POWERTECH® 8.1 L 6081 Natural Gas Engines

Repair

COMPONENT TECHNICAL MANUAL

POWERTECH 8.1 L 6081 NG Engines

CTM87 27MAY04 (ENGLISH)

For complete service information also see:

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.

Use this component technical manual in conjunction with the vehicle technical manual. An application listing in the introduction identifies product-model/component type-model relationship. See the vehicle technical manual for information on component removal and installation, and gaining access to the components.

This manual contains the necessary instructions for removal, repair and installation of various engine components.

Information is organized in groups for the various components requiring service instruction. At the beginning of each group are summary listings of service tools and other materials needed to do the job. Specifications and torques are also listed at the beginning of each group.

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

Refer to the companion manuals, CTM113 (6081HFN01, HFN02, and HFN03) and CTM300 (6081HFN04 only), for diagnostics and testing of 8.1 L natural gas engine systems, including electronic engine controls.

Theory of operation for various engine systems is also covered in CTM113 (6081HFN01, HFN02, and HFN03) or CTM300 (6081HFN04 only).

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.

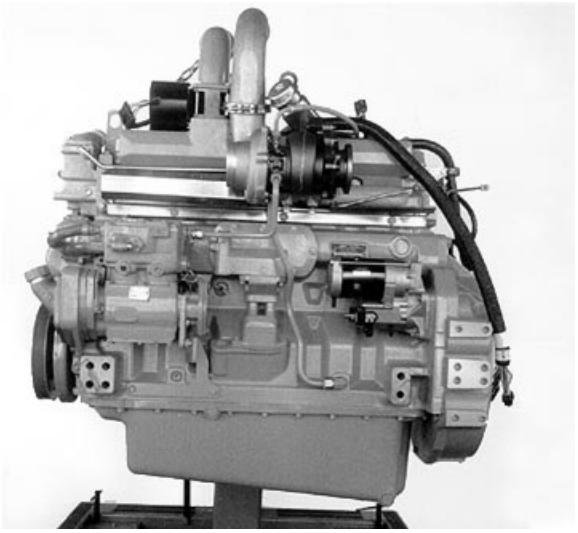
RG,CTM87,IFC –19–29MAR04–1/1

John Deere Dealers

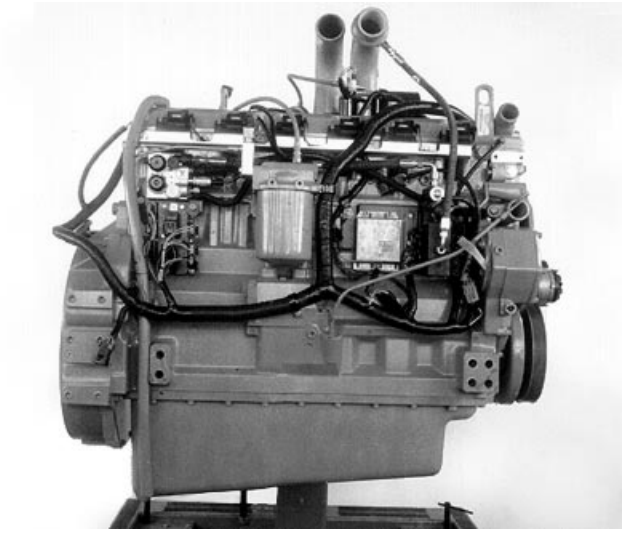
This manual has been expanded to include repair procedures both CNG and LNG versions of the 6081HFN04 engine. **Discard CTM87 dated 20Aug02 and replace with this new manual.**

OUO1083,00000CA –19–18FEB02–1/1

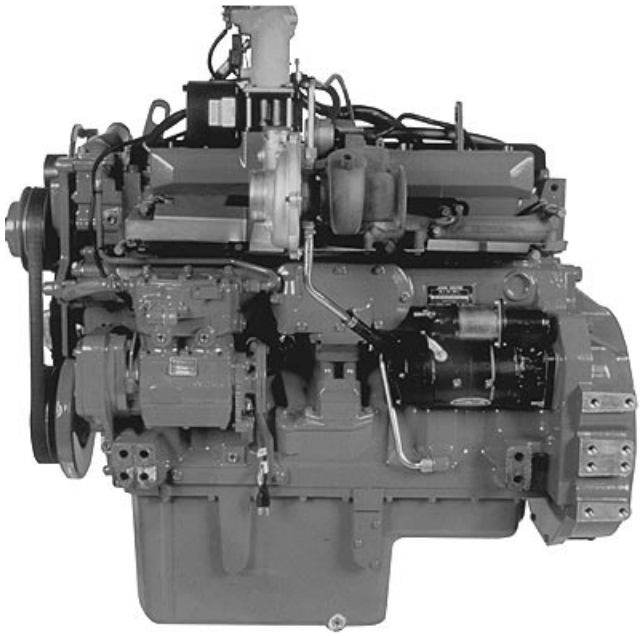
8.1 L HFN01-03 Engines (All CNG)


RG7825 –UN–05DEC97

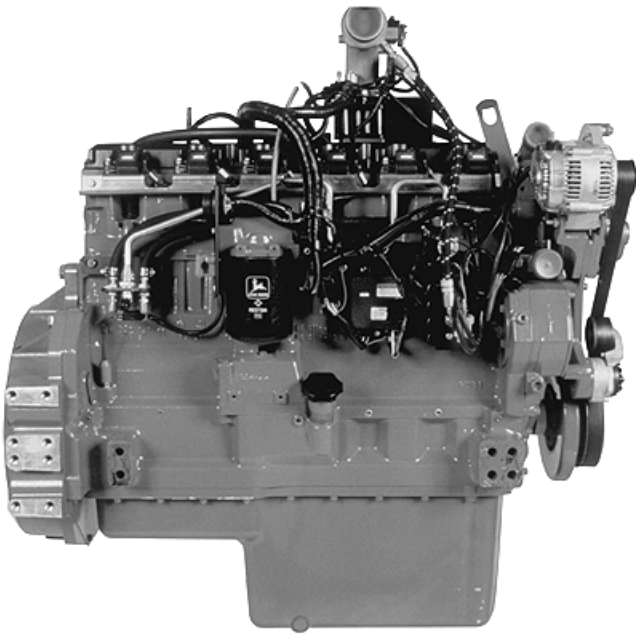
HFN01 8.1 L Natural Gas Engine—Left Side View (HFN03 Similar)


RG7826 –UN–05DEC97

HFN01 8.1 L Natural Gas Engine—Right Side View (HFN03 Similar)


RG10575 –UN–16FEB00

HFN02 8.1 L Natural Gas Engine—Left Side View


RG10574 –UN–16FEB00

HFN02 8.1 L Natural Gas Engine—Right Side View

DPSG,OUOE003,18 –19–29MAR04–1/1

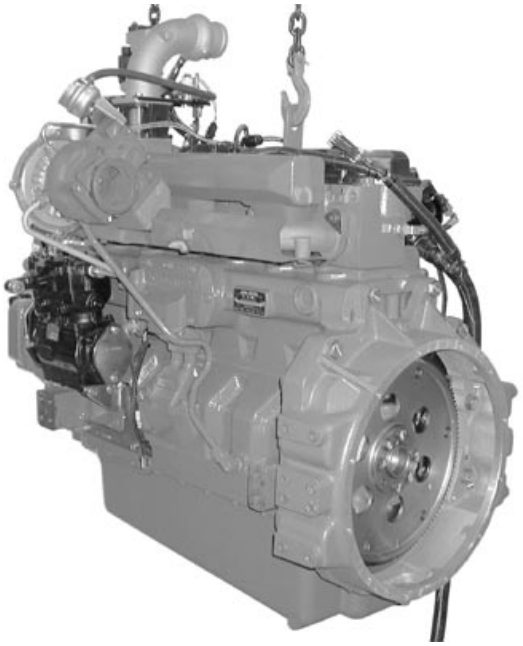
8.1 L HFN04 Natural Gas Engine (CNG Version Shown)

RG12091 –UN–21FEB02

HFN04 8.1 L Natural Gas Engine—Left Front Quarter View

RG12139A –UN–17APR02

HFN04 8.1 L Natural Gas Engine—Right Front Quarter View



RG12093 –UN–21FEB02

HFN04 8.1 L Natural Gas Engine—Left Rear Quarter View

OUO1082,0000247 –19–10MAY04–1/1

About This Manual

IMPORTANT: This manual is a complete revision of CTM87 (20Aug02). Discard your old copy of CTM87 and replace with this new manual.

This component technical manual (CTM) covers the recommended repair procedure for 6081HFN, 8.1 L (496 cu. in.) Compressed Natural Gas (CNG) and Liquid Natural Gas (LNG) engines produced in Waterloo, Iowa.

Before beginning repair of an engine, clean the engine and mount on a repair stand. (See Group 03—Engine Mounting.)

Direction of engine crankshaft rotation in this manual is referenced facing the flywheel looking toward the vibration damper. Front of engine is vibration damper end.

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

Read each repair procedure completely before performing any service.

OUO1082,000023E –19–29MAR04–1/1

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

8.1 L Natural Gas Engine

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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

Handle Natural Gas Safely

Handle natural gas with care: it is highly flammable. DO NOT smoke while working on or around natural gas equipment.

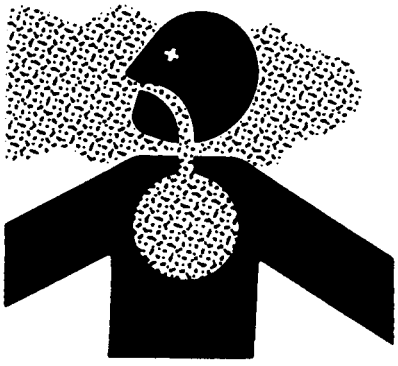
Natural gas fumes may cause sickness or death. Compressed natural gas is normally treated to with an odor producinng chemical so users will be able to detect gas leaks.**Liquid natural gas does not have an odor.** Work in well-ventilated area.

Natural Gas is stored at very high pressure. Shut off manual natural gas supply valve and relieve pressure before servicing fuel system components.

Prevent fires by keeping vehicle clean of accumulated trash, grease, and debris.

TS227 –UN–23AUG88

Avoid Fires



TS220 –UN–23AUG88

Work in Ventilated Area

DPSG,OUOE003,3504 –19–31MAY00–1/1

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Prevent Battery Explosions

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

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

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

TS204 –UN–23AUG88

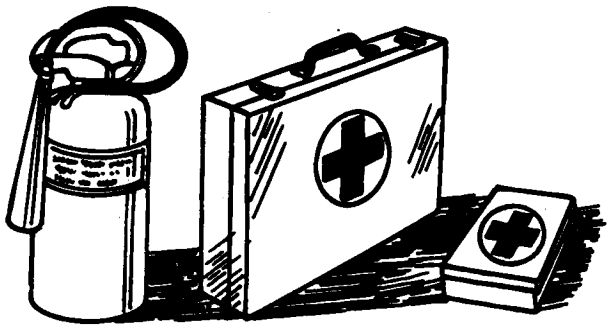
DX,SPARKS –19–03MAR93–1/1

Prepare for Emergencies

Be prepared if a fire starts.

Keep a first aid kit and fire extinguisher handy.

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



TS291 –UN–23AUG88

DX,FIRE2 –19–03MAR93–1/1

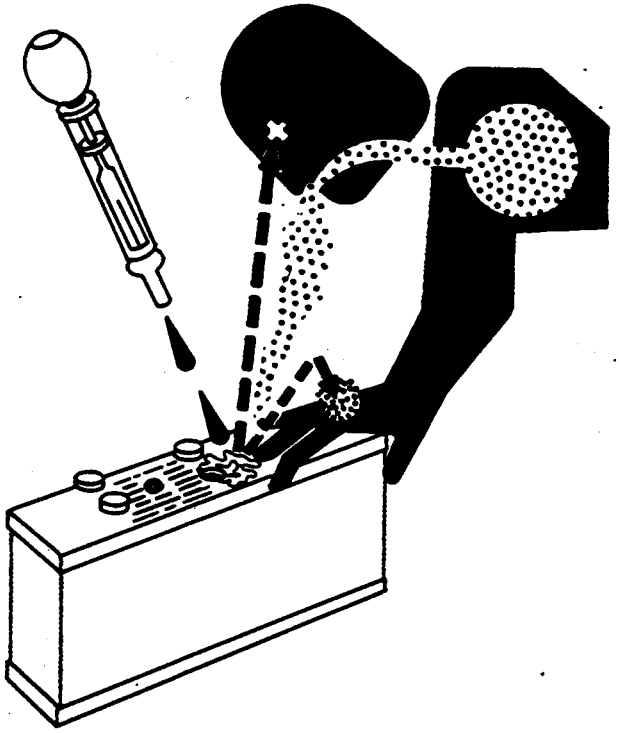
Handling Batteries Safely

TS204 –UN–23AUG88

CAUTION: Battery gas can explode. Keep sparks and flames away from batteries. Use a flashlight to check battery electrolyte level.

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

Always remove grounded (—) battery clamp first and replace it last.



TS203 –UN–23AUG88

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

Avoid the hazard by:

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

If you spill acid on yourself:

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

If acid is swallowed:

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

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

DPSG,OUO1004,2758 –19–11MAY00–1/1

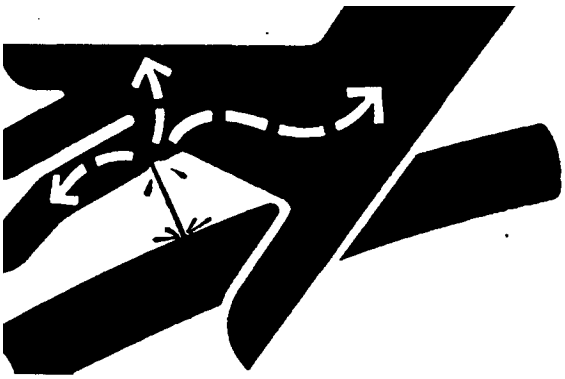
Avoid High-Pressure Fluids

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

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

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

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



X9811 –UN–23AUG88

DX,FLUID –19–03MAR93–1/1

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

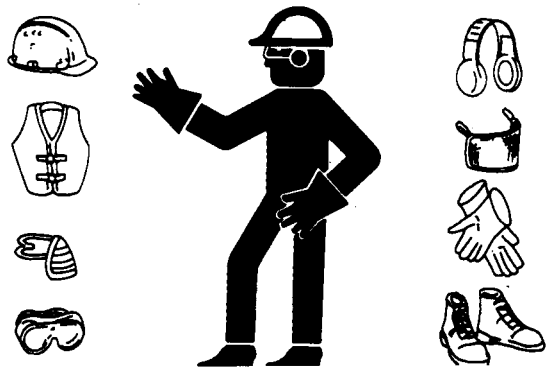
Wear Protective Clothing

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 vehicle.



TS206 –UN–23AUG88

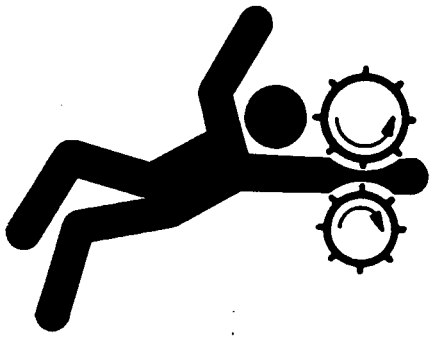
Protective Clothing

DPSG,OUO1004,2777 –19–31MAY00–1/1

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.



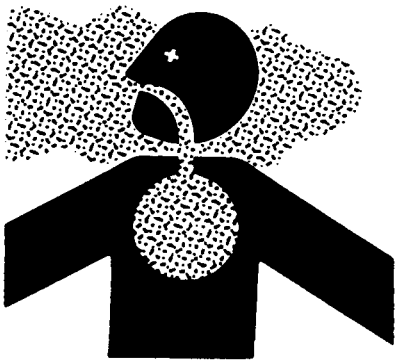
TS228 –UN–23AUG88

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

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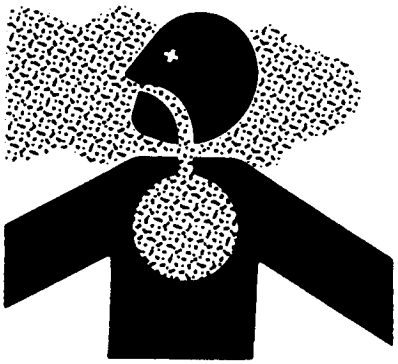
Remove Paint Before Welding or Heating



TS220 –UN–23AUG88

Avoid potentially toxic fumes and dust.

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

Remove paint before heating:

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

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

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

Dispose of paint and solvent properly.

DX,PAINT –19–24JUL02–1/1

Avoid Heating Near Pressurized Fluid Lines

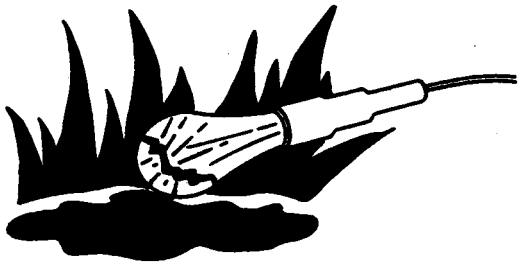
Flammable spray can be generated by heating near pressurized fluid lines, resulting in severe burns to yourself and bystanders. Do not heat by welding, soldering, or using a torch near pressurized fluid lines or other flammable materials. Pressurized lines can be accidentally cut when heat goes beyond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

TS953 –UN–15MAY90

DX,TORCH –19–03MAR93–1/1

Illuminate Work Area Safely

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



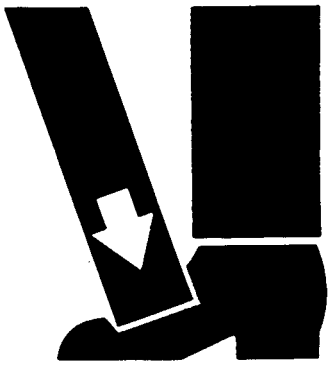
TS223 –UN–23AUG88

DX,LIGHT –19–04JUN90–1/1

Use Proper Lifting Equipment

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

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



TS226 –UN–23AUG88

Use Proper Lifting Equipment

RG,00,SO130 –19–19JAN98–1/1

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Practice Safe Maintenance

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

Never lubricate, service, or adjust vehicle 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 vehicle to cool.

Securely support any vehicle 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.

Disconnect battery ground cable (—) before making adjustments on electrical systems or welding on vehicle.

TS218 –UN–23AUG88

Practice Safe Maintenance

RG,00,SO129 –19–19JAN98–1/1

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.

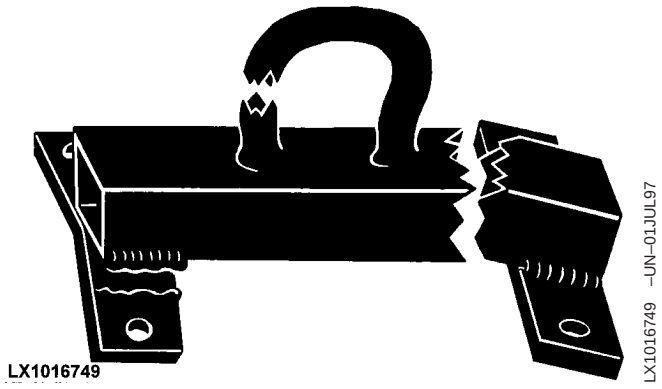
TS779 –UN–08NOV89

DX,REPAIR –19–17FEB99–1/1

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

Dispose of Waste Properly

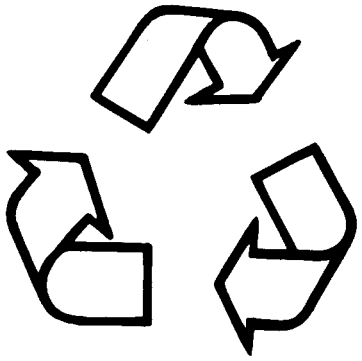
Improperly disposing of waste can threaten the environment and ecology. Potentially harmful waste used with John Deere equipment include such items as oil, fuel, coolant, brake fluid, filters, and batteries.

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.



DX,DRAIN –19–03MAR93–1/1

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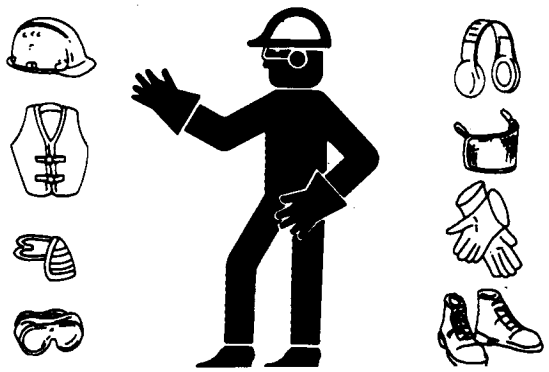
Service Natural Gas (CNG) Systems Safely

Improper installation, service, or operation of CNG and LNG storage and delivery components can result in fire, explosion, and/or serious injury.

See FUEL PRESSURE LEAK-OFF PROCEDURE in Group 35 of this manual before servicing the fuel system.

Relieve CNG or LNG fuel system pressure before working on the system. Properly tighten connections and check for leaks before pressurizing the fuel system.



TS206 –UN–23AUG88

Protective Clothing and Equipment

RG,01,DT7010 –19–29MAR04–1/1

Protect Against High Pressure

Natural gas fuel systems operate at high pressures. DO NOT disassemble or remove any CNG or LNG fuel system components under pressure. Explosive separation of components, and escaping natural gas can cause serious injury.

Relieve fuel system pressure before disconnecting any fuel system component.

TS265 –UN–23AUG88

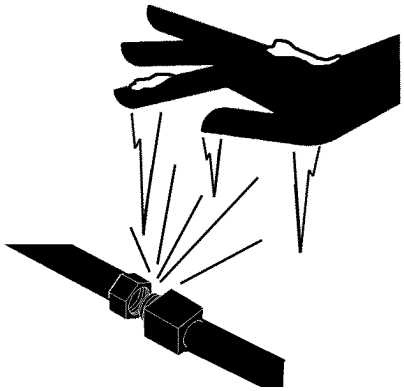
Protect Against High Pressure

RG,01,DT7009 –19–29MAR04–1/1

Protect Against Extremely Cold CNG/LNG Leakage

Gas escaping from the CNG or LNG fuel system is very cold. Frostbite and skin damage can occur from contact with cold escaping gas or surrounding components.

Inspect for leaks by spraying a soap and water solution on joints, fittings, and other areas. Look for bubbles that indicate leakage from the system.



RG8110 –UN–20AUG98

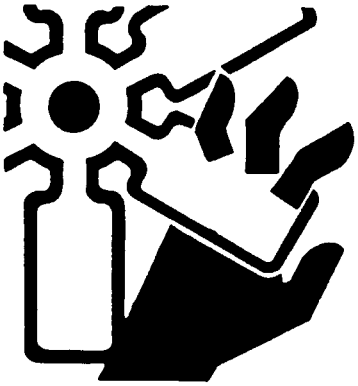
Protect Against Extremely Cold CNG/LNG Leakage

RG,01,DT7008 –19–29MAR04–1/1

Install Fan Guards

Rotating cooling system fans can cause serious injury.

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



TS677 –UN–21SEP89

Rotating Fan

OUOD006,000009D –19–04DEC02–1/1

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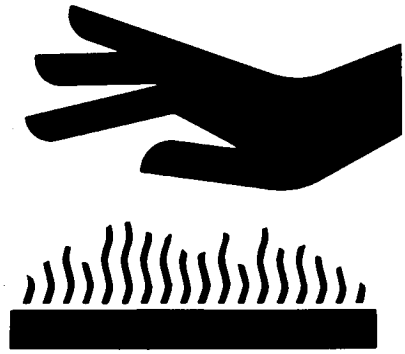
Avoid Hot Parts

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

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



TS271 –UN–23AUG88

Hot Surface

OUOD006,000009E –19–04DEC02–1/1

Live With Safety

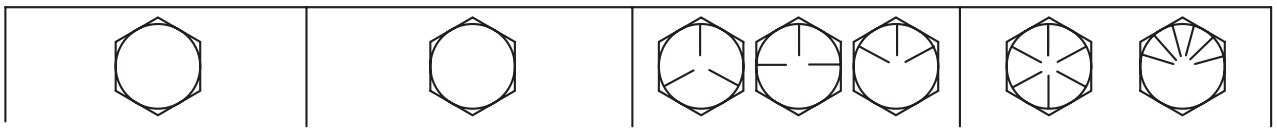
Before returning machine to customer, make sure machine is functioning properly, especially the safety systems. Install all guards and shields.

TS231 –19–07OCT88

DX,LIVE –19–25SEP92–1/1

Unified Inch Bolt and Cap 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.

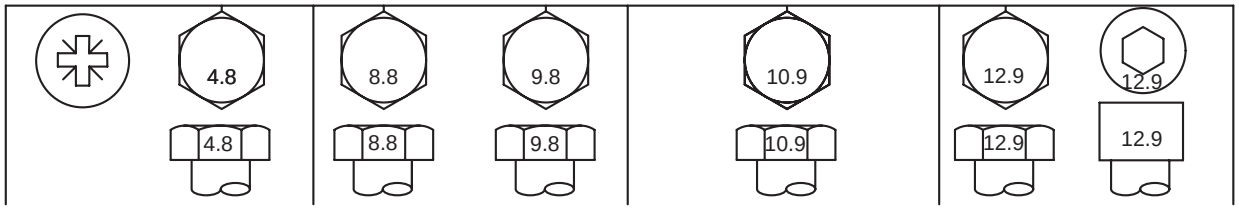
[a]Grade 2 applies for hex cap screws (not hex bolts) up to 6. in (152 mm) long. Grade 1 applies for hex cap screws over 6 in. (152 mm) long, and for all other types of bolts and screws of any length.

[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 –19–11DEC03–1/1

Metric Bolt and Cap 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 –19–11DEC03–1/1

Engine Model Designation

JOHN DEERE ENGINE MODEL 6081HFN

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

6081 HFN01 Engine	
6	Number of cylinders
8.1	Liter displacement
H	Aspiration code
FN	User code
01	OEM code
Aspiration Code	
H	Turbocharged and air-to-air aftercooled
User Code	
FN	OEM (Natural Gas)
OEM Code	
01, 02, 03, or 04	End user designation

RG,01,DT7028 –19–29MAR04–1/1

Engine Serial Number Plate Information

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

Engine Serial Number (A)

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

RG6081H000000	
RG	Factory code producing engine
6081H	Engine model designation
000000	Sequential number
Factory Code Producing Engine	
RG	Waterloo Engine Works
Engine Model Designation	
6081H	Definition explained previously. (See ENGINE MODEL DESIGNATION.)
Sequential Number	
000000	6-digit sequential number.

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

Engine Application Data (B)

The second line of information on the engine serial number plate identifies the Deere engine/vehicle relationship.

Examples:

6081HFN01
6081HFN02
6081HFN03
6081HFN04

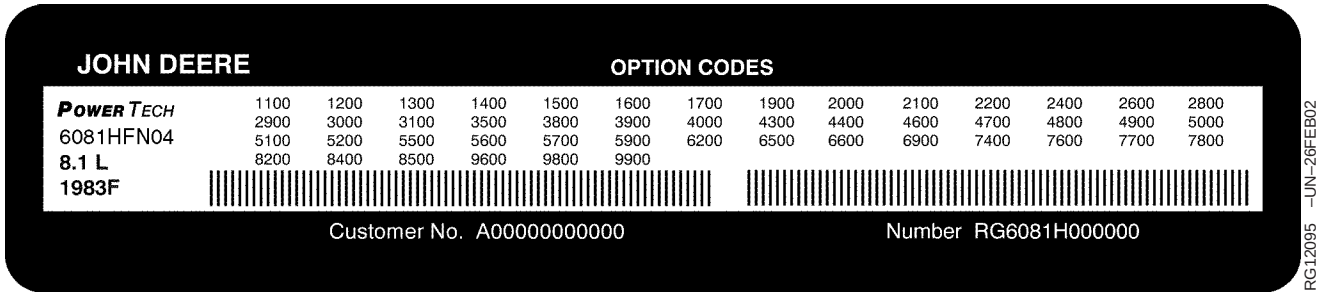
RG12037 –UN–21FEB02

Engine Serial Number

A—Engine Serial Number
B—Application Data or Type

RG41183,000004F –19–18MAR04–1/1

Engine Option Codes



Engine Option Codes

In addition to the serial number plate, John Deere engines have an engine option code label (A) affixed to the right rear side of the block near the oil filter base. These codes indicate which of the engine options were installed on your engine at the factory. When in need of parts or service, furnish your engine servicing dealer with these numbers.

The first two digits of each code identify a specific group, such as alternators. The last two digits of each code identify one specific option provided on your engine, such as a 12-volt, 55-amp alternator.

If an engine is ordered without a particular component, the last two digits of that functional group option code will be 99, 00, or XX. The following list shows only the first two digits of the code numbers. For future reference, such as ordering repair parts, it is important to have these code numbers available. To ensure this availability, enter the third and fourth digits shown on your engine option code label in the spaces provided on the following pages.

NOTE: Your engine option code label may not contain all option codes if an option has been added after the engine left the factory.

If option code label is lost or destroyed, consult your engine servicing dealer for a replacement.

Engine Option Code Label

A—Engine Option Code Label

OUO1043,0000E5B –19–20FEB02–1/1

Engine Option Codes—Continued

Option Codes	Description
11	Rocker Arm Cover
12	Oil Filler
13	Crankshaft Pulley/Damper
14	Flywheel Housing
15	Flywheel
16	Fuel Injection
17	Air Inlet
19	Oil Pan
20	Coolant Pump
21	Thermostat Cover
22	Thermostat
24	Belts
26	Engine Heater
28	Exhaust Manifold
29	Ventilator System
30	Starter Motor
31	Alternator
35	Fuel Filters
38	Operator's Manual
39	Thermostat Housing
40	Oil Dipstick
43	Starting Aid
44	Electronic Sensors
46	Cylinder Block
47	Crankshaft
48	Connecting Rods and Pistons
49	Rocker Arm Assembly
50	Oil Pump
51	Cylinder Head
52	Auxiliary Drive
55	Engine Stand
56	Paint Option
57	Coolant Pump Inlet
59	Oil Cooler and Filter
62	Alternator Mounting
65	Turbocharger
66	Temperature Switch
69	Engine Serial Number Plate
72	Software Performance Option
74	A/C Compressor Mounting
76	Oil Pressure Switch
77	Timing Gear Cover
78	Air Compressor
82	Ignition System
83	Software Vehicle Option
84	Wiring Harness
85	Fuel System Hardware (Including Electronic Control Unit)
96	Engine Installation Kit
98	Lift Straps
99	Service Only Items

_____ **Engine Base Code**

OUO1043,0000E8E –19–27MAY04–1/1

Natural Gas Recommendations

NOTE: Dry natural gas is a mixture of methane, ethane, propane, butane, and other inert gases. Dry natural gas is also referred to as Commercial Pipeline Natural Gas.

Dry natural gas that meets SAE J1616 Fuel Quality Specification is recommended for use in John Deere Natural Gas engines.

Propane Content	Less than 3 percent
Ethane Content	Less than 5 percent
Butane Content	Less than 1 percent
Hydrogen Sulfide (H_2S)	Less than 10 ppm
Octane Rating	More than 118
Lower Heating Value	More than 33.72 kJ/L (905 BTU/cu ft)

OUO1079,00004DE –19–15APR02–1/1

Natural Gas Engine Oil

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

Multi-viscosity, heavy-duty engine oils are preferred.

The use of heating devices may permit extension of the lower temperature limits, but requires special precautions. See your John Deere engine distributor or John Deere machinery dealer for recommendations.

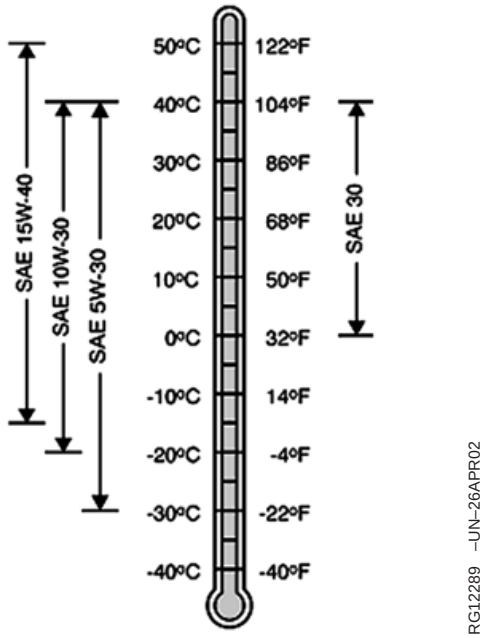
The following oil is preferred:

Any quality natural gas engine oil meeting Cummins 20074 or Detroit Diesel 7SE272-9510 requirements.

Do Not use diesel engine oil in a natural gas engine. Diesel engine oils have a high ash content which may generate excessive piston deposits, causing engine knocking.

The following oils are also recommended:

- API CI-4 oils with 0.4 to 1.0% sulfated ash content
- API CH-4 oils with 0.4 to 1.0% sulfated ash content
- API CG-4 oils with 0.4 to 1.0% sulfated ash content
- API CF-4 oils with 0.4 to 1.0% sulfated ash content



OUO1043,0000E89 –19–30APR02–1/1

Natural Gas Engine Break-In Oil

New engines are filled at the factory with John Deere ENGINE BREAK-IN OIL. During the break-in period, use John Deere ENGINE BREAK-IN OIL (TY22041) as makeup oil when oil level falls BELOW the add mark.

Change the oil and filter after the first 2,500 miles of operation of a new or rebuilt engine. At this time, service engine with regular engine oil as recommended next in this group.

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

If John Deere ENGINE BREAK-IN OIL is not available, use a natural gas engine oil meeting the specifications listed following in this manual.

After the break-in period, always use natural gas engine oils as recommended following in this manual.

IMPORTANT: DO NOT use engine oils meeting API CF-4 or CCMC D5 performance levels during the first 2,500 miles of operation of a new or rebuilt engine. These oils will not allow the engine to break in properly.

DPSG,OUOE003,3518 –19–30MAR04–1/1

Alternative and Synthetic Lubricants

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

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

Consult your engine servicing dealer to obtain information and recommendations.

Synthetic lubricants may be used if they meet the performance requirements as shown in this manual.

The temperature limits and service intervals shown in this manual apply to both conventional and synthetic oils.

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

RG,01,DT7038 –19–29OCT97–1/1

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 engine servicing dealer to obtain specific information and recommendations.

RG,01,DT7037 –19–29OCT97–1/1

OILSCAN®, OILSCAN Plus®, COOLSCAN™ and COOLSCAN PLUS™

T104220 –UN–03OCT96

OILSCAN®, OILSCAN Plus®, COOLSCAN™ and COOLSCAN PLUS™ are John Deere sampling fluid programs to help you monitor machine maintenance and system condition. The objective of a fluid sampling program is to ensure machine availability when you need it and to reduce repair costs by identifying potential problems before they become critical.

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

Check with your John Deere dealer on a maintenance program for your specific application. Your dealer has the sampling products and expertise to assist you in lowering your overall operating costs through fluid sampling.

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

RG,01,DT7040 –19–18FEB02–1/1

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Grease

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

John Deere SD POLYUREA GREASE is preferred.

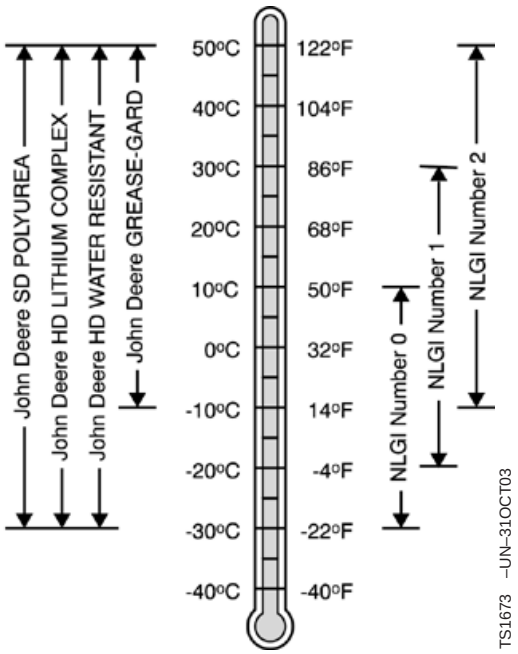
The following greases are also recommended

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

Other greases may be used if they meet the following:

NLGI Performance Classification GC-LB

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



GREASE-GARD is a trademark of Deere & Company

DX,GREA1 –19–07NOV03–1/1

Recommended Engine Coolant

Solutions of antifreeze and supplemental coolant additives MUST be used year-round for freeze protection, boil-over protection, and to provide a stable, noncorrosive environment for seals, hoses, and metal engine parts.

The following engine coolants are preferred for service:

- **JOHN DEERE PREDILUTED ANTIFREEZE/ SUMMER COOLANT**

This product contains all the necessary ingredients that make up the proper coolant solution: chemically pure water, ethylene glycol (low silicate antifreeze), and supplemental coolant additives (SCAs). It is ready to use; no mixing is required.

John Deere Prediluted Antifreeze/Summer Coolant permits extended service life to 36 months or 75,000 miles of operation (37,500 miles for transit buses and refuse trucks).

- **JOHN DEERE ANTIFREEZE/SUMMER COOLANT CONCENTRATE**

This product contains ethylene glycol (low silicate antifreeze) and supplemental coolant additives (SCAs). It must be mixed with quality water, as described later in this section, before adding to the engine cooling system. The proportion of water to be used depends upon the lowest freeze protection temperature desired according to the following table:

John Deere Antifreeze/Summer Coolant Concentrate has a service life of 24 months or 50,000 miles of operation (25,000 miles for transit buses and refuse trucks).

% CONCENTRATE	FREEZE PROTECTION LIMIT
40	-24°C (-12°F)
50	-37°C (-34°F)
60	-52°C (-62°F)

John Deere Antifreeze/Summer Coolant Concentrate has a service life of 24 months or 50,000 miles of operation (25,000 miles for transit buses and refuse trucks).

OUO1043,0000E8B –19–13MAY02–1/1

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Engine Coolant Specifications

Contact your engine servicing dealer to determine what the cooling system of this engine is filled with and the winter freeze protection level.

Coolant solutions of quality water, ethylene glycol concentrate (antifreeze), and supplemental coolant additives (SCAs) MUST be used year-round to protect against freezing, boil-over, liner erosion or pitting, and to provide a stable, noncorrosive environment for seals, hoses, and metal engine parts.

Water Quality

Water quality is important to the performance of the cooling system. Distilled, deionized, or demineralized water is recommended for mixing with ethylene glycol base engine coolant concentrate. Mineral (hard/tap) water should NEVER be put in a cooling system unless first tested. All water used in the cooling system should meet the following minimum specifications for quality:

Water Quality Specifications

	Parts Per Million	Grains Per U.S. Gallon
Chlorides (maximum)	40	2.5
Sulfates (maximum)	100	5.9
Total Dissolved Solids (maximum)	340	20
Total Hardness (maximum)	170	10

pH Level ..... 5.5—9.0

Ethylene Glycol Concentrate (Antifreeze)

IMPORTANT: DO NOT use ethylene glycol concentrate containing sealer or stop-leak additives.

The use of John Deere coolant products, as outlined previously, is **strongly recommended.**

If John Deere coolant products are not used, other low silicate ethylene glycol base coolants for heavy-duty engines may be used when mixed with quality water and supplemental coolant additives (SCAs), if they meet one of the following specifications:

- ASTM D5345 (prediluted coolant)
- ASTM D4985 (coolant concentrate) in a 40% to 60% mixture of concentrate with quality water

Coolants meeting these specifications require the addition of supplemental coolant additives (SCAs), formulated for heavy-duty engines, for protection against corrosion and cylinder liner erosion and pitting.

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

Supplemental Coolant Additives (SCAs)

IMPORTANT: DO NOT over-inhibit antifreeze solutions, as this can cause silicate-dropout. When this happens, a gel-type deposit is created which retards heat transfer and coolant flow, causing engine to overheat.

NOTE: John Deere Prediluted Antifreeze/Summer Coolant and John Deere Antifreeze/Summer Coolant Concentrate contain supplemental coolant additives (SCAs). However, as the coolant solution loses its effectiveness, additional additives will be needed.

Operating without proper coolant additive will result in increased corrosion, cylinder liner erosion and pitting, and other damage to the engine and cooling system. A simple mixture of ethylene glycol and water WILL NOT give adequate protection. However, the use of supplemental coolant additives will reduce the number of vapor bubbles in the coolant and help form a protective film on cylinder liner surfaces. This film acts as a barrier against the harmful effects of collapsing vapor bubbles.

Continued on next page

Inhibit the antifreeze-coolant mix with a non-chromate inhibitor. John Deere Liquid Coolant Conditioner is recommended as a supplemental coolant additive in John Deere engines.

IMPORTANT: Check inhibitors between drain intervals every 12 months or 25,000 miles. Replenish inhibitors by the addition of a supplemental coolant additive as necessary.

DO NOT use soluble oil.

RG7276 –UN–05DEC97

John Deere Liquid Coolant Conditioner

Additives eventually lose their effectiveness and must be recharged with additional supplemental coolant additives available in the form of liquid coolant conditioner. See TESTING ENGINE COOLANT and REPLENISHING SUPPLEMENTAL COOLANT ADDITIVES (SCAs) BETWEEN COOLANT CHANGES in this group

DPSG,OUO1004,2790 –19–27MAY04–2/2

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Supplemental Coolant Additives

The concentration of coolant additives is gradually depleted during engine operation. For all recommended coolants, replenish additives between drain intervals by adding a supplemental coolant additive at recommended service intervals or as determined necessary by coolant testing. See REPLENISHING SUPPLEMENTAL COOLANT ADDITIVES in this group.

John Deere TY16004 or TY16005 Liquid Coolant Conditioner is recommended as a supplemental coolant additive in John Deere engines. See label on container for correct amount of conditioner to add to cooling system.

IMPORTANT: TY16004 or TY16005 Liquid Coolant Conditioner is a non-chromate inhibitor and should be used only with low silicate, ethylene glycol based antifreeze. It does not protect the cooling system from freezing.

Do not add a supplemental coolant additive when the cooling system is drained and refilled with John Deere COOL-GARD.

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

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

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

RG7276 –UN–05DEC97

John Deere Liquid Coolant Conditioner

DPSG,OUO1004,2791 –19–03JUL00–1/1

Testing Engine Coolant

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

Test the coolant solution at 12 months or 25,000 miles of normal engine operation and whenever excessive coolant is lost through leaks or overheating, to ensure the necessary protection. See CHECKING EFFECTIVENESS OF COOLANT SOLUTION in Operator's Manual.

RG7297 –UN–22SEP99

Coolant Test Strips

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.

RG7397 –UN–05DEC97

CoolScan Bellows

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.

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COOLSCAN PLUS is a trademark of Deere & Company.

DPSG,OUOE003,3529 –19–18FEB02–1/1

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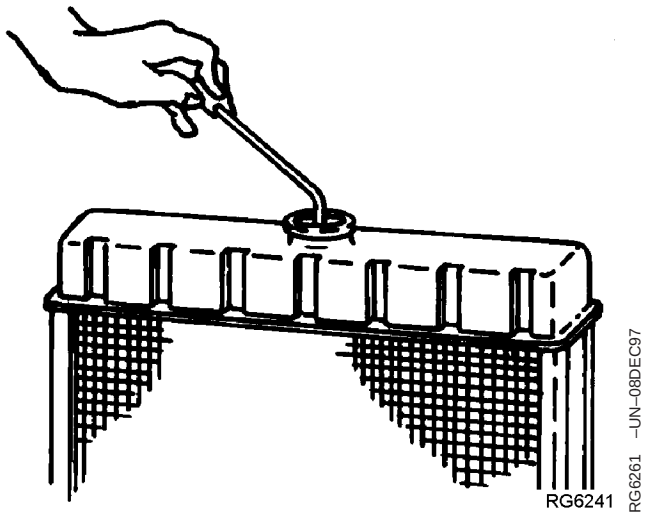
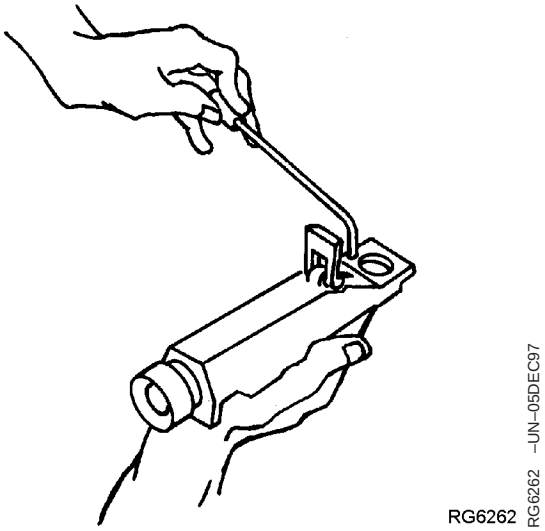
Replenishing Supplemental Coolant Additives (SCAs) between Coolant Changes



Add Supplemental Coolant Additive



Check Glycol Concentration

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

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

Through time and use, original additives eventually lose their effectiveness and must be recharged with additional supplemental coolant additives available in the form of liquid coolant conditioner. Add the manufacturer's recommended concentration of supplemental coolant additive. DO NOT add more than the recommended amount.

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

Test the coolant solution at 12 months or 25,000 miles using either John Deere coolant test strips or a COOLSCAN™ analysis. If a COOLSCAN™ analysis is not available, recharge system per instructions printed on label of TY16004 or TY16005 John Deere Liquid Coolant Conditioner. ALWAYS follow the manufacturer's recommendations printed on the container label.

IMPORTANT: TY16004 or TY16005 Liquid Coolant Conditioner is a non-chromate inhibitor and should be used only with low silicate, ethylene glycol based antifreeze. It does not protect the cooling system from freezing.

Do not add a supplemental coolant additive when the cooling system is drained and refilled with John Deere COOL-GARD.

See ENGINE COOLANT SPECIFICATIONS earlier in this group for proper mixing of coolant ingredients before adding to the cooling system.

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DPSG,OUO1004,2806 –19–17JUL00–1/1

Operating in Warm Temperature Climates

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

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

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

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

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

RG,01,DT7034 –19–29OCT97–1/1

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Flush and Service Cooling System

CAUTION: Explosive release of fluids from pressurized cooling system can cause serious burns. Shut off engine. Remove filler cap only when cool enough to touch with bare hands. Slowly loosen cap to first stop to relieve pressure before removing cap completely.

IMPORTANT: Air must be expelled from cooling system when system is refilled. Follow procedure given in your operator's manual.

TS281 –UN–23AUG88

Flush and Service Cooling System

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

NOTE: Refer to your operator's manual for a specific service interval.

Flush cooling system as described in your operator's manual. Clean cooling system with clean water and a cleaner such as FLEETGUARD® RESTORE™ or RESTORE PLUS™. Follow the instructions provided with the cleaner. Refill cooling system with the appropriate coolant solution. See ENGINE COOLANT SPECIFICATIONS, earlier in this group.

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

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OUO1079,00004DF –19–15APR02–1/2

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

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

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

Contact your engine servicing dealer if there are further questions.

OUO1079,00004DF –19–15APR02–2/2

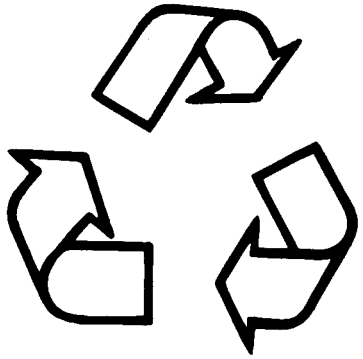
Disposing of Coolant

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 engine servicing dealer.



TS1133 –UN–26NOV90

Disposing of Coolant

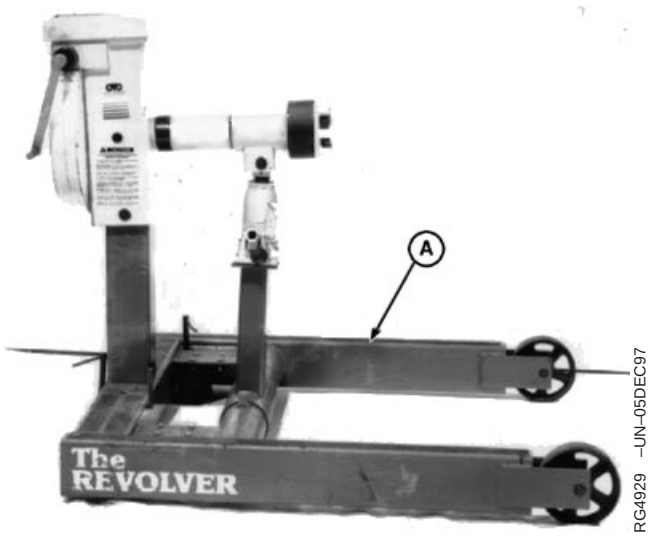
RG,01,DT7032 –19–29OCT97–1/1

Engine Repair Stand

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

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

A—Engine Repair Stand



Engine Repair Stand

RG,RG34710,1043 –19–14AUG00–1/1

Safety Precautions

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

To maintain shear strength specifications, alloy steel SAE Grade 8 or higher socket head cap screws must be used to mount adapters or engine. Use LOCTITE® 242 Thread Lock and Sealer on cap screws when installing lifting straps on engine. Tighten to specification.

Specification	
Socket Head Cap Screws—Torque	170 N•m (125 lb-ft)

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

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

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

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

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

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

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

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RG,01,DT7050 –19–29OCT97–1/1

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Install Adapters onto Engine Repair Stand

Attach the No. 205466 Engine Adapter to mounting hub of the engine repair stand using SAE Grade 8 socket head screws. Tighten to specification.

Specification

Engine Adapter to Mounting Hub
Cap Screws—Torque ..... 135 N•m (100 lb-ft)

RG8183 –UN–08DEC97

Install Adapter onto Engine Repair Stand

RG,01,DT7049 –19–19JAN98–1/1

Engine Lifting Procedure

CAUTION: The only recommended method for lifting the engine is with JDG23 Engine Lifting Sling and safety approved lifting straps that come with engine. Use extreme caution when lifting and NEVER permit any part of the body to be positioned under an engine being lifted or suspended.

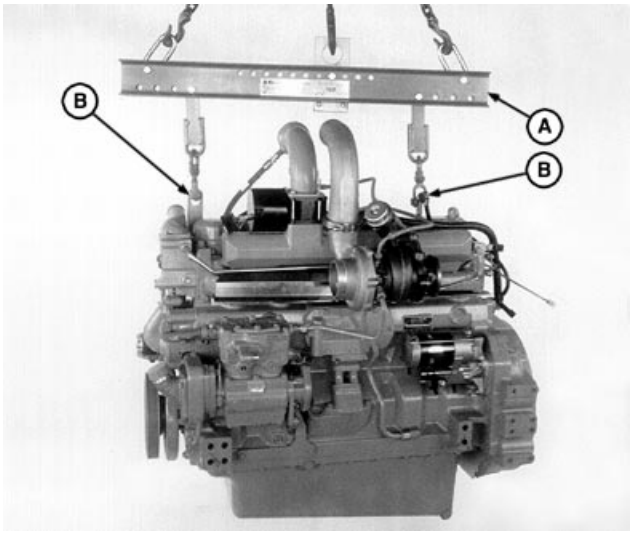
Lift engine with longitudinal loading on lifting sling and lifting brackets only. Angular loading greatly reduces lifting capacity of sling and brackets.

1. Apply TY9370 LOCTITE® 242 Thread Lock and Sealer to lifting strap cap screws. Install lifting straps (B) and tighten cap screws to the following specifications.

Specification	
Engine Lifting Strap Cap Screws—Torque	170 N•m (125 lb-ft)

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

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



Engine Lifting Procedure

A—JDG23 Engine Lifting Sling
B—Engine Lifting Straps (2 used)

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RG,01,DT7048 –19–18FEB02–1/2

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

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

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

RG,01,DT7048 –19–18FEB02–2/2

Clean Engine

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

IMPORTANT: DO NOT steam clean the following parts: Electrical components and connectors, Electronic Engine Control Unit (ECU), fuel injectors, belts and hoses.

2. Steam-clean engine thoroughly.

RG,01,DT7047 –19–29MAR04–1/1

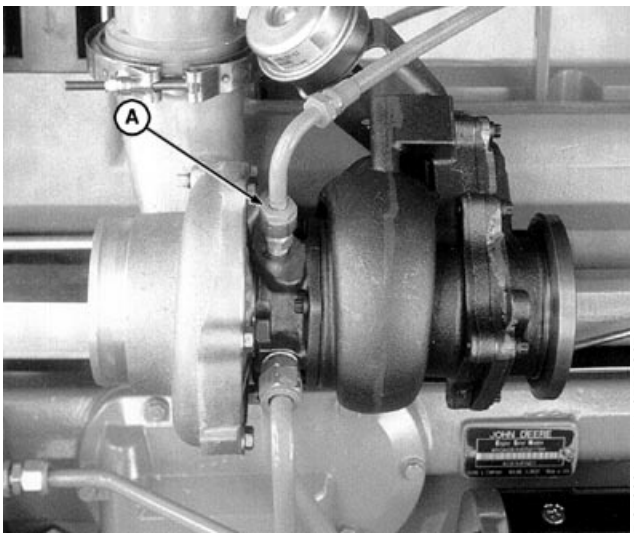
Disconnect Turbocharger Oil Inlet Line

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

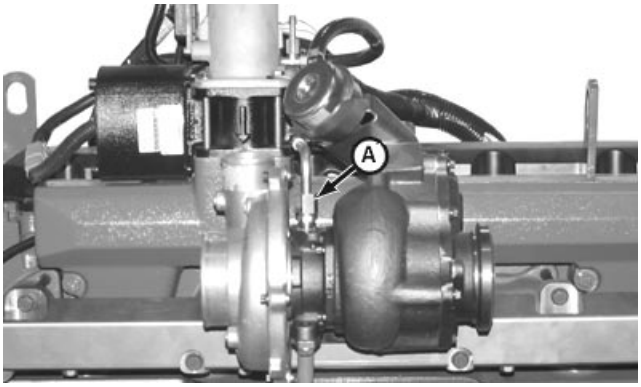
IMPORTANT: When servicing 6081HFN Engines on a rollover stand, disconnect turbocharger oil inlet line (A) from oil filter base or turbocharger before rolling engine over. Failure to do so may cause a hydraulic lock upon starting engine. Hydraulic lock may cause possible engine failure. Hydraulic lock 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.

NOTE: Oil line routing might vary from the one shown. Note orientation to ease assembly.

2. Disconnect turbocharger oil inlet line (A) at turbocharger or oil filter base.



HFN01, HFN03, HFN04 shown



HFN02 shown

A—Turbocharger Oil Inlet Line

RG,01,DT7046 –19–08MAR00–1/1

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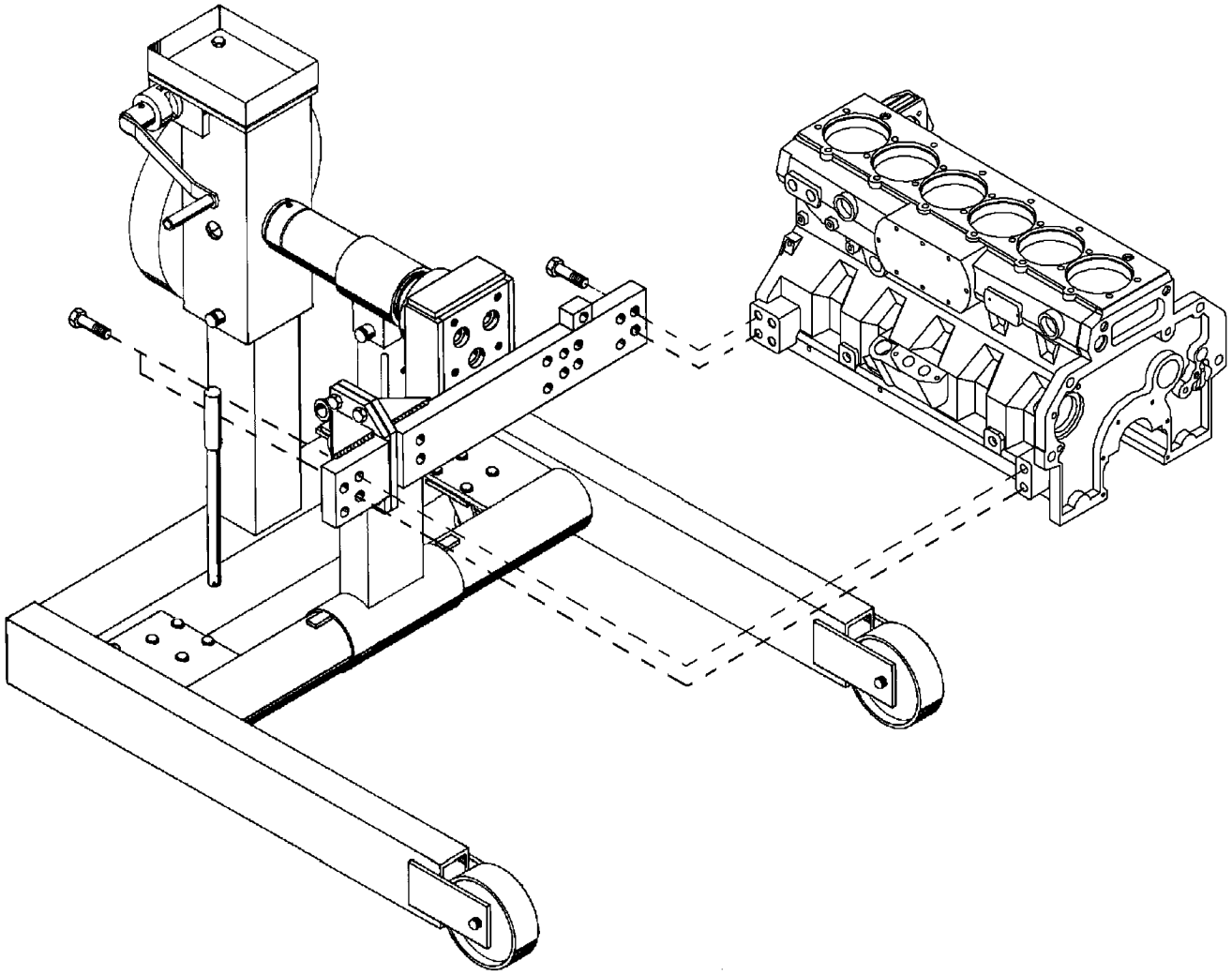
6

Mount Engine on Repair Stand



Mount Engine on Repair Stand

NOTE: If starter motor or air compressor is to be removed from engine, remove before mounting engine onto repair stand.

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

1. Mount the starter side of the engine to the engine adapter with four SAE Grade 8 (or higher grade) 5/8-11 UNC x 3-3/4 in. flanged-head cap screws.

2. Tighten cap screws to specification.

Specification	
Engine-to-Engine Adapter—Torque	203 N•m (150 lb-ft)

Continued on next page

RG,01,DT7045 –19–08MAR00–1/2

3. Carefully remove lifting sling from engine.
4. To remove engine from repair stand, reverse the installation procedures.

RG,01,DT7045 –19–08MAR00–2/2

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 overhauling engine 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 use more oil.
- The engine has high usage hours and the owner wants to take preventive measures to avoid high-cost repairs and costly downtime.

OUO1083,00000C9 –19–18FEB02–1/1

6081HFN Engine Disassembly Sequence

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

Continued on next page

RG,01,DT7051 –19–25MAY04–1/3

ENGINE DISASSEMBLY SEQUENCE	
Procedure	**Reference**
Mount engine on a safety approved repair stand.	See MOUNT ENGINE ON REPAIR STAND in Group 03.
Drain coolant and oil. Perform John Deere OILSCAN Plus® and COOLSCAN™ analysis.	See OILSCAN Plus® and COOLSCAN™ in Group 02.
Remove alternator.	See REMOVE AND INSTALL ALTERNATOR in Group 40.
Remove turbocharger. Remove turbocharger coolant and lubrication lines.	See REMOVE TURBOCHARGER in Group 30.
Remove electronic throttle sensor.	See REMOVE AND INSTALL ELECTRONIC THROTTLE AND THROTTLE POSITION SENSOR in Group 45.
Remove exhaust manifold.	See REMOVE, INSPECT, AND INSTALL EXHAUST MANIFOLD in Group 30.
Remove intake manifold.	See REMOVE, INSPECT, AND INSTALL INTAKE MANIFOLD in Group 30.
Remove air compressor and engine coolant heater.	See REMOVE AIR COMPRESSOR in Group 50.
Remove starter motor.	See REMOVE AND INSTALL STARTER MOTOR in Group 40.
Remove coolant manifold.	See REMOVE COOLANT MANIFOLD in Group 25.
Remove coolant pump.	See REMOVE COOLANT PUMP ASSEMBLY in Group 25.
Remove ignition coils, mounting bracket, spark plug boots and spark plugs.	For HFN01, HFN02, and HFN03 Engines, see REMOVE AND INSTALL IGNITION COILS (HFN01, HFN02, and HFN03 Engines) in Group 45. For HFN04 Engine, see REMOVE AND INSTALL IGNITION COILS (HFN04 Engine) in Group 45.
Remove dipstick, oil filter, oil cooler, and adapter housing pressure regulator.	See REMOVE, INSPECT, AND INSTALL ENGINE OIL COOLER in Group 20. See REMOVE AND INSTALL OIL FILTER BASE AND OIL PRESSURE REGULATING VALVE HOUSING in Group 20.
Remove gas regulator, fuel mixer, fuel metering valve and drier.	See Group 35.
Remove rocker arm cover and breather hose. If option code label is located on rocker arm cover, be careful not to damage label.	See REMOVE CYLINDER HEAD in Group 05.
Remove rocker arm assembly and push rods. Keep rods in order. Check for bent push rods and condition of wear pad contact surfaces on rockers.	See REMOVE CYLINDER HEAD in Group 05.
Remove cylinder head.	See REMOVE CYLINDER HEAD in Group 05.
Remove camshaft followers. Keep followers in order.	See INSPECT AND MEASURE CAMSHAFT FOLLOWERS in Group 16.
Remove flywheel. Remove flywheel housing.	See REMOVE FLYWHEEL in Group 15. For SAE 1 Flywheel Housing, seeREMOVE SAE 1 FLYWHEEL HOUSING in Group 15. For SAE 2 Flywheel Housing, see REMOVE SAE 2 FLYWHEEL HOUSING in Group 15.
Remove oil pan.	See REMOVE AND INSTALL ENGINE OIL PAN in Group 20.
Remove crankshaft vibration damper.	See REMOVE CRANKSHAFT VIBRATION DAMPER in Group 15.
Remove timing gear cover.	See REMOVE TIMING GEAR COVER in Group 15 or 16.

Continued on next page

ENGINE DISASSEMBLY SEQUENCE	
Procedure	**Reference**
Remove oil pump drive gear, outlet tube, and pump body.	See REMOVE ENGINE OIL PUMP in Group 20.
Remove timing gears and camshaft. Perform wear checks.	See REMOVE CAMSHAFT in Group 16.
Stamp cylinder number on connecting rod. Perform wear checks with PLASTIGAGE®. Remove pistons and rods.	See INSPECT AND MEASURE CONNECTING ROD BEARINGS in Group 10.
Perform wear checks with PLASTIGAGE®. Remove crankshaft and main bearings.	See REMOVE CRANKSHAFT in Group 15.
Remove cylinder liners and mark each one with cylinder number.	See REMOVE CYLINDER LINERS in Group 10.
Remove piston cooling orifices.	See REMOVE AND CLEAN PISTON COOLING ORIFICES in Group 10.
Remove cylinder block plugs and serial number plate when block is to be put in a “hot tank”.	See INSPECT AND CLEAN CYLINDER BLOCK in Group 10.
Clean upper and lower liner bores with nylon brush.	See CLEAN CYLINDER LINERS in Group 10.
Measure cylinder block.	See MEASURE CYLINDER BLOCK in Group 10.

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RG,01,DT7051 –19–25MAY04–3/3

Sealant Application Guidelines

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

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

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

TY9370 6 mL (0.2 oz) tube
T43512 50 mL (1.7 oz) bottle

- Threaded plugs and fitting: intake manifold, cylinder block (oil gallery).
- Cap screws: flywheel, auxiliary drive housing, manifold absolute pressure (MAP) sensor, ignition coil, ignition control unit (ICU) and water manifold.
- Oil pressure sending unit.
- Oil filter adapter.
- Shraeder valve and plug on fuel metering valve.

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

TY9374 6 mL (0.2 oz) tube
TY9375 50 mL (1.7 oz) bottle

- Pipe plugs: cylinder block (water manifold), thermostat housing, air intake manifold, and coolant pump.
- Threaded nipples and elbows in coolant pump housing.
- Oil pan (drain hose and drain valve).
- Connectors: turbo line and drain line.
- Adapter fitting for turbo oil inlet line.
- Coolant pump and block coolant drain valves.
- Coolant temperature sending unit.
- Pre-turbine pressure (PTP) sensor.
- Exhaust back pressure (EBP) sensor.
- Oil pressure switch.

LOCTITE® 680 Retaining Compound (green):

TY15969 50 mL (1.7 oz) bottle

- Front and rear wear sleeve-to-crankshaft.
- Expansion (frost) plugs in cylinder block.
- Camshaft nose (for gear installation).

PERMATEX® AVIATION (Form-A-Gasket No. 3):

TY6299 227 g (8 oz) container

- Rear camshaft bore steel cap plug.

PT569 NEVER-SEEZ® COMPOUND:

PT569 227 g (8 oz) brush
PT506 453 g (16 oz) spray

- Cap screws or studs: turbocharger mounting and exhaust manifold.
- Universal exhaust gas oxygen (UEGO) sensor.

LOCTITE® 51048 Moly Paste:

- Camshaft nose (for timing wheel installation).

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

TY6304, 50 mL bottle

- Flywheel housing-to-cylinder block.
- Flywheel housing-to-oil pan.
- Front and rear face of cylinder block.

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TEFLON is a registered trademark of the DuPont Co.
PERMATEX is a registered trademark of the Loctite Corp.
NEVER-SEEZ is a registered trademark of the Emhart Chemical Group.

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- Front timing gear cover-to-oil pan.

RG,01,DT7052 –19–18FEB02–2/2

6081HFN Engine Assembly Sequence

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

Continued on next page

RG,01,DT7053 –19–25MAY04–1/3

ENGINE ASSEMBLY SEQUENCE	
Procedure	**Reference**
Install all plugs and serial number plate in cylinder block (if removed).	See INSTALL PISTON COOLING ORIFICES AND GALLERY PLUGS in Group 10.
Install piston cooling orifices.	See INSTALL PISTON COOLING ORIFICES AND GALLERY PLUGS in Group 10.
Install cylinder liners without O-rings. Measure liner height. Install liners with O-rings.	See INSTALL CYLINDER LINERS IN BLOCK in Group 10.
Install main bearings and crankshaft. PLASTIGAGE® bearings.	See INSTALL CRANKSHAFT in Group 15.
Install rear oil seal. Install flywheel. Install flywheel housing.	See INSTALL CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE in Group 15. See INSTALL FLYWHEEL in Group 15. For SAE 2 Flywheel Housing, see INSTALL SAE 2 FLYWHEEL HOUSING in Group 15. For SAE 1 Flywheel Housing, see INSTALL SAE 1 FLYWHEEL HOUSING in Group 15.
Install pistons and rods. Measure piston protrusion.	See INSTALL PISTON AND CONNECTING ROD in Group 10.
Install oil pump assembly.	See INSTALL ENGINE OIL PUMP in Group 20.
Install camshaft and timing gears. Time all gears with No. 1 cylinder at TDC compression stroke.	See INSTALL CAMSHAFT in Group 16.
Install timing gear cover. Install new front seal.	See INSTALL TIMING GEAR COVER in Group 15 or 16. See INSTALL CRANKSHAFT FRONT OIL SEAL AND WEAR SLEEVE in Group 15.
Install oil filter base and oil pressure regulating valve assembly.	See REMOVE AND INSTALL OIL FILTER BASE AND OIL PRESSURE REGULATING VALVE HOUSING in Group 20.
Install oil pan.	See REMOVE AND INSTALL ENGINE OIL PAN in Group 20.
Install camshaft followers in same order as removed.	See INSTALL CAMSHAFT in Group 16.
Install cylinder head gasket and cylinder head. Install push rods and rocker arm assembly.	See INSTALL CYLINDER HEAD AND CAP SCREWS in Group 05. See INSTALL ROCKER ARM ASSEMBLY in Group 05.
Adjust valves. Install rocker arm cover and vent tube.	See CHECK AND ADJUST VALVE CLEARANCE in Group 05.
Install starter motor.	See REMOVE AND INSTALL STARTER MOTOR in Group 40.
Install oil cooler, new oil filter, and dipstick.	See REMOVE, INSPECT, AND INSTALL ENGINE OIL COOLER in Group 20.
Install coolant manifold.	See INSTALL COOLANT MANIFOLD in Group 25.
Install coolant pump and hoses.	See INSTALL COOLANT PUMP ASSEMBLY in Group 25.
Install belt tensioner, fan, and fan belts.	See REMOVE AND INSTALL ALTERNATOR in Group 40.
Install crankshaft vibration damper. Use new damper.	See INSTALL CRANKSHAFT VIBRATION DAMPER in Group 15.
Install intake manifold.	See REMOVE, INSPECT, AND INSTALL INTAKE MANIFOLD in Group 30.
Install exhaust manifold.	See REMOVE, INSPECT, AND INSTALL EXHAUST MANIFOLD in Group 30.
Install turbocharger. Install turbocharger coolant and lubrication lines.	See INSTALL TURBOCHARGER in Group 30.

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RG,01,DT7053 –19–25MAY04–2/3

ENGINE ASSEMBLY SEQUENCE	
Procedure	**Reference**
Install air compressor and engine coolant heater.	See INSTALL AIR COMPRESSOR in Group 50. See INSTALL COOLANT HEATER in Group 25.
Install electronic throttle and throttle position sensor.	See REMOVE AND INSTALL ELECTRONIC THROTTLE AND THROTTLE POSITION SENSOR in Group 45.
Install gas regulator, fuel mixer, and fuel metering valve.	For early HFN01 engines, see REMOVE AND INSTALL ENGINE MOUNTED NATURAL GAS REGULATOR (Early HFN01 Engines) in Group 35. For later HFN01 engines, see REMOVE AND INSTALL ENGINE MOUNTED NATURAL GAS REGULATOR (Later HFN01 Engines) in Group 35.
Install ignition module, ignition coil mounting bracket, ignition coils, spark plugs, and spark plug boots.	For HFN01, HFN02, and HFN 03 Engines, see REMOVE AND INSTALL IGNITION COILS (HFN01, HFN02, and HFN 03 Engines) in Group 45. For HFN04 engines, see REMOVE AND INSTALL IGNITION COILS (HFN04 Engines) in Group 45.
Install alternator.	See REMOVE AND INSTALL ALTERNATOR in Group 40.
Fill engine with clean oil.	See NATURAL GAS ENGINE OIL in Group 02.
Flush cooling system and refill with proper coolant.	See RECOMMENDED ENGINE COOLANT in Group 02.
Perform engine break-in and standard performance checks.	See PERFORM ENGINE BREAK-IN in this group.

RG,01,DT7053 –19–25MAY04–3/3

Engine Break-In Guidelines

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

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

Pistons, rings, or liners have been replaced.

Camshaft and followers have been removed.

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

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

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Perform Engine Break-In

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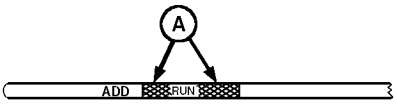


Engine Oil Level Dipstick (Later Version Shown)

A—Crosshatch Areas Showing Proper Oil Level

IMPORTANT: DO NOT use engine oils meeting API CF-4 or CCMC D5 performance levels during the first 2,500 miles of operation of a new or rebuilt engine. These oils will not allow the engine to properly wear during the break-in period.

Do not add makeup oil until the oil level is BELOW the ADD mark (below the crosshatch areas in the dipstick). John Deere Break-In Oil (TY22041) should be used to make up any oil consumed during break-in period.

DO NOT fill above the top mark on the dipstick. Oil levels anywhere within the crosshatch area (A) are considered in the acceptable operating range.

Operate the engine at heavy loads with minimal idling during the break-in period on new and rebuilt engines and engines that have been overhauled.

If the engine has significant operating time at idle, constant speeds, and/or light load usage, or more than three quarts makeup oil is required in the first 2,500 miles, a longer break-in period is required. In these situations, an additional 2,500 mile break-in period is recommended, using a new change of John Deere Engine Break-In Oil and new John Deere oil filter.

Check engine oil level more frequently during engine break-in period. If oil must be added during this period, John Deere Engine Break-In Oil is preferred. See ENGINE BREAK-IN OIL in Group 02.

NOTE: Some increase in oil consumption may be expected when low viscosity oils are used. Check oil levels more frequently. If air temperature is below —10°C (14°F), use an engine block heater.

During the first 500 miles, avoid prolonged periods of engine idling or sustained maximum load operation. **If engine will idle longer than 5 minutes, stop engine.**

Continued on next page

Watch coolant temperatures closely. If coolant temperature rises above 105°C (221°F), reduce load on engine. Unless temperature drops quickly, stop the engine and determine the cause before resuming operation.

1. Fill engine crankcase to proper level with John Deere ENGINE BREAK-IN OIL during break-in operation. Use break-in oil regardless of ambient temperature. This oil is specifically formulated to enhance break-in of John Deere engines. Under normal conditions, do not exceed 2,500 miles with break-in oil.

   If John Deere Engine Break-In Oil is not available, use natural gas engine oil meeting the specifications listed in Group 02. (See NATURAL GAS ENGINE OIL in Group 02.)

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

2. Run engine at slow idle, no load, for approximately two minutes.

3. Increase rpm to fast idle, then load down to 50 rpm above rated speed for 20 minutes.

Specification	
Engine—Oil Pressure at Rated Speed	310 kPa (45 psi)
Coolant Temperature Range	89°—100°C (192°—212°F)
Slow Idle (HFN01, HFN02, and HFN03)	650 rpm
Slow Idle (HFN04)	750 rpm
Rated Speed	2200 rpm

4. Check and readjust valve clearance as necessary. Cylinder head re-torquing is not required. (See CHECK AND ADJUST VALVE CLEARANCE in Group 05.)

5. After the break-in period, change engine oil and replace engine oil filter. Fill crankcase with seasonal viscosity grade oil. (See NATURAL GAS ENGINE OIL in Group 02.)

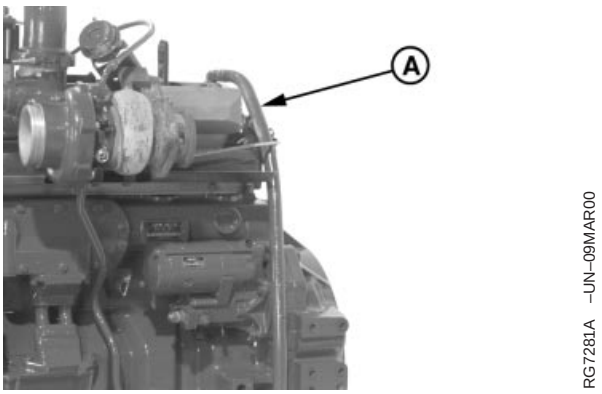
04
10

Check Crankcase Ventilation System

1. Remove and clean crankcase vent tube (A).
2. Install vent tube. Be sure the O-ring fits correctly in the rocker arm cover for elbow adapter. Tighten hose clamp securely.

NOTE: On later engines, the opposite end of vent tube (A) is connected to the vehicle air intake system.

IMPORTANT: Make sure vent hose is routed uphill from rocker arm cover and is free from dips and sags.



Crankcase Vent Tube (Early HFN01 Open Vent System Shown)

A—Crankcase Vent Tube

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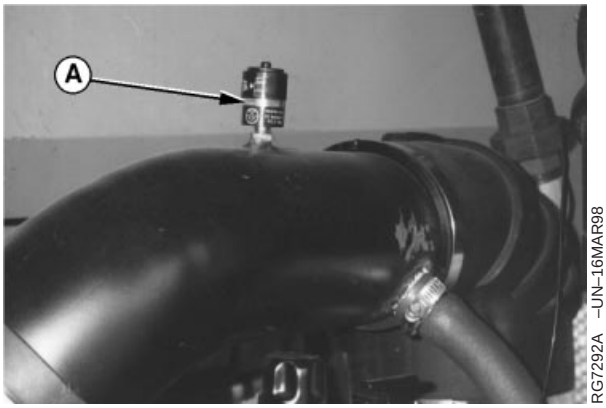
Check Air Intake System

1. Replace air filter elements as required. If vehicle has primary and secondary elements, replace secondary element if primary element has holes in it.
2. Check condition of air intake hose. Replace hoses that are cracked, split, or otherwise in poor condition.
3. Check hose clamps for tightness. Replace clamps that cannot be properly tightened. This will help prevent dust from entering the air intake system which could cause serious engine damage.
4. Test air restriction indicator (A), if equipped, for proper operation. Replace as necessary.



Air Restriction Indicator

A—Air Restriction Indicator

DPSG,OUO1004,2587 –19–07JUL00–1/1

Check Exhaust System

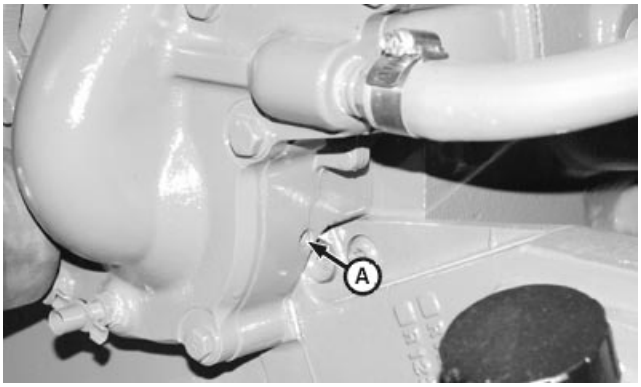
1. Inspect exhaust system for leaks or restrictions. Check manifold for cracks. Repair or replace as necessary.
2. Check that turbocharger-to-exhaust elbow adapter clamps are securely tightened and do not leak.
3. Check exhaust stack for evidence of oil leakage past valve stem seals.

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

RG,RG34710,1057 –19–23OCT97–1/1

Check and Service Cooling System

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



Cooling System Weep Hole with Foam Filter

A—Weep Hole

Continued on next page

DPSG,OUO1004,2588 –19–18FEB02–1/4

04
12

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

6. Slowly open the engine cooling system filler cap or radiator cap to relieve pressure and allow coolant to drain faster.

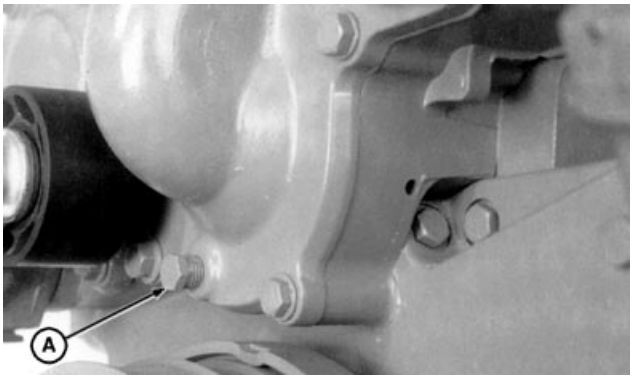
TS281 –UN–23AUG88

Service Cooling System Safely

DPSG,OUO1004,2588 –19–18FEB02–2/4

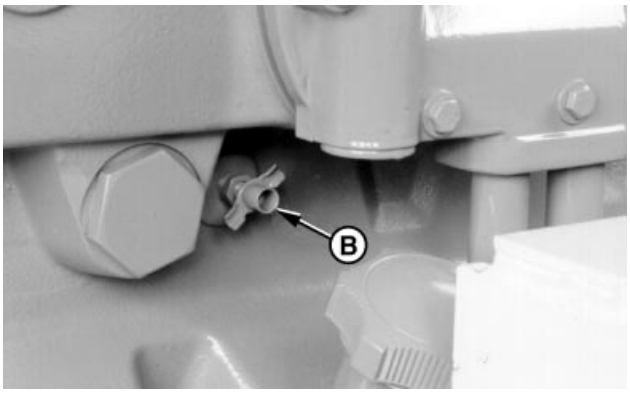
7. **On HFN01 and HFN03 engines:** Open block drain valve (B) on left side of engine and remove drain plug (A) on coolant pump. Drain all coolant from engine block.

A—Drain Plug (HFN01 Engine Shown)
B—Block Drain Valve (HFN01 Engine Shown)



RG7675A –UN–05DEC97

Coolant Pump Drain Plug (HFN01 Engine Shown)



RG7143 –UN–26NOV97

Block Drain Valve (HFN01 Engine Shown)

Continued on next page

DPSG,OUO1004,2588 –19–18FEB02–3/4

8. **On HFN02 and HFN04 engines:** Open coolant pump drain valve (A) on coolant pump and remove coolant heater (B) (if equipped) or plug on left side of engine. Drain all coolant from engine block.

9. Remove and check thermostat(s). (See REMOVE AND TEST THERMOSTATS in Group 25.)

10. Drain and flush cooling system. (See FLUSH AND SERVICE COOLING SYSTEM in Group 02.)

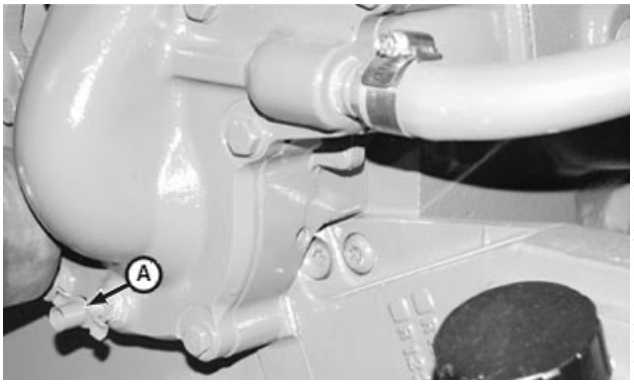
IMPORTANT: Air must be expelled from cooling system when system is refilled. Loosen plug in side of thermostat housing to allow air to escape when filling system. Retighten plug when all the air has been expelled.

11. Fill cooling system with coolant. See RECOMMENDED ENGINE COOLANT in Group 02.

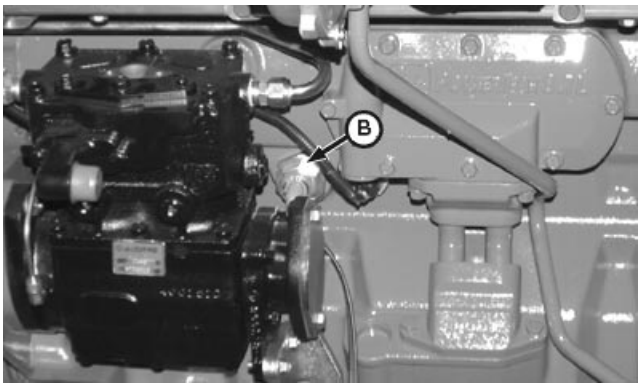
12. Run engine until it reaches operating temperature. Check entire cooling system for leaks.

13. After engine cools, check coolant level.

14. Check system for holding pressure. (See PRESSURE TESTING COOLING SYSTEM in Operator's Manual.)



Drain Valve (HFN02 Engine Shown)



Coolant Heater (HFN02 Engine Shown)

A—Drain Valve (HFN02 Engine Shown)
B—Coolant Heater (HFN02 Engine Shown)

DPSG,OUO1004,2588 –19–18FEB02–4/4

Check Electrical System

NOTE: Refer to vehicle technical manual for procedures to check electrical and electronic control systems.

DPSG,OUO1004,2796 –19–29MAR04–1/1

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14

Preliminary Engine Testing before Tune-Up

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

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

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

3. Perform compression test. (For HFN01—HFN03 engines, see TEST ENGINE COMPRESSION PRESSURE in Group 105 of CTM113.) (For HFN04 engines, see TEST ENGINE COMPRESSION PRESSURE in Group 105 of CTM300.)

DPSG,OUO1004,2797 –19–18FEB02–1/1

General Tune-Up Recommendations

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

IMPORTANT: John Deere compressed natural gas engines are equipped with an electronic control system which has a self-diagnosis feature. Refer to CTM113 (HFN01—HFN03 engines) or CTM300 (HFN04 engines) for diagnostic codes and troubleshooting procedures.

Operation	Detailed Reference
Change engine oil and filters.	Operator's Manual
Replace natural gas filter.	Group 35/Operator's Manual
Clean crankcase vent tube.	This Group/Operator's Manual
Check air intake system. Replace air cleaner elements.	This Group/Operator's Manual
Check exhaust system.	This Group
Check and service engine cooling system.	This Group/Operator's Manual
Check and adjust fan and alternator belts.	Operator's Manual
Check electrical system.	Vehicle Repair Manual
Check crankshaft vibration damper.	Group 15/Operator's Manual
Inspect turbocharger.	Group 30
Leak check fuel system.	Group 35
Check engine oil pressure. Correct as necessary.	For HFN01—03 engines, see CHECK ENGINE OIL PRESSURE in Group 105 of CTM113. For HFN04 engines, see CHECK ENGINE OIL PRESSURE in Group 105 of CTM300.
Check engine valve clearance. Adjust if necessary.	Group 05
Clean spark plugs and adjust gap.	Operator's Manual

DPSG,OUO1004,2798 –19–25MAY04–1/1

Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

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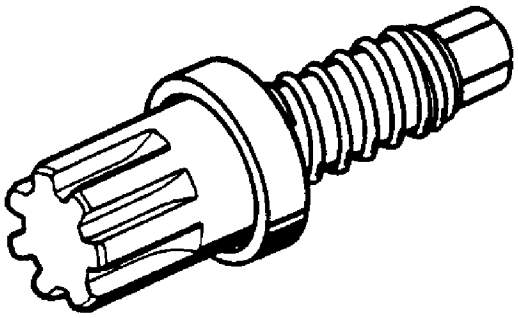
DPSG,OUO1004,2802 –19–11JUL00–1/16

Flywheel Turning Tool JDG820

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



RG7056 –UN–05DEC97

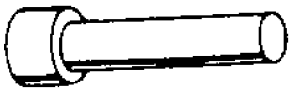
JDG820

DPSG,OUO1004,2802 –19–11JUL00–2/16

RG5068 –UN–05DEC97

Timing Pin JDE81-4

Lock engine at TDC when timing valve train, adjusting valve clearance, and installing fuel injection pump. Use with JDG820 or JDE81-1 Flywheel Turning Tools.



RG5068

JDE81-4

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DPSG,OUO1004,2802 –19–11JUL00–3/16

05
2

RG6246 –UN–05DEC97

Dial Indicator . . . (English, in.) D17526CI or (Metric, mm) D17527CI

Use with JDG451 to measure valve recess and cylinder liner height-to-cylinder block top deck.

RG6246

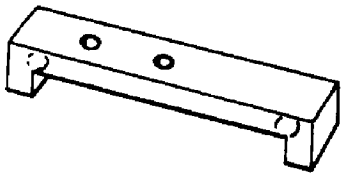
D17526CI or D17527CI

DPSG,OUO1004,2802 –19–11JUL00–4/16

RG7029 –UN–05DEC97

Height Gauge . . . . . (English, in.) JDG451 or (Metric, mm) KJD10123

Used with dial indicator to measure cylinder liner height above block.



RG7029

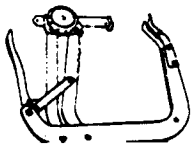
JDG451 or KJD10123

DPSG,OUO1004,2802 –19–11JUL00–5/16

RG5070 –UN–23AUG88

Valve Spring Compressor JDE138

Used to compress valve springs when removing and installing valves.



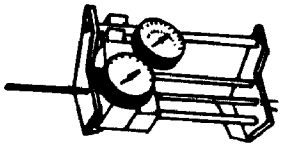
JDE138

DPSG,OUO1004,2802 –19–11JUL00–6/16

RG5061 –UN–05DEC97

Spring Compression Tester D01168AA

Test valve spring compression.



RG5061

D01168AA

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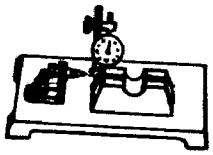
DPSG,OUO1004,2802 –19–11JUL00–7/16

RG5062 –UN–05DEC97

Valve Inspection Center D05058ST

Check valves for out of round.



RG5062

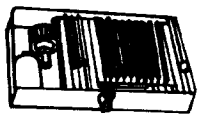
D05058ST

DPSG,OUO1004,2802 –19–11JUL00–8/16

RG5064 –UN–05DEC97

Valve Guide Knurler Kit JT05949

Knurl valve guides.



RG5064

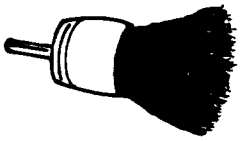
JT05949

DPSG,OUO1004,2802 –19–11JUL00–9/16

RG5063 –UN–05DEC97

End Brush D17024BR

Clean valve seat and bores.



RG5063

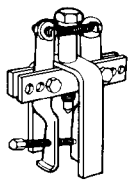
D17024BR

DPSG,OUO1004,2802 –19–11JUL00–10/16

RG5071 –UN–05DEC97

Valve Seat Puller JDE41296

Remove valve seats.



RG5071

JDE41296

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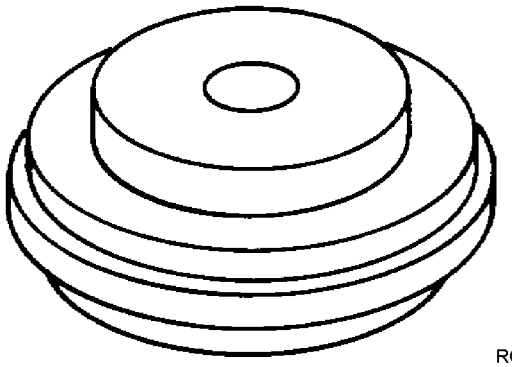
DPSG,OUO1004,2802 –19–11JUL00–11/16

Valve Seat Installer JDG605

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



RG5240 –UN–05DEC97

JDG605

DPSG,OUO1004,2802 –19–11JUL00–12/16

RG5065 –UN–05DEC97

Valve Seat Pilot Driver JDE7

Install intake and exhaust valve seat inserts. Use with JDG605 Valve Seat Installer.

RG5065

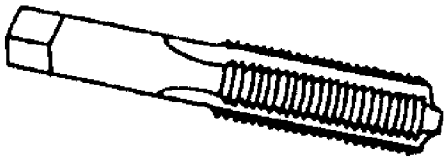
JDE7

DPSG,OUO1004,2802 –19–11JUL00–13/16

RG5100 –UN–05DEC97

Tap JDG681A

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



RG5100

JDG681A

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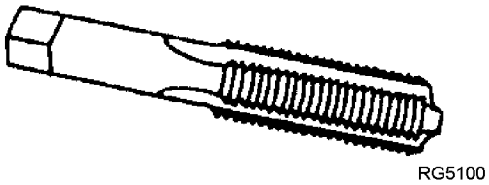
DPSG,OUO1004,2802 –19–11JUL00–14/16

RG5100 –UN–05DEC97

14 mm x 1.25 Plug Tap HAN1749

Clean and repair threads of spark plug holes in cylinder head.



RG5100

HAN1749

DPSG,OUO1004,2802 –19–11JUL00–15/16

RG6776 –UN–05DEC97

14 mm Thread Cleaning Brush JDG816

Clean threads of spark plug holes in cylinder head.

RG6776

JDG816

DPSG,OUO1004,2802 –19–11JUL00–16/16

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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DPSG,OUO1004,2803 –19–11JUL00–1/5

Precision Straightedge D05012ST

Check cylinder head flatness.

DPSG,OUO1004,2803 –19–11JUL00–2/5

Valve Guide Cleaning Brush D17011BR

Used to clean valve guides.

Continued on next page

DPSG,OUO1004,2803 –19–11JUL00–3/5

Eccentrimeter D11010KW

Measure valve seat runout.

DPSG,OUO1004,2803 –19–11JUL00–4/5

Heavy-Duty Seat Grinding Set JT05893

Grind valve seats.

DPSG,OUO1004,2803 –19–11JUL00–5/5

Other Material

Number	Name	Use
AR44402 (U.S.)	Valve Stem Lubricant	Lubricate valve stems.

DPSG,OUO1004,2804 –19–11JUL00–1/1

Cylinder Head and Valves Specifications

Item	Measurement	Specification
Intake Valve Clearance Checking (Rocker Arm-to-Valve Tip with Engine Cold)	Clearance	0.331—0.431 mm (0.013—0.017 in.)
Exhaust Valve Clearance Checking (Rocker Arm-to-Valve Tip with Engine Cold)	Clearance	0.458—0.558 mm (0.018—0.022 in.)
Intake Valve Clearance Adjustment (Rocker Arm-to-Valve Tip with Engine Cold)	Clearance	0.38 mm (0.015 in.)
Exhaust Valve Clearance Adjustment (Rocker Arm-to-Valve Tip with Engine Cold)	Clearance	0.51 mm (0.020 in.)
Valve Adjusting Screw Lock Nut	Torque	27 N•m (20 lb-ft)
Rocker Arm Cover-to-Cylinder Head Cap Screws	Torque	8 N•m (6 lb-ft) (72 lb-in.)
Intake Valve [at 0.00 mm (0.00 in.) Clearance]	Valve Lift Wear Tolerance	13.53—13.71 mm (0.533—0.540 in.) 12.65 mm (0.498 in.)
Exhaust Valve [at 0.00 mm (0.00 in.) Clearance]	Valve Lift Wear Tolerance	14.52—14.70 mm (0.572—0.579 in.) 13.64 mm (0.537 in.)
Rocker Arm	ID	19.07—19.10 mm (0.7507—0.7520 in.)
Rocker Arm Shaft	OD	19.01—19.05 mm (0.7484—0.7500 in.)
Exhaust Valve Recess Below Cylinder Head	Recess Maximum Recess	1.19—1.70 mm (0.047—0.067 in.) 2.46 mm (0.097 in.)
Intake Valve Recess Below Cylinder Head	Recess Maximum Recess	3.35—3.86 mm (0.132—0.152 in.) 4.62 mm (0.182 in.)
HFN01 and HFN03 engines:		
Intake Valve Spring (Closed)	Compressed Height	52.5 mm @ 360—400 N (2.07 in. @ 81—90 lb-force)

Continued on next page

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Item	Measurement	Specification
Intake Valve Spring (Open)	Compressed Height	38.1 mm @ 988—1068 N (1.50 in. @ 222—240 lb-force)
Exhaust Valve Spring (Closed)	Compressed Height	54.5 mm @ 270—310 N (2.15 in. @ 60—70 lb-force)
Exhaust Valve Spring (Open)	Compressed Height	38.5 mm @ 975—1055 N (1.52 in. @ 215—235 lb-force)
HFN02 and HFN04 engines:		
Intake Valve Spring (Closed)	Compressed Height	52.5 mm @ 345—399 N (2.07 in. @ 81—90 lb-force)
Intake Valve Spring (Open)	Compressed Height	38.1 mm @ 810—880 N (1.50 in. @ 182—198 lb-force)
Exhaust Valve Spring (Closed)	Compressed Height	54.5 mm @ 284—338 N (2.15 in. @ 64—76 lb-force)
Exhaust Valve Spring (Open)	Compressed Height	38.5 mm @ 797—867 N (1.52 in. @ 179—195 lb-force)
Exhaust Valve Head	OD	46.87—47.13 mm (1.845—1.856 in.)
Intake Valve Head	OD	50.87—51.13 mm (2.003—2.013 in.)
Exhaust Valve Stem	OD	9.436—9.462 mm (0.3717—0.3724 in.)
Intake Valve Stem	OD	9.461—9.487 mm (0.3724—0.3736 in.)
Valve Stems	Oversize	0.38 mm (0.015 in.)
Intake and Exhaust Valve Face	Runout	0.051 mm (0.0020 in.) maximum
Intake and Exhaust Valve Face	Angle	19.5° ± 0.25°
Water Jacket Access Plate (Top of Cylinder Head)	Torque	34 N•m (25 lb-ft)
Cylinder Head Top Deck	Out-of-Flat	0.102 mm (0.0040 in.) maximum (over entire length and width)

Continued on next page

Item	Measurement	Specification
Cylinder Head Top Deck	Straightness	0.025 mm (0.001 in.) per any 305 mm (12 in.) length
Cylinder Head	Thickness	155.45—155.71 mm (6.120—6.130 in.)
	Wear Limit	154.69 mm (6.09 in.)
Cylinder Head	Combustion Face Surface Finish (AA)	1.5—2.8 micro-meters (60—110 micro-in.)
Cylinder Head	Wave Depth	0.008 mm (0.0003 in.) maximum
Cylinder Head	Maximum Material Removal for Resurfacing Head	0.762 mm (0.030 in.)
Valve Guide in New Head	ID	9.51—9.54 mm (0.3745—0.3755 in.)
New Exhaust Valve Guide-to-Valve Stem	Clearance	0.051—0.102 mm (0.002—0.004 in.)
New Intake Valve Guide-to-Valve Stem	Clearance	0.025—0.076 mm (0.001—0.003 in.)
Intake and Exhaust Valve Seat	Oversize	0.25 mm (0.010 in.)
Intake and Exhaust Valve Seat	Angle	20° ± 0.50°
Exhaust Valve Seat	Width	2.0—3.8 mm (0.079—0.150 in.)
Intake Valve Seat	Width	1.4—3.8 mm (0.055—0.150 in.)
Intake and Exhaust Valve Seat	Runout	0.051 mm (0.0020 in.) maximum
Cylinder Liner	Height Above Block	0.051—0.127 mm (0.002—0.005 in.)
Cylinder Head Flanged-Head “SPECIAL” Cap Screws (No Washers)	Initial Torque	80 N•m (60 lb-ft)
Cylinder Head Flanged-Head “SPECIAL” Cap Screws (No Washers)	Final Torque Turn	90° (accomplished sequentially, three times for a total of 270°)

Continued on next page

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Item	Measurement	Specification
Rocker Arm Shaft Cap Screws	Torque	75 N•m (55 lb-ft)
Rocker Arm Cover Cap Screws	Torque	8 N•m (6 lb-ft) (72 lb-in.)

DPSG,OUO1004,2805 –19–29MAR04–4/4

Check and Adjust Valve Clearance

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

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

Continued on next page

RG,01,DT7055 –19–30MAR04–1/5

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

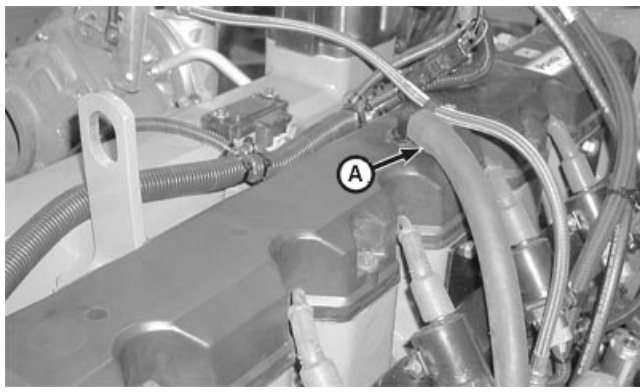
IMPORTANT: Valve clearance MUST BE checked and adjusted with engine COLD.

1. Remove rocker arm cover with ventilator tube.

IMPORTANT: Visually inspect ventilator tube (A) for cracks or restrictions.

Visually inspect contact surfaces of valve tips and rocker arm wear pads. Check all parts for excessive wear, breakage, or cracks (See DISASSEMBLE AND REMOVE ROCKER ARM SHAFT ASSEMBLY, later in this group). Replace parts that show visible damage.

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



Rocker Arm Cover

A—Ventilator Tube

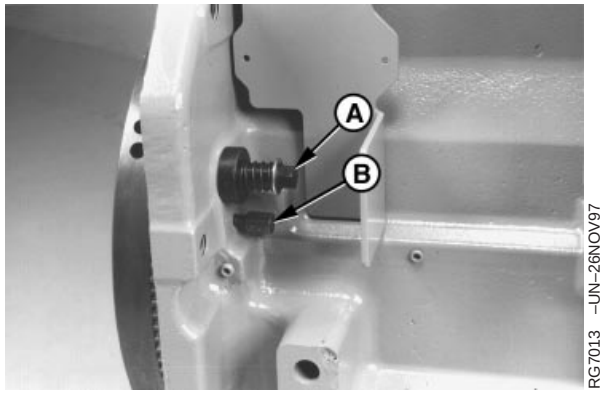
RG,01,DT7055 –19–30MAR04–2/5

2. Remove plastic plug from cylinder block bores and install JDE81-1 or JDG820 Flywheel Turning Tool (A) and JDE81-4 Timing Pin (B).

3. Rotate engine with the flywheel turning tool until timing pin engages timing hole in flywheel.

   If the rocker arms for No. 1 (front) cylinder are loose, the engine is at No. 1 TDC-Compression.

   If the rocker arms for No. 6 (rear) cylinder are loose, the engine is at No. 6 TDC-Compression. Rotate the engine one full revolution (360°) to No. 1 TDC-Compression.



Flywheel Turning Tool and Timing Pin

A—Flywheel Turning Tool
B—Timing Pin

Continued on next page

RG,01,DT7055 –19–30MAR04–3/5

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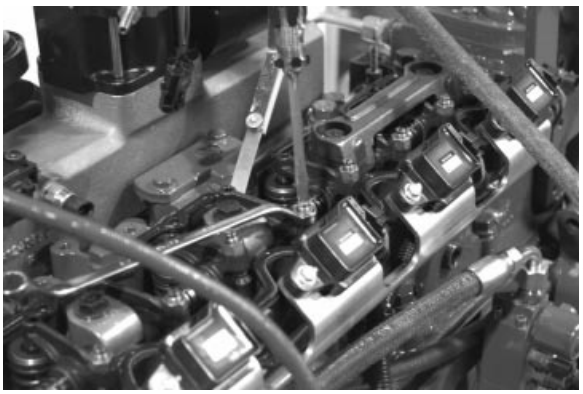
4. With engine lock-pinned at TDC of No. 1 piston's compression stroke, use feeler gauge as shown to check valve clearance on No's. 1, 3, and 5 exhaust valves and No's. 1, 2, and 4 intake valves.

Specification

Intake Valve Clearance Checking (Rocker Arm-to-Valve Tip with Engine Cold)—Clearance	0.331—0.431 mm (0.013—0.017 in.)
Exhaust Valve Clearance Checking (Rocker Arm-to-Valve Tip with Engine Cold)—Clearance	0.458—0.558 mm (0.018—0.022 in.)


RG7280 –UN–09MAR00

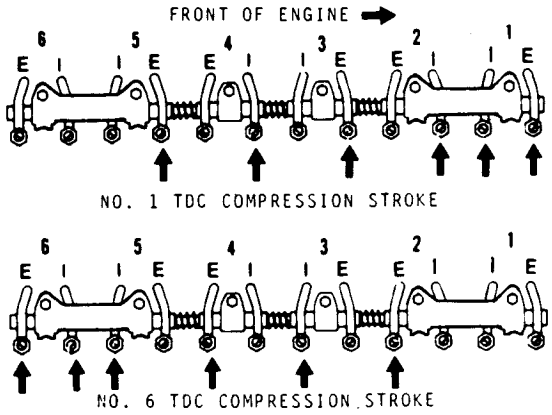
Adjusting Valve Clearance

5. Rotate flywheel 360° until No. 6 piston is at TDC of its compression stroke. Rocker arms for No. 6 piston should be loose.

6. Check valve clearance to the same specifications on No's. 2, 4, and 6 exhaust and No's. 3, 5, and 6 intake valves.

NOTE: Adjust valve clearance in the same sequence used for checking clearance.

7. If valve clearance needs to be adjusted, loosen the lock nut on rocker arm adjusting screw. Turn adjusting screw until feeler gauge slips with a slight drag. Hold the adjusting screw from turning with screwdriver and tighten lock nut.



RG4295 –19–21AUG91

Valve Adjusting Sequence

Specification

Intake Valve Clearance Adjustment (Rocker Arm-to-Valve Tip with Engine Cold)—Clearance	0.38 mm (0.015 in.)
Exhaust Valve Clearance Adjustment (Rocker Arm-to-Valve Tip with Engine Cold)—Clearance	0.51 mm (0.020 in.)

8. Recheck clearance again after tightening lock nut and compare to the following specification. Readjust clearance as necessary and tighten lock nut to specification.

Specification

Valve Adjusting Screw Lock Nut—Torque	27 N•m (20 lb-ft)

Continued on next page

RG,01,DT7055 –19–30MAR04–4/5

9. Install rocker arm cover and tighten cap screws to specification.

Specification	
Rocker Arm Cover-to-Cylinder Head Cap Screws—Torque	8 N•m (6 lb-ft) (72 lb-in.)

RG,01,DT7055 –19–30MAR04–5/5

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Check Valve Lift

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

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

1. Remove turbocharger oil inlet line clamp and rocker arm cover. Loosen lock nut on rocker arm. Set valve clearance at 0.00 mm (0.00 in.) on valve being checked. Tighten lock nut.

2. Put dial indicator tip on valve rotator as shown. Be sure that valve is fully closed.

3. Check pre-set on dial indicator. Set dial indicator pointer at zero.

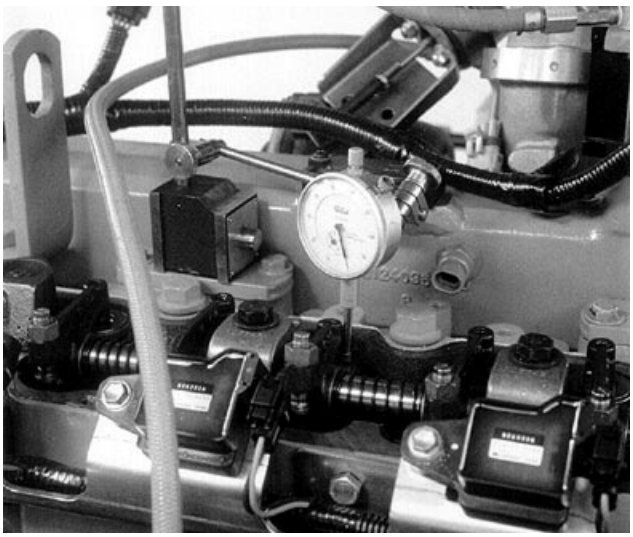
4. Manually turn engine in running direction, using the engine rotation tools previously mentioned for checking valve clearance.

5. Observe dial indicator reading as valve is moved to fully open position. Record reading and valve number.

Specification	
Intake Valve [at 0.00 mm (0.00 in.) Clearance]—Valve Lift	13.53—13.71 mm (0.533—0.540 in.)
Wear Tolerance	12.65 mm (0.498 in.)
Exhaust Valve [at 0.00 mm (0.00 in.) Clearance]—Valve Lift	14.52—14.70 mm (0.572—0.579 in.)
Wear Tolerance	13.64 mm (0.537 in.)

6. Reset valve clearance to specification after measuring lift. (See CHECK AND ADJUST VALVE CLEARANCE, earlier in this group.)

7. Repeat procedure on all remaining valves.



RG7832 –UN–05DEC97

Measuring Valve Lift

RG,01,DT7056 –19–29MAR04–1/1

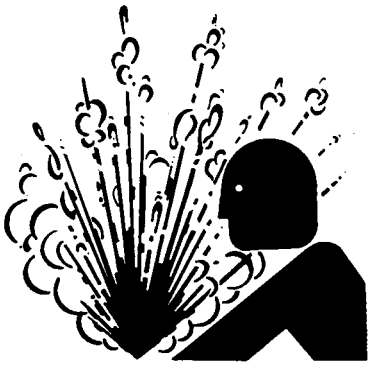
Remove Cylinder Head

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

CAUTION: After operating engine, allow exhaust system to cool before removal. DO NOT drain coolant until the coolant is below operating temperature. Always loosen drain valve slowly to relieve any excess pressure.

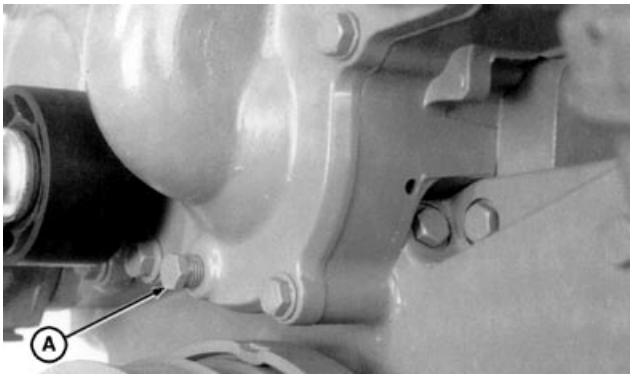
1. Slowly open the engine cooling system filler cap or radiator cap to relieve pressure and allow coolant to drain faster.
2. **On HFN01 and HFN03 engines:** Open drain valve (B) on left side of engine and remove plug (A) on coolant pump. Drain all coolant from engine block.

A—Drain Plug (HFN01 Engine Shown)
B—Block Drain Valve (HFN01 Engine Shown)



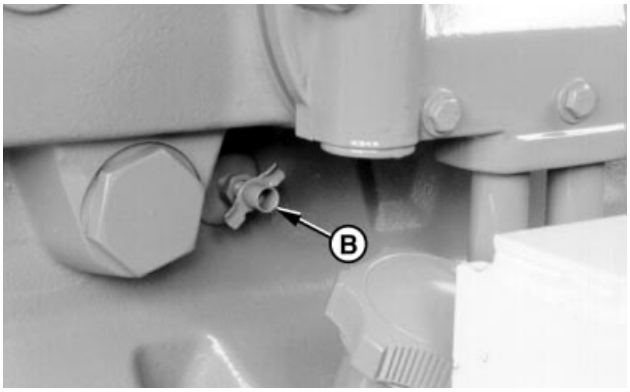
TS281 –UN–23AUG88

Allow Exhaust System to Cool



RG7675A –UN–05DEC97

Coolant Pump Drain Plug (HFN01 Engine Shown)



RG7143 –UN–26NOV97

Block Drain Valve (HFN01 Engine Shown)

Continued on next page

DPSG,OUO1004,2800 –19–20FEB02–1/7

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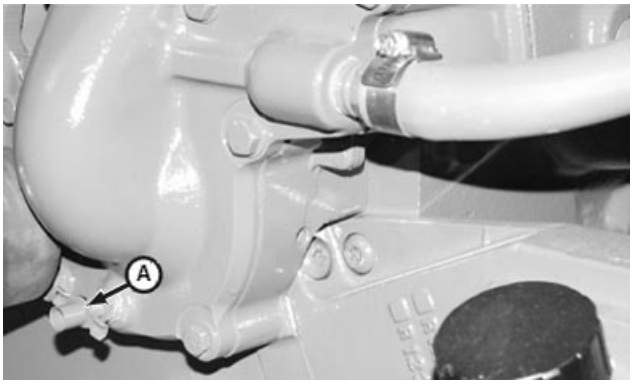
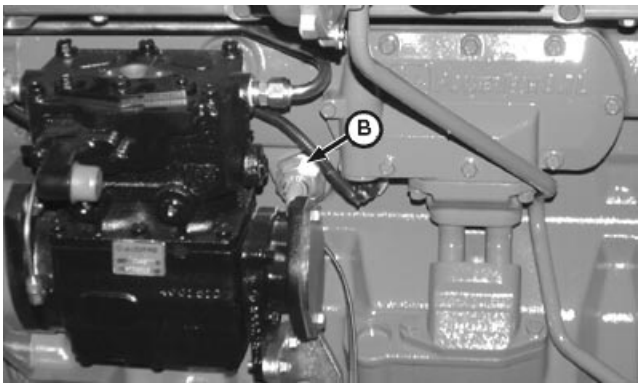
3. **On HFN02 and HFN04 engines:** Open coolant pump drain valve (A) on coolant pump and remove block heater (B) on left side of engine. Drain all coolant from engine block.

4. Drain all engine oil. Disconnect turbocharger oil inlet line at turbocharger or oil filter base. (See DISCONNECT TURBOCHARGER OIL INLET LINE in Group 03.)

A—Drain Valve (HFN02 Engine Shown)
B—Block Heater (HFN02 Engine Shown)



Drain Valve (HFN02 Engine Shown)



Engine Block Heater (HFN02 Engine Shown)

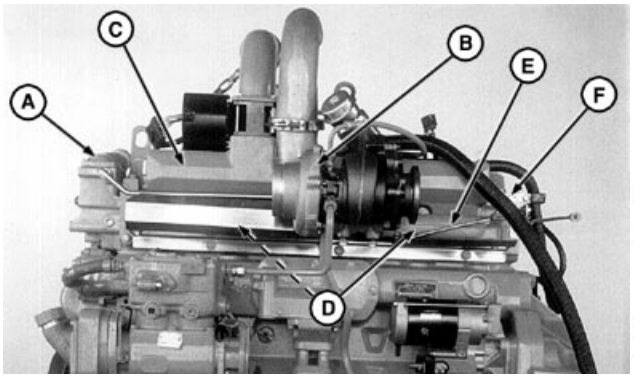
Continued on next page DPSG,OUO1004,2800 –19–20FEB02–2/7

NOTE: If cylinder head is being removed for piston and liner repairs or any other service that does not require disassembly of head, cylinder head can be removed with water manifold (A), turbocharger (B), intake manifold (C), and exhaust manifold (D) installed.

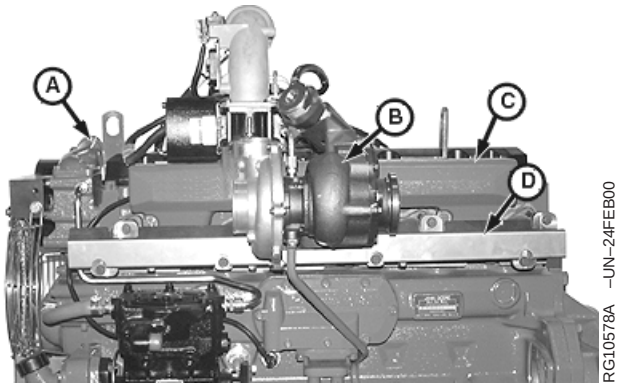
5. Remove wiring harness clamps. Remove wiring harness.

6. Remove coils, rail, spark plug boots, and spark plugs. (See REMOVE AND INSTALL SPARK PLUGS in Group 45.)

A—Water Manifold
B—Turbocharger
C—Intake Manifold
D—Exhaust Manifold Assembly
E—Hose
F—Bracket



Remove Cylinder Head (HFN01 Engine Shown) (HFN03 and HFN04 Similar)



Remove Cylinder Head (HFN02 Engine Shown)

Continued on next page

DPSG,OUO1004,2800 –19–20FEB02–3/7

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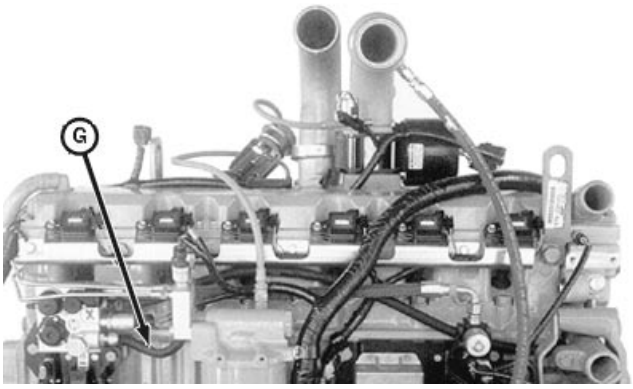
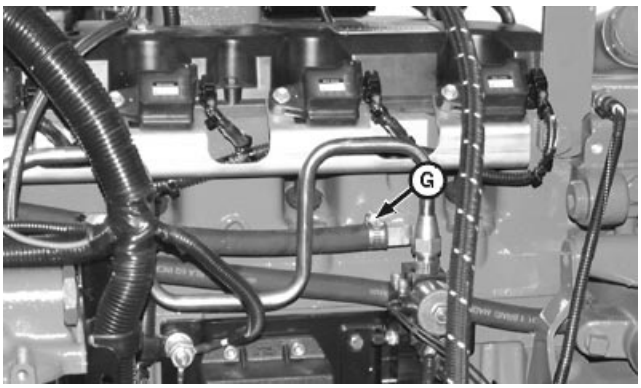
7. Disconnect gas regulator coolant hose (G).
8. If equipped, disconnect EBP line (E) at the exhaust manifold and remove bracket (F).
9. Remove coolant manifold and all coolant piping. (See REMOVE COOLANT MANIFOLD in Group 25.)
10. Disconnect wiring and hoses from turbocharger wastegate control valve as required.
11. Remove turbocharger. (See REMOVE TURBOCHARGER in group 30.)
12. Remove exhaust manifold. (See REMOVE, INSPECT, AND INSTALL EXHAUST MANIFOLD in Group 30.)
13. Disconnect fuel line and wiring connectors from electronic components mounted to air intake manifold.
14. Remove air intake manifold. (See REMOVE, INSPECT AND INSTALL INTAKE MANIFOLD in Group 30.)

G—Regulator Coolant Hose



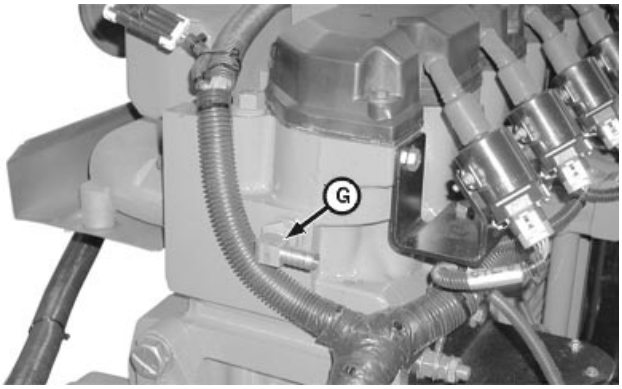
RG10745 –UN–14JUL00

Regulator Coolant Hose (Early HFN01 Engine Shown)



RG10577A –UN–24FEB00

Regulator Coolant Hose (HFN02 Engine Shown) (Current HFN01 and HFN03 Similar)



RG12115A –UN–06MAR02

Regulator Coolant Hose (HFN04 Engine Shown)

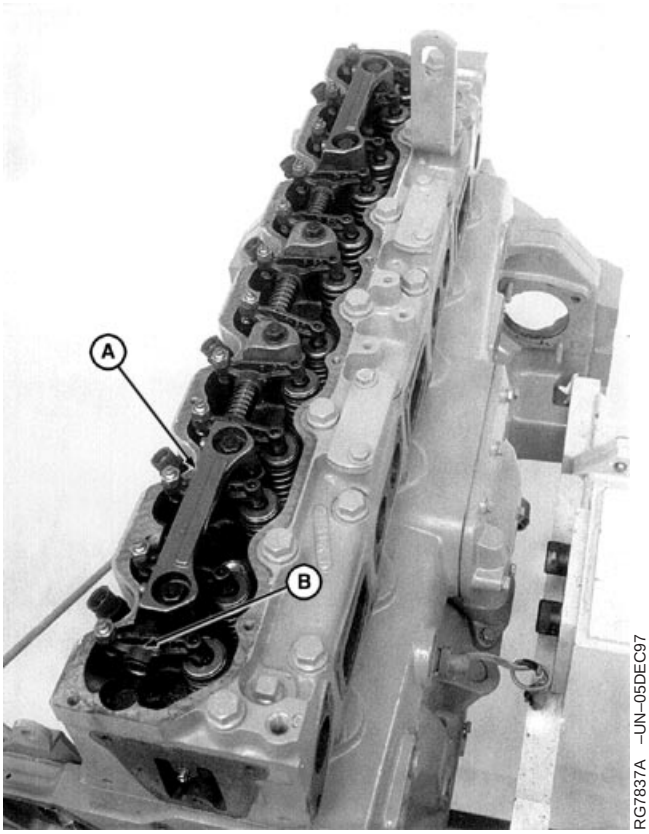
Continued on next page

DPSG,OUO1004,2800 –19–20FEB02–4/7

15. Remove rocker arm cover with ventilator outlet hose assembly.

16. Remove six cap screws and remove all four rocker arm shaft clamps (A). Lift rocker arm assembly (B) up and remove. Remove wear caps from valve stems.

A—Rocker Arm Shaft Clamp
B—Rocker Arm Assembly

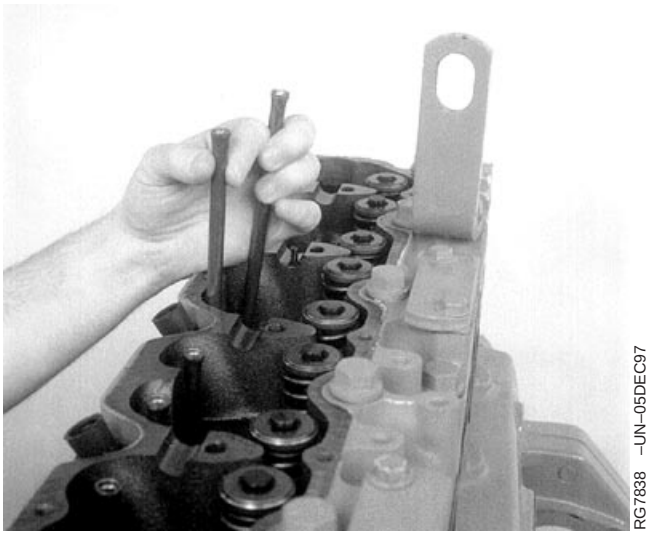


Removing Rocker Arm Assembly

DPSG,OUO1004,2800 –19–20FEB02–5/7

17. Remove all 12 push rods and identify for reassembly.

NOTE: Clean and inspect push rods. (See CLEAN AND INSPECT PUSH RODS in this group.)



Removing Push Rods

Continued on next page

DPSG,OUO1004,2800 –19–20FEB02–6/7

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18. Remove all 26 cylinder head cap screws. Discard cap screws; they are not reusable.

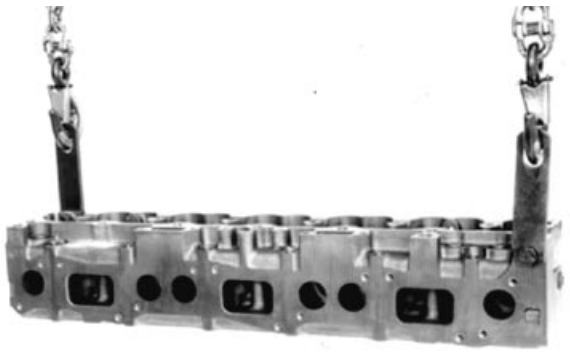
IMPORTANT: DO NOT use screwdrivers or pry bars between cylinder block and cylinder head to loosen head-to-block gasket seal.

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

20. Remove cylinder head gasket. Inspect for possible oil, coolant, or combustion chamber leaks. Also, check for evidence of incorrect or defective head gasket being used.

NOTE: Do not rotate crankshaft with cylinder head removed unless all cylinder liners are secured with cap screws and large flat washers as described in Group 10, Cylinder Block, Liners, Pistons, and Rods—Repair & Replacement Procedures.

For diagnostics, inspection and repair of cylinder head gasket, see DIAGNOSING HEAD GASKET JOINT FAILURES in Group 105 of CTM113, for HFN01—03 engines. For HFN04 engines, see DIAGNOSING HEAD GASKET JOINT FAILURES in Group 105 of CTM300.



RG5245 –UN–05DEC97

Lifting Cylinder Head

DPSG,OUO1004,2800 –19–20FEB02–7/7

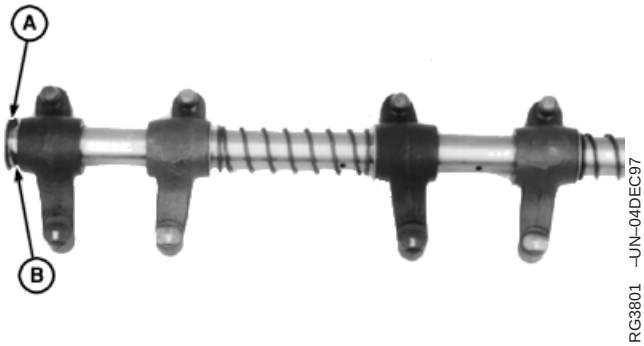
Disassemble and Inspect Rocker Arm Shaft Assembly

NOTE: Make preliminary inspection during disassembly. Look for:

- *Worn or scored rocker arms, shaft, and shaft support.*
- *Weak or broken springs*
- *Lube oil restriction*

1. Remove plugs (A) and washers (B) from ends of rocker arm shaft.

2. Slide springs, rocker arms, and rocker arm supports off rocker arm shaft, identifying their parts for reassembly in the same sequence they were in before disassembly.



Remove Plugs and Washers

A—Plugs
B—Washers

RG,01,DT7058 –19–09MAR00–1/3

3. Inspect rocker arm shaft (A) for severe scratching, scoring, or excessive wear at points of rocker arm contact. Measure rocker arm and shaft. Compare with specifications given below.

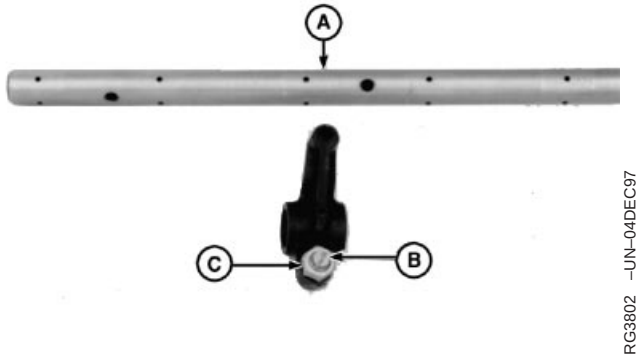
Specification	
Rocker Arm—ID	19.07—19.10 mm (0.7507—0.7520 in.)
Rocker Arm Shaft—OD	19.01—19.05 mm (0.7484—0.7500 in.)

NOTE: Wear could indicate weak valve springs, bent push rods, or lose rocker arm shaft clamps.

4. Check rocker arm adjusting nut (C) and screw (B) for damage. Visually inspect rocker arm for hairline cracks. Replace if necessary.

IMPORTANT: Be sure all oil holes in rocker arm shaft are clean and open.

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



Inspect Rocker Arm Shaft

A—Rocker Arm Shaft
B—Rocker Arm Adjusting Screw
C—Rocker Arm Adjusting Nut

Continued on next page

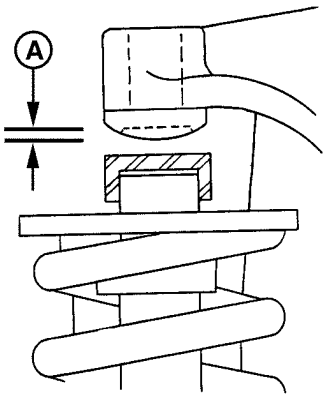
RG,01,DT7058 –19–09MAR00–2/3

6. Check for cups or concave wear (A) on ends of rocker arms where they contact wear caps.

7. Examine spacer springs on shaft between rocker arms. Be sure they are strong enough to exert a positive pressure on rocker arms.

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

8. Roll rocker arm shaft and push rods on a flat surface to check for bends or distortion. Replace parts as necessary.



RGR26131 –UN–12JAN98

Check for Concave Wear

A—Concave Wear

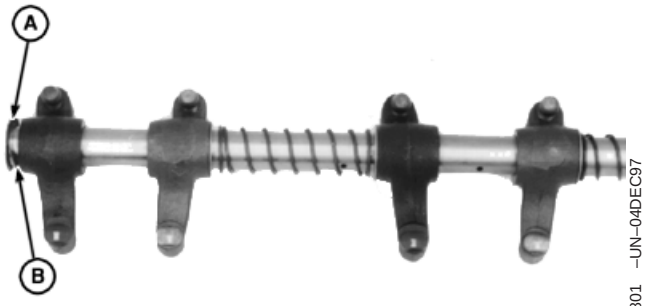
RG,01,DT7058 –19–09MAR00–3/3

Assemble Rocker Arm Shaft Assembly

Assemble parts on rocker arm shaft opposite removal procedure.

Make sure rocker arm shaft end plugs (A) are firmly seated against end of shaft, and washers (B) are installed on shaft.

A—Rocker Arm Shaft End Plugs
B—Washers



RG3801 –UN–04DEC97

Assemble Rocker Arm Shaft

RG,01,DT7059 –19–30OCT97–1/1

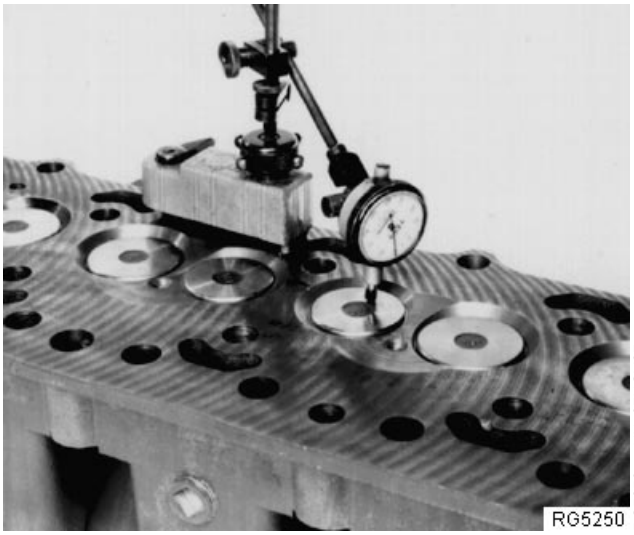
Measure Valve Recess

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

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

Specification	
Exhaust Valve Recess Below Cylinder Head—Recess	1.19—1.70 mm (0.047—0.067 in.)
Maximum Recess	2.46 mm (0.097 in.)
Intake Valve Recess Below Cylinder Head—Recess	3.35—3.86 mm (0.132—0.152 in.)
Maximum Recess	4.62 mm (0.182 in.)

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



Measuring Valve Recess

RG,01,DT7060 –19–25AUG00–1/1

Preliminary Cylinder Head and Valve Checks

Make preliminary inspection of cylinder head and valve assembly during disassembly. Look for the following conditions:

Sticking Valves:

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

Warped, Worn, or Distorted Valve Guides:

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

Distorted Cylinder Head and Gasket Leakage:

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

Worn or Broken Valve Seats:

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

Burned, Pitted, Worn, or Broken Valves:

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

Improper Valve Clearance:

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

Excessive Recession:

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

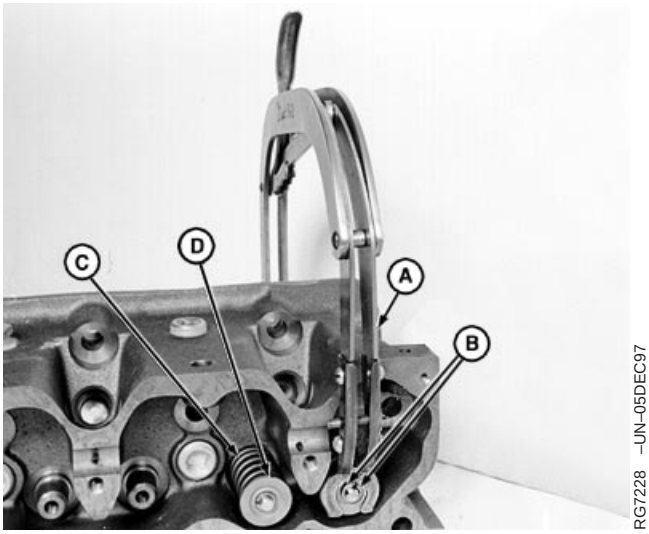
RG,05,DT7367 –19–11NOV97–1/1

Remove Valve Assembly

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

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

1. Compress valve spring using JDE138 Valve Spring Compressor (A) as shown.
2. Remove retaining locks (B) using a small magnet.
3. Remove valve spring compressor from head.
4. Remove valve spring cap (D) and valve spring (C).



RG7228 –UN–05DEC97

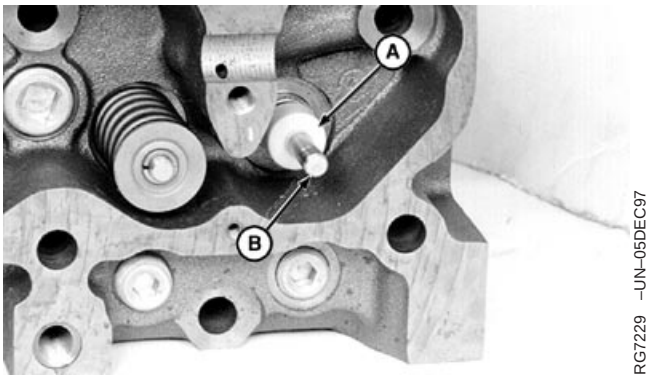
Compress Valve Spring

A—JDE138 Valve Spring Compressor
B—Retainer Locks
C—Valve Springs
D—Valve Spring Caps

RG,05,DT7067 –19–30OCT97–1/2

5. Remove oil seal (A) from valves. Remove valve (B) from cylinder head. Identify valve for reassembly, if valve is to be reused
6. Repeat procedure on remaining valves.

A—Oil Seal
B—Valve



RG7229 –UN–05DEC97

Remove Oil Seal and Valve

RG,05,DT7067 –19–30OCT97–2/2

05
26

Inspect and Measure Valve Springs

1. Inspect valve springs for alignment, wear and damage.
2. Put springs on a flat surface to see that they are square and parallel.
3. Check valve spring tension using D01168AA Spring Compression Tester.

NOTE: Free spring length of 65 mm (2.56 in.) springs differ slightly, but compressed height must be the same.

RG2732 –UN–04DEC97

Inspect Valve Spring

RGT82054 –UN–11DEC97

Checking Valve Spring Tension

Item	Measurement	Specification
HFN01 and HFN03 engines:		
Intake Valve Spring (Closed)	Compressed Height	52.5 mm @ 360—400 N (2.07 in. @ 81—90 lb-force)
Intake Valve Spring (Open)	Compressed Height	38.1 mm @ 988—1068 N (1.50 in. @ 222—240 lb-force)
Exhaust Valve Spring (Closed)	Compressed Height	54.5 mm @ 270—310 N (2.15 in. @ 60—70 lb-force)
Exhaust Valve Spring (Open)	Compressed Height	38.5 mm @ 975—1055 N (1.52 in. @ 215—235 lb-force)

Item	Measurement	Specification
HFN02 and HFN04 engines:		
Intake Valve Spring (Closed)	Compressed Height	52.5 mm @ 345—399 N (2.07 in. @ 81—90 lb-force)
Intake Valve Spring (Open)	Compressed Height	38.1 mm @ 810—880 N (1.50 in. @ 182—198 lb-force)

Continued on next page

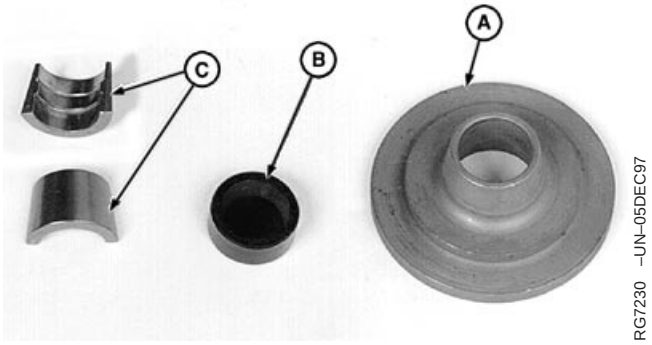
RG,05,DT7068 –19–20FEB02–1/2

Item	Measurement	Specification
Exhaust Valve Spring (Closed)	Compressed Height	54.5 mm @ 284—338 N (2.15 in. @ 64—76 lb-force)
Exhaust Valve Spring (Open)	Compressed Height	38.5 mm @ 797—867 N (1.52 in. @ 179—195 lb-force)

RG,05,DT7068 –19–20FEB02–2/2

Inspect Valve Spring Caps, Wear Caps, and Retainer Locks

1. Inspect valve spring caps (A) in area where valve springs and retaining locks seat for excessive wear. Replace as necessary.
2. Inspect retainer locks (C) for excessive wear. Replace as needed.
3. Inspect valve wear cap (B) contact surfaces. Replace wear caps if pitted or worn.



Inspect Valve Parts

A—Valve Spring Caps
B—Valve Wear Cap
C—Retainer Locks

RG,05,DT7069 –19–30OCT97–1/1

Clean Valves

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

IMPORTANT: Any carbon left on valve stem will affect alignment in refacer if valves need to be refaced. If necessary, soak valve stem in solvent to soften and remove carbon.

2. Make sure all carbon is removed from valve head, face, and stem. Polish valve stem with steel wool or crocus cloth to remove scratch marks left by wire brush.

RG,05,DT7070 –19–29MAR04–1/1

05
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Inspect and Measure Valves

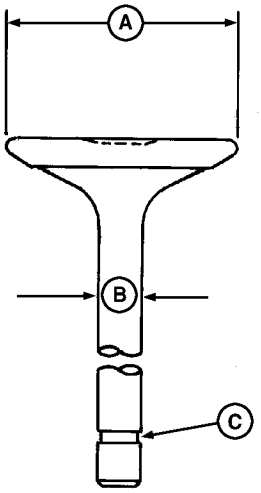
1. Thoroughly clean and inspect valves to help determine if they can be restored to a serviceable condition. Replace valves that are burned, cracked, eroded, or chipped.

2. Inspect valve retainer lock groove (C) on valve stem for damage. Also inspect stems for signs of scuffing, which may indicate insufficient valve guide-to-valve stem clearance. Replace if defects are evident.

3. Measure valve head OD (A). Compare valve stem OD (B) with guide ID to determine clearance, as outlined later in this group.

Specification

Exhaust Valve Head—OD	46.87—47.13 mm (1.845—1.856 in.)
Intake Valve Head—OD	50.87—51.13 mm (2.003—2.013 in.)
Exhaust Valve Stem—OD	9.436—9.462 mm (0.3717—0.3724 in.)
Intake Valve Stem—OD	9.461—9.487 mm (0.3724—0.3736 in.)
Valve Stems—Oversize	0.38 mm (0.015 in.)



RG5795 –UN–05DEC97

Valve Inspection Dimensions

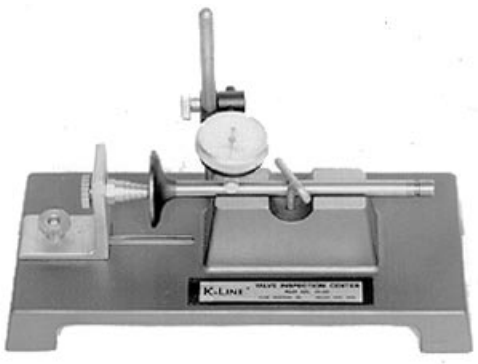
A—Valve Head OD
B—Valve Stem OD
C—Valve Retainer Lock Groove

RG,05,DT7071 –19–29MAR04–1/2

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

Specification

Intake and Exhaust Valve Face—Runout	0.051 mm (0.0020 in.) maximum



RG4234 –UN–05DEC97

Valve Inspection Center

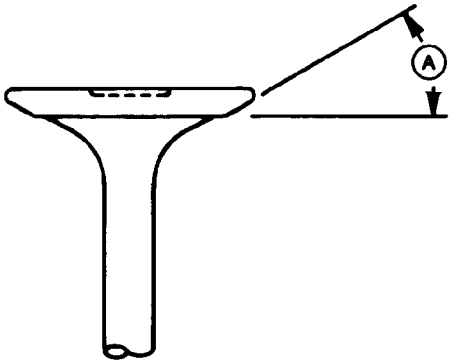
RG,05,DT7071 –19–29MAR04–2/2

Grind (Reface) Valves

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

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

Specification	
Intake and Exhaust Valve Face—	
Angle	19.5° ± 0.25°



RG5247 –UN–05DEC97

Valve Face Dimension

A—Valve Face Angle

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

RG,05,DT7072 –19–30OCT97–1/1

05
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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.

3. Clean spark plug threaded holes in cylinder head using JDG816 14 mm Thread Cleaning Brush.

   If plug hole threads are damaged, repair threads using HAN1749 14 mm x 1.25 Tap.

IMPORTANT: Be sure to remove all plugs and water jacket access plates (on top of cylinder head) before cleaning head, as parts can be damaged or destroyed by hot tank solutions.

4. Clean cylinder head in a chemical hot tank, or with solvent and a brush.

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

6. Reinstall all plugs. Install water jacket access plates with new gaskets and tighten to specifications.

Specification	
Water Jacket Access Plate (Top of Cylinder Head)—Torque	34 N•m (25 lb-ft)

RG,05,DT7073 –19–11JUL00–1/1

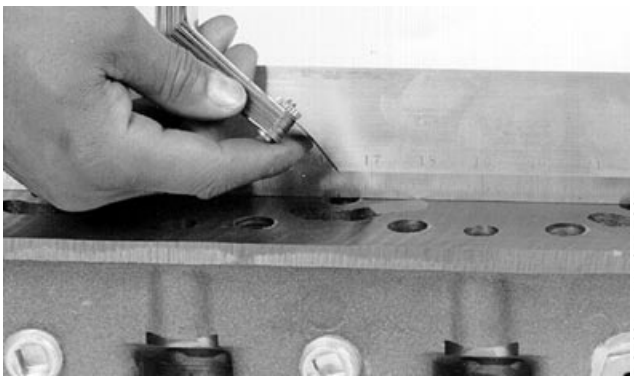
Check Cylinder Head Combustion Face Flatness

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

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

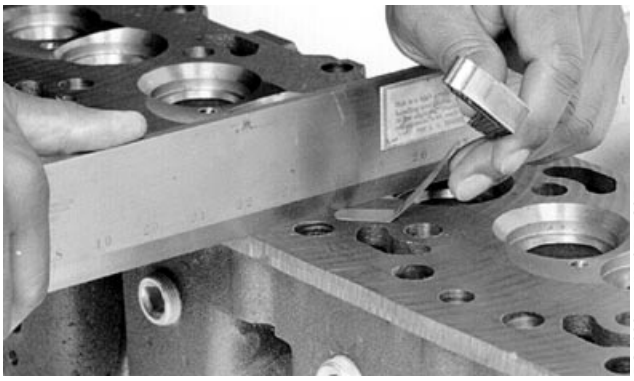
Specification

Cylinder Head Top Deck—Out-of-Flat	0.102 mm (0.0040 in.) maximum (over entire length and width)
Cylinder Head Top Deck—Straightness	0.025 mm (0.001 in.) per any 305 mm (12 in.) length



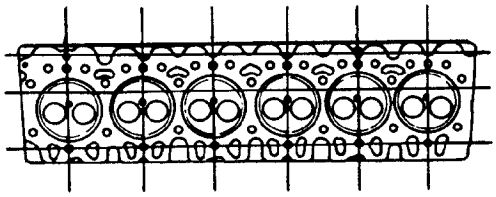
RG7231 –UN–05DEC97

Checking Head Face Flatness



RG7232 –UN–05DEC97

Checking Head Face Flatness



RG4629 –UN–05DEC97

RG4629

Where to Check Head Face Flatness

RG,05,DT7074 –19–09MAR00–1/1

05
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Measure Cylinder Head Thickness

Measure head thickness (A) from valve cover gasket rail-to-combustion face.

If cylinder head thickness is less than wear limit, DO NOT attempt to resurface. Install a new cylinder head.

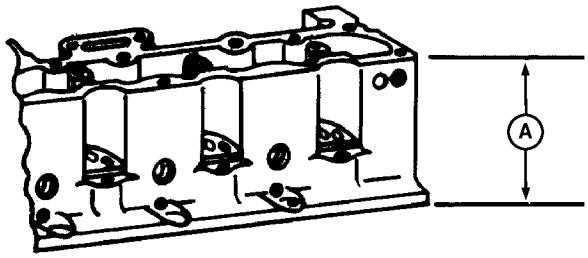
NOTE: If necessary to resurface cylinder head, a MAXIMUM of 0.762 mm (0.030 in.) can be ground from new part dimension. Remove ONLY what is necessary to restore flatness.

IMPORTANT: After resurfacing, check flatness as described earlier and check surface finish on combustion face of head.

Check valve recess after grinding. (See MEASURE VALVE RECESS, earlier in this group.) Valve seat or valve face may be ground to bring this characteristic within specification.

Specification

Cylinder Head—Thickness	155.45—155.71 mm (6.120—6.130 in.)
Wear Limit	154.69 mm (6.09 in.)
Cylinder Head—Combustion Face Surface Finish (AA)	1.5—2.8 micro-meters (60—110 micro-in.)
Cylinder Head—Wave Depth	0.008 mm (0.0003 in.) maximum
Cylinder Head—Maximum Material Removal for Resurfacing Head	0.762 mm (0.030 in.)



RG4421 –UN–05DEC97

Measure Cylinder Head Thickness

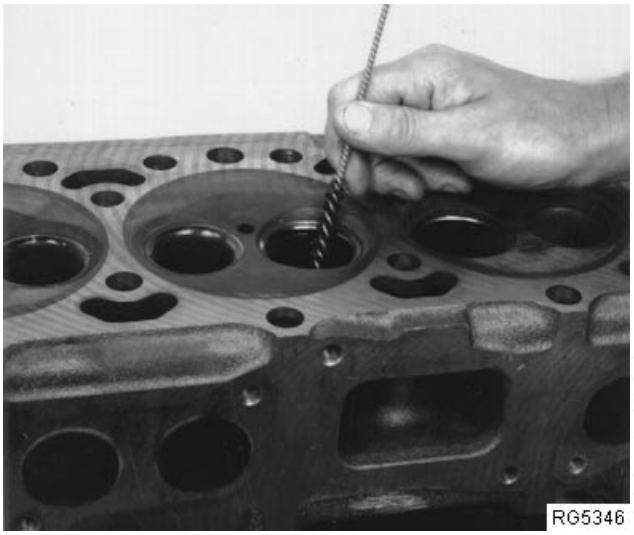
A—Cylinder Head Thickness

RG,05,DT7075 –19–17JUL00–1/1

Clean Valve Guides

Use a D17011BR Valve Guide Cleaning Brush to clean valve guides before inspection or repair.

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



Cleaning Valve Guides

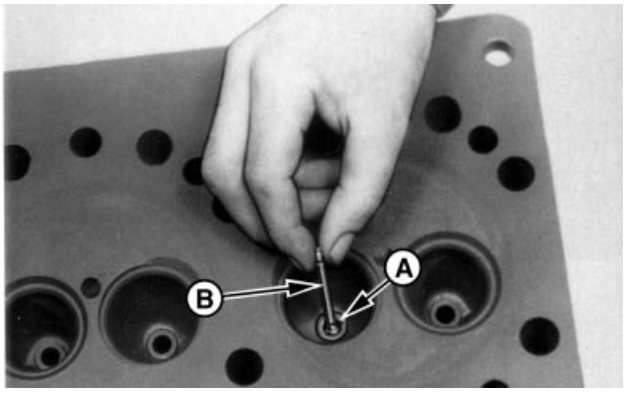
RG,05,DT7076 –19–30OCT97–1/1

Measure Valve Guides

Measure valve guides (A) for wear using a telescope gauge (B) and micrometer.

Specification

Valve Guide in New Head—ID	9.51—9.54 mm (0.3745—0.3755 in.)
New Exhaust Valve Guide-to-Valve Stem—Clearance	0.051—0.102 mm (0.002—0.004 in.)
New Intake Valve Guide-to-Valve Stem—Clearance	0.025—0.076 mm (0.001—0.003 in.)



Measuring Valve Guides

A—Valve Guides
B—Telescope Gauge

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

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

RG,05,DT7077 –19–30OCT97–1/1

05
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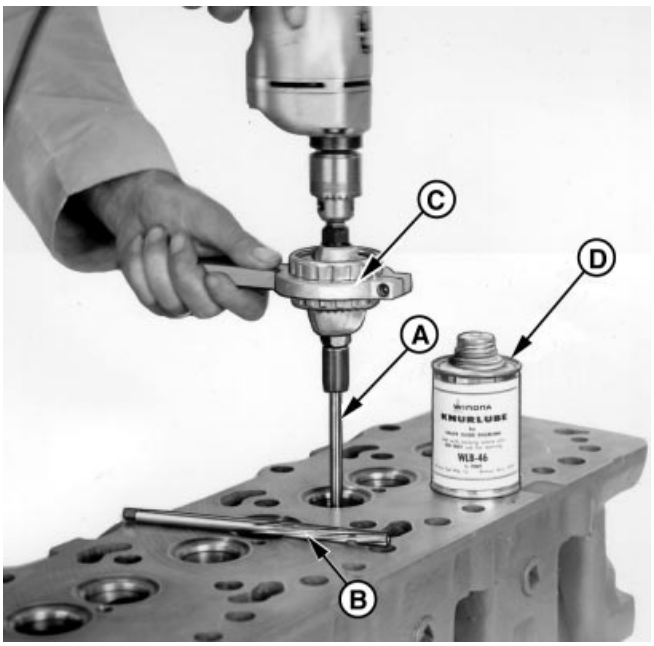
Knurl Valve Guides

1. Use JT05949 (formerly D20002) Valve Guide Knurler Kit to knurl valve guides.

NOTE: Use tool set exactly as directed by the manufacturer.

2. After knurling, ream valve guide to finished size to provide specified stem-to-guide clearance.

A—Knurler
B—Reamer
C—Speed Reducer
D—Lubricant



RGR26141 –UN–12JAN98

Knurling Valve Guides

RG,05,DT7078 –19–30OCT97–1/1

Clean and Inspect Valve Seats

1. Use an electric hand drill with D17024BR End Brush or equivalent brush to remove all carbon on valve seats.

2. Check seats for cracks, pits, or excessive wear.

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

RGR26142 –UN–11DEC97

Clean and Inspect Valve Seats

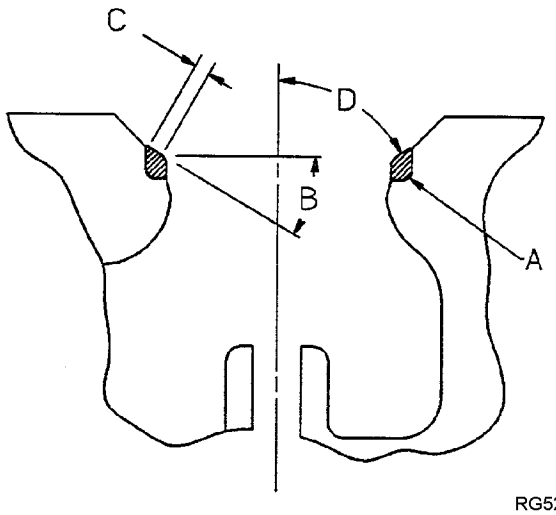
RG,05,DT7079 –19–30OCT97–1/1

Measure Valve Seats

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

Specification

Intake and Exhaust Valve Seat—Angle (B)	20° ± 0.50°
Exhaust Valve Seat—Width (C)	2.0—3.8 mm (0.079—0.150 in.)
Intake Valve Seat—Width (C)	1.4—3.8 mm (0.055—0.150 in.)
Intake and Exhaust Valve Seat—Runout (D)	0.051 mm (0.0020 in.) maximum
Intake and Exhaust Valve Seat—Oversize	0.25 mm (0.010 in.)



Valve Seat Dimensions

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

RG,05,DT7080 –19–09MAR00–1/1

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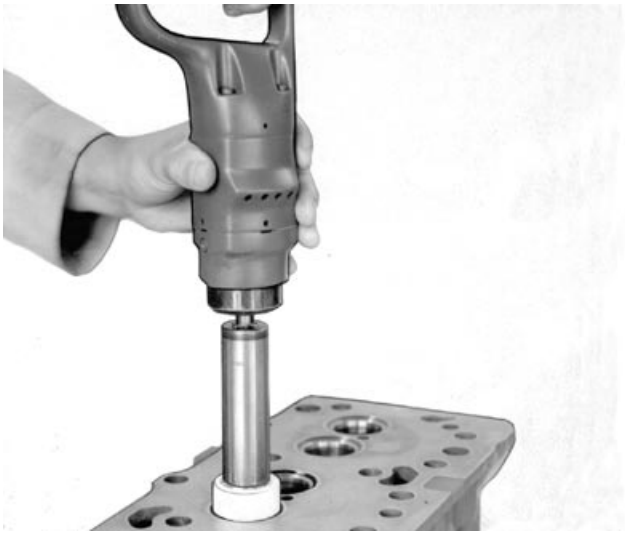
Grind Valve Seats

IMPORTANT: Valve seat grinding should be done only by experienced personnel familiar with equipment and capable of maintaining required specifications. ALWAYS keep work area clean when grinding valve seats. A 120-grit stone MUST BE used for grinding both intake and exhaust valve seat inserts (A). Using JT05893 Heavy-Duty Seat Grinding Set, grind valve seats to obtain correct valve recess in cylinder head. (See MEASURE VALVE RECESS earlier in this group.) Be sure valve guide bores are clean before grinding valve seats. (See CLEAN VALVE GUIDES earlier in this group.)


RGR26143 –UN–11DEC97

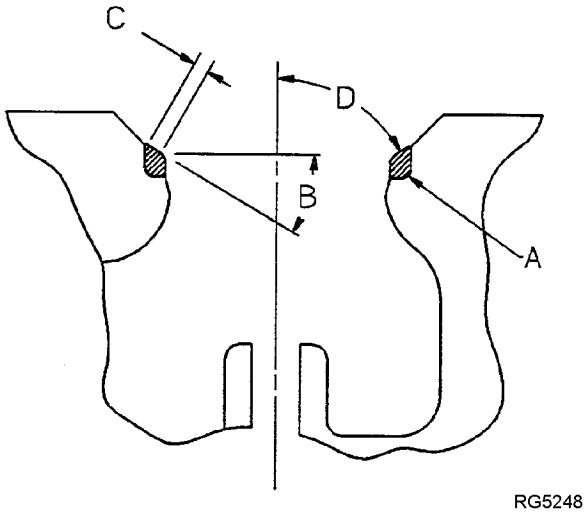
Grinding Valve Seats

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

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

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

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



RG5248 –UN–05DEC97

Valve Seat Dimensions

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

Specification

Intake and Exhaust Valve Seat—	
Angle	20° ± 0.50°
Exhaust Valve Seat—Width	2.0—3.8 mm (0.079—0.150 in.)

Continued on next page

Specification	
Intake Valve Seat—Width	1.4—3.8 mm (0.055—0.150 in.)
Intake and Exhaust Valve Seat—Runout	0.051 mm (0.0020 in.) maximum

RG,05,DT7082 –19–09MAR00–2/2

Remove Valve Seat Inserts and Measure Bores in Cylinder Head

In some cases the valve seat bore in cylinder head may become damaged or oversized and will require machining. In this case, oversize inserts are available in 0.25 mm (0.010 in.) oversize only.

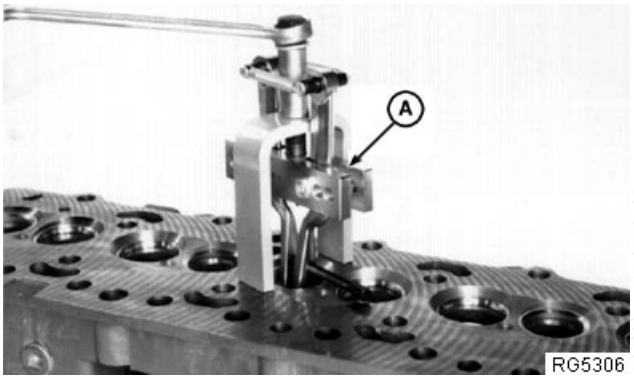
IMPORTANT: Be careful not to damage cylinder head when removing seats.

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

   Valve seat inserts may be removed using one of the following methods:

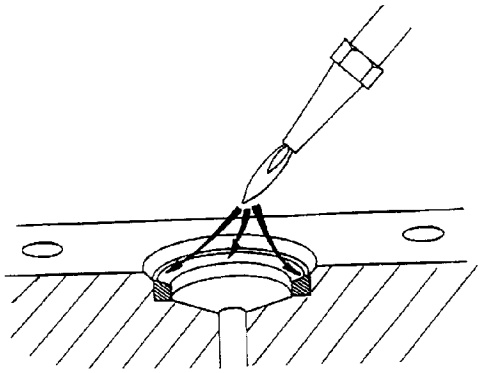
   - Use JDE41296 Puller. Adjusting screw on puller may need to be retightened during removal of inserts.
   - Carefully heat insert at four points around face until insert becomes red hot. Allow seat to cool and carefully pry out the insert(s) with a screwdriver.

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



RG5306 –UN–07NOV97

Removing Valve Seat Inserts



RG5605 –UN–05DEC97

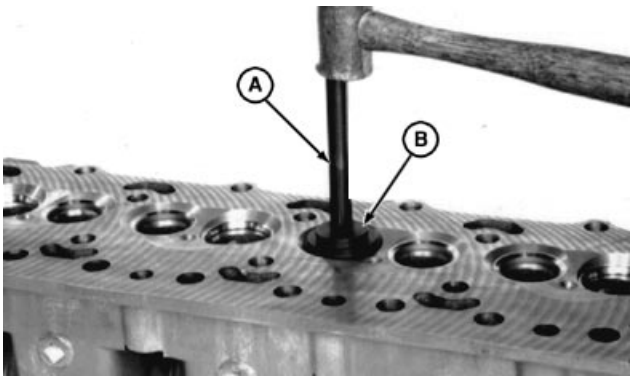
Heating Face of Insert

A—Valve Seat Puller

RG,05,DT7083 –19–30OCT97–1/1

Install Valve Seat Inserts

1. Use JDE7 Valve Seat Pilot Driver (A) along with the JDG605 Valve Seat Installer (B) to drive inserts into place. The larger end of JDG605 Installer is used to install intake valves, and the smaller end is used to install exhaust valves.
2. Install new or refaced valves and check valve recess. (See MEASURE VALVE RECESS, earlier in this group.)
3. Grind valve seats as required to maintain correct valve recess and valve-to-seat seal. (See GRIND VALVE SEATS, earlier in this group.)



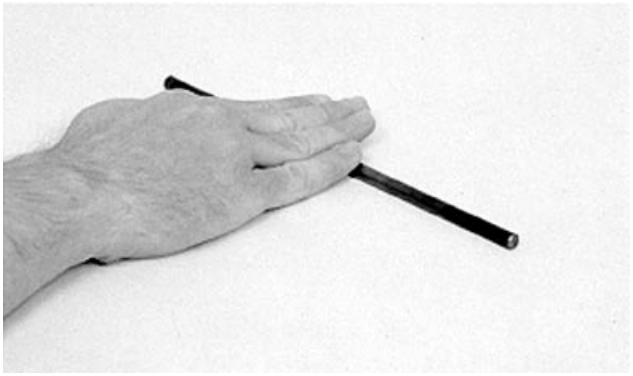
Installing Valve Seat Inserts

A—Pilot Driver
B—Valve Seat Installer

RG,05,DT7084 –19–20FEB02–1/1

Clean and Inspect Push Rods

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



Inspect Push Rods for Straightness

RG,05,DT7085 –19–30OCT97–1/1

Inspect and Clean Ventilator Outlet Hose

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

RG,05,DT7086 –19–30OCT97–1/1

Clean and Inspect Top Deck of Cylinder Block

1. Remove gasket material, rust, carbon, and other foreign material from top deck. Gasket surface must be clean.

2. Use compressed air to remove all loose foreign material from cylinders and top deck.

3. Clean all cylinder head mounting cap screw holes using JDG681A Tap or equivalent 9/16-12 UNC-2A tap about 88.9 mm (3.5 in.) long. Use compressed air to remove debris and any fluids which may be present in the cap screw holes.

4. Measure top deck flatness. (See MEASURE CYLINDER BLOCK in Group 10.)

RG,05,DT7087 –19–30OCT97–1/1

05
40

Measure Cylinder Liner Standout (Height Above Block)

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

NOTE: Liners having obvious defects must be replaced.

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

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

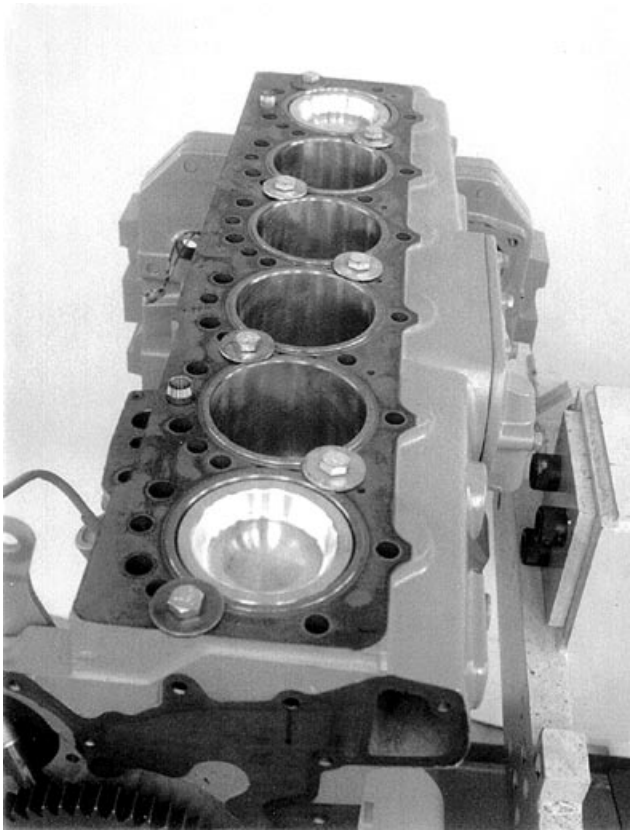
3. Measure each liner in four places, at approximately 1, 5, 7 and 11 o'clock positions as viewed from the rear of the engine (flywheel end). Record all measurements by cylinder number.

4. Remove any liner that does not meet standout specification at any location and install liner shims or replace piston/liner sets as necessary. (See INSTALL LINER SHIMS IF REQUIRED, in Group 10.)

Specification

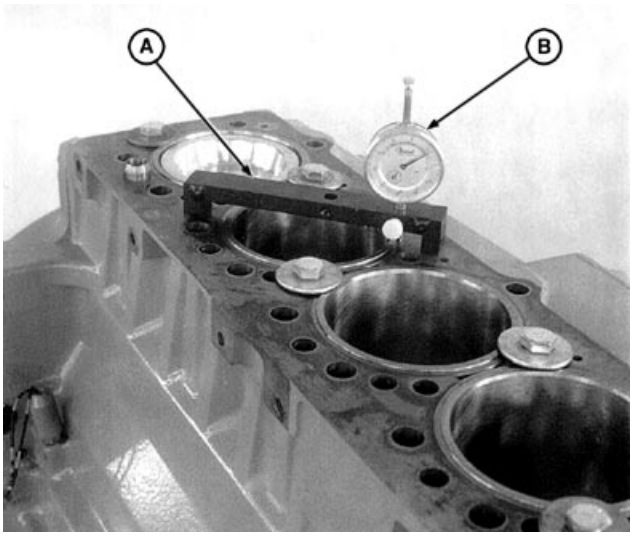
Cylinder Liner—Height Above Block	0.051—0.127 mm (0.002—0.005 in.)

A—Gauge
B—Dial Indicator



RG7839 –UN–05DEC97

Bolt Down Liners



RG7840A –UN–12DEC97

Measuring Height of Bolted Down Liners

RG,05,DT7088 –19–09MAR00–1/1

Assemble Valve Assembly

Valve stem seals (A) are installed onto both exhaust and intake valve stems (B).

NOTE: Intake valves are stamped I20 and exhaust valves stamped E20.

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

NOTE: Exhaust and intake valve stem oil seals will seat on valve guide tower.

2. Service valves are color coded as follows:

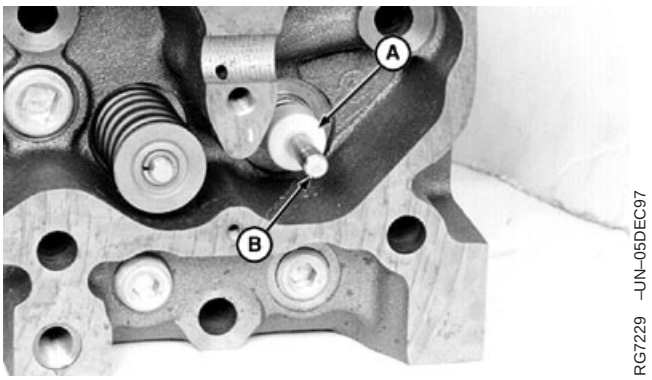
   - Intake Valves—Purple
   - Exhaust Valves—Orange

   Install reconditioned or new valves in head. Reconditioned valves MUST BE installed in same location from which removed.

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

3. Place valve stem seal protector on valve stems and lubricate the valve seals prior to installing.

4. Install oil seal onto exhaust and intake valve stems until seal bottoms in the machined counterbore of the cylinder head. Remove protector after seal is installed.



RG7229 –UN–05DEC97

Assemble Valve Assembly

A—Stem Seals
B—Exhaust and Intake Valve Stems

Continued on next page

RG,05,DT7089 –19–06MAR02–1/3

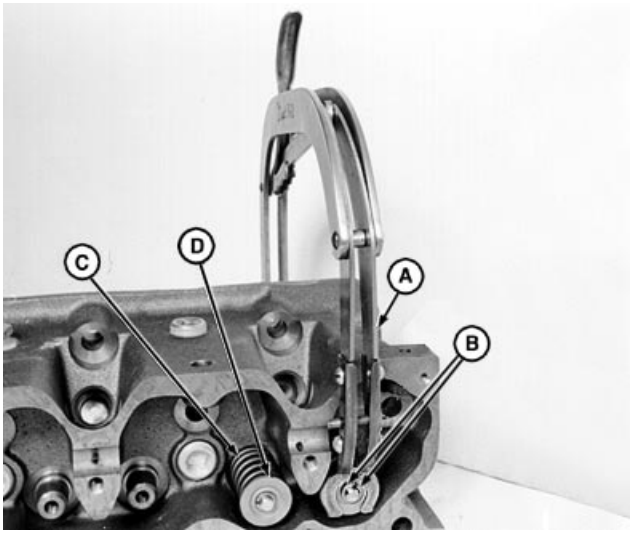
NOTE: On older valve springs (C) without paint marks, there is no top or bottom, and springs may be installed either way. Later valve springs are identified with a yellow paint mark. These springs must be installed with the damper coil end (identified with yellow paint mark) down toward the cylinder head. The unpainted end faces up.

5. Install valve spring over top of oil shield.

6. Install valve rotator (D). Spring must seat in machined counterbore of head.

7. Compress valve springs with JDE138 Valve Spring Compressor (A) and install retainer locks (B).

NOTE: Install wear caps just before installing rocker arm assembly.



RG7228 –UN–05DEC97

Compress Valve Springs

A—Valve Spring Compressor
B—Retainer Locks
C—Valve Springs
D—Valve Rotator

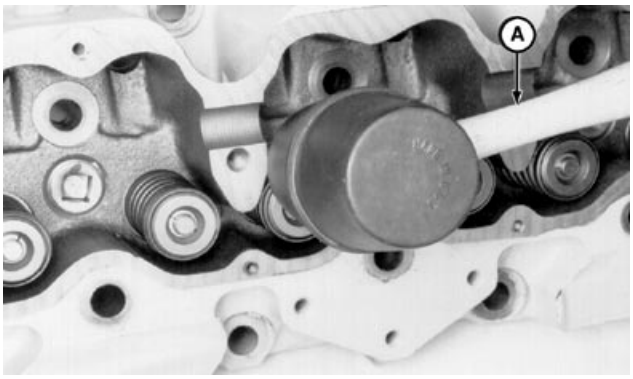
RG,05,DT7089 –19–06MAR02–2/3

8. Strike each valve assembly with a soft mallet (A) three or four times to ensure retainer locks are properly seated.

   Repeat procedure for all remaining valves.

9. Measure valve recess in head. (See MEASURE VALVE RECESS in this Group.)

A—Soft Mallet



RG3807 –UN–04DEC97

Ensure Retainer Locks are Properly Seated

RG,05,DT7089 –19–06MAR02–3/3

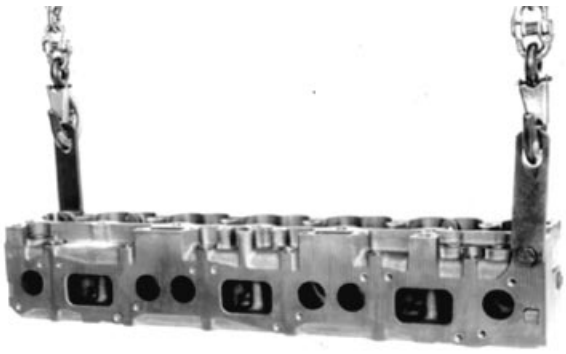
Install Cylinder Head and Cap Screws

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

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

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

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



RG5245 –UN–05DEC97

Lower Cylinder Head Evenly

Continued on next page

RG,05,DT7090 –19–30OCT97–1/2

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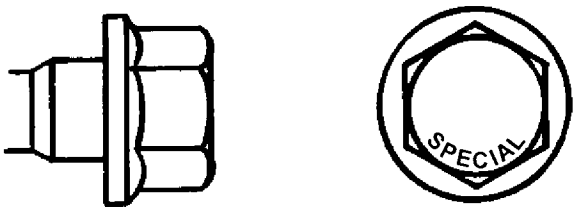
IMPORTANT: Only ASTM Grade 180 Flanged-Head cap screws marked “SPECIAL” (upper illustration) are recommended for use on 6081 engines. ALWAYS use NEW cap screws when installing cylinder head. Cap screws may be used only one time.

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



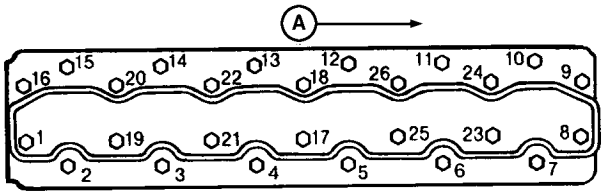
RG7137 –UN–05DEC97

Flanged Head Cap Screw

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

4. Install correct length cap screws marked “SPECIAL” in proper locations shown and tighten using the TORQUE-TO-YIELD tightening procedure, described next in this group. (See TORQUE-TO-YIELD FLANGED-HEAD CAP SCREWS—GRADE 180 MARKED “SPECIAL” in this group.)

   Arrow (A) points toward front of engine.



RG4471 –UN–05DEC97

Cap Screw Locations

A—Front of Engine

Cap Screw Length	Location on Cylinder Head
134 mm (5.2 in.)	2, 3, 4, 5, 6, 7
149 mm (5.9 in.)	23, 25, 17, 21, 19
175 mm (6.9 in.)	1, 15, 14, 13, 12, 11, 10, 8
203 mm (8.0 in.)	16, 20, 22, 18, 26, 24, 9

RG,05,DT7090 –19–30OCT97–2/2

Torque-to-Yield Flanged-Head Cap Screws—Grade 180 Marked “SPECIAL”

Arrow (A) points toward front of engine.

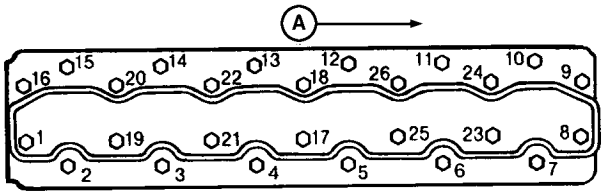
IMPORTANT: DO NOT use multi-viscosity oils to lubricate cap screws.

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

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

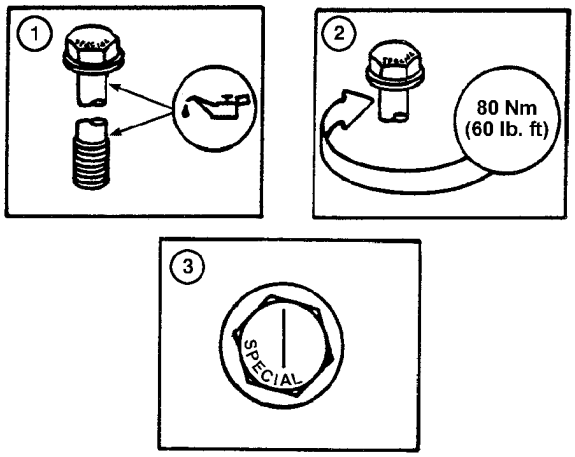
3. Using an oil-proof pen, pencil, or marker, draw a line parallel to the crankshaft across the entire top of each cap screw head. This line will be used as a reference mark.

A—Front of Engine



RG4471 –UN–05DEC97

Head Cap Screw Locations



RG10234 –UN–16JUN99

Tightening Head Cap Screws

Continued on next page

05
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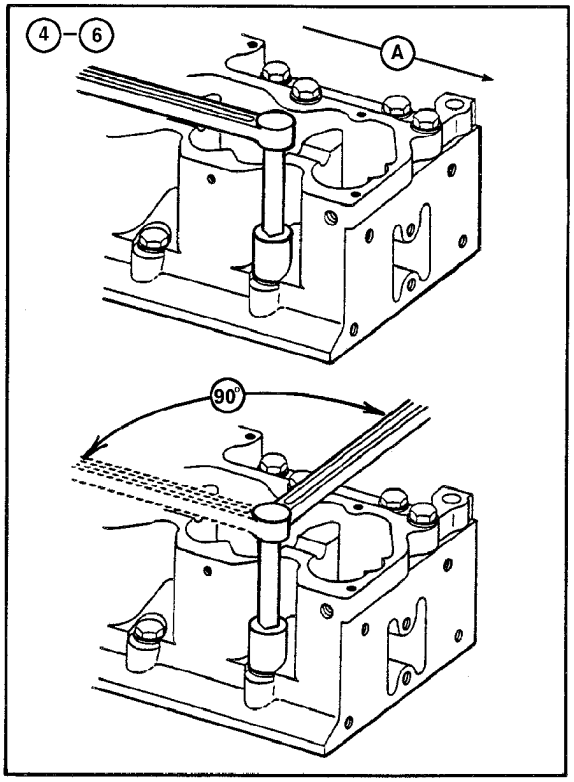
IMPORTANT: If a cap screw is accidentally tightened more than 90° in any one sequence, DO NOT loosen cap screw but make adjustments in the next tightening sequence.

4. Sequentially (start at cap screw No. 1 and proceed through cap screw No. 26) turn each cap screw 90°. Line on top of cap screw will be perpendicular to crankshaft.

5. Again, sequentially (start at cap screw No. 1 and proceed through cap screw No. 26) turn each cap screw 90°. Line on top of cap screw will now be parallel to crankshaft.

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

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

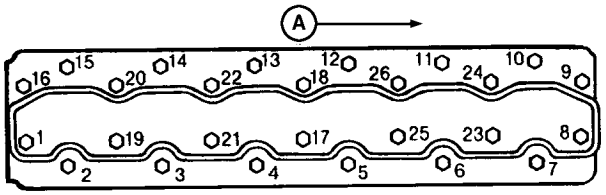


RG10235 –UN–16JUN99

Torque-to-Yield Tightening of Head Cap Screws

Specification	
Cylinder Head Flanged-Head "SPECIAL" Cap Screws (No Washers)—Final Torque Turn.....	90° (accomplished sequentially, three times for a total of 270°)

A—Front of Engine



RG4471 –UN–05DEC97

Head Cap Screw Locations

DPSG,OUO1004,2801 –19–11JUL00–2/2

Install Rocker Arm Assembly

1. Install push rods in holes from which removed.
2. Install wear caps on valve stem tips; make certain caps rotate freely on valve stems.

Installing Push Rods

RG,05,DT7092 –19–30OCT97–1/2

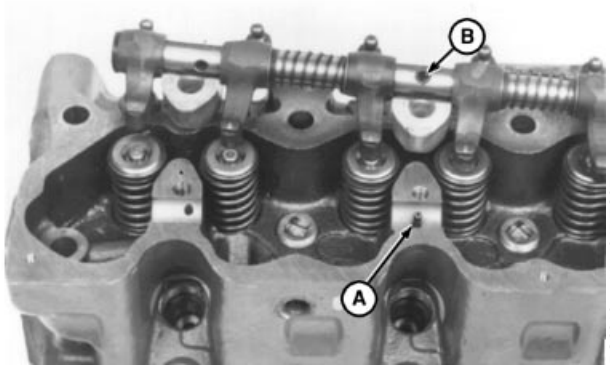
3. Make sure spring pin (A) engages with hole (B) in shaft.
4. Install shaft clamps and all six cap screws. Tighten cap screws to specification.

Specification

Rocker Arm Shaft Cap Screws—
Torque ..... 75 N•m (55 lb-ft)

5. Adjust engine valve clearance. (See CHECK AND ADJUST VALVE CLEARANCE, earlier in this group.)

A—Spring Pin
B—Hole in Shaft



Spring Pin Engages with Hole in Shaft

RG,05,DT7092 –19–30OCT97–2/2

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Complete Final Assembly on Spark Plug Side of Engine

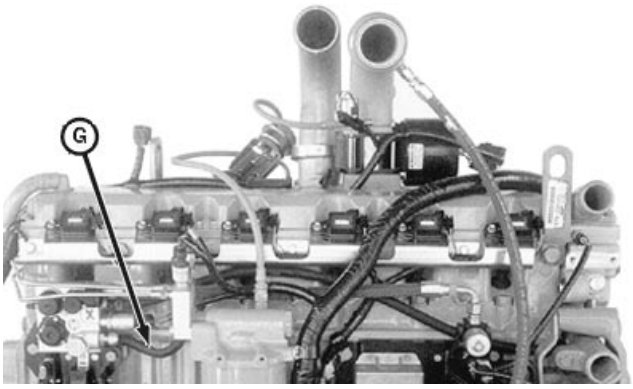
1. Adjust valve clearance, if not previously done. (See CHECK AND ADJUST VALVE CLEARANCE earlier in this group.)
2. Position rocker arm cover gasket on cylinder head and install rocker arm cover. Tighten cap screws to specification.

Specification

Rocker Arm Cover Cap Screws—
Torque ..... 8 N•m (6 lb-ft) (72 lb-in.)

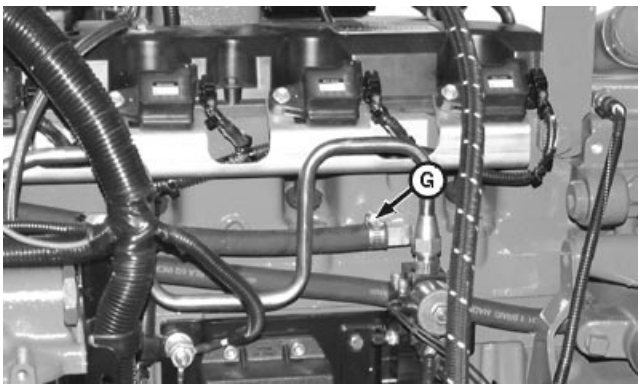
3. Install spark plugs, spark plug boots, ignition coil and ignition rail. (See REMOVE AND INSTALL SPARK PLUGS in Group 45.)
4. Connect gas regulator coolant hose (G).
5. Install coolant manifold. (See INSTALL COOLANT MANIFOLD in Group 25.)
6. Install wiring harness and hose brackets and clamps. Install wiring harness.
7. Connect ventilator outlet hose to adapter on rocker arm cover and tighten clamp securely.

G—Gas Regulator Coolant Hose



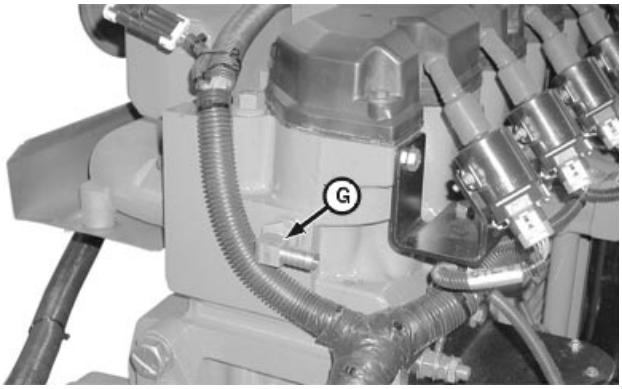
RG10745 –UN–14JUL00

Connect Regulator Coolant Hose (Early HFN01 Engine Shown)



RG10577A –UN–24FEB00

Connect Regulator Coolant Hose (HFN02 Engine Shown) (Current HFN01 and HFN03 Similar)



RG12115A –UN–06MAR02

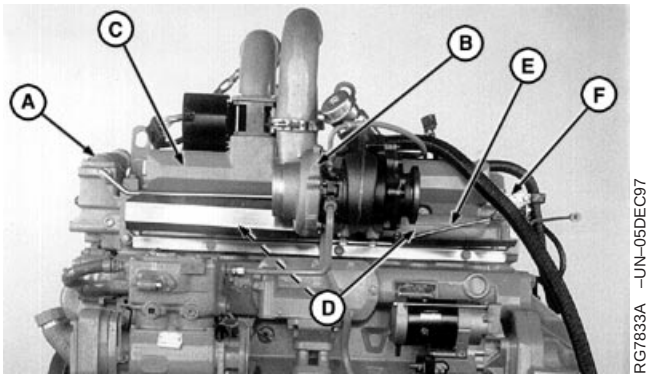
Connect Regulator Coolant Hose (HFN04 Engine Shown)

RG,05,DT7093 –19–20FEB02–1/1

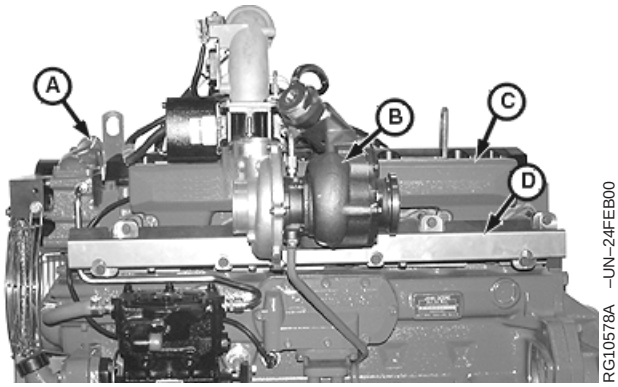
Complete Final Assembly on Exhaust Manifold Side of Engine

NOTE: The intake manifold is installed before the exhaust manifold; however, on HFN01 engines, do not torque intake manifold cap screws to specification until after the exhaust manifold is installed.

1. Install intake manifold (C). (See REMOVE, INSPECT, AND INSTALL INTAKE MANIFOLD in Group 30.)
2. Install exhaust manifold (D). (See REMOVE, INSPECT, AND INSTALL EXHAUST MANIFOLD in Group 30.)
3. Install turbocharger. (See INSTALL TURBOCHARGER in Group 30.)
4. Connect wiring and hoses to turbocharger wastegate control valve as required.
5. Connect fuel line and wiring connectors to electronic components mounted to air intake manifold.
6. Connect EBP line (E) (if equipped) at the exhaust manifold and attach bracket (F).
7. If engine oil was drained from crankcase, install new oil filter and fill with clean oil of correct grade and viscosity. (See NATURAL GAS ENGINE OIL in Group 02.)
8. Fill cooling system with clean coolant. (See ENGINE COOLANT SPECIFICATIONS in Group 02.)
9. Perform engine break-in. (See PERFORM ENGINE BREAK-IN in Group 04.)



Install Cylinder Head (HFN01 Engine Shown) (HFN03 and HFN04 Similar)



Install Cylinder Head (HFN02 Engine Shown)

A—Water Manifold
B—Turbocharger
C—Intake Manifold
D—Exhaust Manifold Assembly
E—Line
F—Bracket

RG,05,DT7094 –19–20FEB02–1/1

Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

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DPSG,OUO1004,2807 –19–19APR02–1/12

RG6246 –UN–05DEC97

Dial Indicator . . . (English, in.) D17526CI or (Metric, mm) D17527CI

Use with JDG451 to measure valve recess and cylinder liner height-to-cylinder block top deck.

RG6246

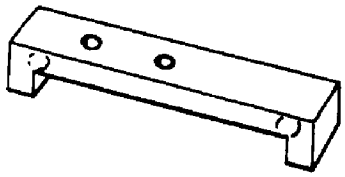
D17526CI or D17527CI

DPSG,OUO1004,2807 –19–19APR02–2/12

RG7029 –UN–05DEC97

Height Gauge . . . . . (English, in.) JDG451 or (Metric, mm) KJD10123

Used with dial indicator to measure cylinder liner height above block.



RG7029

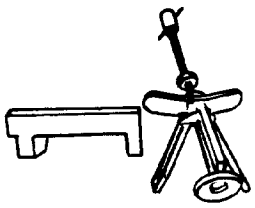
JDG451 or KJD10123

DPSG,OUO1004,2807 –19–19APR02–3/12

RG5019 –UN–05DEC97

Cylinder Liner Puller . . . . . D01062AA, D01073AA, or KCD10001

Remove cylinder liners.



RG5019

D01062AA, D01073AA, or KCD10001

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DPSG,OUO1004,2807 –19–19APR02–4/12

RG5074 –UN–07NOV97

Flexible Cylinder Hone D17005BR

Hone cylinder liners.

RG5074

D17005BR

DPSG,OUO1004,2807 –19–19APR02–5/12

RG5077 –UN–07NOV97

Piston Ring Expander JDE93

Remove and install piston rings.

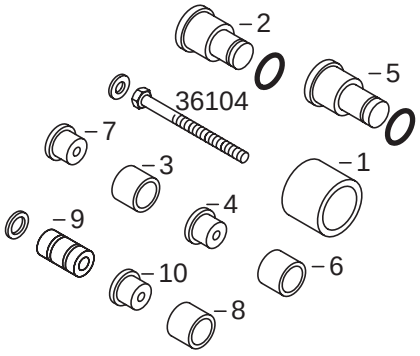
RG5077

JDE93

DPSG,OUO1004,2807 –19–19APR02–6/12

Connecting Rod Bushing Service Set JDE98A

Remove and install connecting rod bushings. Set consists of JDE98-1 Cup (1), JDE98-2 Driver (2), JDE98-3 Pilot (3), JDE98-4 Driver (4), JDE98-5 Driver (5), JDE98-6 Pilot (6), JDE98-7 Driver (7), JDE98-8 Cup (8), JDE98-9 Pilot (9), JDE98-10 Bushing Remover (10) and 36104 Forcing Screw.



RG5078 –UN–25APR02

JDE98A

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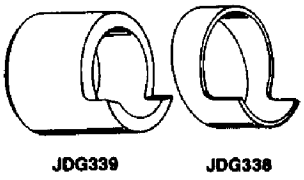
DPSG,OUO1004,2807 –19–19APR02–7/12

RG5079 –UN–07NOV97

Connecting Rod Bushing Service Set JDG337

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



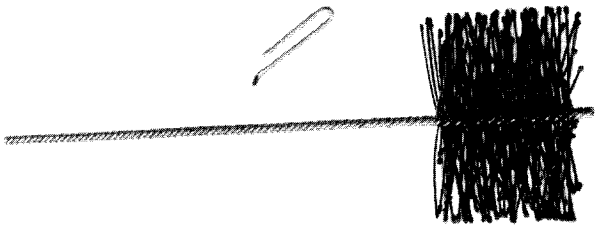
RG5079

JDG337

DPSG,OUO1004,2807 –19–19APR02–8/12

O-Ring Groove Cleaning Brush D17015BR

Clean cylinder liner O-ring groove in block.



RG5075 –UN–07NOV97

RG5075

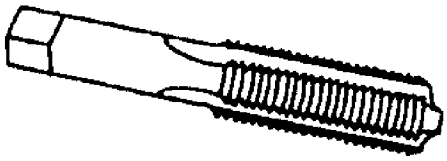
D017015BR

DPSG,OUO1004,2807 –19–19APR02–9/12

RG5100 –UN–05DEC97

Tap JDG681

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



RG5100

JDG681

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DPSG,OUO1004,2807 –19–19APR02–10/12

RG5031 –UN–05DEC97

Piston Ring Compressor JDE96

Compress rings while installing pistons.

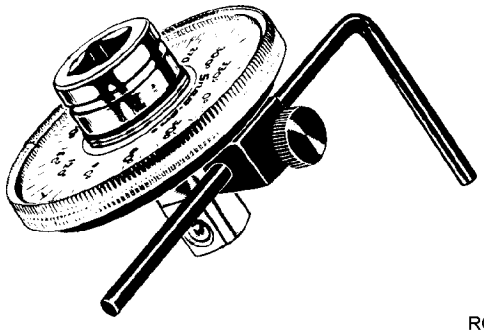
RG5031

JDE96

DPSG,OUO1004,2807 –19–19APR02–11/12

Torque-Turn Tool JT05993

Used to stretch cylinder head and connecting rod bolts to obtain optimum clamping load.



RG5698 –UN–05DEC97

JT05993

DPSG,OUO1004,2807 –19–19APR02–12/12

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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DPSG,OUO1004,2865 –19–19APR02–1/3

Cylinder Liner Holding Fixture . . . . . DRFG3[1]

Secure cylinder liner when deglazing.

[1]Dealer fabricated tool. See Group 99 for instructions to make tool.

DPSG,OUO1004,2865 –19–19APR02–2/3

Precision Straightedge D05012ST

Measure cylinder block top deck flatness.

DPSG,OUO1004,2865 –19–19APR02–3/3

Other Material

Number	Name	Use
— (U.S.)	PLASTIGAGE®	Determine connecting rod bearing-to-journal oil clearance.
AR54749 (U.S.)	Soap Lubricant	Coat O-rings and packings on cylinder liners.

PLASTIGAGE® is a registered trademark of DANA Corp.

DPSG,OUO1004,2809 –19–19APR02–1/1

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6

Cylinder Block, Liners, Pistons and Rods Specifications

Item	Measurement	Specification
Cylinder Liner	Standout (Height Above Block)	0.051—0.127 mm (0.002—0.005 in.)
HFN01—HFN04 No.1 Compression Ring	End Gap	0.35—0.60 mm (0.014—0.023 in.)
HFN01—HFN03 No. 2 Compression Ring	End Gap	0.56—0.82 mm (0.022—0.032 in.)
HFN04 No. 2 Compression Ring	End Gap	0.84—1.04 mm (0.033—0.041 in.)
HFN01—HFN04 Oil Rail (Three-Piece Oil Ring)	End Gap	0.25—0.76 mm (0.010—0.030 in.)
Piston Ring-to-Groove Clearance with New Piston Ring (First and Second Ring Grooves)	Clearance	0.075 mm (0.003 in.) maximum
Oil Control Ring-to-Groove New Part	Clearance	0.111—0.136 mm (0.0044—0.0054 in.)
Oil Control Ring-to-Groove Maximum Serviceable	Clearance	0.2210 mm (0.0087 in.)
Cylinder Liner	Thickness	6.05—6.15 mm (0.238—0.242 in.)
Cylinder Liner Packing Step	Dimension	1.45—1.55 mm (0.057—0.061 in.)
Piston Skirt Diameter [Measured 15.16 mm (0.597 in.) from Bottom of Piston]	OD	115.771—115.789 mm (4.5579—4.5586 in.)

Continued on next page

DPSG,OUO1004,2810 –19–19APR02–1/4

Item	Measurement	Specification
Cylinder Liner	ID	115.865—115.895 mm (4.5616—4.5628 in.)
	OD (Water Jacket Area)	127.94—128.24 mm (5.037—5.049 in.)
	OD (At Upper Bore)	129.08—129.14 mm (5.082—5.084 in.)
	OD (At Lower Bore)	125.044—125.120 mm (4.923—4.926 in.)
	ID of Upper Bore in Block for Seating Liners	129.155—129.205 mm (5.085—5.087 in.)
	ID of Lower Bore in Block for Seating Liners	125.133—125.183 mm (4.9265—4.9285 in.)
	Liner-to-Block Clearance at Upper Bore	0.026—0.126 mm (0.001—0.005 in.)
	Liner-to-Block Clearance at Lower Bore	0.012—0.140 mm (0.0005—0.0055 in.)
	Maximum Out-of-Round	0.051 mm (0.0020 in.)
	Maximum Wear or Taper in Ring Travel Area	0.051 mm (0.0020 in.)
Piston-to-Liner	New Part Clearance (At Bottom of Skirt)	0.076—0.124 mm (0.0030—0.0049 in.)
	Maximum Clearance	0.152 mm (0.0060 in.)
Cylinder Liner Flange	Thickness	11.989—12.039 mm (0.472—0.474 in.)
	OD	135.10—135.16 mm (5.319—5.321 in.)
Tongue-and-Groove Connecting Rod Cap Screw	Initial Torque	27 N•m (20 lb-ft)
Tongue-and-Groove Connecting Rod Cap Screw	Final Torque	75 N•m (55 lb-ft) plus 90—100° turn clockwise
PRECISION JOINT™ Connecting Rod Cap Screw	Torque	95 N•m (71 lb-ft) plus 90—100° turn clockwise
Connecting Rod Cap Screws	Final Torque Turn	1/4 turn (90—100°)
Crankshaft Rod Journal	OD	76.150—76.180 mm (2.9980—2.9992 in.)

PRECISION JOINT™ is a trademark of Deere & Company

Continued on next page

Item	Measurement	Specification
Assembled Connecting Rod Bearing	ID	76.210—76.260 mm (3.0004—3.0024 in.)
Connecting Rod Bearing-to-Journal (New Parts)	Oil Clearance	0.030—0.110 mm (0.0012—0.0044 in.)
Connecting Rod Bore (Without Bearings)	ID	81.051—81.077 mm (3.191—3.192 in.)
Connecting Rod Bore	Maximum Out-of-Round	0.025 mm (0.0010 in.)
Centerline of Piston Pin Bore-to-Crankshaft Bore	Dimension	222.20—222.30 mm (8.748—8.752 in.)
Piston Pin	OD	47.597—47.613 mm (1.8739—1.8745 in.)
Piston Pin Bore in Piston	ID	47.620—47.630 mm (1.8748—1.8752 in.)
Connecting Rod Pin-to-Bushing	Oil Clearance	0.042—0.084 mm (0.0017—0.0033 in.)
	Wear Limit	0.102 mm (0.0040 in.)
Connecting Rod Pin Bore	Diameter without Bushing	52.354—52.380 mm (2.0612—2.0622 in.)
Connecting Rod Pin Bore-to-Bushing	Press Fit	0.084—0.147 mm (0.0033—0.0058 in.)
Installed Service Connecting Rod Pin Bushing (Before Boring)	ID	47.58—47.63 mm (1.8732—1.8751 in.)
Installed Service Connecting Rod Pin Bushing (After Boring)	ID	47.655—47.681 mm (1.8762—1.8772 in.)
Cylinder Liner Flange Counterbore	Depth	11.913—11.963 mm (0.469—0.471 in.)
Crankshaft Main Bearing	Bore ID without Bearing	101.651—101.677 mm (4.0020—4.0030 in.)
	Surface Width	36.28—36.78 mm (1.428—1.448 in.)

Continued on next page

Item	Measurement	Specification
Crankshaft Thrust Bearing	Bore ID without Bearing	101.651—101.677 mm (4.0020—4.0030 in.)
	Surface Width (No. 5 Main)	37.44—37.54 mm (1.474—1.478 in.)
	Overall Cap Width	41.81—42.31 mm (1.646—1.666 in.)
Camshaft Follower	Bore ID in Block	17.384—17.440 mm (0.6845—0.6865 in.)
	Follower OD (New)	17.33—17.35 mm (0.682—0.683 in.)
	Follower-to-Bore Clearance	0.114 mm (0.0045 in.)
Camshaft Bushing	Installed ID	67.076—67.102 mm (2.6408—2.6418 in.)
	Bushing Bore in Block	69.987—70.013 mm (2.7554—2.7564 in.)
	Minimum Runout of Bore in Block	0.038 mm (0.0015 in.)
	Bushing-to-Journal Clearance	0.063—0.115 mm (0.0025—0.0045 in.)
Cylinder Block Top Deck	Maximum Out-of-Flat	0.10 mm (0.004 in.) over entire length or width
	Straightness	0.025 mm (0.001 in.) per any 305 mm (12.0 in.) of length
	Maximum Wave Depth	2.0 micrometers (79 micro-inch)
	Main Bearing Bore Centerline-to-Top Deck Distance	352.35—352.50 mm (13.872—13.878 in.)
Piston Cooling Orifices	Torque	11 N•m (8 lb-ft) (97 lb-in.)
Cylinder Liner Shim	Thickness	0.05 mm (0.002 in.)

DPSG,OUO1004,2810 –19–19APR02–4/4

Preliminary Liner, Piston, and Rod Checks

Scuffed or Scored Pistons:

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

Worn or Broken Compression Rings:

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

Clogged Oil Control Ring:

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

Stuck Rings:

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

Cylinder Liner Wear and Distortion:

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

Broken Connecting Rod:

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

Piston Pin and Snap Ring Failure:

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

Mottled, Grayish or Pitted Compression Rings:

- Internal coolant leaks.

Dull Satin Finish and Fine Vertical Scratches on Rings:

- Dirt and abrasive in air intake system.

Damaged Piston:

- Extended operation with incorrect timing (knock).
- Poor fuel quality (sulfur, low heat value).
- Incorrect spark plug.

Corroded Liners and Piston Rings:

- Low coolant temperatures (thermostats bad, acid formation).
- Sour gas.

Warped Cylinder Block:

- Insufficient cooling.

RG,10,DT7097 –19–18JUL00–1/1

Connecting Rods—General Information

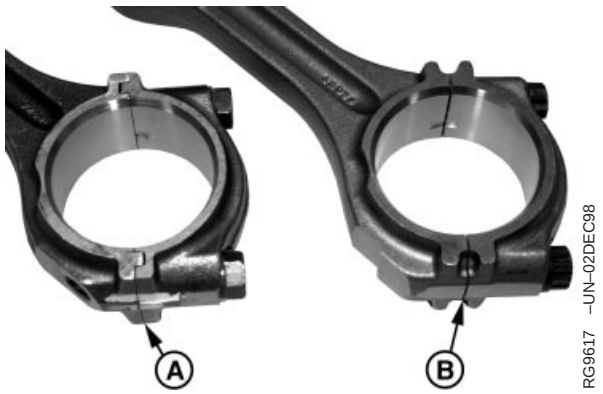
Earlier engines have the traditional tongue-and-groove joint between the connecting rod and cap (A). Later engines have the PRECISION JOINT™ rod and cap (B).

To create the PRECISION JOINT™ fracture, 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 rod at the joints (C).

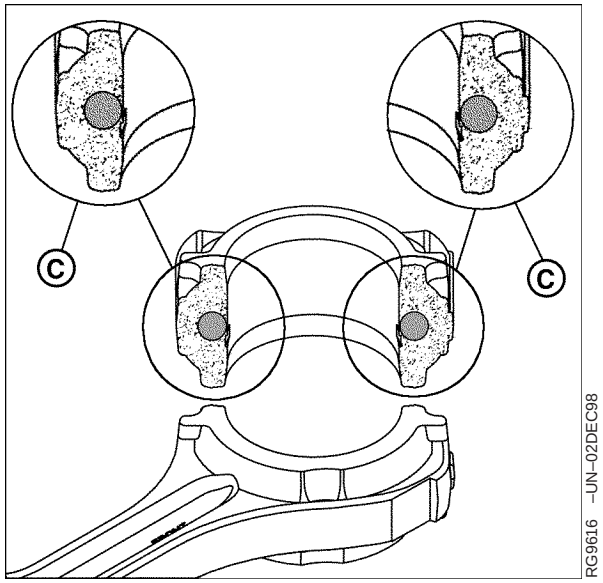
Both types of rods provide a strong joint, but torque on cap screws is different. Removal and installation is similar, with differences noted. (See INSPECT ROD AND CAP and INSTALL PISTON AND CONNECTING ROD later in this group.

IMPORTANT: Replace rods with the same type. Do Not mix tongue-and-groove with PRECISION JOINT™ rods in the same engine. See parts catalog for recommendations.

A—Tongue-and-Groove Joint Rod (Early Engines)
B—PRECISION JOINT™ Rod (Later Engines)
C—PRECISION JOINT™ Details



Connecting Rods



PRECISION JOINT™ Connecting Rod

PRECISION JOINT™ is a trademark of Deere & Company

DPSG,RG34710,6 –19–20FEB02–1/1

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Remove Piston and Connecting Rod Assemblies

IMPORTANT: Replace rods with the same type. Do Not mix tongue-and-groove with PRECISION JOINT™ rods in the same engine. See parts catalog for recommendations.

NOTE: If engine is to be completely disassembled, follow 6081HFN ENGINE DISASSEMBLY SEQUENCE in Group 04.

1. Drain all engine coolant and engine oil. Remove cylinder head. (See REMOVE CYLINDER HEAD in Group 05.)

2. Remove oil pan. (See REMOVE AND INSTALL ENGINE OIL PAN in Group 20.)

3. Remove oil pump. (See REMOVE ENGINE OIL PUMP in Group 20.)

Continued on next page

RG,10,DT7098 –19–09MAR00–1/5

IMPORTANT: Do not rotate crankshaft with cylinder head removed unless liners are bolted down. Bolt liners down before removing pistons. Cap screws and washers must be tightened to specification to achieve an accurate reading when measuring liner standout (height above block). See MEASURE CYLINDER LINER STANDOUT (HEIGHT ABOVE BLOCK), later in this group.

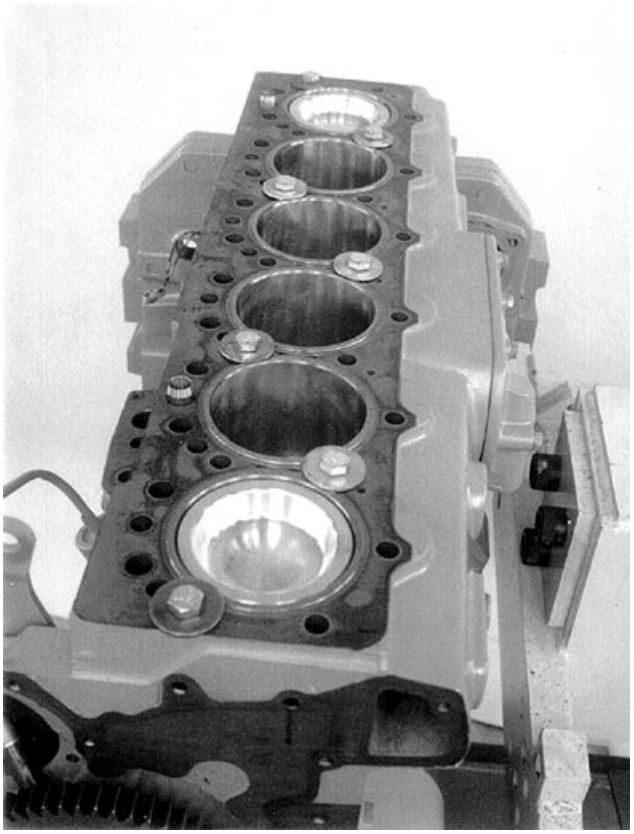
4. Use 9/16-18 cap screws, approximately 51 mm (2.0 in.) long and 5/8 in. ID x 1-3/4 in. OD x 3.18 mm (1/8 in.) thick washers to bolt down cylinder liners in the seven locations as shown. Tighten cap screws to 68 N•m (50 lb-ft).

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

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

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

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



Bolt Down Cylinder Liners

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RG,10,DT7098 –19–09MAR00–2/5

NOTE: Connecting rod-bearing-to-journal oil clearance should be measured before removing piston/rod assembly. Use PLASTIGAGE® as directed by the manufacturer. Remember, the use of PLASTIGAGE® will determine bearing-to-journal oil clearance, but will not indicate the condition of either surface.

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

Measuring Clearance with PLASTIGAGE®

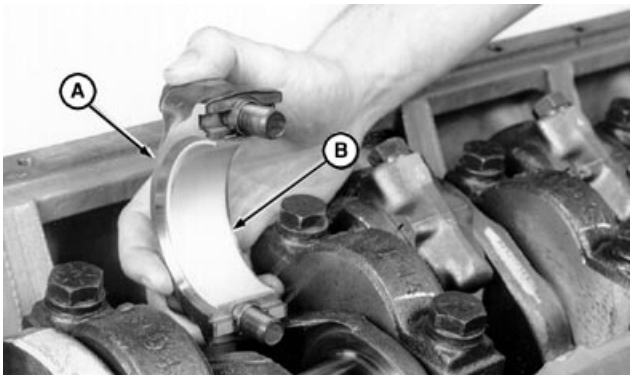
PLASTIGAGE® is a registered trademark of the DANA Corp.

RG,10,DT7098 –19–09MAR00–3/5

IMPORTANT: DO NOT use pneumatic wrenches to tighten 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 ensure correct assembly in same location as removed.

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

A—Rod Caps
B—Bearings



Remove Rod Cap Screws with Bearings

Continued on next page

RG,10,DT7098 –19–09MAR00–4/5

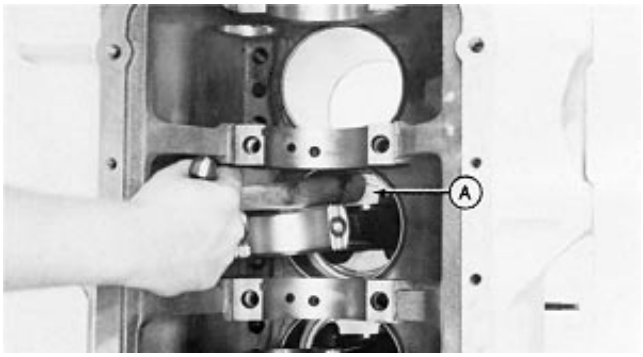
IMPORTANT: Be careful not to let rod nick crankshaft bearing surface as piston and rod assembly is removed.

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

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

NOTE: Crankshaft shown removed. Piston and rod assembly can be removed with crankshaft installed.

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



Gently Tap Piston

A—Piston

RG,10,DT7098 –19–09MAR00–5/5

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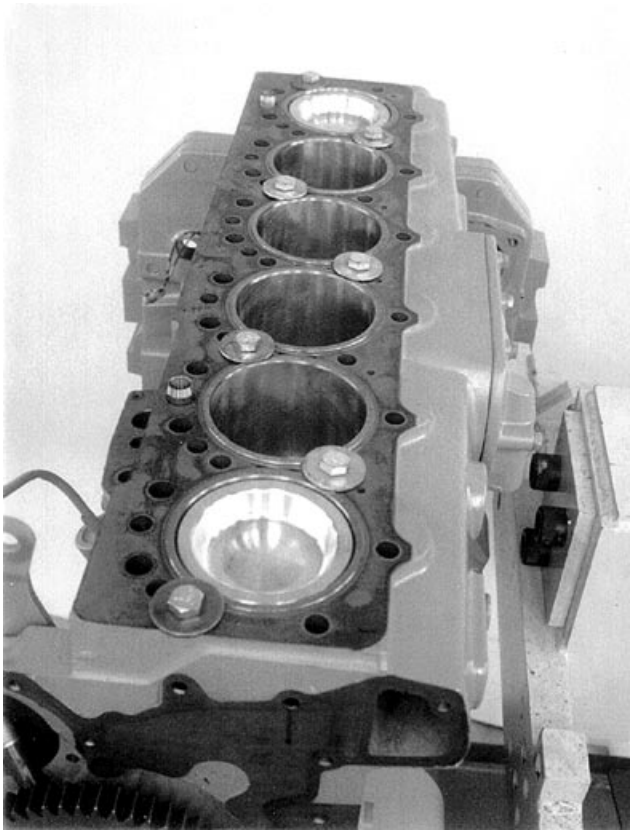
Measure Cylinder Liner Standout (Height Above Block)

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

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

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



Bolt Down Liners

Continued on next page

RG,10,DT7099 –19–31OCT97–1/2

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

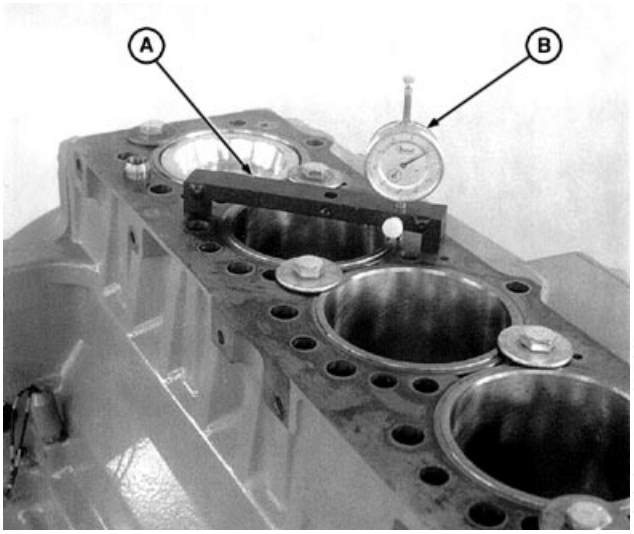
NOTE: Variations in measurement readings may occur within one cylinder and/or between adjacent cylinders.

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

4. Remove any liner that does not meet standout specification at any location and measure liner flange thickness. (See MEASURE LINER FLANGE THICKNESS in this group.) Use liner shims or replace piston/liner sets as necessary.

Specification

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



RG7840A –UN–12DEC97

Measuring Height of Bolted-Down Liners

A—Height Gauge
B—Dial Indicator

RG,10,DT7099 –19–31OCT97–2/2

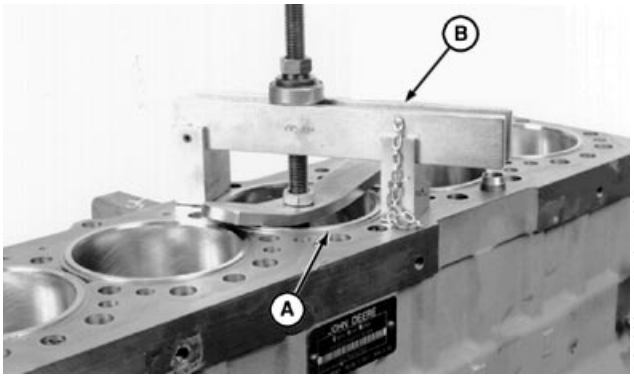
Remove Cylinder Liners

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

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

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

3. Use D1062AA, D01073AA or KCD10001 Cylinder Liner Puller (B) to remove cylinder liner (A).



RG5809 –UN–05DEC97

Removing Cylinder Liners

A—Cylinder Liner
B—Cylinder Liner Puller

Continued on next page

RG,RG34710,1115 –19–23OCT97–1/3

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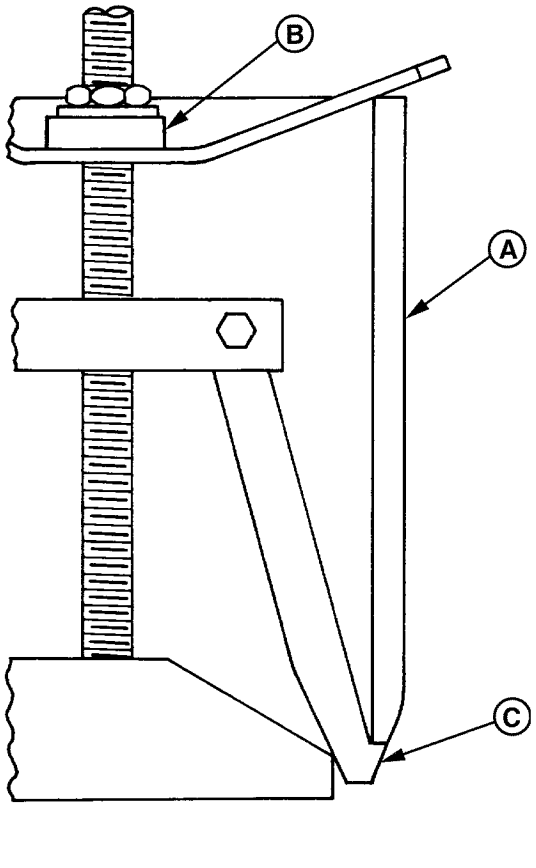
IMPORTANT: When using D01062AA (or D01073AA) Cylinder Liner Puller (B) to remove liners (A), be sure jaw (C) of puller is correctly positioned before attempting to remove liner.

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

A—Cylinder Liner
B—Cylinder Liner Puller
C—Jaw



D01062AA or D01073AA Cylinder Liner Puller

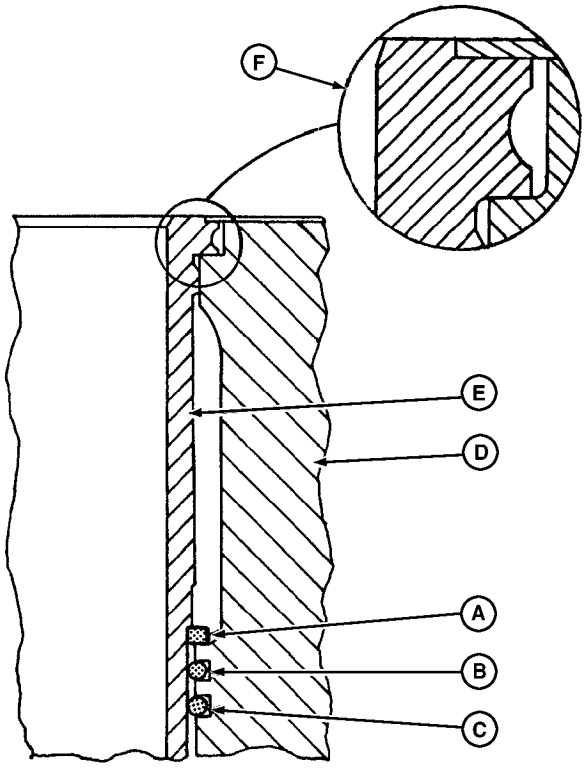
Continued on next page

RG,RG34710,1115 –19–23OCT97–2/3

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

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

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



RG6668 –UN–05DEC97

Cylinder Liner and Seals

RG,RG34710,1115 –19–23OCT97–3/3

Deglaze Cylinder Liners

1. Secure cylinder liner in DRFG3 Cylinder Liner Holding Fixture. See DFRG3 CYLINDER LINER HOLDING FIXTURE in Group 99 for assembly of holding fixture.

2. Use D17005BR Flexible Cylinder Hone to deglaze cylinder liner.

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

RGR26164 –UN–11DEC97

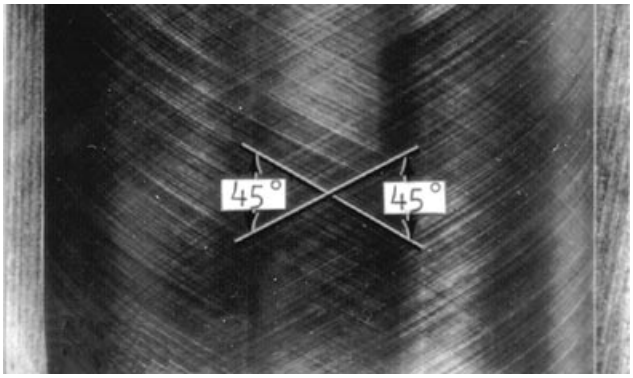
Deglaze Cylinder Liners

Continued on next page

RG,10,DT7108 –19–18JUL00–1/2

3. Use D17005BR Flexible Cylinder Hone according to instructions supplied with tool to obtain a 45° crosshatch pattern.

Thoroughly clean liners after deglazing. See CLEAN CYLINDER LINERS, later in this group, for proper cleaning procedures.



45° Crosshatch Pattern

RG,10,DT7108 –19–18JUL00–2/2

Clean Cylinder Liners

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

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

2. Thoroughly clean liner ID with a 50 percent solution of hot water and liquid detergent.

3. Rinse thoroughly and wipe dry with a clean rag.

4. Swab out a liner as many times as necessary with clean SAE 10W oil.

5. Clean liner until a white rag shows no discoloration.

RG,10,DT7107 –19–31OCT97–1/1

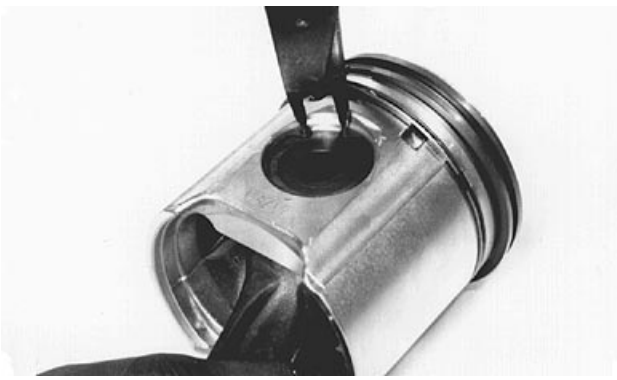
Disassemble Piston/Rod Assembly and Clean Piston

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

Specification	
HFN01—HFN04 No.1 Compression Ring—End Gap	0.35—0.60 mm (0.014—0.023 in.)
HFN01—HFN03 No. 2 Compression Ring—End Gap	0.56—0.82 mm (0.022—0.032 in.)
HFN04 No. 2 Compression Ring—End Gap	0.84—1.04 mm (0.033—0.041 in.)
HFN01—HFN04 Oil Rail (Three-Piece Oil Ring)—End Gap	0.25—0.76 mm (0.010—0.030 in.)

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

NOTE: Discard snap rings. DO NOT reuse.



Remove Piston Snap Ring

RG,10,DT7106 –19–06MAR02–1/3

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

A—Piston Ring Expander
B—Piston Rings

Remove Piston Ring

Continued on next page

RG,10,DT7106 –19–06MAR02–2/3

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

CAUTION: Always follow manufacturer's instructions and safety steps exactly. When washing pistons, always use a stiff bristle brush, NOT A WIRE BRUSH, to loosen carbon residue. DO NOT bead blast ring groove areas.

5. Clean pistons by any of the following methods:

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

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

RG6088 –UN–05DEC97

Clean Piston Ring Grooves

RG,10,DT7106 –19–06MAR02–3/3

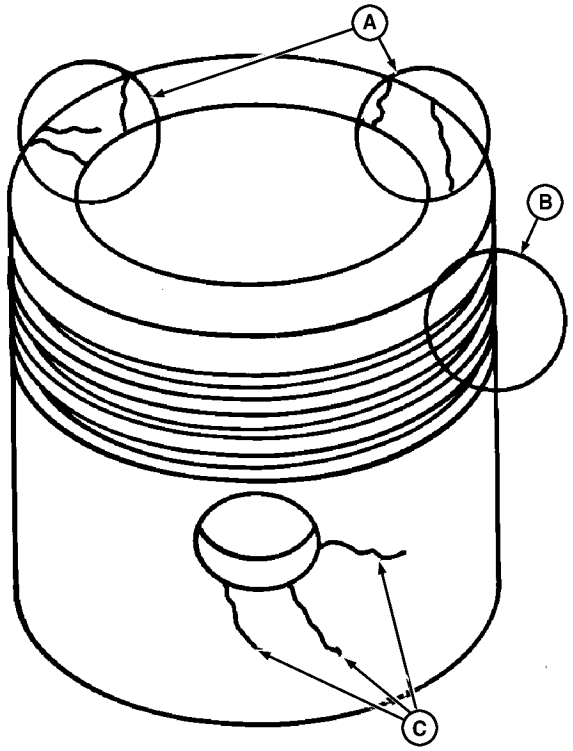
Visually Inspect Pistons

Carefully inspect clean pistons under magnification. Check for:

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

If any defects are found, replace the piston and liner as a set.

A—Piston Head
B—Ring Lands
C—Skirt



RG3326 RG3326 –UN–04DEC97

Piston Defects (Exaggerated)

RG,10,DT7105 –19–31OCT97–1/1

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Check Piston Ring Groove Wear

If ring groove is worn, replace piston and liner as a matched set.

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

   Replace piston and liner (as a set) if clearance exceeds specification.

Specification

Piston Ring-to-Groove Clearance with New Piston Ring (First and Second Ring Grooves)—Clearance ..... 0.075 mm (0.003 in.) maximum

Check Groove Wear

RG,10,DT7104 –19–25FEB02–1/2

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

3. Measure clearance with a feeler gauge at several points. Compare measurements with specifications.

Specification

Oil Control Ring-to-Groove New Part—Clearance ..... 0.111—0.136 mm (0.0044—0.0054 in.)

Oil Control Ring-to-Groove Maximum Serviceable—Clearance ..... 0.2210 mm (0.0087 in.)

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

Cast Oil Ring Shown. Three-Piece Oil Ring Similar.

RG,10,DT7104 –19–25FEB02–2/2

Inspect Piston Pin and Pin Bore

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

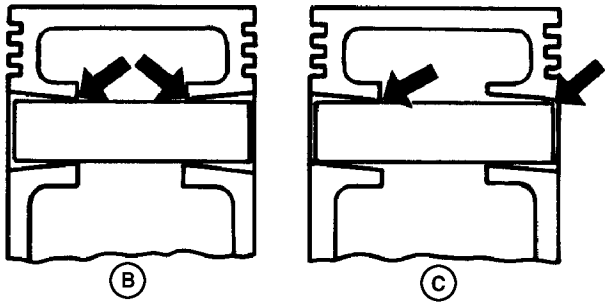
1. Dip piston in clean engine oil.
2. Install pin (A) through piston. Pin should pass through piston using only light thumb pressure.
3. Check taper in piston pin bore by inserting pin from both sides. If pin enters freely, but binds in the center, the bore could be tapered (B).
4. Insert pin in piston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

Specification

Piston Pin Bore—ID	47.620—47.630 mm (1.8748—1.8752 in.)
Piston Pin—OD	47.597—47.613 mm (1.8739—1.8745 in.)

RG5231 –UN–05DEC97

Install Pin through Piston



RG4984 –UN–05DEC97

RG4984

Check for Taper and Alignment in Piston Pin Bore

A—Pin
B—Tapered Bore Problem
C—Bore Out-of-Alignment Problem

RG,10,DT7103 –19–14AUG00–1/1

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Visually Inspect Cylinder Liners

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

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

   Replace piston and liner if:

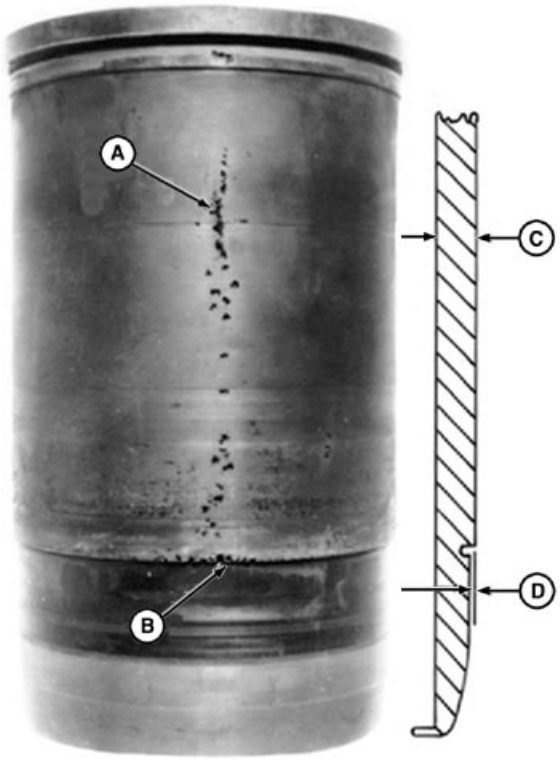
   - Pitting depth is one-half liner thickness (C) or more.
   - Erosion depth is one-half packing step (D) or more.

Specification

Cylinder Liner—Thickness	6.05—6.15 mm (0.238—0.242 in.)
Cylinder Liner Packing Step—Dimension	1.45—1.55 mm (0.057—0.061 in.)

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

New cylinder liners have an improved ID bore finish. New liners also have the letters "NG" as the first two digits of the six-digit code stamped on the top of the liner.



RG4643 –UN–05DEC97

Inspect Exterior Length of Liner

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

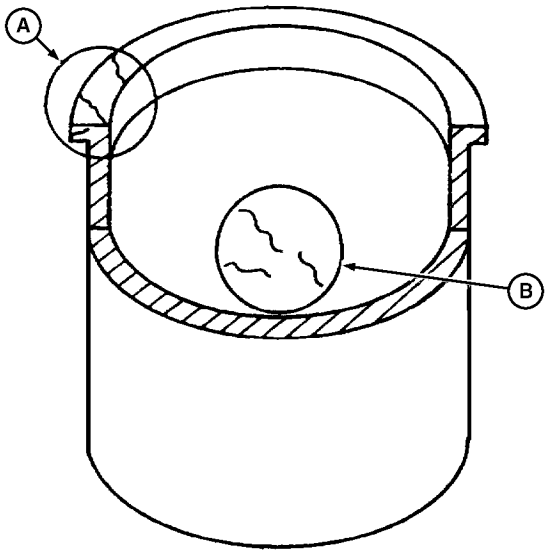
Continued on next page

RG,10,DT7102 –19–31OCT97–1/2

2. Visually examine liner ID. Replace piston and liner if:
   - The crosshatch honing pattern is not visible immediately below the top ring turnaround area.
   - Liners are pitted or contain deep vertical scratches that can be detected by the fingernail.
3. Carefully examine liner for signs of fatigue, such as fine cracks in the flange area (A) and cracks in the ring travel area (B).

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

A—Flange Area
B—Ring Travel Area



Inspect Cylinder Liner

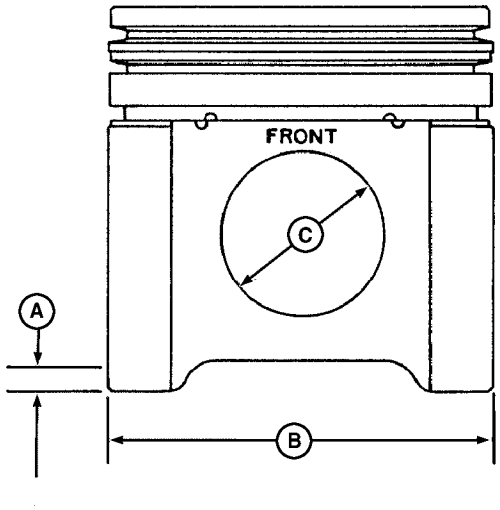
RG,10,DT7102 –19–31OCT97–2/2

Determine Piston-to-Liner Clearance

1. Measure piston skirt diameter (B) at right angles to piston pin bore (C), 15.16 mm (0.597 in.) from the bottom of the piston (A).
2. Record measurement and compare measurement obtained from matching liner.

Specification	
Piston Skirt Diameter [Measured 15.16 mm (0.597 in.) from Bottom of Piston]—OD	115.771—115.789 mm (4.5579—4.5586 in.)

A—Bottom of Piston
B—Piston Skirt Diameter
C—Piston Pin Bore



Measure Piston Skirt Diameter

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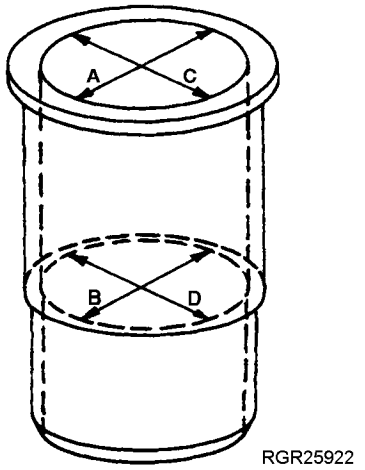
RG,10,DT7101 –19–09MAR00–1/2

IMPORTANT: ALWAYS measure liners at room temperature.

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

Specification	
Cylinder Liner—ID	115.865—115.895 mm (4.5616—4.5628 in.)
OD (Water Jacket Area)	127.94—128.24 mm (5.037—5.049 in.)
OD (At Upper Bore)	129.08—129.14 mm (5.082—5.084 in.)
OD (At Lower Bore)	125.044—125.120 mm (4.923—4.926 in.)
ID of Upper Bore in Block for Seating Liners	129.155—129.205 mm (5.085—5.087 in.)
ID of Lower Bore in Block for Seating Liners	125.133—125.183 mm (4.9265—4.9285 in.)
Liner-to-Block Clearance at Upper Bore	0.026—0.126 mm (0.001—0.005 in.)
Liner-to-Block Clearance at Lower Bore	0.012—0.140 mm (0.0005—0.0055 in.)
Maximum Out-of-Round	0.051 mm (0.0020 in.)
Maximum Wear or Taper in Ring Travel Area	0.051 mm (0.0020 in.)
Piston-to-Liner—New Part Clearance (At Bottom of Skirt)	0.076—0.124 mm (0.0030—0.0049 in.)
Maximum Clearance	0.152 mm (0.0060 in.)

Replace piston and liners (as a set) if they exceed wear specifications given.



RGR25922 –UN–11DEC97

Measure Liner Bore

A—Liner Bore Parallel to Piston Pin at Top End of Ring Travel
B—Liner Bore Parallel to Piston Pin at Bottom End of Ring Travel
C—Right Angle to Piston Pin at Top End of Ring Travel
D—Right Angle to Piston Pin at Bottom End of Ring Travel

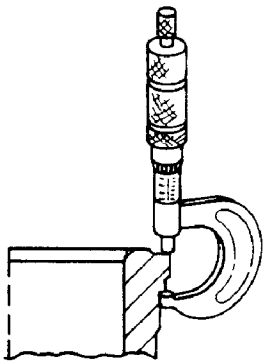
RG,10,DT7101 –19–09MAR00–2/2

Measure Liner Flange Thickness

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

If liner flange is not within specification, either use liner shims as needed, or replace piston and liner as a set if shims don't bring liner standout within specification. (See RECHECK CYLINDER LINER STANDOUT (HEIGHT ABOVE BLOCK), later in this group.)

Specification	
Cylinder Liner Flange—Thickness	11.989—12.039 mm (0.472—0.474 in.)
Cylinder Liner Flange—OD	135.10—135.16 mm (5.319—5.321 in.)



RG4727 –UN–05DEC97

Measure Liner Flange Thickness

RG,10,DT7100 –19–09MAR00–1/1

Inspect and Measure Connecting Rod Bearings

Inspect connecting rod bearings for wear or damage.

IMPORTANT: Each rod bearing half has a built-in "relief" or lube oil pocket on the inner surface. This relief must not be confused as a worn/damaged spot.

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

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

1. With crankshaft removed, measure connecting rod journal OD at several points.

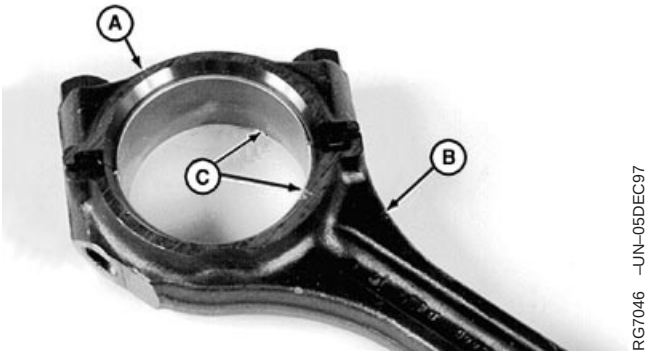
2. Carefully clamp rod in a soft-jawed vise and install connecting rod cap (A) on rod (B) with bearings (C) in correct position.

3. **On tongue-and-groove connecting rods**: Initially tighten blind-hole cap screw, then tighten open-hole cap screw to the following specifications.

	Specification
Tongue-and-Groove Connecting Rod Cap Screw—Initial Torque	27 N•m (20 lb-ft)

Next, tighten rod cap screws to the following specifications. (See TORQUE-TURN CONNECTING ROD CAP SCREWS in this group.)

	Specification
Tongue-and-Groove Connecting Rod Cap Screw—Final Torque	75 N•m (55 lb-ft) plus 90—100° turn clockwise



RG7046 –UN–05DEC97

Connecting Rod Bearings

A—Rod Cap
B—Rod
C—Bearings

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4. **On PRECISION JOINT™ connecting rods**: Initially tighten rod cap screw closest to piston end, then tighten other cap screw to the following specifications.

Specification	
PRECISION JOINT™ Connecting Rod Cap Screw—Torque	95 N•m (71 lb-ft) plus 90—100° turn clockwise

(See TORQUE-TURN CONNECTING ROD CAP SCREWS in this group.)

PRECISION JOINT™ is a trademark of Deere & Company

DPSG,OUO1004,885 –19–14MAY99–2/3

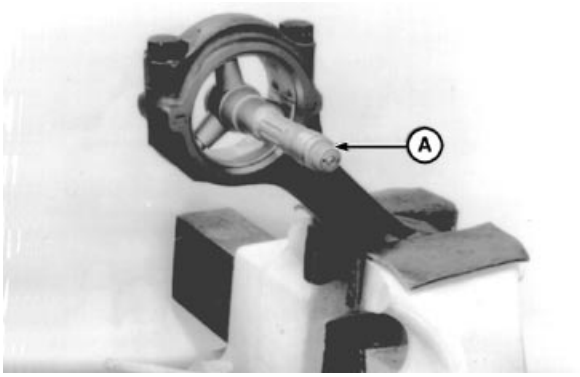
5. Using an inside micrometer (A) measure ID of bearing.

6. Subtract OD of crankshaft journals from ID of rod bearings to obtain oil clearance.

7. Compare measurements with the following specifications.

Specification	
Crankshaft Rod Journal—OD	76.150—76.180 mm (2.9980—2.9992 in.)
Assembled Connecting Rod Bearing—ID	76.210—76.260 mm (3.0004—3.0024 in.)
Connecting Rod Bearing-to-Journal (New Parts)—Oil Clearance	0.030—0.110 mm (0.0012—0.0044 in.)

8. Inspect connecting rod bearings for wear or damage. If bearings are worn or not within specification, replace connecting rod bearings.



RG3824 –UN–04DEC97

Measuring Connecting Rod Bearings

A—Inside Micrometer

DPSG,OUO1004,885 –19–14MAY99–3/3

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Inspect Rod and Cap

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

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

2. Inspect in and around cap screw holes (B) in cap. If any defects are found, replace rod and cap.

IMPORTANT: If replacing a connecting rod, use the same type of joint design. Do Not intermix PRECISION JOINT™ rods and tongue-and-groove rods on the same engine. See parts catalog for recommendations.

3. Carefully clamp rod in a soft-jawed vise (cap end upward).

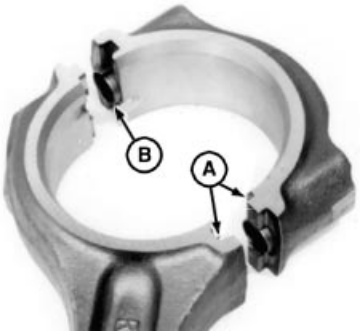
4. Install cap WITHOUT bearing.

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

5. **On tongue-and-groove connecting rods**: Initially tighten blind-hole cap screw, then tighten open-hole cap screw to the following specifications.

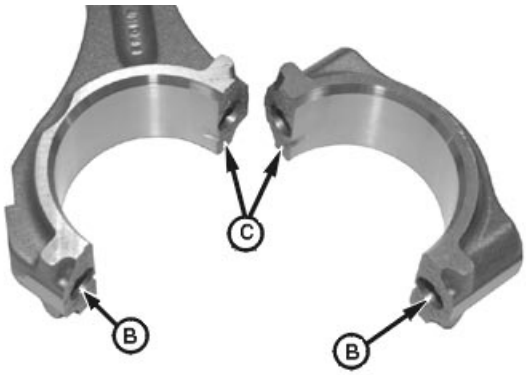
Specification	
Tongue-and-Groove Connecting Rod Cap Screw—Initial Torque	27 N•m (20 lb-ft)

Next, tighten rod cap screws to the following specifications.



RG3749 –UN–04DEC97

Tongue-and-Groove Rod and Cap



RG10052 –UN–09JUN99

PRECISION JOINT™ Rod and Cap

RG4982 –UN–05DEC97

Clamping Rod in Vise

A—Tongue-and-Groove Joints
B—Cap Screw Holes
C—PRECISION JOINT™ Mating Surfaces

Continued on next page

Specification	
Tongue-and-Groove Connecting Rod Cap Screw—Final Torque	75 N•m (55 lb-ft) plus 90—100° turn clockwise

(See TORQUE-TURN CONNECTING ROD CAP SCREWS in this group.)

6. **On PRECISION JOINT™ connecting rods**: Initially tighten rod cap screw closest to piston end, then tighten other cap screw to the following specifications.

Specification	
PRECISION JOINT™ Connecting Rod Cap Screw—Torque	95 N•m (71 lb-ft) plus 90—100° turn clockwise

(See TORQUE-TURN CONNECTING ROD CAP SCREWS in this group.)

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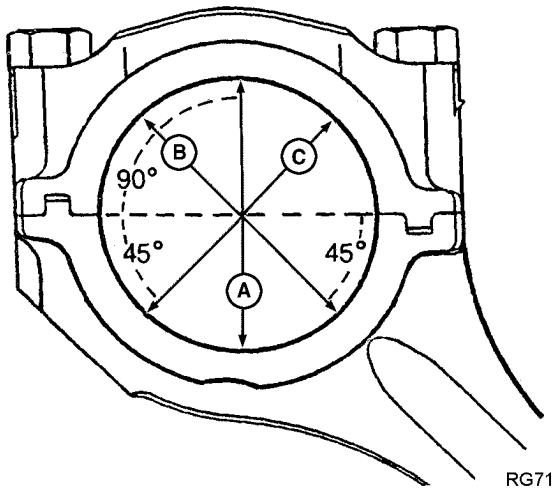
DPSG,OUO1004,884 –19–08JUN99–2/4

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

Specification	
Connecting Rod Bore (Without Bearings)—ID	81.051—81.077 mm (3.191—3.192 in.)

8. Compare the measurements. If difference between the greatest and least measurement is more than 0.04 mm (0.0016 in.), the rod and cap are out-of-round. Replace both connecting rod and cap.

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



Measuring Connecting Rod and Cap Bore

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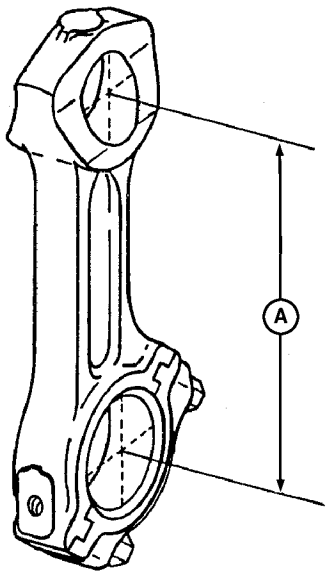
DPSG,OUO1004,884 –19–08JUN99–3/4

9. Measure rod's piston pin bore-to-crankshaft bore center-to-center dimension (A) and compare with specification given. If measurement is not within specification, replace rod.

Specification

Centerline of Piston Pin Bore-to-Crankshaft Bore—Dimension ..... 222.20—222.30 mm (8.748—8.752 in.)

A—Center-to-Center Dimension



RG7141 –UN–05DEC97

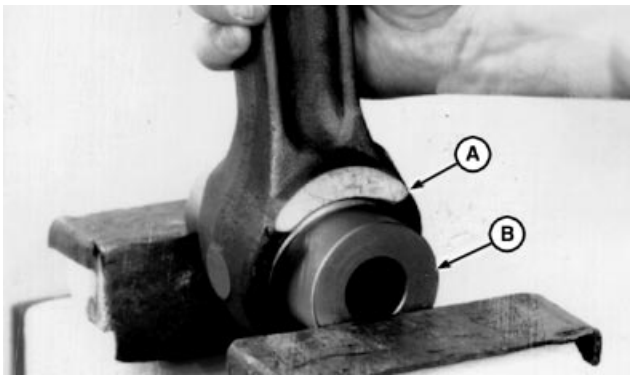
Measuring Pin Bore-to-Crankshaft Bore

DPSG,OUO1004,884 –19–08JUN99–4/4

Inspect Piston Pins and Bushings

1. Insert piston pin (B) through piston pin bushing and carefully clamp in a soft-jawed vise.
2. Rotate connecting rod (A) back and forth several times to make sure connecting rod moves freely on piston pin.
3. Remove piston pin from connecting rod.

A—Connecting Rod
B—Piston Pin



RG3172 –UN–04DEC97

Checking Piston Pin and Rod

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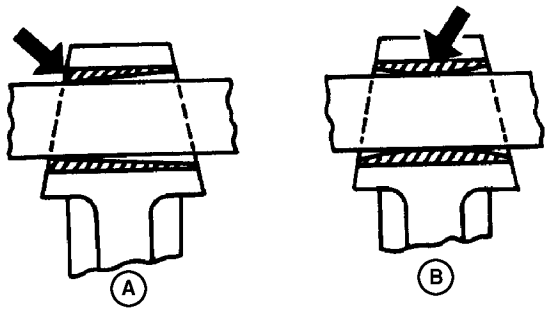
DPSG,OUO1004,891 –19–18MAY99–1/2

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

5. Measure ID of rod pin bushing and OD of piston pin. Compare measurements with specifications given below:

	Specification
Piston Pin—OD	47.597—47.613 mm (1.8739—1.8745 in.)
Piston Pin Bore in Piston—ID	47.620—47.630 mm (1.8748—1.8752 in.)
Installed Connecting Rod Pin Bushing (After Boring)—ID	47.655—47.681 mm (1.8762—1.8772 in.)
Connecting Rod Pin-to-Bushing—Oil Clearance	0.042—0.084 mm (0.0017—0.0033 in.)
Wear Limit	0.102 mm (0.0040 in.)

6. If necessary, remove and replace piston pin bushing. (See REMOVE PISTON PIN BUSHING, CLEAN AND INSPECT PIN BORE, later in this group.)



Inspecting Piston Pin Bores

A—Tapered Bore
B—Bell-Mouthed Bore

DPSG,OUO1004,891 –19–18MAY99–2/2

Remove Piston Pin Bushing, Clean and Inspect Pin Bore

1. If necessary, remove pin bushing with the JDG337 and JDE98A Connecting Rod Bushing Service Sets.

   Use the following tools from the service sets:

   - JDE98-1 Cup (A)
   - JDG338 Adapter (B)
   - JDE98-4 Driver (C)
   - 36104 Forcing Screw with Washer (D)

IMPORTANT: Use care to properly align the JDE98-4 Driver with bushing so that the connecting rod bushing bore is not damaged.

2. Clean rod bushing bore using a medium grit emery cloth, as burrs will distort bushing. Install bushing on opposite side of rod burr.

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

3. Measure rod bushing bore in three places approximately 45° apart. Compare the measurements with the specifications given below:

	Specification
Connecting Rod Pin Bore—Diameter without Bushing	52.354—52.380 mm (2.0612—2.0622 in.)
Connecting Rod Pin Bore-to-Bushing—Press Fit	0.084—0.147 mm (0.0033—0.0058 in.)
Installed Service Connecting Rod Pin Bushing (Before Boring)—ID	47.58—47.63 mm (1.8732—1.8751 in.)
Installed Service Connecting Rod Pin Bushing (After Boring)—ID	47.655—47.681 mm (1.8762—1.8772 in.)

Remove Piston Pin Bushing from Rod

A—JDE98-1 Cup
B—JDG338 Adapter
C—JDE98-4 Driver
D—36104 Forcing Screw with Washer

RG,10,DT7123 –19–09MAR00–1/1

Install Piston Pin Bushing in Connecting Rod

IMPORTANT: Always push new bushing into rod from back side and burnish bushing after installation for proper form and seating in rod bore.

1. Lubricate rod bushing bore and bushing with clean engine oil. Install bushing using the JDG337 and JDE98A Connecting Rod Bushing Service Sets.

   Use the following tools from the above sets and assemble in sequence as shown:

   - 36104 Forcing Screw with Washer (A)
   - JDE98-2 Driver (B)
   - JDG338 Adapter (C)
   - Service Bushing (D)
   - JDE98-3 Pilot (E)
   - JDE98-1 Cup (F)

IMPORTANT: Boring of the rod bushing should be done ONLY by experienced personnel on equipment capable of maintaining bushing specification.

2. Bore ID of newly installed bushing to specification after installation. Remove all residue from boring operation.

Specification	
Installed Service Connecting Rod Pin Bushing (After Boring)—ID	47.655—47.681 mm (1.8762—1.8772 in.)

3. Check distance from centerline of rod's piston pin bore-to-crankshaft journal bore centerline. Distance must be within specification.

Specification	
Centerline of Piston Pin Bore-to-Crankshaft Bore—Dimension	222.20—222.30 mm (8.748—8.752 in.)

4. Check rod-to-bushing clearance. (See INSPECT PISTON PINS AND BUSHINGS, earlier in this group.) Replace rod pin as required.

RG4986 –UN–05DEC97

Install Piston Pin Bushing in Rod

A—36104 Forcing Screw with Washer
B—JDE98-2 Driver
C—JDG338 Adapter
D—Service Bushing
E—JDE98-3 Pilot
F—JDE98-1 Cup

RG,10,DT7124 –19–10MAR00–1/1

Complete Disassembly of Cylinder Block (If Required)

If complete inspection and “Hot Tank” cleaning of cylinder block is required, refer to the appropriate group for removal of all external and internal mounted components listed below:

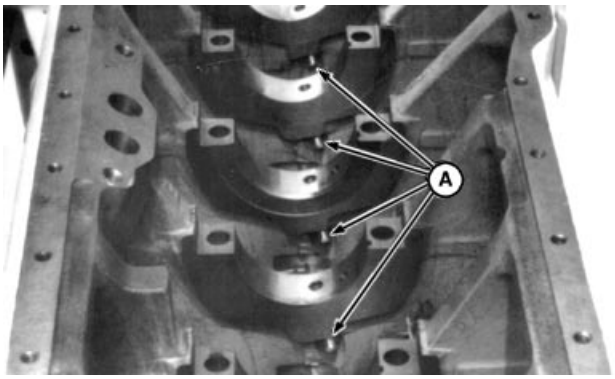
1. Remove crankshaft and pulley if not previously removed. (See procedures in Group 15.)
2. Remove all remaining lubrication system components. (See procedures in Group 20.)
3. Remove starter motor. (See REMOVE AND INSTALL STARTER MOTOR in Group 40.)
4. Remove coolant pump and all remaining cooling system components. (See procedures in Group 25.)
5. Remove timing gear train and camshaft. (See procedures in Group 16.)
6. Remove ignition module, ignition coils, mounting bracket, spark plug boots, and spark plugs. (See procedures in Group 45.)
7. Remove gas regulator, fuel mixer and fuel metering valve. (See procedures in Group 35.)
8. If necessary to “Hot Tank” the block, remove oil gallery plugs, water gallery plugs, piston cooling orifices and the engine serial number plate. (See REMOVE AND CLEAN PISTON COOLING ORIFICES, later in this group.)

RG,10,DT7125 –19–31OCT97–1/1

Remove and Clean 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.

1. Remove all six (four shown) piston cooling orifices (A) and inspect each cooling orifice to make sure it is not plugged or damaged.
2. Use a soft wire and compressed air to clean orifice. Replace, if condition is questionable.



RG3752 –UN–04DEC97

Remove and Clean Piston Cooling Orifices

A—Piston Cooling Orifices

RG,10,DT7126 –19–20JAN98–1/1

Inspect and Clean Cylinder Block

NOTE: All components (including piston cooling orifices), water gallery plugs and oil gallery plugs must be removed from the cylinder block for inspection and cleaning. Refer to the proper group for removal of all external and internal mounted components.

1. Use D17015BR O-Ring Groove Cleaning Brush or an equivalent brush to thoroughly clean all debris from cylinder liner O-ring grooves.

2. Remove cylinder head locating dowels, if not previously removed. Clean out all threaded holes for cylinder head mounting cap screws in top deck of cylinder block. Use JDG681 Tap or an equivalent 9/16-12 UNC-2A tap approximately 88.9 mm (3.5 in.) long. Use compressed air to remove any debris or fluid which may be present in the cap screw hole.

IMPORTANT: If cylinder block is cleaned in a hot tank, be sure to remove any aluminum parts. Aluminum parts can be damaged or destroyed by hot tank solutions. Remove all serial number plates.

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

4. Inspect liner support flange (C) for burrs. If burrs are present, use a small half-moon file and LIGHTLY file (in a circular motion) burr off at approximately a 60° angle. DO NOT let file hit top deck of cylinder block (B) while filing.

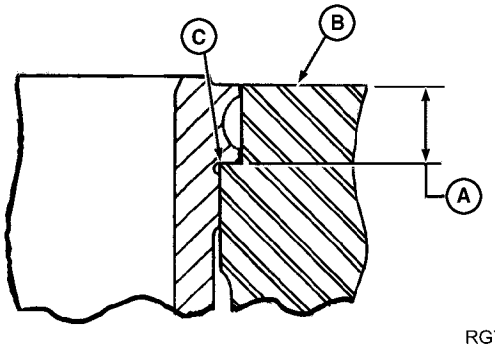
NOTE: DO NOT file liner support flange excessively. Excess filing can damage liner support flange and allow an improper liner fit. Thoroughly clean all filings from cylinder block.

5. Measure liner flange counterbore depth (A) in block and compare with specification given below.

Specification

Cylinder Liner Flange Counterbore—Depth	11.913—11.963 mm (0.469—0.471 in.)

Clean Out Threaded Holes



Inspect Liner Support Flange

A—Liner Flange Counterbore Depth
B—Top Deck of Cylinder Block
C—Liner Support Flange

Continued on next page

6. Carefully inspect block for cracks or any other physical damage. If a cracked block is suspected, pressure-test the block. A procedure for pressure testing is outlined in Deere FOS Manual—ENGINES. Replace block if there is evidence of a crack or physical damage.

RG,10,DT7127 –19–20JAN98–2/2

Measure Cylinder Block

Refer to the appropriate groups for a more detailed description of the features being measured. Compare measurements with specifications given below.

1. Assemble and measure main and thrust bearing bores. Compare measurements with specifications given below:

Specification	
Crankshaft Main Bearing—Bore ID without Bearing	101.651—101.677 mm (4.0020—4.0030 in.)
Surface Width	36.28—36.78 mm (1.428—1.448 in.)
Crankshaft Thrust Bearing—Bore ID without Bearing	101.651—101.677 mm (4.0020—4.0030 in.)
Surface Width (No. 5 Main)	37.44—37.54 mm (1.474—1.478 in.)
Overall Cap Width	41.81—42.31 mm (1.646—1.666 in.)

If any main or thrust bearing cap assembled ID is not within specification, blank (generic) bearing caps are available and must be line bored to specification by a qualified machine shop. (See MAIN BEARING CAP LINE BORE SPECIFICATIONS in Group 15.)

2. Measure cam follower bore diameter at all bore locations. Record each measurement.

Specification	
Camshaft Follower—Bore ID in Block	17.384—17.440 mm (0.6845—0.6865 in.)
Follower OD (New)	17.33—17.35 mm (0.682—0.683 in.)
Follower-to-Bore Clearance	0.114 mm (0.0045 in.)

If any one cam follower bore is not within specification, install a new cylinder block.

3. Measure camshaft bore diameter at all locations and record readings. Compare measurements with specifications below:

Specification	
Camshaft Bushing—Installed ID	67.076—67.102 mm (2.6408—2.6418 in.)
Bushing Bore in Block	69.987—70.013 mm (2.7554—2.7564 in.)
Minimum Runout of Bore in Block	0.038 mm (0.0015 in.)
Bushing-to-Journal Clearance	0.063—0.115 mm (0.0025—0.0045 in.)

If camshaft bushing bore diameter in block is more than specified, install a new cylinder block.

IMPORTANT: The centerline of the main bearing bore-to-top deck of cylinder block MUST be 352.35—352.50 mm (13.872—13.878 in.). If not, replace cylinder block.

4. Measure cylinder block top deck flatness using D05012ST Precision Straightedge and feeler gauge. Compare to specifications below. Resurface as required.

Specification	
Cylinder Block Top Deck—Maximum Out-of-Flat	0.10 mm (0.004 in.) over entire length or width
Straightness	0.025 mm (0.001 in.) per any 305 mm (12.0 in.) of length
Maximum Wave Depth	2.0 micrometers (79 micro-inch)
Main Bearing Bore Centerline-to-Top Deck Distance	352.35—352.50 mm (13.872—13.878 in.)

RG,10,DT7128 –19–10MAR00–1/1

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Install Piston Cooling Orifices and Gallery Plugs

1. Use a soft wire and compressed air to clean orifices. Replace, if condition is questionable.

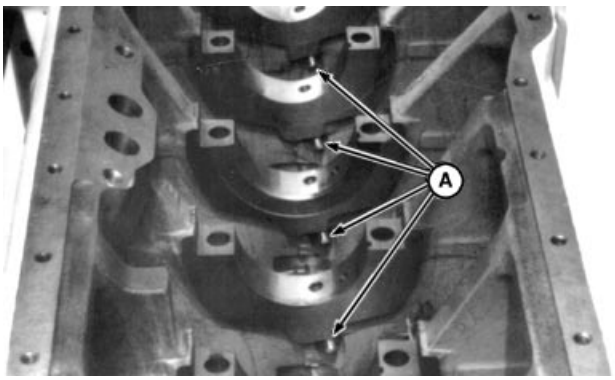
IMPORTANT: A piston cooling orifice failure could cause damage to pistons, piston pins, rod pin bushings, and liners. If a piston cooling orifice is left out, low or no oil pressure will result.

2. Install all six (four shown) piston cooling orifices (A) and tighten to specification.

Specification

Piston Cooling Orifices—Torque ..... 11 N•m (8 lb-ft) (97 lb-in.)

3. Install new oil and water gallery plugs as required, if removed.



RG3752 –UN–04DEC97

Install Piston Cooling Orifices and Plugs

A—Piston Cooling Orifices

RG,10,DT7120 –19–20JAN98–1/1

Recheck Cylinder Liner Standout (Height Above Block)

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

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

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

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

RG,10,DT7119 –19–31OCT97–1/1

Install Liner Shims—If Required

If the liner flange thickness is within specification, but recorded standout was no more than 0.08 mm (0.003 in.) BELOW top deck of block, install liner shims on bottom of liner flange.

The liner shim is 0.05 mm (0.002 in.) thick.

Specification

Cylinder Liner Shim—Thickness ..... 0.05 mm (0.002 in.)

A maximum of two liner shims may be used per cylinder, as required. Shims have tangs in the ID to help hold them in place against bottom of liner flange during liner installation.

1. Make sure counterbore in block is clean and free of burrs. Install liner(s), and shim(s), in block bore without O-rings. Secure liners with cap screws and washers as done previously. Tighten cap screws to 68 N•m (50 lb-ft).

   Liner standout MUST NOT exceed 0.127 mm (0.005 in.) after shim installation.

2. Measure liner standout again at 1, 5, 7, and 11 o'clock positions. Record measurements.

   If standout is still not within specification, remove liner and determine cause.

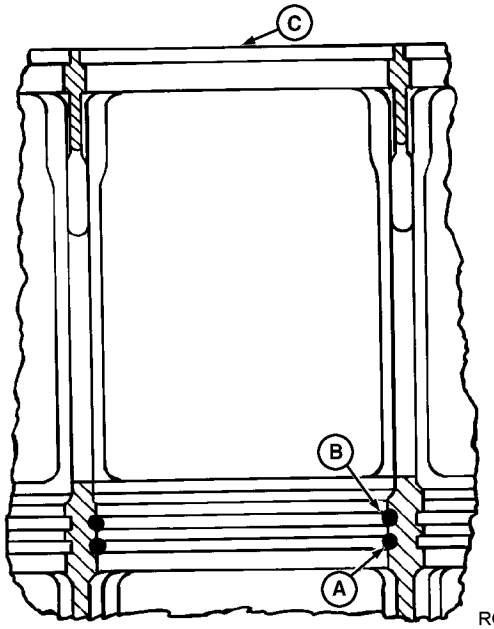
   If standout is within specification, proceed to next step.

RG,10,DT7118 –19–10MAR00–1/1

Install Packing on Cylinder Liner and O-Rings in Block

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

1. Pour AR54749 Soap Lubricant into a suitable container.
2. Dip new packings and O-rings in soap before installation. Do not leave packings or O-rings in soap to soak.
3. Install the black viton O-ring (A) in the lower O-ring groove of the cylinder block (C).
4. Install the red silicone O-ring (B) in the upper O-ring groove of the cylinder block.



Install Liner Packing and O-Rings

A—Black Viton O-Ring
B—Red Silicone O-Ring
C—Cylinder Block

Continued on next page

RG,10,DT7117 –19–20JAN98–1/2

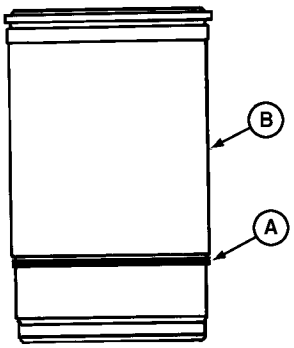
5. Turn cylinder liner (B) upside-down and install the square neoprene packing (A) over outside of liner.

6. Slide packing down firmly against second shoulder of the liner.

NOTE: Make sure the square packing is not twisted.

7. Coat the liner packing sealing area of the cylinder liner and cylinder block O-rings with liquid soap.

A—Square Neoprene Packing
B—Cylinder Liner



Install Square Neoprene Packing on Liner

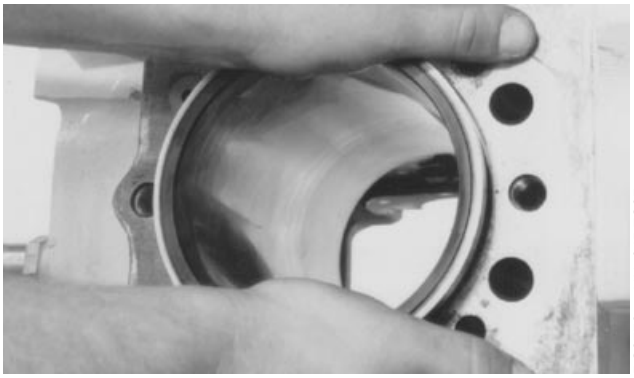
RG,10,DT7117 –19–20JAN98–2/2

Install Cylinder Liners in Block

IMPORTANT: Install cylinder liners into same cylinder block bore as removed.

DO NOT scuff the packing across the upper counterbore.

Pitted or eroded liners that meet reuse guidelines should be rotated 90° from their removed position. See VISUALLY INSPECT CYLINDER LINERS, earlier in this group for reuse guidelines.



Install Liner and Packing in Block Bore

1. Install liner and packing in block bore with manufacturing date code (stamped on flange) toward front of engine, unless liner OD is pitted or eroded. (Liners should have “NG” [for Natural Gas] as the first digits of code on flange.)

   If liner OD is pitted or eroded, but still within acceptable service limits, rotate liner 90° from its removed position. Pitted sections of the liner should be facing the front or rear of engine.

2. A resistance will be felt when cylinder liner is aligned in pilot bore.

3. Use only the pressure of both palms. The cylinder liner should drop to a point nearly flush with the upper flange of the cylinder liner and cylinder block.

Continued on next page

RG,10,DT7116 –19–20JAN98–1/2

4. Finish seating cylinder liners using a clean, hardwood block and mallet.

5. Gently tap hardwood block over top of cylinder liner with mallet.

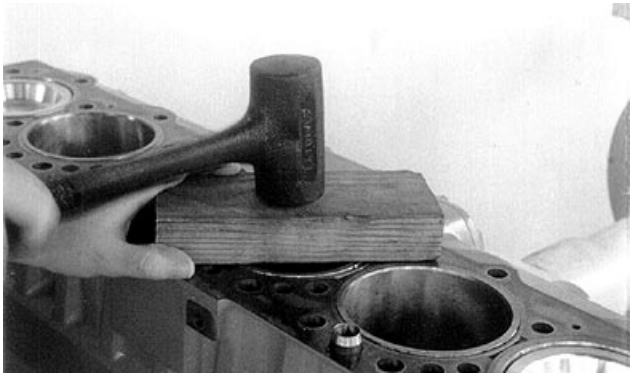
NOTE: Cylinder liner will protrude over top of cylinder block more than normal due to uncompressed packings and O-rings.

IMPORTANT: If you suspect that a packing may have been sheared or displaced during liner installation, remove liner and packing assembly. If no damage is found, check packing and O-rings for proper position. Resoap packings and reinstall liner assembly.

6. Hold liners in place with large flat washers and cap screws. Turn cap screws snug but do not tighten.

7. Clean cylinder liner bores with waterless hand cleaner after installation. Wipe dry with clean towels.

8. Apply clean engine oil to liner bores immediately to prevent corrosion.



Seating Cylinder Liners

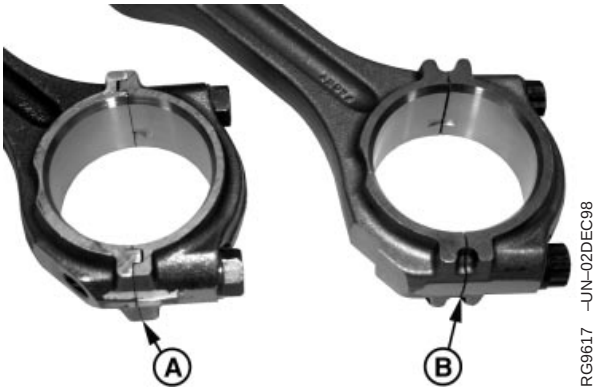
RG,10,DT7116 –19–20JAN98–2/2

Install Piston and Connecting Rod

1. Earlier engines have the traditional tongue-and-groove joint between the connecting rod and cap (A). Later engines have the PRECISION JOINT™ rod and cap (B).

   Installation of the different rods is similar, with differences noted in the following instructions.

IMPORTANT: DO NOT mix tongue-and-groove rods and PRECISION JOINT™ rods in the same engine. See parts catalog for recommendations.



Connecting Rods

A—Tongue-and-Groove Rod (Earlier Engines)
B—PRECISION JOINT™ Rod (Later Engines)

PRECISION JOINT™ is a trademark of Deere & Company

Continued on next page

RG,10,DT7115 –19–30MAR04–1/6

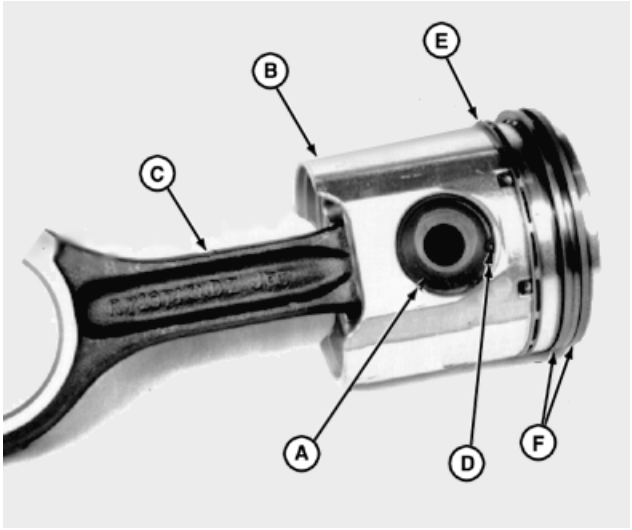
IMPORTANT: Pistons must be installed on same connecting rods from which they were removed and new piston pin snap rings must be used.

If a new piston and liner assembly is to be installed, DO NOT remove piston from liner. Push piston out of liner bottom only far enough to install piston pin.

2. Lubricate piston pin (A) and bushing with clean engine oil.

3. Install piston pin through piston (B) and connecting rod (C). Be sure “FRONT” of rod aligns with arrow or “FRONT” of piston.

4. Install NEW piston pin snap rings (D) in grooves. Make certain snap rings have expanded in grooves of piston.



RG5239 –UN–05DEC97

Installing Piston and Connecting Rod

A—Piston Pin
B—Piston
C—Connecting Rod
D—Snap Rings (2 used)
E—Oil Control Ring with Expander Ring
F—Compression Rings

Continued on next page

RG,10,DT7115 –19–30MAR04–2/6

NOTE: The shiny, barrel-faced, plasma-coated piston ring with one "Pip" mark on it is the No. 1 compression ring. The darker piston ring with two "Pip" marks on it is the No. 2 compression ring. "Pip" mark(s) on No. 1 and No. 2 compression rings (F) must face top of piston.

Some ring sets are also color coded. The No. 1 ring has a white paint stripe, the No. 2 ring has a light blue stripe, and the oil control ring has an orange stripe.

Use only one ring manufacturer on an engine. DO NOT mix ring sets.

Use the JDE93 Piston Ring Expander to prevent distortion when installing piston rings.

5. Install piston rings as follows:

IMPORTANT: Be sure oil expander ring ends are properly butted and do not overlap.

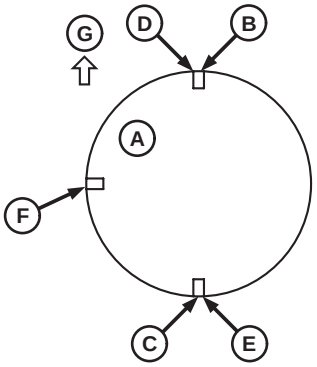
a. Install expander ring, with gap (F) to left side of engine.

b. Install lower oil rail in same groove with expander ring, with gap (E) to rear of engine.

c. Install upper oil rail in same groove with expander ring, with gap (D) facing front of engine.

d. Install No. 2 compression ring, with gap (C) facing rear of engine.

e. Install No. 1 compression ring, with gap (B) facing front of engine.



RG12100 –UN–05MAR02

Position of Piston Ring Gaps

A—Top of Piston
B—Gap Location for No. 1 Compression Ring
C—Gap Location for No. 2 Compression Ring
D—Gap Location for Upper Oil Rail
E—Gap Location for Lower Oil Rail
F—Gap Location for Expander Ring
G—Front of Engine

Continued on next page

RG,10,DT7115 –19–30MAR04–3/6

NOTE: If crankshaft was removed, see INSTALL CRANKSHAFT in Group 15.

6. Coat piston, liners and ID of JDE96 Piston Ring Compressor with clean engine oil.

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

IMPORTANT: Be sure crankshaft journals and liner walls are not damaged when installing piston and rod in liner.

NOTE: Be sure the word "FRONT" on piston and rod face toward front of engine.

8. With piston centered in ring compressor and rings staggered correctly, push piston into liner as shown.

Installing Piston in Cylinder Liners

Continued on next page

RG,10,DT7115 –19–30MAR04–4/6

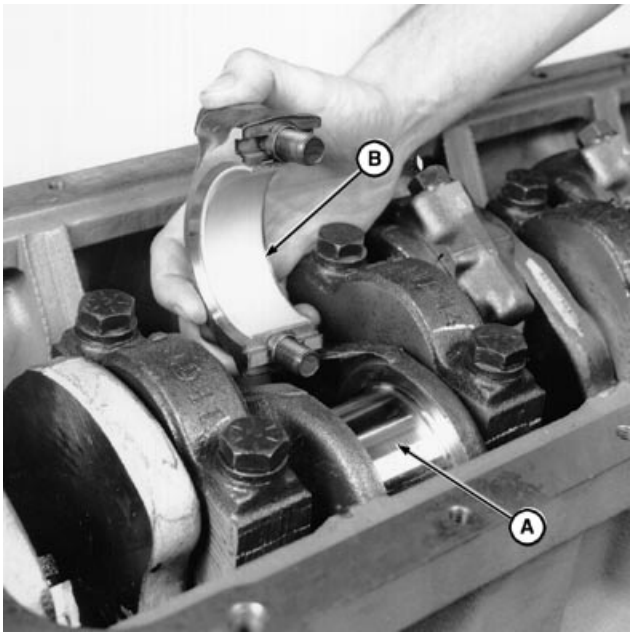
9. Apply clean engine oil to bearing inserts (B) and matching crankshaft rod journals (A).

IMPORTANT: On PRECISION JOINT™ rods, make sure cap is properly aligned on rod with interlocking surfaces sealing tightly and edges aligned. DO NOT reverse cap on rod. Match pads on side of rod and cap.

When installing caps, if there are stamped numbers (C) on rod and cap, make sure they are positioned on the same side.

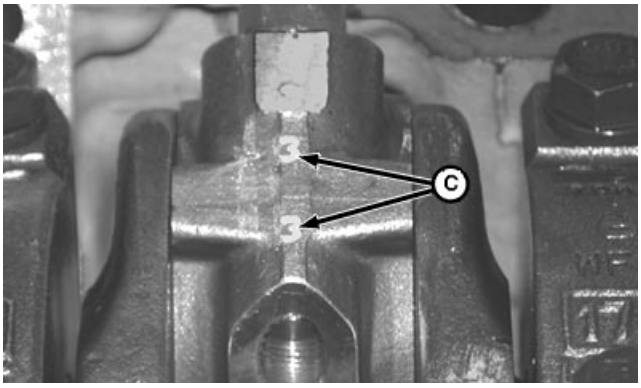
10. Install connecting rod caps.

A—Crankshaft Rod Journals
B—Bearing Inserts
C—Stamped Numbers



RG5817 –UN–05DEC97

Installing Connecting Rod Caps with Bearing Inserts



RG10215 –UN–23JUN99

Stamped Numbers

PRECISION JOINT™ is a trademark of Deere & Company

Continued on next page

RG,10,DT7115 –19–30MAR04–5/6

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

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

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

12. **On tongue-and-groove connecting rods**: Initially, tighten cap screw (A) closest to piston end to specifications. Next, tighten the other cap screw. Feel rod-to-cap joint to check for proper alignment.

Specification	
Tongue-and-Groove Connecting Rod Cap Screw—Initial Torque	27 N•m (20 lb-ft)

Secondly, tighten all cap screws to the following specifications, then torque-turn all cap screws 90—100°.

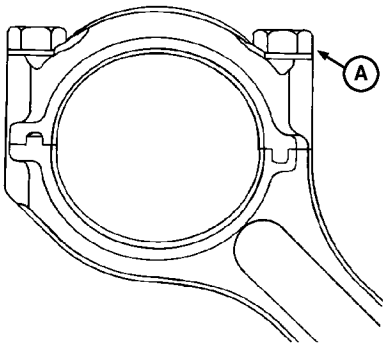
Specification	
Tongue-and-Groove Connecting Rod Cap Screw—Final Torque	75 N•m (55 lb-ft) plus 90—100° turn clockwise

(See TORQUE-TURN CONNECTING ROD CAP SCREWS next in this group.)

13. **On PRECISION JOINT™ connecting rods**: Initially, tighten cap screw closest to piston end to specifications. Next, tighten the other cap screw. Feel rod-to-cap joint to check for proper alignment.

Specification	
PRECISION JOINT™ Connecting Rod Cap Screw—Torque	95 N•m (71 lb-ft) plus 90—100° turn clockwise

(See TORQUE-TURN CONNECTING ROD CAP SCREWS next in this group.)



RG4375 –UN–05DEC97

Install Rod Cap

A—Cap Screw

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RG,10,DT7115 –19–30MAR04–6/6

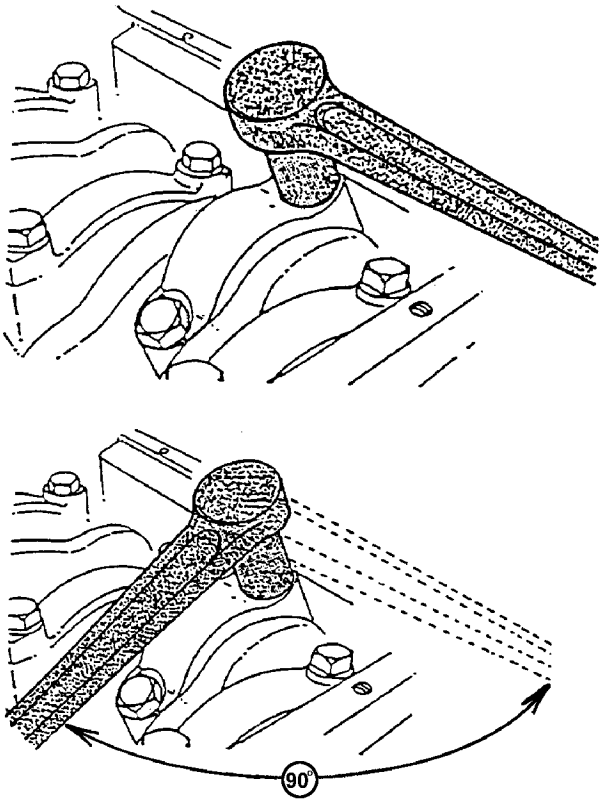
Torque-Turn Connecting Rod Cap Screws

Using engine axis method to torque-turn connecting rod cap screws:

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

Specification

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



RG7047 –UN–05DEC97

Torque-Turn Connecting Rod Cap Screws

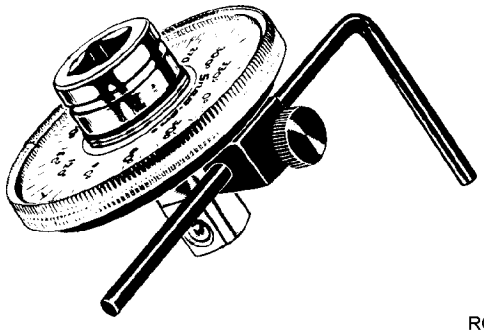
RG,10,DT7114 –19–18JUL00–1/2

Using JT05993 Torque Angle Gauge to torque-turn connecting rod cap screws:

After tightening cap screws to specifications, follow directions provided with gauge and torque-turn each cap screw 90—100°.

Specification

Connecting Rod Cap Screws—
Final Torque-Turn ..... 90—100°



RG5698 –UN–05DEC97

Torque Angle Gauge

RG,10,DT7114 –19–18JUL00–2/2

Check Engine Rotation for Excessive Tightness

1. Rotate crankshaft several revolutions to be sure engine rotates without excessive tightness.
2. Check liners for deep scratches caused by an improperly installed or broken piston ring.
3. Check side clearance of rods. Must have slight side-to-side movement.

RG,10,DT7113 –19–31OCT97–1/1

Complete Final Assembly

NOTE: Refer to the proper group for installation of components.

1. Install camshaft and timing gear cover. (See procedure in Group 16.)
2. Install oiling system components. (See procedures in Group 20.)
3. Install cylinder head using a new gasket and cap screws. Install valve train components. (See procedures in Group 05.)
4. Install ignition module, ignition coils, mounting bracket, spark plug boots, and spark plugs. (See procedures in Group 45.)
5. Install gas regulator, fuel mixer and fuel metering valve. (See procedures in Group 35.)
6. Install vibration damper and crankshaft pulley. (See procedures in Group 15.)
7. Install alternator, fan, and fan belts. (See procedures in Vehicle Technical Manual.)
8. Install exhaust manifold and intake assembly. (See procedures in Group 30.)
9. Install starter motor. (See REMOVE AND INSTALL STARTER MOTOR in Group 40.)
10. Fill engine with clean oil and proper coolant. (See procedures in Group 02.)
11. Install engine in vehicle (if removed) and perform engine break-in. (See procedure in Group 04.)

RG,10,DT7112 –19–20JAN98–1/1

Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

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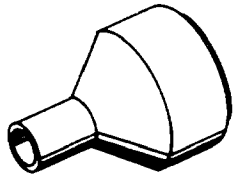
DPSG,OUO1004,2811 –19–08MAR02–1/14

RG6214 –UN–05DEC97

Seal Puller Adapter JDG719

Used with a standard metal screw, JDE38-2 Shank, and JDE38-3 Slide Handle to remove front crankshaft oil seal with timing gear cover installed. Also used to remove rear crankshaft oil seal with seal housing installed.



RG6214

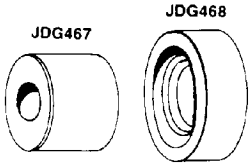
JDG719

DPSG,OUO1004,2811 –19–08MAR02–2/14

RG5508 –UN–05DEC97

Front Wear Sleeve Installer Set JDE3

Install front crankshaft wear sleeve.



RG5508

JDE3

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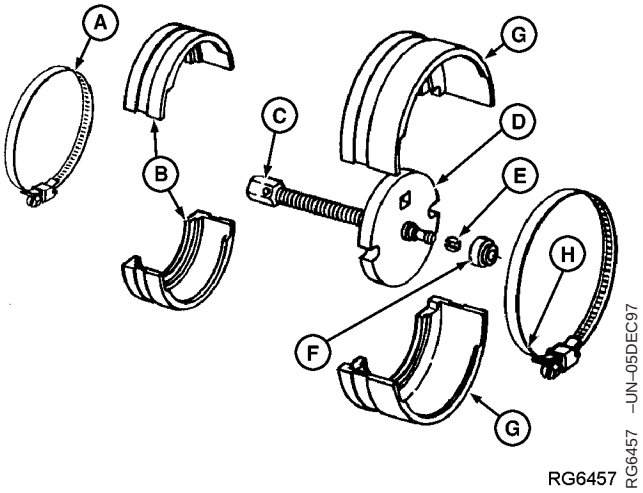
DPSG,OUO1004,2811 –19–08MAR02–3/14

Rear Wear Sleeve Puller Kit JDG790

Used to remove rear wear sleeve with oil seal housing installed on Series 400, 450, and 500 Engines. Set consists of 219469 Hose Clamp (A) (Series 500), JDG790-1 Collet Halves (B) (Series 400/450), 35945 Forcing Screw (C), JDG790-2 Pulling Plate (D) (Series 400/450/500), 13876 Retainer Clip (E) (Series 400/450/500), 215177 Shaft Protector (F) (Series 400/450/500), JDG790-3 Collet Halves (G) (Series 500), 19311 Hose Clamp (H) (Series 400/450).



JDG790

DPSG,OUO1004,2811 –19–08MAR02–4/14

RG5109 –UN–23AUG88

Seal Remover JDG22

Used to remove crankshaft rear oil seal.

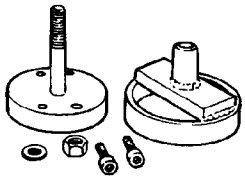
JDG22

DPSG,OUO1004,2811 –19–08MAR02–5/14

RG5106 –UN–05DEC97

Seal and Wear Sleeve Installer . . . . . JDG476(85)

Used to simultaneously install the new teflon unitized oil seal and wear sleeve on the rear crankshaft flange. Set consists of JDG477(85) Pilot and JDG478 Driver. Use with JDG796 Alignment Tool to install rear oil seal housing, eliminating need for dial indicator to measure runout.



RG5106

JDG476(85)

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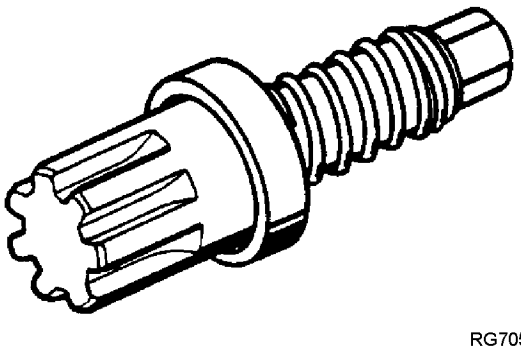
DPSG,OUO1004,2811 –19–08MAR02–6/14

Flywheel Turning Tool JDG820

Used to rotate engine to check damper radial runout and time engine.

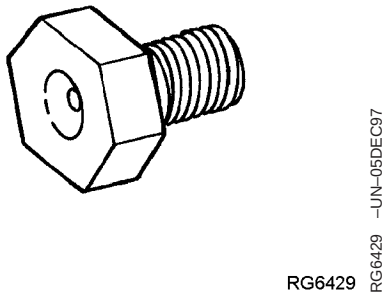


JDG820

DPSG,OUO1004,2811 –19–08MAR02–7/14

Thread Protector. JDG787

Used with JDG721 Hub Puller Kit to remove vibration damper puller assembly. Tool may be used with any puller set where limited space makes it difficult to use puller without a thread protector.



JDG787

Continued on next page

DPSG,OUO1004,2811 –19–08MAR02–8/14

Hub Puller Kit JDG721

Used with JDG787 Thread Protector to remove vibration damper pulley hub or vibration damper (HFN02 Engines Option Code 1301).

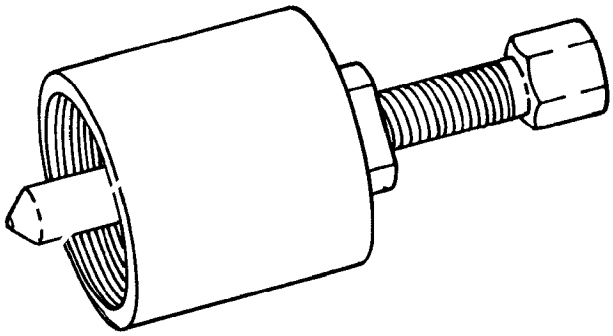
RG5763 –UN–05DEC97

JDG721

DPSG,OUO1004,2811 –19–08MAR02–9/14

Front Wear Sleeve Puller JDG786

Used to remove front crankshaft wear sleeve.



RG6428 –UN–05DEC97

JDG786

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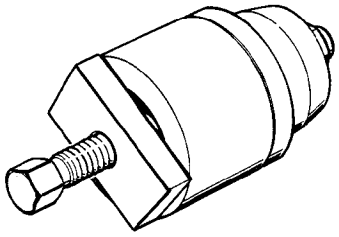
DPSG,OUO1004,2811 –19–08MAR02–10/14

Seal Protector JDG720A

Used to install front crankshaft oil seal with timing gear cover installed. Set consists of JDG720-1 Forcing Screw, JDG720-2 Seal Protector, JDG720-5 Seal Installer and JDG720-4 Ring (500 Series Engines).



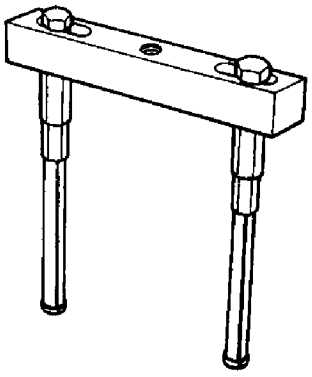
RG6215 –UN–05DEC97

JDG720A

DPSG,OUO1004,2811 –19–08MAR02–11/14

Main Bearing Cap Puller/Installer JDG1069

Use to remove and install the main bearing caps. Due to wider bearing surface, these caps are installed with an increased interference fit.



RG8521 –UN–20MAY98

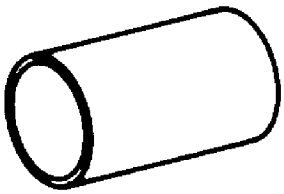
JDG1069

DPSG,OUO1004,2811 –19–08MAR02–12/14

RG5108 –UN–05DEC97

Gear Driver JDH7

Install crankshaft drive gear.



RG5108

JDH7

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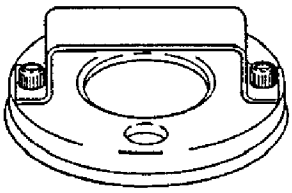
DPSG,OUO1004,2811 –19–08MAR02–13/14

RG6590 –UN–05DEC97

Oil Seal Housing Alignment Tool JDG796

Use with oil seal housing casting numbers R115050 and R125027.



RG6590

JDG796

DPSG,OUO1004,2811 –19–08MAR02–14/14

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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DPSG,OUO1004,2812 –19–08MAR02–1/4

Push-Puller D01200AA

Used to remove damper/pulley assembly on later HFN01, HFN02, HFN03 and HFN04 engines.

DPSG,OUO1004,2812 –19–08MAR02–2/4

Slide Hammer D01300AA

Remove main bearing caps.

DPSG,OUO1004,2812 –19–08MAR02–3/4

Puller[1]. D01251AA

Remove crankshaft gear.

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

DPSG,OUO1004,2812 –19–08MAR02–4/4

Other Material

Number	Name	Use
	Brake Kleen or Ignition Cleaner and Drier	Remove sealant from crankshaft flange.
TY15969 (U.S.) TY9479 (Canadian) 680 (LOCTITE®)	Retaining Compound (Maximum Strength)	Coat OD of crankshaft flange for installation of rear oil seal/wear sleeve and front oil seal and wear sleeve.
	PLASTIGAGE®	Check main bearing-to-crankshaft journal oil clearance during engine disassembly.
T43512 (U.S.) TY9473 (Canadian) 242 (LOCTITE®)	Thread Lock and Sealer (Medium Strength)	Coat threads of auxiliary drive housing, flywheel, and belt tensioner mounting cap screws.
TY6333 (U.S.) TY6347 (U.S.)	High Temperature Grease	Lubricate camshaft gear thrust washer in timing gear cover.

LOCTITE is a registered trademark of the Loctite Corp.
PLASTIGAGE® is a registered trademark of the DANA Corp.

DPSG,OUO1004,2813 –19–21JUL00–1/1

15
8

Crankshaft, Main Bearings and Flywheel Specifications

Item	Measurement	Specification
Vibration Damper	Maximum Radial Runout	1.02 mm (0.040 in.)
Crankshaft	End Play	0.038—0.380 mm (0.0015—0.0150 in.)
Crankshaft Front Oil Seal Bore in Timing Gear Cover	Maximum Radial Runout	0.254 mm (0.010 in.)
Front Oil Seal Installed Below Front Face of Seal Bore	Distance	8.9 mm (0.35 in.)
Flywheel Housing Face Runout	Maximum Variation	0.20 mm (0.008 in.)
Flywheel Face Flatness	Maximum Variation Maximum Variation per 25 mm (1.0 in.) of Travel	0.23 mm (0.009 in.) 0.013 mm (0.0005 in.)
Crankshaft Main Bearing-to-Journal	Oil Clearance	0.030—0.107 mm (0.0012—0.0042 in.)
Crankshaft Main Bearing	ID With Bearing ID Without Bearing	95.270—95.320 mm (3.7508—3.7528 in.) 101.651—101.677 mm (4.0020—4.0030 in.)
Crankshaft Main Journal	OD	95.196—95.222 mm (3.7479—3.7490 in.)
Crankshaft Main Journal	Taper per 25.4 mm (1.0 in.) Length Out-of-Roundness	0.0025 mm (0.0001 in.) 0.025 mm (0.0010 in.)
Main Bearing Cap Bore (Without Bearings) (Standard)	ID Maximum Bore Diameter Variation Maximum Bore Diameter Taper Maximum Straightness Variation (Any Bore-to-Adjacent Bore) Maximum Straightness Variation (5 Center Bores-to-End Bores) Centerline of Bore-to-Top Deck Cap Surface Width	101.651—101.677 mm (4.0020—4.0030 in.) 0.013 mm (0.0005 in.) 0.008 mm (0.0003 in.) 0.038 mm (0.0015 in.) 0.076 mm (0.0030 in.) 352.35—352.50 mm (13.872—13.878 in.) 36.28—36.78 mm (1.428—1.448 in.)

Continued on next page

Item	Measurement	Specification
Thrust Bearing New Part[1]	Thrust Washer Clearance Base Circle OD	129.286—130.810 mm (5.09—5.15 in.)
	Thrust Surface Width (Washer Clearance)	37.44—37.54 mm (1.474—1.478 in.)
	Relief Angle	45°
	Bearing Overall Width	39.16—39.66 mm (1.542—1.561 in.)
Thrust Bearing Surface	Maximum Runout	0.25 mm (0.0010 in.)
Engine Stroke	Length	128.5 mm (5.059 in.)
Main and Rod Journal	Surface Finish	Lap 0.20 Um (8 AA)
Thrust Journal	Surface Finish	Lap 0.40 Um (16 AA)
Rod Journal (Undercut) Fillet	Radius	4.10—4.37 mm (0.158—0.172 in.)
Main Journal (Tangential) Fillet	Radius	3.94—4.44 mm (0.155—0.175 in.)
Thrust Journal (Tangential) Fillet	Radius	3.56—4.06 mm (0.140—0.160 in.)
Thrust Journal	Width	44.387—44.487 mm (1.7475—1.7515 in.)
Crankshaft Main Journal	Maximum Runout Relative to No. 1 and No. 7 Journals	0.13 mm (0.0051 in.)
Crankshaft Main Journal	Maximum Runout Between Adjacent Cylinders	0.06 mm (0.0024 in.)
Crankshaft Main Journal (Using Standard Bearings)	OD	95.196—95.222 mm (3.7479—3.7489 in.)
Crankshaft Rod Journal (Using Standard Bearings)	OD	76.149—76.175 mm (2.9980—2.9990 in.)
Crankshaft Main Journal (Using 0.292 mm (0.0115 in.) Undersize Bearings)	OD	94.909—94.935 mm (3.7366—3.7376 in.)
Crankshaft Rod Journal (Using 0.292 mm (0.0115 in.) Undersize Bearings)	OD	75.857—75.883 mm (2.9865—2.9875 in.)

[1] Thrust (washer) surfaces on bearing cap must be flat in respect to mating thrust (washer) surfaces in cylinder block.

Continued on next page

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Item	Measurement	Specification
Crankshaft Main Journal (Using 0.552 mm (0.0217 in.) Undersize Bearings)[2]	OD	94.649—94.675 mm (3.7263—3.7274 in.)
Crankshaft Oversize Thrust Washers Available	OD	0.18 mm (0.007 in.)
Crankshaft Diameter for Front Pulley	OD	47.650—47.676 mm (1.876—1.877 in.)
Front Pulley	ID	47.594—47.630 mm (1.8738—1.8752 in.)
Piston Cooling Orifices	Torque	11 N•m (8 lb-ft) (97 lb-in.)
Crankshaft Main Bearing Cap Screws	Initial Torque	68 N•m (50 lb-ft)
Crankshaft Main Bearing Cap Screws	Final Torque	230 N•m (170 lb-ft)
Crankshaft	End Play	0.038—0.380 mm (0.00150—0.0150 in.)
Oil Pump Drive Gear-to-Crankshaft	Backlash	0.33—2.00 mm (0.013—0.079 in.)
Crankshaft Rear Oil Seal Housing Cap Screws[3]	Torque	27 N•m (20 lb-ft)
Crankshaft Rear Oil Seal Housing	Recess Inside Block Oil Pan Rail	0.00—0.05 mm (0.00—0.002 in.)
Crankshaft Rear Oil Seal Housing	Maximum Runout	0.152 mm (0.006 in.)
Timing Gear Cover-to-Cylinder Block 5/16-in. Cap Screws[4]	Torque	27 N•m (20 lb-ft)

[2]0.552 mm (0.0217 in.) undersize bearing sizes are available for crankshaft main journals only.

[3] See INSTALL CRANKSHAFT REAR OIL SEAL HOUSING in this group for proper torque sequence of housing cap screws.

[4]See INSTALL TIMING GEAR COVER in this group for proper cap screw tightening sequence.

Continued on next page

Item	Measurement	Specification
Timing Gear Cover-to-Cylinder Block 3/8-in. Cap Screws[4]	Torque	47 N•m (35 lb-ft)
Coolant Pump Cover-to-Timing Gear Cover 5/16-in. Cap Screws[4]	Torque	27 N•m (20 lb-ft)
Coolant Pump Cover-to-Timing Gear Cover 3/8-in. Cap Screws[4]	Torque	47 N•m (35 lb-ft)
Ignition Timing Sensor Cover Cap Screws[4]	Torque	27 N•m (20 lb-ft)
Auxiliary Drive Housing-to-Cylinder Block 3/8-in. Cap Screws[4]	Torque	41 N•m (30 lb-ft)
Auxiliary Drive Housing-to-Cylinder Block 1/2-in. Cap Screws[4]	Torque	127 N•m (94 lb-ft)
Auxiliary Drive Housing-to-Idler Bearing 5/16-in. Cap Screw[4]	Torque	27 N•m (20 lb-ft)
Auxiliary Drive Idler Shaft Button Head Cap Screw[4]	Torque	150 N•m (110 lb-ft)
Belt Tensioner-to-Timing Sensor Cover Cap Screw	Torque	50 N•m (37 lb-ft)
Damper Hub-to Crankshaft Cap Screw (Early HFN01 Engines)	Torque	230 N•m (170 lb-ft)
Damper and Pulley-to-Hub Cap Screws (Early HFN01 Engines)	Torque	70 N•m (52 lb-ft)
Damper Retaining Cap Screw (HFN02 Engines Option Code 1301)	Torque	230 N•m (170 lb-ft)
PTO Adapter, Pulley and Pulley Spacer-to-Damper Socket Head Cap Screws	Torque	61 N•m (45 lb-ft)

[4]See INSTALL TIMING GEAR COVER in this group for proper cap screw tightening sequence.

Continued on next page

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Item	Measurement	Specification
Vibration Damper-to-Pulley Cap Screws (Later HFN01, HFN02, HFN03 and HFN04 Engines)	Torque	70 N•m (52 lb-ft)
Damper/Pulley Assembly-to-Crankshaft Cap Screw (Later HFN01, HFN02, HFN03 and HFN04 Engines)	Torque	230 N•m (170 lb-ft)
Optional V-Pulley-to-Damper Pulley	Torque	61 N•m (45 lb-ft)
Flywheel Attaching Cap Screw	Torque	115 N•m (85 lb-ft)
Flywheel Drive Hub-to-Flywheel Cap Screws (If Equipped)	Torque	115 N•m (85 lb-ft)
Flywheel Housing-to-Cylinder Block Cap Screws	Torque	365 N•m (270 lb-ft)
Flywheel Housing Front Plate Cap Screws	Torque	43 N•m (32 lb-ft)
Flywheel Housing Bottom Plate Cap Screws	Torque	12 N•m (9 lb-ft) (106 lb-in.)

DPSG,OUO1004,2814 –19–08MAR02–5/5

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:

- Coolant in lubrication system (cracked block, liner seal failure, or leaking coolant pump seal with plugged hole).
- Insufficient bearing oil clearance.
- Parts not lubricated prior to engine operation.
- Wrong bearing size.

Inconsistent Wear Pattern:

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

Broken Main Bearing Caps:

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

Cracked, Chipped or Broken Bearings:

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

RG,15,DT7149 –19–03NOV97–1/1

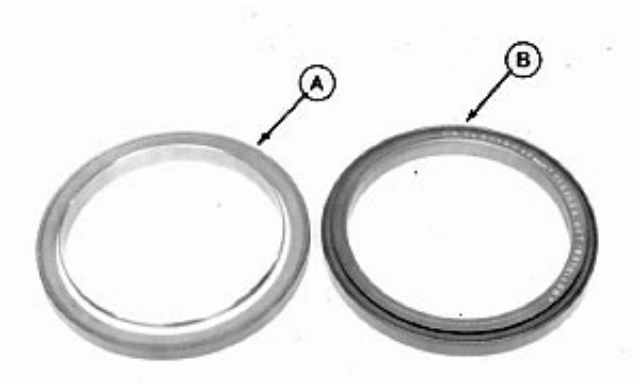
Crankshaft Rear Oil Seal and Wear Sleeve General Information

Two types of oil seal and wear sleeve assemblies are used:

- Earlier engine applications used a two-piece oil seal and wear sleeve assembly (A) that can easily be separated by hand.
- Current production engines use a unitized (non-separable) oil seal and wear sleeve assembly (B).

Removal of the two oil seal and wear sleeve types is different; refer to the appropriate procedure when servicing rear crankshaft oil seal and wear sleeve assembly.

The unitized (non-separable) oil seal assembly is the only type that is currently available through service parts.



RG5634 –UN–02APR90

A—Two-Piece Seal and Sleeve
B—Unitized Seal and Sleeve

CTM8,GR15,18 –19–16FEB95–1/1

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Remove Crankshaft Rear Oil Seal and Wear Sleeve

Using JDG719 Seal Puller Adapter along with JDE38-2 Shank and JDE38-3 Slide Handle is the preferred method for removing the crankshaft rear oil seal. If JDG719, JDE38-2, and JDE38-3 are not available, JDG22 Seal Remover can be used to remove the seal. Follow same procedure for both pullers.

IMPORTANT: If rear oil seal is replaced, also replace rear wear sleeve (as a matched set).

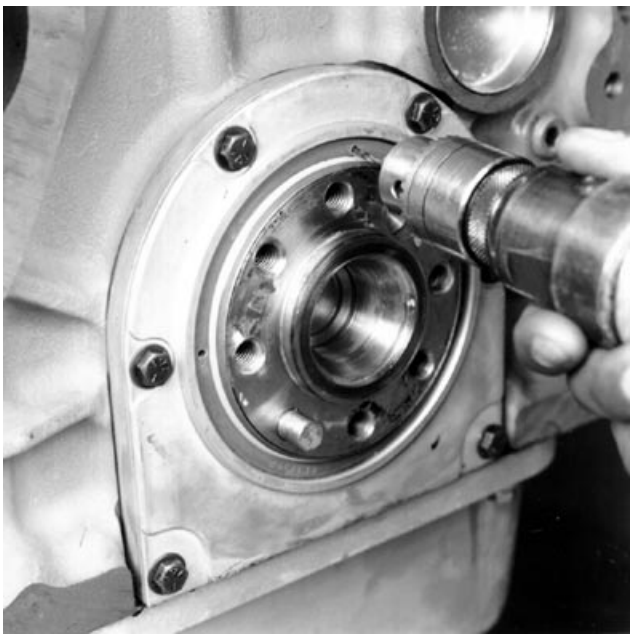
NOTE: If oil seal housing is to be removed, remove seal and wear sleeve after housing is removed. See REMOVE CRANKSHAFT REAR OIL SEAL HOUSING later in this group.

1. Remove rear drive hub (if equipped) and flywheel. (See REMOVE FLYWHEEL later in this group.)

2. Drill two small holes approximately 20° apart in bottom of seal casing. Install sheet metal screws in seal casing with JDG22 Seal Remover attached.

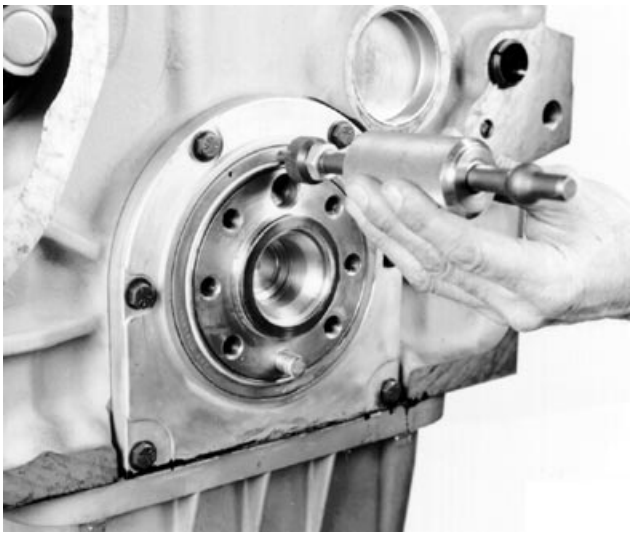
NOTE: It may be necessary to drill a small hole in seal at one or two other locations to aid in removal.

3. Cock seal at 6 o'clock position (180° opposite drilled hole) using a small punch and carefully pull seal from housing.



RG5819 –UN–05DEC97

Drilling Hole in Bottom of Seal Casing



RG6467 –UN–05DEC97

Pulling Seal from Housing

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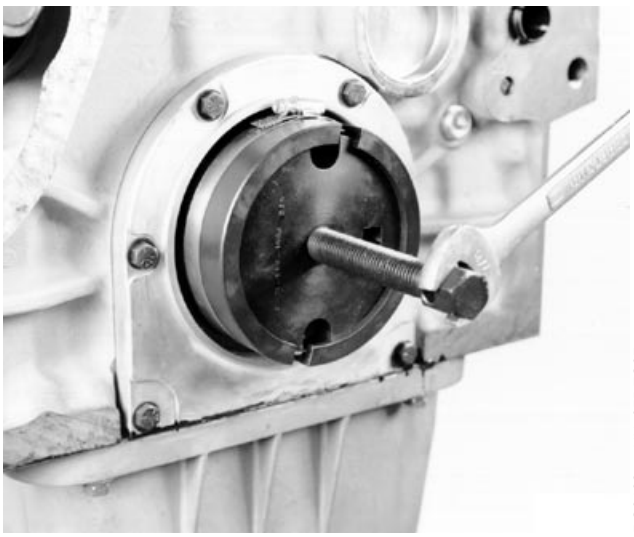
RG,15,DT7148 –19–10MAR00–1/3

4. Assemble JDG790 Rear Wear Sleeve Puller and position onto crankshaft flange with wear sleeve seated in jaws.
5. Securely tighten band clamp in groove on OD of jaws.
6. Tighten forcing screw with disk centered in crankshaft flange until wear sleeve is removed from crankshaft.



Removing Wear Sleeve

RG,15,DT7148 –19–10MAR00–2/3

7. Clean OD of crankshaft flange 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.)
8. Look for nicks or burrs on wear ring surface and bore in flywheel housing. If necessary, use a polishing cloth.
9. Finish cleaning by wiping flange with a clean rag. Any small nicks should be removed with 180-grit or finer polishing cloth.
10. Check oil seal housing runout. (See CHECK OIL SEAL HOUSING RUNOUT in this group.)

Removing Small Nicks

RG,15,DT7148 –19–10MAR00–3/3

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Crankshaft Rear Oil Seal and Wear Sleeve Handling Precautions

Use the following precautions for handling seal and wear sleeve:

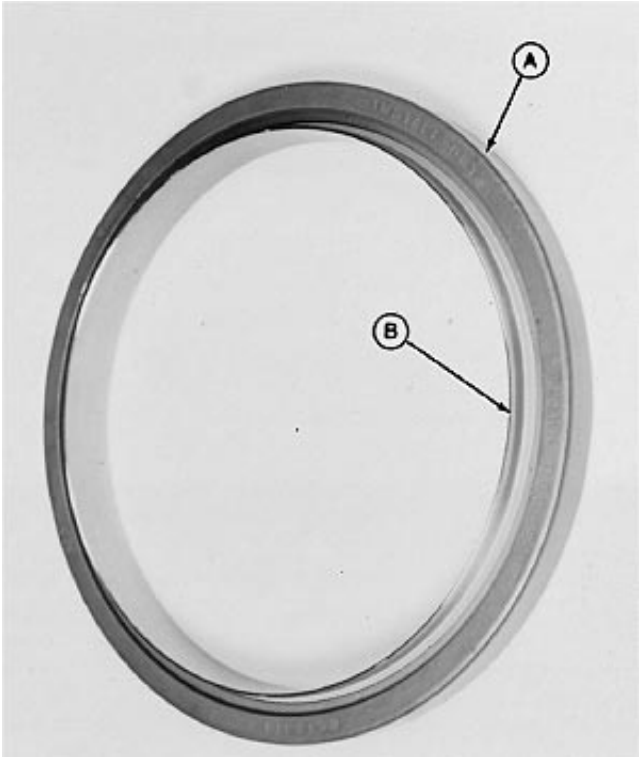
Seal (A) and wear sleeve (B) are assembled. DO NOT SEPARATE. If parts become separated, discard and replace with a new assembly. Attempts to reassemble will cause the wear sleeve to damage the seal allowing engine oil to leak past seal.

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

No 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.

Oil seal/wear sleeve assembly MUST be installed with the JDG476(85) Seal and Wear Sleeve Installer. Tool set consists of JDG477(85) Pilot and JDG478 Driver.



Crankshaft Rear Seal and Sleeve

A—Seal
B—Wear Sleeve

RG,15,DT7147 –19–20JAN98–1/1

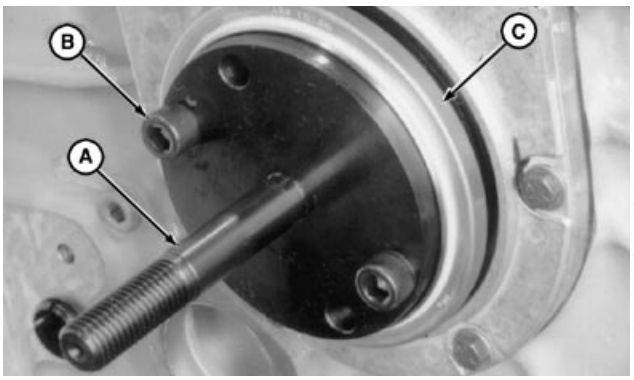
Install Crankshaft Rear Oil Seal and Wear Sleeve

1. Apply light coating of LOCTITE® 680 Retaining Compound, or equivalent, completely around the leading edge of crankshaft flange. Wipe away any sealant that may have gotten on ID of seal housing bore.

2. Install JDG477(85) Pilot (A) from JDG476(85) Seal and Wear Sleeve Installer Set on end of crankshaft using the Allen head cap screws (B) supplied with tool set. Tighten cap screws securely.

IMPORTANT: Handle oil seal/wear sleeve assembly carefully. If assembly becomes separated, discard these parts and install a new assembly. (See CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE HANDLING PRECAUTIONS.)

3. Carefully start oil seal/wear sleeve assembly (C) over JDG477(85) Pilot and crankshaft flange with open side of seal toward engine.



RG4639 –UN–05DEC97

Install Crankshaft Rear Seal and Sleeve

A—Pilot
B—Allen Head Cap Screws
C—Oil Seal/Wear Sleeve Assembly

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RG,15,DT7146 –19–10MAR00–1/2

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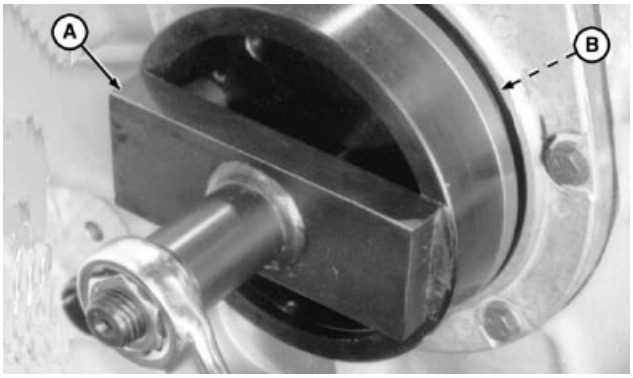
IMPORTANT: When installing the JDG478 Driver on JDG477(85) Pilot and crankshaft flange to position oil seal/wear sleeve assembly, locate crossbar of installer at right angle (90°) to Allen head cap screws. This allows the crossbar to bottom on pilot, not head of cap screws, assuring correct installation.

4. Position JDG478 Driver (A) so that hole in the crossbar goes over threaded stud of pilot. Install washer and nut on stud.

5. Tighten nut to draw JDG478 Driver in until crossbar bottoms on JDG477(85) Pilot. When the tool bottoms, seal wear ring assembly (B) will be correctly positioned.

6. Remove JDG476(85) Seal and Wear Sleeve Installer Set from engine.



Positioning Seal/Wear Sleeve Assembly

A—JDG478 Driver
B—Seal Wear Ring Assembly

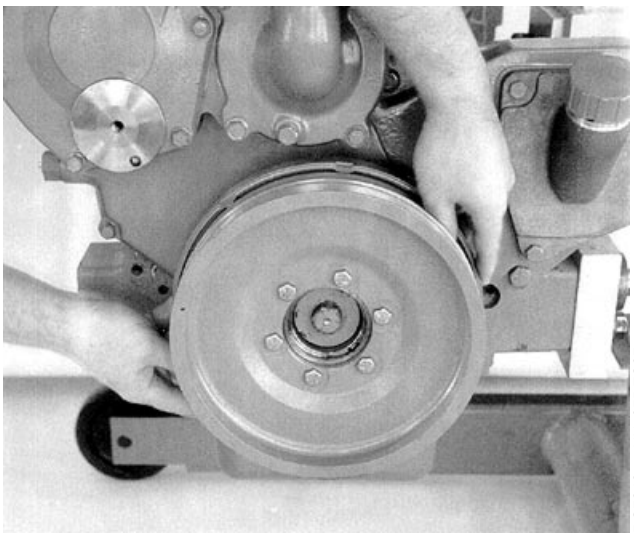
RG,15,DT7146 –19–10MAR00–2/2

Inspect Vibration Damper

IMPORTANT: The damper assembly is not repairable and should be replaced every 5 years or 4500 hours, whichever occurs first. Also, replace damper whenever crankshaft is replaced or major engine overhaul is performed.

Do not immerse the vibration damper or the damper pulley in cleaning solvent. Doing so may damage the rubber portions of this assembly.

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



Grasp Vibration Damper (HFN01 Engine Shown)

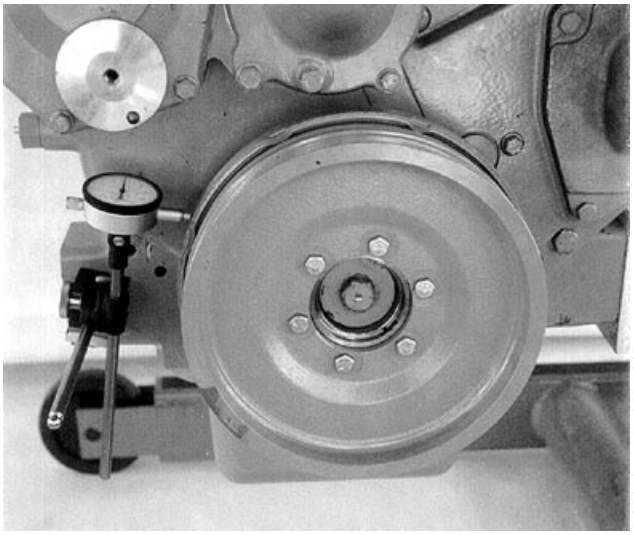
1. Relieve tension or remove V-belts (shown removed).
2. Grasp vibration damper with both hands and attempt to turn it in both directions. If rotation is felt, damper is defective and should be replaced.

RG,15,DT7145 –19–10MAR00–1/2

3. Check vibration damper radial runout by positioning a dial indicator so preloaded probe contacts damper OD.
4. Rotate crankshaft using JDG820 Flywheel Turning Tool.
5. Note total dial indicator movement. Compare reading with specification below.

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

If runout exceeds specifications, replace vibration damper.



Check Damper Radial Runout (HFN01 Engine Shown)

RG,15,DT7145 –19–10MAR00–2/2

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Check Crankshaft End Play

1. Completely engage then release the clutch lever.

2. Place a dial indicator on damper face.

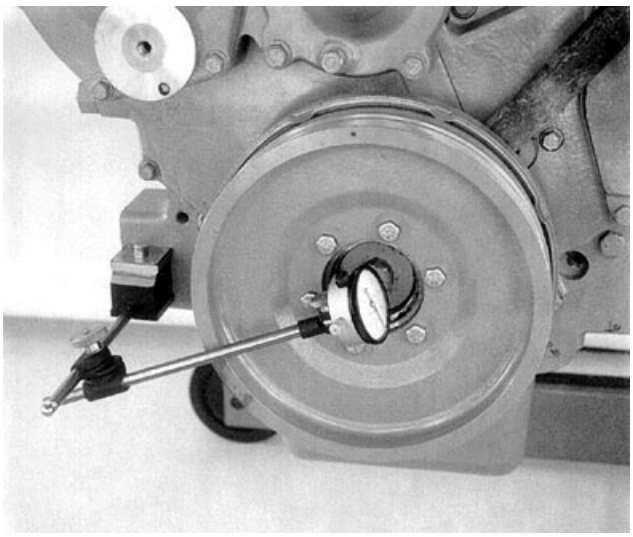
IMPORTANT: Use care not to damage or distort the timing gear cover or bearing inserts when prying. Do not pry on outer inertia ring of damper.

3. Pry with flat bar between the damper pulley and timing gear cover.

Specification

Crankshaft—End Play ..... 0.038—0.380 mm (0.0015—0.0150 in.)

NOTE: New thrust bearings will usually restore proper end play.



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Check Crankshaft End Play (HFN01 Engine Shown)

RG,15,DT7144 –19–03NOV97–1/1

Remove Crankshaft Vibration Damper

NOTE: Later HFN01 engines, HFN02, HFN03 and HFN04 engines do not use a spacer or hub on damper/pulley assembly.

Remove Damper (Early HFN01 Engine)

CAUTION: Plan a safe handling procedure to avoid personal injury or damage to crankshaft hub.

1. Remove cap screws (A). Remove pulley (B) and spacer (C).
2. Remove cap screw and washer (E) securing damper and hub to crankshaft. Remove damper (D).
3. Install JDG787 Thread Protector in nose of crankshaft.
4. Remove crankshaft hub from crankshaft using JDG721 Hub Puller (F).

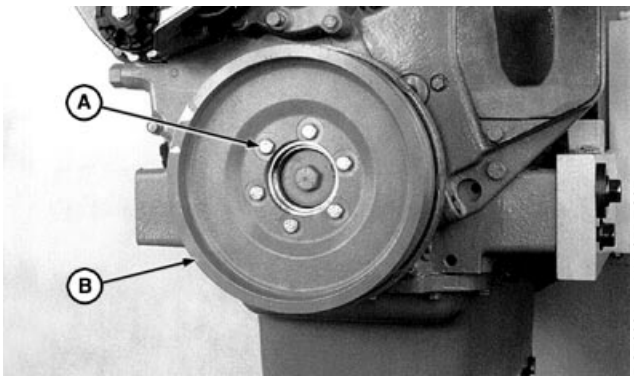
   D01207AA (OCT518) Puller Set (not shown) may also be used to remove damper.

Remove Damper (HFN02 Engines Option Code 1301)

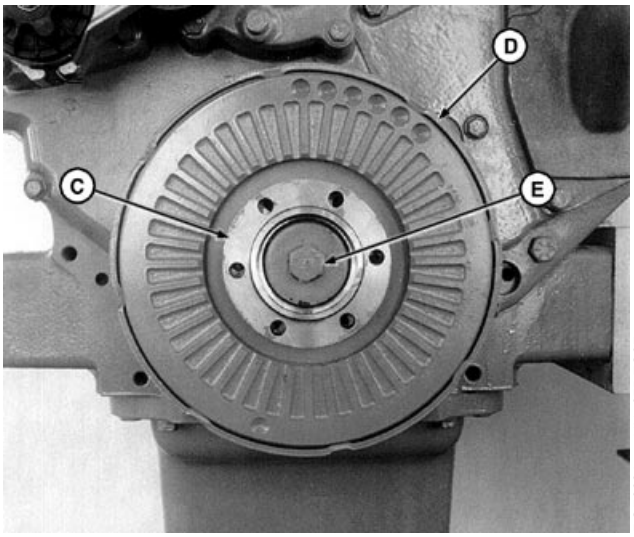
1. Remove 6 socket head cap screws and remove PTO adapter, pulley and pulley spacer.
2. Remove center damper retaining cap screw.
3. Install JDG787 Thread Protector in nose of crankshaft.
4. Remove vibration damper from crankshaft using JDG721 Hub Puller.

   D01207AA (OCT518) Puller Set (not shown) may also be used to remove damper.

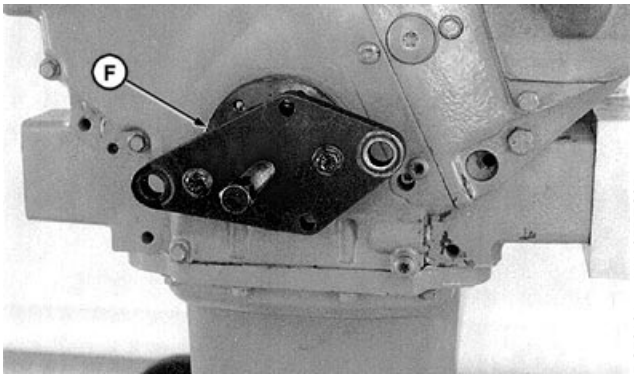
A—Cap Screw (6 used)
B—Pulley
C—Spacer (Early HFN01 Engines)
D—Damper
E—Cap Screw and Washer
F—JDG721 Hub Puller (Early HFN01 Engines)



Remove Cap Screws and Pulley



Remove Damper, Cap Screw, and Washer



JDG721 Hub Puller (Early HFN01 Engines)

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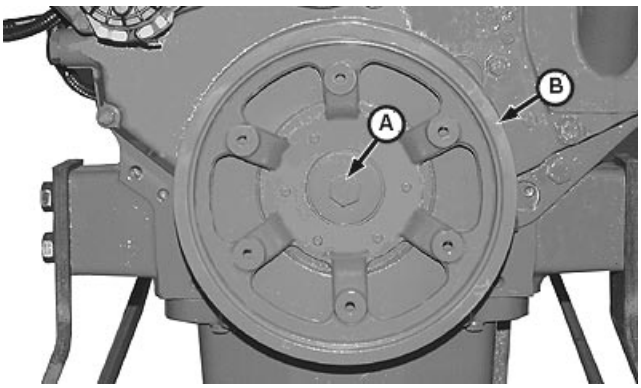
Remove Damper (Later HFN01, HFN02, HFN03 and HFN04 Engines)

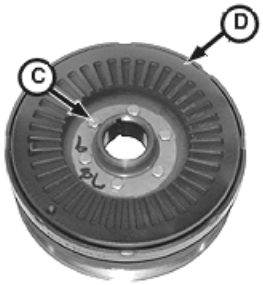
1. If equipped with optional front V-Pulley: Remove pulley retaining cap screws and remove pulley from damper pulley.
2. Remove cap screw (A). Using D01200AA Push-Puller with 3/8-16 adapters or cap screws (or other suitable puller), remove damper/pulley assembly from crankshaft.
3. Remove cap screws (C) and remove damper (D) from pulley.

A—Damper/Pulley-to-Crankshaft Cap Screw
B—Pulley
C—Damper-to-Pulley Cap Screw
D—Damper



RG10580A –UN–24FEB00

Crankshaft Damper and Pulley



RG10581A –UN–24FEB00

Crankshaft Damper

DPSG,OUOE003,14 –19–08MAR02–2/2

Remove Crankshaft Front Oil Seal and Wear Sleeve

To Remove Front Oil Seal:

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

NOTE: If timing gear cover is going to be removed from engine, remove front seal and wear sleeve after timing gear cover is removed.

1. Check oil seal and wear sleeve for wear, damage, or leakage.
2. Center punch seal casing at 12 o'clock position.


RG6471 –UN–05DEC97

Center Punch Seal Casing

Continued on next page

RG,15,DT7142 –19–10MAR00–1/5

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

Drill Hole in Casing

RG,15,DT7142 –19–10MAR00–2/5

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

5. Remove keyway from keyslot of crankshaft.

Remove Seal

Continued on next page

RG,15,DT7142 –19–10MAR00–3/5

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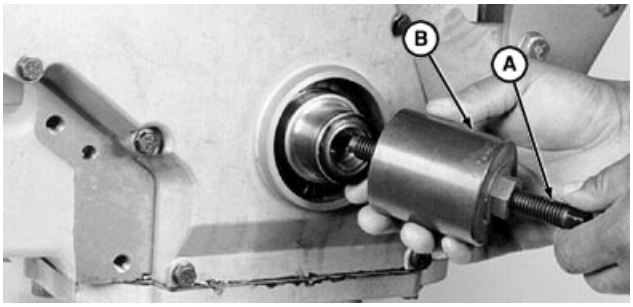
To Remove Wear Sleeve Using JDG786:

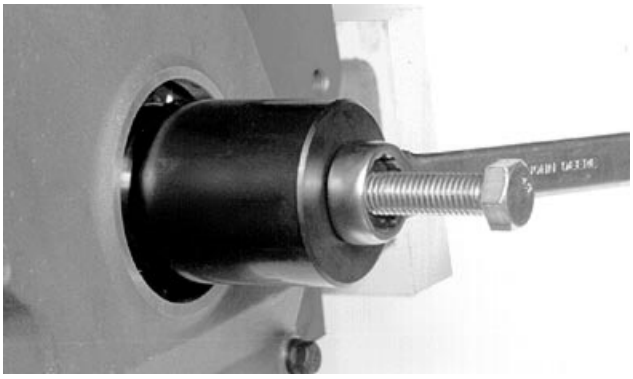
1. Start fully threaded centering screw (A) through hex head end of puller (B) from JDG786 Front Wear Sleeve Puller until head of screw is approximately 1/2 in. from hex on puller.
2. Thread centering screw into nose of crankshaft until it bottoms. Back screw out one full turn after it bottoms.
3. Tighten puller until it is securely threaded onto wear sleeve. Back centering screw out one full turn and tighten threaded puller onto wear sleeve again.
4. Remove centering screw from nose of crankshaft and puller.

A—Centering Screw
B—Hex Head End of Puller



RG6753 –UN–05DEC97

Thread Center Screw into Nose Crankshaft

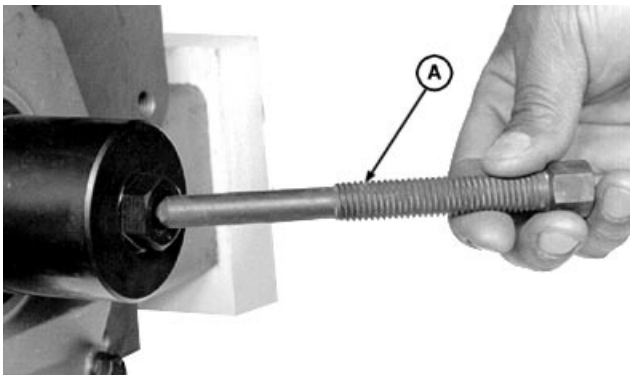

RG7728 –UN–05DEC97

Remove Centering Screw

RG,15,DT7142 –19–10MAR00–4/5

5. Install partially threaded forcing screw (A) into puller and tighten until it bottoms in nose of crankshaft. There is no thread engagement in crankshaft; just with puller.
6. Continue to tighten forcing screw until puller and wear sleeve are free from crankshaft flange.
7. Inspect crankshaft flange for nicks or burrs. Clean up flange with a light file and emery cloth.
8. Measure front oil seal bore runout in timing gear cover and compare to the following specification.

Specification	
Crankshaft Front Oil Seal Bore in Timing Gear Cover—Maximum Radial Runout	0.254 mm (0.010 in.)



RG7729 –UN–05DEC97

Install Forcing Screw

A—Forcing Screw

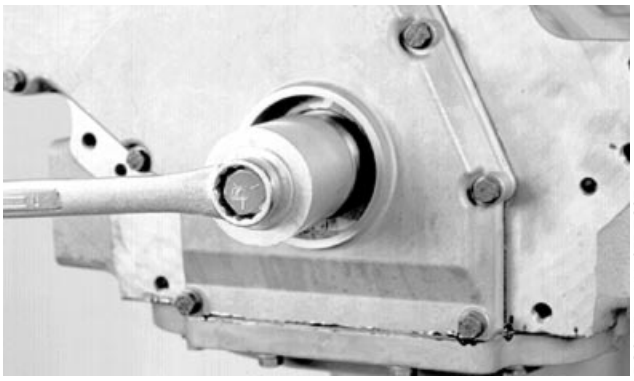
RG,15,DT7142 –19–10MAR00–5/5

Install Crankshaft Front Oil Seal and Wear Sleeve

To Install Front Wear Sleeve:

1. Coat ID of new wear sleeve with LOCTITE® 680 Retaining Compound.
2. Using JDG467 Driver from JDE3 Front Wear Sleeve Installer Set along with washer and 5/8-11 UNC x 3 in. cap screw that secures damper pulley assembly to crankshaft, tighten cap screw until driver bottoms.
3. Remove installation tools and clean any sealant from OD of wear sleeve or ID of seal bore.

Install Wear Sleeve



Tighten Cap Screw

LOCTITE is a registered trademark of the Loctite Corp.

Continued on next page

DPSG,OUO1004,2597 –19–10MAR00–1/2

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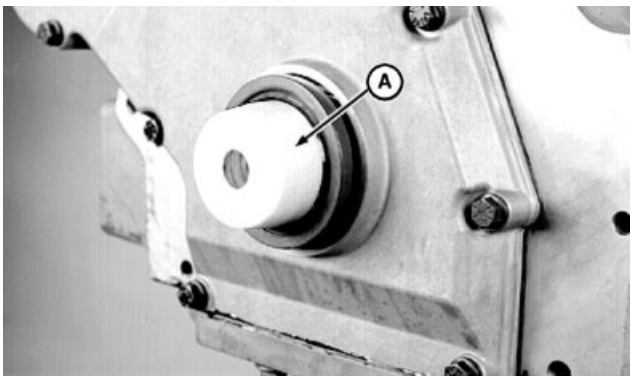
To Install Front Oil Seal:

1. Place JDG720-2 Seal Protector (A) on nose of crankshaft. Lubricate ID of front oil seal lips with clean engine oil. Slide seal with spring side of seal facing engine onto seal protector. Be careful not to roll oil seal lips.
2. Place JDG720-5 Seal Installer onto seal protector against seal. Do not use spacer ring provided with tool set.
3. With nut and washer installed onto JDG720-1 Forcing Screw, thread forcing screw into nose of crankshaft until it bottoms.
4. Tighten nut against cross plate of installer until installer bottoms onto front face of timing gear cover.
5. Remove installation tools. Verify seal is installed square in bore and that seal lips are not rolled on wear sleeve.

   Oil seal should be 8.9 mm (0.35 in.) below front face of seal bore.

Specification

Front Oil Seal Installed Below Front Face of Seal Bore—Distance	8.9 mm (0.35 in.)



Install Seal Protector

Install Seal Installer

A—Seal Protector

DPSG,OUO1004,2597 –19–10MAR00–2/2

Remove Timing Gear Cover (With Auxiliary Drive Housing Attached)

NOTE: Timing gear cover can be removed with or without the auxiliary drive housing attached. If removing auxiliary drive housing from cover, see REMOVE TIMING GEAR COVER (WITH AUXILIARY DRIVE HOUSING REMOVED) in Group 16.

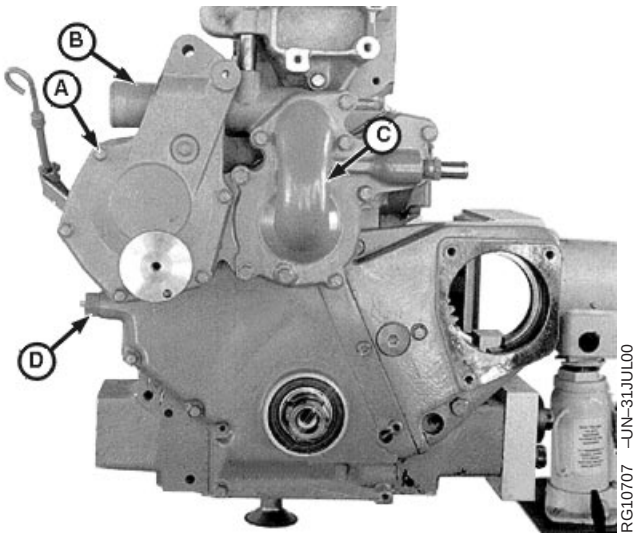
1. Remove vibration damper. (See REMOVE CRANKSHAFT VIBRATION DAMPER earlier in this group.)
2. Remove engine oil pan (K). (See REMOVE AND INSTALL ENGINE OIL PAN in Group 20.)
3. Remove engine oil pump assembly if crankshaft is to be removed. (See REMOVE ENGINE OIL PUMP in Group 20.)
4. Remove idler pulley (shown removed).

NOTE: Speed sensor is located on back of timing gear sensor cover for later applications.

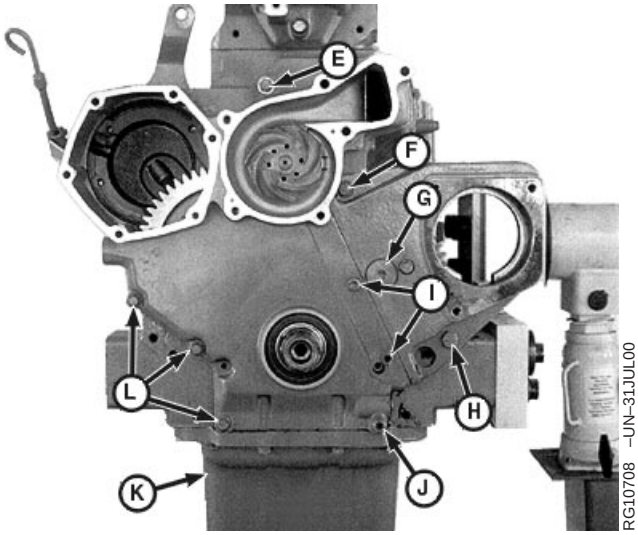
5. Disconnect engine speed sensor connector (shown disconnected) from sensor (D).

NOTE: Mark location of cap screws removed from timing gear cover to aid in reassembly.

6. Remove timing gear sensor cover (A).
7. Disconnect water piping and remove coolant pump cover (C) with inlet housing (B). (See REMOVE COOLANT PUMP ASSEMBLY in Group 25.)
8. Remove air compressor (shown removed). (See REMOVE AIR COMPRESSOR in Group 50.)
9. Loosen air compressor auxiliary drive housing mounting cap screws (F, H and I).



Remove Coolant Pump Cover and Sensor Cover



Remove Timing Gear Cover

A—Timing Gear Sensor Cover
B—Coolant Pump Inlet Housing
C—Coolant Pump Cover
D—Engine Speed Sensor
E—Cap Screw (3/8 x 1-1/4-in.)
F—Torque Head Cap Screw (3/8 x 1-in.)
G—Idler Bearing Button Head Cap Screw
H—Cap Screw (1/2 x 1-1/8-in.)
I—Torque Head Cap Screws (5/16 x 1-7/8-in.)
J—Torque Head Cap Screw (5/16 x 1-7/8-in.)
K—Oil Pan
L—Cap Screws (5/16 x 1-3/8-in.)

Continued on next page

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IMPORTANT: DO NOT loosen auxiliary drive housing to timing gear cover cap screws or auxiliary drive housing to idler gear bearing cap screw.

10. Remove auxiliary drive idler bearing cap screw (G).

    Remove idler shaft using D01209AA. (See REMOVE AUXILIARY DRIVE HOUSING AND IDLER GEAR in Group 50.)

11. Remove cap screws (F, H and I).

12. Remove cap screws (E, L and J) and remove timing gear cover with auxiliary drive housing. Remove and discard gasket.

13. Remove front oil seal from timing gear cover and discard. Remove wear sleeve from crankshaft flange. (See REMOVE CRANKSHAFT FRONT OIL SEAL AND WEAR SLEEVE earlier in this group.)

RG,15,DT7141 –19–10MAR00–2/2

Inspect and Measure Flywheel

1. Examine flywheel ring gear for worn or broken teeth. Replace ring gear if defective. (See REPLACE FLYWHEEL RING GEAR in this group.)

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

2. Measure flywheel housing face runout, flywheel face flatness, and pilot bearing bore concentricity, as outlined later in this group. Resurface flywheel face or replace as required.

RG,15,DT7140 –19–03NOV97–1/1

Check Flywheel Housing Face Runout

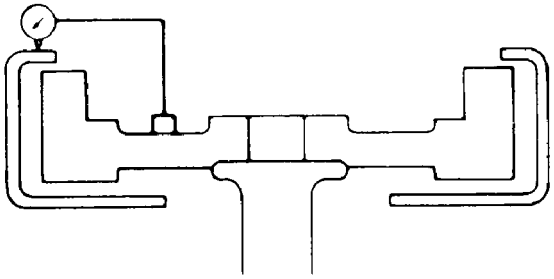
1. Mount dial indicator on flywheel. Set pointer to contact PTO mounting surface on flywheel housing at right angles. Pointer should not contact holes in flywheel housing.

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

2. Rotate flywheel by turning crankshaft. Read total dial indicator movement.

Specification

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



RGR22212 –UN–11DEC97

Check Flywheel Face Runout

RG,15,DT7139 –19–03NOV97–1/1

Check Flywheel Face Flatness

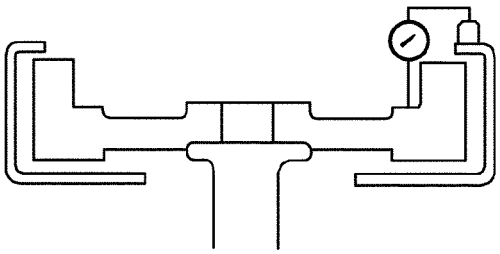
1. Mount dial indicator base on flywheel housing. Position pointer to contact driving ring mounting surface. Do not allow pointer to contact driving ring mounting holes.

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

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

Specification

Flywheel Face Flatness—
Maximum Variation..... 0.23 mm (0.009 in.)
Maximum Variation per 25 mm
(1.0 in.) of Travel..... 0.013 mm (0.0005 in.)



RGR22213 –UN–11DEC97

Check Flywheel Face Flatness

RG,15,DT7138 –19–03NOV97–1/1

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Remove Flywheel

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

NOTE: SAE 1 flywheel housings MUST BE removed before flywheel can be removed from engine. See REMOVE SAE 1 FLYWHEEL HOUSING, later in this group.

1. Remove two flywheel attaching cap screws (A) that are directly opposite of each other and install two pilot studs in their place, if desired.
2. Remove remaining cap screws and carefully pull flywheel from crankshaft using proper lifting equipment.

A—Flywheel Attaching Cap Screws

RG7048 –UN–05DEC97

Flywheel Cap Screws

RG,15,DT7137 –19–15MAY02–1/1

Remove SAE 1 Flywheel Housing

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

1. Remove attaching cap screws.
2. Remove flywheel housing.
3. Inspect mounting holes in flywheel housing for thread damage.

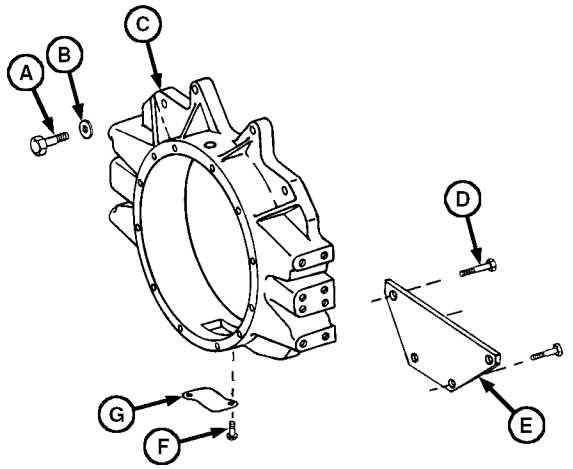
OUO1082,0000245 –19–15MAY02–1/1

Remove SAE 2 Flywheel Housing

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

NOTE: If flywheel is installed on engine, front plate (E) must be removed first, to remove flywheel housing.

1. Remove cap screws (A) with washers and remove flywheel housing.
2. Inspect mounting holes in flywheel housing for thread damage.



Remove Flywheel Housing

A—Cap Screw (8 used)
B—Washer (8 used)
C—Flywheel Housing
D—Cap Screw (2 used)
E—Front Plate
F—Cap Screw (2 used)
G—Bottom Plate

DPSG,OUO1004,2598 –19–15MAY02–1/1

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Replace Flywheel Ring Gear

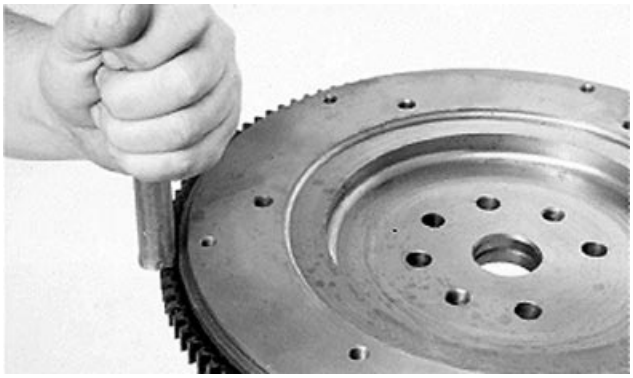
CAUTION: Oil fumes or oil can ignite above 193°C (380°F). Use a thermometer and do not exceed 182°C (360°F). Do not allow a flame or heating element to be in direct contact with the oil. Heat the oil in a well ventilated area. Plan a safe handling procedure to avoid burns.

1. If ring gear is damaged, place the flywheel on a solid flat surface.
2. Remove ring gear with a brass drift and hammer.

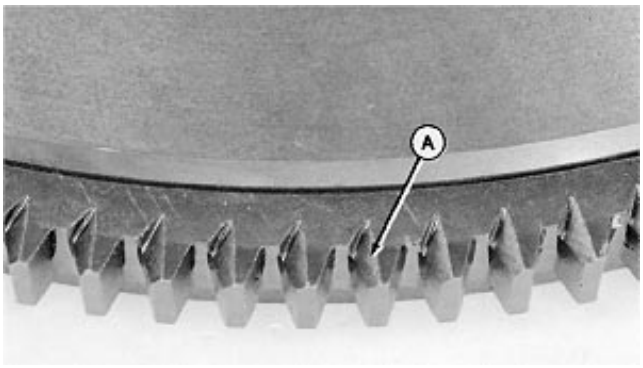
IMPORTANT: If flame heat is used, be sure gear is heated uniformly around circumference. DO NOT OVERHEAT. Overheating may destroy original heat treatment of gear. SEE CAUTION.

3. Heat new ring gear to 148°C (300°F) using either heated oil, oven heat, or flame heat.
4. Install ring gear against shoulder of flywheel so chamfered side (A) is on engine side of flywheel.

A—Chamfered Side


RGT90596 –UN–11DEC97

Removing Ring Gear



RG3838 –UN–14OCT88

Install Ring Gear

RG,15,DT7136 –19–10MAR00–1/1

Remove Crankshaft Rear Oil Seal Housing

1. Remove rear oil seal housing (A).

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

2. Rear oil seal (B) will come off with housing. Use a small punch and hammer to remove oil seal from housing. Discard seal.

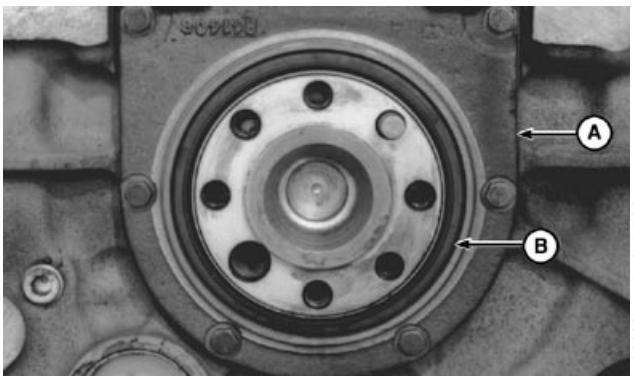
IMPORTANT: The preferred method of removing the rear wear sleeve is with JDG790 Rear Wear Sleeve Puller Kit. If removing wear sleeve with a chisel, DO NOT gouge crankshaft flange. Nicks or burrs should be removed with a medium-grit stone. A polishing cloth (180-grit or finer) may also be used when a stone is not available.

3. Remove rear wear sleeve from crankshaft flange.

   Crankshaft rear wear sleeve can be removed using one of the following procedures. However, the preferred method is using JDG790 Rear Wear Sleeve Puller Kit.

   - Use JDG790 Rear Wear Sleeve Puller Kit to remove wear sleeve from crankshaft flange, as described earlier in this group. (See REMOVE CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE in this group.)
   - Use the ball side of a ballpeen hammer and tap wear sleeve across its width in a straight line (to deform and stretch sleeve).
   - Score the wear sleeve in several places around OD (but do not cut) with a blunt chisel. Remove wear sleeve from crankshaft flange.

   Clean flange with a light file and emery cloth.



Remove Oil Seal Housing

A—Rear Oil Seal Housing
B—Rear Oil Seal

RG,15,DT7135 –19–10MAR00–1/1

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Remove Main Bearing Caps

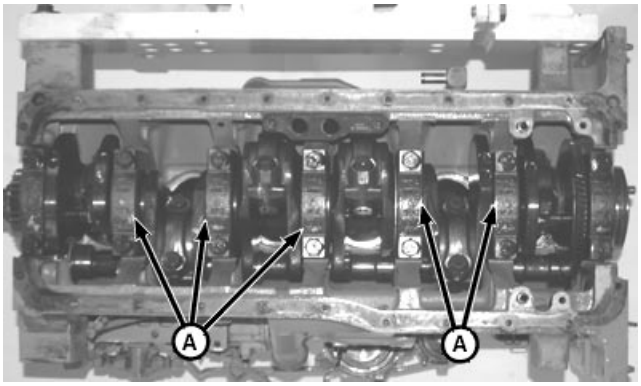
IMPORTANT: Before removing main bearing caps (A), check for proper torque on all main bearings. Also, check each bearing cap to make sure they are numbered for reassembly on the same numbered main bearing bosses. Keep matched main bearings with their respective main bearing cap for comparison with crankshaft journal (surface wear) from which removed.

If arrows are stamped on main bearing caps, note direction arrows are pointing to aid in reassembly.

NOTE: When removing main bearings and caps, leave No. 1 and 7 main bearing caps installed until all of the connecting rod caps have been removed.

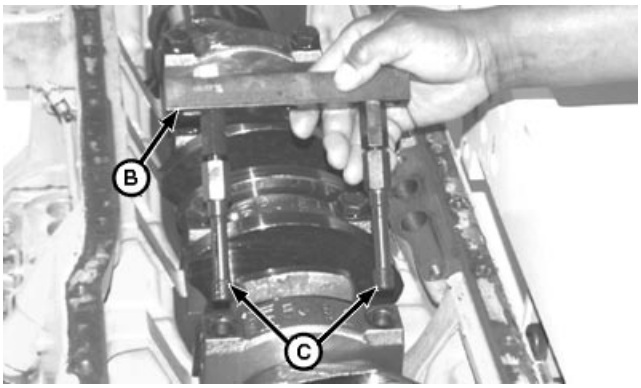
1. Remove main bearing cap screws.
2. Install JDG1069 Main Bearing Cap Puller/Installer (B) so that tips (C) of blind hole puller legs are below bearing cap half.
3. Tighten hex of actuator pin securely while holding collet portion of puller leg with second wrench.
4. Tighten both cap screws (D) on cross block finger tight.

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



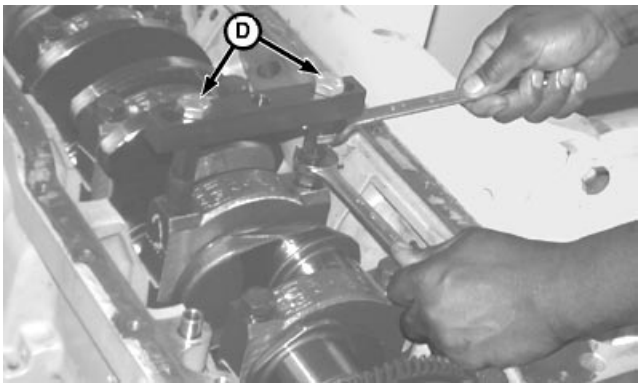
RG10216 –UN–23JUN99

Main Bearing Caps



RG10217 –UN–23JUN99

Installing Main Bearing Cap Puller



RG10218 –UN–23JUN99

Tightening Main Bearing Cap Puller

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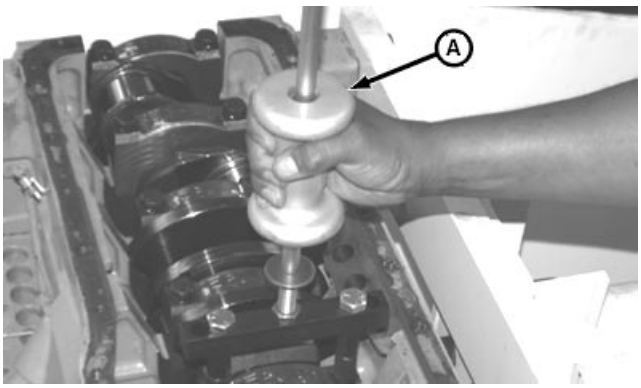
RG,15,DT7134 –19–13MAR00–1/2

5. Attach D01300AA Slide Hammer (A) to cross block. Tighten nut securely.
6. Remove main bearing cap by sliding up on hammer weight.
7. Use PLASTIGAGE® to measure journal-to-bearing oil clearance on each main bearing as they are removed. (See CHECK MAIN BEARING OIL CLEARANCE, later in this group.)

A—Slide Hammer



RG10219 –UN–23JUN99

Using Slide Hammer to Loosen Bearing Cap

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RG,15,DT7134 –19–13MAR00–2/2

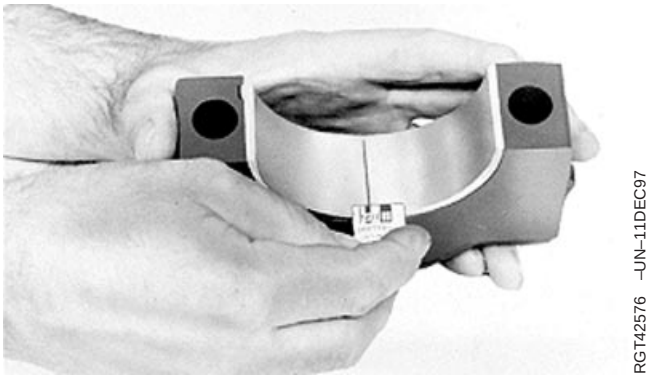
Check Main Bearing Oil Clearance

The use of PLASTIGAGE® will determine bearing-to-journal wear (oil clearance) but will not determine condition of the bearing or journal surfaces.

1. Place a strip of PLASTIGAGE® in the center of the main bearing cap (with insert) about three-fourths of the width of the bearing.
2. Use oil (SAE30) on PLASTIGAGE® to prevent smearing.
3. Install cap and tighten cap screws to 230 N•m (170 lb-ft).
4. Remove cap and compare width of PLASTIGAGE® with scale provided on wrapper to determine oil clearance.

Specification

Crankshaft Main Bearing-to-Journal—Oil Clearance	0.030—0.107 mm (0.0012—0.0042 in.)



RGT42576 –UN–11DEC97

Check Main Bearing Clearance

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RG,15,DT7133 –19–20JAN98–1/1

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Remove Connecting Rod Caps and Remove Crankshaft

1. Rotate crankshaft using JDG820 Flywheel Turning Tool until connecting rod caps can be removed easily. You will be able to remove two rod caps at each position.

2. Remove all connecting rod caps (A) with bearings (B), then remove No. 1 and 7 main bearing caps and bearings. (See REMOVE PISTON AND CONNECTING ROD ASSEMBLIES in Group 10.)

CAUTION: Crankshaft is very heavy. Plan a proper handling procedure to avoid injury.

NOTE: Install a screw on each end of crankshaft to aid in lifting crankshaft.

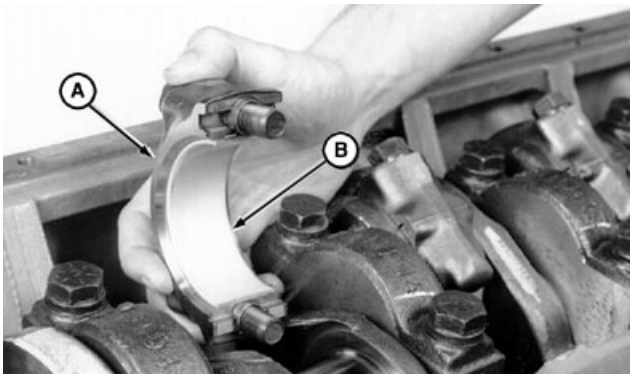
3. Install a cap screw in each end of crankshaft and attach a lifting strap to crankshaft as shown. Using proper lifting equipment, carefully raise crankshaft out of cylinder block.

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

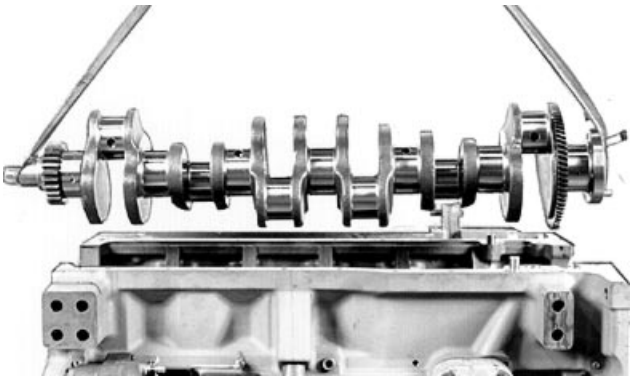
5. Put crankshaft on clean V-blocks.

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

   - Use JDG790 Rear Wear Sleeve Kit Puller to remove wear sleeve from crankshaft, as described earlier in this group. (See REMOVE CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE in this group.) Position crankshaft rod journals in V-blocks so that crankshaft does not rotate while removing wear sleeve.
   - Use the ball side of a ballpeen hammer and tap wear sleeve across its width in a straight line (to deform and stretch sleeve).
   - Score (but do not cut) the wear sleeve in several places around OD with a blunt chisel.



Remove Rod Caps with Bearings



Remove Crankshaft

A—Connecting Rod Cap
B—Bearing

RG,15,DT7131 –19–03NOV97–1/1

Inspect Crankshaft

NOTE: If the crankshaft damper damage was discovered during teardown, it is recommended that the crankshaft be magna-fluxed. This will verify whether or not it has microscopic cracks or fissures. (See INSPECT CRANKSHAFT VIBRATION DAMPER, earlier in this group.)

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

2. Inspect crankshaft for signs of load stress, cracks, or scratches on journals. Also check each journal for evidence of excessive overheating or discoloration. If either condition exists, replace crankshaft since heat treatment has probably been destroyed.

3. Inspect (front) crankshaft gear for cracks, chipped teeth, or excess wear. Replace gear as required. (See REPLACE CRANKSHAFT GEAR, later in this group.)

4. Inspect (rear) oil pump drive gear for cracks, chipped teeth, or excess wear. Replace gear as required. (See REPLACE (CRANKSHAFT) OIL PUMP DRIVE GEAR, later in this group.)

5. Inspect the keyway for evidence of cracks or wear. Replace crankshaft as necessary.

6. 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 leakages. Slight ridges may be cleaned up with emery cloth and crocus cloth.

7. Check each journal for evidence of excessive overheating or discoloration. If either exists, replace crankshaft since heat treatment has probably been destroyed.

Continued on next page

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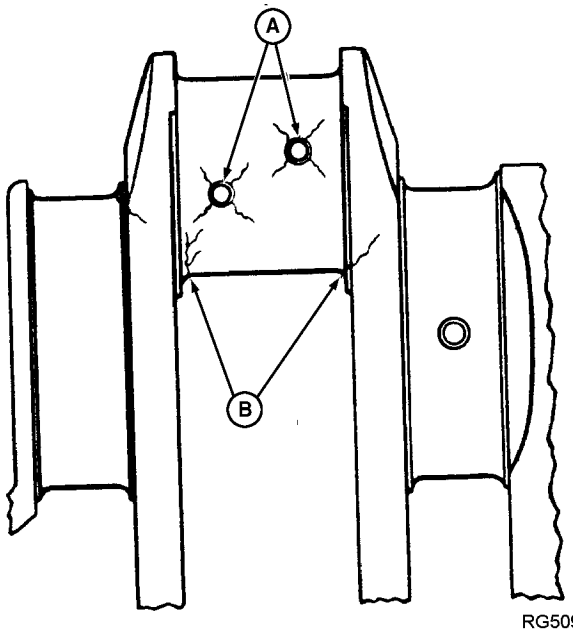
IMPORTANT: Small cracks may not be visible to the eye. Use a method such as the Fluorescent Magnetic Particle method. This method magnetizes the crank, employing magnetic particles which are fluorescent and glow under "black light". The crankshaft must be de-magnetized after inspection.

8. Carefully check the crankshaft for cracks in the area of rod journal oil holes (A) and at journal fillets (B). Replace crankshaft if any cracks are found.

A—Rod Journal Oil Holes
B—Journal Fillets



Inspect Crankshaft for Cracks

RG,15,DT7150 –19–13MAR00–2/2

Measure Assembled ID of Bearings and OD of Crankshaft Journals

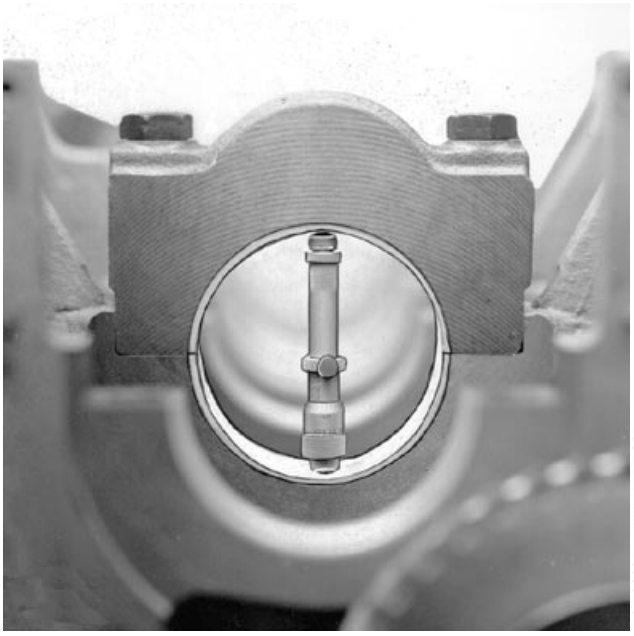
NOTE: Also inspect and measure assembled ID of connecting rod bearings. Compare measurements with connecting rod journal OD on crankshaft. (See INSPECT AND MEASURE CONNECTING ROD BEARINGS in Group 10.)

1. With crankshaft removed from engine, install main bearing caps with bearing inserts. Be sure inserts are installed correctly.

2. Tighten main bearing cap screws to 230 N•m (170 lb-ft).

3. Measure ID of all assembled bearings in four locations, 90° apart, with an inside micrometer. Compare measurements with the following specifications.

Specification	
Crankshaft Main Bearing—ID	
With Bearing	95.270—95.320 mm (3.7508—3.7528 in.)
ID Without Bearing	101.651—101.677 mm (4.0020—4.0030 in.)



RGR26385 –UN–11DEC97

Measuring Main Bearings

Continued on next page

RG,15,DT7167 –19–13MAR00–1/2

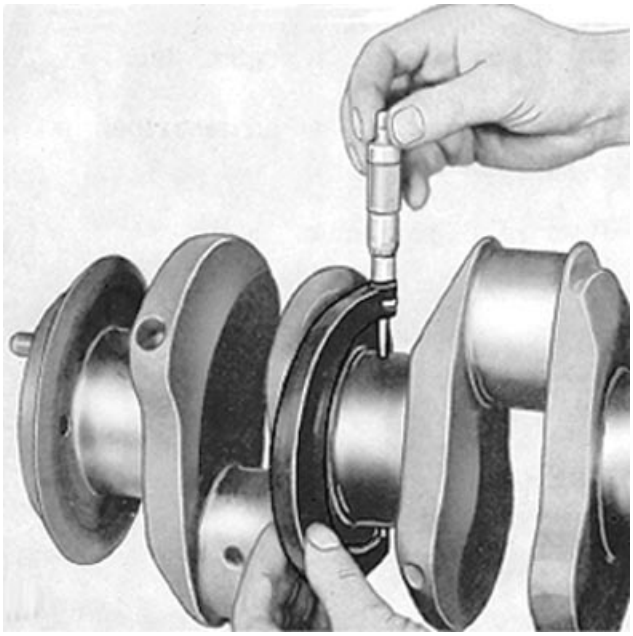
4. Measure OD of all respective crankshaft main journals in four locations, 90° apart. Compare measurements with the following specifications.

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

NOTE: If engine has previously had a major overhaul and undersized bearing inserts were used, ID and OD dimensions may not be the same as those recorded. However, oil clearance must be 0.030—0.107 mm (0.0012-0.0042 in.). Replace bearings as needed.

Use crankshaft journal OD measurements to determine if journal is out-of-round or tapered.

Specification	
Crankshaft Main Journal—Taper per 25.4 mm (1.0 in.) Length	0.0025 mm (0.0001 in.)
Out-of-Roundness	0.025 mm (0.0010 in.)



RG1808 –UN–04DEC97

Measuring Crankshaft Main Journals

RG,15,DT7167 –19–13MAR00–2/2

Main Bearing Cap Line Bore Specifications

If any main bearing cap assembled ID is not within specification, blank (generic) bearing caps are available and must be line bored to finished specification. Replace individual bearing caps as needed.

1. With crankshaft removed from cylinder block, install main bearing caps without bearing inserts.
2. Tighten main bearing cap screws to 230 N•m (170 lb-ft).
3. Measure ID of all bearing caps with an inside micrometer. Main bearing cap ID should be 101.651—101.677 mm (4.0020—4.0030 in.)

Specification	
Main Bearing Cap Bore (Without Bearings) (Standard)—ID	101.651—101.677 mm (4.0020—4.0030 in.)
Maximum Bore Diameter Variation	0.013 mm (0.0005 in.)
Maximum Bore Diameter Taper	0.008 mm (0.0003 in.)
Maximum Straightness Variation (Any Bore-to-Adjacent Bore)	0.038 mm (0.0015 in.)
Maximum Straightness Variation (5 Center Bores-to-End Bores)	0.076 mm (0.0030 in.)
Centerline of Bore-to-Top Deck	352.35—352.50 mm (13.872—13.878 in.)
Bearing Cap Surface Width	36.28—36.78 mm (1.428—1.448 in.)

IMPORTANT: Main bearing cap line boring should be done ONLY by experienced personnel on equipment capable of maintaining bore specifications.

RG,15,DT7168 –19–03NOV97–1/1

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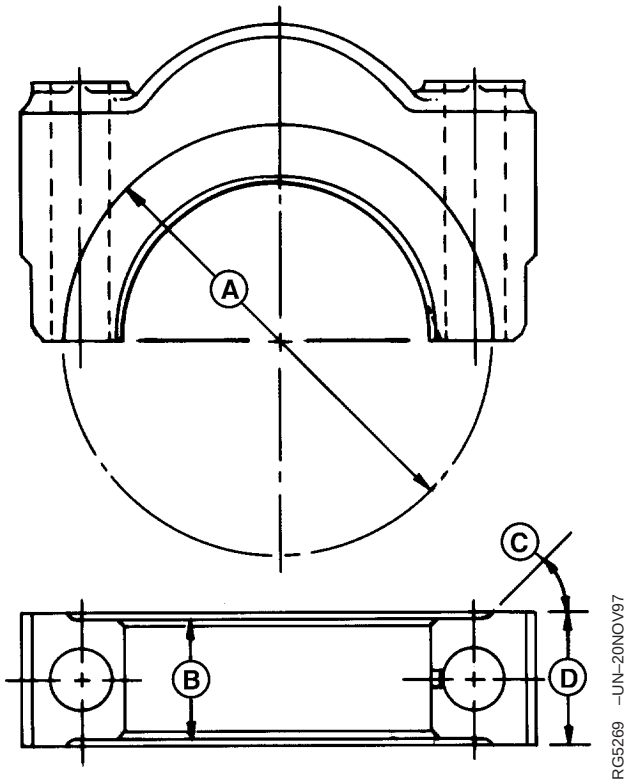
Thrust Bearing New Part Specifications

IMPORTANT: Install thrust bearing in cylinder block and tighten to specification before regrinding or polishing thrust surfaces to ensure that all surfaces on bearing and on block web are correctly aligned.

Specification	
Thrust Bearing New Part[1]—Thrust Washer Clearance Base Circle Diameter (A)	129.286—130.810 mm (5.09—5.15 in.)
Thrust Surface Width (Washer Clearance) (B)	37.44—37.54 mm (1.474—1.478 in.)
Relief Angle (C)	45°
Bearing Overall Width (D)	39.16—39.66 mm (1.542—1.561 in.)

Maximum runout for thrust surface is as follows:

Specification	
Thrust Bearing Surface—Maximum Runout	0.25 mm (0.0010 in.)



Thrust Bearing New Part Specifications

A—Thrust Washer Clearance Base Circle Diameter
B—Thrust Surface Thickness
C—Relief Angle
D—Bearing Overall Width

[1] Thrust (washer) surfaces on bearing cap must be flat in respect to mating thrust (washer) surfaces in cylinder block.

RG,15,DT7169 –19–03NOV97–1/1

Crankshaft Grinding Guidelines

IMPORTANT: Crankshaft grinding should be done ONLY by experienced personnel on equipment capable of maintaining crankshaft size and finish specifications. Crankshaft rod (pin) journals have an undercut fillet radius. DO NOT grind within this undercut area when undersize bearings are used.

In addition to the standard size main bearings, 0.292 mm (0.0115 in.) and 0.552 mm (0.0217 in.) undersize bearings are available for main bearing journals. Rod (pin) journals have only 0.292 mm (0.0115 in.) undersize bearings. If journals are tapered, out-of-round, scored or damaged, grind the crankshaft and install the proper undersize bearings.

IMPORTANT: If undersize bearings are used, check bearing clearance after bearing caps have been tightened to specified torque. If undersize bearings are too tight and clearance is not within specifications, the journal and bearing will be wiped clean of all oil. This would result in premature wear of parts.

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

1. Compare the crankshaft journal measurements taken during inspection and determine the size to which the journals are to be reground.

IMPORTANT: All main journal (tangential) fillet radii must be free of any sharp grind marks or scratches. The fillet must blend smoothly into the journal and crank cheek. Check the radii with a fillet gauge.

2. Grind all main journals or all connecting rod journals to the same required size. (See CRANKSHAFT GRINDING SPECIFICATIONS following in this group.)

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

3. Polish or lap the ground surfaces to the specified finish to prevent excessive wear of the journals.

NOTE: Production crankshafts are induction hardened and shotpeened at the factory. Field shotpeening is not recommended due to the equipment required and part geometry.

4. If the thrust surfaces of the crankshaft are worn or grooved excessively, regrind and polish. Maintain the specified radius between each thrust surface and the bearing journal. An oversize thrust washer set containing one standard washer and two 0.18 mm (0.007 in.) oversize washers is available. (See THRUST BEARING NEW PART SPECIFICATIONS earlier in this group.)

NOTE: When thrust surfaces are reground and an oversize washer is used, crankshaft end play specification must be maintained to within 0.038—0.380 mm (0.0015—0.0150 in.) (See CHECK CRANKSHAFT END PLAY, earlier in this group.)

5. Stone the edge of all oil holes in the journal surfaces smooth to provide a radius of approximately 1.50 mm (0.060 in.).

Continued on next page

6. When finished grinding, inspect the crankshaft for cracks with the Fluorescent Magnetic Particle method, or similar method. De-magnetize crankshaft after inspection.
7. Thoroughly clean the crankshaft and oil passages with solvent. Dry with compressed air.

RG,15,DT7166 –19–13MAR00–2/2

Crankshaft Grinding Specifications

Item	Measurement	Specification
Engine Stroke	Length	128.5 mm (5.059 in.)
Main and Rod Journal	Surface Finish	Lap 0.20 Um (8 AA)
Thrust Journal	Surface Finish	Lap 0.40 Um (16 AA)
Rod Journal (Undercut) Fillet	Radius	4.10—4.37 mm (0.158—0.172 in.)
Main Journal (Tangential) Fillet	Radius	3.94—4.44 mm (0.155—0.175 in.)
Thrust Journal (Tangential) Fillet	Radius	3.56—4.06 mm (0.140—0.160 in.)
Thrust Journal	Width	44.387—44.487 mm (1.7475—1.7515 in.)
Crankshaft Main Journal	Maximum Runout Relative to No. 1 and No. 7 Journals	0.13 mm (0.0051 in.)
Crankshaft Main Journal	Maximum Runout Between Adjacent Cylinders	0.06 mm (0.0024 in.)
Crankshaft Main Journal (Using Standard Bearings)	OD	95.196—95.222 mm (3.7479—3.7489 in.)
Crankshaft Rod Journal (Using Standard Bearings)	OD	76.149—76.175 mm (2.9980—2.9990 in.)
Crankshaft Main Journal (Using 0.292 mm (0.0115 in.) Undersize Bearings)	OD	94.909—94.935 mm (3.7366—3.7376 in.)
Crankshaft Rod Journal (Using 0.292 mm (0.0115 in.) Undersize Bearings)	OD	75.857—75.883 mm (2.9865—2.9875 in.)
Crankshaft Main Journal (Using 0.552 mm (0.0217 in.) Undersize Bearings)[1]	OD	94.649—94.675 mm (3.7263—3.7274 in.)

[1]0.552 mm (0.0217 in.) undersize bearing sizes are available for crankshaft main journals only.

RG,RG34710,1176 –19–13MAR00–1/1

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Replace (Crankshaft) Oil Pump Drive Gear

IMPORTANT: Protect all machined surfaces of crankshaft from grinding debris and weld spatter when removing old gear and installing new gear. DO NOT use a cutting torch to remove failed gear.

1. Using a rotary grinding wheel or parting disk, grind weld beads (A) until flush with crankshaft flange.
2. Remove gear (B) by alternately striking gear at each weld location using a brass drift and soft lead mallet.
3. After removal of gear, clean up OD of crankshaft flange and remove any burrs or remaining weld bead to eliminate interference when installing new gear.

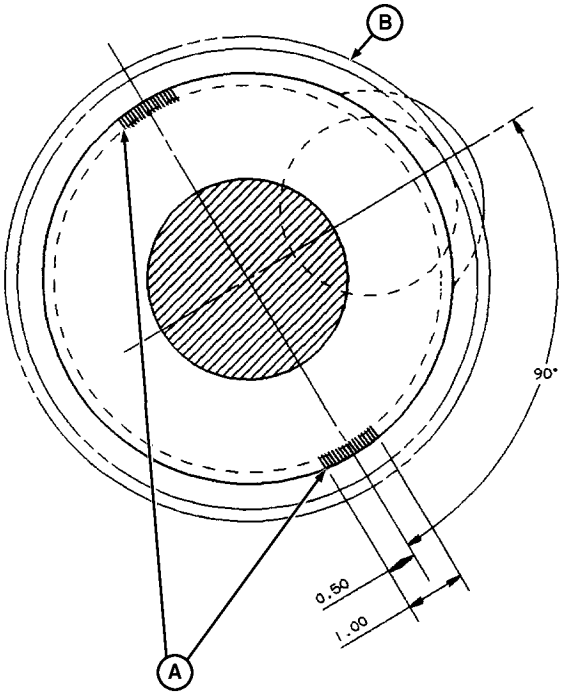
CAUTION: Oil fumes or oil can ignite above 193°C (380°F). Use a thermometer and do not exceed 182°C (360°F). Do not allow a flame or heating element to be in direct contact with the oil. Heat the oil in a well-ventilated area. Plan a safe handling procedure to avoid burns.

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

4. Heat new gear to 148°C (300°F) using either heated oil or oven heat.
5. Drive gear onto crankshaft flange until flush against shoulder.

NOTE: When driving oil pump drive gear onto crankshaft flange, the beveled edge of gear teeth should face the flywheel end of crankshaft.

6. Weld two 25.4 mm (1 in.) beads according to illustration using 1/8 in. diameter 7018 welding rod. Grind away excess weld to eliminate possibility of interference with cylinder block.



Replace (Crankshaft) Oil Pump Drive Gear

A—Weld Beads
B—Gear

RG,15,DT7165 –19–03NOV97–1/1

Replace Crankshaft Gear

IMPORTANT: Crankshaft gear must be installed on crankshaft before crankshaft is installed in engine, otherwise damage to thrust bearings could occur.

NOTE: Remove crankshaft gear for replacement only; it is not necessary to remove gear for crankshaft removal.

1. Install JDG787 Thread Protector in nose of crankshaft.
2. Protect crankshaft wear sleeve surface with masking tape.
3. Remove crankshaft gear using D01251AA[1] Puller or equivalent puller.
4. Discard gear after removal.
5. Remove Woodruff key from crankshaft keyway.
6. Remove masking tape.

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

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

7. Heat crankshaft gear (if removed) to 148°C (300°F), using either heated oil or oven heat.
8. Install Woodruff key in crankshaft.
9. Place gear on crankshaft flange. Be sure key on crankshaft is properly aligned with keyway in gear.

IMPORTANT: When installing gear, do not gouge or nick crankshaft flange.

10. Use JDH7 Gear Driver to firmly seat gear against crankshaft flange.
11. Once gear cools, reseat gear using JDH7 Gear Driver.

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

RG,15,DT7164 –19–03NOV97–1/1

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Inspect Thrust Bearings

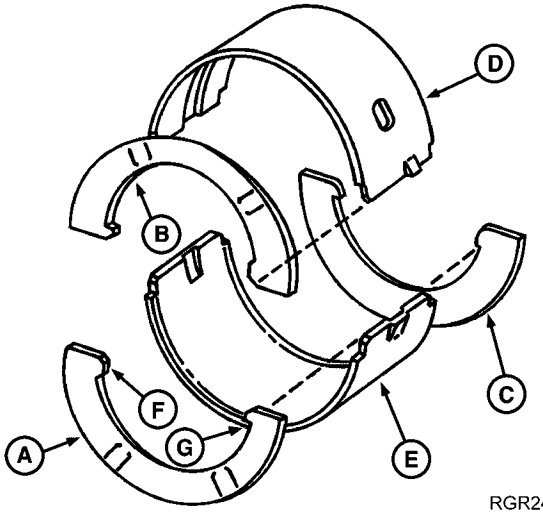
Check thrust surfaces of the thrust bearing and the thrust bearing journal on crankshaft and replace as necessary.

Thrust bearings are available in each of the previously mentioned insert undersizes. An oversize thrust washer set containing one regular size washer and two 0.18 mm (0.007 in.) oversize washers is also available.

Specification

Crankshaft Oversize Thrust Washers Available—OD ..... 0.18 mm (0.007 in.)

NOTE: Thrust bearings must be installed with slots facing crankshaft flange. Two halves (A and C) go on cap side, not block.



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Inspect Thrust Bearings

A—Lower Rear Thrust Washer
B—Upper Rear Thrust Washer
C—Lower Front Thrust Washer
D—Main Bearing Block Thrust Bearing
E—Main Bearing Cap Thrust Bearing
F—Large Tang
G—Small Tang

RG,15,DT7163 –19–13MAR00–1/1

Remove and Clean Piston Cooling Orifices

1. Remove all six (four shown) piston cooling orifices (A) and inspect each cooling orifice to make sure it is not plugged or damaged.

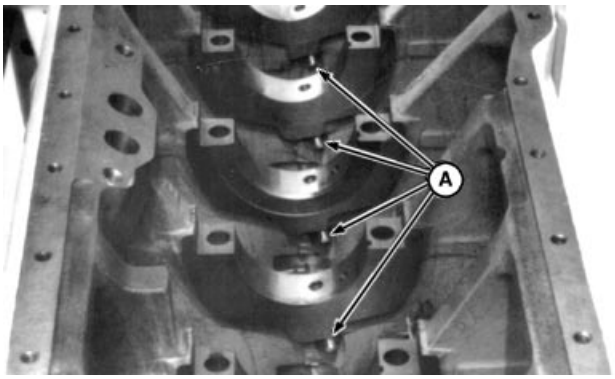
2. Use a soft wire and compressed air to clean orifice. Replace, if condition is questionable.

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

3. Install orifices and tighten to specification.

Specification

Piston Cooling Orifices—Torque ..... 11 N•m (8 lb-ft) (97 lb-in.)



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Remove and Clean Piston Cooling Orifices

A—Piston Cooling Orifice (6 used)

RG,15,DT7162 –19–20JAN98–1/1

Install Main Bearings and Crankshaft

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

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

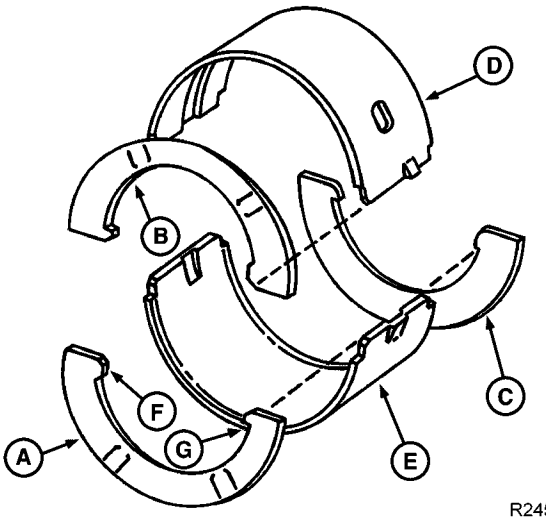
- All main bearing webs in block
- Both sides of main bearing inserts, thrust bearing inserts and thrust washers
- Entire OD of crankshaft main bearing journal

1. Install six main bearing inserts in block except No. 5 thrust bearing insert. Be sure locating tabs on inserts are properly positioned with slot in block web.

IMPORTANT: Thrust washers (A and C) go on both sides of bearing cap. Thrust washer (B) goes on rear side of block web only with the slots facing the crankshaft.

2. Install No. 5 main thrust bearing insert (D) in block. Install upper thrust washer on bearing insert at rear of block web. Be sure tangs on washer are properly positioned on thrust bearing insert.

3. Check to make sure that oil holes in main bearing web are properly aligned with oil holes in bearing inserts.



No. 5 Main Thrust Bearing Assembly

A—Lower Rear Thrust Washer
B—Upper Rear Thrust Washer
C—Lower Front Thrust Washer
D—Main Bearing Block Thrust Bearing
E—Main Bearing Cap Thrust Bearing
F—Large Tang
G—Small Tang

Continued on next page

CAUTION: Crankshaft is heavy. Plan a proper lifting procedure to avoid injuries.

4. Carefully position crankshaft onto main bearing inserts using a hoist and lift sling, as shown.

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

6. Install each bearing cap (B), bearing (C), and cap screw with washer (A) with the recesses and tabs aligned in matching order. Make sure bearing tabs also match up before tightening cap screws.

NOTE: Make sure main bearing caps are installed on the bearing bosses from which they were removed. The numbers stamped on the caps (D) should be on the same side as the numbers on the block. If there is an arrow on cap (E), arrow must be on the camshaft side of the block pointing towards the front of the engine. If bearing caps have been rebored, make sure bearing caps have numbers stamped on them.

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

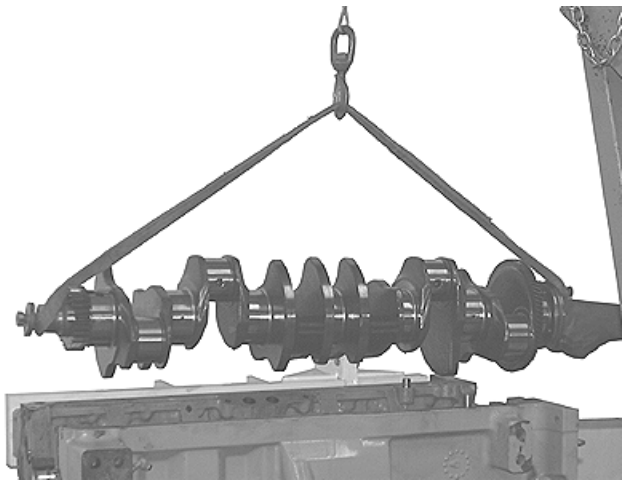
7. Before tightening cap screws on main bearing caps, align upper and lower thrust flanges on main thrust bearings. Using a soft-face hammer, tap crankshaft to the rear and then to the front to line up thrust bearing flanges.

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

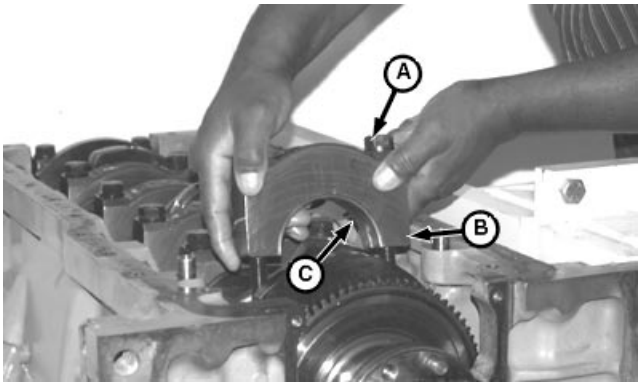
Specification	
Crankshaft Main Bearing Cap Screws—Initial Torque	68 N•m (50 lb-ft)

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

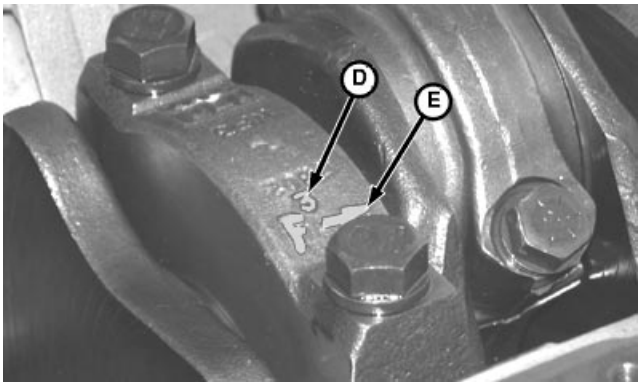
9. Gently pry crankshaft rearward and then forward to align thrust washers on No. 5 main thrust bearing.



Installing Crankshaft



Installing Main Bearing Caps



Stamped Main Bearing Caps

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

Continued on next page

NOTE: DO NOT PRY crankshaft on No. 5 main thrust bearing.

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

Specification

Crankshaft Main Bearing Cap
Screws—Initial Torque ..... 68 N•m (50 lb-ft)

11. Tighten all main bearing cap screws (including No. 5) to final torque specification.

Specification

Crankshaft Main Bearing Cap
Screws—Final Torque ..... 230 N•m (170 lb-ft)

12. Turn crankshaft by hand. If it does not turn easily, disassemble parts and determine the cause.

13. Install connecting rod bearings and connecting rod caps. (See INSTALL PISTONS AND CONNECTING RODS in Group 10.)

14. Check crankshaft for specified end play.

Specification

Crankshaft—End Play ..... 0.038—0.380 mm (0.00150—0.0150 in.)

15. Install oil pump and check drive gear-to-crankshaft backlash. (See INSTALL ENGINE OIL PUMP in Group 20.)

Specification

Oil Pump Drive
Gear-to-Crankshaft—Backlash..... 0.33—2.00 mm (0.013—0.079 in.)

DPSG,OUO1004,2599 –19–13MAR00–3/3

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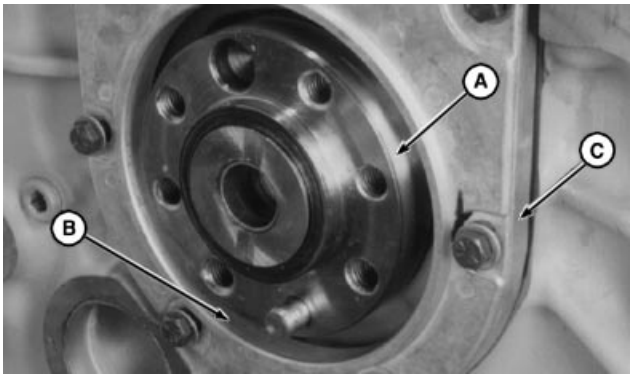
Install Crankshaft Rear Oil Seal Housing

These instructions are for when oil seal housing and oil pan have been removed from cylinder block.

1. Make sure the OD of crankshaft flange (A) and ID of seal housing (B) are free from nicks or burrs. Restore damaged surfaces with a fine file or emery cloth. Clean with compressed air.

2. Install oil seal housing (C) on cylinder block using a new gasket. Apply LOCTITE® 242 (TY9473 or T43512) Thread Lock and Sealer (medium strength) to cap screws. Install all six cap screws with washers. Tighten cap screws finger tight.



Install Crankshaft Rear Oil Seal Housing

A—Crankshaft Flange
B—Seal Housing
C—Oil Seal Housing

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RG,15,DT7160 –19–13MAR00–1/2

IMPORTANT: Alignment and installation tools must be clean to hold runout within specification and to ensure proper positioning on crankshaft flange so oil seal does not fail prematurely.

3. Slip the JDG796 Oil Seal Housing Alignment Tool (A) over crankshaft flange and into seal housing bore to center oil seal housing.

   The tool is designed to center the oil seal housing in relation to crankshaft flange. However, measuring the seal housing runout after installation with a magnetic base dial indicator is recommended. Runout should not exceed specification.

Specification

Crankshaft Rear Oil Seal Housing—Maximum Runout..... 0.152 mm (0.006 in.)

4. Position bottom of oil seal so it is recessed 0.000—0.050 mm (0.000—0.002 in.) inside cylinder block oil pan rail. Tighten seal housing cap screws to specification, using sequence shown in bottom illustration, beginning with cap screw No. 1.

Specification

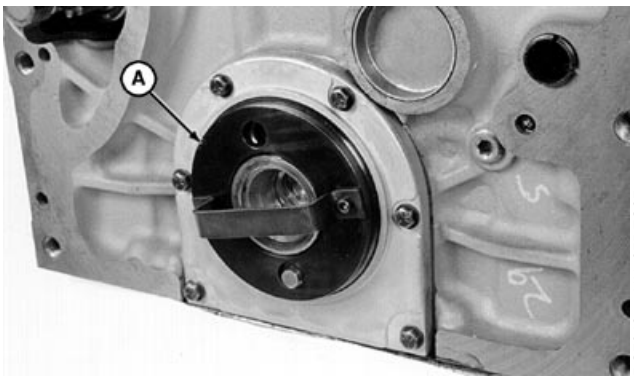
Crankshaft Rear Oil Seal Housing Cap Screws—Torque ..... 27 N•m (20 lb-ft)
Crankshaft Rear Oil Seal Housing—Recess Inside Block Oil Pan Rail ..... 0.00—0.05 mm (0.00—0.002 in.)

5. Remove alignment tool from end of crankshaft flange.

6. Check oil seal housing runout with a magnetic base dial indicator. (See CHECK OIL SEAL HOUSING RUNOUT, later in this group.)

7. Trim off excess gasket material extending below bottom of oil seal housing.

8. Install rear oil seal and wear sleeve. (See INSTALL CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE earlier in this group.)



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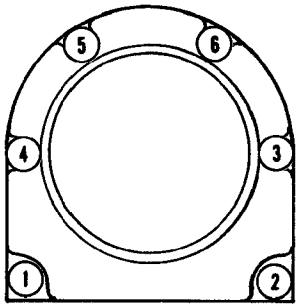
Install JDG796 Tool Over Crankshaft



RG6427 –UN–05DEC97

RG6427

Tightening Sequence for Seal Housing

A—Ailgnment Tool

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Check Oil Seal Housing Runout

IMPORTANT: On service "short block" assemblies, rear oil seal housing runout is preset at the factory. Do not remove housing from block.

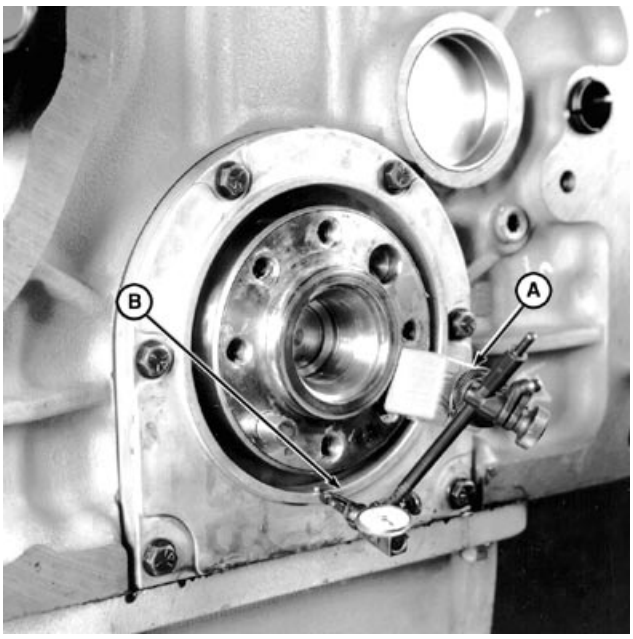
1. Position magnetic base dial indicator (A) on end of crankshaft flange as shown. Preset dial indicator tip on ID of oil seal housing bore (B).

2. Zero dial indicator and rotate crankshaft one full revolution, observe full indicator movement and compare to the following specifications.

Specification	
Crankshaft Rear Oil Seal Housing—Maximum Runout	0.152 mm (0.006 in.)

If runout exceeds specification, loosen cap screws and adjust housing to obtain an acceptable runout while keeping bottom of seal housing flush with oil pan mating surface.

3. Recheck oil seal housing bore runout. If runout still exceeds specification, oil seal housing bore is possibly distorted and should be replaced. (See INSTALL CRANKSHAFT REAR OIL SEAL HOUSING, earlier in this group.)



Check Oil Seal Housing Runout

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

RG,15,DT7159 –19–13MAR00–1/1

Install Timing Gear Cover (With Auxiliary Drive Housing Attached)

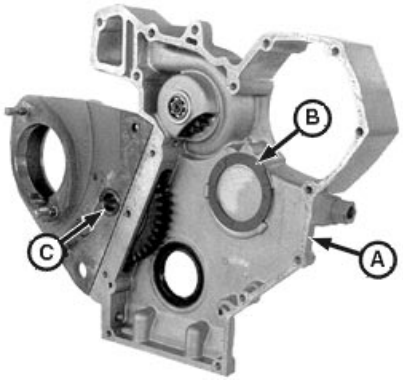
1. Lubricate both sides of thrust washer (B) with TY6333 or TY6347 High Temperature Grease and install in timing gear cover tabs.
2. Grease and install O-ring (C) around rear idler shaft bore.
3. Grease and install O-ring in front idler shaft bore. Install idler shaft into bore on front of auxiliary drive housing. Install shaft until flush with block side of housing.
4. Install a new gasket on engine block. Apply a light film of grease to the gasket to hold it in place.

NOTE: Use the following table and figure to determine the correct cap screw size, location and torque sequence.

Make sure cap screw 5 has a seal on it.

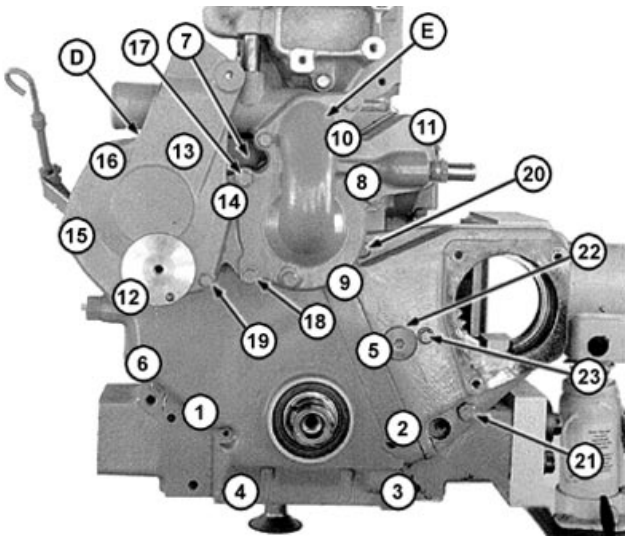
1	5/16 x 1-3/8	9	5/16 x 3-3/4	17	3/8 x 1-1/8
2	5/16 x 1-7/8	10	3/8 x 3-3/4	18	3/8 x 1-1/8
3	5/16 x 1-7/8	11	3/8 x 3-3/4	19	5/16 x 1
4	5/16 x 1-3/8	12	5/16 x 3-3/4	20	3/8 x 1
5	5/16 x 1-7/8	13	5/16 x 3-3/4	21	1/2 x 1-1/8
6	5/16 x 1-3/8	14	5/16 x 3-3/4	22	5/8 x 3
7	3/8 x 1-1/4	15	5/16 x 3-3/4	23	5/16 x 7/8
8	3/8 x 3-3/4	16	5/16 x 3-3/4		

5. Install timing gear cover using cap screws 1—7, ensuring thrust washer (B) and O-ring (C) remain in place. Rotate idler gear as necessary to line up with crankshaft gear. Hand tighten cap screws.



RG10749 –UN–02AUG00

Lubricate Thrust Washer



RG10748 –UN–02AUG00

Timing Gear Cover Torque Sequence

A—Timing Gear Cover
B—Thrust Washer
C—O-Ring
D—Ignition Timing Sensor Cover
E—Coolant Pump Cover

Continued on next page

RG,15,DT7156 –19–13MAR00–1/3

15
56

6.

Grease O-rings (G) and (H) on button head cap screw (F). Install cap screw hand tight.

NOTE: Cap screws 2, 3 5, 20 and 21 are TORX® head cap screws.

1	5/16 x 1-3/8	9	5/16 x 3-3/4	17	3/8 x 1-1/8
2	5/16 x 1-7/8	10	3/8 x 3-3/4	18	3/8 x 1-1/8
3	5/16 x 1-7/8	11	3/8 x 3-3/4	19	5/16 x 1
4	5/16 x 1-3/8	12	5/16 x 3-3/4	20	3/8 x 1
5	5/16 x 1-7/8	13	5/16 x 3-3/4	21	1/2 x 1-1/8
6	5/16 x 1-3/8	14	5/16 x 3-3/4	22	5/8 x 3
7	3/8 x 1-1/4	15	5/16 x 3-3/4	23	5/16 x 7/8
8	3/8 x 3-3/4	16	5/16 x 3-3/4		

IMPORTANT: Tightening the timing gear cover cap screws 1—6 in numerical sequence controls the total runout of the crankshaft flange-to-oil seal bore.

8. Tighten cap screws 1—7 to specifications in sequence shown.

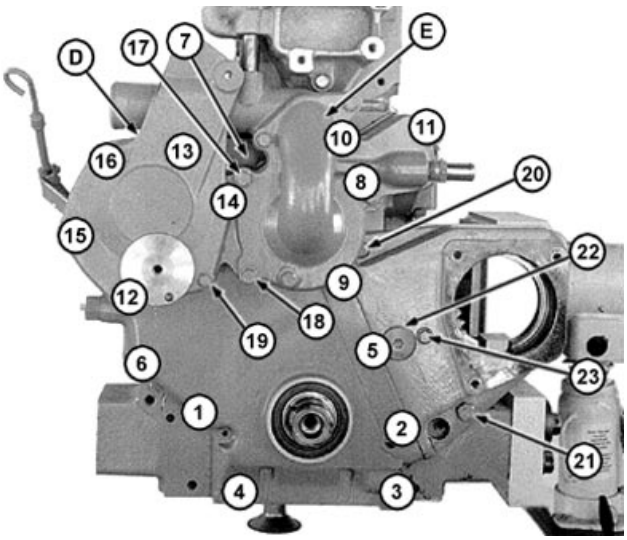
Specification	
Timing Gear Cover-to-Cylinder Block 5/16-in. Cap Screws (1—6)—Torque	27 N•m (20 lb-ft)
Timing Gear Cover-to-Cylinder Block 3/8-in. Cap Screws (7)—Torque	47 N•m (35 lb-ft)

9. Coat bypass tube seal inlet housing with clean engine oil. Carefully install coolant pump cover (E) with inlet housing using new gaskets. Hand tighten cap screws.

10. Install ignition timing sensor cover (D) using a new gasket. Hand tighten cap screws.

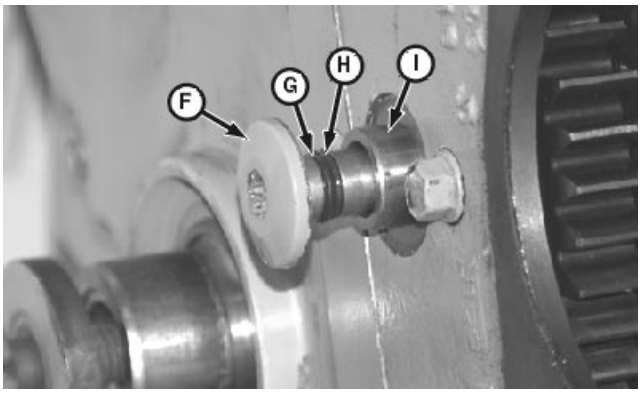
11. Install remaining auxiliary drive housing cap screws and tighten by hand.

12. Tighten all cap screws to specifications following sequence in figure.



RG10748 –UN–02AUG00

Timing Gear Cover Torque Sequence



RG10750 –UN–02AUG00

Install Idler Shaft

D—Ignition Timing Sensor Cover
E—Coolant Pump Cover
F—Button Head Cap Screw
G—O-Ring
H—O-Ring
I—Idler Shaft

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Continued on next page

RG,15,DT7156 –19–13MAR00–2/3

Specification	
Coolant Pump Cover-to-Timing Gear Cover 5/16-in. Cap Screws (9)—Torque	27 N•m (20 lb-ft)
Coolant Pump Cover-to-Timing Gear Cover 3/8-in. Cap Screws (8, 10, 11, 17, 18)—Torque	47 N•m (35 lb-ft)
Ignition Timing Sensor Cover Cap Screws (12—16, 19)—Torque	27 N•m (20 lb-ft)
Auxiliary Drive Housing-to-Cylinder Block 3/8-in. Cap Screws (20)—Torque	41 N•m (30 lb-ft)
Auxiliary Drive Housing-to-Cylinder Block 1/2-in. Cap Screws (21)—Torque	127 N•m (94 lb-ft)
Auxiliary Drive Idler Shaft Button Head Cap Screw (22)—Torque	150 N•m (110 lb-ft)
Auxiliary Drive Housing-to-Idler Bearing 5/16-in. Cap Screw (23)—Torque	27 N•m (20 lb-ft)

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

14. Using a new O-ring, install magnetic speed sensor in timing gear cover, if removed.

15. If removed from timing sensor cover, install belt tensioner. Apply LOCTITE® 242 Thread Lock and Sealer to tensioner retaining cap screw. Install cap screw and tighten specifications.

Specification	
Belt Tensioner-to-Timing Sensor Cover Cap Screw—Torque	50 N•m (37 lb-ft)

16. Install crankshaft front wear sleeve and oil seal. (See INSTALL CRANKSHAFT FRONT OIL SEAL AND WEAR SLEEVE in this group.)

17. Install oil pump. (See INSTALL ENGINE OIL PUMP in Group 20.)

18. Install oil pan. (See REMOVE AND INSTALL ENGINE OIL PAN in Group 20.)

19. Install vibration damper. (See INSTALL CRANKSHAFT VIBRATION DAMPER in this group.)

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RG,15,DT7156 –19–13MAR00–3/3

Install Crankshaft Vibration Damper

IMPORTANT: The vibration damper is not repairable and should be replaced every 60 months or 125,000 miles, whichever occurs first.

Install Damper (Early HFN01 Engine)

1. Install crankshaft Woodruff key with tab facing toward front of engine and key firmly seated in crankshaft keyway. Position crankshaft hub (A) onto crankshaft.
2. Use hardened washer (part of hub assembly) and insert a cap screw that is 25 mm (1 in.) longer than original cap screw (B). Tighten cap screw until it just bottoms out.
3. Remove cap screw and install damper with original cap screw and same hardened washer.
4. Tighten cap screw to specification.

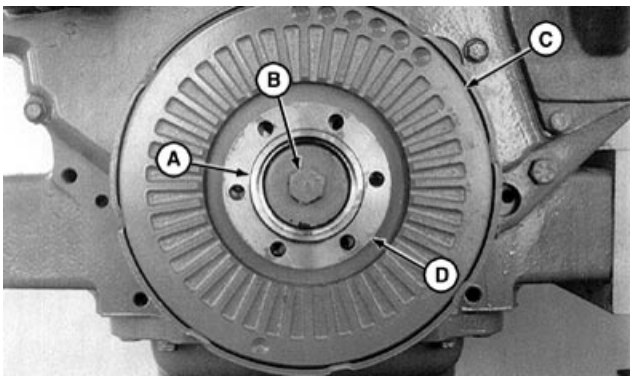
Specification	
Damper Hub-to Crankshaft Cap Screw (Early HFN01 Engines)—Torque	230 N•m (170 lb-ft)

5. Install damper (C).
6. Install spacer (D).
7. Install pulley (E).
8. Install cap screws (F). Tighten cap screws to specification.

Specification	
Damper and Pulley-to-Hub Cap Screws (Early HFN01 Engines)—Torque	70 N•m (52 lb-ft)

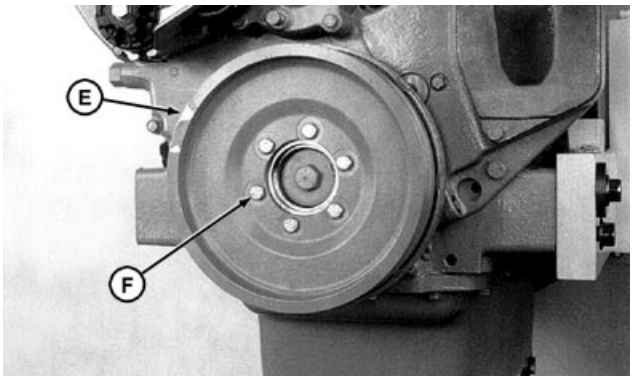
Install Damper (HFN02 Engines Option Code 1301)

1. Install damper on crankshaft.
2. Install damper center retaining cap screw and tighten to specification.



RG7699D –UN–03MAR98

Install Vibration Damper



RG7698C –UN–03MAR98

Install Pulley and Cap Screw

A—Crankshaft Hub
B—Cap Screw
C—Damper
D—Spacer
E—Pulley
F—Cap Screw (6 used)

Continued on next page

RG,15,DT7153 –19–08MAR02–1/3

Specification	
Damper Retaining Cap Screw (HFN02 Engines Option Code 1301)—Torque	230 N•m (170 lb-ft)

3. Install pulley spacer, pulley and PTO adapter to damper using 6 socket head cap screws. Tighten socket head cap screws to specification.

Specification	
PTO Adapter, Pulley and Pulley Spacer-to-Damper Socket Head Cap Screws—Torque	61 N•m (45 lb-ft)

RG,15,DT7153 –19–08MAR02–2/3

Install Damper (Later HFN01, HFN02, HFN03 and HFN04 Engines)

1. Attach damper (D) to pulley. Tighten cap screws (C) to specification.

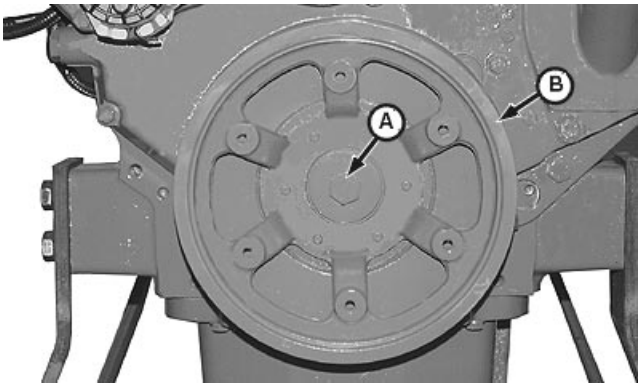
Specification	
Vibration Damper-to-Pulley Cap Screws (Later HFN01, HFN02, HFN03 and HFN04 Engines)—Torque	70 N•m (52 lb-ft)

2. Install damper/pulley assembly (B) on crankshaft and tighten cap screw (A) to specification.

Specification	
Damper/Pulley Assembly-to-Crankshaft Cap Screw (Later HFN01, HFN02, HFN03 and HFN04 Engines)—Torque	230 N•m (170 lb-ft)

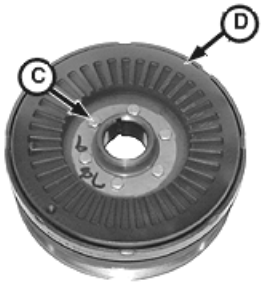
3. If equipped with optional front V-Pulley: Install pulley to damper pulley using 6 cap screws. Tighten cap screws to specification.

Specification	
Optional V-Pulley-to-Damper Pulley—Torque	61 N•m (45 lb-ft)



RG10580A –UN–24FEB00

Crankshaft Damper and Pulley



RG10581A –UN–24FEB00

Crankshaft Damper

A—Damper/Pulley Assembly-to-Crankshaft Cap Screw
B—Damper/Pulley Assembly
C—Damper-to-Pulley Cap Screw
D—Damper

RG,15,DT7153 –19–08MAR02–3/3

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Install Flywheel

On SAE 1 and all aluminum flywheel housings, the flywheel housing is installed AFTER the flywheel.

On SAE 2 cast-iron flywheel housings, the housing MUST be installed BEFORE installing flywheel.

Continued on next page

RG,15,DT7152 –19–15MAY02–1/2

Two guide studs may be used at cap screw locations (A) opposite each other to aid in flywheel installation.

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

NOTE: ALWAYS use new cap screws when installing flywheel. DO NOT use plated cap screws.

IMPORTANT: Flywheel must be clean and free of oil before installing. Clean threaded holes in crankshaft carefully. DO NOT blow them out with compressed air. These are through holes and debris could be blown into the engine crankcase.

1. If flywheel attaching cap screws do not have pre-applied thread lock, coat threads of cap screws with LOCTITE® 242 Thread Lock and Sealer (Medium Strength) or its equivalent.
2. Position flywheel over dowel pin and install drive hub (if equipped). Start four cap screws. Remove guide studs and install remaining cap screws.
3. Install remaining flywheel attaching cap screws.
4. Tighten flywheel attaching cap screws to specification.

Specification	
Flywheel Attaching Cap Screw— Torque	115 N•m (85 lb-ft)
Flywheel Drive Hub-to-Flywheel Cap Screws (If Equipped)— Torque	115 N•m (85 lb-ft)

RG7048 –UN–05DEC97

Install Flywheel

A—Cap Screw Location

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RG,15,DT7152 –19–15MAY02–2/2

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Install SAE 2 Flywheel Housing

On SAE 1 and all aluminum flywheel housings, the flywheel housing is installed AFTER the flywheel.

On SAE 2 cast-iron flywheel housings, the housing MUST be installed BEFORE installing flywheel.

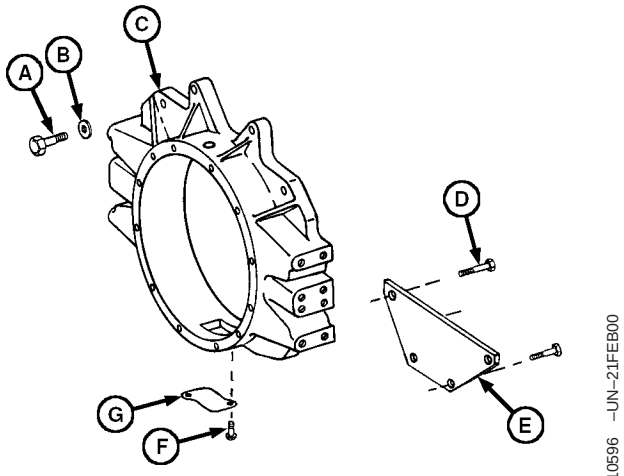
CAUTION: Flywheel housing is heavy. Plan a proper lifting procedure to avoid personal injury.

1. Install flywheel housing and tighten cap screws to specifications.

Specification	
Flywheel Housing-to-Cylinder Block Cap Screws—Torque	365 N•m (270 lb-ft)

2. If removed, install plates (E and G). Tighten cap screws to specifications.

Specification	
Flywheel Housing Front Plate Cap Screws—Torque	43 N•m (32 lb-ft)
Flywheel Housing Bottom Plate Cap Screws—Torque	12 N•m (9 lb-ft) (106 lb-in.)



RG10596 –UN–21FEB00

Install Flywheel Housing

A—Cap Screw (8 used)
B—Washer (8 used)
C—Flywheel Housing
D—Cap Screw (2 used)
E—Front Plate
F—Cap Screw (2 used)
G—Bottom Plate

DPSG,OUO1004,2600 –19–15MAY02–1/1

Install SAE 1 Flywheel Housing

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

On SAE 1 flywheel housings, the flywheel housing is installed AFTER the flywheel.

On SAE 2 cast-iron flywheel housings, the housing MUST be installed BEFORE installing flywheel.

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

NOTE: ALWAYS use new cap screws when installing flywheel housing.

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

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

OUO1082,0000246 –19–15MAY02–1/1

Complete Final Assembly

1. Install oil pump assembly and oil pan, if not previously installed. Fill engine with clean engine oil. (See Group 20.)

2. Fill cooling system with proper coolant after engine installation and perform engine break-in. (See PERFORM ENGINE BREAK-IN in Group 04.)

RG,15,DT7151 –19–30MAR00–1/1

Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

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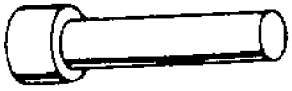
DPSG,OUO1004,2815 –19–31JUL00–1/9

RG5068 –UN–05DEC97

Timing Pin . . . . . JDE81-4[1]

Lock engine at TDC when timing valve train and adjusting valve clearance.



RG5068

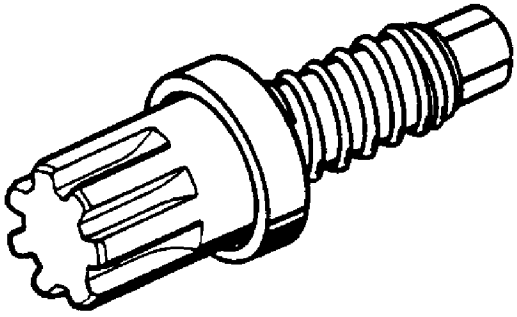
JDE81-4

[1]Use with JDG820 and JDE81-1 Flywheel Turning Tools.

DPSG,OUO1004,2815 –19–31JUL00–2/9

Flywheel Turning Tool JDG820

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



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RG7056

JDG820

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DPSG,OUO1004,2815 –19–31JUL00–3/9

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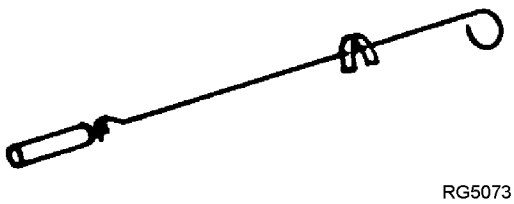
RG5073 –UN–05DEC97

Magnetic Follower Holder Kit D15001NU

Hold cam followers when removing or installing camshaft.



D15001NU

DPSG,OUO1004,2815 –19–31JUL00–4/9

RGR26149 –UN–11DEC97

Camshaft Bushing Service Set. . . . . JDE6[1]

Used with JDG602 Camshaft Bushing Adapter Set to service camshaft bushings.

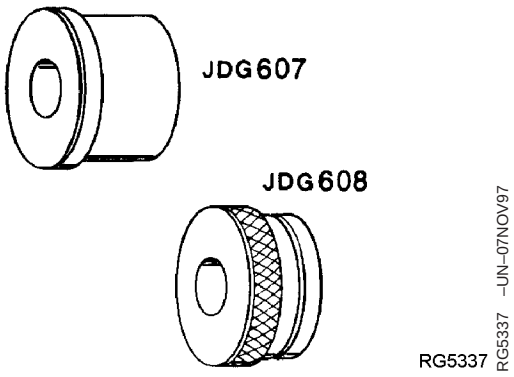
JDE6

[1]JDG405 Service Set may be used along with JDG606 Adapter Set if JDE6 is not available.

DPSG,OUO1004,2815 –19–31JUL00–5/9

Camshaft Bushing Adapter Set JDG606

Used with JDG405 Camshaft Bushing Service Set and D01299AA Slide Hammer to service camshaft bushings. JDG606 consists of JDG607 Driver and JDG608 Pilot.



JDG606

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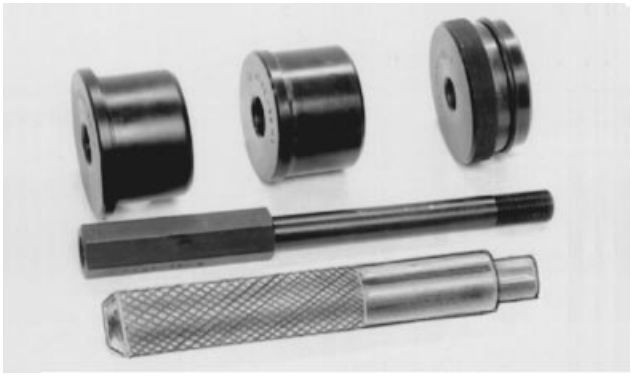
DPSG,OUO1004,2815 –19–31JUL00–6/9

Camshaft Bushing Service Set. . . . . JDG405[1]

Used with JDG606 Camshaft Bushing Adapter Set and D01299AA Slide Hammer to service camshaft bushings.



RG4228 –UN–05DEC97

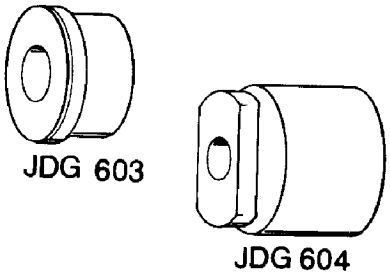
JDG405

[1]JDE6 Service Set may be used along with JDG602 Adapter Set if JDG405 is not available.

DPSG,OUO1004,2815 –19–31JUL00–7/9

Camshaft Bushing Adapter Set JDG602

Used with JDE6 Camshaft Bushing Service Set to service camshaft bushings. JDG602 consists of JDG603 Driver and JDG604 Receiver Cup.



RG5336 –UN–07NOV97

JDG602

DPSG,OUO1004,2815 –19–31JUL00–8/9

Slide Hammer D01299AA

Used with JDG405 Camshaft Bushing Service Set and JDG606 Camshaft Bushing Adapter Set to service camshaft bushings.

RG78104H1 –UN–15DEC88

D01299AA

DPSG,OUO1004,2815 –19–31JUL00–9/9

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Other Material

Number	Name	Use
51048 (LOCTITE®)	Moly Paste	Apply to camshaft nose before installing timing wheel (HFN01—HFN03 engines) or camshaft gear (HFN04 engines).
TY15969 (U.S.) TY9479 (Canadian) 680 (LOCTITE®)	Retaining Compound (Maximum Strength)	Apply to camshaft nose before installing camshaft gear (HFN01—0HFN03 engines).
TY6299 (U.S.)	PERMATEX® AVIATION (Form-A-Gasket No. 3)	Seal camshaft bore steel cap plug.
TY6333 or TY6347 (U.S.)	High Temperature Grease	Lubricate camshaft lobes and thrust washers before camshaft installation.
242 (LOCTITE®)	Medium Strength Thread Lock and Sealer	Apply to belt tensioner mounting cap screw.

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PERMATEX is a registered trademark of Loctite Corp.

DPSG,OUO1004,2817 –19–06MAR02–1/1

Camshaft and Timing Gear Train Specifications

Item	Measurement	Specification
Intake Valve	Lift [at 0.00 mm (0.00 in.) Clearance] Wear Tolerance	13.53—13.71 mm (0.533—0.540 in.) 12.65 mm (0.498 in.)
Exhaust Valve	Lift [at 0.00 mm (0.00 in.) Clearance] Wear Tolerance	14.52—14.70 mm (0.572—0.579 in.) 13.64 mm (0.537 in.)
Camshaft	End Play (New) Maximum Allowable End Play	0.0130—0.5000 mm (0.0005—0.0200 in.) 0.65 mm (0.026 in.)
Camshaft Gear-to-Crankshaft Gear	Backlash	0.076 mm (0.0029 in.) (minimum)
Camshaft Thrust Washer	Thickness	2.24—2.34 mm (0.088—0.092 in.)
Camshaft Follower	OD	17.33—17.35 mm (0.682—0.683 in.)
Camshaft Follower Bore in Block	ID	17.384—17.440 mm (0.6845—0.6865 in.)
Camshaft Journal (New)	OD	66.987—67.013 mm (2.6373—2.6383 in.)
Camshaft Bushing (New)	ID	67.076—67.102 mm (2.6408—2.6418 in.)
Camshaft Lobe (New Part) (Intake)	Lift Wear Limit	7.69—7.79 mm (0.303—0.307 in.) 7.19 mm (0.283 in.)
Camshaft Lobe (New Part) (Exhaust)	Lift Wear Limit	8.25—8.35 mm (0.325—0.329 in.) 7.75 mm (0.305 in.)
Camshaft Timing Wheel Thrust Surface	Runout	0.10 mm (0.004 in.)
Camshaft Bushing Bore in Block (New Part)	ID Runout	69.987—70.013 mm (2.7554—2.7564 in.) 0.038 mm (0.0015 in.)
Camshaft Journal-to-Bushing	Oil Clearance	0.063—0.115 mm (0.0025—0.0045 in.)
Timing Gear Cover-to-Cylinder Block 3/8-in. Cap Screws	Torque	47 N•m (35 lb-ft)

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Item	Measurement	Specification
Timing Gear Cover-to-Cylinder Block 5/16-in. Cap Screws	Torque	27 N•m (20 lb-ft)
Coolant Pump Cover 5/16-in. Cap Screws	Torque	27 N•m (20 lb-ft)
Coolant Pump Cover 3/8-in. Cap Screws	Torque	47 N•m (35 lb-ft)
Ignition Timing Sensor Cover 5/16-in. Cap Screws	Torque	27 N•m (20 lb-ft)
Auxiliary Drive Housing-to-Cylinder Block 3/8-in. Cap Screws	Torque	41 N•m (30 lb-ft)
Auxiliary Drive Housing-to-Timing Gear Cover 3/8-in. Cap Screws	Torque	41 N•m (30 lb-ft)
Auxiliary Drive Housing-to-Cylinder Block 1/2-in. Cap Screws	Torque	127 N•m (94 lb-ft)
Auxiliary Drive Housing-to-Idler Shaft Bearing 5/16-in. Cap Screw	Torque	27 N•m (20 lb-ft)
Auxiliary Drive Idler Shaft Button Head Cap Screw	Torque	150 N•m (110 lb-ft)
Belt Tensioner-to-Timing Sensor Cover Cap Screw	Torque	50 N•m (37 lb-ft)

DPSG,OUO1004,2818 –19–31JUL00–2/2

Check Valve Lift

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

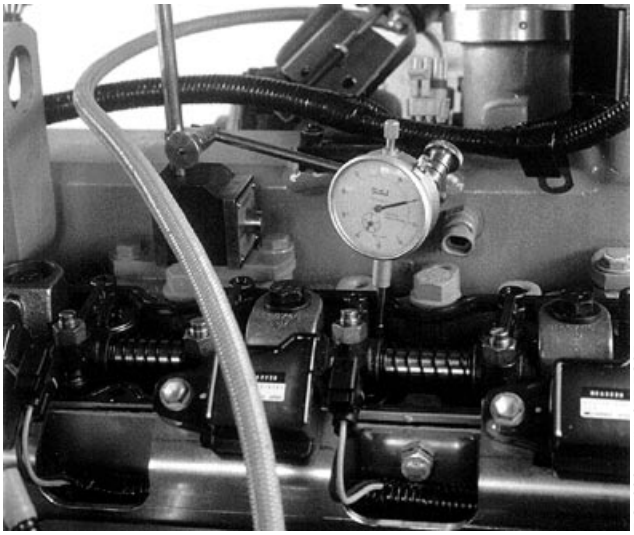
NOTE: Measuring valve lift can give an indication of wear on camshaft lobes and cam followers or bent push rods.

1. Remove rocker arm cover. Loosen lock nut on rocker arm and set valve clearance at 0.00 mm (0.00 in.). Tighten lock nut.
2. Put dial indicator tip on valve rotator. Be sure that valve is fully closed.
3. Check pre-set on dial indicator. Set dial indicator pointer at zero.
4. Manually turn engine in running direction, using the engine rotation tool previously mentioned for checking valve clearance.
5. Observe dial indicator reading as valve is moved to fully open position.

Specification

Intake Valve—Lift [at 0.00 mm (0.00 in.) Clearance]	13.53—13.71 mm (0.533—0.540 in.)
Wear Tolerance	12.65 mm (0.498 in.)
Exhaust Valve—Lift [at 0.00 mm (0.00 in.) Clearance]	14.52—14.70 mm (0.572—0.579 in.)
Wear Tolerance	13.64 mm (0.537 in.)

6. Follow same procedure for all remaining valves and adjust valve clearance to specification. (See CHECK AND ADJUST VALVE CLEARANCE in Group 05.)



Check Valve Lift

RG,16,DT7171 –19–03NOV97–1/1

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Check Camshaft End Play and Measure Gear Backlash

NOTE: Camshaft end play must be measured before removing timing gear cover, as thrust washer in back side of timing gear cover limits camshaft end play.

1. Remove ignition timing sensor cover (shown removed).
2. Install magnetic base dial indicator on front face of cylinder block and position dial indicator tip on front face of camshaft gear, as shown. Set dial indicator to zero.
3. Move camshaft gear back and forth and observe end play reading. Compare reading with specification given below.

Specification

Camshaft—End Play (New)	0.0130—0.5000 mm (0.0005—0.0200 in.)
Maximum Allowable End Play	0.65 mm (0.026 in.)

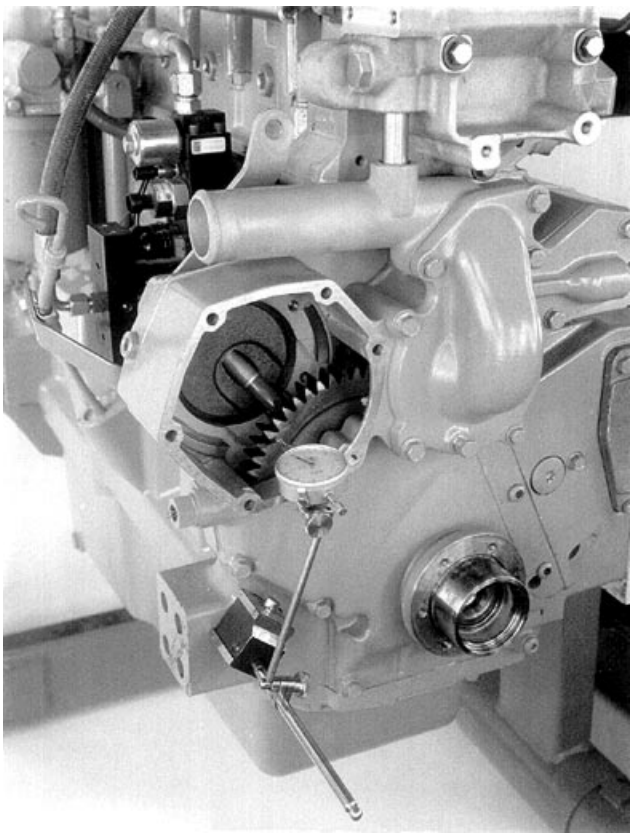
If end play is excessive, remove timing gear cover and camshaft and measure thickness of thrust washers.

4. Position indicator plunger tip against camshaft gear tooth with a preload.
5. Measure backlash between camshaft drive gear and crankshaft gear in three (3) different positions around the camshaft gear. Compare readings with specifications given below.

Specification

Camshaft Drive Gear-to-Crankshaft Gear—Backlash	0.076 mm (0.003 in.) min.

Replace gears if backlash is not within specification.



RG7697 –UN–05DEC97

HFN01, 02, 03 Engines Shown. HFN04 Similar.

RG,16,DT7172 –19–22FEB02–1/1

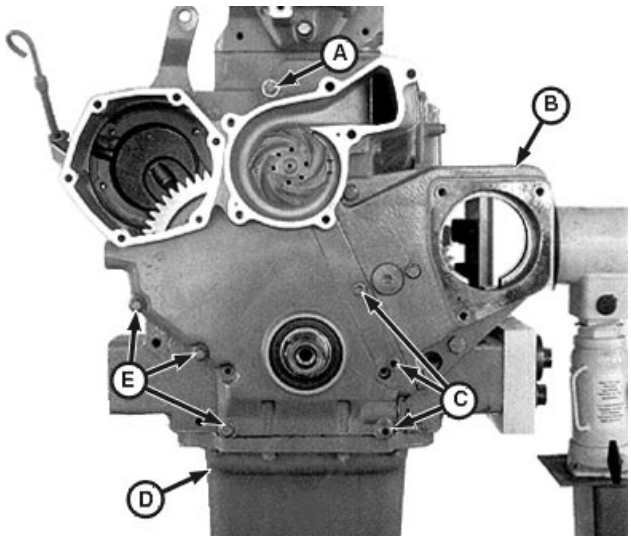
Remove Timing Gear Cover (With Auxiliary Drive Housing Removed)

NOTE: Timing gear cover can be removed with or without the auxiliary drive housing attached. If removing timing cover with auxiliary drive housing attached, see REMOVE TIMING GEAR COVER (WITH AUXILIARY DRIVE HOUSING ATTACHED) in Group 15.

1. Drain engine oil and remove oil pan (D). (See REMOVE AND INSTALL ENGINE OIL PAN in Group 20.)
2. Remove vibration damper. (See REMOVE CRANKSHAFT VIBRATION DAMPER in Group 15.)
3. Remove idler pulley (shown removed).
4. Remove coolant pump cover and inlet elbow (shown removed). (See REMOVE COOLANT PUMP ASSEMBLY in Group 25.)

NOTE: Engine speed sensor is located on back of timing gear sensor cover on later HFN01—HFN03 applications.

5. Remove timing gear sensor cover (shown removed). Disconnect engine speed sensor.
6. Remove air compressor. (See REMOVE AIR COMPRESSOR in Group 50.)
7. Check camshaft end play. (See CHECK CAMSHAFT END PLAY AND MEASURE GEAR BACKLASH earlier in this group.)
8. Remove auxiliary drive housing (B). (See REMOVE AUXILIARY DRIVE HOUSING AND IDLER GEAR in Group 50.)



Remove Timing Gear Cover

A—Cap Screw
B—Auxiliary Drive Housing
C—Cap Screws
D—Oil Pan
E—Cap Screws

Continued on next page

RG,16,DT7173 –19–22FEB02–1/2

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10

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

NOTE: Mark location of cap screws removed from timing gear cover to aid in reassembly.

9. Remove cap screws (A, C and E).

10. Remove timing gear cover. Remove and discard gasket.

11. Remove front oil seal from timing gear cover. Install a new seal after timing gear cover is installed.

12. Remove crankshaft front wear sleeve. (See REMOVE CRANKSHAFT FRONT OIL SEAL AND WEAR SLEEVE in Group 15.)

RG,16,DT7173 –19–22FEB02–2/2

Remove Camshaft

NOTE: It is not necessary to remove cylinder head from engine for camshaft removal. If push rods are bent or show excessive scuffing, it may be necessary to remove cylinder head for inspection of block, head, cam lobes and cam followers.

1. Drain engine oil and coolant, if not previously done. Remove vibration damper and timing gear cover. (See REMOVE TIMING GEAR COVER in this group.)

2. Rotate engine flywheel with JDE81-1 or JDG820 Flywheel Turning Tool and lock engine at No. 1 cylinder's TDC compression stroke with JDE81-4 Timing Pin. Timing marks (A) on camshaft gear and crankshaft gear should be aligned.

   If timing marks are not aligned, remove timing pin and continue to rotate engine until marks align. Timing pin should enter hole in flywheel. Engine will be locked at No. 1 TDC compression stroke.

3. Remove rocker arm cover, rocker arm assembly and push rods. (See Group 05, Cylinder Head and Valves.)

4. When removing camshaft with engine on rollover stand, roll engine to a position where followers fall away from camshaft lobes (oil pan side up) or hold cam followers away from lobes with D15001NU Magnetic Follower Holder Kit.

RG6614 –UN–05DEC97

HFN01—HFN03 Engines Shown. HFN04 Similar.

A—Timing Marks

Continued on next page

RG,16,DT7174 –19–22FEB02–1/3

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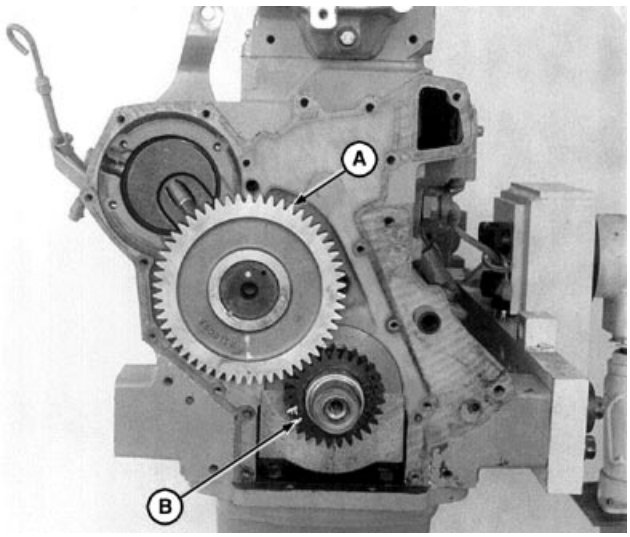
12

5. Examine camshaft gear (A), timing wheel (HFN01—HFN03 engines only) and crankshaft gear (B) for worn or damaged gear teeth. Check gear backlash and compare to the following specifications.

Specification	
Camshaft Gear-to-Crankshaft Gear—Backlash	0.076 mm (0.0029 in.) (minimum)

NOTE: Timing marks on crankshaft and camshaft gear should be aligned and No. 1 cylinder locked at TDC compression stroke when removing camshaft.

A—Camshaft Gear
B—Crankshaft Gear



HFN01—HFN03 Engines Shown. HFN04 Similar.

RG,16,DT7174 –19–22FEB02–2/3

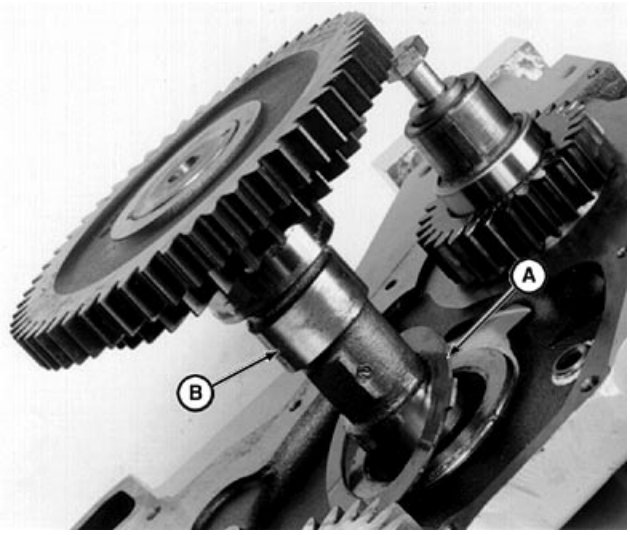
6. Carefully remove camshaft (B) from cylinder block so that camshaft lobes do not drag in bores.

NOTE: Rotate camshaft carefully to aid in removing.

7. Remove thrust washer (A) from behind timing wheel.

8. Remove cam followers from cylinder block.

A—Thrust Washer
B—Camshaft



HFN01—HFN03 Engines Shown. HFN04 Similar.

RG,16,DT7174 –19–22FEB02–3/3

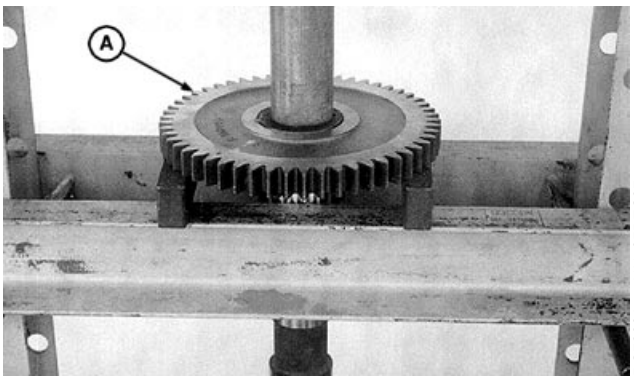
Remove Camshaft Gear and Timing Wheel

IMPORTANT: Prevent camshaft from striking floor when pushing camshaft nose out of gear. Camshaft may be damaged if it is allowed to fall to the floor.

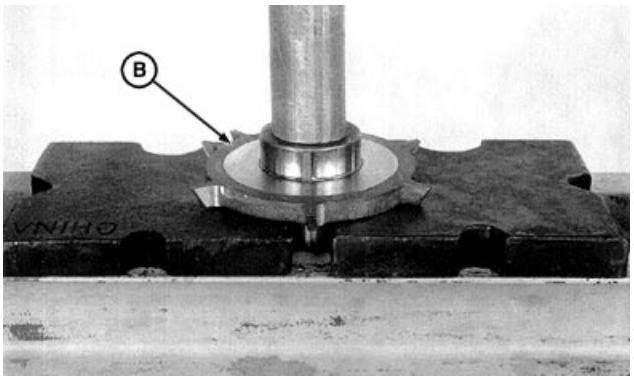
NOTE: Camshaft gear and timing wheel are pressed onto the camshaft. Removal of gear and timing wheel from camshaft will require approximately a 10-ton press.

1. Support camshaft gear (A) in a press.
2. Remove gear from camshaft.
3. Support camshaft timing wheel (B) in a press.
4. Remove timing wheel from camshaft.
5. Clean camshaft, gear, and timing wheel. Dry with compressed air.

A—Camshaft Gear
B—Camshaft Timing Wheel



Support Camshaft Gear



Support Camshaft Timing Wheel

RG,16,DT7175 –19–22FEB02–1/1

Measure Thrust Washer Thickness

1. After removal of camshaft, check the thrust washer for proper thickness.

Specification

Camshaft Thrust Washer—
Thickness..... 2.24—2.34 mm (0.088—0.092 in.)

2. Replace washer if worn or damaged.

Measure Thrust Washer Thickness

RG,16,DT7176 –19–03NOV97–1/1

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Inspect and Measure Camshaft Followers

1. Inspect camshaft followers for uneven wear or damage. Also inspect corresponding camshaft lobe for wear or damage. Replace as necessary.

2. Measure follower OD and follower bore ID in cylinder block.

Specification	
Camshaft Follower—OD	17.33—17.35 mm (0.682—0.683 in.)
Camshaft Follower Bore in Block—ID	17.384—17.440 mm (0.6845—0.6865 in.)

Replace cam followers that are not within specification. Replace cylinder block if any one cam follower bore is not within specification.

RG2745 –UN–04DEC97

Inspect and Measure Camshaft Followers

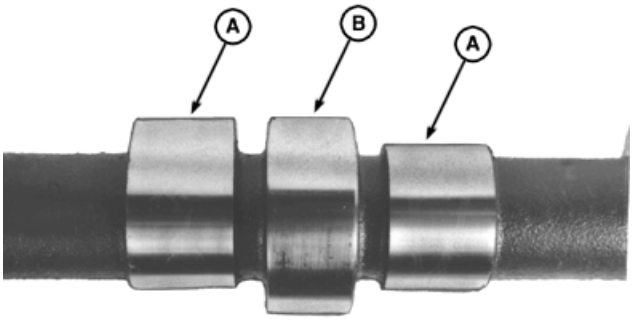
RG,16,DT7177 –19–03NOV97–1/1

Visually Inspect Camshaft

1. Clean camshaft in solvent. Dry with compressed air.

2. Visually inspect camshaft lobes (A) and journals (B) for wear or damage. Replace as necessary. New camshaft followers can be used with old camshaft (if camshaft is serviceable). DO NOT reuse old cam followers with a new camshaft.

NOTE: Very light score marks may be found, but are acceptable if valve lift is within specification. Pitting or galling dictates replacement. (See CHECK VALVE LIFT earlier in this group.)



RG3500A –UN–04DEC97

Visually Inspect Camshaft

A—Camshaft Lobes
B—Journal

RG,16,DT7178 –19–03NOV97–1/1

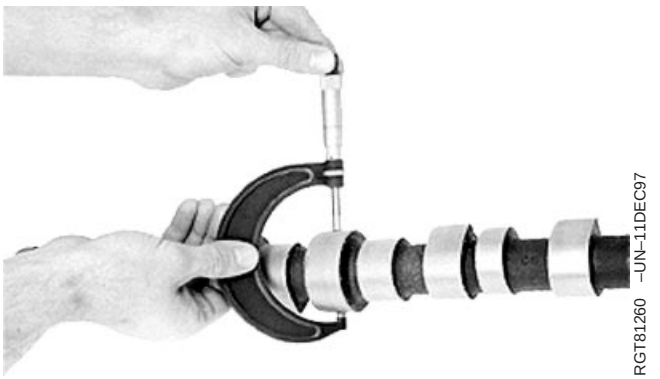
Measure Camshaft Journal OD and Bushing ID

1. Measure each camshaft journal OD. If camshaft journal OD is not within specification, install a new camshaft.
2. Measure each camshaft bushing ID when installed in cylinder block.

Compare measurements with specs given below. Replace camshaft and bushings as needed.

Specification

Camshaft Journal (New)—OD	66.987—67.013 mm (2.6373—2.6383 in.)
Camshaft Bushing (New)—ID	67.076—67.102 mm (2.6408—2.6418 in.)



Measure Camshaft Journal and Bushing

RG,16,DT7179 –19–20JAN98–1/1

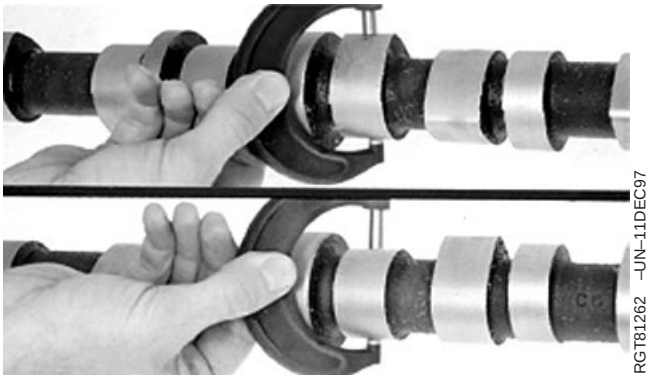
Measure Camshaft Lobe Lift

Measure each camshaft lobe at its highest point and at its narrowest point. Subtract narrowest dimension from highest dimension to find camshaft lobe lift.

If camshaft lobe lift is not within the wear specification on any one lobe, install a new camshaft.

Specification

Camshaft Lobe (New Part) (Intake)—Lift	7.69—7.79 mm (0.303—0.307 in.)
Wear Limit	7.19 mm (0.283 in.)
Camshaft Lobe (New Part) (Exhaust)—Lift	8.25—8.35 mm (0.325—0.329 in.)
Wear Limit	7.75 mm (0.305 in.)



Measure Camshaft Lobe Lift

RG,16,DT7180 –19–20JAN98–1/1

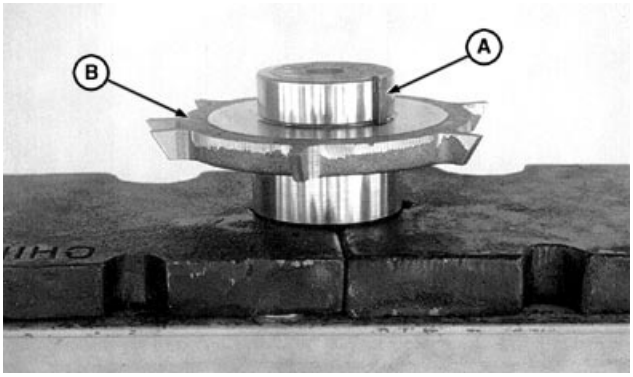
16
16

Install Camshaft Gear

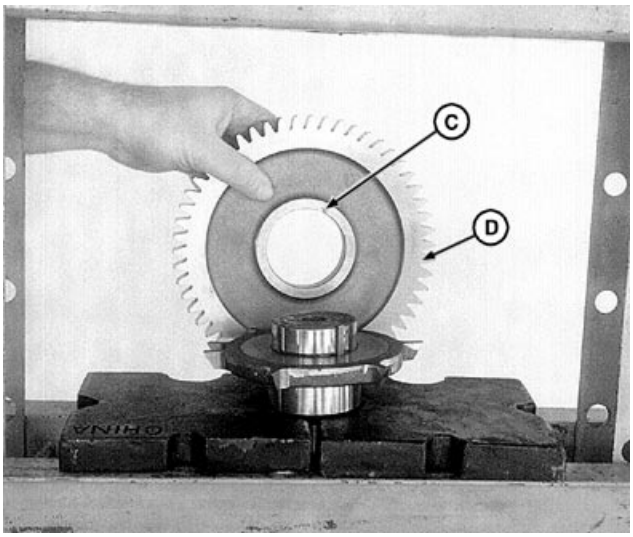
1. Support camshaft under first bearing journal in a hydraulic press.
2. Install Woodruff key (A). Lubricate camshaft nose with LOCTITE® 51048 Moly Paste.
3. Set timing wheel (B) on camshaft with thrust washer surface to the inside (toward the camshaft). Align Woodruff key and keyway.
4. Install timing wheel onto nose of camshaft. Push timing wheel on until tight against the camshaft bearing journal. Wipe off any paste remaining on camshaft nose.
5. Heat camshaft gear to 60—71°C (140—160 °F) before pressing onto shaft to prevent metal transfer.
6. Apply LOCTITE® 680 Retaining Compound to camshaft nose.
7. Set camshaft gear on camshaft with timing mark upward (away from the camshaft). Align Woodruff key and keyway (C) of camshaft gear (D).
8. Push gear onto camshaft nose until tight against timing wheel (HFN01—HFN03 engines) or spacer (HFN04 engines).
9. Support each end of the camshaft on centers. Use a dial indicator with plunger resting on the thrust surface of the timing wheel.
10. Check the runout of the timing wheel thrust surface.

Specification

Camshaft Timing Wheel Thrust Surface—Runout	0.10 mm (0.004 in.)



Set Timing Wheel on Camshaft



Install Camshaft Gear

A—Woodruff Key
B—Timing Wheel
C—Keyway
D—Camshaft Gear

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RG,16,DT7181 –19–22FEB02–1/1

Service Camshaft Bushing Using JDG602 Adapter Set

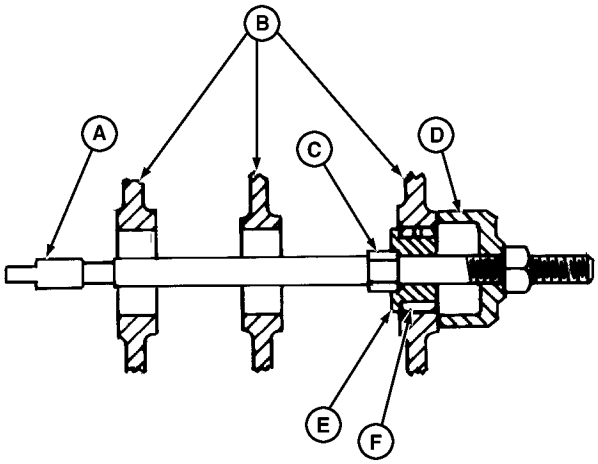
1. Inspect camshaft journals and bushings for wear or damage. Measure cam journals and bushings to determine if proper oil clearance exists. Replace camshaft and/or bushings as necessary.

Specification	
Camshaft Journal (New Part)—	
OD	66.987—67.013 mm (2.6373—2.6383 in.)
Camshaft Bushing Bore in Block (New Part)—ID	69.987—70.013 mm (2.7554—2.7564 in.)
Runout	0.038 mm (0.0015 in.)
Camshaft Bushing (New Part)—	
ID	67.076—67.102 mm (2.6408—2.6418 in.)
Camshaft Journal-to-Bushing—Oil Clearance	0.063—0.115 mm (0.0025—0.0045 in.)

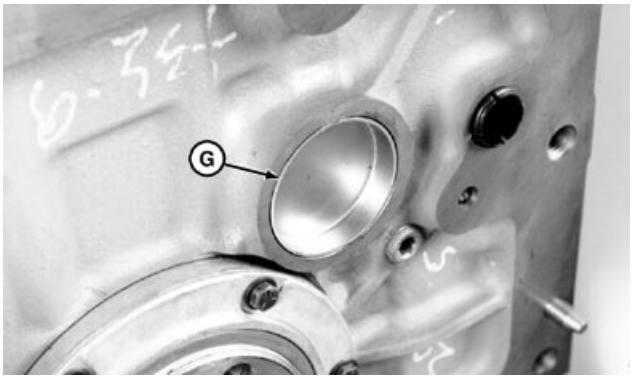
NOTE: The front two bushings can be reached from the front of the engine. The flywheel and rear camshaft bore plug (G) must be removed to reach the other two bushings.

2. Remove camshaft bushings (F) using JDG603 Bushing Driver (E) and JDG604 Receiver Cup (D) from JDG602 Adapter Set along with the components shown from JDE6 Camshaft Bushing Service Set (A and C).

3. Tighten nut on end of bushing screw until bushing is pulled out of camshaft bushing bore. Inspect and measure camshaft bushing bore in block web (B). Follow same procedure for remaining bushings to be replaced.



Inspect/Measure Camshaft Parts



Remove Bore Plug

A—Bushing Screw (JDE6-1)
B—Cylinder Block Web
C—Lock Bushing (No. 25916)
D—Receiver Cup (JDG604)
E—Bushing Driver (JDG603)
F—Camshaft Bushing
G—Camshaft Bore Plug

Continued on next page

RG,16,DT7182 –19–20JAN98–1/2

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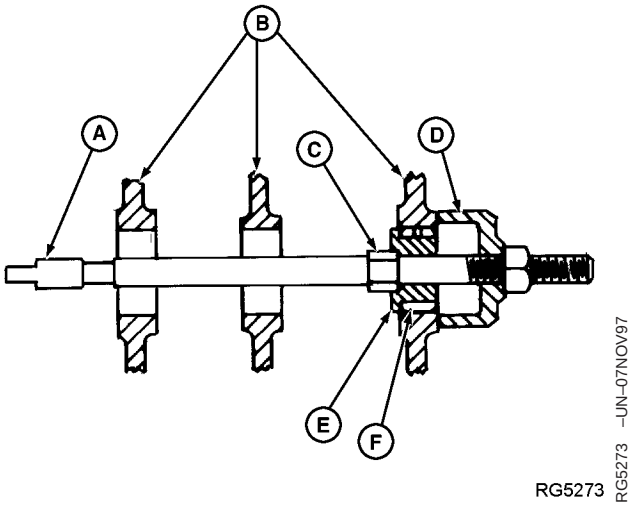
IMPORTANT: Oil holes in bushings and cylinder block must be aligned after installation or oil starvation will occur. The elongated hole in bushing must be toward the top. After installation, use a small mirror with extension to be sure oil holes are properly aligned.

4. Slide a new camshaft bushing (F) onto JDG603 Bushing Driver (E). Assemble driver and JDG604 Receiver Cup (D) along with components shown from JDE6 Camshaft Bushing Service Set (A and C).

5. Be sure bushing is started square in bore and oil holes are aligned with holes in block. Tighten nut to pull bushing in until it is properly positioned in bore.

6. Check bushing-to-cylinder block oil hole alignment using a small mirror with extension.

7. Apply PERMATEX® AVIATION (Form-A-Gasket No. 3) to new camshaft bore steel cap plug and install plug in bore. Plug edge must be seated below edge of bore.



Install Camshaft Bushings

A—Bushing Screw (JDE6-1)
B—Cylinder Block Web
C—Lock Bushing (No. 25916)
D—Receiver Cup (JDG604)
E—Bushing Driver (JDG603)
F—Camshaft Bushing

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RG,16,DT7182 –19–20JAN98–2/2

Service Camshaft Bushing Using JDG606 Adapter Set

1. Inspect camshaft journals and bushings for wear or damage. Measure camshaft journals and bushings to determine if proper oil clearance exists. Replace camshaft and/or bushing as necessary.

Specification	
Camshaft Journal (New Part)—OD	66.987—67.013 mm (2.6373—2.6383 in.)
Camshaft Bushing Bore in Block (New Part)—ID	69.987—70.013 mm (2.7554—2.7564 in.)
Runout	0.038 mm (0.0015 in.)
Camshaft Bushing (New Part)—ID	67.076—67.102 mm (2.6408—2.6418 in.)
Camshaft Journal-to-Bushing—Oil Clearance	0.063—0.115 mm (0.0025—0.0045 in.)

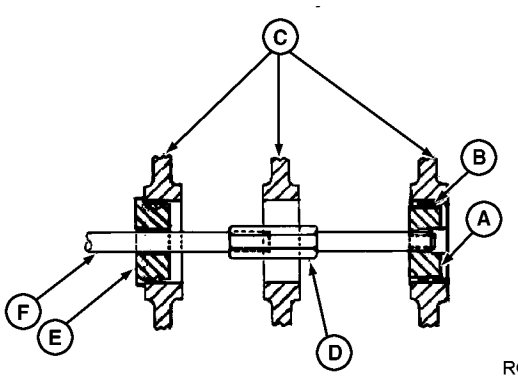
NOTE: The front two bushings can be reached from the front of the engine. The flywheel and rear camshaft bore plug (G) must be removed to reach the other two bushings.

2. Lubricate O-ring on JDG608 Bushing Pilot with clean engine oil before installing in cylinder block web (C).

3. Remove camshaft bushing (B) using JDG607 Bushing Driver (A), JDG408 Slide Hammer Adapter (D) (from JDG405 Camshaft Bushing Service Set), JDG608 Bushing Pilot (E), and D01209AA Slide Hammer (F).

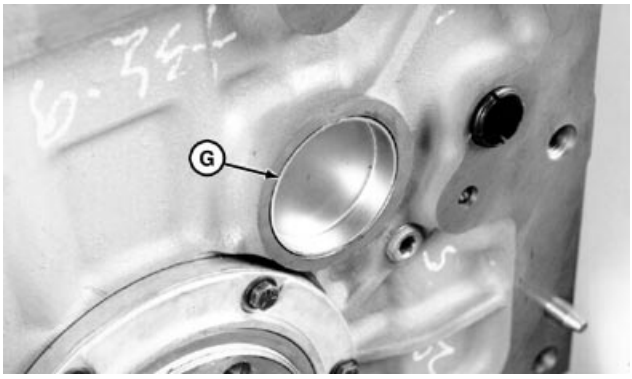
NOTE: End bushing at front and rear of cylinder block may be removed with just JDG607 Bushing Driver and D012099AA Slide Hammer.

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



RG5332 –UN–07NOV97

Camshaft Parts



RG5949A –UN–05DEC97

Remove Bore Plug

A—Bushing Driver (JDG607)
B—Camshaft Bushing
C—Cylinder Block Web
D—Slide Hammer Adapter (JDG408)
E—Bushing Pilot (JDG608)
F—Slide Hammer (D01209AA)
G—Camshaft Bore Plug

Continued on next page

RG,16,DT7183 –19–20JAN98–1/2

16
20

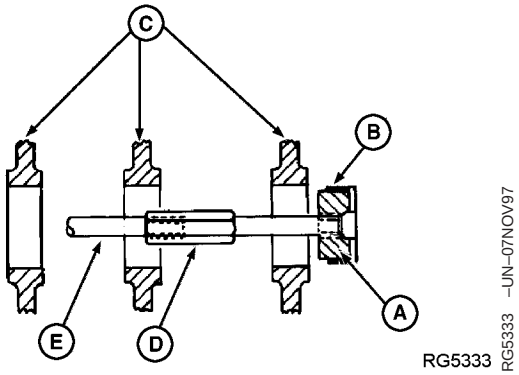
IMPORTANT: Oil holes in bushings and cylinder block must be aligned after installation. The elongated hole in bushing must be toward top. After installation, use a small mirror with extension to be sure oil holes are properly aligned.

5. Slide a new camshaft bushing (B) onto JDG607 Bushing Driver (A). With JDG608 Bushing Pilot installed in outside cylinder block web (C), assemble D01209AA Slide Hammer (E) and JDG408 Slide Hammer Adapter (D) with bushing driver as shown.

6. Be sure bushing is started square in bore and oil holes are aligned with holes in block. Pull bushing into bore with slide hammer until properly positioned.

7. Check bushing-to-cylinder block alignment using a small mirror with extension.

8. Apply PERMATEX® AVIATION (Form-A-Gasket No. 3) to new camshaft bore steel cap plug and install plug in bore. Plug edge must be seated below edge of bore.



Assemble Camshaft Components

A—Bushing Driver (JDG607)
B—Camshaft Bushing
C—Cylinder Block Web
D—Slide Hammer Adapter (JDG408)
E—Slide Hammer (D01209AA)

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RG,16,DT7183 –19–20JAN98–2/2

Install Camshaft

IMPORTANT: Set engine at TDC of No. 1 piston's compression stroke before installing camshaft so timing marks on camshaft and crankshaft gears will be aligned.

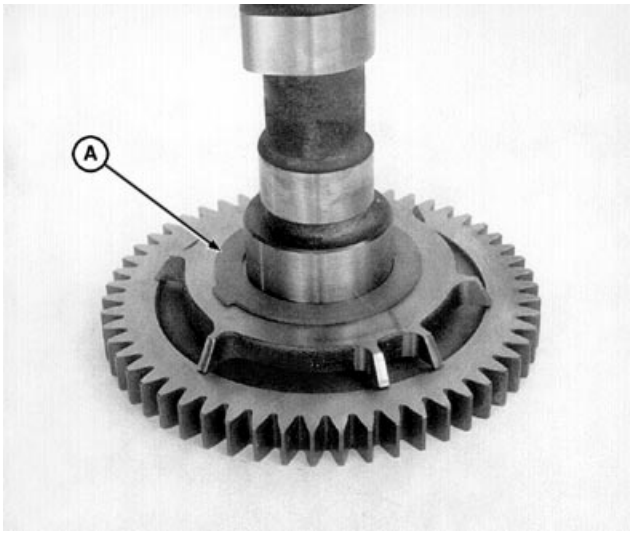
1. If camshaft followers were removed with engine on a rollover stand, reinstall followers but do not obstruct camshaft bore. Roll engine to an angle where followers fall away from camshaft bores.

NOTE: If D15001NU Magnetic Follower Holder Kit is used, hold camshaft followers away from camshaft bore until camshaft is installed.

2. Lubricate thrust washer (A) with TY6333 or TY6347 High Temperature Grease and install on camshaft behind timing wheel.

3. Lubricate camshaft lobes with TY6333 or TY6347 High Temperature Grease and bearing journals with clean engine oil.

4. Carefully install camshaft in cylinder block so that camshaft lobes do not drag in bores. Rotate camshaft during installation to avoid obstruction in any bore.



RG7824A –UN–05DEC97

Lubricate Camshaft Thrust Washer

A—Thrust Washer

RG,16,DT7184 –19–22FEB02–1/2

5. With No. 1 piston on TDC compression, align timing marks (A) on camshaft and crankshaft gears.

A—Timing Marks

RG6614 –UN–05DEC97

Align Timing Marks

RG,16,DT7184 –19–22FEB02–2/2

16
22

Install Timing Gear Cover (With Auxiliary Drive Housing Removed)

1. Lubricate both sides of the thrust washer (B) with TY6333 or TY6347 High Temperature Grease and install inside timing gear cover tabs.

2. Install a new gasket on the engine block. Apply a light film of grease to the gasket to hold it in place.

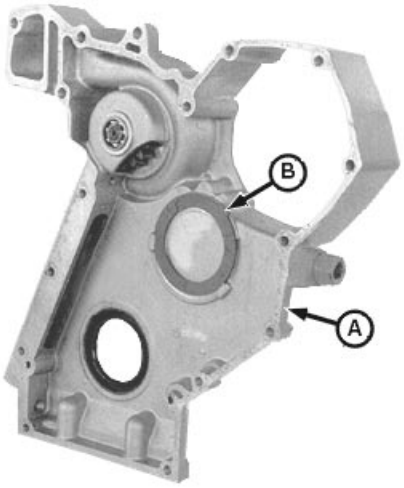
NOTE: Cap screw (7) must have a seal.

3. Install timing gear cover (A) using cap screws (3—9). Tighten cap screws by hand.

1	3/8 x 1	9	3/8 x 1-1/4	17	5/16 x 3-3/4
2	3/8 x 1	10	3/8 x 3-3/4	18	5/16 x 3-3/4
3	5/16 x 1-3/8	11	5/16 x 3-3/4	19	3/8 x 1-1/8
4	5/16 x 1-7/8	12	3/8 x 3-3/4	20	3/8 x 1-1/8
5	5/16 x 1-7/8	13	3/8 x 3-3/4	21	5/16 x 1
6	5/16 x 1-3/8	14	5/16 x 3-3/4	22	3/8 x 1
7	5/16 x 1-7/8	15	5/16 x 3-3/4	23	1/2 x 1-1/8
8	5/16 x 1-3/8	16	5/16 x 3-3/4	25	5/16 x 7/8

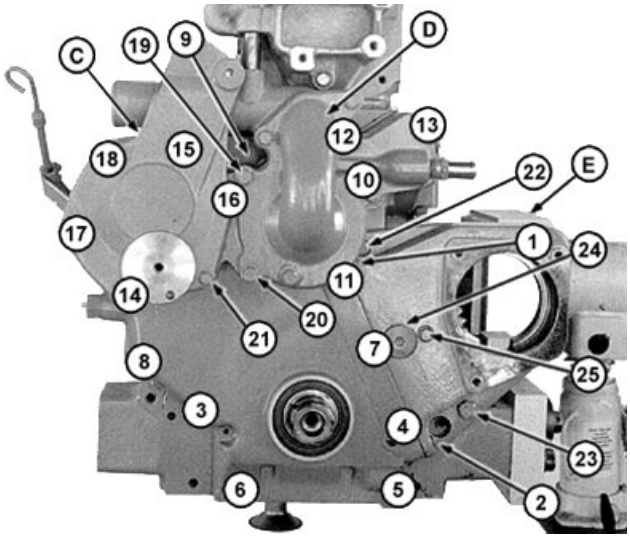
4. Using a new gasket, install the auxiliary drive housing (E) with idler gear onto the timing gear cover using cap screws (1, 2, and 22—25). (See INSTALL AUXILIARY DRIVE HOUSING AND IDLER GEAR in Group 50.) Tighten auxiliary drive housing cap screws by hand. DO NOT torque at this time.

A—Timing Gear Cover
B—Thrust Washer
C—Timing Sensor Cover
D—Coolant Pump Cover
E—Auxiliary Drive Housing



RG11148 –UN–03AUG00

Lubricate Thrust Washer



RG11149 –UN–03AUG00

HFN01—HFN03 Engines Shown. HFN04 Similar.

Continued on next page

RG,16,DT7185 –19–22FEB02–1/3

5. Torque cap screws (1—9) to specifications in sequence shown.

IMPORTANT: Tightening the timing gear cover cap screws (3—8) in proper sequence controls the total runout for the front crankshaft oil seal.

Specification

Auxiliary Drive Housing-to-Timing Gear Cover 3/8-in. Cap Screws (1, 2)—Torque ..... 41 N•m (30 lb-ft)
Timing Gear Cover-to-Cylinder Block 5/16-in. Cap Screws (3—8)—Torque ..... 27 N•m (20 lb-ft)
Timing Gear Cover-to-Cylinder Block 3/8-in. Cap Screws (9)—Torque ..... 47 N•m (35 lb-ft)

6. Install coolant pump cover (D) using a new gasket. Tighten cap screws (10—13) in sequence to specifications.

Specification

Coolant Pump Cover 5/16-in. Cap Screws (11)—Torque ..... 27 N•m (20 lb-ft)
Coolant Pump Cover 3/8-in. Cap Screws (10, 12, 13)—Torque ..... 47 N•m (35 lb-ft)

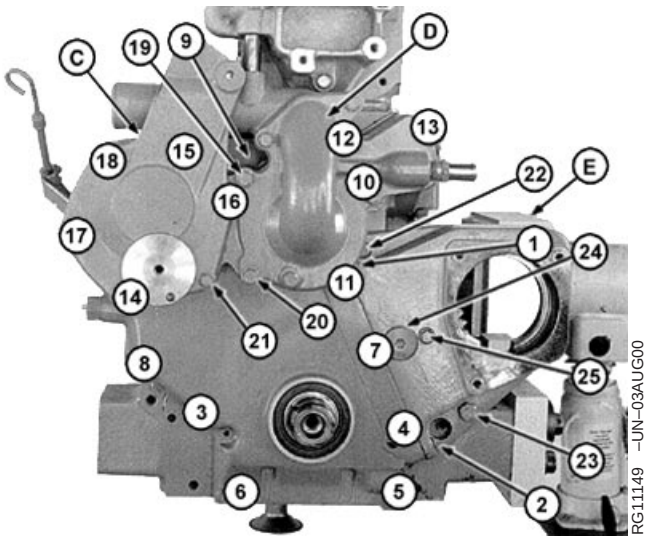
1	3/8 x 1	9	3/8 x 1-1/4	17	5/16 x 3-3/4
2	3/8 x 1	10	3/8 x 3-3/4	18	5/16 x 3-3/4
3	5/16 x 1-3/8	11	5/16 x 3-3/4	19	3/8 x 1-1/8
4	5/16 x 1-7/8	12	3/8 x 3-3/4	20	3/8 x 1-1/8
5	5/16 x 1-7/8	13	3/8 x 3-3/4	21	5/16 x 1
6	5/16 x 1-3/8	14	5/16 x 3-3/4	22	3/8 x 1
7	5/16 x 1-7/8	15	5/16 x 3-3/4	23	1/2 x 1-1/8
8	5/16 x 1-3/8	16	5/16 x 3-3/4	25	5/16 x 7/8

7. Check camshaft end play. (See CHECK CAMSHAFT END PLAY, earlier in this group.)

8. Install ignition timing sensor cover (C) using a new gasket. Tighten cap screws (14—18) in sequence to specifications.

Specification

Ignition Timing Sensor Cover 5/16-in. Cap Screws (14—18)—Torque ..... 27 N•m (20 lb-ft)



HFN01—HFN03 Engines Shown. HFN04 Similar.

C—Timing Sensor Cover
D—Coolant Pump Cover
E—Auxiliary Drive Housing

Continued on next page

9. Tighten remaining coolant pump cover cap screws (19 and 20) and ignition timing sensor cover cap screw (21) in sequence to specifications.

Specification	
Coolant Pump Cover 3/8-in. Cap Screws (19, 20)—Torque	47 N•m (35 lb-ft)
Ignition Timing Sensor Cover 5/16-in. Cap Screws (21)—Torque	27 N•m (20 lb-ft)

10. Tighten auxiliary drive cap screws (22—25) in sequence to specifications.

Specification	
Auxiliary Drive Housing-to-Cylinder Block 3/8-in. Cap Screw (22)—Torque	41 N•m (30 lb-ft)
Auxiliary Drive Housing-to-Cylinder Block 1/2-in. Cap Screws (23)—Torque	127 N•m (94 lb-ft)
Auxiliary Drive Idler Shaft Button Head Cap Screw (24)—Torque	150 N•m (110 lb-ft)
Auxiliary Drive Housing-to-Idler Shaft Bearing 5/16-in. Cap Screw (25)—Torque	27 N•m (20 lb-ft)

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

12. Using a new O-ring, install magnetic speed sensor (HFN01, 02, 03 Engines) or camshaft position sensor (HFN04 Engines) in timing gear cover, if removed.

13. If removed, install belt tensioner. Apply LOCTITE® 242 Thread Lock and Sealer to tensioner retaining cap screw. Install cap screw and tighten to specifications.

Specification	
Belt Tensioner-to-Timing Sensor Cover Cap Screw—Torque	50 N•m (37 lb-ft)

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Complete Final Assembly

1. Install a new crankshaft front wear sleeve and oil seal. (See INSTALL CRANKSHAFT FRONT OIL SEAL AND WEAR SLEEVE in Group 15.)

2. Connect the magnetic speed sensor wiring lead (HFN01—HFN03 Engines) or camshaft position sensor (HFN04 Engines).

3. Install crankshaft vibration damper. (See INSTALL CRANKSHAFT VIBRATION DAMPER in Group 15.)

4. Install valve train and rocker arm assembly. (See Group 05, Cylinder Head and Valves.)

5. Install oil pan using a new gasket (See REMOVE AND INSTALL ENGINE OIL PAN in Group 20.) Fill engine with clean engine oil.

6. Install compressor. (See INSTALL AIR COMPRESSOR in Group 50.)

7. Perform engine break-in as required. (See PERFORM ENGINE BREAK-IN in Group 04.)

RG,16,DT7186 –19–22FEB02–1/1

Other Material

Number	Name	Use
T43512 (U.S.) TY9473 (Canadian) 242 (LOCTITE®)	Thread Lock and Sealer (Medium Strength)	Apply to oil filter adapter threads.
TY6299 (U.S.)	PERMATEX® AVIATION (Form-A-Gasket No.3)	To seal oil pan.

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PERMATEX is a registered trademark of the Loctite Corp.

DPSG,OUO1004,2821 –19–31JUL00–1/1

Lubrication System Specifications

Item	Measurement	Specification
Engine Oil	Normal Operating Pressure @ 850 rpm	138 kPa (1.4 bar) (20 psi)
Engine Oil	Normal Operating Pressure @ 2200 rpm	400 kPa (4 bar) (58 psi)
Oil Pressure Regulating Valve Housing Mounting Cap Screws[1]	Torque	61 N•m (45 lb-ft)
Oil Filter Base-to-Cylinder Block Cap Screws	Torque	80 N•m (60 lb-ft)
Oil Cooler	Test Pressure	140—170 kPa (1.4—1.7 bar) (20—25 psi)
Oil Cooler Adapter Cap Screws	Torque	54 N•m (40 lb-ft)
Oil Cooler Cover Cap Screws[2]	Initial Torque	20 N•m (15 lb-ft)
Oil Cooler Cover Cap Screws[2]	Final Torque	37 N•m (27 lb-ft)
Oil Pressure Regulating Valve Spring (New)	Working Load at 66—74 N (15—17 lb force)	43.0 mm (1.69 in.)
	Free Length	85.0 mm (3.35 in.)
Oil Pressure Regulating Valve Plug	Torque	100 N•m (74 lb-ft)
Oil Pressure Regulating Valve	Operating Pressure (Starts to Operate)	340 kPa (3.4 bar) (49 psi)
Oil Filter Bypass Valve Spring (New)	Working Load at 64—78 N (14—18 lb force)	30.0 mm (1.18 in.)
	Free Length	44.0 mm (1.73 in.)
Oil Filter Bypass Valve Plug	Torque	100 N•m (74 lb-ft)
Oil Filter Bypass Valve	Operating Pressure	220 kPa (2.20 bar) (32 psi)

[1]Some early HFN01 engines may have lower grade cap screws securing regulating valve housing to block. Replace these cap screws with Grade 8 cap screws.

[2] See REMOVE, INSPECT AND INSTALL ENGINE OIL COOLER for torque sequence of cooler cover cap screws.

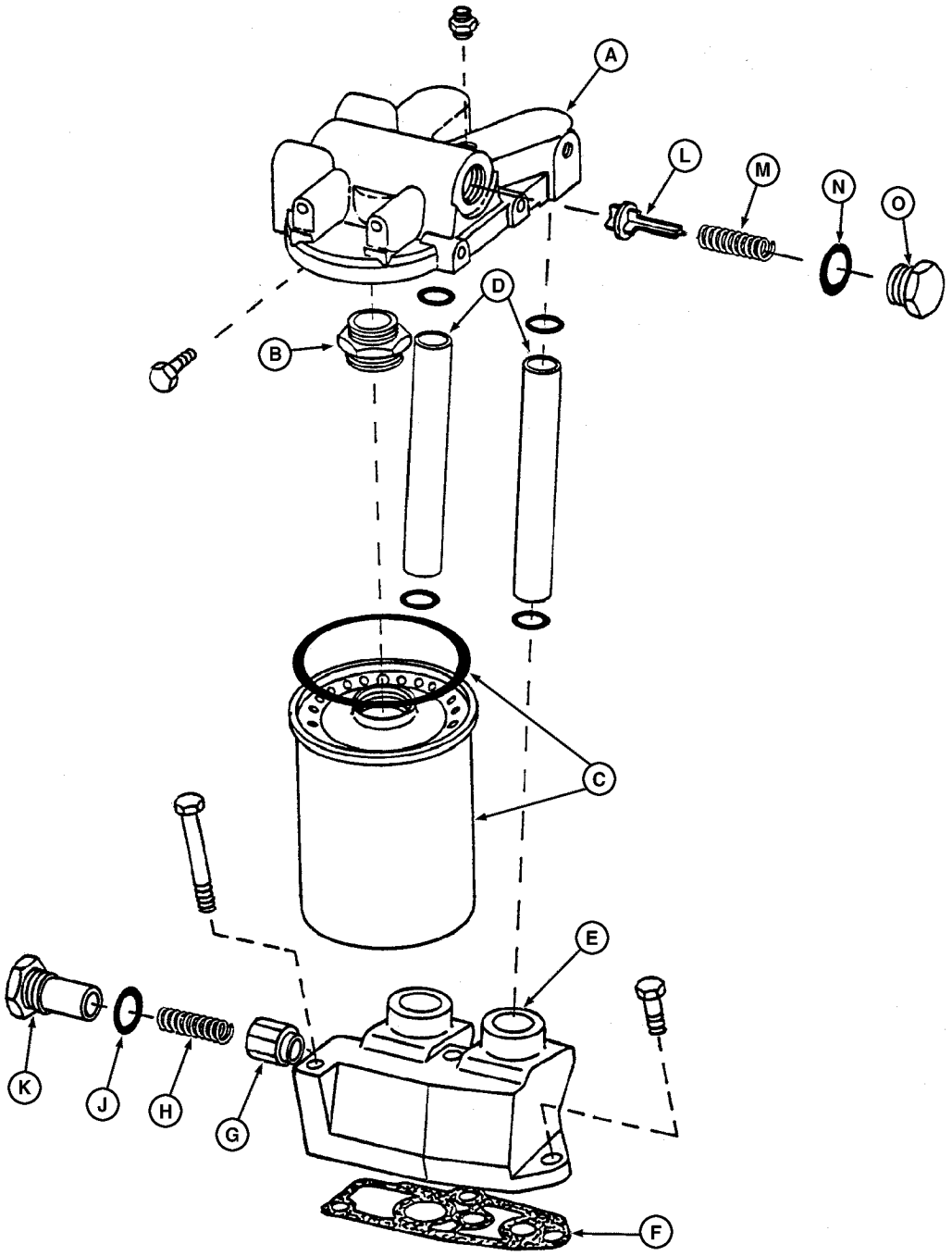
Continued on next page

Item	Measurement	Specification
Oil Cooler Bypass Valve Spring (New)	Working Load at 64—78 N (14—18 lb force)	30.0 mm (1.18 in.)
	Free Length	44.0 mm (1.73 in.)
Oil Cooler Bypass Valve Plug	Torque	100 N•m (74 lb-ft)
Oil Cooler Bypass Valve	Operating Pressure	220 kPa (2.20 bar) (32 psi)
Crankshaft Gear-to-Oil Pump Drive Gear	Backlash	0.08 mm (0.003 in.) (Minimum)
Oil Pump Drive Gear-to-Crankshaft Throw	Clearance	0.38 mm (0.0015 in.) (Minimum)
Oil Pump Drive Shaft	End Play	0.15 mm (0.006 in.) (Maximum)
Oil Pump Drive Shaft	Side Movement	0.17 mm (0.0065 in.) (Maximum)
Oil Pump Pumping Gear	Backlash	0.33—2.00 mm (0.013—0.079 in.)
Oil Pump Cover-To-Housing Cap Screws	Torque	41 N•m (30 lb-ft)
Oil Pump Set Screw Lock Nut	Torque	8 N•m (6 lb-ft) (71 lb-in.)
Oil Pump Drive Gear Nut	Torque	54 N•m (40 lb-ft)
Oil Pump Intake Tube-to-Oil Pump Cover Cap Screws	Torque	41 N•m (30 lb-ft)
Oil Pump Housing-to-Cylinder Block Cap Screws	Torque	47 N•m (35 lb-ft)
Oil Pump Outlet/Cooler Crossover Tube Adapter Cap Screws or Nuts	Torque	54 N•m (40 lb-ft)
Oil Pan 1/2-in. Cap Screws[3]	Torque	133 N•m (98 lb-ft)
Oil Pan 3/8-in. Cap Screws[3]	Torque	58 N•m (43 lb-ft)
Oil Pan Drain Plug	Torque	100 N•m (74 lb-ft)

[3] Oil pan cap screws should be torqued twice. Initially torque all 1/2-in. cap screws, then torque all 3/8-in. cap screws to specification. Next, retorque 3/8-in. cap screws, then retorque 1/2-in. cap screws to specifications.

DPSG,OUO1004,2822 –19–31JUL00–2/2

Oil Filter Base and Oil Pressure Regulating Valve Housing Assembly



RG7008 –UN–05DEC97

Oil Filter Base/Valve Housing Parts

A—Oil Filter Base
B—Oil Filter Adapter
C—Oil Filter with Packing
D—Oil Tubes
E—Oil Pressure Regulating Valve Housing
F—Gasket
G—Oil Pressure Regulating Valve
H—Spring
J—O-Ring
K—Plug
L—Oil Filter Bypass Valve
M—Spring
N—O-Ring
O—Plug

RG,20,DT7204 –19–20JAN98–1/1

Remove and Install Oil Filter Base and Oil Pressure Regulating Valve Housing

Remove Oil Filter Base and Pressure Regulating Valve Housing:

NOTE: All engine models use similar oil filter bases and oil pressure regulating valve housings. Various engine options use different accessories and hardware mounted to the oil filter base, remove as required.

1. Perform the following as required:

   •Remove wiring harness clamps as required.

   •On HFN02 engines, disconnect bracket (H), gas line clamp (J) and bracket (I).

   •If equipped, remove two cap screws (A) securing PTP/EBP manifold block to oil filter base.

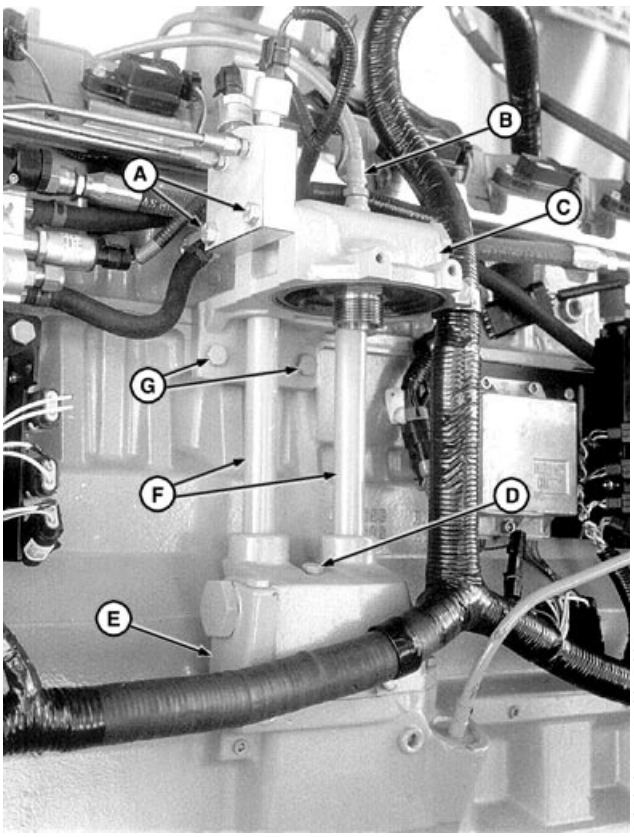
2. Disconnect turbocharger oil inlet line (B) from top of oil filter base.

3. Remove oil filter using a suitable filter wrench (shown removed).

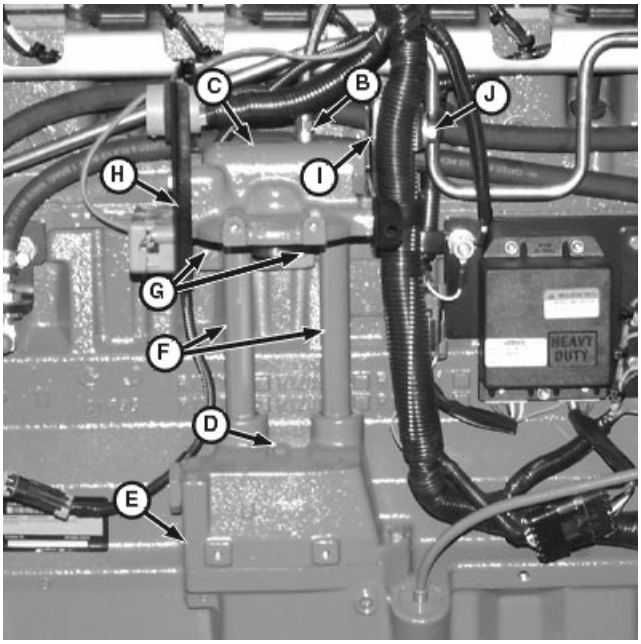
4. Remove two cap screws (G) securing oil filter base to cylinder block. Remove oil filter base (C) and oil tubes (F). Remove and discard four O-rings.

5. Remove three cap screws (D) securing oil pressure regulating valve housing (E) to cylinder block and remove housing. Clean all gasket material from both mating surfaces.

A—Cap Screw (2 used)
B—Turbocharger Oil Inlet Line
C—Oil Filter Base
D—Cap Screw (3 used)
E—Oil Pressure Regulating Valve Housing
F—Oil Tubes
G—Cap Screw (2 used)
H—Wiring Connector Bracket
I—Harness/Gas Line Bracket
J—Line Clamp



Oil Filter Base/Pressure Regulating Valve Housing (HFN01 Engine Shown) (HFN03 Similar)



Oil Filter Base/Pressure Regulating Valve Housing (HFN02 Engine Shown) (HFN04 Similar)

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Install Oil Filter Base and Pressure Regulating Valve Housing:

NOTE: Some early HFN01 engines may have lower grade cap screws securing regulating valve housing to block. Replace these cap screws with Grade 8 cap screws.

1. Install oil pressure regulating valve housing (E) using a new gasket. Tighten cap screws to specification.

Specification

Oil Pressure Regulating Valve Housing Mounting Cap Screws—Torque ..... 61 N•m (45 lb-ft)

2. Install new O-ring in regulator valve housing O-ring bores, lubricate O-rings with clean engine oil, and install oil tubes.

3. Lubricate new O-rings with clean engine oil and install in oil filter base O-ring bores. Install base onto oil tubes.

4. Position filter base (C) on cylinder block and install cap screws. Tighten cap screws to specification.

Specification

Oil Filter Base-to-Cylinder Block Cap Screws—Torque ..... 80 N•m (60 lb-ft)

5. Connect turbocharger oil inlet line at top of filter base and tighten securely.

6. If removed, use new O-rings and install oil filter bypass and oil pressure regulating valves. Tighten plugs to specification.

Specification

Oil Filter Bypass Valve Plug—Torque ..... 100 N•m (74 lb-ft)
Oil Pressure Regulating Valve Plug—Torque..... 100 N•m (74 lb-ft)

7. If oil filter adapter was removed from oil filter base, coat threads of adapter with LOCTITE® 242 Thread Lock and Sealer and install adapter.

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RG,20,DT7205 –19–08MAR02–2/3

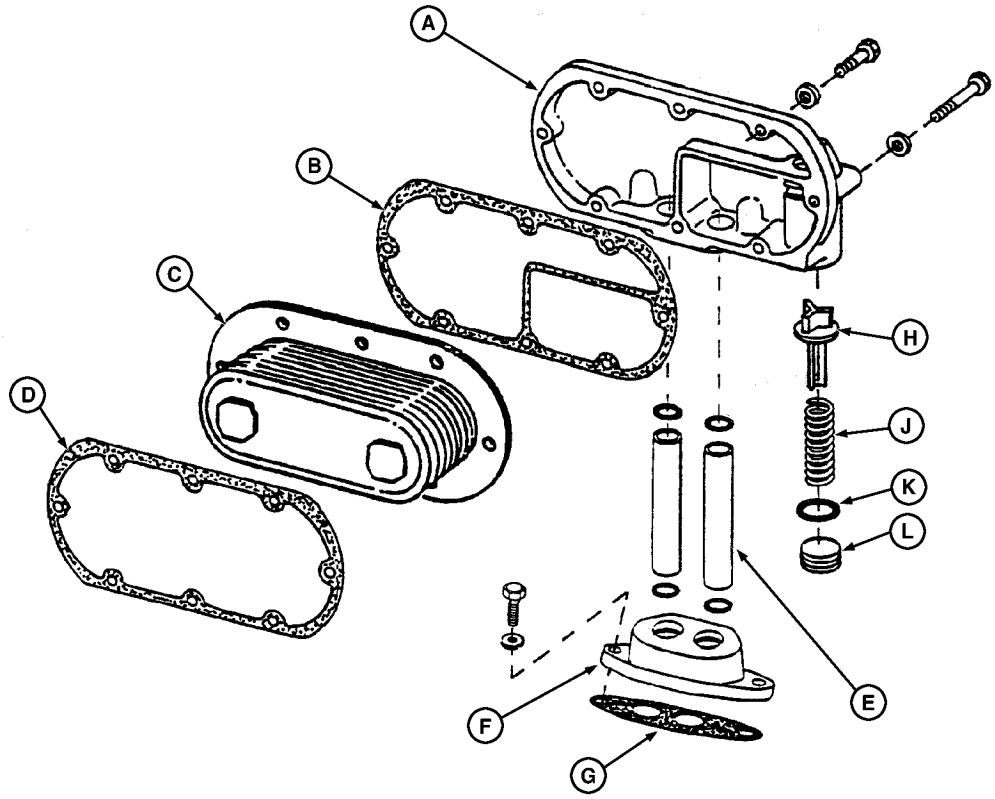
8. Spread a layer of clean engine oil on new filter packing. Install filter and tighten until packing contacts filter base. Tighten an additional 1/2—3/4 turn after packing contacts base. DO NOT overtighten oil filter.

9. If equipped, install two cap screws securing PTP/EBP manifold block to oil filter base.

10. Install wiring harness clamps, line clamps, and brackets as required.

RG,20,DT7205 –19–08MAR02–3/3

Engine Oil Cooler Assembly



Engine Oil Cooler Assembly

A—Oil Cooler Cover/Bypass Valve Housing
B—Cover-to-Cooler Gasket
C—Oil Cooler
D—Cooler-to-Block Gasket
E—Oil Cooler Tube (2 used)
F—Tube Adapter
G—Adapter-to-Block Gasket
H—Oil Cooler Bypass Valve
J—Spring
K—O-Ring
L—Plug

RG,20,DT7206 –19–04NOV97–1/1

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8

Remove, Inspect, and Install Engine Oil Cooler

See ENGINE OIL COOLER ASSEMBLY, earlier in this group, for exploded view of engine oil cooler assembly.

Remove Oil Cooler Assembly:

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

Inspect Oil Cooler Assembly:

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

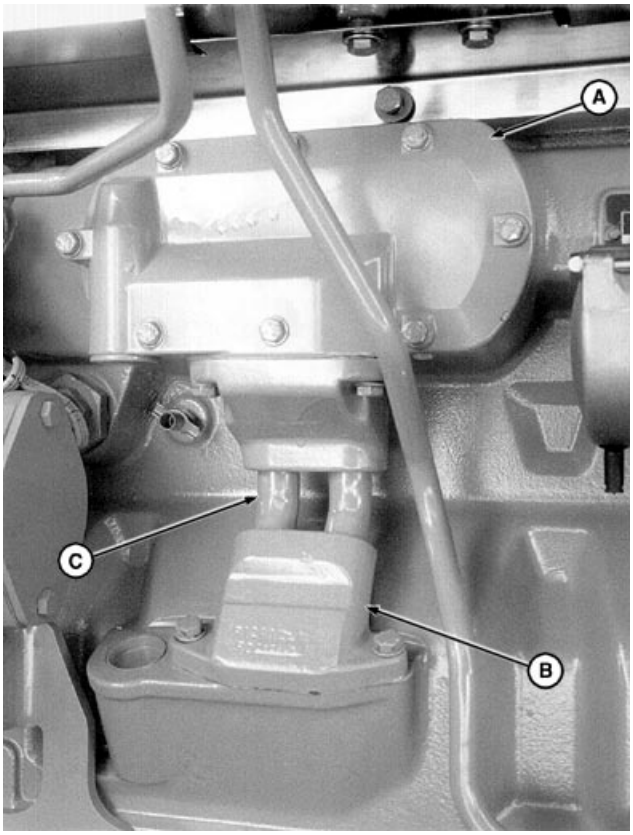
   Oil cooler should show no leakage when specified air pressure is applied for a minimum of 30 seconds.

Specification

Oil Cooler—Test Pressure ..... 140—170 kPa (1.4—1.7 bar) (20—25 psi)

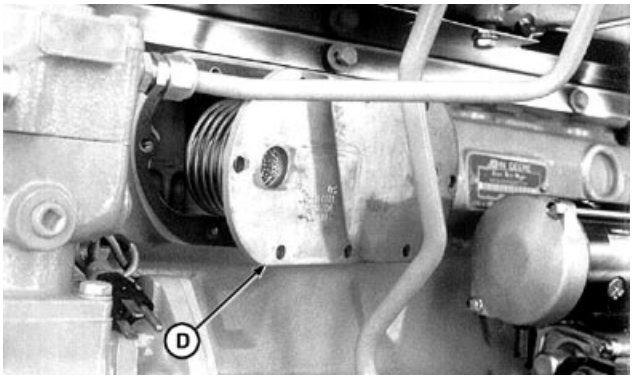
4. Inspect all remaining parts of oil cooler assembly.

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



RG7849A –UN–08DEC97

Remove Oil Cooler Cover Assembly



RG7850A –UN–08DEC97

Remove Oil Cooler

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

Continued on next page

RG,20,DT7203 –19–30MAR00–1/2

Install Oil Cooler Assembly:

1. Install oil cooler using a new gasket on each side of cooler. Be sure gaskets are properly aligned with cap screw holes.

NOTE: If cover, tubes, and adapter were disassembled, lubricate new O-rings with clean engine oil.

2. Install a new gasket on cylinder block and install oil cooler cover, tubes, and adapter as an assembly. Tighten adapter cap screws to specification.

Specification

Oil Cooler Adapter Cap Screws—
Torque ..... 54 N•m (40 lb-ft)

3. Sequentially tighten oil cooler cover (A) cap screws one through eight as shown.

   First tighten cap screws to the following specification.

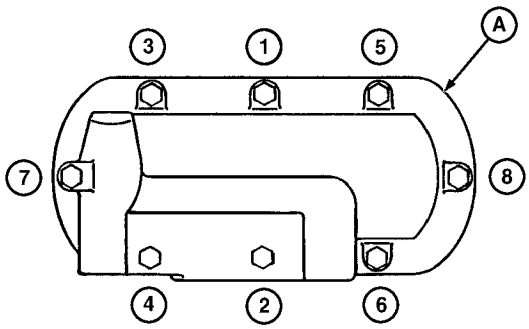
Specification

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

Next, tighten cap screws in same sequence to the following specifications.

Specification

Oil Cooler Cover Cap Screws—
Final Torque ..... 37 N•m (27 lb-ft)



Oil Cooler Cap Screw Tightening Sequence

A—Oil Cooler Cover

RG,20,DT7203 –19–30MAR00–2/2

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Remove, Inspect, and Install Oil Pressure Regulating Valve, Oil Filter Bypass Valve, and Oil Cooler Bypass Valve

See OIL FILTER BASE AND OIL PRESSURE REGULATING VALVE HOUSING ASSEMBLY earlier in this group for illustration of oil pressure regulating and filter bypass valves.

Oil Pressure Regulating Valve:

1. Remove plug (K), O-ring (J), spring (H), and oil pressure regulating valve (G) from housing (E). Discard O-ring.
2. Inspect valve and valve bore for damage. Replace if necessary.
3. Check spring for proper compression. Replace spring if not within specification.

Specification

Oil Pressure Regulating Valve Spring (New)—Working Load at 66—74 N (15—17 lb force)	43.0 mm (1.69 in.)
Free Length	85.0 mm (3.35 in.)

4. Dip all parts in clean engine oil; insert valve and spring in housing.
5. Install plug (K) using a new O-ring and tighten to specification.

Specification

Oil Pressure Regulating Valve Plug—Torque	100 N•m (74 lb-ft)

6. The pressure regulating valve starts to operate at the following specified pressure.

Specification

Oil Pressure Regulating Valve—Operating Pressure (Starts to Operate)	340 kPa (3.4 bar) (49 psi)
Engine Oil—Normal Operating Pressure @ 850 rpm	138 kPa (1.4 bar) (20 psi)
Engine Oil—Normal Operating Pressure @ 2200 rpm	400 kPa (4 bar) (58 psi)

Oil Filter Bypass Valve:

1. Remove plug (O) with O-ring (N), spring (M), and oil filter bypass valve (L) from oil filter base (A). Discard O-ring.
2. Inspect valve and housing bore for scoring or damage. Replace if necessary.
3. Check spring for proper compression. Replace spring if not within specification.

Specification

Oil Filter Bypass Valve Spring (New)—Working Load at 64—78 N (14—18 lb force)	30.0 mm (1.18 in.)
Free Length	44.0 mm (1.73 in.)

4. Dip all parts in clean engine oil; insert valve and spring in filter base.
5. Install new O-ring on plug (O). Install plug and tighten to specifiection.

Specification

Oil Filter Bypass Valve Plug—Torque	100 N•m (74 lb-ft)

6. The filter bypass valve operates at the following specified pressure.

Specification

Oil Filter Bypass Valve—Operating Pressure	220 kPa (2.20 bar) (32 psi)

Oil Cooler Bypass Valve:

See ENGINE OIL COOLER ASSEMBLY earlier in this group for illustration of oil cooler bypass valve.

1. Remove plug (L), O-ring (K), spring (J), and oil cooler bypass valve (H) from oil cooler cover/bypass valve housing (A). Discard O-ring.

Continued on next page

2. Check housing for clogged passages and all other parts for scale build-up.
3. Clean all parts with a stiff bristle brush and solvent, if necessary. Dry with compressed air.
4. Inspect bypass valve for damage. Replace if necessary.
5. Check bypass valve spring for proper compression. Replace spring if not within specification.

Specification

Oil Cooler Bypass Valve Spring (New)—Working Load at 64— 78 N (14—18 lb force)..... 30.0 mm (1.18 in.)
Free Length ..... 44.0 mm (1.73 in.)

6. Dip all parts in clean engine oil; insert valve and spring in housing bore.
7. Install new O-ring on plug (L) and tighten to specifications.

Specification

Oil Cooler Bypass Valve Plug— Torque..... 100 N•m (74 lb-ft)

8. The cooler bypass valve operates at the following specified pressure.

Specification

Oil Cooler Bypass Valve— Operating Pressure..... 220 kPa (2.20 bar) (32 psi)

RG,20,DT7202 –19–31JUL00–2/2

Check Crankshaft Gear-to-Oil Pump Drive Gear Backlash

1. Before removing oil pump, determine if there is adequate backlash between oil pump and crankshaft drive gears.
2. Mount dial indicator (A) and measure backlash between pump drive gear (B) and crankshaft gear (C). Compare reading to the following specifications.

Specification

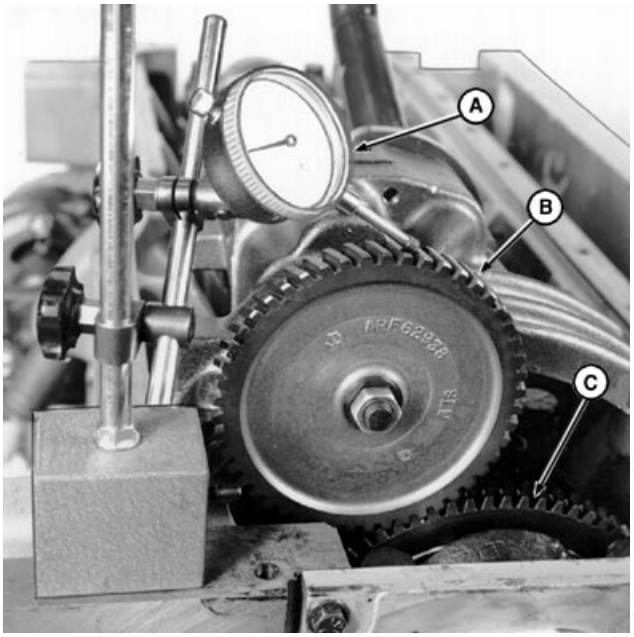
Crankshaft Gear-to-Oil Pump Drive Gear—Backlash..... 0.08 mm (0.003 in.) (Minimum)

IMPORTANT: If backlash is less than 0.08 mm (0.003 in.), replace the oil pump drive gear.

3. Check oil pump gear-to-crankshaft throw and compare to the following specifications.

Specification

Oil Pump Drive Gear-to-Crankshaft Throw— Clearance ..... 0.38 mm (0.0015 in.) (Minimum)



Checking Gear Backlash

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

RG,20,DT7198 –19–31JUL00–1/1

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Remove Engine Oil Pump

1. Remove oil pan. (See REMOVE AND INSTALL ENGINE OIL PAN in this group.)

NOTE: Some HFN03 engines are equipped with an oil pump inlet tube support bracket.

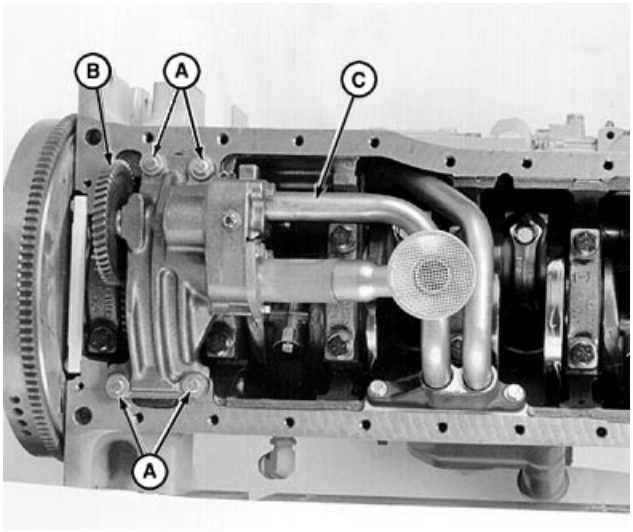
2. Disconnect oil pump inlet tube support bracket (if equipped).

3. Remove four oil pump housing cap screws (A).

NOTE: All oil pump mounting cap screws should be the same, Class 10.9. Replace lower class cap screws with 10.9 cap screws.

4. Remove oil pump assembly with drive gear (B) and oil pump outlet tube (C) attached.

5. Remove oil pump pickup tube. Clean and inspect as detailed later.



Remove Engine Oil Pump

A—Oil Pump Housing Cap Screws
B—Oil Pump Housing with Drive Gear
C—Oil Pump Outlet Tube

RG,20,DT7197 –19–30MAR00–1/1

Inspect and Clean Oil Pump

1. Visually inspect oil pump for wear or damage.

IMPORTANT: DO NOT disassemble engine oil pump for flushing, inspection, or performing wear checks. Individual components of oil pump are not available through service parts. Replace pump as a complete assembly.

Never hammer directly on oil pump housing as it could cause binding of gears.

2. Flush pump assembly internally with clean solvent to remove oil. Spin pump gears to help remove solvent.

IMPORTANT: To help ensure accurate wear measurements, be sure the oil pump is clean and faces the same way as when mounted on the cylinder block.

3. Place oil pump on a work bench with pump-to-cylinder block mounting surface facing upward (same as when mounted on engine).

NOTE: Leave pump drive gear installed when making checks which follow.

RG,20,DT7196 –19–03NOV97–1/1

Check Drive Shaft End Play

1. Mount dial indicator with indicator plunger resting against end of pump drive shaft.

2. Move shaft toward and away from indicator. Compare reading with the following specification.

Specification

Oil Pump Drive Shaft—End Play ..... 0.15 mm (0.006 in.) (Maximum)

If end play exceeds specification, there is excessive wear on the pump cover and/or wear on end of pump drive gear. Replace oil pump.

RG5916 –UN–05DEC97

Check Pump Drive Shaft End Play

RG,20,DT7195 –19–30MAR00–1/1

Check Drive Shaft Side Movement

1. Mount dial indicator with indicator plunger resting on one of the hex nut flats.

2. Move shaft from side-to-side. Compare reading with the following specification.

Specification

Oil Pump Drive Shaft—Side Movement..... 0.17 mm (0.0065 in.) (Maximum)

If shaft side movement exceeds specification, there is excessive wear on drive shaft bushing and/or drive shaft. Replace oil pump.

RG5917 –UN–05DEC97

Check Pump Drive Shaft Side Movement

RG,20,DT7194 –19–30MAR00–1/1

Check Pumping Gear Backlash

1. Mount dial indicator with indicator plunger resting against side of gear tooth.

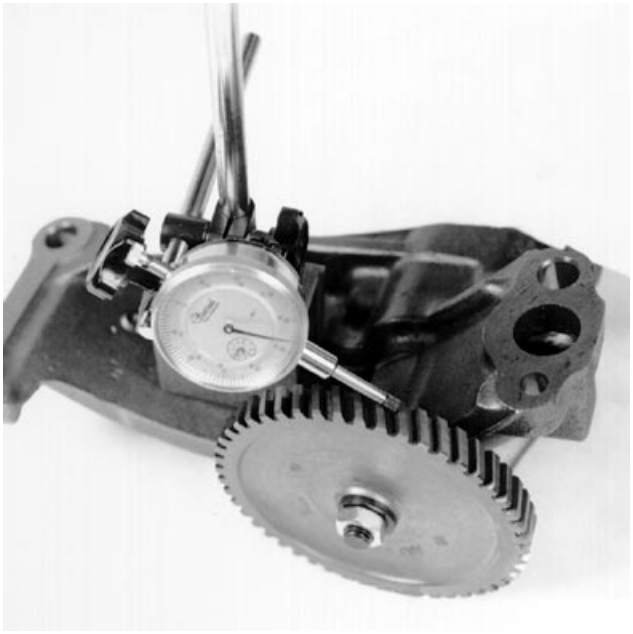
2. Hold idler gear stationary. Slowly rotate drive gear back and forth until contact with idler gear is felt. Compare reading with the following specification.

Specification

Oil Pump Pumping Gear—
Backlash ..... 0.33—2.00 mm (0.013—0.079 in.)

If backlash is not within specification, there is excessive pumping gear wear and/or idler shaft and gear bushing wear. If there is less than 0.33 mm (0.013 in.) backlash, re-clean gears and check backlash again.

3. Replace oil pump if pumping gear backlash exceeds 2.00 mm (0.079 in.).



RG5918 –UN–05DEC97

Check Pumping Gear Backlash

RG,20,DT7193 –19–30MAR00–1/1

Inspect Oil Pump Drive Gear

NOTE: Oil pump does not need to be removed from engine when inspecting drive gear.

Inspect drive gear teeth for chips, cracks, or wear. Replace as necessary.

RG6435 –UN–05DEC97

Inspect Oil Pump Drive Gear

RG,20,DT7192 –19–03NOV97–1/1

Adjust Oil Pump Set Screw

IMPORTANT: Normally the set screw (A) should NOT be adjusted; but if the set screw is altered, the following steps should be followed.

1. Assemble drive gear and idler gear into pump housing.
2. Install oil pump cover (B) and tighten cover-to-housing cap screws to specification.

Specification

Oil Pump Cover-To-Housing Cap Screws—Torque ..... 41 N•m (30 lb-ft)

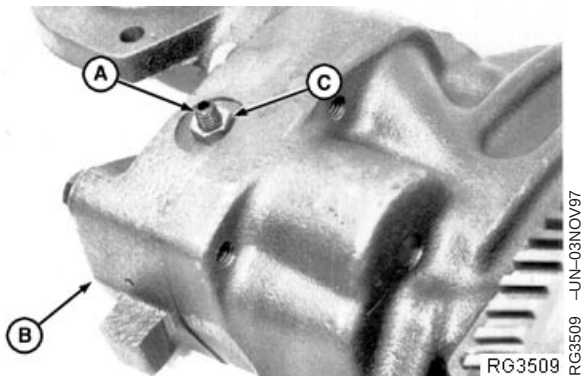
3. Tighten set screw until it contacts idler shaft.
4. Continue to hold set screw and tighten lock nut (C) specification.

Specification

Oil Pump Set Screw Lock Nut—Torque ..... 8 N•m (6 lb-ft) (71 lb-in.)

Do not overtighten set screw or lock nut.

5. Spin drive gear by hand to ensure shaft turns freely in housing. Readjust set screw if shaft does not turn freely.



Adjust Oil Pump Set Screw

A—Set Screw
B—Oil Pump Cover
C—Lock Nut

RG,20,DT7191 –19–03NOV97–1/1

Install Engine Oil Pump

1. Clamp oil pump drive gear (B) in a soft-jawed vise and install drive gear onto oil pump, if removed. Tighten mounting nut to specification.

Specification

Oil Pump Drive Gear Nut—
Torque ..... 54 N•m (40 lb-ft)

2. Using a new gasket, install oil pump intake (pickup) tube onto oil pump cover and tighten cap screws to specification, if removed.

Specification

Oil Pump Intake Tube-to-Oil
Pump Cover Cap Screws—
Torque ..... 41 N•m (30 lb-ft)

NOTE: Lubricate new O-rings with clean engine oil when installing oil pump outlet tube (C) into oil pump and oil cooler (tube) adapter.

3. Install oil pump-to-oil cooler adapter tube into oil cooler adapter.

4. Install oil pump assembly on other end of oil pump-to-oil cooler adapter tube.

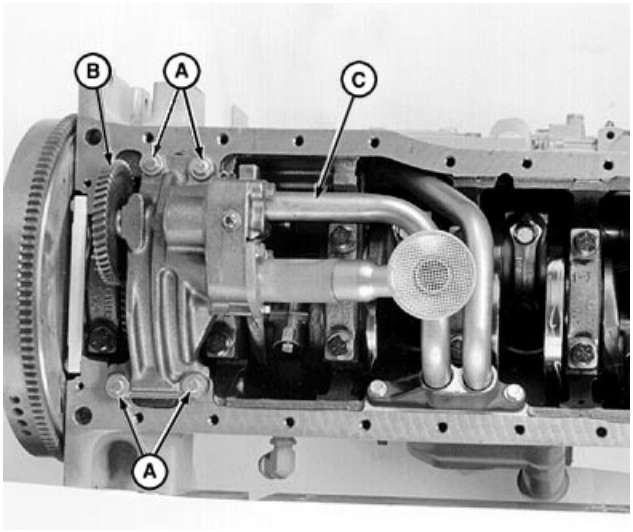
5. Rotate oil pump assembly into position over locating dowels in cylinder block.

IMPORTANT: Do not hammer directly on oil pump housing as it could cause binding of gears.

6. Seat pump onto dowels using a hard rubber hammer; be sure drive gear is properly meshed with crankshaft gear and oil pump outlet tube is properly positioned in O-ring bores.

NOTE: All oil pump mounting cap screws should be the same, Class 10.9. Replace lower class cap screws with 10.9 cap screws.

7. Install and tighten oil pump housing-to-cylinder block cap screws (A) to specification.



RG7220 –UN–05DEC97

Install Engine Oil Pump

A—Oil Pump Housing-to-Cylinder Block Cap Screws
B—Oil Pump Drive Gear
C—Oil Pump Outlet Tube

Continued on next page

Specification	
Oil Pump Housing-to-Cylinder Block Cap Screws—Torque	47 N•m (35 lb-ft)

8. Install oil pump inlet tube support bracket (if equipped).

9. Install oil pan. (See REMOVE AND INSTALL ENGINE OIL PAN in this group.)

RG,20,DT7190 –19–30MAR00–2/2

Remove and Install Oil Pump Outlet Tube and Oil Cooler Crossover Tube Adapter

Remove Adapter

1. Remove engine oil pump (shown removed). (See REMOVE ENGINE OIL PUMP, earlier in this group.)

NOTE: Some HFN03 engines are equipped with an oil pump inlet tube support bracket. This bracket is connected to the inlet tube and the crossover tube adapter. In these applications, the adapter uses mounting studs with lock nuts instead of cap screws.

2. Remove two cap screws (or nuts) securing adapter (A) to cylinder block and remove adapter with oil cooler crossover tube (B).

3. Clean all gasket material from mating surfaces and discard.

Install Adapter

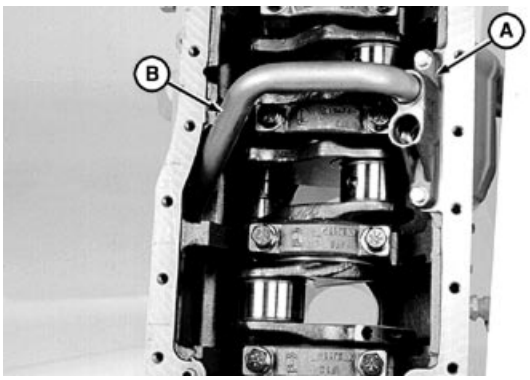
NOTE: Be sure gasket is positioned so that offset matches adapter to avoid blocking oil passage.

1. Lubricate new O-ring with clean engine oil and install adapter (with crossover tube) using a new gasket. Make sure tubes are properly positioned in each O-ring bore.

2. Tighten cap screws (or nuts) to specification.

Specification	
Oil Pump Outlet/Cooler Crossover Tube Adapter Cap Screws or Nuts—Torque	54 N•m (40 lb-ft)

3. Install engine oil pump assembly. (See INSTALL ENGINE OIL PUMP, earlier in this group.)



RG7221 –UN–05DEC97

Remove and Install Adapters

A—Adapter
B—Oil Cooler Crossover Tube

RG,20,DT7189 –19–20JAN98–1/1

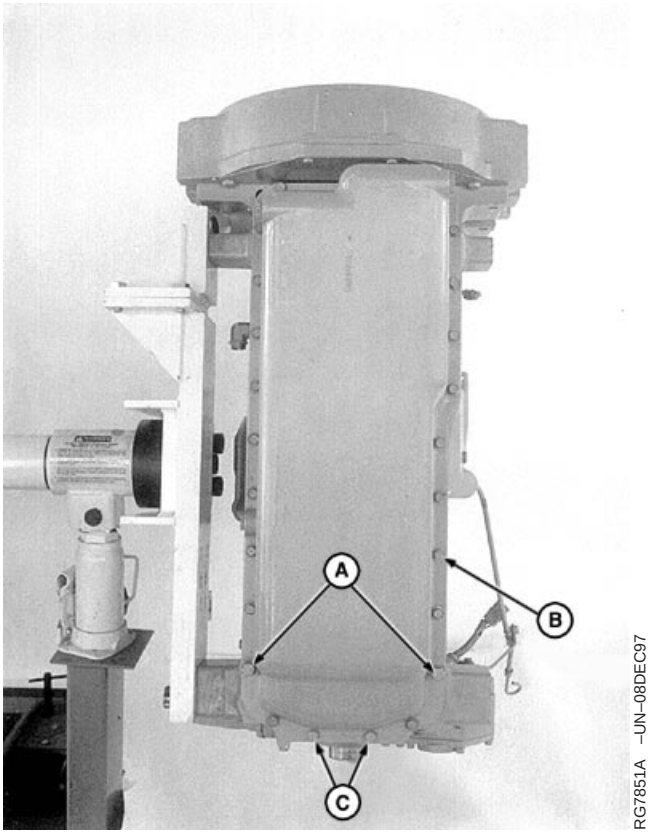
Remove and Install Engine Oil Pan

1. Drain engine oil.
2. Remove cap screws (A, B and C), lock washers and washers.
3. Remove engine oil pan. Discard gasket.

NOTE: All oil pan and cylinder block (including timing gear cover and rear seal housing) gasket sealing surfaces MUST BE free of gasket material or oil, and must be dry.

4. Apply a thin layer of PERMATEX® AVIATION (Form-A-Gasket No. 3, TY6299) at timing gear cover-to-cylinder block mating surface.
5. Apply a thin layer of PERMATEX® AVIATION (Form-A-Gasket No. 3, TY6299) at rear oil seal housing-to-cylinder block mating surface.

A—1/2 Inch Cap Screw (2 used)
B—3/8 x 1-5/8 Inch Cap Screw (20 used)
C—3/8 x 2 Inch Cap Screw (2 used)



Remove Engine Oil Pan

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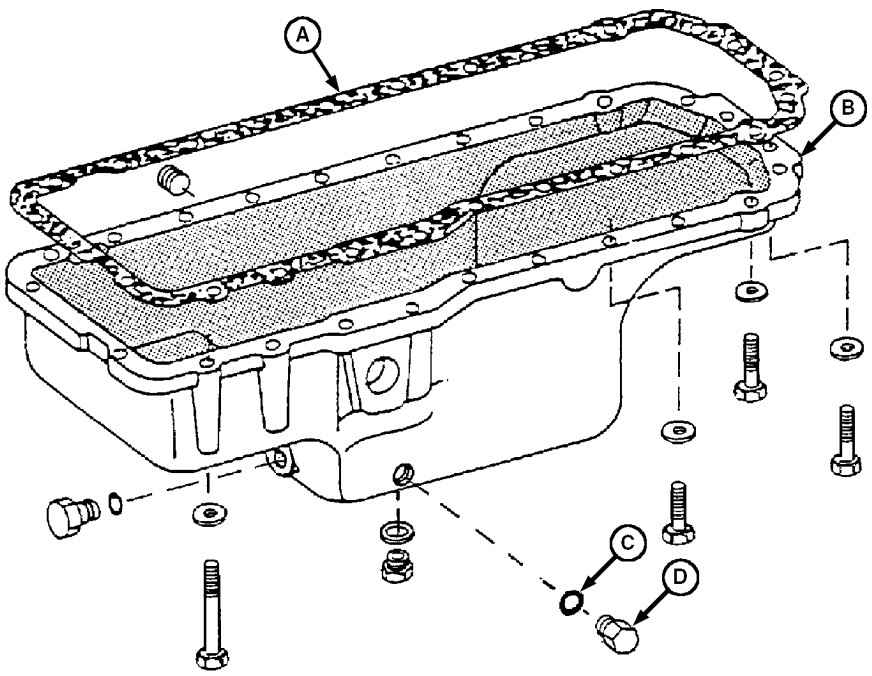
RG,20,DT7188 –19–30MAR00–1/3



RG9544 –UN–30APR99

Install Engine Oil Pan

A—Oil Pan Gasket **B—Oil Pan** **C—O-Ring** **D—Drain Plug**

6. Position new oil pan gasket (A) on cylinder block.

7. Apply a thin layer of PERMATEX® AVIATION (Form-A-Gasket No. 3, TY6299) to gasket at same location as cylinder block in steps 4 and 5 above.

NOTE: Locate rear of oil pan flush to ±0.05 mm (0.002 in.) with rear face of cylinder block.

IMPORTANT: Oil pan cap screws should have only one flat washer and no lock washer. On early engines that have both flat washers and lock washers, discard them and replace with new hardened flat washers.

8. Carefully install oil pan (B) on cylinder block and tighten all oil pan-to-cylinder block cap screws as follows:

   a. First tighten 1/2-in. cap screws to specification.

Specification

Oil Pan 1/2-in. Cap Screws—
Torque..... 133 N•m (98 lb-ft)

   b. Next tighten 3/8-in. cap screws to specification.

Specification

Oil Pan 3/8-in. Cap Screws—
Torque..... 58 N•m (43 lb-ft)

9. Trim oil pan gasket flush at rear surface of cylinder block and oil pan.

10. Retighten oil pan cap screws as follows:

   a. First retighten 3/8-in. cap screws to specification.

Specification

Oil Pan 3/8-in. Cap Screws—
Retorque ..... 58 N•m (43 lb-ft)

   b. Next retighten 1/2-in. cap screws to specification.

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RG,20,DT7188 –19–30MAR00–2/3

Specification

Oil Pan 1/2-in. Cap Screws—
Retorque ..... 133 N•m (98 lb-ft)

NOTE: On oil plugs with aluminum washers, install washer on plug so raised center of washer faces head of plug.

11. Install pan drain plug (D) using new O-ring (C) and tighten to specification.

Specification

Oil Pan Drain Plug—Torque ..... 100 N•m (74 lb-ft)

RG,20,DT7188 –19–30MAR00–3/3

Essential Tools

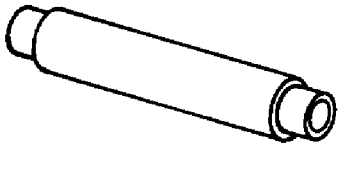
NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

SERVICEGARD is a trademark of Deere & Company

DPSG,OUO1004,2823 –19–01AUG00–1/2

Coolant Bypass Tube Seal Driver JDG908

Used to install bypass tube seal in coolant pump inlet and coolant manifold.



RG5120 –UN–05DEC97

JDG908

DPSG,OUO1004,2823 –19–01AUG00–2/2

Other Material

Number	Name	Use
T43512 (U.S.) TY9473 (Canadian) 242 (LOCTITE®)	Thread Lock and Sealer (Medium Strength)	Coolant manifold-to-cylinder head cap screws and belt tensioner retaining cap screw.

LOCTITE is a registered trademark of the Loctite Corp.

DPSG,OUO1004,2825 –19–01AUG00–1/1

Specifications

Item	Measurement	Specification
Upper Belt Guard-to-Thermostat Housing Cap Screws	Torque	41 N•m (30 lb-ft)
Lower Belt Guard-to-Auxiliary Drive Housing Cap Screws	Torque	41 N•m (30 lb-ft)
Lower Belt Guard-to-Finger Guard Cap Screws	Torque	35 N•m (26 lb-ft)
Finger Guard-to-Timing Sensor Cover Cap Screws	Torque	24 N•m (18 lb-ft)
Belt Tensioner Spring Tension	Torque	24—28 N•m (18—21 lb-ft)
Coolant Pump Cover 3/8-in. Cap Screws	Torque	47 N•m (35 lb-ft)
Coolant Pump Cover 5/16-in. Cap Screws	Torque	27 N•m (20 lb-ft)
Belt Tensioner Mounting Cap Screw	Torque	50 N•m (37 lb-ft)
Thermostat 89°C (192°F)	Opening Temperature	89—100°C (192—212°F)
Thermostat Cover Cap Screws	Torque	47 N•m (35 lb-ft)
Coolant Manifold Cap Screws	Torque	35 N•m (25 lb-ft)
Coolant Heater Flange Nut in Cylinder Block	Torque	68 N•m (50 lb-ft)
Coolant Heater Lock Nut	Torque	34 N•m (25 lb-ft)

DPSG,OUO1004,2826 –19–15APR02–1/1

Diagnosing Cooling System Malfunctions

Engine Overheats:

- Loose or broken fan belt
- Dirty radiator
- Low coolant level
- Low oil level
- Engine overload
- Defective head gasket
- Faulty thermostats
- Faulty coolant pump
- Corroded coolant passages

Low Coolant Level:

- Improper maintenance
- Improper operation
- Damaged radiator
- Coolant pump seal leakage
- Leakage
- Faulty radiator cap

Coolant Pump Failure (Due to Cavitation):

- Improper coolant mixture
- Collapsed radiator hose
- Plugged radiator tubes
- Faulty or improperly rated radiator cap

RG,25,DT7208 –19–15APR02–1/1

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4

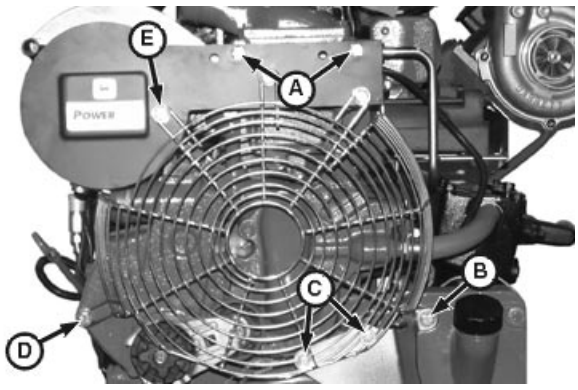
Remove and Install Belt Guard Assembly

1. Remove mounting cap screws (A, B and D) to remove upper and lower guards and finger guard as an assembly.
2. Replace parts as necessary.
3. Position belt guard assembly onto front of engine. Install two cap screws and spacers (A) into thermostat housing threaded locations.
4. Install remaining belt guard mounting cap screws and tighten all cap screws to specification.

Specification

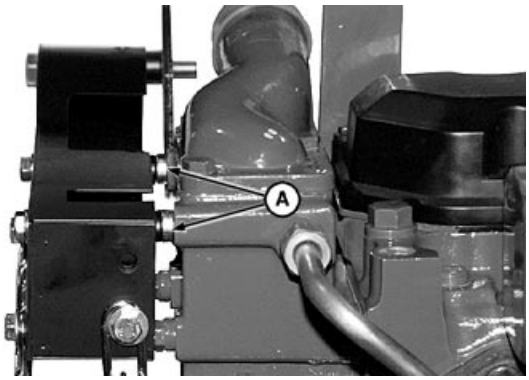
Upper Belt Guard-to-Thermostat Housing Cap Screws—Torque	41 N•m (30 lb-ft)
Lower Belt Guard-to-Auxiliary Drive Housing Cap Screws—Torque	41 N•m (30 lb-ft)
Lower Belt Guard-to-Finger Guard Cap Screws—Torque	35 N•m (26 lb-ft)
Finger Guard-to-Timing Sensor Cover Cap Screws—Torque	24 N•m (18 lb-ft)

A—Upper Belt Guard-to-Thermostat Housing Cap Screws with Spacers
B—Lower Belt Guard-to-Auxiliary Drive Housing Cap Screws
C—Lower Belt Guard-to-Finger Guard Cap Screws
D—Finger Guard-to-Timing Sensor Cover Cap Screws
E—Finger Guard-to-Upper Belt Guard Cap Screws



RG10583A –UN–24FEB00

Remove Belt Guard



RG8678B –UN–11DEC97

Install Spacers

TX,25,LG96 –19–15APR02–1/1

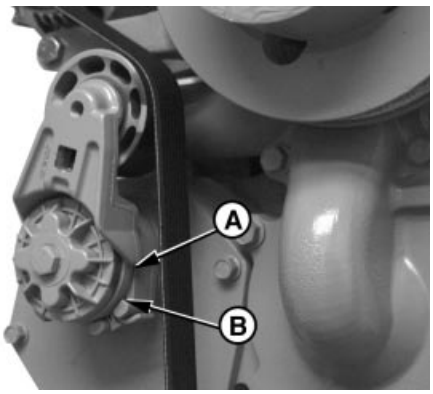
Checking Belt Tensioner

Belt drive systems equipped with automatic (spring) belt tensioners cannot be adjusted or repaired. The automatic belt tensioner is designed to maintain proper belt tension over the life of the belt. If tensioner spring tension is not within specification, replace tensioner assembly.

Checking Belt Wear

The belt tensioner is designed to operate within the limit of arm movement provided by the cast stops (A and B) when correct belt length and geometry are used.

1. Visually inspect cast stops (A and B) on belt tensioner assembly.
2. If the tensioner cast stop (A) on swing arm is hitting the fixed cast stop (B), check mounting brackets (alternator, belt tensioner, idler pulley, etc.) and the belt length. Replace belt as needed.



Cast Stops

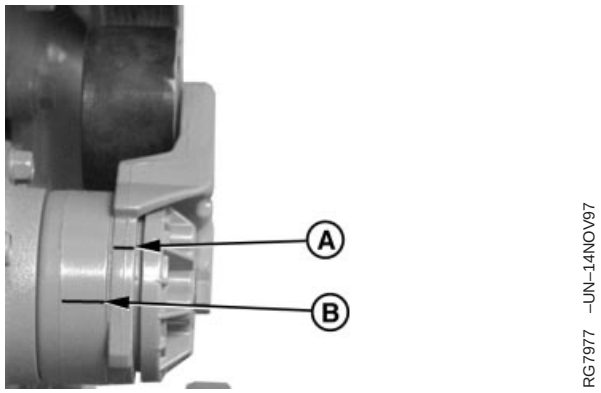
A—Tensioner Cast Stop
B—Fixed Cast Stop

DPSG,OUO1004,2866 –19–28AUG00–1/3

Checking Tensioner Spring Tension

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

1. Release tension on belt using a 12.7 mm (1/2-in.) long-handle breaker bar in tension arm. Remove belt from pulleys.
2. Release tension on tension arm and remove breaker bar.
3. Put a mark on swing arm (A) of tensioner as shown.
4. Measure 21 mm (0.83 in.) from mark (A) and put a mark on tensioner mounting base (B).



Marks on Swing Arm and Mounting Base

A—Mark on Swing Arm
B—Mark on Mounting Base

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DPSG,OUO1004,2866 –19–28AUG00–2/3

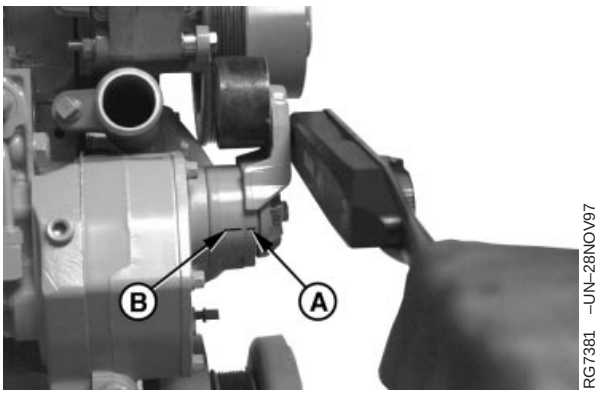
5. Rotate the swing arm using a torque wrench until marks (A and B) are aligned.

6. Record torque wrench measurement and compare with specification below. Replace tensioner assembly as required.

Specification

Belt Tensioner Spring Tension—
Torque ..... 24—28 N•m (18—21 lb-ft)

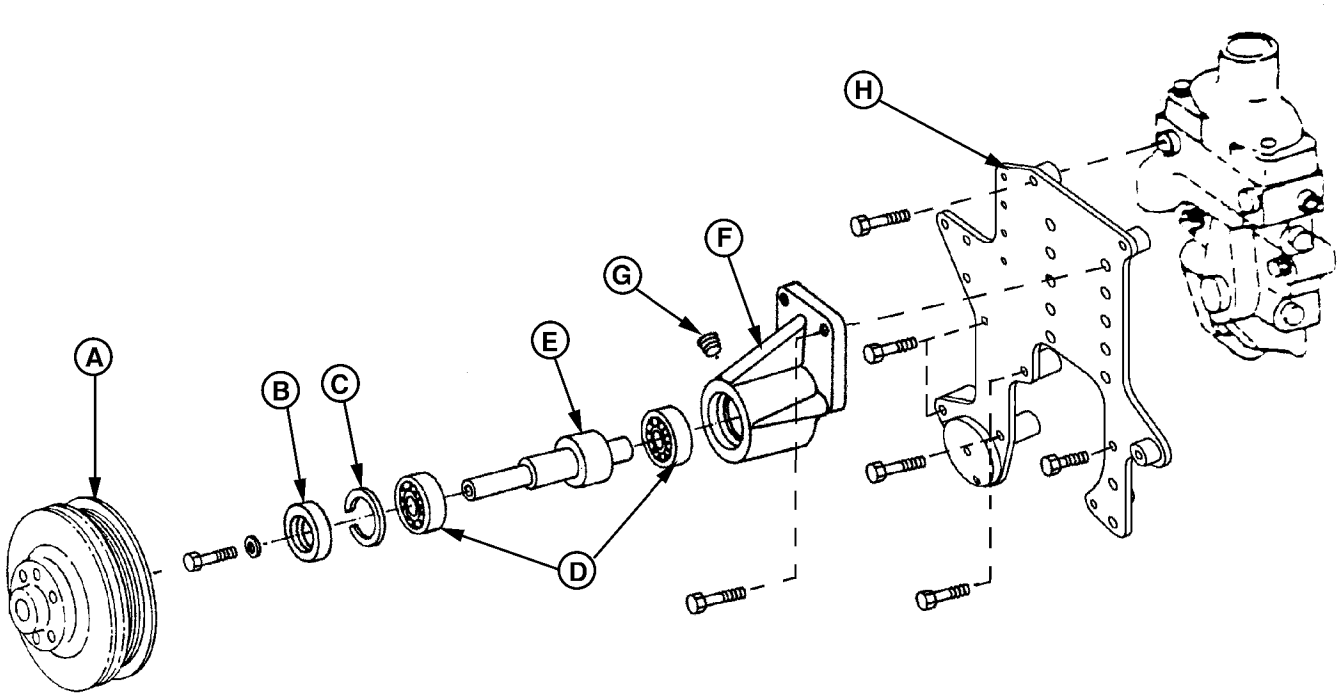
A—Mark on Swing Arm
B—Mark on Mounting Base



Align Marks

DPSG,OUO1004,2866 –19–28AUG00–3/3

Replace Bearings in Heavy-Duty, Adjustable Fan Drive Assembly



RG8754 –UN–02DEC97

Heavy-Duty Adjustable Fan Drive Assembly

A—Fan Hub/Pulley
B—Grease Seal
C—Snap Ring
D—Ball Bearing (2 Used)
E—Shaft
F—Bearing Housing
G—Pipe Plug
H—Support Plate

To Disassemble Fan Drive:

1. Remove belts and remove fan. Remove fan drive assembly from engine.
2. Clamp fan hub/pulley (A) in a soft-jawed vise. Support fan hub (so it does not fall to floor), and remove cap screw securing hub to shaft (E). Remove fan hub.
3. Remove pipe plug (G), grease seal (B), and snap ring (C). Discard seal and snap ring.
4. Remove shaft with bearings (D) by lightly tapping with a rubber mallet or brass hammer.
5. Remove bearings from shaft using a press and discard bearings.
6. Thoroughly clean and inspect shaft and bearing housing (F) for cracks or any other damage. Measure parts and compare with specifications given below.

	Specification
Adjustable Fan Drive Housing—ID	71.999—72.025 mm (2.8346—2.8356 in.)
Adjustable Fan Drive Shaft—OD	35.001—35.017 mm (1.3780—1.3786 in.)
Adjustable Fan Drive Bearing—ID.	34.987—35.013 mm (1.3774—1.3785 in.)
OD	71.987—72.013 mm (2.8341—2.8351 in.)

Replace parts that are cracked or not within specification.

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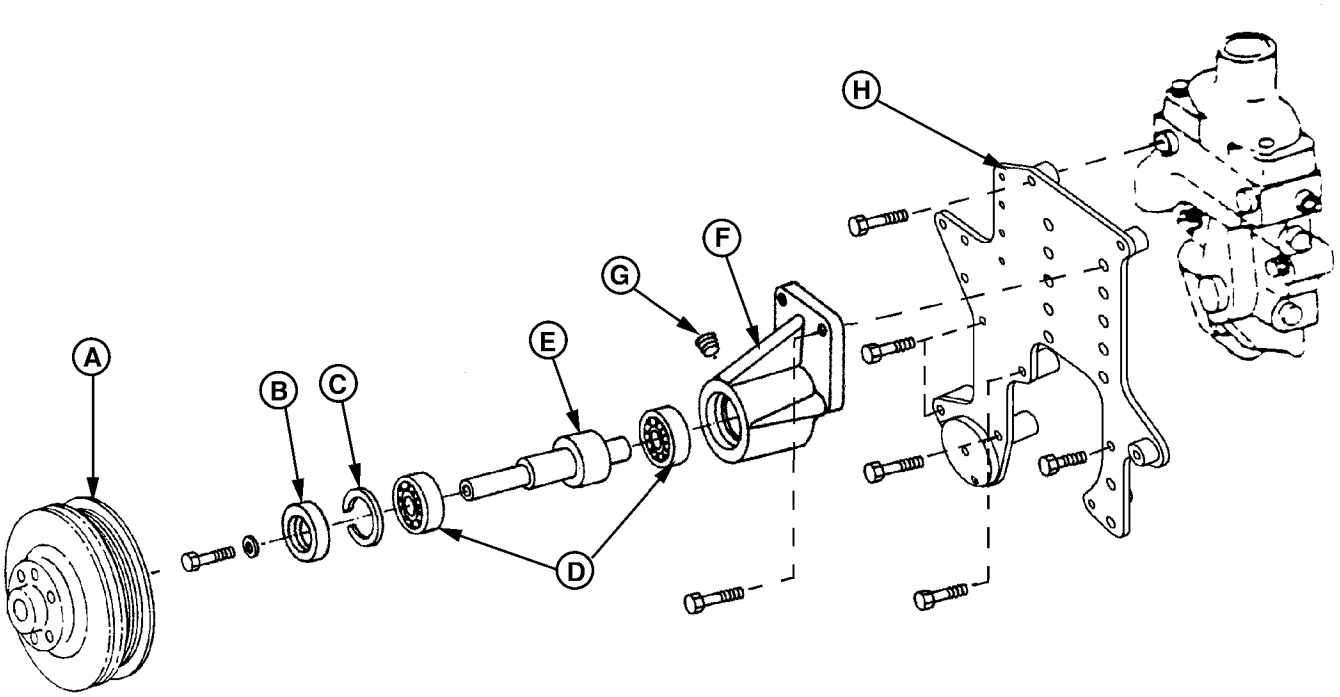

RG8754 –UN–02DEC97

Heavy-Duty Adjustable Fan Drive Assembly

A—Fan Hub/Pulley
B—Grease Seal
C—Snap Ring
D—Ball Bearing (2 Used)
E—Shaft
F—Bearing Housing
G—Pipe Plug
H—Support Plate

To Assemble Fan Drive:

1. Pack inner and outer bearings (D) with TY6333 or TY6347 High Temperature Grease. Apply clean engine oil to bearing I.D. and shaft O.D.

2. Support end of shaft (E) and install bearings against shoulder. *Apply force to bearing inner race only*.

3. Support bearing housing (F) on a firm flat surface with bearing bore in the upward position.

4. Install bearing and shaft assembly into housing. Small end of shaft should extend through housing.

5. Determine proper snap ring (C) thickness needed to obtain specified end play.

Specification

Adjustable Fan Drive Shaft—
End Play ..... 0.10 mm (0.004 in.)

6. Install snap ring in housing groove. Visually inspect snap ring installation for proper seating in housing groove.

7. Apply a thin coat of clean engine oil to O.D. of seal casing (B) and to seal lips. Install seal in housing bore until metal casing is to specified depth below housing face.

Specification

Adjustable Fan Drive Housing
Seal—Depth..... Flush-to-0.50 mm (0.020 in.) below housing face

8. Apply clean engine oil to I.D. of fan hub/pulley (A). Support end of shaft through pipe plug hole in bearing housing and push onto other end of shaft until it bottoms against shoulder.

Continued on next page

NOTE: If engine is equipped with a fan/hub pulley-to-fan spacer, tighten hub/pulley-to-spacer cap screws to the following specification.

Specification

Fan/Hub Pulley-to-Fan Spacer Cap Screws—Torque ..... 60 N•m (45 lb-ft)

9. Install washer and cap screw. Tighten cap screw to specifications.

Specification

Fan Hub/Pulley-to-Fan Shaft—Torque..... 80 N•m (60 lb-ft)

10. Apply LOCTITE® 592 Pipe Sealant to threads of pipe plug (G). Install and tighten plug in bearing housing.

11. Install fan drive assembly onto support plate (H).

12. Install support plate assembly onto engine and tighten cap screws to the following specifications.

Fan Drive Support Plate-to-Engine—Specification

5/16-in. Mounting Cap Screws (To Injection Pump Access Cover)—Torque ..... 24 N•m (18 lb-ft)
5/16-in. Mounting Cap Screws (All Others)—Torque..... 35 N•m (26 lb-ft)
3/8-in. Mounting Cap Screws—Torque..... 61 N•m (45 lb-ft)
1/2-in. Mounting Cap Screws—Torque..... 101 N•m (74 lb-ft)

13. Install fan and belts and adjust tension. See REPLACING BELTS in operator's manual.

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OUO1082,0000244 –19–08MAY02–3/3

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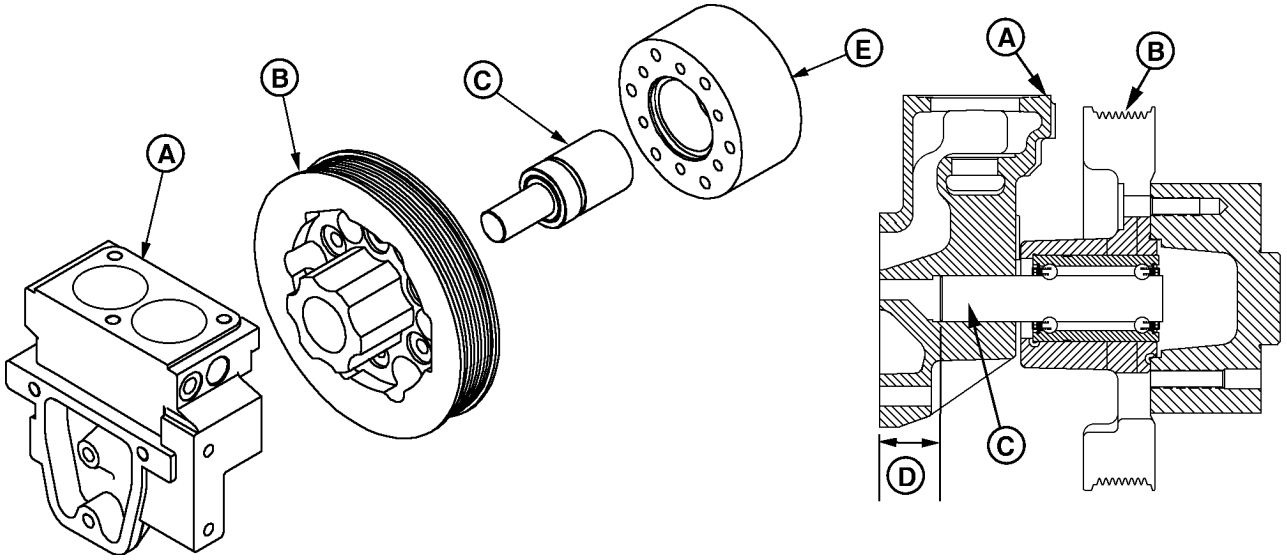
Replace Bearings in Coolant Manifold-Mounted, Fixed Fan Drive Assembly



RG8753 –UN–28NOV97

Fixed Fan Drive Assembly

A—Coolant Manifold **B—Fan Pulley** **C—Bearing Shaft** **D—Bearing Shaft Installed Dimension** **E—Fan Spacer Hub[1]**

To Disassemble Fan Drive:

1. Remove three coolant manifold-to-cylinder head cap screws. Remove coolant manifold (A) and fan pulley (B) assembly from cylinder head and lift to dislodge coolant bypass pipe from manifold.
2. Support front face of coolant manifold and use a press to push bearing (C) and pulley out of manifold.
3. Support front face of fan pulley and push bearing out of pulley, and fan spacer (if equipped). Discard bearing.
4. Thoroughly inspect coolant manifold and pulley for cracks or damage. Measure parts and compare readings with specifications shown. Replace parts as necessary.

IMPORTANT: Support fan pulley on a flat, firm surface and press only on bearing outer race to prevent damage to the bearing.

5. Install new bearing into pulley until outer race bottoms in bore of pulley. End of shaft will extend through bearing stop.

Coolant Manifold-Mounted Fixed Fan Drive Specifications

Coolant Manifold-Mounted Fixed Fan Drive Specifications—Specification

Fixed Fan Drive Shaft—OD	25.387—25.400 mm (0.9995—1.0000 in.)
Fixed Fan Drive Bearing—OD	47.612—47.625 mm (1.8745—1.8750 in.)

[1]In some applications, bearing is pressed into hub (E). The fan spacer and pulley are then bolted to hub. In some applications, the fan spacer is press-fit into the pulley. Dimension (D) is the same for all applications.

Continued on next page

Fixed Fan Drive Pulley (Bearing End)—ID	47.576—47.612 mm (1.8731—1.8745 in.)
Fixed Fan Drive Pulley (Fan Spacer End)[2]—ID	49.485—49.518 mm (1.9482—1.9495 in.)
Fan Spacer[2]—O.D.	49.457—49.483 mm (1.9471—1.9481 in.)
Fixed Fan Drive Manifold—I.D.	25.336—25.362 mm (0.9975—0.9985 in.)
Fixed Fan Drive Shaft (Installed)—Dimension From Manifold Mounting Face to End of Shaft	32.51—32.77 mm (1.280—1.290 in.)

To Assemble Fan Drive:

IMPORTANT: Support coolant manifold on machined surface and press only on inner shaft to prevent damage to bearing.

1. On units with a press-fit fan spacer, press spacer (E) into pulley (B) to the following depth.

Specification	
Adjustable Fan Drive Housing Seal—Depth	Flush-to-0.50 mm (0.020 in.) below housing face

2. Press bearing shaft (C) into coolant manifold (A) to the following specification.

Specification	
Fixed Fan Drive Bearing Shaft—Depth	33.31—33.57 mm (1.311—1.322 in.) below manifold mounting surface

Hold coolant manifold firmly and turn fan pulley by hand to be sure bearings rotate freely.

3. Install a new gasket and O-rings. Insert coolant bypass pipe in manifold and install assembly onto locating pin in front face of cylinder head. Tighten cap screws to specifications.

Specification	
Fixed Fan Drive (Coolant Manifold Mounted) Cap Screws—Torque	60 N•m 45 (lb-ft)

4. Install fan and belts. Refer to appropriate operator's manual for proper belt tensioning.

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

OUO1082,0000243 –19–08MAY02–2/2

Visually Inspect Coolant Pump

Inspect Weep Hole:

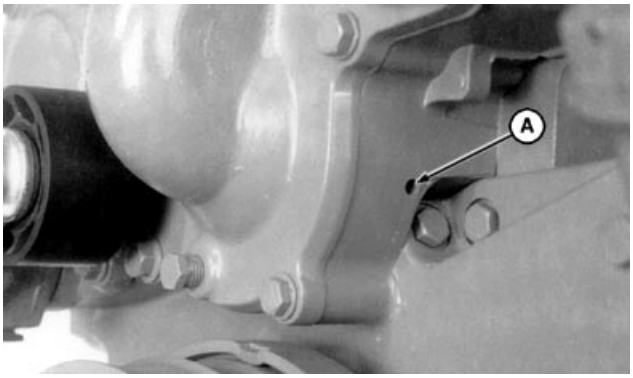
1. Inspect coolant pump weep hole (A) in timing gear cover for oil or coolant leakage.

   Oil leakage indicates a damaged rear seal.

   Coolant leakage indicates a damaged front seal.

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

A—Coolant Pump Weep Hole



Inspect Coolant Pump Weep Hole

RG,25,DT7209 –19–15APR02–1/1

Remove Coolant Pump Assembly

HFN01, HFN02 and HFN03 Engines

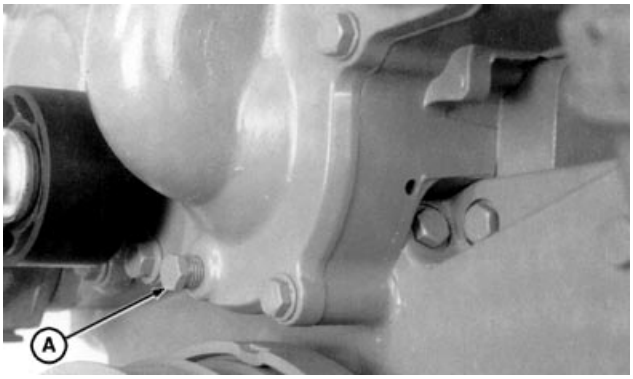
There are no service parts available to repair coolant pump. Replace as a complete assembly.

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

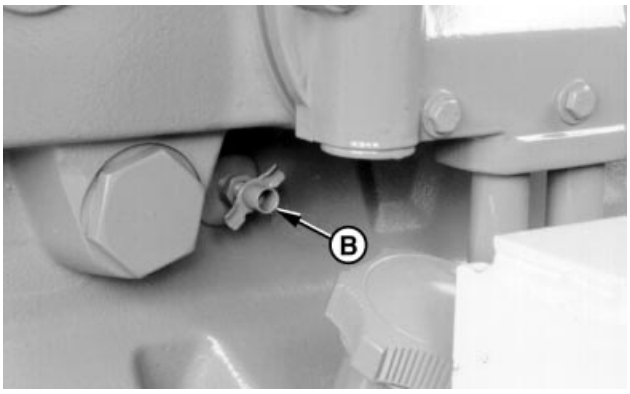
1. Slowly open the engine cooling system filler cap or radiator cap to relieve pressure and allow coolant to drain faster.

2. **On HFN01 and HFN03 engines:** Open drain valve (B) on left side of engine and remove plug (A) on coolant pump. Drain all coolant from engine block.

A—Drain Plug
B—Block Drain Valve



Coolant Pump Drain Plug (HFN01 Engine Shown)



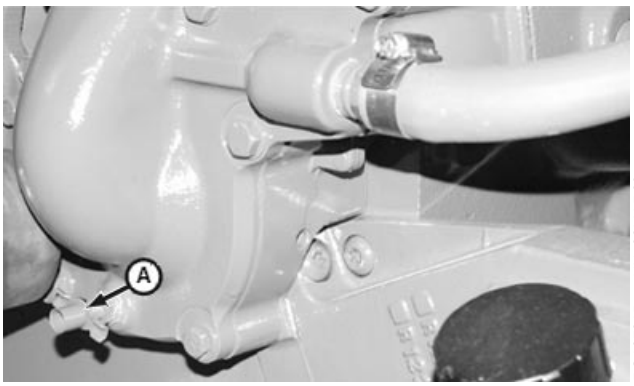
Block Drain Valve (HFN01 Engine Shown)

Continued on next page

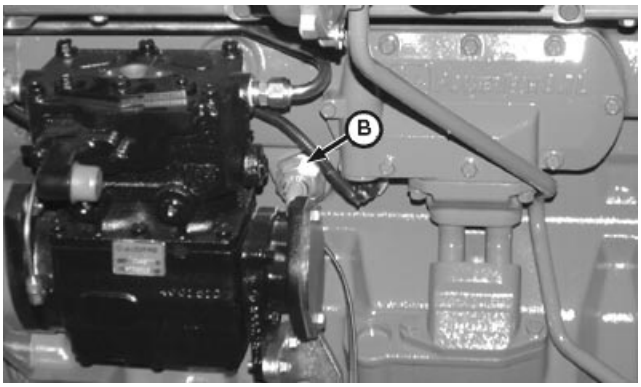
RG,25,DT7228 –19–21FEB02–1/7

3. **On HFN02 engines:** Open coolant pump drain valve (A) on coolant pump and remove coolant heater (B) (if equipped) or plug on left side of engine. Drain all coolant from engine block.

A—Drain Valve
B—Coolant Heater



Drain Valve (HFN02 Engine)

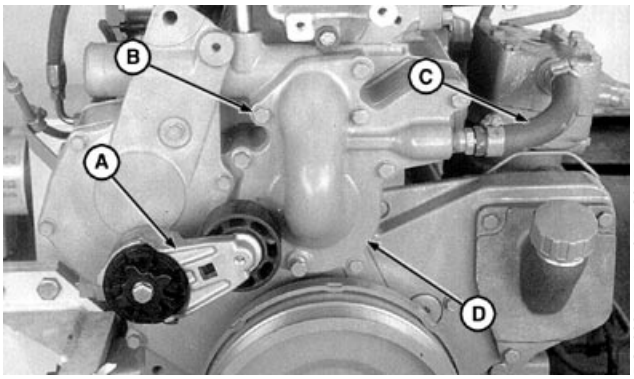


Coolant Heater (HFN02 Engine)

RG,25,DT7228 –19–21FEB02–2/7

4. Remove belt tensioner (A).
5. Remove hose (C).
6. Remove cap screws (B) retaining coolant pump cover (D) and remove cover.
7. Remove gasket from coolant pump cover and inlet housing and discard.

A—Belt Tensioner
B—Cap Screw (9 used)
C—Hose
D—Coolant Pump Cover



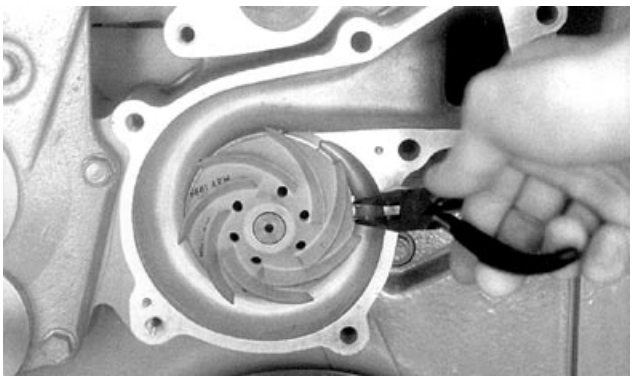
Remove Coolant Pump Cover

Continued on next page

RG,25,DT7228 –19–21FEB02–3/7

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

9. Grasp impeller with large pliers and pull coolant pump from housing using a slight rocking motion. Replace coolant pump assembly if necessary.


RG7677 –UN–05DEC97

Remove Coolant Pump

RG,25,DT7228 –19–21FEB02–4/7

HFN04 Engines

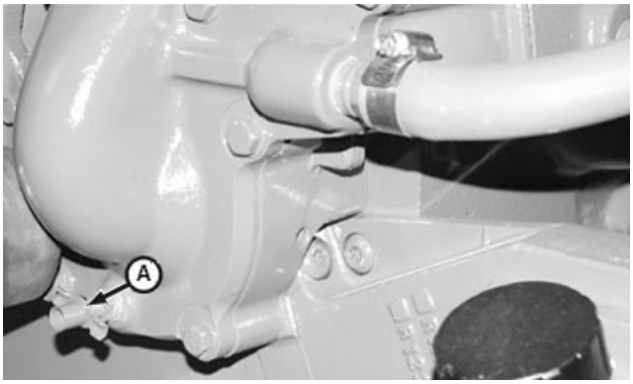
There are no service parts available to repair coolant pump. Replace as a complete assembly.

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

1. Slowly open the engine cooling system filler cap or radiator cap to relieve pressure to allow coolant to drain faster.

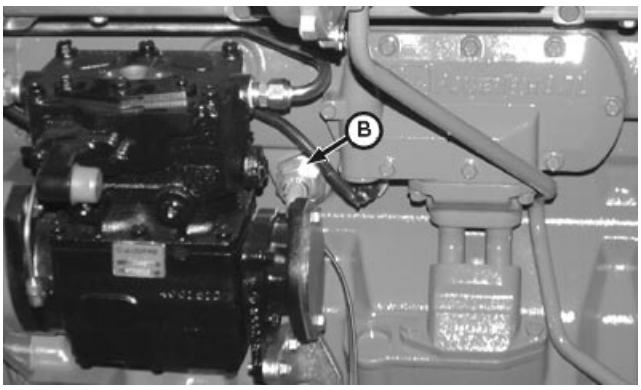
2. Open coolant pump drain valve (A) on coolant pump and remove coolant heater (B) (if equipped) or plug on left side of engine. Drain all coolant from engine block.

A—Drain Valve
B—Coolant Heater



RG10701B –UN–03MAR00

Drain Valve (HFN04 Engine)



RG10734A –UN–11MAY00

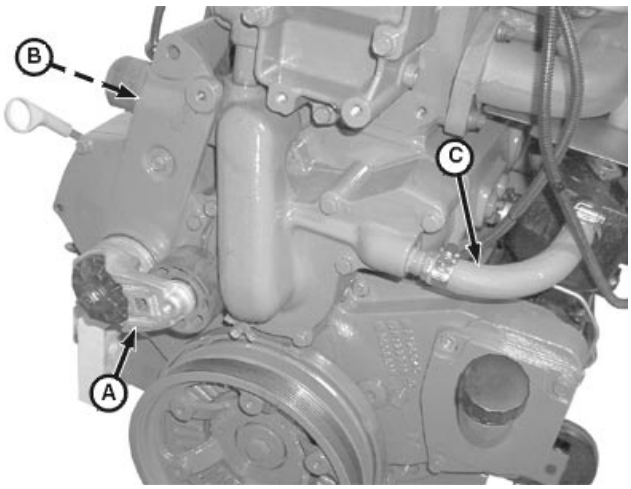
Coolant Heater

Continued on next page

RG,25,DT7228 –19–21FEB02–5/7

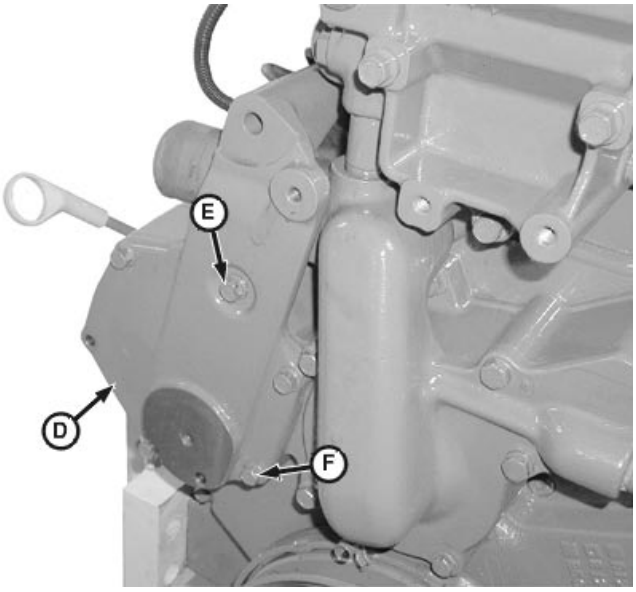
3. Remove belt tensioner (A).
4. Disconnect hoses (B and C) from coolant pump cover.
5. Remove cap screws (E and F) and remove cover (D).
6. Remove cap screws (I and J) and move coolant pump cover (H) out slightly and then down to pull cover away from bypass tube (G).
7. Remove gasket from coolant pump cover and inlet housing and discard.

A—Belt Tensioner
B—Hose
C—Hose
D—Cover
E—Cap Screw (4 used)
F—Cap Screw
G—Bypass Tube
H—Coolant Pump Cover
I—Cap Screw (4 used)
J—Cap Screw (2 used)



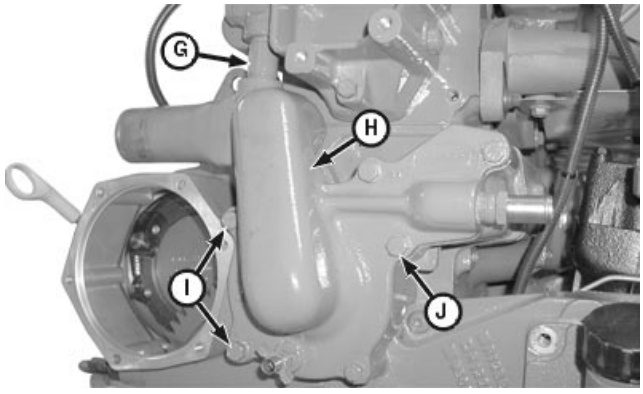
RG12112A –UN–19MAR02

Tensioner Removal and Hose Disconnect



RG12136A –UN–19MAR02

Remove Cap Screws and Cover



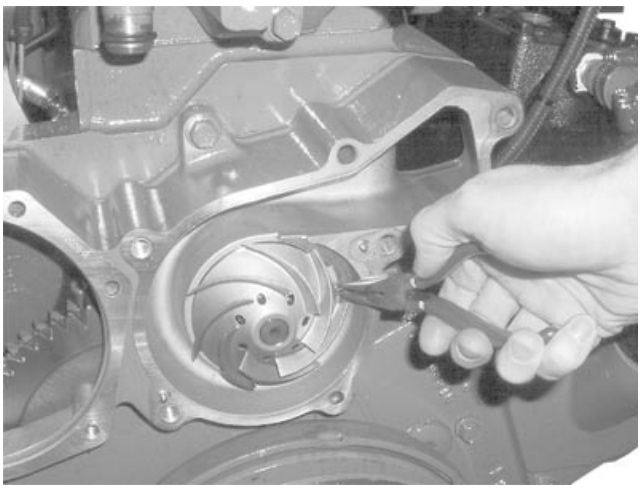
RG12137A –UN–19MAR02

Cap Screw and Coolant Pump Cover Removal

Continued on next page

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

9. Grasp impeller with large pliers and pull coolant pump from housing using a slight rocking motion. Replace coolant pump assembly if necessary.



Remove Coolant Pump

RG,25,DT7228 –19–21FEB02–7/7

Install Coolant Pump Assembly

HFN01, HFN02 and HFN03 Engines

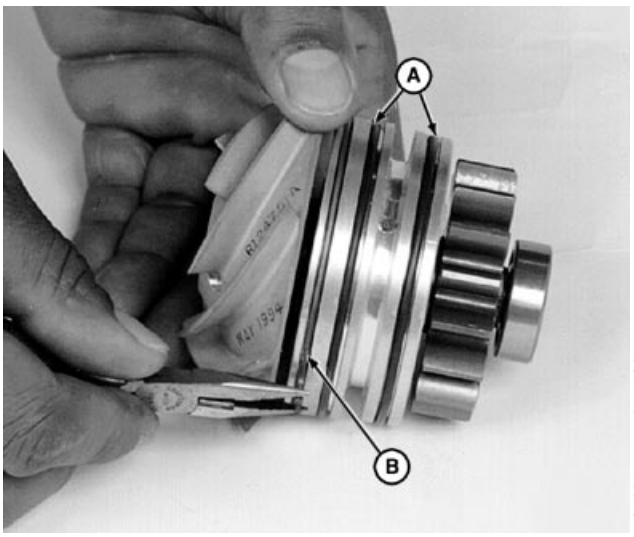
1. Thoroughly clean and inspect coolant pump mounting bore before installing pump assembly.
2. Install two new O-rings (A) in rear grooves of coolant pump housing and apply a light coat of clean engine oil to O-rings.
3. Install a new retaining ring (B) in front (smallest) groove of coolant pump housing and compress both ends of retaining ring together with a small needle-nose pliers.

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

4. Compress retaining ring ends and install coolant pump assembly into mounting bore. Make sure that pump drive gear properly meshes with crankshaft gear.
5. Release retaining ring ends and verify that retaining ring is firmly seated in groove of coolant pump mounting bore.
6. Using new gaskets on the cover and inlet housing, install coolant pump cover (F) carefully to prevent damage to the bypass tube seals. Tighten cap screws to the following specifications.

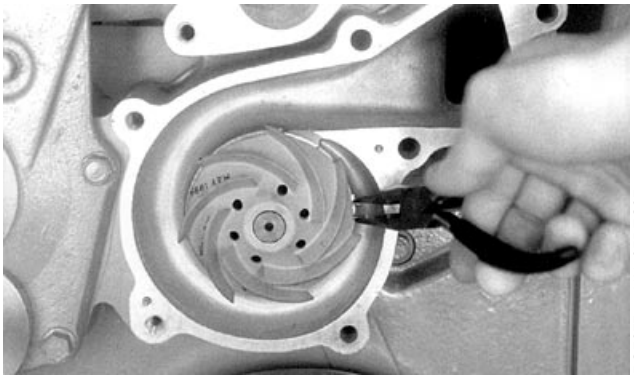
	Specification
Coolant Pump Cover 3/8-in. Cap Screws—Torque	47 N•m (35 lb-ft)
Coolant Pump Cover 5/16-in. Cap Screws—Torque	27 N•m (20 lb-ft)

7. Install hose (E).
8. Install belt tensioner (C). Apply LOCTITE® 242 Thread Lock and Sealer to retaining cap screw threads and tighten cap screw to specifications.

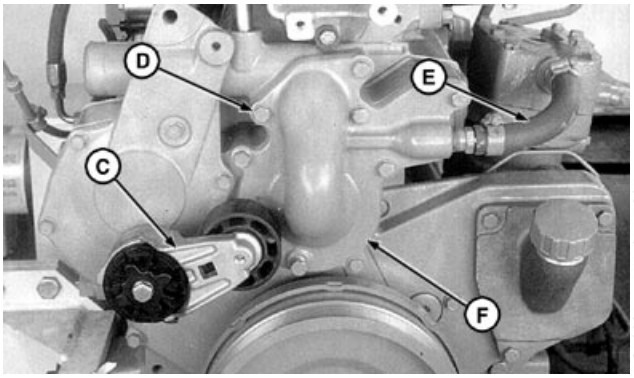


RG7227 –UN–05DEC97

Install O-Rings and Retainer Ring


RG7677 –UN–05DEC97

Install Coolant Pump



RG7668B –UN–05DEC97

Install Coolant Pump Cover

A—O-Ring (2 used)
B—Retaining Ring
C—Belt Tensioner
D—Cap Screw (9 used)
E—Hose
F—Coolant Pump Cover

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RG,25,DT7227 –19–15APR02–1/5

25
18

Specification	
Belt Tensioner Mounting Cap Screw—Torque	50 N•m (37 lb-ft)

IMPORTANT: If a new aluminum coolant pump cover has been installed, the cooling system must be completely drained and flushed. Refer to operator's manual for flushing procedure and the recommended coolant solution.

9. Install coolant heater or plug. (See INSTALL COOLANT HEATER—IF EQUIPPED in this group.)

Continued on next page

RG,25,DT7227 –19–15APR02–2/5

HFN04 Engines

1. Thoroughly clean and inspect coolant pump mounting bore before installing pump assembly.

2. Install two new O-rings (A) in rear grooves of coolant pump housing and apply a light coat of clean engine oil to O-rings.

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

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

4. Compress retaining ring ends and install coolant pump assembly into mounting bore. Make sure that pump drive gear properly meshes with crankshaft gear.

5. Release retaining ring ends and verify that retaining ring is firmly seated in groove of coolant pump mounting bore.

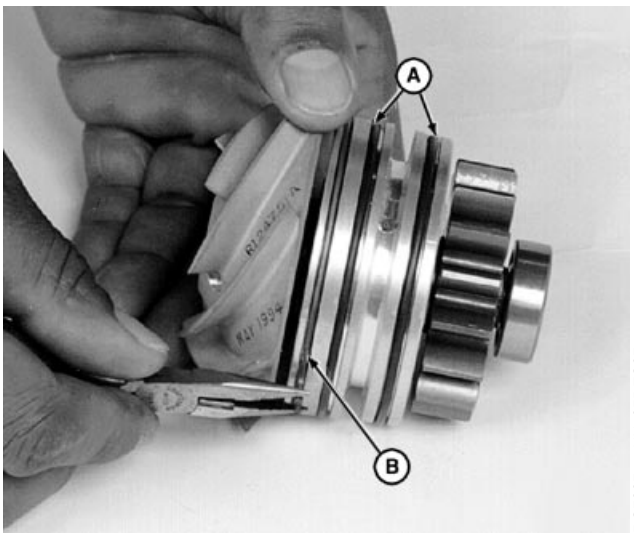
6. Remove bypass tube (C) and install new O-rings.

NOTE: Make sure O-rings do not get pinched when installing bypass tube.

7. Coat new O-rings with clean engine oil and install bypass tube.

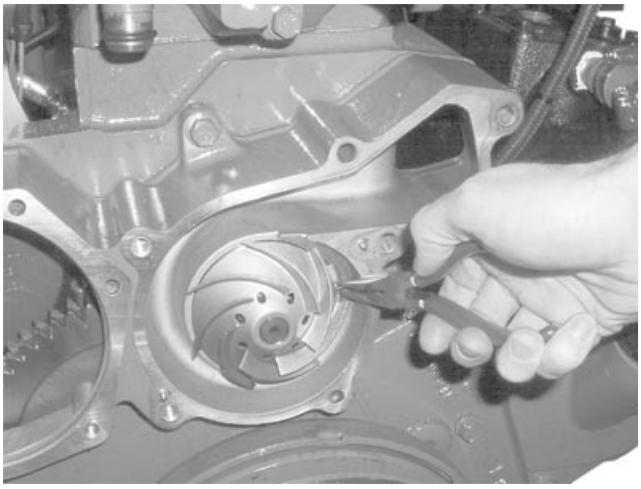
8. Using a new gasket on the coolant pump cover, install coolant pump cover (D) carefully to prevent damage to the bypass tube seals. Tighten cap screws (E and F) to the following specifications.

A—O-Ring (2 used)
B—Retaining Ring
C—Bypass Tube
D—Coolant Pump Cover
E—Cap Screw (4 used)
F—Cap Screw (2 used)



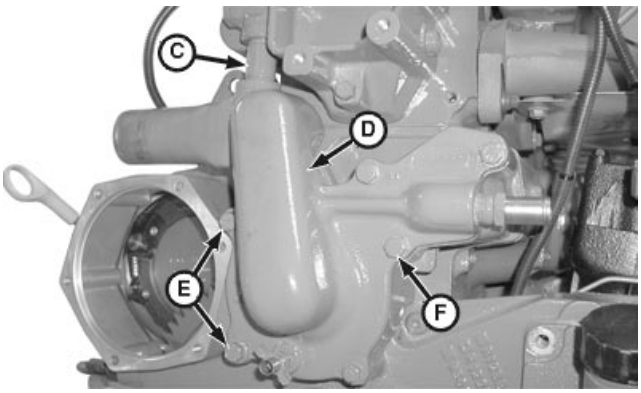
RG7227 –UN–05DEC97

Install O-Rings and Retainer Ring



RG12121A –UN–06MAR02

Install Coolant Pump



RG12138A –UN–19MAR02

Install Coolant Pump Cover

Continued on next page

25
20

Specification	
Coolant Pump Cover 3/8-in. Cap Screws—Torque	47 N•m (35 lb-ft)
Coolant Pump Cover 5/16-in. Cap Screws—Torque	27 N•m (20 lb-ft)

RG,25,DT7227 –19–15APR02–4/5

9. Install cover (D) with cap screws (E and F).

10. Connect hoses (B and C) to coolant pump cover.

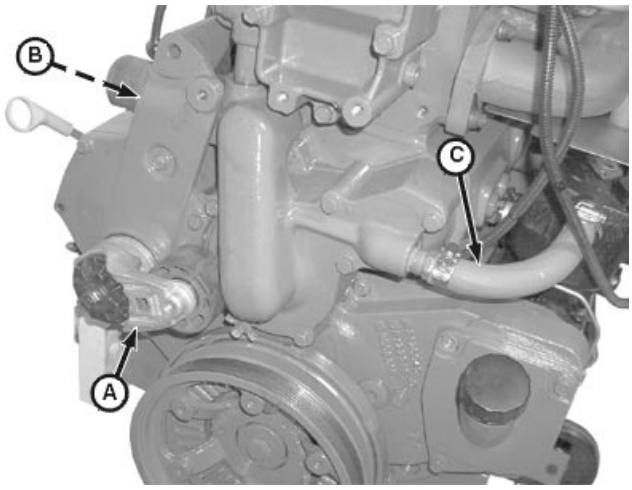
11. Install belt tensioner (A). Apply LOCTITE® 242 Thread Lock and Sealer to retaining cap screw threads and tighten cap screw to specifications.

Specification	
Belt Tensioner Mounting Cap Screw—Torque	50 N•m (37 lb-ft)

IMPORTANT: If a new aluminum coolant pump cover has been installed, the cooling system must be completely drained and flushed. Refer to operator's manual for flushing procedure and the recommended coolant solution.

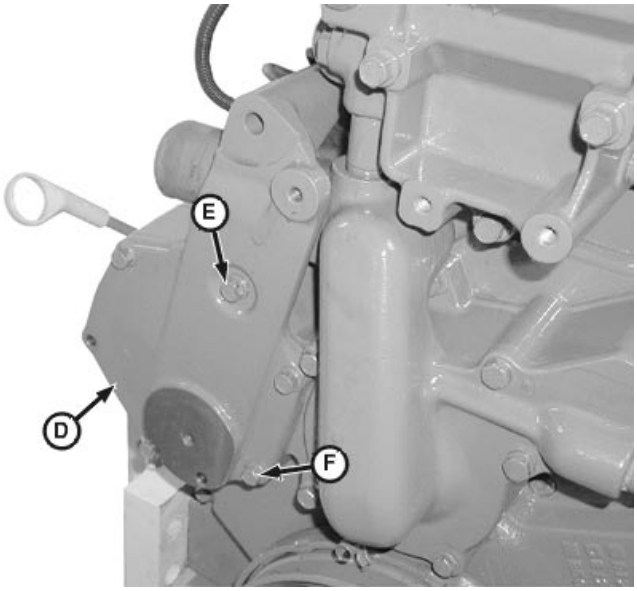
12. Install coolant heater or plug. (See INSTALL COOLANT HEATER—IF EQUIPPED in this group.)

A—Belt Tensioner
B—Hose
C—Hose
D—Cover
E—Cap Screw (4 used)
F—Cap Screw



RG12112A –UN–19MAR02

Tensioner Installation and Hose Connections



RG12136A –UN–19MAR02

Install Cover and Cap Screws

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RG,25,DT7227 –19–15APR02–5/5

Replace Bypass Tube Seal in Coolant Pump Inlet Housing

HFN01, HFN02 and HFN03 Engines

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

1. Drain cooling system.

   Slowly open the engine cooling system filler cap or radiator cap to relieve pressure and allow coolant to drain faster.

2. Remove belt tensioner.

3. Remove coolant pump inlet hose, shown removed. Remove air compressor or turbocharger coolant inlet hose (A).

4. Remove coolant pump cover mounting cap screws. Remove coolant pump cover (B). Discard cover and inlet housing gaskets.

5. Remove hose (C).

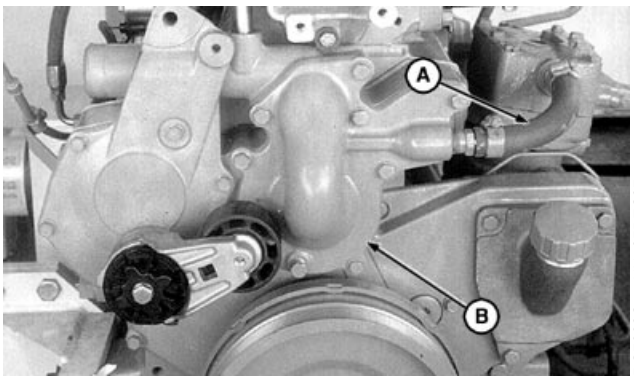
6. Push inlet housing (D) downward to release bypass tube from seal. Remove inlet housing.

7. Carefully clamp inlet housing in a soft-jawed vise and remove bypass tube seal. Be careful not to damage machined gasket surface.

8. Coat seal (E) with clean engine oil and install using JDG908 Coolant Bypass Tube Seal Driver (F). Drive seal into bore until driver bottoms.

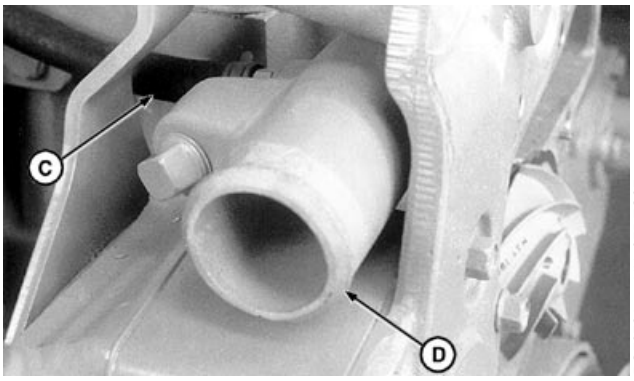
9. Remove inlet housing from vise and inspect seal installation.

10. Lubricate bypass tube seal with grease and position inlet housing in place.



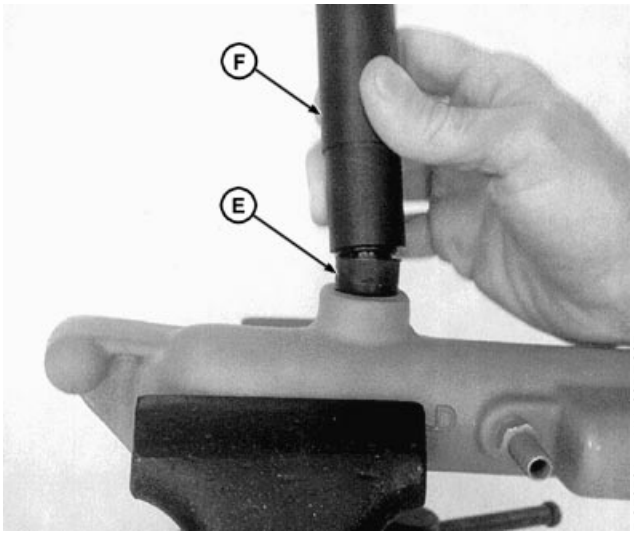
RG7668C –UN–05DEC97

Remove Hose and Coolant Pump Cover



RG7678A –UN–05DEC97

Remove Hose and Push Housing Downward



RG7852A –UN–08DEC97

Install Seal Using Seal Driver

A—Hose
B—Coolant Pump Cover
C—Hose
D—Inlet Housing
E—Seal
F—JDG908 Coolant Bypass Tube Seal Driver

Continued on next page

11. Using new gaskets on the cover and inlet housing, install coolant pump cover (B) carefully to prevent damage to the bypass tube seals. Tighten cap screws to the following specifications.

Specification	
Coolant Pump Cover 3/8-in. Cap Screws—Torque	47 N•m (35 lb-ft)
Coolant Pump Cover 5/16-in. Cap Screws—Torque	27 N•m (20 lb-ft)

12. Connect coolant pump inlet hose and air compressor or turbocharger coolant inlet hose.

13. Connect hose (C).

14. Install belt tensioner. Apply LOCTITE® 242 Thread Lock and Sealer to retaining cap screw threads and tighten cap screw to specifications.

Specification	
Belt Tensioner Mounting Cap Screw—Torque	50 N•m (37 lb-ft)

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RG,25,DT7226 –19–15APR02–2/3

HFN04 Engines

1. Remove coolant pump cover. (See REMOVE COOLANT PUMP ASSEMBLY in this group.)

2. Remove bypass tube from coolant manifold.

3. Replace O-rings (A).

NOTE: Make sure O-rings do not get pinched when installing bypass tube.

4. Install bypass tube into coolant manifold.

5. Install coolant pump cover. (See INSTALL COOLANT PUMP ASSEMBLY in this group.)

RG12127A –UN–06MAR02

Bypass Tube

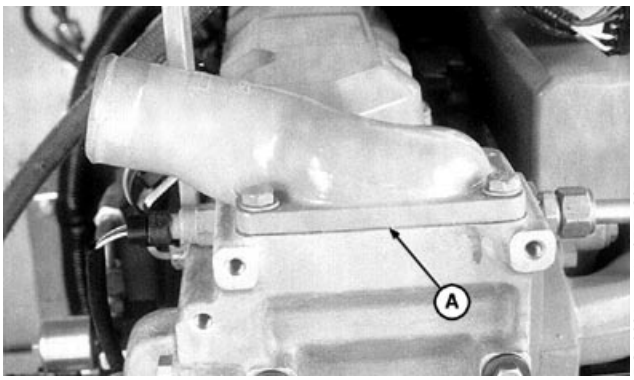
A—O-Ring (2 used)

RG,25,DT7226 –19–15APR02–3/3

Remove and Test Thermostats

CAUTION: Explosive release of fluids from pressurized cooling system can cause serious burns. Do not drain coolant until coolant temperature is below operating temperature. Always loosen cooling system filler cap, radiator cap, or drain valve slowly to relieve pressure.

1. Visually inspect the area around the coolant manifold for leaks.
2. Partially drain coolant from the cooling system.
3. Remove thermostat cover (A) with gasket. Remove and discard all gasket material.



Remove Thermostat Cover (HFN01 Shown)

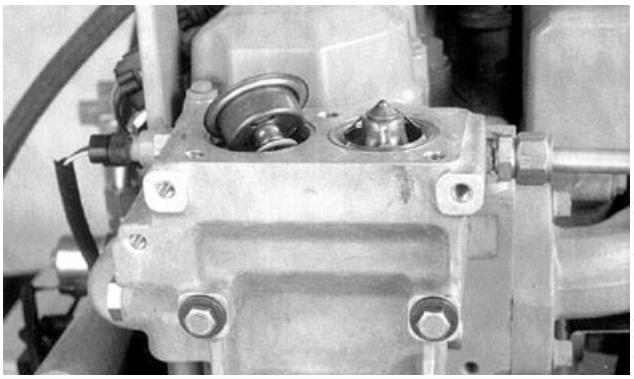
A—Thermostat Cover

RG,25,DT7225 –19–15APR02–1/2

4. Remove thermostats.
5. Inspect thermostats for debris or damage, and test each thermostat using an approved testing procedure. Thermostats should start to open within the range specified below.

Specification	
Thermostat 89°C (192°F)— Opening Temperature	89—100°C (192—212°F)

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



Remove Thermostats

RG,25,DT7225 –19–15APR02–2/2

25
24

Install Thermostats

NOTE: Install thermostats in grooves in housing first, then install gasket after thermostat is properly seated in grooves.

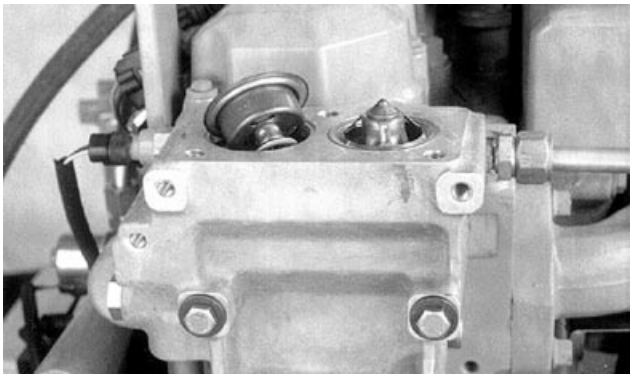
1. Install thermostats. Install a new gasket on housing.

2. Install cover and tighten cap screws to specification.

Specification

Thermostat Cover Cap Screws—
Torque ..... 47 N•m (35 lb-ft)

IMPORTANT: Air must be expelled from cooling system when system is refilled. Loosen temperature sending unit fitting or plug in thermostat housing to allow air to escape when filling system. Retighten fitting when all the air has been expelled.



RG7670 –UN–05DEC97

Install Thermostats

RG,25,DT7224 –19–04NOV97–1/1

Remove Coolant Manifold

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

1. Drain cooling system.

   Slowly open the engine cooling system filler cap or radiator cap to relieve pressure and allow coolant to drain faster.

2. Remove thermostat cover from coolant manifold (shown removed). Remove thermostats (A).

3. Disconnect coolant temperature sensor harness.

NOTE: On HFN01, HFN03 and HFN04 engines, coolant return tube (B) is connected to the turbocharger. On HFN02 engines, it is connected to the air compressor.

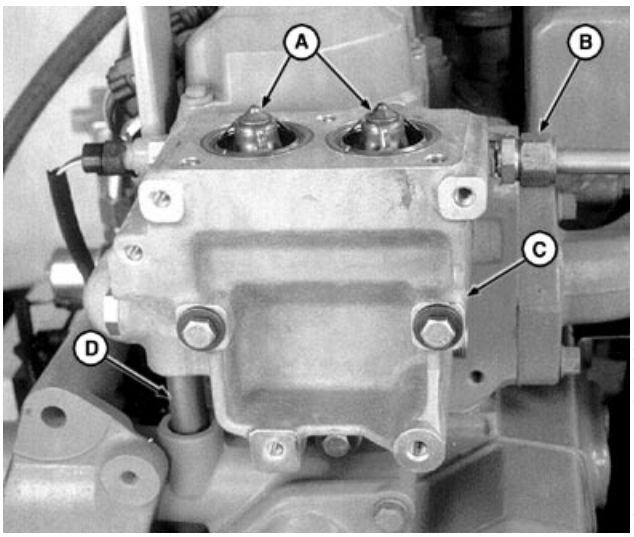
4. Disconnect coolant return tube (B).

NOTE: Pull coolant manifold straight out (toward front of engine) approximately 6.35 mm (0.25 in.) to disengage from locator (spring) pin. Then lift straight up to disengage from bypass tube (D).

5. Remove three coolant manifold-to-cylinder head cap screws, remove coolant manifold (C) and dislodge coolant bypass tube as manifold is removed.

6. Remove and discard coolant manifold gasket.

7. Remove and discard bypass tube seal from manifold, if required.



Remove Coolant Manifold

A—Thermostat
B—Coolant Return Tube
C—Coolant Manifold
D—Bypass Tube

RG,25,DT7223 –19–15APR02–1/1

25
26

Install Coolant Manifold

1. Coat bypass tube seal with clean engine oil and install in coolant manifold bore using JDG908 Coolant Bypass Tube Seal Driver. Drive seal into bore until driver bottoms.

2. Install a new coolant manifold gasket. Lubricate bypass tube seal with grease to ease bypass pipe installation. Install bypass pipe (A) into bore of coolant manifold (B). Be careful not to cut seal.

3. Install coolant manifold assembly. Be sure coolant manifold is properly positioned on spring pin (in front face of cylinder head) and that bypass pipe is fully seated in coolant manifold and coolant pump inlet housing.

4. Apply LOCTITE® 242 Thread Lock and Sealer to coolant manifold-to-cylinder head cap screw threads 360 degrees (except for the leading one to three threads). Tighten coolant manifold cap screws to specification.

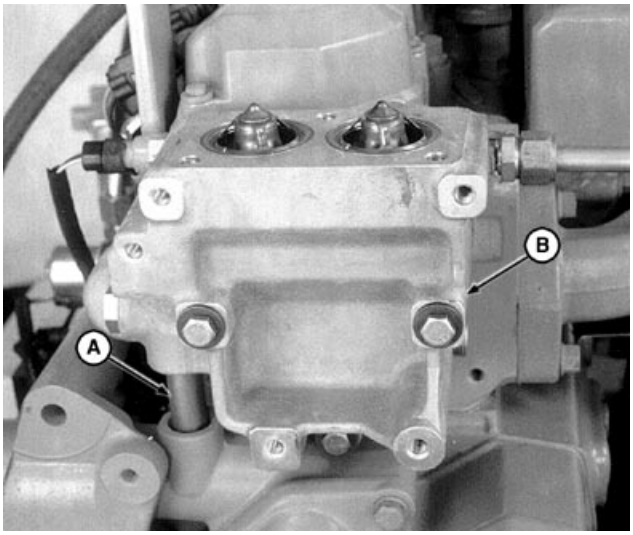
Specification

Coolant Manifold Cap Screws—
Torque ..... 35 N•m (25 lb-ft)

5. Install thermostats and cover. (See INSTALL THERMOSTATS, earlier in this group.)

6. Connect coolant temperature sensor wire.

7. Connect turbocharger or air compressor coolant return tube.



RG7671B –UN–05DEC97

Install Coolant Manifold

A—Bypass Pipe
B—Bore of Coolant Manifold

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RG,25,DT7222 –19–15APR02–1/1

Remove Coolant Heater—If Equipped

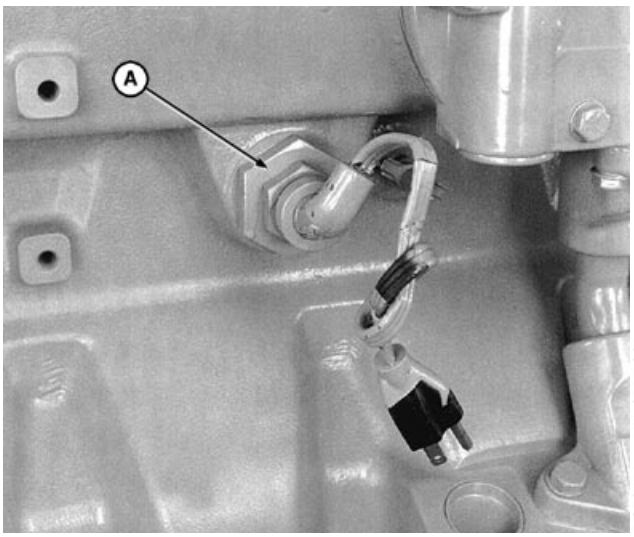
1. Unplug heater (A) from electrical power source.

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

2. Drain cooling system.

   Slowly open the engine cooling system filler cap or radiator cap to relieve pressure and allow coolant to drain faster.

3. Remove electrical cord, loosen nut, and pull heater element out of block.



Remove Coolant Heater—If Equipped

A—Heater

RG,25,DT7220 –19–15APR02–1/1

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28

Install Coolant Heater—If Equipped

CAUTION: To avoid shock or hazardous operation, always use a three-wire heavy-duty electrical cord equipped with three-wire connectors. If a two-to-three contact adapter is used at the wall receptacle, always connect green wire to a good ground. Keep electrical connectors clean to prevent arcing. Plug coolant heater into electrical power only if heater element is immersed in coolant. Sheath could burst and result in personal injury.

TS210 –UN–23AUG88

Avoid Shock or Hazardous Operation

NOTE: The heater element (A) cannot be repaired. If defective, replace with a new one.

1. Lubricate O-ring (C) with clean engine oil and install onto groove of flange nut (D). Install gasket (B) onto heater element and install element into flange nut.
2. Install nut (E) onto threads of heater element finger tight only.
3. Install assembly into threaded heater hole in block. While holding heater element in horizontal position, tighten flange nut (D) to specification making sure O-ring seals against block.

Specification

Coolant Heater Flange Nut in Cylinder Block—Torque..... 68 N•m (50 lb-ft)

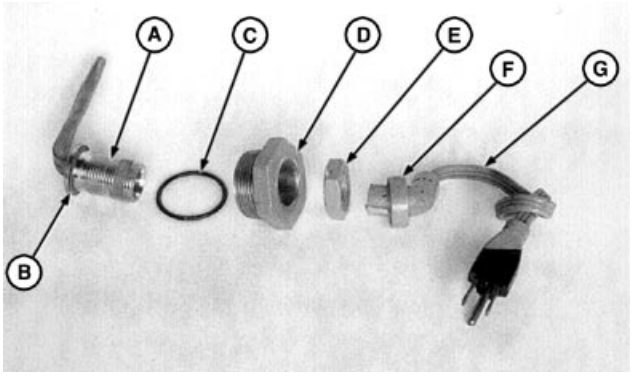
IMPORTANT: Heater element must remain in a horizontal position after installation. Heater element may be damaged if it touches internal walls of block.

4. Hold assembly so that flats on threaded end of heater element are horizontal. Tighten nut (E) to specification.

Specification

Coolant Heater Lock Nut—Torque..... 34 N•m (25 lb-ft)

5. Install wiring lead (G) and tighten retaining nut (F).



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Install Coolant Heater—If Equipped

A—Heater Element
B—Gasket
C—O-Ring
D—Flange Nut
E—Nut
F—Retaining Nut
G—Wiring Lead

RG,25,DT7219 –19–15APR02–1/1

Complete Final Assembly

NOTE: Consult your engine operator's manual or see Group 02 of this CTM for coolant recommendations in your area.

1. Fill cooling system to proper level with the proper coolant.
2. Start engine and run for several minutes to check for leaks in the cooling system.

RG,25,DT7217 –19–30MAR00–1/1

Other Material

Number	Name	Use
PT569 (U.S.)	NEVER-SEEZ® Compound	Threads of exhaust manifold-to-cylinder head studs. (Apply for reuse only.) Threads of turbocharger-to-exhaust manifold studs. (Apply for reuse only.)

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

DPSG,OUO1004,2829 –19–06MAR02–1/1

Air Intake and Exhaust System Specifications

Item	Measurement	Specification
Garret GT35 Turbocharger	Axial End Play	0.0130—0.089 mm (0.0005—0.0035 in.)
Garret GT35 Turbocharger	Radial Bearing Clearance	0.08—0.18 mm (0.003—0.007 in.)
Turbocharger Compressor Housing Cap Screws	Torque	23 N•m (17 lb-ft)
Turbocharger Wastegate Assembly Bracket-to-Turbocharger Cap Screws	Torque	23 N•m (17 lb-ft) (204 lb-in.)
Turbocharger Wastegate Actuator Mounting Nuts	Torque	6 N•m (4 lb-ft) (53 lb-in.)
Turbocharger Wastegate Actuator (Checking)	End Play	0.05—0.56 mm (0.002—0.022 in.)
Turbocharger Wastegate Actuator (Adjusting)	End Play	0.38 mm (0.015 in.)
Turbocharger-to-Exhaust Manifold Nut (HFN01, HFN02, and HFN03 Engine)	Torque	47 N•m (35 lb-ft)
Turbocharger-to-Exhaust Manifold Nut (HFN04 Engine)	Torque	47 N•m (35 lb-ft)
Turbocharger Oil Return Tube Cap Screw	Torque	34 N•m (25 lb-ft)
Turbocharger Oil Inlet Line	Torque	30 N•m (22 lb-ft)
Turbocharger Water Inlet and Outlet Tube Fitting	Torque	16.9 N •m (12.5 lb-ft) (150 lb-in.) maximum
Turbocharger Compressor Outlet Elbow Clamp	Torque	20 N•m (15 lb-ft) (177 lb-in.)
Exhaust Manifold Mounting Nut	Torque	47 N•m (35 lb-ft)

Continued on next page

Item	Measurement	Specification
Exhaust Manifold Heat Shield Cap Screws	Torque	22 N•m (16 lb-ft) (195 lb-in.)
Intake Manifold Cap Screws	Torque	48 N•m (35 lb-ft)

DPSG,OUO1004,2830 –19–29MAR04–2/2

Extending Turbocharger Life

Turbochargers are designed to last the life of the engine, but because they operate at such high speeds (100,000 rpm or more); a moment's carelessness can cause them to fail in seconds.

The major causes of turbocharger failures are attributed to:

- Lack of lube oil (quick starts and hot shutdowns)
- Oil contamination
- Ingestion of foreign objects
- Restricted oil drainage
- Low oil level
- Operation on excessive side slopes
- Abnormally high exhaust temperatures

Lack of Lube Oil

Oil not only lubricates the turbocharger's spinning shaft and bearings, it also carries away heat. When oil flow stops or is reduced, heat is immediately transferred from the hot turbine wheel to the bearings, which are also heating up because of the increased friction due to the lack of oil. This combination causes the turbocharger shaft temperature to increase rapidly.

If oil flow does not increase and the process continues, bearings will fail. Once the bearings fail (which can happen in just seconds), seals, shaft, turbine and compressor wheels can also be damaged.

The principal causes of turbocharger bearing lubrication problems are low oil pressure, a bent, plugged or undersized oil lube supply line, plugged or restricted oil galleries in the turbocharger, or improper machine start-up and shutdown 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 up the engine before applying a load allows oil pressure to build up and lines to fill with oil.

Idling the engine before shutdown allows the engine and turbocharger to cool. "Hot" shutdowns can cause the turbocharger to fail because after high-speed operation the turbocharger will continue to rotate long after the engine has been shut off and oil pressure has dropped to zero. This will cause heat to build up and possible bearing damage. It can also cause carbon and varnish deposits to form.

Oil Contamination

A second cause of turbocharger failures is contaminated oil. It can be caused by a worn or damaged oil filter or not changing the lube oil at recommended intervals. Expecting the oil filter to remove dirt, sand, metal chips, etc., from the oil before they reach the engine or turbocharger can be a costly mistake because contaminated oil may completely bypass the engine oil filter if the oil filter or oil cooler is clogged, if the filter element is improperly installed, or if the oil is thick during cold weather.

Four good ways of avoiding oil contamination are:

- Always inspect the engine thoroughly during major overhaul. Look especially for any sludge or debris left in lube oil galleries.
- Change lube oil at recommended intervals. Analysis of oil samples at filter change periods can help identify potentially harmful contaminants in the oil.
- Clean the area around the oil fill cap before adding oil.
- Use a clean container when adding oil.

Continued on next page

Ingestion of Foreign Objects

The third cause of turbocharger damage is the ingestion of foreign objects. Foreign objects or particles can be ingested and cause damage to the turbocharger on both compressor and turbine sides. This is easy to avoid.

On the compressor side, foreign objects usually take the form of dust, sand or shreds of air cleaner element that enter through improperly installed air cleaner elements. Leaky air inlet piping (loose clamps or torn rubber joints) or torn pleats in dry-type air cleaner elements also create problems.

The result is erosion of compressor blades that can cause the delicately balanced wheel to wobble.

IMPORTANT: Whenever an internal engine failure (valve, valve seat, piston) occurs, a thorough inspection of the turbocharger MUST BE performed before returning engine to service.

Restricted Oil Drainage

A fourth cause of turbocharger damage is restricted lube oil drainage. The lubricating oil carries away heat generated by friction of the bearings and from the hot exhaust gases. If drainage back to the sump is impeded, the bearings will overheat with damage that will ultimately lead to failure.

There are two primary reasons for restricted drainage. A blocked drain tube, due to either damage or a build-up of sludged oil or high crankcase pressure which can be due to restricted crankcase breather or excessive engine blowby.

Periodically check both the turbocharger oil drain tube and engine breather tube for damage or restriction. Correction of these conditions leads to longer turbocharger life.

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.

Over-temperature on a natural gas engine can result from a rich air/fuel mixture, overpowering the engine, or restricted air flow. With a rich air/fuel mixture or restricted air flow, the engine is burning more fuel than necessary to produce the desired power level. The excess energy exits through the exhaust system in the form of heat.

6081 Natural Gas Engines are lean-burn engines, so more air than necessary is available for combustion. Higher efficiency and lower exhaust temperature will result with a leaner air/fuel mixture. The turbocharger center housing on natural gas engines is water-cooled to protect the turbocharger bearings from extreme exhaust temperatures.

If over-temperature operation is identified, check air inlet and exhaust systems, coolant lines, engine load, air/fuel adjustment, and ignition timing.

RG,30,DT7229 –19–25AUG00–2/2

Remove Turbocharger

CAUTION: After operating engine, allow exhaust system components to cool before removing turbocharger.

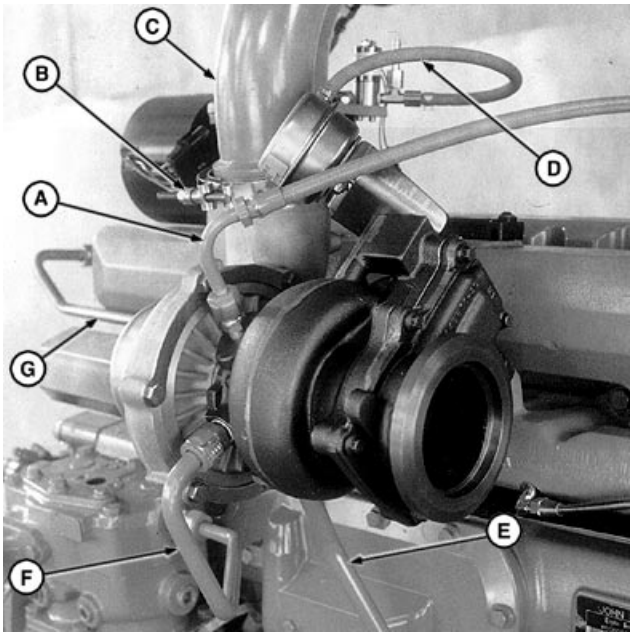
Thoroughly clean exterior of turbocharger and surrounding area to prevent entry of dirt into the air intake system during removal.

IMPORTANT: When cleaning turbocharger, do not spray directly into compressor or turbine housings. If turbocharger inspection is required, do not clean exterior prior to removal. Doing so may wash away evidence of a potential failure mode. (See TURBOCHARGER SEVEN-STEP INSPECTION, later in this group.)

1. Disconnect air intake and exhaust piping from turbocharger (shown disconnected).
2. Disconnect turbocharger oil inlet line (A).
3. Disconnect turbocharger oil return tube (E). Remove and discard gasket.
4. Disconnect turbocharger water inlet tube (F) and outlet tube (G) (HFN01, HFN03, and HFN04 engines only).
5. Disconnect turbocharger wastegate diaphragm hose (D).
6. Remove clamp (B) (shown removed on lower photo).

NOTE: On earlier engine using cap screws to mount turbocharger to exhaust manifold, discard cap screws and replace with studs, spacers, and 12-point flange nuts.

7. Remove four turbocharger mounting cap screws or nuts with spacers securing turbocharger to exhaust manifold. Remove turbocharger.



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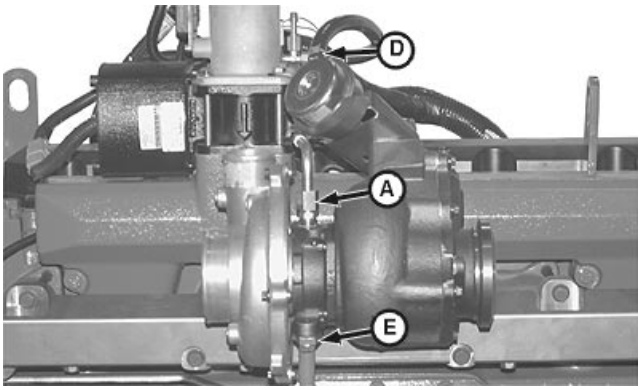
HFN01, HFN03, and HFN04 Engines



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HFN02 Engine

A—Oil Inlet Line
B—Clamp
C—Elbow
D—Wastegate Diaphragm Hose
E—Oil Return Tube
F—Water Inlet Tube (HFN01, HFN03, and HFN04 Engines Only)
G—Water Outlet Tube (HFN01, HFN03, and HFN04 Engines Only)

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RG,30,DT7245 –19–01MAR02–1/2

8. Cap or plug all openings on engine (exhaust and intake manifold related) and place turbocharger on a clean flat table for inspection.

9. Perform turbocharger seven-step inspection, as described later, if failure mode has not been determined.

RG,30,DT7245 –19–01MAR02–2/2

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.
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 clean oil drain line as required.
	Leaking air intake system.	Correct as required (this group).
Oil and/or Excessive Carbon	Internal engine failure.	Verified by oil in turbine housing. Correct as required.
	Turbine seal failure.	Inspect for excessive heat from overfueling and/or restricted air intake.
	Prolonged periods of low rpm engine idling.	Verify with operator to run engine under load or a higher rpm. (See operator's manual).
	Restricted oil drain line.	Inspect and clear oil drain line as required.

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RG,30,DT7244 –19–27MAY04–1/3

Problem	Possible Cause	Suggested Remedy
TURBINE HOUSING INLET DEFECTS		
Oil in Housing	Internal engine failure.	Inspect and repair engine as required.
	Oil leaking from compressor housing seal.	Verify that oil is in compressor housing and refer to "Compressor Housing Outlet Defects" as listed earlier in this chart.
Center Wall Deteriorated	Excessive operating temperature.	Check for restricted air intake.
		Check engine for overfueling.
		Check ignition.
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.
	Object left in intake system.	Disassemble and inspect air intake system.
	Leaking air intake system.	Correct as required (this group).
Oil and/or Excessive Carbon	Internal engine failure.	Verified by oil in turbine housing. Correct as required.
	Turbine seal failure.	Inspect for excessive heat from overfueling and/or restricted air intake.
	Prolonged periods of low RPM engine idling.	Verify with operator to run engine under load or a higher rpm. (See operator's manual).
	Restricted oil drain line.	Inspect and clear oil drain line as required.

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RG,30,DT7244 –19–27MAY04–2/3

Problem	Possible Cause	Suggested Remedy
EXTERNAL CENTER HOUSING AND JOINT DEFECTS		
Leaks from Casting	Defective casting.	Replace turbocharger (this group).
	Defective gasket.	Verify that leaks are not occurring at gasket joints.
Leaks from Joints	Loose attaching screws.	Tighten to specifications (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 the operator's manual.
	Excessive operating temperature.	Restricted air intake, air/fuel mixture too rich, 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.

RG,30,DT7244 –19–27MAY04–3/3

Turbocharger Seven-Step Inspection

The following inspection procedure is recommended for systematic failure analysis of a suspected failed turbocharger. This procedure will help to identify when a turbocharger has failed, and why it has failed, so the primary cause of the failure can be corrected.

Proper diagnosis of a non-failed turbocharger is important for two reasons. First, identification of a non-failed turbocharger will lead to further investigation and repair of the cause of a performance complaint.

Second, proper diagnosis eliminates the unnecessary expense incurred when a non-failed turbocharger is replaced.

The seven recommended inspection steps, which are explained in detail on the following pages, are:

- Compressor Housing Inlet and Compressor Wheel.
- Compressor Housing Outlet.
- Turbine Housing Inlet.
- Turbine Housing Outlet and Turbine Wheel.
- External Center Housing and Joints.
- Internal Center Housing.
- Turbocharger Bench Test.

NOTE: To enhance the turbocharger inspection, an inspection sheet (Form No. DF-2280, available from Distribution Service Center) 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.

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12

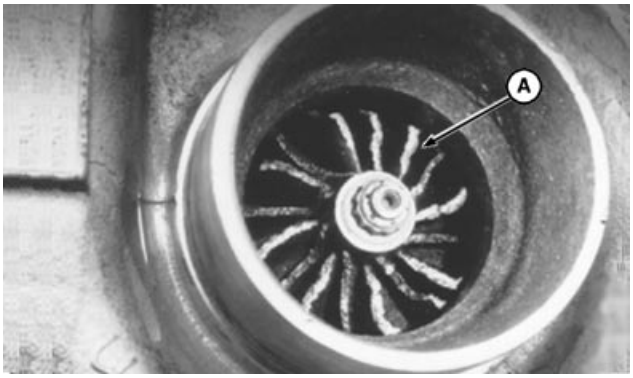
Compressor Housing Inlet and Compressor Wheel

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

NOTE: Foreign object damage may be extensive or minor. In either case, the source of the foreign object must be found and corrected to eliminate further damage.

2. Mark findings on your checklist and continue the inspection.

A—Compressor Wheel

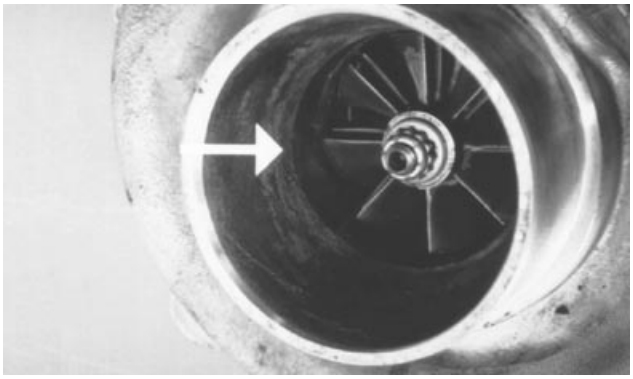


Check Compressor Wheel

RG,30,DT7238 –19–25AUG00–2/13

NOTE: You will need a good light source for this check.

3. Check compressor inlet for wheel rub on the housing (arrow). Look very closely for any score marks on the housing itself and check the tips of the compressor wheel blades for damage.



Check Compressor Inlet

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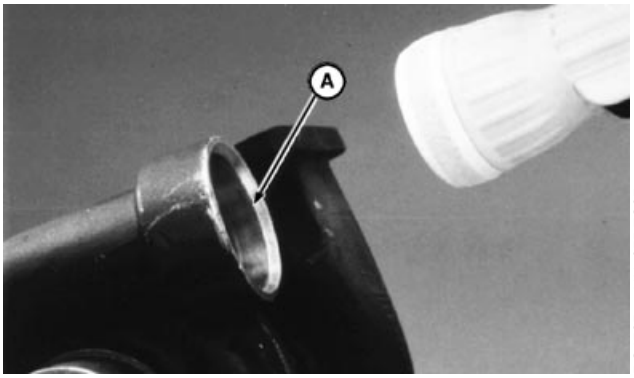
RG,30,DT7238 –19–25AUG00–3/13

Compressor Housing Outlet

1. Check compressor housing outlet (A). The outlet should be clean and free of dirt or oil.
2. Mark it on your checklist if dirt or oil is found and continue the inspection.

A—Compressor Housing Outlet



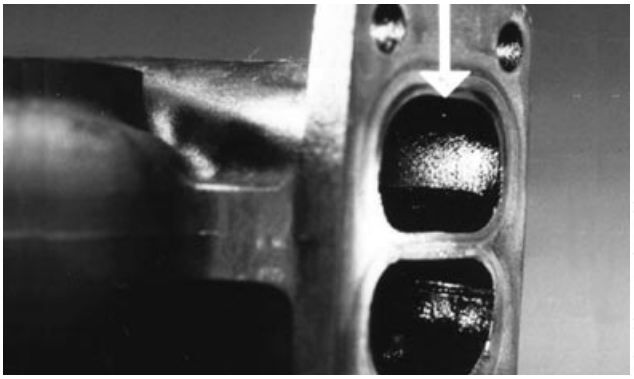
Check Compressor Housing Outlet

RG,30,DT7238 –19–25AUG00–4/13

Turbine Housing Inlet

Check the turbine housing inlet ports (arrow) for oil in housing, excessive carbon deposit or erosion of center walls.

NOTE: If the inlet is wet with oil, or has excessive carbon deposits, an engine problem is likely. Center wall erosion (cracking or missing pieces), indicate excessive exhaust temperature.



Check Turbine Housing Inlet

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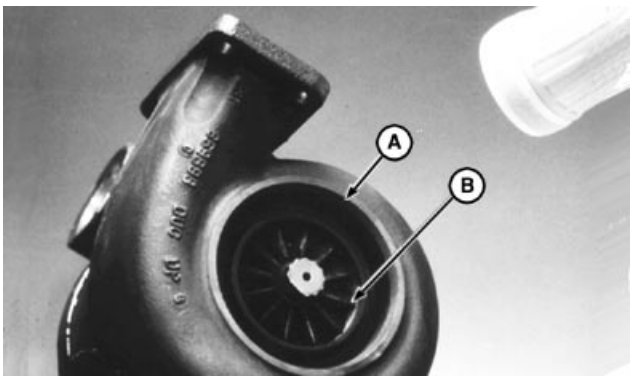
RG,30,DT7238 –19–25AUG00–5/13

Turbine Housing Outlet and Turbine Wheel

1. Use a flashlight to look up inside the turbine housing outlet (A) and check blades (B) for foreign object damage.

A—Turbine Housing Outlet
B—Blades



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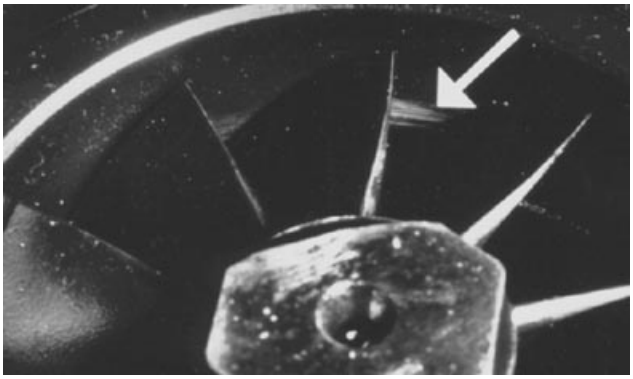
Check Blades for Foreign Object Damage

RG,30,DT7238 –19–25AUG00–6/13

2. Inspect the wheel blades and housing for evidence of wheel rub (arrow). Wheel rub can bend the tips of the blades with the housing showing wear or damage.



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Inspect for Evidence of Wheel Rub

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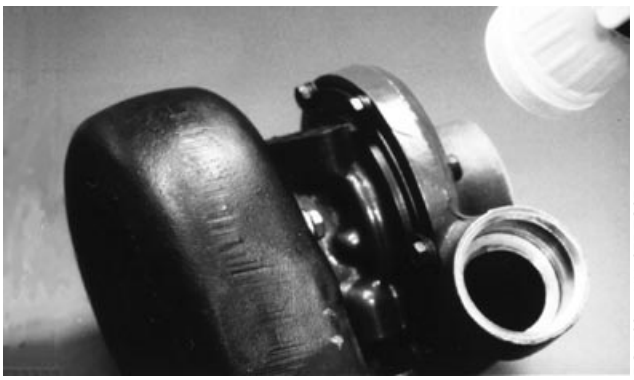
RG,30,DT7238 –19–25AUG00–7/13

External Center Housing and Joints

Visually check the outside of the center housing, all connections to the compressor, and turbine housing for oil.

NOTE: If oil is present, make sure it is not coming from a leak at the oil supply or return line.



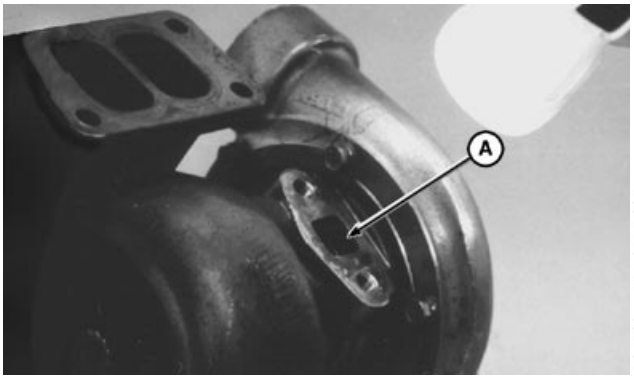
Visually Check Outside Center Housing

RG,30,DT7238 –19–25AUG00–8/13

Internal Center Housing

1. Using a flashlight, look through the oil return hole (A), to check the condition of the shaft and/or bearings. There should not be excess carbon deposits on the shaft or in the housing.

A—Oil Return Hole



Look Through Oil Return Hole

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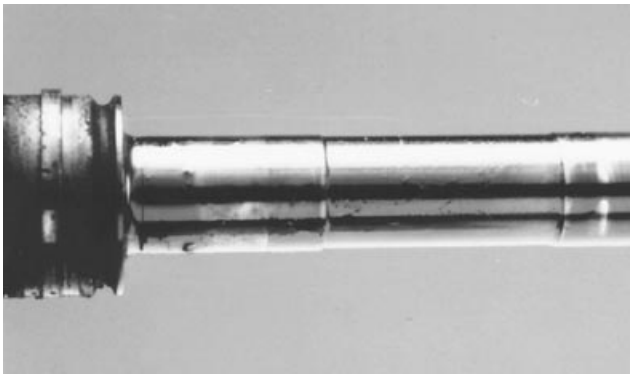
RG,30,DT7238 –19–25AUG00–9/13

2. Excessive “blueing” or “coking” of oil along the complete length of the shaft indicates a possible lack of lubrication caused by an engine failure, or improper operation, such as hot shutdowns.



Inspect Shaft

RG,30,DT7238 –19–25AUG00–10/13

Turbocharger Bench Test

1. Mount the turbocharger in a vise.
2. Rotate the shaft, using both hands, to check rotation and clearance. The shaft should turn freely; however, there may be a slight amount of drag.

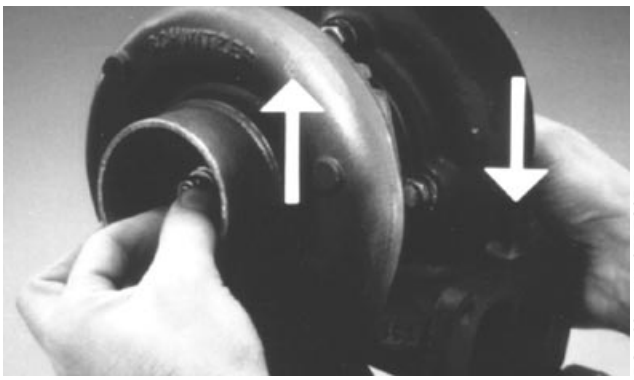
Check Rotation and Clearance

Continued on next page

RG,30,DT7238 –19–25AUG00–11/13

3. Next, pull up on the compressor end of the shaft and press down on the turbine end while rotating shaft. Neither the compressor wheel nor the turbine wheel should contact the housing at any point.

NOTE: There will be some "play" because the bearings inside the center housing are free floating.



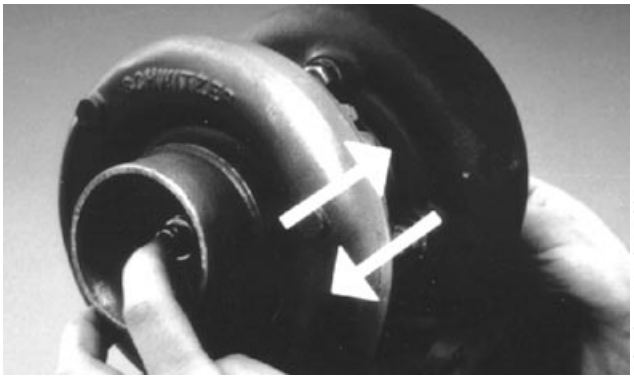
Check for Clearance

RG,30,DT7238 –19–25AUG00–12/13

4. Next, check shaft end play by moving the shaft back and forth while rotating. There will be some end play but not to the extent that the wheels contact the housings.

IMPORTANT: Before you finalize your conclusion that the turbocharger has not failed, it is strongly recommended that the following procedure of checking axial bearing end play with a dial indicator be performed. This procedure is not required if a failure mode has already been identified.

NOTE: These diagnostic procedures will allow you to determine the condition of the turbocharger. If the turbocharger has failed, analysis of your inspection notes should direct you to the specific areas of the engine to correct the problems causing the turbocharger failure (See TURBOCHARGER FAILURE ANALYSIS, outlined earlier in this group). It is not unusual to find that a turbocharger has not failed. If your turbocharger passes all the inspections, the problem lies somewhere else.



Check Shaft End Play

RG,30,DT7238 –19–25AUG00–13/13

Perform Axial Bearing End Play and Radial Bearing Clearance Tests

These tests will give an indication of the condition of the thrust bearing and radial bearing within the center housing and rotating assembly.

1. Remove compressor housing cover, as shown.

2. Mount magnetic base dial indicator so indicator tip rests on end of the rotating shaft on the compressor side. Preload indicator tip and zero dial on indicator.

IMPORTANT: DO NOT apply excessive force to shaft. Use the least amount of force necessary to perform tests.

3. Using minimum force, move shaft axially back and forth by hand.

4. Observe and record total dial indicator movement.

Specification

Garret GT35 Turbocharger—Axial End Play ..... 0.0130—0.089 mm (0.0005—0.0035 in.)

If bearing end play is not within specifications, install a replacement turbocharger.

5. Reposition dial indicator so tip rests on top of shaft (90° to shaft centerline).

6. Using minimum force, move shaft up and down to measure radial bearing clearance.

Specification

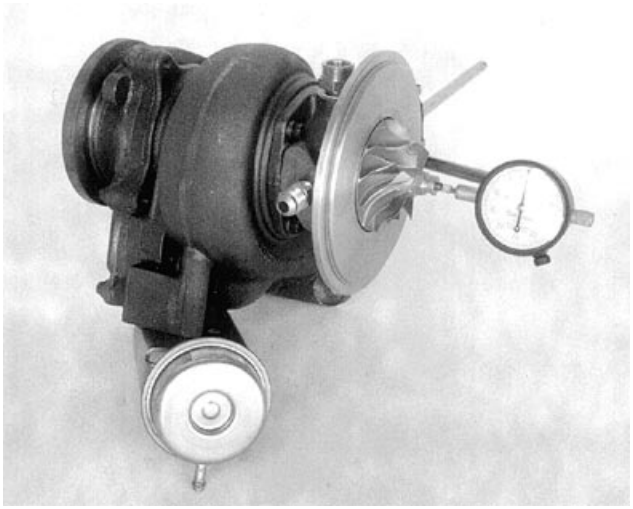
Garret GT35 Turbocharger—Radial Bearing Clearance ..... 0.08—0.18 mm (0.003—0.007 in.)

If bearing clearance is not within specifications, install a replacement turbocharger.

7. Install compressor housing cover and torque cap screws to specifications.

Specification

Turbocharger Compressor Housing Cap Screws—Torque ..... 23 N•m (17 lb-ft)



RG7855 –UN–08DEC97

Axial Bearing End Play Test Shown

RG,30,DT7237 –19–31MAR00–1/1

Repair Turbocharger

Garret turbochargers used on the 6081 engine covered in this manual are available through John Deere service parts as a complete remanufactured assembly only.

RG,30,DT7236 –19–21JAN97–1/1

Adjust Turbocharger Wastegate Actuator

1. If a new turbocharger wastegate assembly is being installed, tighten wastegate bracket-to-turbocharger cap screws to the following specifications.

Specification	
Turbocharger Wastegate Assembly Bracket-to-Turbocharger Cap Screws—Torque	23 N•m (17 lb-ft) (204 lb-in.)

2. Tighten actuator mounting nuts (A) to specification.

Specification	
Turbocharger Wastegate Actuator Mounting Nuts—Torque	6 N•m (4 lb-ft) (53 lb-in.)

3. Install jam nut (B) and rod end (C) onto threaded portion of actuator rod.

4. Disconnect hose to actuator and pressurize actuator to 83 kPa (0.83 bar) (12 psi) and hold at this calibration pressure.

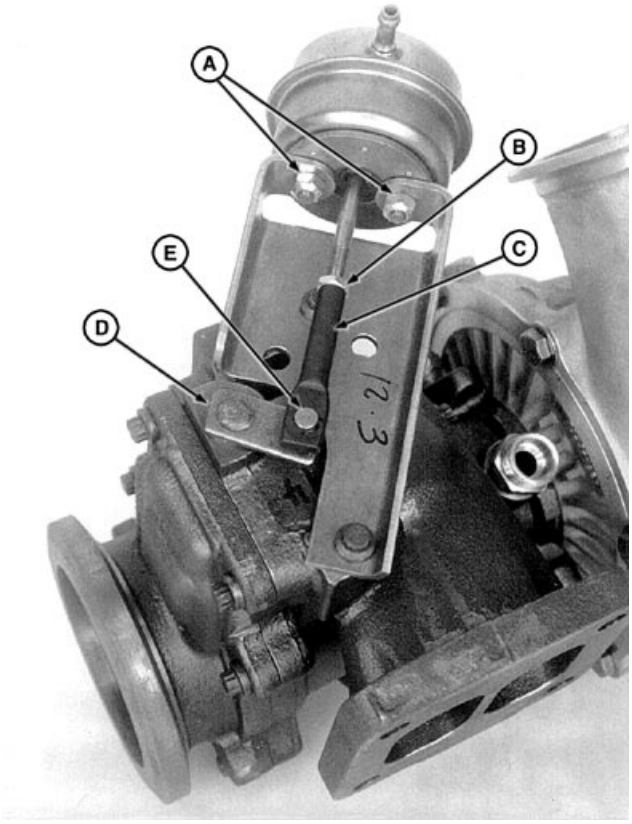
5. Push bypass lever (D) as far as possible toward the actuator and apply pressure to keep lever in that position.

IMPORTANT: Twisting or forcing the entire rod in or out will change the calibration, causing damage to engine from overboost.

6. Turn rod end (C) in either direction until rod end eye can just be slipped over bypass lever pin. Loosen rod end an additional half turn, install onto pin and secure with retainer clip (E). Release pressure on actuator.

7. Pressurize the actuator to 83 kPa (0.83 bar) (12 psi). Measure the end play with a dial indicator, moving the bypass assembly back and forth in a direction perpendicular to the actuator rod. End play should be within the following specifications.

Specification	
Turbocharger Wastegate Actuator (Checking)—End Play	0.05—0.56 mm (0.002—0.022 in.)



Adjust Turbocharger Wastegate Actuator

A—Actuator Mounting Nuts
B—Jam Nut
C—Rod End
D—Bypass Lever
E—Retainer Clip

Continued on next page

8. If necessary to adjust, set end play to the following specification.

Specification	
Turbocharger Wastegate Actuator (Adjusting)—End Play	0.38 mm (0.015 in.)

NOTE: If unable to adjust, replace wastegate actuator.

9. Vary the pressure from 62—83 kPa (0.62—0.83 bar) (9—12 psi) a few times to verify smooth and free operation of the bypass assembly.

10. Attach hose to actuator and secure with hose clamp.

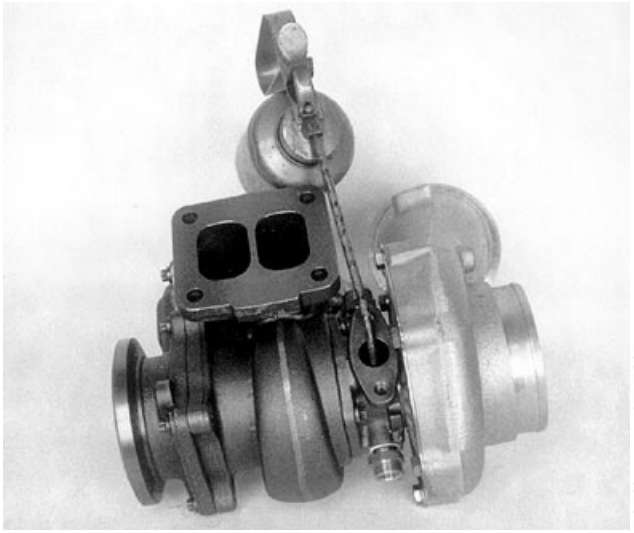
RG,30,DT7234 –19–15APR02–2/2

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.



RG7684 –UN–05DEC97

Prelube Turbocharger

RG,30,DT7233 –19–04NOV97–1/1

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. Turn rotating assembly by hand to lubricate bearings.

NOTE: New turbocharger mounting studs have preapplied anti-seize compound. Apply compound only to used studs.

1. Apply PT569 NEVER-SEEZ® Compound to threads of all reused turbocharger mounting studs. Install studs in exhaust manifold finger-tight.

2. Put a new gasket on turbocharger-to-exhaust manifold mounting surface (not shown). Position turbocharger against gasket.

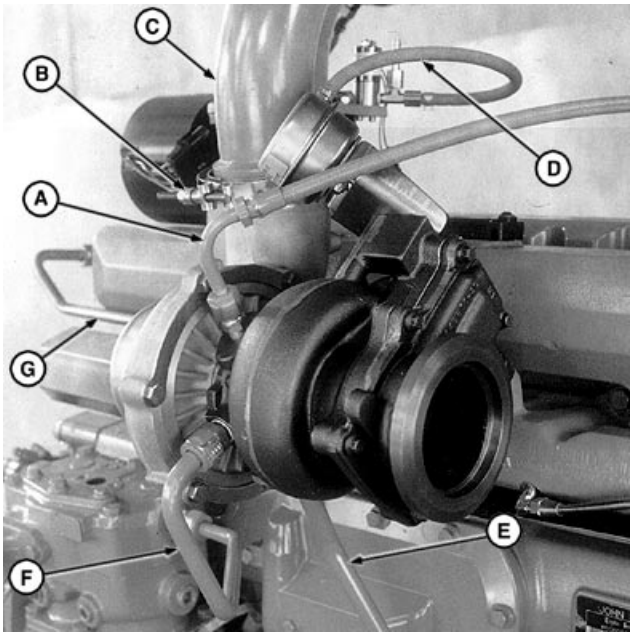
3. Install spacers and 12-point flange nuts on studs. Tighten nuts to specification, using a 12-point box end crow's foot.

Specification	
Turbocharger-to-Exhaust Manifold Nut (HFN01, HFN02, and HFN03 Engine)—Torque	47 N•m (35 lb-ft)
Turbocharger-to-Exhaust Manifold Nut (HFN04 Engine)—Torque	41 N•m (30 lb-ft)

NOTE: Remove all caps or plugs from turbocharger openings.

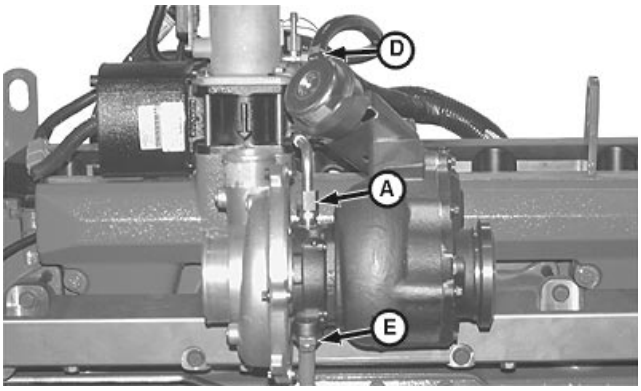
4. If turbocharger oil drain tube was removed from oil pan adapter, apply clean engine oil to end of tube before installing into adapter.

   Install turbocharger oil return tube (E), using a new gasket. Tighten cap screws to specification.



RG7679B –UN–05DEC97

HFN01, HFN03, and HFN04 Engines



RG10584A –UN–03AUG00

HFN02 Engine

A—Oil Inlet Line
B—Clamp
C—Elbow
D—Hose
E—Oil Return Tube
F—Water Inlet Tube (HFN01, HFN03, and HFN04 Engines Only)
G—Water Outlet Tube (HFN01, HFN03, and HFN04 Engines Only)

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

Continued on next page

RG,30,DT7232 –19–01MAR02–1/2

Specification	
Turbocharger Oil Return Tube Cap Screw—Torque	34 N•m (25 lb-ft)

5. Connect oil inlet line (A) and tighten to specification.

Specification	
Turbocharger Oil Inlet Line—Torque	30 N•m (22 lb-ft)

6. Connect turbocharger water inlet tube (F) and outlet tube (G) (HFN01, HFN03, and HFN04 engines). Tighten fittings until they go solid. Do not exceed maximum specified torque.

Specification	
Turbocharger Water Inlet and Outlet Tube Fitting—Torque	16.9 N •m (12.5 lb-ft) (150 lb-in.) maximum

7. Connect turbocharger wastegate diaphragm hose (D).

IMPORTANT: Proper clearance is needed between the compressor elbow (C) and throttle inlet elbow to prevent rubbing.

8. Align compressor housing elbow (C) (not shown on HFN02 photo). Rotate elbow until it is 35 mm (1.38 in.) from throttle inlet elbow at bead of elbow.

9. Tighten compressor outlet elbow clamp (B) to specification.

Specification	
Turbocharger Compressor Outlet Elbow Clamp—Torque	20 N•m (15 lb-ft) (177 lb-in.)

10. Refer to your vehicle technical manual to connect air intake and exhaust piping to turbocharger. Tighten all connections securely to specifications given.

IMPORTANT: BEFORE STARTING an engine with a new or remanufactured 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 starter motor.

RG,30,DT7232 –19–01MAR02–2/2

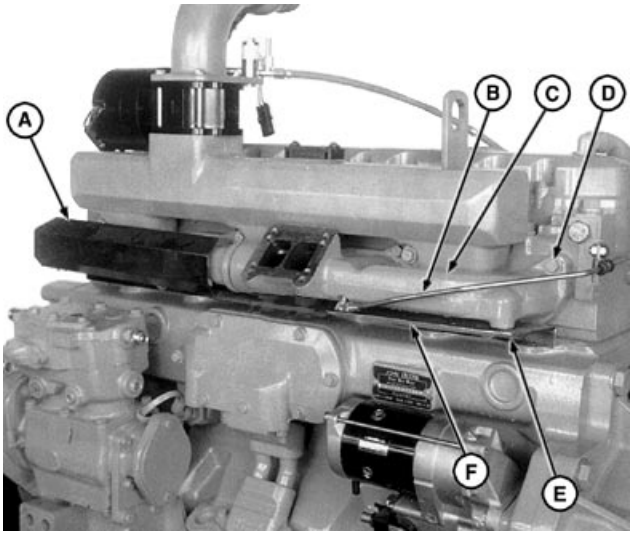
Remove, Inspect, and Install Exhaust Manifold

1. Remove turbocharger from exhaust manifold. (See REMOVE TURBOCHARGER, earlier in this group.)
2. Remove cap screws (E) and exhaust manifold heat shield (F).
3. On HFN01 and HFN03 engines, disconnect exhaust back pressure sensor line (B).

NOTE: On earlier engines using cap screws to mount exhaust manifold to cylinder head, discard cap screws and replace with studs, spacers, and 12-point flange nuts.

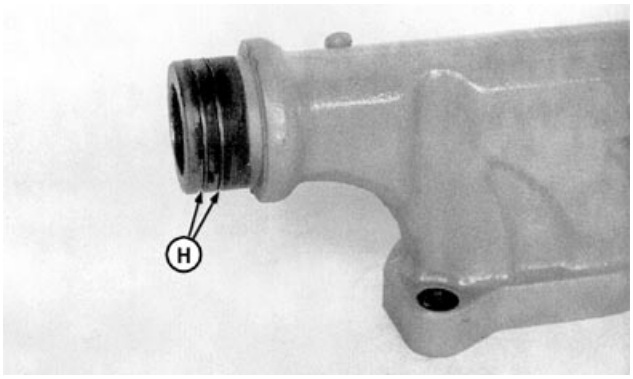
4. Remove cap screws or nuts and spacers (D). On HFN01 engines, remove front and rear exhaust manifolds (A and C). On HFN02, HFN03, and HFN04 engines, remove exhaust manifold (I). Remove manifold gaskets and discard.
5. On HFN01 engines, remove and discard front-to-rear exhaust manifold sealing rings (H).
6. Remove all residue and gasket material from gasket surfaces.
7. Thoroughly clean passages in exhaust manifold.
8. 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 necessary.

A—Front Exhaust Manifold (HFN01)
B—EBP Sensor Line (HFN01 and HFN03)
C—Rear Exhaust Manifold (HFN01)
D—Stud, Spacer, and 12-Point Flange Nut (8 used)
E—Cap Screw (4 used on HFN01) (7 used on HFN02, HFN03, and HFN04)
F—Heat Shield
G—Not Used
H—Sealing Ring (2 used) (HFN01)
I—Exhaust Manifold (HFN02, HFN03, and HFN04)
J—Gasket
K—Gasket



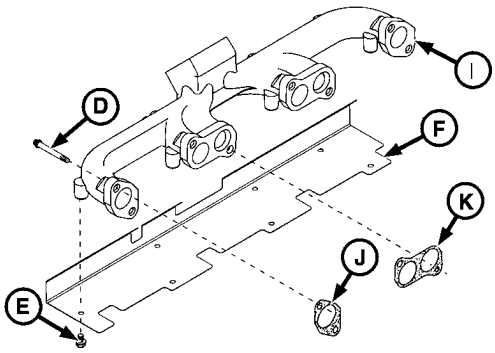
RG7685B –UN–30AUG00

HFN01 Engine



RG7686B –UN–05DEC97

HFN01 Engine



RG11150 –UN–09AUG00

HFN02, HFN03, and HFN04 Engine

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RG,30,DT7231 –19–08MAR02–1/2

NOTE: New exhaust manifold studs have preapplied sealant/anti-sieze compound. If reusing studs, apply PT569 NEVER-SEEZ® Compound to cap screw or stud threads.

9. To install exhaust manifold, reverse removal procedures and use new gaskets. On HFN01 engines, use new sealing rings (H).

10. Tighten 12-point flange nuts to specification, using a 12-point box end crow's foot.

Specification

Exhaust Manifold Mounting Nut—
Torque ..... 47 N•m (35 lb-ft)

11. Install heat shield and cap screws. Tighten cap screws to specification.

Specification

Exhaust Manifold Heat Shield
Cap Screws—Torque ..... 22 N•m (16 lb-ft) (195 lb-in.)

NEVER-SEEZ is a registered trademark of Emhart Chemical Group

RG,30,DT7231 –19–08MAR02–2/2

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 insufficient intake manifold pressure.

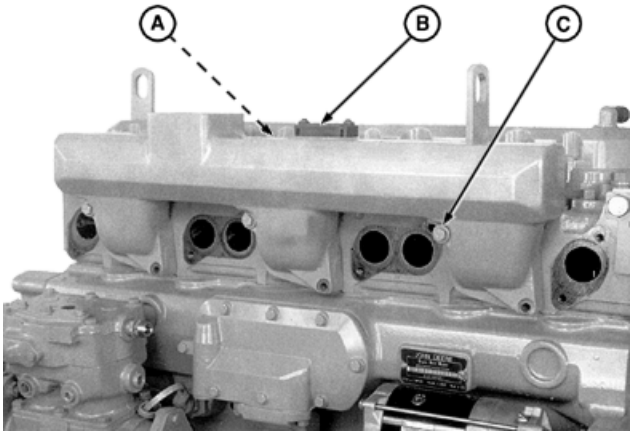
Intake manifold cap screw connections should be inspected periodically for tightness.

Whenever a tune-up has been performed on the engine, or whenever it is suspected that the horsepower output might be low, the intake manifold pressure (turbo-boost) should be checked.

1. On HFN01 engines only, remove exhaust manifold, shown removed. (See REMOVE, INSPECT, AND INSTALL EXHAUST MANIFOLD, earlier in this group.)
2. Remove fuel mixer and throttle actuator (shown removed). (See REMOVE AND INSTALL FUEL MIXER in Group 35.)
3. Disconnect MAT temperature sensor wiring lead (A).
4. Disconnect MAP sensor wiring lead (B).
5. Remove cap screws (C) and remove intake manifold from cylinder head. Remove and discard manifold gaskets.
6. Inspect intake manifold for serviceability. Replace if it is cracked or otherwise damaged.
7. Inspect machined mating surfaces of cylinder head and intake manifold. Clean, as required, by using a scraper and/or wire brush, and compressed air.

NOTE: On HFN01 engines, when installing intake manifold, cap screws should be hand-tightened only. Torque intake manifold cap screws AFTER installing and torquing exhaust manifold and heat shield cap screws.

8. To install intake manifold, reverse removal procedures and use new gaskets.



Remove Intake Manifold (HFN01 Engine Shown)

A—MAT Temperature Sensor Wiring Lead
B—MAP Sensor Wiring Lead
C—Intake Manifold-to-Cylinder Head Cap Screws

Continued on next page

9. On HFN01 engines, install exhaust manifold assembly, heat shield and turbocharger. (See REMOVE, INSPECT, AND INSTALL EXHAUST MANIFOLD in this group.)

10. Tighten intake manifold cap screws to specification.

Specification

Intake Manifold Cap Screws—
Torque ..... 48 N•m (35 lb-ft)

11. Install fuel mixer and throttle actuator. (See REMOVE AND INSTALL FUEL MIXER in Group 35.)

RG,30,DT7230 –19–31MAR00–2/2

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

DPSG,OUO1004,2835 –19–08AUG00–1/2

Spanner Adapter (Early HFN01 Engines) JDG1183

Remove and install filter access plug.

DPSG,OUO1004,2835 –19–08AUG00–2/2

Other Material

Number	Name	Use
242 (LOCTITE®)	Thread Sealant (Medium Strength)	Apply to threads of Schraeder valve and plug on fuel metering valve.

LOCTITE is a registered trademark of Loctite Corp.

DPSG,OUO1004,2842 –19–18APR02–1/1

Fuel System Specifications

Item	Measurement	Specification
Natural Gas Regulator Fuel Outlet Line	Torque	14 N•m (10 lb-ft) (124 lb-in.)
Regulator Support Bracket-to-Block Cap Screws	Torque	47 N•m (35 lb-ft)
Natural Gas Regulator Fuel Inlet Line	Torque	14 N•m (10 lb-ft) (124 lb-in.)
Remote Mount Regulator Bulkhead Bracket-to-Block Cap Screws	Torque	47 N•m (35 lb-ft)
Fuel Metering Valve-to-Bracket Cap Screws and Nuts	Torque	27 N•m (20 lb-ft)
Fuel Metering Valve		
Inlet Hose (Early HFN01 Engines)	Torque	34 N•m (25 lb-ft)
Inlet Steel Line (Early HFN01 Engines)	Torque	14 N•m (10 lb-ft) (124 lb-in.)
Inlet Line (Later HFN01, HFN02, HFN03 and HFN04 Engines)	Torque	14 N•m (10 lb-ft) (124 lb-in.)
Intake Manifold-to-Outlet Manifold Cap Screws	Torque	11 N•m (8 lb-ft) (97 lb-in.)
End Cap-to-Intake Manifold Cap Screws	Torque	7 N•m (5 lb-ft) (62 lb-in.)
Inlet Fitting	Torque	20 N•m (15 lb-ft) (177 lb-in.)
Outlet Fitting	Torque	11 N•m (8 lb-ft) (97 lb-in.)
Natural Gas Temperature (NGT) Sensor	Torque	11 N•m (8 lb-ft) (97 lb-in.)
Natural Gas Pressure (NGP) Sensor	Torque	11 N•m (8 lb-ft) (97 lb-in.)
Fuel Lock-Off Valve Assembly	Torque	7 N•m (5 lb-ft) (62 lb-in.)
Fuel Lock-Off Solenoid Coil Retaining Nut	Torque	7 N•m (5 lb-ft) (62 lb-in.)

Continued on next page

Item	Measurement	Specification
Diagnostic Port (Schraeder Valve)	Torque	11 N•m (8 lb-ft) (97 lb-in.)
Fuel Mixer-to-Intake Manifold Cap Screw	Torque	27 N•m (20 lb-ft)
Fuel Filter Bracket-to-Block Cap Screw and Mounting Stud	Torque	47 N•m (35 lb-ft)
Fuel Filter Outlet Line	Torque	14 N•m (10 lb-ft) (124 lb-in.)
Fuel Filter Inlet Line	Torque	14 N•m (10 lb-ft) (124 lb-in.)

DPSG,OUO1004,2837 –19–08AUG00–2/2

Fuel System Safety

Handle Compressed and Liquid Natural Gas (CNG/LNG) Safely

CAUTION: Handle Compressed Natural Gas (CNG) safely. CNG is methane (natural gas) stored at high pressure. It spreads into air quickly.

Natural gas fumes can cause sickness or death. Always work in a well ventilated area.

Do not smoke when refueling or working on or around natural gas vehicles or equipment.

Keep natural gas vehicles away from sparks, flames, and electrical devices in operation, especially if you suspect a natural gas leak.

TS220 –UN–23AUG88

Work in Well Ventilated Area

Continued on next page

RG,35,DT7247 –19–29MAR04–1/4

35
4

Service Compressed Natural Gas (CNG) and Liquid Natural Gas (LNG) Systems Safely

CAUTION: Service Compressed Natural Gas (CNG) and Liquid Natural Gas (LNG) systems safely. Improper installation, service, or operation of natural gas storage and delivery components can result in fire, explosion, and/or serious injury.

Relieve natural gas fuel system pressure before working on the system. Properly tighten connections and check for leaks before pressurizing the fuel system.

TS227 –UN–23AUG88

Avoid Fires

RG,35,DT7247 –19–29MAR04–2/4

Protect Against High Pressures

CAUTION: Protect against high pressure. Natural gas fuel systems operate at high pressures. DO NOT disassemble or remove any natural gas fuel system components under pressure. Explosive separation of components, and the escaping natural gas can cause serious injury.

Relieve natural gas fuel system pressure before disconnecting any fuel system component.

TS265 –UN–23AUG88

Protect Against High Pressure

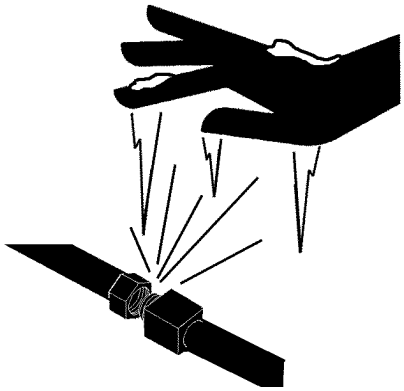
Continued on next page

RG,35,DT7247 –19–29MAR04–3/4

Protect Against Extremely Cold CNG/LNG Leakage

CAUTION: Protect against extremely cold CNG/LNG leakage. Gas escaping from the natural gas fuel system is very cold. Contact with cold escaping gas or surrounding components can cause frostbite or skin damage.

Inspect for leaks by spraying a soap and water solution on joints, fittings, and other areas. Look for bubbles that indicate leakage from the system.



RG8110 –UN–20AUG98

Extremely Cold CNG/LNG Leakage

RG,35,DT7247 –19–29MAR04–4/4

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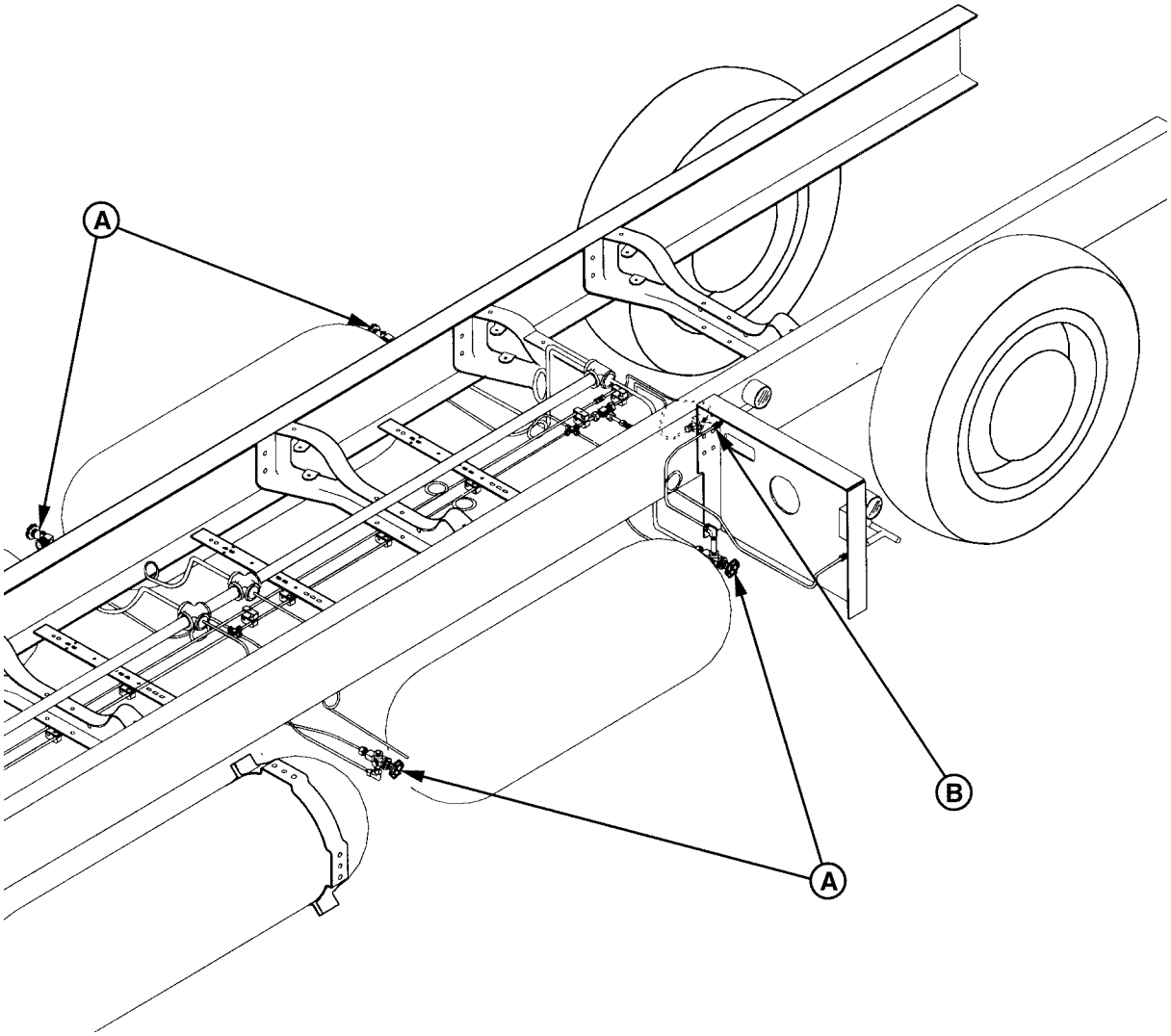
6

Fuel Pressure Leak-Off Procedure



Fuel Valve Locations on Typical Vehicle (CNG System Shown)

A—Fuel Cylinder Manual Shutoff Valve

B—1/4-Turn Valve

IMPORTANT: Always relieve the natural gas pressure by closing each fuel cylinder manual shutoff valve (A). DO NOT relieve the natural gas pressure by closing the 1/4-turn valve (B).

NOTE: The illustration above is a typical application and does not show all of the shutoff valves. Refer to vehicle operator's manual to help locate all fuel cylinder shutoff valves.

The valve is closed when turned fully clockwise viewed from the top, and open when turned counterclockwise viewed from the top.

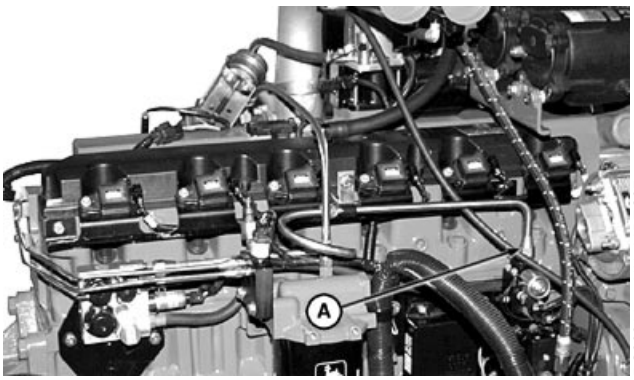
1. Close all fuel cylinder manual shutoff valves (A).
2. If the engine WILL start, let it run until it dies from running out of fuel. Make sure pressure is completely relieved by attempting to start engine several more times.

Continued on next page

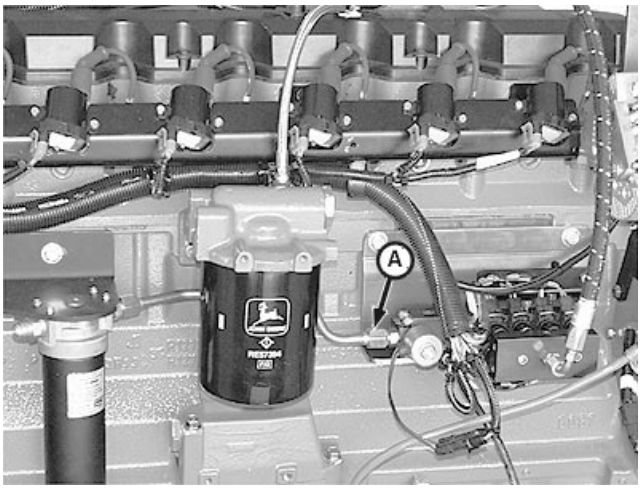
3. If the engine WILL NOT start and run, make sure the vehicle is outside, away from heat, flames, or sparks.

4. Slowly loosen fuel metering block inlet fitting (A) just until escaping gas is heard. Let fuel escape until fuel pressure is completely relieved.

A—Fuel Metering Block Inlet Fitting



HFN01, HFN02 and HFN03 Shown



HFN04 Shown (CNG Version)

OUO1082,0000241 –19–13APR04–2/2

Leak Check Procedure

1. Open fuel cylinder manual shutoff valves.

2. Cycle the ignition to the ON position for 3—4 seconds, then back to the OFF position.

3. Use a non-ammonia soap solution or a commercial leak detector solution and wet all fuel lines and fittings. If bubbles form, the fuel line or fitting is leaking.

4. If a leak is detected, inspect all lines and fittings for damage. Check also for damaged or missing O-rings.

5. Repair and repeat procedure until no leaks are detected.

RG,35,DT7254 –19–04NOV97–1/1

35
8

Remove and Install Engine Mounted Natural Gas Regulator (Early HFN01 Engines)

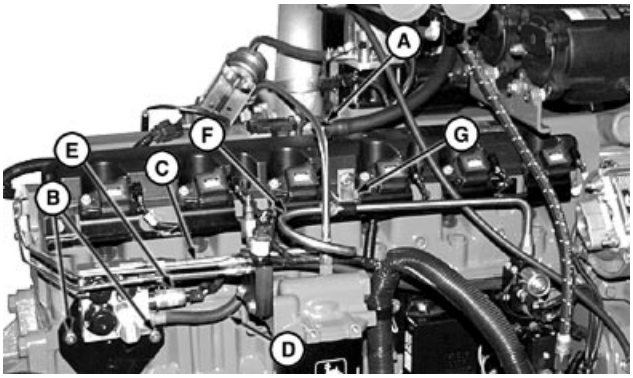
Remove Regulator

CAUTION: Natural gas is highly flammable. DO NOT smoke while working on or near natural gas equipment. Natural gas fumes may cause sickness or death. Work in well ventilated area, shut off natural gas supply, and relieve internal regulator pressure before servicing equipment.

1. Perform fuel pressure leak-off procedure. (See FUEL PRESSURE LEAK-OFF PROCEDURE in this group.)
2. Disconnect batteries.
3. Disconnect natural gas inlet fuel line (F).
4. Disconnect wiring harness connector from natural gas tank pressure (NGTP) sensor (E).

NOTE: Wrap jaws of vise grips with duct tape to protect coolant hoses from damage.

5. Pinch coolant hoses (C and D) with vise grips so coolant is not lost while hoses are disconnected.
6. Remove coolant hoses using lineman's pliers. Discard hose clamps.
7. Remove two cap screws, washers, and spacers (B) securing regulator support bracket to cylinder block.
8. Replace parts as necessary.



Remove NG Regulator (Early HFN01 Engines)

A—Turbocharger Oil Line
B—Cap Screw, Washer and Spacer (2 used)
C—Coolant Inlet Hose
D—Coolant Outlet Hose
E—NGTP Sensor
F—Fuel Line
G—Support Bracket

Install Regulator

1. Install regulator support bracket to cylinder block. Install two cap screws, washers, and spacers (B) finger tight.
2. Install coolant inlet hose (C) and coolant outlet hose (D). Secure hoses with new clamps.
3. Remove vise grips from hoses and inspect hose OD for damage. Replace hose(s) as necessary.

Continued on next page
RG,35,DT7253 –19–31MAR00–1/3

4. Connect wiring harness connector to NGTP sensor (E).

5. Install fuel line (F). Tighten fitting to specification.

Specification

Natural Gas Regulator Fuel
Outlet Line—Torque ..... 14 N•m (10 lb-ft) (124 lb-in.)

6. Install support bracket (G) to fuel line (F).

7. Tighten regulator support bracket-to-cylinder block cap screws to specification.

Specification

Regulator Support
Bracket-to-Block Cap Screws—
Torque ..... 47 N•m (35 lb-ft)

8. Reconnect batteries.

RG,35,DT7253 –19–31MAR00–2/3

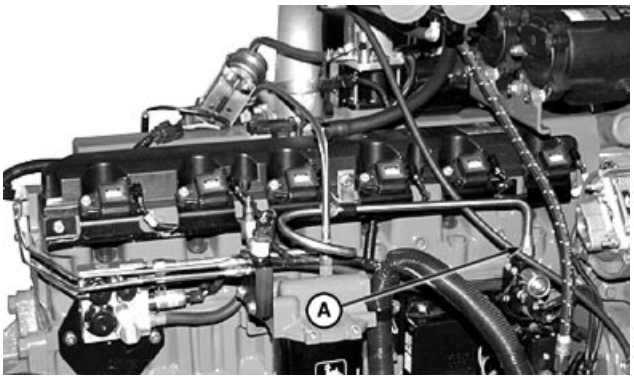
9. Connect fuel metering block inlet fitting (A). Tighten connection to specification.

Specification

Fuel Metering Valve-Inlet Hose
(Early HFN01 Engines)—Torque ..... 34 N•m (25 lb-ft)
Fuel Metering Valve-Inlet Steel
Line (Early HFN01 Engines)—
Torque ..... 14 N•m (10 lb-ft) (124 lb-in.)

10. Double check that all gas and coolant connections are tightened securely.

11. Check for gas leaks. (See LEAK CHECK PROCEDURE in this group.)



RG8681A –UN–11DEC97

Install NG Regulator (Early HFN01 Engines)

A—Inlet Fitting

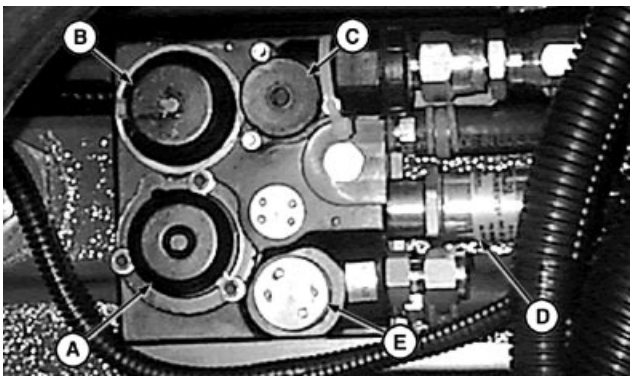
RG,35,DT7253 –19–31MAR00–3/3

35
10

Repair Engine Mounted Natural Gas Regulator (Early HFN01 Engines)

NOTE: No serviceable parts are available for natural gas regulators. Replacement of natural gas regulator assembly is required for repair.

A—First Stage Diaphragm Regulator
B—Second Stage Diaphragm Regulator
C—Pressure Relief Valve
D—Natural Gas Tank Pressure (NGTP) Sensor
E—Natural Gas Filter



RG8877A –UN–11DEC97

Early HFN01 Engine

RG,35,DT7252 –19–04APR00–1/1

Replace Natural Gas Filter (Early HFN01 Engines)

CAUTION: Natural gas is highly flammable. DO NOT smoke while working on or near natural gas equipment. Natural gas fumes may cause sickness or death. Work in well ventilated area, shut off natural gas supply, and relieve internal regulator pressure before servicing equipment.

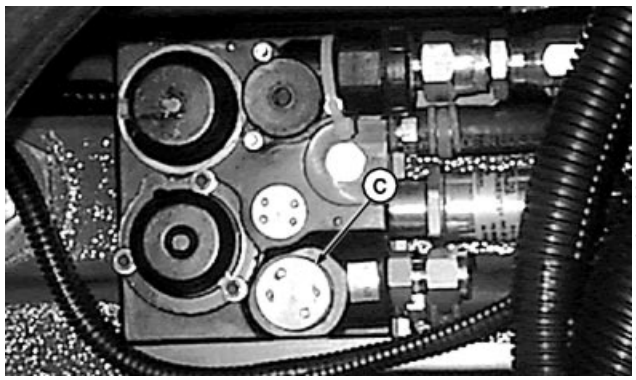
1. Shut off natural gas supply and perform fuel pressure leak-off procedure. (See FUEL PRESSURE LEAK-OFF PROCEDURE in this group.)
2. Disconnect batteries.
3. Relieve internal regulator gas pressure by cracking fuel supply line fitting.
4. Use JDG1183 Spanner Adapter tool (B) and wrench (A) to loosen filter access plug (C).

NOTE: Note order in which parts are removed to aid in assembly.

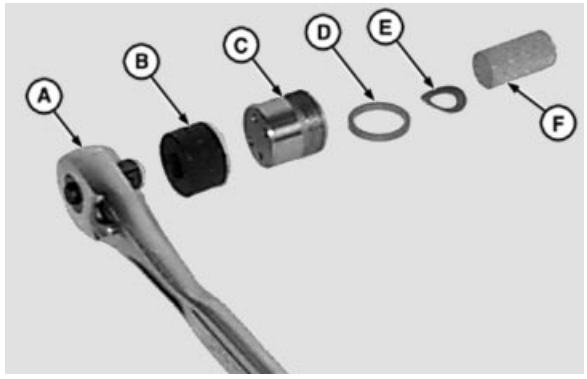
5. Remove filter access plug (C), O-ring (D), spring washer (E), and gas filter (F).
6. Install new filter, spring washer, and O-ring.

NOTE: Center of washer should bow out toward closed end of filter.

7. Install filter plug into regulator housing and tighten. Tighten fuel supply line fitting.
8. Check for gas leaks. (See LEAK CHECK PROCEDURE in this group.)
9. Reconnect batteries.



Replace Gas Filter Element (Early HFN01 Engines)



Natural Gas Filter Components (Early HFN01 Engines)

A—Wrench
B—Spanner Adapter
C—Filter Access Plug
D—O-Ring
E—Spring Washer
F—Gas Filter

RG,35,SO150 –19–04AUG00–1/1

Remove and Install Engine Mounted Natural Gas Regulator (Later HFN01 Engines)

NOTE: Regulator may be mounted on vehicle in some applications. See vehicle technical manual for removal and installation of remote mount natural gas regulator.

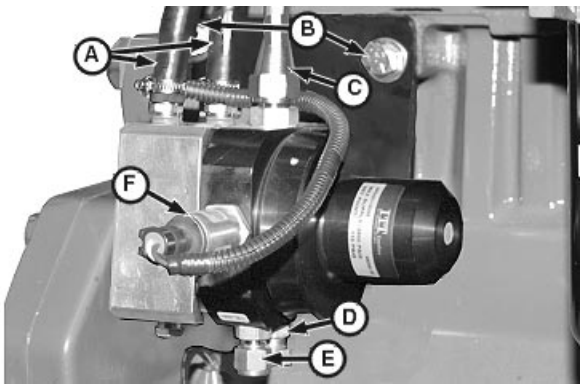
Remove Regulator

CAUTION: Natural gas is highly flammable. DO NOT smoke while working on or near natural gas equipment. Natural gas fumes may cause sickness or death. Work in well ventilated area, shut off natural gas supply, and relieve internal regulator pressure before servicing equipment.

1. Perform fuel pressure leak-off procedure. (See FUEL PRESSURE LEAK-OFF PROCEDURE in this group.)
2. Disconnect batteries.
3. Disconnect natural gas tank pressure (NGTP) sensor (F) wiring harness connector.
4. Loosen fuel outlet line (C) at regulator and metering valve. Remove cap screw and nut from clamp at filter base, securing outlet line. Disconnect fuel outlet line (C) from regulator.
5. Disconnect natural gas fuel inlet line (E) and pressure relief line (D) (shown disconnected).

NOTE: Wrap jaws of vise grips with duct tape to protect coolant hoses from damage.

6. Pinch two coolant hoses (A) with vise grips so coolant is not lost while hoses are disconnected.
7. Mark location of hoses to aid in assembly and remove coolant hoses using lineman's pliers. Discard hose clamps.



Remove NG Regulator

A—Coolant Hoses
B—Support Bracket Cap Screws
C—Fuel Outlet Line
D—Pressure Relief Line
E—Fuel Inlet Line
F—NGTP Sensor

Continued on next page

RG,35,SO152 –19–18APR02–1/3

8. Remove cap screws (B), washers, and spacers, securing regulator support bracket to cylinder block. Lift off regulator.

9. Replace parts as necessary.

Install Regulator

1. Install regulator support bracket to cylinder block. Install cap screws (B), washers, and spacers finger tight.

2. Install coolant hoses (A) to same connectors as when removed. Secure hoses with new clamps.

3. Remove vise grips from hoses and inspect hose OD for damage. Replace hose(s) as necessary.

4. Connect NGTP sensor (F) wiring harness connector.

5. Install fuel inlet line (E) and tighten to specifications.

Specification	
Natural Gas Regulator Fuel Inlet Line—Torque	14 N•m (10 lb-ft) (124 lb-in.)

6. Connect pressure relief line (D).

7. Connect fuel outlet line (C) to regulator. Both ends of line should be snug, but not tight.

8. Connect gas line clamp to oil filter base, but do not tighten cap screw and nut.

9. Tighten regulator support bracket-to-cylinder block cap screws to specifications.

Specification	
Regulator Support Bracket-to-Block Cap Screws—Torque	47 N•m (35 lb-ft)

10. Tighten fuel outlet line (C) to specifications.

Specification	
Natural Gas Regulator Fuel Outlet Line—Torque	14 N•m (10 lb-ft) (124 lb-in.)

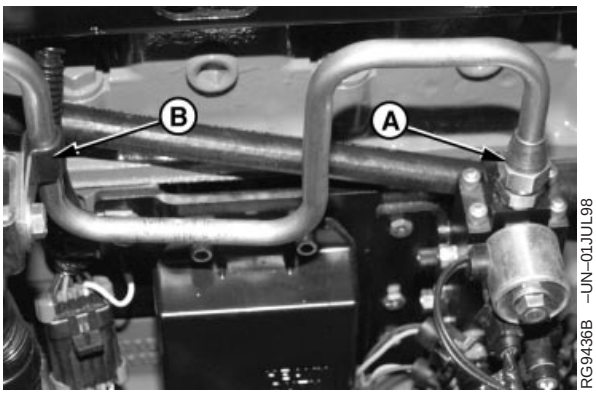
Continued on next page

11. Tighten fuel metering block inlet line (A) to specifications.

Specification

Fuel Metering Valve-Inlet Line
(Later HFN01)—Torque..... 14 N•m (10 lb-ft) (124 lb-in.)

12. Tighten fuel line clamp (B) on oil filter bracket so that no stress is applied to gas line.
13. Double check that all gas and coolant connections are tightened securely.
14. Reconnect batteries.
15. Open gas supply valve.
16. Check for gas leaks. (See LEAK CHECK PROCEDURE in this group.)



Install NG Regulator

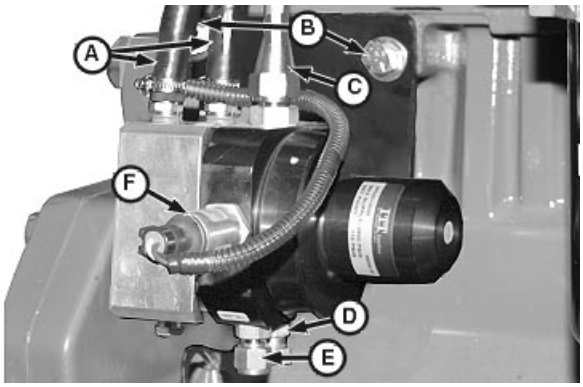
A—Fuel Metering Block Inlet Fitting
B—Fuel Line Clamp

RG,35,SO152 –19–18APR02–3/3

Repair Engine Mounted or Remote Mount Natural Gas Regulator (HFN02, HFN03 and HFN04 Engines)

NOTE: No serviceable parts are available for the natural gas regulator. Replacement of natural gas regulator assembly is required for repair.

NOTE: If fuel supply system has been contaminated, clean fuel inlet filter with dry compressed air. To do this, disconnect fuel inlet line (E) to access the filter.



Engine Mounted Regulator Shown

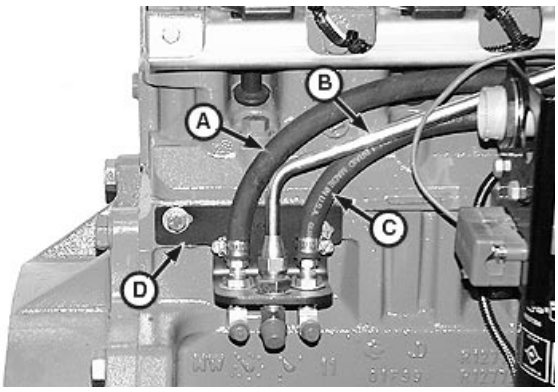
A—Coolant Hoses
B—Support Bracket Cap Screws
C—Fuel Outlet Line
D—Pressure Relief Line
E—Fuel Inlet Line
F—NGTP Sensor (If Equipped)

RG,35,SO155 –19–18APR02–1/1

Remove and Install Remote Mount Natural Gas Regulator Bulkhead

CAUTION: Natural gas is highly flammable. DO NOT smoke while working on or near natural gas equipment. Natural gas fumes may cause sickness or death. Work in well ventilated area, shut off natural gas supply, and relieve internal regulator pressure before servicing equipment.

1. Shut off natural gas supply and perform fuel pressure leak-off procedure. (See FUEL PRESSURE LEAK-OFF PROCEDURE in this group.)
2. Disconnect batteries.
3. See vehicle technical manual for removal and installation of remote mount natural gas regulator.
4. Disconnect vehicle hoses and lines to remote mount regulator. Note position to aid in assembly.
5. Disconnect coolant hoses (A) and (C).
6. Break both ends of line (B) loose (at bulkhead and metering valve). Remove cap screw and nut from clamp at filter base, securing line (B). Disconnect line (B) from bulkhead.
7. Remove cap screws and bulkhead bracket (D).
8. Replace fittings on bulkhead as required.
9. Install bulkhead bracket (D) on block. DO NOT tighten attaching hardware.
10. Install coolant hoses (A) and (C) and tighten hose clamps.
11. Connect line (B) to bulkhead fitting and metering valve. Both ends of line should be snug, but not tight.
12. Connect gas line clamp to oil filter base, but do not tighten cap screw and nut.
13. Tighten bulkhead bracket-to-block cap screws to specifications.



Remote Mount Regulator Bulkhead

A—Short Coolant Hose (To Cylinder Head)
B—Fuel Outlet Line (To Metering Valve)
C—Long Coolant Hose (To Coolant Pump Inlet)
D—Bulkhead Bracket

Continued on next page

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Specification	
Remote Mount Regulator Bulkhead Bracket-to-Block Cap Screws—Torque	47 N•m (35 lb-ft)

14. Tighten both ends of line (B) to specifications.

Specification	
Natural Gas Regulator Fuel Outlet Line—Torque	14 N•m (10 lb-ft) (124 lb-in.)
Fuel Metering Valve-Inlet Line (Later HFN01, HFN02, HFN03 and HFN04 Engines)—Torque	14 N•m (10 lb-ft) (124 lb-in.)

15. Tighten line clamp on oil filter bracket so that no stress is applied to gas line.

16. Double check that all gas and coolant connections are tightened securely.

17. Reconnect batteries.

18. Open gas supply valve.

19. Check for gas leaks. (See LEAK CHECK PROCEDURE in this group.)

DPSG,OUO1004,2831 –19–18APR02–2/2

Remove and Install Fuel Metering Valve

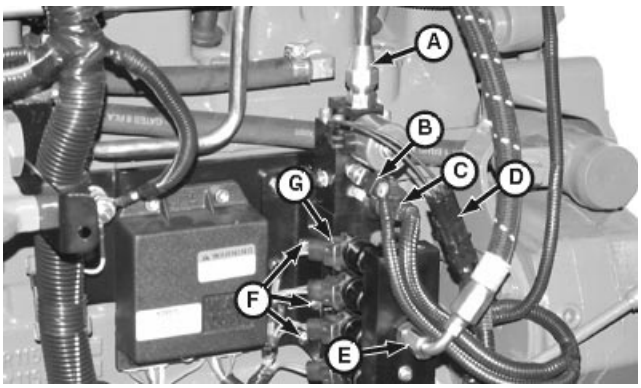
CAUTION: Natural gas is highly flammable. DO NOT smoke while working on or near natural gas equipment. Natural gas fumes may cause sickness or death. Work in well ventilated area, shut off natural gas supply, and relieve internal regulator pressure before servicing equipment.

1. Shut off natural gas supply and perform fuel pressure leak-off procedure. (See FUEL PRESSURE LEAK-OFF PROCEDURE in this group.)
2. Disconnect eight fuel injector wiring harness connectors (G).
3. Disconnect fuel lock-off solenoid wiring harness connector (D).
4. Disconnect natural gas pressure (NGP) sensor wiring harness connector (C).
5. Disconnect natural gas temperature (NGT) sensor wiring harness connector (B).
6. Disconnect outlet hose (E).
7. Break both ends of inlet line (A) loose (at metering valve and regulator or bulkhead). Remove cap screw and nut from clamp at filter base, securing line. Disconnect inlet line (A) from metering valve.
8. Remove three mounting cap screws and nuts (F). Remove fuel metering valve.
9. Install fuel metering valve. Tighten mounting hardware to specifications.

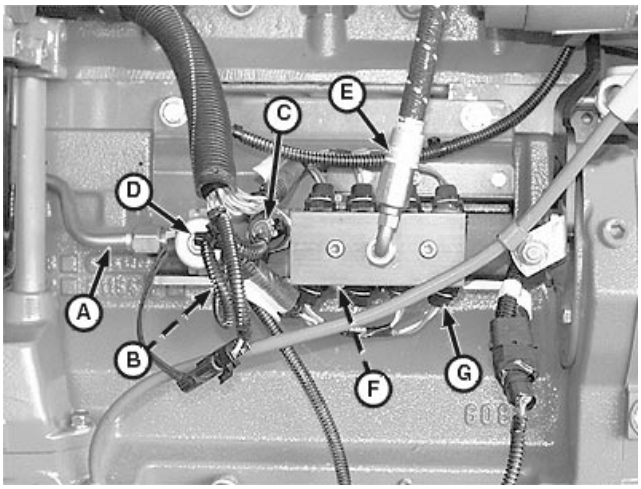
Specification

Fuel Metering Valve-to-Bracket
Cap Screws and Nuts—Torque ..... 27 N•m (20 lb-ft)

10. Connect outlet hose (E) and tighten securely.



HFN02 Shown. HFN01 and HFN03 Are Similar.



HFN04 Shown.

A—Inlet Line
B—NGT Sensor Connector
C—NGP Sensor Connector
D—Fuel Lock-off Solenoid Connector
E—Outlet Hose
F—Mounting Cap Screws and Nuts
G—Fuel Injector Connector (8 used)

Continued on next page

RG,35,DT7250 –19–18APR02–1/2

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11. Tighten both ends of inlet line (A) to specifications.

Specification	
Fuel Metering Valve-Inlet Hose (Early HFN01 Engines)—Torque	34 N•m (25 lb-ft)
Fuel Metering Valve-Inlet Line (Later HFN01, HFN02, HFN03 and HFN04 Engines)—Torque	14 N•m (10 lb-ft) (124 lb-in.)
Natural Gas Regulator Fuel Outlet Line—Torque	14 N•m (10 lb-ft) (124 lb-in.)

12. Tighten fuel line clamp on filter bracket so that no stress is applied to gas line.

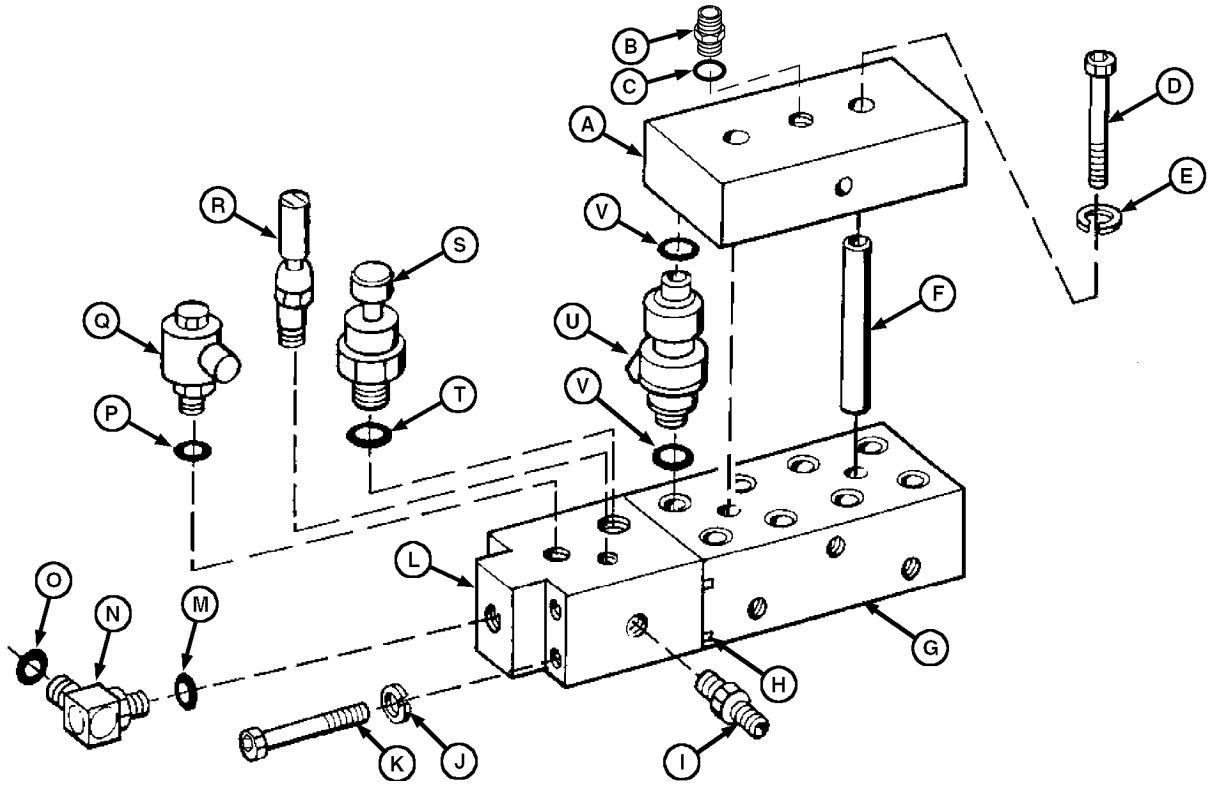
13. Connect all wiring harness connectors.

14. Open gas supply valve.

15. Check for gas leaks. (See LEAK CHECK PROCEDURE in this group.)

RG,35,DT7250 –19–18APR02–2/2

Repair Fuel Metering Valve



RG11153 –UN–14AUG00

Repair Fuel Metering Valve

A—Outlet Manifold
B—Fitting
C—O-Ring
D—Cap Screw (2 used)
E—Lock Washer (2 used)
F—Support Tube
G—Intake Manifold
H—O-Ring
I—Schraeder Valve
J—Lock Washer (4 used)
K—Cap Screw (4 used)
L—End Cap
M—O-Ring
N—Elbow Fitting[1]
O—O-Ring
P—O-Ring
Q—Fuel Lock-Off Solenoid
R—Natural Gas Temperature (NGT) Sensor
S—Natural Gas Pressure (NGP) Sensor
T—O-Ring
U—Pulse-Width-Modulated Fuel Injector (8 used)
V—O-Ring (16 used)

CAUTION: Natural gas is highly flammable. DO NOT smoke while working on or near natural gas equipment. Natural gas fumes may cause sickness or death. Work in well ventilated area, shut off natural gas supply, and relieve internal regulator pressure before servicing equipment.

NOTE: For testing of fuel injectors (U), see INJECTOR TEST in Group 115 of CTM113, for HFN01—03 engines. For HFN04 engines, see ENGINE TEST INSTRUCTIONS — INJECTOR CUTOUT TEST in Group 115 of CTM300.

1. Disassemble, clean and inspect fuel metering valve as required.
2. Note orientation of fittings and injectors for reassembly.

[1] A straight fitting is used in some applications.

Continued on next page

RG,35,DT7249 –19–18APR02–1/2

3. Use all new O-rings for reassembly. Coat O-rings sparingly with soap lubricant.

4. Coat threads of Schraeder valve (I) with LOCTITE® 242 Thread Sealant.

5. Tighten cap screws and valves to specifications.

Fuel Metering Valve—Specification

Intake Manifold-to-Outlet Manifold Cap Screws—Torque ..... 11 N•m (8 lb-ft) (97 lb-in.)
End Cap-to-Intake Manifold Cap Screws—Torque ..... 7 N•m (5 lb-ft) (62 lb-in.)
Inlet Fitting—Torque ..... 20 N•m (15 lb-ft) (177 lb-in.)
Outlet Fitting—Torque ..... 11 N•m (8 lb-ft) (97 lb-in.)
Natural Gas Temperature (NGT) Sensor—Torque ..... 11 N•m (8 lb-ft) (97 lb-in.)
Natural Gas Pressure (NGP) Sensor—Torque ..... 11 N•m (8 lb-ft) (97 lb-in.)
Fuel Lock-Off Valve Assembly—Torque ..... 7 N•m (5 lb-ft) (62 lb-in.)
Fuel Lock-Off Solenoid Coil Retaining Nut—Torque ..... 7 N•m (5 lb-ft) (62 lb-in.)
Diagnostic Port (Schraeder Valve)—Torque ..... 11 N•m (8 lb-ft) (97 lb-in.)

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RG,35,DT7249 –19–18APR02–2/2

Replace Fuel Lock-Off Solenoid or Valve

CAUTION: Natural gas is highly flammable. DO NOT smoke while working on or near natural gas equipment. Natural gas fumes may cause sickness or death. Work in well ventilated area, shut off natural gas supply, and relieve internal regulator pressure before servicing equipment.

NOTE: Lock-off valve components (A—G) are serviceable as an assembly only. Solenoid coil (H) is serviced separately.

1. Shut off natural gas supply and perform fuel leak-off procedure. (See FUEL PRESSURE LEAK-OFF PROCEDURE in this group.)
2. Disconnect harness connector.
3. Remove nut (J), spacer (I) and solenoid coil (H).
4. Remove parts (A—G) from bore in metering valve.
5. Install new O-ring (F) on valve housing (G).

IMPORTANT: Make sure that protruding tip of plunger (A) is facing bottom of plunger (B) as shown.

6. Install new O-ring (D) and coat with a small amount of soap lubricant. Install parts (A—E) in valve housing.
7. Apply white lithium grease to O-ring (F) and install lock-off valve assembly in metering valve bore and tighten to specifications.

Specification	
Fuel Lock-Off Valve Assembly—Torque	7 N•m (5 lb-ft) (62 lb-in.)

IMPORTANT: Do not over-tighten retaining nut.

8. Install coil (H), spacer (I) and nut (J). Tighten nut to specifications.

Specification	
Fuel Lock-Off Solenoid Coil Retaining Nut—Torque	7 N•m (5 lb-ft) (62 lb-in.)

Fuel Lock-Off Solenoid

A—Bottom Plunger
B—Top Plunger
C—Spring
D—O-Ring
E—Valve Stem
F—O-Ring
G—Valve Housing
H—Solenoid Coil
I—Spacer
J—Nut

Continued on next page

9. Open gas supply valve and check for leaks. (See LEAK CHECK PROCEDURE in this group.)

DPSG,OUO1004,2833 –19–02APR04–2/2

Remove and Install Fuel Mixer

CAUTION: Natural gas is highly flammable. DO NOT smoke while working on or near natural gas equipment. Natural gas fumes may cause sickness or death. Work in well ventilated area, shut off natural gas supply, and relieve pressure before servicing equipment.

CNG is methane (natural gas) stored at high pressure. It spreads into air quickly.

Natural gas fumes can cause sickness or death. Always work in a well ventilated area.

Do not smoke when refueling or working on or around natural gas vehicles or equipment.

Keep natural gas vehicles away from sparks, flames, and electrical devices in operation, especially if you suspect a natural gas leak.

Improper installation, service, or operation of CNG storage and delivery components can result in fire, explosion, and/or serious injury.

Relieve CNG fuel system pressure before working on the system. Properly tighten connections and check for leaks before pressurizing the CNG fuel system.

CNG fuel systems operate at high pressures. DO NOT disassemble or remove any CNG fuel system components under pressure. Explosive separation of components, and the escaping natural gas, can cause serious injury.

Relieve CNG fuel system pressure before disconnecting any fuel system component.

Gas escaping from the CNG fuel system is very cold. Frostbite and skin damage can occur from contact with cold escaping gas or surrounding components.

Inspect for leaks by spraying a soap and water solution on joints, fittings, and other areas. Look for bubbles that indicate leakage from the system.

1. Shut off natural gas supply and perform fuel leak-off procedure. (See FUEL PRESSURE LEAK-OFF PROCEDURE in this group.)
2. Disconnect batteries.

Continued on next page

RG,35,DT7248 –19–18APR02–1/3

3. Remove air intake hose from fuel mixer elbow, shown removed.

4. Disconnect fuel line (A).

5. **On HFN01 and HFN03 Engines:** disconnect wiring connector and hoses from turbocharger wastegate control valve.

6. **On HFN02 Engine:** disconnect knock module connector (D) and UTP sensor connector (E).

7. **On HFN04 Engine:** disconnect knock module connector (D), UTP sensor connector (E) and TCT sensor connector (G).

NOTE: On HFN02, HFN03, and HFN04 engines, the turbocharger wastegate control valve, connector and harness clamp can remain on mounting bracket. Bracket can be moved aside when removing fuel mixer elbow

8. Remove four cap screws (B). Remove fuel mixer (C). Discard gasket.

9. Remove components from mixer elbow as required. See appropriate procedure in Group 45.

10. Install fuel mixer and wastegate control valve mounting bracket (if equipped) using a new gasket.

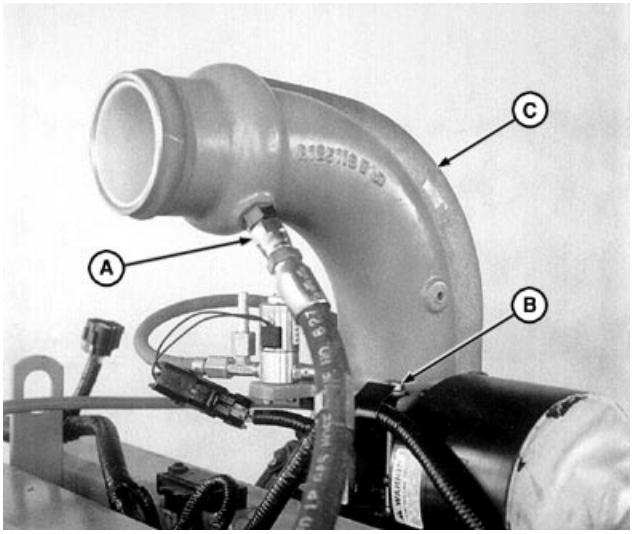
11. Tighten fuel mixer-to-intake manifold cap screws to specification.

Specification

Fuel Mixer-to-Intake Manifold Cap Screw—Torque ..... 27 N•m (20 lb-ft)

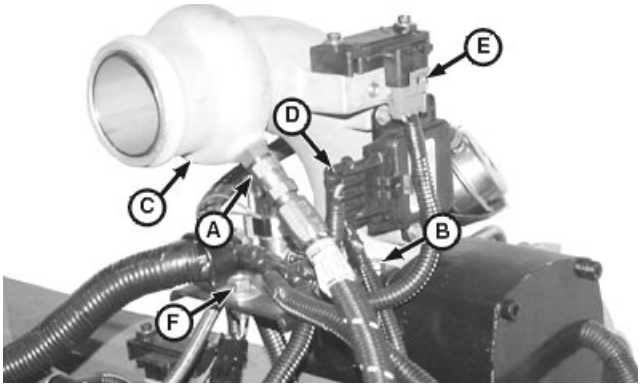
12. Connect fuel line, harness connectors and wastegate hose as required.

A—Fuel Line
B—Cap Screws
C—Fuel Mixer
D—Knock Module Connector
E—Upstream Throttle Pressure (UTP) Sensor Connector
F—Harness Clamp
G—Throttle Charge Temperature (TCT) Sensor Connector



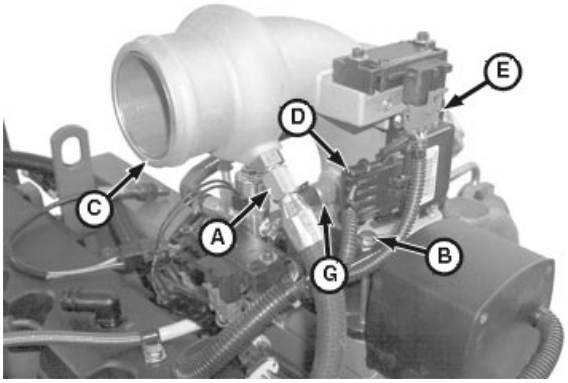
RG7691A –UN–05DEC97

HFN01 Shown, HFN03 Is Similar.



RG10588A –UN–24FEB00

HFN02 Shown.



RG12150A –UN–19APR02

HFN04 Shown.

Continued on next page

13. Reconnect Batteries.
14. Open gas supply valve.
15. Check for gas leaks. (See LEAK CHECK PROCEDURE in this group.)

RG,35,DT7248 –19–18APR02–3/3

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Remove and Install Engine Mounted Fuel Filter Assembly (HFN04 Engines)

Remove Fuel Filter Assembly

CAUTION: Natural gas is highly flammable. DO NOT smoke while working on or near natural gas equipment. Natural gas fumes may cause sickness or death. Work in well ventilated area, shut off natural gas supply, and relieve internal regulator pressure before servicing equipment.

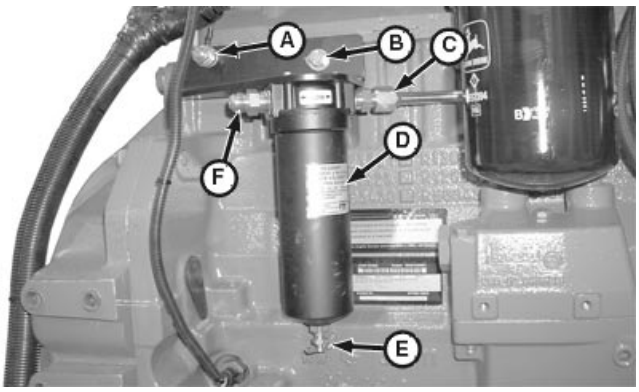
1. Perform fuel pressure leak-off procedure. (See FUEL PRESSURE LEAK-OFF PROCEDURE in this group.)
2. Disconnect batteries.
3. Open filter drain cock (E) and drain off any oil or water that is present. Close drain cock.
4. Disconnect natural gas fuel filter inlet line (shown removed) from inlet fitting (F).
5. Disconnect fuel filter outlet line (C).
6. Disconnect wires from mounting stud (A). Remove mounting stud.
7. Remove cap screw (B) and remove fuel filter assembly (D).
8. Replace parts as necessary.

Install Fuel Filter Assembly

1. Install fuel filter assembly (D) using cap screw (B) and mounting stud (A). Tighten cap screw and mounting stud to specification.

Specification	
Fuel Filter Bracket-to-Block Cap Screw and Mounting Stud—Torque	47 N•m (35 lb-ft)

2. Connect wires to mounting stud.
3. Connect fuel filter outlet line (C). Tighten line to specification.



RG12161 –UN–06MAY02

Fuel Filter Assembly (HFN04)

A—Mounting Stud
B—Cap Screw
C—Fuel Filter Outlet Line
D—Fuel Filter Assembly
E—Drain Cock
F—Fuel Filter Inlet Fitting

Continued on next page

Specification
Fuel Filter Outlet Line—Torque..... 14 N•m (10 lb-ft) (124 lb-in.)

4. Connect fuel filter inlet line to fitting (F). Tighten line to specification.

Specification
Fuel Filter Inlet Line—Torque..... 14 N•m (10 lb-ft) (124 lb-in.)

5. Double check that all gas connections are tightened securely.

6. Reconnect batteries.

7. Check for gas leaks. (See LEAK CHECK PROCEDURE in this group.)

OUO1082,0000242 –19–03MAY02–2/2

Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

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DPSG,OUO1004,2838 –19–28FEB02–1/3

RW17441 –UN–16NOV89

Starter Wrench JDE80

Remove and install starter motor.

JDE80

DPSG,OUO1004,2838 –19–28FEB02–2/3

Digital Multimeter JT05791

Test electrical components for voltage, resistance, or current flow. It is especially good for measuring low voltage or high resistance circuits.

RGR11274 –UN–11DEC97

JT05791

DPSG,OUO1004,2838 –19–28FEB02–3/3

Starting and Charging System Specifications

Item	Measurement	Specification
Starter Motor Mounting Cap Screws and Nut	Torque	47 N•m (35 lb-ft)
RE61406 Starter Motor (Denso 228000-5280)	Rating No-Load Test Current Draw No-Load Test Armature RPM	4.0 kW/12V 220 amps @ 11V 4200
RE37961 Starter Motor (Delco Remy 1993894-37MT)	Rating No-Load Test Current Draw No-Load Test Armature RPM	12V 140—175 amps 6600—8200
Alternator Strap-to-Thermostat Housing	Torque	61 N•m (45 lb-ft)

DPSG,OUO1004,2841 –19–08AUG00–1/1

Remove and Install Starter Motor

CAUTION: Disconnect battery ground strap or serious injury could result if tools ground electrical system.

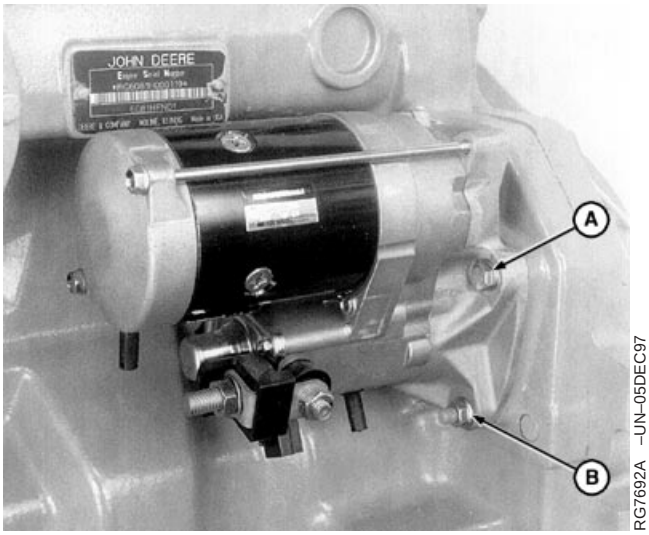
1. Disconnect ground strap from battery.
2. Disconnect wiring harness-to-starter motor wires, shown removed.
3. Remove two mounting cap screws (A). Use JDE80 Starter Wrench, if required.
4. Remove mounting nut (B).
5. Remove starter motor.

NOTE: There are no serviceable parts available. Replacement of entire starter motor is necessary.

6. Install starter motor. Tighten cap screws and nut to specifications.

	Specification
Starter Motor Mounting Cap Screws and Nut—Torque	47 N•m (35 lb-ft)

7. Connect wiring harness-to-starter motor wires.
8. Connect ground strap.



Remove and Install Starter

A—Mounting Cap Screw (2 used)
B—Mounting Nut

RG,40,DT7255 –19–28FEB02–1/1

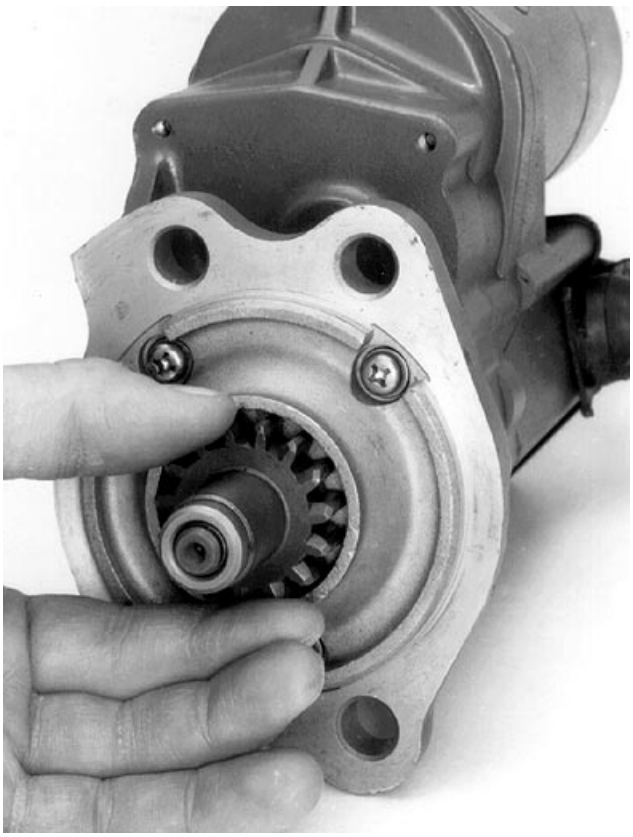
40
4

Bench Test Starter Motor

IMPORTANT: Never operate motor longer than 30 seconds. Allow at least two minutes for cooling and battery recovery before operating again. Overheating, caused by excessive operation, will seriously damage starter motor.

NOTE: Perform bench tests to determine if the starter motor is the cause of the problem.

1. Turn overrunning clutch drive clockwise by hand. Pinion should turn freely.
2. Turn pinion counterclockwise. A definite resistance should be felt. If clutch assembly is defective, replace starter motor.
3. If armature turns freely and the clutch is not defective, test starter under no-load conditions.



RGR2158 –UN–11DEC97

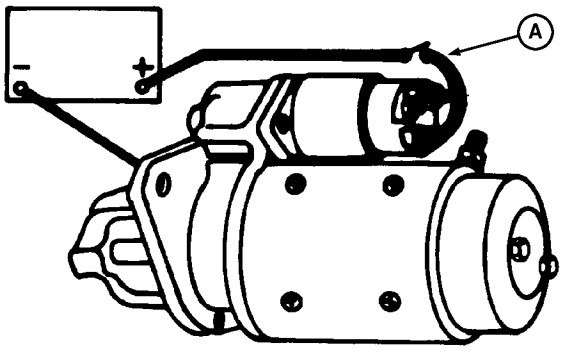
Bench Test Starter Motor

RG,40,DT7265 –19–04NOV97–1/1

Starter Motor Solenoid Return Test

1. Make connections as shown.
2. Close switch (A).
3. Pull the drive out until the pinion contacts the pinion stop. When released, the drive should return without hesitation.

A—Switch



RG3896 –UN–05DEC97

RG3896

Make Solenoid Return Test

RG,40,DT7264 –19–04NOV97–1/1

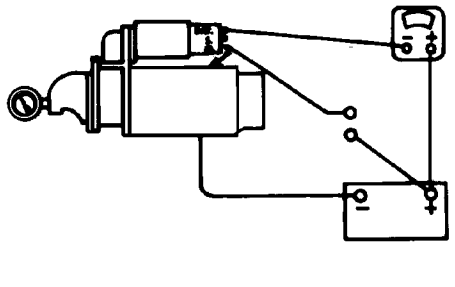
Starter Motor No-Load Test

1. Make connections as shown, and use a ammeter capable of measuring several hundred amps.
2. Measure current draw and compare with specifications.
3. If speed and current are slightly low, connect a voltmeter between motor terminal and frame. Observe voltage during test. Voltage may be reduced because of high current draw on battery.

Specification

RE61406 Starter Motor (Denso 228000-5280)—Rating 4.0 kW/12V
No-Load Test Current Draw ..... 220 amps @ 11V
No-Load Test Armature RPM 4200
RE37961 Starter Motor (Delco Remy 1993894-37MT)—Rating 12V
No-Load Test Current Draw ..... 140—175 amps
No-Load Test Armature RPM ..... 6600—8200

4. If speed or current draw is significantly different than specified, diagnose problem as follows.



Make No Load Test

A—Ammeter
B—Battery
C—Starter Frame
D—Tachometer
E—Battery Terminal
F—Switch
G—Field Coil Connector

RG,40,DT7263 –19–08AUG00–1/1

Diagnose No-Load Test

FAILS TO OPERATE-LOW CURRENT DRAW

- Open series field circuit.
- Open armature coils.
- Defective brush contact with commutator.

FAILS TO OPERATE-HIGH CURRENT DRAW

- Grounded terminal or fields.
- Seized bearings.

LOW SPEED-LOW CURRENT DRAW

- High internal resistance.
- Defective brush contact with commutator.

LOW SPEED-HIGH CURRENT DRAW

- Excessive friction.
- Shorted armature.
- Grounded armature or fields.

HIGH SPEED-LOW CURRENT DRAW

Open shunt field circuit.

HIGH SPEED-HIGH CURRENT DRAW

Shorted series field coils.

RG,40,DT7266 –19–04NOV97–1/1

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 belt guard (if equipped). (See REMOVE AND INSTALL BELT GUARD ASSEMBLY in Group 25.)
4. Remove alternator belt using 1/2 in. drive ratchet on belt tensioner.
5. Remove alternator mounting hardware (A).
6. Remove alternator.

NOTE: There are no serviceable parts available. Replacement of entire alternator is necessary.

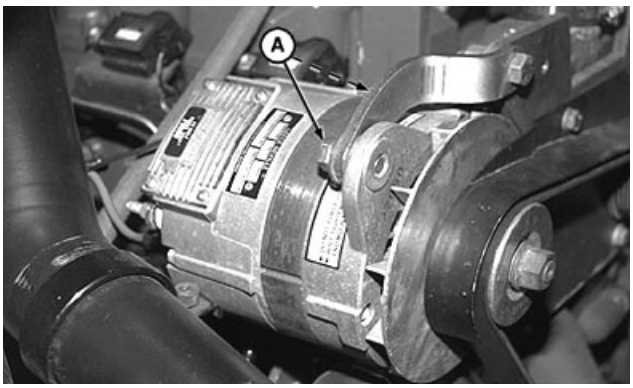
7. Install alternator. Tighten all mounting hardware (A).

Specification	
Alternator Mounting Hardware (Upper)—Torque	25 N•m (18 lb-ft)

Specification	
Alternator Mounting Hardware (Lower)—Torque	50 N•m (37 lb-ft)

8. If alternator mounting bracket or strap are removed and reinstalled, torque cap screws to the following specifications.

Alternator Mounting Bracket and Strap Hardware—Specification	
Alternator Adjusting Strap-to-Thermostat Housing (7/8 in. long) Cap Screws—Torque	35 N•m (26 lb-ft)
Alternator Adjusting Strap-to-Thermostat Housing (2 in. long) Cap Screws—Torque	61 N•m (45 lb-ft)
Alternator Front Support-to-Alternator Rear Support (1-3/4 in. long) Cap Screws—Torque	61 N•m (45 lb-ft)



RG8957A –UN–19JAN98

Remove and Install Alternator

A—Alternator Mounting Hardware

Continued on next page

Alternator Bracket-to-Thermostat Housing (1 in. and 1-1/4 in. long) Cap Screws—Torque ..... 35 N•m (26 lb-ft)
Alternator Bracket-to-Alternator Support (1 in. and 1-1/4 in. long) Cap Screws—Torque ..... 35 N•m (26 lb-ft)
Alternator Support-to-Fan Plate (1 in. and 1-1/4 in. long) Cap Screws—Torque ..... 35 N•m (26 lb-ft)
Alternator Support-to-Thermostat Housing (1 in. and 1-1/4 in. long) Cap Screws—Torque ..... 35 N•m (26 lb-ft)

9. Install alternator belt using 1/2 in. drive ratchet on belt tensioner.

10. Install belt guard (if equipped). (See REMOVE AND INSTALL BELT GUARD ASSEMBLY in Group 25.)

11. Connect positive (+) red wire and regulator connector.

12. Connect battery ground (—) cable.

RG,40,DT7261 –19–08AUG00–2/2

Charging System Failure

Causes of Charging System Failure:

Charging system malfunction is identified by battery condition.

Undercharged batteries caused by one or a combination of the following:

- Loose belts; corroded, broken, loose, or dirty terminals; broken wiring; undersize wiring; defective batteries.
- Alternator field circuit malfunction caused by one or a combination of the following:
  - – Poor contacts between regulator and brushes.
  - – Defective diode trio.
  - – No residual magnetism in rotor.
  - – Defective or improperly adjusted regulator.
  - – Damaged or worn brushes.
  - – Damaged or worn slip rings.
  - – Poor connection between slip ring assembly and field coil leads.
  - – Rotor coil shorted, open, or grounded.
- Alternator generating section malfunction caused by one or a combination of the following:
  - – Stator phase(s) shorted, open, or grounded.
  - – Rectifier assembly grounded.
  - – Rectifier(s) shorted or open.

Overcharged batteries caused by one or a combination of the following:

- Defective battery.
- Defective diode trio.
- Defective or improperly adjusted regulator.
- Poor sensing lead contact to regulator or rectifier assembly.

RG,40,DT7260 –19–04NOV97–1/1

Alternator Troubleshooting

NOTE: For fast and accurate troubleshooting, perform the following test procedures. Ensure that belts are properly tensioned, and that wiring and terminals are in good working condition. Check batteries per manufacturer's specifications to establish if they are defective. Ensure that batteries are 95—100% charged.

RG,40,DT7259 –19–04NOV97–1/1

Alternator Output Test

1. Shut off all electrical accessories and run engine at approximately 1000—1200 rpm.

IMPORTANT: Use an accurate voltmeter to measure output voltage. DO NOT rely on dashboard gauges.

2. Connect a DC voltmeter to the battery terminals and measure voltage. Make a note of the readings, Compare to the values specified by the vehicle manufacturer. If reading is above specified voltage, then an OVERCHARGE condition is present.
3. If the reading is below specified voltage, then an UNDERCHARGE condition is present.

If either condition is observed, perform DIODE TRIO TEST in this group.

NOTE: The following tests are designed to identify the source of alternator failure. Refer to the manufacturer's service manual for detailed descriptions on how to disassemble, test, and properly assemble the alternator.

RG,40,DT7258 –19–04NOV97–1/1

Diode Trio Test

1. Remove the diode trio from the alternator.
2. Connect the negative (—) ohmmeter test lead to the diode trio lead terminal. Connect the positive (+) test lead to each of the three copper contact pads, one at a time. Observe the resistance at each contact pad and write down the resistance for each contact for later reference.
3. Reverse the leads so the positive (+) lead is connected to the diode trio lead terminal and the negative (—) test lead connects to the contact pads. Again observe the resistance at each of the contact pads and record the results for each contact.

NOTE: The diode trio is OK when a LOW resistance reading is observed in one direction and a HIGH resistance is observed in the other direction. Occasionally the diode trio malfunctions under operating conditions only.

4. If the diode trio is malfunctioning, replace alternator. Otherwise, reinstall the diode trio on the alternator.

NOTE: There are no serviceable parts available. Replacement of entire alternator is necessary if failure is detected.

RG,40,DT7257 –19–04NOV97–1/1

Full Field Test

1. Run engine at approximately 1000 RPM with all electrical accessories “OFF.” Measure the output voltage across the alternator terminals and write it down for later reference.

NOTE: Use a digital voltmeter with .01-volt reading capabilities.

2. Attach a short jumper to a 51 mm (2 in.) piece of stiff wire (a paper clip is suitable).

3. Connect the other end of the jumper to the negative (—) alternator output terminal and insert the wire in the FULL FIELD ACCESS HOLE. Hold the wire firmly against the brush terminal inside the housing.

4. With the jumper in place, connect a voltmeter across the alternator terminals and run the engine at approximately 1000 RPM. Compare this voltage reading with the voltage reading obtained in Step 1.

5. With the jumper still hooked up and the wire in the FULL FIELD ACCESS HOLE, connect an AC voltmeter across terminals 1&2, 1&3, and 2&3, and note the voltages. If all of the voltages are approximately the same, they are considered “balanced.”

6. Remove the jumper and wire from the alternator. If the voltage in Step 4 is higher than the voltage in Step 1, and the voltages measured in Step 5 are balanced, the stator and alternator are OK.

If the voltage in Step 4 is higher than the voltage in Step 1, and the voltages measured in Step 5 are not balanced, the alternator stator or rectifier(s) are defective. Replace alternator.

If the voltage in Step 4 is lower or equal to the voltage in Step 1, and the voltages measured in Step 5 are balanced, the alternator is defective. Replace alternator.

If the voltage in Step 4 is lower or equal to the voltage in Step 1, and the voltages measured in Step 5 are not balanced, alternator stator or rectifier(s) are defective. Replace alternator.

RG,40,DT7256 –19–04NOV97–1/1

Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

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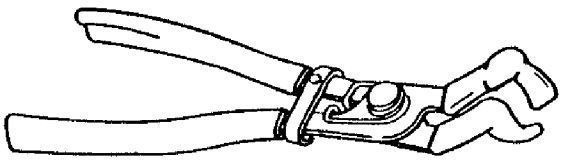
DPSG,OUO1004,2855 –19–10AUG00–1/16

RG6720 –UN–05DEC97

Spark Plug Boot Puller Pliers. JDG815

Use to remove and install spark plug boots.



RG6720

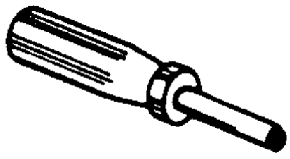
JDG815

DPSG,OUO1004,2855 –19–10AUG00–2/16

RG6783 –UN–05DEC97

WEATHER PACK™ Extraction Tool . . . . . JDG364[1]

Use to replace terminal contact in WEATHER PACK™ connector body.



RG6783

JDG364

WEATHER PACK is a trademark of Packard Electric.

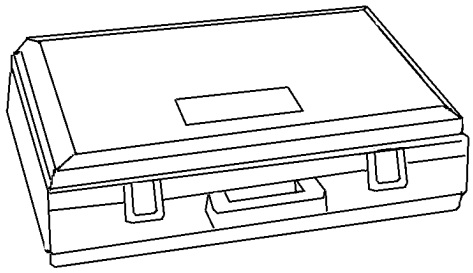
[1]Included in JT07195B Electrical Repair Kit.

Continued on next page

DPSG,OUO1004,2855 –19–10AUG00–3/16

Technician's Electrical Repair Kit JT07195B

Remove and install wires into connectors. Kit includes: JDG140 Contact Extraction Tool, JDG141 Contact Extraction Tool, JDG361 12—14 Gauge Extractor, JDG362 16—18 Gauge Extractor, JDG364 WEATHER PACK™ Extractor, JDG776 WEATHER PACK™/ METRI-PACK™ Extractor, JDG777 WEATHER PACK™/ METRI-PACK™ Narrow Extractor, JDG785 6—8 Gauge DEUTSCH™ Extractor, and 307382 Carrying Case.



RW25558 –UN–29AUG96

JT07195B

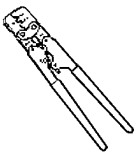
WEATHER PACK is a trademark of Packard Electric.
METRI-PACK is a trademark of Delphi Packard Electric Systems Incorporated
DEUTSCH is a trademark of Deutsch Co.

DPSG,OUO1004,2855 –19–10AUG00–4/16

RW25542 –UN–20AUG96

WEATHER PACK™ Crimping Tool JDG783

Crimp contacts to wires.

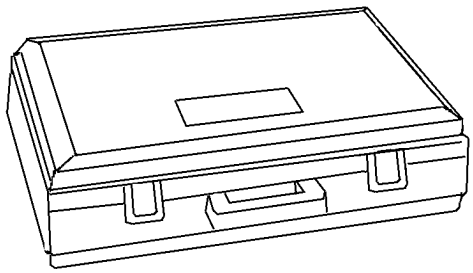


WEATHER PACK is a trademark of Packard Electric

DPSG,OUO1004,2855 –19–10AUG00–5/16

Electrical Repair Tool Kit. JDG155

Use for repair and installation of wires into electrical connectors. Kit consists of: JDG107 Holding Plate, JDG139 Contact Insertion Tool, JDG140 Contact Extraction Tool, JDG141 Contact Extraction Tool, JDG142 Contact Extraction Tool, JDG143 Contact Extraction Tool, JDG144 Crimping Pliers, JDG145 Electrician's Pliers, and JDG146 Carry Case.



RW25558 –UN–29AUG96

JDG155

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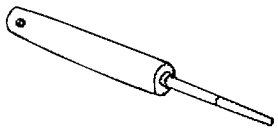
DPSG,OUO1004,2855 –19–10AUG00–6/16

RW25541 –UN–20AUG96

METRI-PACK™ Extractor (Wide) JDG776



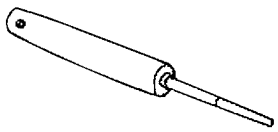
Remove terminals from METRI-PACK™ connectors.

METRI-PACK is a trademark of Delphi Packard Electric Systems Incorporated

DPSG,OUO1004,2855 –19–10AUG00–7/16

RW25541 –UN–20AUG96

METRI-PACK™ Extractor (Narrow) JDG777



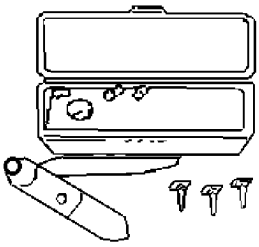
Remove terminals from METRI-PACK™ connectors.

METRI-PACK is a trademark of Delphi Packard Electric Systems Incorporated

DPSG,OUO1004,2855 –19–10AUG00–8/16

DEUTSCH™ Electrical Repair Tool Kit. JDG359

Repair DEUTSCH™ electrical connector bodies. Kit Includes: JDG360 Crimper, JDG361 12—14 Gauge Extractor (Set of Two), JDG362 16—18 Gauge Extractor (Set of Two), and JDG363 20—24 Gauge Extractor (Set of Two).



RW25540 –UN–06SEP96

JDG359

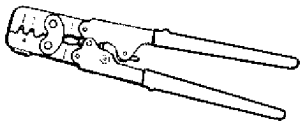
DEUTSCH is a trademark of Deutsch Co.

DPSG,OUO1004,2855 –19–10AUG00–9/16

RW26025 –UN–18DEC98

Crimping Tool. JDG865

Used to crimp contacts on METRI-PACK™connectors.



JDG865

METRI-PACK is a trademark of Delphi Packard Electric Systems Incorporated

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DPSG,OUO1004,2855 –19–10AUG00–10/16

12—14 Gauge Extractor (Set of Two) JDG361

Extracts wire. Part of JDG359 Electrical Repair Kit.

DPSG,OUO1004,2855 –19–10AUG00–11/16

16—18 Gauge Extractor (Set of Two) JDG362

Extracts wire. Part of JDG359 Electrical Repair Kit.

DPSG,OUO1004,2855 –19–10AUG00–12/16

20—24 Gauge Extractor (Set of Two). JDG363

Extracts wire. Part of JDG359 Electrical Repair Kit.

DPSG,OUO1004,2855 –19–10AUG00–13/16

Crimping Tool. JDG360

Install DEUTSCH™ contacts. Part of JDG359 Electrical Repair Kit.

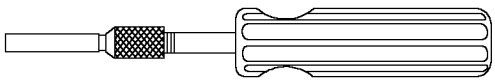
DEUTSCH is a trademark of Deutsch Co.

DPSG,OUO1004,2855 –19–10AUG00–14/16

RG10741 –UN–31MAY00

Terminal Extractor Tool JDG1369

Used to extract terminals from injection pump connector.



JDG1369

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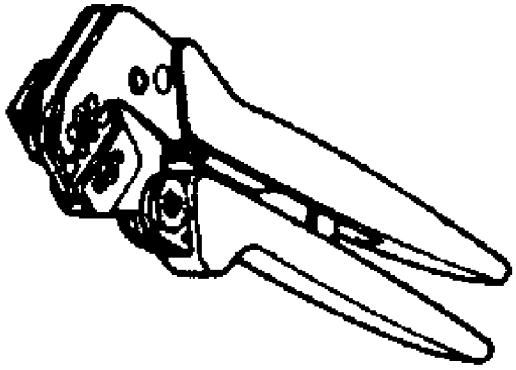
DPSG,OUO1004,2855 –19–10AUG00–15/16

AMP Crimping Tool JDG708

Used to crimp wire terminal ends for injection pump connector.



RG10737 –UN–25MAY00

JDG708

DPSG,OUO1004,2855 –19–10AUG00–16/16

Other Material

Number	Name	Use
	Silicon Dielectric Grease	Apply to spark plug terminal and spark plug boot.
PT569 (U.S.)	NEVER-SEEZ® Compound	Apply to threads of universal exhaust gas oxygen sensor (for UEGO sensor reuse only).
T43512 (U.S.) TY9473 (Canadian) 242 (LOCTITE®)	Thread Lock and Sealer (Medium Strength)	Apply to threads of ignition coil-to-bracket cap screws, MAP sensor cap screws and ICU mounting cap screws.
TY9375 (U.S.) TY9480 (Canadian) 592 (LOCTITE®)	Pipe Sealant with TEFLON®	Apply to threads of preturbine pressure sensor, exhaust back pressure sensor and oil pressure switch.
AT66865 (U.S.)	Electrical Insulating Compound	Apply to connector terminals.

NEVER-SEEZ is a registered trademark of the Emhart Chemical Group.
LOCTITE is a registered trademark of the Loctite Corp.
TEFLON is a registered trademark of the DuPont Co.

DPSG,OUO1004,2857 –19–10AUG00–1/1

Electronic Engine Control System Specifications

Item	Measurement	Specification
Spark Plug	Torque	38 N•m (28 lb-ft)
Spark Plug	Gap	0.38 mm (0.015 in.)
Ignition Coil Retaining Cap Screw	Torque	20 N•m (15 lb-ft) (177 lb-in.)
Ignition Coil Bar-to-Head Retaining Cap Screws	Torque	34 N•m (25 lb-ft)
Ignition Control Unit (ICU) Cap Screws	Torque	16 N•m (12 lb-ft) (142 lb-in.)
Ignition Timing Sensor	Torque	22 N•m (16 lb-ft) (195 lb-in.)
Ignition Timing Sensor Plate Cap Screws	Torque	34 N•m (25 lb-ft)
Ignition Timing Sensor Plate Bracket Cap Screws	Torque	34 N•m (25 lb-ft)
Dipstick Tube Bracket Cap Screw	Torque	34 N•m (25 lb-ft)
Manifold Absolute Pressure (MAP) Sensor Cap Screws	Torque	3.3 N•m (2.4 lb-ft) (30 lb-in.)
Knock Sensor	Torque	19 N•m (14 lb-ft) (168 lb-in.)
Natural Gas Tank Pressure (NGTP) Sensor	Torque	34 N•m (25 lb-ft)
Camshaft Position Sensor (HFN04)	Torque	10 N•m (84 lb-in.)
Manifold Air Temperature (MAT) Sensor (HFN01, 02, and 03)	Torque	10 N•m (84 lb-in.)
Throttle Charge Temperature (TCT) Sensor	Torque	10 N•m (84 lb-in.)
Fuel Mixer-to-Intake Manifold Cap Screw	Torque	27 N•m (20 lb-ft)

Precautions for Welding on Vehicles Equipped with Electronic Engine Control Unit (ECU)

IMPORTANT: ALWAYS disconnect Electronic Engine Control Unit (ECU) connectors and engine control system-to-vehicle ground before welding. High currents or electro-static discharge in electronic components from welding may cause permanent damage.

1. Remove the ground connection for the engine control system-to-vehicle frame.
2. Disconnect the connectors to the ECU.
3. Connect the welder ground close to the welding point and be sure ECU or other electronic components are not in the ground path.

TS953 –UN–15MAY90

Welding Precautions

DPSG,OUO1004,2843 –19–09AUG00–1/1

45
8

Remove and Install Spark Plugs

CAUTION: Electrical shock may occur if you contact live electrical components. Disconnect power before servicing ignition system.

IMPORTANT: Avoid damage to spark plug boots. Pull straight out on boots when removing.

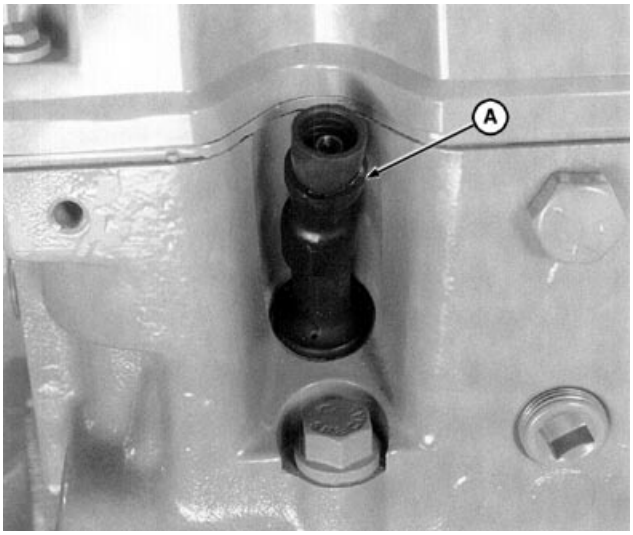
1. **On HFN01, HFN02, and HFN03 Engines:** Remove ignition coil. (See REMOVE AND INSTALL IGNITION COILS in this group.) Remove spark plug boot (A), using JDG815 Spark Plug Boot Pliers if necessary.

2. **On HFN04 Engines:** Remove Spark Plug Boot from Ignition Coil. Remove spark plug boot (B) and insulator (C), using JDG815 Spark Plug Boot Puller Pliers if necessary.

CAUTION: Use eye protection if compressed air is used to clean spark plug bores.

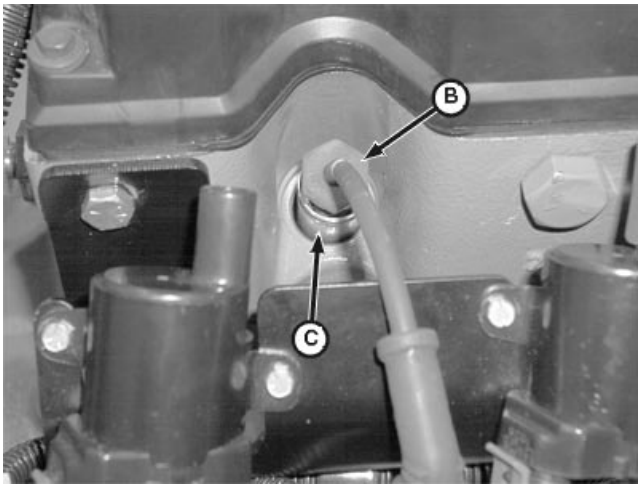
3. Check plug bore for water or debris. If present, use compressed air to remove.

A—Spark Plug Boot
B—Spark Plug Boot
C—Insulator



RG7655A –UN–05DEC97

HFN01, HFN02, and HFN03 Shown



RG12103 –UN–01MAR02

HFN04 Shown

Continued on next page

RG,45,DT7287 –19–30MAR04–1/2

4. Remove spark plug (D).

5. Check spark plug. (See CLEANING AND ADJUSTING SPARK PLUG GAP in this group.) Replace as necessary.

NOTE: If reinstalling used plugs, use NEVER-SEEZ® compound sparingly on plug threads. If installing new plugs, leave dry.

Platinum spark plugs are used to attain maximum plug life.

6. Install spark plug and tighten to specification.

Specification

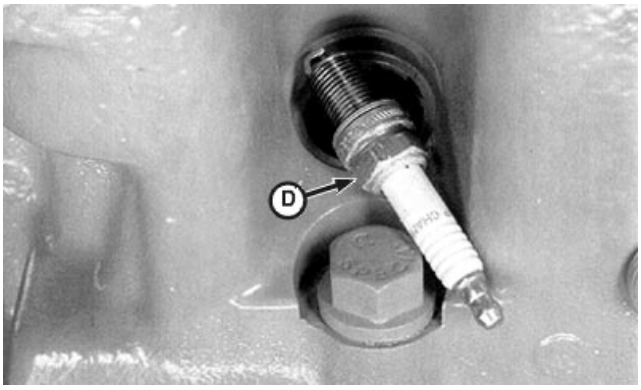
Spark Plug—Torque ..... 38 N•m (28 lb-ft)

7. Apply silicon dielectric grease sparingly to the ceramic portion of the spark plug. Do not apply to metal terminals.

8. Inspect spark plug boots for damage and replace as necessary. Boots should be replaced at every other spark plug change. Install spark plug boot. If dielectric grease is used, install boot with a twisting motion to distribute the grease evenly.

IMPORTANT: Wire and metal terminals should be free of dielectric grease. Repeated use will result in accumulation in the wire and boot which can result in weak or misfiring cylinders. Perodic cleaning and careful installation will prevent grease from contacting the spark plug terminal.

9. **On HFN01, HFN02, and HFN03 Engines:** Install ignition coil. (See REMOVE AND INSTALL IGNITION COILS in this group.)



Remove Spark Plug

D—Spark Plug

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RG,45,DT7287 –19–30MAR04–2/2

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Cleaning and Adjusting Spark Plug Gap

1. Remove spark plugs. (See REMOVE AND INSTALL SPARK PLUGS in this group.)

2. Clean threads by hand with brush and solvent.

RG,45,DT7286 –19–30MAR04–1/3

3. Clean any deposits from electrode (A) and insulator area. Clean the upper portion of the spark plug hex, ceramic body and wire terminal with rubbing alcohol or equivalent which will not leave a conductive residue.

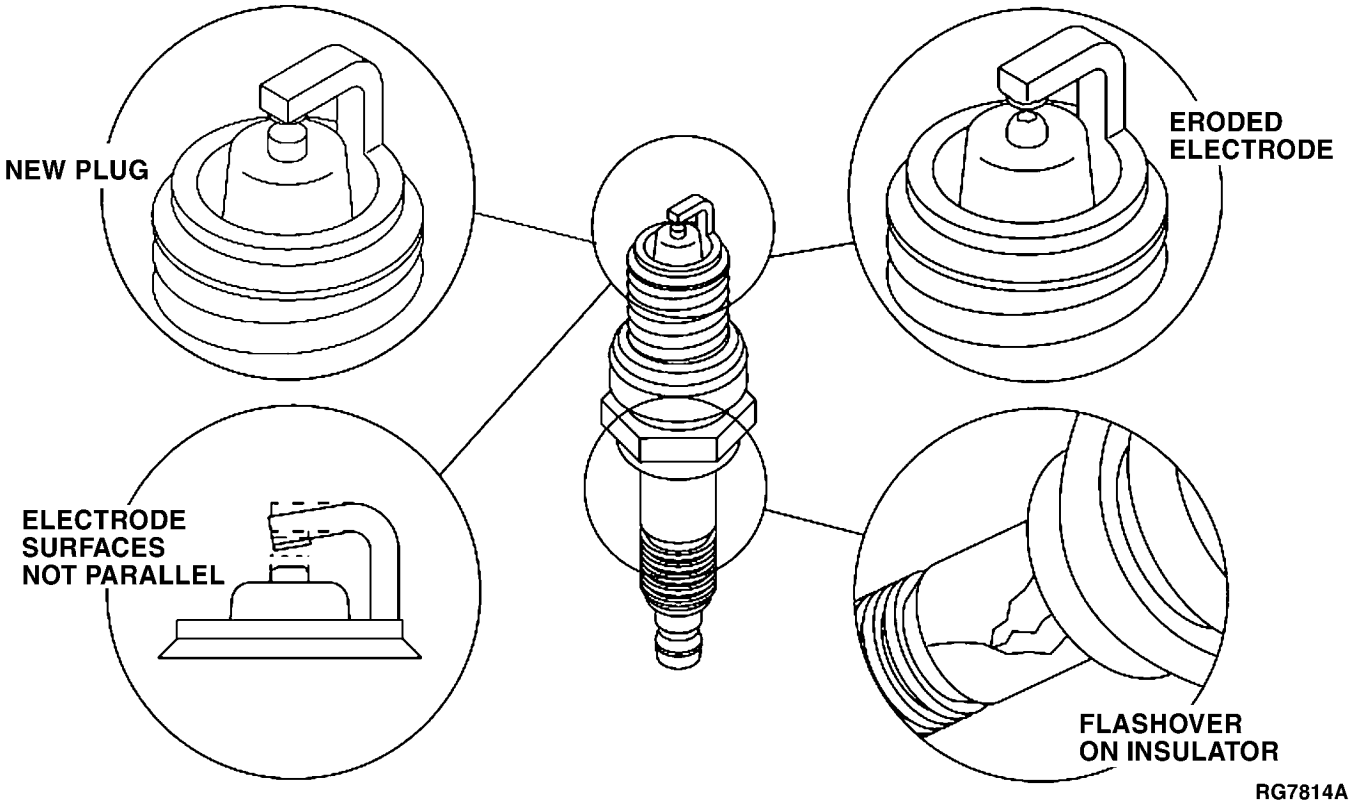
A—Electrode

RG7662 –UN–05DEC97

Clean and Adjust Spark Plug Gap

Continued on next page

RG,45,DT7286 –19–30MAR04–2/3



Spark Plug Inspection Criteria

4. Inspect insulator and electrodes for the following conditions:
   - eroded electrode
   - flashover on insulator
   - ground electrode and center electrode surfaces not parallel
5. Replace plug if necessary.
6. Adjust gap to specifications.

Specification	
Spark Plug—Gap	0.38 mm (0.015 in.)

IMPORTANT: Do not over-tighten spark plugs.

7. Install spark plugs (see REMOVE AND INSTALL SPARK PLUGS in this group) and tighten to specification.

Specification	
Spark Plug—Torque	38 N•m (28 lb-ft)

RG,45,DT7286 –19–30MAR04–3/3

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Remove and Install Ignition Coils (HFN01, HFN02, and HFN03 Engines)

CAUTION: Electrical shock may occur if you contact live electrical components. Disconnect power before servicing ignition system.

1. Disconnect ignition coil electrical connector (C).

IMPORTANT: Avoid damage to spark plug boot or ignition coil. Pull ignition coil straight out when removing.

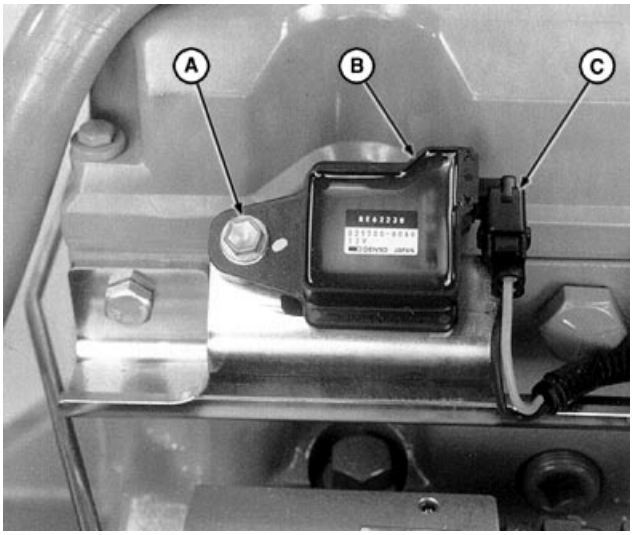
2. Loosen cap screw (A) and remove ignition coil (B).

3. Apply LOCTITE® 242 Thread Lock and Sealer to threads of coil-to-bracket cap screws.

4. Install coil and tighten cap screw to specifications.

Specification	
Ignition Coil Retaining Cap Screw—Torque	20 N•m (15 lb-ft) (177 lb-in.)
Ignition Coil Bar-to-Head Retaining Cap Screws—Torque	34 N•m (25 lb-ft)

5. Connect electrical connector.



RG7654A –UN–05DEC97

Remove and Install Ignition Coils

A—Cap Screw
B—Ignition Coil
C—Connector

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RG,45,DT7285 –19–30MAR04–1/1

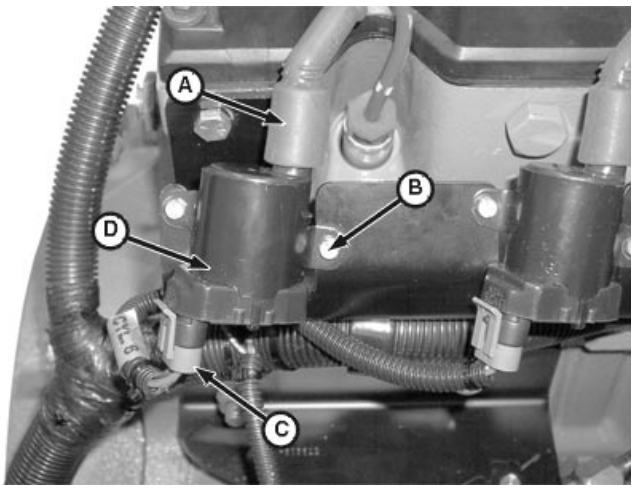
Remove and Install Ignition Coils (HFN04 Engine)

CAUTION: Electrical shock may occur if you contact live electrical components. Disconnect power before servicing ignition system.

1. Remove ignition coil wiring harness (C).

IMPORTANT: Avoid damage to ignition coil boot connector. Pull boot connector straight out when removing.

2. Remove ignition coil boot connector (A).
3. Loosen cap screws (B) and remove ignition coil (D).
4. Apply LOCTITE® 242 Thread Lock and Sealer to threads of coil-to-bracket cap screws.
5. Install coil and tighten cap screws.
6. Connect ignition coil boot connector.
7. Connect ignition coil wiring harness.



Remove and Install Ignition Coils

A—Boot Connector
B—Cap Screw
C—Wiring Harness
D—Ignition Coil

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OUO1080,000021F –19–02APR04–1/1

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Remove and Install Ignition Control Unit (ICU) (HFN01, HFN02, and HFN03 Engines)

NOTE: The ignition control unit (ICU) component is not used on HFN04 engines.

IMPORTANT: Before welding on the vehicle remove the positive (+) and negative (—) battery cables from the battery. Attach the welder ground 2 feet or less away from the part being welded. NEVER attach the welder ground cable to the electronic control unit or to the engine. It is NOT recommended to weld on the engine.

IMPORTANT: DO NOT connect jump starting cables or battery charging cables to the engine or to the electronic control unit.

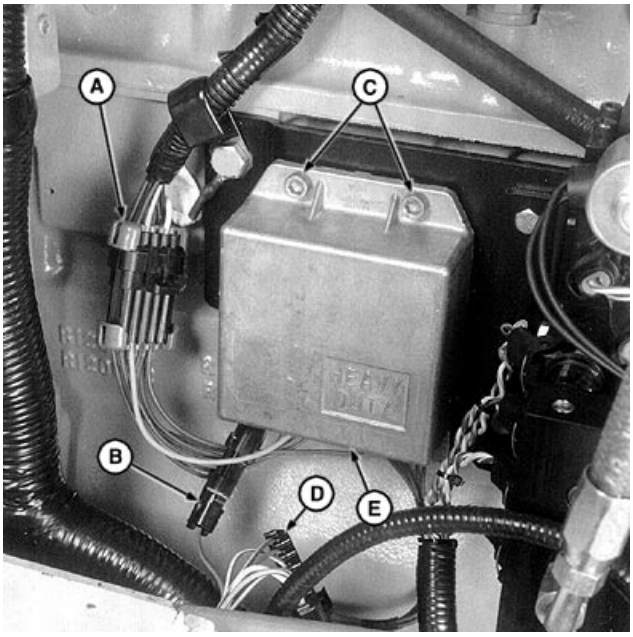
CAUTION: Electrical shock may occur if you contact live electrical components. Disconnect power before servicing ignition system.

NOTE: For diagnosis and testing of the ignition control unit (ICU), see Group 115 in CTM113.

1. Disconnect wire harness connectors (A, B, and D).
2. Remove cap screws (C) and remove ICU (E) from mounting plate.
3. Apply LOCTITE® 242 Thread Lock and Sealer to threads of cap screws. Install ICU and tighten cap screws to specification.

Specification	
Ignition Control Unit (ICU) Cap Screws—Torque	16 N•m (12 lb-ft) (142 lb-in.)

4. Connect wire harness connectors.



Remove and Install Ignition Control Unit

A—Connector
B—Connector
C—Cap Screw (3 used)
D—Connector
E—Ignition Control Unit (ICU)

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RG,45,DT7284 –19–05MAR02–1/1

Remove and Install Engine Control Unit (ECU)

IMPORTANT: DO NOT pressure wash the engine control unit (ECU).

Before welding on engines with ECU, protect the ECU from high-current damage as follows:

1. **Disconnect ECU-to-vehicle frame ground connection.**
2. **Disconnect all other connectors from ECU.**
3. **Connect welder ground close to welding point and make sure ECU and other electrical components are not in the ground path.**

IMPORTANT: DO NOT connect jump starting cables or battery charging cables to the engine or to the electronic control unit.

CAUTION: Electrical shock may occur if you contact live electrical components. Disconnect power before servicing ignition system.

NOTE: For diagnosis and testing of the electronic engine control and sensors, refer to Group 115 in CTM113 or CTM300.

IMPORTANT: DO NOT OPEN ENGINE CONTROL UNIT.

NOTE: The sealed ECU assembly is the system component LEAST likely to fail. Ensure that it is isolated and identified as the defective component before replacing. See operation and test manual for proper troubleshooting procedures.

The ECU is not repairable. If it is found to be defective, replace it as a unit. Provide the 13-digit engine serial number when ordering a new ECU.

Engine Control Unit (ECU) (HFN04 Shown)

Continued on next page

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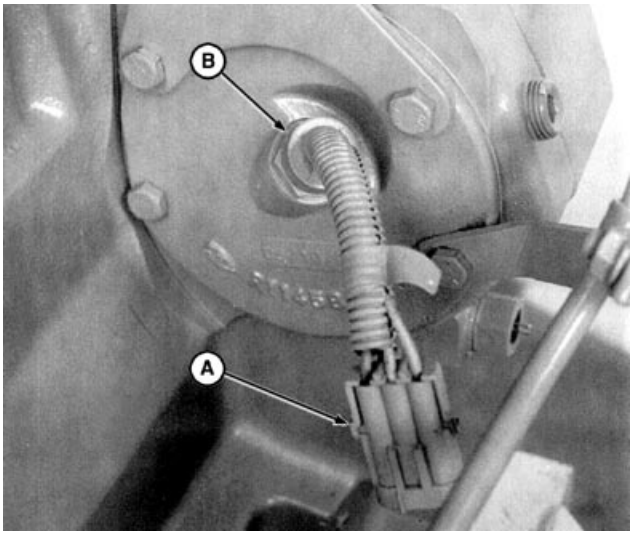
IMPORTANT: If an ECU is not programmed identically with the original (failed) ECU, misleading diagnostic messages, poor performance, or engine damage can occur.

OUO1080,000021C –19–26FEB02–2/2

Remove and Install Ignition Timing Sensor (HFN01, HFN02, and HFN03 Engines)

1. Disconnect wiring (A).
2. Remove ignition timing sensor (B) from ignition sensor plate.

A—Wiring
B—Ignition Timing Sensor



Remove and Install Ignition Timing Sensor

RG,45,DT7283 –19–05MAR02–1/2

3. Inspect O-ring (C). Replace if necessary.

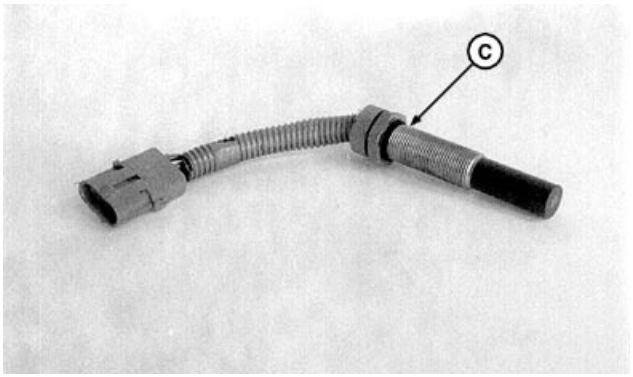
IMPORTANT: DO NOT overtighten sensor. Sensor may be damaged during operation.

4. Install sensor. Tighten to specification.

Specification
Ignition Timing Sensor—Torque..... 22 N•m (16 lb-ft) (195 lb-in.)

5. Connect wiring harness.

C—O-Ring



Inspect O-Ring on Sensor

RG,45,DT7283 –19–05MAR02–2/2

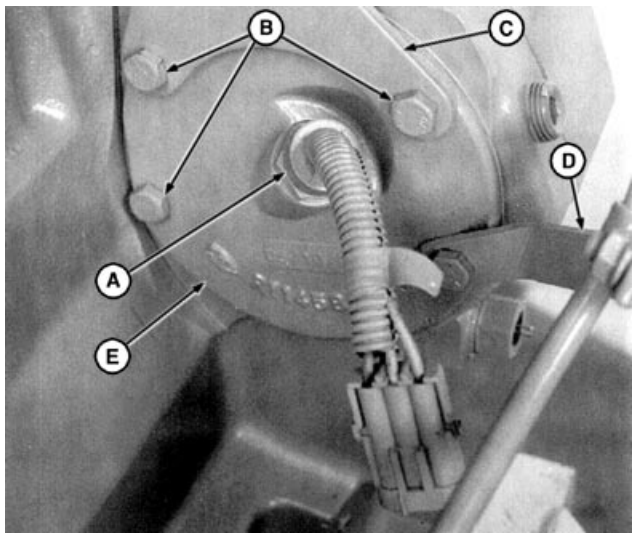
Remove and Install Ignition Timing Sensor Plate (HFN01, HFN02, and HFN03 Engines)

1. Remove ignition timing sensor (A). (See REMOVE AND INSTALL IGNITION TIMING SENSOR, in this group.)
2. Remove cap screws (B). Remove bracket (C) and dipstick tube bracket (D) (if equipped).
3. Remove plate (E) and gasket. Discard gasket.
4. Clean gasket surfaces.
5. Install plate with new gasket. Install brackets (C and D). Tighten cap screws to specification.

Specification

Ignition Timing Sensor Plate Bracket Cap Screws—Torque	34 N•m (25 lb-ft)
Ignition Timing Sensor Plate Cap Screws—Torque	34 N•m (25 lb-ft)
Dipstick Tube Bracket Cap Screw—Torque	34 N•m (25 lb-ft)

6. Install ignition sensor. (See REMOVE AND INSTALL IGNITION TIMING SENSOR, in this group.)



RG7661B –UN–05DEC97

Remove and Install Ignition Sensor Plate

A—Ignition Timing Sensor
B—Bracket Cap Screw
C—Bracket
D—Dipstick Tube Bracket
E—Plate

RG,45,DT7282 –19–05MAR02–1/1

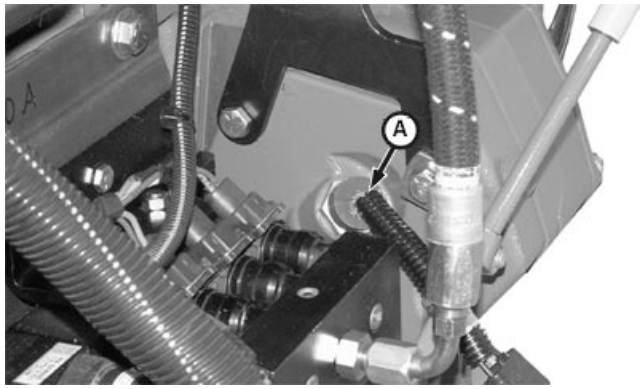
Remove and Install Camshaft Position Sensor (HFN04 Engine)

1. Disconnect wiring harness.
2. Remove camshaft position sensor (A) and O-ring.
3. Install sensor using new O-ring. Tighten to specification.

Specification

Camshaft Position Sensor—Torque	10 N•m (84 lb-in.)

4. Connect wiring harness.



RG12147A –UN–18APR02

Remove and Install Camshaft Position Sensor

A—Camshaft Position Sensor

OUO1080,0000219 –19–25FEB02–1/1

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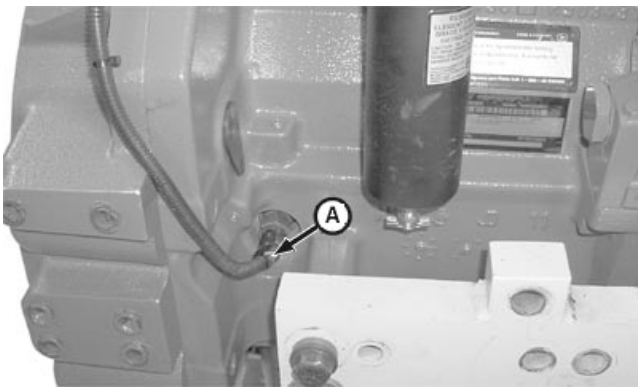
18

Remove and Install Crankshaft Position Sensor (HFN04 Engine)

1. Disconnect wiring harness (A).
2. Remove crankshaft position sensor and O-ring.
3. Install sensor using new O-ring and tighten.
4. Connect wiring harness.

A—Wiring Harness



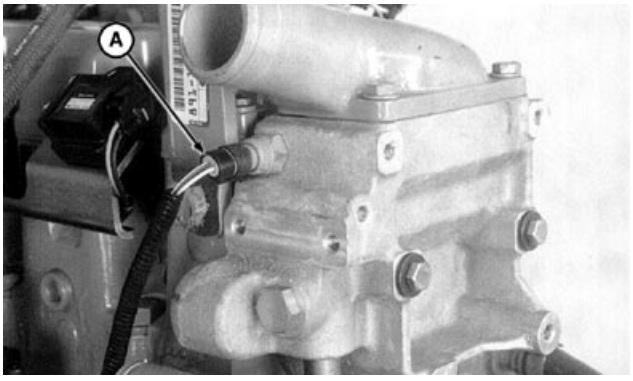
Remove and Install Crankshaft Position Sensor

OUO1080,0000225 –19–12MAR02–1/1

Remove and Install Engine Coolant Temperature (ECT) Sensor

1. Disconnect engine coolant temperature (ECT) sensor electrical connector.
2. Remove ECT sensor (A) and O-ring.
3. Apply LOCTITE® 242 Thread Lock and Sealer to sensor threads. Install ECT using new O-ring.
4. Connect electrical connector.

A—ECT Sensor



HFN01, HFN02, and HFN03 Shown. HFN04 Is Similar.

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RG,45,DT7281 –19–05MAR02–1/1

Remove and Install Foot Pedal Position Sensor

The foot pedal position sensor is located on the operator's accelerator pedal. See vehicle repair manual for replacement procedures.

The foot pedal sensor has no serviceable parts. If it fails, replace the complete foot pedal assembly.

RG,45,DT7280 –19–04NOV97–1/1

Remove and Install Manifold Absolute Pressure (MAP) Sensor

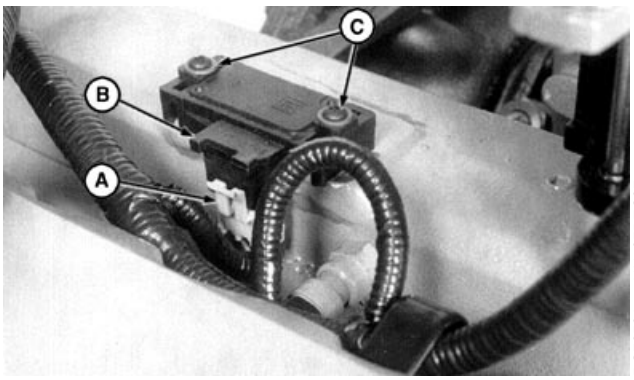
NOTE: Manifold absolute pressure (MAP) sensor is located on the top of the intake manifold.

1. Disconnect MAP wiring harness connector (A).
2. Remove cap screws (C). Remove MAP sensor (B) and O-ring.
3. Apply LOCTITE® 242 Thread Lock and Sealer to threads of cap screws. Install MAP sensor using new O-ring. Tighten cap screws to specification.

Specification

Manifold Absolute Pressure (MAP) Sensor Cap Screws—Torque ..... 3.3 N•m (2.4 lb-ft) (30 lb-in.)

4. Connect wiring harness connector.



RG7659A –UN–05DEC97

HFN01, HFN02, and HFN03 Shown. HFN04 Is Similar

A—MAP Wiring Harness Connector
B—MAP Sensor
C—Cap Screws

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RG,45,DT7279 –19–05MAR02–1/1

Remove and Install Manifold Air Temperature (MAT) Sensor (HFN01, HFN02, and HFN03 Engines)

NOTE: The manifold air temperature (MAT) sensor is located on the inside vertical side of the intake manifold.

1. Disconnect MAT sensor wiring harness connector.
2. Remove MAT sensor (A) and O-ring.
3. Connect wiring harness connector.

RG8916A –UN–08DEC97

Mat Sensor (HFN01, HFN02, and HFN03)

A—MAT Sensor

RG,45,DT7278 –19–26MAY04–1/1

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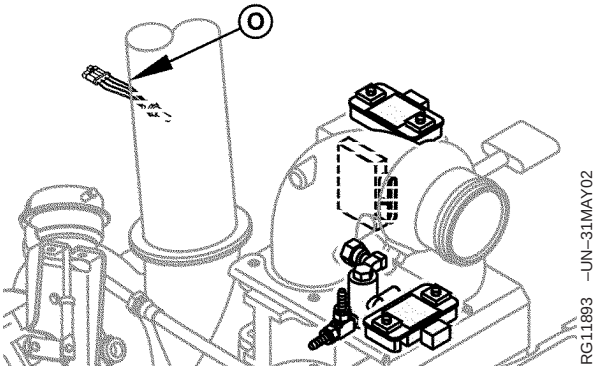
Remove and Install Humidity/Air Inlet Temperature Sensor

1. Disconnect sensor wiring harness connector.
2. Remove sensor (O) and O-ring.
3. Install humidity/inlet air temperature sensor using new O-ring and tighten to specification.

Specification

Humidity/Inlet Air Temperature Sensor—Torque ..... 34 N•m (25 lb-ft.)

4. Connect wiring harness connector.



Humidity/Air Inlet Sensor

RG19661,0000061 –19–27MAY04–1/1

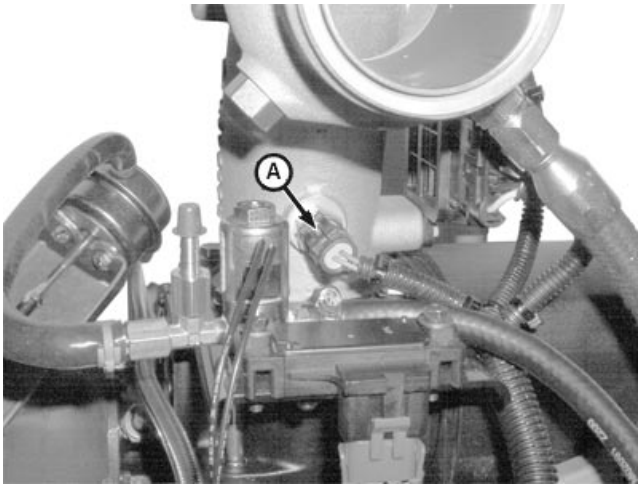
Remove and Install Throttle Charge Temperature (TCT) Sensor (HFN04 Engine)

1. Disconnect throttle charge temperature (TCT) sensor wiring harness connector.
2. Remove TCT sensor (A) and O-ring.
3. Install TCT sensor using new O-ring. Tighten sensor to specification.

Specification

Throttle Charge Temperature (TCT) Sensor—Torque..... 10 N•m (84 lb-in.)

4. Connect wiring harness connector.



TCT Sensor (HFN04)

A—TCT Sensor

OUO1082,000023F –19–01MAY02–1/1

Remove and Install Natural Gas Tank Temperature (NGTT) Sensor (If Equipped)

The natural gas tank temperature (NGTT) sensor is located on the high-pressure fuel line. See vehicle repair manual for replacement procedures.

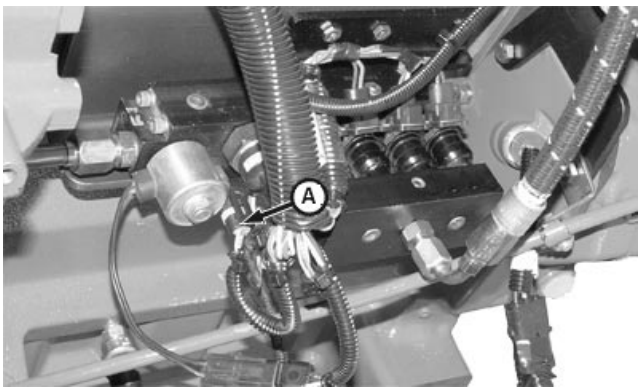
RG,45,DT7277 –19–04NOV97–1/1

Remove and Install Natural Gas Temperature (NGT) Sensor

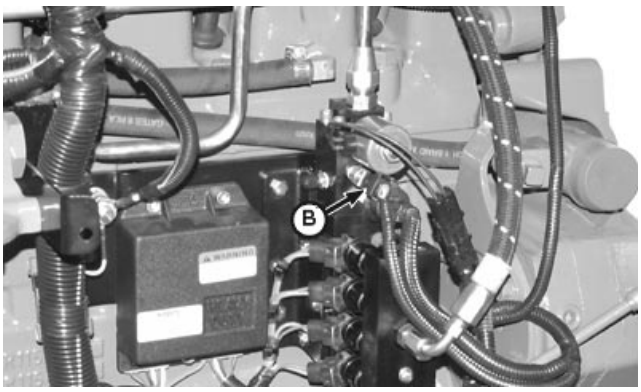
CAUTION: Natural gas is highly flammable. DO NOT smoke while working on or near natural gas equipment. Natural gas fumes may cause sickness or death. Work in well ventilated area, shut off natural gas supply, and relieve internal regulator pressure before servicing equipment.

1. **On HFN01, HFN02, and HFN03 engines:** Disconnect harness connector (B) from sensor.
2. **On HFN04 engine:** Disconnect harness connector (A) from sensor.
3. Remove natural gas temperature (NGT) sensor and discard O-ring.
4. Install sensor with new O-ring and tighten.

A—Connector
B—Connector



HFN04 Shown.



HFN01, HFN02, and HFN03 Shown.

OUO1080,000021D –19–27FEB02–1/1

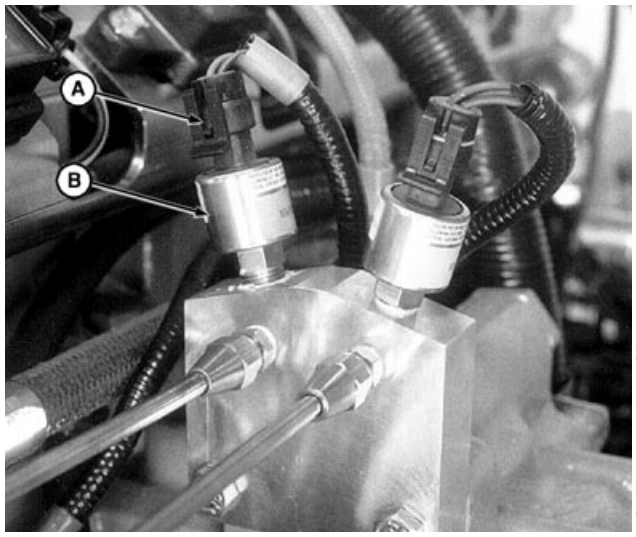
Remove and Install Preturbine Pressure (PTP) Sensor (HFN01 and HFN03 Engines)

1. Disconnect preturbine pressure (PTP) sensor wiring harness connector (A).
2. Remove PTP sensor (B).

IMPORTANT: DO NOT allow sealant to enter pressure sensing hole in sensor.

3. Apply LOCTITE® 592 Pipe Sealant with TEFLON® to sensor threads except first 1—3 threads.
4. Install PTP sensor in manifold and tighten.
5. Connect wiring harness connector.

A—PTP Sensor Wiring Harness Connector
B—PTP Sensor



Preturbine Pressure (PTP) Sensor

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TEFLON is a registered trademark of the DuPont Co.

RG,45,DT7288 –19–09AUG00–1/1

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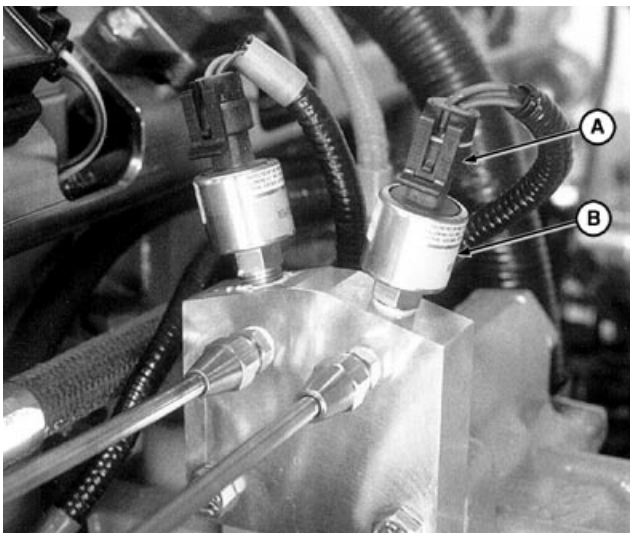
Remove and Install Exhaust Back Pressure (EBP) Sensor (HFN01 and HFN03 Engines)

1. Disconnect exhaust back pressure (EBP) sensor wiring harness connector (A).
2. Remove EBP sensor (B).

IMPORTANT: DO NOT allow sealant to enter pressure sensing hole in sensor.

3. Apply LOCTITE® 592 Pipe Sealant with TEFLON® to sensor threads except first 1—3 threads.
4. Install EBP sensor in manifold and tighten.
5. Connect wiring harness connector.

A—EBP Sensor Wiring Harness Connector
B—EBP Sensor



Exhaust Back Pressure (EBP) Sensor

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TEFLON is a registered trademark of the DuPont Co.

RG,45,DT7276 –19–04NOV97–1/1

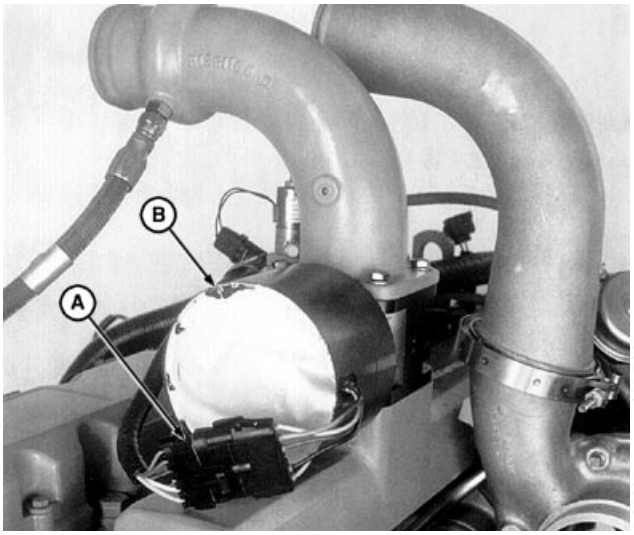
Remove and Install Electronic Throttle and Throttle Position Sensor

NOTE: Throttle position sensor is located within the electronic throttle assembly (B).

1. Remove fuel mixer. (See REMOVE AND INSTALL FUEL MIXER in Group 35.)
2. Disconnect electronic throttle assembly wiring harness connector (A).
3. Remove electronic throttle assembly (B). Discard gasket.
4. Using a new gasket, install electronic throttle assembly.
5. Connect wiring harness connector.
6. Install fuel mixer. (See REMOVE AND INSTALL FUEL MIXER in Group 35.)
7. Tighten fuel mixer cap screws to specification.

Specification

Fuel Mixer-to-Intake Manifold Cap Screw—Torque	27 N•m (20 lb-ft)



RG7665A –UN–05DEC97

HFN01 Shown. HFN02, HFN03, and HFN04 Are Similar.

A—Electronic Throttle Assembly Wiring Harness Connector
B—Electronic Throttle Assembly

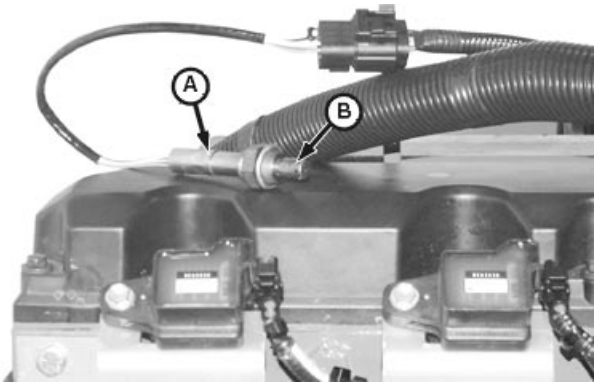
RG,45,DT7275 –19–05MAR02–1/1

Remove and Install Universal Exhaust Gas Oxygen (UEGO) Sensor

NOTE: The universal exhaust gas oxygen (UEGO) sensor is located in the vehicle exhaust piping downstream of the turbocharger.

IMPORTANT: DO NOT attempt to remove wires from UEGO sensor. Sensor can be easily damaged by rough handling, chemicals, water, etc.

1. Disconnect wire harness connector from UEGO sensor (A).
2. Turn UEGO sensor out of exhaust.
3. Inspect holes (B) in tip of sensor. Clean as required.
4. Coat threads of sensor with NEVER-SEEZ® if reusing. Threads of new sensors are already coated with anti-seize compound.
5. Install UEGO and tighten.
6. Connect wiring harness.



HFN01, HFN02, and HFN03 Shown. HFN04 Is Similar.

A—UEGO Sensor
B—Holes

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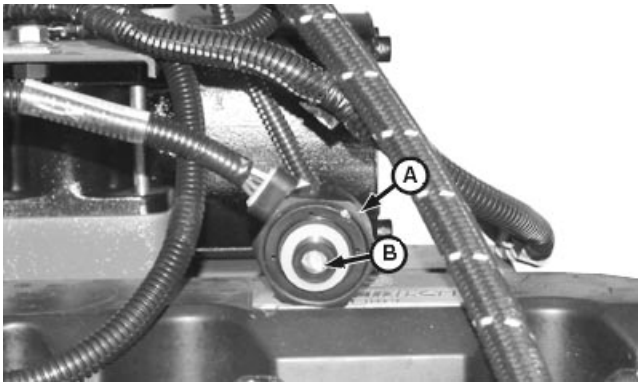
RG,45,DT7274 –19–09AUG00–1/1

Remove and Install Environment Sensor (HFN02 Engine)

NOTE: The environment sensor is installed in the vehicle air intake system between the air cleaner and turbocharger inlet.

1. Disconnect wiring harness connector from environment sensor (A).
2. Remove sensor.
3. Inspect screen (B) for foreign particles. Clean as required.
4. Install sensor and connect wiring harness.



HFN02 Shown

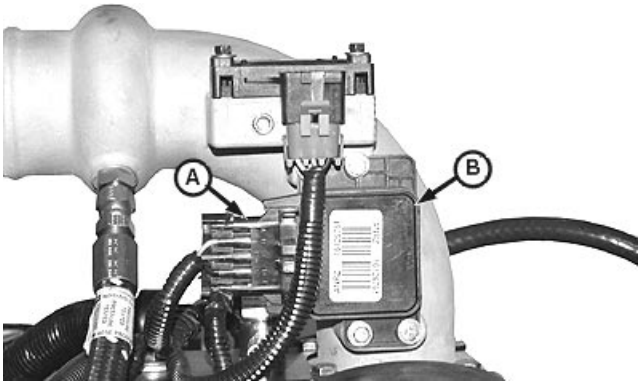
A—Environment Sensor
B—Screen

DPSG,OUO1004,2844 –19–28APR04–1/1

Remove and Install Knock Module (HFN02 and HFN04 Engines)

1. Disconnect harness connector (A).
2. Remove cap screws and knock module (B).
3. Reinstall knock module and connect harness connector.

A—Connector
B—Knock Module



HFN02 Shown. HFN04 Is Similar.

DPSG,OUO1004,2845 –19–05MAR02–1/1

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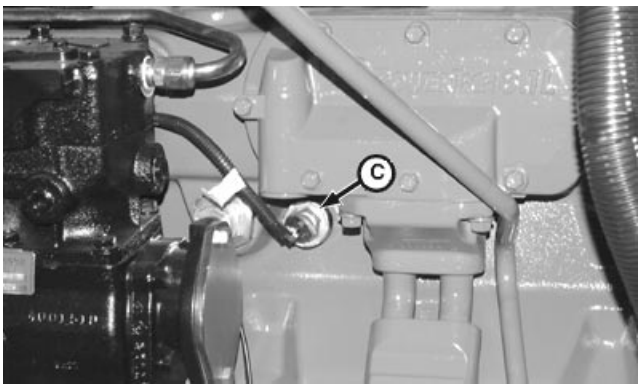
Remove and Install Knock Sensor (HFN02 and HFN04 Engines)

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

1. Slowly open the engine cooling system filler cap or radiator cap to relieve pressure and allow coolant to drain faster.
2. Open drain valve on bottom of coolant pump cover and drain coolant from block.
3. Disconnect harness connector from knock sensor (C).
4. Remove knock sensor.
5. Install knock sensor and tighten to specifications.

Specification	
Knock Sensor—Torque	19 N•m (14 lb-ft) (168 lb-in.)

6. Connect harness connector.
7. Service engine with coolant. (See RECOMMENDED ENGINE COOLANT in Group 02.)



HFN02 Shown. HFN04 Is Similar.

C—Knock Sensor

DPSG,OUO1004,2847 –19–05MAR02–1/1

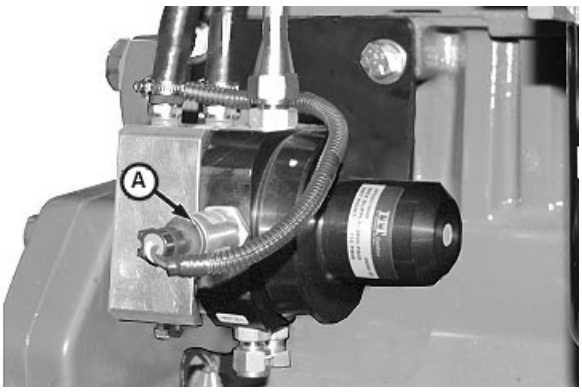
Remove and Install Natural Gas Tank Pressure (NGTP) Sensor (HFN01, HFN03, and HFN04 Engines)

CAUTION: Natural gas is highly flammable. DO NOT smoke while working on or near natural gas equipment. Natural gas fumes may cause sickness or death. Work in well ventilated area, shut off natural gas supply, and relieve internal regulator pressure before servicing equipment.

NOTE: On most HFN01 engines, and all HFN03 and HFN04 engines, the regulator and sensor are mounted remotely on the vehicle. See vehicle repair manual for removal and installation procedures.

1. Perform fuel pressure leak-off procedure. (See FUEL PRESSURE LEAK-OFF PROCEDURE in Group 35.)
2. Disconnect harness connector and remove natural gas tank pressure (NGTP) sensor (A) from regulator.
3. Install sensor and tighten to specifications.

Specification	
Natural Gas Tank Pressure (NGTP) Sensor—Torque	34 N•m (25 lb-ft)



NGTP Sensor (Engine Mounted Regulator Shown)

A—NGTP Sensor

DPSG,OUO1004,2848 –19–05MAR02–1/1

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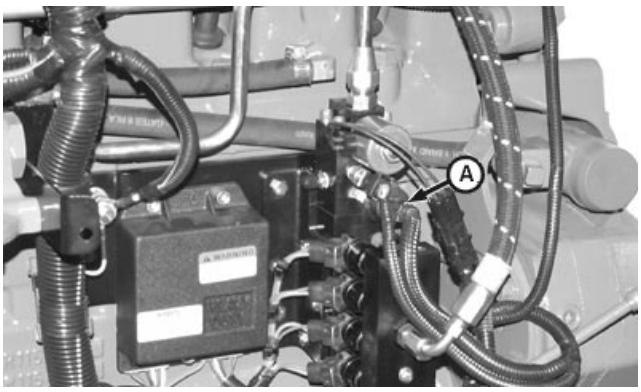
Remove and Install Natural Gas Pressure (NGP) Sensor

CAUTION: Natural gas is highly flammable. DO NOT smoke while working on or near natural gas equipment. Natural gas fumes may cause sickness or death. Work in well ventilated area, shut off natural gas supply, and relieve internal regulator pressure before servicing equipment.

1. **On HFN01, HFN02, and HFN03 engines:** Disconnect harness connector (A).
2. **On HFN04 engine:** Disconnect harness connector (B).
3. Remove natural gas pressure (NGP) sensor and discard O-ring.
4. Install sensor with new O-ring and tighten.

A—Connector
B—Connector



RG12113 –UN–05MAR02

HFN01, HFN02, and HFN03 Shown

RG12145A –UN–18APR02

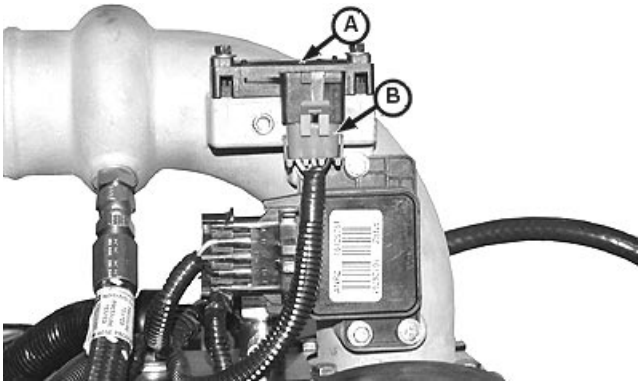
HFN04 Shown (CNG Version)

OUO1080,000021B –19–02APR04–1/1

Remove and Install Upstream Throttle Pressure (UTP) Sensor (HFN02 and HFN04 Engines)

1. Disconnect harness connector (B).
2. Remove UTP sensor (A) and discard O-ring.
3. Using a new O-ring, install UTP sensor and connect harness connector.

A—UTP Sensor
B—Harness Connector



RG10593A –UN–24FEB00

HFN02 Shown. HFN04 Is Similar.

DPSG,OUO1004,2846 –19–05MAR02–1/1

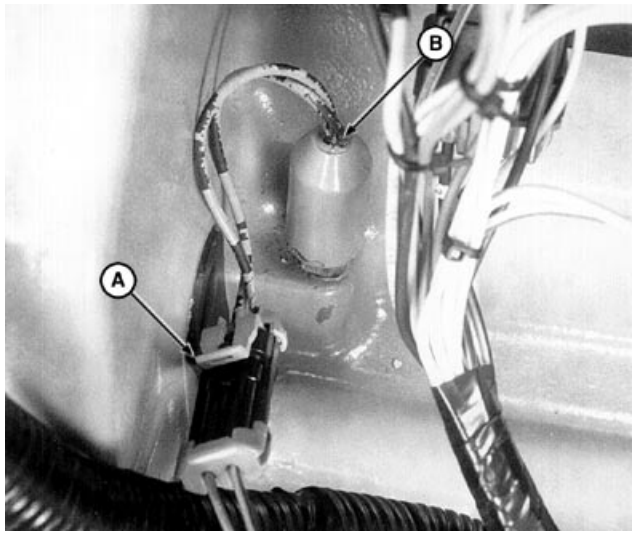
Remove and Install Oil Pressure Switch (HFN01, HFN02, and HFN03 Engines)

1. Remove wiring harness connector (A) and oil pressure switch (B).

IMPORTANT: DO NOT allow sealant to enter pressure sensing hole in switch.

2. Apply LOCTITE® 242 Thread Lock and Sealer to switch threads except first 1—3 threads.
3. Install oil pressure switch and tighten.
4. Connect wiring harness connector.

A—Wiring Harness Connector
B—Oil Pressure Switch



RG7666A –UN–05DEC97

HFN01, HFN02, HFN03

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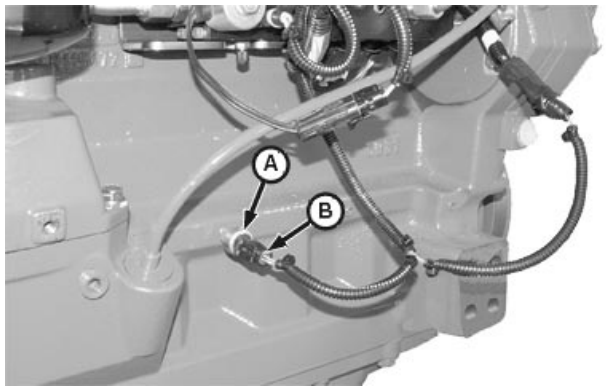
RG,45,DT7273 –19–05MAR02–1/1

Remove and Install Oil Pressure Sensor (HFN04 Engine)

1. Remove wiring harness connector (B) and oil pressure sensor (A).

IMPORTANT: DO NOT allow sealant to enter pressure sensing hole in sensor.

2. Apply LOCTITE® 242 Thread Lock and Sealer to sensor threads except first 1—3 threads.
3. Install oil pressure sensor and tighten.
4. Connect wiring harness connector.



RG12160 –UN–02MAY02

Oil Pressure Sensor (HFN04)

A—Oil Pressure Sensor
B—Wiring Harness Connector

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OUO1082,0000240 –19–02MAY02–1/1

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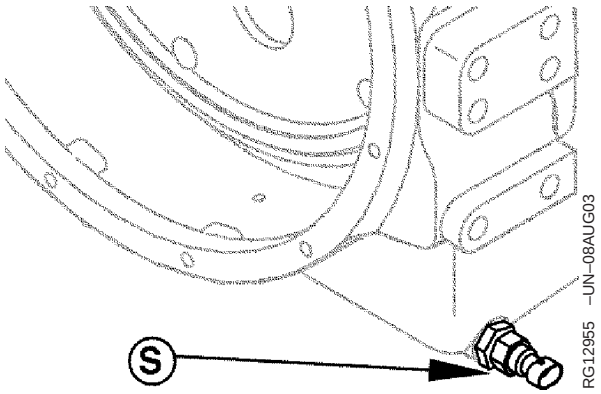
Remove and Install Oil Temperature Sensor

1. Disconnect sensor wiring harness connector.
2. Remove sensor (S).
3. Install sensor and tighten to specifications.

Specification

Oil Temperature Sensor—Torque ..... 10 N•m (84 lb-in.)

4. Connect wiring harness connector.

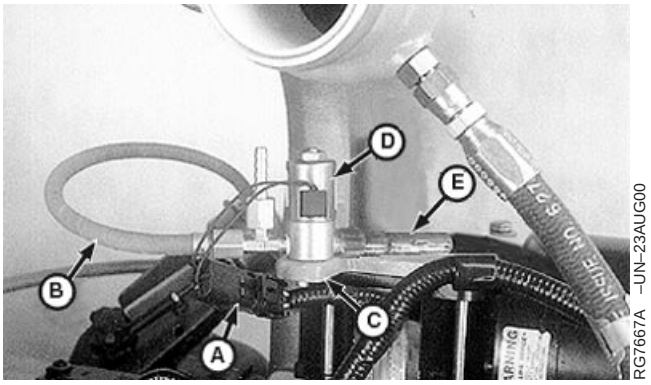


Oil Temperature Sensor

RG19661,0000063 –19–26MAY04–1/1

Remove and Install Turbocharger Wastegate Control Valve

1. Disconnect wiring harness connector (A).
2. Remove inlet hose, shown removed.
3. Remove hoses (B) and (E).
4. Remove cap screws (C). Remove wastegate control valve (D).
5. Install valve and tighten.
6. Connect hoses.
7. Connect wiring harness connector.



HFN01 Shown. HFN02, HFN03, and HFN04 Are Similar.

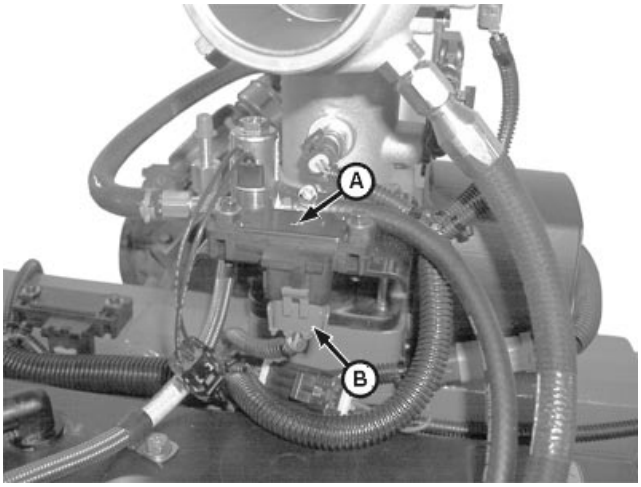
A—Wiring Harness Connector
B—Hose
C—Cap Screw (2 used)
D—Wastegate Control Valve
E—Vent Hose

RG,45,DT7272 –19–05MAR02–1/1

Remove and Install Barometric Air Pressure (BAP) Sensor (HFN04 Engine)

1. Disconnect harness connector (B) from sensor.
2. Remove cap screws and barometric air pressure (BAP) sensor (A).
3. Install barometric air pressure sensor. Tighten cap screws.
4. Connect harness connector to sensor.

A—BAP Sensor
B—Connector



Remove and Install Barometric Air Pressure Sensor (HFN04)

OUO1080,000021E –19–27FEB02–1/1

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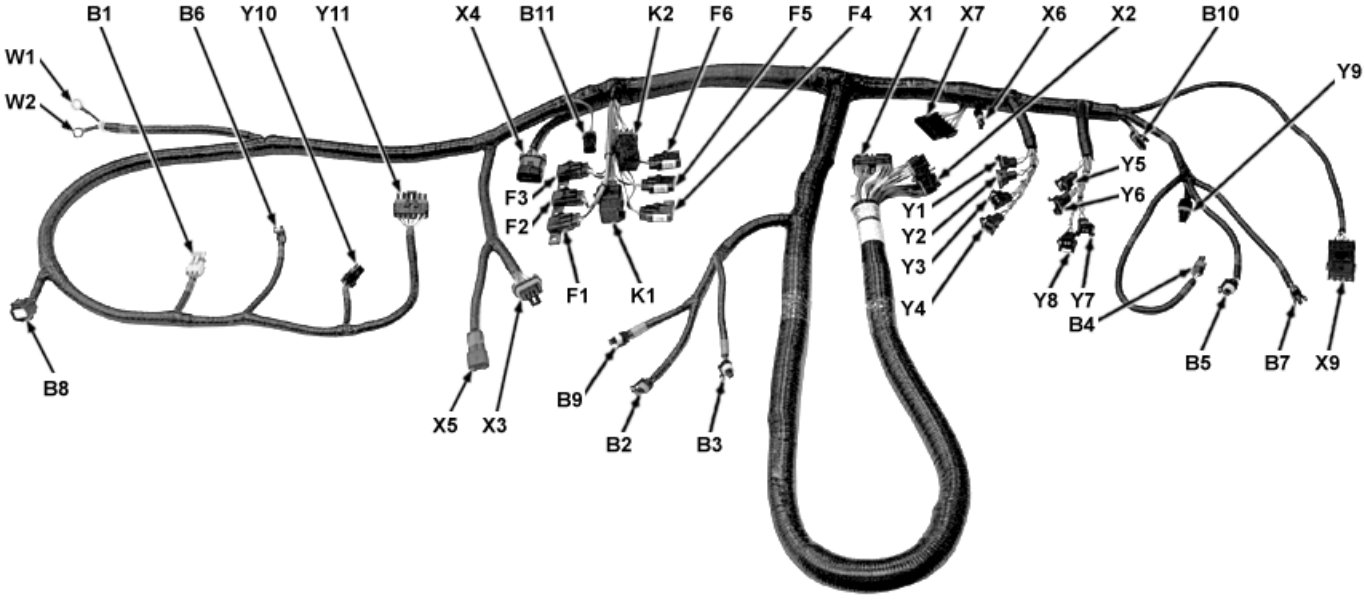
Natural Gas Engine Wiring Harness (HFN01 and HFN03 Engines)



Natural Gas Engine Wiring Harness (Early HFN01 Engines S.N. —045744 Shown)

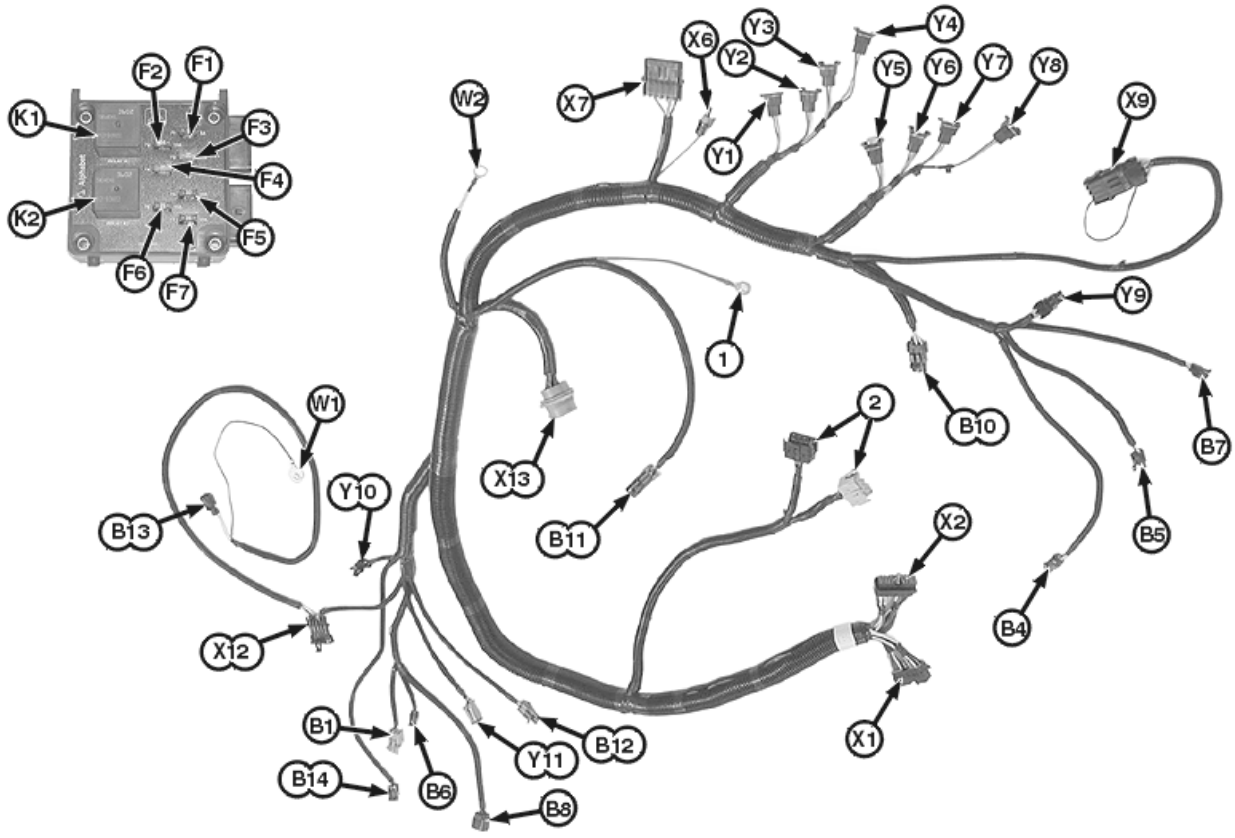
B1—Manifold Absolute Pressure (MAP) Sensor Connector
B2—Preturbine Pressure (PTP) Sensor Connector (Red Marking)
B3—Exhaust Back Pressure (EBP) Sensor Connector (Green Marking)
B4—Engine Coolant Temperature (ECT) Sensor Connector
B5—Natural Gas Pressure (NGP) Sensor Connector
B6—Manifold Air Temperature (MAT) Sensor Connector
B7—Natural Gas Temperature (NGT) Sensor Connector
B8—Universal Exhaust Gas Oxygen (UEGO) Sensor Connector
B9—Natural Gas Tank Pressure (NGTP) Sensor Connector
B10—Cam Position Sensor Connector
B11—Oil Pressure Switch Connector
F1—Fuse (5A)[1]
F2—Fuse (5A)[1]
F3—Fuse (5A)[1]
F4—Fuse (5A)[1]
F5—Fuse (5A)[1]
F6—Fuse (5A)[1]
K1—Relay
K2—Relay
W1—Ground (2 Wires)
W2—Ground (3 Wires)
X1—Electronic Control Module (ECM) Connector
X2—Electronic Control Module (ECM) Connector
X3—Vehicle Interconnect #3
X4—Vehicle Interconnect #4
X5—Vehicle Interconnect #5
X6—Ignition Coil Power
X7—Ignition Control Unit (ICU) Connector
X9—Diagnostic Connector
Y1—To Fuel Injector
Y2—To Fuel Injector
Y3—To Fuel Injector
Y4—To Fuel Injector
Y5—To Fuel Injector
Y6—To Fuel Injector
Y7—To Fuel Injector
Y8—To Fuel Injector
Y9—Low Pressure Lock-Off Solenoid Connector
Y10—Turbocharger Wastegate Control Solenoid Connector
Y11—To Electronic Throttle Connector

IMPORTANT: For diagnosis of engine wiring and electronic sensors and controls, refer to companion technical manual CTM113. This manual also contains detailed wiring diagrams.

[1] Fuses shown are for early engines (S.N. —045744). On current HFN01 and HFN03 engines, fuses F1—F7 are located in box AWAY from engine. See component location drawing and legend (current HFN01 and HFN03 engines) for fuse ratings.

RG,45,DT7289 –19–05MAR02–1/1

Natural Gas Engine Wiring Harness (HFN02 Engine)



HFN02 Natural Gas Engine Wiring Harness

1—Battery Power
2—Fuse/Relay Box Connectors
B1—Manifold Absolute Pressure (MAP) Sensor Connector
B4—Engine Coolant Temperature (ECT) Sensor Connector
B5—Natural Gas Pressure (NGP) Sensor Connector
B6—Manifold Air Temperature (MAT) Sensor Connector
B7—Natural Gas Temperature (NGT) Sensor Connector
B8—Universal Exhaust Gas Oxygen (UEGO) Sensor Connector
B10—Cam Position Sensor Connector
B11—Oil Pressure Switch Connector
B12—Upstream Throttle Pressure (UTP) Sensor Connector
B13—Knock Sensor
B14—Environment Sensor
F1—Fuse (5A)
F2—Fuse (15A)
F3—Fuse (20A)
F4—Fuse (20A)
F5—Fuse (10A)
F6—Fuse (15A)
F7—Fuse (15A)
K1—Relay
K2—Relay
W1—Ground (1 Wire) (16 Gauge)
W2—Ground (1 Wire) (10 Gauge)
X1—Electronic Control Module (ECM) Connector
X2—Electronic Control Module (ECM) Connector
X6—Ignition Coil Power
X7—Ignition Control Unit (ICU) Connector
X9—Diagnostic Connector
X12—Knock Module Connector
X13—Vehicle Interconnect #3
Y1—To Fuel Injector
Y2—To Fuel Injector
Y3—To Fuel Injector
Y4—To Fuel Injector
Y5—To Fuel Injector
Y6—To Fuel Injector
Y7—To Fuel Injector
Y8—To Fuel Injector
Y9—Low Pressure Lock-Off Solenoid Connector
Y10—Turbocharger Wastegate Control Solenoid Connector
Y11—Electronic Throttle

IMPORTANT: For diagnosis of engine wiring and electronic sensors and controls, refer to companion technical manual CTM113. This manual also contains detailed wiring diagrams.

RG10747A –UN–16AUG00

DPSG,OUO1004,2850 –19–09AUG00–1/1

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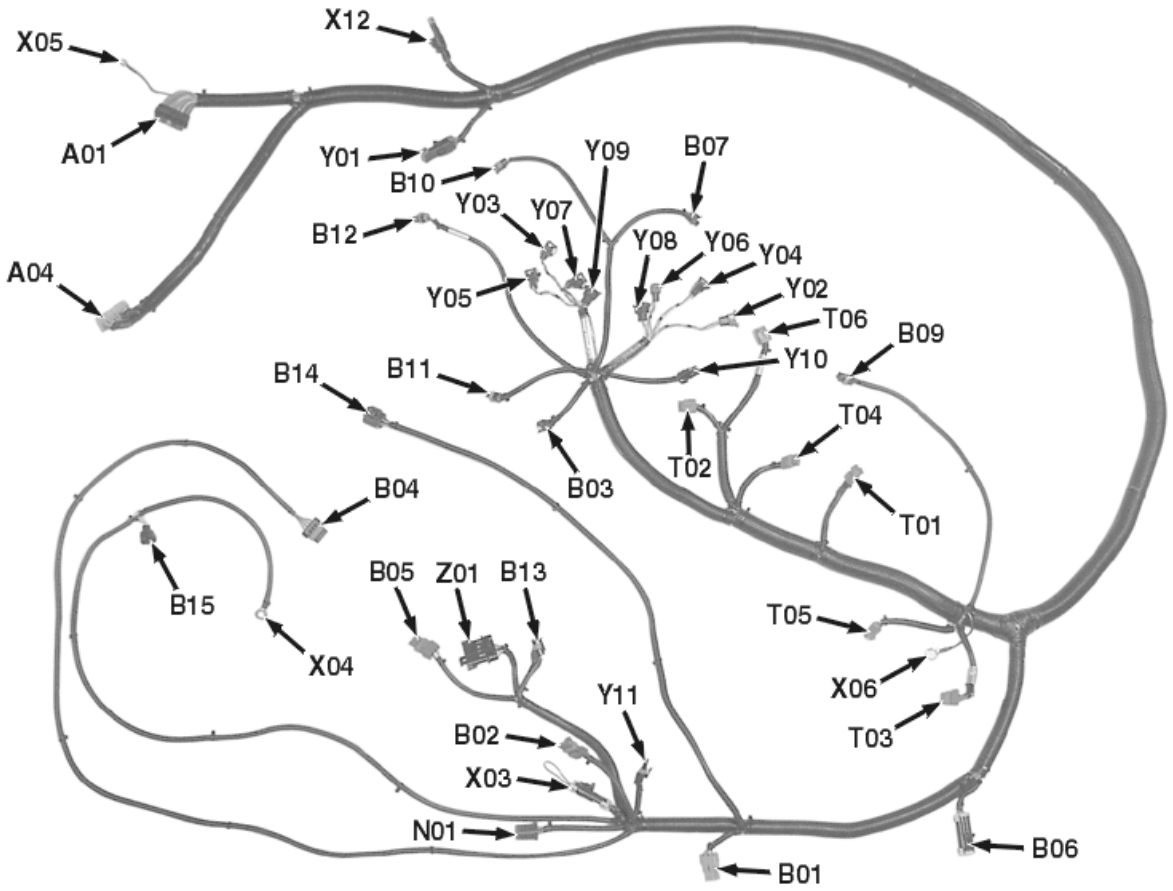
Compressed Natural Gas Engine Wiring Harness (HFN04 Engine)



RG12125A –UN–06MAR02

HFN04 Compressed Natural Gas Engine Wiring Harness

A01—Electronic Control Unit (ECU) Connector (Black)
A04—Electronic Control Unit (ECU) Connector (White)
B01—Manifold Absolute Pressure (MAP) Sensor Connector
B02—Barometric Air Pressure (BAP) Sensor Connector
B03—Natural Gas Pressure (NGP) Sensor Connector
B04—Environment Sensor Connector
B05—Upstream Throttle Pressure (UTP) Sensor Connector
B06—Exhaust Back Pressure (EBP) Sensor Connector
B07—Oil Pressure Switch Connector
B09—Crankshaft Sensor Connector
B10—Camshaft Position Sensor Connector
B11—Natural Gas Temperature (NGT) Sensor Connector
B12—Engine Coolant Temperature (ECT) Sensor Connector
B13—Throttle Charge Temperature (TCT) Sensor Connector
B14—Universal Exhaust Gas Oxygen (UEGO) Sensor Connector
B15—Knock Sensor Connector
N01—Electronic Throttle Connector
T01—Ignition Coil (Spark 6) Connector
T02—Ignition Coil (Spark 5) Connector
T03—Ignition Coil (Spark 4) Connector
T04—Ignition Coil (Spark 3) Connector
T05—Ignition Coil (Spark 2) Connector
T06—Ignition Coil (Spark 1) Connector
X03—Knock Module Power Connector
X04—Knock Module Ground
X05—Electronic Control Unit (ECU) Housing Ground
X06—Ground
X12—Battery Power
Y01—Fan Connector
Y02—Injector 1 Connector
Y03—Injector 2 Connector
Y04—Injector 3 Connector
Y05—Injector 4 Connector
Y06—Injector 5 Connector
Y07—Injector 6 Connector
Y08—Injector 7 Connector
Y09—Injector 8 Connector
Y10—Low Pressure Lock-Off Solenoid Connector
Y11—Turbocharger Wastegate Control Solenoid Connector
Z01—Knock Module Connector

Continued on next page

IMPORTANT: For diagnosis of engine wiring and electronic sensors and controls, refer to companion technical manual CTM300. This manual also contains detailed wiring diagrams.

OUO1080,0000220 –19–27MAY04–2/2

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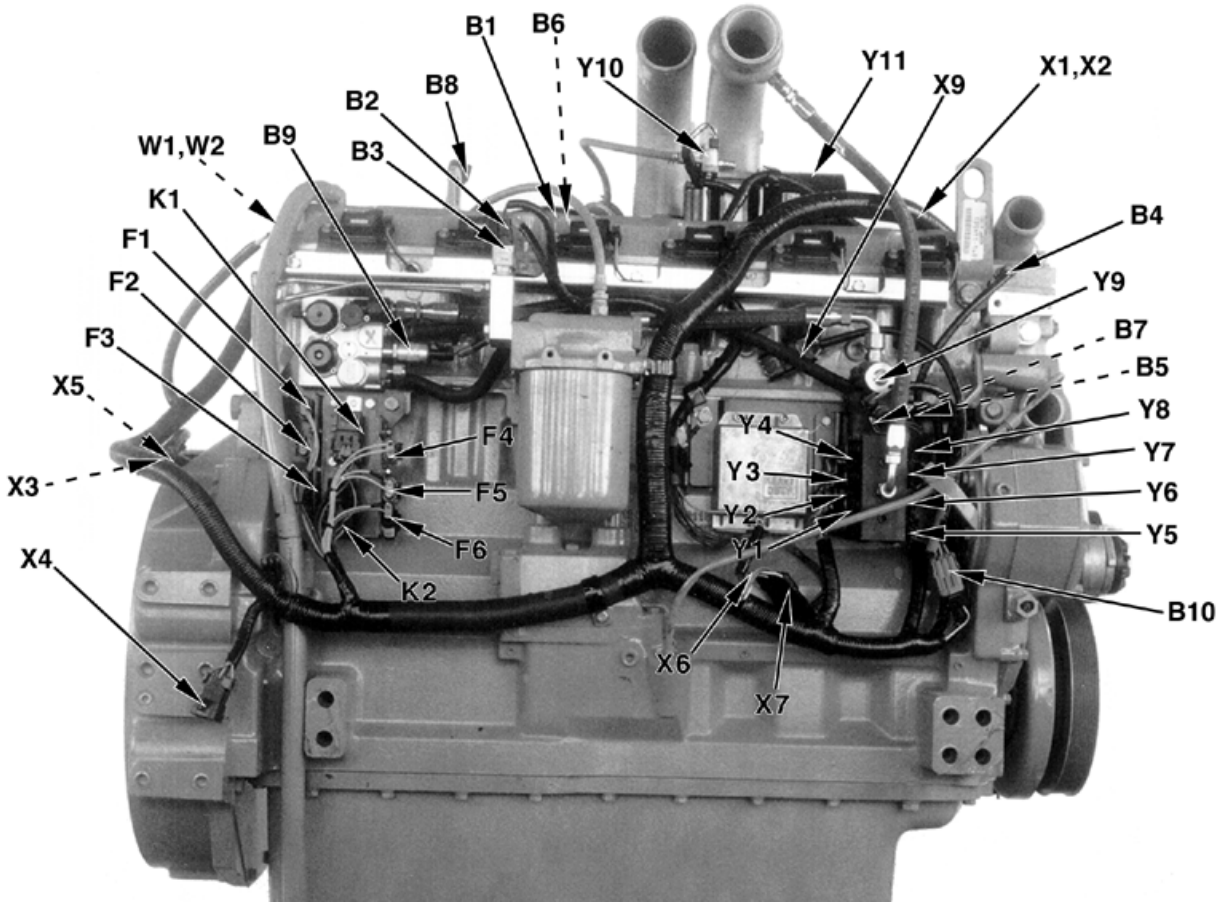
Natural Gas Engine Component Location Diagram (HFN01 Engine S. N. —045744)



Component Location (Early HFN01 Engine S.N. —045744 Shown)

B1—Manifold Absolute Pressure (MAP) Sensor
B2—Preturbine Pressure (PTP) Sensor
B3—Exhaust Back Pressure (EBP) Sensor
B4—Engine Coolant Temperature (ECT) Sensor
B5—Natural Gas Pressure (NGP) Sensor
B6—Manifold Air Temperature (MAT) Sensor
B7—Natural Gas Temperature (NGT) Sensor
B8—Universal Exhaust Gas Oxygen (UEGO) Sensor
B9—Natural Gas Tank Pressure (NGTP) Sensor
B10—Cam Position Sensor
B11—Oil Pressure Switch
F1—Fuse (5A)[1]
F2—Fuse (5A)[1]
F3—Fuse (5A)[1]
F4—Fuse (5A)[1]
F5—Fuse (5A)[1]
F6—Fuse (5A)[1]
K1—Relay
K2—Relay
W1—Ground (2 Wires)
W2—Ground (3 Wires)
X1—Electronic Control Module (ECM) Connector
X2—Electronic Control Module (ECM) Connector
X3—Vehicle Interconnect #3
X4—Vehicle Interconnect #4
X5—Vehicle Interconnect #5
X6—Ignition Coil Power
X7—Ignition Control Unit (ICU) Connector
X9—Diagnostic Connector
Y1—Fuel Injector
Y2—Fuel Injector
Y3—Fuel Injector
Y4—Fuel Injector
Y5—Fuel Injector
Y6—Fuel Injector
Y7—Fuel Injector
Y8—Fuel Injector
Y9—Low Pressure Lock-Off Solenoid
Y10—Turbocharger Wastegate Control Solenoid
Y11—Electronic Throttle
Not Shown—Foot Pedal Position 1 Sensor
Not Shown—Foot Pedal Position 2 Sensor

[1] Fuses shown are for early engines (S.N. —045744). On current HFN01 and HFN03 engines, fuses F1—F7 are located in box AWAY from engine. See component location drawing and legend (current HFN01 and HFN03 engines) for fuse ratings.

RG,45,DT7271 –19–05MAR02–1/1

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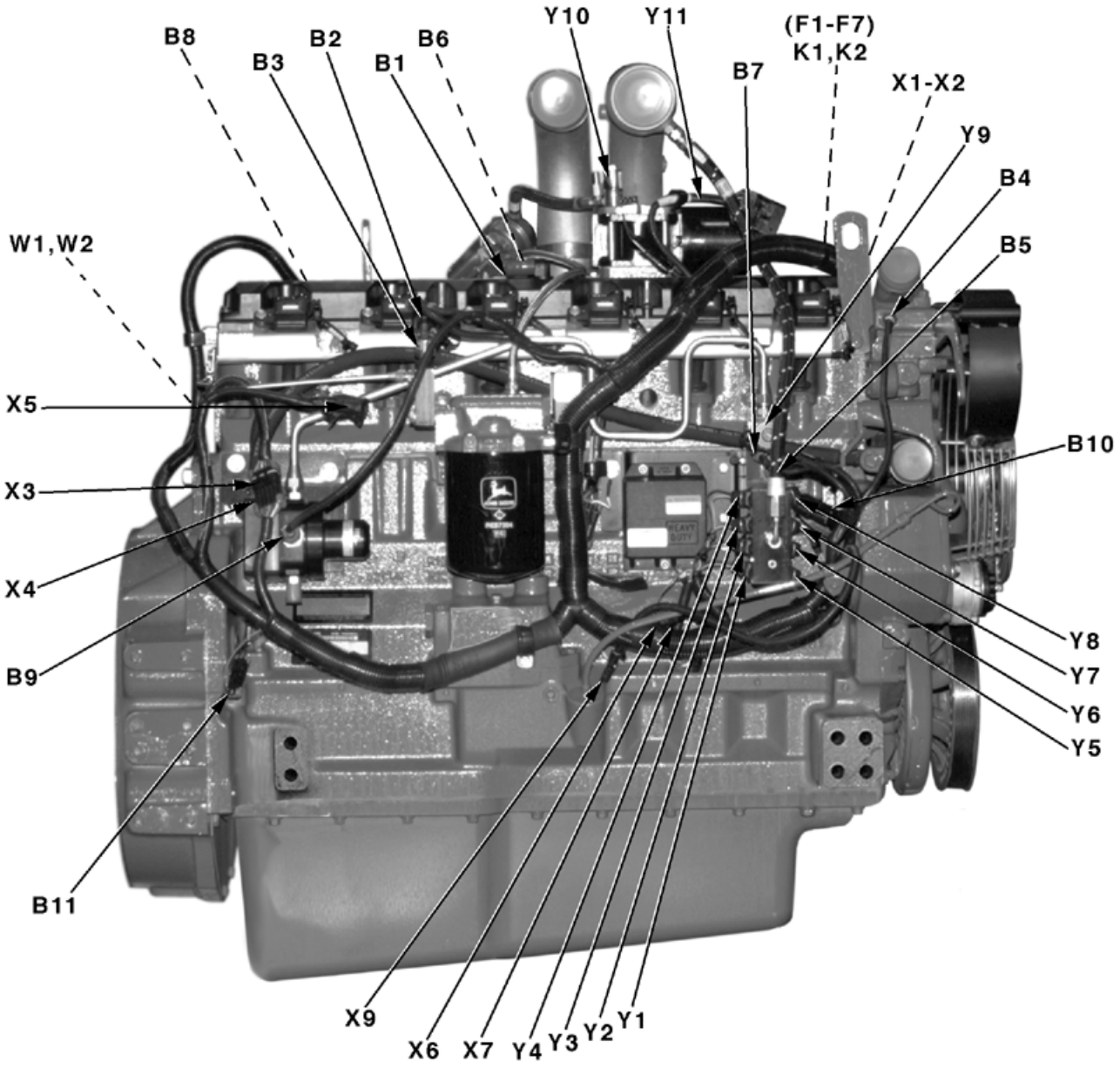
Natural Gas Engine Component Location Diagram (Current HFN01 and HFN03 Engines)



Component Location (Current HFN01 and HFN03 Engine Shown)

Continued on next page

DPSG,OUO1004,2849 –19–09AUG00–1/2

B1—Manifold Absolute Pressure (MAP) Sensor
B2—Preturbine Pressure (PTP) Sensor
B3—Exhaust Back Pressure (EBP) Sensor
B4—Engine Coolant Temperature (ECT) Sensor
B5—Natural Gas Pressure (NGP) Sensor
B6—Manifold Air Temperature (MAT) Sensor
B7—Natural Gas Temperature (NGT) Sensor
B8—Universal Exhaust Gas Oxygen (UEGO) Sensor
B9—Natural Gas Tank Pressure (NGTP) Sensor
B10—Cam Position Sensor
B11—Oil Pressure Switch
F1—Fuse (5A)[1]
F2—Fuse (15A)[1]
F3—Fuse (20A)[1]
F4—Fuse (20A)[1]
F5—Fuse (10A)[1]
F6—Fuse (15A)[1]
F7—Fuse (15A)[1]
K1—Relay[2]
K2—Relay[2]
W1—Ground (2 Wires)
W2—Ground (3 Wires)
X1—Electronic Control Module (ECM) Connector
X2—Electronic Control Module (ECM) Connector
X3—Vehicle Interconnect #3
X4—Vehicle Interconnect #4
X5—Vehicle Interconnect #5
X6—Ignition Coil Power
X7—Ignition Control Unit (ICU) Connector
X9—Diagnostic Connector
Y1—Fuel Injector
Y2—Fuel Injector
Y3—Fuel Injector
Y4—Fuel Injector
Y5—Fuel Injector
Y6—Fuel Injector
Y7—Fuel Injector
Y8—Fuel Injector
Y9—Low Pressure Lock-Off Solenoid
Y10—Turbocharger Wastegate Control Solenoid
Y11—Electronic Throttle

NOTE: Foot Pedal Position 1 Sensor and Foot Pedal Position 2 Sensor not shown in illustration.

[1] On current engines, fuses are located in box AWAY from the engine.

[2] On current engines, relays are located in box AWAY from the engine.

DPSG,OUO1004,2849 –19–09AUG00–2/2

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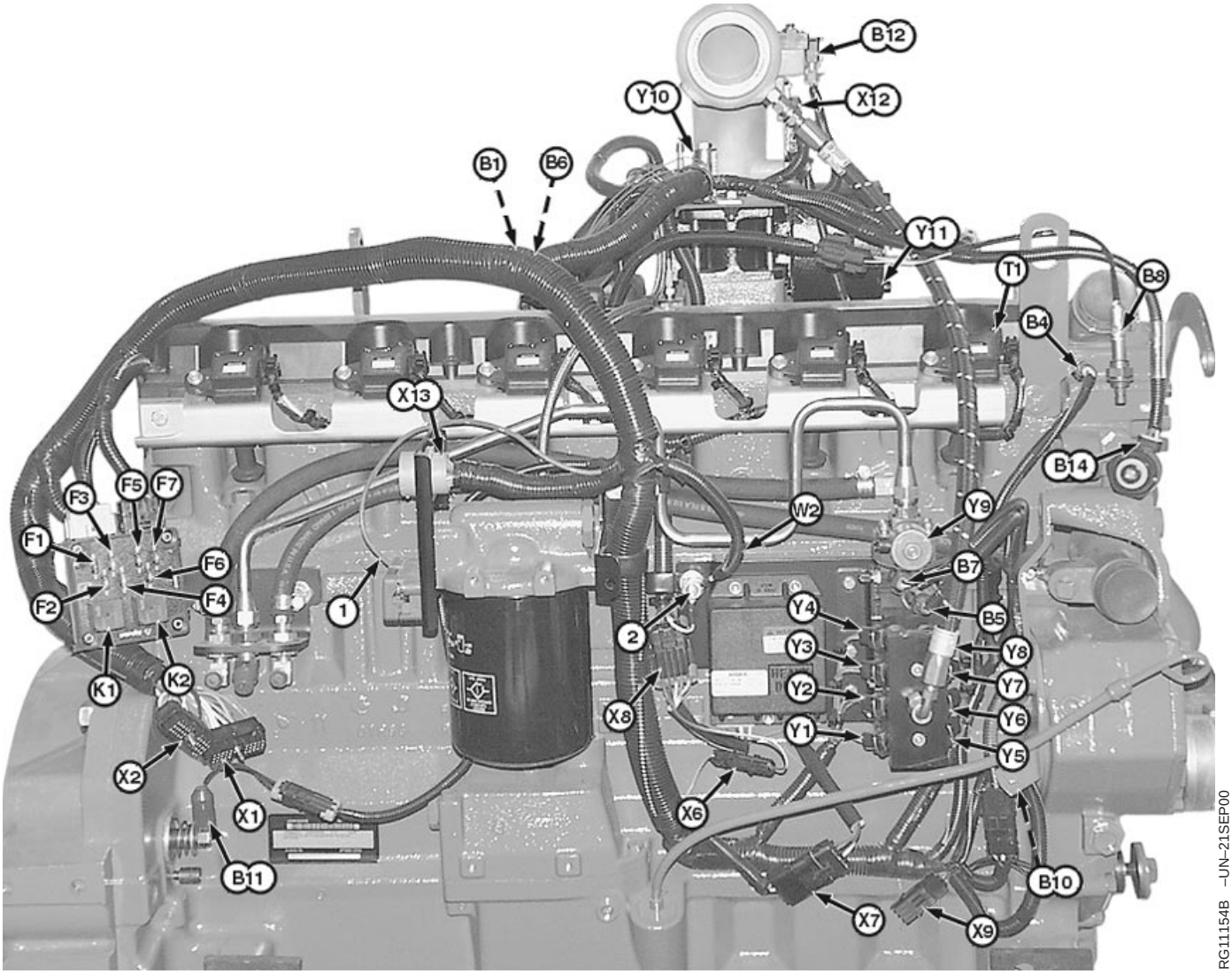
Natural Gas Engine Component Location Diagram (HFN02 Engine)



HFN02 Engine Component Location

Continued on next page

DPSG,OUO1004,2851 –19–27MAY04–1/2

1—Battery Power
2—Engine System Ground Terminal
B1—Manifold Absolute Pressure (MAP) Sensor
B4—Engine Coolant Temperature (ECT) Sensor
B5—Natural Gas Pressure (NGP) Sensor
B6—Manifold Air Temperature (MAT) Sensor
B7—Natural Gas Temperature (NGT) Sensor
B8—Universal Exhaust Gas Oxygen (UEGO) Sensor
B10—Cam Position Sensor
B11—Oil Pressure Switch
B12—Upstream Throttle Pressure (UTP) Sensor
B13—Knock Sensor[1]
B14—Environment Sensor
F1—Fuse (5A)
F2—Fuse (15A)
F3—Fuse (20A)
F4—Fuse (20A)
F5—Fuse (10A)
F6—Fuse (15A)
F7—Fuse (15A)
K1—Relay
K2—Relay
T1—Ignition Coil
W2—Ground Wire (10 Gauge)
X1—Electronic Control Module (ECM) Connector
X2—Electronic Control Module (ECM) Connector
X6—Ignition Coil Power
X7—Ignition Control Unit (ICU) Connector
X8—Spark Plug Harness Connector
X9—Diagnostic Connector
X12—Knock Module Connector
X13—Vehicle Interconnect #3
Y1—To Fuel Injector
Y2—To Fuel Injector
Y3—To Fuel Injector
Y4—To Fuel Injector
Y5—To Fuel Injector
Y6—To Fuel Injector
Y7—To Fuel Injector
Y8—To Fuel Injector
Y9—Low Pressure Lock-Off Solenoid
Y10—Turbocharger Wastegate Control Solenoid
Y11—Electronic Throttle

NOTE: Foot Pedal Position 1 Sensor and Foot Pedal Position 2 Sensor not shown in illustration.

[1] Knock sensor (not shown) is located on left side of engine block.

DPSG,OUO1004,2851 –19–27MAY04–2/2

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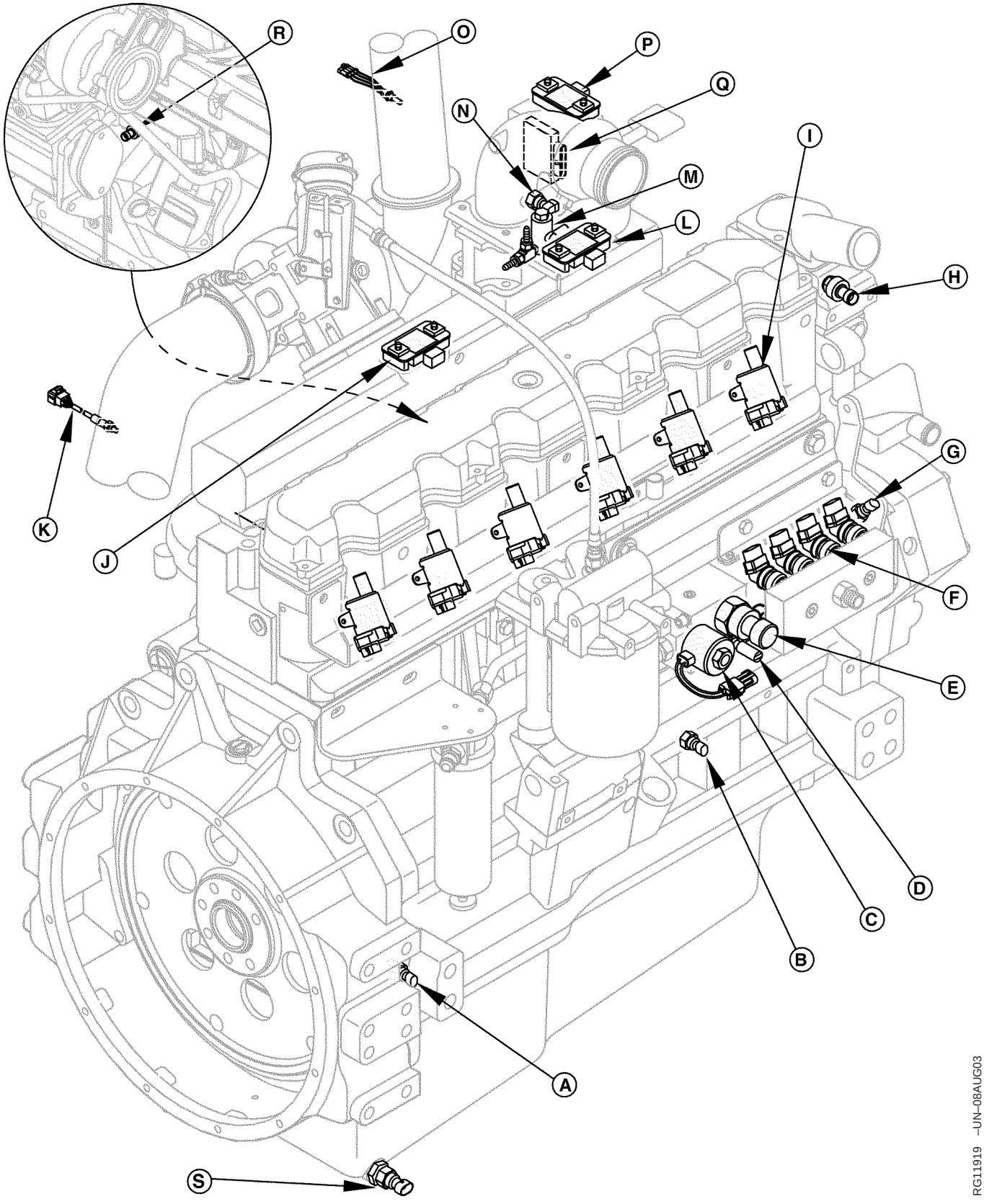
Compressed Natural Gas Engine Component Location Diagram (HFN04 Engine)



Continued on next page

OUO1080,0000221 –19–27MAY04–1/2

A—Crankshaft Position Sensor
B—Oil Pressure Sensor
C—Low Pressure Lock-Off
D—Natural Gas Temperature Sensor
E—Natural Gas Pressure Sensor
F—Injectors (8)
G—Camshaft Position Sensor
H—Engine Coolant Temperature Sensor
I—Ignition Coil (6)
J—Manifold Absolute Pressure Sensor
K—UEGO Sensor
L—Barometric Air Pressure
M—Wastegate Control Solenoid
N—Throttle Charge Temperature Sensor
O—Humidity/Inlet Air Temperature Sensor
P—Upstream Throttle Pressure Sensor
Q—Knock Module
R—Knock Sensor
S—Oil Temperature Sensor

OUO1080,0000221 –19–27MAY04–2/2

Connectors

Connectors are devices that provide for assembly and disassembly of systems. Connectors should always be serviced using tools designed for that type of connector. A good crimp is important to mechanical and electrical soundness. Repaired connectors should be physically tested by pulling to be sure the contact is firmly attached to the conductor.

IMPORTANT: If for some reason the connectors are not connected, it is important to protect the connectors from debris.

NOTE: See diagrams earlier in this group for location of all sensors and connectors. Refer to Operation and Diagnostics manual CTM113 or CTM300 for complete wiring diagrams, including connectors.

Refer to the procedures that follow for repair of various types of connectors.

RG,45,LG97 –19–21JAN98–1/1

Use Electrical Insulating Compound

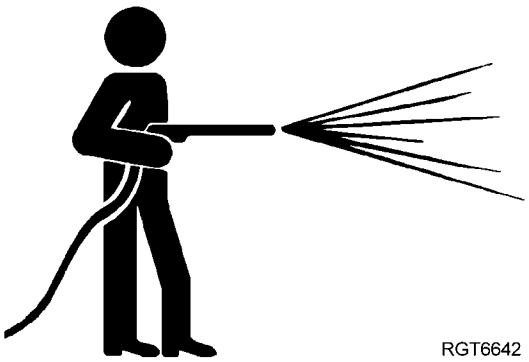
Apply AT66865 Compound directly to the terminals between the wire seal and connector body. This provides a moisture barrier, especially in wet and humid conditions.

RG,45,LG102 –19–24NOV97–1/1

45
44

Using High-Pressure Washer

IMPORTANT: Reduce pressure when directing pressurized water at electronic or electrical components and connectors as this may cause the components to malfunction. Always reduce pressure, and spray at a 45 to 90 degree angle.



Using High-Pressure Washer

RG,45,LG98 –19–24NOV97–1/1

Repair WEATHERPACK™ Connector


TS0128 –UN–23AUG88

1. Disconnect WEATHERPACK™ connector. Remove the tie bands and tape.
2. Open the secondary lock on the back of the connector.
3. Identify wire color/number to the connector cavity. Make sure each wire goes back to the correct cavity location.
4. Insert JDG364 Extraction Tool[1] over terminal contact in connector body. Extraction tool needs to be fully seated to unlock terminal tangs from the connector body. When tool is seated, gently pull the wire from the back of the connector. If the wire(s) or terminal(s) are being repaired, go to step 5. If the wires and terminals are OK and only the connector is being replaced, go to step 9.
5. Using JDG145 Universal Electrical Pliers[2], cut off wire directly behind the terminal seal crimp. If any part of the seal is still on the wire, dispose of it.
6. Using JDG145 Universal Electrical Pliers[2], strip 6 mm (1/4 in.) insulation from end of wire.

WEATHERPACK is a trademark of Packard Electric

[1] Included in JT07195B Electrical Repair Kit

[2]Included in JDG155 Electrical Repair Tool Kit

Continued on next page

AG,OUOD008,296 –19–06MAR02–1/4

7. Select correct size of seal. Slide the seal over the wire insulation with the smaller diameter side facing the end of the wire. Small diameter side of seal should line up with the outer edge of the insulation.

IMPORTANT: The seal must fit snug over the cable insulation without a gap between the cable seal and the insulation.

NOTE: Cable seals are color coded for three sizes of wire:

- *Green - 18—20 Gauge Wire*
- *Gray - 14—16 Gauge Wire*
- *Blue - 10—12 Gauge Wire*

TS0136 –UN–23AUG88

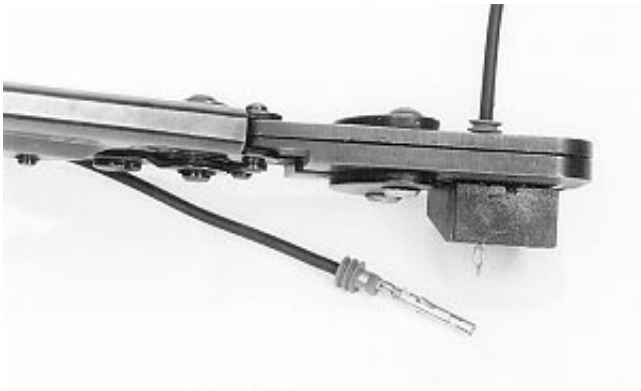
AG,OUOD008,296 –19–06MAR02–2/4

8. Select correct size terminal on wire and crimp in position with a W-type crimp using a JDG783 WEATHER PACK™ Crimping Tool.

NOTE: Terminals have numbered identification for two sizes of wire:

- *#15 - 14—16 Gauge Wire*
- *#19 - 18—20 Gauge Wire*

WEATHER PACK is a trademark of Packard Electric



TS1623 –UN–02NOV94

Continued on next page

AG,OUOD008,296 –19–06MAR02–3/4

9. Insert terminal into connector. Terminal should click when it is fully seated. Make sure the wire is inserted into the correct connector cavity.

IMPORTANT: Terminal tangs must be carefully spread to ensure good seating on connector body. If terminal is being reused in a new connector, make sure tangs are spread.

NOTE: Connector bodies are "keyed" for correct terminals. Be sure terminals are correctly aligned.

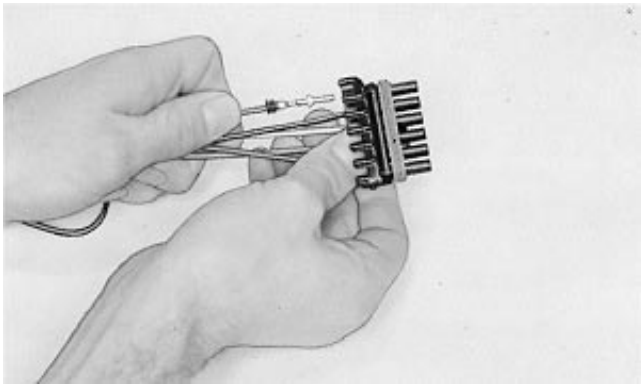
Correct terminal installation for sleeve (A) and pin (B) is illustrated.

10. Gently pull on wire to insure that the terminal is locked in position.

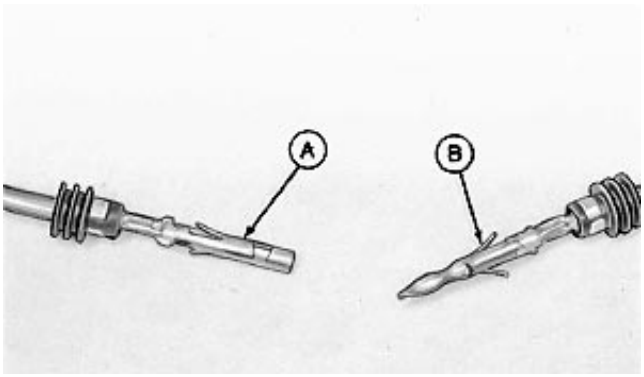
11. Repair or transfer remaining wires.

12. Close the secondary lock on the back of the connector.

13. Retape wires and add the required tie bands to the harness.



TS0130 –UN–23AUG88



TS0139 –UN–02DEC88

A—Sleeve
B—Pin

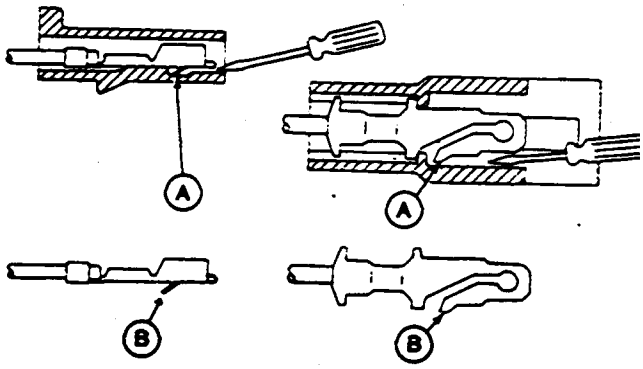
AG,OUOD008,296 –19–06MAR02–4/4

45
48

Remove Blade Terminals from Connector Body

NOTE: Use JDG776 Extraction Tool with 56, 280, and 630 Series METRI-PACK terminals. Use JDG777 Extraction Tool with 150 Series METRI-PACK terminals.

1. Insert JDG776 or JDG777 Terminal Extraction Tool[1] into connector body pushing the terminal locking tang inward.
2. Gently pull wire and remove terminal from connector.
3. Adjust the locking tang on the terminal to it's original position before installing into a connector.



RW4218 –UN–23AUG88

A—Locking Tang
B—Original Position

[1]*Included in JT07195B Electrical Repair Kit*

AG,OUOD008,297 –19–06MAR02–1/1

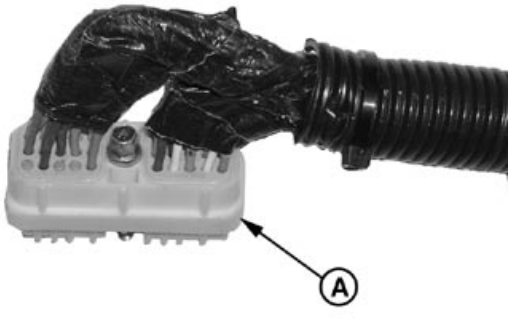
Repair *(Pull Type)* METRI-PACK™ Connectors

1. Disconnect the METRI-PACK connector (A) from the ECU.
2. Remove tie bands and tape from the wiring harness behind the connector.
3. Identify wire color/number to the connector cavity. Make sure each wire goes back to the correct cavity location.
4. Using JDG776 Terminal Extraction Tool (C)[1], carefully remove the connector seal (B) from the back of the connector.

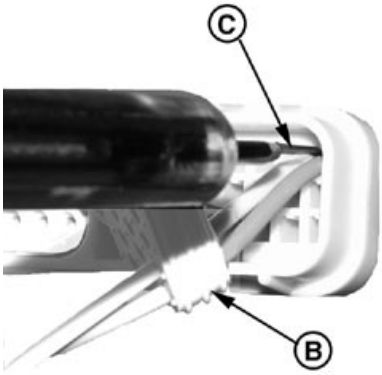
IMPORTANT: Make sure no damage to the seal occurs or water and contaminants will corrode terminals.

NOTE: Extraction tool must be used from the back of the connector.

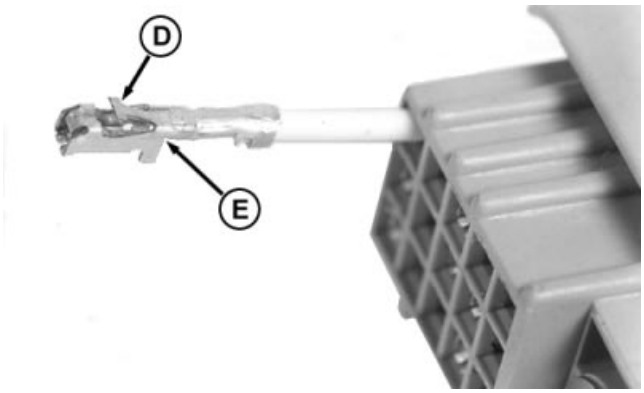
5. Using JDG776 Terminal Extraction Tool (C), angle the tip so it slides along the top edge of the connector. Make sure the extraction tool is centered in the connector cavity and push the tool in until resistance is felt.
6. With extraction tool inserted into the connector, gently rotate tool clockwise and counter-clockwise (no more than 1/8 turn each direction) to depress the terminal locking tang (D).
7. Remove extraction tool from back of connector.
8. Push wire until terminal has extracted from the front of the connector. If terminal does not extract, repeat steps 4-6.



RG12231A –UN–13MAR02



RG12232A –UN–13MAR02



RW16935A –UN–05AUG98

A—Connector
B—Connector Seal
C—JDG777 Terminal Extraction Tool
D—Terminal Locking Tang
E—Terminal

METRI-PACK is a trademark of Delphi Packard Electric Systems

[1] Included JT07195B Electrical Repair Kit

Continued on next page

9. Using JDG145 Universal Electrical Pliers[1], cut off wire directly behind the terminal.

IMPORTANT: Save as much wire as possible. If only a couple of wires are shorter than the rest, all of the strain will be placed on them. Damage to the harness may occur.

10. Using JDG145 Universal Electrical Pliers[1], strip 6 mm (1/4 in.) insulation from end of wire.

11. If wire has been removed from the connector, make sure the wire is fed through the connector (F) and in the correct cavity.

12. Using either JDG783 (G) or JDG707 (H) Crimping Pliers, crimp a new terminal on the wire.

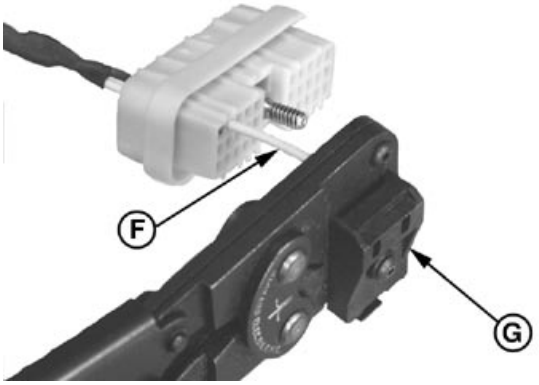
13. Make sure terminal locking tang (D) on new terminal is in outward position. Pull wire back into connector cavity until terminal locks.

NOTE: Terminal will seat only one way. If terminal does not pull into the connector body socket, check for correct terminal alignment (E).

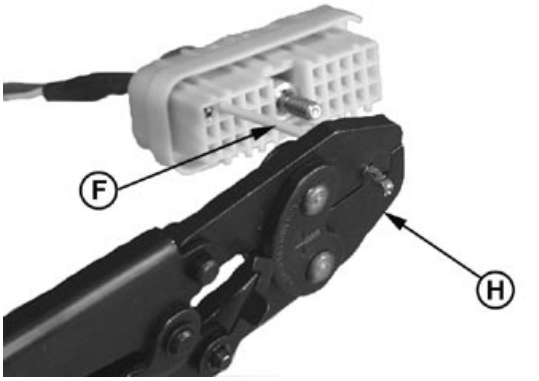
14. Push on the wire to make sure terminal is locked into the connector.

15. Slide the connector seal back into the connector. Make sure seal is in it's original position.

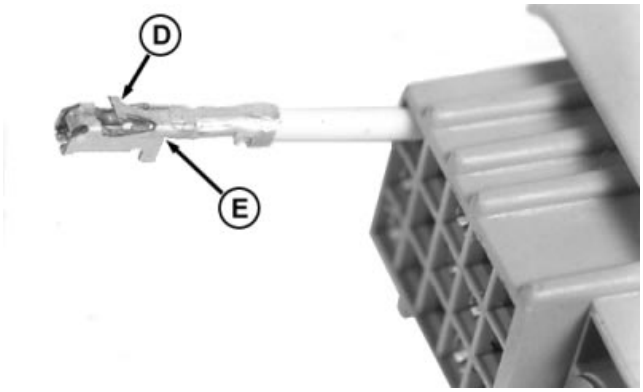
16. Retape the wires and add the required tie bands to the harness.



RG12234A –UN–13MAR02



RG12233A –UN–13MAR02



RW16935A –UN–05AUG98

D—Terminal Locking Tang
E—Correct Terminal Orientation
F—Wire
G—JDG783 Terminal Crimping Tool
H—JDG707 Terminal Crimping Tool

[1]*Included in JDG155 Electrical Repair Tool Kit*

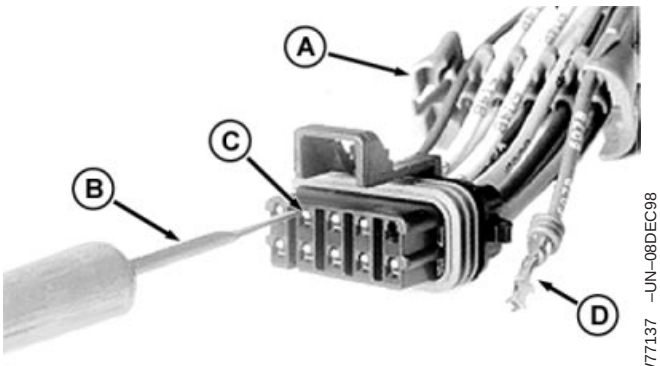
AG,OUOD008,298 –19–06MAR02–2/2

Repair *(Push Type)* METRI-PACK™ Connectors

1. Disconnect the METRI-PACK connector. Remove the tie bands and tape.
2. Remove secondary lock (A).
3. Identify wire color/number to the connector cavity. Make sure each wire goes back to the correct cavity location.
4. Insert JDG776 or JDG777 Terminal Extraction Tool[1] (B) into connector cavity (C) pushing the terminal locking tab inward.

NOTE: Use JDG776 Extraction Tool with 56, 280, and 630 Series METRI-PACK terminals. Use JDG777 Extraction Tool with 150 Series METRI-PACK terminals.

5. Remove extraction tool and pull wire from the back of the connector.
6. Using JDG145 Universal Electrical Pliers[2], cut off wire directly behind the terminal.
7. Using JDG145 Universal Electrical Pliers[2] strip 6 mm (1/4 in.) insulation from end of wire.
8. Select correct size of seal. Slide the seal over the wire insulation with the smaller diameter side facing the end of the wire. Small diameter side of seal should line up with the outer edge of the insulation.



RW77137 –UN–08DEC98

TS0136 –UN–23AUG88

A—Connector Secondary Lock
B—Extraction Tool
C—Connector Body Socket
D—Terminal

METRI-PACK is a trademark of Delphi Packard Electric Systems

[1]Included in JT07195B Electrical Repair Kit

[2]Included in JDG155 Electrical Repair Tool Kit

Continued on next page

AG,OUOD008,299 –19–06MAR02–1/3

IMPORTANT: The seal must fit snug over the cable insulation, without a gap between the cable seal and the insulation.

NOTE: Cable seals are color coded for three sizes of wire:

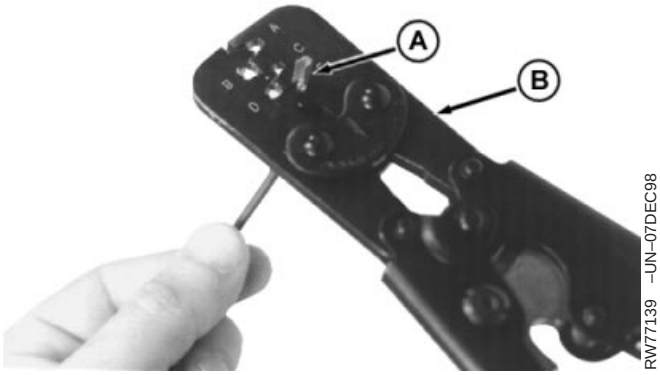
- *Green - 18—20 Gauge Wire*
- *Gray - 14—16 Gauge Wire*
- *Blue - 10—12 Gauge Wire*

9. Select correct size contact for wire.

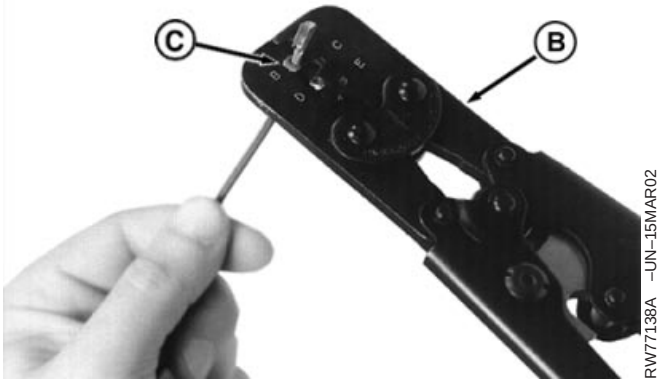
Continued on next page

10. Crimp contact (A) on wire with a “W” type crimp using JDG865 Crimping Tool (B).
11. Crimp cable seal (C) on contact using JDG865 Crimping Tool (B).
12. Make sure locking tang (D) on the new terminal is in the outward position.
13. Push terminal into the correct connector cavity until terminal locks.
14. Gently pull on wire to verify terminal is locked into the connector.
15. Place the secondary lock back on the connector.
16. Retape the wires and add the required tie bands to the harness.

A—Contact
B—Tool
C—Cable Seal
D—Terminal Locking Tang



RW77139 –UN–07DEC98



RW77138A –UN–15MAR02

RW77140A –UN–15MAR02

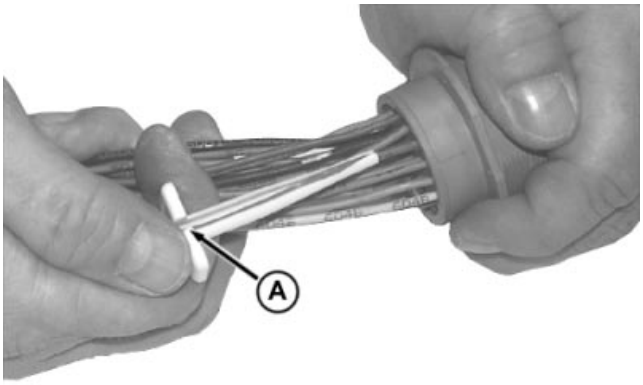
AG,OUOD008,299 –19–06MAR02–3/3

Repair DEUTSCH™ Connectors

1. Disconnect the Deutsch connector. Remove the tie bands and tape.
2. Identify wire color/number to the connector cavity. Make sure each wire goes back to the correct cavity location.
3. Select correct size extractor tool for size of wire to be removed:
   - JDG361 Extractor Tool - 12—14 Gauge Wire[1]
   - JDG362 Extractor Tool - 16—18 Gauge Wire[1]
   - JDG363 Extractor Tool - 20 Gauge Wire[2]
   - JDG785 Extractor Tool - 6-8 Gauge Wire[3]
4. Start inserting the wire into the handle end (A) of the correct size extraction tool.
5. Slide extraction tool rearward along wire until tool tip snaps onto wire.

IMPORTANT: DO NOT twist tool when inserting in connector.

6. Slide extraction tool along wire into connector body until tool is positioned over terminal contact.
7. Pull wire from connector body using extraction tool.
8. Using JDG145 Universal Electrical Pliers[4] cut off wire directly behind the terminal.
9. Using JDG145 Universal Electrical Pliers[4], strip 6 mm (1/4 in.) insulation from end of wire.



RW77142 –UN–07DEC98

A—Handle

DEUTSCH is a trademark of Deutsch Company

[1]Included in JT07195B Electrical Repair Tool Kit and JDG359 DEUTSCH Electrical Repair Kit

[2]Included in JDG359 DEUTSCH Electrical Repair Kit

[3]Included in JT07195B Electrical Repair Tool Kit

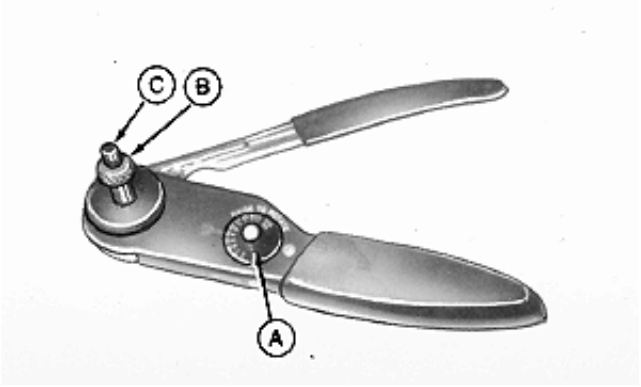
[4]Included in JDG155 Electrical Repair Tool Kit

Continued on next page

10. Adjust selector (A) on JDG360 Crimping Tool[1] for correct wire size .

11. Loosen lock nut (B) and turn adjusting screw (C) in until screw stops.

A—Selector
B—Lock Nut
C—Adjusting Screw



TS117 –UN–23AUG88

[1]*Included in JDG359 Electrical Repair Kit*

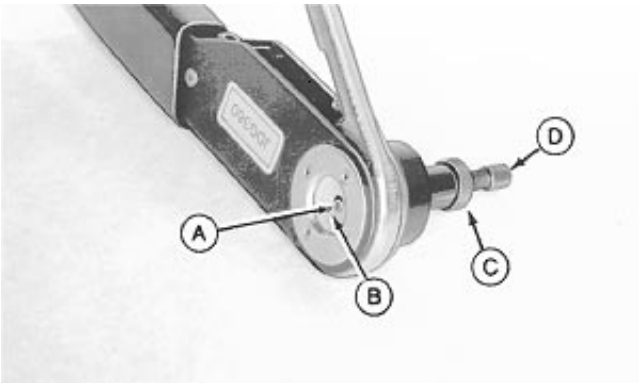
AG,OUOD008,304 –19–26MAR02–2/4

12. Insert terminal (A) and turn adjusting screw (D) until terminal is flush with cover (B).

IMPORTANT: Select correct size terminal to fit connector body.

13. Tighten lock nut (C).

A—Terminal
B—Cover
C—Lock Nut
D—Adjusting Screw



TS0134 –UN–23AUG88

Continued on next page

AG,OUOD008,304 –19–26MAR02–3/4

14. Insert wire in terminal and crimp until handle contacts stop.

IMPORTANT: Terminal must remain centered between indenters while crimping.

15. Release handle and remove terminal.

16. Inspect terminals to ensure all wires are in crimped barrel.

IMPORTANT: If all wire strands are not crimped into terminal, cut off wire at terminal and repeat terminal installation procedures.

NOTE: Readjust crimping tool for each crimping procedure.

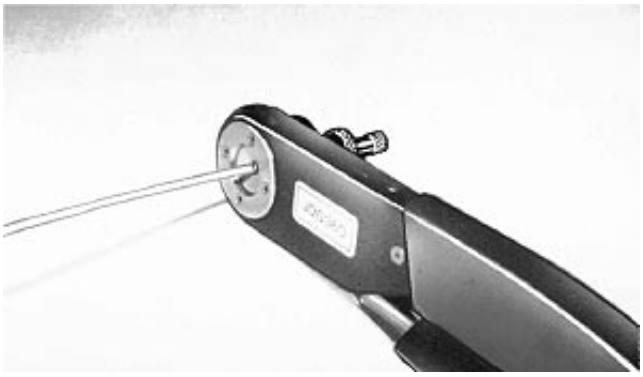
17. Push terminal straight into correct connector cavity until positive stop is felt.

IMPORTANT: Install terminal in correct connector cavity using correct size grommet.

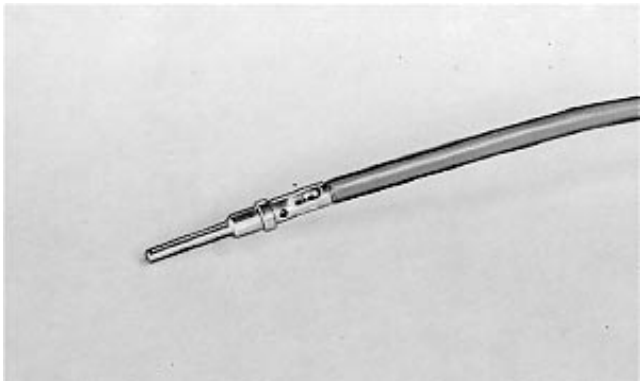
18. Gently pull on wire to verify terminal is locked into the connector.

19. Transfer remaining wires to correct cavity in new connector.

20. Retape the wires and add the required tie bands to the harness.



TS118 –UN–23AUG88

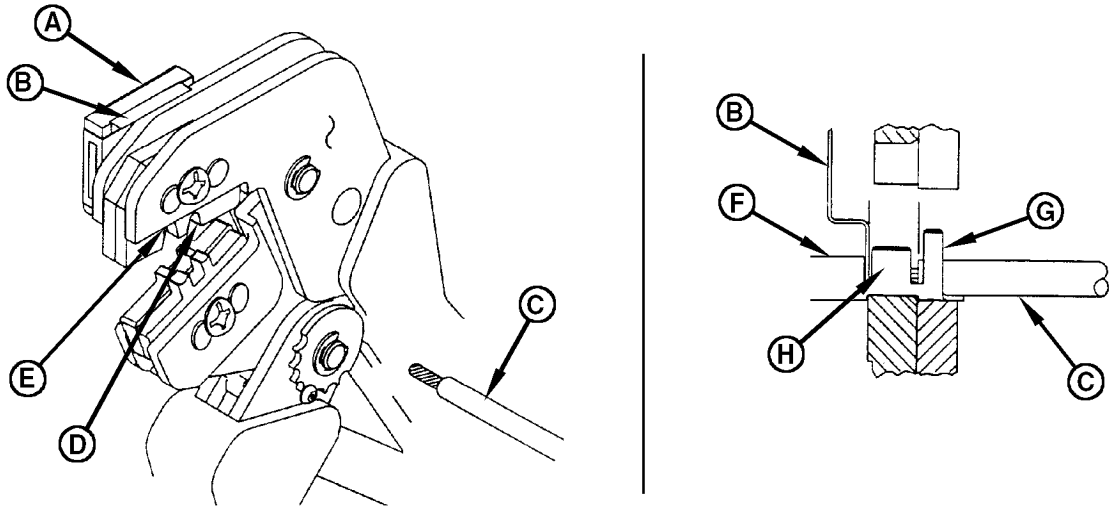


TS0135 –UN–23AUG88

RW77141 –UN–07DEC98

AG,OUOD008,304 –19–26MAR02–4/4

Repair AMP Connector (EUGO Connector)



RG10742 –UN–31MAY00

Using AMP Crimping Tool

A—Locator Assembly
B—Locator
C—Wire
D—Crimping Slot
E—Crimping Slot
F—Terminal
G—Insulation Barrel
H—Wire Barrel

1. Disconnect AMP connector. Remove the tie bands and tape.
2. Identify wire color/number to the connector cavity. Make sure the each wire goes back into the correct cavity location.
3. Press JDG1369 Terminal Extraction Tool into face of connector and remove wire and terminal from back of connector.

NOTE: Verify wire stripping length and crimp height before using AMP crimping tool. See instructions provided with tool.

4. Strip new wire to length indicated in tool instructions. Do not nick or cut wire strands.
5. Hold JDG708 AMP Crimping Tool so that the back (wire side) is facing you. Squeeze tool handles together and allow them to open fully.

NOTE: See instructions provided with tool to determine which crimping slot (D or E) to use.

6. Holding the terminal (F) by the mating end, insert the insulation barrel (G) first, through the front of the tool and into the appropriate crimp slot (D or E).

IMPORTANT: Make sure that both sides of the insulation barrel (G) are started evenly into the crimping section. Do NOT attempt to crimp an improperly positioned terminal.

7. Position the terminal so that the open “U” of the wire and insulation barrels (H and G) face the top of the tool. Place the terminal up into the nest so that the movable locator (B) drops into the slot in the terminal as shown. Butt the front end of the wire barrel (H) against the movable locator.
8. Hold the terminal (F) in position and squeeze the tool handles together until ratchet engages sufficiently to hold the terminal in position. DO NOT deform insulation barrel or wire barrel.
9. Insert stripped wire (C) into terminal insulation and wire barrels until it is butted against the wire stop.

Continued on next page

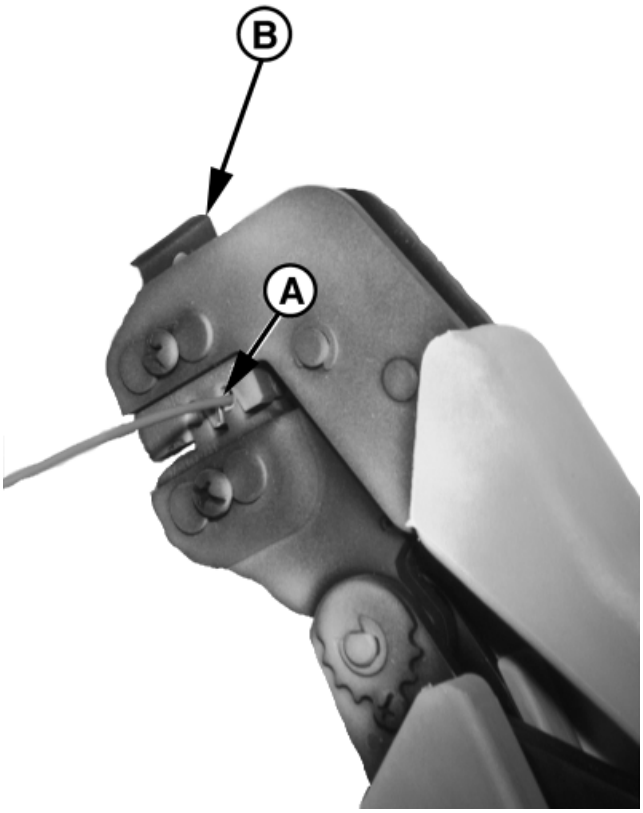
10. Hold the wire and terminal (A) in place. Squeeze tool handles together until ratchet releases. Allow tool handles to open and remove crimped terminal.

NOTE: The crimped terminal may stick in the crimping area. It can be easily removed by pushing downward on the top of the locator (B).

11. Install wire in correct connector cavity.

12. Retape the wires and add the required tie bands to the harness.

A—Wire and Terminal
B—Locator



DPSG,OUO1004,2867 –19–06MAR02–2/2

Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

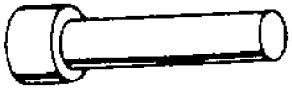
SERVICEGARD is a trademark of Deere & Company

DPSG,OUO1004,2860 –19–28FEB02–1/4

RG5068 –UN–05DEC97

Timing Pin JDE81-4

Lock engine at TDC when timing valve train. Use with JDG820, JDE81-1, or JDE83 Flywheel Turning Tool.



RG5068

JDE81-4

DPSG,OUO1004,2860 –19–28FEB02–2/4

RG7861 –UN–08DEC97

Air Compressor Wrench JDG942

Used to remove air compressor mounting nut.

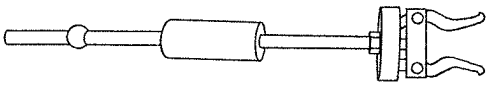
JDG942

DPSG,OUO1004,2860 –19–28FEB02–3/4

RG10060 –UN–10JUN99

Slide Hammer and Attachment. D01209AA

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



D01209AA

DPSG,OUO1004,2860 –19–28FEB02–4/4

50
2

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

DPSG,OUO1004,2861 –19–01MAR02–1/2

Gear Puller D01206AA

Remove gear from compressor shaft.

DPSG,OUO1004,2861 –19–01MAR02–2/2

Air Compressor and Auxiliary Drive Specifications

Item	Measurement	Specification
Auxiliary Drive Idler Housing-to-Timing Gear Cover Cap Screws (3/8-in.)	Torque	41 N•m (30 lb-ft)
Auxiliary Drive Idler Housing-to-Cylinder Block Cap Screws (3/8-in.)	Torque	41 N•m (30 lb-ft)
Auxiliary Drive Idler Housing-to-Cylinder Block Cap Screw (1/2-in.)	Torque	127 N•m (94 lb-ft)
Auxiliary Drive Idler Shaft Button Head Cap Screw	Torque	150 N•m (110 lb-ft)
Timing Gear Cover-to-Cylinder Block Cap Screws (5/16-in.)	Torque	27 N•m (20 lb-ft)
Auxiliary Drive Idler Housing-to-Idler Bearing Cap Screw (5/16-in.)	Torque	27 N•m (20 lb-ft)
Auxiliary Drive Idler Gear-to-Crankshaft Gear	Backlash	0.11—0.7 mm (0.004—0.028 in.)
Midland Air Compressor Mounting Hex Nuts	Torque	102 N•m (75 lb-ft)
Bendix Air Compressor Mounting Hex Nuts	Torque	95 N•m (70 lb-ft)
Air Compressor Support Bracket Cap Screws	Torque	41 N•m (30 lb-ft)
Air Compressor Gear Retaining Nut	Torque	122 N•m (90 lb-ft)
Air Compressor Drive Gear-To-Idler Gear	Backlash	0.08—0.74 mm (0.003—0.029 in.)
Oil Fill Cover Cap Screw	Torque	41 N•m (30 lb-ft)

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Remove Air Compressor

NOTE: Bendix and Midland air compressors are used depending on vehicle applications. Removal and installation procedures are similar, with differences noted.

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

1. Drain cooling system.

   Slowly open the engine cooling system filler cap or radiator cap to relieve pressure and allow coolant to drain faster.

2. Disconnect air and coolant lines from air compressor.

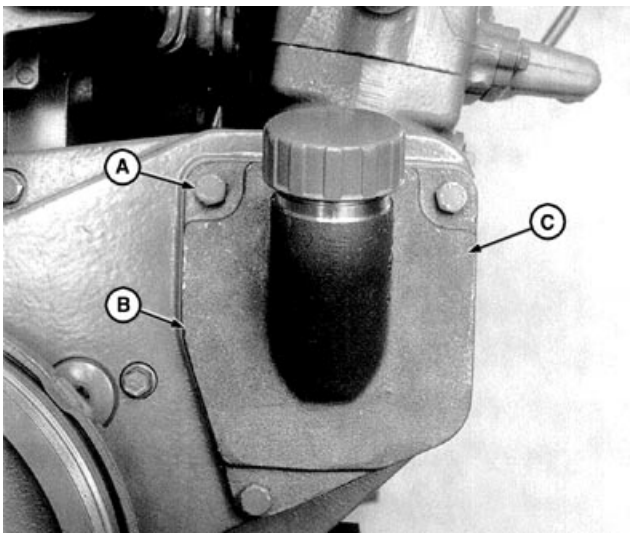
3. Remove oil supply line, shown removed.

4. Remove three cap screws (A). Remove cover (B) and O-ring (C). Discard O-ring.

5. Lock engine with JDE81-4 Timing Pin. Remove gear retaining nut (D) and washer (E).

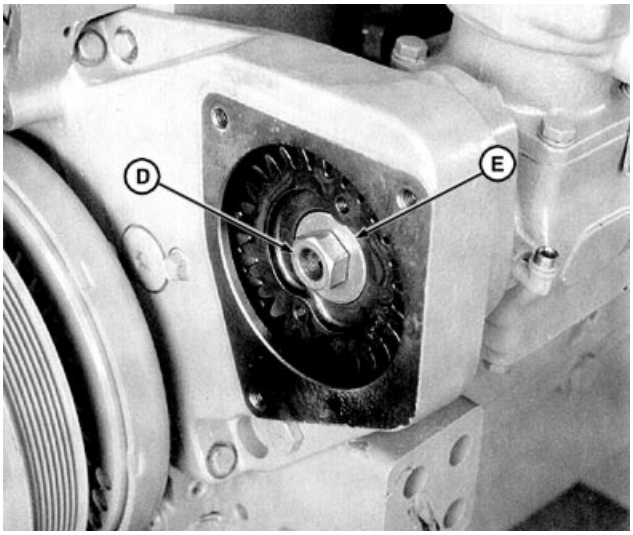
NOTE: Air compressor shaft is tapered and gear may be difficult to remove.

6. Using D01206AA Gear Puller, pull gear off air compressor shaft.



RG7672A –UN–05DEC97

Remove Air Compressor Cover (Midland Compressor Shown)



RG7673A –UN–05DEC97

Remove Air Compressor Gear (Midland Compressor Shown)

A—Cap Screw (3 used)
B—Cover
C—O-Ring
D—Retaining Nut
E—Washer

Continued on next page

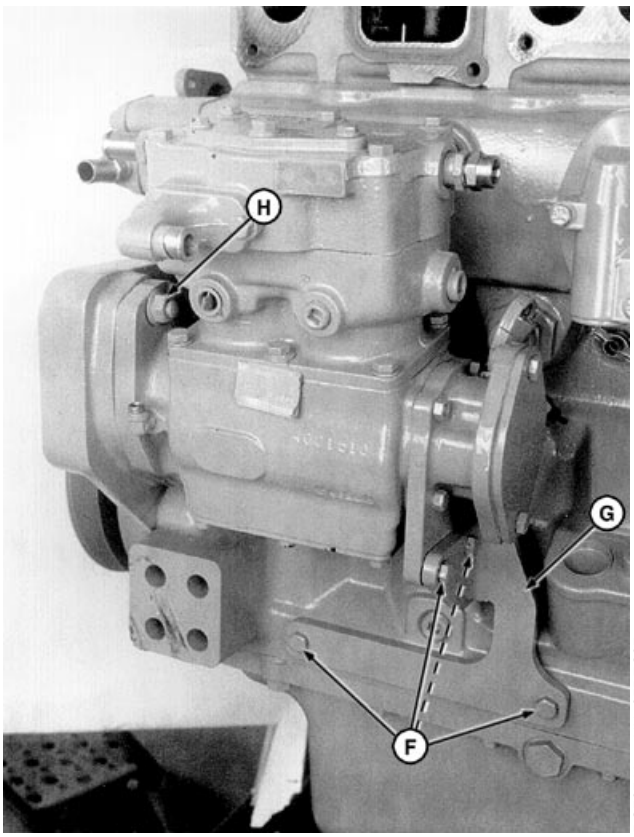
RG,50,DT7295 –19–28FEB02–1/2

7. Remove four cap screws (F). Remove air compressor mounting bracket (G).

NOTE: Use JDG942 Air Compressor Wrench to remove bottom air compressor hex nut.

8. Remove two hex nuts (H). Remove air compressor from gear housing. Discard gasket.

F—Cap Screw (4 used)
G—Air Compressor Mounting Bracket
H—Hex Nut (2 used)



RG7674A –UN–05DEC97

Remove Air Compressor (Midland Compressor Shown)

RG,50,DT7295 –19–28FEB02–2/2

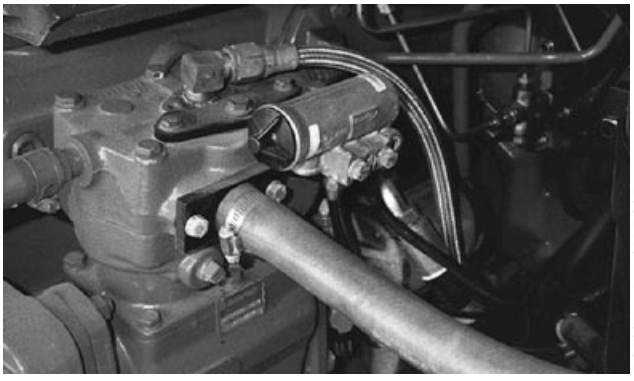
Inspecting Air Compressor

Normal lubrication of air compressor cylinders and piston rings will result in small amount of oil getting into the air system. Normal compressed air temperatures are high enough to result in carboning of the air discharge line.

Relieve pressure from the air system by opening purge valve. Remove and inspect:

- discharge line for carbon build-up
- intake hose
- unloader valve
- governor

Clean lines and components that are fouled with carbon.



RG7294 –UN–05DEC97

Inspect Air Compressor (Midland Compressor Shown)

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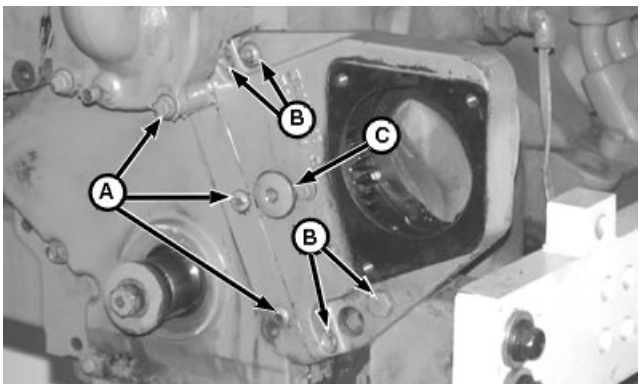
Remove Auxiliary Drive Housing and Idler Gear

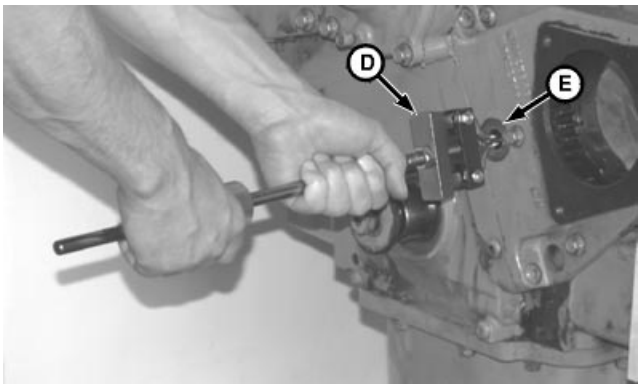
1. Remove air compressor (shown removed). (See REMOVE AIR COMPRESSOR in this group.)
2. Remove vibration damper (shown removed). (See REMOVE CRANKSHAFT VIBRATION DAMPER in Group 15.)
3. Loosen idler housing cap screws (B) and timing gear cover cap screws (A).
4. Remove button head cap screw (C).
5. Remove idler gear bushing/spacer (E) from timing gear cover using D01209AA Slide Hammer and Attachment (D) and discard bushing/spacer.

A—Timing Gear Cover Cap Screws
B—Idler Housing Cap Screws
C—Button Head Cap Screw
D—D01209AA Puller
E—Idler Gear Bushing/Spacer



RG10055 –UN–23JUN99

Button Head Cap Screw



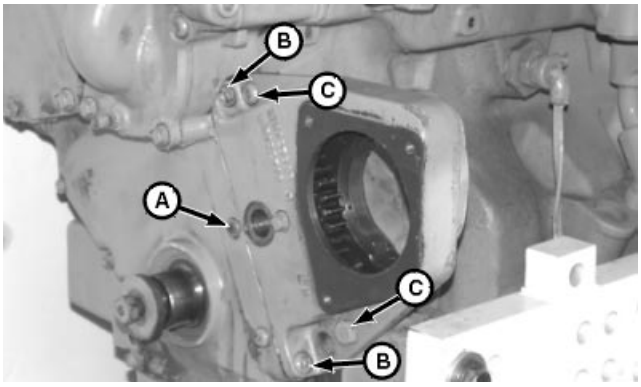
RG10056 –UN–23JUN99

Auxiliary Drive Idler Bushing/Spacer

DPSG,OUO1004,911 –19–10JUN99–1/2

6. Remove cap screws (A—C) and remove idler housing and gear.
7. Remove idler housing-to-timing gear housing face seal and O-ring. Face seal may be reused if not damaged.
8. Clean and inspect auxiliary drive assembly for cracked housing, worn or damaged bearings and damaged gear or spline. Replace components as required.

A—Timing Gear Cover-to-Cylinder Block Cap Screw
B—Idler Housing-to-Timing Gear Cover Cap Screws
C—Idler Housing-to-Cylinder Block Cap Screws



RG10057 –UN–23JUN99

Remove Auxiliary Drive Assembly

DPSG,OUO1004,911 –19–10JUN99–2/2

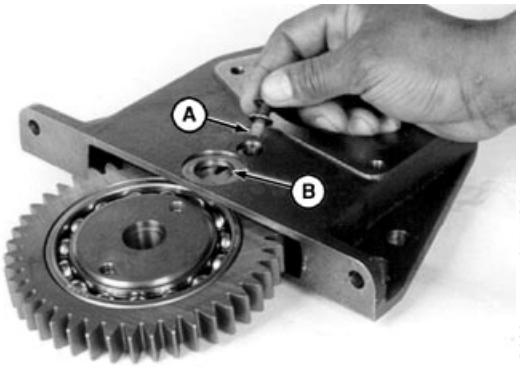
Install Auxiliary Drive Housing and Idler Gear

1. Grease and install O-ring in housing bore (B).

NOTE: Inner idler bearing support has one threaded hole, with threads installed toward block side of housing.

2. If removed, install idler gear into idler housing. Install cap screw with seal (A) through threaded hole of bearing support to hold idler gear in place.

A—Cap Screw
B—Housing Bore



RG6904 –UN–05DEC97

Idler Gear

DPSG,OUO1004,2859 –19–10AUG00–1/5

3. Insert idler shaft through idler housing and idler gear until flush with block side of housing.

IMPORTANT: White dot on one end of shaft must face out toward front of engine.

4. Grease O-ring groove (A) in back side of idler housing. Insert O-ring.

A—O-Ring Groove

RG6903 –UN–05DEC97

O-Ring Groove

Continued on next page

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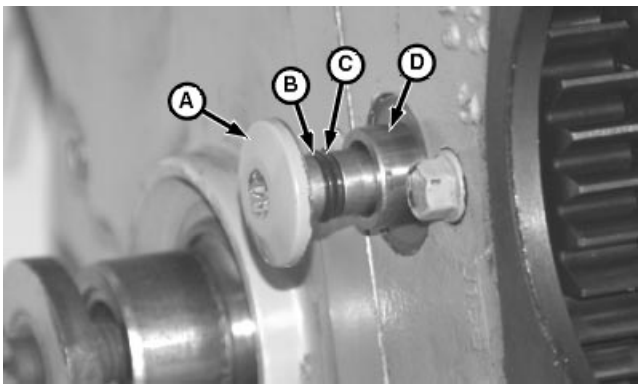
NOTE: Face seal may be reused if it is not cut, nicked, or damaged.

5. Using a short guide stud, place face seal on timing gear cover opening. Gauge hole in seal must be positioned toward bottom of opening.

IMPORTANT: Be careful not to damage face seal or displace O-ring on back side of idler housing during assembly.

6. Carefully insert idler gear into opening of timing gear cover until idler gear meshes with crankshaft gear, and housing is seated against face seal. Push idler bushing/spacer (D) into block.

7. Check condition of O-rings (B) and (C) on large button head cap screw (A). Grease O-rings and install cap screw through idler shaft. Thread into block until finger tight.



RG10059 –UN–23JUN99

Button Head Cap Screw

A—Button Head Cap Screw
B—Large O-Ring
C—Small O-Ring
D—Idler Bushing/Spacer

Continued on next page

DPSG,OUO1004,2859 –19–10AUG00–3/5

NOTE: Center timing gear cover-to-cylinder block cap screw must have a seal.

8. Remove guide stud. Install timing gear cover cap screws (E), idler housing cap screws (A and B) and cap screw (D) finger tight.

9. Tighten cap screws to specifications in the following sequence:

   - Idler housing-to-timing gear cover (A):

Specification

Auxiliary Drive Idler
Housing-to-Timing Gear Cover
Cap Screws (3/8-in.)—Torque..... 41 N•m (30 lb-ft)

   - Idler housing-to-cylinder block (B) 3/8 inch cap screws:

Specification

Auxiliary Drive Idler
Housing-to-Cylinder Block Cap
Screws (3/8-in.)—Torque ..... 41 N•m (30 lb-ft)

   - Idler housing-to-cylinder block (D) 1/2 inch cap screws:

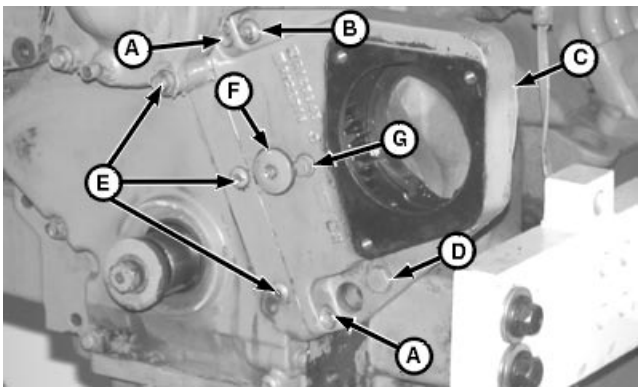
Specification

Auxiliary Drive Idler
Housing-to-Cylinder Block Cap
Screw (1/2-in.)—Torque ..... 127 N•m (94 lb-ft)

   - Idler bushing/spacer button head cap screw (F):

Specification

Auxiliary Drive Idler Shaft Button
Head Cap Screw—Torque ..... 150 N•m (110 lb-ft)



RG10236 –UN–30JUN99

Install Auxiliary Drive Assembly

A—Idler Housing-to-Timing Gear Cover Cap Screws
B—Idler Housing-to-Cylinder Block Cap Screw
C—Idler Housing
D—Idler Housing-to-Cylinder Block Cap Screw
E—Timing Gear Cover-to-Cylinder Block Cap Screws
F—Idler Bushing Button Head Cap Screw
G—Idler Housing-to-Idler Bearing Cap Screw

Continued on next page

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- Timing gear cover-to-cylinder block (E):

Specification	
Timing Gear Cover-to-Cylinder Block Cap Screws (5/16-in.)—Torque	27 N•m (20 lb-ft)

- Idler housing-to-idler bearing (G):

Specification	
Auxiliary Drive Idler Housing-to-Idler Bearing Cap Screw (5/16-in.)—Torque	27 N•m (20 lb-ft)

10. Check idler gear-to-crankshaft gear backlash. Backlash must be within specification.

Specification	
Auxiliary Drive Idler Gear-to-Crankshaft Gear—Backlash	0.11—0.7 mm (0.004—0.028 in.)

11. Install vibration damper. (See INSTALL CRANKSHAFT VIBRATION DAMPER in Group 15.)

12. Install air compressor. (See INSTALL AIR COMPRESSOR in this group.)

DPSG,OUO1004,2859 –19–10AUG00–5/5

Install Air Compressor

NOTE: Bendix and Midland air compressors are used depending on vehicle applications. Removal and installation procedures are similar, with differences noted.

1. Using a new gasket, install the air compressor to the gear housing. Install hex nuts (A) and tighten to specification.

Specification

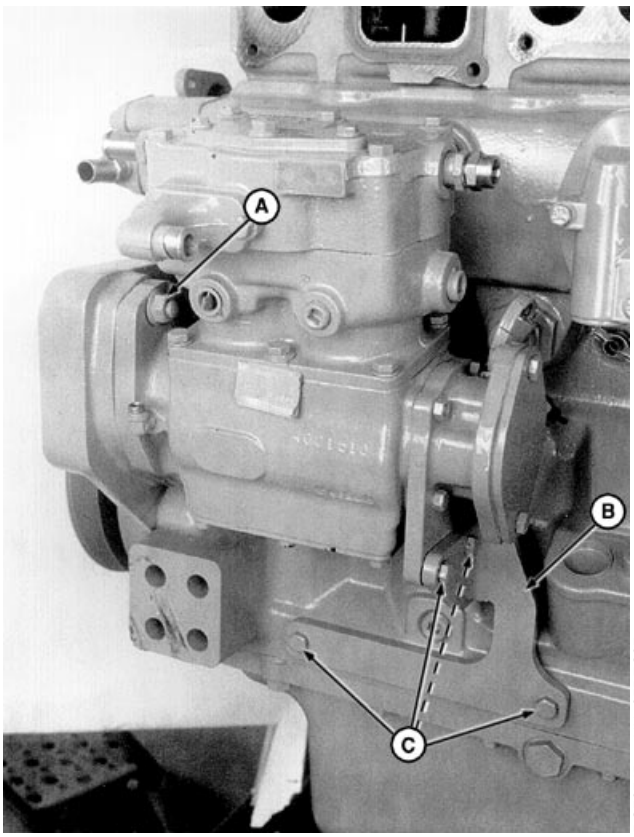
Midland Air Compressor Mounting
Hex Nuts—Torque ..... 102 N•m (75 lb-ft)
Bendix Air Compressor Mounting
Hex Nuts—Torque ..... 95 N•m (70 lb-ft)

2. Install bracket (B) and cap screws (C) and tighten cap screws to specifications.

Specification

Air Compressor Support Bracket
Cap Screws—Torque ..... 41 N•m (30 lb-ft)

3. Clean tapered ID of gear and tapered OD of air compressor shaft.



Installing Air Compressor (Midland Compressor Shown)

A—Hex Nut (2 used)
B—Bracket
C—Bracket Cap Screw (4 used)

Continued on next page

RG,50,DT7291 –19–28FEB02–1/3

4. Install gear (E), washer (F) and retaining nut (D) on air compressor shaft.

5. Lock engine with JDE81-4 Timing Pin. Tighten gear retaining nut (D) to specification.

Specification

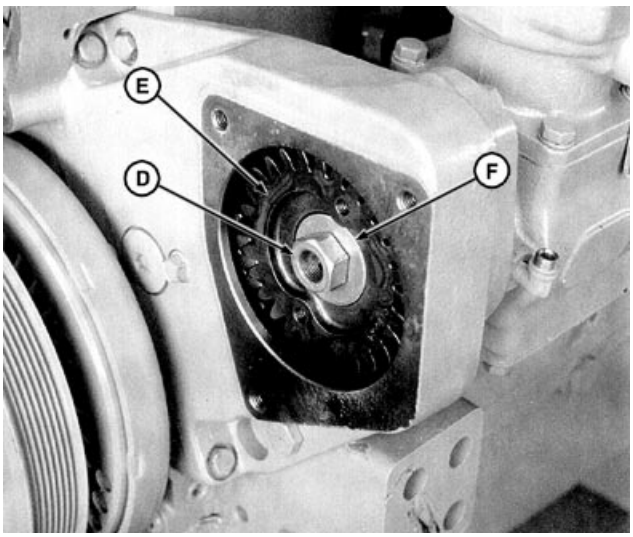
Air Compressor Gear Retaining Nut—Torque ..... 122 N•m (90 lb-ft)

6. Check air compressor drive gear-to-idler gear backlash. Backlash must be within specification.

Specification

Air Compressor Drive Gear-To-Idler Gear—Backlash..... 0.08—0.74 mm (0.003—0.029 in.)

D—Retaining Nut
E—Gear
F—Washer



RG7673B –UN–05DEC97

Install Air Compressor Gear (Midland Compressor Shown)

RG,50,DT7291 –19–28FEB02–2/3

7. Using a new O-ring, install front cover (G). Tighten cap screws (H) to specification.

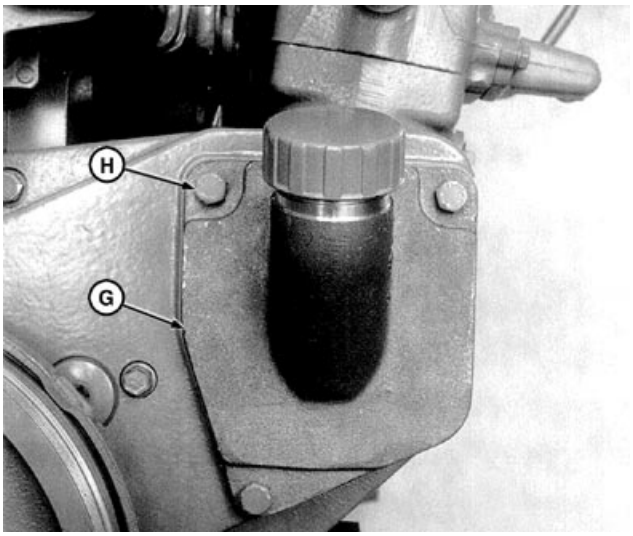
Specification

Oil Fill Cover Cap Screw—Torque..... 41 N•m (30 lb-ft)

8. Install oil supply line.

9. Connect air and coolant lines to air compressor.

G—Front Cover
H—Front Cover Cap Screw



RG7672B –UN–05DEC97

Install Front Cover (Midland Compressor Shown)

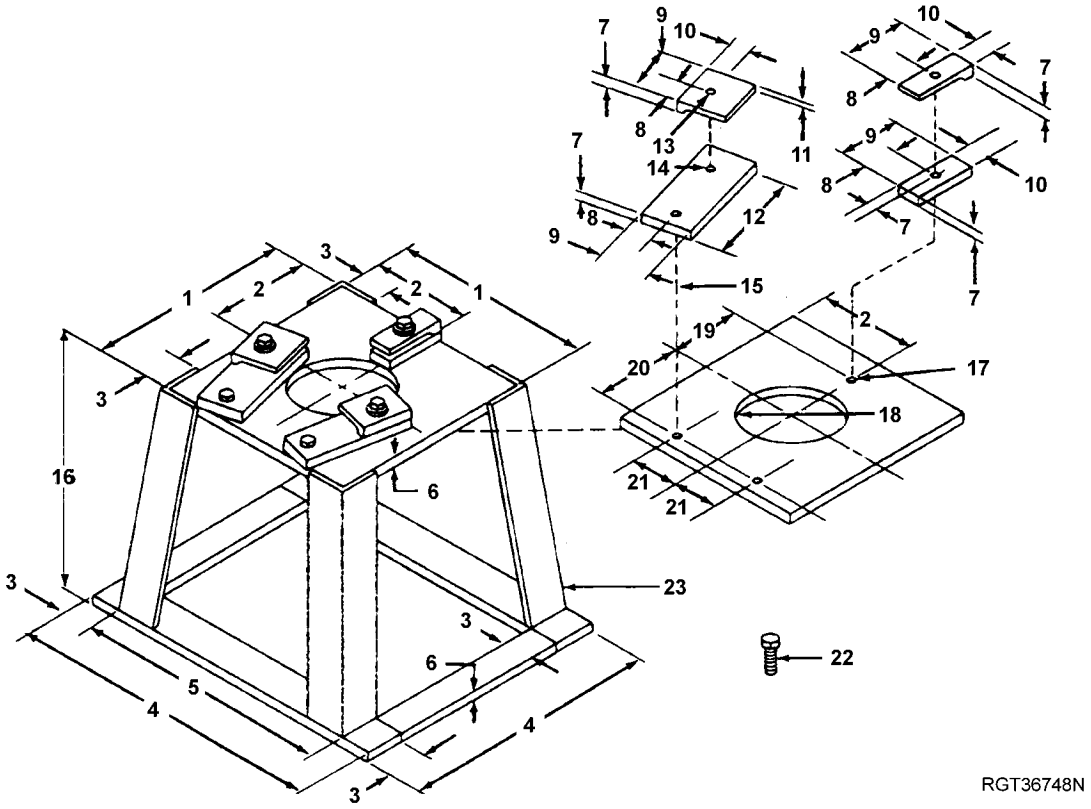
RG,50,DT7291 –19–28FEB02–3/3

How to Make Tools

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

RG,99,SO156 –19–21JAN98–1/1

DFRG3 Cylinder Liner Holding Fixture



Cylinder Liner Holding Fixture

1—254.0 mm (10 in.)
2—127.0 mm (5 in.)
3—38.1 mm (1.5 in.)
4—405.4 mm (16 in.)
5—330.2 mm (13 in.)
6—9.52 mm (0.38 in.)
7—12.7 mm (0.5 in.)
8—31.8 mm (1.25 in.)
9—63.5 mm (2.5 in.)
10—25.4 mm (1 in.)
11—6.35 mm (0.25 in.)
12—152.4 mm (6 in.) Radius
13—0.328 in. Drill Through
14—5/16 in. 18 Tap
15—2 used
16—304.8 mm (12 in.)
17—5/16 in 18 Tap
18—69.85 mm (2.75 in.) Screw
19—101.6 mm (4 in.) Angle
20—25 mm (4.38 in.)
21—60.45 mm (2.38 in.)
22—5/16 in. x 1 in. Cap Screw
23—38.1 mm (1.5 in.) Angle

RG,198,DT7306 –19–05NOV97–1/1

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