. Does engine develop rated power on dynamometer?	**YES:** Engine is operating as designed. **NO:** GO TO 16 **NO:** Engine cannot be tested on a dynamometer. Open DTAC case.

RG40854,000000E -19-27SEP07-17/18

16 Replace Injector Nozzles	*NOTE: There are two different injector nozzle part numbers which have different flow rates. Installing the lower flow rate injector nozzles in an engine designed for the higher flow rate nozzles will decrease engine power.* Replace injector nozzles. Does engine develop rated power on dynamometer?	 **YES:** Problem fixed. **NO:** Open DTAC case.

RG40854,000000E -19-27SEP07-18/18

Engine Emits Excessive White Exhaust Smoke

RG40854,0000006 -19-14SEP07-1/11

Engine Emits Excessive White Exhaust Smoke Diagnostic Procedure

RG40854,0000006 -19-14SEP07-2/11

1 Check for Active DTCs	Were you referred to this test while performing the diagnostic procedures for a diagnostic trouble code (DTC)?	**YES:** GO TO 2 **NO:** Check for and resolve any active DTCs prior to performing this test.

RG40854,0000006 -19-14SEP07-3/11

2 Check for Type of White Smoke	*NOTE: White exhaust smoke is caused by condensing liquid in the exhaust system. The liquid is typically diesel fuel or coolant. Unburned diesel fuel in the exhaust has an strong diesel fuel odor and causes a severe burning sensation in the eyes. Unburned diesel fuel is caused by a misfire or incomplete combustion. Too low of a coolant temperature may result in white smoke due to incomplete combustion. Poor quality fuel or fuel not blended for the operating conditions may also cause incomplete combustion. Coolant in the exhaust causes an odor that can be described as sweet. White smoke accompanied with coolant loss and overheating indicates that the white smoke is likely due to coolant in the exhaust.* Are you able to determine if the white smoke is caused by fuel or coolant?	**YES:** White smoke is due to fuel in exhaust. GO TO 3 **YES:** White smoke is due to coolant in exhaust. GO TO 9 **NO:** Not sure if fuel or coolant. Perform steps 3-9. Open DTAC case if no problem found.

RG40854,0000006 -19-14SEP07-4/11

3 Check Engine Performance	Is engine idle quality and engine performance good?	**YES:** Reprogram ECU with latest payload. If white smoke still present, GO TO 4 **NO:** Engine performance is not acceptable. GO TO 4

RG40854,0000006 -19-14SEP07-5/11

4 Misfire and Cut-Out Test	*NOTE: If white smoke is decreased substantially when a cylinder is cut-out, the white smoke is likely caused by a misfire of that cylinder.* 1. Perform Cylinder Misfire Test in Service ADVISOR. 2. Perform Cylinder Cut-Out Test in Service ADVISOR with engine at low idle. Is each cylinder's contribution within 10 percent of the others during the Cylinder Misfire Test and does the sound of the engine change equally when each injector is disabled during the Cylinder Cut-Out Test?	**YES:** GO TO 6 **NO:** GO TO 5

Continued on next page

RG40854,0000006 -19-14SEP07-6/11

5 Check Compression Pressure	Perform procedure TEST ENGINE COMPRESSION PRESSURE found in Section 04, Group 150. Is compression pressure and variation between cylinders within specification?	**YES:** Replace electronic unit pump and injector nozzle in the cylinders with low contribution identified in previous step. Recheck for white smoke. **NO:** Fix cause of low compression in the affected cylinder. Recheck for white smoke.

RG40854,0000006 -19-14SEP07-7/11

6 Fuel Quality	Perform CHECK FUEL SUPPLY QUALITY procedure found later in this section. Is white smoke still present?	**YES:** GO TO 7 **NO:** Problem fixed.

RG40854,0000006 -19-14SEP07-8/11

7 Check Cooling System	1. Operate engine, under load if possible, until coolant temperature is above 88°C (190°F). 2. Return engine to low idle, no load for 10 minutes. Were you able to cause coolant temperature to increase to 88°C (190°F) and is coolant temperature greater than 80°C (175°F) after 10 minutes at low idle?	**YES:** GO TO 8 **NO:** Replace thermostat and check for sources of excessive cooling system heat loss.

RG40854,0000006 -19-14SEP07-9/11

8 Reprogram ECU	Reprogram ECU with latest payload, if not already performed during this procedure. Is white smoke still present?	**YES:** Perform step 9. Open DTAC case if no problem found. **NO:** Problem fixed.

RG40854,0000006 -19-14SEP07-10/11

9 Check for Head Gasket Failure	Check for failed head gasket. See CHECK FOR HEAD GASKET FAILURES in Section 04 Group 150. Was problem found?	**YES:** Fix problem. **NO:** Locate source of coolant leakage into combustion chamber.

RG40854,0000006 -19-14SEP07-11/11

Engine Emits Excessive Black Or Gray Exhaust Smoke

RG40854,0000008 -19-21SEP07-1/10

Engine Emits Excessive Black or Gray Exhaust Smoke Diagnostic Procedure

RG40854,0000008 -19-21SEP07-2/10

1 Check for Active DTCs	Were you referred to this test while performing the diagnostic procedures for a diagnostic trouble code (DTC)?	**YES:** GO TO 2 **NO:** Check for and resolve any active DTCs prior to performing this test, then GO TO 2

RG40854,0000008 -19-21SEP07-3/10

2 Check Charge Air System	Perform CHARGE AIR SYSTEM DIAGNOSTIC test. Is black smoke still present when engine is operated under conditions where black smoke was observed?	**YES:** GO TO 3 **NO:** Problem fixed.

RG40854,0000008 -19-21SEP07-4/10

3 Intake and Exhaust Restriction and Air Leak Test	Check for intake and exhaust restrictions and leaks. See CHECK FOR INTAKE AND EXHAUST RESTRICTIONS and CHECK FOR EXHAUST AIR LEAKS Is black smoke still present when engine is operated under conditions where black smoke was observed?	**YES:** GO TO 4 **NO:** Problem fixed.

RG40854,0000008 -19-21SEP07-5/10

4 Check Intake Manifold Pressure	Perform MEASURE INTAKE MANIFOLD PRESSURE test. Is intake manifold pressure within specifications?	**YES:** GO TO 5 **NO:** Fix cause of low intake manifold pressure.

RG40854,0000008 -19-21SEP07-6/10

5 Cut-Out Test	Perform Cylinder Cut-Out Test in Service ADVISOR and watch for a decease in exhaust smoke when each cylinder is cut out. Did smoke decrease substantially when a cylinder was cut-out?	**YES:** Replace injector nozzle in the affected cylinder and recheck for black smoke. **NO:** GO TO 6

RG40854,0000008 -19-21SEP07-7/10

6 Fuel Quality	Perform CHECK FUEL SUPPLY QUALITY procedure found later in this section. Is black smoke still present when engine is operated under conditions where black smoke was observed?	**YES:** GO TO 7 **NO:** Problem fixed.

Continued on next page

RG40854,0000008 -19-21SEP07-8/10

7 Reprogram ECU	Reprogram ECU with latest payload, if not already performed during this procedure. Is black smoke still present when engine is operated under conditions where black smoke was observed?	**YES:** GO TO 8 **NO:** Problem fixed.

RG40854,0000008 -19-21SEP07-9/10

8 Check Injector Nozzles	*NOTE: There are two different injector nozzle part numbers which have different flow rates. Installing the higher flow rate injector nozzle in an engine designed for the lower flow rate injector nozzle will result in black smoke.* 1. Remove injector nozzles. 2. Verify injector nozzle part number shown on each injector nozzle is correct for the engine. Are each of the injector nozzles the correct part for the engine?	**YES:** Open DTAC case. **NO:** Replace injector nozzles with the correct part number. Recheck for black smoke.

RG40854,0000008 -19-21SEP07-10/10

Engine Will Not Crank

RG40854,000000B -19-04SEP07-1/15

Engine Will Not Crank Diagnostic Procedure

Control Unit Response:
The ECU is not part of the engine cranking circuit.

Additional References:

NOTE: The wiring diagrams provided are for a typical John Deere supplied OEM harness. Wire number, colors, and jumper connectors do not apply to all applications.

For wiring information see 2.4L/3.0L ECU WIRING DIAGRAM 4, 6 located in Section 06, Group 210 later in this manual.

RG40854,000000B -19-04SEP07-2/15

1 Preliminary Checks	1. Inspect batteries, stater motor, starter solenoid, starter relay, and single point ground for loose connections, corroded terminals, or cables that are not connected. 2. Check fuse F01. 3. Verify that any remote switch used to shut down engine is in the RUN position. 4. If application has no remote switches, verify that remote switch jumper at connector C15 is present. Were any problems found?	**YES:** Fix problem. GO TO 13 **NO:** GO TO 2

RG40854,000000B -19-04SEP07-3/15

2 Check Battery State of Charge	1. Ignition OFF, engine OFF. 2. Measure battery terminal voltage. Is the voltage greater than 12.2V for 12V systems or 24.4V for 24V systems?	**YES:** GO TO 3 **NO:** Recharge or replace batteries. GO TO 13

RG40854,000000B -19-04SEP07-4/15

3 Check Battery Voltage While Attempting Crank	1. Ignition ON, engine OFF for 30 seconds. 2. Monitor battery terminal voltage. 3. Hold key switch in start position for 3 seconds. Is the voltage greater than 11V for 12V systems or 22V for 24V systems while attempting to crank engine?	**YES:** GO TO 5 **NO:** GO TO 4

Continued on next page

RG40854,000000B -19-04SEP07-5/15

4 Load Test Batteries	1. Ignition OFF, engine OFF. 2. Load test batteries. Do batteries pass load test?	**YES:** Check for internal starter problem Check for hydro locked or seized engine, or load not disengaged. **NO:** Recharge or replace batteries. GO TO 13

RG40854,000000B -19-04SEP07-6/15

5 Check Starter Relay Battery Supply Voltage	1. Ignition OFF, engine OFF. 2. Measure the voltage from the starter relay battery voltage supply terminal to single point ground. Is the voltage within 1V of battery terminal voltage?	**YES:** GO TO 6 **NO:** Fix problem. GO TO 13

RG40854,000000B -19-04SEP07-7/15

6 Check Voltage at Starter Relay Coil	*NOTE: Some applications may have safety switches or other interlocks which interrupt the starter relay control circuit (high side or ground). Consult equipment manufacturer's information to determine if application has any starter interlocks.* 1. Monitor the voltage between the starter relay coil high side terminal (wire between key switch and relay) and single point ground. 2. Hold key switch in start position for 3 seconds. Is the voltage within 2V of battery terminal voltage while attempting to crank engine?	**YES:** GO TO 7 **NO:** GO TO 11

RG40854,000000B -19-04SEP07-8/15

7 Check Starter Relay Coil Ground	1. Monitor the voltage between the starter relay coil high side terminal and starter relay coil ground terminal. 2. Hold key switch in start position for 3 seconds. Is the voltage within 2V of battery terminal voltage while attempting to crank engine?	**YES:** GO TO 8 **NO:** Fix open ground circuit. GO TO 13

RG40854,000000B -19-04SEP07-9/15

8 Check Starter Relay Output Voltage	1. Monitor the voltage between the starter relay output terminal and single point ground. 2. Hold key switch in start position for 3 seconds. Is the voltage within 2V of battery terminal voltage while attempting to crank engine?	**YES:** GO TO 9 **NO:** Replace starter relay. GO TO 13

Continued on next page

RG40854,000000B -19-04SEP07-10/15

9 Check Starter Solenoid Control Circuit

NOTE: Some gear-reduction type starter motors may have an additional starter relay located near the starter motor which controls the voltage supplied to the starter solenoid. Consult stater motor manufacturer for more information.

1. Monitor the voltage between the starter solenoid "S" terminal and single point ground.
2. Hold key switch in start position for 3 seconds.

Is the voltage within 2V of battery terminal voltage while attempting to crank engine?

YES: GO TO 10

NO: Fix open circuit between starter relay output and starter solenoid. GO TO 13

RG40854,000000B -19-04SEP07-11/15

10 Check Starter Cables

1. Monitor the voltage between the starter solenoid battery terminal and starter ground terminal (large cable connections).
2. Hold key switch in start position for 3 seconds.

Is the voltage within 2V of battery terminal voltage while attempting to crank engine?

YES: Remove and bench test stater motor and starter solenoid.

NO: Check starter cables for poor connections or high resistance. GO TO 13

RG40854,000000B -19-04SEP07-12/15

11 Check Key Switch Voltage Supply

1. Ignition OFF, engine OFF.
2. Measure the voltage between the key switch battery supply terminal and single point ground.

Is the voltage within 2V of battery terminal voltage?

YES: GO TO 12

NO: Fix open circuit between key switch and battery positive terminal. GO TO 13

RG40854,000000B -19-04SEP07-13/15

12 Check Key Switch

1. Monitor the voltage between the key switch start terminal and single point ground.
2. Hold key switch in start position for 3 seconds.

Is the voltage within 2V of battery terminal voltage while attempting to crank engine?

YES: Fix open circuit between key switch and starter relay coil high side terminal. GO TO 13

NO: Replace key switch. GO TO 13

RG40854,000000B -19-04SEP07-14/15

13 Verification

Attempt to crank engine.

Does engine crank?

YES: Problem fixed.

NO: GO TO 1

RG40854,000000B -19-04SEP07-15/15

E7 - Engine Idles Poorly

Symptom	Problem	Solution
E7 - Engine Idles Poorly	Poor fuel quality	Drain fuel and replace with quality fuel of the proper grade.
	Air leak on suction side of air intake system	Check hose and pipe connections for tightness; repair as required. See Test for Intake Air Leaks later in this section.

RG40854,000000A -19-14OCT02-1/1

E8 - Abnormal Engine Noise

Symptom	Problem	Solution
E8 - Abnormal Engine Noise	Worn main or connecting rod bearings	Determine bearing clearance. See INSPECT AND MEASURE CONNECTING ROD BEARINGS (ROD AND CRANKSHAFT IN ENGINE) or CHECK MAIN BEARING OIL CLEARANCE in Section 02, Group 030 of this manual.
	Excessive crankshaft end play	Check crankshaft end play. See CHECK CRANKSHAFT END PLAY in Section 02, Group 040 of this manual.
	Loose main bearing caps	Check bearing clearance; replace bearings and bearing cap screws as required. See CHECK MAIN BEARING OIL CLEARANCE in Section 02, Group 030 of this manual.
	Worn connecting rod bushings and piston pins	Inspect piston pins and bushings. See INSPECT PISTON PINS AND BUSHINGS in Section 02, Group 030 of this manual.
	Scored pistons	Inspect pistons. See PRELIMINARY BORE, PISTON, AND ROD CHECKS in Section 02, Group 030 of this manual.
	Worn timing gears or excess back lash	Check timing gear back lash. See MEASURE TIMING GEAR BACKLASH in Section 02, Group 050 of this manual.
	Worn camshaft	Inspect camshaft. See VISUALLY INSPECT CAMSHAFT in Section 02, Group 040 of this manual.
	Worn rocker arm shaft(s)	Inspect rocker arm shafts. See DISASSEMBLE AND INSPECT ROCKER ARM SHAFT ASSEMBLY in Section 02, Group 020 of this manual.
	Insufficient engine lubrication	See L2 - ENGINE OIL PRESSURE LOW in Group 151 of this Section of this manual.
	Turbocharger noise	See TURBOCHARGER INSPECTION in Section 02, Group 080 in this manual.

RG40854,0000009 -19-14OCT02-1/1

F1 - Fuel Supply System Check

RG40854,0000010 -19-16APR04-1/9

F1 - Fuel Supply System Check Diagnostic Procedure

NOTE: The F1 - Fuel Supply System Check Diagnostic Procedure is intended to supplement the E1 - Engine Cranks/Won't Start and E3 - Engine Does Not Develop Full Power Diagnostic Procedures. It provides a diagnostic path for the low pressure fuel system.

RG40854,0000010 -19-16APR04-2/9

1 F1 - Preliminary Check	1. Ensure fuel quantity and quality are OK. See CHECK FUEL SUPPLY QUALITY later in this Group. 2. Inspect all fuel lines and fittings for ruptures or leaks. 3. If fuel system has recently been opened, bleed fuel system. See BLEED THE FUEL SYSTEM later in this Group.	**No problems found:** GO TO 2 **Problem found:** Repair and retest.

RG40854,0000010 -19-16APR04-3/9

2 Air In Fuel Check	Check for air in the fuel. See TEST AIR IN FUEL later in this Group.	**No air found in fuel system:** GO TO 3 **Air found in fuel system:** Bleed fuel system. See BLEED THE FUEL SYSTEM later in this Group.

RG40854,0000010 -19-16APR04-4/9

3 Fuel Transfer Pressure Check	Check fuel transfer pressure. See MEASURE FUEL TRANSFER PUMP PRESSURE later in this Group.	**Pressure within specification:** GO TO 7 **Pressure is below specification:** GO TO 3

RG40854,0000010 -19-16APR04-5/9

4 Fuel Filter Test	1. Replace final fuel filter and retest. 2. Replace primary fuel filter (if equipped) and retest.	**Problem solved:** No further investigating is required. **Problem still exist:** GO TO 5

RG40854,0000010 -19-16APR04-6/9

5 Fuel Supply Lines Check	Remove fuel supply lines and determine if there are any internal restrictions.	**No restrictions found:** GO TO 6 **Restrictions found:** Repair or replace components as needed.

Continued on next page

RG40854,0000010 -19-16APR04-7/9

6 Fuel Transfer Pump Check	At this point, the most likely cause for low fuel pressure is a failure in the fuel supply pump. See BENCH TEST FUEL TRANSFER PUMP later in this Group.	**Problem solved:** No further investigating is required. **Problem still exist:** GO TO 7

RG40854,0000010 -19-16APR04-8/9

7 Return Fuel Check	1. Disconnect return fuel line from engine	**Good fuel flow, but engine still doesn't start:** No fuel supply system problems found. Return to: E1 - ENGINE CRANKS/WON'T START DIAGNOSTIC PROCEDURE or E3 - ENGINE DOES NOT DEVELOP FULL POWER DIAGNOSTIC PROCEDURE
	2. Operate hand primer on fuel transfer pump until fuel flows out the return line. If transfer pump doesn't have a hand primer then use DFRG6 priming pump connected to the output side of the transfer pump.	**NOT good fuel flow or no flow:** Inspect fuel rail check valve for proper operation. See "Remove and Install Fuel Rail Check Valve" in Section 2, Group 90.

RG40854,0000010 -19-16APR04-9/9

Excessive Fuel Consumption

Symptom	Problem	Solution
Excessive Fuel Consumption	Diagnostic trouble codes	Resolve active diagnostic trouble codes.
	Check for engine smoke	Perform test for white smoke or black smoke, if observed.
	Poor fuel quality	Drain fuel and replace with quality fuel of the proper grade.
	Engine overloaded	Reduce engine load
	Air cleaner restricted or dirty	Replace air cleaner element.
	Engine oil overfilled or incorrect viscosity	Fill engine oil to the correct level with the prescribed oil.
	Leaks in fuel supply system	Locate source of leak and repair as required. Check for fuel in oil indicating an internal engine fuel leak.
	Low engine temperature.	Check thermostat. See INSPECT THERMOSTAT AND TEST OPENING TEMPERATURE.
	Check for ECU software updates	Reprogram ECU with latest payload.
	Compression too low	Determine cause of low compression and repair as required.
	Camshaft timing incorrect	Set camshaft timing.
	Injector nozzles or unit pumps defective, incorrect injector nozzles are installed or calibration codes not entered correctly for unit pumps	Verify calibration codes in ECU memory match unit pump calibration codes. Replace defective or incorrect parts.

RG40854,0000011 -19-26SEP07-1/1

Fuel in Oil

Additional Information
Possible sources of fuel in oil:

- Low pressure fuel pump
- Unit pumps and O-rings
- Loose or damaged high pressure fuel lines
- Injector nozzles and O-rings
- Cylinder head or block casting porosity or cracks

RG40854,0000012 -19-27SEP07-1/12

Fuel in Oil Diagnostic Procedure

RG40854,0000012 -19-27SEP07-2/12

1 Oil Contamination Test	*NOTE: Hydraulic oil leaking into the engine crankcase from a hydraulic pump may be mistaken as fuel in the oil. Laboratory analysis can be used to determine if the contaminate is fuel or hydraulic oil.* 1. Check for an increase in engine oil level and a decrease in oil viscosity (oil is too thin). 2. Submit oil sample to laboratory to identify contaminant, if uncertain. Is the contaminant fuel?	**YES:** GO TO 2 **NO:** Perform test for identified contaminant.

RG40854,0000012 -19-27SEP07-3/12

2 Check for Black Smoke	Does engine emit black or gray exhaust smoke?	**YES:** Perform procedure ENGINE EMITS EXCESSIVE BLACK OR GRAY EXHAUST SMOKE. **NO:** GO TO 3

RG40854,0000012 -19-27SEP07-4/12

3 Check for Restricted Fuel Return Lines	Perform CHECK FOR RESTRICTED FUEL LEAK-OFF LINE test in this group. Did return fuel system pass test?	**YES:** GO TO 4 **NO:** Repair problem. GO TO 4

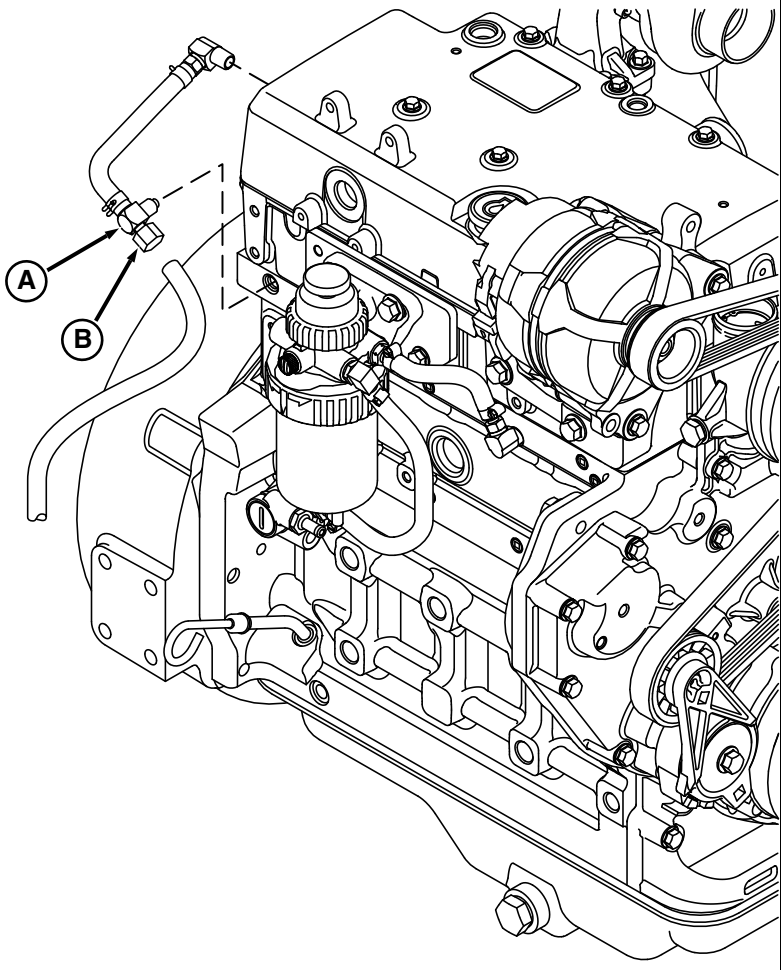
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RG40854,0000012 -19-27SEP07-5/12

4 Check For Internal Fuel Leak

CAUTION: Do NOT operate engine with the fuel return system blocked.

1. Ignition OFF, engine OFF.
2. Remove fuel return line from fuel check valve (A) and install a cap (B) on the fuel check valve.



RG15493 —UN—12SEP07

Temporarily Block Fuel Return

A—Fuel Check Valve
B—Cap

3. Pressurize fuel system to 35 kPa (5 psi) using primer pump.
4. Ignition ON, engine OFF. DO NOT START ENGINE!
5. Monitor Fuel Supply Pressure data point in Service ADVISOR for 1 minute or until pressure drops below 20 kPa (3 psi).

Does fuel pressure remain above 20 kPa (3 psi) for 10 minute?

YES: GO TO 10

NO: GO TO 5

Continued on next page

RG40854,0000012 -19-27SEP07-6/12

5 Check For Internal Fuel Leak

NOTE: The source of an internal fuel leak can often be found by looking for places inside the engine that are cleaner than the surrounding area. The leaking fuel tends to wash away lubrication oil and deposits.

1. Remove rocker cover.
2. Inspect internal fuel system components for evidence of fuel leakage.
3. Pressurize fuel system to 35 kPa (5 psi) using hand primer pump.
4. Check for internal fuel leaks.

Was internal fuel leak found?

YES: Fix problem. Recheck for fuel leak.

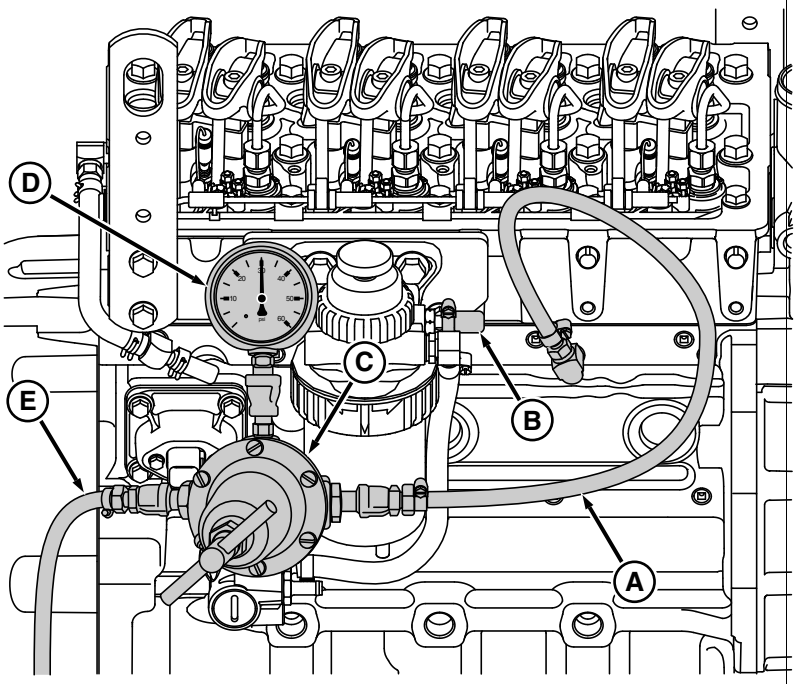
NO: GO TO 6

RG40854,0000012 -19-27SEP07-7/12

6 Pressurize Fuel Supply System with Air and Check for Leaks

NOTE: This test will pressurize the fuel supply and return galleries, the unit pump internal components, and the area between the unit pump O-rings. This test will not pressurize the high pressure lines between the unit pumps and injector nozzles.

1. Remove fuel supply line (A) at fuel filter outlet fitting and install a cap (B) on the fitting.



RG15499 —UN—25SEP07

Testing for Internal Fuel Leaks with Regulated Compressed Air

A—Fuel Supply Line
B—Cap on Fuel Filter Outlet Fitting
C—Pressure Regulator
D—Pressure Gauge
E—Compressed Air Supply

2. Install an air pressure regulator (C) with gauge (D) to the fuel supply line (A).
3. Connect regulator to a compressed air supply (E) and regulate air pressure to 200 kPa (29 psi).
4. Slowly rotate engine using JDG1704 or JDG10221 Engine Turning Tool.
5. Look and listen for air leaks around the unit pumps as engine is rotated. Use a mirror to check for leaks at the lower unit pump O-rings and around the unit pump camshaft follower.

Were any leaks found?

YES: Fix problem. Retest for leaks.

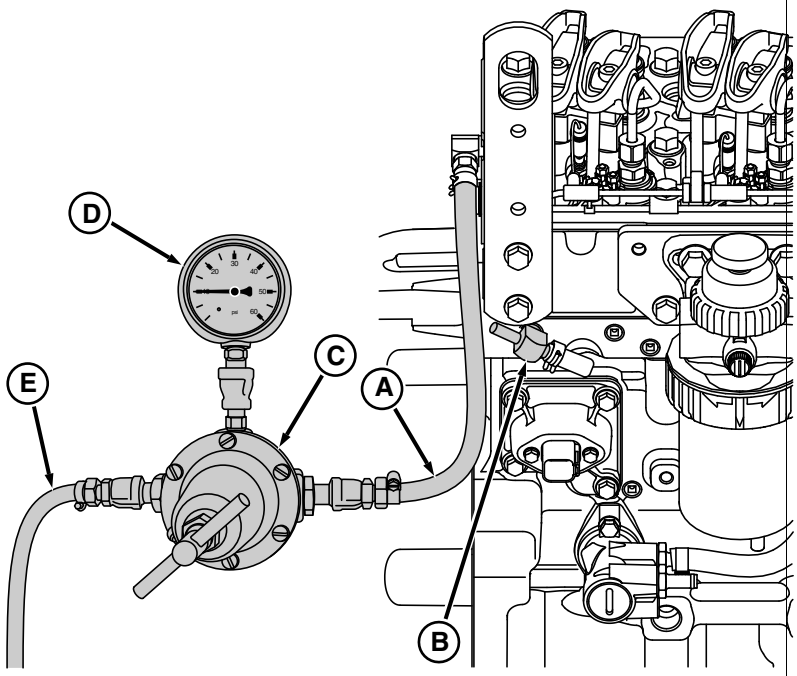
NO: GO TO 7

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RG40854,0000012 -19-27SEP07-8/12

7 Pressurize Injector Nozzle Leak-Off with Compressed Air and Check for Leaks

1. Remove injector nozzle leak-off line (A) at fuel check valve (B).



RG15514 —UN—21SEP07

Testing Injector Leak Off System with Regulated Compressed Air

A—Injector Nozzle Leak-Off Line
B—Fuel Check Valve
C—Pressure Regulator
D—Pressure Gauge
E—Compressed Air Supply

2. Install the air pressure regulator (C) with gauge (D) to the injector nozzle leak-off line.
3. Regulate air pressure to 200 kPa (29 psi).
4. Look and listen for air leaks around the injector nozzles.

Were any leaks found?

YES: Fix problem. Retest for leaks.

NO: GO TO 8

RG40854,0000012 -19-27SEP07-9/12

8 Check High Pressure Fuel Line Fitting Torque

NOTE: For high pressure fuel line torque specifications and procedure, see ELECTRONIC UNIT PUMP, INSTALLATION and INJECTOR NOZZLE, INSTALLATION. Rocker arm and push rod removal may be necessary to access injector nozzle ends of the high pressure fuel lines.

Check high pressure fuel line fitting torque at unit pump and injector nozzle ends.

Were any high pressure fuel line fittings loose?

YES: Torque fittings. Retest for leaks.

NO: GO TO 9

Continued on next page

RG40854,0000012 -19-27SEP07-10/12

9 Remove and Inspect Fuel System Components	*NOTE: For removal procedures, see ELECTRONIC UNIT PUMP, REMOVAL and INJECTOR NOZZLE, REMOVAL.* 1. Remove unit pumps and inspect O-rings and unit pump bores in engine block. 2. Remove injector nozzles and inspect O-rings and injector bores in cylinder head. 3. Inspect high pressure fuel lines. Was cause of fuel leakage found?	**YES:** Fix problem. Retest for leaks. **NO:** Low pressure fuel pump has NOT been tested. GO TO **10** **NO:** Low pressure fuel pump has been tested. Open DTAC case.

RG40854,0000012 -19-27SEP07-11/12

10 Bench Test Low Pressure Fuel Pump	1. Remove low pressure fuel pump. 2. Install a regulated compressed air supply with pressure gauge to the low pressure fuel pump inlet fitting. 3. Install a cap on the low pressure fuel pump outlet fitting. 4. Regulate air pressure to 70 kPa (10 psi). 5. Submerge the low pressure fuel pump in a container of diesel fuel. 6. Check for air bubbles. Are air bubbles present in the fuel?	**YES:** Replace low pressure fuel pump. **NO:** Steps 5-9 have NOT been performed. Reinstall low pressure fuel pump. GO TO **5** **NO:** Steps 5-9 have been performed. Open DTAC case.

RG40854,0000012 -19-27SEP07-12/12

Check Fuel Supply Quality

RG40854,000001C -19-26SEP07-1/8

Check Fuel Supply Quality Diagnostic Procedure

Additional References:
Fuel samples can be analyzed in a laboratory for contamination and ratings. See TESTING DIESEL FUEL in Group 01, Section 002, for more information.

RG40854,000001C -19-26SEP07-2/8

1 Low Pressure Fuel System Check	Has LOW PRESSURE FUEL SYSTEM CHECK been performed?	**YES:** GO TO 5 **NO:** GO TO 2

RG40854,000001C -19-26SEP07-3/8

2 Check Fuel in Filters	1. Ignition OFF, engine OFF. 2. Drain fuel filter into a clean container. 3. Check for water, dirt, or other contaminants in the drained fuel. Is an abnormal amount of water or contaminants present in the drained fuel?	**YES:** GO TO 3 **NO:** GO TO 4

RG40854,000001C -19-26SEP07-4/8

3 Check Fuel Supply	Check fuel in tank for water or contaminants. Is an abnormal amount of water or contaminants present in the fuel?	**YES:** Inspect fuel tank for cause of contamination. Drain and replace fuel in tank with known good fuel. GO TO 4 **NO:** GO TO 4

RG40854,000001C -19-26SEP07-5/8

4 Replace Fuel Filters	*NOTE: For fuel filter replacement and priming instructions, see REMOVE AND INSTALL FUEL FILTER in Group 02, Section 90 earlier in this manual.* 1. Replace fuel filter. 2. Prime fuel system using primer pump on filter housing. 3. Start engine and check performance. Does engine start and have good performance?	**YES:** Problem solved. **NO:** Fuel in tank was NOT replaced. GO TO 5 **NO:** Fuel in tank was replaced. GO TO 6

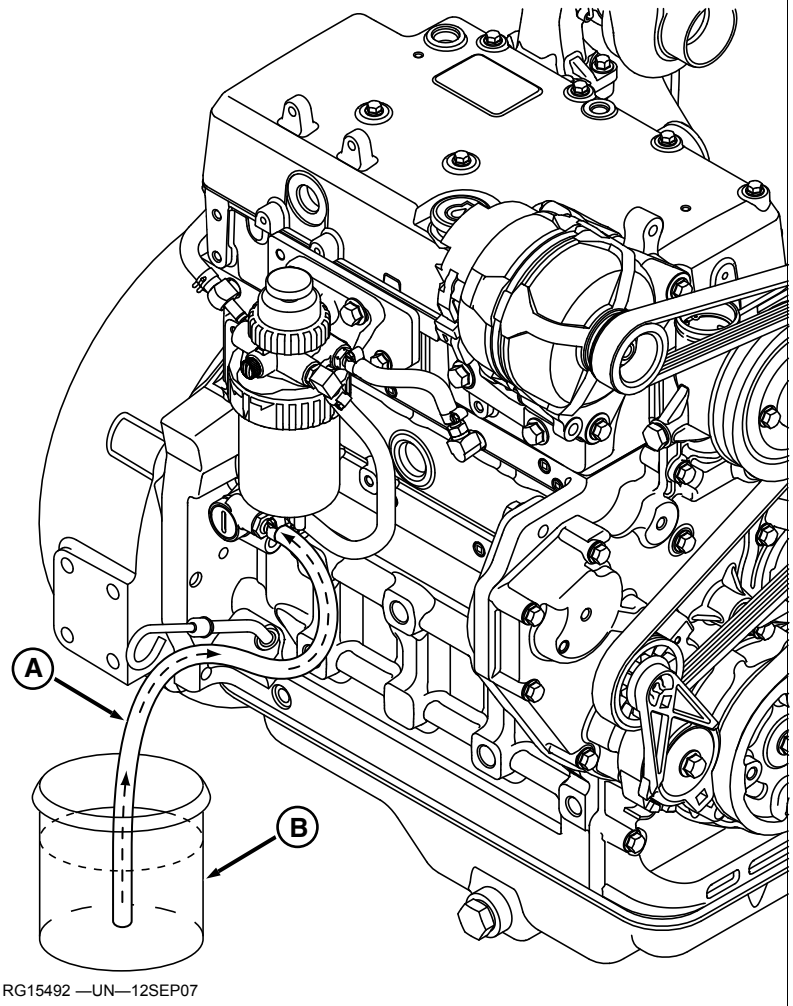
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RG40854,000001C -19-26SEP07-6/8

5 Temporary Known Good Fuel Supply Installation

NOTE: Use a clean hose and fresh fuel that has known-good quality in a clean container for this step. Do not use fuel from the fuel tank.

1. Ignition OFF, engine OFF.
2. Disconnect fuel inlet line from the low pressure fuel pump.
3. Install a hose (A) on low pressure fuel pump inlet port and place other end of hose in a container of at least 3.8L (1 gal) of clean fuel (B).



RG15492 —UN—12SEP07

Temporary Fuel Supply

A—Temporary Fuel Supply Hose
B—Container of Known-Good Diesel Fuel

IF OK: Once temporary fuel supply has been installed,

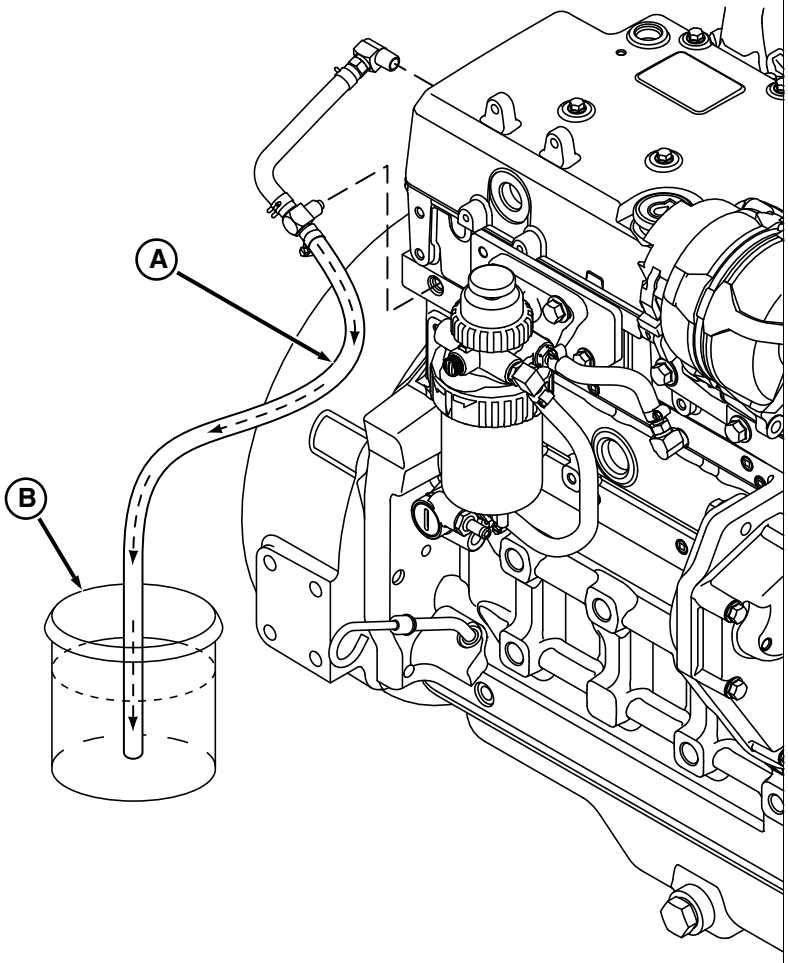
GO TO 6

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RG40854,000001C -19-26SEP07-7/8

6 Purge Fuel in Engine

1. Disconnect fuel return line at fuel check valve.
2. Connect a hose (A) to the fuel check valve and place the other end of the hose in an empty container suitable for diesel fuel (B).



RG15495 —UN—12SEP07

Collecting Return Fuel

A—Temporary Fuel Return Hose
B—Empty Container

   a. If engine starts, start engine and operate at low idle until at least 1.9L (1/2 gal) of return fuel is present in container.

   b. If engine does not start, crank engine for 20 second intervals with 2 minutes between intervals. Repeat until at least 1.9L (1/2 gal) of return fuel is present in the container or until engine starts.

3. Ignition OFF, engine OFF.
4. Reconnect fuel lines.

Does engine start and have good performance?

YES: Problem fixed. Replace fuel in tank, if not already performed.

NO: Fuel quality is not the cause of the problem. Return to DTC or other procedure.

RG40854,000001C -19-26SEP07-8/8

Test for Fuel Drain Back

Fuel draining back through the fuel system may cause hard starting. This procedure will determine if air is entering the system at connections and allowing fuel to siphon back to the fuel tank.

1. Disconnect fuel supply and return lines 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 the fuel transfer pump, fuel filters, and water separator (if equipped).
3. Securely plug off the end of the fuel return pipe.

CAUTION: Maximum air pressure should be 100 kPa (1 bar) (15 psi) when performing this test.

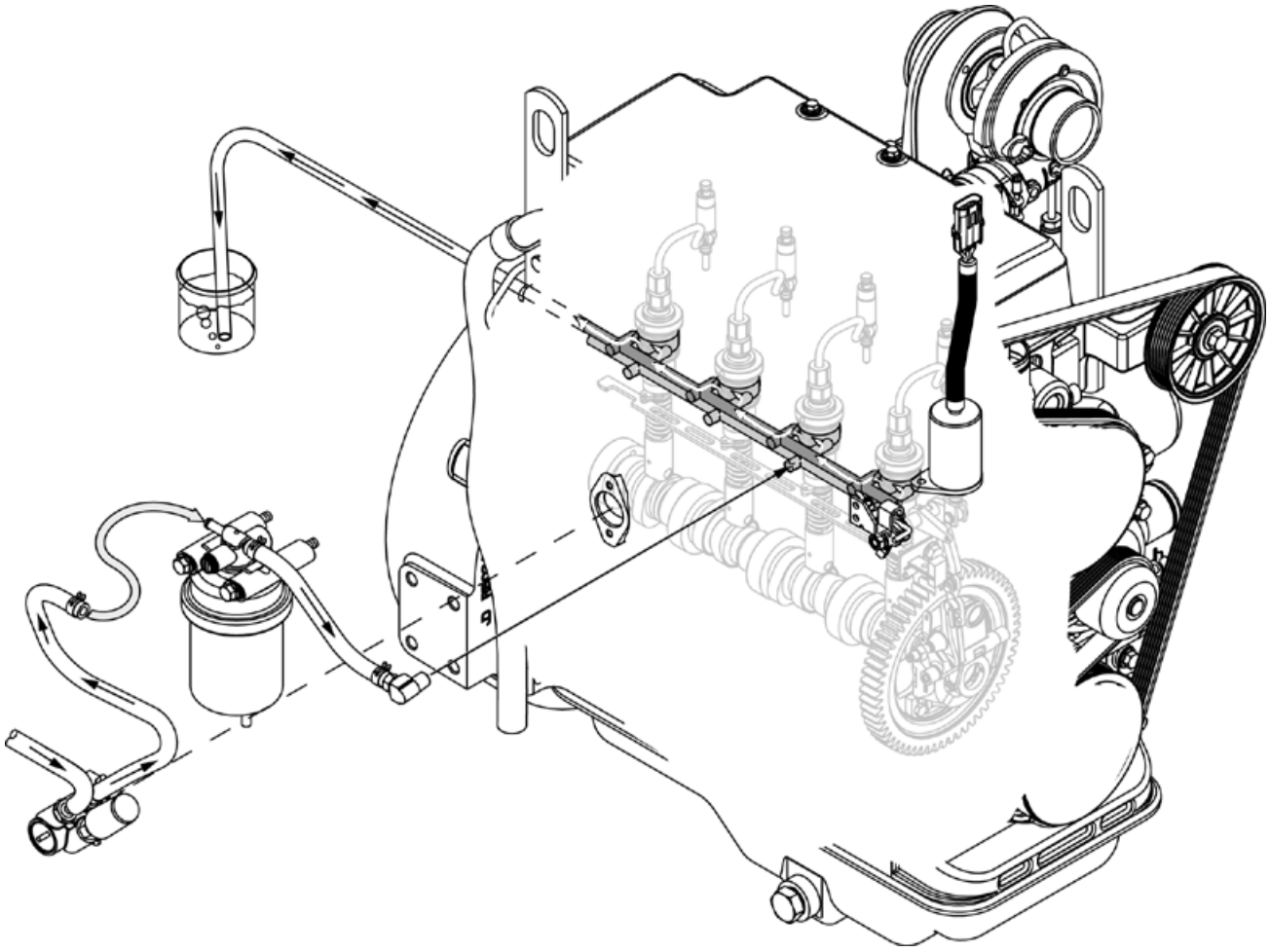
4. Using a low pressure air source, pressurize the fuel system at the fuel supply line.
5. Apply liquid soap and water solution to all joints and connections in the fuel system and inspect for leaks.

NOTE: Connections may allow air to enter the system without allowing fuel to leak out.

6. If any leaks are found, take necessary steps to repair.
7. Reconnect supply and return lines and prime system.
8. Start engine and run for approximately 10 minutes.
9. Allow engine to sit overnight and try starting the following morning.

RG40854,000001D -19-15OCT02-1/1

Test Air in Fuel



Test Air in Fuel

Air in the fuel system will make the engine hard to start, run rough, misfire or produce low power. Additionally, it can cause excessive smoke and knocking.

Whenever the fuel system is opened for repair, it must be bled to remove any air that has entered the system.

1. Disconnect hose from end of fuel leak-off line assembly. Connect a hose to end of leak-off line assembly and place opposite end of hose in a suitable container filled with fuel as shown.
2. Operate engine and check for air bubbles in container. If bubbles are present, bleed the fuel system and repeat test. See BLEED THE FUEL SYSTEM in this Group.
3. If bubbles are still present, check the following:

- Check for loose fuel fittings from the suction side of the fuel supply pump to the fuel tank to include all lines and filters.
- Check fuel tank suction tube (if equipped) and welded joints for cracks or holes.

Perform any necessary repairs, bleed fuel system and repeat test.

RG41183,0000003 -19-27MAY03-1/1

Bleed the Fuel System

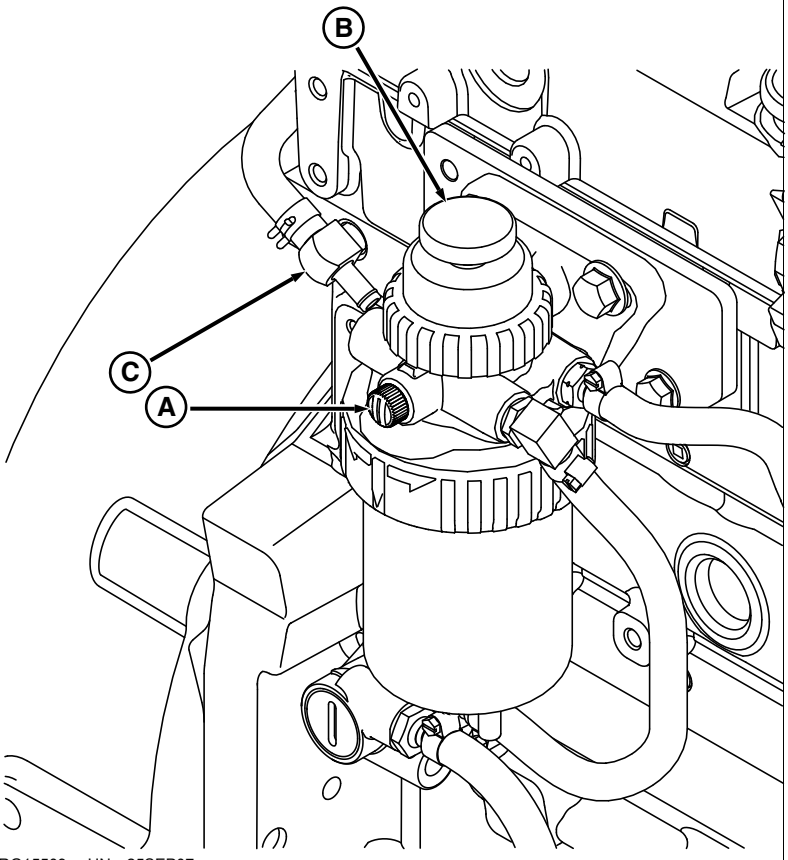
RG41183,0000002 -19-26SEP07-1/4

Bleed the Fuel System Procedure

RG41183,0000002 -19-26SEP07-2/4

1 Fill Fuel Filter Using Hand Primer Pump

1. Place a container suitable for diesel fuel beneath fuel filter assembly.
2. Loosen bleeder screw (A) located on filter header.



RG15509 —UN—25SEP07

Bleed the Fuel System

A—Bleeder Screw
B—Hand Primer Pump
C—Fuel Check Valve

3. Operate hand primer pump (B) by pushing down and releasing the pump handle until a continuous stream of fuel exits the bleeder screw.
4. Tighten bleeder screw.

NOTE: Do NOT crank engine longer than 30 seconds. Provide two minutes between start attempts to permit starter motor to cool.

5. Attempt to start engine. If engine starts, run engine until performance is acceptable.
6. Dispose of fuel in container in an approved manner.

Did engine start?

YES: Engine starts and performance is acceptable. Procedure complete.

YES: Engine starts but performance indicates air is still present in fuel. GO TO 2.

NO: GO TO 2.

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RG41183,0000002 -19-26SEP07-3/4

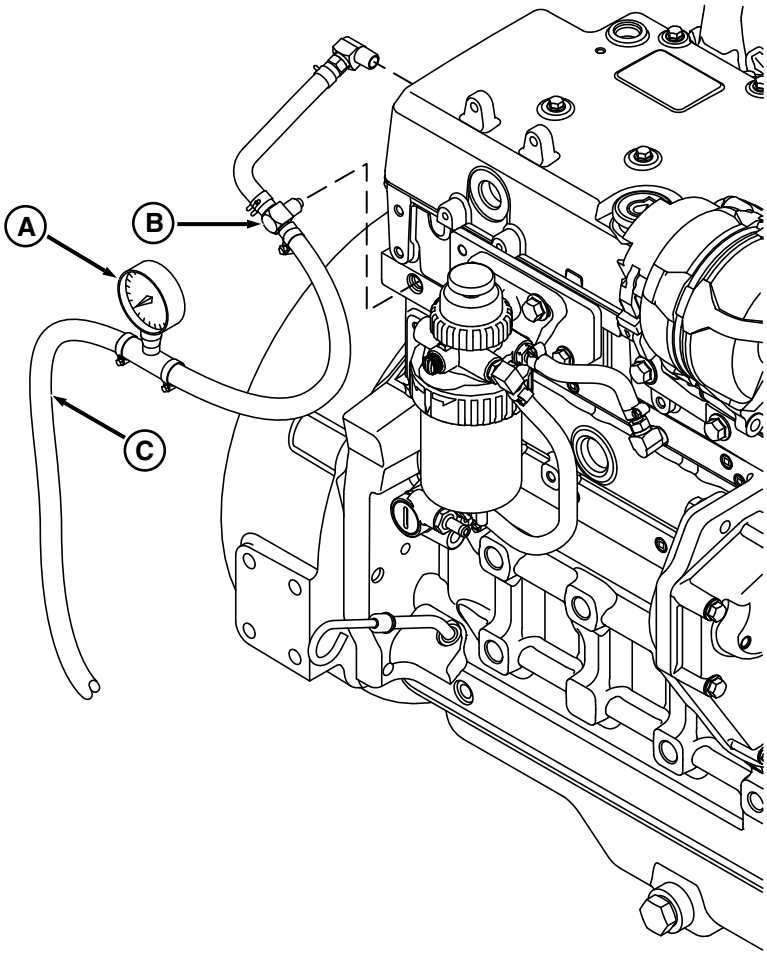
❷ **Purge Fuel Gallery**	1. Place a container suitable for diesel fuel beneath the fuel check valve (C).	
	2. Remove fuel return line and injector leak-off line from fuel check valve.	
	3. Remove fuel check valve.	
	4. Operate hand primer pump until a continuous stream of fuel exits the tapped hole in engine block for the fuel check valve.	
	5. Reinstall the fuel check valve and the fuel lines.	
	6. Attempt to start engine. If engine starts, run engine until performance is acceptable.	**YES:** Engine starts and performance is acceptable. Procedure complete.
	7. Dispose of fuel in container in an approved manner.	**YES:** Engine starts but performance indicates air is still present in fuel. Perform procedure CHECK FOR AIR IN FUEL located in Section 04, Group 151.
	Did engine start?	**NO:** Perform procedure ENGINE CRANKS BUT WILL NOT START located in Section 04, Group 151.

RG41183,0000002 -19-26SEP07-4/4

Check for Restricted Fuel Return Line

This check will determine if the fuel return line is restricted or not designed correctly for the application.

1. Check all return lines and ensure there are no kinked or pinched lines.
2. Install a pressure gauge (A) capable of accurately reading 20 kPa (2.9 psi) between fuel check valve (B) and fuel return line (C).



RG15502 —UN—25SEP07

Checking Fuel Return Pressure

A—Pressure Gauge **B—Fuel Check Valve** **C—Fuel Return Line**

3. Do NOT remove fuel tank cap.
4. Monitor pressure gauge.
5. Operate engine under various conditions from low idle to governed rpm under load.
6. Determine if pressure gauge exceeds 20 kPa (2.9 psi) at any time.
7. Remove fuel tank cap if pressure gauge exceeds 20 kPa (2.9 psi) and recheck return pressure.
8. If return pressure is less than 20 kPa (2.9 psi) with fuel cap removed, inspect tank vent. If pressure does not decrease with fuel cap removed, locate source of restriction in fuel return line. If no restrictions are found, fuel return line diameter may be too small for the application.

RG41183,0000006 -19-27SEP07-1/1

Measure Fuel Transfer Pump Pressure

1. Remove plug on fuel filter base.
2. Install test equipment as shown.
3. Start engine and run at 2400 rpm. Fuel pump should maintain minimum positive pressure listed below. If pressure is low, replace filter element and recheck pressure.

Specification	
Fuel Supply Pump—Minimum Positive Pressure at 2400 rpm Engine Speed	69 kPa (0.69 bar) (10 psi)



RG12645 —UN—02JUN03

Supply Pump Pressure

If pressure is still low, perform the following:

1. Disconnect pump-to-filter fuel line at the filter.
2. With throttle set at no-fuel position (or injection pump shut-off solenoid wire disconnected) so engine will not start, turn engine over several times with starting motor.
3. If fuel spurts from the line, the pump is operating properly.

NOTE: Look for a possible restriction in filter/filter base. Make sure pressure gauge/hose assembly is not at fault.

RG41183,0000007 -19-29MAY03-1/1

Bench Test Fuel Transfer Pump

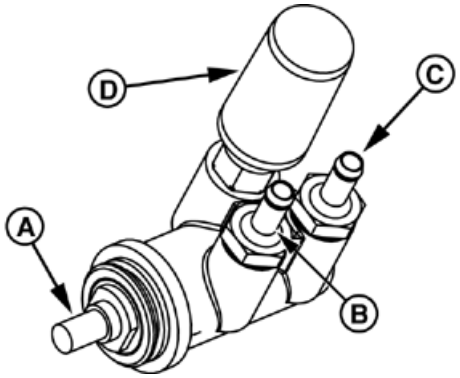
The following bench tests can be performed on a supply pump installed on the engine when the pump is suspected to be defective. See CHECK FUEL TRANSFER PRESSURE in Section 04, Group 150.

Perform the Vacuum/Pressure Test and Leakage Test, listed below. Replace the supply pump if either test shows the pump to be defective. There is no repair procedure.

Vacuum/Pressure Test

NOTE: This test will give a good indication of condition of both the inlet and outlet valves. The numerical values obtained on both the vacuum and pressure sides are not important; rather it is the needle movement that is important (very slow for a good pump; very fast or not at all for a defective pump).

1. Install vacuum/pressure gauge to inlet side of pump (C).
2. Move hand primer (D) all the way downward. Release plunger and at the same time observe gauge:
   - The gauge needle should read the same value each time, and then very slowly return to “0”. This indicates that the inlet valve is in good condition. Proceed to next step.
   - If the gauge needle does not move at all, or if the needle rapidly returns to “0”, the pump is defective and must be replaced.
3. Remove vacuum/pressure gauge and install onto outlet side of pump (B).
4. Move hand primer all the way downward and observe gauge reading:



RG12646 —UN—28MAY03

Fuel Supply Pump

A—Pump Shaft
B—Outlet Side of Pump
C—Inlet Side of Pump
D—Hand Primer

   - The gauge needle should initially read 34—48 kPa (0.34—0.48 bar) (5—7 psi), then return to “0” very slowly. This indicates that the outlet valve is in good condition. Supply pump is operating properly and should be reinstalled on engine.

Specification

Fuel Supply Pump—Pressure..... 34—48 kPa (0.34—0.48 bar) (5—7 psi)

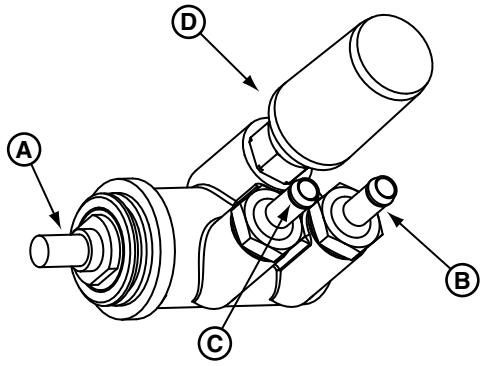
   - If the gauge needle initially reads same value as above and then returns immediately back to “0”, the pump is defective and must be replaced.

RG41183,0000004 -19-11MAR04-1/2

Leakage Test

The leakage test should be performed if a supply pump is suspected of leaking fuel externally, or internally into the engine crankcase.

1. Install an air line on inlet side of pump (C) and apply 140 kPa (1.4 bar) (20 psi) pressure.
2. Hold finger over outlet side of pump (B) or install a plug. Submerge pump into a container of clean diesel fuel.
   - If air bubbles occur around pump shaft (A), (indicating leakage), replace pump.
   - If air bubbles occur around hand primer (D), replace pump.



RG13584 —UN—11MAR04

Fuel Supply Pump

A—Pump Shaft
B—Outlet Side of Pump
C—Inlet Side of Pump
D—Hand Primer

RG41183,0000004 -19-11MAR04-2/2

Check Cold Start Advance Operation

NOTE: Checks must be performed from the right hand oil gallery and with engine cold. See COLD START ADVANCE OPERATION in Section 3, Group 120.

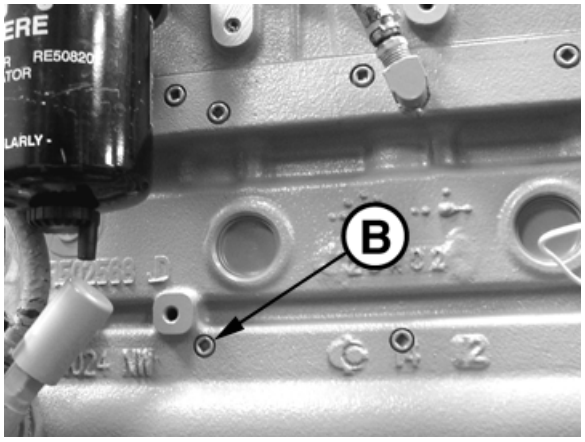
1. Remove oil gallery plug (B) and install pressure gauge.
2. Start engine and monitor pressure gauge.

Oil pressure will be above 206 kPa (30 psi) at start up. As engine warms up the oil pressure will drop to 103 kPa (15 psi) causing the cold start advance thermostat (A) to close and disable the cold start advance.

If pressure does not decrease in the cold start advance oil gallery then shut engine off and replace cold start advance thermostat (A).

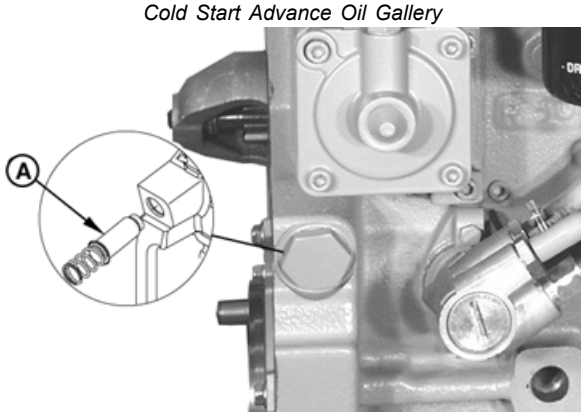
A—Cold Start Advance Thermostat

B—Cold Start Advance Oil Gallery



RG13035 —UN—29SEP06

Cold Start Advance Oil Gallery



RG12647 —UN—06JUN03

Cold Start Advance System Check

DPSG,OUO1004,123 -19-11MAR04-1/1

Check Fuel Shut-Off Solenoid Operation

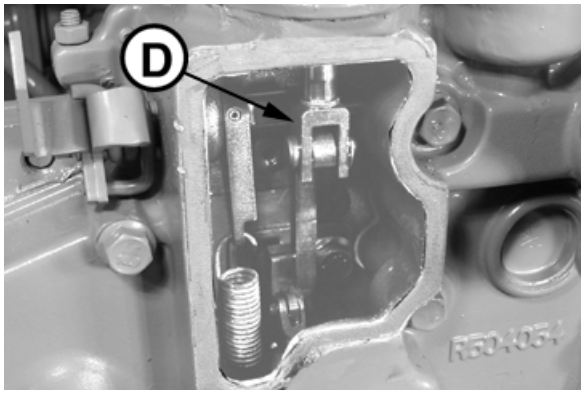
1. Observe fuel shut-off lever (D) when key switch is turned from OFF to START (engine running at slow idle) and then released to ON position.
2. Fuel shut-off lever should move from NO FUEL position to RUN position when starting motor begins to crank. The lever should remain at the RUN position after key switch is released to ON position.

   If fuel shut-off lever returns to NO FUEL position with key switch at ON position, check for:

   - Loss of battery voltage to fuel shut-off winding. Check voltage and wiring connection to solenoid.
   - Binding of fuel shut-off lever, or solenoid rod does not allow solenoid to lock in position. Repair or replace solenoid.
3. Start engine and run at slow idle. Turn key switch to OFF position.
4. Fuel shut-off lever should move to NO FUEL position and engine should stop.

If engine continues to run with key switch at OFF position, unplug shut-off solenoid 3-way connector and observe for the following:

- If solenoid moves lever to NO FUEL position, problem is in the electrical circuit.



RG12709 —UN—23JUN03

Fuel Shut-Off Lever

- If solenoid does not shut off fuel to engine, check linkage for binding or excessive tightness. Replace as necessary.

1. Measure “PULL” coil resistance between black lead and white lead.
2. Measure “HOLD” coil resistance between black lead and red lead. Replace solenoid if resistance is not within specification given below.

Specification

Pull Coil—Resistance.....5 Ohms
Hold Coil—Resistance.....14 Ohms

RG41183,0000001 -19-11MAR04-1/1

Check and Adjust Fast Idle Speed

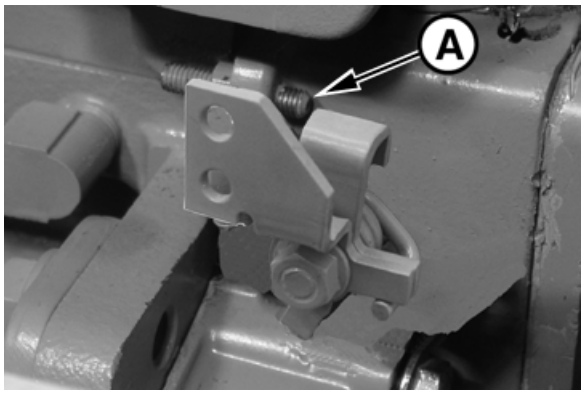
IMPORTANT: Fast idle speeds are preset at the factory. It is recommended that fast idle adjustments be performed only by an authorized dealer.

Check and adjust fast idle speed per specifications listed in ENGINE POWER RATINGS AND SPEED SPECIFICATIONS, Section 06, Group 200 for OEM engines. See machine technical manual for other applications.

If necessary to reset fast idle speed, reset only to specifications. If fast idle speed is not set to specification, the engine may not comply with federal emissions regulations.

1. Remove speed control rod (shown removed). With the engine running, move governor control lever (A) against the fast idle stop screw.
2. Using a tachometer, check fast idle speed to see if it is within specification.

IMPORTANT: If fast idle speed is adjusted, DO NOT adjust idle speed above specifications or pump and engine damage may occur.



RG13579 —UN—02MAR04

3. Adjust fast idle stop screw as required to specified fast idle speed.
4. Tighten adjusting screw lock nut.
5. Connect speed control rod.

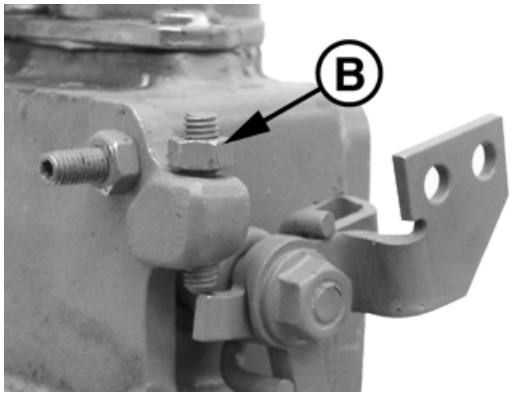
RG,115,JW7686 -19-02MAR04-1/1

Check and Adjust Slow Idle Speed

CAUTION: ALWAYS STOP ENGINE before making adjustments.

NOTE: Check and adjust slow idle speed per specifications listed in ENGINE POWER RATINGS AND SPEED SPECIFICATIONS, Section 06, Group 200 for OEM engines. See machine technical manual for other applications.

1. With the engine running, pull the governor control lever downward to the slow idle speed position. Record engine speed.
2. Stop engine and compare recorded engine speed with the specification. To adjust slow idle speed to specification continue to the next step.
3. Loosen lock nut and adjust slow idle screw (B) to obtain specified idle speed.



RG13580 —UN—02MAR04

4. Tighten adjusting screw lock nut.
5. Start engine and record engine speed. Continue steps 2 - 4 until specified engine speed is obtained.

RG,115,JW7685 -19-03MAR04-1/1

Governor Adjustment

1. Remove the governor cover screw plug (A).
2. Insert a 3 mm hex wrench through the hole until it engages the low idle bumper screw.
3. Turn screw clockwise until screw head bottoms on spring control arm (approximately 3/4 to 1 1/2 revolutions).
4. Start engine and position throttle to fast idle.

IMPORTANT: To insure optimum engine performance, governor adjustments must be made with the coolant (or engine operating temperature) at 85°C.

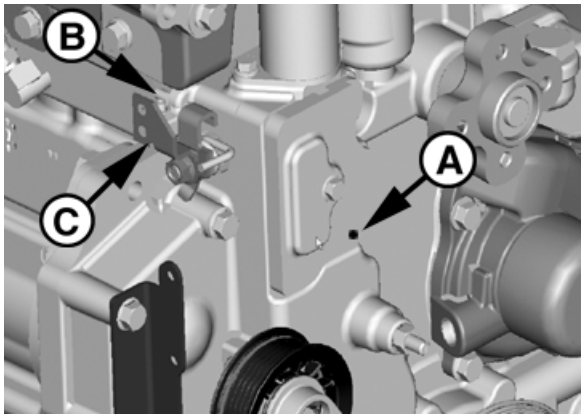
5. Run engine for 10-15 minutes at wide open throttle to allow engine to warm up to operating temperature. Operating temperature is defined as 85°C.
6. Reduce engine speed to low idle.
7. Push the throttle rod rod forward to ensure that the throttle lever (C) is against the low idle stop screw (B).

NOTE: When setting the low idle, the engine may be unstable, and a best estimate of average speed should be used to set engine speed with the stop screw.

8. With engine running, use the low idle stop screw to set the low idle speed to approximately 810—820 rpm (do not set below 810 rpm with engine at operating temperature).

IMPORTANT: The objective with the governor setting is to have approximately 85-100 rpm added to the engine low idle speed using the bumper spring. When making this final adjustment, DO NOT use the low idle screw for any adjustments.

9. Stop the engine.



RG13702 —UN—08SEP04

Governor Adjustment

10. Insert the 3 mm hex wrench through the hole until it engages the low idle bumper screw.
11. On the first adjustment, turn the bumper screw 1/2 turn counterclockwise. On subsequent adjustments, turn the screw 1/8 turn, counterclockwise.
12. Remove the hex wrench and start engine.
13. Insure the throttle lever is against the low idle stop screw and check low idle speed.
14. The target low idle speed is 890—900 rpm. When set, stop the engine and re-install the governor cover screw plug.

IMPORTANT: Check for stability and low idle speed using the following procedure: run engine for 10-15 minutes at wide open throttle. Quickly drop the throttle to low idle and check for engine stability and low idle speed. If the engine speed is not stable, repeat the procedure to set low idle speed.

15. Install pipe plug in the front cover.

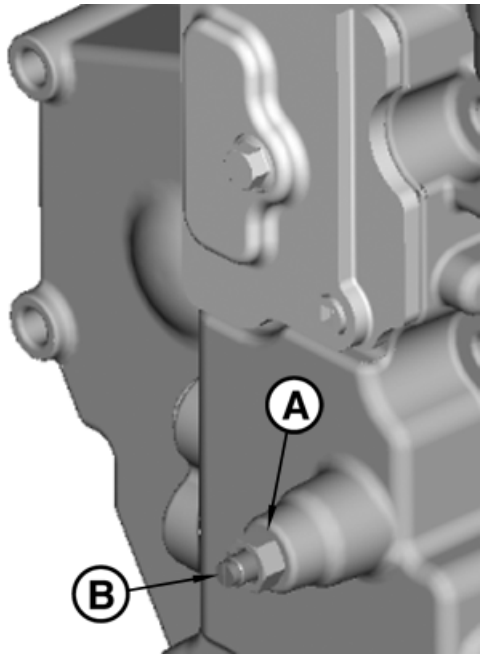
RG19661,0000074 -19-14SEP04-1/1

Disable Fuel Control Rack Magnet

1. Loosen rack magnet adjusting screw jam nut (A).
2. Turn rack magnet adjusting screw (B) 1—2 turns counter-clockwise.
3. Tighten jam nut.
4. Test engine for ramp-up speed.

A—Jam Nut

B—Rack Magnet Adjusting Screw



RG13752 —UN—27SEP04

Disabling Rack Magnet

RG19661,000007E -19-27SEP04-1/1

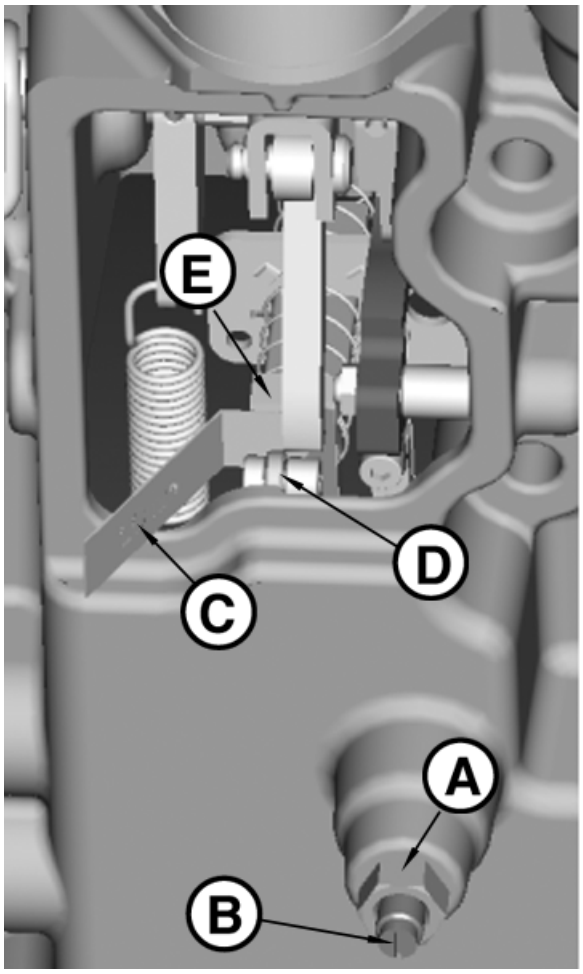
Fuel Control Rack Magnet Adjustment

1. Energize the electric shut-off solenoid to allow the fuel control rack to move forward.
2. Loosen rack magnet adjusting screw jam nut (A).
3. Turn magnet adjusting screw (B) counter-clockwise 1—2 turns.

IMPORTANT: Feeler gauge must be flush with the fuel control rack plate surface.

4. Place and hold a bent 1 mm (0.039 in.) feeler gauge (C) between the governor lever roller and the fuel control rack plate surface (E).
5. Reach behind the control rack plate with a finger and pull firmly to hold the rack at the maximum forward travel position.
6. Slowly turn the magnet adjusting screw (B) clockwise until the governor lever roller (D) contacts the feeler gauge with no play. Do not push the control rack from the maximum forward position.
7. Hold the magnetic adjusting screw in position and tighten the jam nut.

A—Jam Nut
B—Rack Magnet Adjusting Screw
C—Feeler Gauge
D—Governor Lever Roller
E—Fuel Control Rack Plate



RG13753 —UN—27SEP04

Rack Magnet Adjustment

RG19661,000007F -19-27SEP04-1/1

Check Engine Power

1. Connect engine or vehicle to a PTO dynamometer and operate until operating temperature is reached.

IMPORTANT: Operating temperature is required to ensure the cold start advance valve is closed so the engine will be on baseline timing.

2. Move the engine throttle to the full throttle position and apply dynamometer load until engine speed is pulled down to the rated speed for the vehicle. Record the following information:
   - Engine Speed
   - PTO Speed
   - PTO Torque
   - Turbocharger Boost Pressure
   - Horsepower
3. After rated speed horsepower has been recorded, remove dynamometer load, reduce engine speed, allow engine to cool and shut off.
4. Compare recorded information to vehicle/engine specifications.

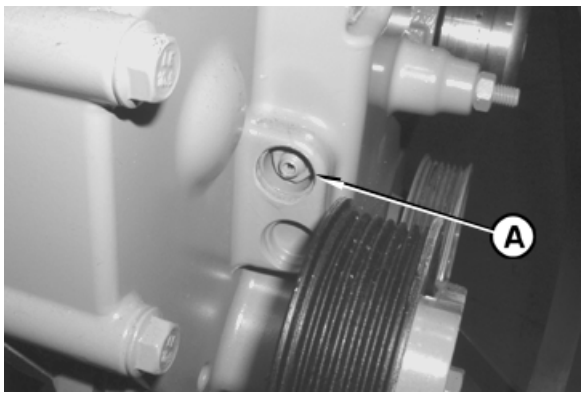
RG19661,0000021 -19-15SEP05-1/1

Adjust Engine Power

If adjustment to engine power is necessary:

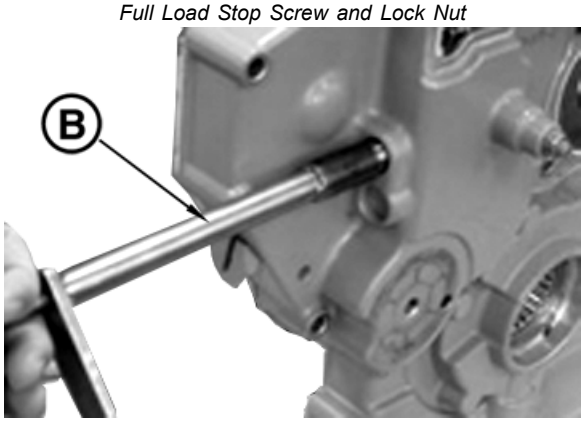
1. Shut off engine and position the throttle to the low speed position.

   Drill 1/8 in. hole in full load screw cup plug located on the right-hand side of the front cover and remove using JDG22 Seal Remover.
2. Loosen full load stop screw lock nut using JDG10038 Full Load Stop Screw Socket Wrench.
3. Insert a 1/4 in. drive extension and JDG1791 Socket Adapter through JDG10038 Full Load Stop Screw Socket Wrench.
4. Adjust full load stop screw by turning 1/4 in. drive.
   - Decrease fuel delivery by turning counter-clockwise.
   - Increase fuel delivery by turning clockwise.
5. After adjusting the full load stop screw, hold the 1/4 in. drive to ensure the screw does not move and tighten the screw lock nut with JDG10038 Full Load Stop Screw Socket Wrench.
6. Start engine and verify engine is operating at the correct specifications. See “Check Engine Power” described earlier in this section.
7. Check throttle settings. Apply a bead of LOCTITE 277® on a new inverted cup plug and install in the timing gear cover.



RG14500 —UN—21SEP05

Full Load Stop Screw and Lock Nut



RG14501 —UN—21SEP05

Adjust Full Load Stop Screw

A—Full Load Stop Screw and Lock Nut

B—JDG10038 Full Load Stop Screw Socket Wrench

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RG19661,0000022 -19-22SEP05-1/1

Test Cylinder Misfire

The Cylinder Misfire Test is used to compare the output temperature of a cylinder relative to each of the other cylinders. The test will help identify problems such as an engine misfire or irregularly running engine. The test results are only a guide to help determine if there is a problem in a cylinder. The results alone should not be used as a conclusive reason for replacing the injection pump or nozzles. Other information such as the results of a Compression Test, Cylinder Cutout Test, and other engine diagnostic procedures should be used to accurately determine the source of an engine problem.

1. Operate engine at intermediate speed with no load.
2. Using Noncontact Temperature Measuring Gun, aim at each exhaust port and record findings. Repeat process several times and compare readings.

NOTE: Cylinder misfire checks are only a guide to determine if there is an engine problem (valve leakage, faulty nozzles, etc.).

Resulting temperatures should be compared for below average or above average. If a cylinder temperature is below average, this indicates that the cylinder may not be contributing enough. A temperature that is above average would indicate that the cylinder is contributing too much.

The Compression Test should be performed to help determine the cause of the problem in the cylinder(s) that was above or below average.

RG41183,0000011 -19-27SEP04-1/1

About this Group of the Manual

This section of the manual contains necessary information to diagnose the electronic control system.

Parts such as sensors, actuators, and connectors are serviceable and available.

To help diagnose electronic control system problems, Section 6, Group 210 DIAGNOSTIC SPECIFICATIONS contains useful information, such as ECU terminal identification and a system wiring schematic.

IMPORTANT: Under NO circumstances, should the Engine Control Unit (ECU) be opened.

NOTE: Instruction is given throughout the diagnostic charts to make resistance and voltage measurements in the ECU connector. Note that these measurements are always made in the harness end of the connector. Measurements should never be made in the ECU end of the connection.

RG41183,0000082 -19-23JAN04-1/1

Electrical Concepts

Tests will include making measurements of voltage and resistance and making checks for open circuits and short circuits. An understanding of the following concepts is required to use the diagnostic procedures:

- Voltage (volts)
- Current (amps)
- Resistance (ohms)
- Open Circuit
- Short Circuit

RG,RG34710,1553 -19-30SEP97-1/1

Using a Digital Multimeter

It is recommended that a digital multimeter (JT07306 or equivalent with an analog display) be used to make the required measurements in the diagnostic procedures. A knowledge of the operation of the particular meter used is assumed.

Instructions for measuring voltages take the following form:

- Measure voltage from Point A (+) to Point (B) (-)

In this example, the positive test lead from the volt-ohm input of the meter should be connected to Point A and the negative test lead from the common input of the meter should be connected to Point B.

Unless otherwise stated, all voltage measurements are direct current (D.C.).

In making a resistance measurement, be careful to use the correct resistance range on the meter. Disconnect appropriate connectors or turn off key switch, as directed by diagnostic procedures later in this group.



Digital Multimeter

RG11126 —UN—08JUN07

RG,RG34710,1554 -19-30SEP97-1/1

Electrical Circuit Malfunctions

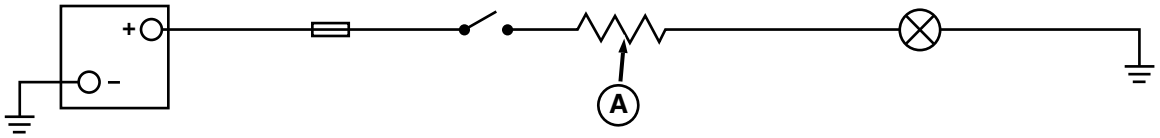
Circuit Malfunctions

There are four major circuit malfunctions. They are:

1. High-resistance circuit
2. Open circuit
3. Grounded circuit
4. Shorted circuit

Definition of Circuit Malfunctions

RG9891 —UN—03MAR08



High Resistance Circuit

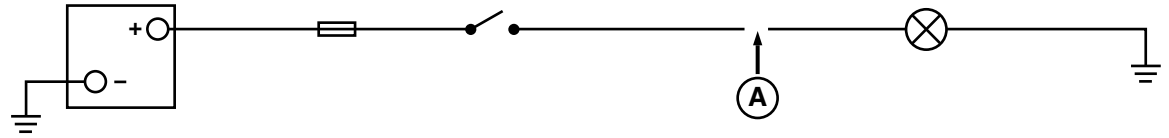
A—Unwanted Resistance

1. **High Resistance Circuit:** A circuit having unwanted resistance (A) that causes a voltage drop and reduces current flow.

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DPSG,RG40854,37 -19-15DEC98-1/3

RG9892 —UN—03MAR08



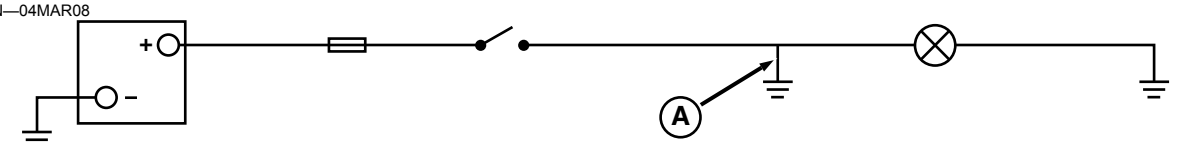
Open Circuit

A—Break or Separation in Circuit

2. **Open Circuit:**

A circuit having a break or a separation (A) that prevents current from flowing in the circuit.

RG9893 —UN—04MAR08

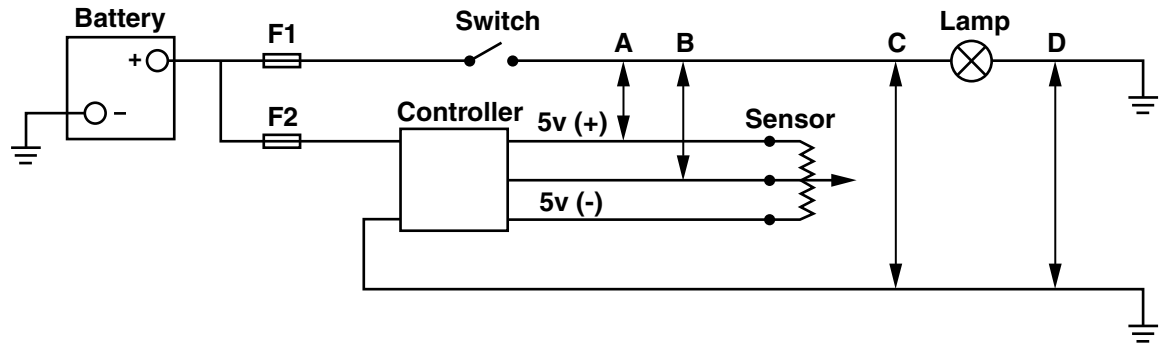


Grounded Circuit

A—Voltage Wire in Contact with Machine Frame

3. **Grounded Circuit:**

A voltage wire in contact with the machine frame (A), providing continuity with the battery ground terminal.



RG9894 —UN—12MAY10

Shorted Circuit

4. **Shorted Circuit:**

A wire-to-wire contact of two adjacent wires that provides unwanted continuity between the two wires. The following are types of short circuits:

- Voltage wire shorted to another voltage wire (wires of equal or unequal voltage).
- Voltage wire shorted to a sensor signal wire (wires of unequal voltage).
- Voltage wire shorted to a ground wire (wires of battery voltage or regulated voltage, shorted to a ground wire connecting a component to the battery negative terminal).
- Ground wire shorted to another ground wire (wires of zero voltage).

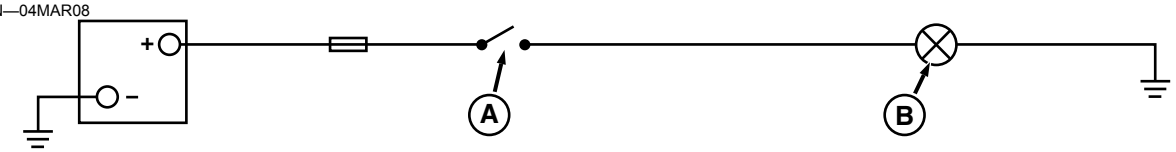
NOTE: This type of short does not create an observable malfunction. Therefore, no further explanation for trouble shooting is necessary.

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DPSG,RG40854,37 -19-15DEC98-2/3

Locations of Circuit Malfunctions:

RG9895 —UN—04MAR08



Locations of Circuit Malfunctions

A—Controlling Switch **B—Load**

In a “Simple Electrical Circuit” the circuit malfunctions occur at only three locations. They are:

1. Before the controlling switch (A).
2. Between the controlling switch (A) and the load (B).
3. After the load (B).

Electrical components can become faulty with the same four circuit malfunctions. Sometimes component malfunctions can easily be confused with circuit malfunctions. Therefore, care must be exercised when isolating the cause of the problem.

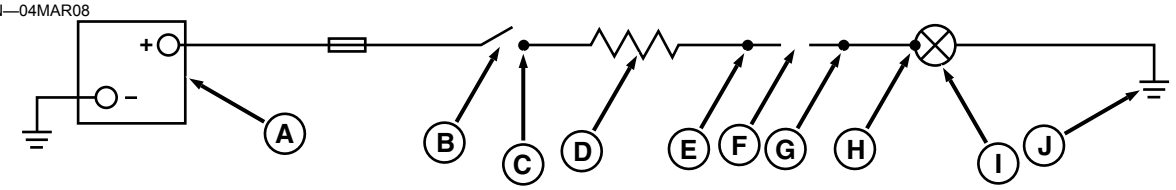
Example: A component may not operate before disconnecting an electrical connection, but it operates after reconnecting the connector.

Reason: Oxidation of the terminals created “High Resistance” and a voltage drop that prevents the proper amount of current flow to the component. Disconnecting and reconnecting the connector, removed some oxidation and re-established good continuity through the connector.

DPSG,RG40854,37 -19-15DEC98-3/3

Troubleshooting Circuit Malfunctions

RG9896 —UN—04MAR08



Troubleshooting Circuit Malfunctions

A—Battery
B—Switch
C—Component Terminal
D—Unwanted Resistance
E—Circuit Connector
F—Open Circuit
G—Circuit Connector
H—Component Terminal
I— Load (Lamp)
J— Ground

1. **High Resistance Circuit:**

   A “High Resistance” circuit can result in slow, dim or no component operation (for example: loose, corroded, dirty or oily terminals, gauge of wire too small or broken strands of wire).

2. **Open Circuit:**

   An “Open” circuit results in no component operation because the circuit is incomplete (for example: broken wire, terminals disconnected, open protective device or open switch).

   Do the following to isolate the location of a “High Resistance” or “Open” circuit:

   a. With the controlling switch (B) closed (on) and the load (I) connected into the circuit, check for proper voltage at a location easily accessible between (C) and (H).

   - If voltage is low, move toward the voltage source (A) to locate the point of voltage drop.
   - If voltage is correct, move toward the load (I) and ground terminal (J) to locate the voltage drop.

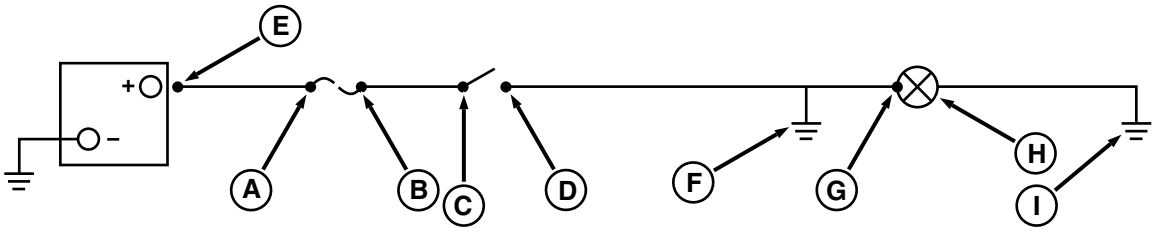
   NOTE: The example shows high resistance (D) between (C) and (E) and the open circuit (F) between (E) and (G).

   b. Repair the circuit as required.

   c. Perform an operational check-out on the component after completing the repair.

Continued on next page

DPSG,RG40854,38 -19-15DEC98-1/4



RG9897 —UN—12MAY10

Ground Circuit

A—Fuse "A" Terminal
B—Fuse "B" Terminal
C—Switch
D—Component Terminal
E—Wire Terminal
F—Grounded Circuit
G—Component Terminal
H—Load (Lamp)

3. **Ground Circuit:**

A "Grounded" circuit (F) results in no component operation and the fuse or circuit breaker opens (for example: a power wire contacting the machine frame, chassis or component housing).

Do the following to isolate the location of a "Grounded" circuit:

a. Switch (C) must be open (off). Check for continuity to ground between (B) and (C).

- If there is continuity, there is a grounded circuit between (B) and (C). Repair the circuit.
- No continuity, go to step b.

b. Disconnect the load (H) at component terminal (G).

c. With the controlling switch (C) open (off), check for continuity to ground between (D) and (E).

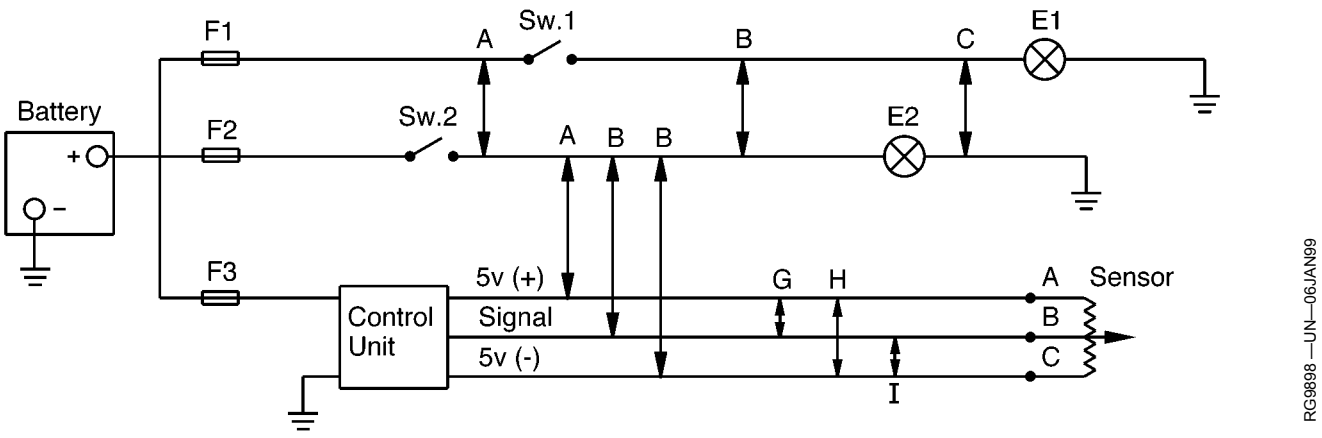
- If there is continuity, there is a grounded circuit between (D) and (E). Repair the circuit.

NOTE: The example is grounded between (D) and (E) at (F).

- Perform an operational check-out on the component after completing the repair.

Continued on next page

DPSG,RG40854,38 -19-15DEC98-2/4



Shorted Circuit

4. **Shorted Circuit:**

Machines equipped with several electronic control devices contain wiring harnesses that can become shorted by one of the following ways shown above.

1. Battery wire from fuse (F1) is shorted at (A) to another battery wire after switch (Sw.2).
   - Result: Lamp (E1) is on all of the time.
2. Battery wire from fuse (F1) is shorted at (B) to another battery wire after switches (Sw.1 & 2).
   - Result: Both lamps (E1 & E2) operate on either switch (Sw. 1 or 2).
3. Battery wire from fuse (F1) is shorted at (C) to a ground wire.
   - Result: Fuse (F1) opens after closing switch (Sw. 1)
4. Battery wire from switch (Sw. 2) is shorted at (D) to a regulated voltage wire.
   - Result: The sensor signal voltage is distorted.[1]
5. Battery wire from switch (Sw. 2) is shorted at (E) to the sensor signal voltage wire.
   - Result: The sensor signal is distorted.[1]
6. Battery wire from switch (Sw. 2) is shorted at (F) to the sensor ground wire.
   - Result: Fuse (F2) opens after closing switch (Sw. 2) and the sensor signal is distorted.[1]
7. Controller regulated voltage wire is shorted at (G) to the sensor signal voltage wire.
   - Result: The sensor signal is distorted.
8. Controller regulated voltage wire is shorted at (H) to the sensor ground wire.
   - Result: The sensor signal is distorted.[1]
9. Sensor voltage wire is shorted at (I) to the sensor ground wire.
   - Result: The sensor signal is distorted.[1]

Do the following to isolate a "Shorted Circuit:"

a. Review the machine electrical schematic to identify the circuits for the component that does not operate.

b. Disconnect the components at each end of the circuits, to single out the affected wires.

c. To prevent damage to connector terminals, obtain mating connector terminals from repair parts. DO NOT force meter probes into connector terminals.

d. Connect the meter leads across two of the affected circuits. The meter should show no continuity between the two circuits. Repeat the check across another combination of two circuits until all affected circuits have been checked.

e. Then, connect a meter lead to each affected circuit one at a time and touch the other meter leads to all terminals in the connector. The meter should show no continuity between any two circuits.
Example: A 37 pin connector contains three wires to a sensor. With one meter probe attached to each of the three wires, one at a time, touch the other meter probe to the remaining 36 wires. If there is continuity between any two wires, the circuit is shorted. Repair the circuit.

f. Alternate Method to Check for Shorted Circuit. With the components disconnected at each end of the suspected circuits, turn the key switch on. Connect one meter lead to a good frame ground. With the other meter probe, touch each of the suspected circuits one at a time. If there is a voltage reading, the circuit is shorted to another voltage wire. Repair the circuit.

g. Repair the "Shorted Circuit" as follows:

- Wires not in a loom: Wrap individual wires with electrical tape or replace the damaged wire and band as required.
- Wires in a loom: If hot spots exist in shorted area of the harness, replace the harness. If hot sports are not noticeable, install a new wire of proper gauge between the last two connections. Use tie bands to secure the wire to outside of the harness.

Continued on next page

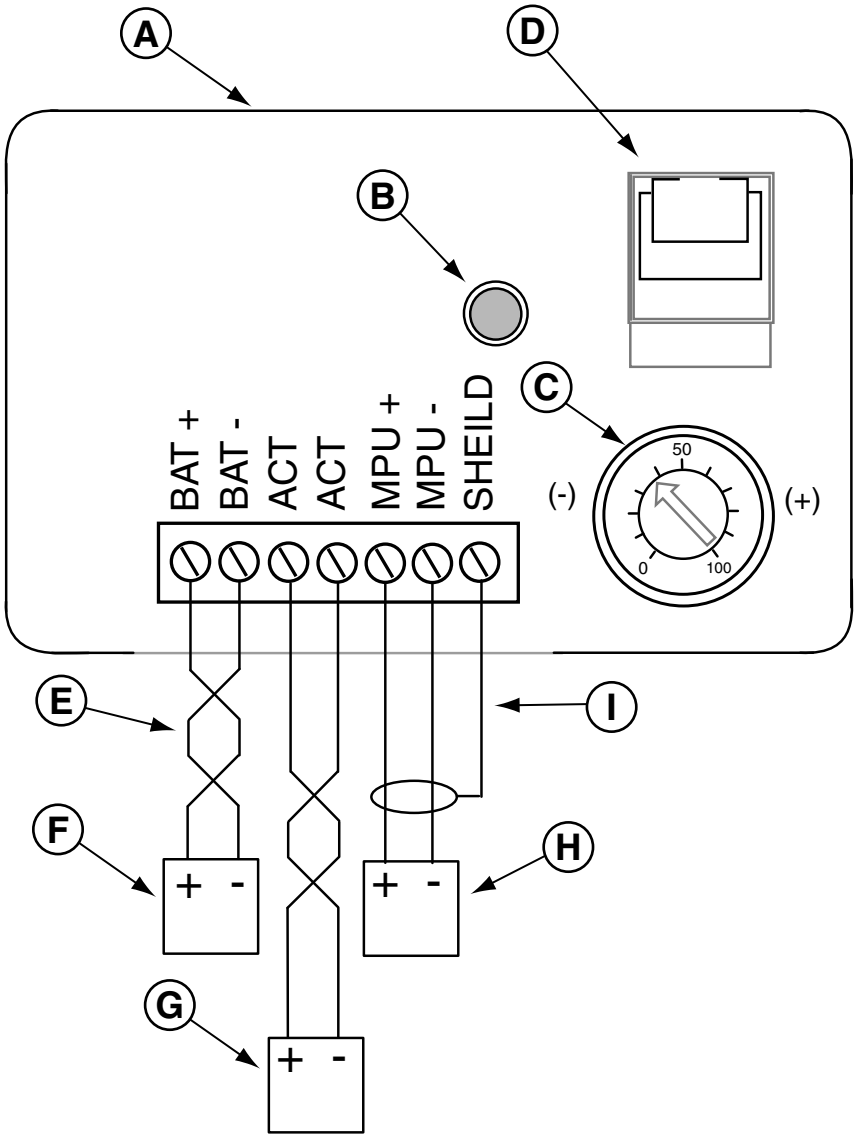
DPSG,RG40854,38 -19-15DEC98-3/4

h. Perform an operational check-out on the component after completing the repair.

[1]The sensor signal voltage goes out of range and a fault code may be restored. The controller may shut down or provide limited operation for its function.

DPSG,RG40854,38 -19-15DEC98-4/4

Engine Control Unit (ECU) Wiring



RG13581 —UN—03MAR04

A—Engine Control Unit (ECU)
B—Light Emitting Diode (LED)
C—Gain Adjustment
D—COMM Port
E—14 GA Twisted Wire
F—Battery
G—Actuator
H—Magnetic Pickup Unit
I— Shielded Ground Connection

ECU Terminal Description	
Name	**Description**
BAT+	Battery positive (Supply voltage range is 9VDC-30VDC)
BAT-	Battery negative
ACT	Actuator Drive output
ACT	Actuator Drive return
MPU	Magnetic Pickup Signal Input
MPU	Magnetic Pickup Ground
SHIELD	Ground connection for cable shielding

RG41183,000008C -19-03MAR04-1/1

Connecting Parameter Setup Tool (PST)

Refer to your John Deere Dealer web site for obtaining the latest version of software used for communicating with the electronic control unit (ECU).

The Universal PST software requires a computer with Microsoft® Windows 98se (Second Edition), NT4, 2000, or XP. The display resolution needs to be set to SVGA (800x600) or higher.

NOTE: The Universal PST software is not supported on Microsoft® Windows 95.

NOTE: Ensure computer serial port or USB is configured to COMM 1. USB to serial port adapter (C) is not included in kit DS10083.

1. Connect DB9 to RJ11 adapter (A) to the serial port on computer. For computers without a serial port, a USB to serial port adapter (C) will be required .
2. Connect the RJ11 cable (B) to the DB9 adapter and to the diagnostic receptacle on the ECU.
3. Key ON, engine OFF, verify that the LED on the controller is on.



RG13773 —UN—18OCT04

DS10083 Diagnostic Hardware for PC

A—DB9 to RJ11 Adapter
B—RJ11 Cable
C—USB to Serial Port Adapter *(not included in kit)*

4. Start the Universal PST software and verify communications with the ECU.

RG41183,0000086 -19-19OCT04-1/1

Parameter Reference

Proportional:
The proportional term is one of the interrelated PID terms that determine how well the ECU governs the engine's speed. A speed change creates a speed error (the difference between the target speed and the actual speed.) The proportional gain controls the size of the governor output response to a step change in the speed error.

Integral:
The integral term is one of the interrelated PID terms that determine how well the ECU governs the engine's speed. The integral term acts to drive speed error to zero. In a proportional-only control with constant load, there will be a constant speed error that inversely relates to the proportional gain of the system. The integral term is key to isochronous speed control. The term eliminates the difference between the programmed set speed and the actual speed. The integral gain changes the time it takes to drive the error is to zero.

NOTE: Integral is needed to eliminate speed offsets due to proportional gain and should never be left at zero.

Derivative:
The derivative term is one of the interrelated PID terms that determine how well the ECU governs the engine's speed. The derivative responds to the rate of change in the speed error. This parameter is primarily used to dampen very rapid oscillations resulting from large speed changes. The derivative responds to rapid engine acceleration or deceleration. If the engine speed approaches the target speed at a fast rate, the derivative acts to minimize or eliminate overshoot. A zero value is allowed but systems typically require some derivative gain to improve overall engine speed control.

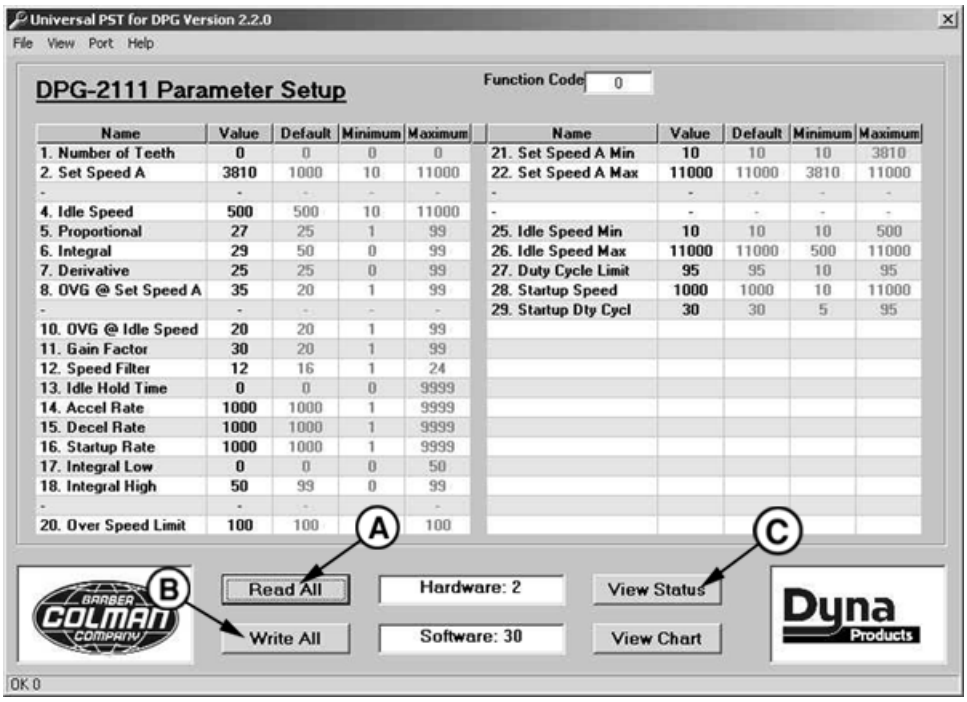
Gain at Set Speed A:
This gain acts as the multiplier on the three PID terms (proportional, integral, and derivative) when Set Speed A is selected as the active target speed.

Gain Factor:
The gain factor parameter is used to obtain more range of adjustment from the PID terms. In other words, if any of the PID terms or the Gain terms reach their adjustment limits then this value can be modified to provide for more range of adjustment in the PID and Gain terms. For example, if the PID terms are set to 90, 80, and 50 respectively and the Gain Factor is set to 20, then doubling the Gain Factor by setting it to 40 allows the PID terms to be halved to 45, 40, and 25 respectively. These new settings are equivalent to the previous settings with respect to the governor's tuning response and now allow the PID terms to be adjusted higher if needed.

Speed Filter:
This parameter indicates the number of speed signal pulses to use when computing an average engine speed and is used to dampen out speed measurement variations that can make PID tuning difficult. But keep in mind the following.
—Too little filtering can make the governor overly sensitive and tuning difficult.
—Too much filtering will slow down the governor's response to speed changes.

RG41183,0000089 -19-29FEB04-1/1

Viewing and Modifying ECU Parameters



RG13575 —UN—01MAR04

IMPORTANT: It is recommended that the current parameters in the ECU be saved to a data file prior to modifying existing parameters in the ECU.

Configuration parameters can be viewed with the Universal PST. To refresh the parameter table click on “Read All” (A). Parameters may be edited from this view by double clicking on the cell in the “Value” column. Type in the new value and then click once on a different row. The value will be changed on the screen but will not update in the ECU. Click on “Write All” (B) to have the parameters updated in the ECU.

Click on “View Status” (C) to display read only parameters in the Status view window.

RG41183,0000087 -19-27FEB04-1/1

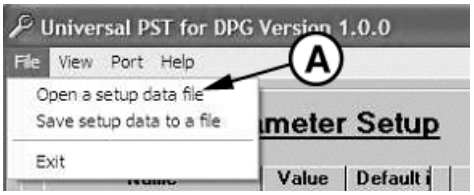
Reprogramming the ECU

IMPORTANT: It is recommended that the current parameters in the ECU be saved to a data file prior to reprogramming an ECU.

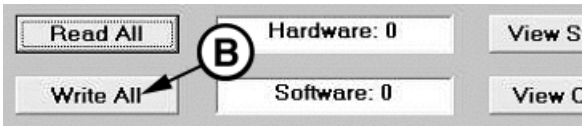
The ECU can be reprogrammed from a file that contains parameter settings using the Universal PST.

1. Key ON, engine off connect to the ECU using Universal PST.
2. Open a previously saved setup data file by clicking on “File” and “Open a setup data file” (A). Select the correct file for the engine.
3. Click on “Write All” (B) and the software will update the ECU with the updated parameters.

RG13577 —UN—01MAR04



RG13576 —UN—01MAR04



RG41183,0000088 -19-29FEB04-1/1

Electronic Governor Calibration

Basic Adjustments

The controller is programmed at the factory with default parameter settings (See Electronic Governor Specifications, later in this book). These settings allow the engine to operate but will usually require some further adjustments to obtain the best performance. The parameters listed below are the primary settings that should be modified to get the governor tuned and the engine running at desired operation. It is recommended that these parameters be adjusted first and leave all other parameters at their default settings.

After the the settings are set in the software, start the engine and use the gain adjustment potentto fine tune gain needs.

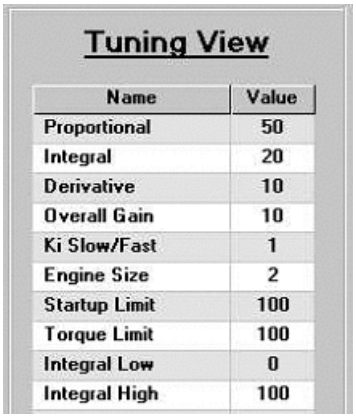
- Proportional
- Integral
- Derivative
- OVG @ Set Speed A
- Gain Factor (*See Note*)
- Speed Filter (*See Note*)
- Gain Adjustment

NOTE: Modify Gain Factor only if you run out of adjustment in a PID or OVG.

A Speed Filter setting of 24 is the default for 4 cylinder engines. 5 cylinder engines vary and should be referenced in the specifications chart.

Tuning Procedure

1. Increase the proportional term until you get continuous oscillations greater than 2Hz.



RG13578 —UN—01MAR04

2. Reduce the proportional term by 25% to 50%.
3. Now experiment with small value changes in the derivative to dampen out “ringing” in response to load transients.
4. Add some integral to eliminate any steady-state error in the engine’s speed and help decrease error recovery time.
5. The overall gain can be increased to improve response time while keeping the ratios of the PID (Proportional, Integrated, and Derivative) terms relative to each other constant.

RG41183,0000083 -19-03DEC04-1/1

LED Status Indicators

The LED (Light Emitting Diode) is used as a status indicator. The following table describes the different faults depending on the status of the LED.

LED Status	Description
Off	The ECU is either not currently being powered, or is being reverse powered (check polarity of supplied power). If correctly powered then the controller is malfunctioning.
Blinking Slow (1/2 Hz)	The ECU is powered but not sensing a speed signal. OK if engine is not running. If the engine is running then this indicates a fault with the speed signal.
Blinking Fast (1 1/2 Hz)	The ECU is powered and an engine speed signal is being detected. If the engine is not running then this indicates electrical noise on the speed signal wires.
On and Not blinking	The ECU is powered and is malfunctioning. Replace the controller.

RG41183,0000085 -19-16APR04-1/1

Electronically Controlled Governor System Diagnostics

System	Solution
LED Display Does Not Light Up When Governor Is Powered	• BAT + and BAT – leads are reversed. Check wiring. • Battery voltage too low. Should measure between 9 and 30 VDC • Controller is defective. Replace it.
Unable to Modify Parameters	• The parameter's value is at the maximum value allowed. • The parameter's value is at the minimum value allowed. • Universal PST not communicating with the controller • Keypad Failure, replace unit.
Engine Does Not Start	• Actuator leads not connected or shorted. • No Fuel Source. Turn on fuel source. • Battery voltage is low. Charge or replace the battery. • Set speed is lower than crank speed. Increase the set speed. • Startup Rate setting is too low. The target speed ramps up too slow. • Startup Limit is too low, limiting the actuator drive signal too much. • Is the MPU speed signal present? It should read 2.0VRMS minimum. Adjust magnetic pickup (MPU) gap. Try reversing the MPU leads. • If a speed signal is present, measure actuator output duty cycle. If not greater than 5%, then restore all parameter values to factory default settings and crank the engine again. • Final target speed must be greater than crank speed before the governor will attempt to drive the actuator open.
Engine Over Speeds at Startup	• Increase the Proportional value. • Increase the appropriate Gain value. • Decrease the Startup Ramp Rate.
Engine Does Not Reach the Set Speed	• Improve PID tuning. • Integral too low or zero • PID values are too low. A tuning that is too soft can prevent the governor from delivering the needed actuator drive signal to reach the set speed. • PID values are too high. Tuning is too hot or over sensitive to small speed errors which causes the governor to make large rapid changes in actuator drive signal which creates an average signal that is inadequate. • The Integral Low Limit setting is too high. Return the value to the default setting of zero. • The Integral High Limit setting is too low. Return the value to the default setting of 99.
Engine takes too long to reach the set speed.	• Improve PID tuning. • Integral setting is too low. • Startup Rate setting is too low. • Accel Rate setting is too low. • Speed Filter setting is too high.
Engine Does Not Track Speed Setting Changes	• Is the LED blinking fast (3Hz)? No = not sensing speed • Is the selected set speed parameter being modified? • A PID value or a Gain value is too high. • A PID value is too low or zero. • Accel Rate is set too low. • Decel Rate is set too low.
Sluggish Response to load changes	• Gain too low. • Improve PID tuning. • Speed Filter setting is too high.
Engine Instability With No-load	• Improve PID tuning. • Speed Filter setting is too low. • Fuel is restricted. Check actuator linkage. • Battery voltage is too low.
Engine Instability With Load	• Improve PID tuning. • Fuel is restricted. Check actuator linkage. • Battery voltage is too low.
Engine Unable to Carry Rated Load	• PID values may be too high causing the governor to over react and make large rapid changes in PWM duty cycle output to the actuator. • Improve PID tuning. • Fuel is restricted. Check actuator linkage.

RG41183,000008A -19-02MAR04-1/1

Section 05
Tools and Other Materials

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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).

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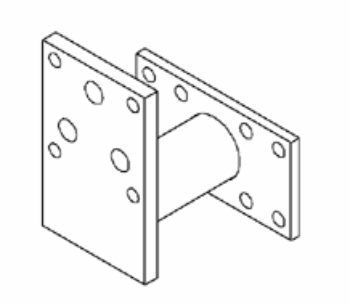
OUO1082,0000233 -19-09JAN07-1/3

Engine Lifting Sling..... JDG23 — Lift engine.

OUO1082,0000233 -19-09JAN07-2/3

Engine Mounting Fixture..... JDG1676

Use to mount engine to engine repair stand.



JDG1676

RG13000 —UN—19JUN03

OUO1082,0000233 -19-09JAN07-3/3

Engine Rebuild Service Equipment and Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC). Some tools may be available from a local supplier.

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RG41183,000003D -19-09JAN07-1/3

Engine Repair Stand ..... D05223ST — Used with JDG1676 Engine Adapter to mount engine.

RG41183,000003D -19-09JAN07-2/3

Engine Repair Stand ..... D01003AA — Used with JDG1676 Engine Adapter to mount engine.

RG41183,000003D -19-09JAN07-3/3

Group 020 — Cylinder Head and Valves Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

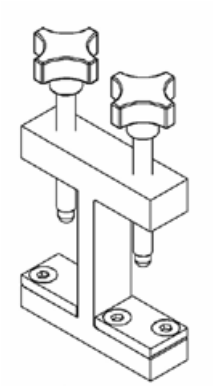
SERVICEGARD is a trademark of Deere & Company

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RG41183,000002C -19-09JAN07-1/8

Hydraulic Lifter Bleed-down Tool JDG1678

Use to bleed-down hydraulic lifters.



RG12995 —UN—19JUN03

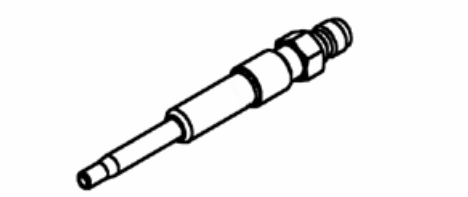
JDG1678

RG41183,000002C -19-09JAN07-2/8

Compression Test Adapter JDG1687

Used to check cylinder compression pressure. Use adapter with gauge/hose assembly from JT01674 (formerly D14546BA or FKM10021).

RG12994 —UN—19JUN03



JDG1687

RG41183,000002C -19-09JAN07-3/8

Dial Indicator.....(English, in.) D17526CI or (Metric, mm) D17527CI

Use with JDG451 to measure valve recess and cylinder liner height-to-cylinder block top deck.



RG6246

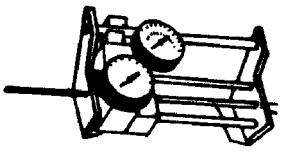
RG6246 —UN—05DEC97

D17526CI or D17527CI

RG41183,000002C -19-09JAN07-4/8

Spring Compression Tester D01168AA

Test valve spring compression.



RG5061

RG5061 —UN—05DEC97

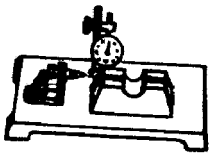
D01168AA

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RG41183,000002C -19-09JAN07-5/8

Valve Inspection Center..... D05058ST

Check valves for out-of-round.



RG5062

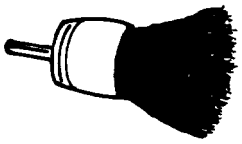
RG5062 —UN—05DEC97

D05058ST

RG41183,000002C -19-09JAN07-6/8

End Brush.....D17024BR

Clean valve seat and bores.



RG5063

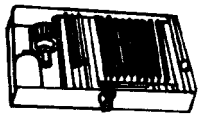
RG5063 —UN—05DEC97

D172024BR

RG41183,000002C -19-09JAN07-7/8

Valve Guide Knurler Kit JT05949

Knurl valve guides.



RG5064

RG5064 —UN—05DEC97

JT05949

RG41183,000002C -19-09JAN07-8/8

Group 020 — Cylinder Head and Valves Service Equipment and Tools

RG41183,000002D -19-09JAN07-1/1

Group 020 — Cylinder Head and Valves Other Materials

Number	Name	Use
AR44402 (U.S.)	Valve Stem Lubricant	Lubricate valve stems.
PT569 (U.S.)	NEVER-SEEZ® Compound	Turbocharger-to-exhaust manifold cap screws.
RE524832 (Hylomar 3400) (U.S.)	Silicone Sealant	Gasket
PM710XX280 (Hylomar 101) (U.S.)	Silicone Sealant	Gasket

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

RG41183,000002E -19-09JAN07-1/1

Group 030 — Cylinder Block, Liners, Pistons, and Rods Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

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RG41183,000002F -19-09JAN07-1/7

Precision “Bevelled Edge” Straightedge..... D05012ST — Check cylinder head flatness.

RG41183,000002F -19-09JAN07-2/7

Piston Ring Compressor..... JDG1690 — Compress rings while installing pistons.

RG41183,000002F -19-09JAN07-3/7

Torque Angle Gauge.....JT05993 — Used to TORQUE-TURN flanged-head cylinder head and connecting rod cap screws.

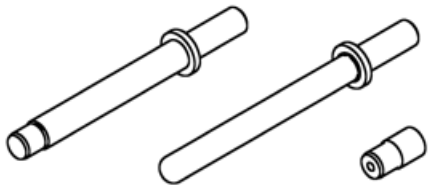
RG41183,000002F -19-09JAN07-4/7

Piston and Liner Height Gauge ..... JDG451 — Measure piston height.

RG41183,000002F -19-09JAN07-5/7

Balancer Bushing Drivers..... JDG1691

Use to remove and install balancer bushings



RG13758 —UN—28SEP04

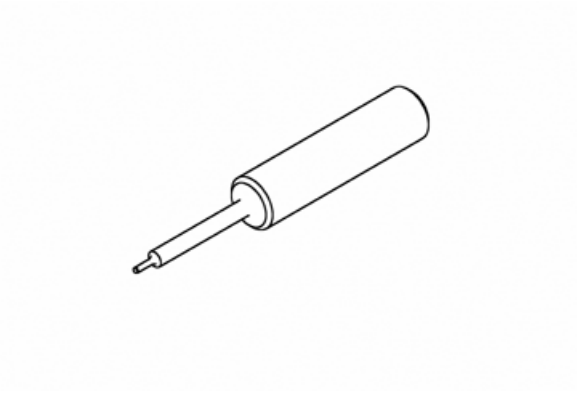
JDG1691

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RG41183,000002F -19-09JAN07-6/7

Piston Spray Jet Installer JDG1697

Use to install piston oil spray jets



RG13757 —UN—28SEP04

JDG1697

RG41183,000002F -19-09JAN07-7/7

Group 040 — Crankshaft, Main Bearings and Flywheel Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

SERVICEGARD is a trademark of Deere & Company

RG41183,0000031 -19-09JAN07-1/11

Dial Indicator..... D17526CI (English, in.) or D17527CI (Metric, mm)

Used with magnetic base to measure radial runout (concentricity) and wobble on vibration damper.



RG6246

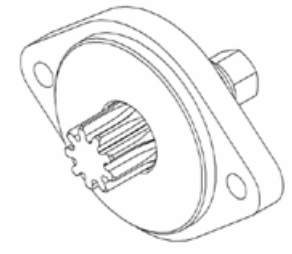
RG6246 —UN—05DEC97

D17526CI or D17527CI

RG41183,0000031 -19-09JAN07-2/11

Flywheel Turning Tool..... JDG1704

Used to rotate engine crankshaft and/or camshaft to specific locations.



RG13004 —UN—19JUN03

JDG1704

Continued on next page

RG41183,0000031 -19-09JAN07-3/11

Seal Remover..... JDG22

Remove crankshaft front oil seal with timing gear cover installed. Also used to remove crankshaft rear oil seal without removing flywheel housing.

RG5109 —UN—23AUG88

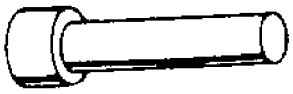


JDG22

RG41183,0000031 -19-09JAN07-4/11

Timing Pin.....JDE81-4

Used to lock engine/flywheel.



RG5068

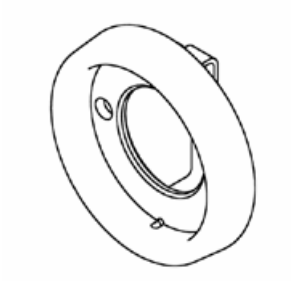
RG5068 —UN—05DEC97

Timing Pin

RG41183,0000031 -19-09JAN07-5/11

Rear Seal Housing Alignment Tool..... JDG1703

Use to center rear oil seal housing during installation.



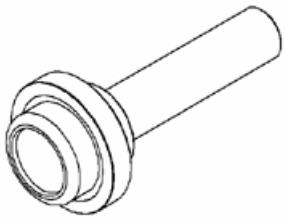
RG13003 —UN—19JUN03

JDG1703

RG41183,0000031 -19-09JAN07-6/11

Timing Gear Cover Alignment/Front Oil Seal Installer Tool..... JDG1660

Use to install front oil seal into timing gear cover. Also use to center timing gear cover with the crankshaft.



RG12998 —UN—19JUN03

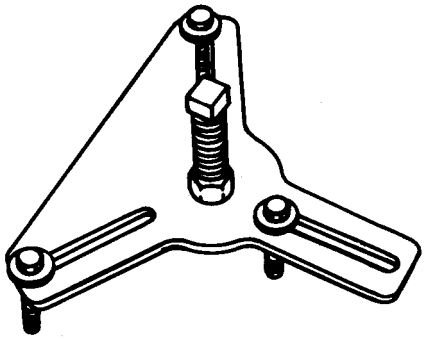
JDG1660

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RG41183,0000031 -19-09JAN07-7/11

Seal and Wear Sleeve Remover JDG698A

Remove unitized crankshaft rear oil seal and wear sleeve.



RG5631 —UN—12APR90

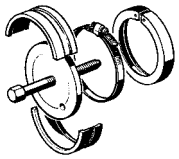
JDG698A

RG41183,0000031 -19-09JAN07-8/11

Rear Crankshaft Oil Seal/Wear Sleeve Puller JDG645E

Remove rear oil seal/wear sleeve from crankshaft flange.

CD30241 —UN—08MAR95

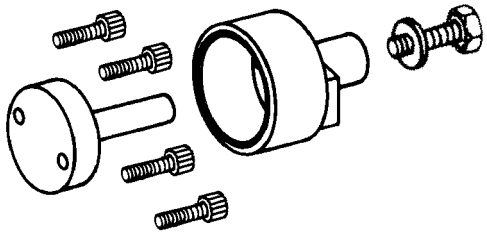


JDG645E

RG41183,0000031 -19-09JAN07-9/11

Rear Oil Seal/Wear Sleeve Installer Set..... JT30040B or KCD10002A

Install crankshaft rear oil seal/wear sleeve assembly.



RG9122 —UN—22APR98

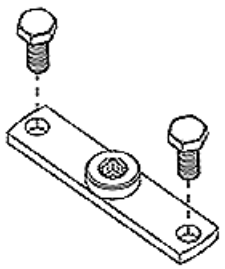
JT30040B or KCD10002A

Continued on next page

RG41183,0000031 -19-09JAN07-10/11

Engine Turning Tool.....JJDG10221

Used to rotate engine crankshaft and/or camshaft to specific locations.



RG15105 —UN—01SEP06

JDG10221

RG41183,0000031 -19-09JAN07-11/11

Group 040 — Crankshaft, Main Bearings and Flywheel Service Equipment and Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC). Some tools may be available from a local supplier.

SERVICEGARD is a trademark of Deere & Company

RG41183,0000032 -19-09JAN07-1/4

Bushing, Bearing and Seal Driver Set..... D01045AA — Install pilot bearing in flywheel.

RG41183,0000032 -19-09JAN07-2/4

Pulling Attachment..... D01218AA — Use with D01200AA Push Puller to remove crankshaft gear from crankshaft.

RG41183,0000032 -19-09JAN07-3/4

Push Puller..... D01200AA — Use with D01218AA to remove crankshaft gear from crankshaft.

RG41183,0000032 -19-09JAN07-4/4

Group 040 — Crankshaft, Main Bearings and Flywheel Other Materials

Number	Name	Use
TY16285 (U.S.) CXTY16285 (Canadian) 7649 (LOCTITE®)	Cure Primer	Used to clean nose of crankshaft for damper installation.
	Brake Kleen or Ignition Cleaner	Remove sealant from crankshaft flange.
	PLASTIGAGE®	Check main bearing-to-crankshaft journal oil clearance.
PM710XX280 (Hylomar 101) (U.S.)	Silicone Sealant	Gasket

LOCTITE is a trademark of Loctite Corp.
PLASTIGAGE is a registered trademark of DANA Corp.

RG41183,0000033 -19-09JAN07-1/1

Group 050 — Camshaft and Timing Gear Train Essential Tools

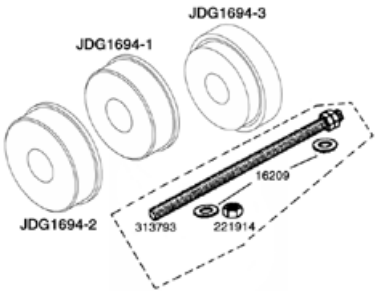
NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC). Some tools may be available from a local supplier.

SERVICEGARD is a trademark of Deere & Company

RG41183,0000034 -19-22JUL09-1/3

Camshaft Bushing Driver..... JDG1694

Use to remove and install to specification the camshaft bushings. Pilots are designed to protect bushings during installation. 313793 Forcing Screw Assembly can be used from JDG968 or ordered if not available.



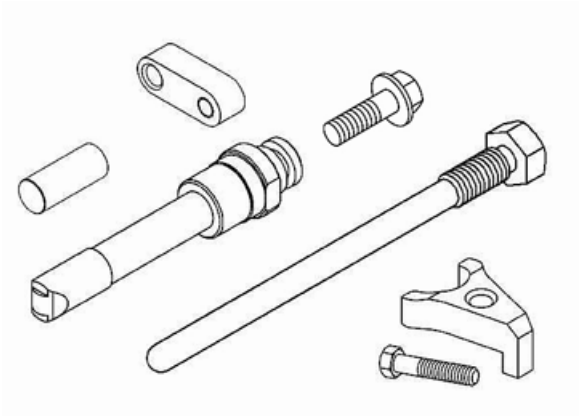
JDG1694

Continued on next page

RG41183,0000034 -19-22JUL09-2/3

Engine Timing Set JDG1700

Used to position camshaft while installing camshaft gear



RG13710A —UN—22JUL09

JDG1700

RG41183,0000034 -19-22JUL09-3/3

Group 060 — Lubrication System Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

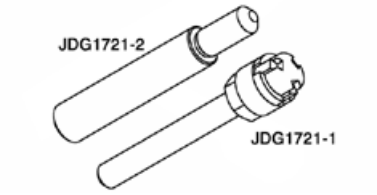
SERVICEGARD is a trademark of Deere & Company

RG41183,000003E -19-29SEP04-1/6

Oil Pressure Regulator Valve Installer..... JDG1721

Use to install oil pressure regulating valve body to specification and install cap.

RG13010 —UN—19JUN03

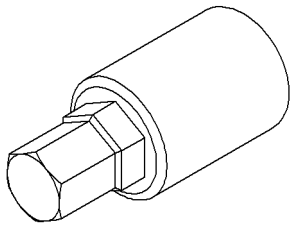


JDG1721

RG41183,000003E -19-29SEP04-2/6

Oil Filter Adapter Socket..... JDG1702

Used to remove oil filter nipple, allowing the oil cooler to be removed.



RG13031 —UN—01JUL03

JDG1702

Continued on next page

RG41183,000003E -19-29SEP04-3/6

Dipstick Driver JDG1658

Install dipstick tube in block.



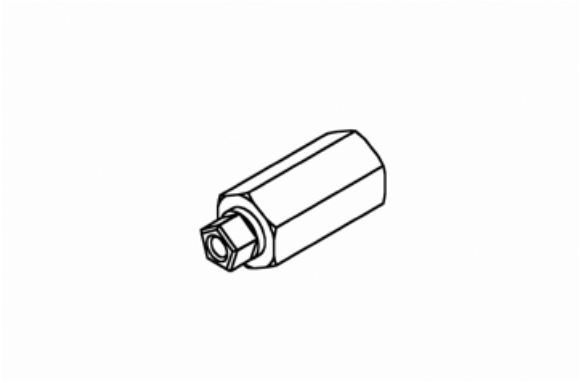
RG12997 —UN—19JUN03

JDG1658

RG41183,000003E -19-29SEP04-4/6

Cold Start Advance Plug Socket Adapter..... JDG1755

Use to remove and install tamper-proof cold advance plug



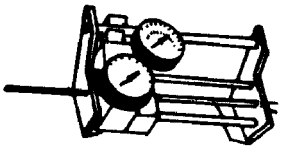
RG13756 —UN—28SEP04

JDG1755

RG41183,000003E -19-29SEP04-5/6

Spring Compression Tester D01168AA

Test oil pressure regulating valve spring compression.



RG5061

RG5061 —UN—05DEC97

D01168AA

RG41183,000003E -19-29SEP04-6/6

Group 070 — Cooling 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 tools may be available from a local supplier.

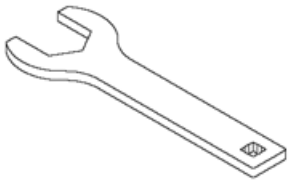
SERVICEGARD is a trademark of Deere & Company

Continued on next page

RG19661,000017C -19-09JAN07-1/2

Wrench Adapter..... JDG10409

Use to remove and install the fan bearing bushing assembly to the proper specification.



RG15104 —UN—01SEP06

JDG10409

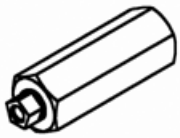
RG19661,000017C -19-09JAN07-2/2

Group 090 — Fuel Injection System Essential Tools

RG19661,000006B -19-26JAN06-1/10

Aneroid Cap Screw Socket Adapter..... JDG1791

Used to remove tamper-proof screw



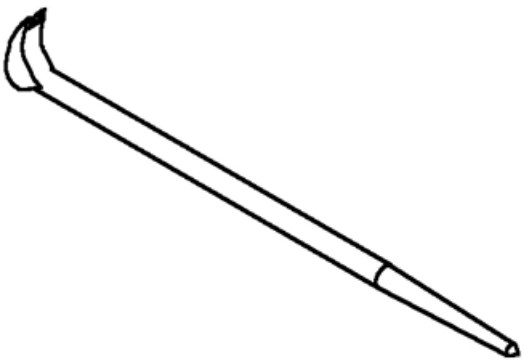
RG13759 —UN—29SEP04

JDG1791

RG19661,000006B -19-26JAN06-2/10

Injection Nozzle Puller..... JDG1822

Pull injection nozzle from cylinder head



RG13713 —UN—10SEP04

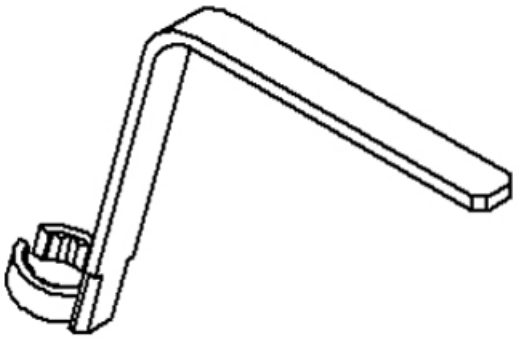
Fuel Injection Nozzle Puller

Continued on next page

RG19661,000006B -19-26JAN06-3/10

Pump Wrench..... JDG1854

Use to rotate and position fuel pumps



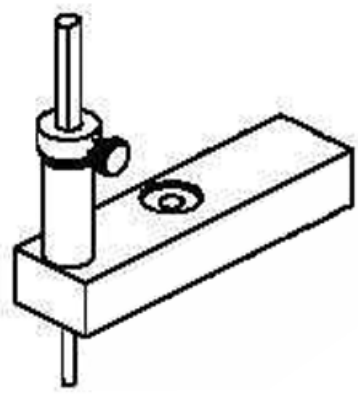
RG13711 —UN—10SEP04

Pump Wrench

RG19661,000006B -19-26JAN06-4/10

Fuel Control Rack Measuring Tool JDG2073

Use to measure fuel control rack travel



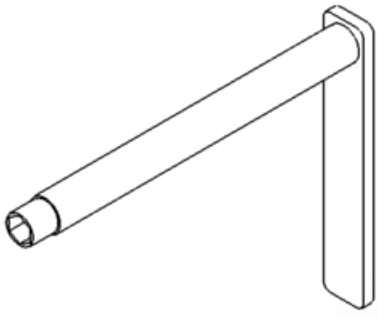
RG14489 —UN—20SEP05

Fuel Control Rack Measuring Tool

RG19661,000006B -19-26JAN06-5/10

Full Load Stop Screw Socket Wrench JDG10038

Use to access the full load stop screw lock nut



RG14497 —UN—21SEP05

Full Load Stop Screw Socket Wrench

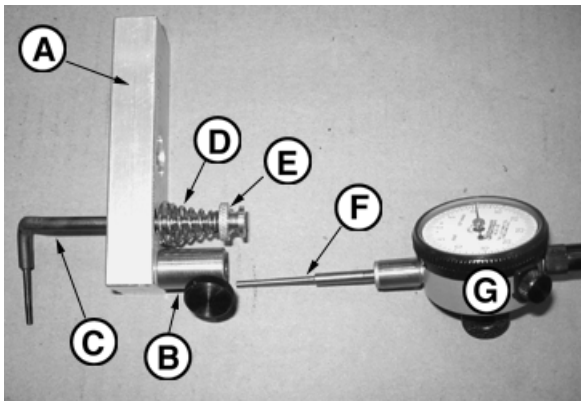
Continued on next page

RG19661,000006B -19-26JAN06-6/10

Fuel Control Rack Tool with Dial Indicator..... JDG10245

Use to set and synchronize fuel injection pumps

A—Base
B—Gauge Bushing
C—Retaining Pin
D—Tapered Spring
E—Knurled Nut
F—Dial Indicator Extension
G—Dial Indicator



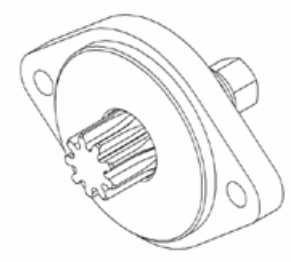
RG14615 —UN—30NOV05

Fuel Control Rack Tool with Dial Indicator

RG19661,000006B -19-26JAN06-7/10

Flywheel Turning Tool..... JDG1704

Used to rotate engine flywheel positioning crankshaft and/or camshaft to specific locations.



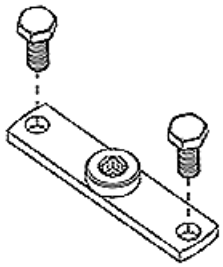
RG13004 —UN—19JUN03

JDG1704

RG19661,000006B -19-26JAN06-8/10

Engine Turning Tool..... JDG10221

Used to rotate engine crankshaft and/or camshaft to specific locations.



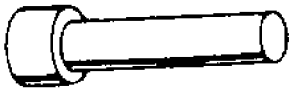
RG15105 —UN—01SEP06

JDG10221 Turning Tool

RG19661,000006B -19-26JAN06-9/10

Timing Pin.....JDE81-4

Used to lock engine/flywheel.



RG5068

RG5068 —UN—05DEC97

Timing Pin

RG19661,000006B -19-26JAN06-10/10

Base Engine Diagnostic Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

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RG41183,000003B -19-17MAR09-1/8

Compression Test Adapter JDG1687

To check cylinder compression pressure on 2.4 L & 3..0 L diesel engines

RG41183,000003B -19-17MAR09-2/8

Cylinder Leak-Down Test Kit JDG10854

Used to diagnose in-cylinder leakage associated with loss of compression.



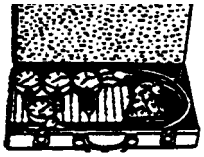
RG16890 —UN—13MAR09

RG41183,000003B -19-17MAR09-3/8

Universal Pressure Test Kit .....JT05470 (D15027NU or FKM10002)

Used to check engine oil pressure.

RG5162 —UN—23AUG88



JT05470

Continued on next page

RG41183,000003B -19-17MAR09-4/8

Cooling System Pressure Pump..... D05104ST

Used to pressure test radiator cap and cooling system.



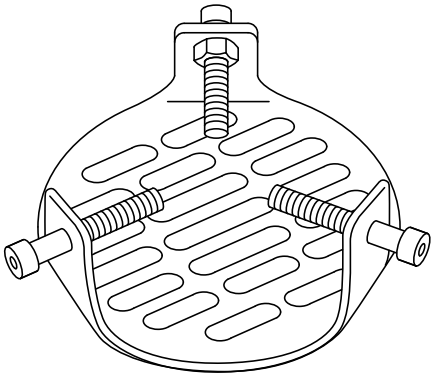
R26406N —UN—29NOV88

D05104ST

RG41183,000003B -19-17MAR09-5/8

Turbocharger Shield JDG576

Cover turbocharger inlet when testing engine with air filter system removed.



RG15521 —UN—25SEP07

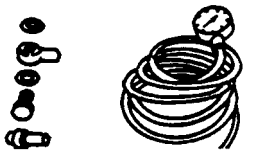
Turbocharger Shield

RG41183,000003B -19-17MAR09-6/8

Manifold Pressure Tester..... JDE147 or FKM10002

Used to test intake manifold pressure on turbocharged engines.

RG5163 —UN—23AUG88



JDE147

RG41183,000003B -19-17MAR09-7/8

Air Regulator with Gauge

Pressurize wastegate actuator to test operation of wastegate.

RG41183,000003B -19-17MAR09-8/8

Fuel System Observable Diagnostic Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

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RG41183,0000048 -19-07JUL03-1/3

Pressure Gauge 0—200 kPa (0—2 bar) (0—30 psi), Hose and Fittings. JT05470

JT05470 Universal Pressure Test Kit or any other suitable equipment.

Measure transfer pump pressure in rotary injection pump systems. Assemble test equipment from

RG41183,0000048 -19-07JUL03-2/3

Noncontact Temperature Measuring Gun.....JT07254

Spots heat problems early in your electrical and mechanical systems.

RG41183,0000048 -19-07JUL03-3/3

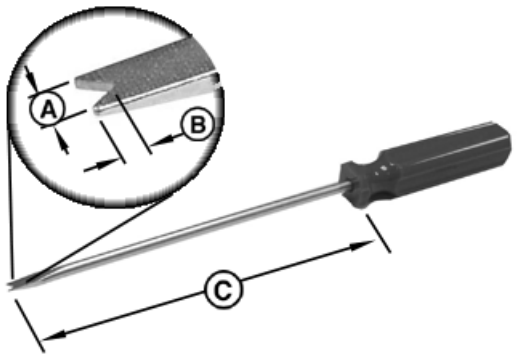
How to Make Tools

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

RG,199,JW7719 -19-13SEP04-1/1

DFRG7 — Notched Screwdriver Spring Tool

A—3 mm (0.16 in.)
B—2 mm (0.12 in.)
C—152 mm (6.00 in.) Minimum



RG13703 —UN—13SEP04

Notched Screwdriver Spring Tool

RG19661,000006F -19-14SEP04-1/1

Section 06
Specifications

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Electronic Governor Specifications 06-210-1
Glow Plug Specifications 06-210-2

General OEM Engine Specifications—2.4 L Engines

NOTE: For John Deere vehicle engines, see Machine Technical Manual.

Item	Engine	
	4024TF270	4024TF220 (GenSet)
Number of Cylinders	4	4
Bore	86 mm (3.39 in.)	86 mm (3.39 in.)
Stroke	105 mm (4.13)	105 mm (4.13)
Displacement	2.4 L (149 cu. in.)	2.4 L (149 cu. in.)
Compression Ratio	18.01:1	18.01:1
Max. Crank Pressure	0.5 kPa (2 H_2O)	0.5 kPa (2 H_2O)
Governor Regulation	7—10 %	3—5 %
Oil Pressure At Rated Speed, Full Load (±15 psi)	345 kPa (50 psi)	345 kPa (50 psi)
Oil Pressure At Low Idle (Minimum)	105 kPa (15 psi)	105 kPa (15 psi)
Length	541 mm (21.3 in.)	541 mm (21.3 in.)
Width	514 mm (20.2 in.)	514 mm (20.2 in.)
Height	810 mm (31.9 in.)	810 mm (31.9 in.)
Weight	237 kg (522 lb)	237 kg (522 lb)

NOTE: Engine models listed with numbers ending in “270” are standard industrial engines while engines with numbers ending in “220” are generator (standby) units. Engines with suffix “T” are turbocharged.

RG41183,000005B -19-07SEP07-1/1

General OEM Engine Specifications—3.0 L Engines

Item	Engine			
	5030TF270	5030HF270	5030TF220 (GenSet)	5030HF220 (GenSet)
Number of Cylinders	5	5	5	5
Bore	86 mm (3.39 in.)	86 mm (3.39 in.)	86 mm (3.39 in.)	86 mm (3.39 in.)
Stroke	105 mm (4.13 in.)	105 mm (4.13 in.)	105 mm (4.13 in.)	105 mm (4.13 in.)
Displacement	3.0 L (186 cu. in.)	3.0 L (186 cu. in.)	3.0 L (186 cu. in.)	3.0 L (186 cu. in.)
Compression Ratio	18.0:1	18.0:1	18.0:1	18.0:1
Max. Crank Pressure	0.5 kPa (2 H_2O)	0.5 kPa (2 H_2O)	0.5 kPa (2 H_2O)	0.5 kPa (2 H_2O)
Governor Regulation	7—10 %	7—10 %	3—5 %	3—5 %
Oil Pressure At Rated Speed, Full Load (±15 psi)	345 kPa (50 psi)	345 kPa (50 psi)	345 kPa (50 psi)	345 kPa (50 psi)
Oil Pressure At Low Idle (Minimum)	105 kPa (15 psi)	105 kPa (15 psi)	105 kPa (15 psi)	105 kPa (15 psi)
Length	638 mm (25.1 in.)	638 mm (25.1 in.)	638 mm (25.1 in.)	638 mm (25.1 in.)
Width	514 mm (20.2 in.)	514 mm (20.2 in.)	514 mm (20.2 in.)	514 mm (20.2 in.)
Height	810 mm (31.9 in.)	810 mm (31.9 in.)	810 mm (31.9 in.)	810 mm (31.9 in.)
Weight	232 kg (511 lb)	237 kg (522 lb)	232 kg (511 lb)	237 kg (522 lb)

NOTE: Engine models listed with numbers ending in “270” are standard industrial engines while engines with numbers ending in “220” are generator (standby) units. Engines with suffix “T” are turbocharged while engines with suffix “H” are turbocharged and aftercooled.

RG41183,0000068 -19-19MAY04-1/1

Engine Power Rating and Speed Specifications

NOTE: Specifications are subject to change. Refer to factory DTAC for assistance.

Engine speeds listed are as preset to factory specification. In some 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.

POWER RATINGS ON DYNAMOMETER FOR OEM ENGINES

Engine Model	Fuel System Option Code	Engine Application	Slow Idle (rpm)	Fast Idle (rpm)	Rated Speed at Full Load (rpm)	Power Rating kW (HP)[a]
4024DF270	1602	Industrial	900	3000	2800	37 (49)
4024TF270	1601	Industrial	900	3000	2800	45 (60)
4024TF270	1603	Industrial	900	3000	2800	49 (66)
5030TF270	1604	Industrial	900	3000	2800	56 (75)
5030TF270	1605	Industrial	900	3000	2800	63 (84)
5030HF270	1606	Industrial	900	3000	2800	74 (99)

[a] *Power rating is under full load and at rated speed listed*

RG41183,0000069 -19-30SEP04-1/1

Engine Crankcase Oil Fill Quantities

To determine the option code for the oil fill quantity of your engine, refer to the engine option code label affixed to the rocker arm cover. The first two digits of the code (19) identify the oil pan option group. The last two digits of each code identify the specific oil pan on your engine.

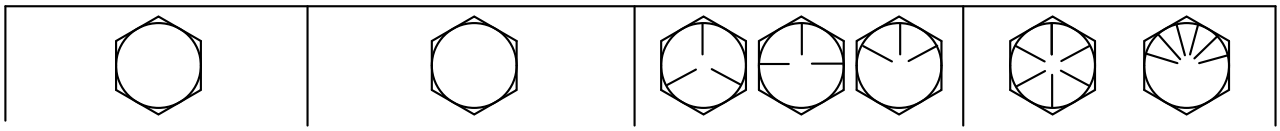
The following table lists engine crankcase oil fill quantities for each “19__” option code for these engines.

Engine Model	Option Code	Crankcase Oil Capacity L (qt)
4024	1901	6.5 (7)
5030	1902	10 (11)

RG41183,000006A -19-21JAN03-1/1

Unified Inch Bolt and Screw Torque Values

TS1671 —UN—01MAY03



Bolt or	SAE Grade 1				SAE Grade 2[a]				SAE Grade 5, 5.1 or 5.2				SAE Grade 8 or 8.2			
Screw	Lubricated[b]		Dry[c]		Lubricated[b]		Dry[c]		Lubricated[b]		Dry[c]		Lubricated[b]		Dry[c]	
Size	N·m	lb.-in.	N·m	lb.-in.	N·m	lb.-in.	N·m	lb.-in.	N·m	lb.-in.	N·m	lb.-in.	N·m	lb.-in.	N·m	lb.-in.
1/4	3.7	33	4.7	42	6	53	7.5	66	9.5	84	12	106	13.5	120	17	150
													N·m	lb.-ft.	N·m	lb.-ft.
5/16	7.7	68	9.8	86	12	106	15.5	137	19.5	172	25	221	28	20.5	35	26
									N·m	lb.-ft.	N·m	lb.-ft.				
3/8	13.5	120	17.5	155	22	194	27	240	35	26	44	32.5	49	36	63	46
			N·m	lb.-ft.	N·m	lb.-ft.	N·m	lb.-ft.								
7/16	22	194	28	20.5	35	26	44	32.5	56	41	70	52	80	59	100	74
	N·m	lb.-ft.														
1/2	34	25	42	31	53	39	67	49	85	63	110	80	120	88	155	115
9/16	48	35.5	60	45	76	56	95	70	125	92	155	115	175	130	220	165
5/8	67	49	85	63	105	77	135	100	170	125	215	160	240	175	305	225
3/4	120	88	150	110	190	140	240	175	300	220	380	280	425	315	540	400
7/8	190	140	240	175	190	140	240	175	490	360	615	455	690	510	870	640
1	285	210	360	265	285	210	360	265	730	540	920	680	1030	760	1300	960
1-1/8	400	300	510	375	400	300	510	375	910	670	1150	850	1450	1075	1850	1350
1-1/4	570	420	725	535	570	420	725	535	1280	945	1630	1200	2050	1500	2600	1920
1-3/8	750	550	950	700	750	550	950	700	1700	1250	2140	1580	2700	2000	3400	2500
1-1/2	990	730	1250	930	990	730	1250	930	2250	1650	2850	2100	3600	2650	4550	3350

Torque values listed are for general use only, based on the strength of the bolt or screw. DO NOT use these values if a different torque value or tightening procedure is given for a specific application. For plastic insert or crimped steel type lock nuts, for stainless steel fasteners, or for nuts on U-bolts, see the tightening instructions for the specific application. Shear bolts are designed to fail under predetermined loads. Always replace shear bolts with identical grade.

Replace fasteners with the same or higher grade. If higher grade fasteners are used, tighten these to the strength of the original. Make sure fastener threads are clean and that you properly start thread engagement. When possible, lubricate plain or zinc plated fasteners other than lock nuts, wheel bolts or wheel nuts, unless different instructions are given for the specific application.

[a] Grade 2 applies for hex cap screws (not hex bolts) up to 6. in (152 mm) long. Grade 1 applies for hex cap screws over 6 in. (152 mm) long, and for all other types of bolts and screws of any length.

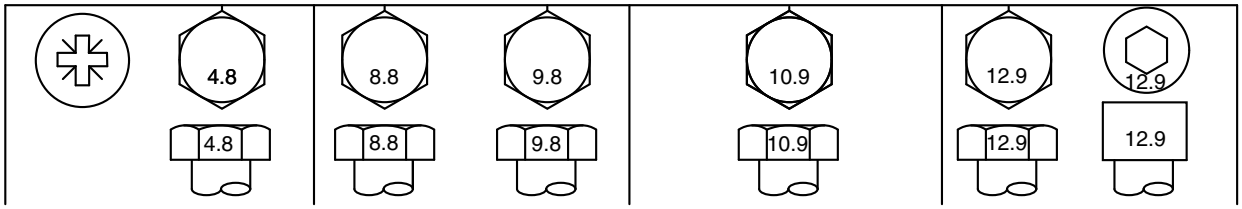
[b] “Lubricated” means coated with a lubricant such as engine oil, fasteners with phosphate and oil coatings, or 7/8 in. and larger fasteners with JDM F13C zinc flake coating.

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

DX,TORQ1 -19-08DEC09-1/1

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 -19-08DEC09-1/1

Engine Rebuild Specifications

Item	Measurement	Specification
D05226ST Special Adapter-to-Mounting Hub SAE Grade 8 Socket Head Cap Screws.	Torque	600 N·m (450 lb-ft)
JDG1676 Engine Adapter-to-Special Adapter SAE Grade 8 Cap Screws.	Torque	135 N·m (100 lb-ft)

RG41183,0000065 -19-26SEP07-1/1

Cylinder Head and Valves Specifications

Item	Measurement	Specification
Unit Pump Clamp	Torque	50 N•m (37 lb-ft)
Glow Plug	Torque	13 N•m (9 lb-ft)
Glow Plug Wire Harness Nut	Torque	3.5 N•m (31 lb-in.)
Cylinder Head Cap Screw/Glow Plug Wire Harness	Torque	28 N•m (21 lb-ft)
Intake Valve	Recess in Cylinder Head	0.72—1.48 mm (0.028—0.058 in.)
Exhaust Valve	Recess in Cylinder Head	0.72—1.48 mm (0.028—0.058 in.)
Spring Free Length 0 N (0 lb-force)[1]	Height	46.2 mm (1.818 in.)
Spring Compressed 166 N (37 lb-force)	Height	37.2 mm (1.46 in.)
Spring Compressed 356 N (80 lb-force)	Height	27.0 mm (1.06 in.)
Intake Valve Head	OD	36.87—37.13 mm (1.452—1.462 in.)
Exhaust Valve Head	OD	33.87—34.13 mm (1.333—1.344 in.)
Intake Valve Stem	OD	6.987—7.013 mm (0.2751—0.2761 in.)
Exhaust Valve Stem	OD	6.974—7.000 mm (0.2746—0.2755 in.)
Valve Face	Maximum Runout (Intake and Exhaust)	0.038 mm (0.0015 in.)
Valves	Face Angle	29.25° ± 0.25°
Initial Cylinder Head Cap Screw (4-cylinder)	Torque	110 N•m (81 ft-lb)
Final Cylinder Head Cap Screws No.1 - No.8 (4-cylinder)	Torque	70 N•m (52 ft-lb) plus 150° +10/-0
Final Cylinder Head Cap Screws No.9 - No.10 (4-cylinder)	Torque	70N•m (52 ft-lb) plus 120° +10°/-0°
Initial Cylinder Head Cap Screw (5-cylinder)	Torque	110 N•m (81 ft-lb)
Final Cylinder Head Cap Screws No.1 - No.10 (5-cylinder)	Torque	70 N•m (52 ft-lb) plus 150° +10°/-0°
Final Cylinder Head Cap Screws No.11 - No.12 (5-cylinder)	Torque	70N•m (52 ft-lb) plus 120° +10°/-0°
Unit Pump Clamp	Torque	50 N•m (37 lb-ft)
Top of valve spring retainer to cylinder head	Height	37.0 mm (1.46 in.) minimum
Rocker Arm Capscrew	Torque	40 N·m (30 lb-ft)

[1]Free length may vary slightly between valve springs.

RG41183,000005C -19-12OCT04-1/1

Cylinder Block, Liners, Pistons, and Rods Specifications

Item	Measurement	Specification
Piston Ring-to-Groove Clearance—New Piston Ring (First Compression Ring Groove)	Maximum Clearance	0.12 mm (0.005 in.)
Piston Ring-to-Groove Clearance—New Piston Ring (Second Compression Ring Groove)	Maximum Clearance	0.098 mm (0.004 in.)
Piston Ring-to-Groove Clearance—New Piston Ring (Third Oil Control Ring Groove, Standard Ring)	Maximum Clearance	0.09 mm (0.004 in.)
Piston Pin Bore	ID	30.003—30.009 mm (1.1812—1.1815 in.)
Piston Skirt (Measurement Taken at Bottom of Skirt 12 mm (0.5 in.) from Bottom of Piston)	Diameter	85.876—85.908 mm (3.381—3.382 in.)
Piston — Turbocharged Engines	Height	53.415—53.465 mm (2.103—2.105 in.)
Cylinder Bore	ID	85.987—86.013 mm (3.385—3.386 in.)
Piston-to-Cylinder Bore Clearance (Measured at Bottom of Piston Skirt)	Clearance	0.079—0.137 mm (0.003—0.005 in.)
Crankshaft Journal	OD	59.987—60.013 mm (2.361—2.363 in.)
Assembled Rod Bearing	ID	60.030—60.073 mm (2.363—2.365 in.)
Connecting Rod Bearing-to-Journal Minimum	Clearance	0.017 mm (0.001in.)
Maximum	Clearance	0.086 mm (0.003 in.)
Connecting Rod Bore (Without Bearing Inserts)	ID	63.437—63.463 mm (2.498—2.499 in.)
Piston Pin	OD	29.994—30.000 mm (1.1809—1.1811 in.)
	OD Wear Limit	29.980 mm (1.1808 in.)
Piston Pin	Length	67.75—68.00 mm (2.667—2.677 in.)
Rod Bearing Bore-to-Piston Pin Bushing Bore (Center-to-Center)	Measurement	170 mm (6.69 in.)
Plug (Oil Gallery)	Torque	15 N·m (11 lb-ft)
Camshaft Follower Bore in Block	ID	21.428—21.454 mm (0.8436—0.8446 in.)
Camshaft Follower (New)	OD	21.392—21.404 mm (0.8422—0.8427 in.)
Connecting Rod Cap Screws	Initial Torque	35 N·m (18 lb-ft)
Connecting Rod Cap Screws	Torque-Turn	1/4 Turn (90—100°) After Initial Torque

RG41183,000005D -19-12OCT09-1/1

Crankshaft, Main Bearings, and Flywheel Specifications

Item	Measurement	Specification
Damper	Maximum Radial Runout (Concentricity)	1.00 mm (0.040 in.)
Damper Pulley Outer Ring	Wobble (Maximum)	1.50 mm (0.060 in.)
Damper Pulley Inner Ring	Wobble (Maximum)	0.5 mm (0.020 in.)
Starter Motor Mounting Cap Screws	Torque	80 N·m (59 lb-ft)
Initial Pulley Mounting Cap Screw	Torque	100 N·m (74 lb-ft)
Final Pulley Mounting Cap Screw	Torque Turn	50 N·m + 90° (37 lb-ft + 90°)
Crankshaft	End Play	0.089—0.396 mm (0.004—0.016 in.)
Flywheel Face Flatness	Maximum Variation	0.23 mm (0.009 in.)
Flywheel Bearing Bore Concentricity	Maximum Variation	0.127 mm (0.005 in.)
Rear Oil Seal Housing Cap Screws	Torque	17 N·m (13 lb-ft)
Crankshaft Main Bearing Cap Screws	Torque	80 N·m (59 lb-ft)
Crankshaft Main Bearing-to-Journal	Oil Clearance	0.021—0.090 mm (0.0008—0.0035 in.)
Main Bearing Cap Screws	Torque	80 N·m (59 lb-ft)
Crankshaft Main Bearing	ID	75.034—75.077 mm (2.9541—2.9558 in.)
Crankshaft Main Journal	OD	74.987—75.013 mm (2.9522—2.9533 in.)
Crankshaft Rod Journal	OD	59.987—60.013 mm (2.36170—2.3627 in.)
Crankshaft Main or Rod Journal	Maximum Taper	0.010 mm (0.0004 in.)
Crankshaft Main or Rod Journal	Maximum Out-of-Round	0.008 mm (0.0003 in.)
Crankshaft Main Thrust Bearing Journal Width	Width	31.302—31.378 mm (1.2340—1.2350 in.)
Crankshaft Main Thrust Washer	Overall Thickness	2.95—3.05 mm (0.120—0.116 in.)
Crankshaft Main Bearing Bore (Without Bearings)	ID	79.892—79.918 mm (3.1454—3.1464 in.)
Crankshaft Main Bearing Cap Screws	Torque	80 N·m (59 lb-ft)
Crankshaft	End Play	0.089—.396 mm (0.004—0.016 in.)
Initial Flywheel Housing Cap Screws	Torque	35 N·m (26 lb-ft)
Final Flywheel Housing Cap Screws	Torque	140 N·m (105 lb-ft)
Initial Flywheel Mounting Cap Screws	Torque	30 N·m (20 lb-ft)
Final Flywheel Mounting Cap Screws	Torque	110 N·m (80 lb-ft)

Continued on next page

RG41183,000005E -19-09JAN07-1/2

Item	Measurement	Specification
Balancer Shaft Weight Cap Screws	Torque	16.5 N·m (12 lb-ft)

RG41183,000005E -19-09JAN07-2/2

Camshaft, Balancer Shafts and Timing Gear Train Specifications

Item	Measurement	Specification
Camshaft	End Play	0.08—0.23 mm (0.003—0.009 in.)
Balancer Shaft	End Play	0.08—0.38 mm (0.003—0.015 in.)
Camshaft Journal	OD	55.872—55.898 mm (2.1997—2.2007 in.)
Camshaft Bore, Front No. 1(Ball Bearing)	ID	55.961—55.987 mm (2.2031—2.2042 in.)
Camshaft Bore, All Except No. 1	ID	55.986—56.012 mm (2.2042—2.2052 in.)
Camshaft Journal-to-Bushing, No. 1 Bore (With Bushing)	Oil Clearance	0.063—0.115 mm (0.0025—0.0045 in.)
Camshaft Intake Lobe	Height	7.05—7.31 mm (0.278—0.288 in.)
Camshaft Exhaust Lobe	Height	6.89—7.15 mm (0.271—0.281 in.)
Fuel Supply Pump Camshaft Lobe	Diameter	42.67—42.93 mm (1.68—1.69 in.)
Camshaft Follower	OD	31.61—31.64 mm (1.245—1.246 in.)
Camshaft Follower Bore in Block	ID	31.70—31.75 mm (1.248—1.250 in.)
Camshaft Follower-to-Bore	Clearance	0.06—0.13 mm (0.002—0.005 in.)
Balancer Shaft Bushing (New)	ID	30.038—30.104 mm (1.1826—1.1852 in.)
Balancer Shaft Journal	OD	29.987—30.013 mm (1.1806—1.1816 in.)
Balancer Shaft Journal-to-Bushing	Oil Clearance	0.025—0.117 mm (0.0009—0.0046 in.)
Cylinder Block Bore for Balancer Shaft Bushing	ID	33.500—33.526 mm (1.3189—1.3199 in.)
Balancer Shaft Thrust Plate (New)	End Play	Not to Exceed 0.45 mm (0.02 in.)

RG41183,000005F -19-30APR04-1/1

Lubrication System Specifications

Item	Measurement	Specification
Nipple	Torque	37 N•m (27 lb-ft)
Oil Pan Drain Plug	Torque	35 N·m (26 lb-ft)
Oil Pick-up Tube Support Bracket Cap Screws	Torque	28 N·m (21 lb-ft)
Oil Pick-up Tube Hold Down Clamp Cap Screw	Torque	16.5 N·m (12 lb-ft)

RG41183,0000060 -19-09JAN07-1/1

Cooling System Specifications

Item	Measurement	Specification
Coolant Temperature Sensor	Torque	15 N•m (11 lb-ft)
Belt Tensioner-to-Timing Cover and Engine Cap Screws	Torque	50 N·m (37 lb-ft)
Belt Tensioner Pulley Cap Screw	Torque	40 N·m (29 lb-ft)
Belt Tensioner	Spring Tension	18—22 N·m (13—16 lb-ft)
Standard Flow Coolant Pump Impeller Diameter	Diameter	56 mm (2.20 in.)
High Flow Coolant Pump Impeller Diameter	Diameter	70 mm (2.75 in.)
Coolant Pump-to-Timing Cover Cap Screws	Torque	40 N·m (30 lb-ft)
Fan-to-Pulley Hub M8 Cap Screws	Torque	35 N·m (26 lb-ft)
Fan-to-Pulley Hub M10 Cap Screws	Torque	70 N·m (52 lb-ft)
Fan Pulley Cap Screws	Torque	32 N·m (24 lb-ft)

RG41183,0000061 -19-09JAN07-1/1

Air Intake and Exhaust System Specifications

Item	Measurement	Specification
Turbocharger Shaft	Axial Bearing End Play	0.064—0.114 mm (0.0025—0.0045 in.)
Turbocharger-to-Exhaust Manifold Cap Screws	Torque	32 N·m (22 lb-ft)
Turbocharger Oil Return Line (Turbocharger End)	Torque	36 N·m (26 lb-ft)
Oil Return Line (Block End)	Turns	2-3 Beyond Hand Tight
Turbocharger Oil Inlet Line (Turbocharger End)	Torque	19 N•m (14 lb-ft)
Turbocharger Oil Inlet Line (Block End)	Torque	16 N•m (12 lb-ft)
Exhaust Manifold Cap Screw	Torque	32 N•m (24 lb-ft)
Rocker Arm Cover Cap Screws	Torque	12 N•m (9 lb-ft)
Aneroid line to Intake Manifold	Torque	15 N•m (11 lb-ft)

RG41183,0000062 -19-21JAN03-1/1

Starting and Charging Systems Specifications

Item	Measurement	Specification
Starter Motor	Torque	80 Ṅn (59 lb-ft)
Alternator Cap Screws	Torque	40 Ṅn (29.5 lb-ft)

RG41183,0000063 -19-09JAN07-1/1

Fuel System Specifications

Item	Measurement	Specification
Fuel Filter Bracket to Rear of Cylinder Head	Torque	40 ±4 N•m (30 lb-ft)
Fuel Filter Assembly to Fuel Filter Bracket	Torque	40 ±4 N•m (30 lb-ft)
Elbow Fitting to Outlet Port of Fuel Filter (Right Side)	Torque	20 ±2 N•m (15 lb-ft)
Straight Fitting to Inlet Port of Fuel Filter (Right Side)	Loctite	592
	Torque	20 ±2 N•m (15 lb-ft)
Hose Clamps on Fuel Lines	Torque	1.8 ±0.4 N•m (16 lb-in)
Low Pressure Fuel Pump	Torque	15 ±1.5 N•m (11 lb-ft)
Unit Pump Clamp Cap Screw	Torque	70 ±5 N•m (52 lb-ft)
Injector Clamp Cap Screw (Initial)	Torque	20 ±3 N•m (15 lb-ft)
Injector Clamp Cap Screw (Final)	Torque	35 ±3.5 N•m (26 lb-ft)
Injector Line Nut at Injector	Torque	24 ±3 N•m (18 lb-ft)
Injector Line Nut at Electronic Unit Pump	Torque	24 ±3 N•m (18 lb-ft)
Unit Pump Harness Support Bracket at Rear of Cylinder (M6 Cap Screw)	Torque	15 ±1.5 N•m (11 lb-ft)
Unit Pump Harness Connector to Cover (M5 Screws)	Loctite	222 (Purple)
	Torque	2 ±0.25 N•m (17 lb-in)
Unit Pump Harness Connector Cover to Cylinder Block (M6 Screws)	Loctite	222 (Purple)
	Torque	15 ±1.5 N•m (11 lb-ft)
Ring Terminals to Electronic Unit Pump Posts	Torque	3 ±0.5 N•m (27 lb-in)

RG41183,0000064 -19-26SEP07-1/1

Intake Manifold Pressure (Turbocharger Boost) Specifications

Turbocharger Boost Pressure					
Machine Model	**Engine Model**	**Injection Pump Part #**	**Rated Power at Full Load Rated Speed**	**Full Load Rated Speed RPM**	**Turbo Boost Pressure at Full Load Rated Speed kPa (bar) (psi) ±10%**
Augusta					
4120 Tractor	4024TLV04	RE515967	30.5 (41)	2400	52 kPa (.5) (7.5)
4320 Tractor	4024TLV01	RE515967	35 (47)	2400	62 kPa (.6) (9)
4520 Tractor	4024TLV02	RE515968	39 (52)	2400	90 kPa (.9) (13)
4720 Tractor	4024TLV03	RE515968	42 (56)	2400	100.5 kPa (1) (14.5)
Dubuque					
317 Skid Steer	4024TT001	RE515949	45.5 (61)	2800	116 kPa (1.16) (17)
320 Skid Steer	4024TT002	RE515949	49 (66)	2800	121 kPa (1.21) (17.5)
325 Skid Steer	5030TT001	RE509660	57 (76)	2800	115 kPa (1.15) (17)
328 Skid Steer	5030TT002	RE509661	61.5 (82)	2800	120 kPa (1.2) (17)
332 Skid Steer	5030HT001	RE515975	68 (91)	2800	106 kPa (1) (15)

RG41183,000009C -19-16APR04-1/1

Electronic Governor Specifications

Electronic Governor Default Settngs										
	4024TF220	4024TF220	4024TF270	4024TF281	5030TF220	5030HF220	5030TF270	5030HF270		
	20 kVa Prime @ 1500 RPM	30 kVa Prime @ 1500 RPM	30 kWe Standby @ 1800 RPM	30 kWe Standby @ 1800 RPM	40 kVa Prime @ 1500 RPM	60 kVa Prime @ 1500 RPM	50 kWe Standby @ 1800 RPM	60 kWe Standby @ 1800 RPM	Minimum	Maxi-mum
Number of Teeth	0	0	0	0	0	0	0	0	0	0
Set Speed A	3175	3175	3810	3810	3175	3175	3810	3810	10	11000
Idle Speed	500	500	500	500	500	500	500	500	10	11000
Proportional	40	40	31	31	40	47	33	34	1	99
Integral	25	25	40	40	28	30	27	29	0	99
Derivative	30	30	15	15	34	35	27	40	0	99
OVG @ SSA	40	40	67	67	24	30	38	35	1	99
OVG @ Idle Speed	20	20	20	20	20	20	20	20	1	99
Gain Factor	20	20	24	24	27	20	20	30	1	99
Speed Filter	24	24	24	24	24	16	24	16	1	24
Idle Hold Time	0	0	0	0	0	0	0	0	0	9999
Accel Rate	1000	1000	1000	1000	1000	1000	1000	1000	1	9999
Decel Rate	1000	1000	1000	1000	1000	1000	1000	1000	1	9999
Startup Rate	1000	1000	1000	1000	1000	1000	1000	1000	1	9999
Integral Low	0	0	0	0	0	0	0	0	0	50
Integral High	70	70	76	76	99	80	60	69	0	99
Overspeed Limit	100	100	100	100	100	100	100	100	0	100
Set Speed A Min	10	10	10	10	10	10	10	10	10	3810
Set Speed A Max	11000	11000	11000	11000	11000	11000	11000	11000	3810	11000
Idle Speed Min	10	10	10	10	10	10	10	10	10	500
Idle Speed Max	11000	11000	11000	11000	11000	11000	11000	11000	500	11000
Duty Cycle Limit	95	95	95	95	95	95	95	95	10	95
Startup Speed	829	829	829	829	1000	1000	1000	1000	18	11000
Startup Duty Cycle	30	30	30	30	30	30	30	30	5	95

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Glow Plug Specifications

NOTE: Preheat time has an additional 5 seconds after the indicator light turns off.

NOTE: If engine is started during preheat time, the glow plugs are turned off. Glow plugs are turned back on after engine reaches idle speed.

	-Glow Plug Operation - OEM	
Fuel Temperature	**Preheat Time**	**Reheat Time**
-20°C (-4°F)	15 seconds	10 seconds
-15°C (5°F)	15 seconds	10 seconds
-10°C (14°F)	10 seconds	10 seconds
-5°C (23°F)	5 seconds	10 seconds
0°C (32°F)	0 seconds	0 seconds

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