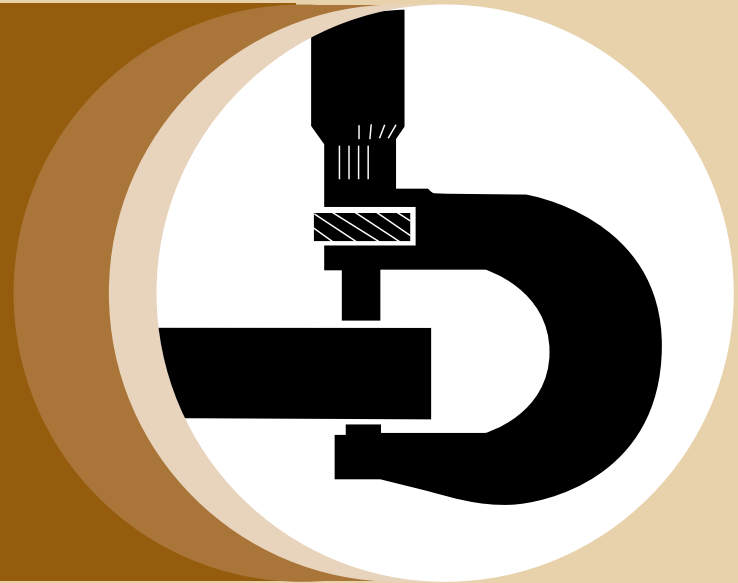


6101 Engines

Serial Number (500000—)

COMPONENT TECHNICAL MANUAL



Deere Power Systems Group
CTM61 (13MAY93)

LITHO IN U.S.A.
ENGLISH



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

This manual is divided in two parts: repair and operation and tests. Repair sections contain

necessary instructions to repair the component. Operation and tests sections help you identify the majority of routine failures quickly.

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

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

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

ABOUT THIS MANUAL

This component technical manual covers the recommended repair procedure for 6101, 10.1 L (619 cu. in.) diesel engines produced in Waterloo, Iowa beginning with Engine Serial No. (500000—). For 6101 engines produced prior to Engine Serial No. (—500000), refer to CTM20.

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

Direction of engine crankshaft rotation in this manual is referenced as counterclockwise, facing the flywheel looking toward the front (fan drive end).

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

Read each module completely before performing any service.



3/4 Left Front View 6101HZ Engine

RG6228
-UN-12MAR92



3/4 Right Rear View of 6101HZ Engine

RG6229
-UN-12MAR92

RG,CTM61,G0,1 -19-31MAR93



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A John Deere ILLUSTRATION™ Manual

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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.



DX,FLAME -19-04JUN90

TS227 -UN-23AUG88

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).



DX,SPARKS -19-03MAR93

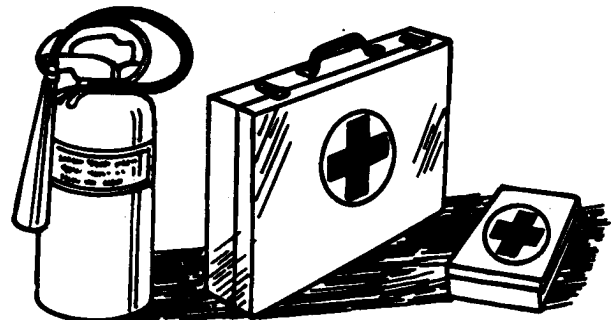
TS204 -UN-23AUG88

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.



DX,FIRE2 -19-03MAR93

TS291 -UN-23AUG88

PREVENT ACID BURNS

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

Avoid the hazard by:

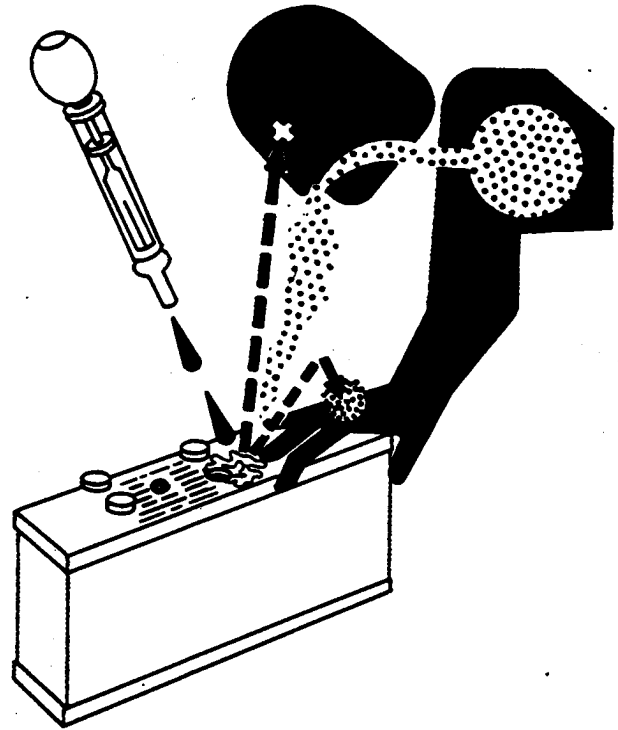
1. Filling batteries in a well-ventilated area.
2. Wearing eye protection and rubber gloves.
3. Avoiding breathing fumes when electrolyte is added.
4. Avoiding spilling or dripping electrolyte.
5. Use proper jump start procedure.

If you spill acid on yourself:

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

If acid is swallowed:

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



TS203 -UN-23AUG88

DX,POISON -19-21APR93

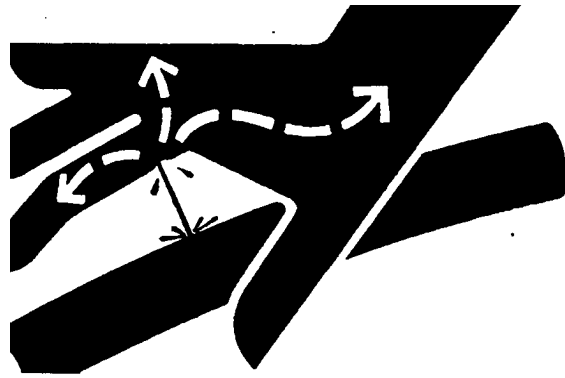
AVOID HIGH-PRESSURE FLUIDS

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.



DX,FLUID -19-03MAR93

-UN-23AUG88
X9811

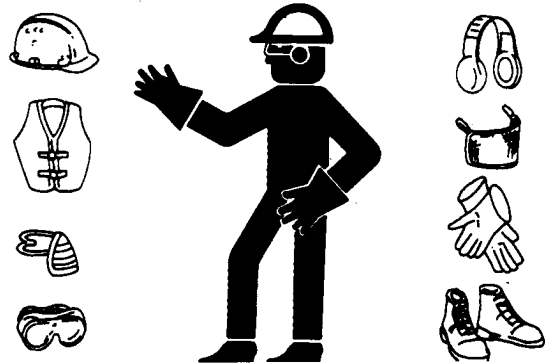
WEAR PROTECTIVE CLOTHING

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

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

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

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



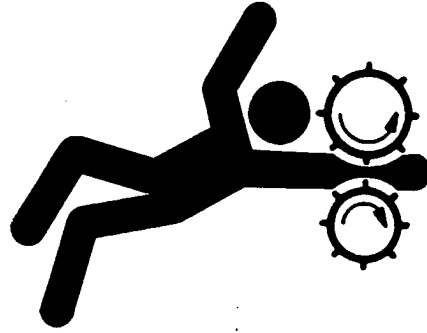
DX,WEAR -19-10SEP90

-UN-23AUG88
TS206

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.



DX, LOOSE -19-04JUN90

TS228 -UN-23AUG88

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.



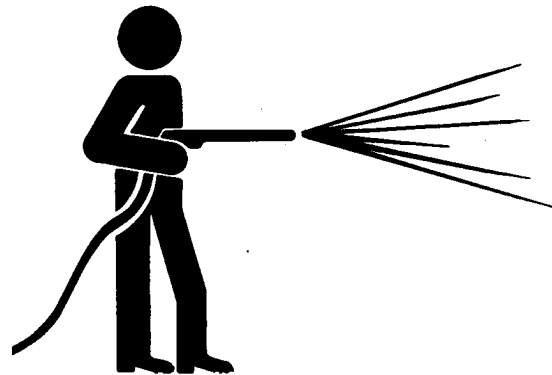
DX, AIR -19-04JUN90

TS220 -UN-23AUG88

WORK IN CLEAN AREA

Before starting a job:

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



DX, CLEAN -19-04JUN90

T6642EJ -UN-18OCT88

REMOVE PAINT BEFORE WELDING OR HEATING

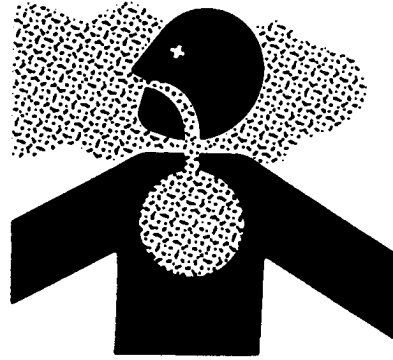
Avoid potentially toxic fumes and dust.

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

Do all work outside or in a well ventilated area. Dispose of paint and solvent properly.

Remove paint before welding or heating:

- 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.



DX,PAINT -19-03MAR93

TS220 -UN-23AUG88

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.



DX,TORCH -19-03MAR93

TS953 -UN-15MAY90

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.



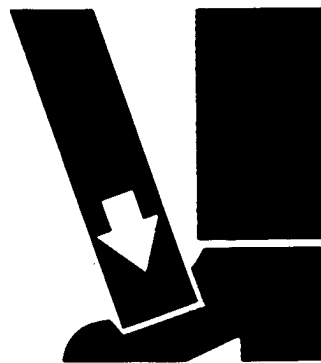
DX,LIGHT -19-04JUN90

TS223 -UN-23AUG88

USE PROPER LIFTING EQUIPMENT

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

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



DX,LIFT

-19-04JUN90

TS226
-UN-23AUG88**PRACTICE SAFE MAINTENANCE**

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

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

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

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

Disconnect battery ground cable (-) before making adjustments on electrical systems or welding on machine.



DX,SERV

-19-03MAR93

TS218
-UN-23AUG88

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.



DX,REPAIR -19-04JUN90

TS779 -UN-08NOV89

DISPOSE OF WASTE PROPERLY

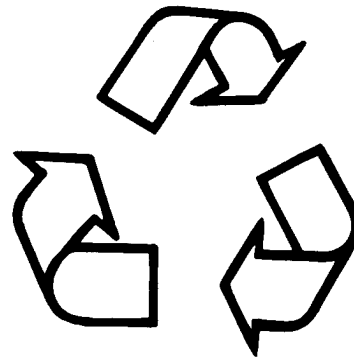
Improperly disposing of waste can threaten the environment and ecology. Potentially harmful waste used with John Deere equipment include such items as oil, fuel, coolant, brake fluid, filters, and batteries.

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

TS1133 -UN-26NOV90

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8

LIVE WITH SAFETY

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

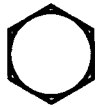


DX,LIVE

-19-25SEP92

TS231 -19-07OCT88

UNIFIED INCH BOLT AND CAP SCREW TORQUE VALUES

SAE Grade and Head Markings	NO MARK	1 or 2 ^b 	5 	5.1 	5.2 	8 	8.2 
		2 	5 		8 		8 

Size	Grade 1				Grade 2 ^b				Grade 5, 5.1, or 5.2				Grade 8 or 8.2			
	Lubricated ^a		Dry ^a		Lubricated ^a		Dry ^a		Lubricated ^a		Dry ^a		Lubricated ^a		Dry ^a	
	N·m	lb-ft	N·m	lb-ft	N·m	lb-ft	N·m	lb-ft	N·m	lb-ft	N·m	lb-ft	N·m	lb-ft	N·m	lb-ft
1/4	3.7	2.8	4.7	3.5	6	4.5	7.5	5.5	9.5	7	12	9	13.5	10	17	12.5
5/16	7.7	5.5	10	7	12	9	15	11	20	15	25	18	28	21	35	26
3/8	14	10	17	13	22	16	27	20	35	26	44	33	50	36	63	46
7/16	22	16	28	20	35	26	44	32	55	41	70	52	80	58	100	75
1/2	33	25	42	31	53	39	67	50	85	63	110	80	120	90	150	115
9/16	48	36	60	45	75	56	95	70	125	90	155	115	175	130	225	160
5/8	67	50	85	62	105	78	135	100	170	125	215	160	215	160	300	225
3/4	120	87	150	110	190	140	240	175	300	225	375	280	425	310	550	400
7/8	190	140	240	175	190	140	240	175	490	360	625	450	700	500	875	650
1	290	210	360	270	290	210	360	270	725	540	925	675	1050	750	1300	975
1-1/8	470	300	510	375	470	300	510	375	900	675	1150	850	1450	1075	1850	1350
1-1/4	570	425	725	530	570	425	725	530	1300	950	1650	1200	2050	1500	2600	1950
1-3/8	750	550	950	700	750	550	950	700	1700	1250	2150	1550	2700	2000	3400	2550
1-1/2	1000	725	1250	925	990	725	1250	930	2250	1650	2850	2100	3600	2650	4550	3350

DO NOT use these values if a different torque value or tightening procedure is given for a specific application. Torque values listed are for general use only. Check tightness of fasteners periodically.

Shear bolts are designed to fail under predetermined loads. Always replace shear bolts with identical grade.

^a "Lubricated" means coated with a lubricant such as engine oil, or fasteners with phosphate and oil coatings. "Dry" means plain or zinc plated without any lubrication.

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

Fasteners should be replaced with the same or higher grade. If higher grade fasteners are used, these should only be tightened to the strength of the original.

Make sure fasteners threads are clean and that you properly start thread engagement. This will prevent them from failing when tightening.

Tighten plastic insert or crimped steel-type lock nuts to approximately 50 percent of the dry torque shown in the chart, applied to the nut, not to the bolt head. Tighten toothed or serrated-type lock nuts to the full torque value.

DX,TORQ1 -19-15MAR91

METRIC BOLT AND CAP SCREW TORQUE VALUES

Property Class and Head Markings	4.8		8.8		9.8		10.9		12.9	
										
Property Class and Nut Markings	5		10		10		10		12	
										

Size	Class 4.8				Class 8.8 or 9.8				Class 10.9				Class 12.9			
	Lubricated ^a		Dry ^a		Lubricated ^a		Dry ^a		Lubricated ^a		Dry ^a		Lubricated ^a		Dry ^a	
	N·m	lb-ft	N·m	lb-ft	N·m	lb-ft	N·m	lb-ft	N·m	lb-ft	N·m	lb-ft	N·m	lb-ft	N·m	lb-ft
M6	4.8	3.5	6	4.5	9	6.5	11	8.5	13	9.5	17	12	15	11.5	19	14.5
M8	12	8.5	15	11	22	16	28	20	32	24	40	30	37	28	47	35
M10	23	17	29	21	43	32	55	40	63	47	80	60	75	55	95	70
M12	40	29	50	37	75	55	95	70	110	80	140	105	130	95	165	120
M14	63	47	80	60	120	88	150	110	175	130	225	165	205	150	260	190
M16	100	73	125	92	190	140	240	175	275	200	350	225	320	240	400	300
M18	135	100	175	125	260	195	330	250	375	275	475	350	440	325	560	410
M20	190	140	240	180	375	275	475	350	530	400	675	500	625	460	800	580
M22	260	190	330	250	510	375	650	475	725	540	925	675	850	625	1075	800
M24	330	250	425	310	650	475	825	600	925	675	1150	850	1075	800	1350	1000
M27	490	360	625	450	950	700	1200	875	1350	1000	1700	1250	1600	1150	2000	1500
M30	675	490	850	625	1300	950	1650	1200	1850	1350	2300	1700	2150	1600	2700	2000
M33	900	675	1150	850	1750	1300	2200	1650	2500	1850	3150	2350	2900	2150	3700	2750
M36	1150	850	1450	1075	2250	1650	2850	2100	3200	2350	4050	3000	3750	2750	4750	3500

DO NOT use these values if a different torque value or tightening procedure is given for a specific application. Torque values listed are for general use only. Check tightness of fasteners periodically.

Shear bolts are designed to fail under predetermined loads. Always replace shear bolts with identical property class.

Fasteners should be replaced with the same or higher property class. If higher property class fasteners are used, these should only be tightened to the strength of the original.

^a "Lubricated" means coated with a lubricant such as engine oil, or fasteners with phosphate and oil coatings. "Dry" means plain or zinc plated without any lubrication.

Make sure fasteners threads are clean and that you properly start thread engagement. This will prevent them from failing when tightening.

Tighten plastic insert or crimped steel-type lock nuts to approximately 50 percent of the dry torque shown in the chart, applied to the nut, not to the bolt head. Tighten toothed or serrated-type lock nuts to the full torque value.

ENGINE MODEL DESIGNATION**JOHN DEERE ENGINE MODEL—6101**

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

6101HZ011 Engine

6 Number of cylinders
10.1 Liter displacement
H Aspiration code
Z0, RW, T0, F0 User code
11 Application code

Aspiration Code

A Turbocharged and air-to-coolant aftercooled
H Turbocharged and air-to-air aftercooled

User Code

F0 OEM
RW Waterloo Works
T0 Dubuque Works
Z0 Zweibrücken Werke

Application Code

10, 11, etc., ... Code for specific application

RG,CTM61,G1,1 -19-14APR93

01
3

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.



-UN-21JAN92
RG6083

1. Engine Serial Number (A)

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

RG6101H000000

RG Factory code producing
6101H Engine Model designation
000000 Sequential number

Factory Code Producing Engine
RG Waterloo Engine Works

Engine Model Designation
6101H Definition explained previously
(See Engine Model Designation)

Sequential Number
000000 6-digit sequential number

2. Engine Application Data (B)

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

RG,CTM61,G1,2 -19-16APR92

ENGINE APPLICATION CHART**• John Deere Agricultural Equipment Applications**

Machine Model No.	Engine Model

FORAGE HARVESTERS

Zweibrucken

6710 6101HZ011

TRACTORS

Waterloo

8770 6101HRW11

8870 6101HRW10

• John Deere Industrial Equipment Applications

Machine Model No.	Engine Model

LOADER

744E* 6101AT011

SCRAPER

862B 6101AT012

• OEM Applications

6101AF010

6101HF010

• Other Applications

Planned production 1994 6101AT010 and 6101HZ012

* Beginning with loader serial number (744E000376—).

RG,CTM61,G1,3 -19-31MAR93

DIESEL FUEL

IMPORTANT: To ensure proper engine performance, buy good quality, clean fuel from a reputable supplier.

Use either Grade No. 1-D or Grade No. 2-D fuel as defined by ASTM Designation D-975 for diesel fuels. In European countries, use ISO 1585 commercial diesel fuel. Find expected air temperature at time of start on thermometer scale in chart. Recommended diesel fuel grade (A,B) is shown to the right of scale.

NOTE: At altitudes above 1500 m (5000 ft) and for engines operated under "stand-by" conditions, use Grade No. 1-D for all temperatures.

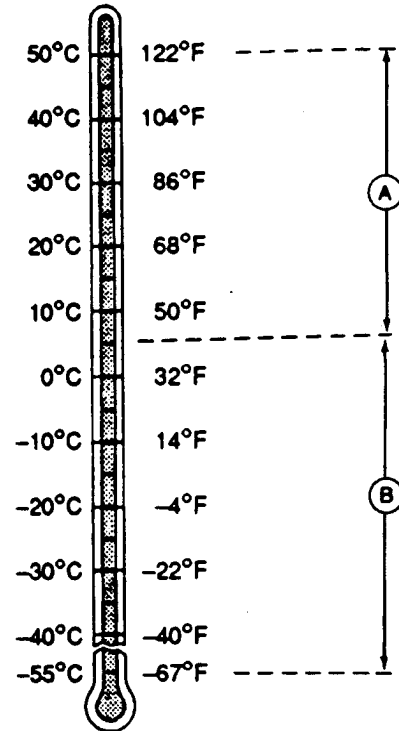
IMPORTANT: If engine is operated at temperatures of -40° to -57°C (-40° to -70°F), Grade DF-A arctic fuel is recommended. Also, consult your authorized servicing dealer or engine distributor for special lubricants and starting aids when operating at or below the temperatures shown.

If fuel sulphur content exceeds 0.5 per cent, the engine oil drain interval must be reduced by 50 percent (100 hours). DO NOT use fuel with more than 1.0 per cent sulfur.

Cetane number should be minimum of 40 to assure satisfactory starting and overall performance. At low temperatures and/or high altitude, a minimum cetane number of 45 is recommended.

NOTE: Excessive white smoke at start-up could be the result of low cetane fuel.

Cloud point should be at least 6°C (10°F) below lowest expected air temperature at time of starting. Wax can separate from fuel when temperature decreases to cloud point and may plug filter.



A—Use Grade No. 2-D Fuel
B—Use Grade No. 1-D Fuel

RG6201 -UN-03MAR92

02
1

DIESEL ENGINE OIL

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

IMPORTANT: John Deere TORQ-GARD SUPREME PLUS-50™ engine oil is not recommended during engine break-in (first 100 hours on a new or overhauled engine). The superior lubricating properties of this oil will not allow the engine to properly wear during break-in period.

The following oil is preferred:

- John Deere TORQ-GARD SUPREME PLUS-50

The following oils are also recommended:

- John Deere TORQ-GARD SUPREME®
- John Deere UNI-GARD™

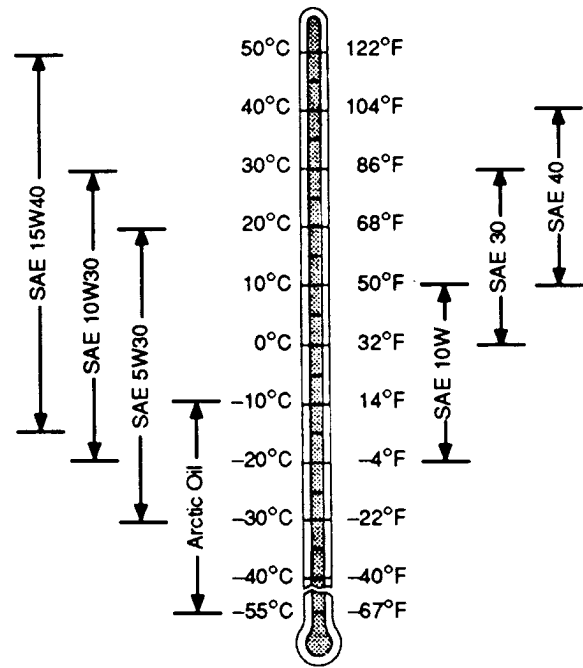
Other oils may be used if they meet one of the following:

- API Service Classification CE
- API Service Classification CD
- CCMC Specification D5
- CCMC Specification D4

If John Deere TORQ-GARD SUPREME PLUS-50 engine oil and a John Deere oil filter are used, the oil and filter service interval may be extended by 50 hours.

If diesel fuel exceeding 0.5% sulfur content is used, reduce the service interval for engine oil and filter by 50%.

Oils meeting Military Specification MIL-L-46167B may be used as arctic oils.



-UN-29MAY92

TS1411

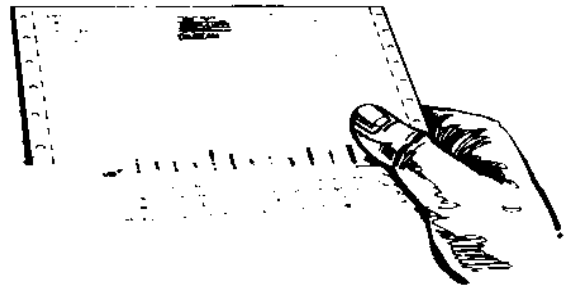
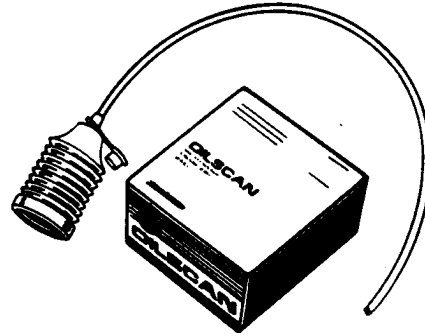
CTM,ENOIL -19-31MAR93

OILSCAN® AND COOLSCAN™

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

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

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



DX,OILSCAN -19-16APR92

T6829AB -UN-15JUN89

-UN-18OCT88

T6829AB

GREASE

Use grease based on the expected air temperature range during the service interval.

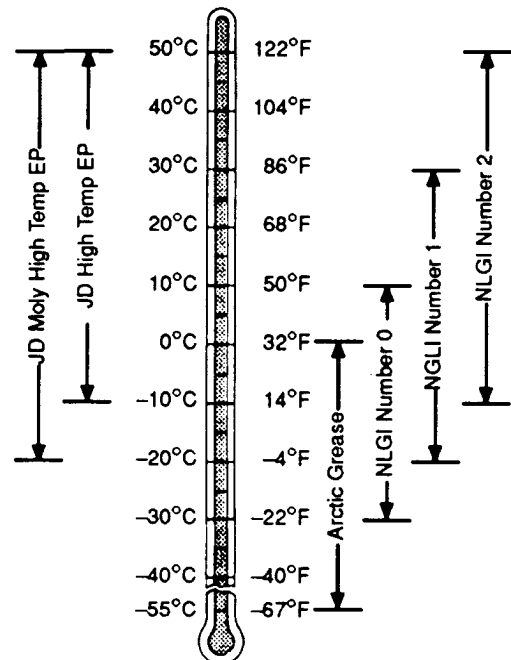
The following greases are preferred:

- John Deere MOLY HIGH TEMPERATURE EP GREASE
- John Deere HIGH TEMPERATURE EP GREASE
- John Deere GREASE-GARD™

Other greases may be used if they meet one of the following:

- SAE Multipurpose EP Grease with a maximum of 5% molybdenum disulfide
- SAE Multipurpose EP Grease

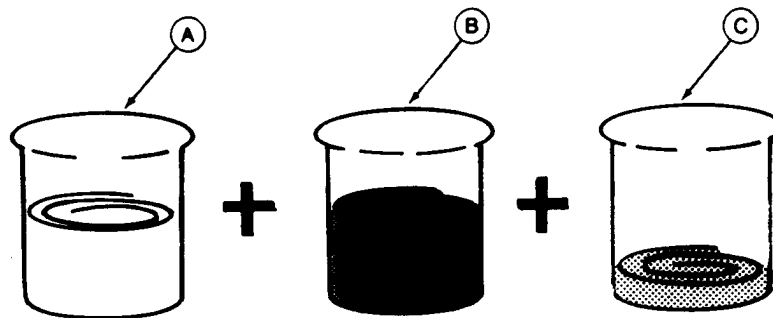
Greases meeting Military Specification MIL-G-10924F may be used as arctic grease.



DX,GREA1 -19-03MAR93

TS1417 -UN-29MAY92

ENGINE COOLANT REQUIREMENTS



A—Quality Water

B—Ethylene Glycol Concentrate
(Antifreeze)C—Supplemental Coolant Additives
(SCA's)*Engine Coolant*

RG6258 -UN-22APR92

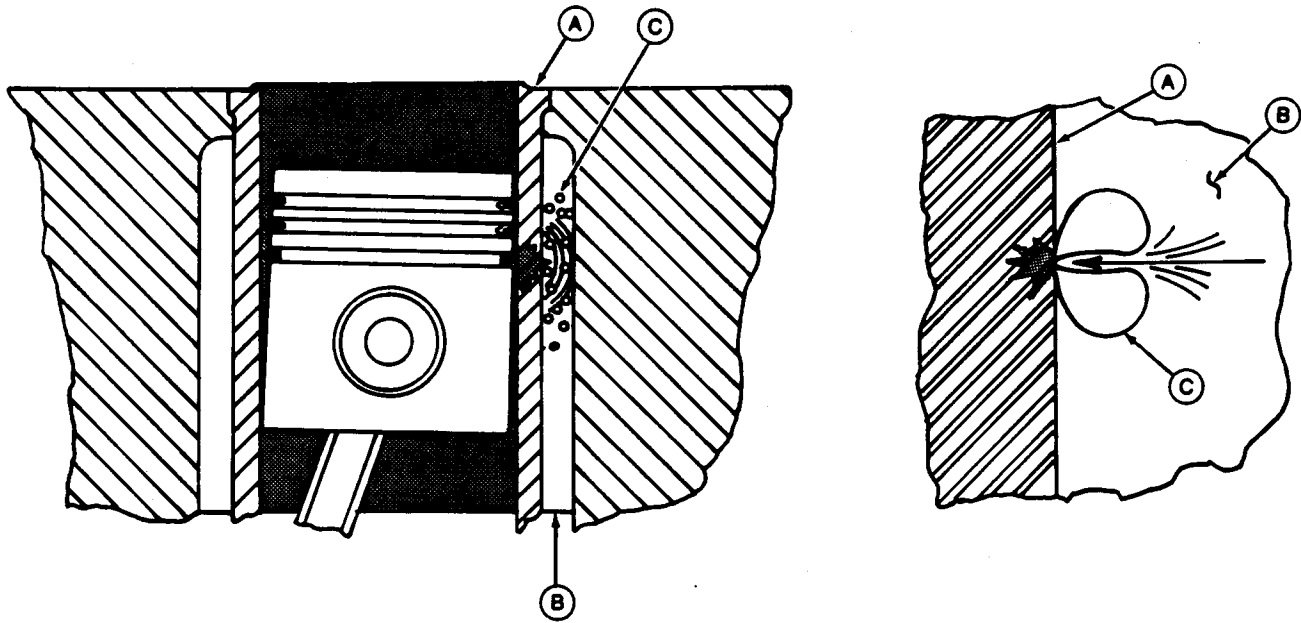
To meet cooling system protection requirements, the coolant **MUST** consist of a 50/50 mixture of quality water and ethylene glycol concentrate (antifreeze). Add to the mixture 3% (by volume) supplemental coolant additives (SCA's). See ENGINE COOLANT SPECIFICATIONS, later in this group, for further definition.

IMPORTANT: Supplemental coolant additives **MUST** be added to the coolant solution. Ethylene glycol concentrate (antifreeze) **DOES NOT** contain chemical inhibitors needed to control liner pitting or erosion, rust, scale, and acidity.

Makeup of the coolant between changes **MUST** consist of the same requirements as during a complete change. Performing a COOLSCAN analysis is the recommended method for determining the amount of quality water, ethylene glycol concentrate, and supplemental coolant additives that should be added.

RG,COOL,REQ1AA -19-28OCT92

ENGINE COOLANT REQUIREMENTS—CONTINUED



A—Cylinder Liner Walls

B—Engine Coolant

C—Vapor Bubbles

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

Water pump impellers and cylinder liner walls (A) which are in contact with engine coolant (B) can be eroded or pitted unless the proper concentration and type of SCA's are present in the coolant solution.

Vapor bubbles (C) are formed when piston impacts against liner ID causing walls to vibrate; sending compression waves into the coolant.

Erosion or pitting is caused by the formation and collapse of tiny vapor bubbles in the coolant on the surface of metal parts. Over a period of time, this pitting will progress completely through the metal. Generally, the most critical erosion occurs in the cylinder liner area of wet-sleeve, heavy-duty engines. If coolant is allowed to enter the combustion chamber, engine failure or other serious damage will result.

Use of SCA's will reduce the effects of erosion and pitting. The chemicals in the additives form a protective film on cylinder liner surface. This film acts as a barrier against collapsing vapor bubbles and also reduces the quantity of bubbles formed.

RG.COOL.REQ10 -19-06APR93

RG6263 -UN-22APR92

02

ENGINE COOLANT SPECIFICATIONS**1. Water Quality:**

Distilled, de-ionized, or soft water is preferred for use in cooling systems. Mineral (hard/tap) water should NEVER be put in a cooling system unless first tested. However, water that meets the following water quality specifications is acceptable.

Water Quality Specifications

Item	Parts Per Million	Grains Per 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

If Chlorides, Sulfates, or Total Dissolved Solids are higher than the above given specifications, the water must be distilled, de-mineralized, or de-ionized before using in cooling system.

If Total Hardness is higher than the above given specification and all other parameters are within the given specifications, the water must be softened before using in cooling system.

2. Ethylene Glycol Concentrate (Antifreeze):

IMPORTANT: DO NOT use methyl alcohol or methoxy propanol base concentrate. This concentrate is not compatible with additives used in supplemental coolant additives. Damage can occur to rubber seals on cylinder liners which are in contact with coolant.

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

IMPORTANT: DO NOT use concentrate containing less than 10% ethylene glycol.

DO NOT use concentrate containing more than 0.1% anhydrous metasilicate. This type of concentrate, which is intended for use in aluminum engines, may cause a gel-like deposit to form that reduces heat transfer and coolant flow. Check container label or consult with supplier before using.

John Deere Low Silicate Antifreeze is the ethylene glycol concentrate recommended for all John Deere Diesel Engines. This product is concentrated and should be mixed 50/50 with quality water. Add to the mixture 3% (by volume) supplemental coolant additives (SCA's).

John Deere Low Silicate Antifreeze is available in the following sizes:

TY6377 - 208 L (55 U.S. Gal) container

TY15886 - 3.8 L (1 U.S. Gal) container

Contact your John Deere Parts Network for local availability.

If John Deere Low Silicate Antifreeze is not available, use an ethylene glycol concentrate meeting ASTM D 4985, SAEJ1941, General Motors Performance Specification GM1899M, or formulated to GM6038M.

ENGINE COOLANT SPECIFICATIONS—CONTINUED



Liquid Coolant Conditioner (SCA)

3. Supplemental Coolant Additives (SCA's):

IMPORTANT: Ethylene glycol concentrate (antifreeze) **DOES NOT** contain sufficient additives to prevent liner erosion or pitting which could occur in wet-sleeve, heavy-duty engines. **ALWAYS** mix the coolant solution with a supplemental coolant additive such as John Deere Liquid Coolant Conditioner or spin-on coolant filter conditioner element.

CAUTION: John Deere Liquid Coolant Conditioner contains alkali. Avoid contact with eyes. Avoid prolonged or repeated contact with skin. Do not take internally. In case of contact, immediately wash skin with soap and water. For eyes, flush with large amounts of water for at least 15 minutes. Call physician. **KEEP OUT OF REACH OF CHILDREN.**

- John Deere Liquid Coolant Conditioner

IMPORTANT: **ALWAYS** mix the 50/50 solution of ethylene glycol concentrate with quality water in a separate container **BEFORE** adding the SCA's. Then add solution to the radiator. **NEVER** pour cold water into a hot engine, as it may crack cylinder block or head.

John Deere Liquid Coolant Conditioner **MUST** be added at a rate of 3% (by volume) to the coolant solution. When adding John Deere Liquid Coolant Conditioner, follow the supplier's recommendations printed on the container.

John Deere Liquid Coolant Conditioner is available in the following sizes:

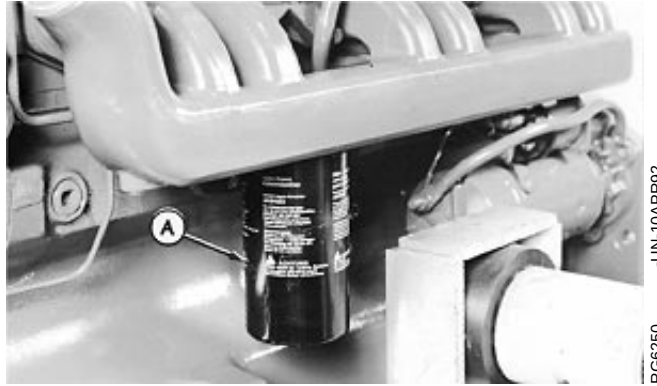
- RE23182 473 mL (16 oz) container
- RE35992 3.8 L (1 gal) container

Contact your John Deere Parts Network for local availability.

IMPORTANT: John Deere Liquid Coolant Conditioner **does NOT** protect against freezing.

DO NOT over-concentrate coolant solutions with supplemental coolant additives, as this can cause silicate-dropout. When this happens, a gel-type deposit is created which retards heat transfer and coolant flow. **DO NOT** use soluble oil.

ENGINE COOLANT SPECIFICATIONS—CONTINUED



Spin-on Coolant Filter Conditioner

3. Supplemental Coolant Additives (SCA's)—continued:

- Spin-on Coolant Filter Conditioner Element (A)

The coolant filter conditioner element is another method of providing the coolant solution with supplemental coolant additives. The coolant filter conditioner element performs two functions at once:

— The outer paper element filters out rust, scale, or dirt particles in the coolant.

— The inner element releases chemicals into the coolant to maintain a proper acid/alkaline balance, inhibit corrosion, and suppress erosion pitting.

RG,COOL,REQ9 -19-28OCT92

JOHN DEERE ENGINE COOLING FLUID

In certain regions of the world, John Deere Engine Cooling Fluid is marketed for use in the engine cooling system. John Deere Cooling Fluid is premixed and contains the proper mixture of quality water, low silicate antifreeze to protect the engine from freezing down to -37°C (-35°F), and supplemental coolant additives (SCA's).



IMPORTANT: Additional SCA's should NOT be added to the Cooling Fluid.

John Deere Engine Cooling Fluid is available in the following sizes:

AL66606 (formerly DD14134) - 5 L (1.3 U.S. Gal) can
AL66607 (formerly DD14345) - 20 L (5.3 U.S. Gal) can
AL67171 (formerly DD14136) - 60 L (15.9 U.S. Gal) drum
AL66608 (formerly DD14346) - 200 L (53 U.S. Gal) drum

Contact your John Deere Parts Network for local availability.

RG,COOL,REQ6 -19-26FEB93

RG5214 -UN-14DEC88

02
9

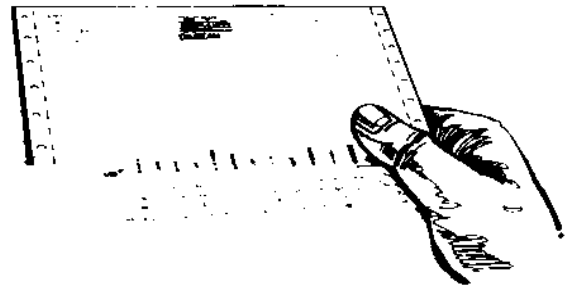
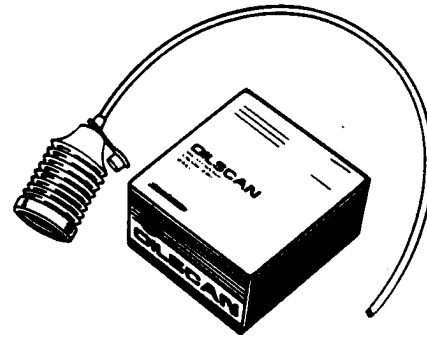
CHECK EFFECTIVENESS OF COOLANT SOLUTION

Prior to the recommended change interval or if concentration of coolant solution is in question, a coolant sample should be taken and a COOLSCAN analysis performed.

COOLSCAN is a John Deere sampling program to help you monitor the effectiveness of your engine's coolant solution and identify potential problems before they cause serious damage.

Check with your John Deere dealer for the availability of DS0251 COOLSCAN kit. Refer to instructions provided with kit.

Usually recharging your engine coolant with the recommended amount of John Deere Liquid Coolant Conditioner at the appropriate time is adequate. However, with a COOLSCAN analysis report, you will be given a more thorough evaluation of your engine coolant condition along with a detailed service recommendation.



RG.COOL.REQ7 -19-16SEP92

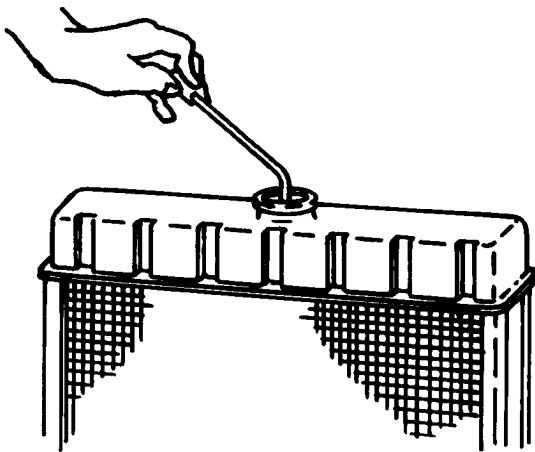
-UN-15JUN89

T6829AB

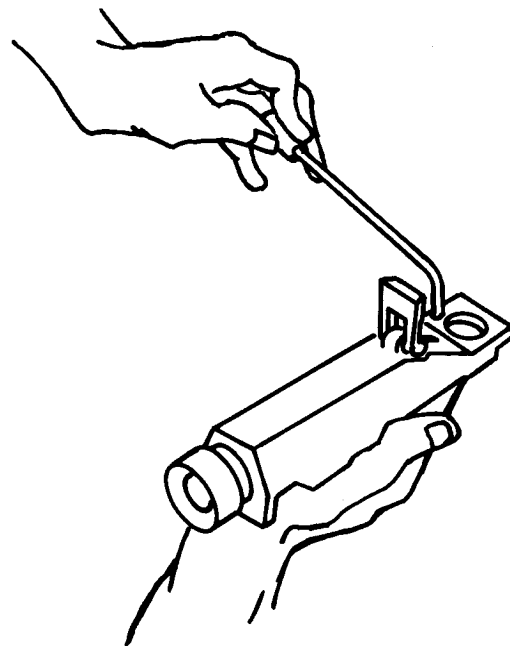
-UN-18OCT88

T6829AB

REPLENISHING SUPPLEMENTAL COOLANT ADDITIVES (SCA'S) BETWEEN COOLANT CHANGES



RG6261 -UN-22APR92



RG6262 -UN-22APR92

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.

NOTE: Service intervals listed are a recommended engineering guideline. Refer to your vehicle operator's manual for a specific service interval.

At 600 hours or 1 year service interval, it is recommended to perform a COOLSCAN analysis as described earlier. If a COOLSCAN analysis is not available, recharge system per instructions printed on bottle.

IMPORTANT: DO NOT CHANGE the spin-on filter element at the 600 hour or 1 year service interval. If the filter is replaced at this time, the result could be an overcharged system. This could cause "solder bloom" in the radiator because the over concentration of nitrite will attack the solder. Replace the filter only if the entire cooling system is drained and coolant replaced.

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 JT05460 Refractometer to assure that the desired freeze point is maintained. Follow manufacturer's instructions provided with refractometer.

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

FLUSHING AND SERVICING COOLING SYSTEM



-UN-23AUG88

TS281



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

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

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

Engine coolant **MUST BE** drained and replaced at a maximum of 1200 hours or 2 years of engine operating time, whichever comes first.

The ethylene glycol base (antifreeze) can become depleted of SCA's 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: Service intervals listed are a recommended engineering guideline. Refer to your vehicle operator's manual for a specific service interval.

At 1200 hours/2-year service interval, flush cooling system and replace thermostats as described in your operator's manual. Clean cooling system with a heavy duty cooling system cleaner, such as FLEETGUARD® RESTORE™. Follow the instructions provided with the cleaner. Refill cooling system with the appropriate coolant solution. See ENGINE COOLANT SPECIFICATIONS, earlier in this group.

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 approximately 19 mm (3/4 in.) below bottom of radiator filler neck.

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 authorized servicing dealer or engine distributor, if there are further questions.

FLEETGUARD® is a registered trademark of Cummins Engine Company.

RESTORE™ is a trademark of FLEETGUARD®.

RG,COOL,REQ8 -19-16SEP92

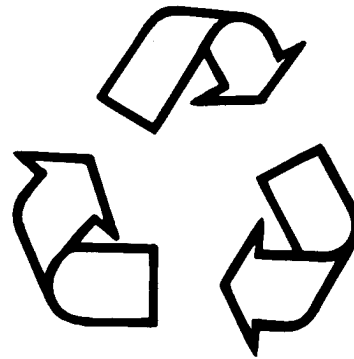
DISPOSING OF COOLANT

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

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

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

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



RG,COOL,REQ5 -19-26FEB93

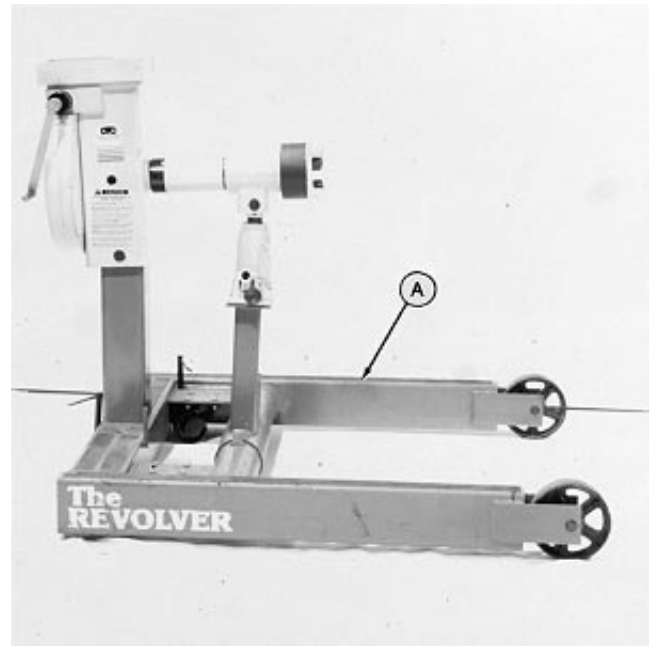
TS1133 -UN-26NOV90

02
13

ENGINE REPAIR STAND

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.

⚠ CAUTION: Never mount engine on a repair stand not capable of supporting engine weight.



RG4929 -UN-15DEC88

03
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S11,2000,EM -19-31MAR93

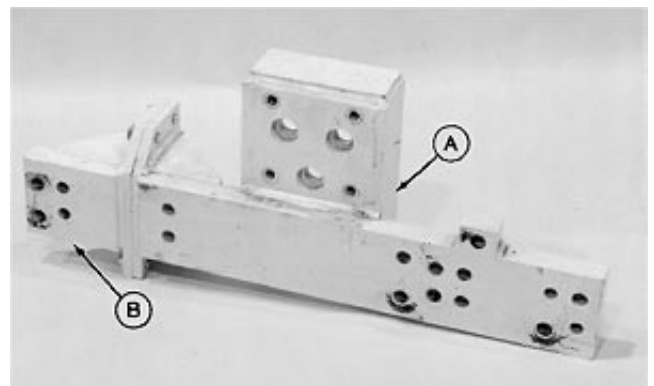
SAFETY PRECAUTIONS

- 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.
- For full thread engagement, be certain that tapped holes in adapters and engine blocks are clean and not damaged. A thread length engagement equal to 1-1/2 screw diameters minimum is required to maintain strength requirements.
- To avoid structural or personal injury, do not exceed the maximum capacity rating of 2722 kg (6000 lb). Maximum capacity is determined with the center of the engine located not more than 330 mm (13 in.) from the mounting hub surface of the engine stand.
- To avoid an unsafe off-balance load condition, the center of balance of an engine must be located within 51 mm (2 in.) of the engine stand rotating shaft. Engine center of balance is generally located a few millimeters above the crankshaft.
- To prevent possible personal injury due to engine slippage, recheck to make sure engine is solidly mounted before releasing support from engine lifting device.
- Never permit any part of the body to be positioned under a load being lifted or suspended. Accidental slippage may result in personal injury.
- The lifting jack is to be used when it is necessary to lift the engine for rotation. When working on the engine, the jack should be at its lowest position to keep the center of gravity low and the possibility of tipping low.
- To prevent possible personal injury due to sudden engine movement, lower engine by operating jack release valve slowly. Do not unscrew release valve knob more than two turns from its closed position.

S11,2000,DZ -19-05APR90

INSTALL 500 SERIES ENGINE ADAPTERS ON REPAIR STAND

1. Attach the No. 60581 Engine Adapter (A) to mounting hub of engine repair stand using three SAE Grade 8 socket head screws. Tighten screws to 135 N·m (100 lb-ft).



S55,0000,P -19-14MAR89

RG4930 -UN-15DEC88

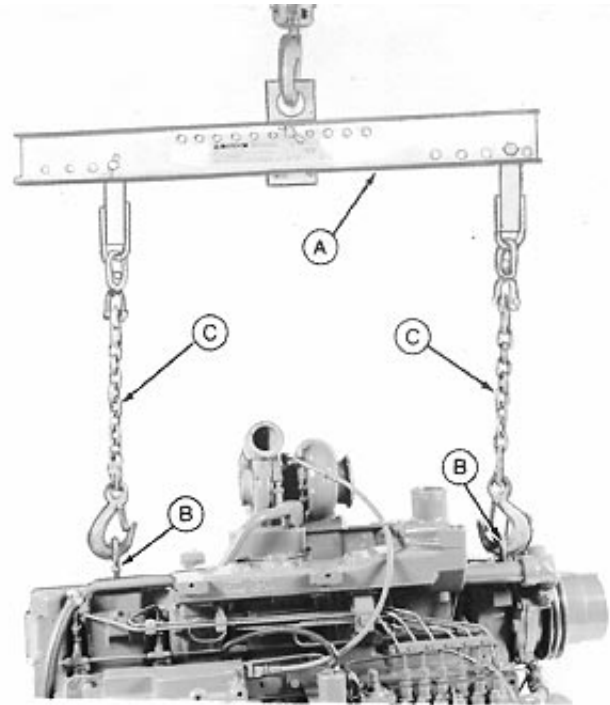
ENGINE LIFTING PROCEDURE

CAUTION: The only recommended method for lifting the 6101 Engine is with the use of JDG23 Lifting Sling (A) and R60980 Eyebolts (B) with locknuts. Use extreme caution when lifting and **NEVER** permit any part of the body to be positioned under a load being lifted or suspended.

1. Screw both eyebolts to fullest depth in cylinder head and securely tighten locknuts.

NOTE: The spacing of the lift chains (C) is adjustable. Center lift chains on sling.

2. Attach the JDG23 Engine Lifting Sling to eyebolts and overhead hoist or floor crane of adequate lifting capacity.
3. Carefully lift engine to desired location.



RG,CTM61,G3,2 -19-31MAR93

CLEAN ENGINE

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

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

S11,2000,EC -19-20AUG92

DISCONNECT TURBOCHARGER OIL INLET LINE

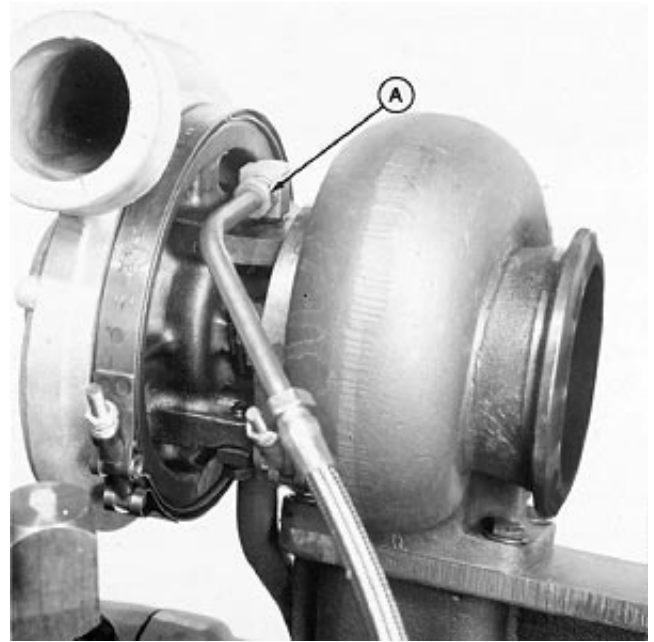
1. Drain all engine oil and coolant, if not previously done.

IMPORTANT: When servicing the 6101 Engine on a rollover stand, disconnect turbo oil inlet line (A) before rolling engine over. Failure to do so may cause a hydraulic lock upon starting the engine. Hydraulic lock may cause possible engine failure.

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

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

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



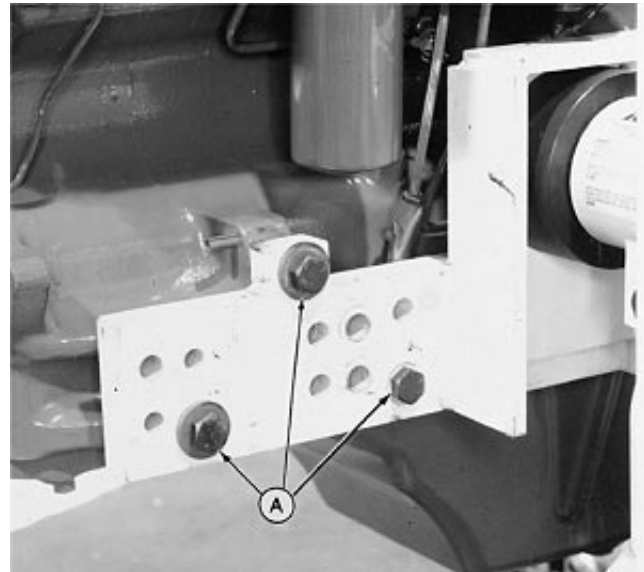
RG5520 -UN-09JAN90

RG,CTM61,G3,1 -19-16APR92

MOUNT ENGINE ON REPAIR STAND

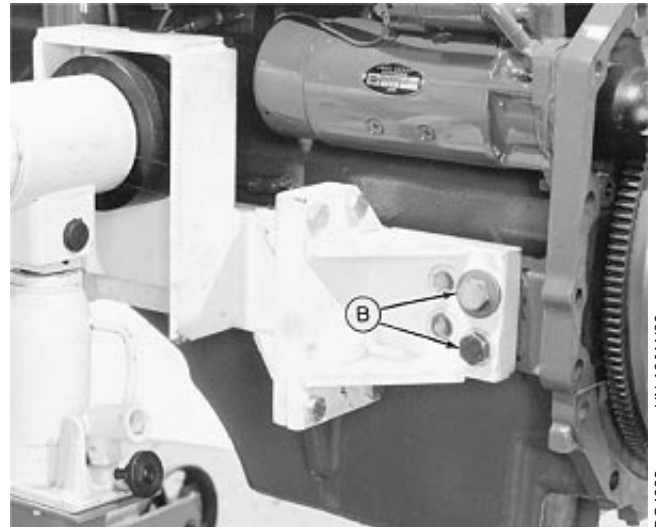
NOTE: If complete engine disassembly is required, remove starting motor before installing engine into repair stand.

1. Mount engine to front engine adapter using three 3/4-10 UNC x 2-3/4 in. cap screws (A). Tighten cap screws to 365 N·m (270 lb-ft).



RG4931
-UN-19JAN90

2. Mount engine to rear engine adapter using two 3/4-10 UNC x 2-3/4 in. cap screws (B). Tighten cap screws to 365 N·m (270 lb-ft).



RG4932
-UN-19JAN90

RG,CTM61,G3,3 -19-31MAR93

6101 ENGINE DISASSEMBLY SEQUENCE

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

NOTE: Remove starting motor, flywheel and flywheel housing before mounting engine into repair stand.

1. Mount engine on a safety approved repair stand. (See Group 03.)
2. Drain all coolant and engine oil. Perform John Deere OILSCAN and COOLSCAN analysis.
3. Remove fan, fan belts and alternator. (Machine Technical Manual.)
4. Remove fan drive assembly. (See Group 15.)
5. Remove alternator and mounting brackets.
6. Disconnect turbocharger oil inlet and oil return line.
7. Disconnect water piping. Remove coolant filter conditioner element. Remove air intake manifold. (See Groups 25 and 30.)
8. Disconnect fuel shutoff solenoid bracket. (See Group 35.)
9. Remove exhaust manifold with turbocharger. Remove water manifold and thermostats. (See Groups 25 and 30.)
10. Remove water pump (See Group 25).
11. Remove combination full flow or bypass oil filters. (See Group 20.) Disconnect fuel lines, remove fuel filter and mounting base. (See Group 35).
12. Remove oil and fuel filter mounting plate assembly from block.
13. Remove oil dipstick. Remove oil pressure regulating housing and valve assembly. Remove oil bypass valve housing and oil cooler assembly. (See Group 20.)

14. Remove injection pump drive gear cover. Remove injection pump drive gear. (See Group 35.)

15. Remove fuel injection lines, fuel injection pump, and fuel injection nozzles. (See Group 35.)

16. Remove rocker arm cover with vent tube assembly. (See Group 05.)

17. Check valve lift at zero (0.0) valve clearance. Remove rocker arm assembly and push rods. Remove cylinder head and cam followers. Identify parts for reassembly. (See Group 05.)

18. Check vibration damper for runout and wobble. Remove damper assembly. Remove timing gear cover. (See Group 15.)

19. Check camshaft endplay. Remove camshaft. (See Group 16.)

20. Remove engine oil pan and oil pump. (See Group 20.)

21. Rotate engine to vertical position. Remove pistons and connecting rods. Identify for reassembly. (See Group 10.) Perform wear checks with PLASTIGAGE™.

NOTE: Perform wear check on main bearing surfaces with PLASTIGAGE™, when removing main bearing caps.

22. Check crankshaft endplay. Remove crankshaft and main bearings. Identify for re-assembly. (See Group 15.)

23. Remove cylinder liners and piston cooling orifices. Mark liners for reassembly in same bore from which removed. (See Group 10.)

24. Remove cylinder block plugs and serial number plate (as required if block is to be put in a "hot tank").

25. Refer to appropriate group for inspection and repair of engine components.

PLASTIGAGE™ is a trademark of the Perfect Circle Division of Dana.

RG,CTM61,G4,2 -19-14APR93

SEALANT APPLICATION GUIDELINES

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

LOCTITE® 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 & Sealer (Medium Strength) (blue):

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

—Plugs and fittings: fuel filter base, intake manifold, oil pan drain plug, cylinder block (oil galley).

—Capscrews: injection pump access cover, electronic tachometer cover, oil filler inlet, flywheel, oil filter manifold mounting plate.

—Oil pressure sending unit

• LOCTITE 271 Thread Lock & Sealer (High Strength) (clear):

TY9371 6 mL (0.2 oz) tube
T43513 50 mL (1.7 oz) bottle

—Studs: Injection pump-to-block and exhaust manifold-to-turbocharger.

• LOCTITE 277 Plastic Gasket (High Strength) (red):

T43514 50 mL (1.7 oz) bottle

—Steel cap plugs: cylinder block, cylinder head, and water pump

—O-ring adapter for oil pump outlet tube

—Bypass oil check valve adapter

—Coolant conditioner filter adapter

• LOCTITE 515 Flexible Sealant (General Purpose) (purple):

TY6304 50 mL (1.7 oz) bottle

—Water pump and thermostat cover gaskets

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

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

—Pipe plugs: cylinder block (water manifold), thermostat housing, air intake manifold, and water pump.

—Injection pump governor cover fitting (fuel return)

—Threaded nipples and elbows in water pump housing

—Temperature sending unit

—Oil pan (drain hose and drain valve)

—Connectors: turbo line and turbo drain.

—Adapter fitting for turbo oil inlet line

• LOCTITE 609 Retaining Compound (green):

TY9372 6 mL (0.2 oz) tube
T43515 50 mL (1.7 oz) bottle

—Crankshaft flange for rear oil seal/wear sleeve installation.

—Front wear sleeve ID

SEALANT APPLICATION GUIDELINES—CONTINUED

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

TY6299 227 g (8 oz) container

—Timing gear cover-to oil pan

—Timing gear cover-to-cylinder block

—Rear crankshaft oil seal housing-to-cylinder block

—Oil pressure regulating housing

—Flywheel housing-to-oil pan

—Camshaft bore steel cap plug

- **PT569 NEVER-SEEZ®** COMPOUND:

PT569 227 g (8 oz) Brush

PT506 453 g (16 oz) Spray

—Cap Screws: exhaust manifold, aftercooler cover,
and turbine housing-to-center housing.

- **AR31790 SCOTCH-GRIP®** EC-1099 Plastic
Adhesive:

AR31790 141 g (5 oz) tube

—Rocker arm cover gasket

LOCTITE® and PERMATEX® are registered trademarks of Loctite Corporation.

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

*TEFLON® is a registered trademark of DuPont Co. FNOTE:
SCOTCH-GRIP® is a registered trademark of 3M Company.*

RG,CTM61,G4,4 -19-31MAR93

04
3

6101 ENGINE ASSEMBLY SEQUENCE

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

1. Install all plugs in cylinder block that were removed to service or clean block. Install engine serial number plate. Install new cam bushings if removed during engine overhaul.

2. Install clean piston cooling orifices. (See Group 10.)

3. Install cylinder liners without O-rings, in bores from which removed, and measure liner stand-out. Install liner O-rings in block and position square packing on liners. Install liners. (See Group 10.)

IMPORTANT: If new piston and liner kit assemblies are being installed, install the crankshaft and DO NOT remove pistons from matched liners.

4. Install crankshaft (with new front wear sleeve) and main bearings. Rotate crankshaft by hand to assure correct assembly. Check crankshaft end play. (See Group 15.)

5. Install pistons and connecting rods. Rotate crankshaft by hand to verify correct assembly. (See Group 10.)

6. Install camshaft. Check camshaft end play. Install timing gear cover with new oil seal. Check runout. (See Group 16.)

7. Install rear crankshaft oil seal housing and check runout. Install rear crankshaft oil seal/wear sleeve assembly. (See Group 15.)

8. Install oil pump assembly and engine oil pan. (See Group 20.)

9. Install damper pulley assembly, flywheel and flywheel housing. (See Group 15.)

10. Install cam followers in their respective bores. (See Group 16.)

11. Install cylinder head gasket, cylinder head, valve assembly, push rods and rocker arm assembly. Adjust valve clearance. Install rocker arm cover. (See Group 05.)

12. Install fuel injection pump, injection pump drive gear, injection pump drive gear cover, and fuel injection nozzles. (See Group 35.)

13. Install water pump and water manifold. (See Group 25.)

14. Install engine oil cooler and bypass valve housing assembly, connect all water piping. (See Group 20.)

15. Install oil pressure regulating housing and valve assembly. Install dipstick assembly. Install oil filter header, oil tubes and mounting plates. (See Group 20.)

16. Install fuel filter base and fuel filter. Connect fuel lines. Install fuel shutoff solenoid bracket. (See Group 35.)

17. Install air intake manifold. (See Group 30.)

18. Install exhaust manifold with turbocharger. (See Group 30.)

19. Connect and securely tighten all fuel, coolant, air, and oil line connections.

20. Install fan drive assembly. (See Group 15.)

21. Install alternator, fan, and fan belts.

22. Install starting motor.

23. Install NEW coolant filter conditioner element. Fill engine to proper level with clean engine oil and 50% mixture of quality water and 50% ethylene glycol concentrate (antifreeze). (See Group 02.)

24. Perform engine break-in and normal standard performance checks.

SPECIAL OR ESSENTIAL TOOLS

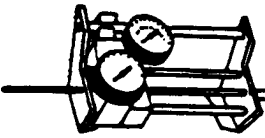
NOTE: Order tools according to information given in the U.S. SERVICE-GARD™ Catalog or in the European Microfiche Tool Catalog (MTC).

DX,TOOLS -19-05JUN91

Spring Compression Tester D01168AA

Test valve spring compression.

RG5061 -UN-23AUG88

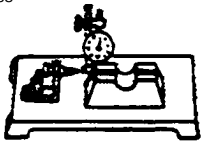


S53,D01168,AA -19-13MAR92

Valve Inspection Center D05058ST

Check valves for out-of round.

RG5062 -UN-23AUG88

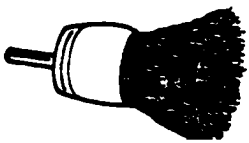


S53,D05058,ST -19-02APR87

End Brush D17024BR

Clean valve seat and bores.

RG5063 -UN-23AUG88

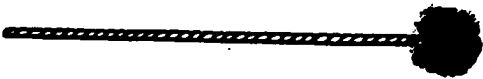


S53,D17024,BR -19-26JAN87

Nozzle Thread Cleaning Brush D17030BR

Used to clean nozzle threads in cylinder head.

RG5099 -UN-23AUG88



S53,D17030,BR -19-16FEB87

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.



RG,D17526CI -19-29OCT92

Valve Guide Knurler Kit JT05949

Knurl valve guides.

RG5064 -UN-23AUG88



S53,D20002,WI -19-16SEP92

Cylinder Head and Valves/Special or Essential Tools

Valve Guide Pilot Driver JDE7

RG5065

-UN-23AUG88

Used with JDE75 to install replacement valve guides.
Also used to install replacement valve seat inserts. Use
with JDE73 and JDG756.



RG,JDE7,A

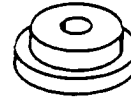
-19-30MAR93

Exhaust Valve Insert Adapter JDG756

RG5066

-UN-23AUG88

Install exhaust valve seat inserts. Use with JDE7.



RG,JDG756

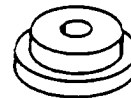
-19-30MAR93

Intake Valve Insert Adapter JDE73

RG5066

-UN-23AUG88

Install intake valve seat inserts. Use with JDE7.



S53,JDE73

-19-30MAR93

Valve Guide Driver JDE75

RG5067

-UN-06APR89

Install replacement valve guides. Use with JDE7.



RG,JDE75

-19-13MAR92

Torque Wrench Adapter JDE141

RG5069

-UN-06APR89

Retighten cylinder head cap screws when rocker arm
assembly is installed.



S53,JDE141

-19-24APR92

Flywheel Turning Tool JDE81-1

RG4950

-UN-23AUG88

Rotate engine flywheel. Use with JDE81-4.



S53,JDE811

-19-07JUL89

Timing Pin JDE81-4

RG5068

-UN-23AUG88

Lock engine at TDC when timing valve train. Use with
JDE81-1.



S55,JDE814,B

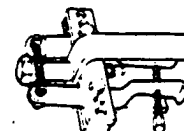
-19-24FEB88

Valve Seat Puller JDE41296

RG5071

-UN-23AUG88

Remove valve seats.



S53,JDE,41296

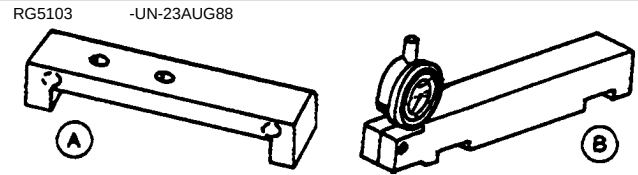
-19-26JAN87

Cylinder Head and Valves/Special or Essential Tools

Piston and Liner Height Gauge A-JDG451 or
B-KJD10123

Measure piston and liner heights.

*NOTE: A dial indicator is not supplied with JDG451. Use
D17526CI (English, in.) or D17527CI (Metric,
mm) Dial Indicator with JDG451.*



RG,JDG451 -19-29OCT92

Tap JDF5

Used to restore nozzle threads in cylinder head.

RG5100 -UN-23AUG88



S53,JDF5 -19-16FEB87

Tap JDG682

Clean cylinder head mounting threads on top deck of
cylinder block.

RG5100 -UN-23AUG88

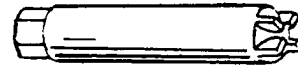


S55,JDG682 -19-24APR92

Nozzle Seat Reamer JDG609

Used to clean carbon from nozzle seats in cylinder head.

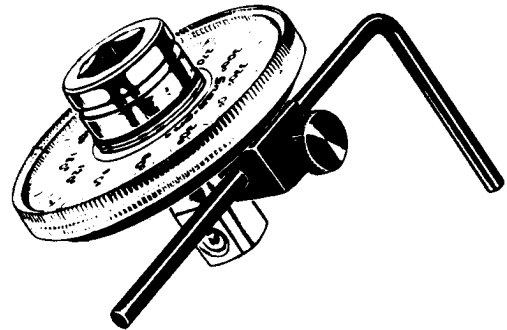
RG5289 -UN-23AUG88



S53,JDG609 -19-02DEC87

Torque Angle Gauge JT05993

Used to TORQUE-TURN flanged-head cylinder head and
connecting rod cap screws.



RG,JT05993 -19-22AUG91

RG5698 -UN-27AUG90

CYLINDER HEAD AND VALVES SPECIFICATIONS

ITEM	SPECIFICATION	WEAR LIMIT
Valve Clearance (Rocker Arm-to-Valve Tip):		
Intake Valve	0.33—0.43 mm (0.013—0.017 in.)	—
Exhaust Valve	0.58—0.68 mm (0.023—0.027 in.)	—
Valve Lift at 0.00 mm (in.)		
Clearance:		
Intake Valve	12.50—12.90 mm (0.492—0.508 in.)	11.66 mm (0.459 in.)
Exhaust Valve	15.37—15.77 mm (0.605—0.621 in.)	14.50 mm (0.571 in.)
Valve Spring Working Height:		
Valve Closed-Intake	52.5 mm @ 345—399 N (2.07 in. @ 78—90 lb-force)	—
-Exhaust	54.5 mm @ 284—338 N (2.15 in. @ 64—76 lb-force)	—
Valve Open-Intake	38.1 mm @ 810—880 N (1.50 in. @ 182—198 lb-force)	—
-Exhaust	38.5 mm @ 797—867 N (1.52 in. @ 179—195 lb-force)	—
Valve Stem OD:		
Intake	9.461—9.487 mm (0.3725—0.3735 in.)	—
Exhaust	9.436—9.462 mm (0.3715—0.3725 in.)	—
Valve Head OD:		
Intake and Exhaust Valve	52.87—53.13 mm (2.081—2.092 in.)	—
Valve Guide ID	9.512—9.538 mm (0.3745—0.3755 in.)	—
Valve Stem-to-Guide Clearance:		
Intake	0.025—0.077 mm (0.001—0.003 in.)	0.13 mm (0.005 in.)
Exhaust	0.050—0.102 mm (0.002—0.004 in.)	0.15 mm (0.006 in.)
Valve Guide Installed Height:		
Rocker Arm Cover Gasket		
Rail-to-Top of Valve Guide	36.17—39.17 mm (1.424—1.542 in.)	—
Standard Valve Seat Inserts:		
Valve Seat Bore in Head	54.165—54.191 mm (2.1325—2.1335 in.)	—
Valve Seat OD	54.237—54.263 mm (2.1353—2.1363 in.)	—
Oversize Valve Seat Inserts:		
Available Size	0.25 mm (0.010 in.)	—
Intake and Exhaust Valve		
Seat Bore in Head	54.415—54.441 mm (2.1423—2.1433 in.)	—
Valve Seat OD	54.491—54.517 mm (2.1453—2.1463 in.)	—
Valve Face Angle:		
Intake Valve	29.25° ±0.25°	—
Exhaust Valve	36.75° ±0.25°	—
Valve Seat Angle:		
Intake Valve	30° ±0.50°	—
Exhaust Valve	37.50° ±0.50°	—

RG,CTM61,G5,1 -19-13MAY93

CYLINDER HEAD AND VALVES SPECIFICATIONS—CONTINUED

ITEM	SPECIFICATION	WEAR LIMIT
Valve Seat Width:		
Intake Valve	1.60—3.00 mm (0.063—0.118 in.)	—
Exhaust Valve	1.20—3.00 mm (0.047—0.118 in.)	—
Valve Seat Concentricity		
with Guide	0.05 mm (0.020 in.)	—
Maximum Valve Seat Runout	0.05 mm (0.002 in.)	—
Maximum Vave Face Runout	0.05 mm (0.002 in.)	—
Valve Recess in Cylinder Head:		
Intake Valve	2.69—3.34 mm (0.106—0.131 in.)	—
Exhaust Valve	1.64—2.29 mm (0.064—0.090 in.)	—
Cylinder Head Reconditioning:		
Thickness of Head		
(Rocker Arm Cover Gasket-to-Combustion Face)	166.55—166.80 mm (6.557—6.567 in.)	—
Minimum Acceptable Thickness	166.29 mm (6.547 in.)	—
Maximum Acceptable Head Out-of-Flat		
Entire Length or Width	0.10 mm (0.004 in.)	—
For Every 236.5 mm (9.31 in.)	0.025 mm (0.001 in.)	—
Combustion Face Surface		
Finish (Surface Grind Only) (AA)	0.0015—0.0028 mm (60—110 micro-in.)	—
Maximum Material Removal for Resurfacing Head	0.25 mm (0.010 in.)	—
Valve Seat Insert		
Counterbore Depth:		
Intake	13.12—13.38 mm (0.517—0.527 in.)	—
Exhaust	12.02—12.28 mm (0.473—0.483 in.)	—
Rocker Arm ID	25.418—25.458 mm (1.0007—1.0023 in.)	—
Rocker Arm Shaft OD	25.360—25.400 mm (0.9984—1.0000 in.)	—
Cylinder Liner Height		
above Block	0.025—0.102 mm (0.0010—0.0040 in.)	—
Maximum Permissible Height		
Difference at Nearest Point of Two Adjacent Liners or Within One Liner	0.05 mm (0.002 in.)	—
Cylinder Firing Order	1-5-3-6-2-4	—

RG,CTM61,G5,2 -19-13MAY93

CYLINDER HEAD AND VALVES SPECIFICATIONS—CONTINUED**TORQUES**

Cylinder Head-to-Cylinder Block:*

Flanged-Head Cap Screws with Washers

Initial 200 N·m (150 lb-ft)

Final Tighten an additional 90°—100°

Cylinder Head Front Cover Plate 34 N·m (25 lb-ft)

Rocker Arm Shaft Clamps 88 N·m (65 lb-ft)

Valve Adjusting Screw Lock Nut 27 N·m (20 lb-ft)

Rocker Arm Cover-to-Cylinder Head 8 N·m (6 lb-ft)

Intake Manifold-to-Cylinder Head 75 N·m (55 lb-ft)

Exhaust Manifold-to-Cylinder Head 95 N·m (70 lb-ft)

Water Manifold-to-Cylinder Head 47 N·m (35 lb-ft)

Turbocharger Mounting Cap Screws 24 N·m (18 lb-ft)

Turbocharger Heat Shield-to-Cylinder Head 47 N·m (35 lb-ft)

Fuel Shutoff Solenoid Bracket-to-Cylinder Head 47 N·m (35 lb-ft)

Cylinder Liner Cap Screws (for checking liner standout) 68 N·m (50 lb-ft)

Fan Support Plate-to-Cylinder Block 68 N·m (50 lb-ft)

Fan Support Plate-to-Timing Gear Cover 68 N·m (50 lb-ft)

*See **TIGHTEN FLANGED-HEAD CYLINDER HEAD CAP SCREWS**
(with flat washers), later in this group, for proper cap screw tightening
sequence.

RG,CTM61,G5,71 -19-13MAY93

SERVICE EQUIPMENT AND TOOLS

NOTE: Order tools from your **SERVICE-GARD™**
Catalog. Some tools may be available from a
local supplier.

Name	Use
JDE138 Valve Spring Compressor	Compress valve springs when removing and installing valves
D05012ST Precision "Bevelled Edge" Straightedge	Check cylinder head flatness
Plastic Brush	Clean valve guides
D11010KW Eccentrimeter	Measure valve seat runout
JT05893 Heavy-Duty Seat Grinder Set	Grind valve seats

S55,2505,AH -19-13MAR92

OTHER MATERIAL

Name	Use
AR44402 Valve Stem Lubricant	Lubricate valve stems.
PT569 NEVER-SEEZ Compound	Exhaust manifold and cylinder head front plate cap screws.
AR31790 SCOTCH-GRIP Plastic Adhesive	Rocker arm cover gasket.

S11,2505,BW -19-30MAR93

CHECK AND ADJUST VALVE CLEARANCE

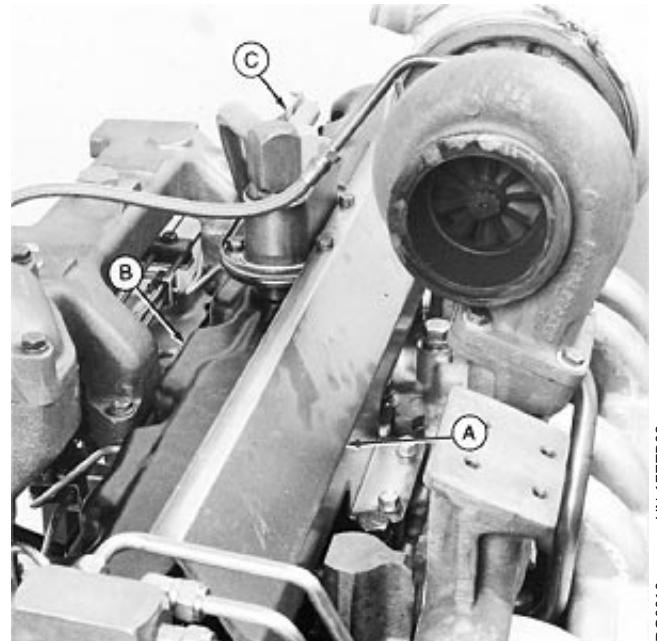
Too little valve clearance throws valves out of time. Valves open too early and close too late. This causes the valves to overheat due to hot combustion gases rushing past valves when out of time. Overheating lengthens valve stems which prevents proper seating of valves. The valves seat so briefly or 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.

NOTE: Valve clearance should be checked with engine cold.

1. Remove turbocharger heat shield (A), if equipped.
2. Remove rocker arm cover (B) with ventilator tube (C) from cylinder head.
3. Remove plastic plugs (D) from timing holes.

A—Turbocharger Heat Shield
B—Rocker Arm Cover
C—Ventilator Tube
D—Plastic Plugs



RG6616 -UN-17FEB93



RG6617 -UN-17FEB93

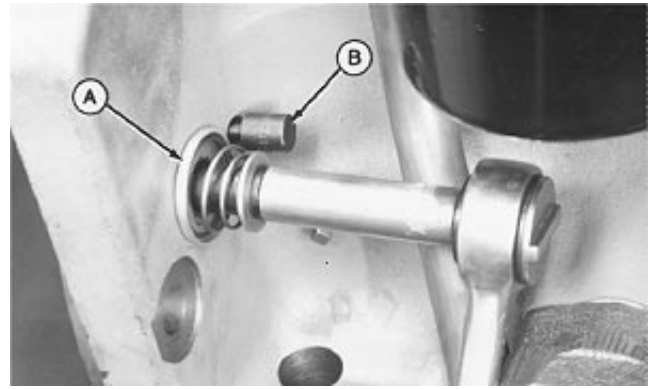
RG,CTM61,G5,67 -19-30MAR93

4. Install JDE81-1 Flywheel Turning Tool (A) and JDE81-4 Timing Pin (B) in holes in block.

5. Rotate engine until timing pin engages timing hole in flywheel.

If the rocker arms for No. 1 cylinder are loose, the engine is at No. 1 "TDC-Compression." If the rocker arms for No. 6 cylinder are loose, the engine is at No. 6 "TDC-Compression." Rotate the engine one full revolution to No. 1 "TDC-Compression," until timing pin enters flywheel again.

IMPORTANT: Visually inspect contact surfaces of wear caps and rocker arm wear pads. Check all parts for excessive wear, breakage, or cracks. Replace parts that show visible damage.



RG5521 -UN-05JAN90

RG,CTM61,G5,68 -19-30MAR93

NOTE: After setting each valve, tighten valve adjusting screw locknut to 27 N·m (20 lb-ft).

6. Adjust valve clearance on No. 1, 3 and 5 exhaust valves and 1, 2 and 4 intake valves.

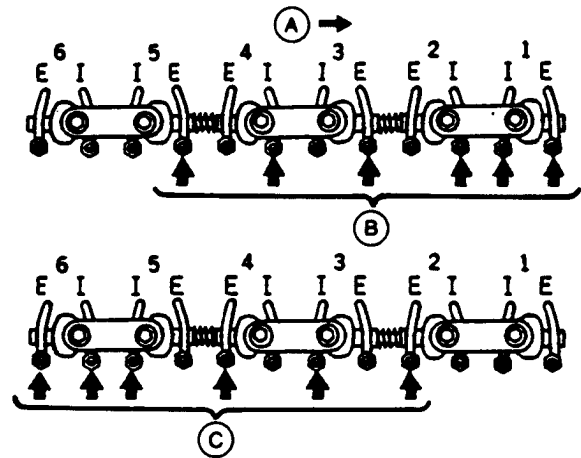
VALVE CLEARANCE SPECIFICATIONS

Intake Valves 0.33—0.43 mm (0.013—0.017 in.)
Exhaust Valves 0.58—0.68 mm (0.023—0.027 in.)

7. Rotate flywheel 360 degrees until No. 6 piston is at "TDC" of its compression stroke.

8. Adjust valve clearance to the same specifications on No. 2, 4 and 6 exhaust and 3, 5 and 6 intake valves.

A—Front of Engine
B—No. 1 TDC Compression Stroke
C—No. 6 TDC Compression Stroke



RG6247 -UN-31MAR92

RG,CTM61,G5,39 -19-30MAR93

CHECK VALVE LIFT

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

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

1. Remove turbocharger heat shield (if equipped) and rocker arm cover, if not previously done.
2. Remove vent tube from hole in block. Remove plastic plugs.
3. Loosen locknut on rocker arm shaft and set valve clearance at zero (0.00) using a wrench and screwdriver. Tighten locknut.
4. Place dial indicator tip on top of valve spring cap, as shown. Preload indicator tip and set dial at zero (0.00).
5. Manually turn engine in running direction one full revolution using the JDE81-1 Flywheel Turning Tool.
6. Observe dial indicator reading as valve is moved to full open. Record readings and compare with specifications given below.

VALVE LIFT SPECIFICATIONS [at 0.00 mm (in.) Valve Clearance]

Intake Valves	12.50—12.90 mm (0.492—0.508 in.)
Wear Tolerance	11.66 mm (0.459 in.)
Exhaust Valves	15.37—15.77 mm (0.605—0.621 in.)
Wear Tolerance	14.50 mm (0.571 in.)

7. Follow same procedure for all remaining valves and adjust valve clearance when valve lift measurements are complete. (See CHECK AND ADJUST VALVE CLEARANCE in Group 05.)



-UN-17JAN92

RG6037

05
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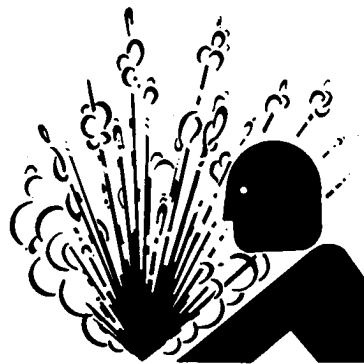
RG,CTM61,G5,3 -19-30MAR93

REMOVE CYLINDER HEAD AND VALVES

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

CAUTION: After operating the engine, allow enough time for the exhaust system to cool before removal.

DO NOT drain coolant until the coolant temperature is below operating temperature. Always loosen drain valve (arrow) slowly to relieve any excess pressure.



RG,CTM61,G5,4 -19-30MAR93

-UN-23AUG88

TS281

-UN-06MAR92

RG6209

1. Drain engine coolant and oil. Disconnect turbocharger oil inlet line at turbocharger or oil filter housing. See DISCONNECT TURBOCHARGER OIL INLET LINE in Group 03.

2. Remove coolant conditioner filter (A).

3. Disconnect turbocharger oil return pipe from block (B).



RG,CTM61,G5,69 -19-30MAR93

-UN-17JAN92

RG6078

4. Disconnect aneroid line (A) and both lines leading to coolant conditioner filter base.



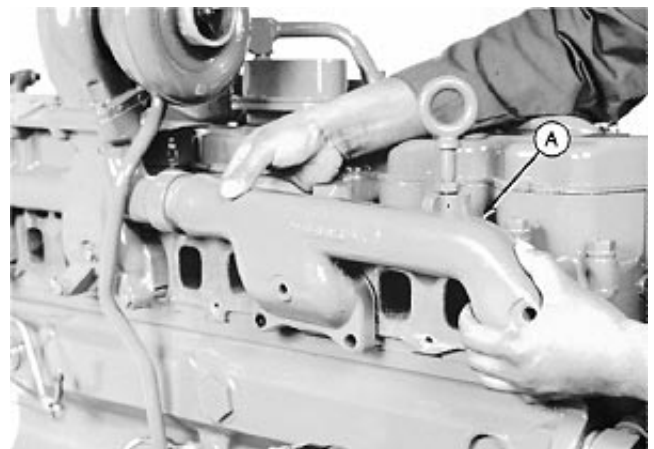
RG,CTM61,G5,40 -19-13MAR92

5. Remove intake manifold (A). (Coolant conditioner filter shown installed.)



RG,CTM61,G5,41 -19-13MAR92

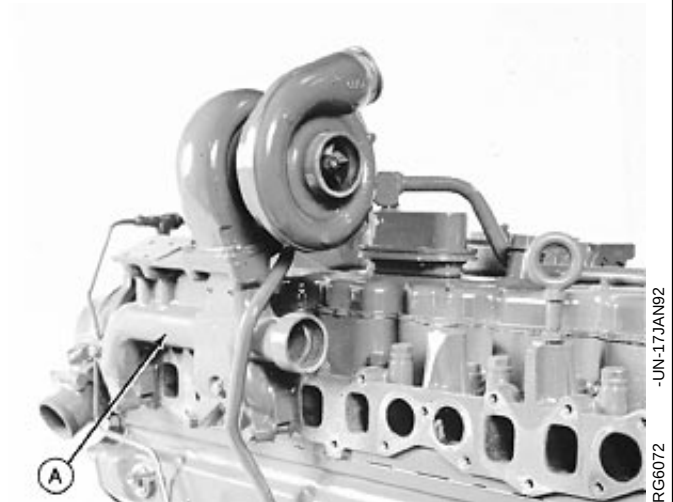
6. Remove rear half of exhaust manifold (A).



RG,CTM61,G5,42 -19-24APR92

7. Remove front half of exhaust manifold (A).

NOTE: Turbocharger does not need to be removed from exhaust manifold unless desired. (See REMOVE TURBOCHARGER in Group 30.)



-UN-17JAN92
RG6072

RG,CTM61,G5,43 -19-13MAR92

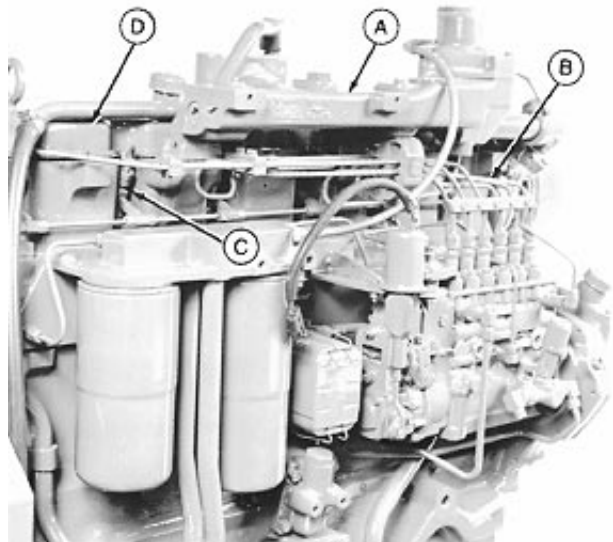
8. Disconnect water piping and remove water manifold (A). (See Group 25.)

9. Remove fuel injection lines (B) from engine. Cap all fittings on injection pump. (See Group 35.)

10. Remove fuel injection nozzles (C). Plug nozzle bores in cylinder head. (See Group 35.)

11. Remove rocker arm cover (D).

A—Water Manifold
B—Fuel Injection Lines
C—Fuel Injection Nozzles
D—Rocker Arm Cover

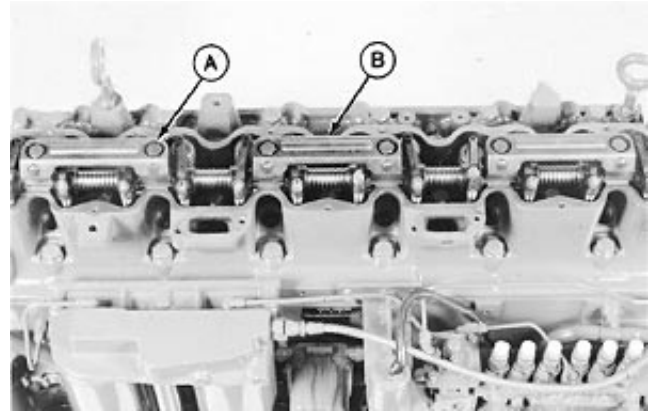


-UN-17JAN92
RG6080

RG,CTM61,G5,5 -19-13MAR92

12. Remove six cap screws with washers (A) and all three rocker arm shaft clamps (B).

13. Remove rocker arm assembly.



RG6039
-UN-17JAN92

RG,CTM61,G5,44 -19-30MAR93

14. Remove wear caps from valve stems.

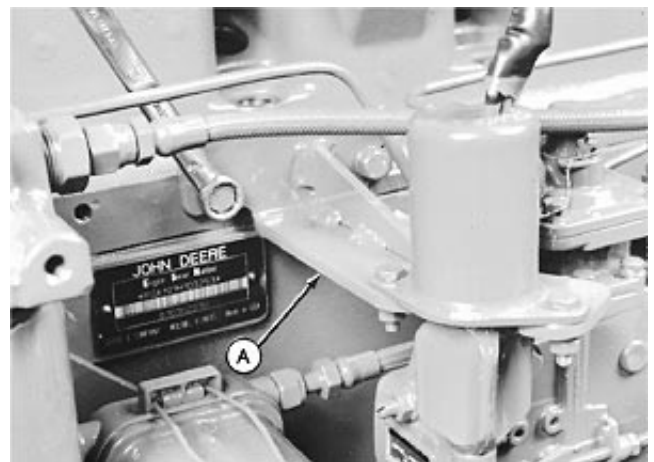
15. Remove push rods and identify for reassembly in the same location.



RG6040
-UN-17JAN92

RG,CTM61,G5,45 -19-30MAR93

16. Disconnect fuel shutoff solenoid bracket (A) from cylinder head.



RG6041
-UN-17JAN92

RG,CTM61,G5,61 -19-24APR92

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

Make a reference mark (in-line) on socket and cylinder head surface. Loosen cap screw at least 1/2 turn. Retighten cap screw (using a torque wrench) until reference marks align and record torque.

17. Remove all 26 cylinder head cap screws and washers.

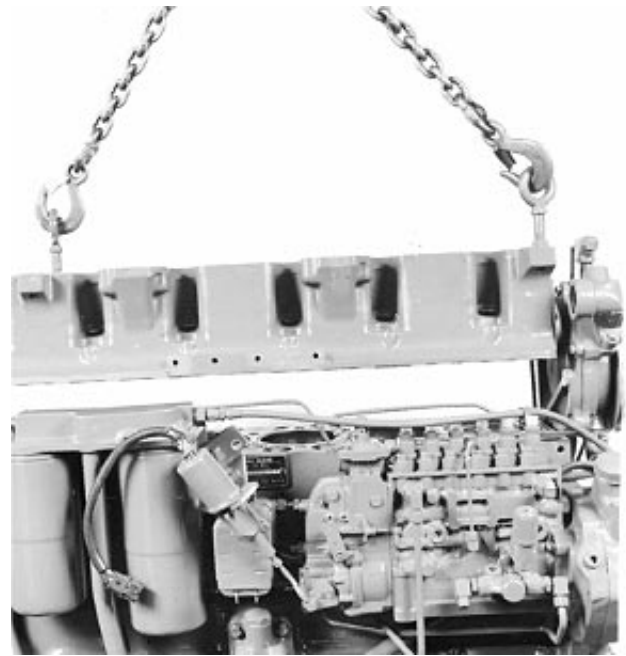
IMPORTANT: DO NOT use screwdrivers or pry bars between cylinder block and cylinder head to loosen head-to-block gasket seal. These tools can damage cylinder head and block gasket surfaces.

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

19. Remove cylinder head and gasket. Inspect 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.

20. Check valve recess and record measurements. See MEASURE VALVE RECESS, as described later in this group.



-UN-27JAN92

RG6042

RG,CTM61,G5,6 -19-30MAR93

DISASSEMBLE AND INSPECT ROCKER ARM SHAFT ASSEMBLY

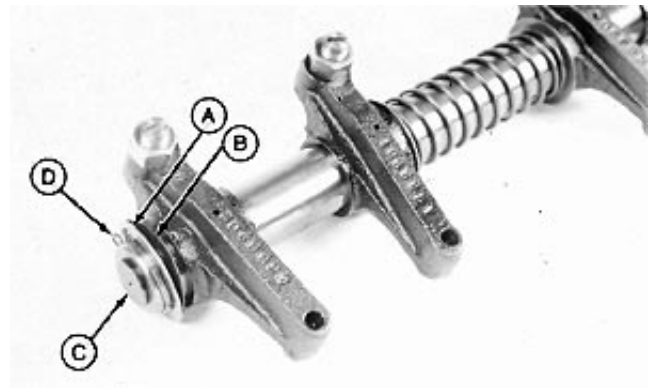
NOTE: Make preliminary inspection during disassembly.

Look for:

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

1. Remove spring washer (A), washer (B), end plug (C), and cotter pin (D) 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.



A—Spring Washer
B—Washer
C—End Plug
D—Cotter Pin

RG,CTM61,G5,46 -19-24APR92

3. Inspect rocker arm shaft (A) for severe scratching, scoring, or excessive wear at points of rocker arm contact.

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

ROCKER ARM ASSEMBLY SPECIFICATIONS

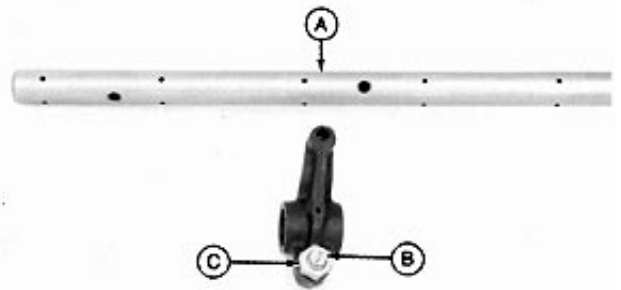
Rocker Arm ID 25.418—25.458 mm
(1.0007—1.0023 in.)

Rocker Arm Shaft OD 25.360—25.400 mm
(0.9984—1.0000 in.)

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

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

IMPORTANT: Be sure all oil holes in rocker arm shaft are open and clean. Remove end plug and clean center hole in shaft.



S11,2505,I -19-13MAY93

-UN-17JAN92

RG6043

05
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-UN-23FEB89

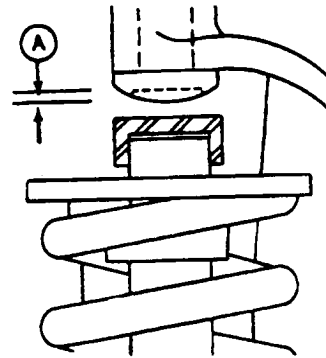
RG3802

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.



R26131 -UN-09DEC88

S11,0401,N -19-05FEB85

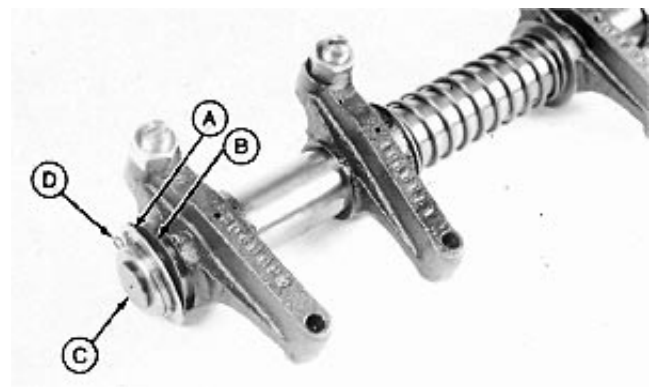
ASSEMBLE ROCKER ARM SHAFT ASSEMBLY

1. Assemble parts on rocker arm shaft in reverse of sequence removed.

2. Make sure rocker arm shaft end plugs (C) are firmly seated in shaft.

3. Check for proper installation of washer (B) and spring washer (A). Be sure cotter pin (D) is bent securely.

A—Spring Washer
B—Washer
C—End Plug
D—Cotter Pin



RG6043 -UN-17JAN92

RG,CTM61,G5,47 -19-24APR92

MEASURE VALVE RECESS IN CYLINDER HEAD

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

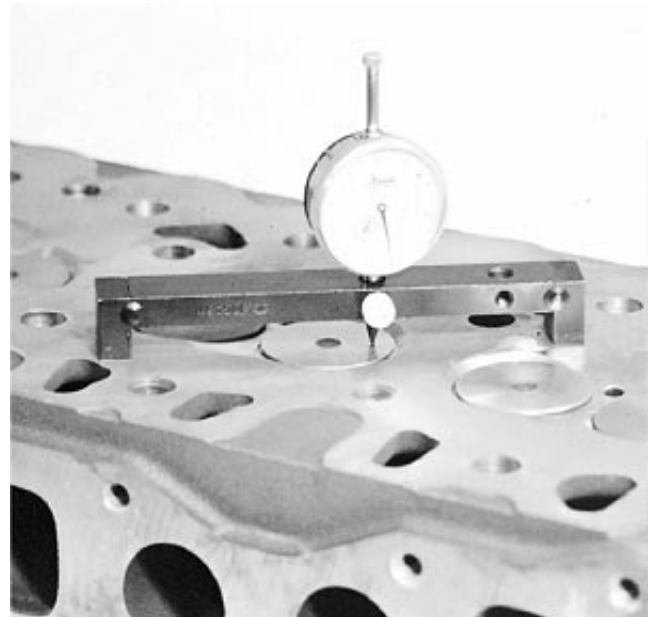
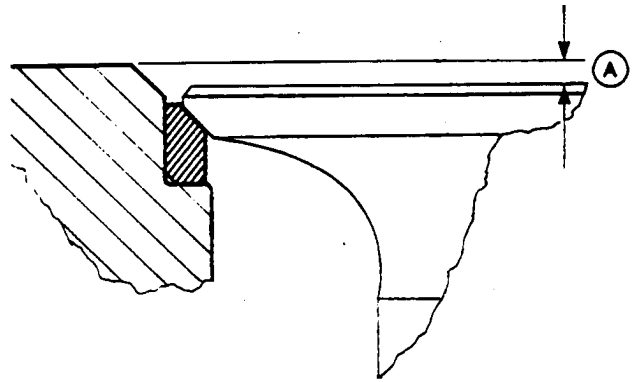
NOTE: Thoroughly clean all gasket material from cylinder head combustion face before measuring.

VALVE RECESS SPECIFICATIONS

Valve Recess Below Cylinder Head:

Exhaust	1.64—2.29 mm (0.064—0.090 in.)
Intake	2.69—3.34 mm (0.106—0.131 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, later in this group.)



RG,CTM61,G5,7 -19-30MAR93

RG4756 -UN-06DEC88

RG6248 -UN-31MAR92

05
17

DIAGNOSING MALFUNCTIONS**• Sticking Valves:**

Carbon deposits on valve stem.
 Worn valve guides.
 Warped valve stems.
 Cocked 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 stand-out.
 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.

• Burned, Pitted, Worn, or Broken Valves:

Worn or distorted 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.

• Improper Valve Clearance:

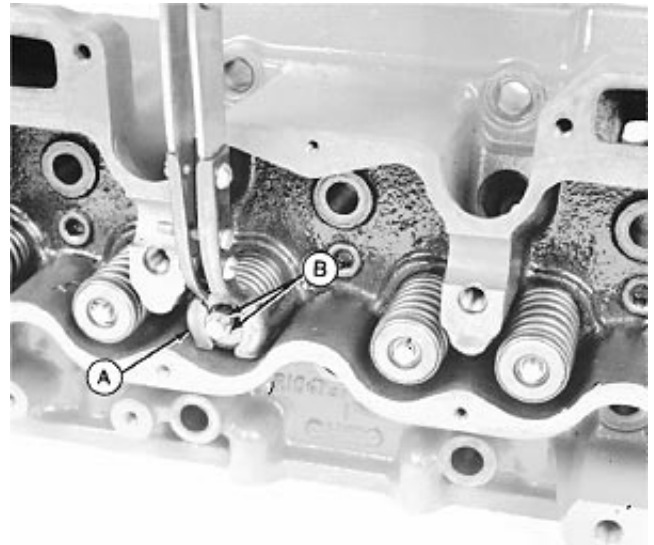
Inefficient use of fuel.
 Engine starts harder.
 Maximum engine power will not be achieved.
 Shorter service life of valve train.
 Greater chance for engine to overheat.

REMOVE VALVE ASSEMBLY

1. Remove rocker arm assembly as previously described.
2. Remove cylinder head as previously described.

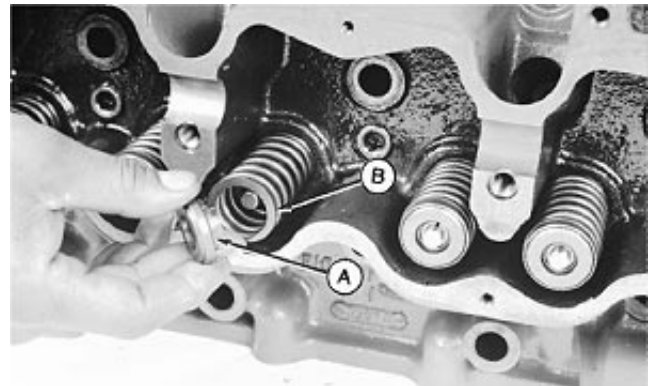
NOTE: When removing valves, valve springs, and valve rotators identify them for reassembly in original positions.

3. Compress JDE138 Valve Spring Compressor (A) over valves.
4. Remove wear cap (shown removed) and retaining locks (B).
5. Release valve spring compressor.



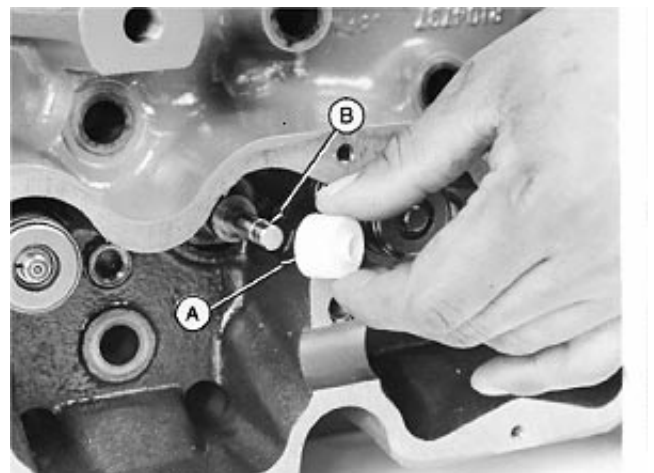
RG,CTM61,G5,48 -19-30MAR93

6. Remove valve rotator (A).
7. Remove valve spring (B).



RG,CTM61,G5,26 -19-13MAR92

8. On exhaust valves only, remove valve stem shield (A). Discard shields.
9. Remove valve (B). Identify for reassembly.



RG,CTM61,G5,49 -19-24APR92

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.

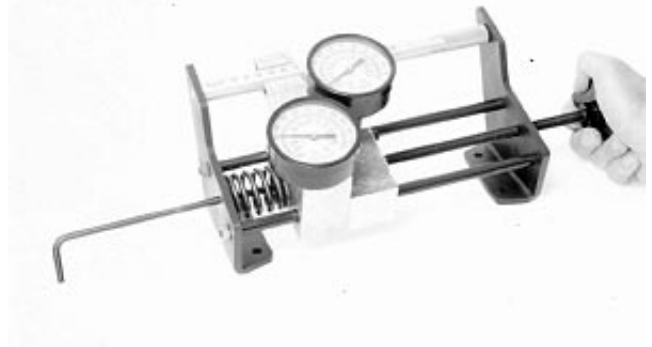
NOTE: Free spring length of 65 mm (2.56 in.) springs differ slightly, but compressed height must be the same.

VALVE SPRING SPECIFICATIONS

Spring Load	Height
Intake:	
Open: 810—880 N (182—198 lb-force)	38.1 mm (1.50 in.)
Closed: 345—399 N (78—90 lb-force)	52.5 mm (2.07 in.)
Exhaust:	
Open: 797—867 N (179—195 lb-force)	38.5 mm (1.52 in.)
Closed: 284—338 N (64—76 lb-force)	54.5 mm (2.15 in.)



RG2732 -UN-23FEB89



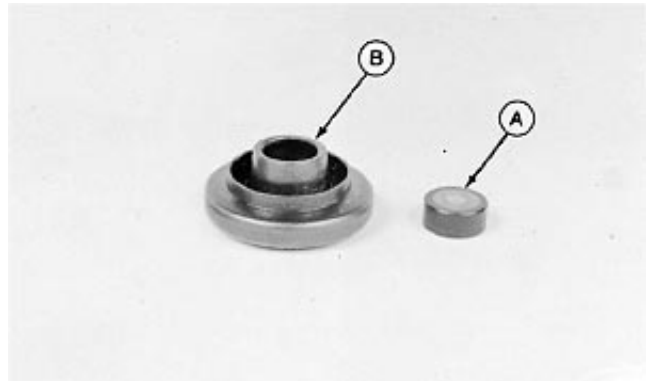
T82054 -UN-08NOV88

RG,CTM42,G5,11 -19-03MAY93

INSPECT WEAR CAPS AND VALVE ROTATORS

1. Inspect wear caps (A) for wear or damage.
2. Insure that valve rotators (B) will turn freely in one direction only.

Replace parts if they are worn or show any signs of damage.



RG6049 -UN-17JAN92

RG,CTM61,G5,50 -19-13MAR92

CLEAN VALVES

1. Hold each valve firmly against a soft wire wheel on a bench grinder.
2. Remove all carbon from valve head, face, and unplated portion of stem.

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

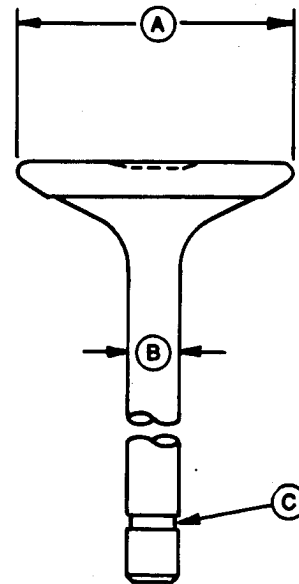
RG,CTM8,G05,33 -19-10JUL92

INSPECT AND MEASURE VALVES

1. Replace valves that are burned, cracked, eroded, chipped, scuffed, or otherwise damaged.
2. Inspect valve retainer lock groove (C) on valve stem for damage.
3. Measure valve head OD (A). Compare valve stem OD (B) with guide ID to determine clearance, as outlined later in this group.

VALVE SPECIFICATIONS

A—Valve Head OD:	
Intake and Exhaust	52.87—53.13 mm (2.081—2.092 in.)
B—Valve Stem OD:	
Intake	9.461—9.487 mm (0.3725—0.3735 in.)
Exhaust	9.436—9.462 mm (0.3715—0.3725 in.)



RG,CTM61,G5,8 -19-13MAY93

UN-12AUG91
RG5795

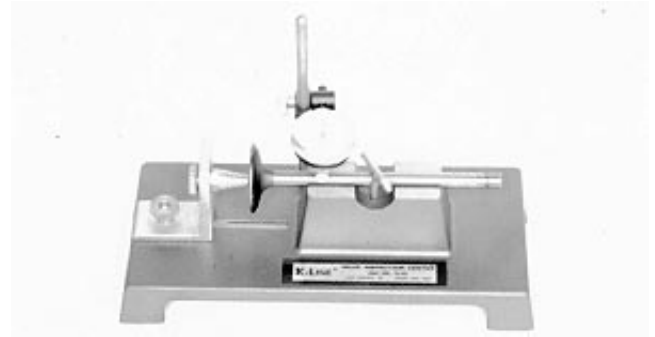
4. Use D0508ST Valve Inspection Center to determine if valves are out of round, bent, or have excessive runout.

VALVE FACE RUNOUT SPECIFICATION

Maximum Permissible Runout of

Valve Face 0.05 mm (0.002 in.)

5. Valves determined to be serviceable should be refaced. See GRIND VALVES later in this group.



RG,CTM61,G5,51 -19-30MAR93

RG4234 -UN-23FEB89

GRIND VALVES

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

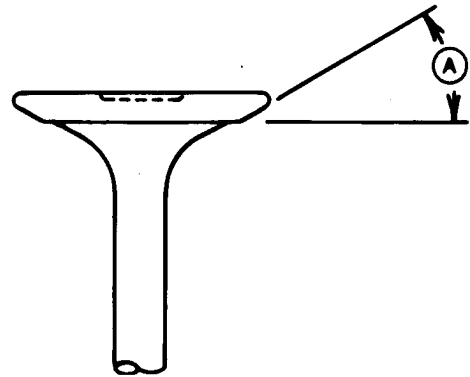
Measure valve face angle (A). Regrind valve face angle or replace valves as necessary.

VALVE FACE ANGLE SPECIFICATIONS

Intake $29.25^{\circ} \pm 0.25^{\circ}$

Exhaust $36.75^{\circ} \pm 0.25^{\circ}$

IMPORTANT: When valve faces are ground, be extremely careful not to nick radius (from valve head-to-stem) with facing stone. A nick in this area will cause valve to break. Break all sharp edges after grinding.



RG,CTM61,G5,52 -19-24APR92

RG5247 -UN-12AUG91

INSPECT AND CLEAN CYLINDER HEAD

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.

Scrape gasket material, oil, carbon, and rust from head. Use a powered wire brush to clean sealing surfaces.

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

RG,CTM8,G05,37 -19-10JUL92

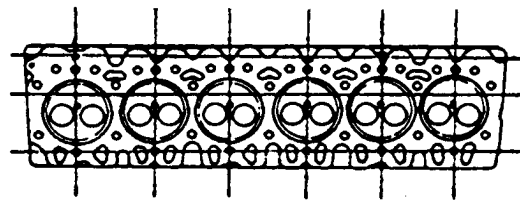
CHECK CYLINDER HEAD COMBUSTION FACE FLATNESS

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

CYLINDER HEAD FLATNESS SPECIFICATIONS

Maximum Acceptable Out-of-Flat:
For Entire Length or Width 0.10 mm (0.004 in.)

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



-UN-17JAN92

RG6050

-UN-06DEC88

RG4629

RG,CTM61,G5,53 -19-30MAR93

MEASURE CYLINDER HEAD THICKNESS

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

If cylinder 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 0.25 mm (0.010 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.

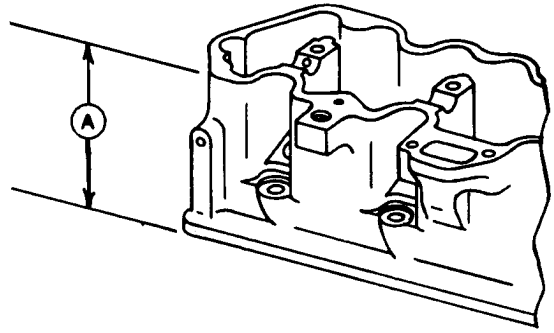
Check valve recess after grinding. See **MEASURE VALVE RECESS**, earlier in this group. Valve seat or valve face may be ground to bring this characteristic within specification.

CYLINDER HEAD SPECIFICATIONS

Thickness 166.55—166.80 mm
(6.557—6.567 in.)

Wear Limit 166.29 mm
(6.547 in.)

Combustion Face Surface Finish
(Surface Grind Only) (AA) 0.0015—0.0028 mm
(60—110 micro-in.)



RG6036 -UN-17JAN92

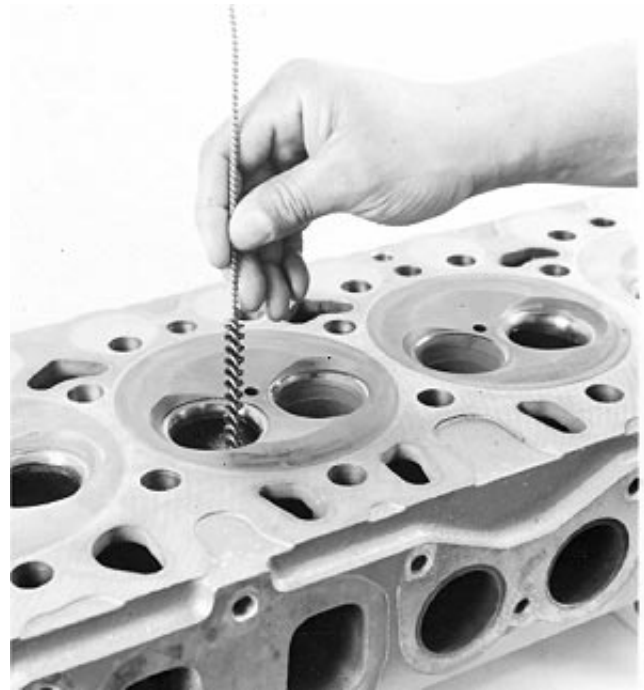
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RG,CTM61,G5,9 -19-13MAY93

CLEAN VALVE GUIDES

1. Use a plastic brush to clean valve guides before inspection or repair.

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



-UN-17JAN92

RG6051

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RG,CTM61,G5,28 -19-30MAR93

MEASURE VALVE GUIDES

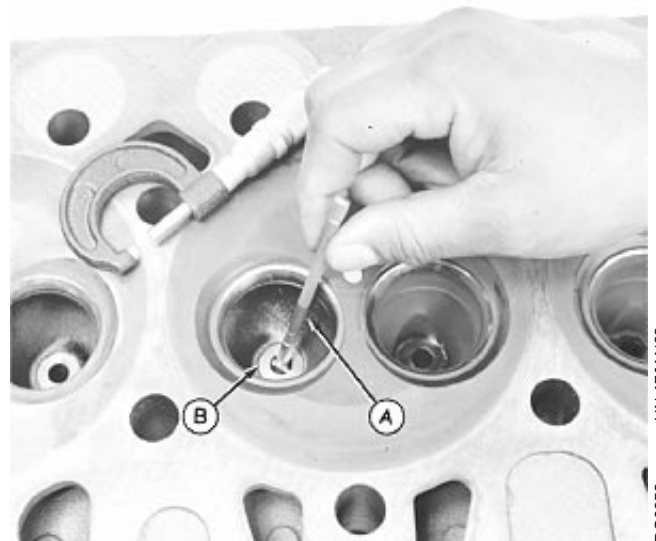
1. Measure valve guides (B) for wear using a telescopic gauge (A) and micrometer.

VALVE GUIDE SPECIFICATIONS

Valve Guide ID in a New Head 9.512—9.538 mm
(0.3745—0.3755 in.)

New Valve Guide-to-Valve Stem Clearance

Intake	0.025—0.077 mm (0.001—0.003 in.)
Maximum Allowable Clearance	0.13 mm (0.005 in.)
Exhaust	0.050—0.102 mm (0.002—0.004 in.)
Maximum Allowable Clearance	0.15 mm (0.006 in.)



-UN-17JAN92

RG6052

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.), replacement valve guides are available. (See REPLACE VALVE GUIDES, later in this group.)

RG,CTM61,G5,22 -19-13MAY93

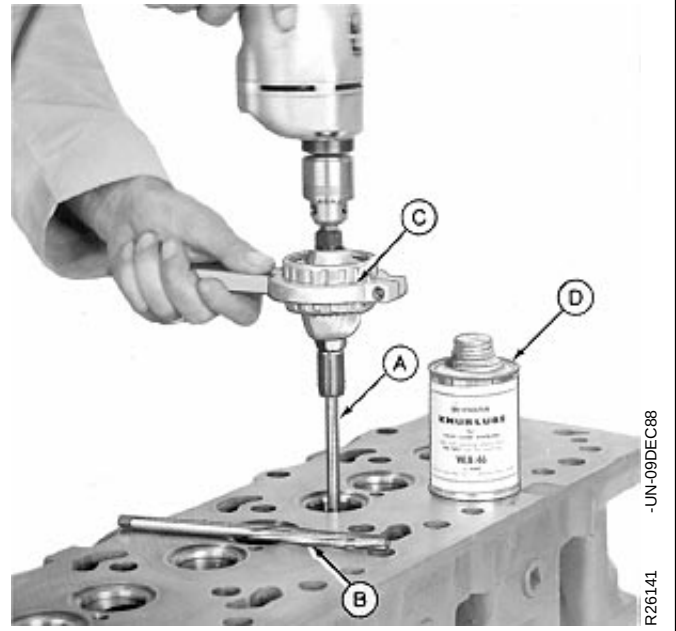
KNURL VALVE GUIDES

1. Use JT05949 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



RG,CTM61,G5,29 -19-30MAR93

REPLACE VALVE GUIDES

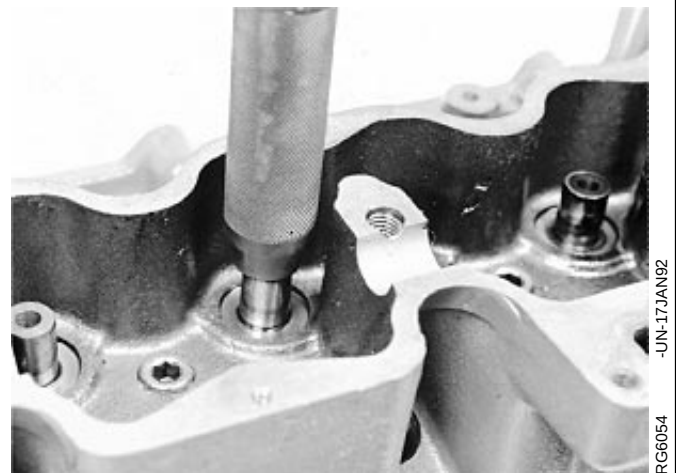
1. Guides allowing more than 0.25 mm (0.010 in.) clearance should be replaced. Remove valve guide with a press and driver.

IMPORTANT: O.D. of driver must be smaller than valve guide insert to prevent damage to valve guide bores.



RG,CTM61,G5,54 -19-13MAY93

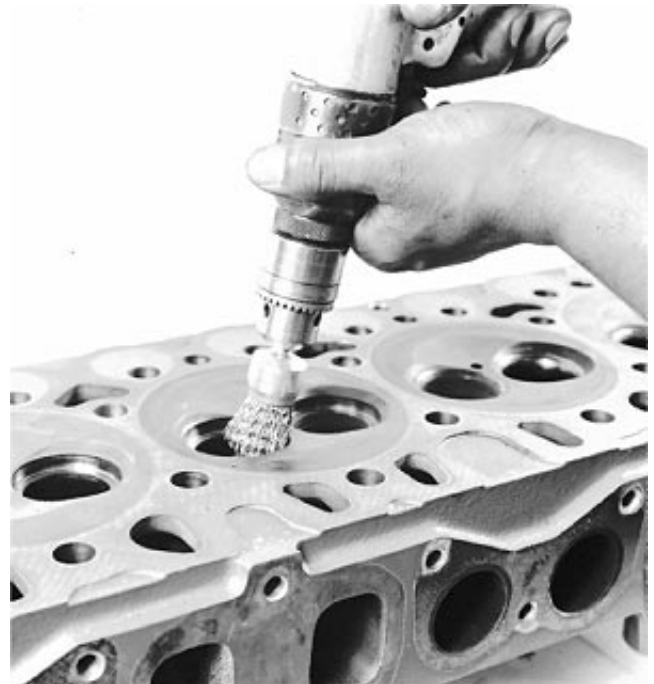
2. Install new guide with JDE75 Driver and JDE7 Pilot Driver. Drive new guide to 48 mm (1.89 in.) from bottom of cylinder head. If reconditioned valves are used, new guides can be knurled to provide a more uniform fit.



RG,CTM61,G5,55 -19-13MAR92

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.



RG6055
-UN-17JAN92

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RG,CTM61,G5,30 -19-30MAR93

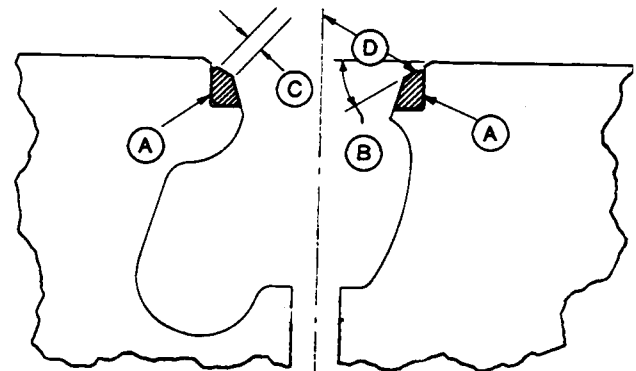
MEASURE VALVE SEATS

1. Measure valve seats for proper specifications as listed below.
2. Using D11010KW Eccentrimeter, measure valve seat runout.

VALVE SEAT SPECIFICATIONS

A—Valve Seat Insert	
B—Valve Seat Angle:	
Intake	30° ±0.50°
Exhaust	37.50° ±0.50°
C—Valve Seat Width:	
Intake	1.60—3.00 (0.063—0.118 in.)
Exhaust	1.20—3.00 (0.047—0.118 in.)
D—Maximum Valve Seat Runout	
0.05 mm (0.002 in.)	

3. If valve seats are not within specification, recondition valve seats or replace valve seat inserts if reconditioning is not possible. (See GRIND VALVE SEATS, later in this group.)



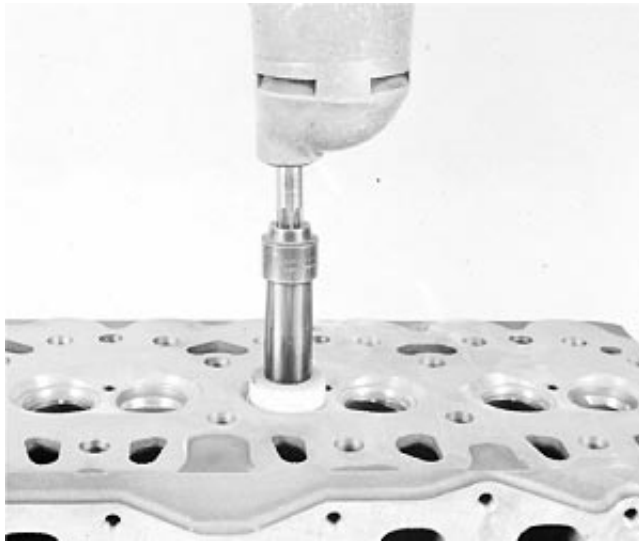
R26126N

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

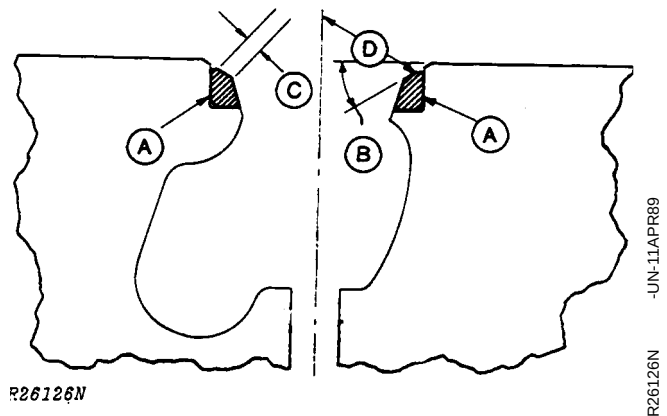
R26126N
-UN-11APR89

RG,CTM61,G5,10 -19-30MAR93

GRIND VALVE SEATS



RG6257



R26126N

A—Valve Seat Insert

B—Valve Seat Angle

C—Valve Seat Width

D—Maximum Valve Seat Runout

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

Using JT05893 Heavy-Duty Seat Grinder 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.)

A 120-grit stone **MUST** be used for grinding both intake and exhaust valve seat inserts.

1. If valve seats need grinding, do not grind too long. Only a few seconds are required to recondition the average valve seat. Avoid the tendency to grind off too much.

2. Do not use too much pressure. While grinding, support the weight of the dresser to avoid excessive pressure on the stone.

NOTE: ALWAYS keep work area clean when grinding valve seats.

3. Check the seat width 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 at the top of the seat and increase the diameter. If valve seat width is too narrow, valve may burn or erode. Varying the valve seat width changes the fine contact between valve face and seat.

4. **ALWAYS** measure valve seat runout after grinding, using D11010KW Eccentrimeter.

VALVE SEAT SPECIFICATIONS

A—Valve Seat Insert

B—Valve Seat Angle:

Intake Valve 30° ±0.50°

Exhaust Valve 37.50° ±0.50°

C—Valve Seat Width:

Intake Valve 1.60—3.00 mm (0.063—0.118 in.)

Exhaust Valve 1.20—3.00 mm (0.047—0.118 in.)

D—Maximum Valve Seat Runout 0.05 mm (0.002 in.)

IMPORTANT: Blend or radius all sharp edges after grinding valve seats. Always check valve recess in relation to cylinder head after grinding.

RG,CTM61,G5,11 -19-30MAR93

REMOVE VALVE SEAT INSERTS

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

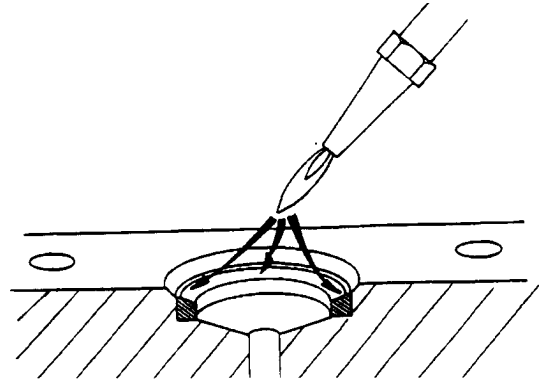
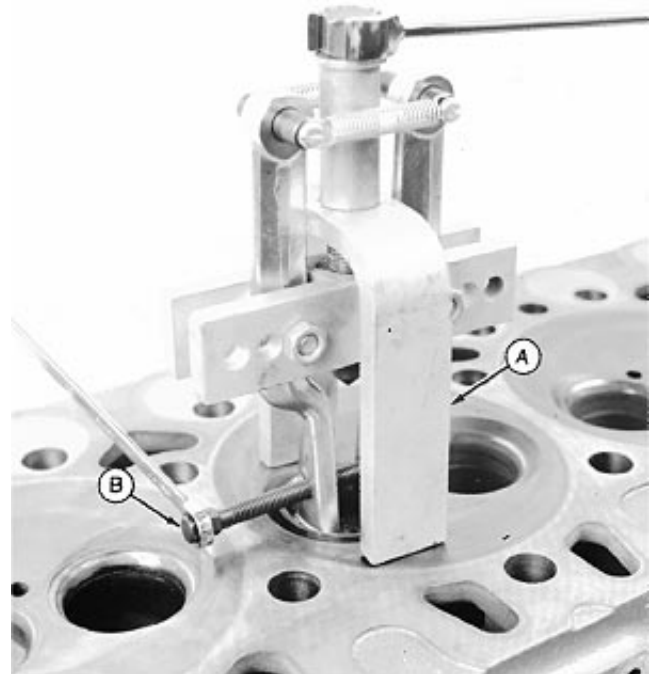
IMPORTANT: Be careful not to damage cylinder head when removing valve seats.

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

- Use JDE41296 Valve Seat Puller (A). Adjusting screw (B) may need to be retightened during removal of inserts.
- Using an arc welder, weld two or three short beads equidistant from each other around the face of the valve seat insert. Allow seat to cool and carefully pry out the insert(s) with a screwdriver.

IMPORTANT: If an arc welder is used to remove valve seat inserts, protect entire combustion face and valve throat area from weld spatter.

After removal of inserts, thoroughly clean area around valve seat bore and inspect for damage or cracks. Replace cylinder head as necessary.



RG,CTM61,G5,31 -19-30MAR93

RG6056 -UN-17JAN92

RG6056 -UN-17JAN90

RG6056

05-29

MEASURE VALVE SEAT BORES IN CYLINDER HEAD

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

VALVE SEAT INSERT SPECIFICATIONS

Standard Valve Seat Inserts:

Valve Seat Bore in Head	54.165—54.191 mm (2.1325—2.1335 in.)
Valve Seat OD	54.237—54.263 mm (2.1353—2.1363 in.)

Oversize Valve Seat Inserts:

Available Size	0.25 mm (0.010 in.)
Valve Seat Bore in Head	54.415—54.441 mm (2.1423—2.1433 in.)
Valve Seat OD	54.491—54.517 mm (2.1453—2.1463 in.)

Valve Seat Insert

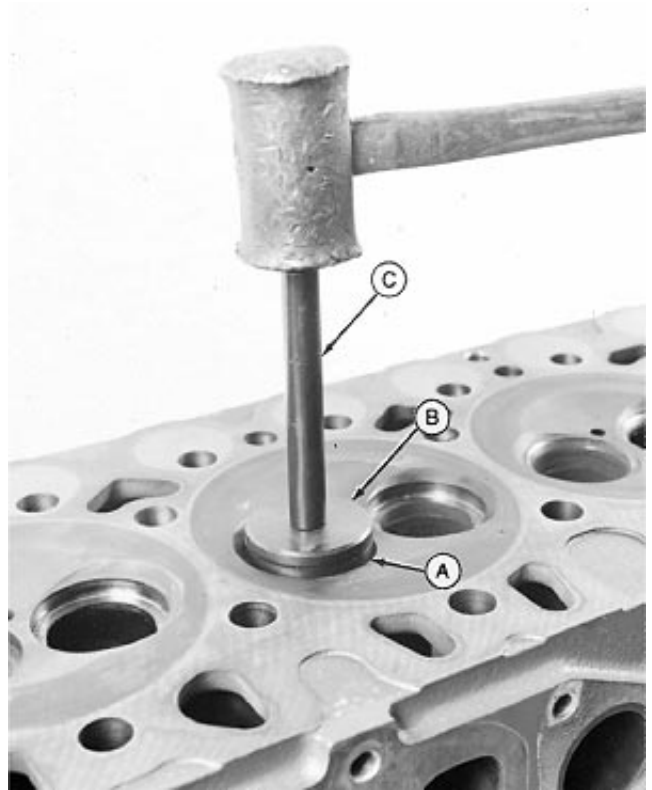
Counterbore Depth:	
Intake	13.12—13.38 mm (0.517—0.527 in.)
Exhaust	12.02—12.28 mm (0.473—0.483 in.)

2. If valve seat bores are not within the new part specification limits, have a qualified machine shop machine the valve seat bores to specifications given and install oversize valve seat inserts. (See INSTALL VALVE SEAT INSERTS—STANDARD OR OVERSIZE, later in this group.)

RG,CTM61,G5,72 -19-13MAY93

INSTALL VALVE SEAT INSERTS (STANDARD OR OVERSIZE)

1. Have a qualified machine shop machine seat bore to 54.415—54.441 mm (2.1423—2.1433 in.). Thoroughly clean seat bores.
2. Use JDE73 (intake) and JDG756 (exhaust) valve seat insert adapters (B) to install new inserts (A).
3. JDE7 Driver (C) is used with the correct adapter to drive inserts into place. Be sure inserts are firmly seated in bores.
4. Measure valve seats and check valve recess. See MEASURE VALVE RECESS as detailed earlier in this group. Grind valve seats as required to obtain correct valve recess.



RG6057
-UN-21JAN92

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31

RG,CTM61,G5,32 -19-30MAR93

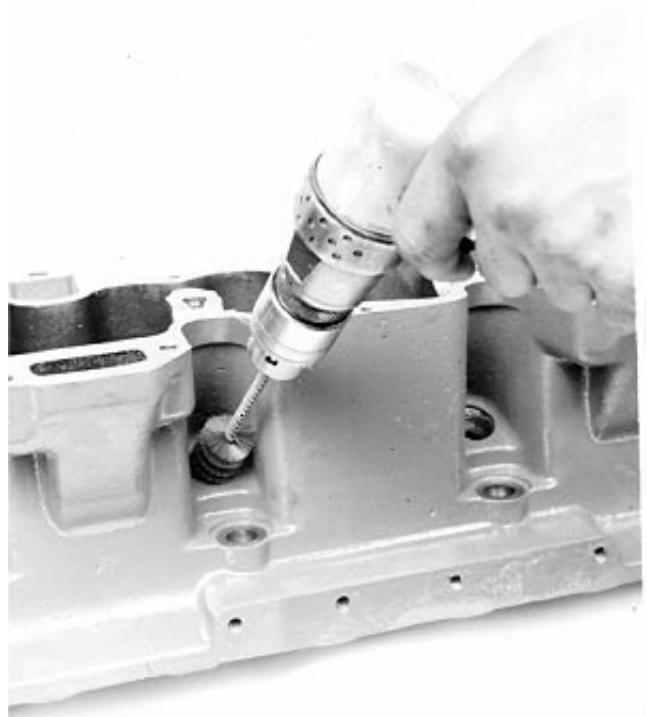
INSPECT AND CLEAN CYLINDER HEAD NOZZLE BORE

1. Inspect condition of threads for gland nut and nozzle seating surface in cylinder head.

Cylinder head threads and nozzle seating surface must be free of debris and carbon deposits.

IMPORTANT: If injection nozzle gland nut threads are not clean, a false torque reading may be obtained when injection nozzle is installed. This may prevent injection nozzle from seating properly in cylinder head.

2. Clean threads which have light foreign deposits using a drill and D17030BR Nozzle Thread Cleaning Brush. Work brush up and down several times to clean threads.



RG6058
-UN-21JAN92

RG,CTM61,G5,34 -19-13MAY93

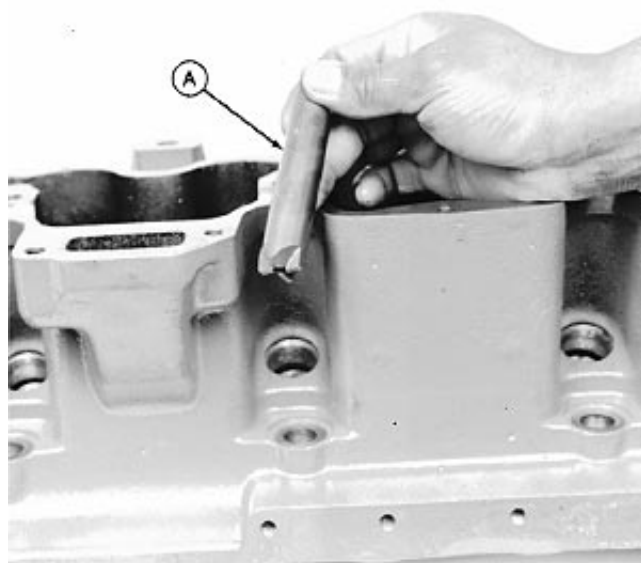
3. Clean threads with heavy foreign deposits or clean up damaged threads using the JDF5 Tap (M28 x 1.5 mm) or an equivalent M28 x 1.5 mm (metric) tap (A). Be sure to start tap straight to avoid possible cross-threading. A light coat of grease on tap will help collect foreign deposits on tap and prevent them from falling into the nozzle tip bore.



RG6059 -UN-21JAN92

RG,CTM61,G5,35 -19-13MAY93

4. Clean nozzle seating surface by using the JDG609 Nozzle Seat Reamer (A) to remove carbon deposits.
5. Blow out debris with compressed air and thoroughly clean nozzle bores.

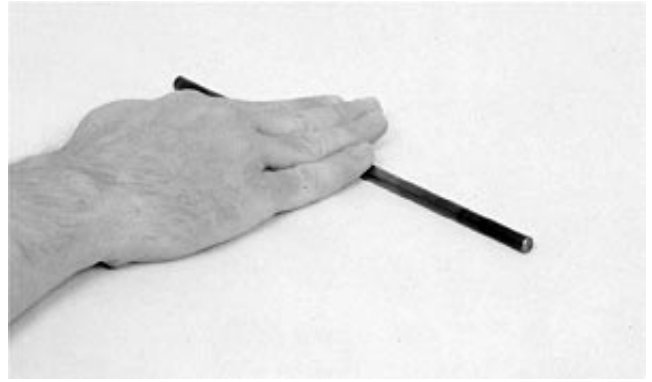


RG6060 -UN-21JAN92

RG,CTM61,G5,36 -19-13MAY93

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.



S11,2005,JN -19-24APR92

T81233 -UN-01NOV88

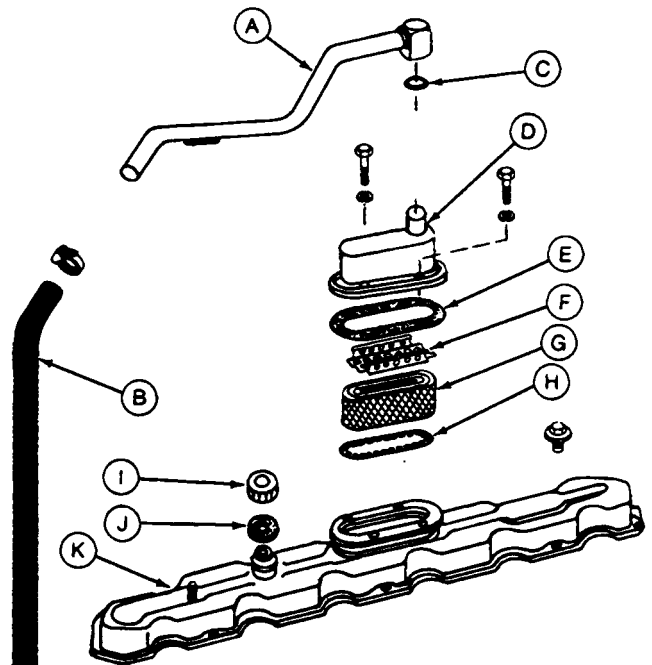
CLEAN AND INSPECT CRANKCASE VENTILATION ASSEMBLY

1. Remove outlet tube (A) and (B). Discard O-ring (C).
2. Remove cover (D), gasket (E), deflector (F), filter element (G), and isolator (H). Discard gasket.
3. Remove oil filler cap (I) and discard gasket (J).
4. Inspect components for restrictions or damage. Clean or replace as necessary.
5. Use new gaskets and O-ring when reassembling ventilation assembly.

NOTE: Be sure filter element is clean and all gasket material is removed before installing on engine.

6. Reverse order to assemble ventilation components.

A—Outlet Tube
 B—Outlet Tube
 C—O-Ring
 D—Cover
 E—Gasket
 F—Deflector
 G—Filter Element
 H—Isolator
 I—Oil Filler Cap
 J—Gasket
 K—Rocker Arm Cover



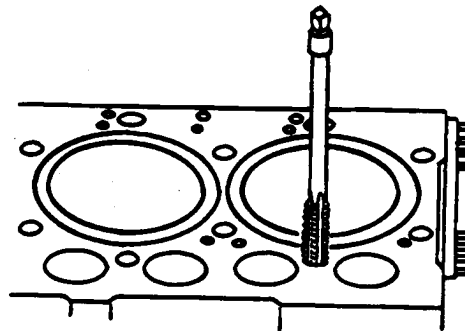
S11,2505,CF -19-13MAY93

RG3530 -UN-06APR89

05
33

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. Remove two cylinder head locating dowels from top deck of cylinder block, if necessary.
3. Clean threaded holes in cylinder block using JDG682 Tap or an equivalent 5/8-11 UNC-2A tap about 127 mm (5.0 in.) long. Use compressed air to remove debris and fluids from cap screw holes. Replace block if there is evidence of damage.
4. Use compressed air to remove all loose foreign material from cylinders and top deck.
5. Inspect cylinder block top deck for flatness and serviceability. (See MEASURE CYLINDER BLOCK, in Group 10.)
6. Install two new locating dowels in top deck of cylinder block.



RG4718 -UN-13DEC88

RG,CTM61,G5,70 -19-30MAR93

MEASURE CYLINDER LINER STANDOUT (HEIGHT ABOVE BLOCK)

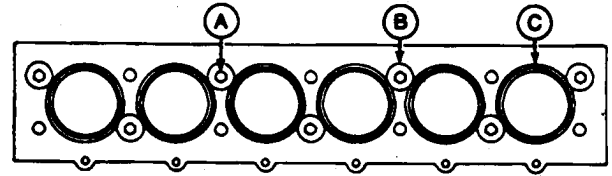
1. Use short cap screws (A) and 3.18 mm (1/8 in.) thick washers (B) to bolt down cylinder liners (C) in the seven locations as shown. Tighten cap screws to 68 N·m (50 lb-ft) to achieve an accurate standout reading.

NOTE: Do not rotate crankshaft with cylinder head removed unless liners are bolted down. Bolt liners down removing pistons.

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

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

4. Replace any liner that does not meet standout (height) specification at any location. (See INSTALL LINER SHIMS—IF REQUIRED in Group 10.) Use liner shims or replace piston/liner sets as necessary.



LINER HEIGHT SPECIFICATION

Height Above Block 0.025—0.102 mm
(0.0010—0.0040 in.)

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

RG,CTM61,G5,56 -19-13MAY93

-UN-07DEC88

RG3819

-UN-21JAN92

RG6062

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35

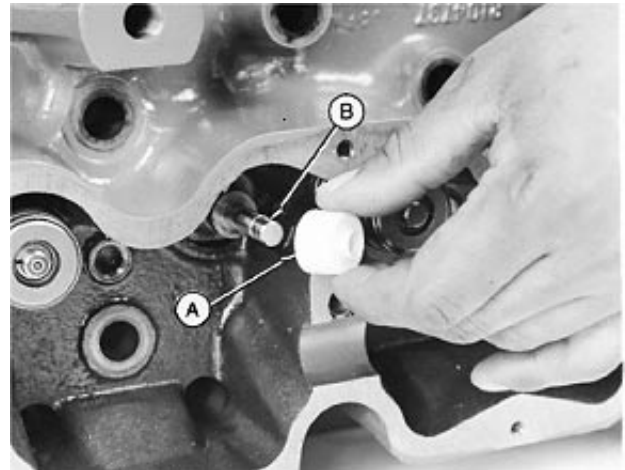
ASSEMBLE VALVE ASSEMBLY

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

NOTE: Exhaust valve stem shields (A) will not seat on valve guide tower; they ride up and down with valve stem.

2. Install valves (B) in guides from which they were removed.
3. Install valve stem shields on exhaust valve stems only.

NOTE: Valves must move freely and seat properly.



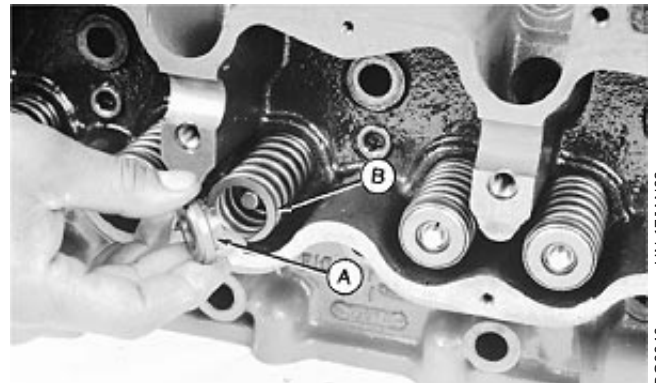
-UN-17JAN92

RG6047

RG,CTM61,G5,13 -19-13MAR92

NOTE: There is no top or bottom to valve springs; they may be installed either way. However, there is a difference between intake and exhaust springs.

4. Install valve springs (B) making certain that spring is correctly seating in machined counterbore of head.
5. Install valve rotators (A) on springs and valves.



-UN-17JAN92

RG6046

RG,CTM61,G5,14 -19-24APR92

6. Compress valve springs with JDE138 Valve Spring Compressor (A).

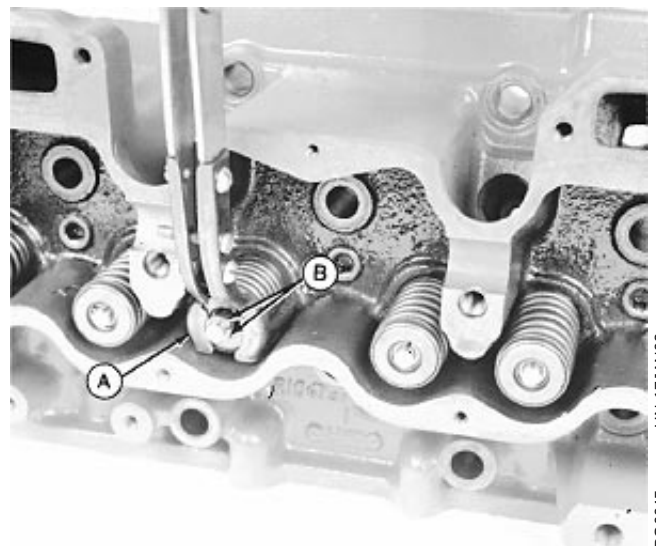
7. Install retaining locks (B).

8. Release valve spring compressor.

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

9. Strike end of each valve with a soft mallet, three or four times to insure proper seating of the retainer locks.

Repeat procedure for all remaining valves, and remember valve stem seals are installed onto exhaust valve stems only.



-UN-17JAN92

RG6045

RG,CTM61,G5,15 -19-13MAR92

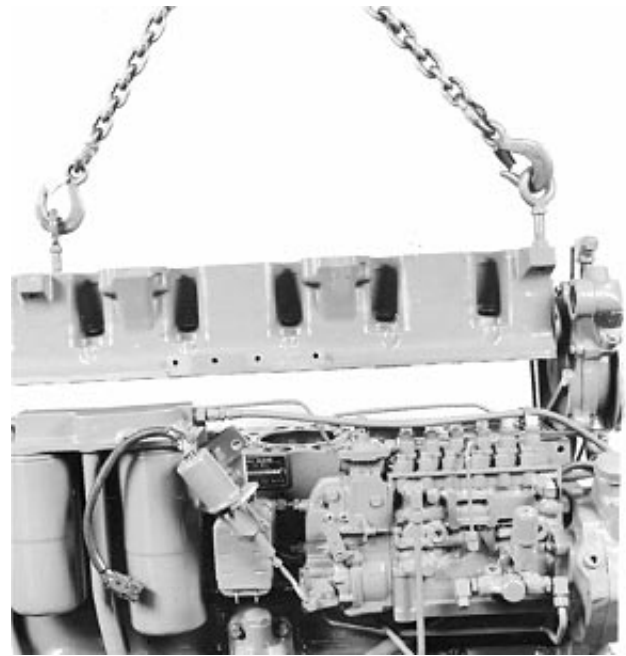
INSTALL CYLINDER HEAD

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

1. Place a new head gasket on top of cylinder block. Do not use sealant on gasket.

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

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



RG,CTM61,G5,16 -19-24APR92

-UN-27JAN92

RG6042

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37

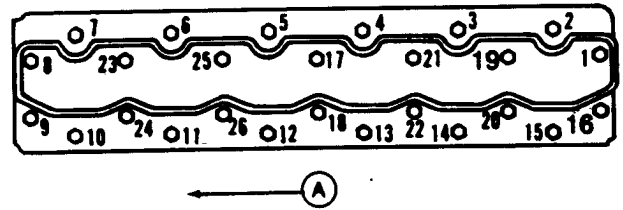
3. Using a wire brush and solvent, clean entire length of cap screw (if reusing) to remove rust and scale. Dry cap screws with compressed air.

4. Inspect cap screws for corrosion damage and condition of threads.

IMPORTANT: ANY CAP SCREW WITH CORROSION OR OTHER IMPERFECTIONS MUST BE REPLACED.

5. Dip entire cap screws and washers in clean SAE30 engine oil. Remove excess oil.

Arrow (A) points toward front of engine.



CAP SCREW LENGTH LOCATION ON CYLINDER HEAD

197 mm (7.75 in.)	10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26
171 mm (6.75 in.)	2, 3, 4, 5, 6, 7
248 mm (9.75 in.)	1, 8, 9

6. Install washers on cap screws.

7. Install cap screws and washers in proper location.

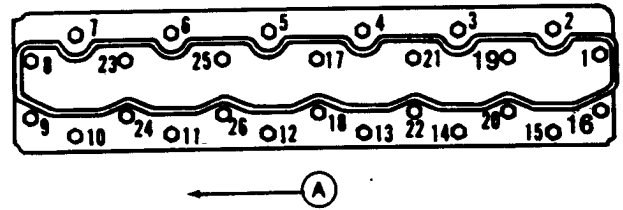
RG,CTM61,G5,17 -19-13MAY93

RG5699 -UN-31AUG90

TIGHTEN FLANGED-HEAD CYLINDER HEAD CAP SCREWS (WITH FLAT WASHERS)

Arrow (A) points toward front of engine.

1. Initially tighten cap screw No. 17 (illustration) to 200 N·m (150 lb-ft) first. This will prevent the cylinder head from tipping during tightening sequence.
2. Start with cap screw No. 1 and proceed in numerical sequence, tighten all cap screws to 200 N·m (150 lb-ft), including cap screw No. 17.
3. Finally TORQUE-TURN all flanged-head cap screws in the same sequence an additional 90—100°, using one of the methods described in the following module. (See TORQUE-TURN FLANGED-HEAD CYLINDER HEAD CAP SCREWS, later in this group.)

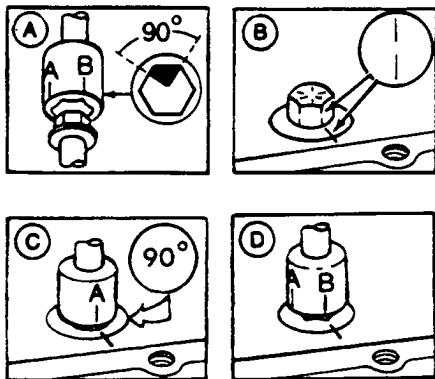


-UN-31AUG90
RG5699

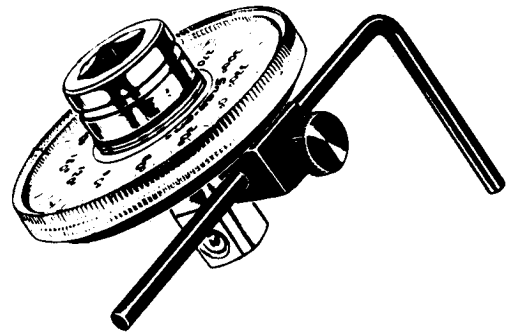
05
39

RG,CTM61,G5,18 -19-24APR92

TORQUE-TURN FLANGED-HEAD CYLINDER HEAD CAP SCREWS



Line Scribe Method



JT05993 Torque Angle Gauge

RG5563 -UN-04JUL89

RG5698 -UN-27AUG90

05
40

Refer to illustration in previous module for numerical location of cylinder head cap screws.

• Using line scribe method to TORQUE-TURN cylinder head cap screws:

After tightening cylinder head cap screws (in proper sequence) to 200 N·m (150 lb-ft), follow steps A—D below for each cap screw beginning with the No. 1 cap screw and sequentially proceed thru to No. 26.

Step A— Make a mark on socket and a second mark 90°—100° (1/4 turn) counterclockwise from first mark on socket.

Step B— Make a reference mark next to cap screw on cylinder head.

Step C— Place socket on cap screw so that the first mark on socket aligns with mark on cylinder head.

Step D— Tighten cap screw 1/4 turn (90°—100°) until second mark on socket aligns with mark on cylinder head.

• Using JT05993 Torque Angle Gauge:

After tightening cylinder head cap screws (in proper sequence) to 200 N·m (150 lb-ft), follow directions provided with gauge and TORQUE-TURN each cap screw 90°—100°, beginning with cap screw No. 1 and sequentially proceed thru to No. 26.

4. Complete engine final assembly following procedures outlined later in this group.

IMPORTANT: Retorque of cylinder head cap screws after engine run-in is not required when using flanged-head cap screws with washers and the recommended TORQUE-TURN tightening procedure.

RG,CTM61,G5,19 -19-30MAR93

INSTALL ROCKER ARM ASSEMBLY

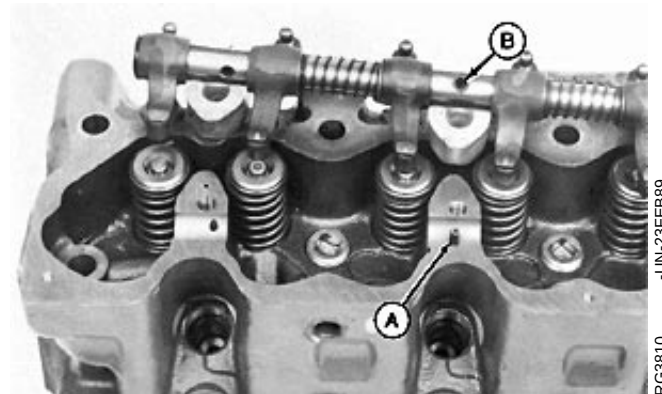
1. Install push rods in holes from which removed.
2. Install wear caps on valve tips, making certain caps rotate freely.



RG,CTM61,G5,37 -19-30MAR93

RG6040
-UN-17JAN92

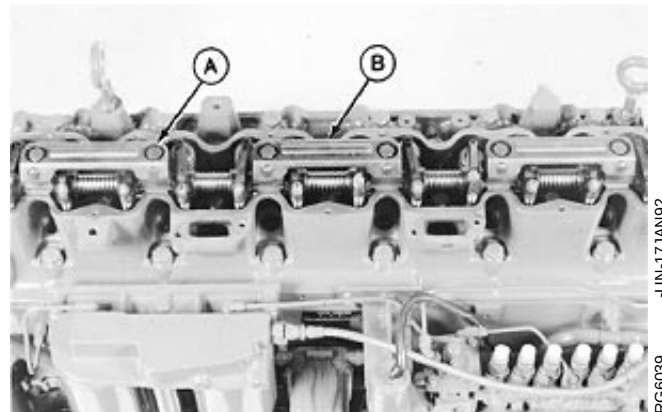
3. Install rocker arm shaft assembly. Make sure spring pin (A) engages with hole (B) in shaft.



RG,CTM61,G5,38 -19-13MAR92

RG3810
-UN-23FEB89

4. Install rocker arm shaft clamps (B) and all six cap screws (A) with washers. Tighten cap screws to 88 N·m (65 lb-ft).



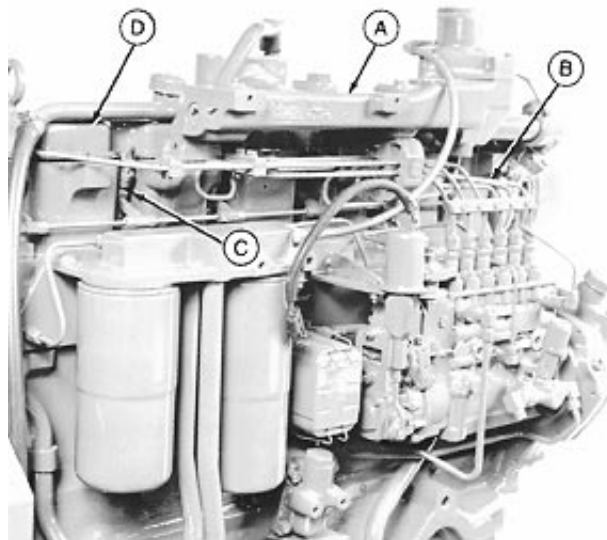
RG,CTM61,G5,59 -19-13MAR92

RG6039
-UN-17JAN92

COMPLETE FINAL ASSEMBLY ON INJECTION PUMP SIDE

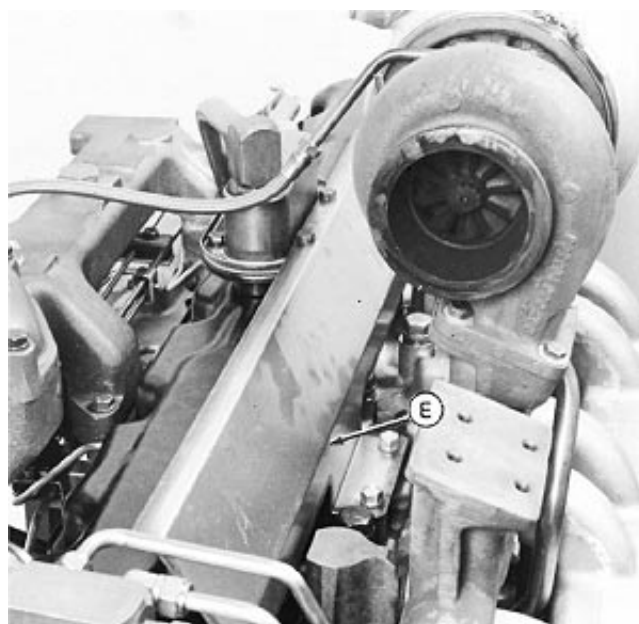
1. Adjust valve clearance. See CHECK AND ADJUST VALVE CLEARANCE, as outlined earlier in this group.
2. Apply AR31790 SCOTCH-GRIP Adhesive or equivalent to new gasket, and seal gasket to the rocker arm cover (D). Be sure to follow the manufacturer's directions on the package for correct application procedures and curing times.
3. Install rocker arm cover and tighten cap screws to 8 N·m (6 lb-ft).
4. Install turbocharger heat shield (E), if equipped. Tighten cap screws to 47 N·m (35 lb-ft).
5. Install fuel injection nozzles (C) and fuel injection lines (B). (See Group 35.)
6. Install water manifold (A) and connect water piping. (See Group 25.)

A—Water Manifold
B—Fuel Injection Lines
C—Fuel Injection Nozzles
D—Rocker Arm Cover
E—Turbocharger Heat Shield



-UN-17JAN92

RG6080

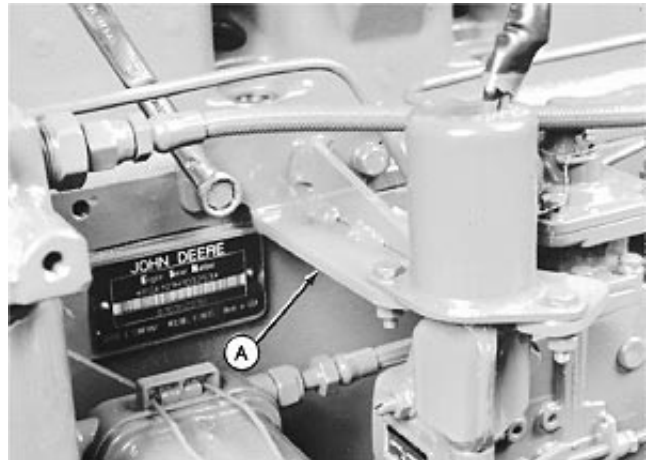


-UN-17FEB93

RG6618

RG,CTM61,G5,20 -19-30MAR93

7. Connect fuel shutoff solenoid bracket (A) to cylinder head. Tighten cap screws to 47 N·m (35 lb-ft).



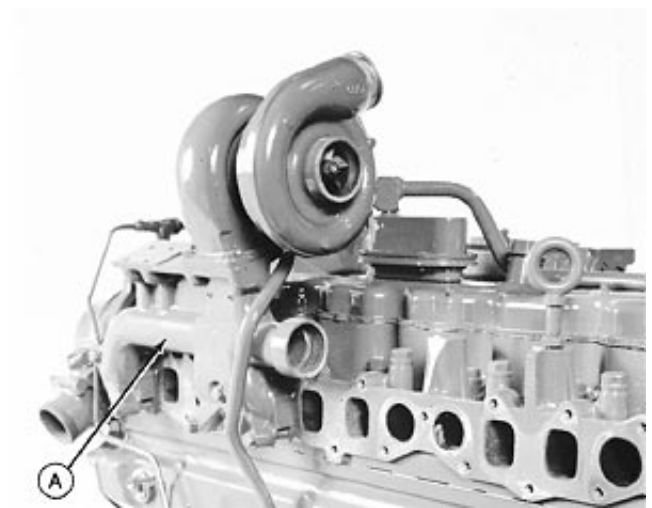
RG,CTM61,G5,62 -19-30MAR93

COMPLETE FINAL ASSEMBLY ON EXHAUST MANIFOLD SIDE

Apply PT569 NEVER-SEEZ Compound or equivalent to all exhaust manifold cap screws during assembly.

NOTE: Guide studs may be used to ease installation of exhaust manifold.

1. Using new gaskets, install front half of exhaust manifold (A) with turbocharger. Tighten cap screws to 95 N·m (70 lb-ft).
2. Install turbocharger oil return pipe to block.



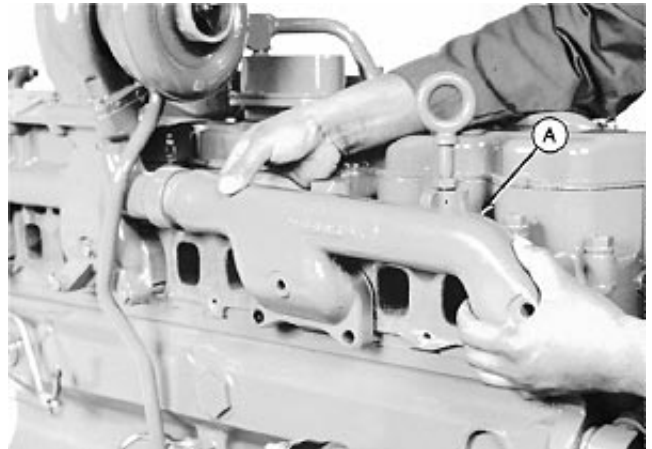
RG,CTM61,G5,21 -19-13MAY93

3. Install a new sealing ring (A) in groove on front end of rear exhaust manifold.



RG,CTM61,G5,63 -19-13MAR92

4. Using new gaskets, install rear half of exhaust manifold (A). Tighten cap screws to 95 N·m (70 lb-ft).



RG,CTM61,G5,64 -19-30MAR93

5. Install intake manifold (A) using new gaskets. Tighten cap screws to 75 N·m (55 lb-ft).

NOTE: Guide studs may be used for aligning intake manifold and gaskets.

6. Connect all exhaust and air intake piping, tighten connections securely. (See Group 30 and machine technical manual.)



RG,CTM61,G5,23 -19-13MAR92

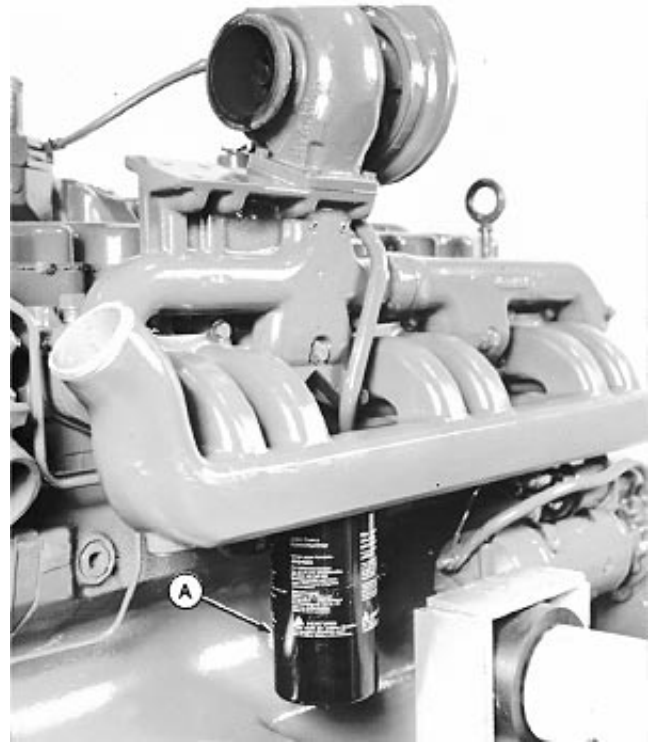
7. Connect aneroid line (A) and both coolant lines leading to coolant conditioner filter base.



RG,CTM61,G5,65 -19-24APR92

8. Install coolant conditioner filter (A).
9. Fill engine with proper oil and coolant to the proper levels. See Group 02.
10. Perform engine break-in as outlined next.

IMPORTANT: After engine break-in, follow **ALL** recommended hourly service intervals outlined in your Operator's Manual.



RG6061
-UN-21JAN92

05
45

RG,CTM61,G5,66 -19-24APR92

PERFORM ENGINE BREAK-IN

1. Run engine at slow idle no load for 2 minutes. Check for liquid leaks.

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

NOTE: Dynamometer is the preferred load control, but engine can be loaded by matching drag loads to gear selection.

3. Recheck valve clearance and adjust as necessary. (See CHECK AND ADJUST VALVE CLEARANCE, earlier in this group.)

4. Install rocker arm cover gasket and cover. Tighten rocker arm cover cap screws to 8 N·m (6 lb-ft) (72 lb-in.). (See COMPLETE FINAL ASSEMBLY OF INJECTION PUMP SIDE, earlier in this group.)

Retorque of cylinder head cap screws after engine break-in is not required.

IMPORTANT: After engine break-in, follow ALL recommended hourly service intervals outlined in your Operator's Manual.

RG,CTM6,G05,5 -19-31MAR93

Group 10 Cylinder Block, Liners, Pistons and Rods

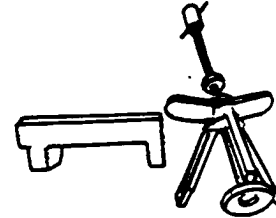
SPECIAL OR ESSENTIAL TOOLS

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

DX,TOOLS -19-05JUN91

Cylinder Liner Puller D01062AA
(or D01073AA)

Remove cylinder liners.



S53,D01062,AA -19-07AUG91

RG5019 -UN-23AUG88

Magnetic Follower Holder Kit D15001NU

Hold cam followers when removing or installing camshaft.



S53,D15001,NU -19-24APR92

RG5073 -UN-23AUG88

Flexible Cylinder Hone D17006BR

Hone cylinder liners.

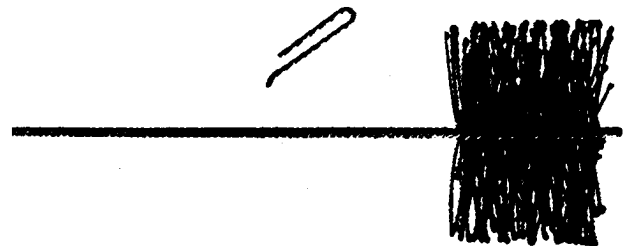


S53,D17006,BR -19-14JUN89

RG5074 -UN-23AUG88

O-Ring Groove Cleaning Brush D17015BR

Clean cylinder liner O-ring groove in block.



S53,D17015,BR -19-25MAR91

RG5075 -UN-23AUG88

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.

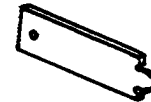


RG,D17526CI -19-29OCT92

RG6246 -UN-27MAR92

Ring Groove Wear Gauge JDE55

Check wear of keystone ring groove on pistons.

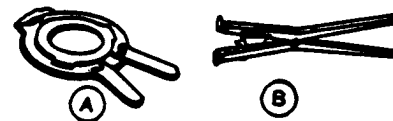


S53,JDE55 -19-25MAR91

RG5076 -UN-23AUG88

Piston Ring Expander A—JDE94
B—JDE135

Remove and install piston rings.



S55,JDE94 -19-27APR92

RG6244 -UN-23MAR92

Piston Ring Compressor JDE97

Compress rings while installing pistons.



S53,JDE97 -19-14JUN89

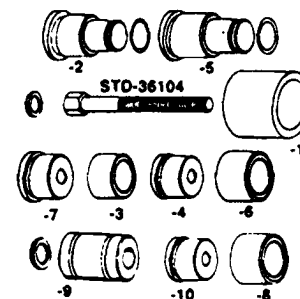
RG5031 -UN-23AUG88

Connecting Rod Bushing Service Set JDE98A

Remove and install connecting rod bushings.

Set consists of:

- 1—Cup JDE98-1
- 2—Driver JDE98-2
- 3—Pilot JDE98-3
- 4—Driver JDE98-4
- 5—Driver JDE98-5
- 6—Pilot JDE98-6
- 7—Driver JDE98-7
- 8—Cup JDE98-8
- 9—Pilot JDE98-9
- 10—Remover Bushing JDE98-10
- Forcing Screw STD36104



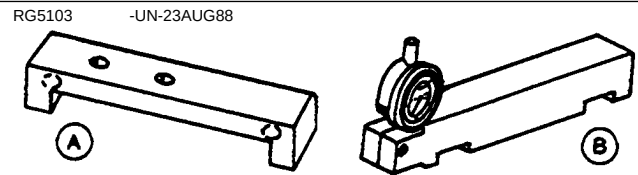
S53,JDE98A -19-13MAR92

RG5078 -UN-23AUG88

Piston and Liner Height Gauge A-JDG451 or
B-KJD10123

Measure piston and liner heights.

*NOTE: A dial indicator is not supplied with JDG451. Use
D17526CI (English, in.) or D17527CI (Metric,
mm) Dial Indicator with JDG451.*



RG,JDG451 -19-29OCT92

Tap JDG682

Clean cylinder head mounting threads on top deck of
cylinder block.

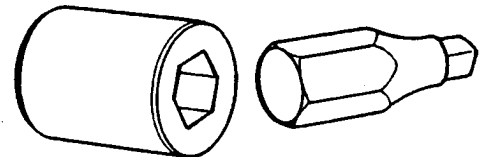
RG5100 -UN-23AUG88



S55,JDG682 -19-24APR92

Oil Galley Plug Tool JDG782

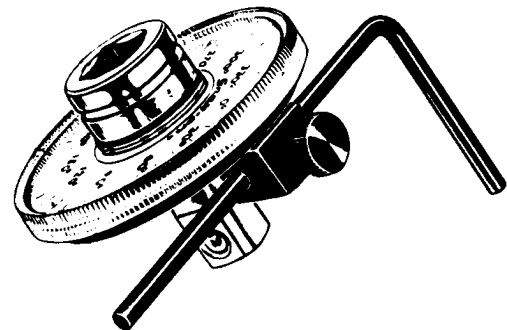
Used to remove and install oil galley plug.



RG,JDG782 -19-02APR93

Torque Angle Gauge JT05993

Used to TORQUE-TURN flanged-head cylinder head and
connecting rod cap screws.



RG,JT05993 -19-22AUG91

RG6612 -UN-29JAN93

10
3

RG5698 -UN-27AUG90

SERVICE EQUIPMENT AND TOOLS

NOTE: Order tools from the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC). Some tools may be available from a local supplier.

Name	Use
D05012ST Precision "Bevelled Edge" Straightedge	Check cylinder block flatness
Piston Ring Groove Cleaner	Clean piston ring grooves
Cylinder Bore Ridge Reamer	Remove carbon from liner bore

RG,CTM61,G10,6 -19-29OCT92

OTHER MATERIAL

Name	Use
AR54749 Soap Lubricant	Coat O-rings on cylinder liners.
PLASTIGAGE	Determine connecting rod bearing-to-journal oil clearance.

S11,2010,BS -19-29OCT92

CYLINDER BLOCK, LINERS, PISTONS, AND RODS SPECIFICATIONS

ITEM	SPECIFICATION	WEAR LIMIT
Maximum Piston Protrusion Above Block Deck	0.762 mm (0.030 in.)	—
Piston Oil Control Ring-to- Groove Clearance	0.061—0.102 mm (0.0024—0.0040 in.)	0.165 mm (0.0065 in.)
Piston OD at 10.00 mm (0.394 in.) from Bottom of Skirt:		
matched with Liners marked "A" or "D" . .	130.040—130.050 mm (5.1197—5.1201 in.)	—
matched with Liners marked "B" or "E" . .	130.051—130.069 mm (5.1201—5.1208 in.)	—
matched with Liners marked "C" or "F" . .	130.070—130.080 mm (5.1209—5.1213 in.)	—
Piston-to-Liner Clearance at 10.00 mm (0.394 in.) from Bottom of Skirt:		
Liners marked "A" or "D"	0.115—0.135 mm (0.0045—0.0053 in.)	0.15 mm (0.006 in.)
Liners marked "B" or "E"	0.106—0.144 mm (0.0042—0.0057 in.)	0.15 mm (0.006 in.)
Liners marked "C" or "F"	0.115—0.135 mm (0.0045—0.0053 in.)	0.15 mm (0.006 in.)
Piston Pin OD	50.772—50.787 mm (1.9989—1.9995 in.)	—
Piston Pin Bore ID in Piston	50.793—50.801 mm (1.9997—2.0000 in.)	—
Piston Ring End Gap:*		
No. 1 Compression Ring	0.43—0.69 mm (0.017—0.027 in.)	—
No. 2 Compression Ring	1.03—1.27 mm (0.040—0.050 in.)	—
No. 3 Oil Control Ring	0.33—0.64 mm (0.013—0.025 in.)	—
Cylinder Liner ID at 75 mm (2.95 in.) from top (average of two measurements):		
Liners marked "A" or "D"	130.165—130.175 mm (5.1246—5.1250 in.)	—
Liners marked "B" or "E"	130.175—130.195 mm (5.1250—5.1258 in.)	—
Liners marked "C" or "F"	130.195—130.205 mm (5.1258—5.1262 in.)	—
Cylinder Liner Thickness	7.26—7.42 mm (0.286—0.292 in.)	—
Cylinder Liner Packing Step Dimension	2.13—2.29 mm (0.084—0.090 in.)	—
Cylinder Liner Height Above Block	0.025—0.102 mm (0.001—0.004 in.)	—
Cylinder Liner Maximum Out-of Round		0.05 mm (0.002 in.)
Cylinder Liner Wear or Taper in Ring Travel Area (Maximum)		0.038 mm (0.0015 in.)
Liner Flange Thickness	9.538—9.563 mm (0.3755—0.3765 in.)	—

* When measuring piston ring end gap, the No. 2 compression ring gap should be greater than the No. 1 compression ring.

RG,CTM61,G10,1 -19-06MAY93

CYLINDER BLOCK, LINERS, PISTONS, AND RODS SPECIFICATIONS—CONTINUED

ITEM	SPECIFICATION	WEAR LIMIT
Liner Shim Thickness:		
R81276	0.05 mm (0.002 in.)	—
R81277	0.10 mm (0.004 in.)	—
Maximum Shim Thickness Per Cylinder . . .	0.10 mm (0.004 in.)	—
Cylinder Liner Counterbore Depth	9.46—9.51 mm (0.3725—0.3745 in.)	—
Lower Block Bore Diameter for Seating Liners	140.465—140.515 mm (5.530—5.532 in.)	— —
Upper Block Bore Diameter for Seating Liners	145.845—145.895 mm (5.742—5.744 in.)	— —
Outer Diameter of Liner at Upper Bore . . .	145.795—145.845 mm (5.740—5.742 in.)	— —
Outer Diameter of Liner at Lower Bore . . .	140.398—140.448 mm (5.527—5.529 in.)	— —
Liner-to-Block Clearance at Lower Bore . . .	0.014—0.114 mm (0.0005—0.0045 in.)	— —
Liner-to-Block Clearance at Upper Bore . . .	0.00—0.10 mm (0.000—0.004 in.)	— —
Cylinder Block Top Deck Maximum Out-of-Flat	0.10 mm (0.004 in.)	
Centerline of Main Bearing Bore-to-Top Deck of Cylinder Block	374.57—374.73 mm (14.747—14.753 in.)	—
Camshaft Bushing Bore in Block	69.987—70.013 mm (2.7554—2.7564 in.)	—
Cam Follower Bore in Block	34.976—35.027 mm (1.3770—1.3790 in.)	—
Camshaft Bushing ID	67.076—67.102 mm (2.6408—2.6418 in.)	—
Centerline of Piston Pin Bore-to-Crankshaft Bore in Rod	228.55—228.65 mm (8.998—9.002 in.)	—
Connecting Rod Pin Bushing Bore without Bushing	55.529—55.555 mm (2.1862—2.1872 in.)	—
Press Fit of Bushing in Rod Pin Bore	0.100—0.163 mm (0.0039—0.0064 in.)	—

RG,CTM61,G10,2 -19-05MAY93

CYLINDER BLOCK, LINERS, PISTONS, AND RODS SPECIFICATIONS—CONTINUED

ITEM	SPECIFICATION	WEAR LIMIT
ID of Installed Rod Pin Bushing before Boring	50.729—50.781 mm (1.9972—1.9992 in.)	—
Connecting Rod Pin Bushing ID after Boring	50.805—50.830 mm (2.0002—2.0012 in.)	—
Connecting Rod Pin-to-Bushing Oil Clearance	0.017—0.059 mm (0.0007—0.0023 in.)	0.076 mm (0.0030 in.)
Connecting Rod Bearing Assembled ID . . .	88.93—88.98 mm (3.501—3.503 in.)	—
Connecting Rod Bearing Bore without Bearing	93.76—93.79 mm (3.6915—3.6925 in.)	—
Crankshaft Rod Journal OD	88.844—88.874 mm (3.4980—3.4990 in.)	—
Bearing-to-Journal Oil Clearance	0.06—0.13 mm (0.002—0.005 in.)	0.15 mm (0.006 in.)
Connecting Rod Bore Out-of-Round without Bearing	0.038 mm (0.0015 in.)	

RG,CTM61,G10,3 -19-05MAY93

CYLINDER BLOCK, LINERS, PISTONS, AND RODS SPECIFICATIONS—CONTINUED**TORQUES**

Connecting Rod Caps:	
Initial (Blind Hole Cap Screws)	27 N·m (20 lb-ft)
Final (All Cap Screws)	75 N·m (55 lb-ft) plus 90°—100°
Piston Cooling Orifices	11 N·m (8 lb-ft) (97 lb-in.)
Cylinder Liner Cap Screws (for checking liner standout)	68 N·m (50 lb-ft)
Oil Pressure Regulating Housing	47 N·m (35 lb-ft)
Block Heating Element Nut	34 N·m (25 lb-ft)

RG,CTM61,G10,33-19-02APR93

PRELIMINARY LINER, PISTON, AND ROD CHECKS

• Scuffed or Scored Pistons:

Insufficient lubrication.
Insufficient cooling.
Improper piston-to-liner clearance.
Coolant leakage in crankcase.
Misaligned or bent connecting rod.
Improperly installed piston.
Low oil level.
Improper operation.
Incorrect connecting rod bearing clearance.
Carbon build-up in ring groove.
Improper break-in.
Worn piston.
Contaminated oil.
Distorted cylinder liner.

• Worn or Broken Compression Rings:

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

• Clogged Oil Control Ring:

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

• Dull Satin Finish and Fine Vertical Scratches on Rings:

Dirt and abrasive in air intake system.

• Stuck Rings:

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

• Cylinder Liner Wear and Distortion:

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

• Warped Cylinder Block:

Insufficient cooling.

• 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.

REMOVE PISTONS AND CONNECTING RODS

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

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



RG6209 -UN-06MAR92

1. Drain all coolant and engine oil.
2. Disconnect turbocharger oil inlet line at oil filter housing or turbocharger. See DISCONNECT TURBOCHARGER OIL INLET LINE in Group 03.

NOTE: If engine is to be completely disassembled, follow 6101 ENGINE DISASSEMBLY SEQUENCE in Group 04.

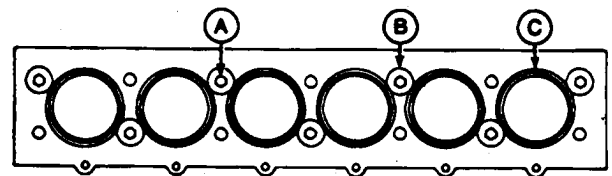
3. Remove cylinder head. (See REMOVE CYLINDER HEAD in Group 05.)
4. Remove oil pan and oil pump. (See REMOVE OIL PUMP in Group 20.)

RG,CTM61,G10,26-19-02APR93

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

NOTE: Do not rotate crankshaft with cylinder head removed unless liners are bolted down. Bolt liners down before removing pistons.

IMPORTANT: Cap screws and washers must be tightened to the above specification to achieve an accurate reading when checking liner standout (height above block), as detailed later in this group.



RG3819 -UN-07DEC88

RG,CTM61,G10,27-19-02APR93

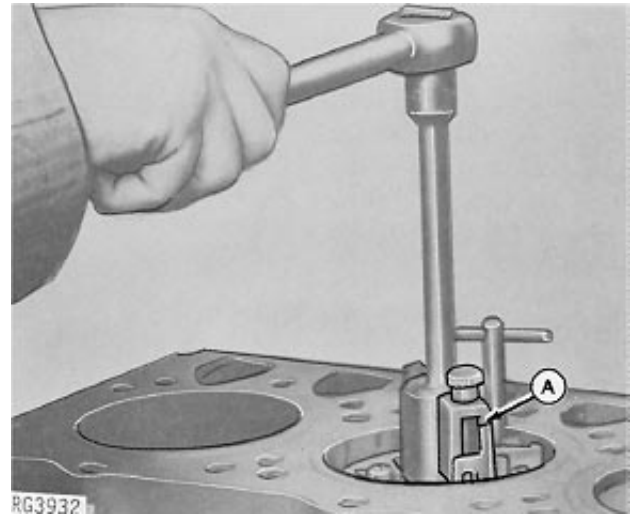
6. Remove carbon or ridge from liner bore with a scraper or ridge reamer (A) before removing pistons. Use compressed air to remove loose material from cylinders.

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

—The crosshatch honing pattern is not visible immediately below the top ring turn around area.

—Liners are pitted or contain deep vertical scratches that can be detected by the fingernail.

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



-UN-07DEC88

RG3932

RG,CTM61,G10,28-19-02APR93

NOTE: Connecting rod bearing clearance should be measured before removing piston/rod assembly.

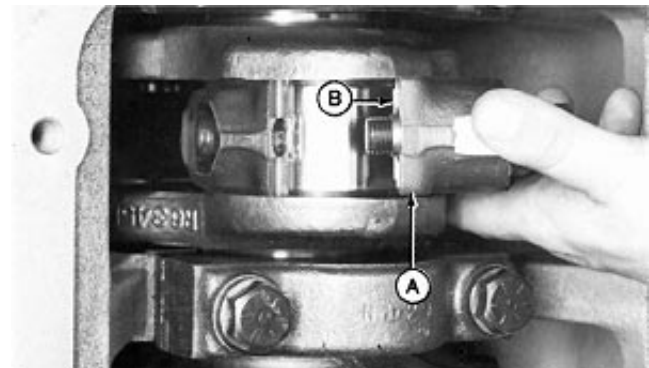
Rod bearing-to-journal oil clearance can be checked with PLASTIGAGE if rod is connected to crankshaft. If rod is out of engine, measure ID of assembled connecting rod bearings and compare with OD of crankshaft journal.

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

IMPORTANT: Using pneumatic wrenches may cause thread damage.

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

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



-UN-07DEC88

RG3820

RG,CTM61,G10,29-19-02APR93

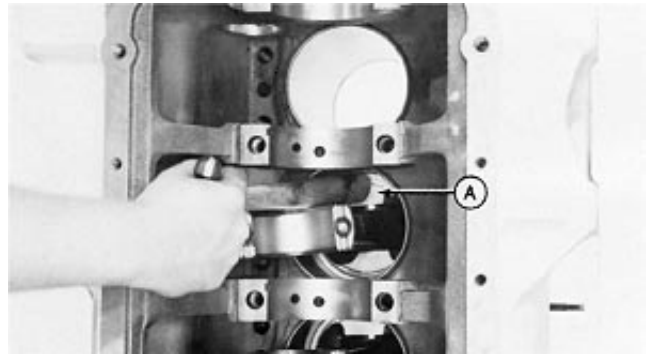
NOTE: Crankshaft shown removed for photographic purposes only. It is not necessary to remove crankshaft for piston removal.

8. Gently tap piston (A) through top of cylinder block from the bottom.

NOTE: Once piston rings have cleared cylinder liner, hold on to piston to prevent piston from dropping.

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



RG3821 -UN-07DEC88

RG,CTM61,G10,30-19-02APR93

9. Remove piston snap rings (A), and remove piston pins (B) and connecting rods.

NOTE: Discard snap rings. DO NOT REUSE.



RG3171 -UN-28JUL89

RG,CTM61,G10,31-19-02APR93

MEASURE CYLINDER LINER STANDOUT (HEIGHT ABOVE BLOCK)

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

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



RG6062 -JUN-21JAN92

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

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

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

4. Replace any liner that does not meet standout specification at any location and measure liner flange thickness. (See INSTALL LINER SHIMS—IF REQUIRED, later in this group.) Use liner shims or replace piston/liner sets as necessary.

LINER HEIGHT SPECIFICATION

Liner Height Above Block 0.025—0.102 mm
(0.0010—0.0040 in.)

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

RG,CTM61,G10,5 -19-05MAY93

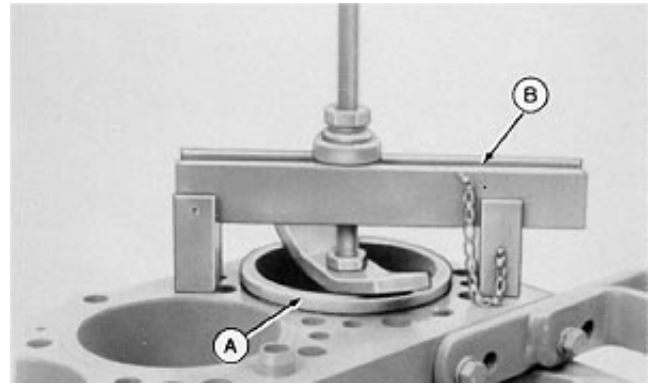
REMOVE CYLINDER LINERS

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

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

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

3. Use D01062AA or D01073AA Cylinder Liner Puller (B) to remove cylinder liner (A).

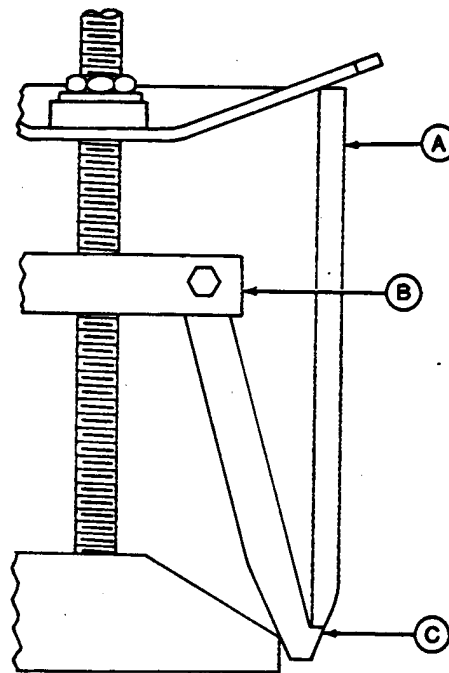


R24531 -UN-13DEC88

S11,2010,IX -19-02APR93

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.



RG1179 -UN-13DEC88

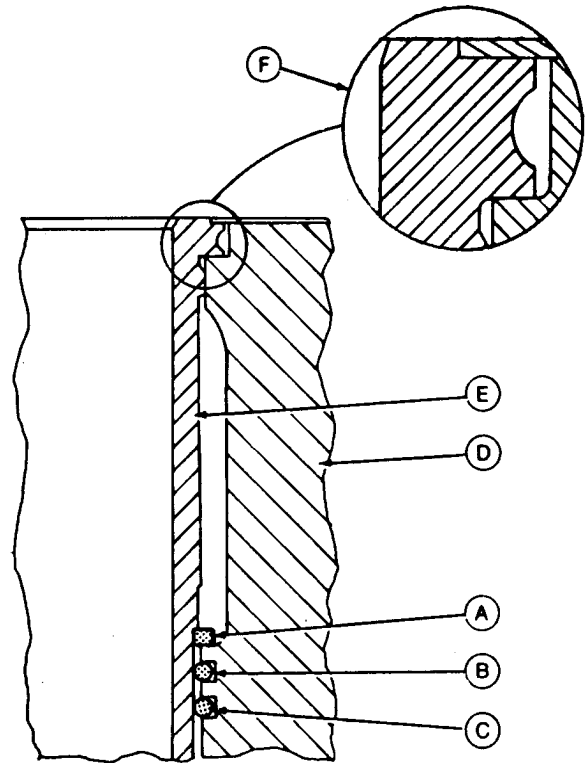
S11,0402,AK -19-02APR93

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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*



* On directed coolant engines only. For a complete explanation of directed coolant engines, see *HOW THE COOLING SYSTEM WORKS* in Group 105.

RG,CTM61,G10,7 -19-05MAY93

RG6668 -UN-13MAR93

REMOVE PISTON RINGS

1. Remove piston rings (B) using JDE94 Piston Ring Expander (A). Discard rings.

NOTE: JDE135 Universal Piston Ring Expander (not shown) may also be used.



RG,CTM61,G10,21-19-02APR93

R26155 -UN-09FEB90

CLEAN PISTONS

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

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

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

DO NOT bead blast ring groove areas.

2. Clean pistons by any of the following methods:

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

If cleaning with hot water and liquid detergent, soak pistons in a 50 per cent solution of liquid household detergent and hot water for 30 to 60 minutes. Use a stiff bristle brush to loosen carbon residue. Dry with compressed air.



RG6088 -UN-27JAN92

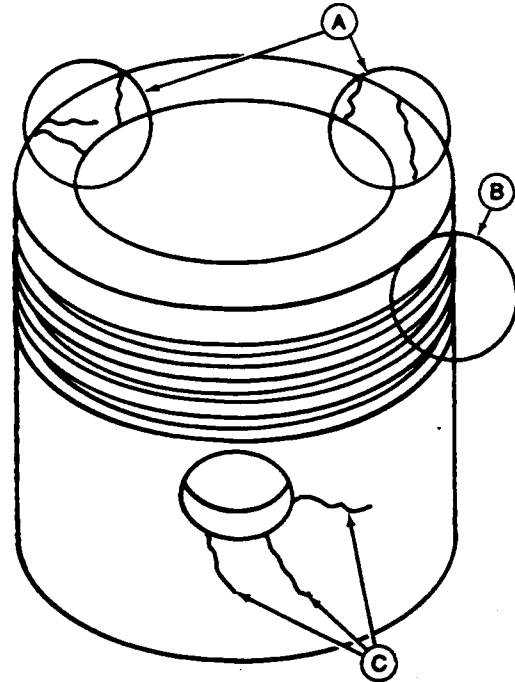
RG,CTM61,G10,8 -19-02APR93

VISUALLY INSPECT PISTONS

1. 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.



(Defects Exaggerated)

RG3326 -UN-13DEC88

RG,CTM61,G10,10-19-29OCT92

CLEAN CYLINDER LINERS

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

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

2. Thoroughly clean liner I.D. with a 50 per cent solution of hot water and liquid detergent.

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

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

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

RG,CTM61,G10,9 -19-02APR93

VISUALLY INSPECT CYLINDER LINERS

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.

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

Replace liner if:

—Depth of any pit is one-half or more of liner thickness (C).

—Depth of erosion is one-half or more of the packing step (D).

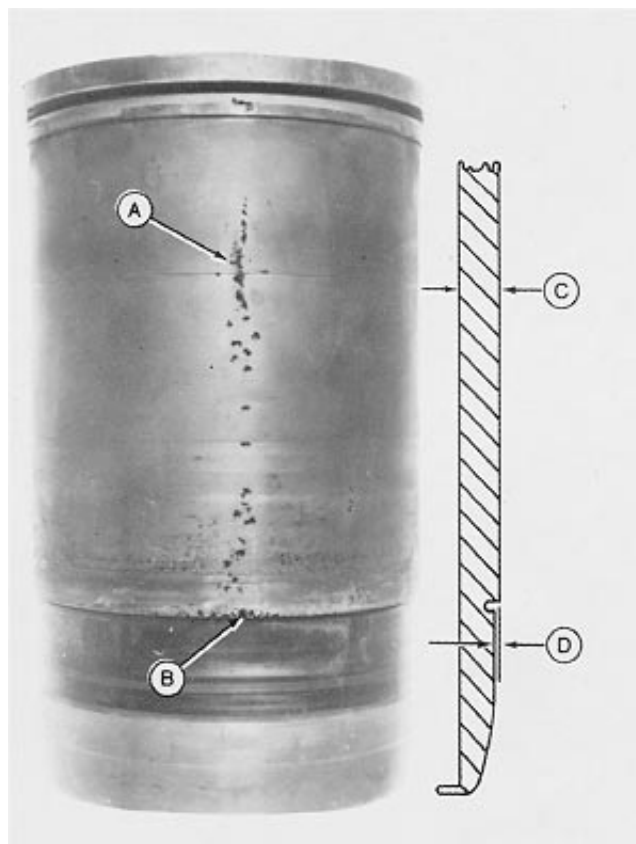
LINER SPECIFICATIONS

Cylinder Liner Thickness 7.26—7.42 mm
(0.286—0.292 in.)

Packing Step Dimension 2.13—2.29 mm
(0.084—0.090 in.)

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

If no defects are found, proceed to next step.



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

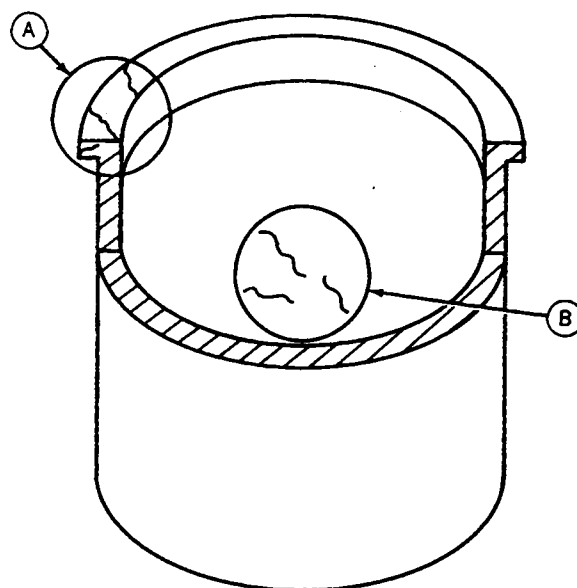
RG,CTM61,G10,13-19-02APR93

2. Visually examine liner ID. Replace piston and liner if:

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

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

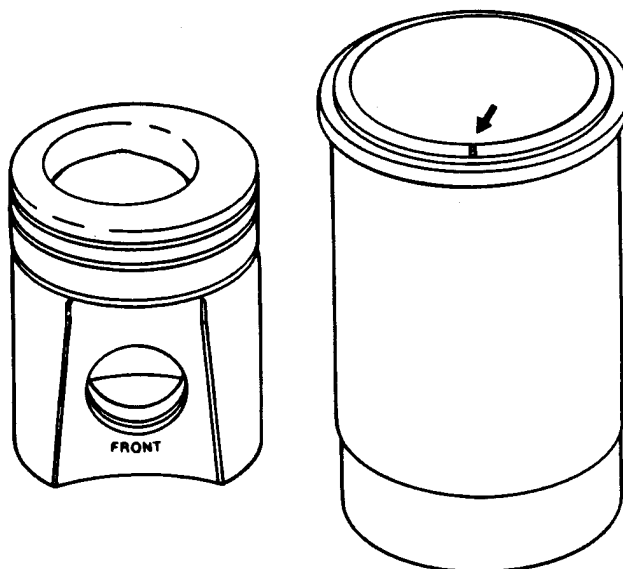
NOTE: Inspect block for cracks or erosion in the O-ring packing areas. See *INSPECT AND CLEAN CYLINDER BLOCK*, later in this group.



(Exaggerated defects)

RG,CTM61,G10,14-19-29OCT92

PISTON AND LINER IDENTIFICATION MARKINGS



RG6125 -UN-06FEB92

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NOTE: Do not confuse piston and liner identification markings with the four-digit liner manufacturing date code. See *CYLINDER LINER MANUFACTURING DATE CODE EXPLANATION*, later in this group.

IMPORTANT: Pistons and liners are selectively fitted to maintain piston-to-liner clearance. Always keep matched pistons and liners together as a set.

Pistons and liners are marked as follows:

• Cylinder Liners

Engine Serial No. (—500277) liners are marked “A”, “B”, or “C”.

Engine Serial No. (500278—) liners are marked “D”, “E”, or “F”.

• Pistons

Engine Serial No. (—500277) pistons do not have any identification markings.

Engine Serial No. (500278—) pistons are marked “G”, “H”, or “J”.

Liners are permanently marked for identification purposes. Current service pistons are ink stamped “G”, “H”, or “J”. Service piston and liner sets are matched as follows:

LINER MARKING	PISTON MARKING
“A”	no marking
“B”	no marking
“C”	no marking
“D”	“G”
“E”	“H”
“F”	“J”

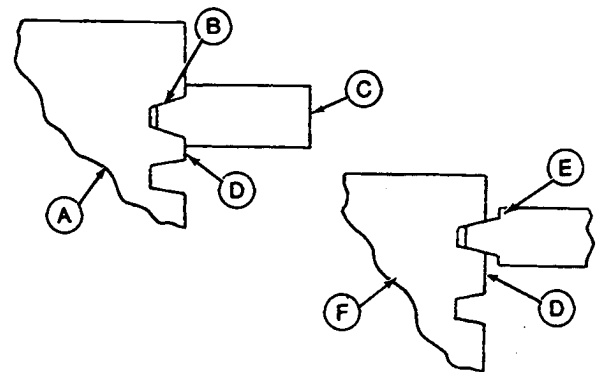
CHECK PISTON RING GROOVE WEAR

1. Use JDE55 Ring Groove Wear Gauge (C) to check wear of keystone ring grooves (B). Gauge shoulders (E) should not contact ring land (D) of piston. If ring grooves are worn (A), replace piston and liner as a set. If ring grooves are good (F), proceed to next step.

- A—Piston with Worn Ring Groove
- B—Keystone Ring Groove
- C—JDE55 Ring Groove Wear Gauge
- D—Ring Land
- E—Gauge Shoulder
- F—Piston with Good Ring Groove



RG6089 -UN-27JAN92



R 24201

R24201 -UN-13DEC88

RG,CTM61,G10,11-19-05MAY93

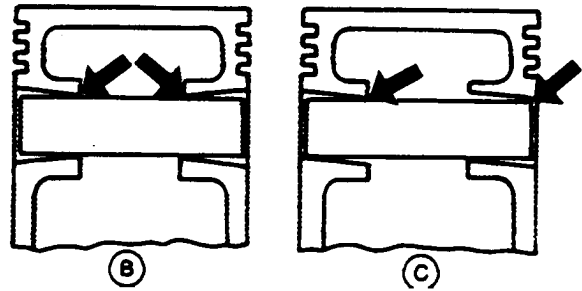
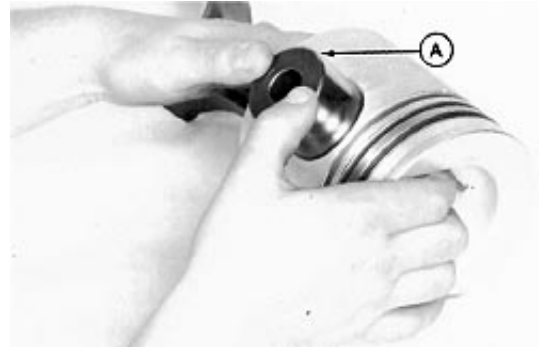
INSTALL PISTON PIN IN PISTON

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

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

PISTON PIN/BORE SPECIFICATIONS

Piston Pin OD	50.772—50.787 mm (1.9989—1.9995 in.)
Piston Pin Bore ID	
in Piston	50.793—50.801 mm (1.9997—2.0000 in.)



-UN-13DEC88

RG3747

-UN-13DEC88

RG4984

RG,CTM61,G10,12-19-05MAY93

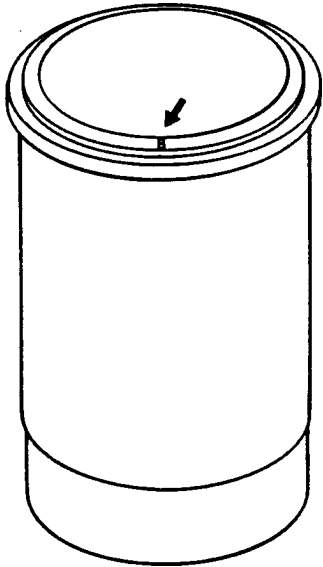
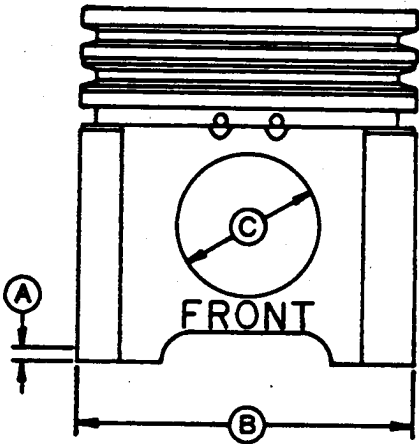
MEASURE PISTON SKIRT OD

- 1. Measure piston skirt diameter (B) at right angles to piston pin bore (C) at 10.00 mm (0.394 in.) from bottom of piston skirt (A). Record measurements.
- 2. Measure cylinder liner, as directed later in this group, and compare with piston measurement.

NOTE: Engine Serial No. (—500277) pistons did not have any identification markings.

PISTON SKIRT OD SPECIFICATIONS

Piston Skirt OD:	
matched with	
Liners marked "A" or "D"	130.040—130.050 mm (5.1197—5.1201 in.)
matched with	
Liners marked "B" or "E"	130.051—130.069 mm (5.1201—5.1208 in.)
matched with	
Liners marked "C" or "F"	130.070—130.080 mm (5.1209—5.1213 in.)



RG,CTM61,G10,15-19-02APR93

RG5232 -UN-13DEC88

RG6126 -UN-06FEB92

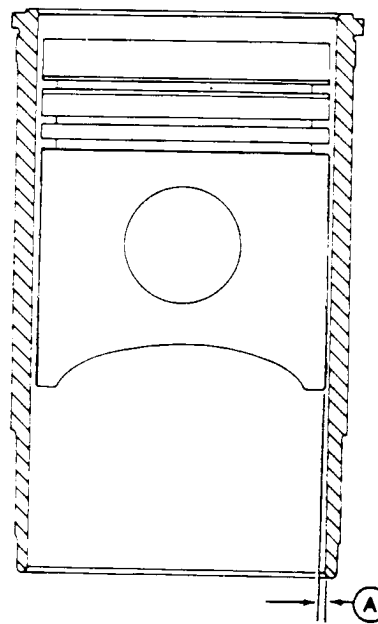
DETERMINE PISTON-TO-LINER CLEARANCE

1. Place piston (without rings) in matched liner.
2. Compare liner ID measurement with piston skirt OD measurement to determine piston-to-liner clearance (A).
Piston-to-liner specifications are:

LINER MARKING	PISTON MARKING	PISTON-TO-LINER CLEARANCE
"A" or "D"	no marking or marked "G"	0.115—0.135 mm (0.0045—0.0053 in.)
"B" or "E"	no marking or marked "H"	0.106—0.144 mm (0.0042—0.0057 in.)
"C" or "F"	no marking or marked "J"	0.115—0.135 mm (0.0045—0.0053 in.)
Maximum Wear Tolerance		0.15 mm (0.006 in.)

Replace piston and liner as a matched set if clearance exceeds limit.

NOTE: *Pistons and liners require replacement if liner taper or out of roundness, top-to-bottom in ring travel area is more than 0.05 mm (0.002 in.). Recheck piston-to-liner measurements with liners removed. See MEASURE CYLINDER LINERS, later in this group.*



RG5582 -UN-11JUL89

RG,CTM61,G10,16-19-02APR93

MEASURE OIL CONTROL RING GROOVE

1. Check oil control ring-to-groove clearance by installing a new ring in groove.
2. Measure clearance with a feeler gauge at several points. Compare measurements with specifications given below.

OIL CONTROL RING-TO-GROOVE CLEARANCE SPECIFICATIONS

New Part Clearance 0.061—0.102 mm
(0.0024—0.0040 in.)

Maximum Serviceable Clearance 0.165 mm
(0.0065 in.)

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



RG5234 -JUN-13DEC88

RG,CTM61,G10,17-19-02APR93

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MEASURE CYLINDER LINERS

IMPORTANT: ALWAYS measure liners at room temperature.

A—Measure liner bore parallel to piston pin at top end of ring travel.

B—Measure bore in same position at bottom end of ring travel.

C—Measure bore at right angle to piston pins at top end of ring travel.

D—Measure bore in same position at bottom end of ring travel.

Compare measurements A, B, C, and D to determine if liner is tapered or out-of-round.

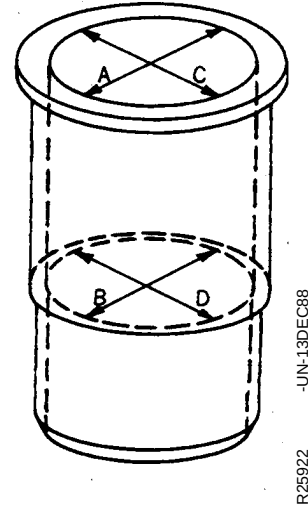
Compare liner I.D. with piston O.D.

CYLINDER LINER SPECIFICATIONS

Maximum Wear or Taper in Ring Travel Area	0.038 mm (0.0015 in.)
Maximum Liner Out-of-Round	0.05 mm (0.002 in.)
Maximum Piston-to-Liner Clearance	0.15 mm (0.006 in.)

NOTE: Replace piston and liner (as a set), if they exceed wear specifications given.

R25922N



S11,2510,Y -19-05MAY93

DEGLAZE CYLINDER LINERS

1. Secure cylinder liner in a holding fixture. See Dealer Fabricated Tools, Group 199 for assembly of holding fixture.

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

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

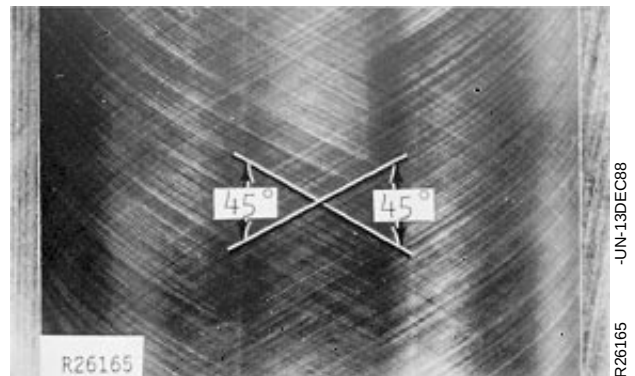


S11,2510,K -19-13MAR92

R26164 -UN-13DEC88

3. Use D17006BR Flex-Hone according to instructions supplied with tool to obtain a 45-degree cross-hatch pattern.

Thoroughly clean liners after deglazing. See CLEAN CYLINDER LINERS, earlier in this group.



RG,CTM61,G10,22-19-02APR93

R26165 -UN-13DEC88

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25

INSPECT AND MEASURE CONNECTING ROD BEARINGS

Inspect rod bearings for damage or wear.

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

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

1. With crankshaft removed, measure connecting rod journal OD at several points.
2. Install connecting rod cap (A) on rod (B) with bearings (C) in correct position.
3. Tighten rod cap-to-rod using TORQUE-TURN method. (See USE TORQUE-TURN METHOD FOR PROPER TORQUE, as described later in this group.)



RG3823 -UN-13DEC88

4. Using an inside micrometer (A), measure assembled ID of bearing.

5. Subtract OD of each crankshaft journal from ID of each respective rod bearing to obtain oil clearance.

6. Compare measurements with the specifications given below.

CONNECTING ROD BEARING-TO-JOURNAL SPECIFICATIONS

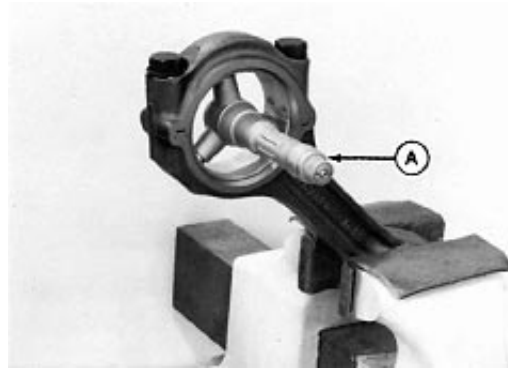
Crankshaft Rod Journal OD 88.844—88.874 mm
(3.4980—3.4990 in.)

Connecting Rod Bearing Assembled ID 88.93—88.98 mm
(3.501—3.503 in.)

Bearing-to-Journal Oil Clearance 0.06—0.13 mm
(0.002—0.005 in.)

Maximum Serviceable Clearance 0.15 mm
(0.006 in.)

7. Inspect connecting rod bearings for wear or damage. If bearings are worn or not within specification, replace both connecting rod bearing and rod pin bearing.



RG3824 -UN-13DEC88

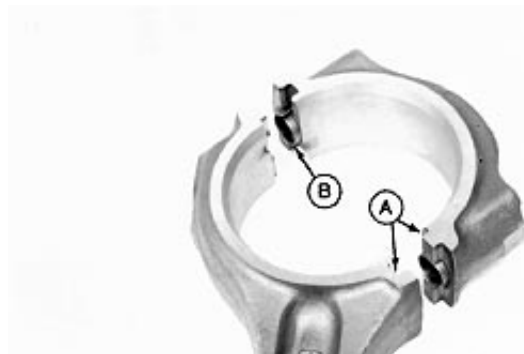
S11,2510,H -19-02APR93

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27

INSPECT ROD AND CAP

1. Inspect rod and cap for wear or damage, such as chips or cracks in the area of the tongue-and-groove joints (A).

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



RG3749 -UN-13DEC88

S11,0402,AE -19-13MAR92

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

4. Install cap WITHOUT bearing inserts.

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. Tighten cap screws to 75 N·m (55 lb-ft), then tighten each cap screw an additional 90°—100°. (See USE TORQUE-TURN METHOD FOR PROPER TORQUE, later in this group.)



-UN-13DEC88

RG4982

S11,2010,JS -19-23AUG91

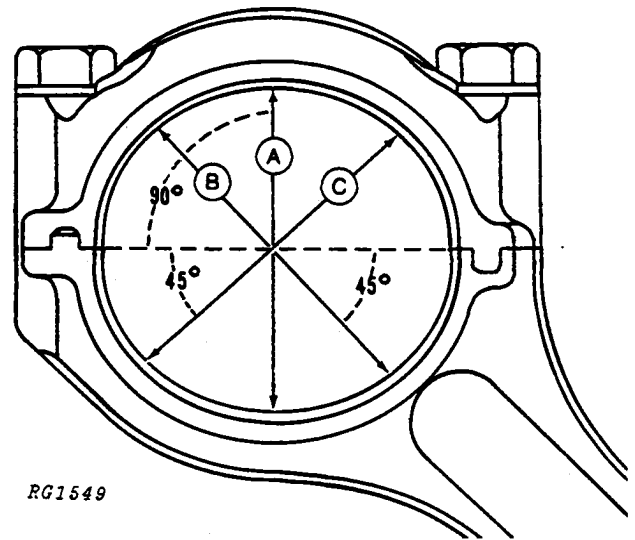
6. Using an inside micrometer, measure rod bore at center of bore and record measurements as follows:

- A. At right angle to rod/cap joint.
- B. At 45 degrees left of measurement "A".
- C. At 45 degrees right of measurement "A".

ROD BORE SPECIFICATIONS

Rod Bore
(for crankshaft journal bearing) 93.76—93.79 mm
(3.6915—3.6925 in.)

7. Compare the measurements. If difference between the greatest and least measurement is more than 0.038 mm (0.0015 in.), the rod and cap are out of round. Replace both connecting rod and cap.



RG1549

-UN-13DEC88

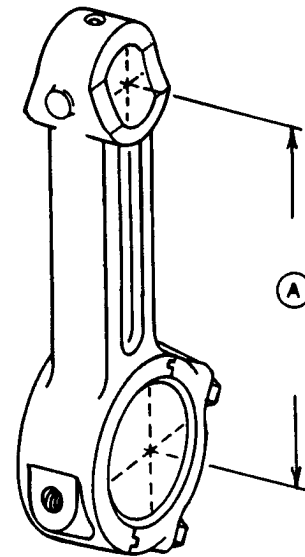
RG1549

S11,2010,FO -19-05MAY93

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

CENTERLINE OF PISTON BORE-TO-CRANKSHAFT BORE SPECIFICATION

New part 228.55—228.65 mm (8.998—9.002 in.)



RG,CTM61,G10,25-19-05MAY93

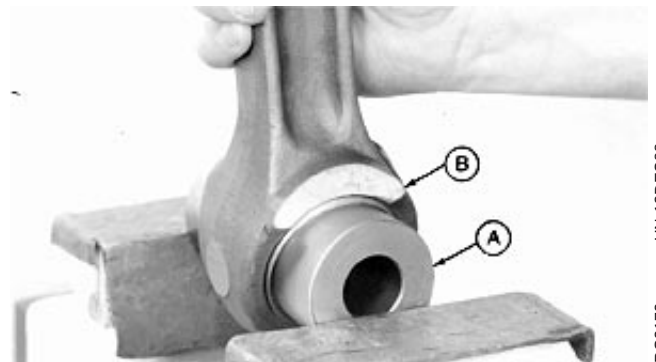
RG6123 -UN-06FEB92

RG6123

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29

INSPECT PISTON PINS AND BUSHINGS

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



S11,2010,DM -19-12APR93

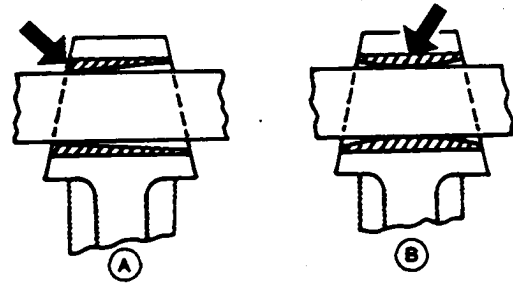
RG3172 -UN-13DEC88

RG3172

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 bellmouthed (B).

5. Inspect piston pin bushing lubrication hole in rod for damage, excessive wear or contaminants.

6. Measure pin bushing ID for specified clearance with pin OD.



PISTON PIN BORE SPECIFICATIONS

Piston Pin OD	50.772—50.787 mm (1.9989—1.9995 in.)
Piston Pin Bore ID in Piston	50.793—50.801 mm (1.9997—2.0000 in.)
Rod Pin Bore Without Bushing	55.529—55.555 mm (2.1862—2.1872 in.)
ID of Installed Rod Pin Bushing (Before Boring)	50.729—50.781 mm (1.9972—1.9992 in.)
ID of Installed Rod Pin Bushing (After Boring)	50.805—50.830 mm (2.0002—2.0012 in.)
Rod Pin-to-Bushing Oil Clearance	0.017—0.059 mm (0.0007—0.0023 in.)
Maximum Serviceable Clearance	0.076 mm (0.0030 in.)
Press Fit of Bushing in Rod Pin Bore	0.100—0.163 mm (0.0039—0.0064 in.)

7. If necessary, remove and replace piston pin bushing. See REMOVE PISTON PIN BUSHING, as described later in this group.

S11,2510,AN -19-05MAY93

RG4924 -UN-06APR89

REMOVE PISTON PIN BUSHING

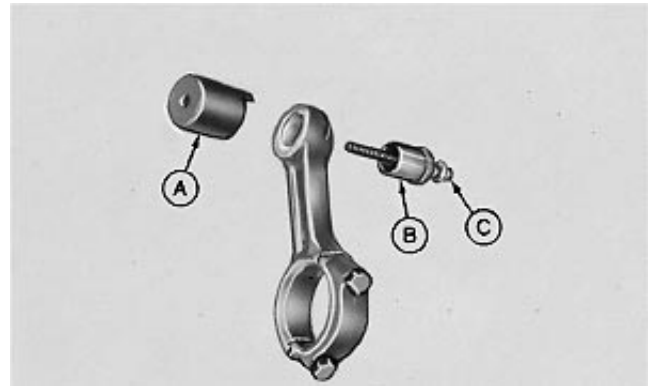
IMPORTANT: Do not use any power tools to remove or install piston pin bushing.

1. Remove the used pin bushing with the JDE98A Connecting Rod Bushing Service Set.

Use the following tools from tool set:

- A—JDE98-8 Cup
- B—JDE98-10 Driver
- C—STD36104 Forcing Screw

IMPORTANT: Use care to properly align the JDE98-10 Driver with bushing so that the connecting rod bushing bore is not damaged.



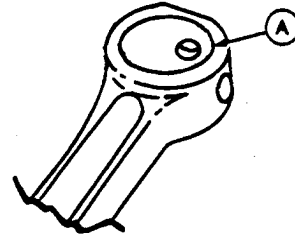
RG4723 -JUN-09APR90

S55,2510,D -19-02APR93

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CLEAN AND INSPECT PISTON PIN BUSHING BORE IN CONNECTING ROD

1. Clean rod bushing bore using a medium grit emery cloth, as burrs will distort bushing. Install bushing on side opposite rod burr.
2. If necessary, file a slight chamfer (A) around bore to remove any sharp edges. Chamfer will also aid in the bushing installation.
3. Measure rod bushing bore in three or more places approximately 45° apart.



CONNECTING ROD PIN BUSHING SPECIFICATIONS

Connecting Rod Pin Bushing Bore 55.529—55.555 mm
(2.1862—2.1872 in.)

Press Fit of Bushing in Rod Pin Bore 0.100—0.163 mm
(0.0039—0.0064 in.)

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

RG5227 -UN-13DEC88

S11,2510,AZ -19-02APR93

INSTALL PISTON PIN BUSHING IN CONNECTING ROD

1. Lubricate connecting rod bushing bore with clean engine oil.
2. Assemble JDE98-10 Driver (B) with JDE98-9 Pilot (C). Install new bushing (E) onto driver. Lubricate OD of bushing. Install and lubricate STD36104 Forcing Screw threads (D).
3. Assemble JDE98-6 Pilot (F) onto driver.

NOTE: Be sure lubrication holes (E, lower photo) in bushing and rod are properly aligned.

4. Engage forcing screw threads with threads in JDE98-8 Cup (A) to install new bushing.

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

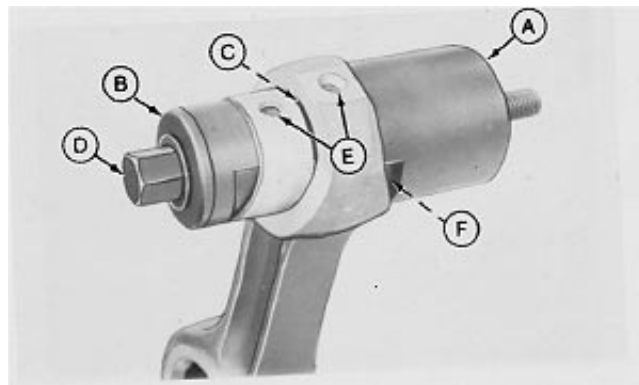
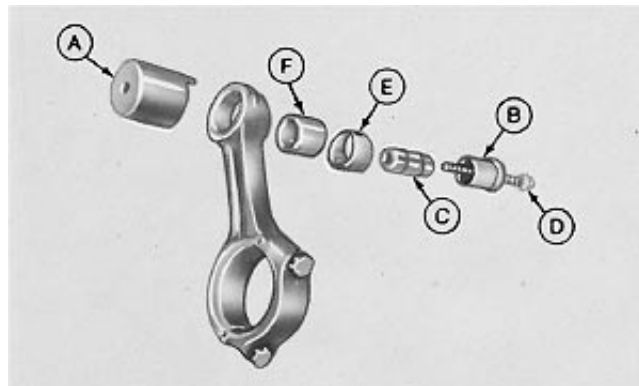
5. If necessary, bore ID of newly installed bushing. Distance from centerline of rod's piston pin bore-to-crankshaft bore must be within specification.

CONNECTING ROD PIN BUSHING SPECIFICATION

Connecting Rod Pin Bushing ID
(after Boring) 50.805—50.830 mm
(2.0002—2.0012 in.)

Centerline of Piston Pin Bore-to-Crankshaft
Bore in Rod 228.55—228.65 mm
(8.998—9.002 in.)

6. Check rod pin-to-bushing clearance. See CLEAN AND INSPECT PIN BUSHING BORE IN CONNECTING ROD, as described earlier in this group. Replace rod pin as required.



A—JDE98-8 Cup
B—JDE98-10 Driver
C—JDE98-9 Pilot
D—STD36104 Forcing Screw
E—Pin Bushing
F—JDE98-6 Pilot

RG.CTM61.G10.32-19-05MAY93

RG4722 -UN-26JAN90

RG7815311 -UN-09JAN90

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COMPLETE DISASSEMBLY OF CYLINDER BLOCK (IF REQUIRED)

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

1. Remove crankshaft and pulley if not previously removed. (Group 15.)
2. Remove all remaining lubrication system components. (Group 20.) Remove starting motor.
3. Remove water pump and all remaining cooling system components. (Group 25.)

4. Remove timing gear train and camshaft. (Group 16).

5. Remove fuel injection pump and fuel filter assembly (Group 35.)

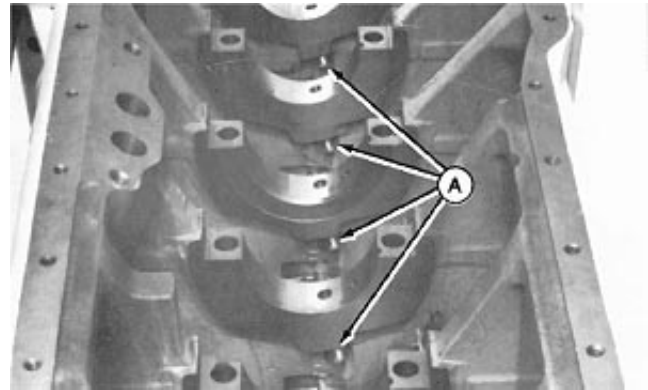
6. Remove all components (including piston cooling orifices, water galley plugs, oil galley plugs, bushings, and engine serial number plate) before inspecting and cleaning cylinder block. Use JDG782 Oil Galley Plug Tool to remove and install galley plugs. See REMOVE AND CLEAN PISTON COOLING ORIFICES, later in this group, for servicing piston cooling orifices.

S55,2510,F -19-02APR93

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.



RG3752 -UN-14DEC88

S11,2010,KF -19-13MAR92

INSPECT AND CLEAN CYLINDER BLOCK

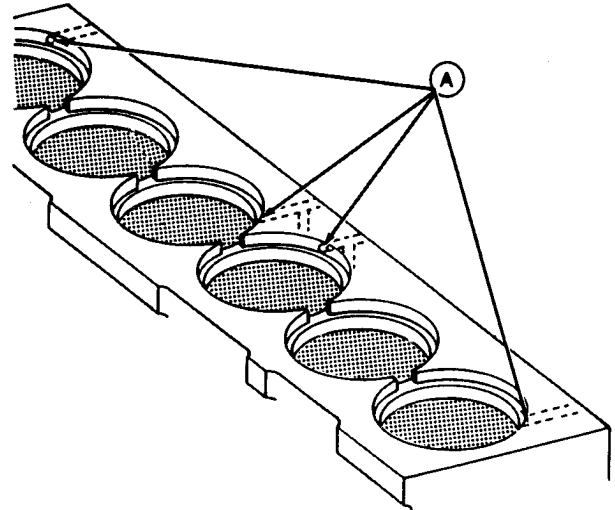
1. Thoroughly clean block using cleaning solvent, pressure steam, or a hot tank.

IMPORTANT: If block is cleaned in a "Hot Tank", remove all external and internal mounted components. See **COMPLETE DISASSEMBLY OF CYLINDER BLOCK (IF REQUIRED)**, earlier in this group.

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

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

NOTE: On directed coolant engines, be sure coolant ports (A) are also clean. For a complete explanation of directed coolant engines, see HOW THE COOLING SYSTEM WORKS in Group 105.



RG6662 -UN-13MAR93

RG.CTM61,G10,36-19-05MAY93

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4. Be sure liner support flange (A) is free of any 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 of cylinder block while filing.

IMPORTANT: DO NOT file liner support flange excessively. Excess filing can damage liner support flange and cause improper liner fit. Thoroughly clean all filings from cylinder block (B).

5. Inspect block for cracks or damage. If a cracked block is suspected, pressure-test the block. A procedure for pressure testing is outlined in FOS (Fundamentals of Service) Manual-ENGINES. Replace cracked or damaged block.

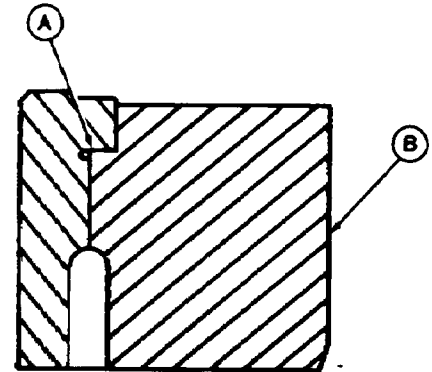
COUNTERBORE DEPTH AND LINER FLANGE SPECIFICATIONS

Cylinder Liner Counterbore Depth 9.46—9.51 mm
(0.3725—0.3745 in.)

Liner Flange Thickness 9.538—9.563 mm
(0.3755—0.3765 in.)

6. When determined that the cylinder block is serviceable, clean out threads for cylinder head cap screws in top deck of cylinder block using JDG682 Tap (C).

7. Install new locating dowel pins in cylinder block.



-UN-13DEC88

RG3329

-UN-09JAN90

RG5580

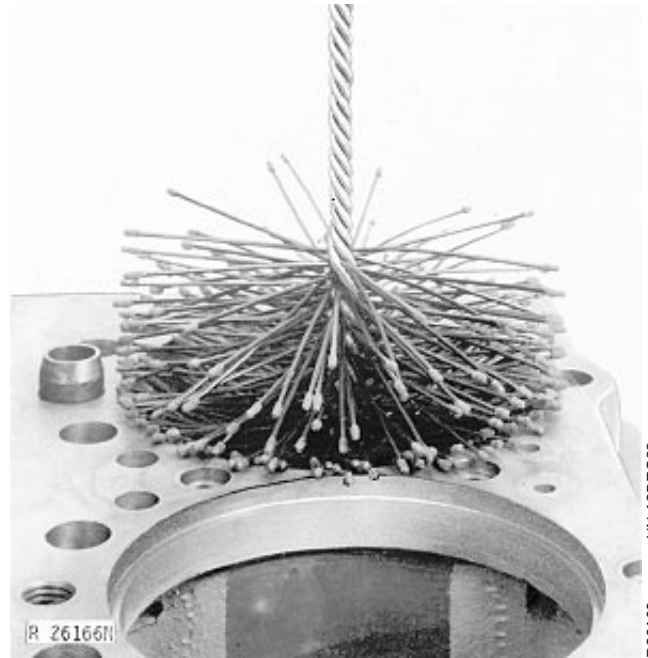
S11,0402,CL -19-02APR93

CLEAN CYLINDER LINER O-RING BORE

1. Use D17015BR O-Ring Bore Cleaning Brush to clean O-ring bore.

NOTE: Use brush exactly as directed by the manufacturer.

2. Thoroughly clean all debris from O-ring bore.



S11,0402,AY -19-02APR93

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MEASURE CYLINDER BLOCK

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

1. Check cylinder block top deck flatness using D05012ST Precision Straightedge and feeler gauge.

CYLINDER BLOCK SPECIFICATIONS

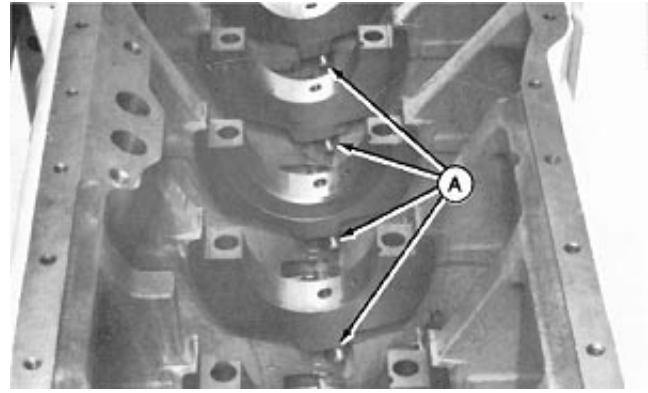
Main Bearing Bore Diameter (without bearings)	101.651—101.677 mm (4.0020—4.0030 in.)
Main Thrust Bearing Cap Width	34.52—34.62 mm (1.359—1.363 in.)
Cam Follower Bore Diameter	34.976—35.027 mm (1.3770—1.3790 in.)
Cam Follower OD	34.874—34.900 mm (1.3730—1.3740 in.)
Maximum Cam Follower-to-Bore Clearance	0.152 mm (0.0060 in.)
Camshaft Bore Diameter: without bushings	69.987—70.013 mm (2.7554—2.7564 in.)
with bushings	67.076—67.102 mm (2.6408—2.6418 in.)
Maximum Camshaft Journal-to-Bushing Clearance	0.152 mm (0.0060 in.)
Maximum Cylinder Block Top Deck Out-of-Flat for Entire Length or Width	0.10 mm (0.004 in.)
Center Line of Main Bearing Bore-to-Top Deck of Cylinder Block	374.57—374.73 mm (14.747—14.753 in.)

If any one cam follower bore is not within specification, install a new cylinder block. If camshaft journal-to-bushing clearance is not within specification, replace bushings as needed. If cylinder block top deck flatness is not within specification, resurface block as required.

INSTALL PISTON COOLING ORIFICES AND GALLEY PLUGS

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. Install all six (four shown) piston cooling orifices (A) and tighten to 11 N·m (8 lb-ft) (97 lb-in.).
2. Install new oil and water galley plugs as required, if removed.



RG3752 -UN-14DEC88

RG,CTM61,G10,18-19-02APR93

RECHECK CYLINDER LINER STANDOUT (HEIGHT ABOVE BLOCK)

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

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

1. Install liners (B) without O-ring and secure with cap screws and washers, as outlined earlier in this group.

NOTE: Install liner with the identifying mark "A", "B", "C", "D", "E", or "F" (stamped on flange), toward the front of the engine. Rotate 90° if wear is within limits outlined during liner inspection.

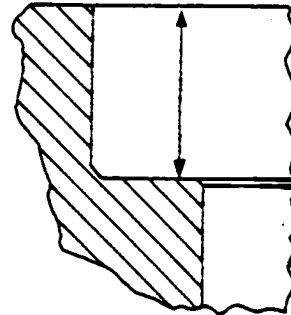
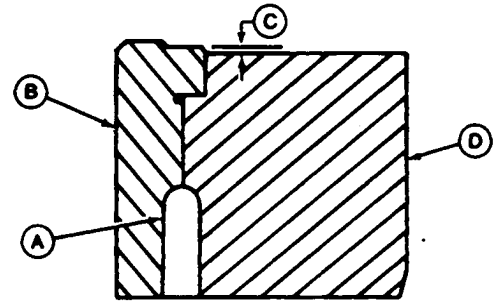
2. Measure liner standout (C) with dial indicator or gauges, as directed earlier in this group.

LINER STANDOUT (HEIGHT ABOVE BLOCK) SPECIFICATION

Liner Height	0.025—0.102 mm (0.001—0.004 in.)

If liner standout is above specification, recheck liner support flange for possible remaining burrs or incorrect counterbore depth in block. If burrs are present, file support flange vertically again until burr is gone. Completely clean cylinder liner bore of any filings.

Counterbore depth as shown in bottom illustration is 9.46—9.51 mm (0.3725—0.3745 in.).



A—Water Jacket
B—Cylinder Liners
C—Liner Height
D—Cylinder Block

-UN-06APR89

RG3330

-UN-13DEC88

RG4726

S11,2510,AF -19-02APR93

MEASURE LINER FLANGE THICKNESS

Measure cylinder liner flange thickness at several locations. If liner flange is not within specifications, replace piston and liner set.

LINER FLANGE SPECIFICATION

Flange Thickness 9.538—9.563 mm (0.3755—0.3765 in.)



-UN-27JAN92

RG6090

S11,2510,AG -19-02APR93

INSTALL LINER SHIMS—IF REQUIRED

1. 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 shims on bottom of liner flange. Two sizes of shims are available:

LINER SHIM SPECIFICATIONS

R81276	0.05 mm (0.002 in.)
R81277	0.10 mm (0.004 in.)
Maximum Shim Thickness	
per Cylinder	0.10 mm (0.004 in.)

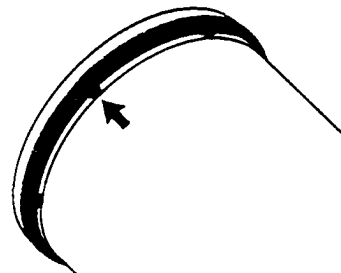
2. Install a maximum of **two thin** shims or **one thick** shim on liner. Shims have tangs on the ID to help hold them in place against bottom of liner flange when installing liner.

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

4. 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.

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-UN-04MAY89

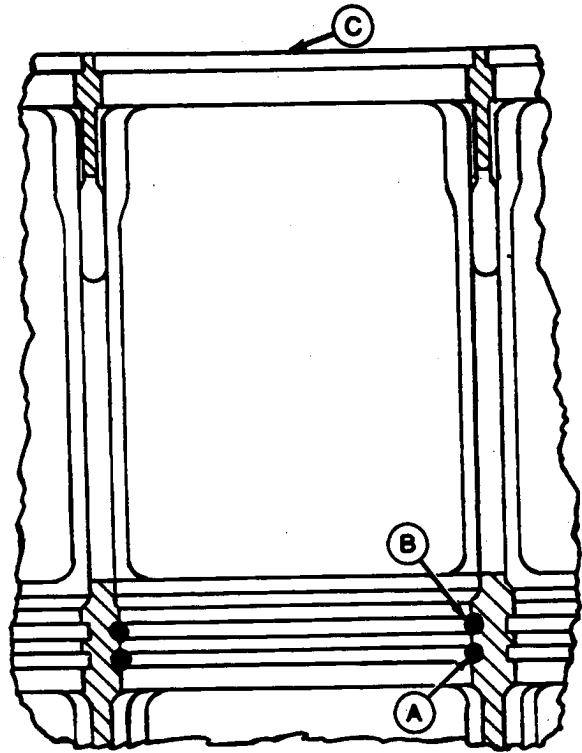
RG4728

S11,2510,AH -19-13MAR92

INSTALL CYLINDER LINER O-RINGS AND PACKINGS

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

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



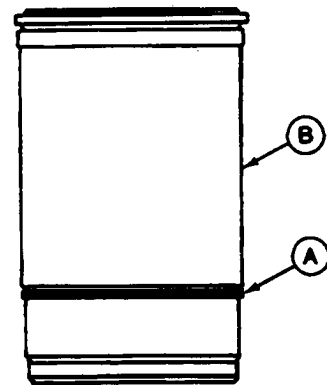
RG3826 -UN-13DEC88

S11,0402,BA -19-29OCT92

5. Turn cylinder liner (B) upside-down and install the neoprene square packing (A) over outside of liner.
6. Slide packing down firmly against second shoulder on the liner.

NOTE: Make sure the packing is not twisted.

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



RG3827 -UN-13DEC88

S11,0402,BB -19-02APR93

CYLINDER LINER MANUFACTURING DATE CODE EXPLANATION



Four-Digit Date Code

A manufacturing four-digit date code will appear on the liner. The following is an example of this four-digit date code:

SF91

S Liner Material Type
 F Month Liner was Manufactured
 91 Year Liner was Manufactured

Liner Material Specification

S Non-Hardened Bore

Month Liner was Manufactured

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

Year Liner Was Manufactured

91	1991
92	1992
etc.	

RG,CTM61,G10,19-19-13MAR92

INSTALL CYLINDER LINERS

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

DO NOT scuff the liner packing across the upper bore.

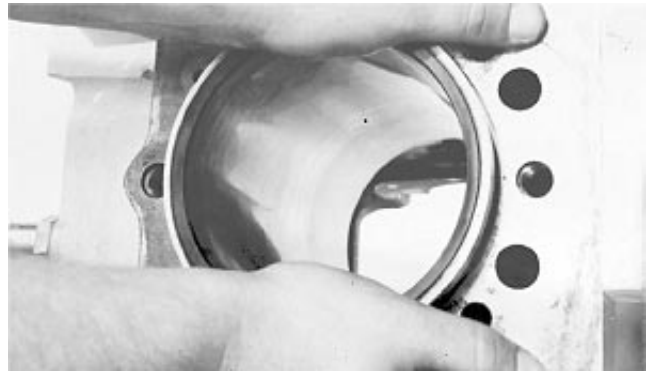
1. Carefully place the cylinder liner, with packing installed into the cylinder block bore.

IMPORTANT: When liners are pitted or eroded on the OD and are under one-half the liner thickness, rotate liners 90° from their removed position. Rotate the pitted section of the liner either toward the front or rear of the engine.

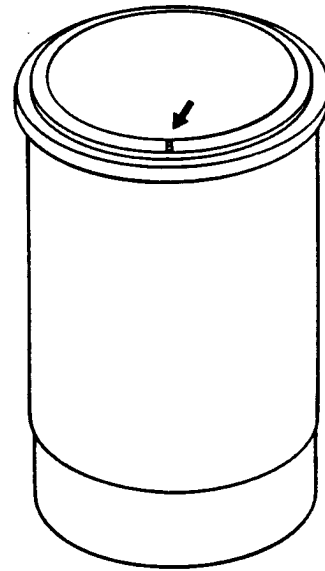
If liners are not pitted or eroded, rotation will not be necessary. Install liners with the identifying mark "A", "B", "C", "D", "E", or "F" (stamped on flange), toward the front of the engine.

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

2. Using only the pressure of both palms, the cylinder liner should drop to a point nearly flush at the upper flange of the cylinder liner and cylinder block.



RG2772 -UN-23FEB89



RG6126 -UN-06FEB92

RG,CTM61,G10,23-19-02APR93

3. Finish seating cylinder liners using a clean, hardwood block and hammer.

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

NOTE: Cylinder liner will protrude over the top of the 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 when liner was lowered into position, remove and examine liner, packing, and O-rings. If no damage is found, check packing and O-rings for proper position. Resoap packings and reinstall cylinder liner assembly.



RG6092 -UN-27JAN92

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

6. Clean cylinder liner bores with waterless hand cleaner after installation.

7. Wipe dry with clean towels.

8. Immediately apply clean engine oil to liner bores to prevent corrosion.

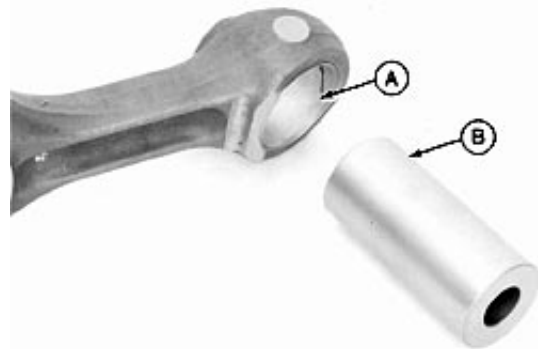
S11,0402,BD -19-02APR93

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INSTALL PISTONS AND CONNECTING RODS

NOTE: Pistons must be installed on same connecting rods from which they were removed.

IMPORTANT: 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.



RG3180 -UN-28JUL89

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

S11,0402,BE -19-13MAR92

2. Install piston pin (A) through piston (B) and connecting rod (C). Be sure front of rod aligns with front of piston.

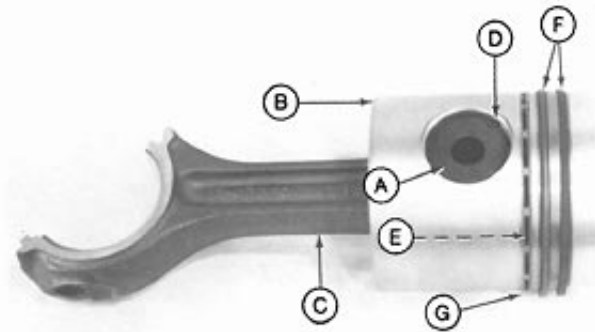
3. Insert NEW piston pin snap rings (D) in grooves. Make certain snap rings have expanded in grooves of piston.

4. Install expander ring (E) in bottom ring groove.

NOTE: "Pip" marks on No. 1 and No. 2 compression rings must face top of piston.

5. Use JDE94 or JDE135 Ring Expander to install piston rings (F) and oil control ring (G).

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



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

RG3828 -UN-25SEP89

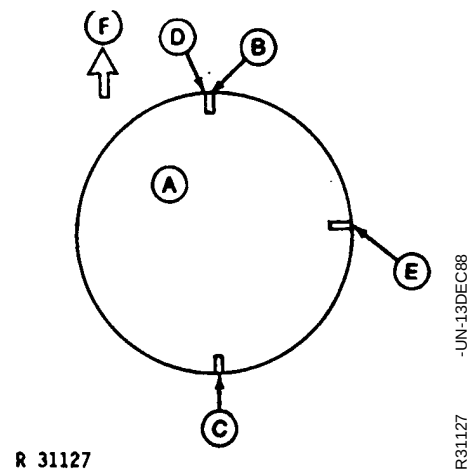
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S11,2510,AY -19-13MAR92

6. Stagger ring gaps on pistons as shown.

7. Coat pistons, liners and inside of JDE97 Piston Ring Compressor with clean engine oil.

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



R31127 -UN-13DEC88

S11,2510,AT -19-05MAY93

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

8. Carefully place ring compressor (A) with piston (B) and rod over liner.

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

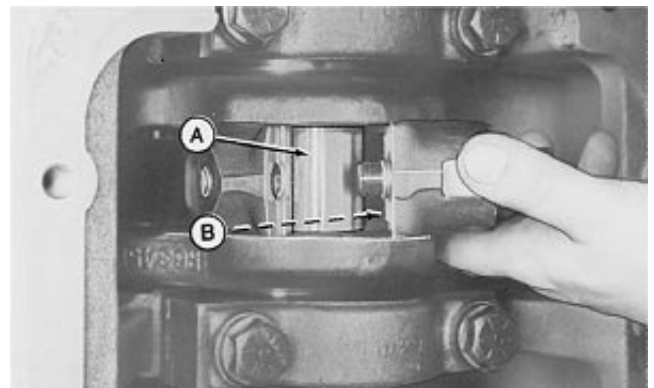
9. With piston centered in ring compressor and rings staggered correctly, push piston into liner.



RG,CTM61,G10,24-19-02APR93

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

11. Install connecting rod caps.



S11,0402,BI -19-02APR93

IMPORTANT: DO NOT reuse connecting rod cap screws. **ALWAYS** replace old cap screws with new ones once they are removed or their torque is disturbed.

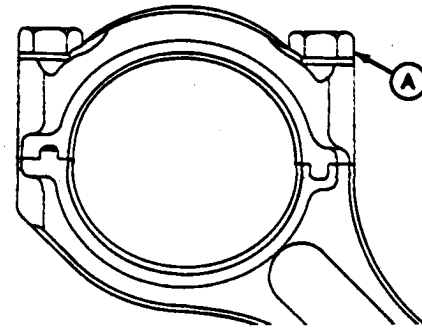
12. Dip NEW cap screws and washers in clean engine oil. Make sure top of cap screws have oil on them also.

IMPORTANT: Using pneumatic wrenches to install cap screws may cause damage to the threads.

13. Initially tighten all blind hole cap screws (A) to 27 N·m (20 lb-ft).

14. Secondly, tighten all cap screws to 75 N·m (55 lb-ft).

15. Finally TORQUE-TURN all cap screws 90—100 degrees. (See USE TORQUE-TURN METHOD FOR PROPER TORQUE, as described later in this group.)



RG4375 -UN-13DEC88

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S11,0402,BI1 -19-02APR93

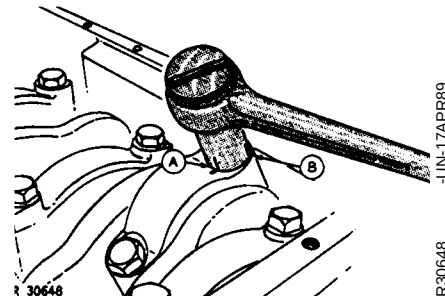
USE TORQUE-TURN METHOD FOR PROPER TORQUE

• Using line scribe method to TORQUE-TURN connecting rod cap screws:

1. After tightening cap screws to 75 N·m (55 lb-ft), mark connecting rod cap and socket (A).

2. Make a second mark on socket (B) 90° counterclockwise from the first mark.

3. Tighten 1/4 turn (90—100°) clockwise until mark (B) is in line with reference mark on rod cap.

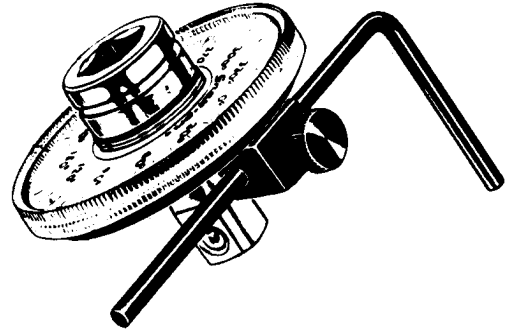


-UN-17APR89
R30648

S11,2010,CE -19-02APR93

- Using JT05993 Torque Angle Gauge to TORQUE-TURN connecting rod cap screws:

1. After tightening cap screws to 75 N·m (55 lb-ft), follow directions provided with gauge and TORQUE-TURN each cap screw 90°—100°.



JT05993 Torque Angle Gauge

RG,CTM6,G10,4 -19-22AUG91

RG5698
-UN-27AUG90

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.

S11,0402,BK -19-16SEP92

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MEASURE PISTON PROTRUSION

1. Press down on top of piston to remove oil clearances.
2. Use JDG451 Gauge along with D17526CI (English scale) or D17527CI (Metric scale) Dial Indicator or KJD10123 Gauge to measure piston protrusion. Place gauge on top of cylinder block so dial indicator can be set to "zero" with top of block.
3. Measure piston height at several locations around three pistons. Position gauge across piston. While pressing gauge downward, rotate crankshaft until piston is at "TDC". Install timing pin in flywheel.
4. Rotate engine one full revolution until timing pin enters flywheel again. Measure piston height at several locations on three remaining pistons and compare with specifications.

NOTE: If using JDG451 Gauge, piston height must be checked at outer most diameter of piston.

5. Piston protrusion must be within the following specification to prevent piston-to-exhaust valve contact.

PISTON PROTRUSION SPECIFICATION

Maximum Piston Protrusion

Above Block Deck 0.762 mm (0.030 in.)

If protrusion does not meet specification, check dimensions of piston, connecting rod, cylinder block, crankshaft, and bearings to determine the cause.

RG,CTM61,G10,37-19-05MAY93

COMPLETE FINAL ASSEMBLY

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

1. Install camshaft, valve actuators, timing gears and timing gear cover. (Group 16).
2. Install the lubrication system components. (Group 20)
3. Install the cylinder head with new head gasket. (Group 05)
4. Install fuel injection system components. (Group 35)
5. Install the water pump and water piping. (Group 25)

6. Install crankshaft pulley. (Group 15)
7. Install the alternator, fan, and fan belts.
8. Install the exhaust manifold and intake assembly. (Group 30)
9. Install the starting motor.
10. Fill engine with clean oil and proper coolant. (Group 02)
11. Install engine in unit and perform engine break-in. (Group 05 or Machine Technical Manual)

S55,2510,G -19-02APR93

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Group 15 Crankshaft, Main Bearings and Flywheel

SPECIAL OR ESSENTIAL TOOLS

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

DX,TOOLS -19-05JUN91

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.



RG,D17526CI -19-29OCT92

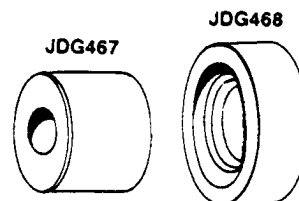
-UN-27MAR92
RG6246

Front Wear Sleeve Installer Set JDE3

Install front crankshaft wear sleeve.

Set consists of:

Driver JDG467
Spacer JDG468

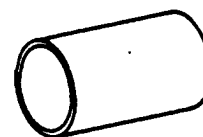


S53,JDE3A -19-16MAR92

-UN-04JUL89
RG5508

Gear Driver JDH7

Install gear on crankshaft.



RG5108 -UN-23AUG88

S53,JDH7 -19-23FEB87

Flywheel Turning Tool JDE81-1

Rotate engine flywheel. Use with JDE81-4.

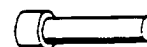


RG4950 -UN-23AUG88

S53,JDE811 -19-07JUL89

Timing Pin JDE81-4

Lock engine at TDC when timing valve train. Use with JDE81-1.



RG5068 -UN-23AUG88

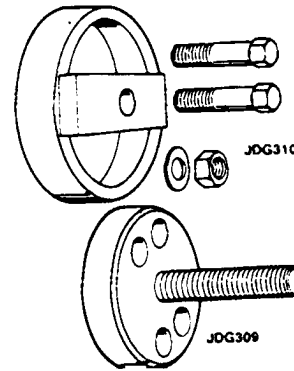
S55,JDE814,B -19-24FEB88

Oil Seal and Wear Sleeve Installer JDG300

Used to install rear crankshaft oil seal/wear sleeve assembly.

Set consists of:

- Pilot JDG309
- Installer JDG310



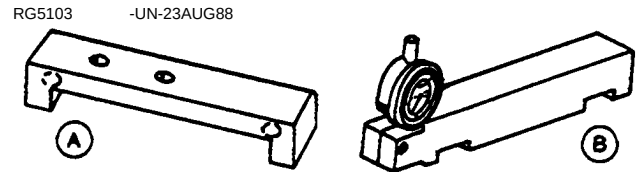
S53,JDG300 -19-16MAR92

RG5022 -UN-06APR89

Piston and Liner Height Gauge A-JDG451 or B-KJD10123

Measure piston and liner heights.

NOTE: A dial indicator is not supplied with JDG451. Use D17526CI (English, in.) or D17527CI (Metric, mm) Dial Indicator with JDG451.



RG,JDG451 -19-29OCT92

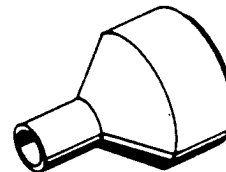
RG5103 -UN-23AUG88

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.

Set consists of:

- 1—Adapter JDG719-1
- 2—Screw (not shown) 11200



RG,JDG719 -19-29OCT92

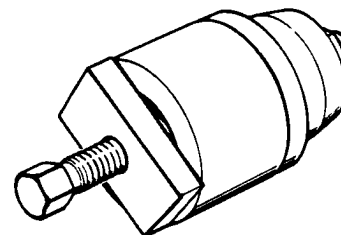
RG6214 -UN-06MAR92

Seal Installer JDG720

Used to install front crankshaft oil seal with timing gear cover installed.

Set consists of:

- 1—Forcing Screw JDG720-1
- 2—Seal Protector JDG720-2
- 3—Seal Installer JDG720-3
- 4—Ring (500 Series Engines) JDG720-4



RG,JDG720 -19-01APR93

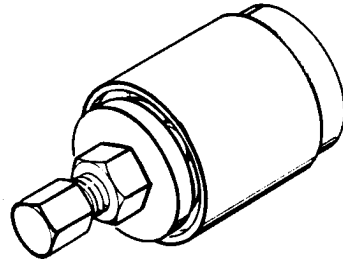
RG6215 -UN-06MAR92

Front Wear Sleeve Puller JDG726

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

Set consists of:

- 1—End Cap JDG726-1
- 2—Sleeve JDG726-2
- 3—Forcing Screw JDG726-3
- 4—Half Collet (2 Used) JDG726-4

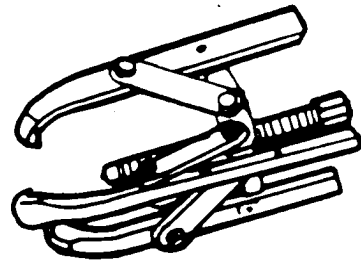


RG,JDG726 -19-02APR93

RG6216 -UN-06MAR92

Vibration Damper and Pulley Puller Set JDG728

Used to remove vibration damper pulley.



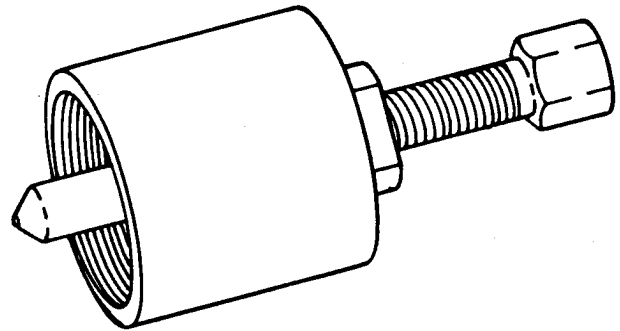
RG,JDG728 -19-29APR93

RG6218 -UN-06MAR92

Front Wear Sleeve Puller JDG786

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

NOTE: JDG726 Front Wear Sleeve Puller may be used in place of JDG786.

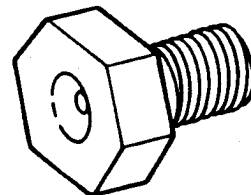


RG,JDG786,1 -19-02APR93

RG6428 -UN-13OCT92

Thread Protector JDG787

Used with any puller set to remove vibration damper pulley assembly.



RG,JDG787 -19-03FEB93

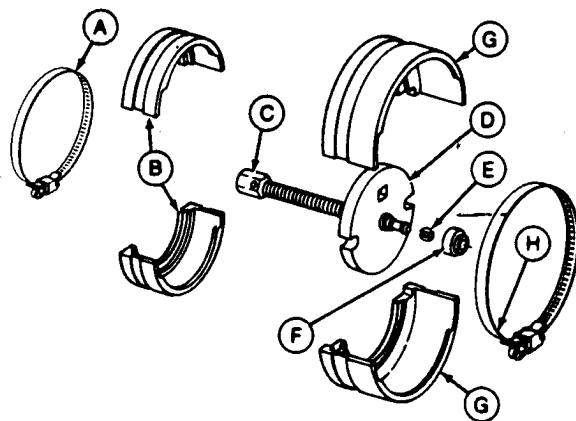
RG6429 -UN-13OCT92

Rear Wear Sleeve Puller Kit JDG790

Used to remove rear wear sleeve with oil seal housing installed on 400 and 500 Series Engines.

Set consists of:

- A—Hose Clamp (500 Series) 219469
 B—Collet Halves (400 Series) JDG790-1
 C—Forcing Screw (Both Series) 35945
 D—Pulling Plate (Both Series) JDG790-2
 E—Retainer Clip (Both Series) 13876
 F—Shaft Protector (Both Series) 215177
 G—Collet Halves (500 Series) JDG790-3
 H—Hose Clamp (400 Series) 19311



RG,JDG790 -19-02APR93

RG6457 -UN-22OCT92

SERVICE EQUIPMENT AND TOOLS

NOTE: Order tools from the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC). Some tools may be available from a local supplier.

Name	Use
D01251AA Puller*	Remove crankshaft gear.

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

RG,CTM61,G15,19-19-02APR93

OTHER MATERIAL

Name	Use
LOCTITE 242 (TY9370/T43512) Thread Lock and Sealer	Coat threads of flywheel mounting cap screws.
LOCTITE 609 (TY9372/T43515) Retaining Compound	Coat OD of crankshaft flange for installation of rear oil seal/wear sleeve. Coat ID of front wear sleeve for installation.
PLASTIGAGE	Check main bearing-to-crankshaft journal oil clearance during engine disassembly.
Brake Kleen or Ignition Cleaner and Drier	Remove sealant from crankshaft flange.

S55,2515,B -19-29APR93

GROUP 15—CRANKSHAFT, MAIN BEARINGS, AND FLYWHEEL SPECIFICATIONS

ITEM	SPECIFICATION	WEAR LIMIT
Crankshaft End Play	0.038—0.380 mm (0.0015—0.0150 in.)	—
Main Bearing Journal OD	95.200—95.225 mm (3.7480—3.7490 in.)	—
Main Bearing Assembled ID	95.270—95.320 mm (3.7508—3.7528 in.)	—
Main Bearing Cap Surface Width	36.28—36.78 mm (1.428—1.448 in.)	—
No. 5 Main (Thrust) Bearing Surface Width (thrust washer clearance cut)	34.52—34.62 mm (1.359—1.363 in.)	—
Overall Cap Width	41.81—42.31 mm (1.646—1.666 in.)	—
Base Circle OD for Thrust Washer Clearance*	129.28—130.81 mm (5.09—5.15 in.)	—
Crankshaft Thrust Journal Width	47.57—47.67 mm (1.873—1.877 in.)	—
Main Bearing-to-Journal Oil Clearance . . .	0.046—0.122 mm (0.0018—0.0048 in.)	0.152 mm (0.0060 in.)
Connecting Rod Journal OD	88.844—88.874 mm (3.4978—3.4990 in.)	—
Journal Taper per 25.4 mm (1.0 in.) of Journal Length	0.0025 mm (0.0001 in.)	—
Journal Out-of-Roundness	0.025 mm (0.0010 in.)	—
Maximum Serviceable	0.038 mm (0.0015 in.)	—
Undersize Bearings Available	0.05, 0.25, 0.51, 0.76 mm (0.002, 0.010, 0.020, 0.030 in.)	—
Oversize Thrust Washer Available	0.18 mm (0.007 in.)	—
Crankshaft Rod Journal OD	88.844—88.874 mm (3.4980—3.4990 in.)	—
Main Bearing Cap Bore Specifications:		
ID (Without Bearing Inserts)	101.651—101.677 mm (4.0020—4.0030 in.)	—
Maximum Bore Diameter Variation	0.013 mm (0.0005 in.)	—
Maximum Bore Diameter Taper	0.005 mm (0.0002 in.)	—
Maximum Straightness Variation (Any Bore-to-Adjacent Bores)	0.038 mm (0.0015 in.)	—
Maximum Straightness Variation (5 Center Bores-to End Bore)	0.076 mm (0.0030 in.)	—
Centerline of Bore-to-Top Deck of Block	374.57—374.73 mm (14.747—14.753 in.)	—
Clutch Shaft Pilot Bushing ID	25.50—25.55 mm (1.004—1.006 in.)	—
Engine Stroke	127 mm (5.0 in.)	—
Main and Rod Journal Surface Finish	Lap 0.25 Um (9.8 AA)	—
Thrust Journal Surface Finish	Lap 0.40 Um (16 AA)	—
Rod Journal Fillet Radius	4.49—4.85 (0.177—0.191 in.)	—
Main and Thrust Journal Fillet Radius	3.94—4.44 mm (0.155—0.175 in.)	—
Crankshaft OD for Front Pulley	47.650—47.676 mm (1.8760—1.8770 in.)	—
Front Pulley ID	47.594—47.630 mm (1.8738—1.8752 in.)	—
Maximum Damper Pulley Radial Runout	0.76 mm (0.030 in.)	—

* Thrust (washer) surfaces on bearing cap must be flat in respect to mating thrust (washer) surfaces in cylinder block.

RG,CTM61,G15,1 -19-02APR93

GROUP 15—CRANKSHAFT, MAIN BEARINGS, AND FLYWHEEL SPECIFICATIONS—CONTINUED

ITEM	SPECIFICATION	WEAR LIMIT
Front Oil Seal Installed Depth	Flush—0.25 mm (0.010 in.) from front face of seal bore.	—
Maximum Crankshaft Front Oil Seal Bore Runout		0.254 mm (0.010 in.)
Oil Pump Drive Gear-to Crankshaft Clearance	0.38 mm (0.015 in.)	—
Crankshaft Rear Oil Seal-to-Housing Runout (Maximum)	0.152 mm (0.0060 in.)	—
Flywheel Face Flatness: Maximum Variation	0.23 mm (0.009 in.)	—
Maximum Variation per 25 mm (1.0 in.) of travel	0.013 mm (0.0005 in.)	—
Flywheel Bearing Bore Concentricity Maximum Variation	0.127 mm (0.005 in.)	—
Flywheel Housing Face Runout Maximum Variation	0.20 mm (0.008 in.)	—

RG,CTM61,G15,2 -19-02APR93

GROUP 15—CRANKSHAFT, MAIN BEARINGS, AND FLYWHEEL SPECIFICATIONS—CONTINUED**TORQUES**

Damper Pulley-to-Crankshaft	230 N·m (170 lb-ft)
Damper Assembly-to-Pulley	70 N·m (52 lb-ft)
Main and Thrust Bearing Caps	285 N·m (210 lb-ft)
Crankshaft Rear Oil Seal Housing	27 N·m (20 lb-ft)
Flywheel-to-Crankshaft	176 N·m (130 lb-ft)
Piston Cooling Orifices	11 N·m (8 lb-ft) (97 lb-in.)
Timing Gear Cover-to-Cylinder Block	41 N·m (30 lb-ft)
Flywheel Housing-to-Cylinder Block	407 N·m (300 lb-ft)
Flywheel Housing-to-Oil Pan	325 N·m (240 lb-ft)
Hub Drive-to-Flywheel	176 N·m (130 lb-ft)
Starting Motor-to-Flywheel Housing	102 N·m (75 lb-ft)
Injection Pump Gear Cover-to-Timing Gear Cover:	
6101HRW10 and 6101HRW11 Engine Applications	68 N·m (50 lb-ft)
All other Applications	41 N·m (30 lb-ft)

RG,CTM61,G15,21-19-02APR93

FAILURE ANALYSIS

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

• **Oil Starvation:**

Contaminated oil.
Engine parts failure.
Excessive heat.
Poor periodic service.

• **Galled or “Wiped” Bearings:**

Fuel in lubricating oil (incomplete combustion).
Coolant in lubrication system (cracked block or liner seal failure).
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.

S11,2515,A -19-02APR93

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7

DISCONNECT TURBOCHARGER OIL INLET LINE

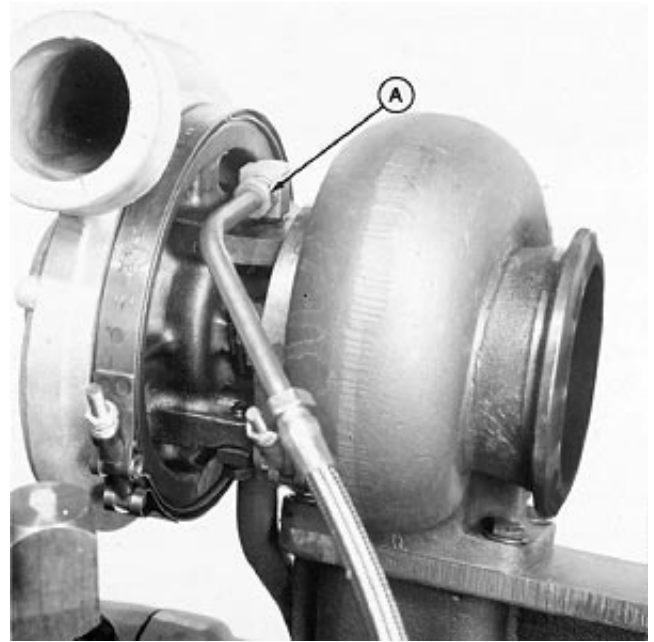
1. Drain all engine oil and coolant, if not previously done.

IMPORTANT: When servicing the 6101 Engine on a rollover stand, disconnect turbo oil inlet line (A) before rolling engine over. Failure to do so may cause a hydraulic lock upon starting the engine. Hydraulic lock may cause possible engine failure.

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

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

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



RG5520 -UN-09JAN90

RG,CTM61,G3,1 -19-16APR92

REMOVE CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE (WITH OIL SEAL HOUSING INSTALLED)

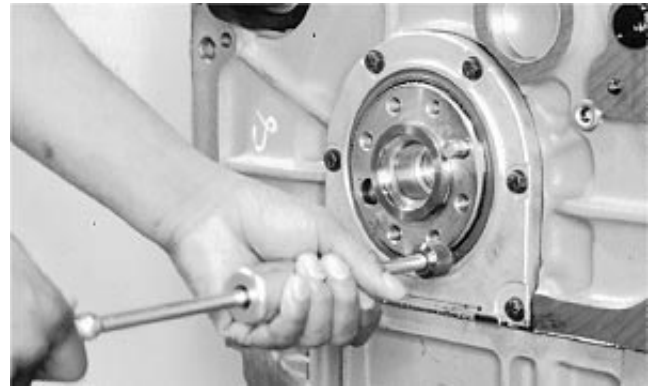
Using JDG719 Seal Puller Adapter along with JDE38-2 Shank and JDE38-3 Slide Handle is the preferred method for removing the crankshaft rear oil seal. If these tools are not available, JDG22 Seal Remover can be used to remove the seal. Follow same procedure for both pullers.

NOTE: If oil seal housing is to be removed, remove seal and wear sleeve after housing is removed.

1. Remove flywheel as described 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.

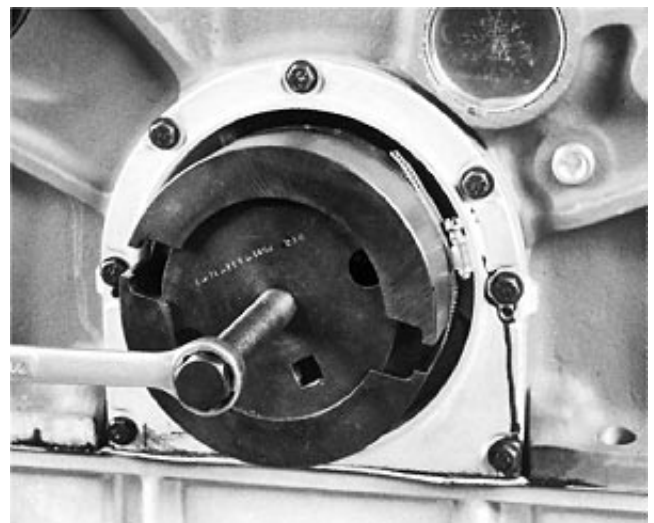
3. Cock seal at 6 O'clock position (180° opposite drilled hole) using a small punch and carefully pull seal from housing.



RG5210 -UN-14DEC88

S11,2515,BM -19-02APR93

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 disc centered in crankshaft flange until wear sleeve is removed from crankshaft.



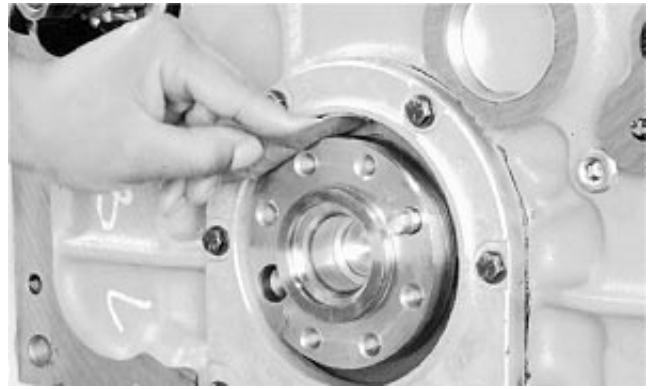
RG6615 -UN-17FEB93

RG,CTM61,G15,23-19-02APR93

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. Any small nicks should be removed with 180-grit or finer polishing cloth. Finish cleaning by wiping flange with a clean rag.

9. Check oil seal housing runout as explained later in this group.



RG5212 -UN-14DEC88

S11,2515,BO -19-29APR93

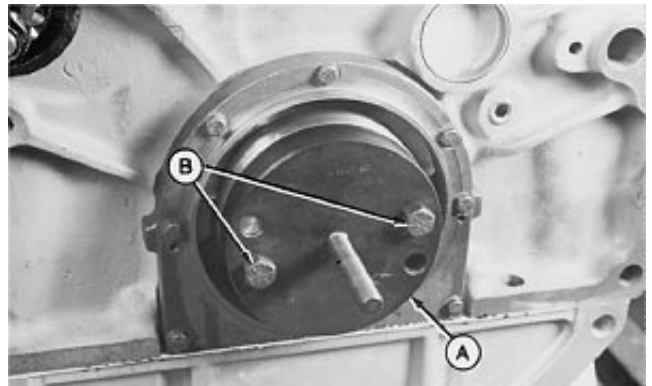
INSTALL CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE ASSEMBLY (WITHOUT ENGINE DISASSEMBLY)

NOTE: These instructions are for use when the oil seal housing and oil pan would not be removed. Refer to **INSTALL CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE (WITH ENGINE DISASSEMBLED)**, later in this group, for instructions with oil seal housing and oil pan removed.

IMPORTANT: Installation tools must be clean to assure proper positioning on crankshaft flange and to hold run-out within specification so oil seal does not fail prematurely.

1. Install JDG309 Pilot (A) over dowel pin on rear end of crankshaft.

2. Tighten two cap screws (B) securely.



RG5576 -UN-10NOV89

RG,CTM61,G15,20-19-02APR93

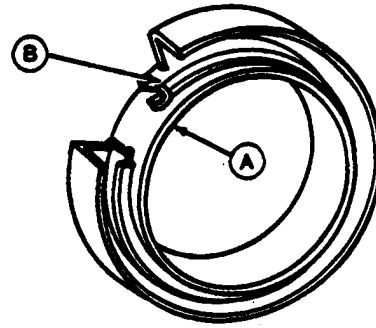
IMPORTANT: Handle seal and wear sleeve carefully. If assembly becomes separated, discard these parts and install a new assembly. See **CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE HANDLING PRECAUTIONS**, earlier in this group.

Chamfer on wear sleeve (A), upper illustration, and open side of seal (B, upper illustration) must be on the same side.

3. Apply a light coating of LOCTITE 609 Retaining Compound around the leading edge of crankshaft.

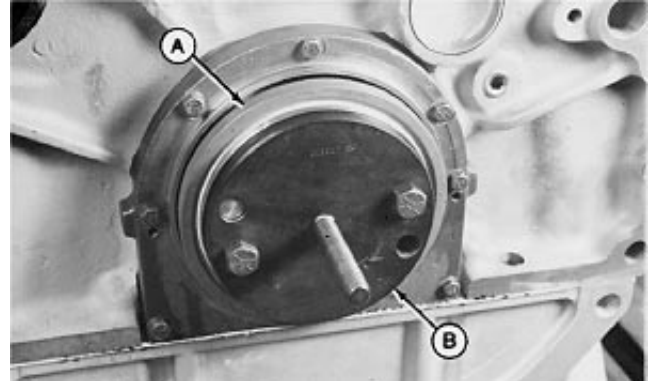
IMPORTANT: DO NOT allow sealant to get on any part of wear sleeve OD or oil seal.

4. Carefully install oil seal/wear sleeve assembly (A) over JDG309 Pilot (B) on crankshaft flange with black seal lip toward engine.



-UN-14OCT88

T88560



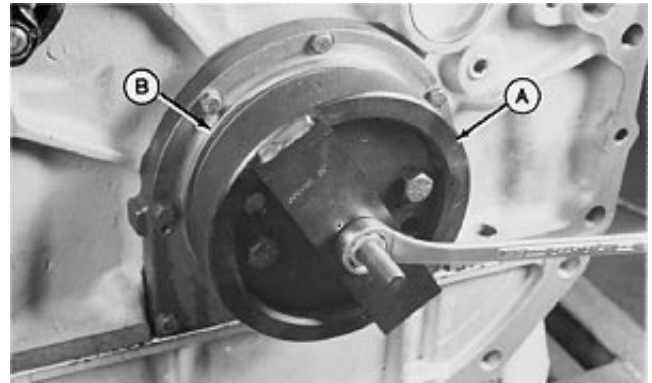
RG5577 -UN-10NOV89

S11,2515,AN -19-02APR93

5. Position JDG310 Installer (A) so that hole in the installer cross plate goes over threaded stud of pilot and that cross plate can not bottom on cap screws of pilot. Install washer and nut on stud.

6. Tighten nut to draw JDG310 Installer in until it bottoms on oil seal housing flange (B). When the tool bottoms, seal and wear ring assembly will be correctly positioned.

7. Remove JDG309 and JDG310 Tools from end of crankshaft.



RG5578 -UN-10NOV89

S11,2515,AO -19-15JUN89

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11

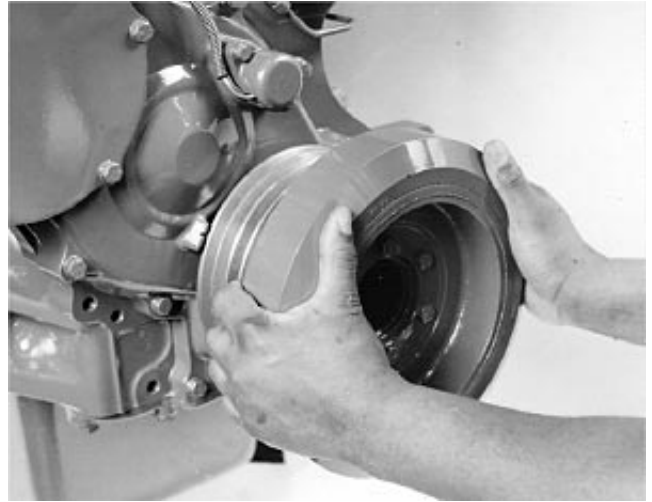
INSPECT VIBRATION DAMPER

1. Remove fan belts (shown removed).

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

NOTE: The vibration damper assembly is not repairable and should be replaced every 5 years or 4500 hours, whichever occurs first.

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.



RG6098 -UN-27JAN92

RG,CTM61,G15,3 -19-16MAR92

3. Check vibration damper radial runout by positioning a dial indicator so probe (A) contacts damper OD.
4. With engine at operating temperature, rotate crankshaft using JDE81-1 Flywheel Turning Tool.
5. Note dial indicator reading. If runout exceeds specification given below, replace vibration damper.

DAMPER RADIAL RUNOUT SPECIFICATION

Maximum 0.76 mm (0.030 in.)



RG6099 -UN-27JAN92

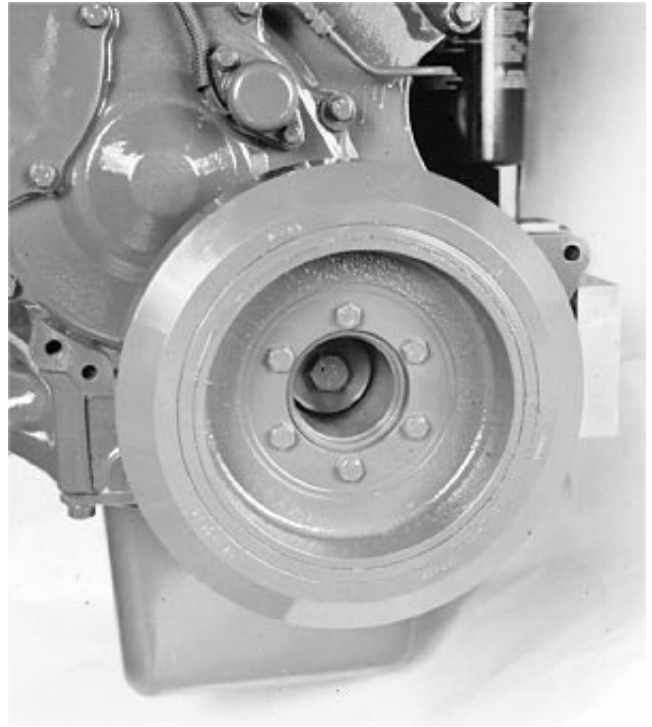
RG,CTM61,G15,4 -19-02APR93

REMOVE VIBRATION DAMPER AND PULLEY

CAUTION: Damper and pulley are very heavy. Plan a proper handling procedure to avoid injuries.

ALWAYS use an assistant when removing and installing pulley.

1. Remove six cap screws securing vibration damper to pulley and remove damper from pulley.



RG6100 -UN-27JAN92

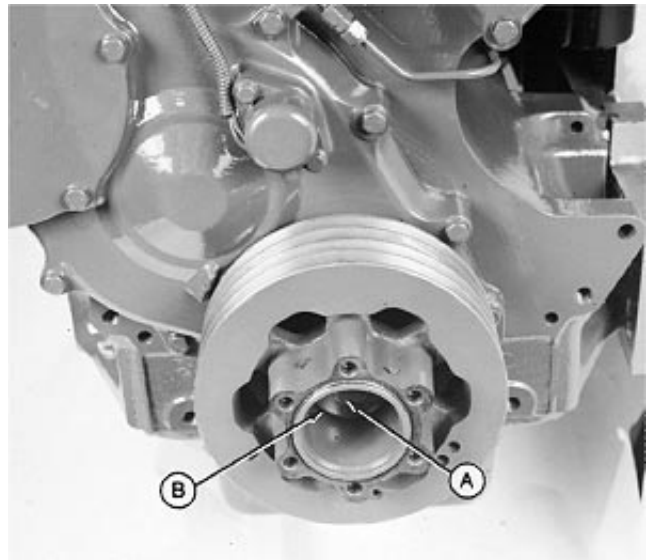
RG,CTM61,G15,5 -19-24APR92

IMPORTANT: Be extremely careful when using a jaw-type puller to remove vibration damper and pulley assembly. **ALWAYS** remove damper from pulley first, if possible. Pull **ONLY** on back side of pulley closest to the engine. **DO NOT** drop or hammer on damper and **NEVER** apply thrust on outer ring.

2. Remove cap screw (A) and washer securing damper pulley (B) to end of crankshaft. Remove damper from pulley, if possible, and carefully place on a clean flat table.

IMPORTANT: **DO NOT** immerse damper assembly in petroleum products (such as gasoline, oil, solvent, etc.). Doing so may damage the rubber portion of the assembly.

3. Install JDG787 Thread Protector into nose of crankshaft.

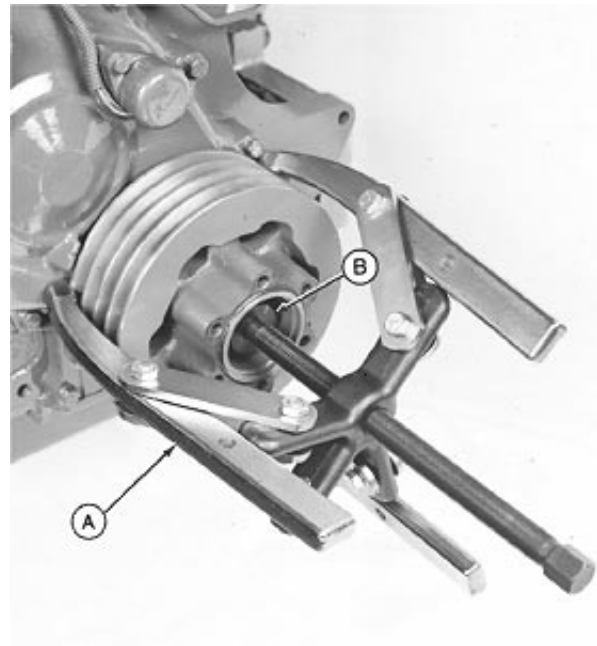


RG6101 -UN-27JAN92

RG,CTM61,G15,6 -19-29APR93

4. Using JDG728 Puller (A), remove pulley from crankshaft. Be sure JDG787 Thread Protector (B) is in ID of pulley to protect threads in nose of crankshaft from damage and pulling jaws are securely clamped on back side of pulley closest to engine.

IMPORTANT: Carefully and thoroughly inspect the pulley for cracks or any visible damage (ID, V-belt grooves, keyway, etc.). Replace pulley as needed.



RG6102
-UN-27JAN92

RG,CTM61,G15,7 -19-02APR93

REMOVE CRANKSHAFT FRONT OIL SEAL (WITH TIMING GEAR COVER INSTALLED ON ENGINE)

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

NOTE: If timing gear cover is going to be removed from engine, remove front seal after timing gear cover is removed.

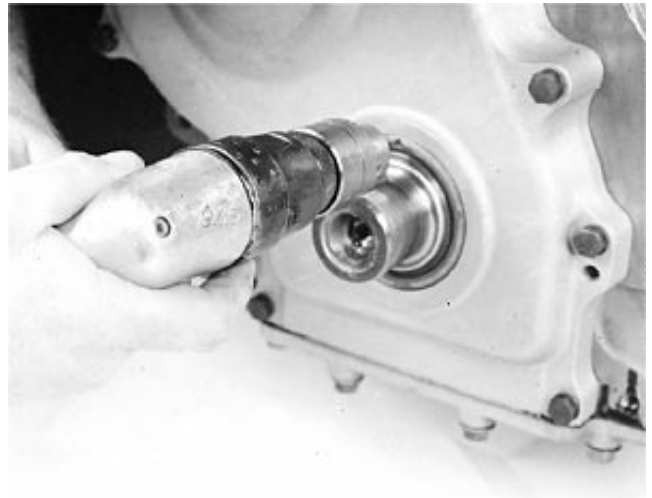
1. Check oil seal and wear sleeve for wear, damage, or leakage.
2. Center punch seal casing at 12 O'clock position.



RG6105
-UN-27JAN92

RG,CTM61,G15,9 -19-02APR93

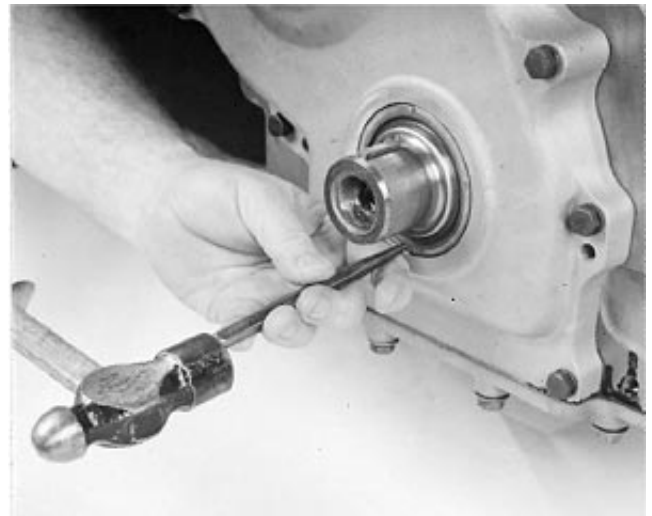
3. Drill hole at 12 O'clock position.



RG6106
-UN-27JAN92

RG,CTM61,G15,17-19-16MAR92

4. Using a punch, cock seal at 6 O'clock position.



RG6107
-UN-27JAN92

RG,CTM61,G15,18-19-24APR92

5. Using JDG719 Seal Puller Adapter along with JDE38-2 Shank and JDE38-3 Slide Handle is the preferred method for removing crankshaft rear oil seal. If these tools are not available, JDG22 Seal Remover can be used to remove the seal. Follow same procedure for both pullers.

6. Remove keyway on stub of crankshaft.



RG6108
-UN-27JAN92

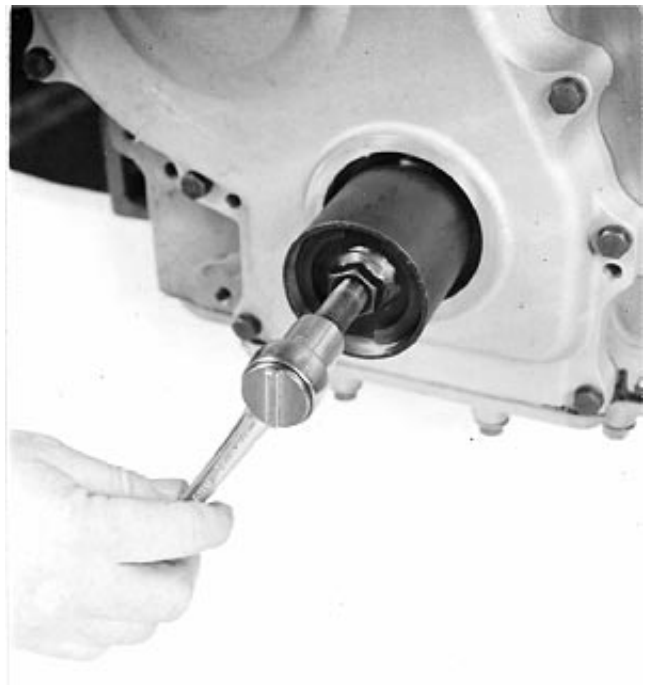
RG,CTM61,G15,10-19-02APR93

REMOVE CRANKSHAFT FRONT WEAR SLEEVE (WITH TIMING GEAR COVER INSTALLED OR REMOVED)

NOTE: Front wear sleeve can be removed with timing gear cover installed or removed using either JDG726 or JDG786 puller set.

• To Remove Wear Sleeve Using JDG726:

1. Position pulling jaws and jack screw assembly onto lip of wear sleeve. Slide collar over pulling jaws.
2. Hold collar onto pulling jaws and tighten jack screw until wear sleeve is free from crankshaft flange.
3. Inspect crankshaft flange for nicks or burrs.
4. Clean up flange with a light file and emery cloth.
5. Measure crankshaft front oil seal bore runout. Maximum allowable runout is 0.254 mm (0.010 in.).

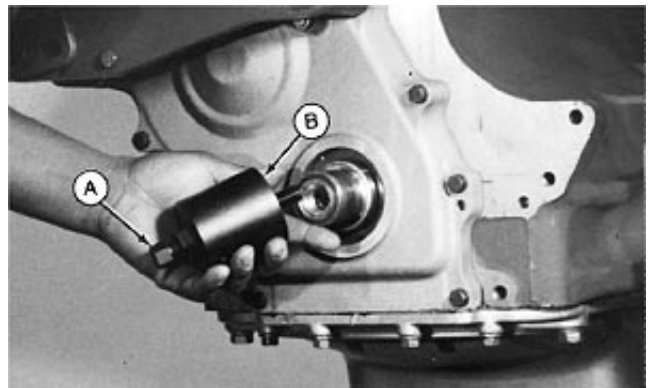


RG6109
-UN-27JAN92

RG,CTM61,G15,11-19-02APR93

• **To Remove Wear Sleeve Using JDG786:**

1. Start fully threaded centering screw (A) through hex head end of puller (B) until head of screw is approximately 1/2 in. from hex on puller.
2. Thread centering screw into nose of crankshaft and tighten until it bottoms.
3. Tighten puller until it is securely threaded onto wear sleeve.
4. Remove centering screw from nose of crankshaft and puller.



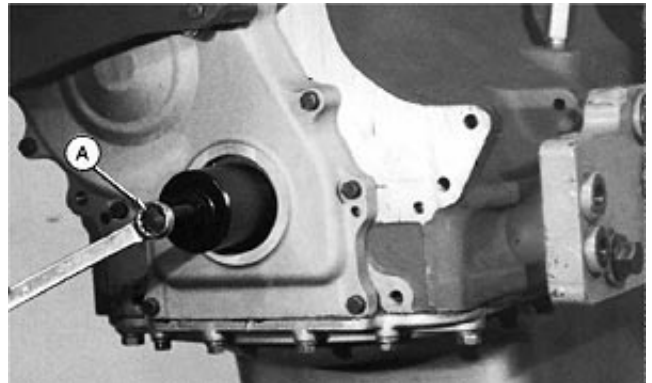
RG6713
-UN-02APR93



RG6714
-UN-02APR93

RG,CTM61,G15,25-19-04MAY93

5. Install 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.
8. Clean up flange with a light file and emery cloth.
9. Measure crankshaft front oil seal bore runout. Maximum allowable runout is 0.254 mm (0.010 in.).



RG6715
-UN-02APR93

RG,CTM61,G15,26-19-29APR93

INSTALL CRANKSHAFT FRONT WEAR SLEEVE (WITH TIMING GEAR COVER INSTALLED ON ENGINE)

NOTE: Wear sleeve may be installed with timing gear cover removed or installed.

1. Coat ID of new wear sleeve with LOCTITE 609 Retaining Compound.
2. Using JDG467 Driver from JDE3 Installer along with washer and cap screw that secures damper pulley assembly to crankshaft, install wear sleeve.
3. Remove installation tools and clean any sealant from OD of wear sleeve or ID of seal bore.



-UN-27JAN92

RG6110

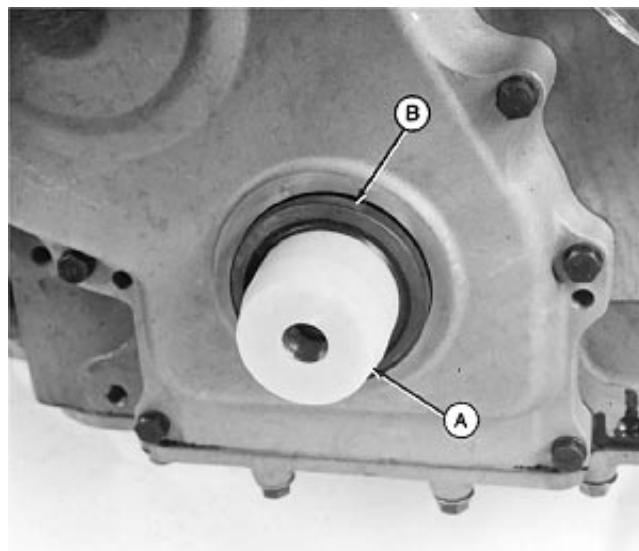
RG,CTM61,G15,12-19-02APR93

INSTALL CRANKSHAFT FRONT OIL SEAL (WITH TIMING GEAR COVER INSTALLED ON ENGINE)

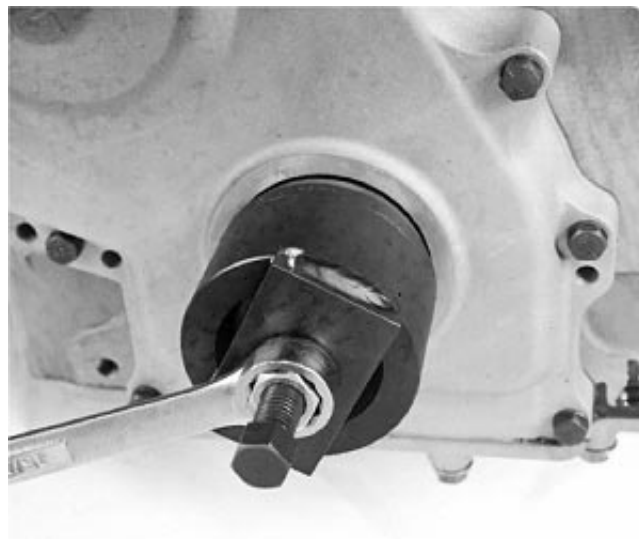
IMPORTANT: Whenever front oil seal is replaced,
wear sleeve **MUST** be replaced also.

1. Place JDG720-2 Seal Protector (A) on nose of crankshaft. Lubricate ID of front oil seal (B) lips with clean engine oil and slide seal onto seal protector. Be careful not to roll oil seal lips.
2. Position JDG720-4 Spacer Ring on end of JDG720-3 Seal Installer and place installer onto seal protector against seal.
3. With nut installed onto JDG720-1 Forcing Screw, thread forcing screw into nose of crankshaft until it bottoms.
4. Tighten nut against crossplate of installer until installer bottoms onto front face of timing gear cover.
5. Remove installation tools.

IMPORTANT: Verify seal is installed square in bore, flush with front face of timing gear cover, and that seal lips are not rolled on wear sleeve.



RG6111 -UN-27JAN92

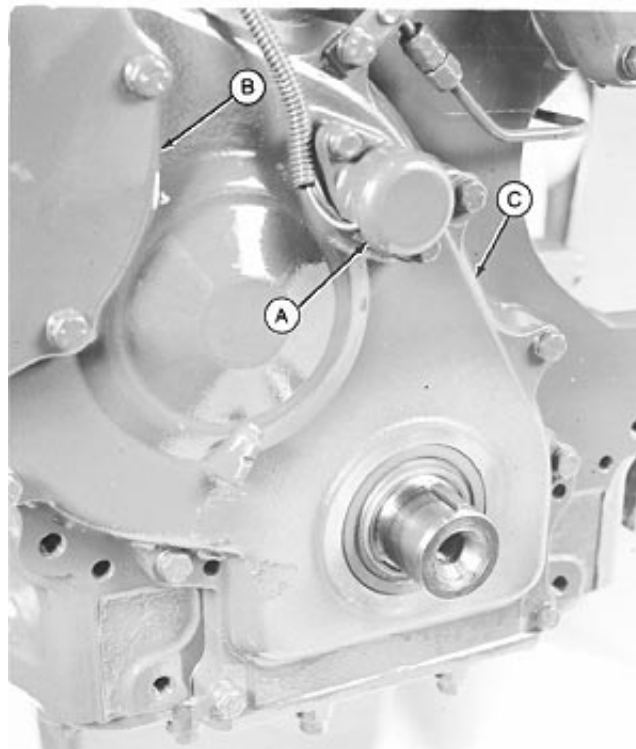


RG6112 -UN-27JAN92

RG,CTM61,G15,13-19-02APR93

REMOVE TIMING GEAR COVER

1. Remove vibration damper as detailed earlier. See REMOVE VIBRATION DAMPER AND PULLEY.
2. Drain engine oil, if not previously done. Remove engine oil pan and oil pump. (See Group 20.)
3. Remove idler pulley assembly, if equipped.
4. Remove magnetic pickup (A), if equipped.
5. Remove injection pump drive gear cover (B). Discard gasket.
6. Remove timing gear cover (C). Discard gasket.
7. Remove front oil seal from timing gear cover using a small punch. Remove wear sleeve from crankshaft flange.
8. Thoroughly clean and inspect seal bore in cover. Check for nicks and burrs. Smooth rough areas with a medium-grit emery cloth.



RG6103 -UN-27JAN92

RG,CTM61,G15,14-19-02APR93

CHECK CRANKSHAFT END PLAY

1. Position dial indicator on end of crankshaft.
2. Push crankshaft as far to rear of engine as possible.
3. Preload and zero the dial indicator.
4. Using a bar, gently pry the crankshaft as far forward as possible.

IMPORTANT: Do not apply too much pressure with bar, as this could damage thrust bearings.

CRANKSHAFT END PLAY SPECIFICATIONS

New Parts 0.038—0.380 mm
(0.0015—0.0150 in.)

NOTE: New thrust bearings will usually restore proper end play.



RG6104 -UN-27JAN92

RG,CTM61,G15,8 -19-24APR92

INSPECT, MEASURE, AND REPAIR FLYWHEEL

1. Inspect the clutch contact face for scoring, overheating, or cracks. Replace flywheel if defective.
2. Examine flywheel ring gear for worn or broken teeth. Replace ring gear if defective, as described later in this group.

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

3. Measure flywheel housing face run-out, flywheel face flatness, and pilot bearing bore concentricity, as outlined later in this group. Resurface flywheel face or replace as required.

S55,2015,N -19-24APR92

CHECK FLYWHEEL HOUSING FACE RUNOUT

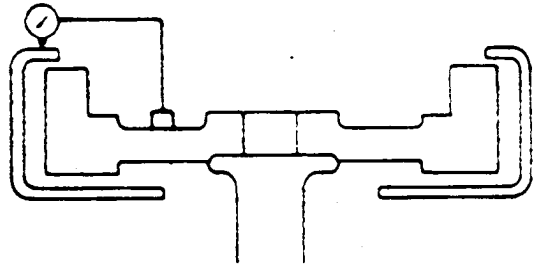
1. Mount dial indicator on flywheel. Set pointer to contact PTO mounting surface on flywheel housing at right angles. Pointer should not contact holes in flywheel housing.

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.

FLYWHEEL HOUSING FACE RUNOUT SPECIFICATION

Maximum Variation 0.20 mm (0.008 in.)



-UN-14DEC88
R22212

S55,2015,L -19-29OCT92

CHECK FLYWHEEL FACE FLATNESS

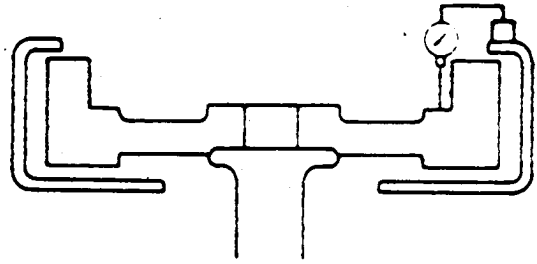
1. Mount dial indicator base on flywheel housing. Position pointer to contact driving ring mounting surface. Do not allow pointer to contact driving ring mounting holes.

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.

FLYWHEEL FACE FLATNESS SPECIFICATION

Maximum Variation 0.23 mm (0.009 in.)
Maximum Variation per 25 mm
(1.0 in.) of Travel 0.013 mm (0.0005 in.)



R22213 -UN-14DEC88

S11,5005,AM -19-29OCT92

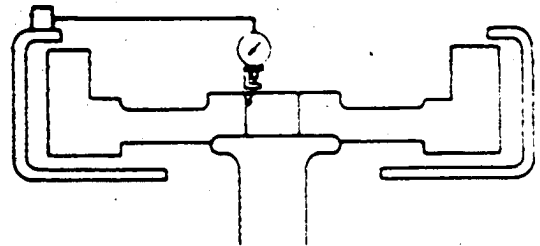
CHECK PILOT BEARING BORE CONCENTRICITY

1. Mount dial indicator on flywheel housing face and position pointer to contact ID of pilot bearing bore in flywheel.

2. Rotate flywheel by turning crankshaft. Read total dial indicator movement.

BEARING BORE CONCENTRICITY SPECIFICATION

Maximum Variation 0.127 mm (0.005 in.)



R22214 -UN-14DEC88

S55,2015,M -19-29OCT92

REMOVE FLYWHEEL AND FLYWHEEL HOUSING

1. Disconnect clutch housing and clutch, if not previously done.
2. Remove starting motor.

⚠ CAUTION: Flywheel housing and flywheel are very heavy. Plan proper handling procedure to avoid injuries.

3. Remove flywheel housing (A).
4. Remove two flywheel attaching cap screws (B), and install two pilot studs in their place.
5. Remove the remaining cap screws, and carefully pull flywheel from crankshaft.



RG4323 -UN-09NOV89

S11,2515,G -19-02APR93

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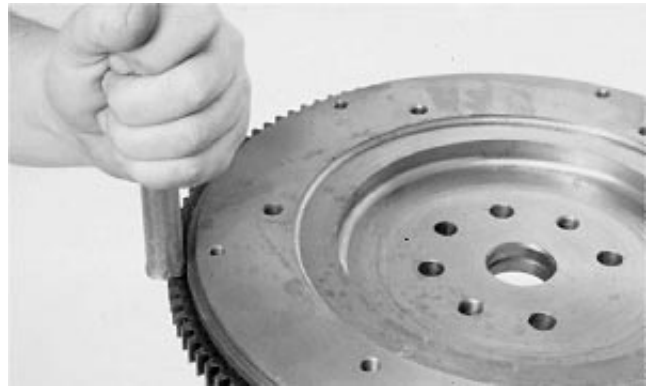
REPLACE FLYWHEEL RING GEAR

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.

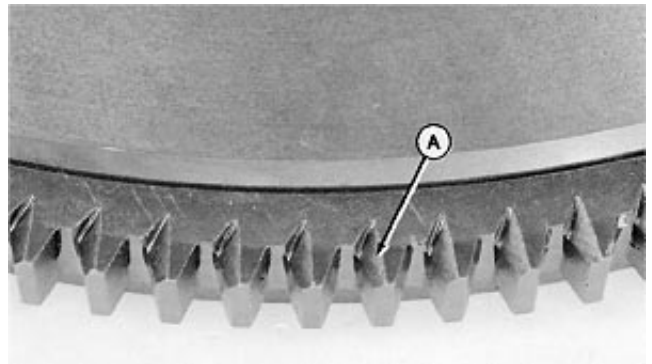
1. If ring gear is damaged, place the flywheel on a solid flat surface.
2. Remove ring gear with a brass drift and hammer.

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.



T90596 -UN-14OCT88



RG3838 -UN-14OCT88

REMOVE REAR OIL SEAL HOUSING AND WEAR SLEEVE (WITH ENGINE DISASSEMBLED)

NOTE: These instructions are for use when the oil seal housing and oil pan will be removed. Refer to REMOVE CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE (WITHOUT REMOVING OIL SEAL HOUSING), earlier in this group, for instructions without the oil seal housing and oil pan being removed.



1. Remove rear oil seal housing (A).

IMPORTANT: If rear oil seal is replaced, also replace wear sleeve. If oil seal and wear sleeve are not damaged, wear sleeve does not have to be removed to remove crankshaft.

2. Rear oil seal (B) will come off with housing. Use a small punch and hammer to remove oil seal. Discard seal.

S11,2020,G -19-02APR93

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IMPORTANT: The preferred method of removing the wear sleeve is with JDG790 Rear Wear Sleeve Puller. When removing wear sleeve with a chisel, DO NOT gouge crankshaft flange. Nicks or burrs should be removed with a medium-grit stone. Polishing cloth (180-grit or finer) may also be used when a stone is not available.

Rear wear sleeve can be removed using one of the following procedures: These procedures may also be followed when crankshaft has been removed from engine.

- Use JDG790 Wear Sleeve Puller to remove wear sleeve from crankshaft flange, as described earlier 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 but do not cut the wear sleeve in several places around OD with a blunt chisel.

Remove wear sleeve from crankshaft flange. Clean flange with a light file and emery cloth.

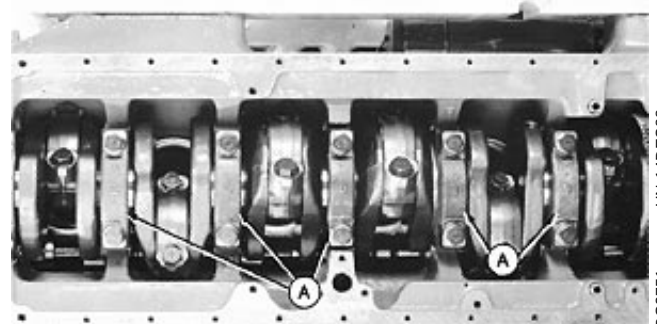
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RG,CTM42,G15,54-19-02APR93

REMOVE CRANKSHAFT MAIN BEARINGS

IMPORTANT: Before removing main bearing caps (A, five shown), check for proper torque on all main bearings. Also, check each bearing cap to make sure they are numbered. This will assure assembly of bearing caps in the correct location, if caps were not stamped during production.

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.

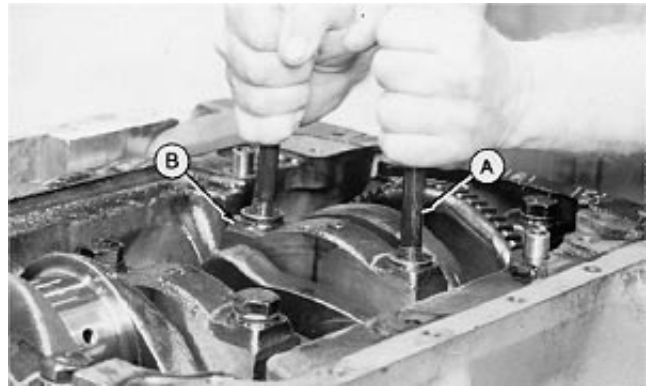


RG3751 -UN-14DEC88

S11,2515,H -19-02APR93

NOTE: Main bearing caps are numbered for reassembly on the same numbered main bearing bosses. Keep matched bearing inserts with their respective main bearing cap for comparison with crankshaft journal (surface) from which removed.

1. Drain oil from engine crankcase if not previously done.
2. Remove oil pan. (See Group 20.)
3. Remove oil pump. (See Group 20.)
4. Loosen main bearing cap screws and washers.
5. Remove main bearing caps by extending cap screws (A) and forcing heads of screws together. Wiggle bearing cap (B) back and forth while applying an upward force with cap screws until free from main bearing cap support.
6. Use PLASTIGAGE to measure oil clearance on each main bearing as they are removed. (See CHECK MAIN BEARING CLEARANCE, later in this group.)



RG4469 -UN-14DEC88

S11,2515,AJ -19-02APR93

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CHECK MAIN BEARING CLEARANCE

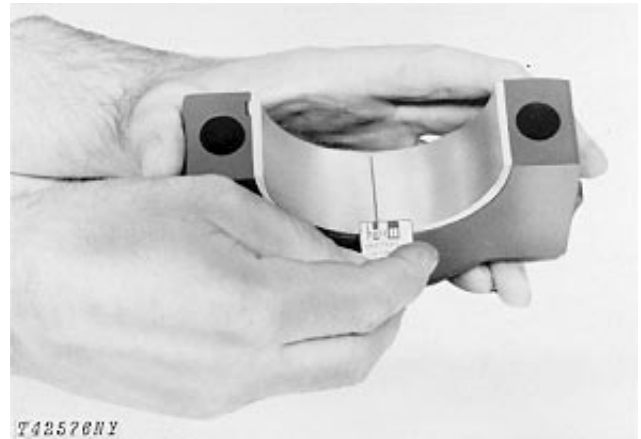
1. Place a strip of PLASTIGAGE in the center of the main bearing cap about three-fourths of the width of the bearing.
2. Use clean engine oil on PLASTIGAGE to prevent smearing.
3. Install cap and tighten cap screws to 285 N·m (210 lb-ft).
4. Remove cap and compare width of PLASTIGAGE with scale provided to determine clearance.

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

MAIN BEARING CLEARANCE SPECIFICATION

Main Bearing-to-Journal Clearance 0.046—0.122 mm
(0.0018—0.0048 in.)

Maximum Acceptable Oil Clearance 0.152 mm
(0.0060 in.)



T42576NY -JUN-09NOV88

REMOVE CRANKSHAFT

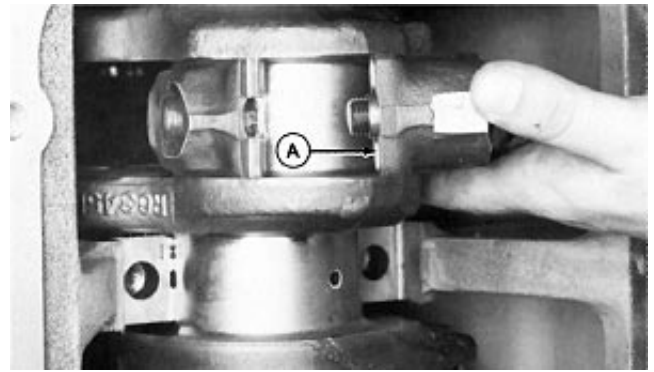
NOTE: If crankshaft gear needs to be replaced, crankshaft must be removed from engine.

1. Rotate crankshaft using the JDE81-1 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 with bearings (A), then remove No. 1 and 7 main bearing caps and bearings. (See REMOVE PISTONS AND CONNECTING RODS in Group 10.)



CAUTION: Crankshaft is very heavy. Plan a proper handling procedure to avoid injury.

3. Attach a lifting strap to crankshaft. 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.



RG3840 -JUN-14DEC88

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S11,0403,AA -19-02APR93

REPLACE CRANKSHAFT GEAR

NOTE: Remove crankshaft gear for replacement only; it is not necessary to remove gear for crankshaft removal.

1. Install JDG787 Thread Protector in nose of crankshaft.
2. Protect crankshaft wear sleeve surface with masking tape.
3. Remove crankshaft gear using D01251AA* Puller or an equivalent puller.
4. Discard gear after removal.
5. Remove Woodruff key from crankshaft keyway.
6. Remove masking tape.

IMPORTANT: Crankshaft gear must be installed on crankshaft before crankshaft is installed in engine, otherwise damage to thrust bearings could occur.



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.

7. Heat crankshaft gear (if removed) to 148°C (300°F), using either heated oil or oven heat.

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.

8. Install Woodruff key in crankshaft.
9. Place gear on crankshaft flange. Be sure key on crankshaft is properly aligned with keyway in gear.
- IMPORTANT: When installing gear, do not gouge or nick crankshaft flange.**
10. Use JDH7 Driver to firmly seat gear against crankshaft flange.
11. Once gear cools, reseal gear using JDH7 Driver.

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

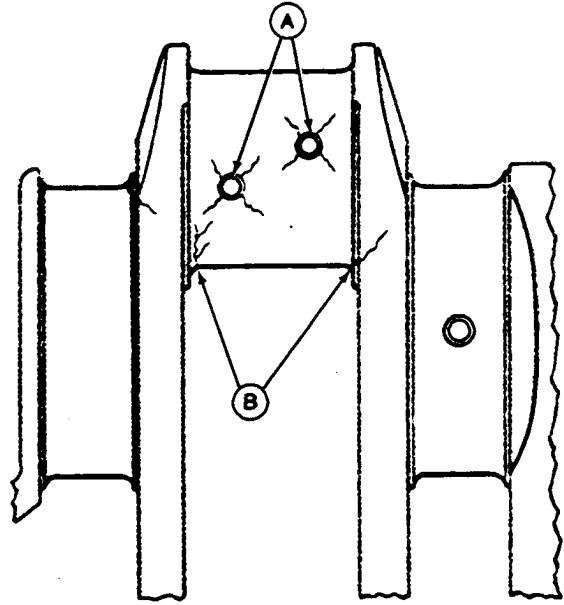
INSPECT CRANKSHAFT

NOTE: If crankshaft damper damage was discovered during teardown, it is recommended that crankshaft be magna-fluxed. This will verify whether or not it has microscopic cracks or fissures. See INSPECT VIBRATION DAMPER, earlier in this group.

1. Inspect the keyway for evidence of cracks or wear. Replace crankshaft as necessary.
2. Carefully inspect the rear hub of the crankshaft in the area of the wear sleeve contact surface for evidence of a rough or grooved condition. Any imperfections in this area will result in oil leakage. Slight ridges may be cleaned up with emery cloth and crocus cloth.
3. Check the crankshaft timing gear and the oil pump drive gear for worn and chipped teeth. Replace the gears as necessary. (See REPLACE CRANKSHAFT OIL PUMP DRIVE GEAR, later in this group.)
4. Check each journal for evidence of excessive overheating or discoloration. If either condition exists, replace crankshaft since heat treatment has probably been destroyed.

IMPORTANT: When inspecting crankshaft for cracks, a method must be used that is capable of detecting minute cracks that are not visible to the eye such as the Fluorescent Magnetic Particle method. This method magnetizes the crank, employs magnetic particles which are fluorescent and glow under "black light". The crankshaft must be de-magnetized after the test.

5. 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.



RG5093 -UN-15DEC88

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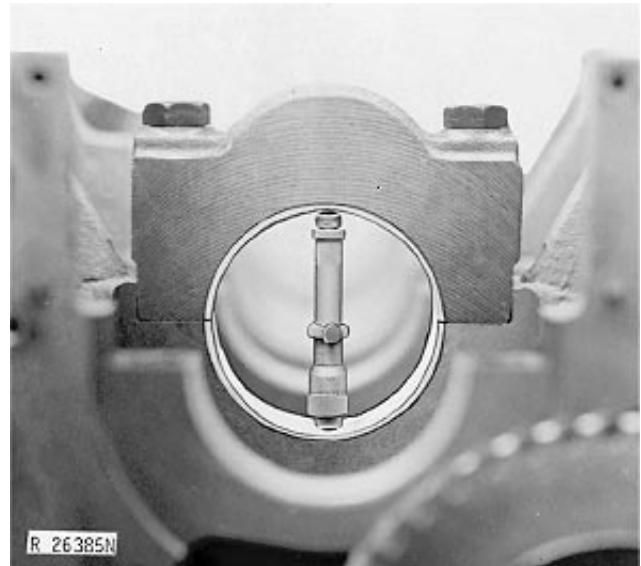
MEASURE ASSEMBLED I.D. OF BEARINGS AND O.D. OF CRANKSHAFT JOURNALS

1. With crankshaft out of cylinder block, install main bearing inserts and caps (be sure inserts are installed correctly).
2. Tighten main bearing cap screws to 285 N·m (210 lb-ft).
3. Measure I.D. of all bearings with an inside micrometer.

MAIN BEARING ID SPECIFICATIONS

With Bearing	95.270—95.320 mm (3.7508—3.7528 in.)
Without Bearing	101.651—101.677 mm (4.0020—4.0030 in.)

NOTE: *Inspect and measure assembled ID of connecting rod bearings. Compare measurements with connecting rod journal OD on crankshaft (See Group 10.)*



S11,2515,M -19-16MAR92

4. Measure OD of all respective crankshaft journals at several points around journal.

CRANKSHAFT SPECIFICATIONS

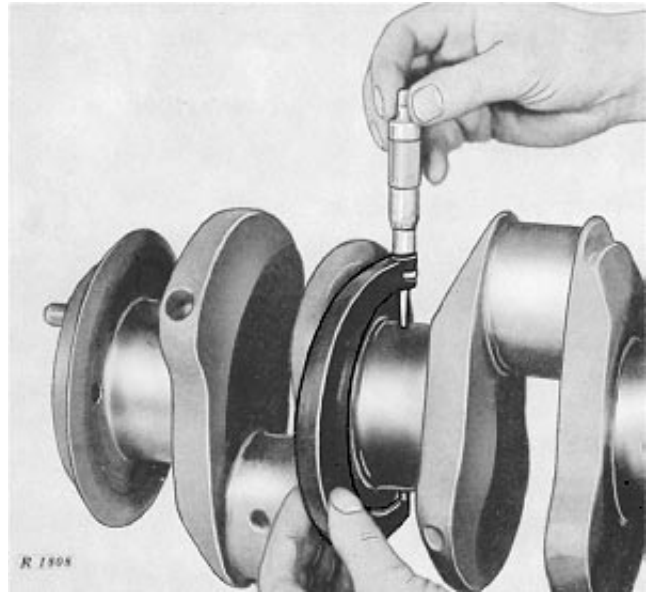
OD of Main Bearing Journal	95.200—95.225 mm (3.7480—3.7490 in.)
ID of Main Bearing (assembled)	95.270—95.320 mm (3.7508—3.7528 in.)

NOTE: If engine has previously had a major overhaul and undersized bearing inserts were used, above listed ID and OD dimensions may not be the same as those recorded. However, oil clearance should be within specifications. Oil clearance is 0.046—0.122 mm (0.0018—0.0048 in.). The maximum serviceable clearance is 0.152 mm (0.0060 in.).

Use crankshaft journal OD measurements to determine if journal is out-of-round or tapered.

CRANKSHAFT WEAR SPECIFICATIONS

Journal Taper per 25.4 mm (1.0 in.) of Journal Length	0.0025 mm (0.0001 in.)
Journal Out-of-Roundness	0.025 mm (0.0010 in.)



S11,2515,N -19-02APR93

MEASURE ASSEMBLED I.D. OF MAIN BEARING CAPS (WITHOUT BEARINGS)

- 1. With crankshaft removed from cylinder block, install main bearing caps without bearing inserts.
- 2. Tighten main bearing cap screws to 285 N·m (210 lb·ft).
- 3. Measure I.D. of all bearing caps with an inside micrometer. Main bearing cap I.D. should be 101.651—101.677 mm (4.0020—4.0030 in.)

If any main bearing cap assembled I.D. is not within specification, blank (generic) bearing caps are available and must be line bored to specification. Replace individual bearing caps as needed.

IMPORTANT: Main bearing cap line boring should be done **ONLY** by experienced personnel on equipment capable of maintaining bore specifications.

MAIN BEARING CAP BORE SPECIFICATION

I.D. Without Bearings	101.651—101.677 mm (4.0020—4.0030 in.)
Maximum Bore Diameter Variation	0.013 mm (0.0005 in.)
Maximum Bore Diameter Taper	0.005 mm (0.0002 in.)
Maximum Straightness (Any bore-to-adjacent bore)	0.038 mm (0.0015 mm)
Maximum Straightness (5 center bores-to-adjacent bore)	0.076 mm (0.0030 in.)
Centerline of Bore-to-Top Deck	374.57—374.73 mm (14.747—14.753 in.)

S11,2515,BX -19-29APR93

CRANKSHAFT GRINDING GUIDELINES

IMPORTANT: Crankshaft grinding should be done **ONLY** be experienced personnel on equipment capable of maintaining crankshaft size and finish specifications.

In addition to the standard size main and connecting rod bearings, 0.05, 0.25, 0.51 and 0.76 mm (0.002, 0.010, 0.020 and 0.030 in.) undersize bearings are available. If journals are tapered, out-of-round, scored or damaged, grind the crankshaft and install the proper undersize bearings.

NOTE: The 0.05 mm (0.002 in.) undersize bearings are used normally to compensate for slight un-even wear on crankshafts. Regrinding is usually unnecessary when this size bearing is used.

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 which the journals are to be reground.
2. If one or more main or connecting rod journals require grinding, then grind all of the main journals or all of the connecting rod journals to the same required size.
3. All journal fillet radii must be free of any sharp grind marks or scratches. The fillet must blend smoothly into the journal and crank cheek. Check the radius with a fillet gage.

IMPORTANT: Care must be taken to avoid localized heating which often produces grinding cracks.

S11,2015,DM -19-04FEB93

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CRANKSHAFT GRINDING GUIDELINES—CONTINUED

4. Cool the crankshaft while grinding by using coolant generously. DO NOT crowd the grinding wheel into the work.

IMPORTANT: Grind crankshaft with journals turning clockwise, as viewed from the front end of crankshaft. Lap or polish journals in opposite direction of grinding.

5. Polish or lap the ground surfaces to the specified finish to prevent excessive wear of the journals.

NOTE: Production crankshafts are induction hardened and shotpeened at the factory. Field shotpeening is not recommended due to the equipment required and port geometry.

6. If the thrust surfaces of the crankshaft are worn or grooved excessively, regrind and polish. Maintain the specified radius between each thrust surface and the bearing journal. An oversize thrust washer set containing one standard washer and two 0.18 mm (0.007 in.) oversize washers is available. (See THRUST BEARING NEW PART SPECIFICATIONS, later in this group.)

NOTE: When thrust surfaces are reground and oversize washers used, crankshaft end play specification must be maintained to within 0.038—0.380 mm (0.0015—0.0150 in.). See CHECK CRANKSHAFT END PLAY, earlier in this group.

7. Stone the edge of all oil holes in the journal surfaces smooth to provide a radius of approximately 1.50 mm (0.060 in.).

8. When finished grinding, inspect the crankshaft for cracks with the Florescent Magnetic Particle method, or similar method.

9. De-magnetize the crankshaft.

10. Thoroughly clean the crankshaft and oil passages with solvent. Dry with compressed air.

CRANKSHAFT GRINDING SPECIFICATIONS

Engine Stroke	127 mm (5.0 in.)
Main and Rod Journal Surface Finish	Lap 0.25 Um (9.8 AA)
Thrust Journal Surface Finish	Lap 0.40 Um (16 AA)
Rod Journal Fillet Radius	4.49—4.85 mm (0.177—0.191 in.)
Main and Thrust Journal Fillet Radius	3.94—4.44 mm (0.155—0.175 in.)
Thrust Journal Width	47.57—47.67 mm (1.873—1.877 in.)

Bearing Size	Crankshaft Main Journal OD	Crankshaft Rod Journal OD
Standard	95.000—95.225 mm (3.7480—3.7490 in.)	88.844—88.874 mm (3.4980—3.4990 in.)
0.05 mm (0.002 in.) Undersize	94.950—95.175 mm (3.7460—3.7470 in.)	88.794—88.824 mm (3.4960—3.4970 in.)
0.25 mm (0.010 in.) Undersize	94.750—94.975 mm (3.7380—3.7390 in.)	88.594—88.624 mm (3.4880—3.4890 in.)
0.51 mm (0.020 in.) Undersize	94.490—94.715 mm (3.7280—3.7290 in.)	88.334—88.364 mm (3.4780—3.4790 in.)
0.76 mm (0.030 in.) Undersize	94.240—94.465 mm (3.7180—3.7190 in.)	88.064—88.114 mm (3.4680—3.4690 in.)

S11,2515,BZ -19-24APR92

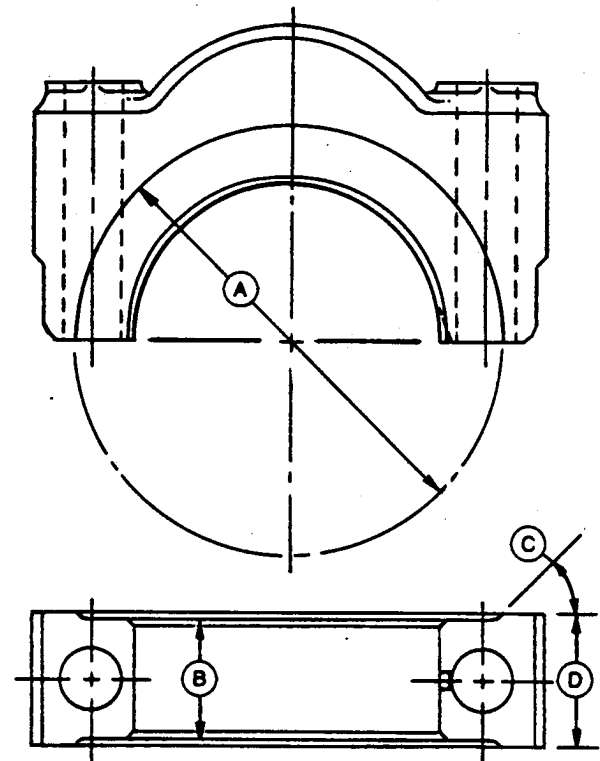
THRUST BEARING NEW PART SPECIFICATIONS

IMPORTANT: Install thrust bearing in cylinder block and tighten to specification before regrounding or polishing thrust surfaces to assure that all surfaces on bearing and on block web are correctly aligned.

THRUST BEARING NEW PART SPECIFICATION

A—Thrust Washer Clearance Base Circle	129.28—130.81 mm (5.09—5.15 in.)
B—Thrust Surface Thickness	40.615—40.716 mm (1.559—1.603 in.)
C—Relief Angle	45°
D—Bearing Cap Overall Width	41.81—42.31 mm (1.646—1.666 in.)

Maximum runout for thrust surface is 0.025 mm (0.0010 in.)

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S55,2515,K -19-16MAR92

REPLACE CRANKSHAFT OIL PUMP DRIVE GEAR

IMPORTANT: Protect all machined surfaces of crankshaft from grinding debris and weld spatter when removing old gear and installing new gear. **DO NOT** use a cutting torch to remove failed gear.

1. Using a rotary grinding wheel or parting disc, grind weld beads (A) until flush with crankshaft flange.
2. Remove gear (B) by alternately striking gear at each weld location using a brass drift and soft lead mallet.
3. After removal of gear, clean up 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.

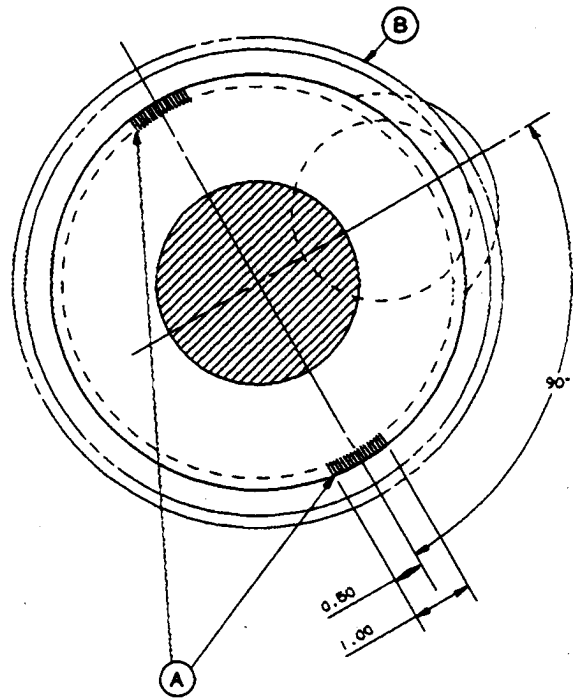
4. Heat new gear to 148°C (300°F) using either heated oil or oven heat.

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

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 the possibility of interference with cylinder block.



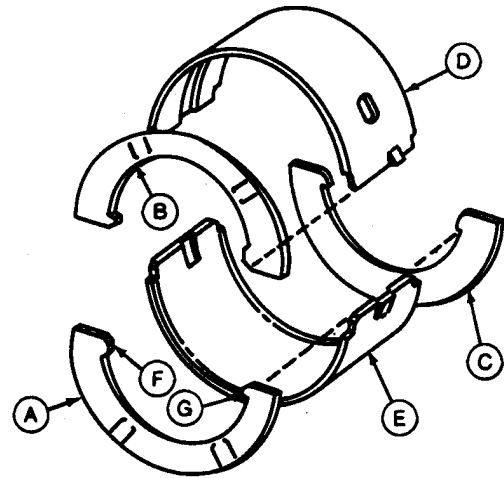
RG5018 -UN-14DEC88

INSPECT THRUST BEARINGS

1. 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.

NOTE: Thrust bearings must be installed with slots facing crankshaft flange.



- 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

S11,0403,AF -19-16MAR92

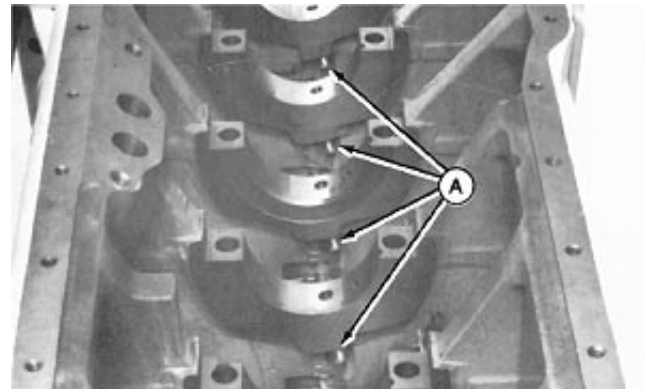
REMOVE AND CLEAN PISTON COOLING ORIFICES

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 11 N·m (8 lb-ft) (97 lb-in.).



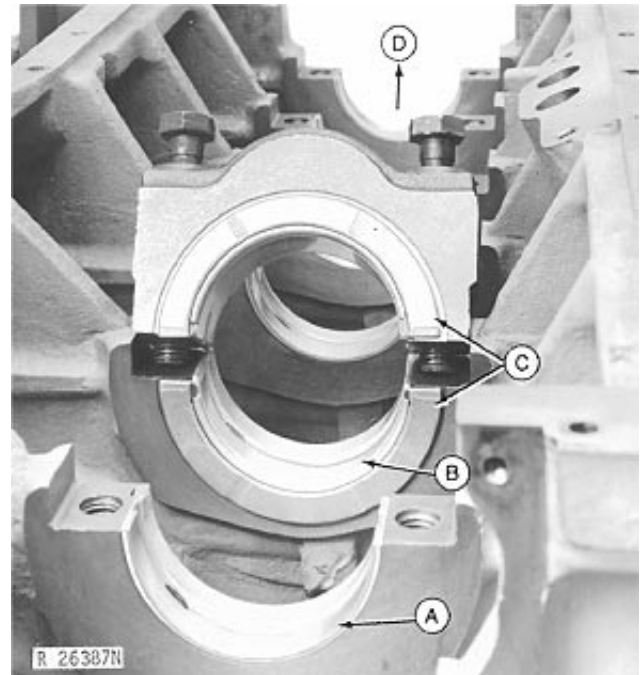
S11,2015,CN -19-24APR92

INSTALL MAIN BEARING INSERTS IN BLOCK

1. Install main bearing inserts (A) (crankshaft shown removed).
2. Be sure main thrust bearing insert (B) and thrust washers (C) are installed in fifth bore from front of engine. Washers go on both sides of bearing cap; and on rear side of block web only with the slotted face toward the crankshaft.
3. Make sure tangs on all bearings fit in recesses in bore and that oil slots line up with oil passages in block.
4. Apply a film of clean oil to bearing ID surfaces and to crankshaft journals.

NOTE: Before installing any main bearing and connecting rod cap screws, immerse each cap screw and washer entirely in clean engine oil.

IMPORTANT: If new thrust bearing inserts or thrust washers are installed, they must be installed as a set.



A—Main Bearing Insert
B—Main Thrust Bearing
C—Thrust Washers (3 used)
D—To Front of Engine

S11,0403,AI -19-02APR93

INSTALL CRANKSHAFT



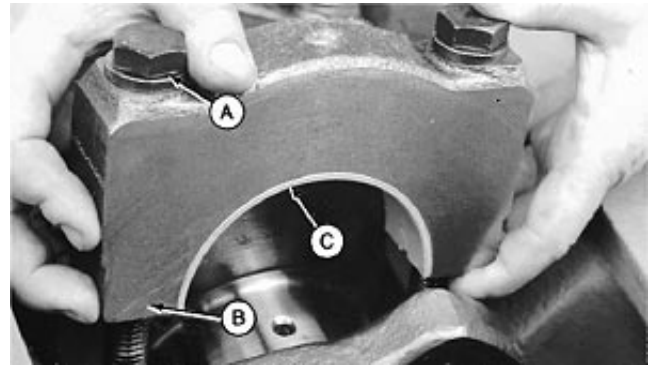
CAUTION: Crankshaft is heavy. Plan a proper lifting procedure to avoid injuries.

1. Carefully position crankshaft onto main bearings using a hoist and lift sling.
2. Dip entire main bearing cap screws in clean engine oil and position them in the main bearing caps. Apply a liberal amount of oil to bearing inserts in caps.
3. Install each bearing cap (B), bearings (C), and cap screws with washer (A) with the recesses and tabs aligned in matching order. Make sure bearing tabs also match up before tightening cap screws.

NOTE: Make sure main bearing caps are installed on the bearing bosses from which they were removed. The numbers stamped on the caps should be on the same side as the numbers on the block. If there is an arrow on cap, arrow must point toward front of engine. If bearing caps have been rebored, make sure new bearing caps have numbers stamped on them.

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

4. Before tightening cap screws on main bearing caps, align upper and lower thrust flanges on main thrust bearings. Using a pry bar between block web and crankshaft throw, gently pry crankshaft to the rear and then to the front to line up thrust bearing flanges.
5. Tighten No. 1, 2, 3, 4, 6 and 7 main bearing cap screws to 68 N·m (50 lb-ft). Hand tighten No. 5 main bearing cap screws.
6. Gently pry crankshaft rearward then forward to align thrust washers on No. 5 main bearing. DO NOT pry crankshaft at No. 5 main.
7. Tighten all main bearing cap screws to 285 N·m (210 lb-ft).
8. Turn crankshaft by hand. If it does not turn easily, disassemble parts and determine the cause.



RG3741 -UN-14DEC88

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41

9. Install connecting rod caps (A) with bearings (B), using new cap screws and tighten to 75 N·m (55 lb-ft). Tighten an additional 90—100° after initial tightening. (See USE TORQUE-TURN METHOD FOR PROPER TORQUE in Group 10.)

IMPORTANT: Using pneumatic wrenches to tighten connecting rod cap screws may cause damage to the threads.

10. Check crankshaft for 0.038—0.380 mm (0.0015—0.0150 in.) end play.



RG3743 -UN-14DEC88

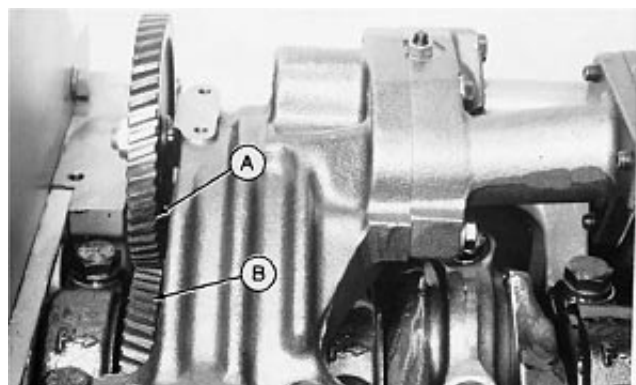
S11,2515,AU -19-02APR93

INSTALL OIL PUMP AND CHECK DRIVE GEAR-TO-CRANKSHAFT CLEARANCE

1. Install engine oil pump at this time. (See INSTALL OIL PUMP in Group 20.)

IMPORTANT: Gently pry crankshaft forward and check that oil pump drive gear (A) and crankshaft gear (B) are properly meshed.

Gently pry crankshaft rearward (toward flywheel end), and check for clearance between oil pump drive gear face and throw of crankshaft. There should be at least 0.38 mm (0.015 in.) clearance. If clearance is below specification, check thrust bearing for proper placement.



RG5509 -UN-10NOV89

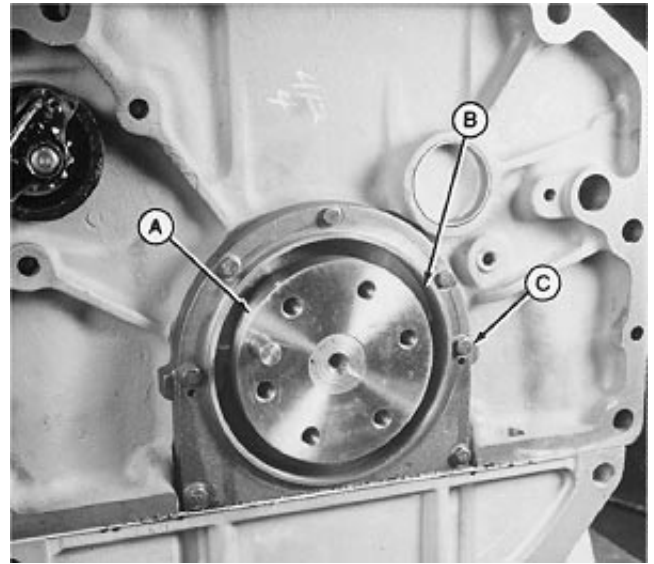
S55,2515,M -19-16MAR92

INSTALL CRANKSHAFT REAR OIL SEAL HOUSING

NOTE: Oil pan (shown installed) must be either removed or cap screws loosened and pan lowered to accurately install crankshaft rear oil seal housing.

Make sure the OD of crankshaft flange (A) and ID of seal housing (B) are free from nicks or burrs. Restore damaged surfaces with file or emery cloth. Clean with compressed air.

1. Using a new gasket, install oil seal housing (C) on to locating dowels in cylinder block. Install all seven cap screws and tighten to 27 N·m (20 lb-ft).
2. Check oil seal housing runout on ID of housing. See CHECK OIL SEAL HOUSING RUN-OUT, later in this group.



RG5526 -UN-10NOV89

S55,2515,N -19-02APR93

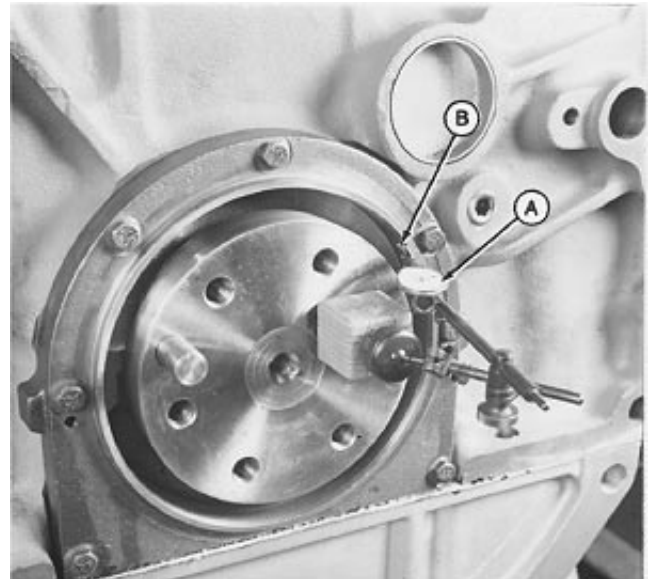
CHECK OIL SEAL HOUSING RUNOUT

IMPORTANT: Rear oil seal housing is located by two dowel pins in cylinder block. If housing bore run-out is not within specification, install a new housing; there is not adjustment for run-out specification.

1. Position magnetic base dial indicator (A) on crankshaft flange. Locate indicator tip on ID of oil seal housing bore (B) with a preload.
2. Zero dial indicator and rotate crankshaft one full revolution and check oil seal housing runout. The maximum oil seal housing runout is 0.152 mm (0.0060 in.).

If runout exceeds specification, install a new housing and check run-out.

3. Trim off excess gasket material extending below bottom of oil seal housing.



RG5528 -UN-07JUL89

S55,2515,P -19-24APR92

CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE HANDLING PRECAUTIONS

Use the following precautions for handling seal and wear sleeve:

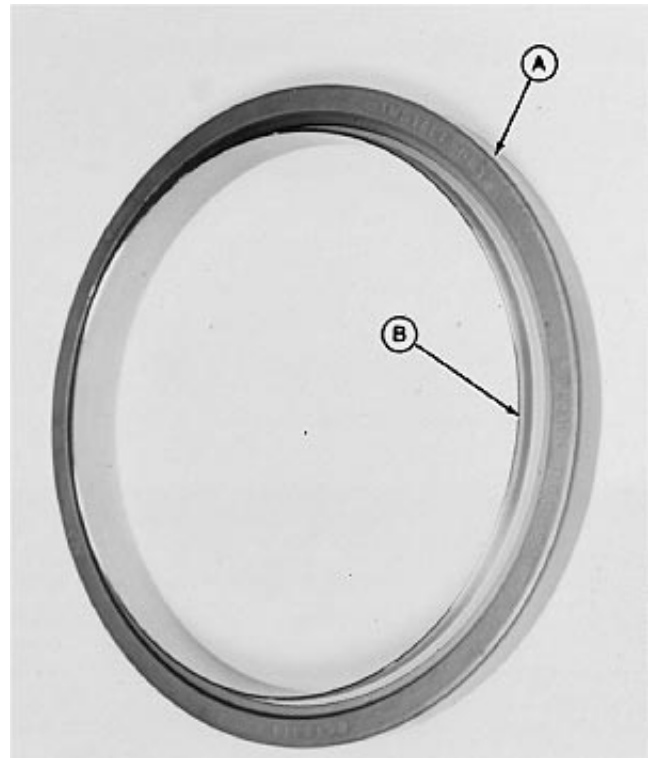
—Seal (A) and wear sleeve (B) are assembled. DO NOT SEPARATE. If parts become separated, discard and replace with a new assembly. Attempts to reassemble will cause the wear sleeve to damage the seal allowing engine oil to leak past seal.

—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 black seal lip 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 JDG300 Oil Seal and Wear Sleeve Installer. Tool set consists of JDG309 Pilot and JDG310 Installer.



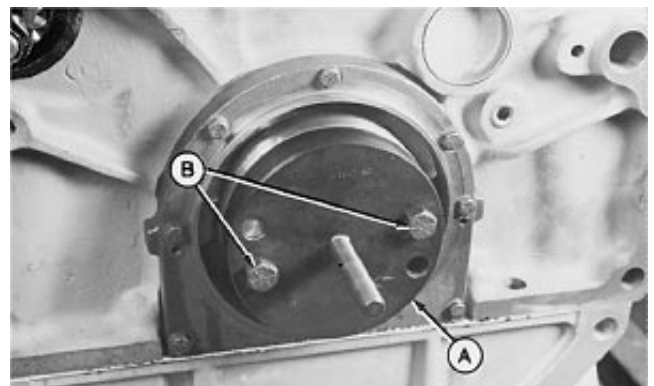
RG5575 -UN-07JUL89

S11,2515,AL -19-24APR92

INSTALL CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE ASSEMBLY

IMPORTANT: Installation tools must be clean to assure proper positioning on crankshaft flange and to hold run-out within specification so oil seal does not fail prematurely.

1. Install JDG309 Pilot (A) over dowel pin on rear end of crankshaft.
2. Tighten two cap screws (B) securely.



RG5576 -UN-10NOV89

S11,2515,AM -19-24APR92

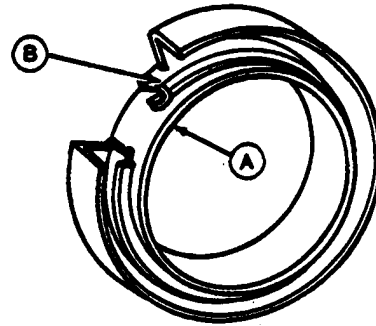
IMPORTANT: Handle seal and wear sleeve carefully. If assembly becomes separated, discard these parts and install a new assembly. See **CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE HANDLING PRECAUTIONS**, earlier in this group.

Chamfer on wear sleeve (A), upper illustration, and open side of seal (B, upper illustration) must be on the same side.

3. Apply a light coating of LOCTITE 609 Retaining Compound around the leading edge of crankshaft.

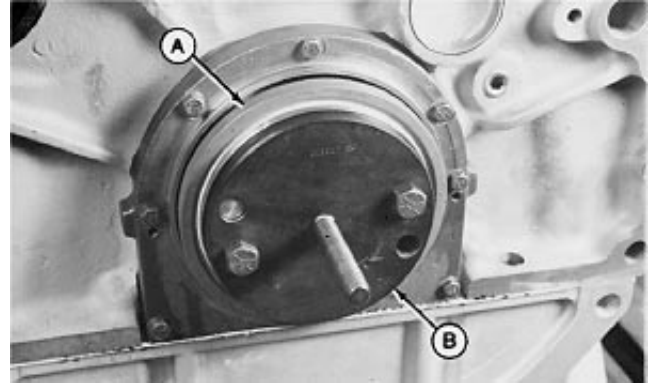
IMPORTANT: DO NOT allow sealant to get on any part of wear sleeve OD or oil seal.

4. Carefully install oil seal/wear sleeve assembly (A) over JDG309 Pilot (B) on crankshaft flange with black seal lip toward engine.



-UN-14OCT88

T88560



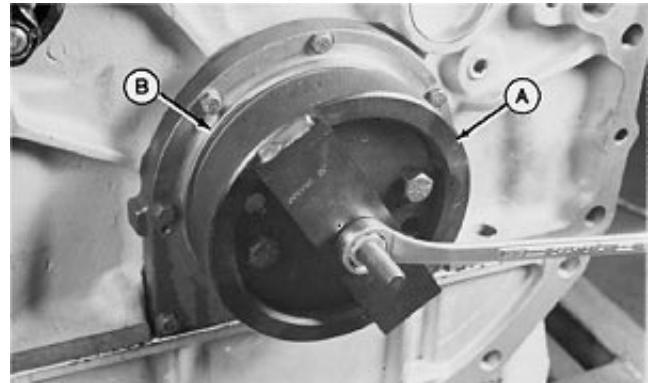
RG5577 -UN-10NOV89

S11,2515,AN -19-02APR93

5. Position JDG310 Installer (A) so that hole in the installer cross plate goes over threaded stud of pilot and that cross plate can not bottom on cap screws of pilot. Install washer and nut on stud.

6. Tighten nut to draw JDG310 Installer in until it bottoms on oil seal housing flange (B). When the tool bottoms, seal and wear ring assembly will be correctly positioned.

7. Remove JDG309 and JDG310 Tools from end of crankshaft.



RG5578 -UN-10NOV89

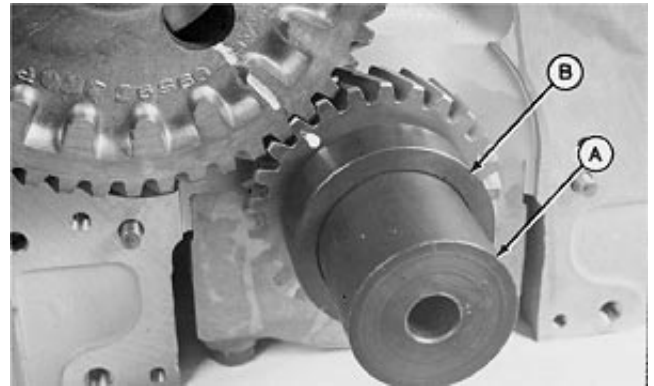
S11,2515,AO -19-15JUN89

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45

INSTALL CRANKSHAFT FRONT WEAR SLEEVE

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

1. Coat ID of new wear sleeve with LOCTITE 609 Retaining Compound or equivalent.
2. Use the JDG467 Driver (A) and JDG468 Spacer (B), from the JDE3 Front Wear Sleeve Installer Set to properly seat wear sleeve on crankshaft flange.



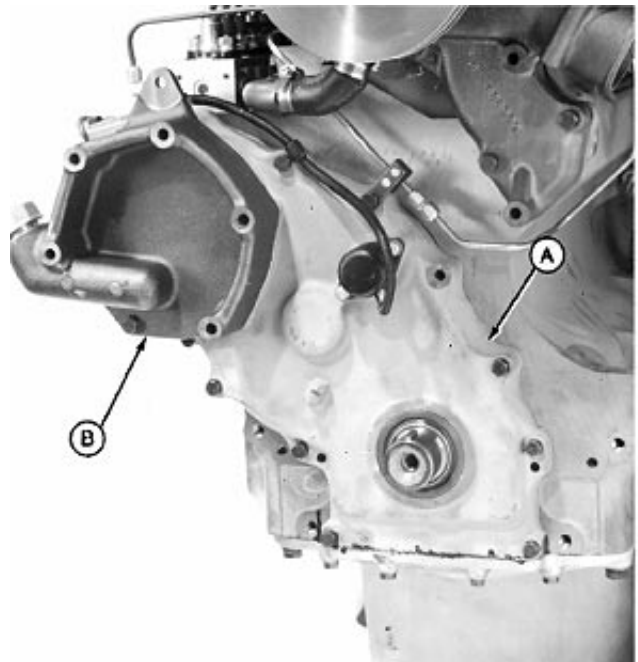
RG5529 -UN-10NOV89

S55,2515,Q -19-02APR93

INSTALL TIMING GEAR COVER

NOTE: Coat threads of lower two cap screws for injection pump gear cover with LOCTITE 242 Thread Lock and Sealer to prevent oil leakage.

1. Using a new gasket, install timing gear cover (A) and injection pump gear cover (B).
2. Tighten timing gear cover and injection pump gear cover cap screws to 41 N·m (30 lb-ft).
3. Trim gasket flush with oil pan mounting face.
4. Install magnetic pickup, if equipped.



RG6619 -UN-17FEB93

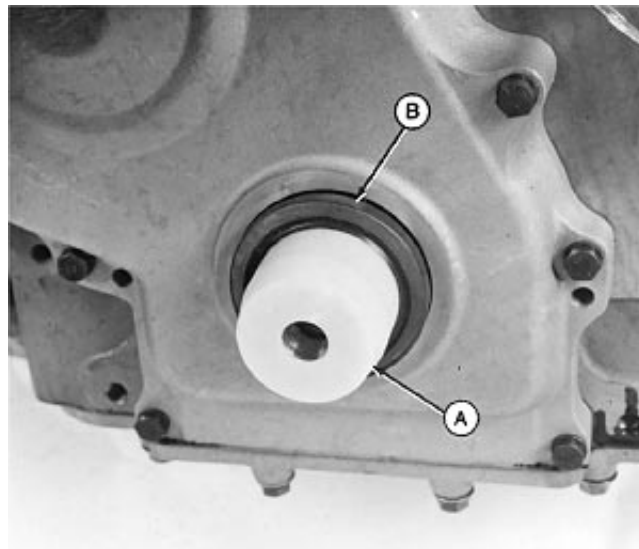
S55,2515,R -19-02APR93

**INSTALL CRANKSHAFT FRONT OIL SEAL
(WITH TIMING GEAR COVER INSTALLED ON
ENGINE)**

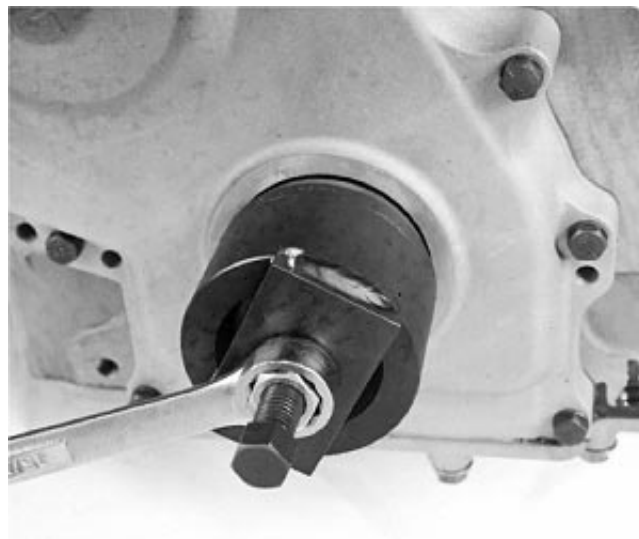
IMPORTANT: Whenever front oil seal is replaced,
wear sleeve **MUST** be replaced also.

1. Place JDG720-2 Seal Protector (A) on nose of crankshaft. Lubricate ID of front oil seal (B) lips with clean engine oil and slide seal onto seal protector. Be careful not to roll oil seal lips.
2. Position JDG720-4 Spacer Ring on end of JDG720-3 Seal Installer and place installer onto seal protector against seal.
3. With nut installed onto JDG720-1 Forcing Screw, thread forcing screw into nose of crankshaft until it bottoms.
4. Tighten nut against crossplate of installer until installer bottoms onto front face of timing gear cover.
5. Remove installation tools.

IMPORTANT: Verify seal is installed square in bore, flush with front face of timing gear cover, and that seal lips are not rolled on wear sleeve.



RG6111 -UN-27JAN92



RG6112 -UN-27JAN92

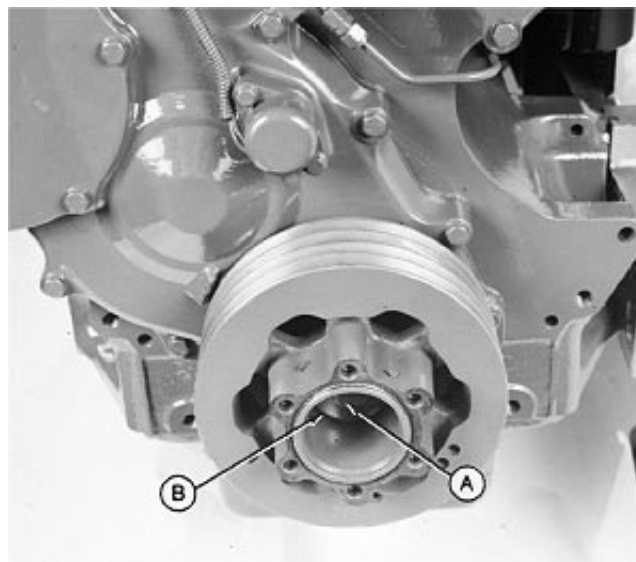
RG,CTM61,G15,13-19-02APR93

INSTALL DAMPER PULLEY AND VIBRATION DAMPER

IMPORTANT: Improper damper installation may cause damper inertia ring/crankshaft pulley contact. This contact severely hampers damper operation and can result in crankshaft and/or gear train failures.

NOTE: Damper and pulley may be installed as an assembly if desired.

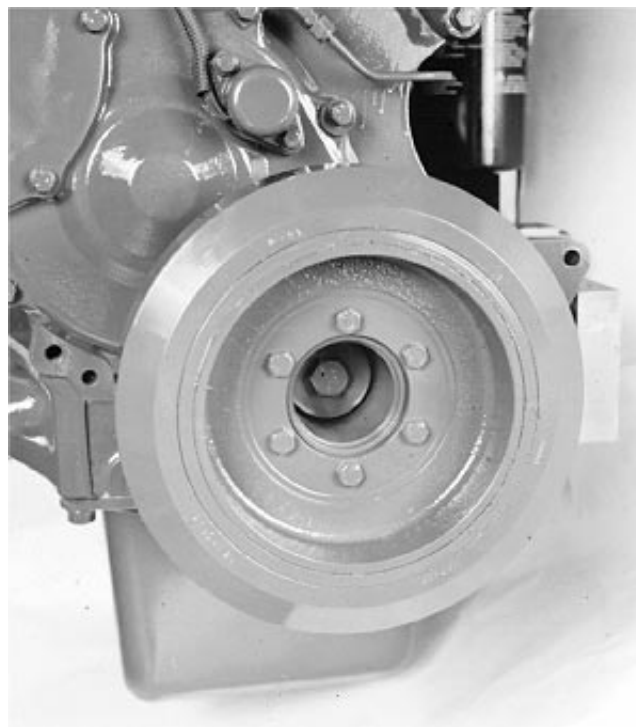
1. Make sure Woodruff key on crankshaft is in place. Position damper pulley onto crankshaft.
2. Use the special washer and insert a 5/8-11 UNC-2A x 3.00 in. cap screw. Tighten cap screw until it bottoms in nose of crankshaft.
3. Remove longer cap screw and insert original cap screw (A) with special washer (B).
4. Tighten cap screw to 230 N·m (170 lb-ft).



RG6101
-UN-27JAN92

RG,CTM61,G15,15-19-02APR93

5. Install vibration damper onto pulley with chamfered side of damper facing engine. Using new cap screws, tighten to 70 N·m (52 lb-ft).



RG6100
-UN-27JAN92

RG,CTM61,G15,16-19-24APR92

INSTALL FLYWHEEL HOUSING AND FLYWHEEL

1. Coat threads of NEW flywheel attaching cap screws with LOCTITE 242 Thread Lock and Sealer or its equivalent.
2. Position flywheel over dowel pin and start two cap screws (B). Do not tighten.
3. Install remaining flywheel attaching cap screws.
4. Tighten flywheel attaching cap screws to 176 N·m (130 lb-ft).

NOTE: For wet clutch applications, use a new gasket while installing flywheel housing.

5. Install flywheel housing (A) and tighten flywheel housing-to-cylinder block cap screws with lock washers to 407 N·m (300 lb-ft). Tighten flywheel housing-to-oil pan cap screws to 325 N·m (240 lb-ft).

IMPORTANT: Perform flywheel-to-flywheel housing runout checks as outlined earlier in this group.

6. Coat threads of cap screws with LOCTITE 242 and install starting motor. Tighten cap screws to 102 N·m (75 lb-ft).



S11,2515,X -19-02APR93

COMPLETE FINAL ASSEMBLY

1. Install oil pump, oil pan, and clean engine oil. (See Lubrication System, Group 20.)
2. Fill cooling system with proper coolant. (See Fuels, Lubricants, and Coolant, Group 02.)
3. Perform engine break-in as instructed in Group 05 or your machine technical manual.

S11,2515,AX -19-24APR92

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SPECIAL OR ESSENTIAL TOOLS

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

DX,TOOLS -19-05JUN91

Magnetic Follower Holder Kit D15001NU

Hold cam followers when removing or installing camshaft.

RG5073 -UN-23AUG88



S53,D15001,NU -19-24APR92

Slide Hammer D01299AA

Used with JDG405 Camshaft Bushing Service Set and JDG606 Camshaft Bushing Adapter Set to service camshaft bushings.



RG78104H1 -UN-15DEC88

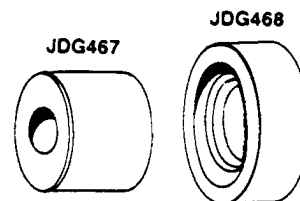
S53,D01299,AAA -19-09SEP91

Front Wear Sleeve Installer Set JDE3

Install front crankshaft wear sleeve.

Set consists of:

Driver JDG467
Spacer JDG468



16
1

-UN-04JUL89

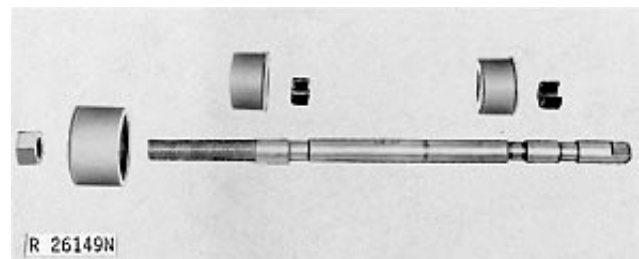
RG5508

S53,JDE3A -19-16MAR92

Camshaft Bushing Service Set JDE6

Used with JDG602 Camshaft Bushing Adapter Set to service camshaft bushings.

NOTE: JDG405 Service Set may be used along with JDG606 Adapter Set if JDE6 is not available.



R26149N -UN-23AUG88

S53,JDE6A -19-09SEP91

Camshaft and Timing Gear Train/Special or Essential Tools

Flywheel Turning Tool JDE81-1

RG4950

-UN-23AUG88

Rotate engine flywheel. Use with JDE81-4.



S53,JDE811

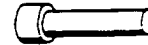
-19-07JUL89

Timing Pin JDE81-4

RG5068

-UN-23AUG88

Lock engine at TDC when timing valve train. Use with JDE81-1.



S55,JDE814,B

-19-24FEB88

Camshaft Bushing Service Set JDG405

Used with JDG606 Camshaft Bushing Adapter Set and D01299AA Slide Hammer to service camshaft bushings.

NOTE: JDE6 Service Set may be used along with JDG602 Adapter Set if JDG405 is not available.



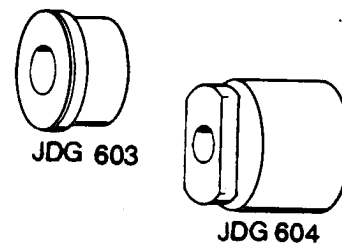
RG4228 -UN-27JAN92

S53,JDG405,A

-19-28APR92

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.



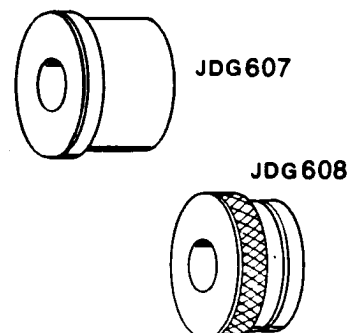
RG5336 -UN-23AUG88

S53,JDG602

-19-09SEP91

Camshaft Bushing Adapter Set JDG606

Used with JDG405 Camshaft Bushing Service Set and D01299AA Slide Hammer to service camshaft bushings. JDG606 consists of JDG607 Driver and JDG608 Pilot.



RG5337 -UN-28AUG91

S53,JDG606

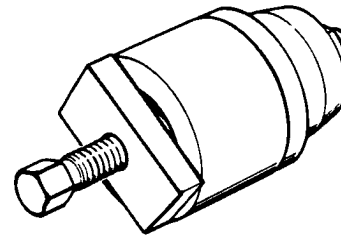
-19-09SEP91

Seal Installer JDG720

Used to install front crankshaft oil seal with timing gear cover installed.

Set consists of:

- 1—Forcing Screw JDG720-1
- 2—Seal Protector JDG720-2
- 3—Seal Installer JDG720-3
- 4—Ring (500 Series Engines) JDG720-4

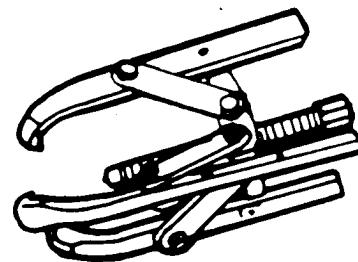


RG,JDG720 -19-01APR93

RG6215 -UN-06MAR92

Vibration Damper and Pulley Puller Set JDG728

Used to remove vibration damper pulley.

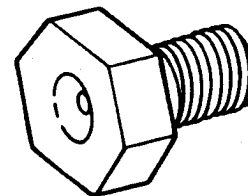


RG,JDG728 -19-29APR93

RG6218 -UN-06MAR92

Thread Protector JDG787

Used with any puller set to remove vibration damper pulley assembly.



RG,JDG787 -19-03FEB93

RG6429 -UN-13OCT92

OTHER MATERIAL

Name	Use
High Temperature Grease (TY6333 or TY6347)	Lubricate camshaft lobes and bearing journals before camshaft installation.
LOCTITE 609 Retaining Compound (TY9372/T43515)	Coat ID of wear sleeve.
LOCTITE 242 Thread Lock and Sealer (TY9370/T43512)	Coat threads of lower two injection pump drive gear cover cap screws and camshaft thrust plate cap screws.

RG,CTM61.G16,1 -19-07MAY93

CAMSHAFT AND TIMING GEAR TRAIN SPECIFICATIONS

ITEM	SPECIFICATION	WEAR LIMIT
Valve Lift at 0.00 mm (in.) Clearance:		
Intake Valve	12.50—12.90 mm (0.492—0.508 in.)	11.66 mm (0.459 in.)
Exhaust Valve	15.37—15.77 mm (0.605—0.621 in.)	14.50 mm (0.571 in.)
Cam Lobe Lift:		
Intake Lobe	7.61—7.87 mm (0.300—0.310 in.)	7.14 mm (0.281 in.)
Exhaust Lobe	9.38—9.64 mm (0.369—0.380 in.)	8.78 mm (0.346 in.)
Camshaft End Play		
(Front Camshaft Journal-to-Thrust Plate Clearance)	0.115—0.241 mm (0.0045—0.0095 in.)	0.342 mm (0.0135 in.)
Camshaft Thrust Plate Thickness	4.724—4.800 mm (0.1860—0.1890 in.)	4.623 mm (0.1820 in.)
Thrust Spacer Thickness	4.915—4.965 mm (0.1935—0.1955 in.)	—
Cam Follower OD	34.874—34.900 mm (1.3730—1.3740 in.)	—
Cam Follower Bore Diameter in Block	34.976—35.027 mm (1.3770—1.3790 in.)	—
Camshaft Bushing Bore in Block		
(without bushing)	69.987—70.013 mm (2.7554—2.7564 in.)	—
Maximum Runout of Camshaft Bore	0.038 mm (0.0015 in.)	—
Camshaft Bushing ID	67.076—67.102 mm (2.6408—2.6418 in.)	—
Camshaft Journal OD	66.987—67.013 mm (2.6373—2.6383 in.)	—
Camshaft Bushing-to-Journal Clearance		
Maximum Serviceable	0.050—0.128 mm (0.0020—0.0050 in.)	—
Maximum Serviceable	0.152 mm (0.0060 in.)	—
Front Camshaft Journal-to-Thrust		
Plate Clearance	0.115—0.241 mm (0.0045—0.0095 in.)	—
Maximum Serviceable	0.342 mm (0.0135 in.)	—
Camshaft Gear-to-Injection Pump		
Drive Gear Backlash	0.05 mm (0.002 in.) minimum	—
Camshaft Drive Gear-to-Crankshaft		
Gear Backlash	0.08 mm (0.003 in.) minimum	—
Crankshaft Front Oil Seal		
Installed Depth	8.4 mm (0.33 in.)	—
Maximum Crankshaft Front Oil Seal		
Bore Runout	0.254 mm (0.020 in.)	—

RG,CTM61,G16,2 -19-01APR93

CAMSHAFT AND TIMING GEAR TRAIN SPECIFICATIONS—CONTINUED**TORQUES**

Camshaft Thrust Plate-to-Cylinder Block	41 N·m (30 lb-ft)
Camshaft Drive Gear-to-Camshaft	115 N·m (85 lb-ft)
Timing Gear Cover-to-Cylinder Block	41 N·m (30 lb-ft)
Injection Pump Gear Cover-to-Timing Gear Cover:	
6101HRW10 and 6101HRW11 Engine Applications	68 N·m (50 lb-ft)
All Other Applications	41 N·m (30 lb-ft)
Damper Pulley-to-Crankshaft	230 N·m (170 lb-ft)
Damper Assembly-to-Pulley	70 N·m (52 lb-ft)
Rocker Arm Shaft Clamps	88 N·m (65 lb-ft)
Rocker Arm Cover-to-Cylinder Head	8 N·m (6 lb-ft)

RG,CTM61,G16,22-19-02APR93

CHECK VALVE LIFT

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

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

1. Remove turbocharger heat shield (if equipped) and rocker arm cover, if not previously done.
2. Remove vent tube from hole in block. Remove plastic plugs.
3. Loosen locknut on rocker arm shaft and set valve clearance at zero (0.00) using a wrench and screwdriver. Tighten locknut.
4. Place dial indicator tip on top of valve spring cap, as shown. Preload indicator tip and set dial at zero (0.00).
5. Manually turn engine in running direction one full revolution using the JDE81-1 Flywheel Turning Tool.
6. Observe dial indicator reading as valve is moved to full open. Record readings and compare with specifications given below.

VALVE LIFT SPECIFICATIONS [at 0.00 mm (in.) Valve Clearance]

Intake Valves	12.50—12.90 mm (0.492—0.508 in.)
Wear Tolerance	11.66 mm (0.459 in.)
Exhaust Valves	15.37—15.77 mm (0.605—0.621 in.)
Wear Tolerance	14.50 mm (0.571 in.)

7. Follow same procedure for all remaining valves and adjust valve clearance when valve lift measurements are complete. (See CHECK AND ADJUST VALVE CLEARANCE in Group 05.)



RG6037 -UN-17JAN92

RG,CTM61,G5,3 -19-30MAR93

CHECK CAMSHAFT END PLAY

1. Install magnetic base dial indicator on front face of cylinder block.
2. 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 specifications given below.

CAMSHAFT END PLAY SPECIFICATION

New Camshaft End Play 0.115—0.241 mm
(0.0045—0.0095 in.)

Maximum Allowable End Play 0.342 mm (0.0135 in.)

If end play exceeds specifications, check thrust washer thickness during disassembly.



-UN-29JAN92

RG6114

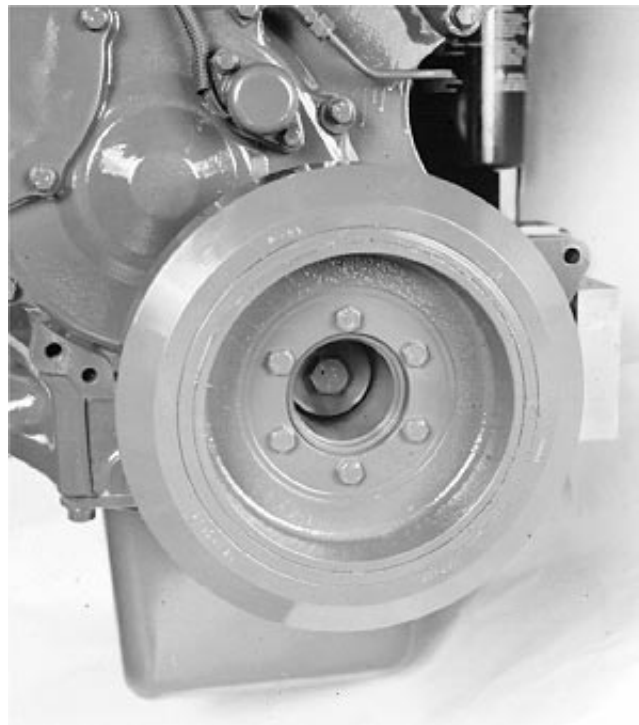
RG,CTM61,G16,3 -19-01APR93

REMOVE VIBRATION DAMPER AND PULLEY

CAUTION: Damper and pulley are very heavy. Plan a proper handling procedure to avoid injuries.

ALWAYS use an assistant when removing and installing pulley.

1. Remove six cap screws securing vibration damper to pulley and remove damper from pulley.



-UN-27JAN92

RG6100

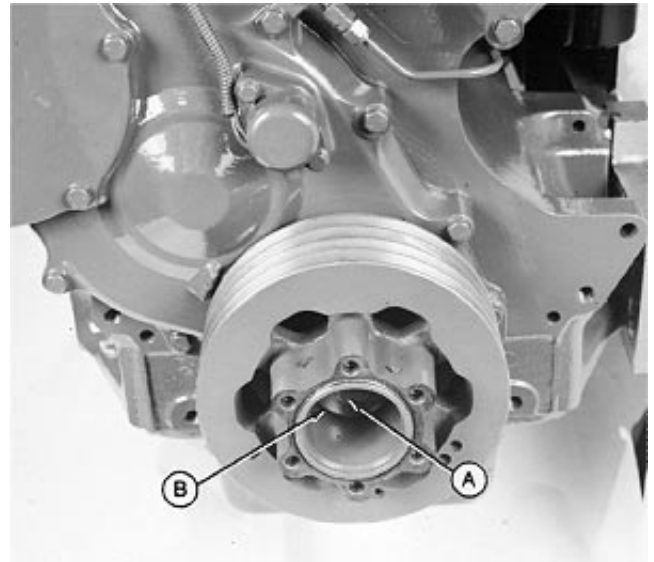
RG,CTM61,G15,5 -19-24APR92

IMPORTANT: Be extremely careful when using a jaw-type puller to remove vibration damper and pulley assembly. ALWAYS remove damper from pulley first, if possible. Pull ONLY on back side of pulley closest to the engine. DO NOT drop or hammer on damper and NEVER apply thrust on outer ring.

2. Remove cap screw (A) and washer securing damper pulley (B) to end of crankshaft. Remove damper from pulley, if possible, and carefully place on a clean flat table.

IMPORTANT: DO NOT immerse damper assembly in petroleum products (such as gasoline, oil, solvent, etc.). Doing so may damage the rubber portion of the assembly.

3. Install JDG787 Thread Protector into nose of crankshaft.

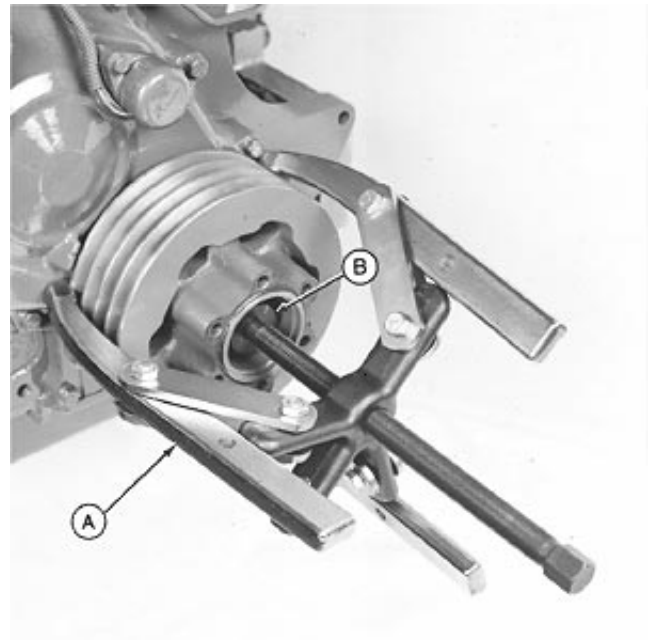


RG6101
-UN-27JAN92

RG,CTM61,G15,6 -19-29APR93

4. Using JDG728 Puller (A), remove pulley from crankshaft. Be sure JDG787 Thread Protector (B) is in ID of pulley to protect threads in nose of crankshaft from damage and pulling jaws are securely clamped on back side of pulley closest to engine.

IMPORTANT: Carefully and thoroughly inspect the pulley for cracks or any visible damage (ID, V-belt grooves, keyway, etc.). Replace pulley as needed.



RG6102
-UN-27JAN92

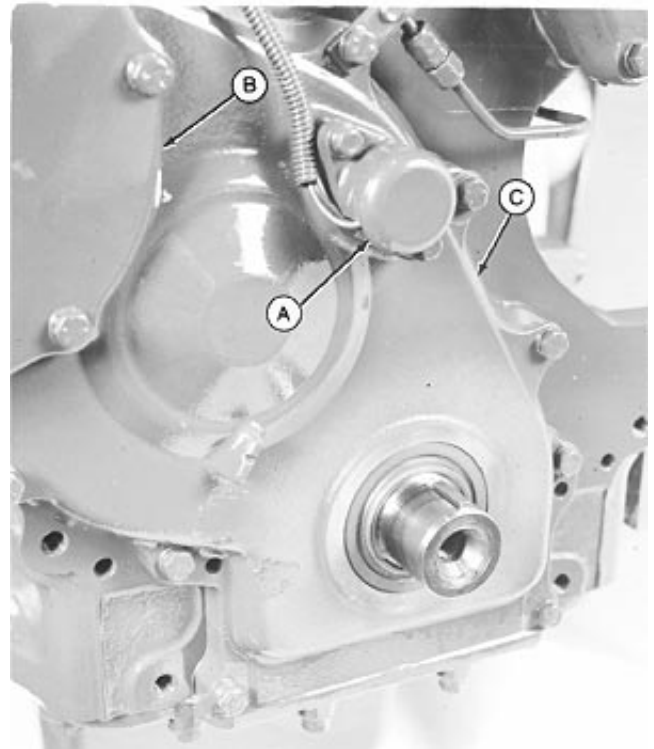
RG,CTM61,G15,7 -19-02APR93

REMOVE TIMING GEAR COVER

1. Drain engine oil and coolant if not previously done.
2. Disconnect turbocharger oil inlet line at turbocharger or oil filter housing. See DISCONNECT TURBOCHARGER OIL INLET LINE in Group 03.
3. Remove oil pan and oil pump.
4. Remove magnetic pickup (A), if equipped.
5. Remove injection pump drive gear cover (B). Discard gasket.

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

6. Remove timing gear cover (C). Discard gasket.
7. Thoroughly clean and inspect oil seal bore in cover. Check for nicks and burrs. Smooth rough areas with a medium-grit emery cloth.
8. Remove front oil seal and wear sleeve. See Group 15.



RG6103 -UN-27JAN92

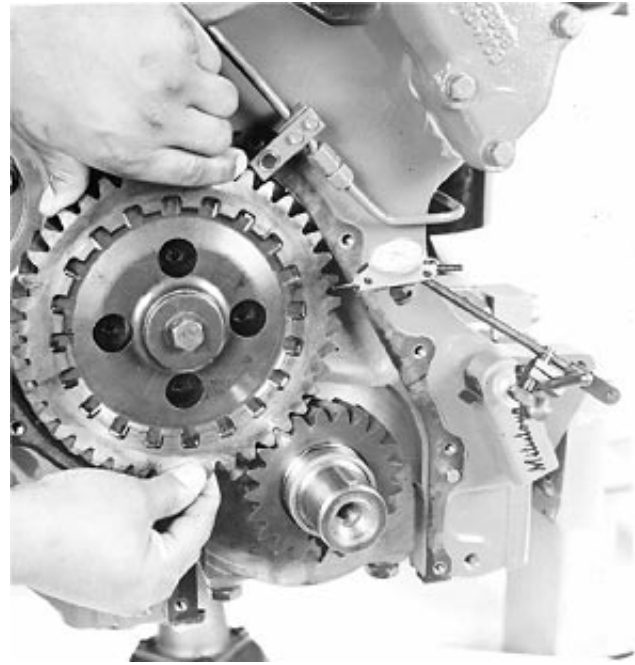
MEASURE CAMSHAFT DRIVE GEAR-TO-CRANKSHAFT GEAR BACKLASH

Measure backlash between camshaft drive gear and crankshaft using a magnetic base dial indicator.

CAMSHAFT DRIVE GEAR-TO-CRANKSHAFT GEAR BACKLASH SPECIFICATION

Minimum Camshaft Gear Backlash 0.08 mm (0.003 in.)

Replace gears if backlash is not within specification.



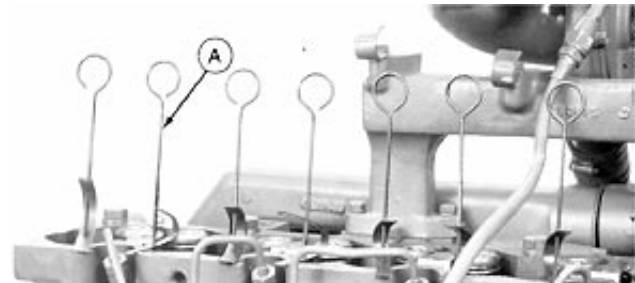
RG6115
-UN-29JAN92

RG,CTM61,G16,4 -19-16MAR92

REMOVE CAMSHAFT

NOTE: It is not necessary to remove cylinder head from engine to remove camshaft. If camshaft lobes show excessive wear, then cylinder head should be removed so block, head, cam lobes, cam followers, and push rods can be inspected.

1. Remove turbocharger heat shield (if equipped) and rocker arm cover, if not previously done.
2. Remove rocker arm assembly, push rods, and wear caps. (See Group 05.)
3. Revolve engine to an angle where cam followers fall away from camshaft lobes and hold camshaft followers with D15001NU Magnetic Follower Holder Kit (A).



RG3499
-UN-31JUL89

RG,CTM61,G16,20-19-05MAY93

4. Use the JDE81-1 and JDE81-4 Engine Rotation Tools and rotate flywheel to align thrust plate cap screws (A) with opening in camshaft gear. Remove all four cap screws.

NOTE: Do not remove nut securing gear to camshaft unless gear is being replaced.

5. Examine camshaft gear (B), injection pump drive gear (C), and crankshaft gear (D) for unusual wear, chips or cracks.

IMPORTANT: Set No. 1 Piston at TDC on compression stroke, using the JDE81-1 and JDE81-4 Engine Rotation Tool Set. This will align timing marks on crankshaft and camshaft gears and aid in correct timing during assembly.

A—Thrust Plate Cap Screws (4 used)
B—Camshaft Gear
C—Injection Pump Drive Gear
D—Crankshaft Gear



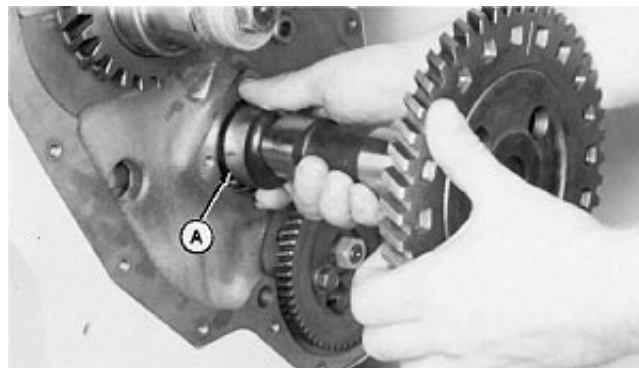
RG6116 -UN-29JAN92

RG,CTM61,G16,5 -19-05MAY93

NOTE: Rotate camshaft carefully to aid in removing.

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

NOTE: If camshaft followers are to be removed, the cylinder head **MUST BE** removed. See **REMOVE CYLINDER HEAD** in Group 05.



RG3818 -UN-23FEB89

RG,CTM61,G16,21-19-01APR93

REMOVE CAMSHAFT GEAR, SPACER, AND THRUST PLATE

NOTE: Camshaft gears are installed onto the camshaft using a press.

1. Remove cap screw with special washer and support camshaft gear in a press.

IMPORTANT: Prevent camshaft from striking floor when pressing camshaft from gear.

2. Press camshaft out of gear.
3. Remove spacer and thrust plate from camshaft.
4. Clean camshaft, thrust plate, and thrust spacer in solvent. Dry with compressed air.



RG78153H1 -UN-09JAN90

S11,2505,AS -19-24APR92

MEASURE THRUST PLATE AND SPACER

1. After removal of camshaft gear, measure thrust plate and spacer for proper thickness.

THRUST PLATE AND SPACER SPECIFICATIONS

Thrust Plate Thickness	4.724—4.800 mm (0.1860—0.1890 in.)
Allowable Wear Thickness	4.623 mm (0.1820 in.)
Thrust Spacer Thickness	4.915—4.965 mm (0.1935—0.1955 in.)

Replace parts as required.



RG2743 -UN-17JUL89

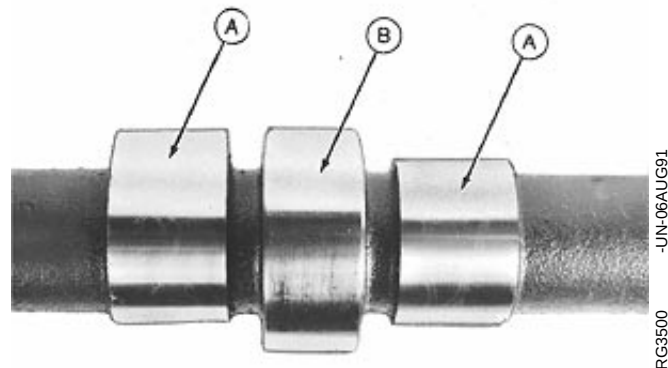
S55,2505,Z -19-24APR92

INSPECT AND MEASURE CAMSHAFT

1. Inspect camshaft lobes (A) and journals (B) for wear or damage. Replace camshaft as necessary.

IMPORTANT: 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.) It is not always necessary to replace cam followers when camshaft is replaced. (See REMOVE, INSPECT, AND MEASURE CAMSHAFT FOLLOWERS, later in this group.)

2. If camshaft lobes show excessive pitting or galling, remove cylinder head. Remove and thoroughly inspect camshaft followers.



RG3500 -UN-06AUG91

S11,2505,CY1 -19-24APR92

MEASURE CAMSHAFT JOURNAL O.D. AND BUSHING I.D.

1. Measure each camshaft journal O.D. If camshaft journal O.D. is not within specification, install a new camshaft.

CAMSHAFT JOURNAL AND BUSHING SPECIFICATIONS

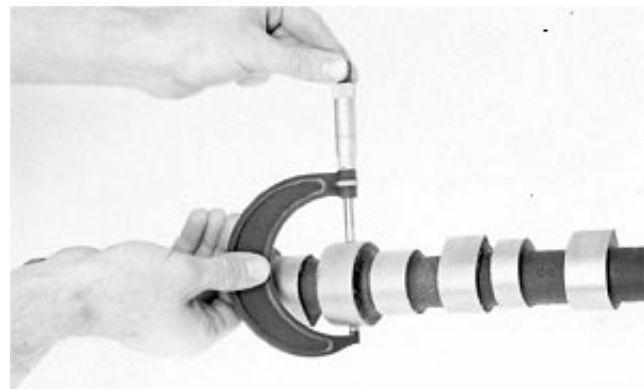
Camshaft Journal Diameter 66.987—67.013 mm
(2.6373—2.6383 in.)

Camshaft Bushing I.D. 67.076—67.102 mm
(2.6408—2.6418 in.)

Maximum Bushing-to-Journal Clearance 0.050—0.128 mm
(0.0020—0.0050 in.)

Maximum Serviceable 0.152 mm
(0.0060 in.)

2. Measure each camshaft bushing I.D. when installed in cylinder block.



T81260 -UN-07NOV88

RG,CTM61,G16,6 -19-05MAY93

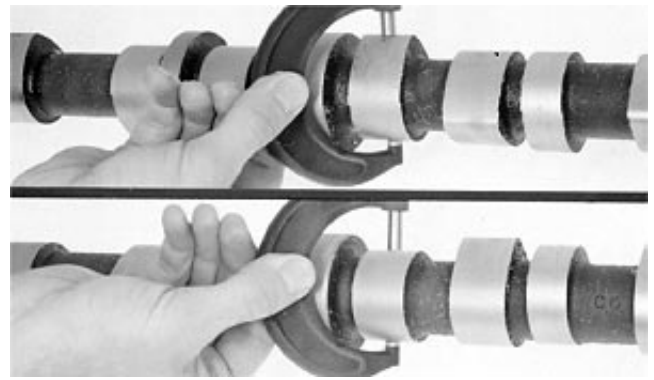
MEASURE CAMSHAFT LOBE LIFT

1. Measure each camshaft lobe at its highest point and at its narrowest point. Subtract narrowest height from highest to find cam lobe lift.

If camshaft lobe lift is not within specification on any one lobe, install a new camshaft.

CAM LOBE LIFT NEW PART SPECIFICATION

Intake Lobe Lift	7.61—7.87 mm (0.300—0.310 in.)
Wear Tolerance	7.14 mm (0.281 in.)
Exhaust Lobe Lift	9.38—9.64 mm (0.369—0.380 in.)
Wear Tolerance	8.78 mm (0.346 in.)



T81262 -UN-01NOV88

RG,CTM61,G16,7 -19-01APR93

REMOVE, INSPECT, AND MEASURE CAMSHAFT FOLLOWERS

IMPORTANT: It is not always necessary to replace camshaft followers when a camshaft is replaced.

1. Remove cylinder head. (See REMOVE CYLINDER HEAD in Group 05).
2. Remove camshaft followers from bores in block.
3. Inspect camshaft followers for uneven wear or damage. Also inspect corresponding camshaft lobe for wear or damage.

CAMSHAFT FOLLOWER AND BORE SPECIFICATIONS

Camshaft Follower OD	34.874—34.900 mm (1.3730—1.3740 in.)
Camshaft Follower Bore in Block	34.976—35.027 mm (1.3770—1.3790 in.)

4. Measure camshaft follower and bore in block. Compare measurements with specifications given. Replace camshaft followers or cylinder block as necessary.



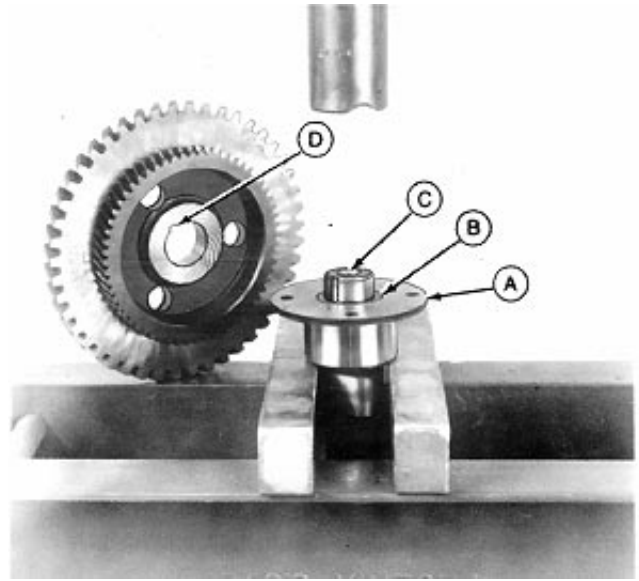
RG3041 -UN-17JUL89

S11,2505,AV -19-01APR93

ASSEMBLE CAMSHAFT

1. Support camshaft under first journal in a hydraulic press.
2. Install thrust plate (A) and spacer (B).
3. Install Woodruff key (C).
4. Align Woodruff key and keyway (D) and place gear on camshaft with timing mark facing away from camshaft.

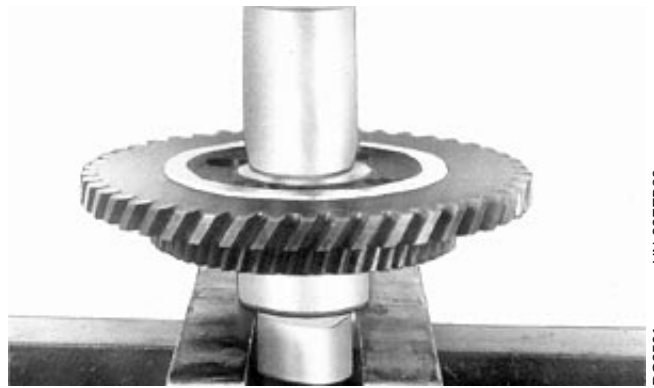
A—Thrust Plate
B—Spacer
C—Woodruff Key
D—Keyway



RG3042
-UN-17JUL89

S11,2505,AW -19-16MAR92

5. Press gear on until tight against spacer.



RG3501
-UN-23FEB89

S11,0401,BO -19-13NOV86

SERVICE CAMSHAFT BUSHINGS 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.

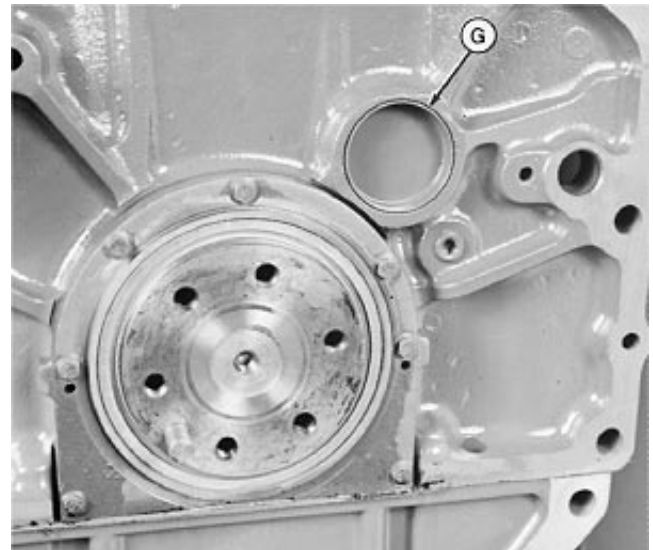
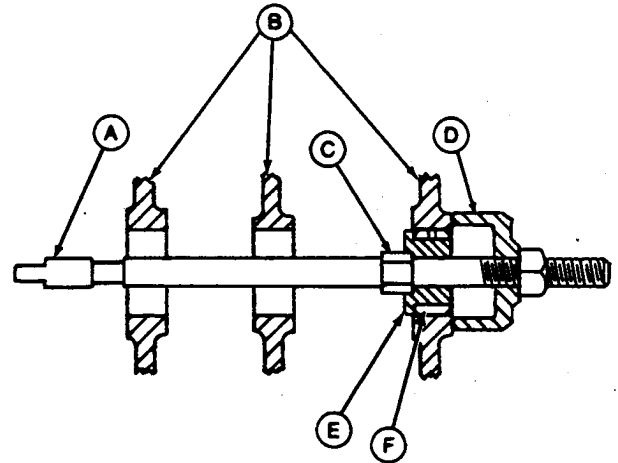
CAMSHAFT JOURNAL AND BUSHING NEW PART SPECIFICATION

Camshaft Bushing Bore in Block	69.987—70.013 mm (2.7554—2.7564 in.)
Journal OD	66.987—67.013 mm (2.6373—2.6383 in.)
Bushing ID	67.076—67.102 mm (2.6408—2.6418 in.)
Oil Clearance	0.050—0.128 mm (0.0020—0.0050 in.)
Maximum Acceptable Oil Clearance	0.152 mm (0.0060 in.)

NOTE: The front two bushings can be reached from the front of the engine. The flywheel and rear camshaft bore steel cap 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) along with the components shown from JDE6 Camshaft Bushing Replacement Set (A and C).

3. Tighten nut on end of bushing screw until bushing is pulled out of camshaft bushing bore. Inspect and measure camshaft bushing bore in block (B). Follow same procedure for remaining bushings to be replaced.



- 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 Steel Cap Plug

-UN-06DEC88

RG5272

-UN-29JAN92

RG6118

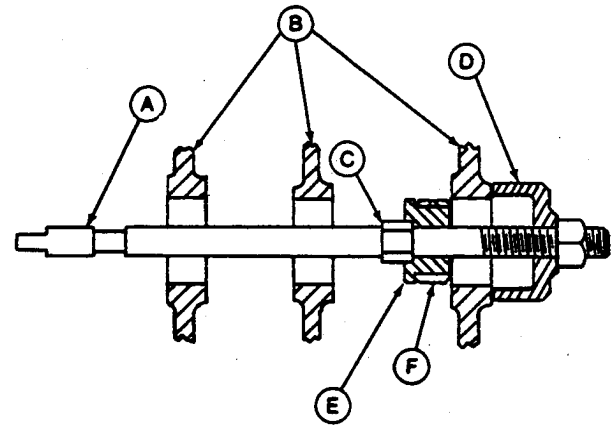
16
17

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 Replacement Set (A and C).

5. Be sure bushing is started square in bore and oil holes are aligned with holes in block. Tighten nut to pull bushing in until it is properly positioned in bore.

6. Check bushing-to-cylinder block oil hole alignment using a small mirror with extension.



- 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

S55,2016,N -19-23SEP91

RG5273 -UN-06DEC88

SERVICE CAMSHAFT BUSHINGS USING JDG606 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.

CAMSHAFT JOURNAL AND BUSHING NEW PART SPECIFICATIONS

Camshaft Bushing Bore in Block	69.987—70.013 mm (2.7554—2.7564 in.)
Journal OD	66.987—67.013 mm (2.6373—2.6383 in.)
Bushing ID	67.076—67.102 mm (2.6408—2.6418 in.)
Oil Clearance	0.050—0.128 mm (0.0020—0.0050 in.)
Maximum Acceptable Oil Clearance	0.152 mm (0.0060 in.)

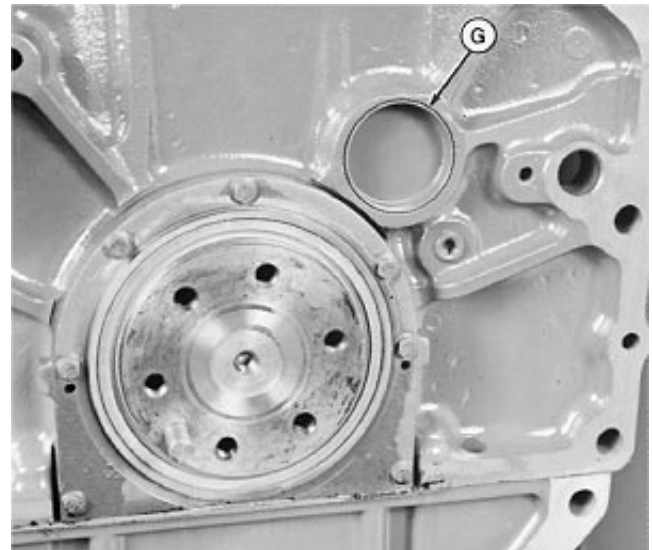
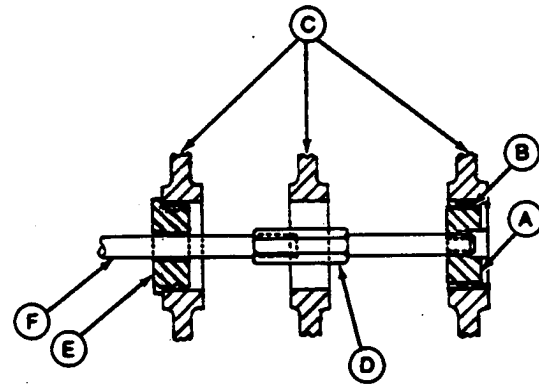
NOTE: The front two bushings can be reached from the front of the engine. The flywheel and rear camshaft bore steel cap plug (G) must be removed to reach the other two bushings.

Lubricate O-ring on JDG608 Bushing Pilot with clean engine oil before installing in cylinder block web (C).

2. 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 D01299AA Slide Hammer (F).

NOTE: End bushing at front and rear of cylinder block may be removed with just JDG607 Bushing Driver and D01299AA Slide Hammer.

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



- A—Bushing Driver (JDG607)
- B—Camshaft Bushing
- C—Cylinder Block Web
- D—Slide Hammer Adapter (JDG408)
- E—Bushing Pilot (JDG608)
- F—Slide Hammer (D01299AA)
- G—Camshaft Bore Steel Cap Plug

RG,CTM61,G16,9 -19-24APR92

-UN-06DEC88

RG5332

-UN-29JAN92

RG6118

16
19

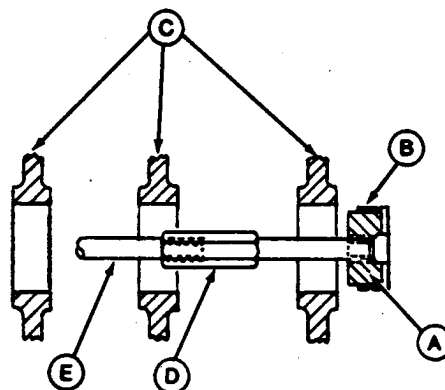
IMPORTANT: Oil holes in bushings and cylinder block must be aligned after installation. The elongated hole in bushing must be toward top. After installation, use a small mirror with extension to be sure oil holes are properly aligned.

4. Slide a new camshaft bushing (B) onto JDG607 Bushing Driver (A). With JDG608 Bushing Pilot installed in outside cylinder block web (C), assemble D01299AA Slide Hammer (E) and JDG408 Slide Hammer Adapter (D) with bushing driver as shown.

5. Be sure bushing is started square in bore and oil holes are aligned with holes in block. Pull bushing into bore with slide hammer until properly positioned.

6. Check bushing-to-cylinder block 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.



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

S55,2016,P -19-29OCT92

RG5333 -UN-06DEC88

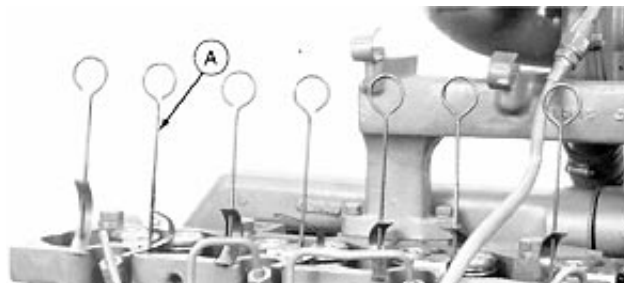
INSTALL CAMSHAFT

IMPORTANT: With engine locked at TDC of No. 1 piston's compression stroke, install camshaft so timing marks on camshaft and crankshaft gears are aligned.

1. If camshaft followers were removed with engine on a rollover stand, roll engine to an angle where followers fall away from camshaft bore.

NOTE: If D15001NU Magnetic Follower Holder Kit (A) is used, hold camshaft followers away from camshaft bore until camshaft is installed.

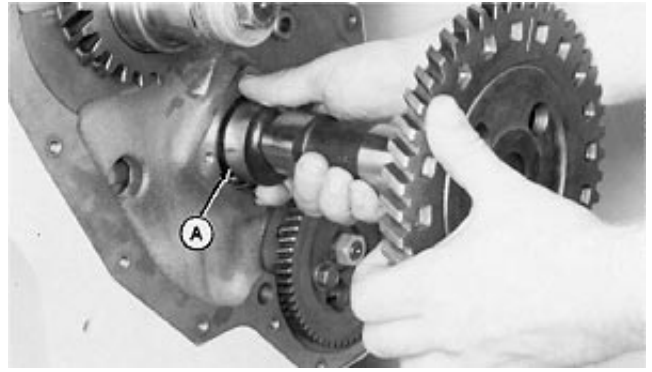
2. Coat camshaft lobes and bearing journals with TY6333 or TY6347 High Temperature Grease.



S11,0401,BP -19-05MAY93

RG3499 -UN-31JUL89

3. Carefully install camshaft (A) in cylinder block so that camshaft lobes do not drag in bores. Rotate camshaft during installation to avoid obstruction in any bore.



RG3818 -UN-23FEB89

S55,2016,R -19-11APR91

4. With No. 1 piston on "TDC" compression stroke, align timing marks (D) on camshaft and crankshaft gears.

5. Turn camshaft gear to align thrust plate holes with threads in cylinder block.

6. Coat thrust plate-to-cylinder block cap screws (A) with LOCTITE 242 Thread Lock and Sealer and tighten to 41 N·m (30 lb-ft).

7. If removed, install special washer (B) and cap screw (C) in nose of camshaft. Tighten cap screw to 115 N·m (85 lb-ft).

NOTE: Check injection pump timing and reset as required. (See Group 35.)

- A—Cap Screws (4 used)
- B—Special Washer
- C—Cap Screw
- D—Timing Marks



RG6119 -UN-03FEB92

RG,CTM61,G16,10-19-07MAY93

8. Check camshaft for 0.115—0.241 mm (0.0045—0.0095 in.) end play. Maximum acceptable end play is 0.342 mm (0.0135 in.).

9. Replace thrust plate and/or thrust washer if end play is not within specification.



RG,CTM61,G16,11-19-01APR93

INSTALL TIMING GEAR COVER

IMPORTANT: Coat threads of lower two cap screws for injection pump drive gear cover (B) with **LOCTITE 242 Thread Lock and Sealer** to prevent oil leakage.

1. Install timing gear cover (C) using new gasket. Tighten cap screws to 41 N·m (30 lb-ft). Install injection pump gear cover using new gasket. Tighten cap screws to the following specification:

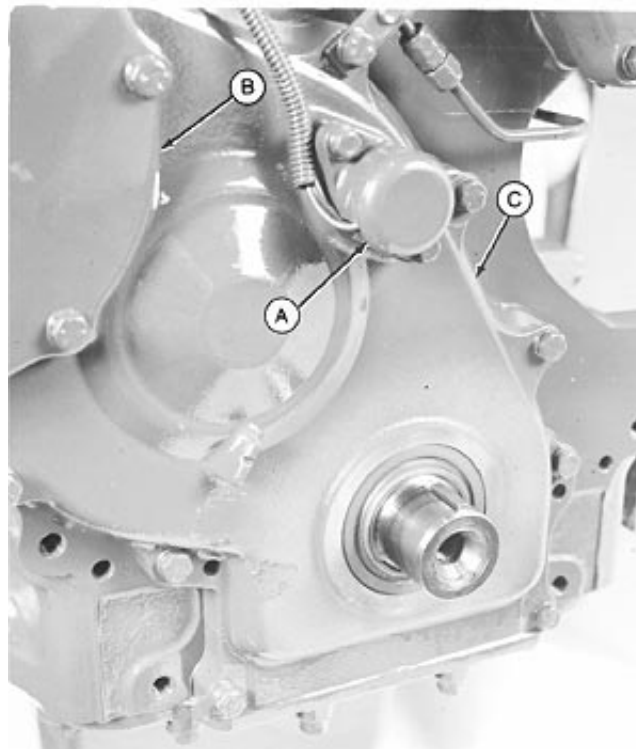
INJECTION PUMP GEAR COVER TORQUE SPECIFICATIONS

6101HRW10 and 6101HRW11	
Engine Applications	68 N·m (50 lb-ft)
All Other Applications	41 N·m (30 lb-ft)

2. Check crankshaft front oil seal bore runout. Maximum allowable runout is 0.254 mm (0.010 in.).

3. Install magnetic pickup (A) in timing gear cover, if equipped.

4. Trim timing gear cover gasket flush with oil pan mounting surface. Install oil pan as outlined in Group 20. Fill engine with clean engine oil.



RG6103
-UN-27JAN92

RG,CTM61,G16,12-19-07MAY93

INSTALL CRANKSHAFT FRONT WEAR SLEEVE (WITH TIMING GEAR COVER INSTALLED ON ENGINE)

NOTE: Wear sleeve may be installed with timing gear cover removed or installed.

1. Coat ID of new wear sleeve with **LOCTITE 609 Retaining Compound**.

2. Using JDG467 Driver from JDE3 Installer along with washer and cap screw that secures damper pulley assembly to crankshaft, install wear sleeve.

3. Remove installation tools and clean any sealant from OD of wear sleeve or ID of seal bore.



RG6110
-UN-27JAN92

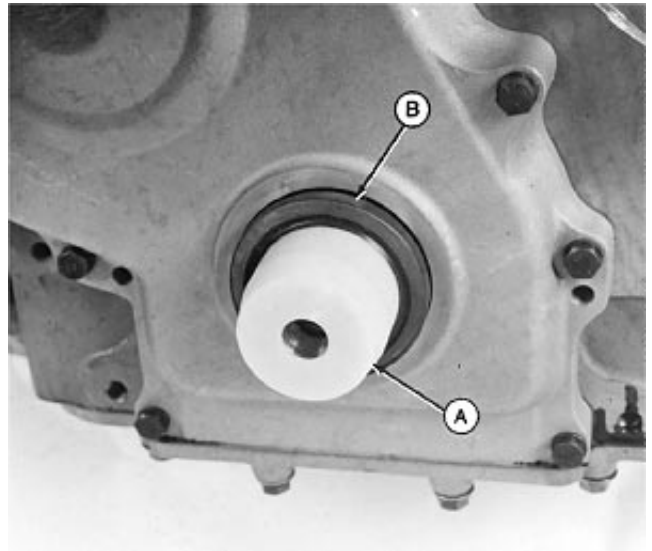
RG,CTM61,G15,12-19-02APR93

**INSTALL CRANKSHAFT FRONT OIL SEAL
(WITH TIMING GEAR COVER INSTALLED ON
ENGINE)**

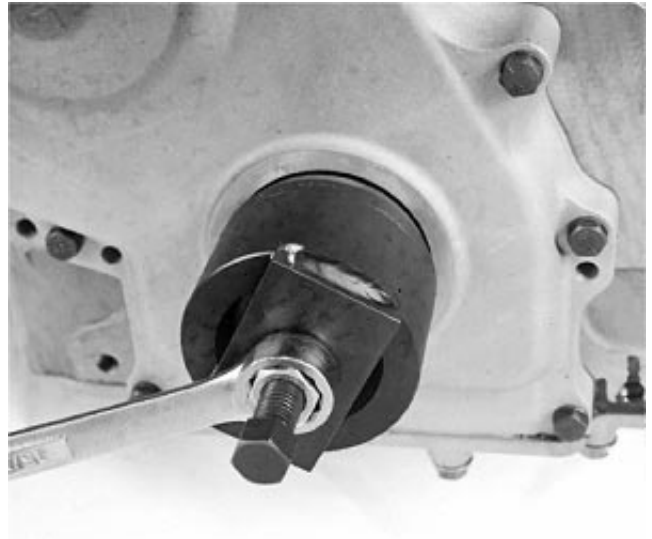
IMPORTANT: Whenever front oil seal is replaced,
wear sleeve **MUST** be replaced also.

1. Place JDG720-2 Seal Protector (A) on nose of crankshaft. Lubricate ID of front oil seal (B) lips with clean engine oil and slide seal onto seal protector. Be careful not to roll oil seal lips.
2. Position JDG720-4 Spacer Ring on end of JDG720-3 Seal Installer and place installer onto seal protector against seal.
3. With nut installed onto JDG720-1 Forcing Screw, thread forcing screw into nose of crankshaft until it bottoms.
4. Tighten nut against crossplate of installer until installer bottoms onto front face of timing gear cover.
5. Remove installation tools.

IMPORTANT: Verify seal is installed square in bore, flush with front face of timing gear cover, and that seal lips are not rolled on wear sleeve.



RG6111 -UN-27JAN92



RG6112 -UN-27JAN92

RG,CTM61,G15,13-19-02APR93

COMPLETE FINAL ASSEMBLY

1. Install damper pulley and vibration damper. (See Group 15.)
2. Install camshaft followers and cylinder head, if removed. (See Group 05.)
3. Install push rods, wear caps, and rocker arm shaft assembly. (See Group 05.)
4. Measure valve lift and compare readings with specifications. (This group.)
5. Adjust engine valve clearance and install rocker arm cover. (See Group 05.)
6. Perform engine break-in as required. (See Group 05.)

RG,CTM61,G16,13-19-01APR93

OTHER MATERIAL

Name	Use
PERMATEX AVIATION (Form-A-Gasket No. 3)	To seal gasket surfaces.
LOCTITE 242 Thread Lock and Sealer (TY9370/T43512)	To coat oil filter manifold mounting plate cap screws and oil pan drain plug.
LOCTITE 277 Plastic Gasket (High Strength) (T43514)	To coat bypass oil check valve adapter.
High Temperature Grease (TY6343 or TY6347)	To lubricate oil pump components.

RG,CTM61,G20,1 -19-01APR93

LUBRICATION SYSTEM SPECIFICATIONS

ITEM	SPECIFICATION	WEAR LIMIT
Oil Filter Bypass Valve Spring:		
Compressed Length	35 mm @ 80—98 N (1.38 in. @ 18—22 lb-force)	— —
Free Length	51.5 mm (2.03 in.)	—
Oil Cooler Bypass Valve Spring:		
Compressed	35 mm @ 80—98 N (1.38 in. @ 18—22 lb-force)	— —
Free Length	51.5 mm (2.03 in.)	—
Oil Pressure Regulating Valve Spring:		
Compressed	48.5 mm @ 83—98 N (1.91 in. @ 19—22 lb-force)	— —
Free Length	74.2 mm (2.92 in.)	—
Oil Pressure Relief Valve Spring:		
Compressed	65 mm @ 180—220 N (2.56 in. @ 40.5—49.5 lb-force)	— —
Free Length	79 mm (3.11 in.)	—
Oil Pump:		
Maximum Driveshaft End Play	0.15 mm (0.006 in.)	—
Maximum Driveshaft Side Movement	0.17 mm (0.0065 in.)	—
Pump Gear Backlash	0.33—2.00 mm (0.013—0.079 in.)	— —
Crankshaft Gear-To-Oil Pump Drive		
Gear Minimum Backlash	0.08 mm (0.003 in.)	—

RG,CTM61,G20,2 -19-05MAY93

LUBRICATION SYSTEM SPECIFICATIONS—CONTINUED**TORQUES**

Bypass Valve Housing-to-Cylinder Block	41 N·m (30 lb-ft)
Pressure Regulating Housing-to-Cylinder Block*	47 N·m (35 lb-ft)
Pressure Relief Valve Housing-to-Cylinder Block	41 N·m (30 lb-ft)
Oil Cooler End Caps	41 N·m (30 lb-ft)
Oil Cooler-to-Bypass Valve Housing	47 N·m (35 lb-ft)
Oil Filter Manifold Mounting Cap Screws	41 N·m (30 lb-ft)

Oil Pump:

Drive Gear-to-Pump Drive Shaft Nut	54 N·m (40 lb-ft)
Pump Cover-to-Housing	41 N·m (30 lb-ft)
Pump-to-Cylinder Block	47 N·m (35 lb-ft)
Outlet Elbow-to-Cylinder Block	47 N·m (35 lb-ft)
Intake Elbow-to-Pump Cover	41 N·m (30 lb-ft)
Pickup Screen-to-Intake Elbow	24 N·m (18 lb-ft)
Set Screw-to-Cover	8 N·m (6 lb-ft)
Locknut-to-Set Screw	8 N·m (6 lb-ft)

Oil Pan:**

3/8 in. cap screws	68 N·m (50 lb-ft)
1/2 in. cap screws	156 N·m (115 lb-ft)
Oil Pan-to-Flywheel Housing	325 N·m (240 lb-ft)
Oil Pan Drain Plug	102 N·m (75 lb-ft)

* Tighten cap screws to 47 N·m (35 lb-ft) in diagonal sequence.
Retighten all cap screws to 47 N·m (35 lb-ft) in diagonal sequence.

** Initially tighten all cap screws to 54 N·m (40 lb-ft), starting at right rear corner of oil pan (facing toward flywheel end) and proceed counterclockwise. Finish tightening cap screws to torques specified above, using the same sequence and tighten all 3/8 in. cap screws first.

RG,CTM61,G20,3 -19-24APR92

DIAGNOSING LUBRICATION SYSTEM MALFUNCTIONS

• Low Oil Pressure:

Low oil level.
Clogged cooler or filter.
Excessive oil temperature.
Incorrect oil.
Oil pressure regulating valve failure.
Excessive main or rod bearing clearance.
Clogged oil pump screen.
Excessive clearance between oil pump gears and cover.
Piston cooling orifice not installed.

• Bypass Oil Check Valve Failure:

Low oil pressure at slow idle.

• High Oil Pressure:

Improper oil classification.
Clogged oil lines.
Oil pressure regulating valve failure.

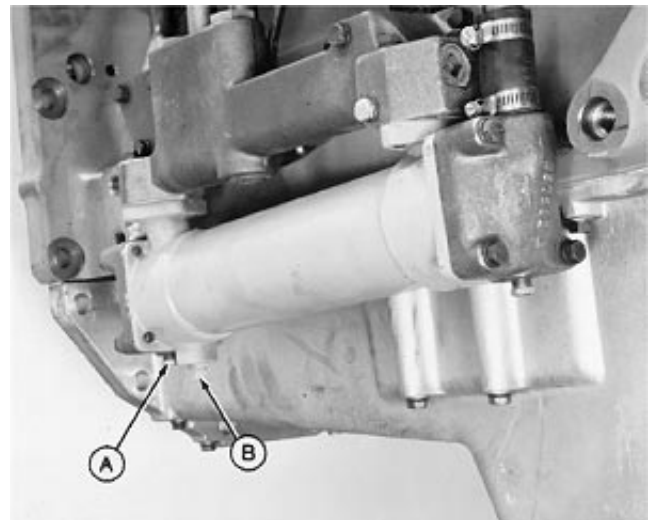
• Oil Sludge and Dilution:

Improper operation and servicing.
Coolant leakage into lubrication system.
Incomplete combustion.
Excessive oil consumption.
Defective injection pump (Failed internal O-ring seals)

RG,CTM61,G20,14-19-24APR92

DRAIN ENGINE OIL, COOLANT, AND REMOVE OIL PAN

1. Disconnect turbocharger oil inlet line at oil filter housing or turbocharger. See Group 03.
2. Remove drain plug from bottom of oil pan and drain engine oil.
3. Remove oil drain plug (B) from rear of oil cooler and drain all oil from cooler.
4. Remove coolant drain plug (A) from rear end cap of engine oil cooler and drain coolant. Drain all remaining coolant from engine block.
5. Remove engine oil pan and discard all gasket material.



RG5531 -UN-10NOV89

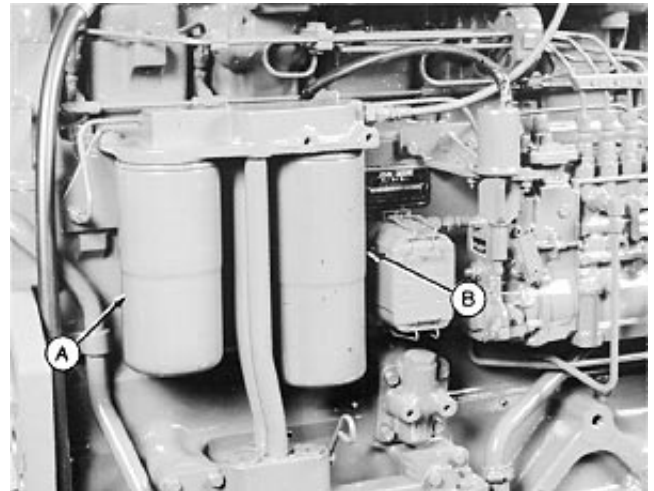
S55,2520,B -19-05MAY93

LUBRICATION SYSTEM GENERAL INFORMATION

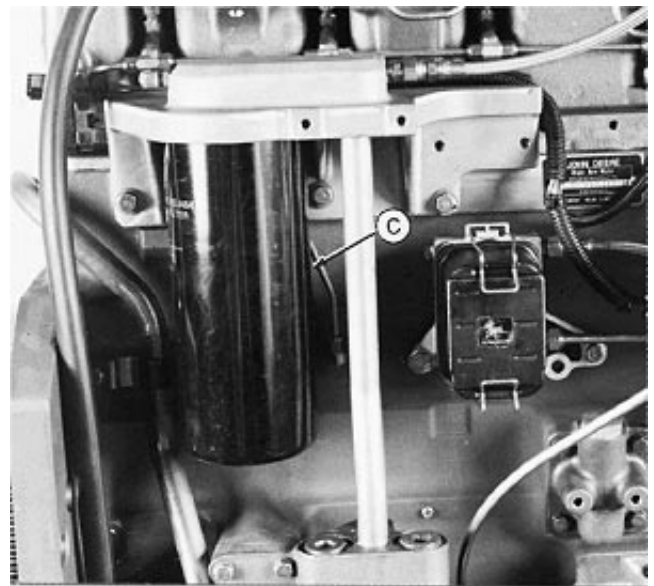
Early 6101 Engines, Serial No. (—500277) were produced with a separate bypass filter (A) and full flow filter (B).

Current 6101 Engines, Serial No. (500278—) are produced with a combination full flow and bypass filter (C) all in one canister.

Refer to HOW THE LUBRICATION SYSTEM WORKS in Group 105 for a detailed explanation of each system.



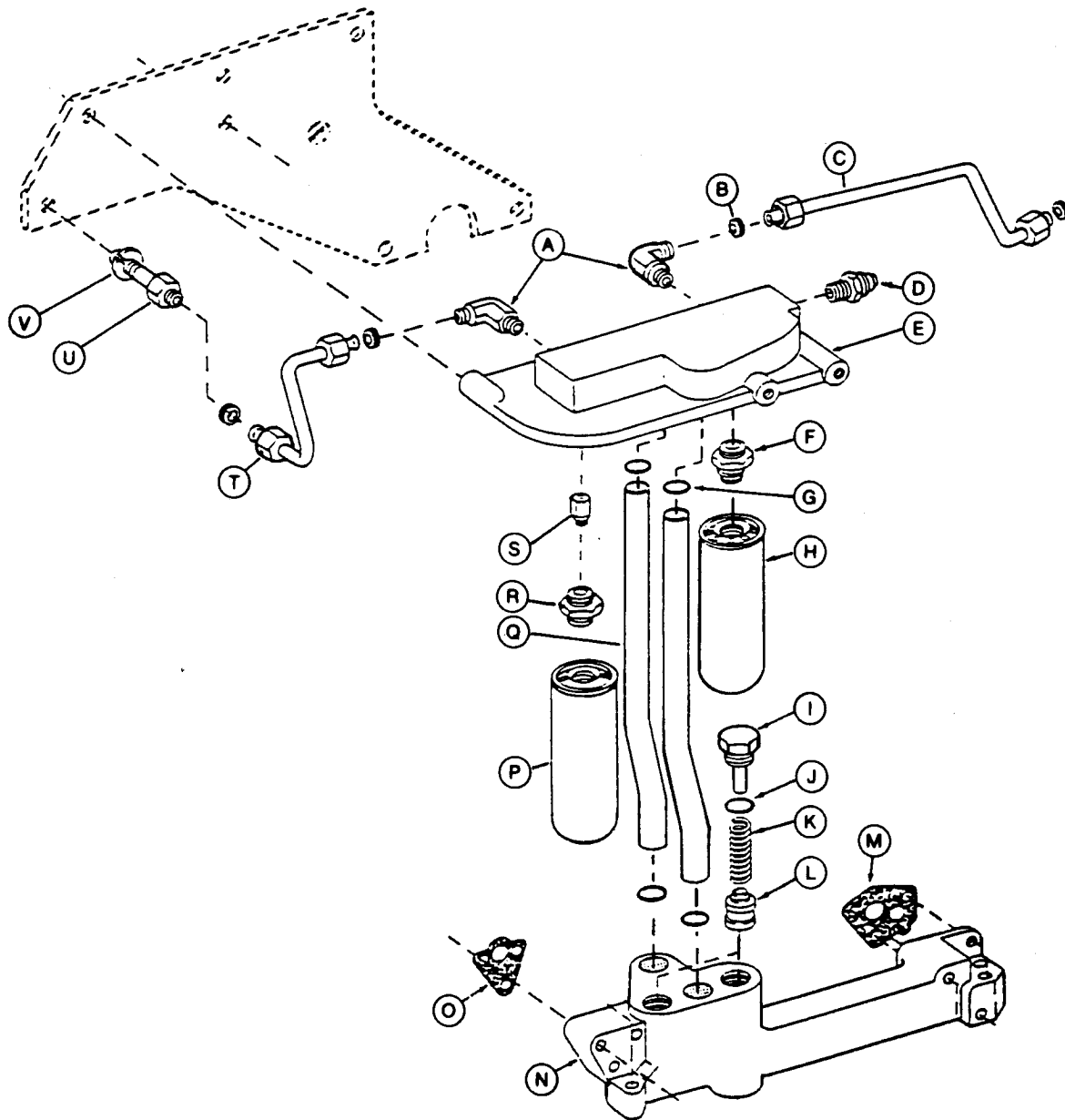
RG6657 -UN-25FEB93



RG6658 -UN-25FEB93

RG,CTM61,G20,16-19-01APR93

ENGINE OIL BYPASS VALVE HOUSING, OIL COOLER, AND DUAL FILTER SYSTEM



A—Elbow Fitting (2 used)
B—Packing (4 used)
C—Oil Line
D—Fitting
E—Manifold
F—Adapter

G—O-Ring (4 used)
H—Full Flow Oil Filter
I—Fitting (2 used)
J—O-Ring (2 used)
K—Spring (2 used)
L—Bypass Valve (2 used)

M—Gasket
N—Housing
O—Gasket
P—Bypass Oil Filter
Q—Oil Line (2 used)

R—Adapter
S—Bypass Oil Check Valve
T—Oil Line
U—Cap Screw
V—Lock Washer

RG6129 -UN-09MAR92

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REPLACE BYPASS OIL CHECK VALVE ON DUAL FILTER SYSTEM

Refer to illustration on previous page.

IMPORTANT: A plugged bypass oil check valve may cause low engine oil pressure at slow idle. If valve is plugged, replace with a new one.

1. Remove bypass oil filter (P).
2. Remove filter base-to-bypass oil filter adapter (R).
Remove and discard bypass oil check valve (S).
3. Clean and inspect oil filter manifold (E). If necessary remove manifold, clean in solvent, and dry with compressed air.
4. Apply LOCTITE 277 Plastic Gasket to threads of filter base-to-bypass oil filter adapter. Install bypass oil check valve and adapter as an assembly. Tighten securely.
5. Remove excess sealant from adapter.
6. Apply a thin layer of clean engine oil to bypass oil filter packing. Install filter and tighten until packing contacts base. Tighten an additional full turn. DO NOT overtighten.

RG,CTM61,G20,13-19-01APR93

RG6659 -UN-08MAR93



- RG6659

REPLACE BYPASS OIL CHECK VALVE ON COMBINATION FILTER SYSTEM

Refer to illustration on previous page.

IMPORTANT: A plugged bypass oil check valve may cause low engine oil pressure at slow idle. If valve is plugged, replace with a new one.

1. Disconnect oil line (B) from elbow fitting (C).
2. Remove elbow bushing (D) and bypass oil check valve (E) from oil filter housing (G).
3. Replace valve and install bushing in housing. Tighten securely.
4. Reconnect elbow fitting and tighten securely.

RG,CTM61,G20,17-19-05MAY93

REMOVE OIL BYPASS VALVE HOUSING AND OIL COOLER ASSEMBLY

Be sure all coolant and oil is drained from oil cooler/oil bypass valve housing assembly before removing from engine.

1. Remove bypass filter (A) and full flow filter (B) or combination bypass/full flow filter.

NOTE: Oil filter manifold (G) may be removed for easier removal and installation of bypass valve housing and oil cooler assembly.

2. Disconnect fuel lines at fuel filter base. Disconnect turbocharger oil line.

3. Disconnect lube line and remove hollow screw from oil filter manifold mounting plate (H). Remove allen head countersunk cap screw and remove plate with oil filter manifold attached.

4. Remove oil tubes (F) and discard O-rings.

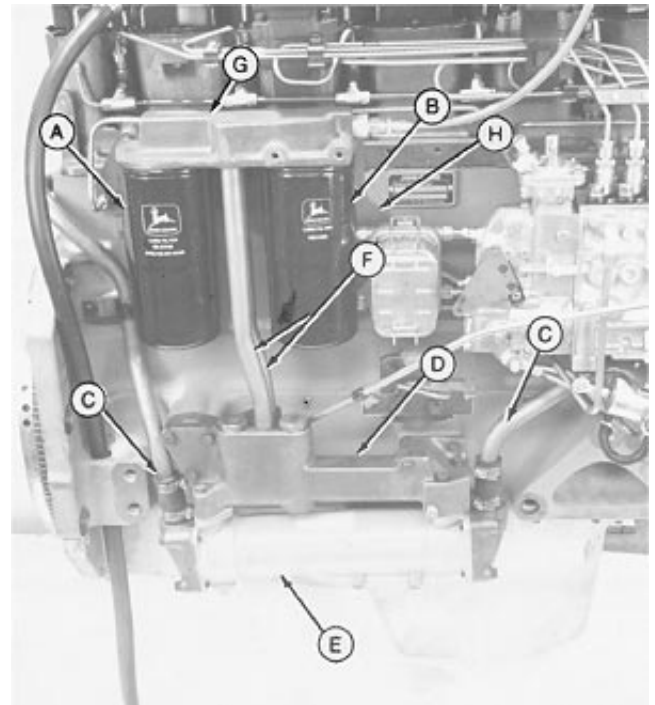
5. Loosen lower hose clamp on both oil cooler coolant tubes (C) and remove hoses from oil cooler end caps.



CAUTION: Oil bypass valve housing (D) and oil cooler (E) are heavy. Plan a proper handling procedure to avoid injuries.

NOTE: As mounting cap screws are removed, install guide studs in three or four locations to aid removal of assembly.

6. Remove six oil bypass valve housing cap screws and dislodge oil tubes as assembly is removed from engine.



A—Bypass Filter
B—Full Flow Filter
C—Coolant Tubes
D—Bypass Valve Housing
E—Oil Cooler
F—Oil Tubes
G—Oil Filter Manifold
H—Oil Filter Manifold Mounting Plate

RG5533 -UN-09JAN90

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S55,2520,C -19-01APR93

REMOVE AND INSPECT OIL COOLER BYPASS AND OIL FILTER BYPASS VALVES

NOTE: Before disassembling oil cooler/oil pressure regulating housing assembly, inspect all mating surfaces and plugs for evidence of oil or coolant leaks. Correct as necessary. When installing pipe plugs, always coat threads with a teflon sealant.

1. Remove oil cooler (A) from oil bypass valve housing (B).
2. Remove oil cooler bypass valve (C) and oil filter bypass valve (D) from bypass valve housing.
3. Thoroughly inspect valves and valve bores for wear or damage. Replace as necessary.

NOTE: If mixing of oil and coolant is suspected, pressure test oil cooler in solvent (not water) and compressed air. Use 140—170 kPa (1.4—1.7 bar) (20—25 psi) air pressure for testing. Replace oil cooler as necessary.

4. Check oil cooler bypass valve spring and oil filter bypass valve spring tension. If either or both springs do not meet specifications, replace as necessary.

SPRING TENSION SPECIFICATION

Oil Filter Bypass Valve Spring:

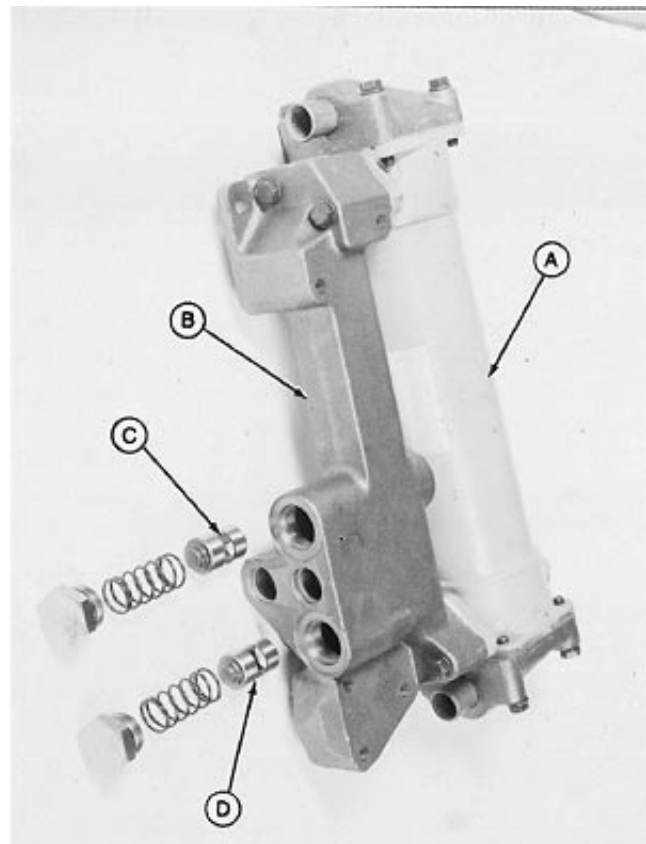
Compressed	35 mm @ 80—98 N (1.38 in. @ 18—22 lb force)
Free Length	51.5 mm (2.03 in.)

Oil Cooler Bypass Valve Spring:

Compressed	35 mm @ 80—98 N (1.38 in. @ 18—22 lb force)
Free Length	51.5 mm (2.03 in.)

5. Make sure all passages in bypass valve housing and oil cooler are clean.

NOTE: Under normal conditions, the oil cooler need not be removed to clean water passages. Remove oil cooler end caps, clean and inspect tubes with a brush and compressed air.



A—Oil Cooler
B—Bypass Valve Housing
C—Oil Cooler Bypass Valve
D—Oil Filter Bypass Valve

RG5534 -UN-10NOV89

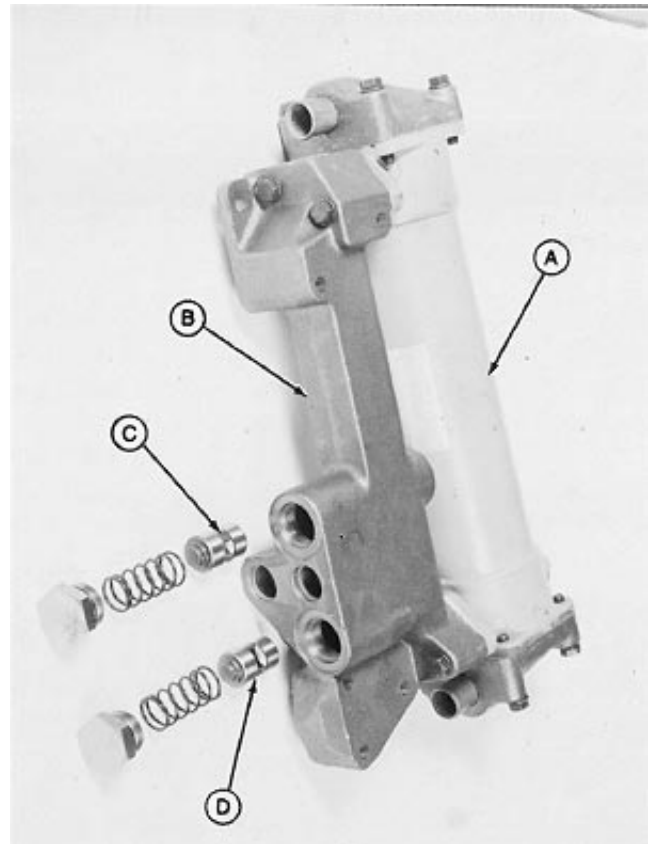
ASSEMBLE BYPASS VALVE HOUSING AND OIL COOLER ASSEMBLY

1. Using new gaskets install oil cooler end caps and tighten cap screws to 41 N·m (30 lb-ft), if removed.
2. Using new gaskets assemble oil cooler (A) onto bypass valve housing (B). Tighten cap screws 47 N·m (35 lb-ft).

NOTE: Dip valves in clean engine oil before installing.

3. Using new O-rings on plugs, install oil cooler bypass valve (C) and oil filter bypass valve (D) assemblies as shown. Tighten plugs securely.

A—Oil Cooler
B—Bypass Valve Housing
C—Oil Cooler Bypass Valve
D—Oil Filter Bypass Valve



RG,CTM61,G20,7 -19-16MAR92

RG5534 -UN-10NOV89

INSTALL OIL BYPASS VALVE HOUSING AND OIL COOLER ASSEMBLY

1. Install guide studs at each side of bypass valve housing mounting location.

CAUTION: Bypass valve housing (D) and oil cooler (E) assembly is very heavy. Plan a proper handling procedure to avoid injuries.

2. Using new gaskets, install bypass valve housing and oil cooler assembly onto cylinder block by sliding over guide studs. Guide studs will support assembly while cap screws are installed.

3. Install mounting cap screws and tighten to 41 N·m (30 lb-ft). Remove guide studs and install remaining cap screws and tighten to 41 N·m (30 lb-ft).

4. Lubricate new O-rings with clean engine oil and install both oil tubes (F) into bypass valve housing. Bend in tubes must be closest to bypass valve housing.

5. Install oil filter manifold onto mounting plate (H) and tighten cap screws to 41 N·m (30 lb-ft), if removed.

6. Lubricate new O-rings with clean engine oil and install upper end of oil tubes into oil filter manifold (G).

NOTE: Apply *LOCTITE 242 Thread Lock and Sealer* to threads of mounting plate screws. Leading three threads of hollow screw must be free of sealant.

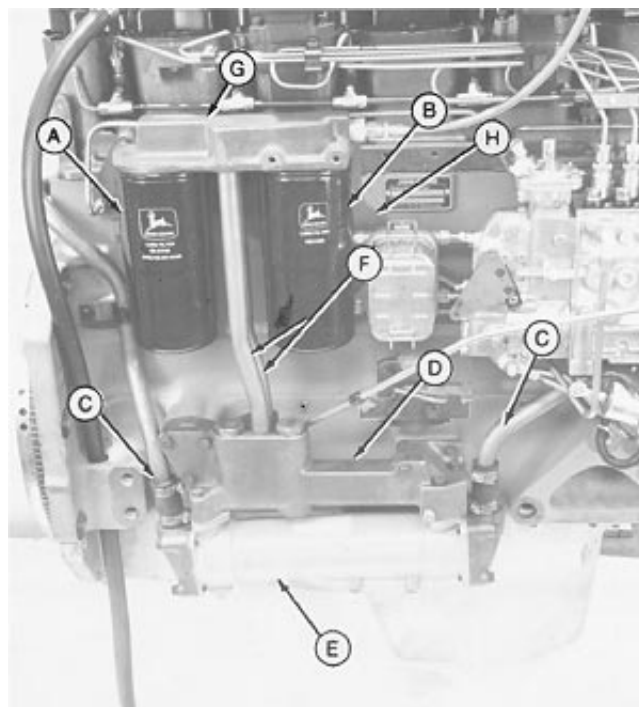
7. Position mounting plate onto cylinder block, tighten allen head countersunk screw and hollow cap screw securely.

8. Reconnect oil lines and fuel lines using new packing. Tighten lines securely.

9. Position hoses onto coolant tubes (C) and tighten clamps securely.

10. Lubricate new packing on bypass oil filter (A), if equipped, with clean engine oil. Install filter and tighten until packing contacts mounting base. Tighten one additional full turn.

11. Lubricate new packing on full flow oil filter (B) or combination bypass/ full flow filter with clean engine oil. Install filter and tighten until packing contact mounting base. Tighten an additional 1/2 to 3/4 turn.



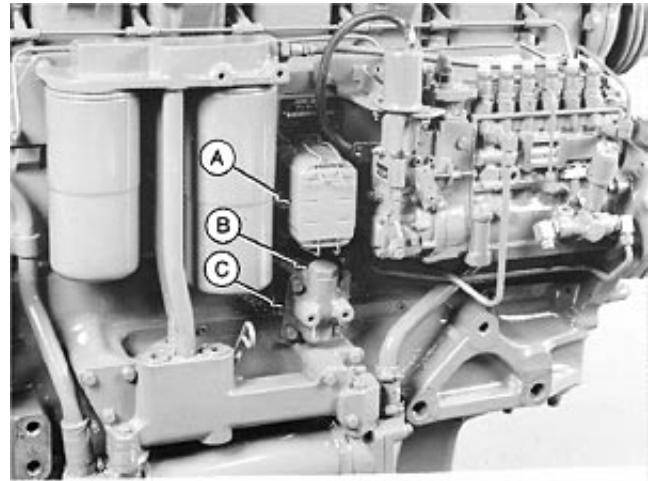
A—Bypass Oil Filter
B—Full Flow Oil Filter
C—Coolant Tubes
D—Bypass Valve Housing
E—Oil Cooler
F—Oil Tubes
G—Oil Filter Manifold
H—Oil Filter Manifold Mounting Plate

RG5533 -UN-09JAN90

REMOVE, DISASSEMBLE, INSPECT, AND INSTALL OIL PRESSURE REGULATING VALVE AND HOUSING

NOTE: The pressure regulating valve (B) may be removed without removing pressure regulating housing (C) from engine, however, the fuel filter canister (A) must be removed first.

1. Remove four cap screws securing pressure regulating valve housing to engine and remove housing. Remove and discard all gasket material.



RG6130 -JUN-12FEB92

RG,CTM61,G20,9 -19-16MAR92

2. Remove plug (A) with spring pin (J), O-ring (B), shims (C), spring (I), and valve (D) from housing (F).

3. Count shim(s) for reassembly.

NOTE: If valve housing, or spring is replaced, assembly must be re-shimmed until correct oil pressure is achieved. Do not exceed five shims.

4. Inspect valve and valve housing bore for damage. Replace parts as necessary.

5. Check spring for proper compression. Replace as necessary.

VALVE SPRING SPECIFICATION

Compressed 48.5 mm @ 83—98 N
(1.91 in. at 19—22 lb-force)
Free Length 74.2 mm (2.92 in.)

6. Dip valve in clean engine oil and install valve and spring in housing.

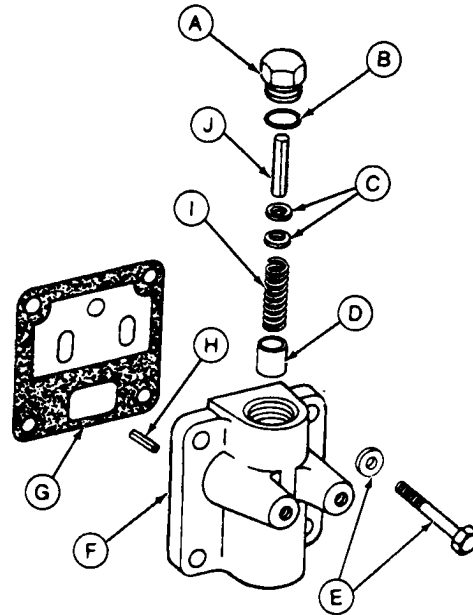
7. Position shim(s) on plug with spring pin.

NOTE: It may be easier to tighten plug after housing assembly is installed on block.

8. Install plug using a new O-ring and tighten securely.

IMPORTANT: Coat both sides of gasket (G) with PERMATEX AVIATION (Form-A-Gasket No. 3) before installing.

9. With spring pin (H) positioned in cylinder block, use a new gasket and install valve housing assembly. Tighten cap screws with washers (E) to 47 N·m (35 lb-ft) in diagonal sequence. Retighten each cap screw to 47 N·m (35 lb-ft) in diagonal sequence.



- A—Plug
- B—O-ring
- C—Shims (As required)
- D—Valve
- E—Cap Screws and Washer (4-used)
- F—Valve Housing
- G—Gasket
- H—Spring Pin
- I—Spring
- J—Spring Pin

RG5511 -UN-04JUL89

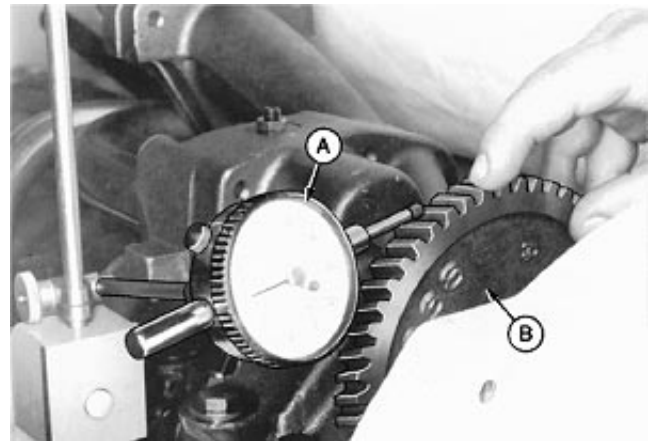
RG.CTM61,G20,10-19-05MAY93

CHECK CRANKSHAFT GEAR-TO-OIL PUMP DRIVE GEAR BACKLASH

Before removing oil pump, determine if there is adequate backlash between oil pump drive gear and crankshaft drive gear.

1. Mount dial indicator (A) and measure backlash between pump drive gear (B) and crankshaft gear.

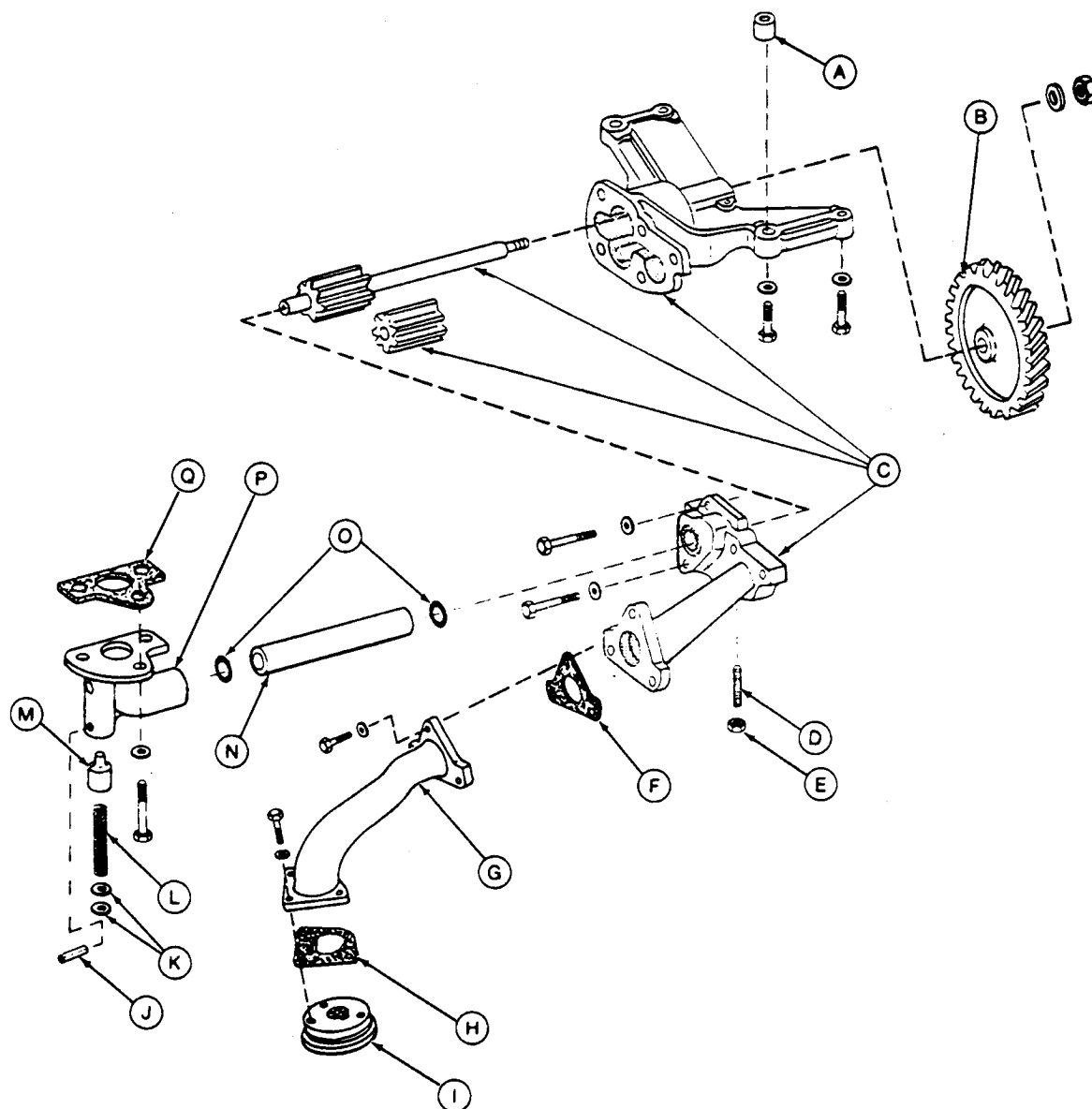
IMPORTANT: Backlash must be at least 0.08 mm (0.003 in.). If backlash is less than 0.08 mm (0.003 in.), replace the oil pump drive gear.



RG3849 -UN-29NOV88

S55,2520,H -19-16MAR92

ENGINE OIL PUMP ASSEMBLY



A—Hollow Dowel (2 used)
B—Drive Gear
C—Oil Pump Assembly
D—Set Screw
E—Lock Nut

F—Gasket
G—Intake Elbow
H—Gasket
I—Pickup Screen
J—Spring Pin

K—Shim(s)
L—Spring
M—Valve
N—Outlet Tube

O—O-Rings (2 used)
P—Oil Pressure Relief Valve
Housing/Outlet Elbow
Q—Gasket

RG5512 -UN-04JUL89

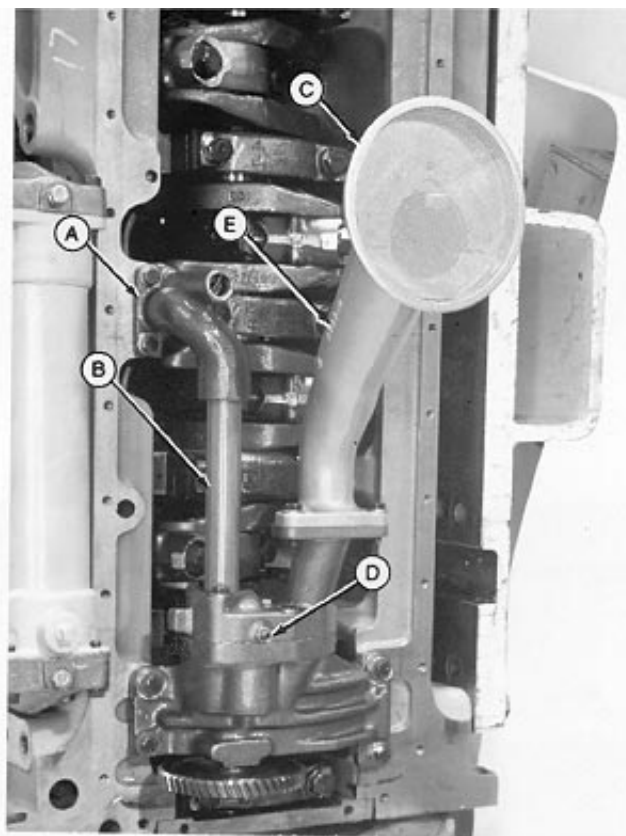
S55,2520,I -19-24APR92

REMOVE ENGINE OIL PUMP

1. Remove oil pressure relief valve housing/outlet elbow (A) and outlet tube (B) with O-rings. Discard used gasket and O-rings.
2. Remove intake elbow (E) with pickup screen (C) attached.
3. Remove four oil pump-to-cylinder block cap screws and carefully lift pump assembly from cylinder block. Remove two hollow dowels.
4. Place pump assembly on a clean flat table and remove all gasket material.

IMPORTANT: Do not alter adjustment of set screw and lock nut (D). If adjustment has been altered, follow procedure during assembly. (See ADJUST OIL PUMP SET SCREW, later in this group.)

A—Oil Pressure Relief Valve Housing/Outlet Elbow
 B—Outlet Tube
 C—Pickup Screen
 D—Set Screw and Lock Nut
 E—Intake Elbow



RG5536 -UN-09JAN90

S55,2520,J -19-24APR92

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17

INSPECT AND CLEAN OIL PUMP

1. Visually inspect oil pump for wear or damage.
2. Flush pump assembly internally with clean solvent to remove oil. Spin pump gears to help remove solvent.
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.

IMPORTANT: To help insure accurate wear measurements, be sure the oil pump is clean and faces the same way as when mounted on the cylinder block.

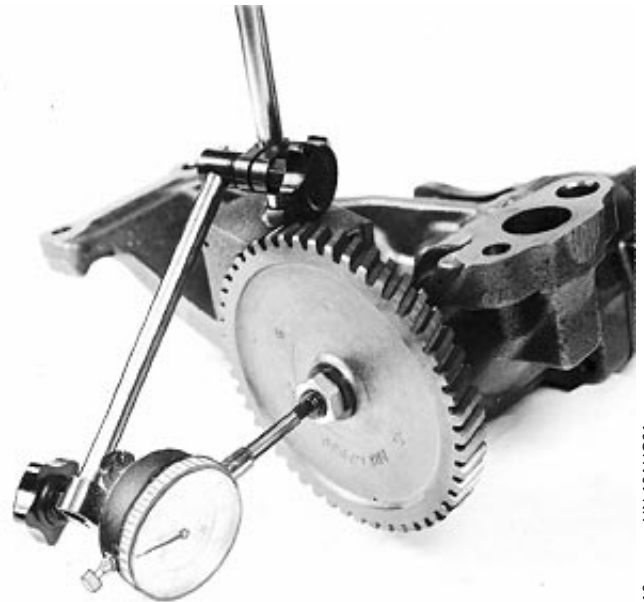
S11,0404,T -19-24APR92

CHECK DRIVE SHAFT END PLAY

1. Mount dial indicator with plunger tip resting against end of pump drive shaft.
2. Move shaft toward and away from indicator.

If end play exceeds 0.15 mm (0.006 in.), there is excessive wear on pump cover and/or wear on end of pump drive gear.

Replace oil pump if end play exceeds 0.15 mm (0.006 in.).



-UN-16AUG91
RG5916

S11,0404,U -19-01APR93

CHECK DRIVE SHAFT SIDE MOVEMENT

1. Mount dial indicator with plunger tip resting on one of the hex nut flats.
2. Move shaft from side-to-side.

If shaft side movement exceeds 0.17 mm (0.0065 in.), there is excessive wear on drive shaft bushing and/or drive shaft.

Replace oil pump if shaft side movement exceeds 0.17 mm (0.0065 in.).



RG5917 -UN-16AUG91

S11,0404,V -19-02APR93

CHECK PUMPING GEAR BACKLASH

1. Mount dial indicator with indicator plunger resting against side of gear tooth.
2. Hold idler gear stationary (by reaching through oil discharge hole) and slowly rotate drive gear back and forth until contact with idler gear is felt.

If backlash is not within 0.33—2.00 mm (0.013—0.079 in.) 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, reclean gears and check backlash again.

3. Replace oil pump if pumping gear backlash exceeds 2.00 mm (0.079 in.).



RG5918 -UN-16AUG91

S11,0404,W -19-01APR93

INSPECT OIL PUMP DRIVE GEAR

NOTE: Oil pump does not need to be removed from engine, when inspecting drive gear.

1. Inspect drive gear teeth for chips, cracks, or wear. Replace as necessary.



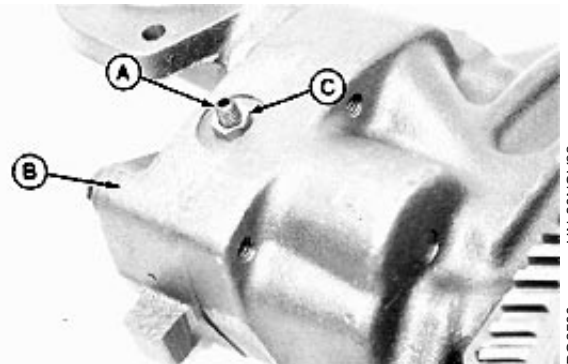
RG6435
-UN-13OCT92

RG,CTM42,G20,31-19-09OCT92

ADJUST OIL PUMP SET SCREW

IMPORTANT: Normally the set screw (A) should NOT need to be adjusted; but if the set screw is altered, the following steps should be followed.

1. Install drive gear and idler gear into oil pump housing.
2. Install oil pump cover (B) onto housing and tighten cover-to-housing cap screws to 41 N·m (30 lb-ft).
3. Loosen lock nut (C) and tighten set screw until it lightly contacts idler gear shaft. Shaft should spin freely with limited axial movement.
4. Hold set screw stationary and tighten lock nut to 8 N·m (6 lb-ft). Do not overtighten set screw or lock nut.
5. Spin drive gear to assure shaft turns freely in housing. Readjust set screw if shaft does not turn freely.

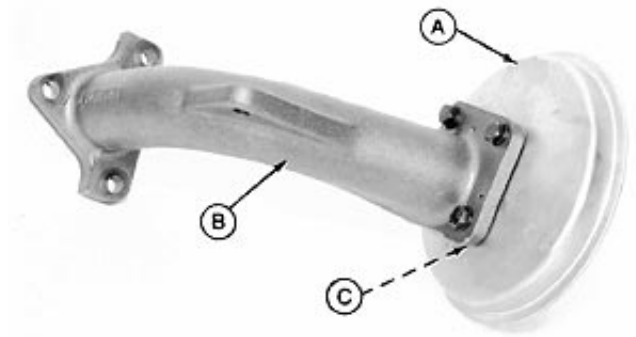


RG3509
-UN-29NOV88

S11,2020,BZ -19-05MAY93

INSTALL ENGINE OIL PUMP

1. Install pickup screen (A) with a new gasket (C) to intake elbow (B).
2. Tighten cap screws to 24 N·m (18 lb-ft).



S55,2520,K -19-16MAR92

RG3756 -UN-25SEP89

3. Lubricate bottom surface of oil pump housing gear pocket bores, idler shaft, gear teeth on drive shaft, and oil pump cover ends of both gears with TY6343 or TY6347 High Temperature Grease.
4. Install intake elbow (A) with new gasket onto oil pump cover (B). Tighten cap screws to 41 N·m (30 lb-ft).
5. Mount oil pump onto engine block using two hollow dowels as locators.

IMPORTANT: Be sure oil pump drive gear is properly meshed with crankshaft gear.

6. Install oil pump mounting cap screws and finger tighten.

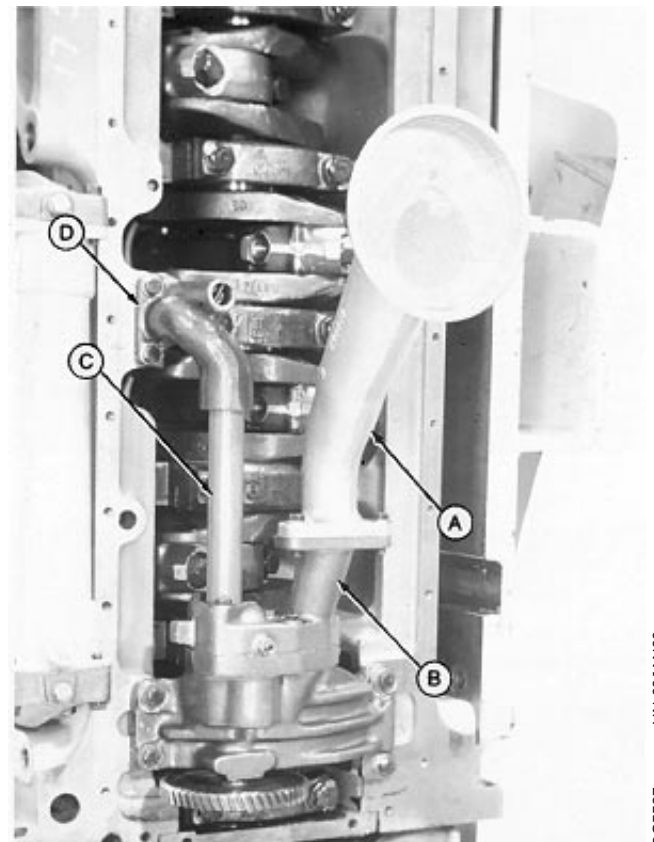
IMPORTANT: Be careful not to cut or dislodge O-ring when installing outlet tube.

7. Lubricate new O-rings with clean engine oil. Install O-rings on each end of outlet tube (C) and install tube into cover and oil pressure relief valve housing outlet elbow (D).

8. Install oil pressure relief valve housing/outlet elbow onto cylinder block using a new gasket. Tighten cap screws to 41 N·m (30 lb-ft).

9. Tighten oil pump mounting cap screws to 47 N·m (35 lb-ft).

10. Tighten oil pump drive gear nut to 54 N·m (40 lb-ft).



A—Intake Elbow
B—Oil Pump Cover
C—Outlet Tube
D—Oil Pressure Relief Valve Housing/Outlet Elbow

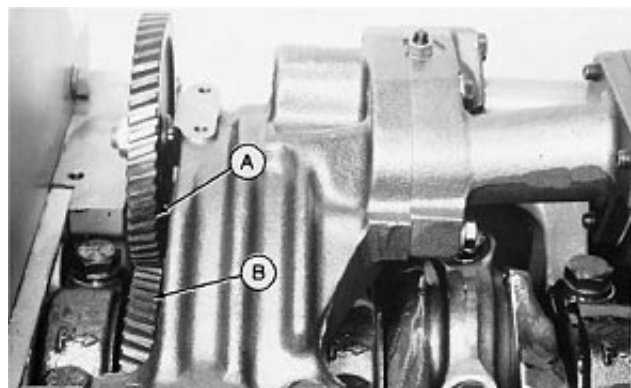
S55,2520,L -19-05MAY93

RG5537 -UN-09JAN90

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IMPORTANT: Push crankshaft rearward (toward flywheel end). Check clearance between oil pump drive gear face and throw of crankshaft. There should be a clearance of at least 0.38 mm (0.0015 in.). If clearance is below specification, check thrust bearing for proper placement.

Gently pry crankshaft forward and check (after oil pump is installed) the oil pump drive gear (A), and crankshaft gear (B) to see that they are properly meshed.



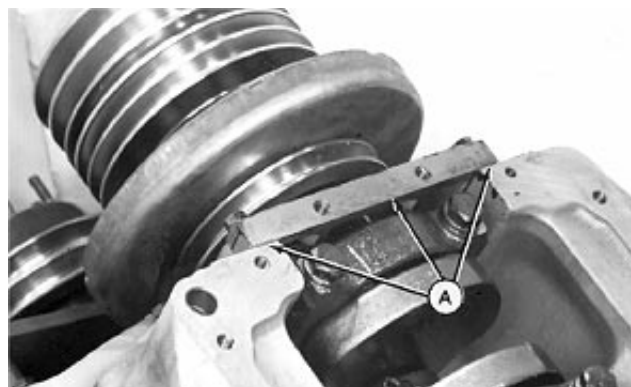
RG5509 -UN-10NOV89

S55,2520,N -19-16MAR89

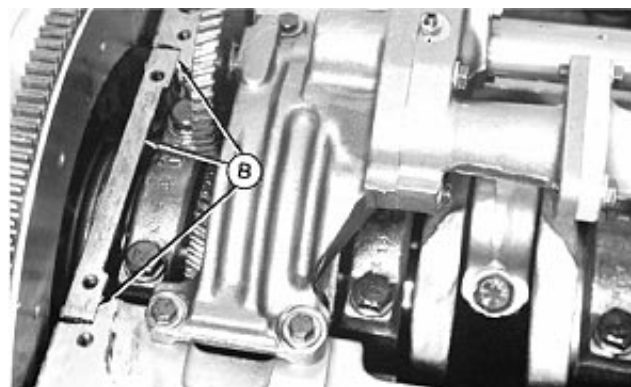
INSTALL OIL PAN

Before installing the engine oil pan, remove old gasket material and sealant from pan and cylinder block mating surfaces. Be sure all gasket surfaces are clean and dry before assembly.

IMPORTANT: Apply a thin layer of PERMATEX AVIATION (Form-A-Gasket No. 3) at timing gear cover-to-cylinder block mating surfaces, along entire surface of timing gear cover (A), at rear crankshaft oil seal housing-to-cylinder block mating surfaces, and entire rear face of block (B) before installing oil pan gasket.



RG5539 -UN-09JAN90



RG5540 -UN-09JAN90

S55,2520,O -19-01APR93

1. Place a new gasket (A) on cylinder block and install oil pan. Be sure oil pan is flush with flywheel end of cylinder block. Guide studs may be used, if desired.

NOTE: Use a straightedge against flywheel end of oil pan and cylinder block to assure a flush to ± 0.05 mm (0.002 in.) alignment.

2. Insert all 3/8 in. and 1/2 in. cap screws in their appropriate hole location. Initially tighten all 3/8 in. cap screws to 54 N·m (40 lb-ft), starting at right rear corner of oil pan (B) and proceed counterclockwise (bold arrows). Follow same procedure for all 1/2 in. cap screws.

3. Finish tightening cap screws to specifications listed below, start at (B) and proceed counterclockwise as outlined earlier. Tighten all 3/8 in. cap screws before tightening 1/2 in. cap screws.

OIL PAN CAP SCREW FINAL TORQUE SPECIFICATION

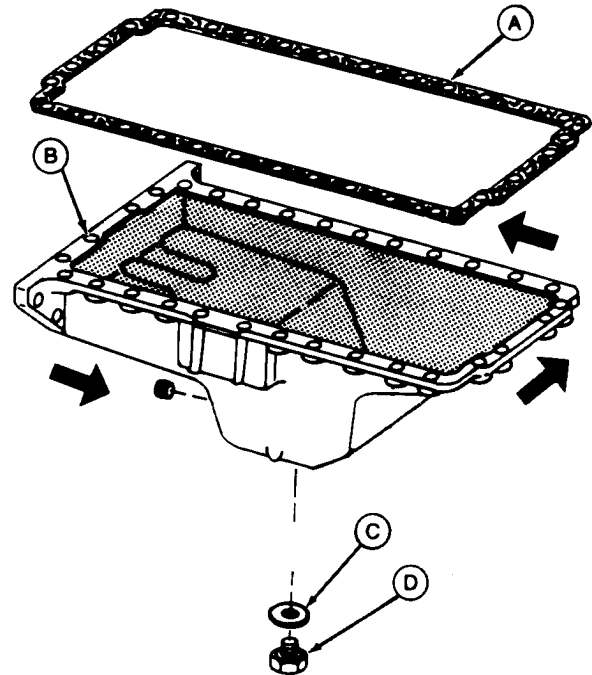
3/8 in. Cap Screws	68 N·m (50 lb-ft)
1/2 in. Cap Screws	156 N·m (115 lb-ft)

NOTE: Check torque on all 3/8 in. cap screws after final torque of 1/2 in. cap screws.

4. Install all 3/4 in. oil pan-to-flywheel housing cap screws and tighten to 325 N·m (240 lb-ft).

5. Lubricate O-ring (C) with clean engine oil and install on drain plug (D). Install drain plug and tighten to 102 N·m (75 lb-ft).

NOTE: On engines equipped with an elbow fitting and drain hose on oil pan, the threads and sealing surfaces must be free of any film to insure an effective seal. Apply a light coat of LOCTITE 242 Thread Lock and Sealer to fittings except for the leading one to three threads. Tighten fittings securely.



A—Oil Pan Gasket
B—Location Of First Cap Screw
C—O-Ring
D—Drain Plug

RG6249 -UN-07APR92

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RG.CTM61,G20,12-19-07MAY93

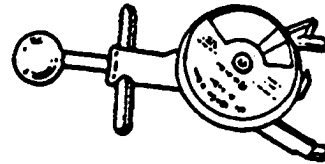
SPECIAL OR ESSENTIAL TOOLS

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

DX,TOOLS -19-05JUN91

Belt Tension Gauge JDG529

Used to check and adjust fan belt tension.

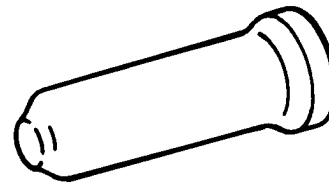


S53,JDG529 -19-09SEP91

RG5082 -UN-23AUG88

Water Pump Bearing Driver JDG743

Used to install bearings on water pump shaft and the water pump bearing shaft assembly into the water pump housing.



RG,JDG743 -19-22APR92

RG6219 -UN-06MAR92

RG5588 -UN-13SEP89

Belt Tension Gauge JDST28

Used with a straightedge to check fan belt tension.



RG,CTM61,G25,26-19-17MAR92

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OTHER MATERIAL

Name	Use
LOCTITE 515 Flexible Sealant (TY6304)	Water pump, thermostat cover and water manifold gaskets.
High Temperature Grease (TY6341)	Pack water pump bearings.
High Temperature Grease (TY6333 or TY6347)	Pack bearings in fan drive.
LOCTITE 592 Pipe Sealant with TEFLON (TY9374/TY9375)	Coat threads of water pump pipe plugs and fan drive pipe plug.

RG,CTM61.G25,1 -19-05MAY93

COOLING SYSTEM SPECIFICATIONS**ITEM****NEW PART SPECIFICATION****Water Pump:**

Impeller Bore	15.854—15.880 mm (0.6242—0.6252 in.)
Shaft OD Impeller End	15.905—15.931 mm (0.6262—0.6272 in.)
Shaft OD Pulley End	30.200—30.226 mm (1.1890—1.1900 in.)
Pulley Bore	30.137—30.163 mm (1.1865—1.1875 in.)
Bearing Bore in Water Pump Housing	71.995—72.017 mm (2.8344—2.8353 in.)
Maximum Serviceable	72.047 mm (2.8365 in.)
Impeller-to-Housing Clearance	0.39—0.89 mm (0.015—0.035 in.)
Maximum Pump Shaft End Play	0.25 mm (0.010 in.)
Pulley-to-Shaft Interference Press Fit	0.037—0.089 mm (0.0015—0.0035 in.)
Shaft OD for Bearing	35.001—35.017 mm (1.3780—1.3786 in.)

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

V-Belt Tension (2-Belt System, Tension Front Belt Only)

New Belts	423—467 N (95—104 lb)
Belts in Service (minimum 10-minutes use)	378—423 N (85—94 lb)

Pulley Installed Dimension

(Pulley Front Face-To-Housing Rear Face) 198.0 mm (7.795 in.) Ref.—Pulley ID should contact shoulder on shaft.

Heavy Duty Adjustable Fan Drive*

Bearing Bore in Housing	71.999—72.025 mm (2.8346—2.8356 in.)
Shaft OD for Bearings	35.001—35.017 mm (1.3780—1.3786 in.)
Bearing OD	71.987—72.013 mm (2.8341—2.8351 in.)
Bearing ID	34.987—35.013 mm (1.3774—1.3785 in.)
Maximum Shaft End Play	0.50 mm (0.020 in.)

**Specifications apply only to fan drives supplied by John Deere Factory.
Refer to manufacturers specifications for other fan drives.*

RG,CTM61,G25,2 -19-05MAY93

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COOLING SYSTEM SPECIFICATIONS—CONTINUED**TORQUES**

Water Pump Cover-to-Housing	24 N·m (18 lb-ft)
Water Pump-to-Cylinder Block	68 N·m (50 lb-ft)
Bypass Elbow-to-Water Pump	27 N·m (20 lb-ft)
Water Manifold-to-Cylinder Head	47 N·m (35 lb-ft)
Thermostat Cover-to-Water Manifold	27 N·m (20 lb-ft)
Coolant Heater Nut	34 N·m (25 lb-ft)
Coolant Conditioner Filter Base-to-Filter Bracket	47 N·m (35 lb-ft)
Coolant Conditioner Filter Bracket-to-Intake Manifold	47 N·m (35 lb-ft)
Coolant Conditioner Filter Bracket-to-Water Manifold	47 N·m (35 lb-ft)
Belt Tightener Bracket-to-Fan Support Plate	115 N·m (85 lb-ft)
Belt Tightener Pulley-to-Belt Tightener Bracket	75 N·m (55 lb-ft)
Fan Drive Assembly-to-Fan Support Plate	115 N·m (85 lb-ft)
Fan Pulley-to-Fan Drive	115 N·m (85 lb-ft)
Fan Support Plate-to-Cylinder Block	68 N·m (50 lb-ft)
Fan Support Plate-to-Timing Gear Cover	68 N·m (50 lb-ft)

RG,CTM61,G25,29-19-05MAY93

SERVICE EQUIPMENT AND TOOLS

NOTE: Order tools from your SERVICE-GARD™ Catalog. Some tools may be available from a local supplier.

Name	Use
D01045AA—Bushing, Bearing and Seal Driver Set	Install inner seal in water pump housing and bearing in fan belt tightener pulley.
D01173AA—17-1/2 Ton Puller Set	Remove pulley from water pump shaft.

S55,2525,A -19-05MAY93

DIAGNOSING COOLING SYSTEM MALFUNCTIONS**Engine Overheats**

Loose or broken fan belt
 Dirty radiator
 Low coolant level
 Low oil level
 Engine overloaded
 Defective head gasket
 Incorrect timing (engine/injection pump)
 Faulty thermostats
 Faulty water pump
 Corroded coolant passages
 Improper grade of fuel
 Excessive fuel delivery

Low Coolant Level

Improper maintenance
 Improper operation
 Damaged radiator
 Water pump seal leakage
 System leakage
 Faulty radiator pressure cap

S11,2025,DH -19-17JUN91

GENERAL COOLING SYSTEM INFORMATION

Engines may have a directed coolant flow or a conventional coolant flow.

• Directed Coolant Flow

On directed coolant flow engines, coolant flows around the cylinder liners. Also, there are two cylinder block vertical passages nearest number 3 and 4 cylinder liner bores which are cross drilled to deliver coolant to the passage created by a groove in the upper liner flange. The liner flange coolant is inter-connected by the cut-out voids in the block between liners. Cross drilled passages at number 1 and 6 liner flanges direct return coolant through external tubes to the suction side of the water pump.

• Conventional Coolant Flow

On conventional coolant flow engines, coolant flows around the cylinder liners and progresses upward toward the cylinder head without passing between the liners or within the upper liner flange groove.

See HOW THE COOLING SYSTEM WORKS in Group 105 for an explanation of the differences and flow diagrams of each system.

Engines are equipped with a heavy-duty, belt-driven water pump which utilize a shaft with two roller bearings pressed on each end of shaft. Water pump housings and water piping to the pump may vary by application, but repair to all internal components are the same.

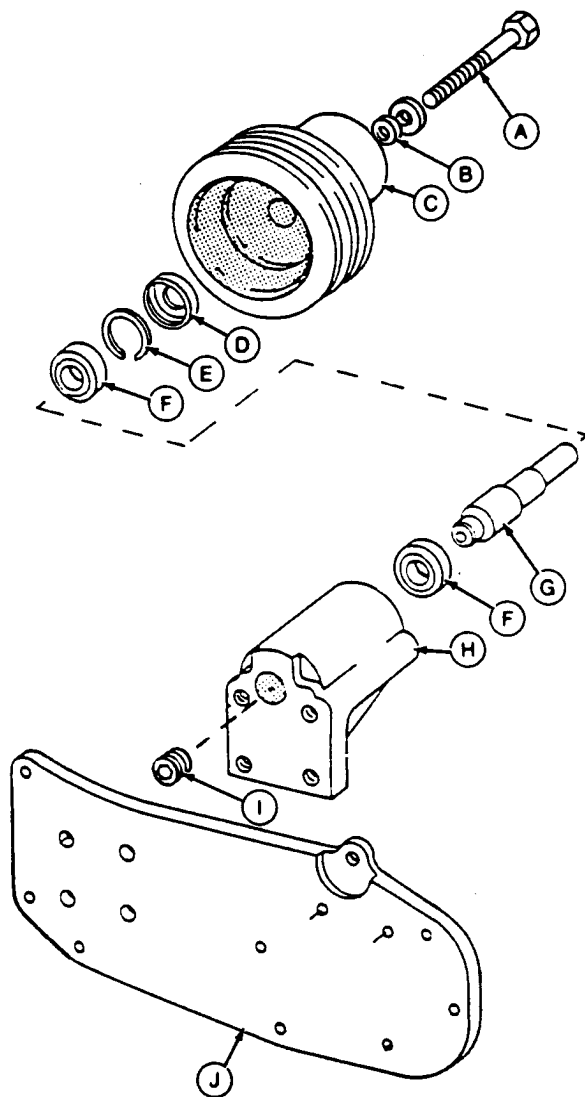
RG,CTM61,G25,31-19-05MAY93

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5

REMOVE AND INSTALL HEAVY DUTY FAN DRIVE ASSEMBLY

1. Remove fan belts and fan.
2. Remove fan support plate with fan drive assembly from engine.
3. Reverse removal steps and install fan support plate. Tighten mounting cap screws to 68 N·m (50 lb-ft).
4. Install fan and fan belts. Refer to the appropriate operator's manual for proper belt tensioning.

RG,CTM61,G25,32-19-05MAY93

REMOVE FAN DRIVE BEARINGS

RG6670
-UN-17MAR93

A—Cap Screw
B—Spacer
C—Fan Pulley

D—Grease Seal
E—Snap Ring
F—Ball Bearing (2 used)

G—Shaft
H—Bearing Housing

I—Pipe Plug
J—Support Plate

1. Remove fan drive assembly from fan support plate (J).

2. Clamp fan pulley (C) in a soft-jawed vise. Support fan pulley (so it does not fall to floor), and remove cap screw (A) securing pulley to shaft (G). Remove fan pulley.

3. Remove pipe plug (I), grease seal (D), and snap ring (E). Discard seal and snap ring.

4. Remove shaft with bearings (F) by tapping lightly 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 for cracks or any other damage. Measure parts and compare with specifications given below.

HEAVY DUTY FAN DRIVE SPECIFICATIONS

Housing ID 71.999—72.025 mm (2.8346—2.8356 in.)

Shaft OD 35.001—35.017 mm (1.3780—1.3786 in.)

Bearing ID 34.987—35.013 mm (1.3774—1.3785 in.)

Bearing OD 71.987—72.013 mm (2.8341—2.8351 in.)

RG,CTM61,G25,44-19-05MAY93

INSTALL FAN DRIVE BEARINGS

Refer to artwork in REMOVE FAN DRIVE BEARINGS, earlier in this group.

1. Pack inner and outer bearings with TY6333 or TY6347 High Temperature Grease. Apply clean engine oil to bearing ID and shaft OD.
2. Support end of shaft (G) and install bearings (F) against shoulder. Using a press and JDG743 Driver, apply force to bearing inner race only.
3. Support bearing housing (H) 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 thickness needed to obtain 0.10 mm (0.004 in.) end play.
6. Install snap ring (E) in housing groove. Visually inspect snap ring installation for proper seating in housing groove.

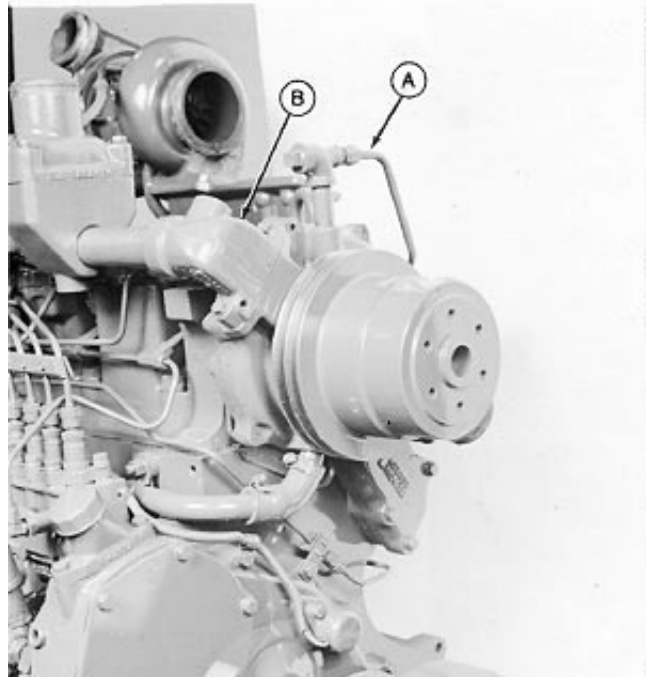
7. Apply a thin coat of clean engine oil to OD of seal casing and to seal lips. Install seal (D) in housing bore until metal casing is flush-to-0.50 mm (0.020 in.) below housing face.
8. Apply clean engine oil to ID of fan pulley (C). Support end of shaft through pipe plug hole in bearing housing and push hub onto other end of shaft until it bottoms against shoulder.
9. Install spacer (B). Install cap screw with washer (A). Tighten cap screw to 102 N·m (75 lb-ft).
10. Apply LOCTITE 592 Pipe Sealant to threads of pipe plug (I). Install and tighten plug in bearing housing.
11. Install fan drive assembly onto support plate (J). Tighten cap screws to 115 N·m (85 lb-ft).
12. Depending on application, install fan support plate to timing gear cover or cylinder block. Tighten cap screws to 68 N·m (50 lb-ft).

RG,CTM61,G25,34-19-05MAY93

REMOVE WATER PUMP

⚠ 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. Always loosen drain valve on left-hand side of block (arrow) slowly to relieve any pressure.

1. Drain coolant from cylinder block if not previously done.
2. Remove fan and fan belts.
3. Disconnect coolant filter conditioner line (A).
4. Remove bypass elbow (B).

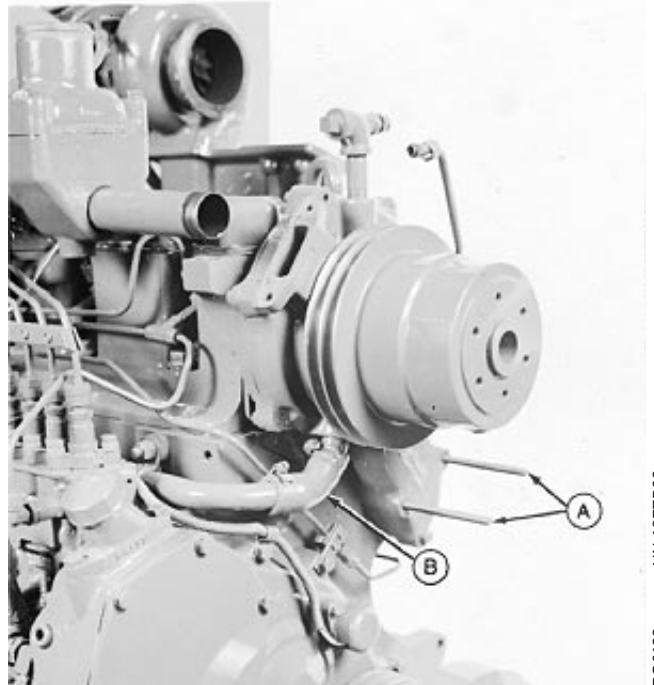

 -UN-06MAR92
RG6209

 -UN-18FEB92
RG6131

RG,CTM61,G25,3 -19-17MAR92

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5. Remove two water pump housing cap screws and install guide studs (A) for ease in removing water pump.

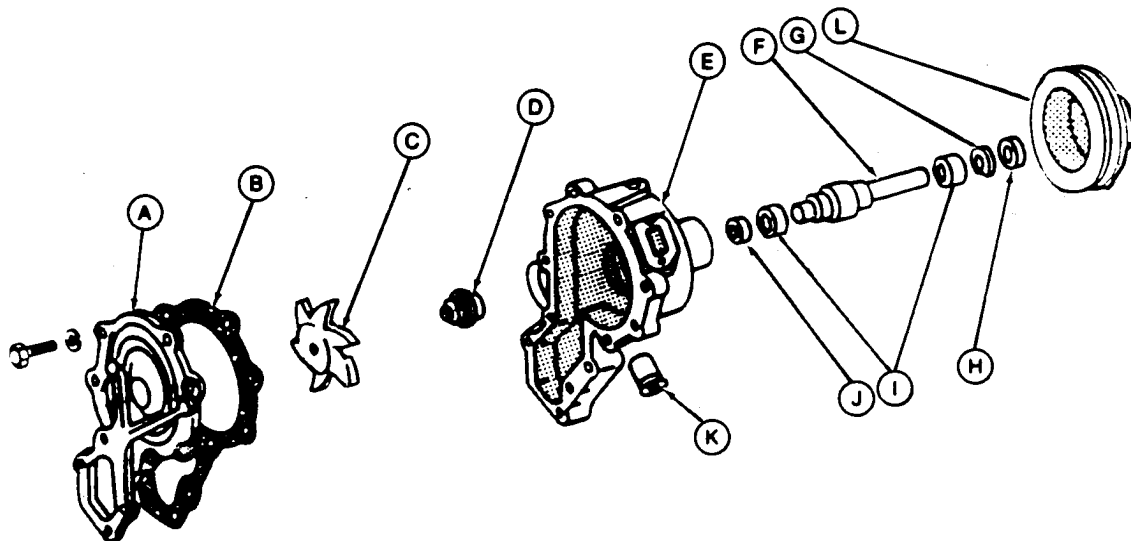
6. Loosen hose clamp and remove oil cooler-to-water pump hose (B).



RG6132 -UN-18FEB92

RG,CTM61,G25,4 -19-17MAR92

WATER PUMP ASSEMBLY



A—Cover
B—Gasket
C—Impeller

D—Seal
E—Housing
F—Shaft

G—Snap Ring
H—Seal
I—Ball Bearing (2 used)

J—Seal
K—Tube
L—Pulley

RG6133 -UN-18FEB92

RG,CTM61,G25,6 -19-17MAR92

DISASSEMBLE WATER PUMP

1. Remove water pump pulley using D01290AA Push-Puller from D01173AA 17-1/2 Ton Puller Set and two 3/8-16 UNC-2B cap screws (with flat washers) approximately 4.0 in. long.
2. Measure pulley bore and shaft OD. If measurements are not within specification, replace pulley or shaft.

WATER PUMP PULLEY SPECIFICATIONS

Pulley Bore	30.137—30.163 mm (1.1865—1.1875 in.)
Shaft OD Pulley End	30.200—30.226 mm (1.1890—1.1900 in.)



RG6491 -UN-17NOV92

RG.CTM61,G25,16-19-05MAY93

3. Remove six cap screws and remove cover (A). Scrape all gasket material from cover and housing face.

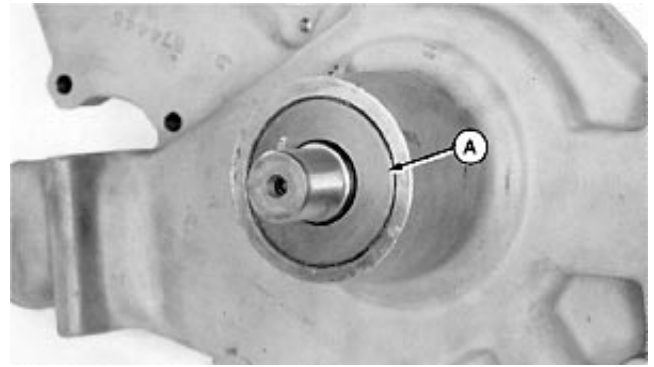


RG6156 -UN-24FEB92

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RG.CTM61,G25,17-19-05MAY93

4. Use a small sharp punch and punch a hole through outer seal (A). Pry outer grease seal from housing. Discard seal.



RG3560
-UN-31JUL89

S11,2525,AC -19-05MAY93

5. Remove snap ring (A).

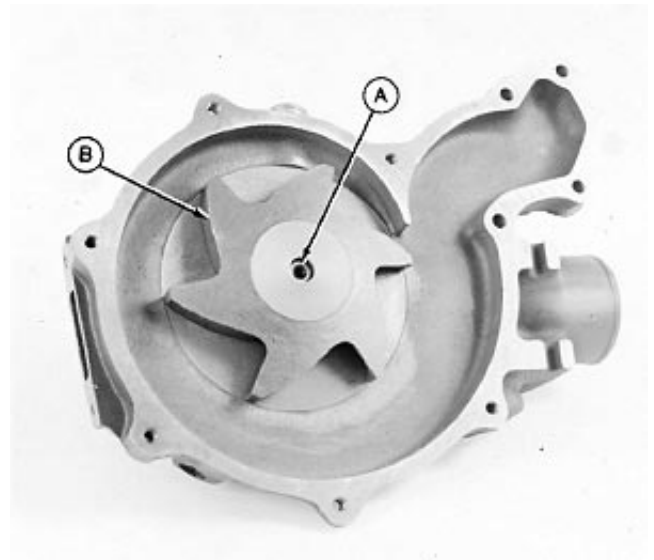


RG3561
-UN-31JUL89

S11,2525,AD -19-05MAY93

IMPORTANT: Whenever an impeller is removed from a shaft, it should be replaced with a new one. This assures that adequate pump shaft-to-impeller bore press fit is maintained.

6. Use a press and press shaft (A) through impeller (B). Press on shaft only. Remove impeller and discard.

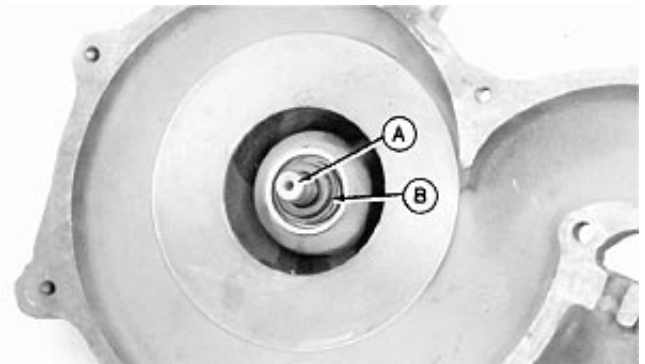


RG6157
-UN-24FEB92

RG,CTM61,G25,7 -19-05MAY93

7. Use a press to remove shaft and bearing assembly (A). Press until bearing and shaft assembly are clear from pump housing.

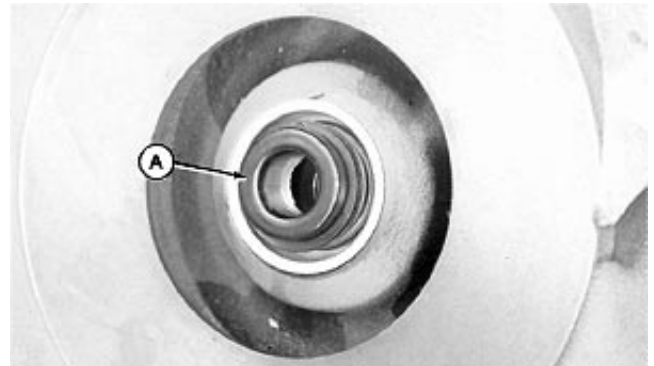
NOTE: Press only on diameter of shaft and not on water pump seal (B).



S11,2525,AF -19-05MAY93

RG3563 -UN-31JUL89

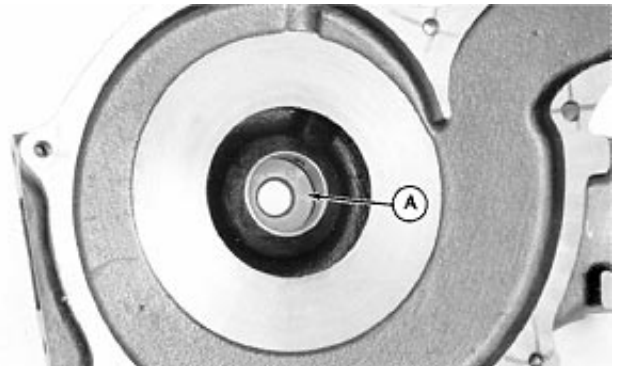
8. Use a small punch to drive unitized seal (A) from housing. Discard seal.



S11,2525,AG -19-05MAY93

RG3564 -UN-31JUL89

9. Use a driver with approximately the same O.D. as the O.D. of the inner grease seal (A) and drive seal from housing. Discard seal.



S11,2525,AH -19-05MAY93

RG3565 -UN-31JUL89

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13

MEASURE BEARING BORE IN WATER PUMP HOUSING

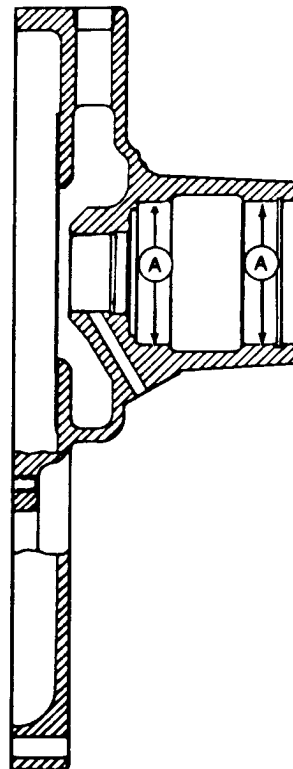
NOTE: Thoroughly clean housing bores before measuring to achieve an accurate measurement.

1. Measure bearing bore in pump housing at both bearing locations (A) using a telescoping gauge or dial bore gauge. Take the average of three readings at each bearing location.

WATER PUMP HOUSING SPECIFICATIONS

Bearing Bore in	
Housing	71.995—72.017 mm (2.8344—2.8353 in.)
Maximum Serviceable	72.047 mm (2.8365 in.)
Shaft OD	
Impeller End	15.905—15.931 mm (0.6262—0.6272 in.)
Shaft OD	
Pulley End	30.200—30.226 mm (1.1890—1.1900 in.)
Pulley Bore	30.137—30.163 mm (1.1865—1.1875 in.)
Impeller Bore	15.854—15.880 mm (0.6242—0.6252 in.)
Pulley-to-Shaft Interference	
Press Fit	0.037—0.089 mm (0.0015—0.0035 in.)
Shaft OD	
for Bearing	35.001—35.017 mm (1.3780—1.3786 in.)

If pump housing bearing bore is not within maximum service specification, install a new water pump assembly.



RG5055 -UN-31MAR92

RG,CTM61,G25,8 -19-05MAY93

ASSEMBLE WATER PUMP

1. Use handle and driver (A) from D01045AA Bushing, Bearing and Seal Driver Set to install inner grease seal (B) into housing bore until seal bottoms against shoulder.



RG3567 -UN-31JUL89

S55,2525,I -19-17MAR92



RG6255 -UN-20APR92



RG6256 -UN-20APR92

2. Pack bearings with TY6341 High Temperature Grease. Install bearings onto shaft with a press and JDG743 Water Pump Bearing Driver which bears on INNER and OUTER bearing race.

3. Fill the cavity between bearings about half full with grease around the entire OD of bearing shaft before installing into housing.

4. Install shaft and bearing assembly into water pump housing using JDG743 Driver and lightly tap with a hard RUBBER mallet until inner bearing bottoms in housing bore.

IMPORTANT: The bearing shaft assembly should slip into housing with little resistance. DO NOT use excessive force to install assembly.

RG,CTM61,G25,9 -19-05MAY93

5. Install 1.96 mm (0.077 in.) thick green snap ring (A) in housing groove with sharp edge of snap ring facing up.



RG3561 -UN-31JUL89

S11,2525,BN -19-17MAR92

6. Use a magnetic base dial indicator and measure shaft end play. The maximum end play allowed is 0.25 mm (0.010 in.).

7. Install the correct size snap ring which will achieve the proper end play.

Snap Ring Sizes:

- 1.70 mm (0.067 in.) (red)
- 1.96 mm (0.077 in.) (green)
- 2.21 mm (0.087 in.) (blue)
- 2.46 mm (0.097 in.) (white)

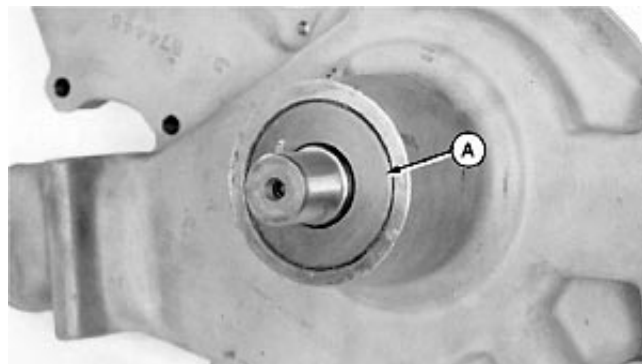


RG2656 -UN-17JUL89

RG,CTM61,G25,10-19-17MAR92

IMPORTANT: Generously lubricate ID of seal lip and fill the entire seal casing with grease prior to installing seal onto shaft. As seal is being installed over shoulder of pump shaft, rotate seal to prevent damage to lip.

8. Install outer grease seal (A) onto housing with spring loaded lip facing bearings. Tap lightly with small hammer until seal is flush with housing face.

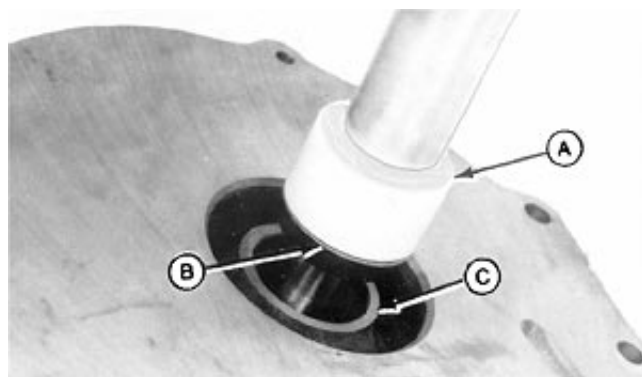


RG3560 -UN-31JUL89

S11,2525,AO -19-17MAR92

IMPORTANT: Use R78350 Driver (A), that is included with water pump seal kit and repair kit to drive seal to proper depth.

9. Support pump assembly on front pulley shaft and place new seal (B) onto impeller shaft with R78350 Driver over seal. Drive seal until it bottoms on water pump housing (C).



RG3568 -UN-14DEC88

S11,2525,BP -19-15JUN89

10. Support pulley end of shaft and press impeller (A) onto shaft until there is 0.39—0.89 mm (0.015—0.035 in.) clearance (B) between machined surface of housing and impeller.

IMPORTANT: Pump seal should NOT touch impeller.



RG,CTM61,G25,11-19-17MAR92

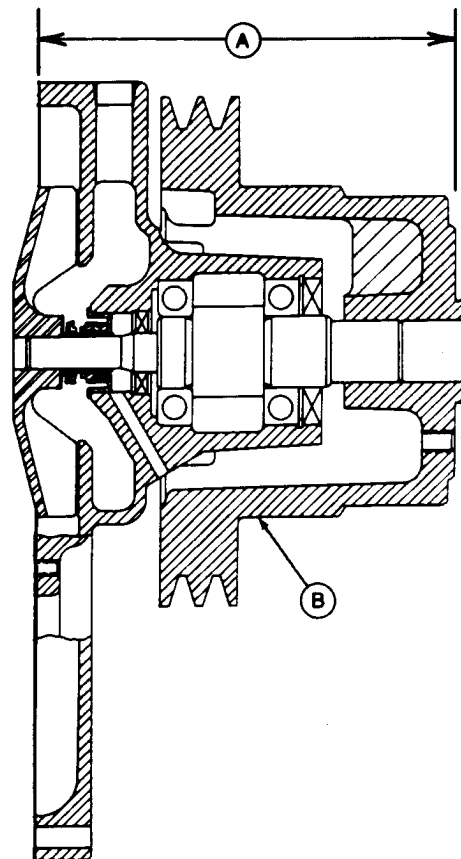
11. Support bearing shaft assembly through impeller bore. Press pulley (B) onto shaft until pulley ID bottoms on shoulder on shaft. At this point reference dimension (A), from front face of pulley-to-rear housing face will be achieved. Refer to the table below for reference dimension to assure correct pulley alignment.

IMPORTANT: The interference press fit between pulley and shaft must be 0.037 mm (0.0015 in.) minimum to 0.089 mm (0.0035 in.) maximum. Replace pulley and/or shaft if interference press fit is not within this range.

PULLEY FRONT FACE-TO-REAR HOUSING FACE SPECIFICATION

Dimension (A) 198.0 mm (7.795 in.)*

* Reference dimension only. Press pulley onto shaft until ID of pulley bottoms on shoulder of shaft.



RG,CTM61,G25,12-19-05MAY93

12. Using a new gasket, install pump housing cover (A). Tighten cap screws to 24 N·m (18 lb-ft).

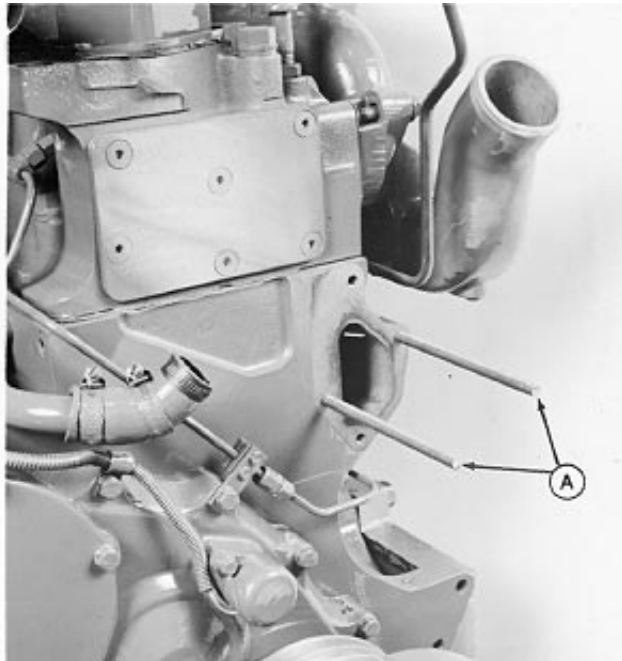
13. Turn pump pulley by hand to be sure there is no interference between rotating parts. Disassemble and correct any interference problems.



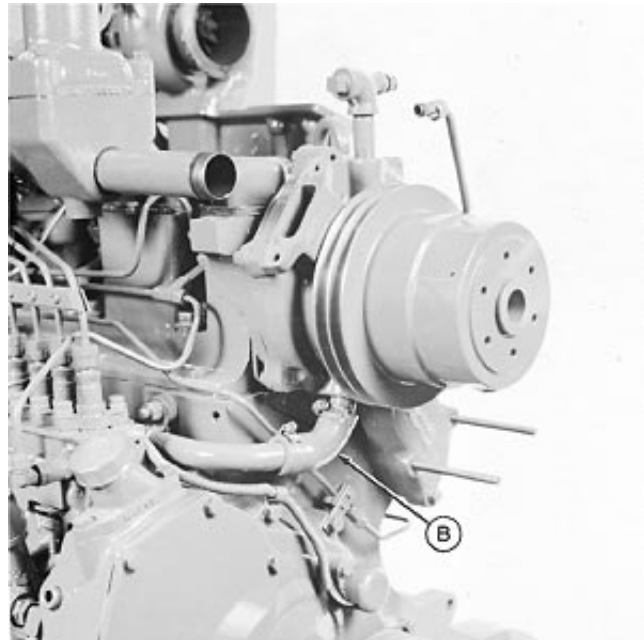
RG6156 -UN-24FEB92

RG,CTM61,G25,20-19-17MAR92

INSTALL WATER PUMP



RG6136 -UN-18FEB92



RG6137 -UN-18FEB92

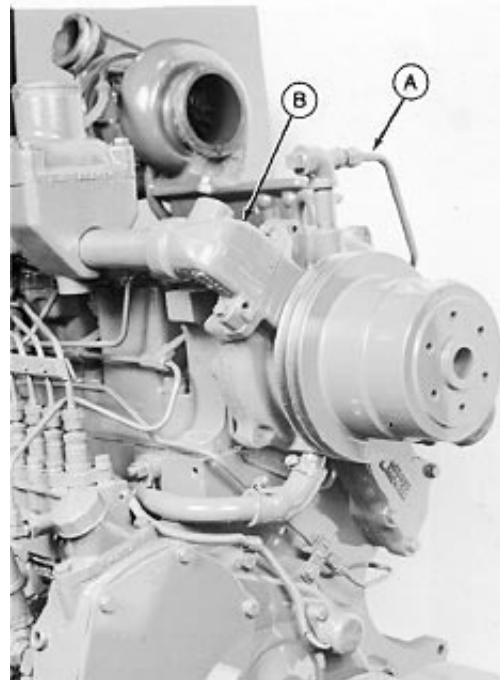
1. With two guide studs (A) installed in water pump mounting holes, install water pump with pulley onto cylinder block using a new gasket. Apply LOCTITE 515 Flexible Sealant to gasket prior to installation.

2. Tighten four mounting cap screws to 68 N·m (50 lb-ft).

3. Install oil cooler-to-water pump hose (B) on pump elbow and tighten hose clamp securely.

RG,CTM61,G25,13-19-05MAY93

4. Install bypass elbow (B) on pump and tighten cap screws securely.
5. Connect coolant filter conditioner line (A) using new packing and tighten securely.



RG6131
-UN-18FEB92

RG,CTM61,G25,14-19-17MAR92

6. On engines equipped with an aftercooler, install aftercooler inlet hose onto water pump and tighten hose clamp securely.
7. Install fan and fan belts. Adjust belts to proper specification. (See CHECK AND ADJUST V-BELT TENSION, later in this group.)

IMPORTANT: Air must be expelled from cooling system when refilling system. Loosen temperature sending unit fitting at rear of cylinder head or plug in water manifold to allow air to escape when filling system. Retighten fitting or plug when the cooling system is full and all the air has been expelled.

RG,CTM61,G25,15-19-22APR92

25
19

REMOVE WATER MANIFOLD

1. Drain coolant from the cooling system, if not previously done.



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. Always loosen drain valve on left-hand side of block (arrow) slowly to relieve any excess pressure.

2. Remove turbocharger oil line clamp (B) from thermostat cover (C).

3. On engines with coolant filter conditioner assembly mounted on water manifold, remove coolant filter, mounting bracket, and hoses. See REMOVE WATER MANIFOLD MOUNTED COOLANT FILTER CONDITIONER ASSEMBLY, later in this group.

4. Remove four mounting cap screws to remove water manifold (A). Dislodge O-ring and bypass tube (D) from water manifold bore as manifold is being removed.

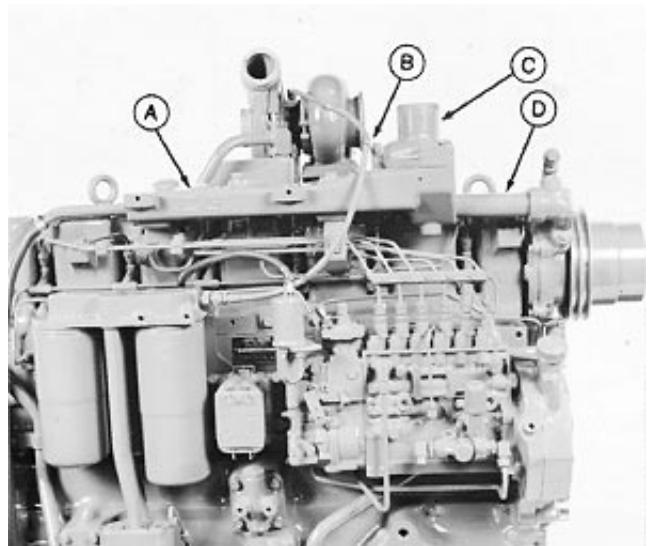
NOTE: Thermostat cover may be removed without removing water manifold. (See REMOVE AND TEST THERMOSTATS, later in this group.)

- A—Water Manifold
- B—Turbocharger Oil Line Clamp
- C—Thermostat Cover
- D—Bypass Tube



-UN-06MAR92

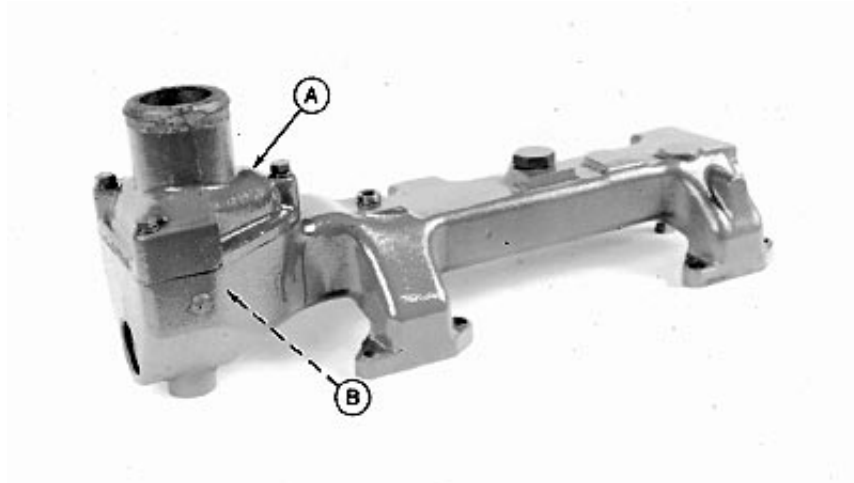
RG6209



-UN-18FEB92

RG6138

RG,CTM61,G25,18-19-05MAY93

INSPECT AND CLEAN WATER MANIFOLD

-UN-18FEB92

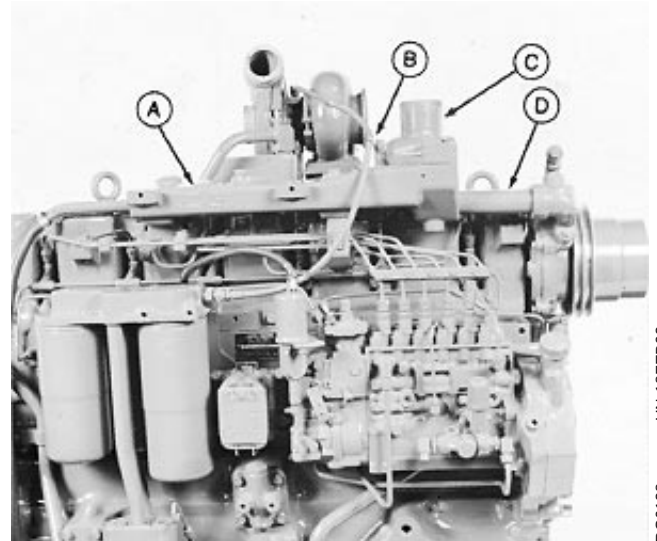
RG6139

1. Remove thermostat cover (A) and thermostats (B).
2. Remove all gasket material and debris from manifold and cylinder head.
3. Inspect water manifold for cracks or damage.
4. Clean all passages to remove debris with clean solvent. Dry with compressed air.

RG,CTM61,G25,19-19-05MAY93

INSTALL WATER MANIFOLD

1. Install thermostats in water manifold. Install thermostat cover (C) using a new gasket and LOCTITE 515 Flexible Sealant. Tighten cap screws to 27 N·m (20 lb-ft).
2. Apply LOCTITE 515 to both water manifold mounting surfaces and position a new gasket at each location.
3. Using a new O-ring install bypass tube (D) into bore of water manifold (A).
4. Position water manifold at the appropriate mounting surface and tighten cap screws to 47 N·m (35 lb-ft).
5. Install turbocharger oil line clamp (B) onto thermostat cover and tighten cap screw at 27 N·m (20 lb-ft).
6. On engines with coolant filter conditioner assembly mounted on water manifold, install mounting bracket, filter, and correct hoses. See REMOVE AND INSTALL WATER MANIFOLD MOUNTED COOLANT FILTER CONDITIONER ASSEMBLY, later in this group.



-UN-18FEB92

RG6138

- A—Water Manifold
 B—Turbocharger Oil Line Clamp
 C—Thermostat Cover
 D—Bypass Tube

RG,CTM61,G25,21-19-05MAY93

REMOVE AND TEST THERMOSTATS

1. Remove thermostat cover (shown removed). Inspect cover for cracks or damage.
2. Remove thermostats (A) from water manifold. Remove all gasket material from water manifold.
3. Test each thermostat. See INSPECT THERMOSTAT AND TEST OPENING TEMPERATURE in Group 105.

If any thermostat is defective, replace all thermostats.



RG3735 -UN-25SEP89

S11,2525,BX -19-05MAY93

INSTALL THERMOSTATS

1. Install thermostats where previously removed, using a new gasket.
2. Apply LOCTITE 515 Flexible Sealant on water manifold-to-thermostat cover gasket surfaces.
3. Install thermostat cover and tighten cap screws to 27 N·m (20 lb-ft).

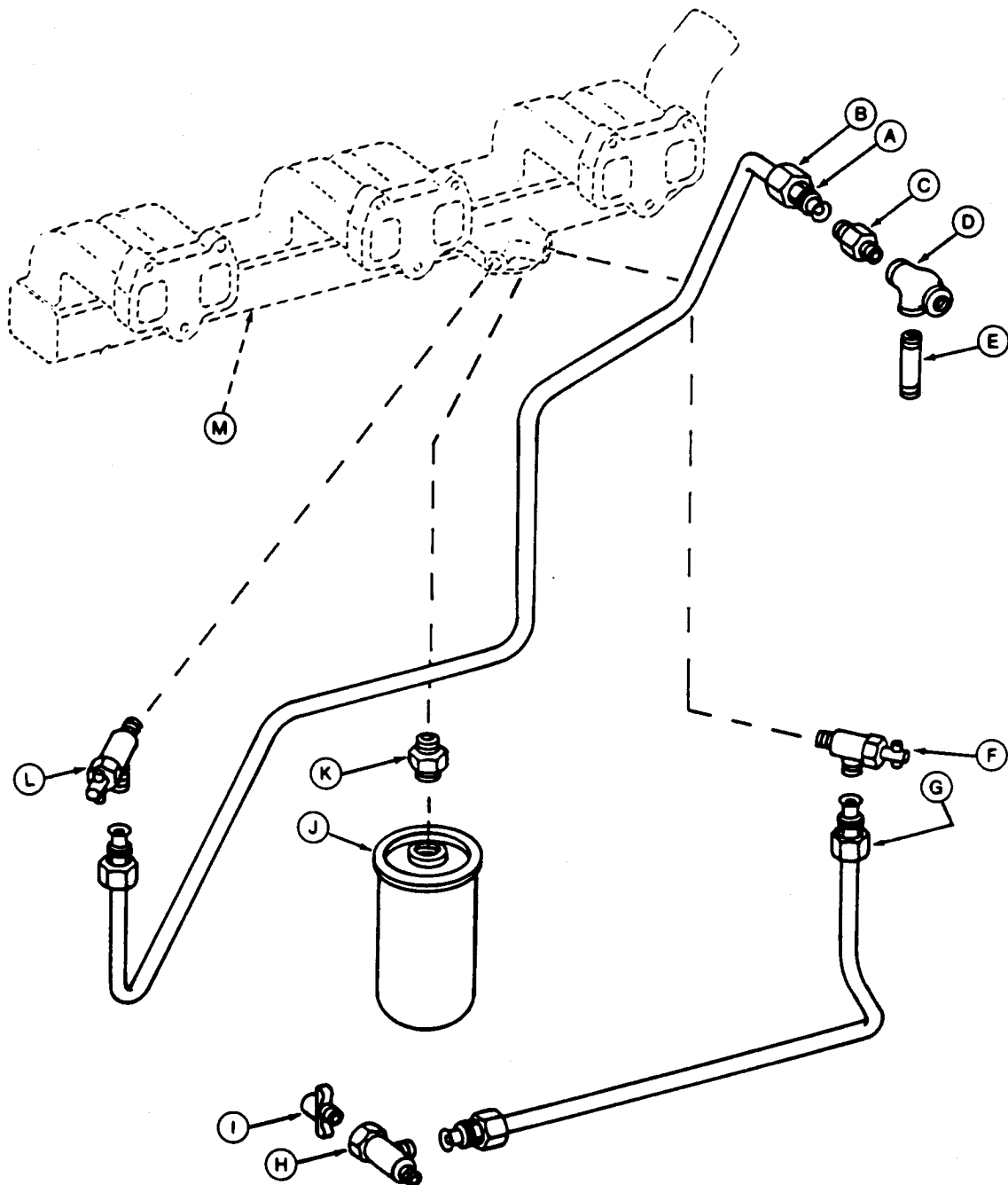
S11,2525,S -19-05MAY93

COOLANT CONDITIONER FILTER GENERAL INFORMATION

Coolant conditioner filter assemblies can be an intergal part of the air intake manifold, or a mounted assembly to the water manifold or air intake manifold. Servicing of these assemblies are similar, however, removal and installation procedures differ.

RG,CTM61,G25,35-19-05MAY93

INTERGAL (AIR INTAKE) COOLANT FILTER CONDITIONER ASSEMBLY



A—Packing (4 used)
B—Outlet Line
C—Fitting
D—Tee Fitting

E—Threaded Nipple
F—Inlet Shut-off Valve
G—Inlet Line

H—Tee Fitting
I—Drain Valve
J—Filter

K—Adapter
L—Outlet Shut-off Valve
M—Intake Manifold

RG6143 -UN-18FEB92

RG,CTM61,G25,22-19-05MAY93

REMOVE AND INSTALL INTERGAL (AIR INTAKE) COOLANT FILTER CONDITIONER ASSEMBLY



CAUTION: Do not remove coolant filter conditioner until coolant temperature is below operating temperature. Always loosen drain valve on left-hand side of block (arrow) slowly to relieve any excess pressure. If coolant is to be reused put in a clean container and cover to prevent entry of contaminants.

• To Remove Coolant Filter Conditioner Assembly:

1. Close outlet shut-off valve (B) and inlet shut-off valve (A).
2. Remove and discard coolant filter element (C).
3. Clean all coolant filter conditioner component parts using liquid household soap and water. Rinse thoroughly.
4. Dry with compressed air.
5. Inspect filter base and shut-off valves for debris and damage. Replace as necessary.

• To Install Coolant Filter Conditioner Assembly:

IMPORTANT: Apply joint sealing compound to all fittings before installation.

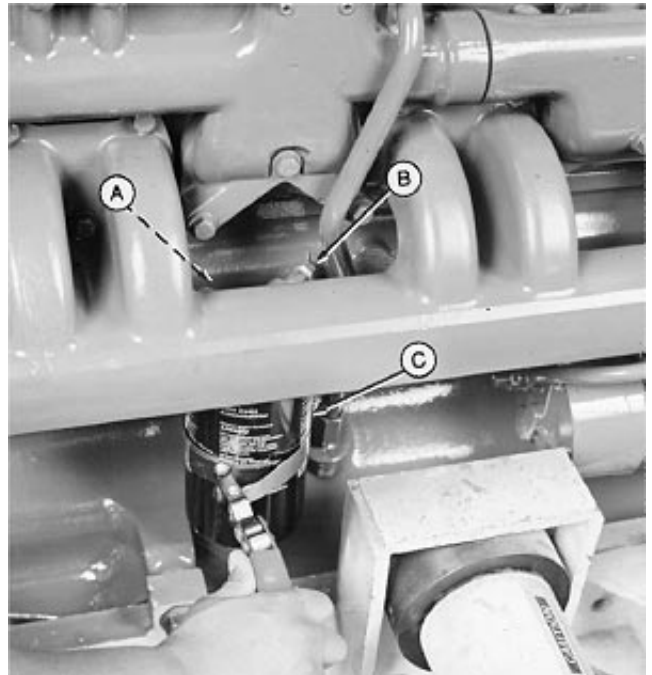
NOTE: Replace all packings at coolant line connections.

1. Apply a thin layer of clean engine oil on new coolant conditioner filter element gasket and install filter element.
2. Hand tighten filter element until gasket contacts filter base. Tighten element another 1/2—3/4 turn. DO NOT overtighten.
3. Open inlet and outlet shut-off valves. Tighten all connections securely.



-UN-06MAR92

RG6209

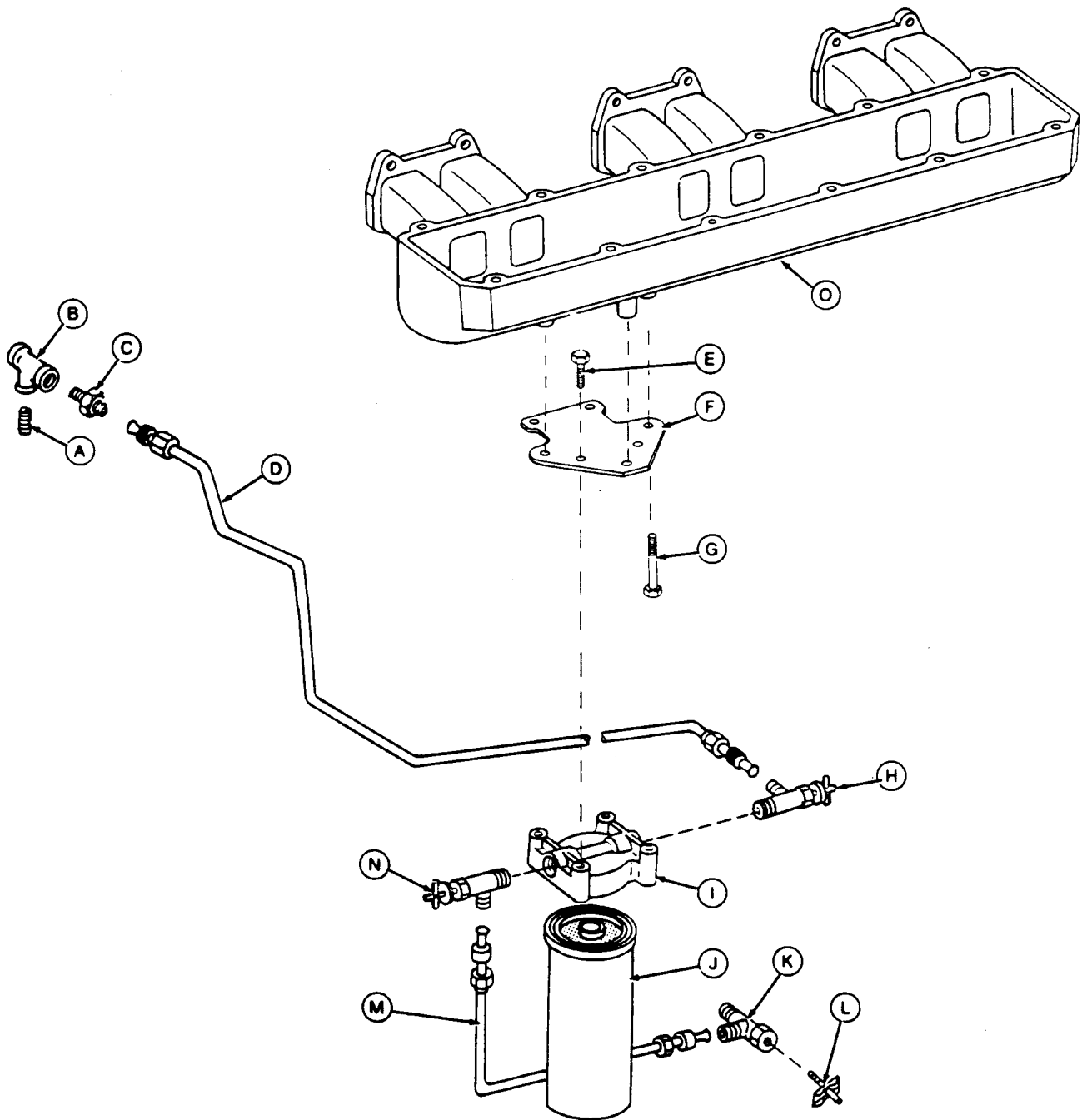


-UN-18FEB92

RG6144

RG.CTM61,G25,23-19-05MAY93

AIR INTAKE MANIFOLD MOUNTED COOLANT FILTER CONDITIONER ASSEMBLY



A—Nipple
B—Tee Fitting
C—Fitting
D—Line

E—Cap Screw (4 used)
F—Bracket
G—Cap Screw (3 used)
H—Outlet Shut-off Valve

I—Base
J—Coolant Filter
K—Tee Fitting
L—Drain Valve

M—Line
N—Inlet Shut-off Valve
O—Intake Manifold

RG,CTM61,G25,36-19-05MAY93

REMOVE AND INSTALL AIR INTAKE MANIFOLD COOLANT FILTER CONDITIONER ASSEMBLY

Refer to artwork on previous page.



CAUTION: Do not remove coolant filter conditioner until the coolant temperature is below operating temperature. Then loosen drain cock slowly to relieve any excess pressure. Put all coolant in a clean container, and cover to prevent entry of contaminants.

• To Remove Coolant Filter Conditioner Assembly:

1. Close outlet shut-off valve (H) and inlet shut-off valve (N).
2. Remove and discard coolant filter element (J).
3. Remove attaching hardware and remove both inlet and outlet lines.
4. Remove filter base (I).

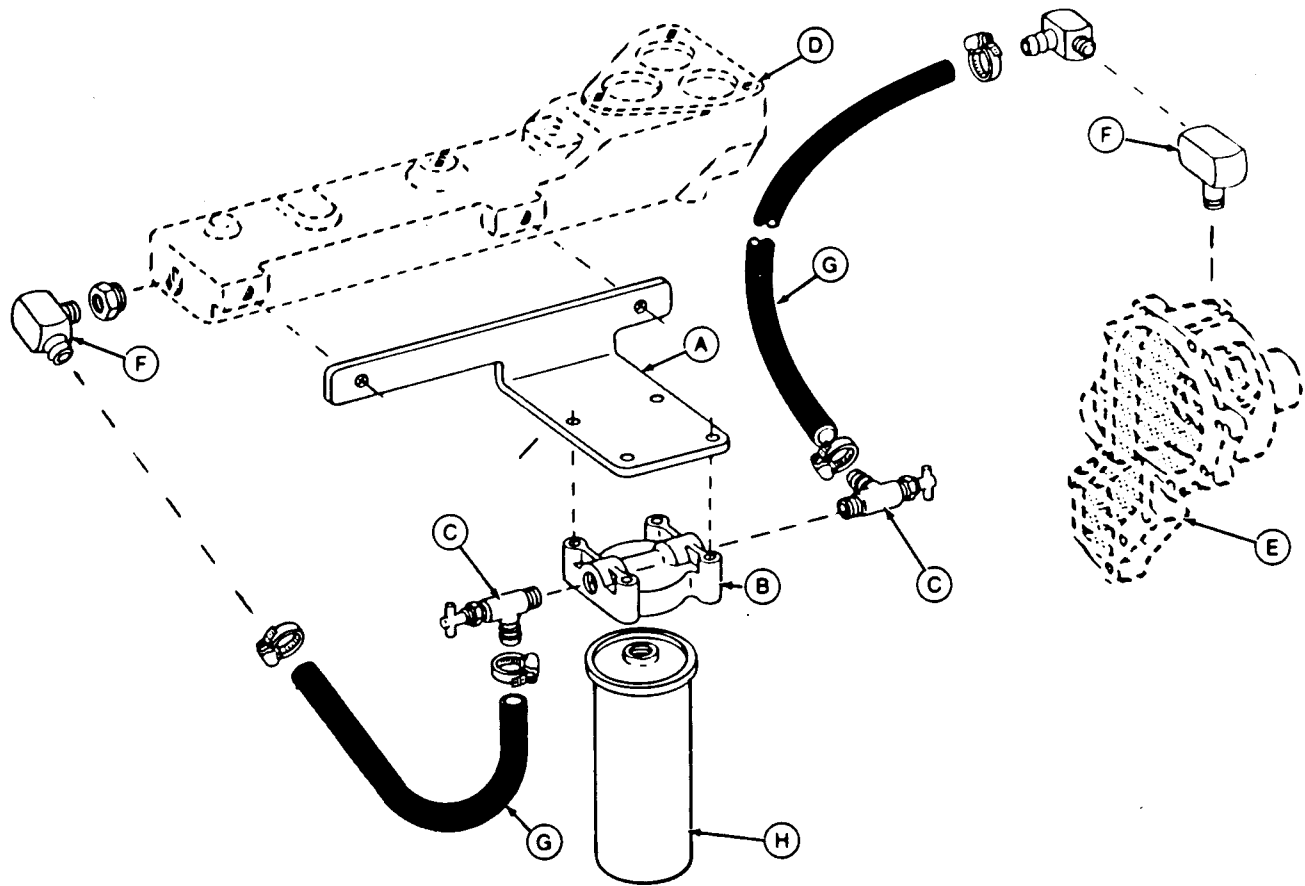
• To Install Coolant Conditioner Filter Assembly:

1. Apply LOCTITE 592 to all fittings before installation.
2. Install filter base (I) to mounting bracket (F). Tighten cap screws to 47 N·m (35 lb-ft).

NOTE: Replace all O-ring packings at coolant line connections.

3. Install inlet shut-off valve (N) and outlet shut-off valve (H).
4. Install mounting bracket. Tighten cap screws to 47 N·m (35 lb-ft).
5. Install inlet and outlet lines. Tighten connections securely.
6. Apply a thin layer of clean oil on new coolant filter element gasket, and install filter (J).
7. Hand-tighten until filter gasket contacts filter base. Tighten filter element another 1/2—3/4 turn. DO NOT overtighten.

WATER MANIFOLD MOUNTED COOLANT FILTER CONDITIONER ASSEMBLY



A—Mounting Bracket
B—Filter Base

C—T-Pipes
D—Water Manifold

E—Water Pump
F—Elbows

G—Inlet and Outlet Hoses
H—Filter Element

RG6672 -UN-17MAR93

25
27

RG,CTM61,G25,39-19-05MAY93

REMOVE AND INSTALL WATER MANIFOLD MOUNTED COOLANT FILTER CONDITIONER ASSEMBLY

Refer to artwork on previous page.



CAUTION: Do not remove coolant filter conditioner until coolant temperature is below operating temperature. Then loosen drain cock slowly to relieve any excess pressure. Put all coolant in a clean container and cover to prevent entry of contaminants.

• To Remove Coolant Conditioner Filter Assembly:

1. Partially drain engine coolant, if not previously done.
2. Remove and discard coolant filter element (H).
3. Remove attaching hardware and remove both inlet and outlet hoses (G).
4. Remove cap screws and washers and remove filter base (B).
5. Remove mounting bracket (A).
6. Clean all coolant filter conditioner component parts using liquid household soap and water. Rinse thoroughly.
7. Dry with compressed air.
8. Inspect filter base and shut-off valves for debris and damage. Replace as necessary.

• To Install Coolant Conditioner Filter Assembly:

1. Attach mounting bracket to water manifold (D). Tighten cap screws to 47 N·m (35 lb-ft).
 2. Install filter base and tighten cap screws to 47 N·m (35 lb-ft).
 3. Apply LOCTITE 592 to threads of T-pipes (C) and elbows (F).
 4. Install elbows and T-pipes. Tighten securely.
- NOTE: Replace all O-ring packings at coolant line connections.*
5. Attach inlet and outlet hoses with hose clamps. Tighten all hose clamps securely.
 6. Apply a thin layer of engine oil on new filter gasket.
 7. Install filter and hand-tighten until gasket contacts filter base. Tighten filter element another 1/2—3/4 turn. DO NOT overtighten.

COMPLETE FINAL ASSEMBLY

1. Fill cooling system to proper level with the proper coolant. (See ENGINE COOLANT RECOMMENDATIONS AND ENGINE COOLANT SPECIFICATIONS in Group 02.)
2. Start engine and run for several minutes to check for leaks in the cooling system.
3. After fan belts cool, check belt tension. (See CHECK AND ADJUST V-BELT TENSION, later in this group.)

S11,2525,CD -19-22APR92

CHECK AND ADJUST V-BELT TENSION



1. Check belt tension and replace belts as required. If adjustment is necessary, use JDG529 Belt Tension Gauge (A) or JDST28 Belt Tension Gauge with straightedge. Follow manufacturer's instructions.

IMPORTANT: Do not check tension or adjust belts when hot.

NOTE: Measure tension on long part of front belt. Replace both belts if either of the pair is to be replaced. The belts must be replaced as a matched set to obtain satisfactory service life.

2. Loosen alternator mounting bolts.

IMPORTANT: DO NOT pry against alternator rear frame as this may damage the alternator housing.

3. Apply outward force to the front frame of the alternator until belt tension is correct.

4. Tighten alternator mounting cap screws securely.

After installing a new belt, run engine for about 10 minutes. Stop engine and check belt tension. If tension is not within new belt specifications, wait 10 minutes, loosen belt and adjust to used belt specifications.

• **JDG529 Gauge Method:**

V-BELT TENSION SPECIFICATIONS

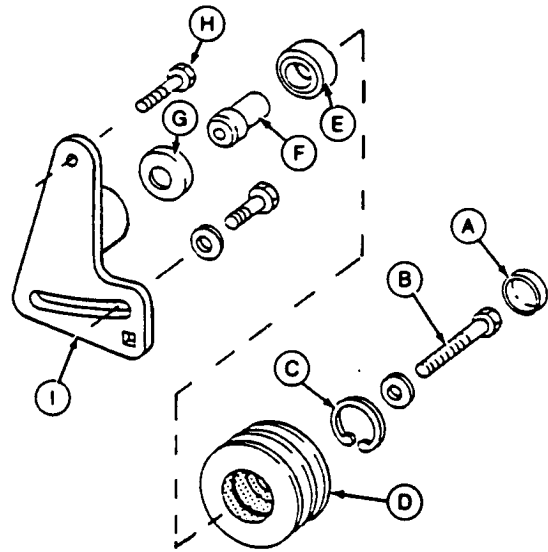
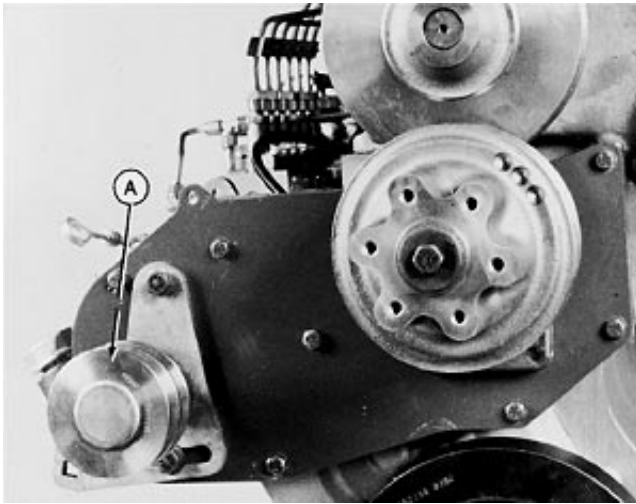
	New Belt	Used Belt*
2-Belt System (Tension front belt only)	423—467 N (95—104 lb)	378—423 N (85—94 lb)

• **JDST28 Belt Tension Gauge/Straightedge Method:**

On new and used standard V-belts, an 89 N (20 lb-force) halfway between the pulleys should deflect the belt 19 mm (3/4 in.).

*Belts are considered used after 10 minutes of operation.

REPLACE FAN BELT TIGHTENER BEARINGS



A—Dust Cap
B—Cap Screw
C—Wear Ring

D—Pulley
E—Ball Bearing

F—Hub
G—Seal

H—Cap Screw (2 used)
I—Bracket

1. Remove and discard dust cap (A) and loosen cap screw (B) with washer to release belt tension. Remove fan belts from idler pulley (D).

2. Loose mounting cap screws (H) and remove belt tightener assembly. Remove cap screw with washer and remove idler pulley from bracket (I).

3. Remove wear ring (C), ball bearing (E), hub (F), and seal (G) from pulley. Inspect bearing and hub for wear or damage. Replace as necessary.

4. Inspect idler pulley for worn or damaged grooves. Replace as necessary.

5. Install bearing into pulley. Be sure bearing bottoms in bore. If necessary, drive bearing to bottom of bore using No. 27515 Disk from D1045AA Disk and Driver Set. Be sure tool contacts OD of bearing race only.

6. Install wear ring making sure ring is fully seated in groove.

7. Position seal in pulley bore so closed side faces out. Tap seal into place using No. 27511 Disk from D01045AA Disk and Driver Set. Seal face should be flush to 0.50 mm (0.020 in.) below pulley face.

8. Apply a thin coat of engine oil to hub and insert small OD of hub through seal and into bearing bore. Support large OD of hub and drive bearing onto hub until bearing inner race contacts shoulder on hub. Drive only on bearing inner race using a tubular driver, such as a short length of 25 mm (1.0 in.) ID pipe.

9. Position pulley assembly on side and install cap screw with washer. Tighten cap screw to 75 N·m (55 lb-ft).

10. Support rear face of pulley and install dust cap to within 2.62—3.38 mm (0.103—0.133 in.) of the idler pulley face, using a flat-faced driver.

IMPORTANT: DO NOT drive cap flush with pulley.

11. Install bracket to plate but do not tighten cap screws.

12. Position belts over pulley. Adjust tension. See CHECK AND ADJUST V-BELT TENSION, earlier in this group. Tighten mounting cap screws to 55 N·m (40 lb-ft).

RG,CTM61,G25,42-19-05MAY93

REMOVE COOLANT HEATER—IF EQUIPPED



CAUTION: DO NOT plug coolant heater into electrical power unless element is completely immersed in water or coolant. Heater element sheath could burst and result in personal injury.

1. Unplug heater from electrical power source.
2. Drain cooling system.
3. Remove electrical cord, loosen nut, and pull heater element out of block.

RG,CTM61,G25,25-19-17MAR92

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.

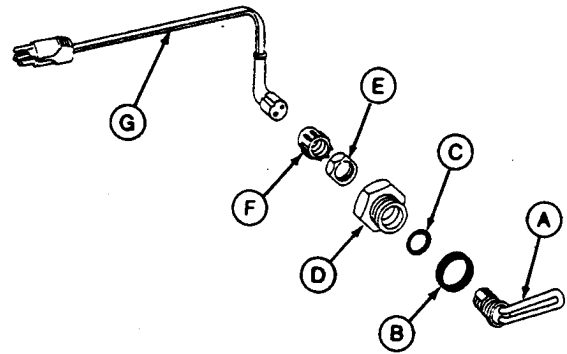
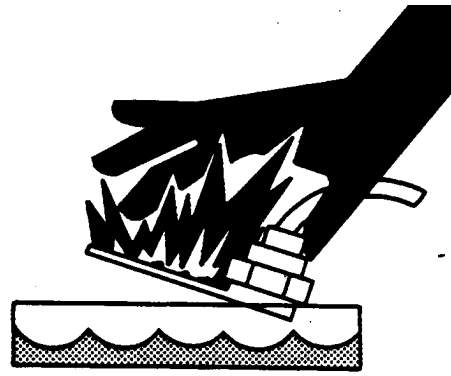
Only plug coolant heater into electrical power if heating element is immersed in coolant. Sheath could burst and result in personal injury.

NOTE: The heater element (A) cannot be repaired. If defective, replace with a new one.

1. Lubricate O-ring (B) with clean engine oil and install onto groove of flange nut (D). Install gasket (C) 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 the upward, vertical position, tighten flange nut to 68 N·m (50 lb-ft) making sure O-ring seals against block.

IMPORTANT: HEATER element must remain in upright vertical 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 vertical. Tighten nut to 34 N·m (25 lb-ft).
5. Install wiring lead (G) or dust cap (F) when wiring lead is not being used.



A—Heating Element
B—O-Ring
C—Gasket
D—Flange Nut Adapter
E—Nut
F—Cap
G—Wiring Lead

-UN-23AUG88

TS210

-UN-14DEC88

RG5275

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33

RG,CTM42,G25,30-19-05MAY93

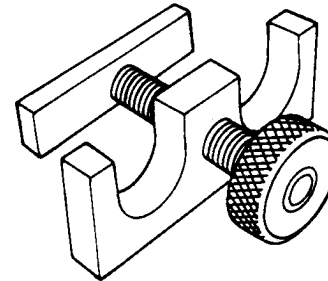
SPECIAL OR ESSENTIAL TOOLS

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

DX,TOOLS -19-05JUN91

Sealing Ring Compression Tool JDG683

Used to compress aftercooler sealing ring for cover-to-intake manifold alignment during assembly.



RG,JDG683 -19-09SEP91

RG5571 -UN-04JUL89

OTHER MATERIAL

Name	Use
PT569 NEVER-SEEZ Compound	T-bolt threads on turbocharger V-band clamps, turbocharger cap screws, aftercooler cover cap screws, and exhaust manifold cap screws.
LOCTITE 592 Pipe Sealant with TEFLON (TY9374/TY9375)	Turbocharger oil supply and drain lines.
LOCTITE 277 Plastic Gasket (T43514)	Coolant conditioner filter adapter.

RG,CTM61,G30,1 -19-16APR93

AIR INTAKE AND EXHAUST SYSTEM SPECIFICATIONS

- SCHWITZER S3A TURBOCHARGER

ITEM	SPECIFICATION
Total Indicator Reading Limits:	
Maximum Radial Bearing Clearance	0.84 mm (0.033 in.)
Bearing Axial End Play	0.081—0.119 mm (0.0032—0.0047 in.)

RG,CTM61,G30,2 -19-16APR93

AIR INTAKE AND EXHAUST SYSTEM SPECIFICATIONS—CONTINUED**TORQUES**

ITEM	SPECIFICATION
Compressor V-Band Clamp Nut	9.5—11 N·m (7—8 lb-ft)
Turbine V-Band Clamp Nut	9.5—11 N·m (7—8 lb-ft)
Turbocharger Mounting Cap Screw	24 N·m (18 lb-ft)
Turbocharger Oil Return Line	27 N·m (20 lb-ft)
Turbocharger Heat Shield-to-Cylinder Head	47 N·m (35 lb-ft)
Exhaust Elbow Mounting Cap Screw	47 N·m (35 lb-ft)
Exhaust Manifold-to-Cylinder Head	95 N·m (70 lb-ft)
Intake Manifold-to-Cylinder Head	75 N·m (55 lb-ft)
Aftercooler Cover-to-Intake Manifold	34 N·m (25 lb-ft)

RG,CTM61,G30,15-19-26APR93

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

S55,3005,E -19-11SEP92

• Lack of Lube Oil

Oil not only lubricates the turbo'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 turbo shaft temperature to increase rapidly.

If oil flow does not increase and the process continues, bearings will fail. Once the bearings fail (which can happen in just seconds) seals, shaft, turbine and compressor wheels can also be damaged.

The principle causes of turbo bearing lubrication problems are low oil pressure, a bent, plugged or undersized oil lube supply line, plugged or restricted oil galleries in the turbo, 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 turbo 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 turbo is through improper start-up and shutdown procedures. Always idle the engine for at least 30 seconds (no load) after start-up and before shutdown. Warming the engine up before applying a load allows oil pressure to build up and lines to fill with oil.

Idling the engine before shutdown allows the engine and turbo to cool. "Hot" shutdowns can cause the turbo to fail because after high-speed operation the turbo 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.

S55,3005,F -19-19AUG92

• Oil Contamination

A second cause of turbo failure 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.

S11,3005,MK -19-19AUG92

• Ingestion of Foreign Objects

The third cause of turbo damage is the ingestion of foreign objects. Foreign objects or particles can be ingested and cause damage to the turbo 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.

S11,3005,ML -19-19AUG92

• Restricted Oil Drainage

A fourth cause of turbocharger damage is restricted lube oil drainage. The lubricating oil carries away heat generated by friction of the bearings and from the hot exhaust gases. If drainage back to the sump is impeded, the bearings will overheat with damage that will ultimately lead to failure.

There are two primary reasons for restricted drainage. A blocked drain tube, due to either damage or a buildup of sludged oil or high crankcase pressure which can be due to restricted crankcase breather or excessive engine blowby.

Periodically check both the turbocharger oil drain tube and engine breather tube for damage or restriction. Correction of these conditions lead to longer turbo life.

RG,CTM8,G30,R1 -19-23FEB93

• Abnormally High Exhaust Temperatures

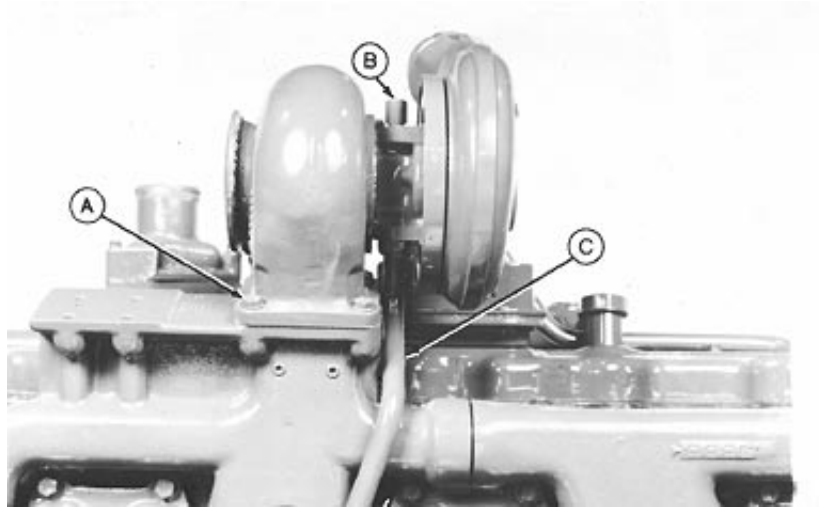
A fifth cause of turbocharger damage is abnormally high exhaust temperatures. Elevated exhaust temperatures cause coking of oil which can lead to bearing failure. Extreme over-temperature operation can cause wheel burst.

There are two basic causes of over-temperature. The first is restricted air flow and the second is overpowering the engine. In either case the engine has more fuel than available air for proper combustion, this overfueled condition leads to elevated exhaust temperatures.

Causes of restricted air flow can include damaged inlet piping, clogged air filters, excessive exhaust restriction, or operation at extreme altitudes. Overpowering generally is due to improper fuel delivery or injection timing. If overtemperature operation has been identified, an inspection of the air inlet and exhaust systems should be performed. Also, check the fuel delivery and timing.

RG,CTM8,G30,R2 -19-19AUG92

REMOVE TURBOCHARGER



RG6151
-UN-12MAR92

CAUTION: Turbocharger may be hot enough to cause serious burns. Allow exhaust system to cool before removing turbocharger from the engine.

Clean exterior of turbocharger to prevent entry of dirt into the air intake system during removal.

IMPORTANT: When cleaning turbocharger, do not spray directly into compressor cover or turbine housing. Spinning rotor with compressed air may damage bearing.

NOTE: 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 oil inlet line (B). Disconnect oil return tube (C).
2. Remove turbocharger mounting cap screws (A). Carefully lift turbocharger from exhaust manifold.
3. Place turbocharger on a clean flat surface.
4. Cap or plug all air intake and exhaust openings.
5. Perform turbocharger seven-step inspection as described later, if failure mode has not yet been determined.

RG,CTM61,G30,10-19-16APR93

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DIAGNOSING TURBOCHARGER MALFUNCTIONS

The following is a guide for diagnosing air intake system malfunctions by inspection of the turbocharger when removed from the engine. Refer to Operation and Tests section of the machine technical manual for diagnosis of air intake system malfunctions BEFORE removal of turbocharger from engine.

Symptom	Problem	Solution
COMPRESSOR HOUSING INLET DEFECTS:		
Foreign Object Damage	Objects left in intake system.	Disassemble and inspect intake system for foreign objects (this group).
	Leaking and/or defective intake system.	Inspect air intake system connections including air filter; repair as required (this group). Inspect air intake related engine components
Compressor Wheel Rub	Bearing failure.	Determine if engine and/or operator contributed to lack of lubrication, contaminated lubrication, excessive temperature, or debris generating engine failure in progress. Correct as required.
	Manufacturing defects.	Correct as required.
COMPRESSOR HOUSING OUTLET DEFECTS:		
Oil and/or Dirt in Housing	Restricted air intake system.	Inspect and clean air cleaner.
	Prolonged periods of low RPM engine idling.	Check with operator to confirm conditions. (See Operators manual.)
	Defective oil seal ring.	Repair as required. (This group.)
	Restricted oil drain line.	Inspect and clear oil drain line as required.
TURBINE HOUSING INLET DEFECTS:		
Oil in Housing	Internal engine failure.	Inspect and repair engine as required.

Continued on next page

Symptom	Problem	Solution
	Oil leaking from compressor housing seal.	Verify that oil is in compressor housing and refer to "Compressor Housing Outlet Defects" as listed earlier in this chart.
Center Wall Deteriorated	Excessive operating temperature.	Check for restricted air intake. Check engine for overfueling. Check injection pump timing.
TURBINE HOUSING OUTLET DEFECTS:		
Turbine Wheel Rub	Bearing Failure.	Determine if engine and/or operator contributed to lack of lubrication, contaminated lubrication, excessive temperature, or debris generating engine failure in progress. Correct as required.
	Manufacturing defect.	Correct as required (this group).
Foreign Object Damage	Internal engine failure.	Inspect and repair engine as required.
	Objects left in intake or exhaust system.	Disassemble and inspect air intake or exhaust system, (this group).
	Leaking air intake system.	Correct as required, (this group).
Oil and/or Excessive Carbon in Housing	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 high RPM. (Operator's Manual).
	Restricted oil drain line.	Inspect and clear oil drain line as required.
EXTERNAL CENTER HOUSING AND JOINT DEFECTS:		
Leaks from Casting	Defective casting.	Replace turbocharger, (this group).

Continued on next page

Symptom	Problem	Solution
Leaks from Joints	Defective gasket.	Verify that leaks are not occurring at gasket joints.
	Loose attaching screws.	Tighten to specifications in CTM, (this group).
	Defective gasket.	Inspect and repair as required.
INTERNAL CENTER HOUSING DEFECTS:		
Excessive Carbon Build up in Housing or on Shaft	Hot engine shut-down.	Review proper operation with operator as shown in Operator's manual.
	Excessive operating temperature.	Restricted air intake; Overfueling or Mistimed engine
	Restricted oil drain line.	Inspect and clean oil drain lines as required.
	Operating engine at high speeds and loads immediately after start-up.	Idle engine for a few minutes to allow oil to reach bearings before applying heavy loads.

RG,CTM42,G30,10-19-24APR92

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 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.
- Turbo 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.

S11,3005,IF -19-16APR93

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 damages.

2. Mark findings on your checklist and continue the inspection.

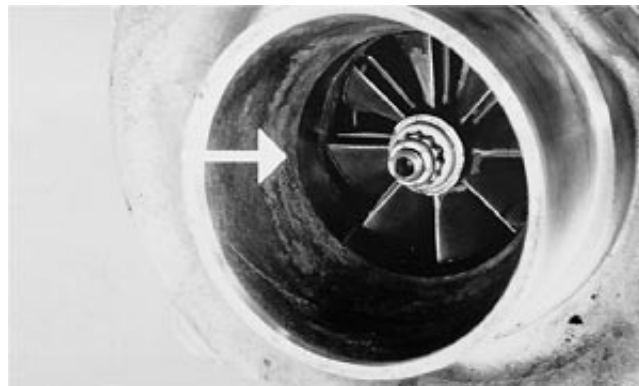


RG4523 -UN-20DEC88

S11,3005,IG -19-07AUG92

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.

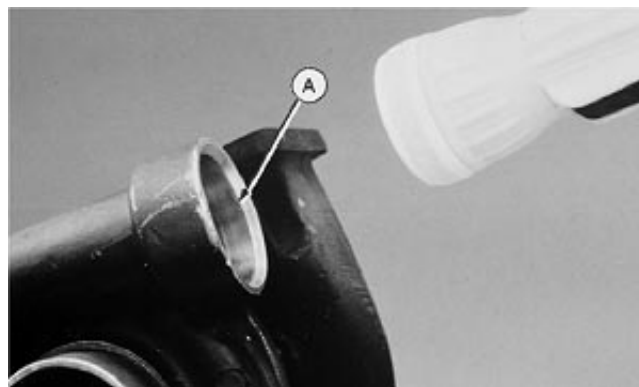


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RG4524 -UN-20DEC88

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.



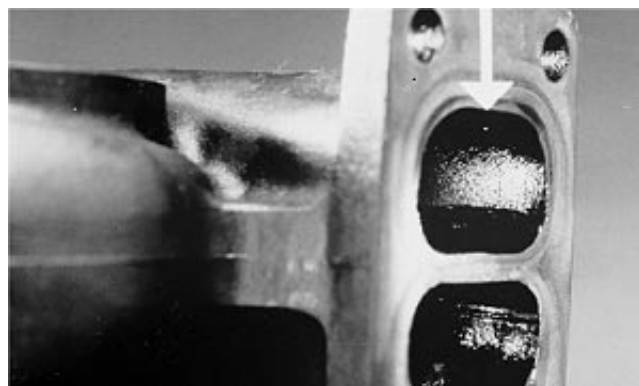
S11,3005,II -19-07AUG92

RG4525 -UN-20DEC88

Turbine Housing Inlet

1. 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.

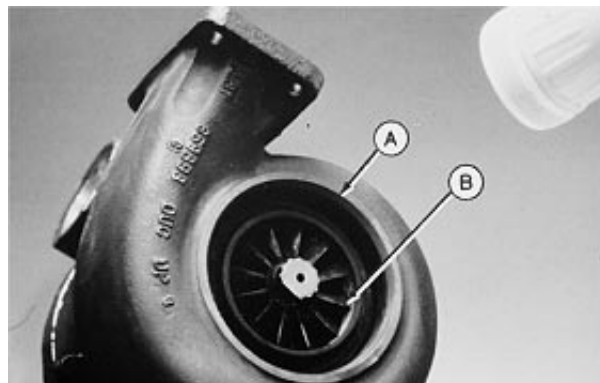


S11,3005,IJ -19-11SEP92

RG4526 -UN-20DEC88

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.



S11,3005,IK -19-11SEP92

RG4527 -UN-20DEC88

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.



S11,3005,IL -19-11SEP92

External Center Housing and Joints

1. Visually check the outside of the center housing, all connections to the compressor, and turbine housing for oil.

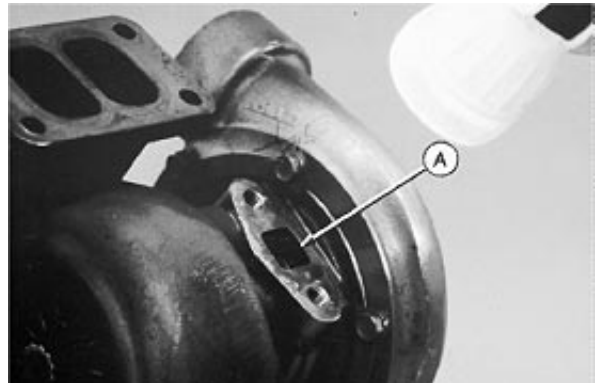
NOTE: If oil is present, make sure it is not coming from a leak at the oil supply or return line.



S11,3005,IM -19-07AUG92

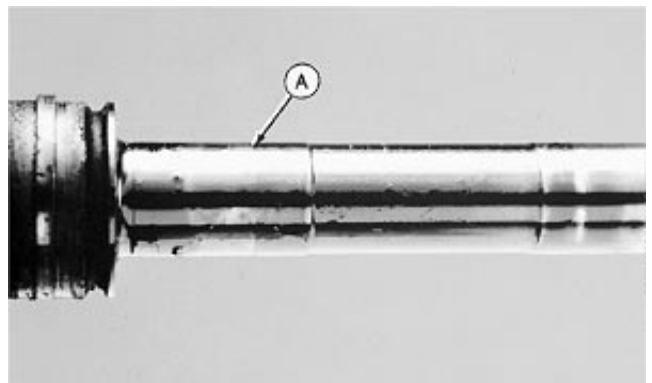
Internal Center Housing

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.



S11,3005,IN -19-07AUG92

2. Excessive "blueing" or "coking" of oil along the complete length of the shaft (A) indicates a possible lack of lubrication caused by an engine failure, or improper operation, such as hot shutdowns.



S11,3005,IO -19-07AUG92

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.

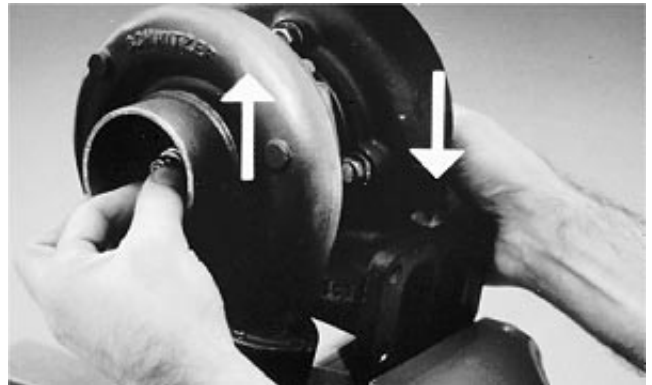


S11,3005,IP -19-29APR93

RG4532 -UN-20DEC88

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.



S11,3005,IQ -19-07AUG92

RG4533 -UN-20DEC88

4. Next, check shaft endplay by moving the shaft back and forth while rotating. There will be some endplay but not to the extent that the wheels contact the housings.



S11,3005,IR -19-07AUG92

RG4534 -UN-20DEC88

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 **DIAGNOSING TURBOCHARGER MALFUNCTIONS**, 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.

IMPORTANT: Before you finalize your conclusion that the turbocharger has not failed, it is strongly recommended that the following procedures of checking radial bearing clearance and axial bearing endplay with a dial indicator be performed. These procedures are not required if a failure mode has already been identified.

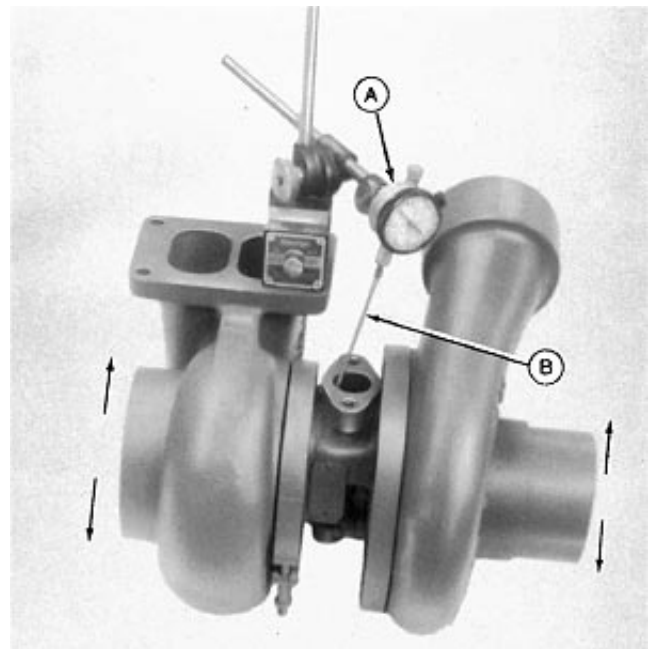
S11,3005,IS -19-07AUG92

PERFORM RADIAL BEARING CLEARANCE TEST

This test will give an indication of the condition of the radial bearings within the center housing and rotating assembly.

1. Fasten a magnetic base (plunger-type) dial indicator (A) to turbocharger mounting base. Assemble an extension adapter and a 51 mm (2.0 in.) indicator extension rod (B) onto dial indicator.
2. Position indicator tip (thru center housing oil return) on center of shaft. Preload indicator tip and zero dial on indicator.
3. Grasp rotating shaft at both ends and move the shaft toward the indicator then away from the indicator (arrows). Use care to move the shaft in the same direction as the dial indicator tip travels and apply equal pressure at both ends of the shaft.
4. Observe and record the total dial indicator reading. Maximum acceptable bearing clearance is 0.84 mm (0.033 in.).

If clearance exceeds specification given above replace center housing and rotating assembly. (See **REPLACE CENTER HOUSING AND ROTATING ASSEMBLY**, later in this group.)



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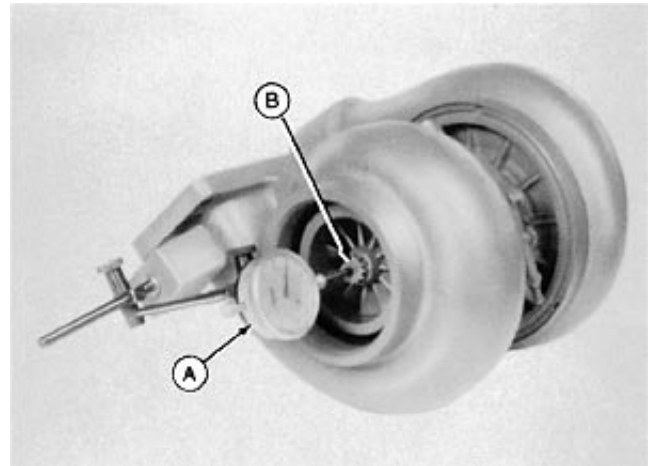
RG,CTM61,G30,11-19-24APR92

PERFORM AXIAL END PLAY BEARING TEST

This test will give an indication of the condition of thrust bearing within the center housing and rotating assembly.

1. Mount magnetic base dial indicator (A) so that indicator tip (B) rests on end of shaft. Preload indicates tip and zero dial on indicator.
2. Move shaft axially back and forth by hand.
3. Observe and record total dial indicator reading. Bearing end play specification is 0.081—0.119 mm (0.0032—0.0047 in.).

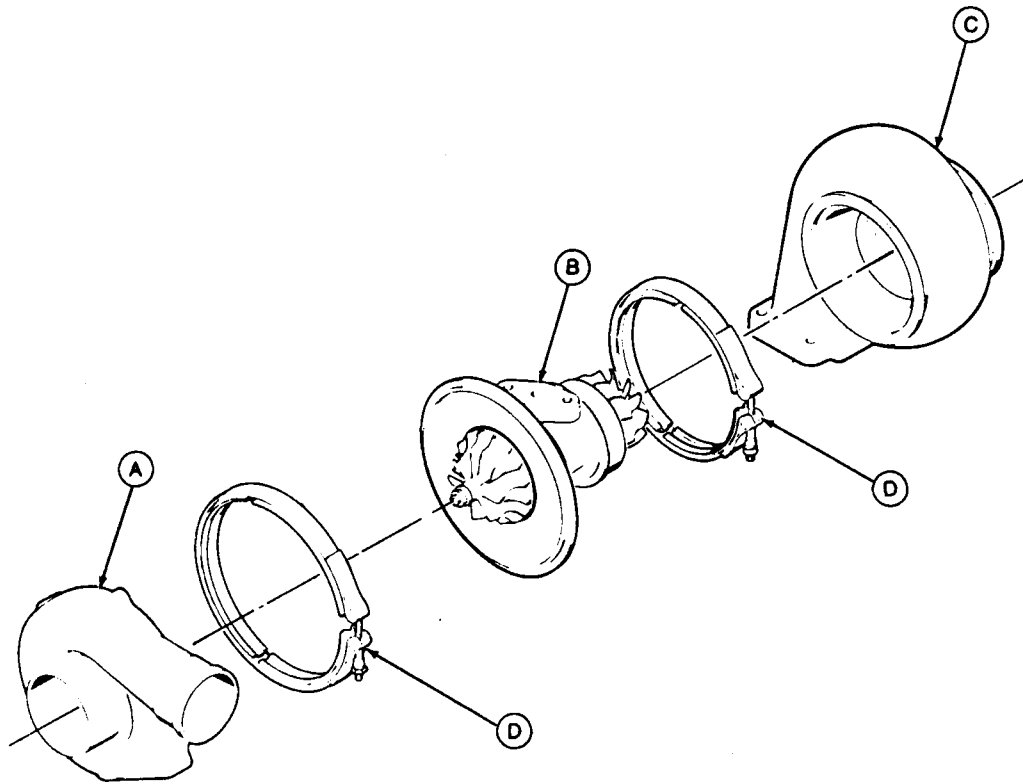
If bearing end play is not within specification, replace center housing and rotating assembly as outlined later in this group.



R24641 -UN-09FEB90

RG,CTM61,G30,12-19-24APR92

DISASSEMBLE AND INSPECT TURBOCHARGER



-UN-04JUL89

RG5553

A—Compressor Housing

B—Center Housing and
Rotating Assembly

C—Turbine Housing

D—V-Band Clamps (2 used)

RG,CTM61,G30,13-19-24APR92

IMPORTANT: Use a scribe to mark index positions of the compressor, center and turbine housings prior to disassembly. These reference marks are essential for proper indexing of turbine and compressor housings, when turbocharger is reassembled.

1. Loosen V-band clamp nut (A) on both clamps. Remove locknut if necessary.

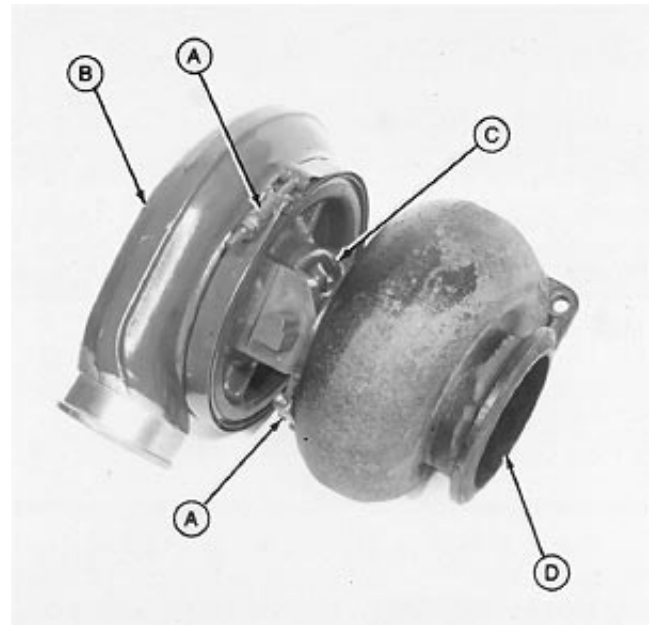
NOTE: DO NOT press on rotating assembly and carefully remove housings to eliminate any further component damage.

2. Remove the compressor housing (B) and turbine housing (D) from center housing and rotating assembly (C).

3. Thoroughly clean compressor and turbine housings using a commercially approved solvent only. A caustic solution may damage housings. Dry housings with compressed air.

4. Inspect the compressor and turbine housings for:
 - Wheel rub damage within the contour area that cannot be polished out with 80-grit (60-grit for turbine housing) silicon carbide abrasive cloth.
 - Nicks, dents or warpage that could prevent proper sealing between the turbine/compressor housing and center housing.

Replace either housing if either of the above defects are found.



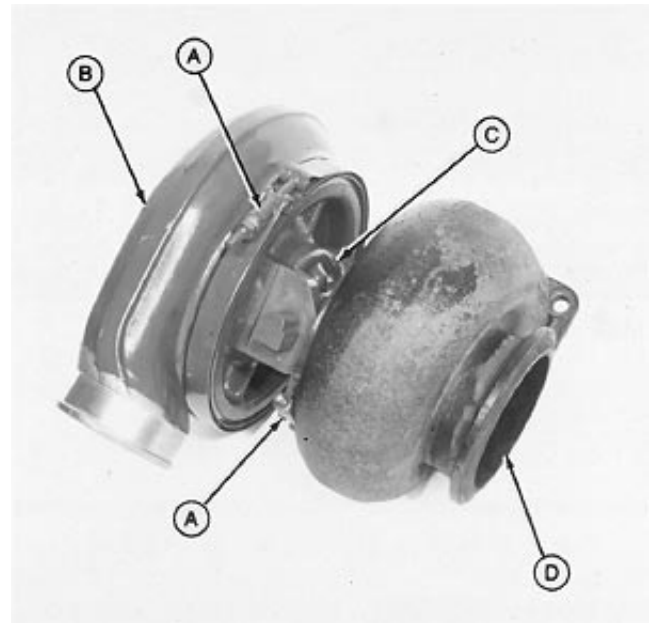
A—V-Band Clamp (2 used)
B—Compressor Housing
C—Center Housing and Rotating Assembly
D—Turbine Housing

RG5569 -UN-05JAN90

S55,3005,AY -19-16APR93

REPLACE CENTER HOUSING AND ROTATING ASSEMBLY

1. Carefully transfer the scribed marks from the original center housing (C) to the replacement assembly, if necessary. Use the same procedure for compressor (B) and turbine (D) housings if they are being replaced.
2. Install both V-band clamps (A) loosely on center housing. Align the turbine and center housing scribed marks and position the V-band clamp.
3. Coat T-bolt threads on V-band clamps with PT569 NEVER-SEEZ and tighten clamp nut to 9.5—11 N·m (7—8 lb-ft).
4. Follow the same above procedure and install the compressor housing. Tighten V-band clamp nut to 9.5—11 N·m (7—8 lb-ft).
5. After assembly, prelube center housing and check the center housing and rotating assembly for binding or wheel rub. If either condition exists, disassemble turbocharger and correct the cause.



A—V-Band Clamp (2 used)
B—Compressor Housing
C—Center Housing and Rotating Assembly
D—Turbine Housing

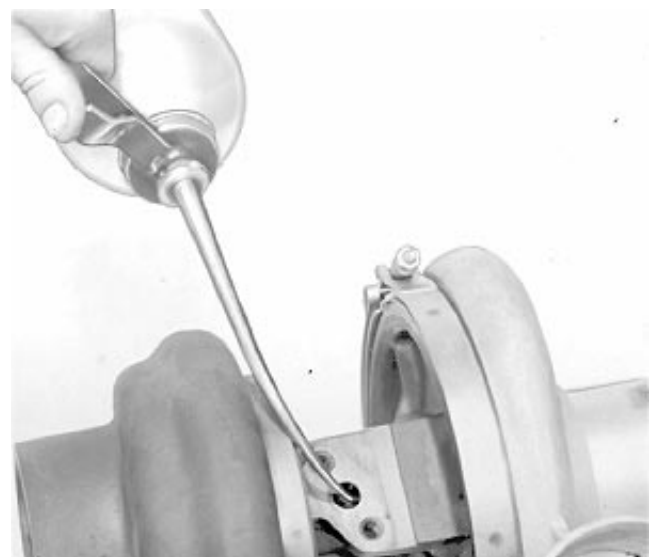
RG,CTM61,G30,14-19-16APR93

PRELUBE TURBOCHARGER

IMPORTANT: DO NOT spin the rotor assembly with compressed air. Damage to bearings can occur when using compressed air.

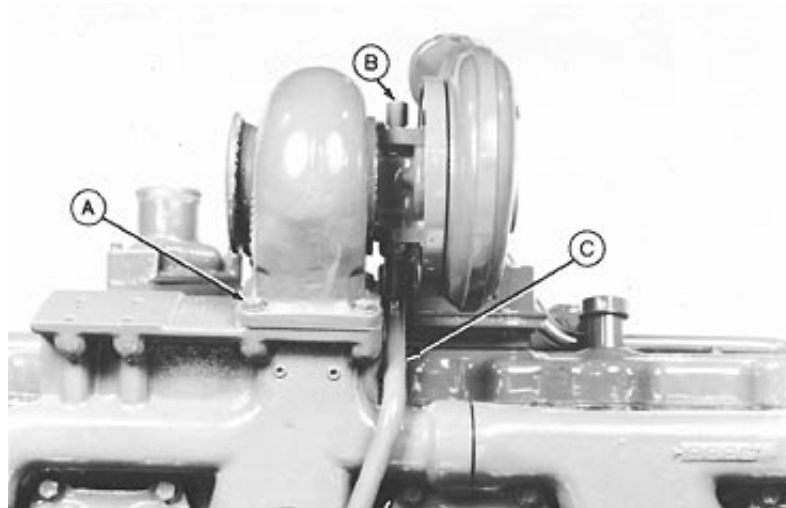
Fill oil inlet or drain port with clean engine oil and spin rotating assembly by hand to properly lubricate bearings.

If turbocharger is to be stored for an extended period of time, lubricate internally and install protective covers on all openings.



S55,3005,BA -19-17MAR92

INSTALL TURBOCHARGER



RG6151
-UN-12MAR92

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.

Just prior to mounting the turbocharger, prime the turbocharger lubrication system. Fill the center housing with clean engine oil through the oil drain hole. Turn the rotating assembly by hand to lubricate the bearings and thrust washer.

Inspect the air cleaner-to-turbocharger air intake hose to see that it is in good condition. Replace hose if it is hardened, cracked, or shows any sign of deterioration.

1. Mount turbocharger on engine.

NOTE: Guide studs may be used to position exhaust gasket during turbocharger installation.

2. Apply PT569 NEVER-SEEZ or equivalent to all turbocharger mounting cap screws (A). Install cap screws with washers and tighten to 24 N·m (18 lb-ft).

NOTE: Remove all caps or plugs from turbocharger openings.

3. Using a new gasket, install oil return tube (C). Tighten cap screws securely. Connect oil inlet line (B) and tighten securely.

4. Refer to your machine technical manual for details on all air intake hose connections.

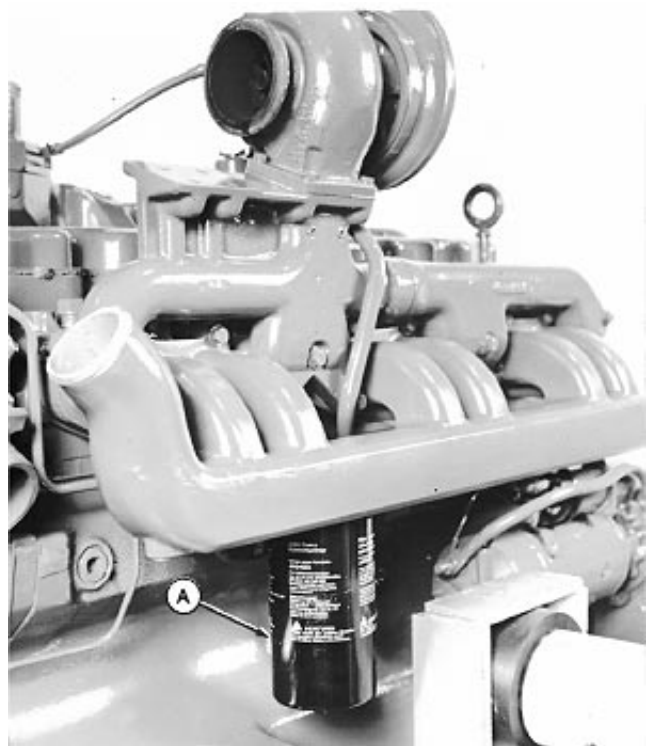
5. Inspect the air cleaner-to-turbocharger hoses to see that they are in good condition. If they are not, replace as needed. Install air intake hose and tighten hose clamps securely.

IMPORTANT: BEFORE STARTING an engine with a new or repaired turbocharger, crank the engine over (but do not start) for several seconds to allow engine oil to reach turbocharger bearings.

6. Start and run engine at low idle while checking oil inlet and air passage connections for leaks.

REMOVE AND INSTALL INTAKE MANIFOLD (6101H ENGINES)

1. Close coolant filter inlet and outlet valves and remove coolant filter conditioner element (A).
2. Disconnect coolant inlet and outlet lines from intake manifold.



RG6061 -UN-21JAN92

RG,CTM61,G30,6 -19-16APR93

3. Refer to your machine technical manual and disconnect air intake piping at intake manifold (A).
4. Disconnect aneroid-to-intake manifold line.
5. Remove cap screws and remove intake manifold.
6. Check intake manifold for damage. Scrape all gasket material from cylinder block and intake manifold. See INSPECT AND REPAIR INTAKE MANIFOLD, later in this group.



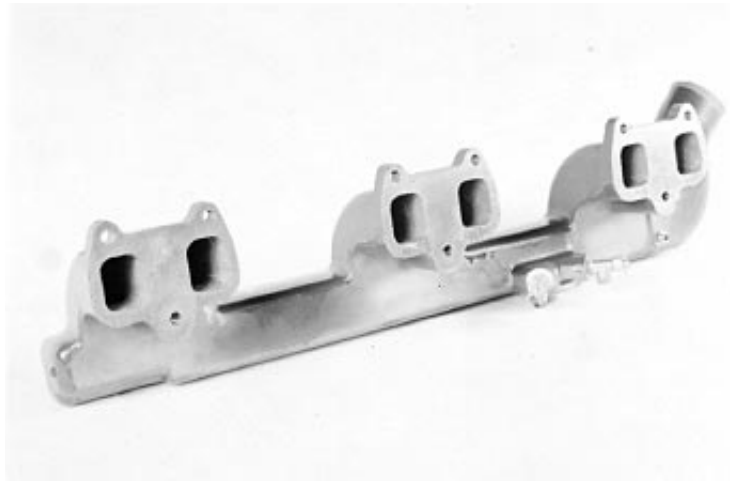
RG6070 -UN-17JAN92

IMPORTANT: Make sure intake manifold is clean and debris-free before assembly.

7. To install intake manifold, reverse removal procedure and use new gaskets.
8. Tighten intake manifold cap screws to 75 N·m (55 lb-ft).

RG,CTM61,G30,7 -19-16APR93

INSPECT AND REPAIR INTAKE MANIFOLD—6101H ENGINES



-UN-24FEB92

RG6153

IMPORTANT: Do not use a hot tank to clean aluminum parts as damage and severe deterioration can occur.

1. Thoroughly clean and inspect interior and exterior of manifold.

2. On engines where the coolant conditioner filter is an integral part of the intake manifold, inspect coolant conditioner filter adapter for thread damage. If adapter needs replacing, remove old adapter, clean threads in intake manifold, and apply LOCTITE 277 Plastic Gasket to threads of new adapter and tighten securely.

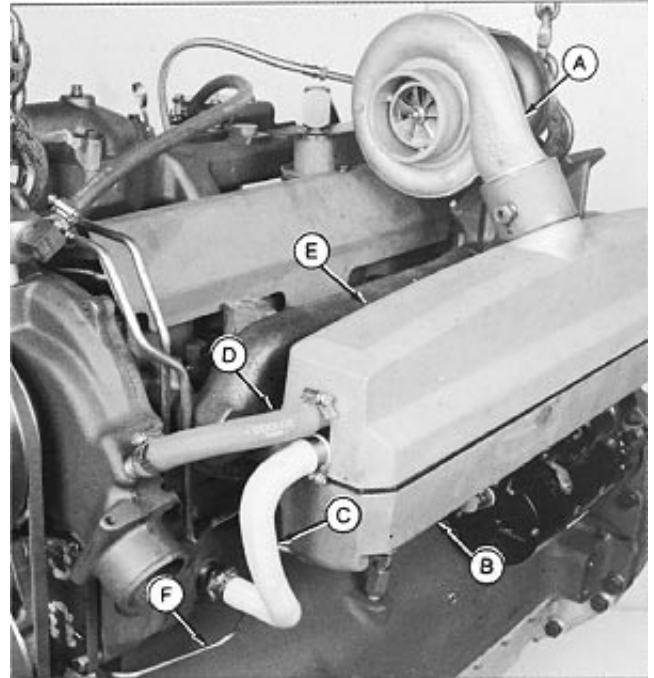
RG,CTM61,G30,5 -19-21APR93

REMOVE AFTERCOOLER ASSEMBLY AND INTAKE MANIFOLD (6101A 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 engine coolant.
2. Thoroughly clean exterior of turbocharger (A), intake manifold, (B), and adjacent areas to prevent entry of dirt into the engine when parts are removed.
3. Remove turbocharger as described earlier in this group.
4. Remove coolant inlet hose (C) and outlet hose (D) from aftercooler ends.
5. Remove aftercooler cover (E) with aftercooler from intake manifold. Remove aftercooler from cover and discard both gaskets and sealing ring.
6. Remove aneroid-to-intake manifold line (F) and ether starting aid pipe, if equipped, from intake manifold.
7. Remove intake manifold along with coolant conditioner filter mounting bracket, if equipped.

NOTE: On some applications, the coolant conditioner filter may be mounted to the water manifold or an integral part of manifold.



A—Turbocharger
B—Intake Manifold
C—Inlet Hose
D—Outlet Hose
E—Aftercooler Cover
F—Aneroid-to-Intake Manifold Line

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RG6697 -UN-19MAR93

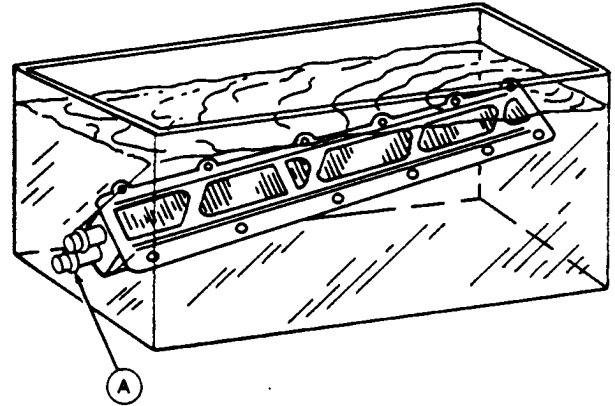
INSPECT AND REPAIR AFTERCOOLER (6101A ENGINES)

1. Inspect aftercooler for overall condition. The fins should be reasonably straight, and cross straps should be free of cracks.
2. Inspect aftercooler inlet and outlet hoses. Replace either hose if cracked or damaged.
3. Test the aftercooler for leaks by plugging one of the tubes (A).
4. Apply compressed air to the other tube while unit is submerged under water. Use 140—170 kPa (1.4—1.7 bar) (20—25 psi) air pressure for testing.

A minor leak that is accessible may be repaired. However, if the condition of the core is questionable, replace aftercooler.

IMPORTANT: Coolant leakage from the aftercooler may cause severe engine damage.

5. Inspect air intake cover for cracks or damage. Replace as necessary.
6. Clean cover with clean solvent and dry with compressed air.

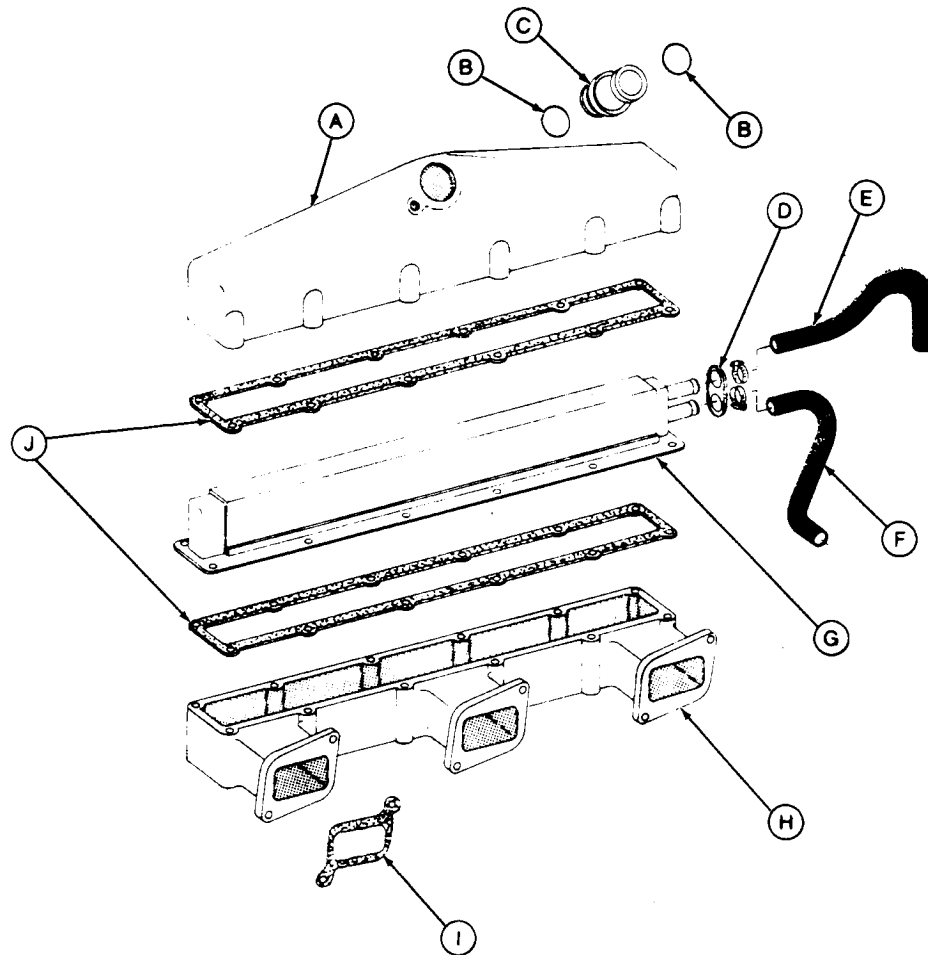


-UN-04JUL89

RG5572

RG,CTM61,G30,17-19-16APR93

INSTALL INTAKE MANIFOLD AND AFTERCOOLER ASSEMBLY (6101A ENGINES)



RG5556
-UN-04JUL89

A—Aftercooler Cover
B—O-Ring (2 Used)
C—Adapter (Coupling)

D—Sealing Ring
E—Outlet Hose
F—Inlet Hose

G—Aftercooler
H—Intake Manifold

I—Gasket (3 Used)
J—Gasket (2 Used)

1. Install coolant conditioner filter mounting bracket (not shown) as intake manifold is being installed. On some engines, the coolant conditioner filter is mounted on the water manifold.

2. Using new gaskets (I), install intake manifold (H) and tighten cap screws with washers to 75 N·m (55 lb-ft).

3. Using new gaskets (J) and a new sealing ring (D), install aftercooler (G) with cover (A) into intake manifold.

IMPORTANT: Make sure sealing ring is properly positioned in intake manifold and not crimped.

4. Compress sealing ring with JDG683 Compression Tool to align mounting holes in aftercooler, gaskets, cover, and intake manifold. See **INSTALL AFTERCOOLER COVER**, later in this group.

5. Apply PT569 NEVER-SEEZ to cap screws and tighten to 34 N·m (25 lb-ft).

6. Install coolant inlet (F) and outlet (E) hoses. Tighten clamps securely.

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7. Install aneroid-to-intake manifold pipe.

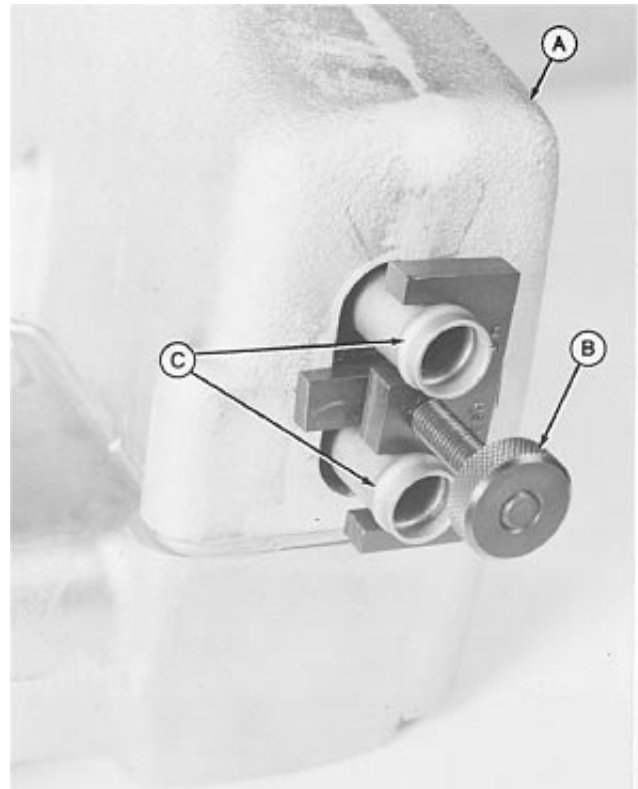
IMPORTANT: All intake manifold and aftercooler connections at the turbocharger and cylinder head must be tight to prevent loss of power resulting in low manifold pressure.

8. Install turbocharger as described earlier in this group.

RG,CTM61,G30,23-19-16APR93

INSTALL AFTERCOOLER COVER (6101A ENGINES)

1. Position gaskets and aftercooler (with new sealing ring) onto intake manifold and install aftercooler cover (A) as detailed in earlier module. See INSTALL INTAKE MANIFOLD AND AFTERCOOLER ASSEMBLY (6101A ENGINES).
2. Install JDG683 Sealing Ring Compression Tool (B) onto aftercooler ends (C) with crossbar across slot as shown.
3. While pulling on aftercooler end, crossbar will push on aftercooler cover (as tool is tightened).
4. When cover, aftercooler, gaskets, and intake manifold are aligned, apply PT569 NEVER-SEEZ to cap screws and tighten to 34 N·m (25 lb-ft).

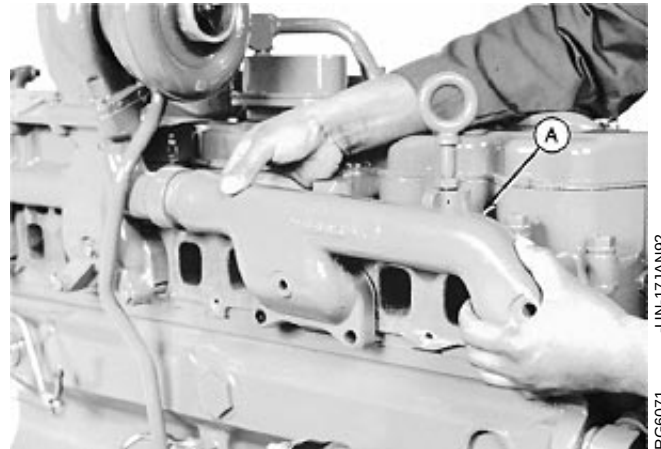


RG5570 -UN-09JAN90

RG,CTM61,G30,19-19-16APR93

REMOVE, INSPECT, AND INSTALL EXHAUST MANIFOLD ASSEMBLY

1. Refer to your machine technical manual to disconnect air intake piping at intake manifold and remove manifold as described earlier in this group.
2. Remove rear exhaust manifold (A) and front exhaust manifold.



RG6071
-UN-17JAN92

RG,CTM61,G30,8 -19-16APR93

3. Remove and discard sealing ring (A).
4. Scrape all gasket material from cylinder head and exhaust manifolds. Check exhaust manifolds for damage or cracks.
5. Inspect machined mounting surfaces and front-to-rear mating surfaces for burrs or other defects which might prevent gaskets from sealing properly. Repair or replace as required.
6. To install exhaust manifolds, install new sealing ring in groove on front end of rear exhaust manifold section.

NOTE: Apply PT569 NEVER-SEEZ compound or its equivalent to all exhaust manifold cap screws.

7. Install front exhaust manifold using new gaskets. Install, but do not tighten cap screws.
8. Install rear exhaust manifold using new gaskets. Sealing ring should be in place at this time.
9. Tighten exhaust manifold-to-cylinder head cap screws to 95 N·m (70 lb-ft).
10. Refer to appropriate groups to complete final assembly of components removed.



RG6075
-UN-21JAN92

RG,CTM61,G30,9 -19-16APR93

SPECIAL OR ESSENTIAL TOOLS

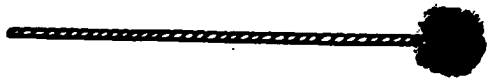
NOTE: Order tools according to information given in the
U.S. SERVICE-GARD™ Catalog or in the
European Microfiche Tool Catalog (MTC).

DX,TOOLS -19-05JUN91

Nozzle Thread Cleaning Brush D17030BR

Used to clean nozzle threads in cylinder head.

RG5099 -UN-23AUG88



S53,D17030,BR -19-16FEB87

Flywheel Turning Tool JDE81-1

Rotate engine flywheel. Use with JDE81-4.

RG4950 -UN-23AUG88

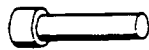


S53,JDE811 -19-07JUL89

Timing Pin JDE81-4

Lock engine at TDC when timing valve train. Use with
JDE81-1.

RG5068 -UN-23AUG88

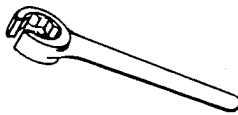


S55,JDE814,B -19-24FEB88

Serrated Wrench JDE90

Use to hold injection pump fuel outlet fittings from turning
when loosening and tightening fuel pipe connections.

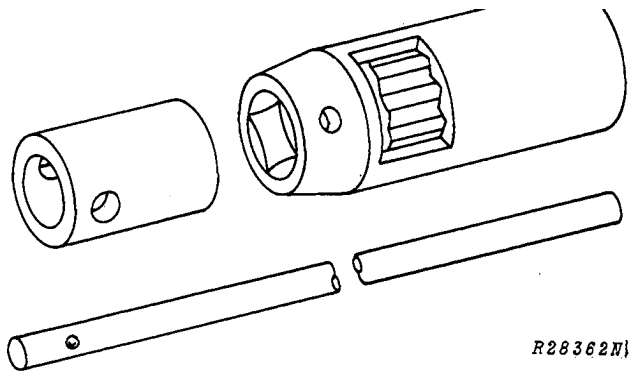
RG5290 -UN-15OCT92



S53,JDE90 -19-13MAY93

Nozzle Socket JDE92

Used to remove and install 21 mm injection nozzles.



-UN-20DEC88
R28362N

S11,3010,OU -19-09SEP91

Tap JDF5

Used to restore nozzle threads in cylinder head.

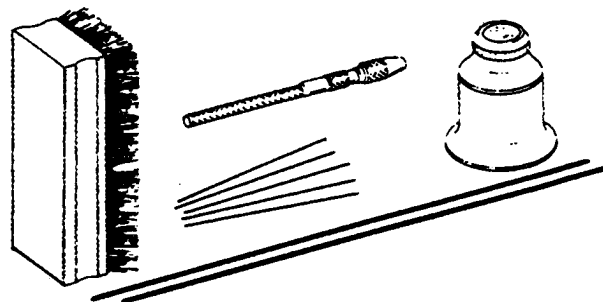
RG5100 -UN-23AUG88



S53,JDF5 -19-16FEB87

Nozzle Cleaning Kit JDF13 (JDE105)

Used to clean injection nozzles.



S11,3010,OW -19-09SEP91

RG4953 -UN-14DEC88

3/4 in. Special Crowsfoot Wrench JDF22

Tighten injection lines at pump and nozzles.



S53,JDF22 -19-10JUL89

RG5154 -UN-23AUG88

Nozzle Seat Reamer JDG609

Used to clean carbon from nozzle seats in cylinder head.



S53,JDG609 -19-02DEC87

RG5289 -UN-23AUG88

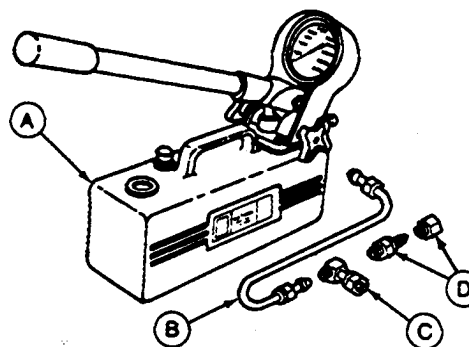
A—Fuel Injection Nozzle Tester . . . D01109AA (Y900)

B—Fuel Line Assembly Y900-2A*

C—Adapter Nut Y900-21**

D—Straight Adapters Y900-7* and Y900-15*

Used to test operational performance and opening pressure of nozzles.



S11,3010,OX -19-09SEP91

RG4954 -UN-14DEC88

*Included in D01110AA (Y910A) Adapter Set.

**May be used instead of Y900-7 and Y900-15.

OTHER MATERIAL

Name	Use
PT569 NEVER-SEEZ Compound	Gland nut threads and fuel injection nozzle barrel.
LOCTITE 242 Thread Lock and Sealer (TY9370/T43512)	Injection pump timing hole plug.
LOCTITE 592 Pipe Sealant with TEFLON (TY9374/TY9375)	Fuel filter drain plug and bleed plug.

S55,3010,BB -19-05APR93

FUEL SYSTEM SPECIFICATIONS

ITEM	SPECIFICATION
Engine Speeds	See applicable Machine TM
Fuel Injection Pump Timing-to-Engine	TDC
Overflow Valve Opening Pressure	130—180 kPa (1.3—1.8 bar) (19—26 psi)
Hydraulic Aneroid Activator Opening Pressure	100 kPa (1.0 bar) (14.5 psi)
Fuel Supply Pump Minimum Operating Pressure	200 kPa (2.0 bar) 29.0 psi)
Fuel Shut-Off Solenoid Adjustment Gap	0.25—0.51 mm (0.01—0.02 in.)
Fuel Injection Nozzles:	
Model	KDEL—21 mm
Nozzle Tip Size	7 x 0.230 mm and 7 x 0.255 mm
New Nozzle Opening Pressure	29000 kPa (290 bar) (4200 psi)
Used Nozzle Minimum Opening Pressure	26200 kPa (262 bar) (3800 psi)

RG,CTM61,G35,1 -19-05APR93

FUEL SYSTEM SPECIFICATIONS—CONTINUED

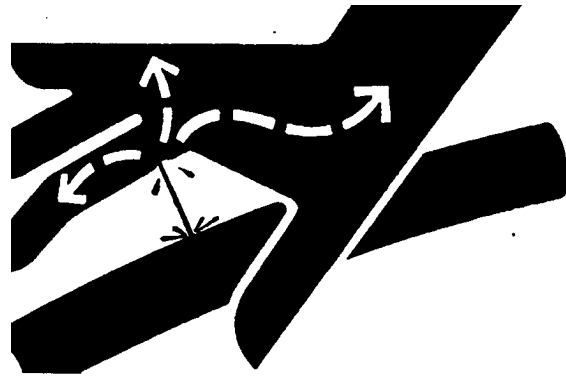
TORQUES

Injection Pump Drive Hub Hex Nut	100—110 N·m (74—81 lb-ft)
Injection Pump Oil Fill Plug	25 N·m (18 lb-ft)
Aneroid Activator Special Screw	14 N·m (10 lb-ft)
Fuel Line Connections at Filter Base	17—20 N·m (12—15 lb-ft)
Rectangular Fuel Filter Base Mounting	34—54 N·m (25—40 lb-ft)
Primary Fuel Filter/Water Separator Mounting	34 N·m (25 lb-ft)
Supply Pump-to-Injection Pump	5—8 N·m (4—6 lb-ft)
Injection Pump-to-Cylinder Block	47 N·m (35 lb-ft)
Injection Pump Drive Gear-to-Drive Hub	61 N·m (45 lb-ft)
Injection Pump Drive Gear Cover-to-Timing Gear Cover:	
6101HRW10 and 6101HRW11 Applications	68 N·m (50 lb-ft)
All Other Applications	41 N·m (30 lb-ft)
Fuel Delivery Line Nuts (at nozzles and delivery valves)	27 N·m (20 lb-ft)
Injection Nozzle Gland Nut	75—88 N·m (55—65 lb-ft)
Injection Nozzle Retaining Nut	88 N·m (65 lb-ft)
Leak-Off Connectors	Tighten Securely
Fuel Shut-off Solenoid Bracket-to-Cylinder Head	47 N·m (35 lb-ft)
Fuel Shut-off Solenoid-to-Bracket Hex Nuts	8 N·m (6 lb-ft)

RG,CTM61,G35,39-19-13MAY93

RELIEVE SYSTEM PRESSURE

CAUTION: 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.

S11,3010,OZ -19-10MAY93

-UN-23AUG88
X9811

REPLACE RECTANGULAR FINAL FUEL FILTER

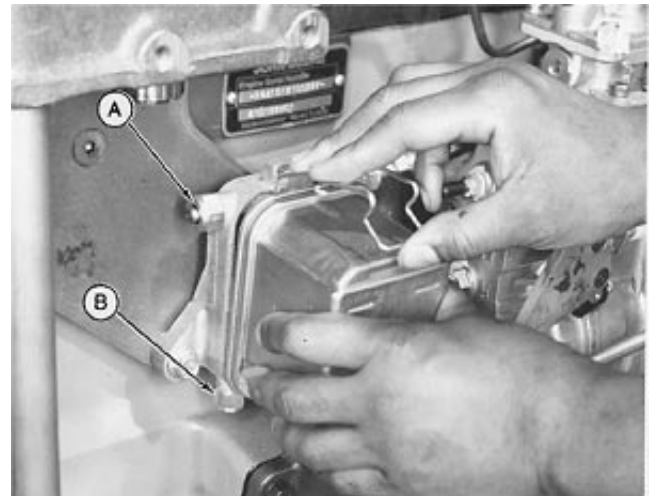
Full flow oil filter shown removed for photographic purposes.

NOTE: Refer to your operator's manual for proper servicing and (hourly) replacement intervals.

1. Close fuel shut-off valve at bottom of fuel tank, if equipped.
2. Loosen bleed plug (A) and remove drain plug (B) to drain fuel from filter. Remove and discard packing from drain plug.

NOTE: Keep a small container under drain plug to catch draining fuel.

3. With fuel filter held firm against base, lift up on top retaining spring and pull down on bottom retaining spring. Pull fuel filter off guide pins of fuel filter base. Discard filter.



-UN-10NOV89
RG5543

S55,3010,CB -19-05APR93

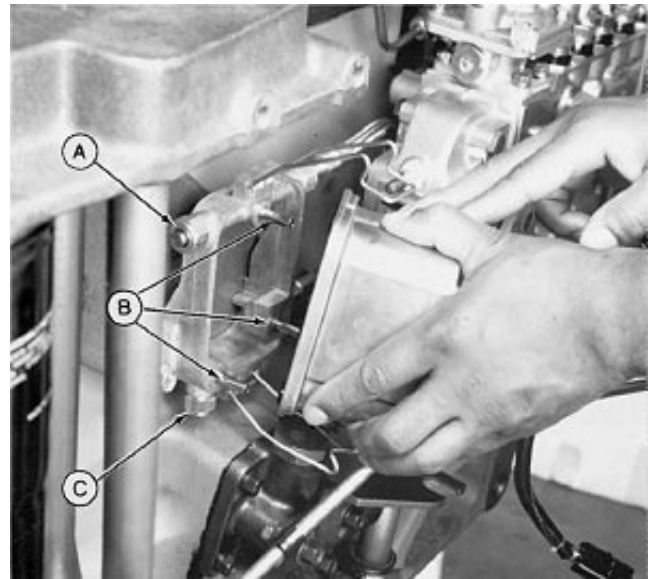
4. Install new fuel filter onto guide pins (B) of fuel filter base. Hold filter firmly against base.

NOTE: Secure retaining spring by pushing on center (at highest point) until spring seats in groove.

5. Secure bottom retaining spring first, then top spring.

6. Install drain plug (C) using new packing, shown installed. Tighten bleed plug (A) and drain plug securely. Do not overtighten.

7. Open fuel shut-off valve and bleed the fuel system as described in Group 115.



RG5544 -UN-10NOV89

S55,3010,CC -19-05APR93

REPLACE FUEL CHECK VALVE ASSEMBLY

IMPORTANT: Remove fuel check valve only for replacement purposes, since O-ring seals tightly in bore, removal usually damages check valve assembly.

1. Drain and remove fuel filter (shown removed) as described earlier in this group.

2. Remove filter base fuel inlet line (A). Remove and discard packing.

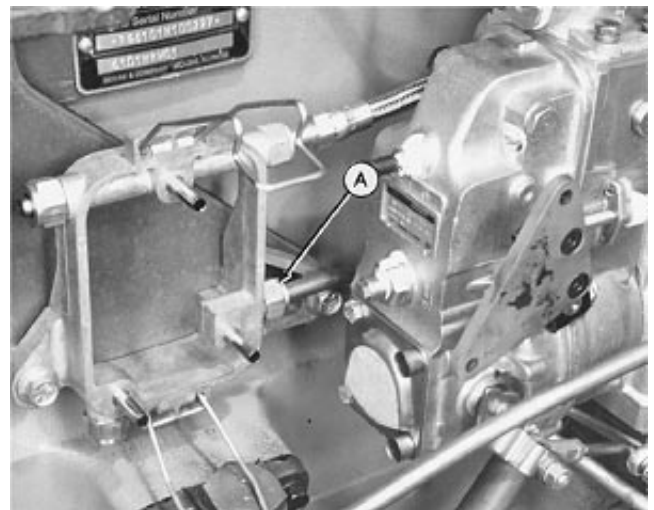
3. Remove check valve and discard.

4. Inspect and clean fuel filter base.

5. Lubricate new check valve assembly with clean diesel fuel and install. The end with O-rings must enter bore in filter base first.

6. Install filter base fuel inlet line using new packing and tighten connection 17—20 N·m (12—15 lb-ft). DO NOT overtighten.

7. Install fuel filter and bleed the fuel system as described in Group 115.



RG5545 -UN-10NOV89

S55,3010,CD -19-13MAY93

REPLACE PRIMARY FUEL FILTER/WATER SEPARATOR—IF EQUIPPED

NOTE: Refer to your operator's manual for proper servicing and (hourly) replacement intervals.

Primary fuel filter/water separator assembly kits are available through service parts.

1. Thoroughly clean exterior of filter element (E) and bracket (A). Also clean around filter mounting area.

NOTE: Lifting up on ring as it is rotated helps to get it past retaining detent.

2. Rotate retaining ring (F) counterclockwise (left) 1/4 turn. Remove ring with filter element.

3. Remove water separator (G) from filter element. Clean water separator and dry with compressed air.

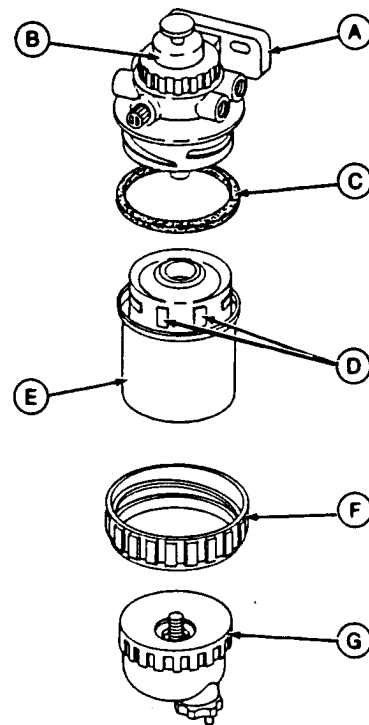
NOTE: Notice indexing keys (D) on filter element. These keys insure proper alignment of filter element to filter base.

4. Install water separator onto new filter element.

5. Index filter element until longer, vertical keys are oriented away from engine. Insert filter element into base securely. It may be necessary to rotate filter for correct alignment.

6. Install retaining ring to filter base, making certain dust seal (C) is in place on filter base. Tighten retaining ring until it locks into detent position and a click sound can be heard.

7. Bleed fuel system. See BLEED THE FUEL SYSTEM in Group 115.



A—Bracket
B—Primer Pump
C—Dust Seal
D—Indexing Keys
E—Filter
F—Retaining Ring
G—Water Separator

RG6666 -UN-13MAR93

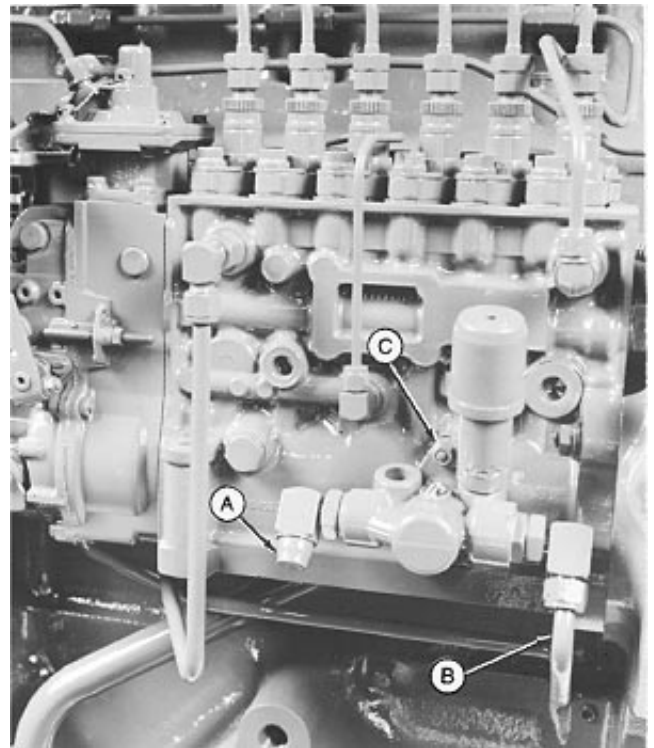
RG,CTM61,G35,45-19-05APR93

REMOVE FUEL SUPPLY PUMP

NOTE: To diagnose fuel supply pump malfunctions or test for leaks, refer to Group 115.

Thoroughly clean exterior of supply pump. Also clean around supply pump mounting area on injection pump housing.

1. Disconnect fuel inlet line (A), shown disconnected, and outlet line (B). Cap all line openings so contaminants do not enter fuel system.
2. Remove three mounting nuts (C) and pull fuel supply pump straight out from injection pump housing.
3. Cover supply pump mounting bore so debris cannot enter injection pump.



RG6162 -UN-24FEB92

RG,CTM61,G35,5 -19-05APR93

TEST FUEL SUPPLY PUMP FOR LEAKS

Fuel delivery pressure should be checked before removing supply pump from injection pump. See CHECK SUPPLY PUMP OPERATION in Group 115.

1. Connect compressed air line (A) to a pressure gauge (B) and to the supply pump inlet fitting. The air line should have a regulating valve to control pressure.
2. Cap or plug supply pump outlet fitting (C).
3. Submerge supply pump in a container of clean diesel fuel. Regulate air pressure to 200 kPa (2.0 bar) (29 psi).
4. Move spindle in and out by hand. No air bubbles should appear around spindle bore.

NOTE: If bubbles appear, it is an indication that either the spindle seal is defective or that the spindle is worn (or possibly both).

IMPORTANT: If enough diesel fuel leaks past the spindle and seal, serious damage to the injection pump or engine (or both) could occur. Fuel leakage past spindle dilutes engine oil.



RG5894 -UN-19AUG91

RG,CTM61,G35,6 -19-05APR93

DISASSEMBLE FUEL SUPPLY PUMP

1. Remove inlet elbow fitting (A) and outlet elbow fitting (B) by loosening locknut and unscrewing fittings from pump housing. Remove and discard O-rings.

2. Remove hand primer (C) from housing. Remove and discard copper washer (D).

A—Inlet Elbow Fitting
B—Outlet Elbow Fitting
C—Hand Primer Pump
D—Copper Washer



RG5909 -UN-19AUG91

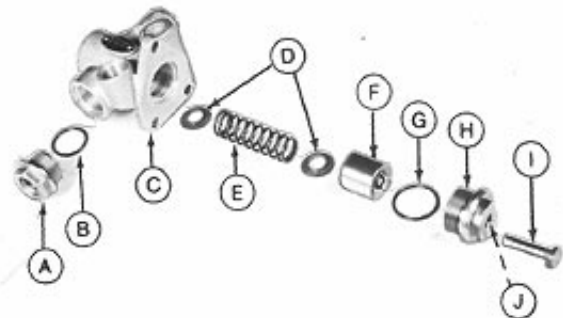
RG,CTM61,G35,7 -19-17MAR92

3. Remove fuel pump outlet valve fitting (A) from pump housing (C). Remove and discard O-ring (B).

4. Remove spindle (I) and spindle guide plug (H) by unscrewing guide plug from pump housing. Remove and discard O-rings (J and G).

5. Remove plunger (F), spring wear plates (D), and spring (E).

A—Outlet Valve Fitting
B—O-Ring
C—Supply Pump Housing
D—Spring Wear Plates
E—Spring
F—Plunger Assembly
G—O-Ring
H—Spindle Guide Plug
I—Spindle
J—O-Ring



RG5912 -UN-28AUG91

RG,CTM42,G35,64-19-28OCT92

6. Push inlet valve (B) and seal (C) out of plunger (A) by poking rounded end of a small pin through closed end of plunger.

NOTE: The outlet valve is located in outlet valve fitting (D) and is not removable from fitting.

- A—Plunger
- B—Inlet Valve Seal
- C—Inlet Valve
- D—Outlet Valve and Fitting



RG,CTM42,G35,65-19-03OCT92

RG5913 -UN-28AUG91

INSPECT AND REPAIR FUEL SUPPLY PUMP

1. Inspect supply pump housing (C) for cracks and wear. Be sure plunger bore is not worn or scored. Check condition of threads for inlet and outlet fittings, hand primer pump, and spindle guide plug (H).

2. Inspect spindle (I) for wear, scoring on OD, and burrs. Check lands that contact plunger and fuel pump cam lobe to be sure they are flat and undamaged. Remove any deposits with a suitable solvent.

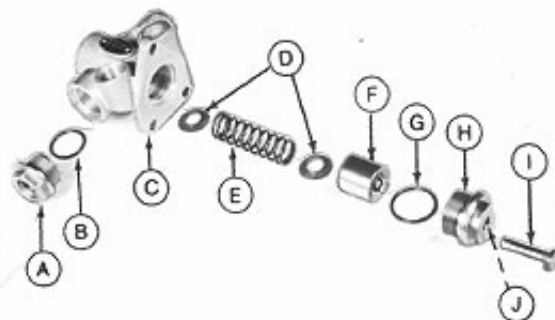
3. Inspect plunger (F) for burrs and pits. Remove any deposits with a suitable solvent.

4. Inspect spring (E) and wear plates (D) for cracks, distortion, and wear.

5. Inspect inlet valve and seal (not shown) for wear, cracks, and broken or missing spring.

6. Inspect outlet valve and fitting (A) for wear, cracks, broken or missing spring, or damaged threads.

If any of the above parts are damaged, worn, or defective, replace as necessary.



- A—Outlet Valve Fitting
- B—O-ring
- C—Supply Pump Housing
- D—Spring Wear Plates
- E—Spring
- F—Plunger Assembly
- G—O-ring
- H—Spindle Guide Plug
- I—Spindle
- J—O-ring

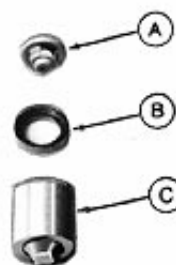
RG,CTM61,G35,8 -19-17MAR92

RG5912 -UN-28AUG91

ASSEMBLE FUEL SUPPLY PUMP

IMPORTANT: Always use new copper gaskets and O-rings. Dip parts in clean diesel fuel before assembly. Hands should be wet with diesel fuel when assembling internal components of fuel supply pump.

1. Assemble seal (B) into plunger (C) so that flat side of seal is against the closed end of the plunger. Install inlet valve (A) into plunger so that spring side of valve protrudes through the center of seal and faces toward closed end of plunger.



RG5946 -JUN-28AUG91

RG,CTM61,G35,9 -19-17MAR92

2. Install a new O-ring (J) in spindle guide plug bore, and a new O-ring (G) on spindle guide plug (H) flange.

3. Dip spindle (I) in clean diesel fuel and install in bore of spindle guide plug.

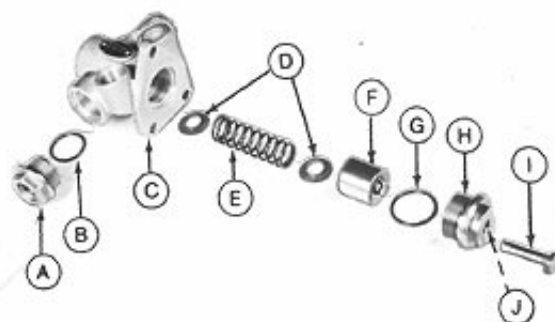
4. Install one spring wear plate (D) in plunger (F) so that flat side of wear plate rests against flat side of inlet valve.

5. Install spring (E) in plunger on top of wear plate. Wear plate should act as a guide for the spring.

6. Install the other wear plate on the end of the spring and insert spring and plunger assembly into pump housing bore.

7. Put spindle guide plug against plunger and push the plug in toward the pump housing until plug threads engage with threads in the housing. Tighten plug securely.

8. Install a new O-ring on the outlet valve fitting and install fitting in pump housing. Tighten fitting securely.



RG5912 -JUN-28AUG91

A—Outlet Valve Fitting
B—O-ring
C—Supply Pump Housing
D—Spring Wear Plates
E—Spring
F—Plunger Assembly
G—O-ring
H—Spindle Guide Plug
I—Spindle
J—O-ring

RG,CTM42,G35,68-19-17MAR92

9. Using a new copper washer (D), install hand primer pump (C) into top of pump housing and tighten securely.

10. Using new O-rings, install inlet (A) and outlet (B) fittings. Tighten lock nuts securely.

Perform leak test described earlier in this group.

A—Inlet Elbow Fitting
B—Outlet Elbow Fitting
C—Hand Primer Pump
D—Copper Washer



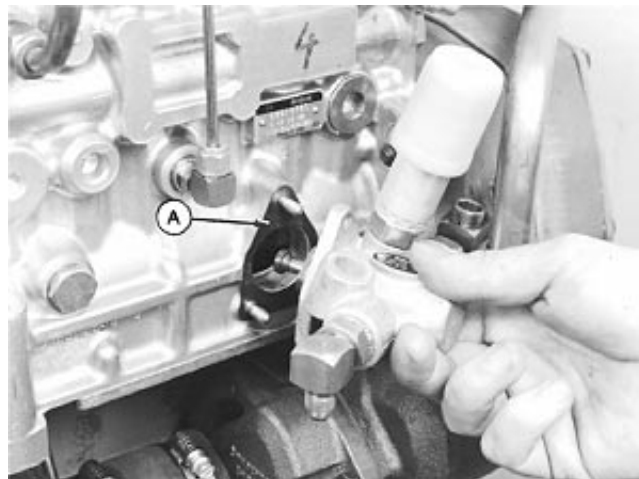
RG,CTM42,G35,69-19-10SEP91

RG5909 -UN-19AUG91

INSTALL FUEL SUPPLY PUMP

IMPORTANT: Before installing supply pump, test pump to make sure that fuel will not leak around spindle and spindle seal. See **TEST FUEL SUPPLY PUMP FOR LEAKS** in Group 115.

1. Install a new gasket on the supply pump mounting face (A).
2. Position pump over mounting studs. Tighten mounting stud nuts 5—8 N·m (4—6 lb-ft).
3. Install fuel inlet and outlet lines when engine is installed in vehicle. Tighten all connections securely.
4. Bleed fuel system. See **BLEED THE FUEL SYSTEM** in Group 115.



RG,CTM61,G35,10-19-05APR93

RG5906 -UN-19AUG91

GENERAL INFORMATION FOR ANEROID—MECHANICAL GOVERNORS ONLY

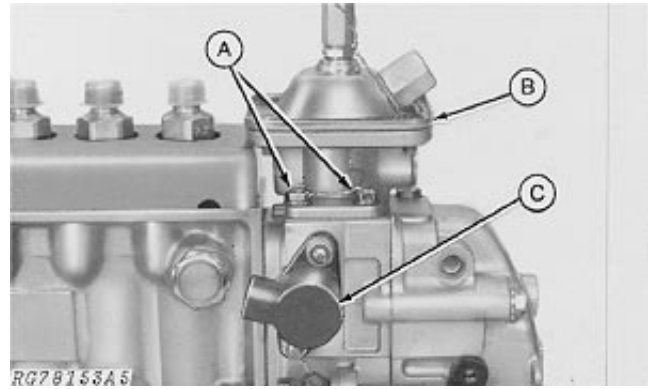
The aneroid (B) is a diaphragm-type control unit that mounts on top of injection pump governor housing. Aneroid mounting screws (A) are sealed to prevent tampering by unauthorized service personnel. Intake manifold pressure is directed to the upper side of the diaphragm chamber to actuate the diaphragm.

A hydraulic aneroid activator located inside activator housing (C), utilizes engine lubricating oil pressure to control aneroid operation.

The purpose of the aneroid is to limit black smoke produced during acceleration, until sufficient manifold pressure is reached, under two conditions:

—When load is moderate to heavy with engine speed from 800 to approximately 1000 rpm.

—When load is light at any engine speed.



RG78153A5 -UN-10NOV89

RG,CTM61,G35,14-19-05APR93

REPAIR ANEROID—MECHANICAL GOVERNORS ONLY

For aneroid repair and adjustment, have an authorized ADS diesel repair station perform the work.

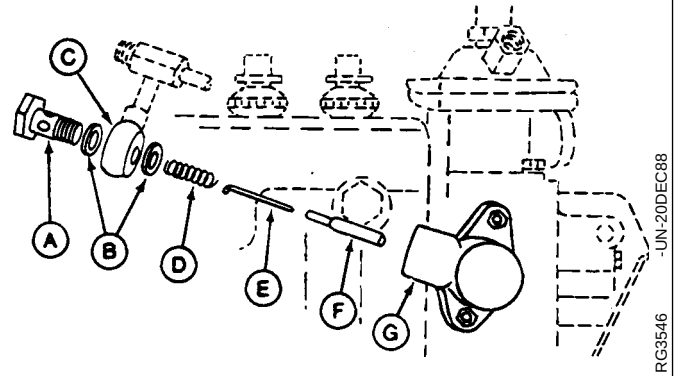
S55,3010,CH -19-13MAY93

REMOVE HYDRAULIC ANEROID ACTIVATOR—MECHANICAL GOVERNORS ONLY

NOTE: The hydraulic aneroid activator is located on the back side of the governor housing next to the cylinder block. Remove the injection pump as described later in this group.

1. Remove special screw (A), copper washers (B) and banjo connector (C).
2. Remove spring (D), restrictor wire (E) and capillary valve (F) from activator housing (G).
3. Remove activator housing from governor housing.

NOTE: Do not bend restrictor wire or other activator parts.

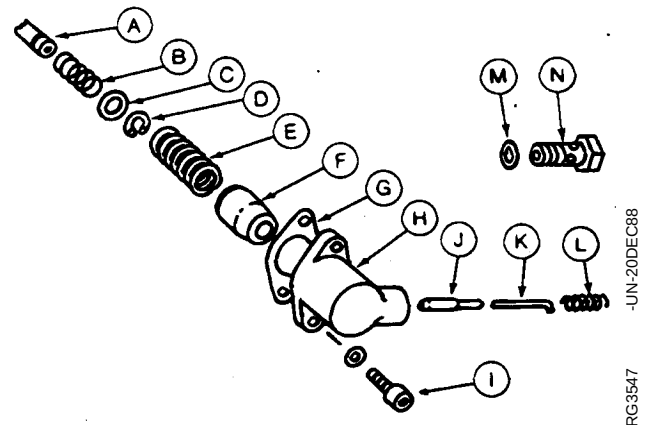


- A—Special Screw
B—Copper Washer (2 used)
C—Banjo Connector
D—Spring
E—Restrictor Wire
F—Capillary Valve
G—Activator Housing

S55,3010,CI -19-05APR93

DISASSEMBLE AND CLEAN HYDRAULIC ANEROID ACTIVATOR PARTS—MECHANICAL GOVERNORS ONLY

1. Remove gasket (G), piston (F) and piston spring (E).
2. Wash all parts in clean solvent and dry with compressed air. Blow out all openings to make sure they are open.
3. Check piston (F) and activator housing (H) for general condition. Piston must move freely in its bore.
4. Inspect piston spring (E) and capillary valve spring (L). Replace if weak or broken.
5. Inspect condition of restrictor wire (K). Wire must not be bent or broken and must fit loosely in capillary valve (J).
6. Check condition of return spring (B), washer (C) and retaining ring (D) on starting fuel control shaft (A). Replace spring if weak or broken. Be sure retaining ring is secure on shaft.



- A—Starting Fuel Control Shaft
B—Return Spring
C—Washer
D—Retaining Ring
E—Piston Spring
F—Piston
G—Gasket
H—Activator Housing
I—Mounting Screw (2 used)
J—Capillary Valve
K—Restrictor Wire
L—Capillary Valve Spring
M—Washers
N—Special Screw

S11,3010,DT -19-05APR93

ASSEMBLE AND INSTALL HYDRAULIC ANEROID ACTIVATOR—MECHANICAL GOVERNORS ONLY

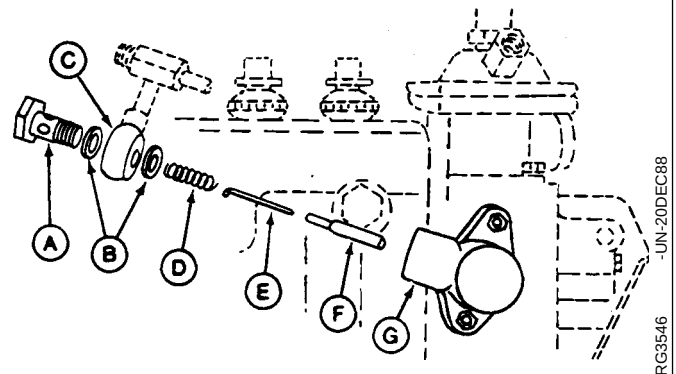
NOTE: Refer to previous illustration.

1. Insert piston spring (E) into piston (F). Place these parts in activator housing (H).
2. Using a new gasket (G) mount activator assembly on governor housing. Tighten Allen head mounting screws (I) and washers securely.

S11,3010,DU -19-13MAY93

3. Assemble capillary valve (F), restrictor wire (E) and spring (D) into activator housing (G).
4. Using two new copper washers (B) install banjo connector (C) and special screw (A).
5. Install injection pump as described later in this group.
6. Connect lube lines to banjo connector.

A—Special Screw
B—Copper Washers
C—Banjo Connector
D—Spring
E—Restrictor Wire
F—Capillary Valve
G—Activator Housing



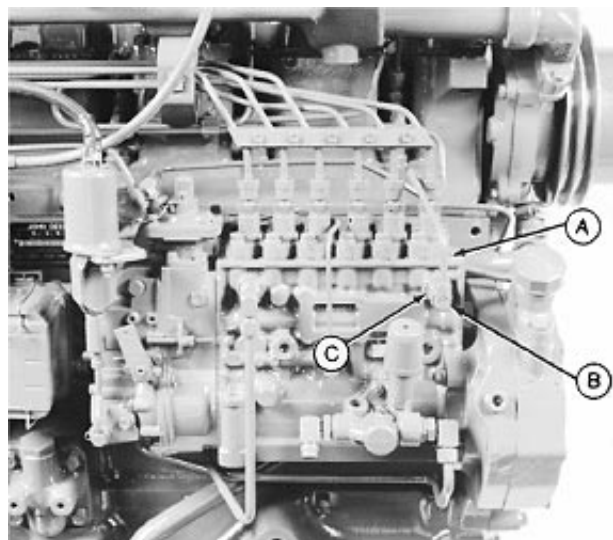
RG3546 -UN-20DEC88

RG,CTM61,G35,48-19-13MAY93

SERVICE OVERFLOW VALVE

NOTE: The overflow valve can be serviced with injection pump installed.

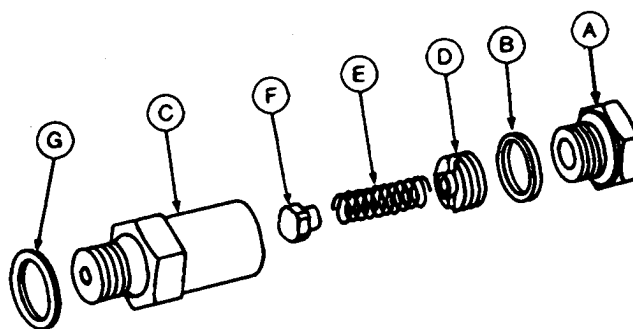
1. Remove leak-off line (A) and remove elbow (B).
2. Remove valve assembly (C) from pump.



RG6169 -UN-24FEB92

RG,CTM61,G35,11-19-17MAR92

3. Remove reducer (A) and copper washer (B) from valve body (C). Discard copper washers.
4. Unscrew spring seat (D); then remove spring (E) and valve (F).
5. Inspect for foreign material imbedded in seat of nylon valve.
6. Check spring to see that it is not weak or broken.
7. Wash all parts in solvent and air dry.



RG3549 -UN-20DEC88

NOTE: There is no adjustment on valve to regulate housing pressure. If suspected that the valve is malfunctioning replace valve to restore proper operation.

8. Reverse order of removal for reassembly of overflow valve. Install new copper washers.

A—Reducer
B—Washer
C—Valve Body
D—Spring Seat
E—Spring
F—Valve
G—Washer

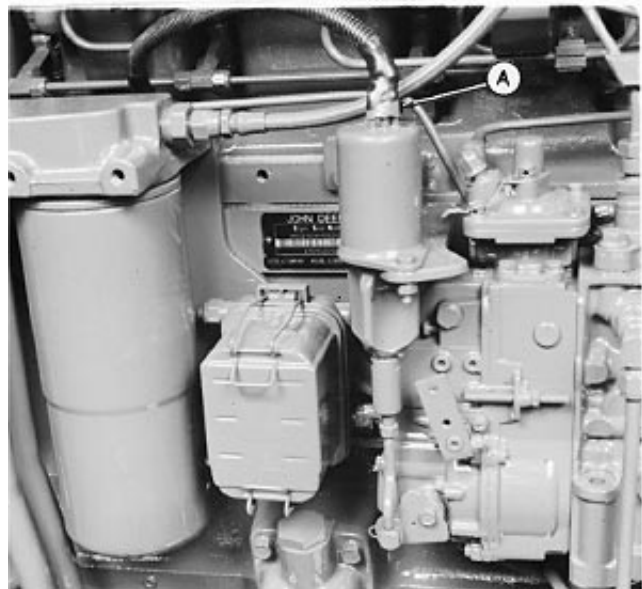
S11,3010,DX -19-11SEP91

REMOVE FUEL SHUT-OFF SOLENOID—MECHANICAL GOVERNORS ONLY

IMPORTANT: Electric fuel shut-off solenoids are factory adjusted to a specified length and should not require adjustment. See **FUEL SHUT-OFF SOLENOID LINKAGE ADJUSTMENT** in Group 115.

NOTE: To perform fuel shut-off solenoid resistance test or operational checks, refer to Group 115.

1. Disconnect solenoid electrical wiring connector (A).



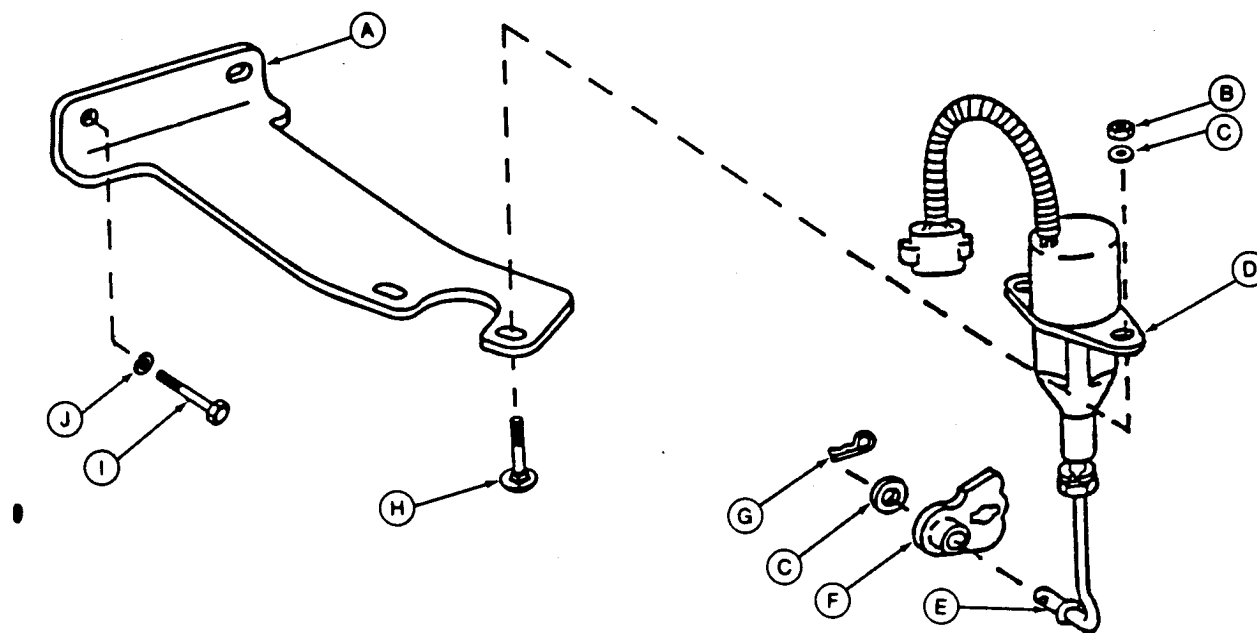
RG,CTM61,G35,13-19-13MAY93

Refer to illustration in the following module.

2. Remove cotter pin (G), washer (C), and pull solenoid shaft (E) out of fuel shut-off lever (F).
3. Remove fuel shut-off solenoid (D) from solenoid mounting bracket (A) by removing lock nuts (B), lock washers (J), and bolts (H).
4. If solenoid mounting bracket is to be removed, remove two cap screws (I) and lock washers that fasten bracket to cylinder head.

RG,CTM61,G35,47-19-13MAY93

INSTALL FUEL SHUTOFF SOLENOID—MECHANICAL GOVERNORS ONLY



A—Bracket
B—Lock Nut (2 used)
C—Washer (3 used)

D—Solenoid
E—Solenoid Shaft
F—Lever

G—Cotter Pin
H—Bolt (2 used)

I—Cap Screw (2 used)
J—Lock Washer (2 used)

1. If removed, install solenoid mounting bracket (A), cap screws (I), and lock washers (J). Tighten cap screws to 47 N·m (35 lb-ft).

2. Mount shutoff solenoid (D) on bracket with two bolts (H). Tighten hex nuts (B) to 8 N·m (6 lb-ft).

3. Insert solenoid shaft (E) in fuel shutoff lever (F) and install washer (C) and cotter pin (G).

4. Plug solenoid lead connector into engine wiring harness.

IMPORTANT: Electric fuel shutoff solenoids are factory adjusted to a specified length and should not require additional adjustment. See the machine technical manual for fuel shutoff solenoid diagnostics.

5. Turn key switch to "ON" position. Check clearance between fuel shutoff lever and stop on injection pump housing. Clearance should be about 0.25 mm (0.010 in.) or less to ensure engine is receiving full fuel.

RG6168 -UN-24FEB92

RG,CTM61,G35,15-19-05APR93

REMOVE FUEL INJECTION PUMP

IMPORTANT: Never steam clean or pour cold water on an injection pump while pump is running, or while it is still warm. To do so may cause seizure of pump parts.

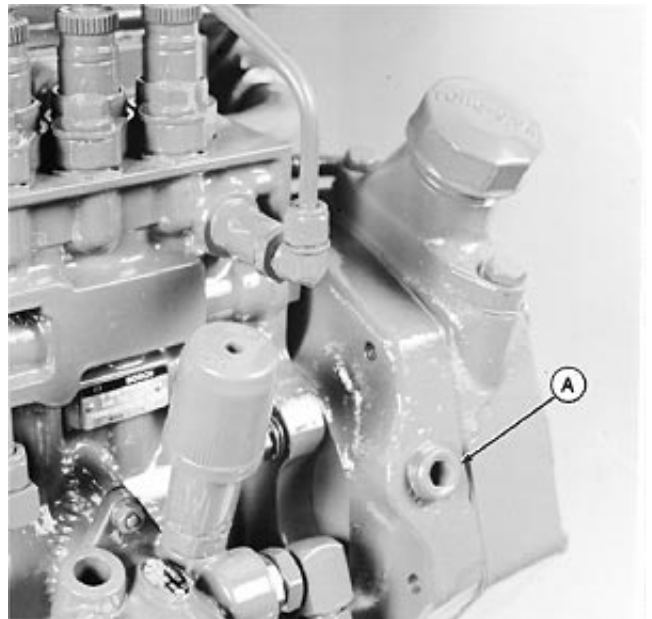
1. Clean injection lines and area around injection pump with cleaning solvent or a steam cleaner to keep debris out of fuel system.

NOTE: Follow same removal procedure for injection pumps equipped with mechanical governor and electronic governor. Differences will be noted.

2. Remove timing hole plug (A).

3. Using JDE81-1 Engine Rotation Tool, rotate crankshaft until No. 1 piston is at "TDC" on its compression stroke.

4. Timing marks on injection pump drive hub and on timing pointer should be aligned and visible through timing hole. At this time, JDE81-4 Timing Pin should enter hole in flywheel.



RG6171 -UN-24FEB92

RG,CTM61,G35,16-19-13MAY93

5. Remove fan and fan belts, if equipped.

6. Remove injection pump drive gear cover (shown removed), remove and discard all gasket material.

7. Remove four injection pump drive gear cap screws (B). Injection pump drive gear (A) should be free from pump drive hub and gear will stay in housing.

8. Remove final fuel filter from filter base.

9. On mechanical governor pumps, remove fuel shut-off solenoid assembly. See REMOVE FUEL SHUT-OFF SOLENOID—MECHANICAL GOVERNORS ONLY, earlier in this group.



RG6176 -UN-24FEB92

RG,CTM61,G35,18-19-13MAY93

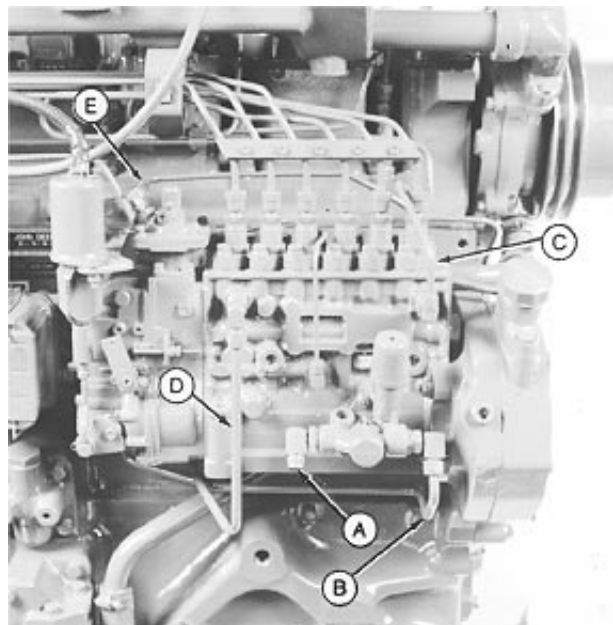
10. Disconnect fuel inlet (A) and outlet (B) lines from fuel supply pump and fuel leak-off line (C) from injection pump.

11. Disconnect injection pump fuel inlet line (D).

12. On mechanical governor pumps, disconnect aneroid line (E).

13. Disconnect lubrication line (not shown) at hydraulic aneroid activator junction located on inboard side of injection pump.

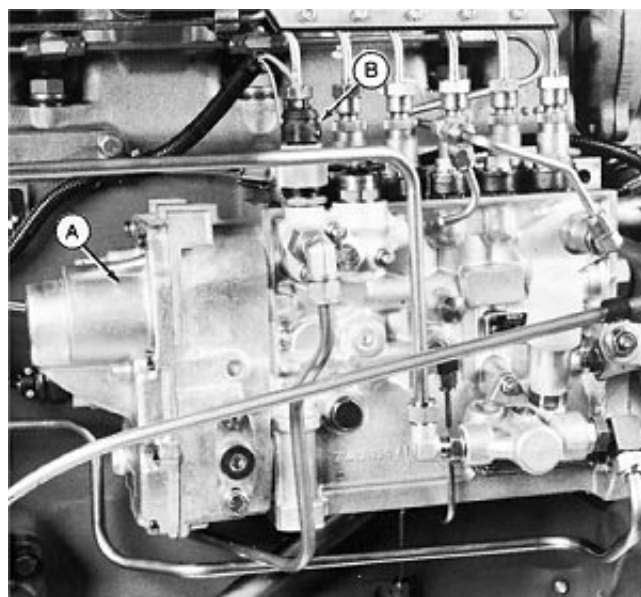
A—Supply Pump Inlet
B—Supply Pump Outlet
C—Leak-Off Line
D—Injection Pump Inlet
E—Aneroid Line



RG,CTM61,G35,19-19-05APR93

RG6173 -UN-24FEB92

NOTE: For injection pumps equipped with electronic governors (A), disconnect wiring harness at governor and shut-off solenoid (B). Protect connectors on wiring harness while pump is disconnected so debris does not enter connector ends.



RG,CTM61,G35,43-19-05APR93

RG6699 -UN-22MAR93

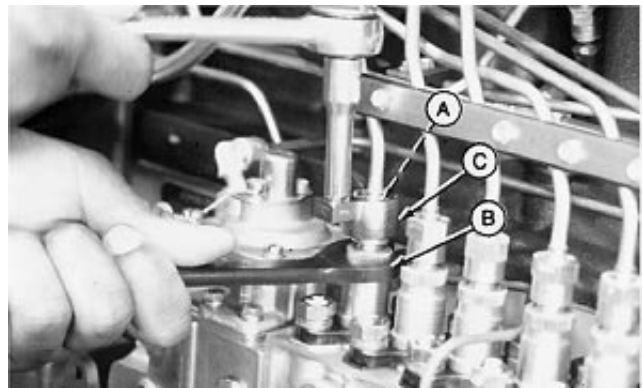
14. To remove fuel injection line nuts (A) use JDE90 Serrated Wrench (B) with either JDF22 Crowsfoot Wrench (C) or a standard 3/4 in. line wrench (D).

IMPORTANT: JDE90 Serrated Wrench must be used to keep delivery valve fittings stationary while loosening line nuts. If a delivery valve and barrel housing rotates while loosening or tightening a fuel line nut, injection pump delivery will be altered. Pump will have to be recalibrated on a test stand.

15. Remove four mounting stud nuts which secure injection pump to cylinder block.

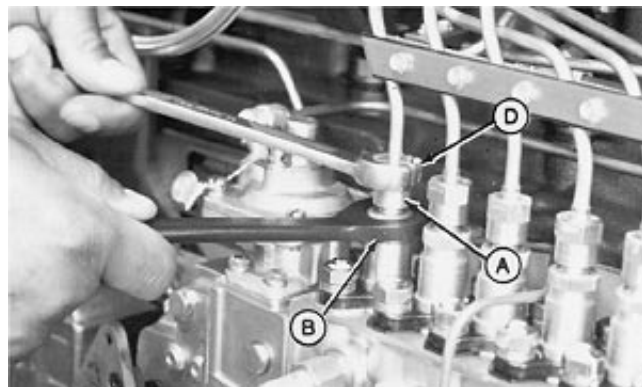
16. Carefully remove injection pump from block bore and place it on a clean flat surface.

A—Fuel Injection Line Nuts
B—JDE90 Serrated Wrench
C—JDF22 Crowsfoot Wrench
D—3/4 in. Line Wrench



-UN-07JUL89

RG5573



-UN-10NOV89

RG5574

RG,CTM61,G35,37-19-05APR93

REPAIR FUEL INJECTION PUMP

IMPORTANT: Do not disassemble fuel injection pump further than necessary for installing available service parts, not even for cleaning.

For injection pump repair and testing, have an authorized diesel injection repair station perform the work.

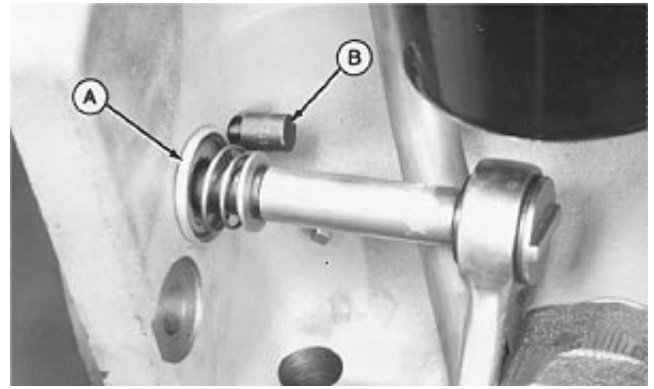
S11,3010,PE -19-05APR93

INSTALL FUEL INJECTION PUMP

NOTE: When turning flywheel to "TDC", JDE81-4 Timing Pin (B) can engage in flywheel with either No. 1 or No. 6 cylinder on "TDC" compression stroke. When installing fuel injection pump, No. 1 cylinder must be on No. 1 "TDC" compression.

1. If crankshaft was rotated after injection pump was removed, rotate flywheel using JDE81-1 Flywheel Turning Tool (A) until timing pin engages flywheel with No. 1 cylinder at "TDC" compression stroke.

NOTE: When No. 1 cylinder is on "TDC" compression stroke, intake and exhaust valves for No. 1 cylinder will be closed and both rocker arms will be loose.



RG5521 -UN-05JAN90

S55,3010,CN -19-13MAY93

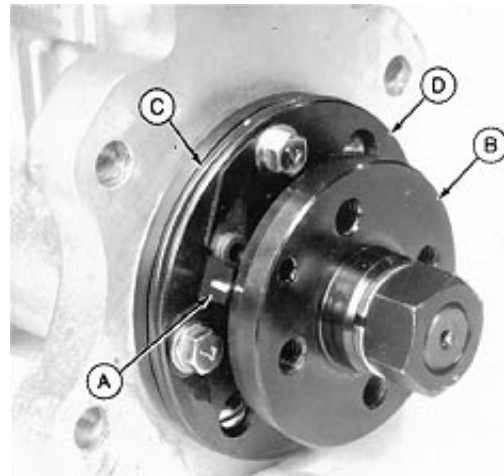
IMPORTANT: Clean drive hub OD and drive gear ID with a degreaser such as trichloroethylene to eliminate seizure of gear on hub.

2. Rotate injection pump drive hub until marks on drive hub (B) and pointer (A) are aligned.

3. Install a new O-ring (C) on bearing plate (D). Lightly lubricate O-ring with clean engine oil to make pump installation easier and prevent O-ring damage.

4. Install injection pump using moderate forward pressure and slight rocking motion to work O-ring into mounting hole. Injection pump flange should seat flush against cylinder block.

5. Install four injection pump-to-cylinder block mounting stud nuts and finger tighten.



A—Pointer
B—Drive Hub
C—O-Ring
D—Bearing Plate

RG5302 -UN-14DEC88

RG,CTM61,G35,20-19-05APR93

35
23

6. Carefully install pump drive gear (A) on pump drive hub, positioning gear so that cap screws (B) will be in the approximate center of gear slots. Doing so will permit pump timing to be adjusted, should the need arise.

7. Install four drive gear cap screws and tighten to 61 N·m (45 lb-ft).



RG,CTM61,G35,21-19-05APR93

RG6176 -UN-24FEB92

8. Tighten four injection pump-to-cylinder block mounting stud nuts to 47 N·m (35 lb-ft).

IMPORTANT: Normal backlash of gears is enough to throw pump timing off by several degrees, resulting in poor engine performance. Therefore, it is very important that pump timing be rechecked after it has been installed. To avoid backlash, always approach timing mark on pointer by rotating crankshaft in direction of engine rotation.

9. To check alignment of injection pump, remove JDE81-4 Timing Pin from flywheel. Rotate flywheel with JDE81-1 Flywheel Turning Tool 1-1/2 revolutions in direction of normal rotation. Install timing pin and continue rotating until timing pin engages flywheel.

10. Look into timing window, and if timing marks ARE NOT in alignment, loosen pump drive gear (A) cap screws (B). Rotate pump drive hub and bring pump hub timing marks into alignment. Repeat timing check to be sure marks are aligned. Install timing hole plug.

NOTE: Apply LOCTITE 242 Thread Lock and Sealer to cap screws before securing cover plate to prevent oil leakage.

11. Install injection pump gear cover with new gasket and tighten cap screws to specification given below.

INJECTION PUMP GEAR COVER TORQUE SPECIFICATIONS

6101HRW10 and 6101HRW11

Applications 68 N·m (50 lb-ft)

All Other Applications 41 N·m (30 lb-ft)



RG6176 -UN-24FEB92

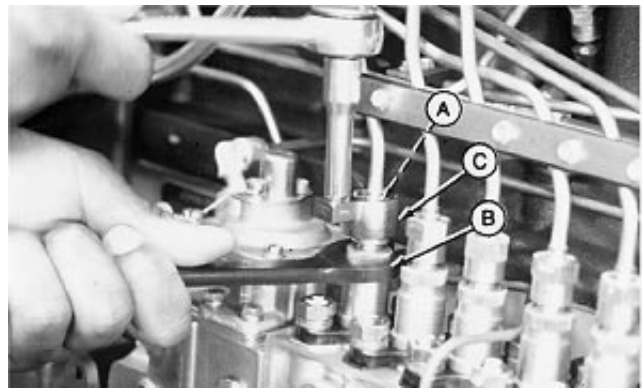
NOTE: Remove protective caps and plugs from fuel system components installed during injection pump removal.

IMPORTANT: JDE90 Serrated Wrench (B) **MUST BE** used to keep delivery valves fittings stationary while tightening fuel line nuts (A). If a delivery valve and barrel housing rotates while tightening a line nut, injection pump fuel delivery will be altered. Injection pump will then have to be recalibrated on a test stand by an authorized diesel repair station.

12. Connect fuel delivery line nuts to injection pump delivery valves and tighten to 27 N·m (20 lb-ft) using JDE90 Serrated Wrench with either JDF22 Crowsfoot Wrench (C) or a standard 3/4 in. line wrench (D).

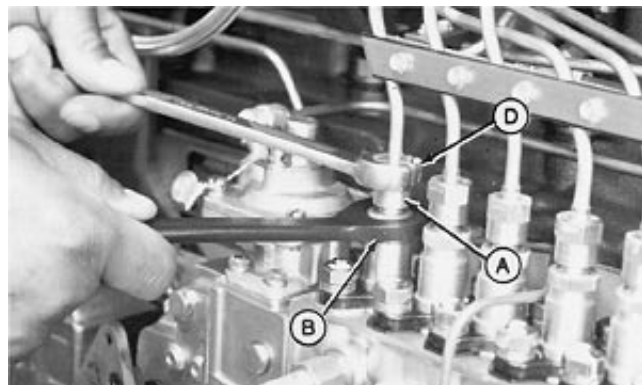
13. On mechanical governor pumps, install fuel shut-off solenoid assembly. See INSTALL FUEL SHUT-OFF SOLENOID, earlier in this group.

- A—Fuel Injection Line Nut
- B—JDE90 Serrated Wrench
- C—JDF22 Crowsfoot Wrench
- D—3/4 in. Line Wrench



-UN-07JUL89

RG5573

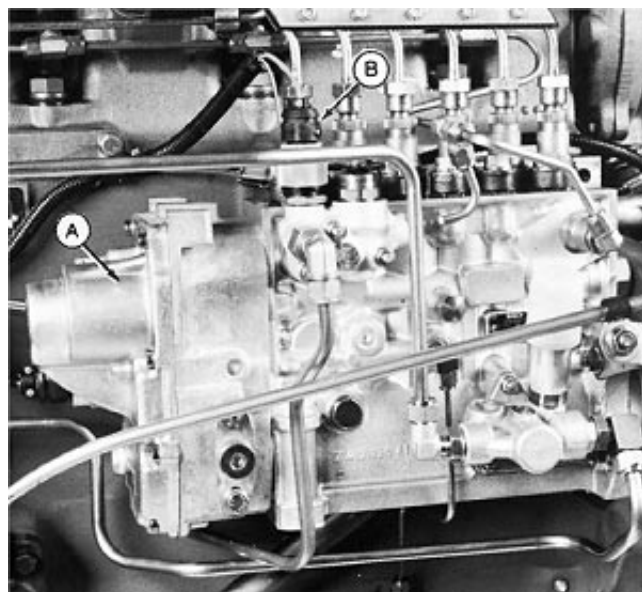


-UN-10NOV89

RG5574

RG,CTM61,G35,38-19-13MAY93

NOTE: On injection pumps equipped with electronic governors, connect wiring harness at governor (A) and shut-off solenoid (B). Tighten connections securely.



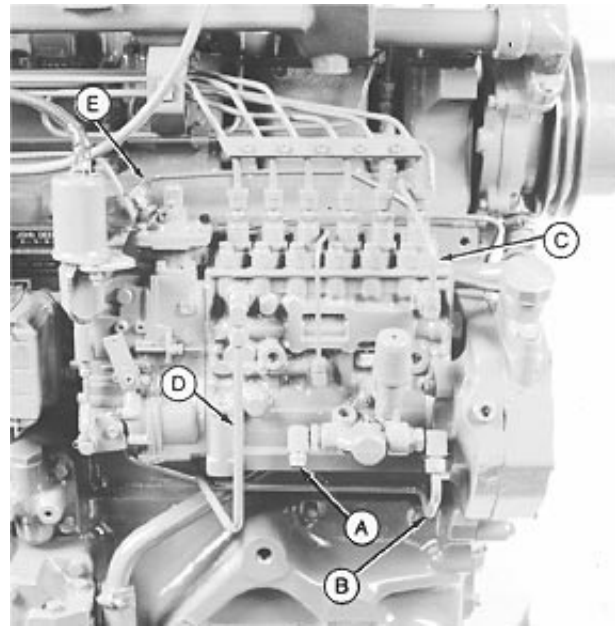
-UN-22MAR93

RG6699

RG,CTM61,G35,44-19-05APR93

14. On mechanical governor pumps, connect aneroid line (E).
15. Connect fuel supply pump inlet (A) and outlet lines (B).
16. Connect injection pump inlet line (D) and fuel leak-off line (C).
17. Install fuel filter onto mounting base.

A—Supply Pump Inlet
 B—Supply Pump Outlet
 C—Leak-Off Line
 D—Injection Pump Inlet
 E—Aneroid Line

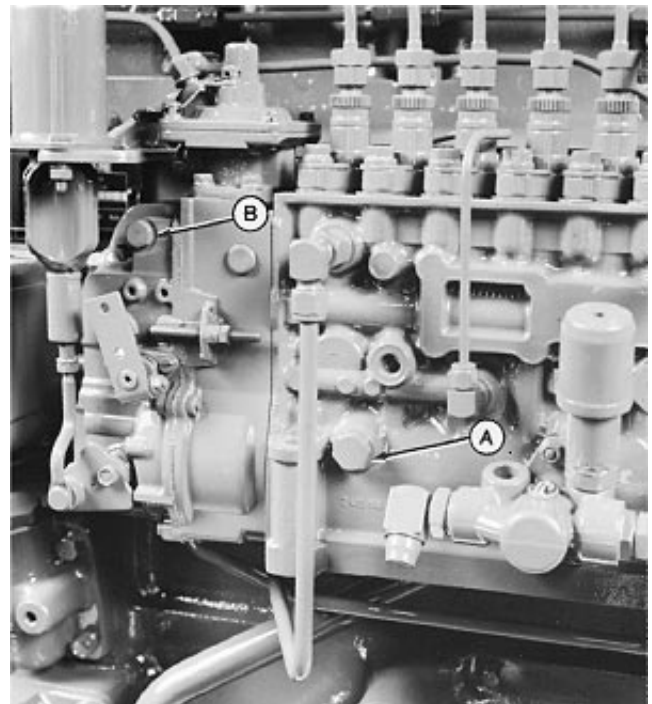


RG,CTM61,G35,23-19-05APR93

RG6173 -UN-24FEB92

IMPORTANT: Oil fill locations may vary by injection pump applications. Familiarize yourself with the location on your engine before adding oil to pump.

18. Remove oil filler cap (A) and add enough clean engine oil until oil comes out oil fill hole. Engine should be level when checking oil level.
19. Remove oil filler cap (B) from mechanical governor housing and check oil level. Add clean engine oil as needed.
20. Bleed fuel system. See BLEED THE FUEL SYSTEM in Group 115.
21. Connect throttle levers and adjust engine speeds as required. See ADJUST ENGINE SPEEDS in Group 115.



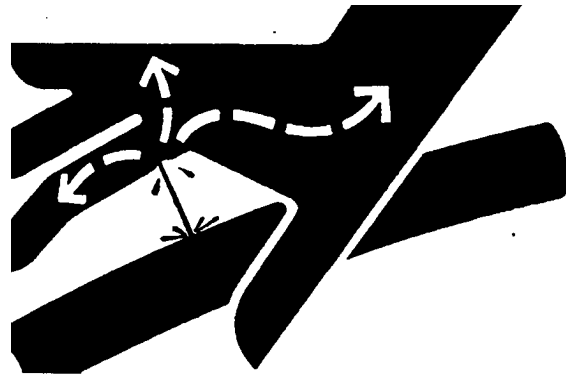
RG,CTM61,G35,24-19-05APR93

RG6178 -UN-24FEB92

REMOVE FUEL INJECTION NOZZLES

CAUTION: Escaping fluid under pressure can penetrate skin causing serious injury. Relieve pressure before disconnecting lines. Tighten all connections before applying pressure. Keep hands and body away from pinholes and nozzles which eject fluids under high pressure. Use a piece of cardboard or paper to search for leaks. Do not use your hand.

If ANY fluid is injected into skin, it must be surgically removed within a few hours by a doctor familiar with this type injury or gangrene may result.



-UN-23AUG88

X9811

1. Thoroughly clean area around injection pump and nozzles, including all line connections, using compressed air.

2. Cap or plug all fuel lines as they are disconnected to prevent dirt and debris from entering fuel system. Debris in fuel system can plug injectors and cause engine damage.

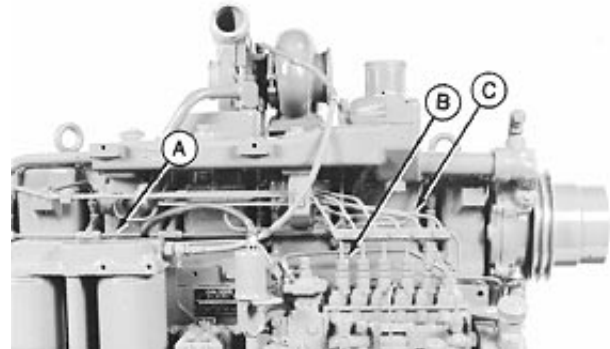
3. Disconnect turbocharger oil inlet line and remove water manifold. (See Group 25.)

4. Disconnect fuel delivery lines (C) at nozzles using JDF22 Crowsfoot Wrench.

IMPORTANT: JDE90 Serrated Wrench must be used to keep fuel delivery valve fittings stationary while loosening line nuts. If a delivery valve and barrel housing rotates while loosening a fuel line nut, injection pump fuel delivery will be altered. Pump will have to be recalibrated on a test stand.

5. Disconnect fuel delivery line nuts (B) from each delivery valve using JDE90 Serrated Wrench from either JDF22 Crowsfoot Wrench or a 3/4 in. line wrench. Remove fuel delivery lines as an assembly.

6. Disconnect fuel leak-off line (A) from each injection nozzle leak-off connector. Remove complete leak-off assembly.

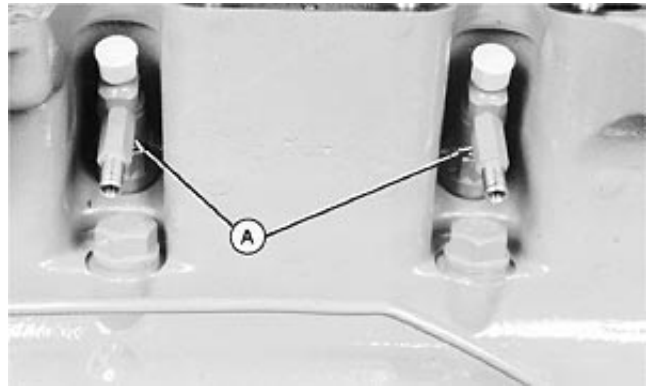


-UN-24FEB92

RG6179

7. Remove packing and line nuts from each leak-off connector. Discard packing.

8. Remove leak-off connector (A) with washer from each injection nozzle.



RG6180 -UN-24FEB92

RG,CTM61,G35,26-19-05APR93

NOTE: Socket portion of JDE92 Nozzle Wrench (A) may be used to remove nozzles from cylinder head.

9. Use JDE92 Nozzle Wrench or a 24 mm (15/16 in.) deep socket on nozzle gland nut and remove fuel injection nozzles.

10. Remove special steel washer from nozzle bore, if it does not come out with nozzle.

11. Insert a 12.7 mm (1/2 in.) hardwood dowel in nozzle bore to prevent debris from entering combustion chamber after nozzles are removed.



RG5757 -UN-05AUG91

RG,CTM61,G35,27-19-13MAY93

DIAGNOSE INJECTION NOZZLE MALFUNCTION

Problem	Possible Cause	Suggested Remedy
Failed Carbon Stop Seal Washer	Nozzle replaced without using new seal or washer.	Install new seal or washer.
	Carbon stop seal groove not cleaned when new seal was installed.	Clean groove. Install new seal.
Incorrect Opening Pressure	Improper adjustment.	Adjust opening pressure.
	Broken spring.	Replace spring.
Nozzle Will Not Open	Plugged orifices.	Clean.
	Chipped orifices.	Replace nozzle.
	Bottomed lift screw.	Adjust lift screw.
Poor Spray Pattern	Plugged orifices.	Clean.
	Chipped orifices.	Replace nozzle.
	Cracked nozzle tip.	Replace nozzle.
Poor Atomization	Plugged orifice.	Clean.
	Chipped orifice.	Replace nozzle.
	Cracked nozzle tip.	Replace nozzle.
	Valve not free.	See "Inconsistent Chatter".
Inconsistent Chatter	Spring components misaligned.	Adjust opening pressure.
	Varnish on valve.	Clean guide area.
	Deposits in seat area.	Clean seat.
	Bent valve.	Replace nozzle.
	Distorted body.	Replace nozzle.

DIAGNOSE INJECTION NOZZLE MALFUNCTION—CONTINUED

Problem	Possible Cause	Suggested Remedy
No Chatter	Spring components misaligned.	Adjust opening pressure.
	Varnish on valve.	Clean guide area.
	Deposits in seat area.	Clean seat.
	Bent valve.	Replace nozzle.
	Valve seat eroded or pitted.	Lap valve to seat. Replace nozzle as necessary.
	Tip seat pitted.	Lap tip to seat. Replace nozzle as necessary.
	Seat interference angle worn.	Replace nozzle.
	Distorted body.	Replace nozzle.
Seat Leakage	Deposits in seat area	Clean seat.
	Valve seat eroded or pitted.	Lap valve to seat. Replace nozzle as necessary.
	Tip seat pitted.	Lap tip to seat. Replace nozzle as necessary.
	Valve not free.	See "Inconsistent Chatter". See "No Chatter".
	Distorted body.	Replace nozzle.
	Cracked tip.	Replace nozzle.
High Leak-Off	Wear or Scratched at Guide	Lap valve to guide. Replace nozzle.
Low Leak-Off	Varnish on valve.	Clean guide area.
	Insufficient clearance.	Clean nozzle. Lap valve to guide. Replace nozzle as necessary.

TEST FUEL INJECTION NOZZLES

Before disassembling, test injection nozzles with clean filtered fuel to determine its condition.

Test for:

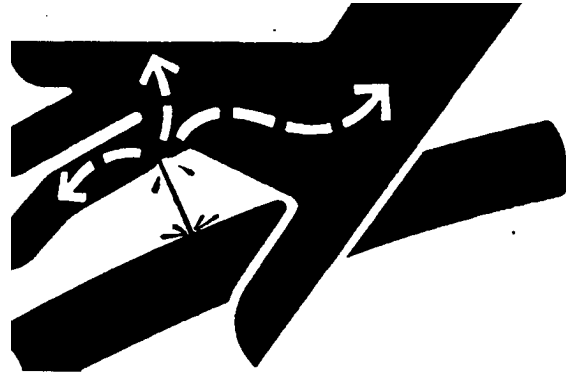
- Opening Pressure
- Leakage
- Chatter
- Spray Pattern



CAUTION: Nozzle tip should always be directed away from operator. Fuel from spray orifices can penetrate skin and clothing, causing serious personal injury. Enclosing nozzle in a transparent cover, or glass beaker is recommended.

Before applying pressure to nozzle tester, be sure all connections are tight and fittings are not damaged. Fuel escaping from a very small hole can be almost invisible. Use a piece of cardboard or wood; rather than your hands, to search for suspected leaks.

If ANY fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type injury or gangrene may result.



X9811 -UN-23AUG88

S11,0408,AL -19-29OCT92

PERFORM OPENING PRESSURE TEST

1. Connect KDEL injection nozzle to D01109AA Nozzle Tester (Y900) (A), using No. Y900-2A Fuel Line (B) and Y900-7 and Y900-15 Straight Adapters (C). The Y900-21 90° Adapter may also be used.

CAUTION: To avoid personal injuries, place a glass beaker (D) around nozzle during opening pressure test.

2. Pump handle several times to flush out nozzle fittings. Tighten fittings.

3. Expel air from nozzle by operating pump handle several strokes. Then raise pressure at which valve opens.

4. Recheck by completely releasing pressure, then gradually building pressure until valve opens.

IMPORTANT: Nozzle tester should be checked periodically for accuracy.



A—Nozzle Tester
B—Fuel Line
C—Adapter
D—Beaker

S11,3010,PS -19-05APR93

RG5883 -UN-19AUG91

FUEL INJECTION NOZZLE SPECIFICATIONS

A new nozzle or a used nozzle with a new spring (A), should open at approximately the following pressures. A used nozzle that has been rebuilt with a new spring and/or valve should be reset to the same pressures as a new nozzle. New nozzle opening pressures are:



NEW NOZZLE OPENING PRESSURE (by nozzle tip size)*

7 x 0.230 mm	29000 kPa (290 bar) (4200 psi)
7 x 0.255 mm	29000 kPa (290 bar) (4200 psi)

On nozzles which have been in service, spring and spring seat (B) will have taken a normal set. In this case, opening pressure is satisfactory if its meets or exceeds used nozzle minimum opening pressure given below, but does not exceed new opening pressure given above. Used nozzle minimum opening pressures are:

USED NOZZLE MINIMUM OPERATING PRESSURES (by nozzle tip size)*

7 x 0.230 mm	26200 kPa (262 bar) (3800 psi)
7 x 0.255 mm	26200 kPa (262 bar) (3800 psi)

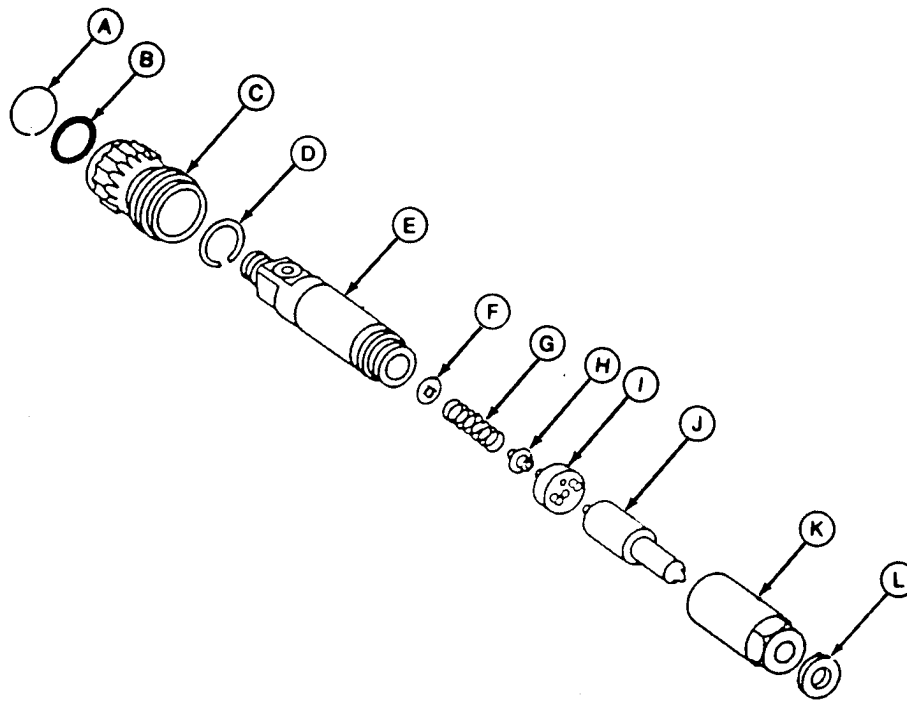
Shims (C) of different thicknesses are available for changing opening pressure adjustment. Each 0.05 mm (0.002 in.) shim thickness changes opening pressure approximately 700 kPa (7 bar) (100 psi).

IMPORTANT: Always use John Deere nozzle adjusting shims which are specially hardened. Other shims will not be satisfactory.

If nozzle opening pressure is not correct, disassemble injection nozzles (as described later in this group) and change shims until nozzle opens at proper new nozzle pressure given above. The difference in nozzle opening pressures between cylinders in an engine should not exceed 350 kPa (3.5 bar) (50 psi).

* See ASSEMBLE FUEL INJECTION NOZZLE, later in this group, for nozzle tip size identification.

PERFORM LEAKAGE TEST



RG6184 -UN-24FEB92

A—Snap Ring (Upper)
B—Gland Nut O-Ring
C—Gland Nut

D—Snap Ring (Lower)
E—Nozzle Holder
F—Shim

G—Nozzle Valve Spring
H—Spring Seat
I—Intermediate Plate

J—Nozzle
K—Nozzle Retaining Nut
L—Washer

1. Wipe nozzle dry.

2. Bring pressure up slowly to 1970 kPa (20 bar) (285 psi) below opening pressure. Watch for an accumulation of fuel from spray orifice, indicating a bad seat.

If nozzle drips within 10 seconds, replace nozzle valve and nozzle (J).

3. Check for leakage around nozzle retaining nut (K) thread connection with nozzle holder (E).

Leakage indicates a bad seat either between nozzle and intermediate plate (I) or between nozzle holder and intermediate plate.

RG,CTM61,G35,29-19-05APR93

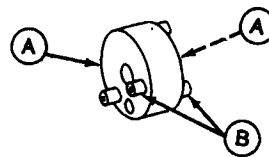
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35

IMPORTANT: Do not lap machined surfaces (A) of intermediate plate in an attempt to stop fuel leakage at these locations. Dowels (spring pins) (B) in plate have to be removed before surfaces can be lapped. Removing these dowels is not recommended as removal is likely to damage them, and replacement dowels are not available as service parts.

RG2248

-UN-20APR89

RG2248



If leakage is observed, tighten nozzle retaining nut to a maximum of 88 N·m (65 lb-ft). Replace injection nozzle if leakage continues.

S55,3010,BG -19-05APR93

MAKE CHATTER AND SPRAY PATTERN TEST

1. Injection nozzle should chatter very softly, and only when hand lever movement is very rapid (four to six downward movements per second). Failure to chatter may be caused by a binding or bent nozzle valve.
 2. Until chattering range is reached, test oil emerges as non-atomized streams. When lever movement is accelerated, sprays should be very broad and finely atomized.
- A partially clogged or eroded orifice will usually cause the spray to deviate from correct angle. The spray will also be steady rather than finely atomized.
3. Disassemble nozzle for cleaning or reconditioning if it fails to chatter or spray properly.

S11,0408,AQ -19-05APR93

DISASSEMBLE FUEL INJECTION NOZZLE

General Nozzle Repair Notes:

NOTE: Disassembly of nozzles is not recommended unless servicing is indicated by nozzle operation and testing.

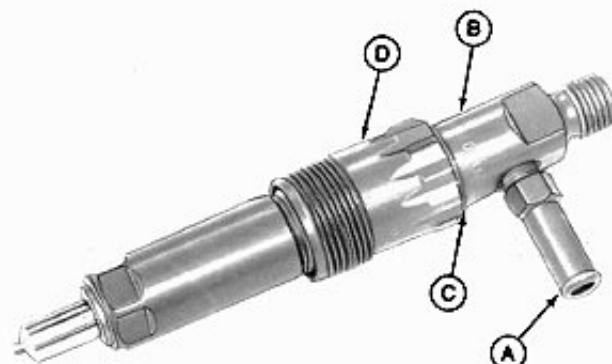
- Since dirt and water are the worst contaminants in fuel injection system, working area, tools and cleaning materials must be kept spotlessly clean. Whenever possible, work in an isolated, dust-free area.
- Cover workbench with clean paper before disassembly of injection nozzles.
- As parts are disassembled, place them in a pan of clean diesel fuel and leave there until needed. Do not permit parts to strike each other.
- Use a separate pan of clean diesel fuel for washing parts before assembly.

S11,0408,AR -19-05APR93

NOTE: The Bosch KDEL injection nozzle is a metric unit and only metric tools should be used.

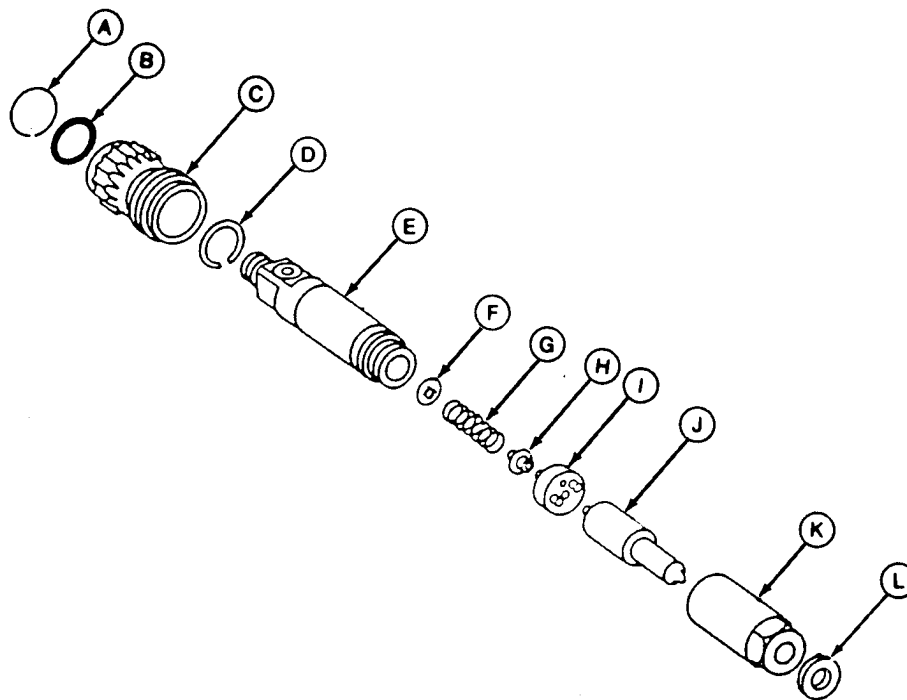
1. Use a 11 mm box or open-end wrench and unscrew leak-off connector (A) (if not removed previously) out of nozzle holder (B).
2. Remove O-ring and upper snap ring (C) from nozzle holder.
3. Slip gland nut (D) off nozzle holder.

A—Leak-Off Connector
B—Nozzle Holder
C—O-Ring and Upper Snap Ring
D—Gland Nut



RG3887 -UN-20DEC88

S11,0408,AS -19-05APR93



RG6184 -UN-24FEB92

A—Snap Ring (Upper)
B—Gland Nut O-Ring
C—Gland Nut

D—Snap Ring (Lower)
E—Nozzle Holder
F—Shim

G—Nozzle Valve Spring
H—Spring Seat
I—Intermediate Plate

J—Nozzle
K—Nozzle Retaining Nut
L—Washer

4. Remove lower snap ring (D).
5. Clamp the two flats of the nozzle holder (fuel inlet end) in a soft-jawed vise and remove nozzle retaining nut (K), using a 12-point 19 mm wrench.
6. Remove nozzle assembly (J).
7. Pull off intermediate plate (I).
8. Remove spring seat (H), spring (G), and shims (F).

9. Withdraw nozzle valve from nozzle. If valve is stuck, it may be necessary to soak nozzle assembly in Bendix cleaner, acetone, or other commercial cleaners sold especially for freeing stuck valves.

CAUTION: Use these nozzle cleaning fluids in accordance with manufacturer's instructions.

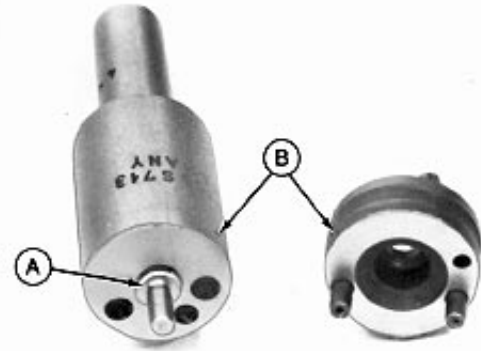
Do not permit lapped surfaces of valve and nozzle to come in contact with any hard substance. DO NOT touch valve unless your hands are wet with fuel.

CLEAN AND INSPECT FUEL INJECTION NOZZLE ASSEMBLY

IMPORTANT: Never use a steel brush to clean nozzles. Steel brush may damage injection nozzles.

1. Remove anti-corrosive coating from new or reconditioned nozzles by washing them thoroughly with diesel fuel.
2. Remove carbon from used nozzles and clean by washing them in diesel fuel. If parts are coated with hardened carbon or lacquer, it may be necessary to use a brass wire brush.
3. After removing carbon or lacquer from nozzle exterior, inspect lapped surface for nicks or scratches. Replace if not in good condition.
4. Inspect piston part of nozzle valve (A) to see that it is not scratched or scored. If any of these conditions are present, replace nozzle assembly.
5. Inspect nozzle valve seat, nozzle, and intermediate plate. Contact area of parts (B) must not be scored or pitted. Use inspection magnifier in JDF13 (JDE105) Nozzle Cleaning Kit to aid inspection.

NOTE: A bad nozzle valve seat will cause fuel to drip from nozzle. This condition will usually be noted when making the "Leakage Test".



RG3411 -UN-20DEC88

S11,0408,AU -19-05APR93

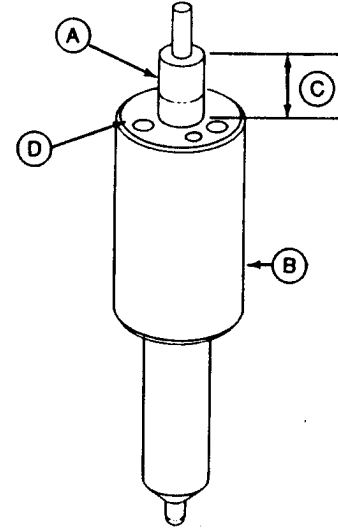
PERFORM NOZZLE SLIDE TEST

NOTE: DO NOT touch lapped surface (D) unless hands are wet with diesel fuel.

1. Dip nozzle valve (A) in clean diesel fuel.
2. Insert valve in nozzle (B).
3. Hold nozzle vertical and pull valve out about one-third of its engaged length (C).
4. Release nozzle valve. Valve should slide down to its seat by its own weight.

Always replace a nozzle assembly if valve does not slide freely to its seat.

A—Nozzle Valve
B—Nozzle
C—Free-Fall Distance
D—Lapped Surface



S11,3010,CZ -19-13MAY93

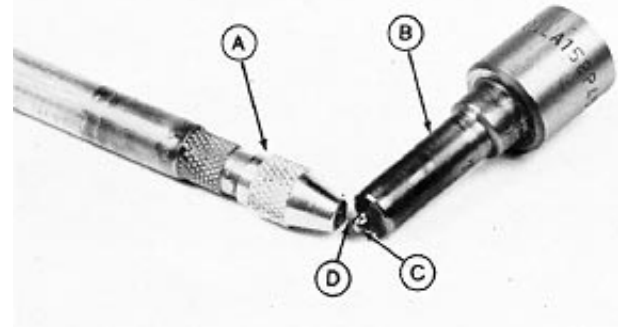
RG2233 -UN-12APR93

CLEAN SPRAY ORIFICES

1. Begin with cleaning wire (D) 0.07—0.10 mm (0.003—0.004 in.) from JDF13 (JDE105) Nozzle Cleaning Kit.

NOTE: Stoning wire to provide a flat surface on one side will help in reaming carbon from clogged hole.

2. Clamp cleaning wire in pin vise (A). Wire should not protrude from vise more than 0.8 mm (1/32 in.).
3. Insert wire into orifice (C) and rotate.
4. For final cleaning, use cleaning wire 0.03 mm (0.001 in.) smaller than orifice size. Follow previous steps until orifices are clean of any carbon deposits.



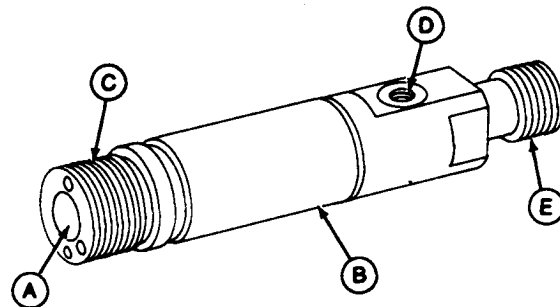
A—Pin Vise
B—Nozzle
C—Orifice
D—Cleaning Wire

RG,CTM42,G35,54-19-05APR93

RG5954 -UN-30AUG91

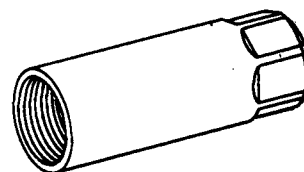
INSPECT NOZZLE HOLDER

1. Inspect lapped surface (A) on bottom end of nozzle holder (B) for nicks or scratches. Replace holder if not in good condition.
2. Inspect threads M19 x 0.75 (C), M6 x 1 (D), and M14 x 1.5 (E) on nozzle holder for general condition. Threads that are nicked slightly may be "dressed-up." Replace holder if threads cannot be restored to a serviceable condition.
3. Check fuel passages in nozzle holder to make sure they are open. Clean with compressed air.
4. Remove carbon deposits on both inner and outer surfaces of nozzle retaining nut.
5. Inspect retaining nut for cracks caused by overtightening or a damaged lower seating surface. A seat may be restored by rubbing surface with emery cloth. Any nozzle nut which cannot be reconditioned, must be replaced.



-UN-20DEC88

RG3413



-UN-20DEC88

RG2247

RG2247

- A—Lapped Surface
- B—Nozzle Holder
- C—M19 x 0.75
- D—M6 x 1
- E—M14 x 1.5

RG,CTM61,G35,30-19-05APR93

6. Examine lapped surfaces on intermediate plate (A) for nicks, scratches, or worn areas which would permit fuel to leak past.

7. Replace intermediate plate if lapped surfaces are worn or damaged.

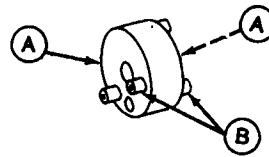
IMPORTANT: Do not lap machined surfaces of intermediate plate. Dowel pins (B) in plate have to be removed before surfaces can be lapped. Removing dowels is not recommended as removal is likely to damage them. Replacement dowels are not available as service parts.

8. Inspect spring seat for splitting, cracking, or excessive wear.

Replace seat if any of these conditions are evident.

RG2248

-UN-20APR89



RG2248

RG2249

-UN-20APR89



RG2249

S11,3010,DC -19-05APR93

9. Examine spring and shims for pitting or excessive wear.

Replace as necessary.

The edge-type filter is pressed into nozzle holder and is not removable for service.

10. Clean filter by applying compressed air to nozzle holder fuel passage (A) at nozzle end.



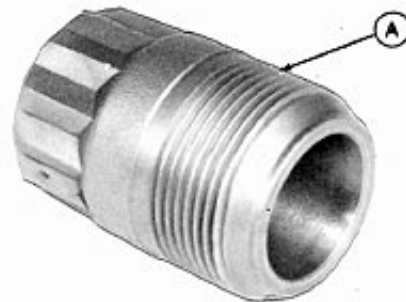
RG,CTM61,G35,31-19-05APR93

INSPECT GLAND NUT

1. Inspect nozzle holder gland nut for general condition, be sure that it is not cracked or split.

2. Inspect M28 x 1.5 threads (A) for general condition. Threads which are slightly nicked or damaged may be "dressed up."

Replace gland nut if unable to restore to a serviceable condition.

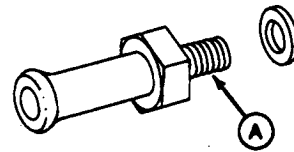


RG,CTM42,G35,57-19-05APR93

RG3888

-UN-20DEC88

3. Check passage in leak-off connector to see that it is open.
4. Blow through connector passage with compressed air.
5. Inspect M6 x 1 threads (A) for general condition. Replace connector if threads are damaged and can not be restored to a serviceable condition.



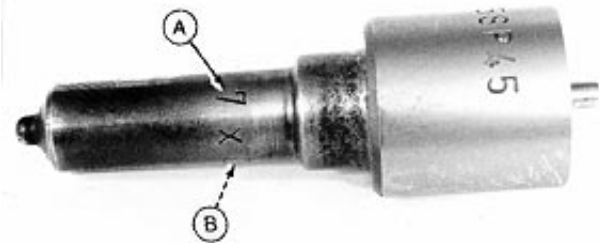
S11,0408,BG -19-05APR93

ASSEMBLE FUEL INJECTION NOZZLE

IMPORTANT: Be sure to install correct nozzle assembly on nozzle holder. Do not intermix different size nozzle assemblies.

To help determine correct nozzle assembly for each application, note markings on lower part of nozzle.

The illustration shows a nozzle marked 7 x 0.255. The number "7" (A) indicates the number of orifices and "0.255" (B) indicates the size of each orifice in millimeters.



RG5958 -UN-30AUG91

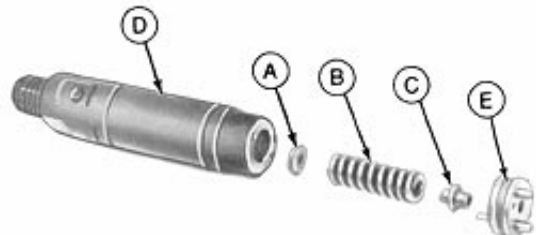
IMPORTANT: Immerse parts in clean fuel before assembly. DO NOT dry parts with towels or compressed air. Dust particles might collect and stay on pressure faces of nozzle valve and nozzle holder.

RG,CTM42,G35,35-19-03OCT92

1. Place shims (A), spring (B), and spring seat (C) in nozzle holder (D) while still wet with diesel fuel.

NOTE: Make sure intermediate plate (E) is free of any foreign material before reassembling.

- A—Shims
- B—Spring
- C—Spring Seat
- D—Nozzle Holder
- E—Intermediate Plate



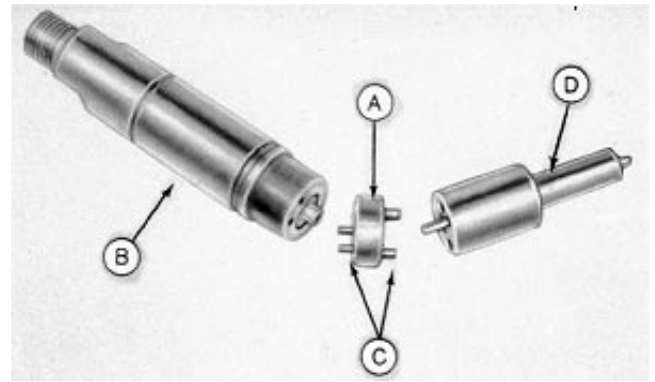
RG3415 -UN-20DEC88

S11,3010,DF -19-19JUL82

2. Position intermediate plate (A) on nozzle holder (B). Note dowel pins (C) in plate will permit installation only one way.

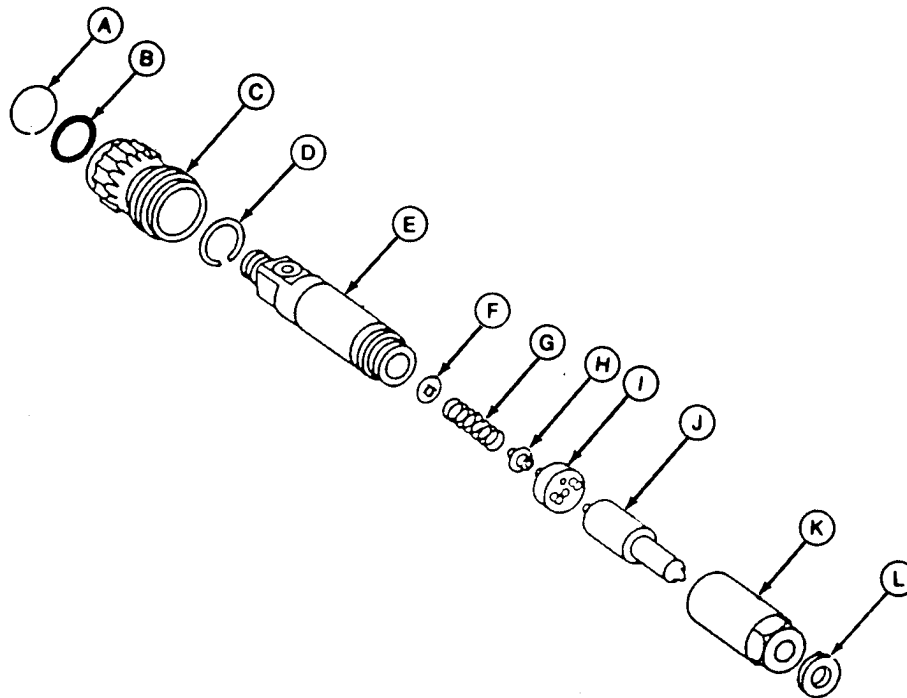
3. Insert nozzle valve into nozzle (D) while holding parts below diesel fuel level in pan.

A—Intermediate Plate
B—Nozzle Holder
C—Dowel Pins
D—Nozzle and Valve



S11,3010,DG -19-05APR93

RG2254 -UN-29NOV88



RG6184 -UN-24FEB92

A—Snap Ring (upper)
B—Gland Nut O-Ring
C—Gland Nut

D—Snap Ring (Lower)
E—Nozzle Holder
F—Shim

G—Nozzle Valve Spring
H—Spring Seat
I—Intermediate Plate

J—Nozzle
K—Nozzle Retaining Nut
L—Washer

4. Install nozzle assembly on nozzle holder (E) and secure with nozzle retaining nut (K).

5. Clamp nozzle holder in a soft-jawed vise. Tighten nozzle retaining nut (12) 88 N·m (65 lb-ft).

6. Install lower snap ring (D) on nozzle holder.

7. Coat bore of gland nut (C) liberally with PT569 NEVER-SEEZ compound to prevent gland nut from seizing on holder body.

8. Install upper snap ring (A) on nozzle holder and position O-ring (B) against gland nut.

9. Install leak-off connector on nozzle holder (E), using a new washer.

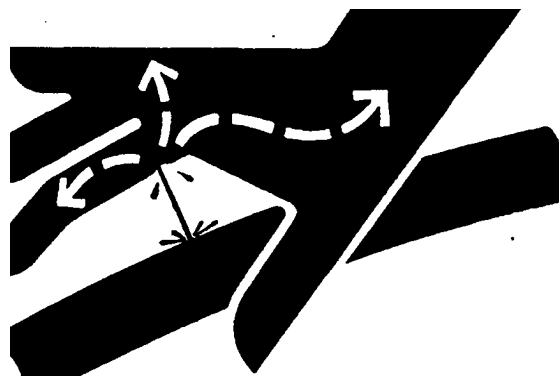
NOTE: Leak-off connector and washer should be installed on nozzle holder even though they will have to be removed to install injection nozzle in cylinder head. This will prevent misplacement of connector and washer before installation on engine.

ADJUST FUEL INJECTION NOZZLES

CAUTION: Nozzle tip should always be directed away from operator. Fuel from spray orifices can penetrate clothing and skin causing serious personal injury. Enclosing nozzle in a glass beaker is recommended.

Before applying pressure to nozzle tester, be sure all connections are tight, and fittings are not damaged. Fluid escaping from a very small hole can be almost invisible. Use a piece of cardboard or wood, rather than hands, to search for suspected leaks.

If injured by escaping fluid, 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 may call the Deere & Company Medical Department in Moline, Illinois, or other knowledgeable medical source.



X9811
-UN-23AUG88

1. Connect nozzle to nozzle tester, as directed earlier in this group.
2. Refer to PERFORM OPENING PRESSURE TEST, earlier in this group, to test opening pressure of nozzle. Adjust as needed.
3. Refer to PERFORM NOZZLE LEAKAGE TEST, earlier in this group, to test for leakage.
4. Refer to PERFORM CHATTER AND SPRAY PATTERN TEST, earlier in this group, to test nozzle overall operation.

S11,3010,OE -19-13MAY93

35
47

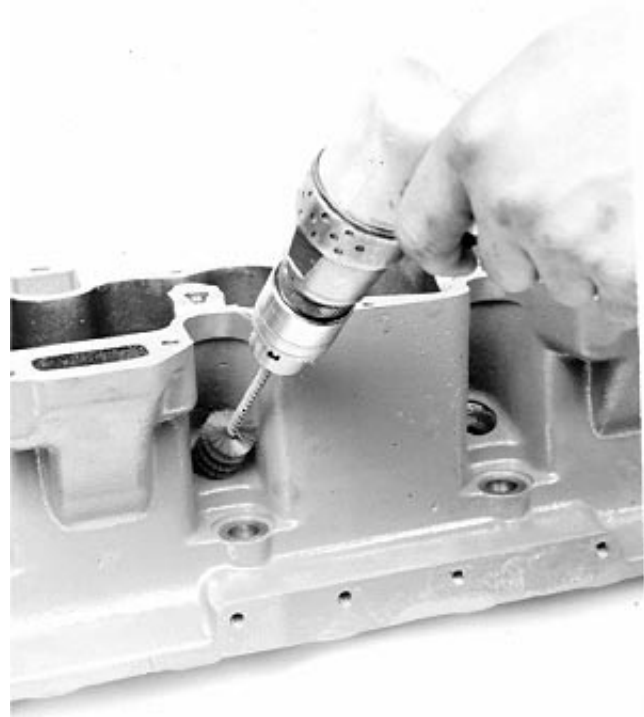
INSPECT AND CLEAN CYLINDER HEAD NOZZLE BORE

1. Inspect condition of threads for gland nut and nozzle seating surface in cylinder head.

Cylinder head threads and nozzle seating surface must be free of debris and carbon deposits.

IMPORTANT: If injection nozzle gland nut threads are not clean, a false torque reading may be obtained when injection nozzle is installed. This may prevent injection nozzle from seating properly in cylinder head.

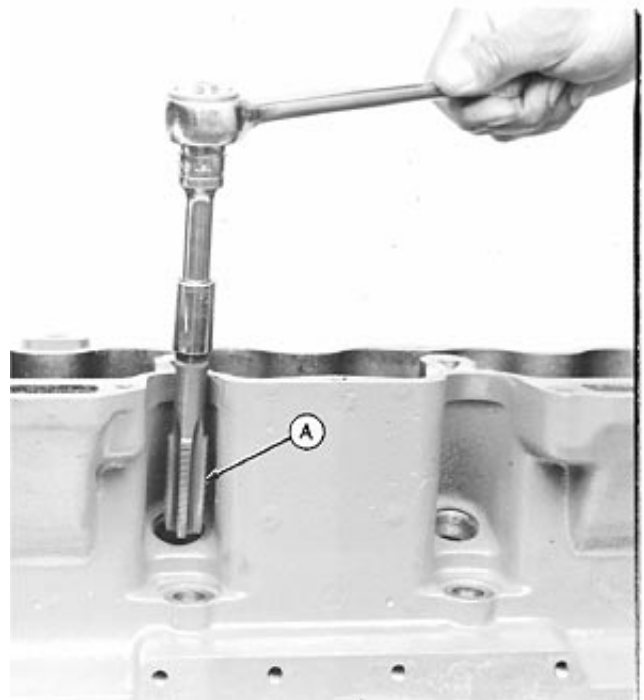
2. Clean threads which have light foreign deposits using a drill and D17030BR Nozzle Thread Cleaning Brush. Work brush up and down several times to clean threads.



RG6058 -UN-21JAN92

RG,CTM61,G5,34 -19-13MAY93

3. Clean threads with heavy foreign deposits or clean up damaged threads using JDF5 Tap or an equivalent M28 x 1.5 mm tap (A). Be sure to start tap straight to avoid possible cross-threading. A light coat of grease on tap will help collect foreign deposits on tap and prevent them from falling into nozzle tip bore.

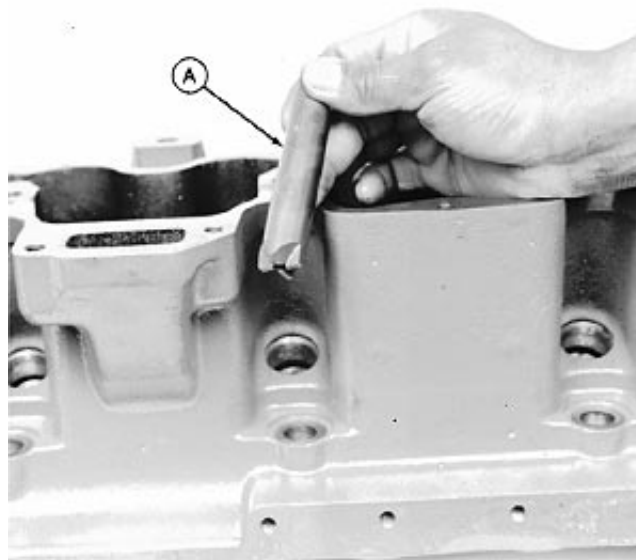


RG6059 -UN-21JAN92

RG,CTM61,G35,41-19-13MAY93

INSPECT AND CLEAN NOZZLE SEATING SURFACE

1. Clean nozzle seating surface by using the JDG609 Nozzle Seat Reamer (A) to remove carbon deposits.
2. Insert a 13 mm (1/2 in.) tapered hardwood dowel into nozzle tip bore.
3. Blow out debris with compressed air; then remove wood dowel.



RG,CTM61,G35,42-19-05APR93

-UN-21JAN92

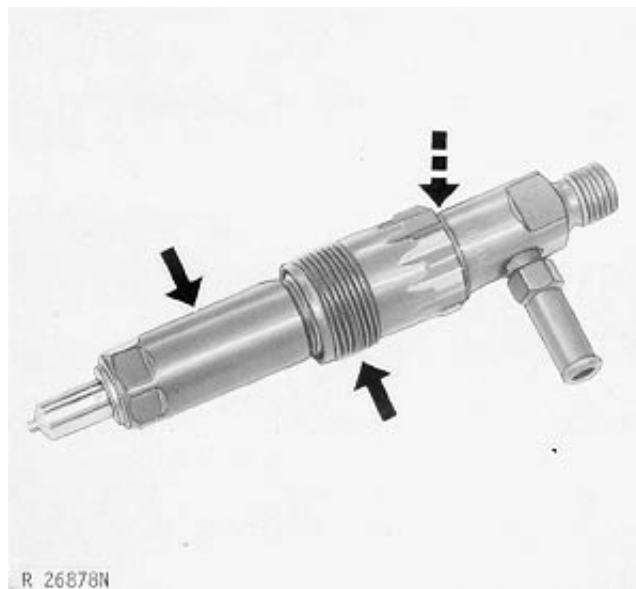
RG6060

INSTALL FUEL INJECTION NOZZLES

1. Apply PT569 NEVER-SEEZ compound to gland nut threads and nozzle barrel (arrows). Be sure that NEVER-SEEZ compound was also applied to inside bore of gland nut during assembly.

NOTE: Applying NEVER-SEEZ compound at these locations will help prevent possible seizure of gland nut to holder body.

IMPORTANT: Do not intermix injection nozzles of different suppliers or different tip sizes within any one engine.



R 26878N

S11,0408,BO -19-05APR93

-UN-20DEC88

R26878N

2. Install a new R84472 Special Steel Washer (A) on tip end of assembled injection nozzle.

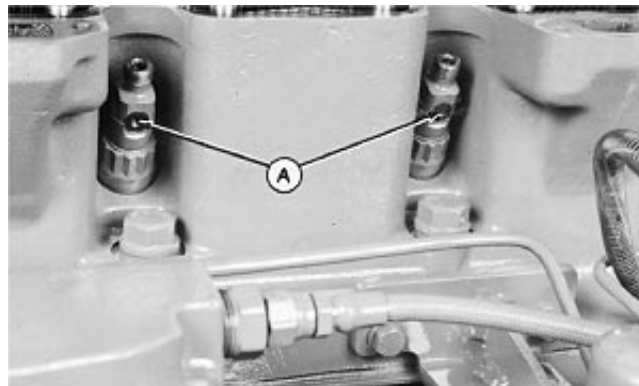


RG,CTM61,G35,46-19-13MAY93

-UN-20DEC88

RG3678

3. Insert injection nozzle into cylinder head. Turn gland nut by hand to make sure that it is threaded straight in cylinder head.
4. Use outer socket of JDE92 Nozzle socket and turn gland nut down to remove most of the looseness.
5. Rotate nozzle holder so that hole for leak-off connector threads (A) is facing straight out from cylinder head.



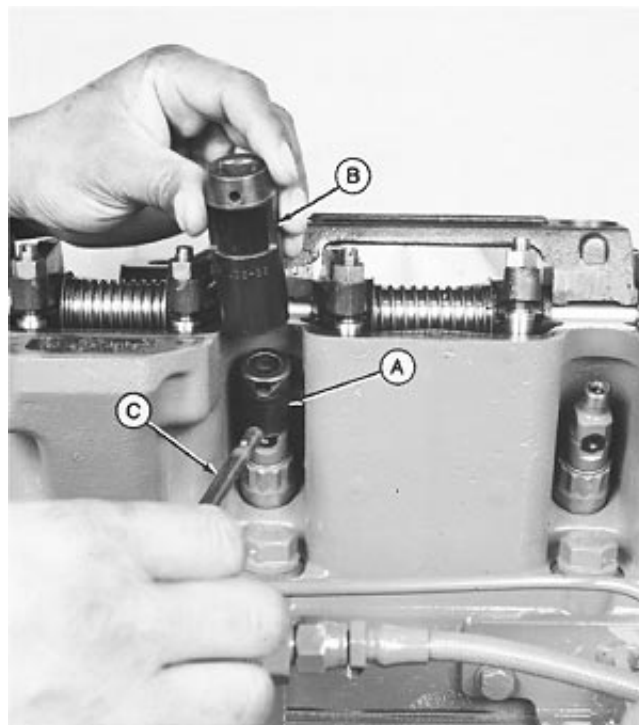
RG6185 -UN-24FEB92

RG,CTM61,G35,32-19-05APR93

In illustrations shown, rocker arm cover has been removed. This is not necessary when installing nozzles.

6. Position inner socket (A) over nozzle holder and engage with two flats at top of nozzle holder.
7. Place outer socket portion of JDE92 Nozzle Socket on gland nut with socket "window" (B) facing outward.
8. Insert handle (C) through window into inner socket. Ball detent in handle will keep it secured to inner socket.

NOTE: Handle simulates position of leak-off connector, which must be at 90° with engine to permit proper installation of leak-off lines.



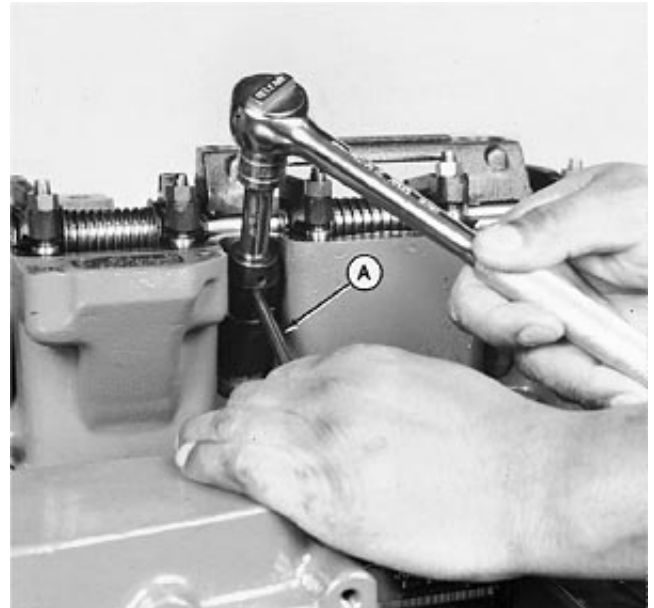
RG6186 -UN-12MAR92

RG,CTM61,G35,33-19-05APR93

9. Tighten injection nozzle gland nut to 75—88 N·m (55—65 lb-ft). Keep handle (A) pointing straight out while tightening.

Socket window is cut deep enough to obtain a new “bite” without removing inner socket.

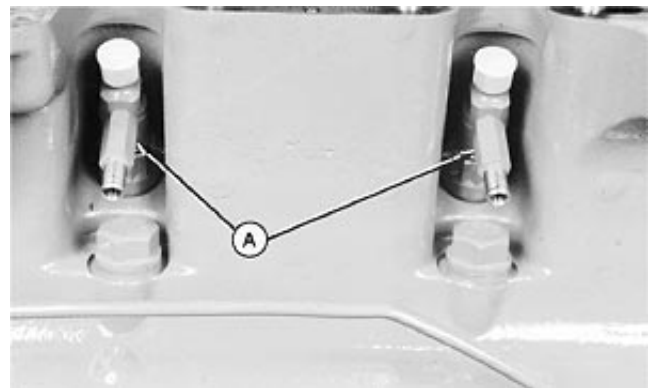
10. Be sure that O-ring is positioned against injection nozzle gland nut.



RG,CTM61,G35,34-19-05APR93

RG6187 -UN-12MAR92

11. Install leak-off connectors (A) with washers on injection nozzles. Tighten securely.



RG,CTM61,G35,35-19-17MAR92

RG6180 -UN-24FEB92

INSTALL FUEL LEAK-OFF AND FUEL DELIVERY LINE ASSEMBLIES

1. Before installing all-metal, multi-piece leak-off lines, loosen all fittings (A), remove pipes (B) and inspect all packings (C). Discard any packings that are worn or cut.

NOTE: Mark each leak-off pipe before disassembly to assure assembly in correct location.

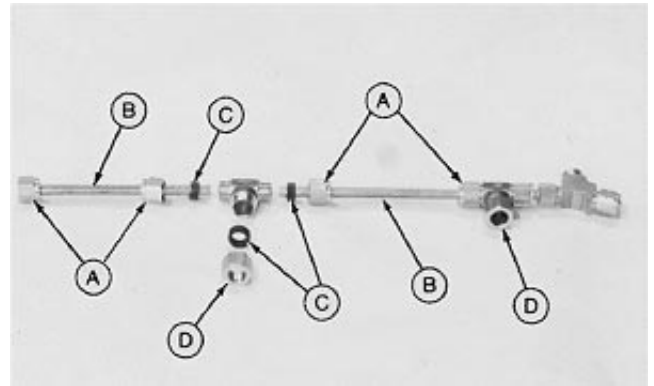
2. Check all pipes and fittings for wear or damage and replace as necessary.

3. Reinstall new packings (if needed), and pipes into tee-fittings. Tighten all connections securely.

4. Install nuts (D) and packing onto leak-off connectors. Install complete assembly over appropriate leak-off line connectors.

5. Tighten all leak-off line connections securely at each injection nozzle.

6. Connect leak-off line at injection pump and tighten securely.



A—Line Nuts
B—Packing
C—Packings
D—Connector Nuts

S55,3010,BM -19-05APR93

IMPORTANT: JDE90 Serrated Wrench (B) must be used to keep delivery valve fittings stationary while tightening fuel line nuts. If a delivery valve and barrel housing rotates while tightening a fuel line nut, injection pump fuel delivery will be altered. Pump will have to be recalibrated on a test stand.

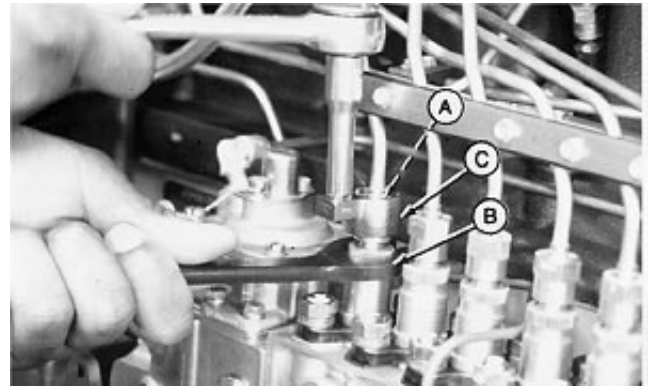
7. Remove protective caps and plugs from injection lines, nozzles, and delivery valves installed during disassembly. Install and connect injection line assembly at each respective injection nozzle and delivery valve.

8. Tighten fuel injection line nozzle nuts (A) to 27 N·m (20 lb-ft).

9. Tighten line nuts at delivery valves to 27 N·m (20 lb-ft) using JDF22 Crowsfoot Wrench (C) or a 3/4 in. Line Wrench (D) along with JDE90 Serrated Wrench.

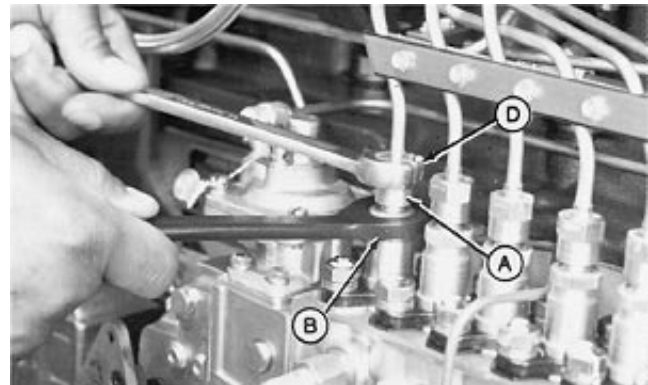
10. Install fuel delivery and fuel leak-off line clamps and tighten connections securely.

11. Bleed fuel system. See BLEED THE FUEL SYSTEM in Group 115.



-UN-07JUL89

RG5573



-UN-10NOV89

RG5574

A—Fuel Injection Line Nuts
B—JDE90 Serrated Wrench
C—JDF22 Crowsfoot Wrench
D—3/4 in. Line Wrench

S55,3010,BN -19-05APR93

35
54

ALTITUDE COMPENSATION GUIDELINE

Altitude, fuel temperature, air temperature, and humidity may affect engine performance. As a general rule, atmospheric changes will usually cause a decrease in engine power by the percentages shown in chart below.

ATMOSPHERIC CHANGE	% POWER DECREASE
Fuel Temperature Rise of 1°C (1.8° F) above 40°C (104°F)	0.29
Air Temperature Rise of 5.5° C (10° F) above 25°C (77°F)	0.50
Altitude Rise of 300 m (1000 ft) above 183 m (600 ft)	0.50*
Relative Humidity Rise of 10% above 0%	0.07

If engine required less fuel for acceptable performance at higher elevation, contact your local authorized fuel injection pump repair station for service.

** Engine may have to be defueled when a substantial percentage of operating time occurs at 2250 m (7500 ft) or higher.*

RG,CTM42,G100,6-19-13MAY93

PRELIMINARY ENGINE TESTING

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

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

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

3. Perform a dynamometer test and record power output. See DYNAMOMETER TEST later in this group. Repeat dynamometer test after tune-up. Compare power output before and after tune-up.

4. Perform compression test (See Group 105).

S11,22010,BW -19-13MAY93

GENERAL TUNE-UP RECOMMENDATIONS

The following services are recommended each time a tune-up is performed. Disregard those services that do not apply to any particular application.

Operation	Detailed Reference
Check overall engine for fuel, lubricant, and coolant leaks. Repair leaks as necessary.	
Change engine oil and filters.	Operator's Manual
Lubricate PTO clutch internal levers and linkage.	Operator's Manual
Replace fuel filter and water separator, if equipped.	Group 35/Operator's Manual
Clean crankcase ventilation assembly.	This Group/Operator's Manual
Replace air cleaner elements and check air intake system.	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. Replace if necessary.	Operator's Manual
Check electrical system.	This Group
Check crankshaft vibration damper.	Group 15/Operator's Manual
Inspect turbocharger and check turbocharger boost pressure.	Group 110
Check fuel injection system: Check engine-to-injection pump timing, clean injection nozzles, and adjust nozzle opening pressure.	Group 35 and 115
Check engine oil pressure. Adjust if necessary.	Group 105
Check engine valve clearance. Adjust if necessary.	Group 05/Operator's Manual
Check engine speeds. Adjust if necessary.	Group 115
Check engine performance on dynamometer.	Group 105

DYNAMOMETER TEST

*NOTE: High elevations may affect engine performance.
See ALTITUDE COMPENSATION GUIDELINES,
earlier in this group.*

1. Connect engine to dynamometer using manufacturer's instructions.
2. Operate engine at one-half load until coolant and crankcase oil temperatures are up to normal.
3. Run engine at fast idle.
4. Gradually increase load on engine until speed is reduced to rated speed rpm.
5. Read horsepower on dynamometer.
6. Compare readings taken with power rating level for your engine application listed on the following chart.

RG,CTM61,105,16-19-13MAY93

DYNAMOMETER TEST SPECIFICATIONS*

Engine Model	Option Code	Original (part no.)	Replaced By (part no.)	Governor Regulation	Rated Speed (rpm)	Fast Idle (rpm)	Power Ratings* kW (BHP)
6101HF	1601	RE46178	—	Std.	2100	2300	280 (375)
	1612	RE46178	—	Std.	2100	2300	280 (375)
	1632	RE42302	—	Electric	2100	2300	280 (375)
6101AF	1601	RE46179	—	Std.	2100	2300	224 (300)
	1602	RE42225	—	Std.	2100	2300	224 (300)
	1610	RE42226	—	3—5%	2100	2300	285 (382)
	1611	RE42302	—	Electric	1800	2100	285 (382)
	1612	RE46179	—	Std.	2100	2300	242 (324)
	1613	RE42225	—	Std.	2100	2300	225 (302)
	1614	RE42226	—	3—5%	1800	2000	285 (382)
	1632	RE42302	—	Electric	2100	2300	242 (324)

* Average power ratings are given; allow $\pm 5\%$ for maximum and minimum power. Specifications given are for OEM applications only. Refer to your machine technical manual for engine speeds that are different from those preset at the factory.

CTM61,GR105,7 -19-13MAY93

ENGINE BREAK-IN GUIDELINES

Engine break-in should be performed when the following repair have been:

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

RG,CTM61,G105,2-19-13MAY93

PERFORM ENGINE BREAK-IN

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

IMPORTANT: DO NOT use TORQ-GARD SUPREME PLUS-50™ engine oil during the first 100 hours of operation on a new engine or engine that has had a major overhaul. TORQ-GARD SUPREME PLUS-50 oil will not allow a new or overhauled engine to properly wear during this break-in period.

Fill engine crankcase with TORQ-GARD SUPREME™ multi-viscosity oil (according to expected ambient operating temperatures) to proper level for use during the break-in operation.

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

ENGINE BREAK-IN AFTER MAJOR OVERHAUL

Time	Load	Engine Speed*
5 Minutes	No Load	850 rpm
5 Minutes	No Load	1500—2000 rpm
5 Minutes	1/4 Load	1900—2100 rpm
10 Minutes	1/2 Load	1900—2100 rpm
10 Minutes	1/2—3/4 Load	1900—2100 rpm
10 Minutes	3/4—Full Load	Rated Speed

Check and readjust valve clearance as necessary. Cylinder head retorque is not required. (See Group 05, Cylinder Head and Valves.)

During the first 100 hours of operation, avoid over-loads, excessive idling, and no-load operation. Do NOT use foot throttle.

After 100 hours maximum, drain crankcase oil and change oil filter. Fill crankcase with oil of proper viscosity and service classification. See DIESEL ENGINE OIL in Group 02, Fuels, Lubricants, and Coolant.

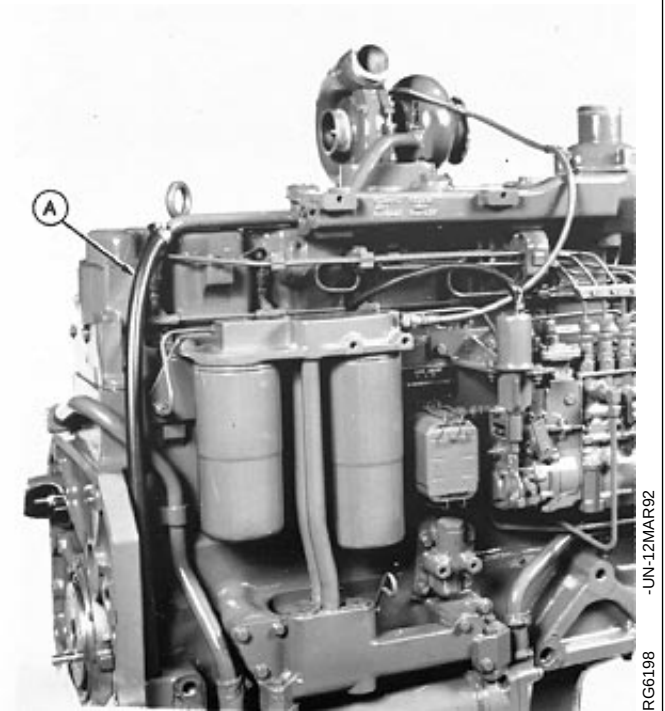
** Engine speeds listed are for engines equipped with a mechanical governor (8—10% regulation). For engines equipped with an electronic governor, run at rated speed.*

CTM61,G105,27 -19-13MAY93

CHECK CRANKCASE VENTILATION SYSTEM

Lack of ventilation causes sludge to form in engine crankcase. This can lead to clogging of oil passages, filters, and screens, resulting in serious engine damage.

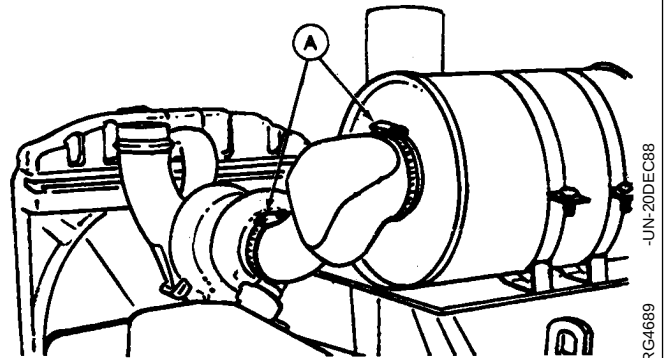
1. Inspect crankcase ventilation system for restrictions; clean as needed. See CLEAN AND INSPECT CRANKCASE VENTILATION ASSEMBLY in Group 05.
2. Clean crankcase vent tube (A) with solvent and compressed air if restricted. Install and tighten hose clamps securely.



RG.CTM61,G100,1-19-13MAY93

CHECK AIR INTAKE SYSTEM

1. Replace air cleaner primary filter element. Replace secondary element if primary element has holes in it.
2. Check condition of air intake hose(s). Replace hoses that are cracked, split, or otherwise in poor condition.
3. Check hose clamps (A) for tightness. Replace clamps that cannot be properly tightened. This will help prevent dust from entering the air intake system which could cause serious engine damage.



S11,22010,CU -19-13MAY93

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.

S55,22010,C -19-13MAY93

CHECK AND SERVICE COOLING SYSTEM



TS281 -UN-23AUG88



RG6209 -UN-06MAR92

1. Visually inspect entire cooling system and all components for leaks or damage. Repair or replace as necessary.
2. Remove trash that has accumulated on or near radiator.
3. Inspect radiator hoses for signs of leakage or rot. Replace hoses as necessary.



CAUTION: Do not drain coolant until it has cooled below operating temperature. Always loosen block drain valve (arrow) slowly to relieve any excess pressure.

4. Drain coolant, remove thermostats, and flush cooling system. See FLUSHING AND SERVICING COOLING SYSTEM in Group 02.

5. Test thermostat opening temperature. Replace defective thermostats as needed. See INSPECT THERMOSTAT AND TEST OPENING TEMPERATURE in Group 105.

IMPORTANT: Air must be expelled from cooling system when system is refilled. Loosen plug in water manifold to allow air to escape when filling system. Retighten plug when cooling system is full and all air has been expelled.

NOTE: If a coolant conditioner filter is used on engine, do not add additional inhibitors during coolant change; install a new coolant filter element.

6. Fill cooling system with recommended concentration of coolant, clean soft water, and inhibitors. (See ENGINE COOLANT RECOMMENDATIONS/SPECIFICATIONS in Group 02.)
7. Run engine until it reaches operating temperature. Check cooling system for leaks.
8. After engine cools, check coolant level.

NOTE: Coolant level should be approximately 19 mm (3/4 in.) below bottom of radiator filler neck.

9. Check system for holding pressure. See PRESSURE TEST COOLING SYSTEM and RADIATOR CAP in Group 105.

CHECK ELECTRICAL SYSTEM

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

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

Always remove grounded (-) cable clamp from battery first and replace it last.

1. Clean, test, and service batteries as detailed in operator's manual.
2. If batteries appear to be either undercharged or overcharged, check fan belt tension (Group 25) and charging circuit.
3. Check operation of starting motor and gauges.



S11,22010,CZ -19-13MAY93

TS204 -UN-23AUG88

RG4694 -UN-15DEC88

SPECIAL OR ESSENTIAL TOOLS

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

DX,TOOLS -19-05JUN91

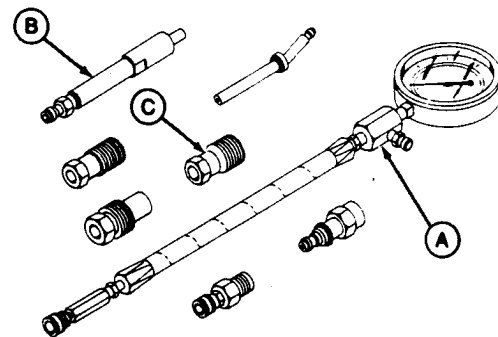
Compression Test Kit JT01674 (D14546BA)

A—Gauge and Hose Assembly JT01682 (D14547BA)

B—Nozzle Adapter JT01675A (D14557BA)

C—Adapter Nut JT01677

Used to test each cylinder's compression pressure.

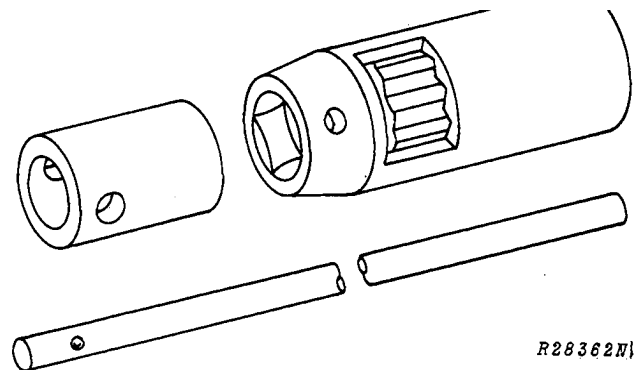


RG5784 -UN-09AUG91

RG, JT01674 -19-17SEP91

Nozzle Socket JDE92

Used to remove and install fuel injection nozzles.



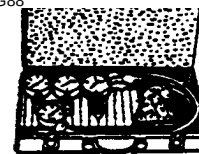
R28362N -UN-20DEC88

S11,22005,R -19-17SEP91

Universal Pressure Test Kit JT05470 (D15027NU)

Used for testing engine oil pressure.

RG5162 -UN-23AUG88



S55,22005,B -19-17SEP91

Flywheel Turning Tool JDE81-1

Rotate engine flywheel. Use with JDE81-4.

RG4950 -UN-23AUG88

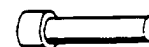


S53,JDE811 -19-07JUL89

Timing Pin JDE81-4

Lock engine at TDC when timing valve train. Use with JDE81-1.

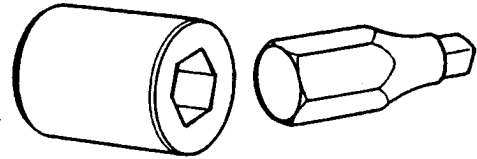
RG5068 -UN-23AUG88



S55,JDE814,B -19-24FEB88

Oil Galley Plug Tool JDG782

Used to remove and install oil galley plug.



RG6612 -UN-29JAN93

RG,JDG782 -19-02APR93

Cooling System Pressure Pump D05104ST

Used to pressure test radiator cap and cooling system.



R26406N -UN-29NOV88

S55,22005,C -19-17SEP91

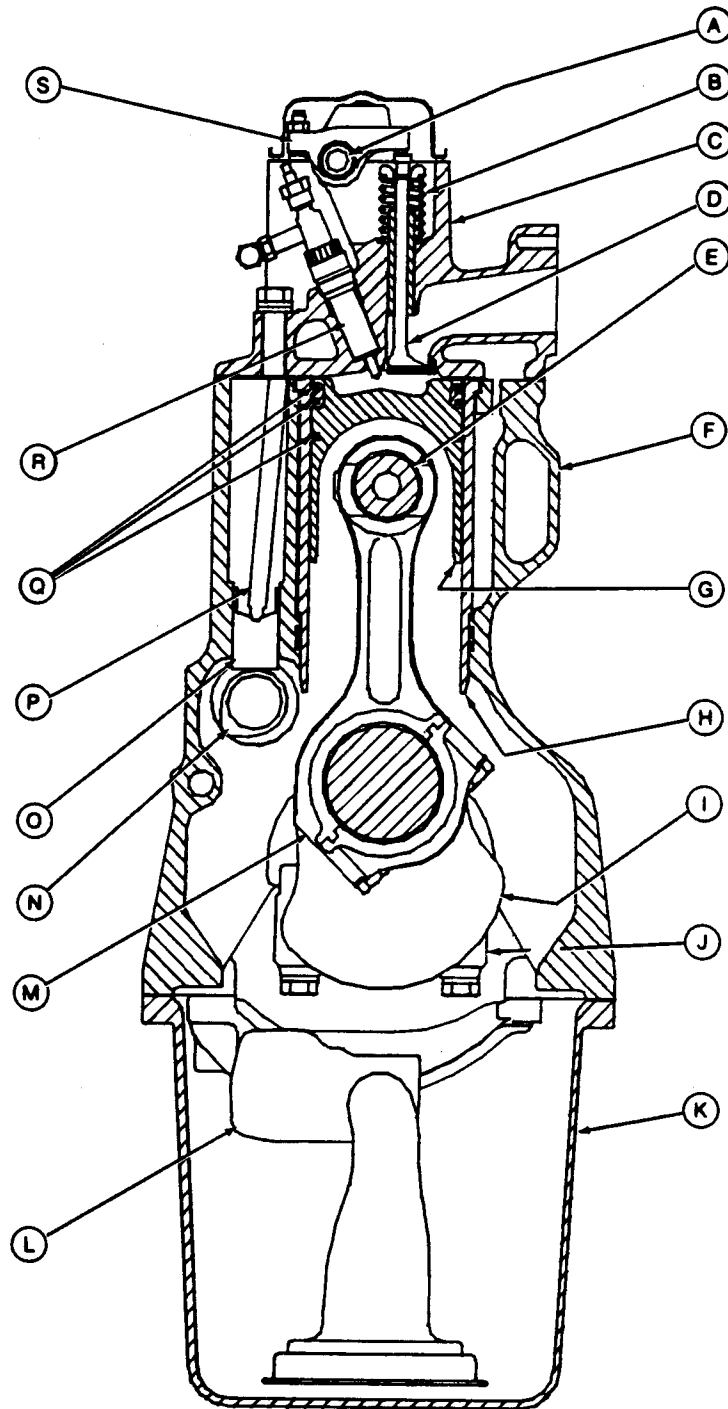
ENGINE TEST SPECIFICATIONS

ITEM	SPECIFICATION
Compression Pressure:	
(at 275—325 rpm cranking speed)	2480—2830 kPa (24.8—28.3 bar) (360—410 psi)
Maximum Variation between Cylinders	350 kPa (3.5 bar) (50 psi)
Engine Oil Pressure at 105°C (220°F) Sump:	
Minimum No Load at 800 rpm (Slow Idle)	103 kPa (1.03 bar) (15 psi)
Maximum Full Load at 2100 rpm (Rated Speed) . .	414 kPa (4.14 bar) (60 psi)
Oil Filter Bypass Valve Operating Pressure	210 kPa (2.10 bar) (30 psi)
Maximum Engine Blow-By at Crankcase Vent Tube:	
6101HF Engines	17 m ³ /h (600 cu ft/h)
6101AF Engines	17 m ³ /h (600 cu ft/h)
Cooling System and Radiator Pressure Cap	
Leakage Test Pressure*	50 kPa (0.5 bar) (7 psi)

* Applies to OEM applications with 50 kPa (0.5 bar) (7 psi) pressure caps. Refer to vehicle technical manual for recommended cooling system specifications.

RG.CTM61.G105,1-19-13MAY93

ENGINE SECTIONAL VIEW



RG6124 -UN-06FEB92

A—Rocker Arm Shaft
B—Valve Spring
C—Cylinder Head
D—Valve
E—Piston Pin

F—Cylinder Block
G—Piston
H—Cylinder Liner
I—Crankshaft
J—Main Bearing

K—Oil Pan
L—Oil Pump
M—Connecting Rod
N—Camshaft
O—Cam Follower

P—Push Rod
Q—Piston Rings
R—Fuel Injection Nozzle
S—Rocker Arm

105
4

GENERAL ENGINE DESCRIPTION

Model 6101 Engines are vertical stroke, in-line, valve in head, 6-cylinder engines.

Direct fuel injection is provided by an in-line, multi-plunger injection pump and 21 mm injection nozzles mounted in cylinder head. The pump is driven by an intermediate gear in the timing gear train connected to the camshaft gear.

6101 Engines are equipped with a turbocharger. Driven by exhaust gases, the turbocharger compresses intake air from air cleaner and routes it to the combustion chamber.

6101H Engines are air-to-air aftercooled, which incorporates a separate heat exchanger (usually attached to or physically close to the vehicle radiator) which cools the charge (intake) air before entering intake manifold. This heat exchanger uses no liquid as a means of cooling but relies strictly on air flow.

On 6101A Engines, the aftercooler functions as a heat exchanger. Engine coolant circulates through the aftercooler core and carries heat out of the aftercooler.

The high-carbide material camshaft is driven by the crankshaft gear. The camshaft rotates in precision honed bushings in machined bores of cylinder block at one-half engine speed (replaceable bushings are used).

Intake and exhaust valves are operated by camshaft followers, push rods and rocker arm assembly, valve seat inserts and positive rotators are used in cylinder head to increase valve seat life and to prevent valve stem scuffing.

The crankshaft is a one-piece, heat-treated, dynamically balanced, steel forging which rotates in replaceable two-piece main bearings. The rear thrust bearing has a flange on each side to reduce crankshaft deflection and to limit end play during high load operation.

Cylinder liners are of a wet sleeve, flanged, and centrifugally cast design. O-rings are used to seal the connection between cylinder block and liners. Liners are induction hardened and are replaceable as a matched piston-liner kit.

Pistons are cast of high-grade aluminum alloy and cam ground. The deep combustion chamber design provides maximum combustion efficiency. Two compression rings and one oil control ring are used. The top compression ring has self-cleaning characteristics that reduces ring groove deposits and eliminates ring sticking. The oil control ring is a cast iron rail type with expander.

The highly polished, hardened piston pins are full-floating and held in position by means of snap rings. Spray jets (piston cooling orifices) in cylinder block direct pressure oil to the underside of piston to lubricate piston pins and cool pistons.

The forged steel connecting rods have replaceable bushing and bearing inserts. They are selectively matched by weight within each engine to minimize engine vibration.

The engine lubrication system consists of a crankshaft-driven, positive displacement oil pump, an oil pressure regulating housing containing a pressure regulating valve. The oil filter manifold serves as a mounting base for the full flow and bypass oil filters, or the combination filter. Bypass valve housing contains both the oil cooler and oil filter bypass valves. Because of the thick viscosity of oil during extreme cold weather, an oil pressure relief valve is located in the oil pan as a safety measure.

Oil is pumped from the oil pan, by the oil pump into the oil bypass valve housing, into the oil pressure regulating valve housing and through the oil gallery in the cylinder block. Oil is then distributed, under pressure to each main bearing, piston cooling orifice, camshaft bearing, and cylinder head component.

The engine has a pressurized cooling system, consisting of radiator, water pump, multi-blade fan and three thermostats.

The cylinder block is a heavy-duty one piece block. On engines with directed coolant flow, two vertical passages nearest number 3 and 4 liner bores, are cross-drilled to deliver coolant to the passage created by the liners upper flange groove. This coolant is inter-connected by the cut-out voids in the block between liners.

HOW THE LUBRICATION SYSTEM WORKS

A—Oil Pump	I—ByPass Oil Check Valve*	Q—Connecting Rod Piston Pin Bushings	V—From Oil Pump
B—Engine Oil Cooler	J—Pressure Relief Valve	R—Turbocharger Oil Inlet Line	W—To Oil Cooler*
C—Full Flow Oil Filter	K—Main Oil Gallery	S—Turbocharger Oil Return Line	X—From Oil Cooler*
D—ByPass Oil Filter	L—Main Bearing	T—To Oil Pan	Y—Oil Pressure Regulating Valve Housing
E—Combination Filter	M—Piston Cooling Orifice	U—From Main Oil Gallery	Z—High Pressure Engine Oil
F—Oil Cooler ByPass Valve*	N—Connecting Rod Bearings		AA—Low Pressure Engine Oil
G—Oil Pressure Regulating Valve*	O—Camshaft Bushings		
H—Filter ByPass Valve*	P—Injection Pump Lube Line		

Refer to illustration on the following page.

The engine lubrication system consists of a gear-driven (crankshaft), positive displacement pump (A), oil cooler (B), full flow oil filter (C), bypass oil filter (D), oil cooler bypass valve (F), oil pressure regulating valve (G), filter bypass valve (H), bypass oil check valve (I), and pressure relief valve (J).

NOTE: On Engines beginning with Serial No. (500278—), a combination filter (E) serves as a full flow and bypass filter.

When excessively high viscosity oil (during cold starts) is sensed, oil is pumped from the oil pan through the oil pump (V) into the oil pressure relief valve housing which discharges oil back into the sump. The oil proceeds to the bypass valve housing and then through the oil cooler (W) where it exchanges heat with the coolant. If high restriction is sensed at the bypass valve housing, the oil bypasses the oil cooler and goes directly towards the oil filter. If excessively high restriction is sensed across the full flow oil filter or combination filter, oil is diverted directly to the main oil gallery.

If high restriction is sensed, such as during a cold start, oil bypasses the oil cooler through the oil cooler bypass valve and goes directly to the oil filter. If excessively high restriction is sensed at the filter, oil is diverted directly to the regulating valve. After flowing past the regulating valve; pressurized, cooled clean oil is supplied to the main oil gallery (K) in the cylinder block. Oil is then distributed, under pressure, to each main bearing (L) and piston cooling orifice (M).

During normal operation, oil from the oil cooler (X) or bypass valve housing goes up the outside vertical tube and enters the combination filter or full flow oil filter, migrating from the outside of the filter element

to the inside. Once the oil is filtered, it goes through the filter base towards the inside vertical tube. A small portion of this already filtered oil is diverted to the bypass filter for super cleaning and then to the oil pan sump. A check valve orifice controls the amount of oil to the bypass filter.

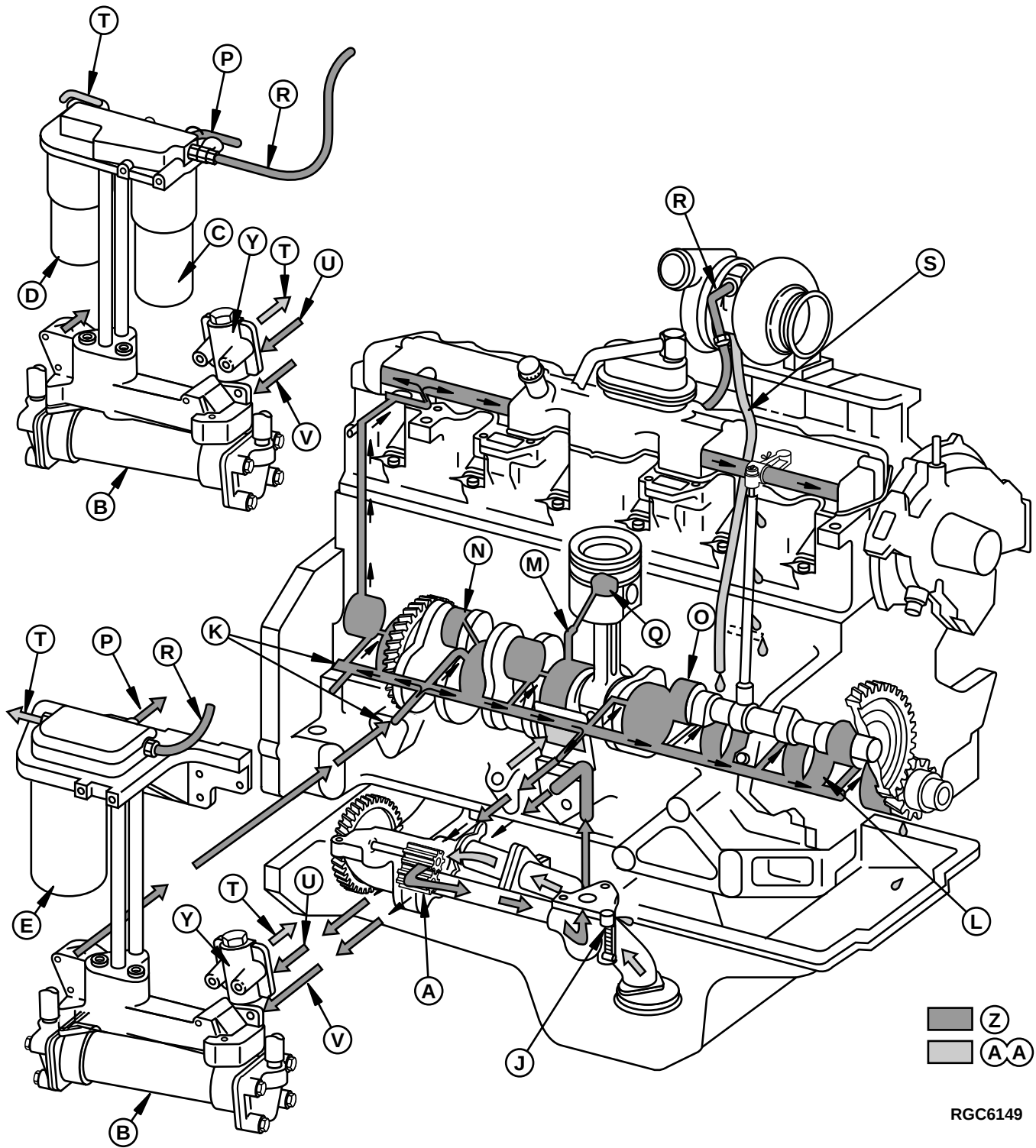
The majority of the filtered flow, however, is directed to the bypass valve housing and then on to the main oil gallery in the cylinder block. Engine oil pressure is sensed along this gallery by the oil pressure regulating valve and excess flow is diverted back to the sump to maintain an acceptable oil pressure operating level.

Drilled passages in the crankshaft distribute oil from the main bearing journals to the connecting rod journals to lubricate connecting rod bearings (N). Numbers 1, 3, 5 and 7 main bearing supports are also drilled to lubricate the four camshaft bushings (O). Oil from the front camshaft bushing is fed through a drilled hole in the camshaft nose which splash lubes the front gears. The injection pump is pressure lubed by the injection pump lube line (P).

A drilled passage from the rear camshaft bushing through the cylinder block and cylinder head provides lubrication to the rocker arm shaft. Oil from the shaft is distributed to the rocker arms. Oil from the rocker arms lubricates the other valve train components and camshaft followers.

The piston cooling orifices spray oil to cool pistons and liners and lubricate the connecting rod piston pin bushings (Q) through an oil cup in the top of the connecting rod.

Clean oil from the oil filter goes to the turbocharger oil inlet line (R) and is returned through the turbocharger oil return line (S). Oil completes the circuit by returning to the oil pan (T).



RG C6149
UN-18FEB97

RGC6149

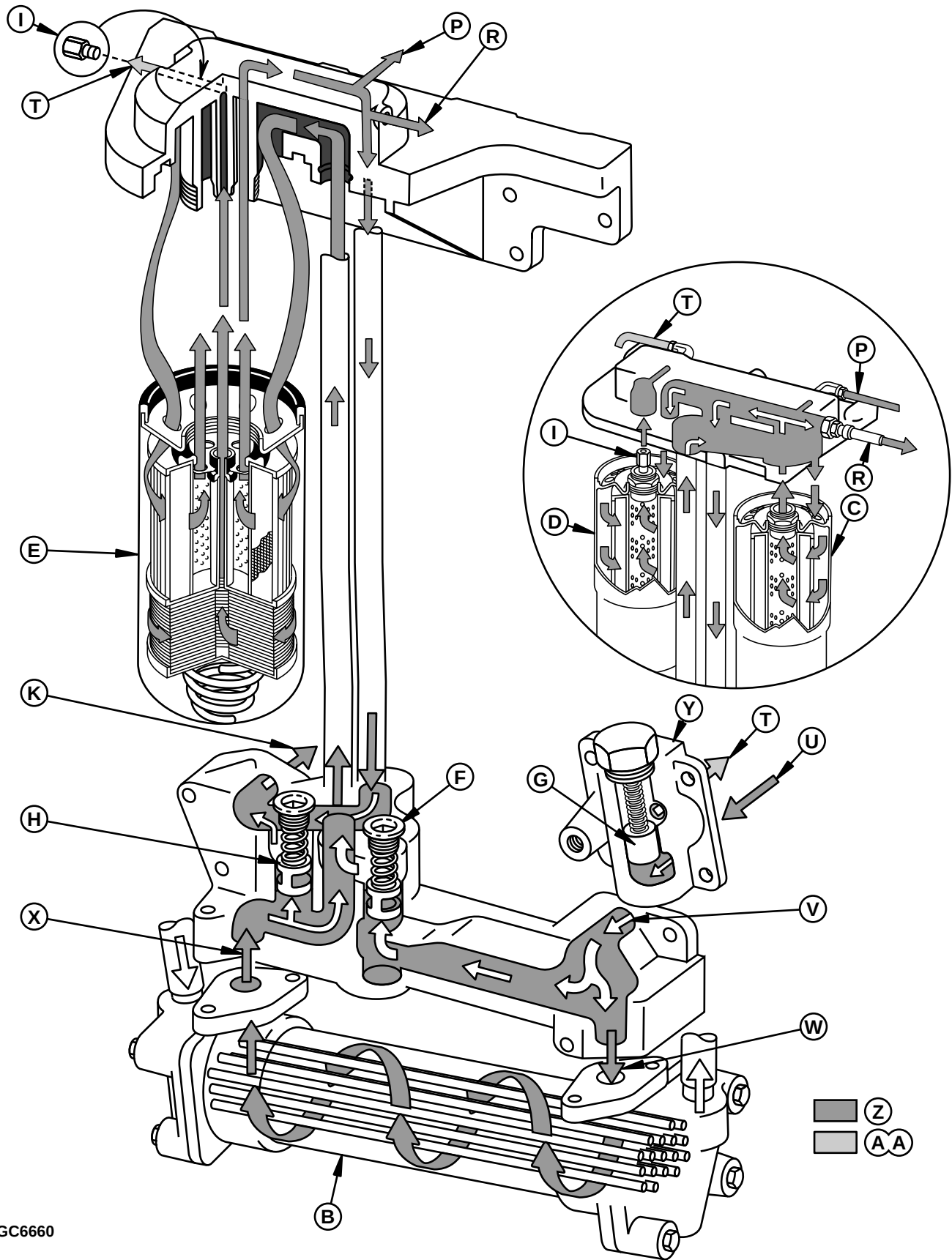
HOW THE LUBRICATION SYSTEM WORKS—CONTINUED

A—Oil Pump*	I—ByPass Oil Check Valve	Q—Connecting Rod Piston Pin Bushings*	V—From Oil Pump
B—Engine Oil Cooler	J—Pressure Relief Valve*		W—To Oil Cooler
C—Full Flow Oil Filter	K—To Main Oil Gallery	R—Turbocharger Oil Inlet Line	X—From Oil Cooler
D—ByPass Oil Filter	L—Main Bearing*	S—Turbocharger Oil Return Line*	Y—Oil Pressure Regulating Valve Housing
E—Combination Filter	M—Piston Cooling Orifice*		Z—High Pressure Engine Oil
F—Oil Cooler ByPass Valve	N—Connecting Rod Bearings*	T—To Oil Pan	AA—Low Pressure Engine Oil
G—Oil Pressure Regulating Valve	O—Camshaft Bushings*	U—From Main Oil Gallery	
H—Filter ByPass Valve	P—Injection Pump Lube Line		

Refer to illustration on the following page.

* Not shown on this artwork. Refer to artwork on HOW THE LUBRICATION SYSTEM WORKS, earlier in this group.

RG,CTM61,105,4C-19-13MAY93



RGC6660

RG,CTM61,105,4D-19-13MAY93

-JUN-18FEB97

RGC6660

105
9

HOW THE COOLING SYSTEM WORKS

A—Water Pump	J—To Water Pump	Q—Suction Side of Water Pump	W—From Cylinder Block
B—Thermostats (3 Used)	K—Cylinder Block Vertical Passages (2)	R—Cylinder Block Deck Passes	X—Aftercooler ("A" Engines)
C—Water Manifold	L—Liner Upper Flange Groove	S—Cylinder Head	Y—Aftercooler Core
D—Coolant Conditioner Filter	M—Cut-Out Voids in Block	T—ByPass Pipe	Z—To Water Pump
E—Water Pump Inlet	N—Cross Drilled Passages	U—Water Pump Inlet	AA—High Temperature Engine Coolant
F—Main Coolant Gallery	O—External Tubes	V—To Radiator	BB—Low Temperature Engine Coolant
G—To Oil Cooler	P—Suction Side of Water Pump		
H—Oil Cooler Tubes			
I—From Oil Cooler			

Refer to illustration on the following page.

The pressurized cooling system consists of a conventional radiator, water pump (A), thermostats (B), water manifold (C), and coolant conditioner filter (D). The pump pulls low temperature coolant from bottom of radiator and discharges it through the water pump inlet (E), into the main coolant gallery (F) on left-hand side of engine. Coolant from the main coolant gallery flows into the rear end of engine oil cooler cavity (G), passes through oil cooler tubes (H) to cool engine oil, and then flows out front end of oil cooler cavity (I) and back to water pump (J).

On directed coolant engines, two cylinder block vertical passages (K) nearest number 3 and 4 liner bores, are cross drilled to deliver coolant to the passage created by the liner upper flange groove (L). Liner flange coolant is inter-connected by cut-out voids in block (M) between liners. Cross drilled passages (N) at number 1 and 6 liner flanges direct return coolant through external tubes (O) to suction side of water pump (P).

Coolant enters coolant jacket near rear of engine, and flows around cylinder liners progressing upward toward cylinder head. As coolant circulates around cylinder liners, it carries excess heat away from liners.

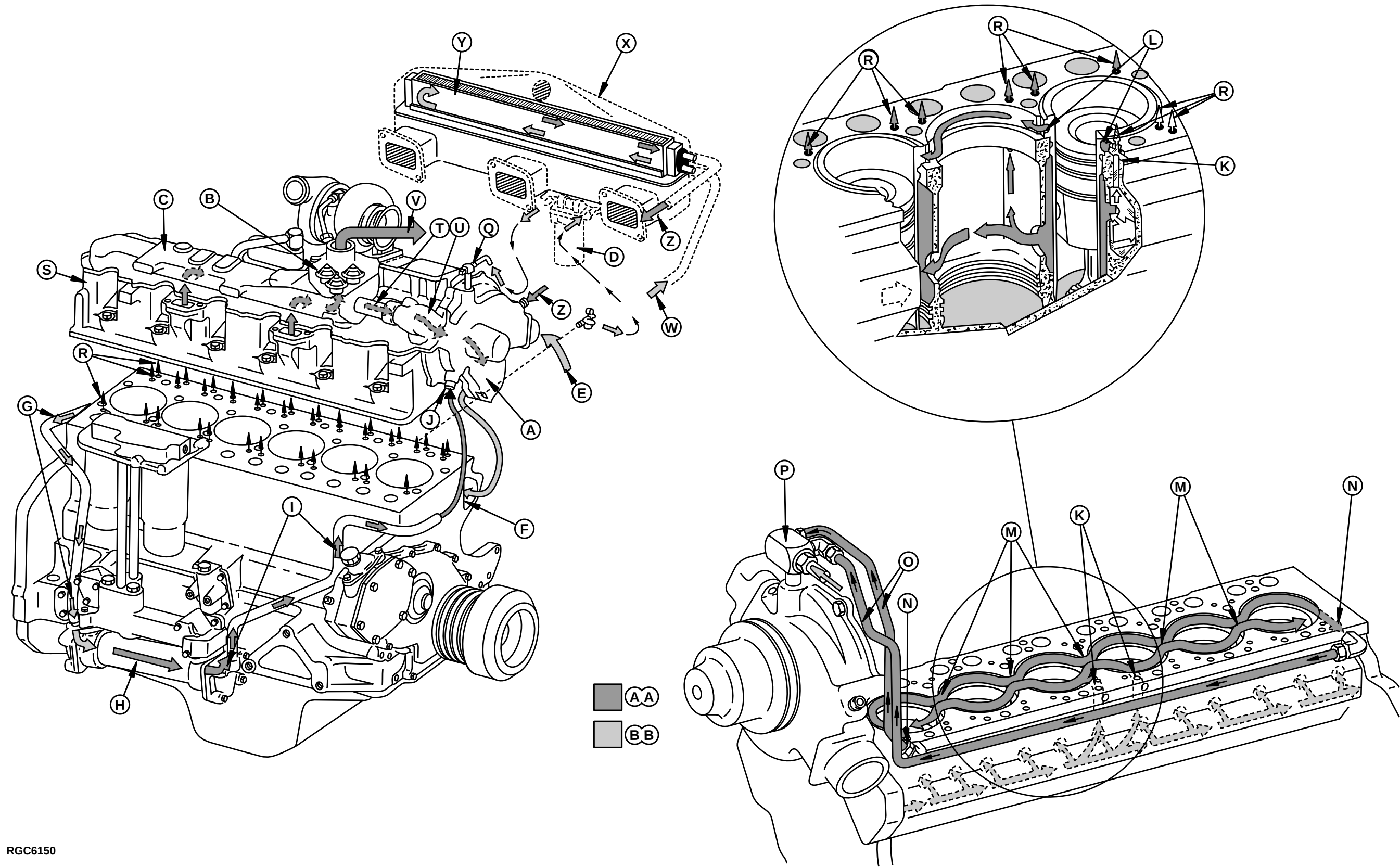
Additionally, coolant is drawn off main coolant gallery and routed through coolant conditioner filter canister. Here an anticorrosive chemical is added to coolant while any debris that may be present in cooling system is removed. Coolant returns to the system at suction side of water pump (Q).

Coolant flows through block deck passages (R) and cylinder head gasket into cylinder head (S). These coolant passages are sized to provide even coolant flow in all parts of cylinder head. Upon entering the head, coolant circulates through cavities around intake and exhaust ports, injection nozzle bores, valve guides, and valve seats to keep all parts of the head at acceptable temperature levels.

Coolant flows through the cylinder head where it passes into water manifold and thermostat housing. If coolant temperature in thermostat housing is below thermostat opening temperature, thermostats will remain closed (as during warm-up periods), causing coolant to be directed back through bypass pipe (T) and into water pump inlet (U) to be recirculated through the engine. This provides a faster and more uniform warm-up.

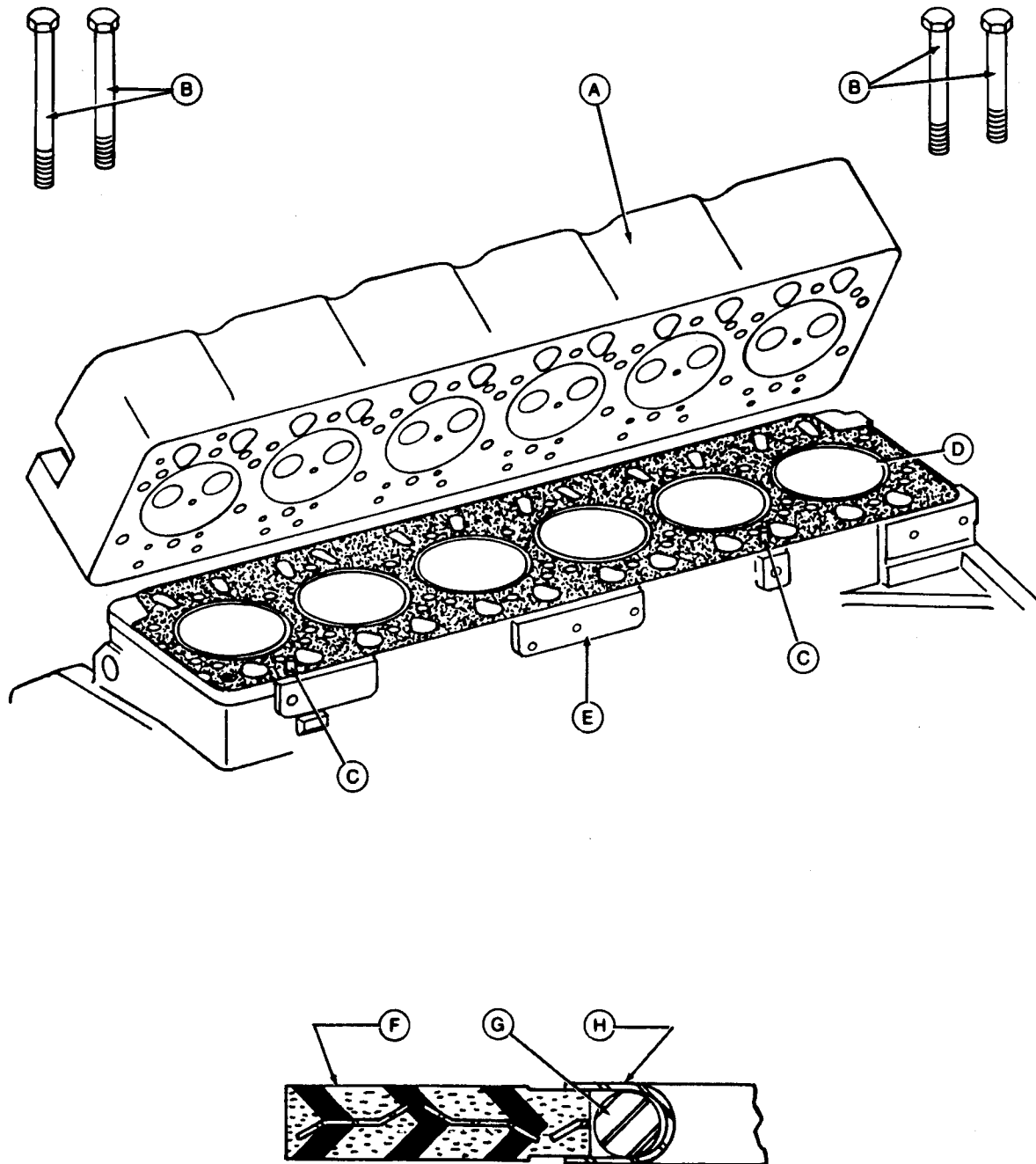
If coolant temperature in thermostat housing is above thermostat opening temperature, thermostats will be open (engine is at normal operating temperature) and coolant will flow through thermostats into thermostat cover and on to radiator top tank (V) to be cooled.

On aftercooled engines, coolant is taken from cylinder block (W) and routed into aftercooler (X) where it circulates through the aftercooler core (Y) and back out to water pump (Z). Coolant circulating through aftercooler absorbs heat from the pressurized intake air and carries heat back to engine cooling system to be dissipated through the radiator.



RGC6150

HEAD GASKET JOINT CONSTRUCTION AND OPERATION



A—Cylinder Head
B—Cylinder Head Cap
Screws

C—Dowel Pins
D—Cylinder Liners
E—Cylinder Block

F—Gasket Body
G—Fire Ring Combustion
Seal

H—Stainless Steel Flange

HEAD GASKET JOINT CONSTRUCTION AND OPERATION—CONTINUED

Refer to illustration on previous page.

The head gasket joint consists of:

- Cylinder head gasket (F)
- Cylinder head (A)
- Cylinder block (E)
- Cylinder liners (D)
- Cylinder head cap screws (B)

The head gasket must form an air-tight seal between cylinder liners and cylinder head that can withstand the temperatures and pressures of the combustion process. The gasket must also form a liquid-tight seal between the cylinder head and cylinder block to retain coolant and oil in their respective passages. The gasket is constructed of thin, formed sheets of steel-inserted, non-asbestos material. The surface of gasket is treated to improve liquid sealing and anti-stick characteristics. A fire ring combustion seal (G) is located at each cylinder bore and is held in place by a U-shaped stainless steel flange (H).

The cylinder head and block must be flat to provide an even clamping pressure over the entire surface of gasket, and must have the proper surface finish to keep gasket material from moving in the joint. Dowel pins (C) are used to properly locate head gasket on block.

The cylinder liners must protrude evenly from top of cylinder block the specified amount to provide adequate clamping force on fire ring of each cylinder.

The cap screws must be proper length, made of proper material, and be tightened to proper torque in order to provide an adequate clamp load between other joint components.

Each of the above components contributes to the integrity of the head gasket joint. If any of these components do not conform to specifications, gasket joint may fail resulting in combustion leaks, coolant leaks, or oil leaks.

Operating conditions such as coolant, oil, and combustion temperatures, and combustion pressures can reduce the ability of the head gasket joint to function properly. Failure of head gasket and mating parts may occur when coolant and oil temperatures become excessive, or when abnormally high combustion temperatures and pressures persist.

CTM61,G105,26 -19-13MAY93

DIAGNOSING HEAD GASKET JOINT FAILURES

Head gasket failures generally fall into three categories:

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

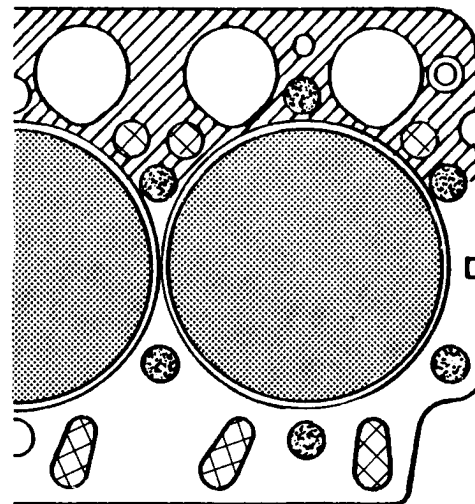
Combustion seal leakage failures occur when combustion gases escape between cylinder head and head gasket combustion flange, or between combustion flange and cylinder liner. Leaking combustion gases may vent to an adjacent cylinder, to a coolant or oil passage, or externally.

Coolant or oil seal leakage failures occur when oil or coolant escapes between cylinder head and gasket body, or between cylinder block and gasket body. The oil or coolant may leak to an adjacent coolant or oil passage, or externally. Since oil and coolant passages are primarily on right hand (camshaft) side of engine, fluid leaks are most likely to occur in that area.

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

1. Before starting or disassembling engine, conduct a visual inspection of machine, and note any of the following:

- Oil or coolant in head gasket seam, or on adjacent surfaces. Especially right rear corner of gasket joint.
- Displacement of gasket from normal position.
- Discoloration or soot from combustion gas leakage.
- Leaking radiator, overflow tank, or hoses.
- Leaking coolant from water pump weep hole.
- Damaged or incorrect radiator, fan, or shroud.
- Obstructed air flow or coolant flow.
- Worn or slipping belts.
- Damaged or incorrect pressure cap.
- Presence of oil in coolant.
- Low coolant levels.
- Improper coolant.
- Unusually high or low oil levels.
- Oil degradation, dilution, or contamination.
- Correctly specified injection pump.
- Indications of fuel or timing adjustments.
- Unburned fuel or coolant in exhaust system.



- A—Combustion Sealing Areas
 B—Coating Sealing Around Push Rod Holes
 C—Coolant Sealing Areas
 D—Cylinder Head Cap Screws

RG6664 -UN-13MAR93

2. Obtain coolant and oil samples for further analysis.

3. Start and warm up engine if it can be safely operated. Examine all potential leakage areas again as outlined previously. Using appropriate test and measurement equipment, check for the following:

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

4. Shut engine down. Recheck crankcase, radiator, and overflow tank for any significant differences in fluid levels, viscosity, or appearance.

5. Compare your observations from above steps with the following diagnostic charts. If diagnostic evaluations and observations provide conclusive evidence of combustion gas, coolant, or oil leakage from head gasket joint, the cylinder head must be removed for inspection and repair of gasket joint components.

RG,CTM8,G105,11-19-29OCT92

Combustion Seal Leakage

Symptoms:

- Exhaust from head gasket crevice
- Air bubbles in radiator/overflow tank
- Coolant discharge from overflow tube
- Engine overheating
- Power loss
- Engine runs rough
- White exhaust smoke
- Loss of cab heat
- Gasket section dislodged, missing (blown)
- Coolant in cylinder
- Coolant in crankcase oil
- Low coolant level

Possible Causes:

- Insufficient liner standout
- Excessive liner standout differential between cylinders
- Low head bolt clamping loads
- Rough/damaged liner flange surface
- Cracked/deformed gasket combustion flange
- Out-of-flat/damaged/rough cylinder head surface
- Missing/mislocated gasket fire ring
- Block cracked in liner support area
- Excessive fuel delivery
- Advanced injection pump timing
- Hydraulic or mechanical disturbance of combustion seal

NOTE: Cracked cylinder head or liners may also allow combustion gas leakage into coolant.

RG,CTM8,G105,12-19-16SEP92

Coolant Seal Leakage

Symptoms:

- Coolant discharge from head gasket crevice
- Coolant in crankcase oil
- Low coolant level
- High oil level
- Coolant discharge from crankcase vent

Possible Causes:

- Excessive liner standout
- Excessive liner standout differential between cylinders
- Low head bolt clamping loads
- Out-of-flat/damaged/rough block surface
- Out-of-flat/damaged/rough cylinder head surface
- Oil or coolant overheating
- Cracks/creases in gasket body surfaces
- Damage/voids in elastomer beading

NOTE: Cracked cylinder head, liners, liner packings, defective oil cooler or aftercooler may also allow coolant leakage into crankcase.

RG,CTM8,G105,13-19-13MAY93

Oil Seal Leakage

Symptoms:

- Oil discharge from head gasket crevice
- Oil in coolant
- Low crankcase oil level
- Reduced oil to rocker arms (noisy)

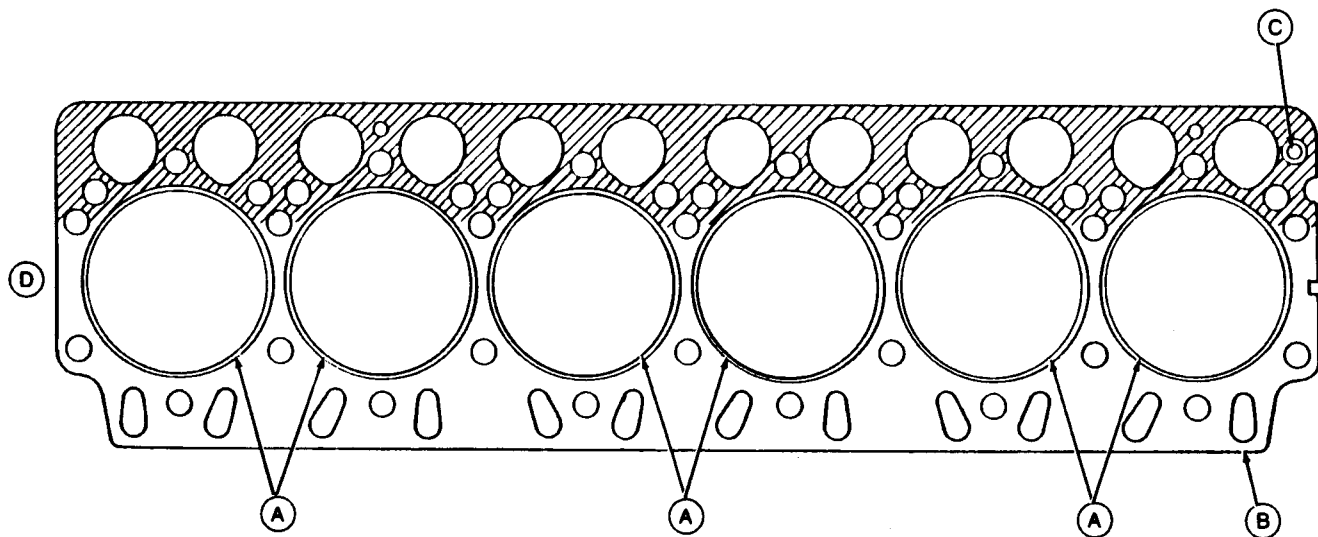
Possible Causes:

- Excessive liner standout
- Excessive liner standout differential between cylinders
- Low head bolt clamping loads
- Out-of-flat/damaged/rough block surface
- Out-of-flat/damaged/rough cylinder head surface
- Oil or coolant overheating
- Cracks/creases in gasket body surfaces
- Damage/voids in elastomer beading
- Damaged/missing O-ring seal at oil port to rocker arms

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

RG,CTM8,G105,14-19-16SEP92

HEAD GASKET INSPECTION AND REPAIR SEQUENCE



A—Combustion Seals
(Flanges)

B—Gasket Body

C—Rocker Arm Oil Port

D—Front of Engine

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

1. Review historical data relating to machine operation, maintenance and repair, along with diagnostic observations. Note all areas requiring further inspection and analysis.
2. Remove rocker arm cover and check for presence of coolant in the oil.
3. Record head cap screw torques prior to removal. Upon removal, check cap screw length differences.
4. Remove cylinder head using appropriate lifting devices to prevent handling damage to head gasket. See REMOVE CYLINDER HEAD in Group 05.

5. Observe surfaces of removed head gasket.

Examine combustion seals (A) for the following:

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

Examine gasket body (B) for the following:

- Combustion gas erosion paths or soot deposits originating at combustion seals.
- Extreme discoloration/hardening/embrittlement in localized areas.
- O-ring seal missing/damaged in port area (C).
- Oil or coolant paths from port areas.
- Localized areas of low compression.

6. Before cleaning components, inspect head, block, and liners for evidence of combustion gas and fluid leakage. Inspect cylinders and valve ports for unusual deposits.

RG6663 -UN-13MAR93

7. Clean block, head, liners, and cap screws. (See Groups 05 and 10.)

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

Cylinder Head (See Group 05.)

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

Cylinder Block and Liners (assembled and clamped) (See Group 05 or 10.)

- Check liner standout at four places on each liner.
- Check liner standout difference between cylinders.

Cylinder Block (See Group 10.)

- Check surface flatness/finish.
- Inspect for surface damage.
- Check liner counterbore depth (if liner is removed).
- Check top deck to crankshaft centerline dimension.
- Inspect cap screw bosses, must be clean/intact.

Cylinder Liner (See Group 10.)

- Check liner flange flatness/finish.
- Check liner flange thickness (if liner is removed).
- Inspect flange for damage.

Cylinder Head Cap Screws (See Group 05.)

- Inspect for corrosion damage.
- Inspect condition of threads.
- Inspect for straightness.
- Check length.

9. When inspections and measurements have been completed, determine most probable causes of joint failure. Make all necessary repairs to joint components, cooling system, and fuel injection system.

10. Reassemble the engine according to procedures and specifications in the repair groups of this manual.

CTM42,G105,18 -19-13MAY93

DIAGNOSING ENGINE MALFUNCTIONS

• Will Not Crank

Electrical System Malfunction

- Weak battery
- Corroded or loose battery connections
- Defective main switch or start safety switch
- Starter solenoid defective
- Starter defective

• Hard to Start or Will Not Start

Electrical System Malfunction

- Loose or corroded battery connections
- Weak battery
- Excessive resistance in starter circuit

Fuel System Malfunction - See Group 115

- Empty fuel tank
- Improper fuel
- Fuel shut off at tank
- Water, dirt or air in fuel system
- Plugged fuel filter
- Fuel shut-off cable not pushed in
- Dirty or faulty fuel injection nozzles
- Defective fuel injection pump
- Defective fuel supply pump
- Fuel injection pump incorrectly timed

Service Problem

- Too high viscosity crankcase oil

• Engine Runs Irregularly or Stalls Frequently

Basic Engine Problem

- Coolant temperature too low
- Improper valve clearance
- Cylinder head gasket leaking
- Worn or broken compression rings
- Valves sticking or burned
- Exhaust system restricted
- Engine compression too low
- Engine overheating
- Worn camshaft lobes

Fuel System Malfunction - See Group 115

- Defective fuel injection pump
- Low fuel supply
- Air in fuel
- Vent on fuel tank cap obstructed
- Fuel injection nozzles defective or leaking
- Fuel filter or fuel lines restricted
- Defective fuel supply pump
- Fuel injection pump incorrectly timed

Service Problem

- Improper fuel

• Engine Misfiring

Service Problem

- Water in fuel
- Mixture of gasoline and diesel fuel

Fuel System Malfunction - See Group 115

- Air in fuel system
- Defective fuel injection nozzles
- Defective fuel injection pump
- Fuel injection nozzles improperly installed
- Leaking fuel injection nozzle seals
- Worn or defective fuel supply pump
- Fuel injection pump incorrectly timed

Basic Engine Problem

- Engine overheated
- Lobes of camshaft worn
- Weak valve springs
- Pre-ignition
- Engine compression too low
- Improper valve clearance
- Burnt, damaged or stuck valves

• Lack of Engine Power

Service Problem

- Air cleaner restricted or dirty
- Excessive resistance in air intake system
- Improper crankcase oil
- Improper fuel
- Restricted exhaust system

Fuel System Malfunction - See Group 115

- Fuel filter restricted
- Defective fuel supply pump
- Defective fuel injection pump
- Fuel injection pump incorrectly timed
- Faulty injection nozzles
- Plugged fuel tank vent

Basic Engine Problem

- Engine overheated
- Engine clutch slipping
- Defective cylinder head gasket
- Lobes of camshaft worn
- Improper valve clearance
- Improper valve timing
- Burnt, damaged or stuck valves
- Weak valve springs
- Piston rings and cylinder liners excessively worn
- Engine compression too low
- Improper coolant temperature

DIAGNOSING ENGINE MALFUNCTIONS—CONTINUED

• Low Oil Pressure

Basic Engine Problem

- Stuck or improper regulating valve adjustment
- Excessive main and connecting rod bearing clearance
- Plugged oil pump intake screen
- Faulty bypass oil check valve
- Leakage at internal oil passages
- Faulty oil pump

Service Problem

- Low oil level
- Improper viscosity of oil
- Faulty gauge

• High Oil Pressure

Basic Engine Problem

- Stuck or improperly adjusted regulating valve

• Excessive Fuel Consumption

Basic Engine Problem

- Low compression

Fuel System Malfunction - See Group 115

- Leaks in fuel system
- Restricted air cleaners
- Faulty injection pump timing
- Improper valve clearance
- Service problem
- Improper grade of fuel

Fuel System Malfunction - See Group 115

- Excessive fuel delivery
- Faulty injection nozzles
- Restricted air cleaners
- Improper injection pump timing

• Slow Acceleration

Fuel System Malfunction - See Group 115

- Faulty injection pump
- Faulty injection nozzles

• Detonation

Fuel System Malfunction - See Group 115

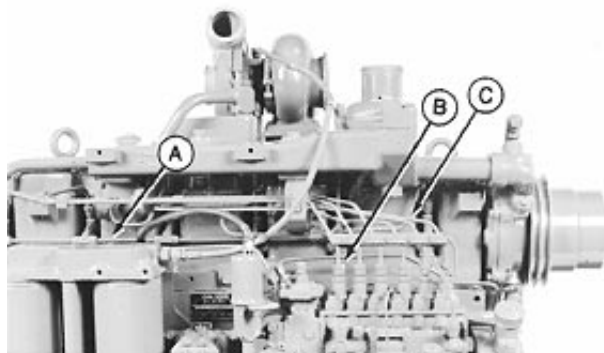
- Faulty injection pump
- Faulty injection nozzles
- Improper fuel

• Abnormal Engine Noise

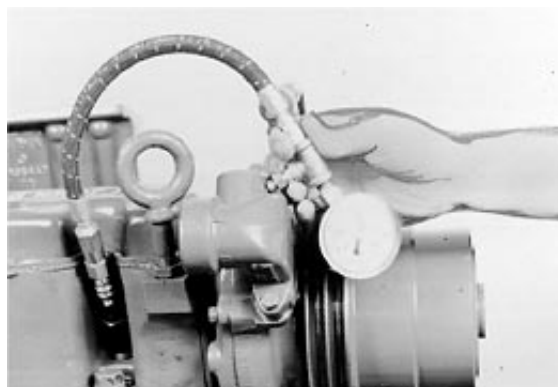
Basic Engine Problem

- Low engine oil level
- Excessive valve clearance
- Worn cam followers
- Bent push rods
- Worn rocker arm shafts
- Worn main or connecting rod bearings
- Foreign material in combustion chamber
- Worn Piston pin bushings and pins
- Scored piston
- Incorrect engine timing
- Excessive crankshaft end play
- Loosen main or connecting rod bearing caps
- Crankshaft oil pump drive gear worn or broken
- Crankshaft vibration damper worn or separated

TEST ENGINE COMPRESSION PRESSURE



RG6179 -UN-24FEB92



RG6210 -UN-14APR93

IMPORTANT: Compression pressures are affected by the cranking speed of the engine. Before beginning test, insure that batteries are fully charged and injection nozzle area is thoroughly cleaned.

1. Start engine and run at rated speed until it warms up to normal operating temperature. From a cold start, operate engine 10—15 minutes.

2. Remove V-belts from engine and remove water manifold.

3. Disconnect fuel delivery lines (C) at injection pump delivery valves (B) and nozzles. Remove delivery lines as an assembly.

4. Disconnect leak-off assembly (A) from nozzles and remove. Remove ALL injection nozzles from cylinder head.

5. Install the JT01675A Nozzle adapter and JT01677 Adapter Nut into injection nozzle bore. Tighten adapter nut to 80 N·m (60 lb-ft).

6. Connect JT01682 Gauge and Hose Assembly to nozzle adapter.

7. Crank engine over at 275—325 rpm cranking speed and record compression readings.

ENGINE COMPRESSION

Engine	Compression Pressure
6101AF, 6101HF	2480—2830 kPa (24.8—28.3 bar) (360—410 psi)
Maximum variation between cylinders	340 kPa (3.4 bar) (50 psi)

NOTE: Pressure given was taken at 183 m (600 ft) above sea level. A 3.6 percent reduction in gauge pressure will result for each additional 300 m (1000 ft) rise in altitude.

8. If pressure is much lower than shown, remove gauge and apply oil to ring area of piston through injection nozzle bore. Do not use too much oil and do not get oil on valves.

9. Crank engine over and record compression reading again.

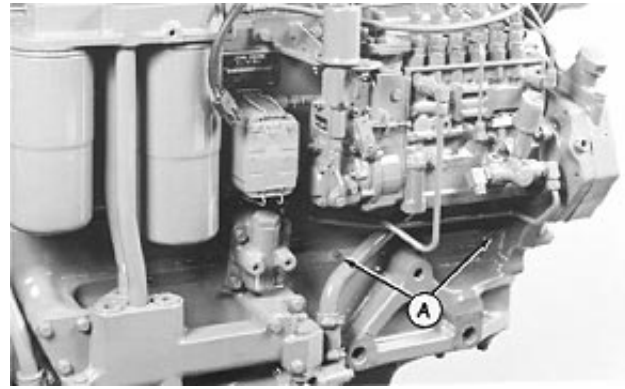
If pressure is higher than 2830 kPa (28.3 bar) (410 psi), worn or stuck rings are indicated. Either replace piston rings or install new piston and liner set as needed. (See Group 10.)

If pressure is below 2480 kPa (24.8 bar) (360 psi), it is possible that valves are worn or sticking. Recondition cylinder head as needed. (See Group 05.)

10. Measure compression pressure in all remaining cylinders and compare readings. Recondition cylinders and valves as required.

CHECK ENGINE OIL PRESSURE

1. Remove one pipe plug (A) from main oil galley using JDG782 Oil Galley Plug Tool.



RG6200
-UN-03MAR92

RG,CTM61,G105,5-19-13MAY93

2. Install No. 2106 (19-HP) Hose (A) with JT05472* Gauge (B) into main oil gallery hole.

IMPORTANT: To achieve an accurate oil pressure reading, warm up engine crankcase oil to 105°C (220°F) or high oil pressure readings will occur.

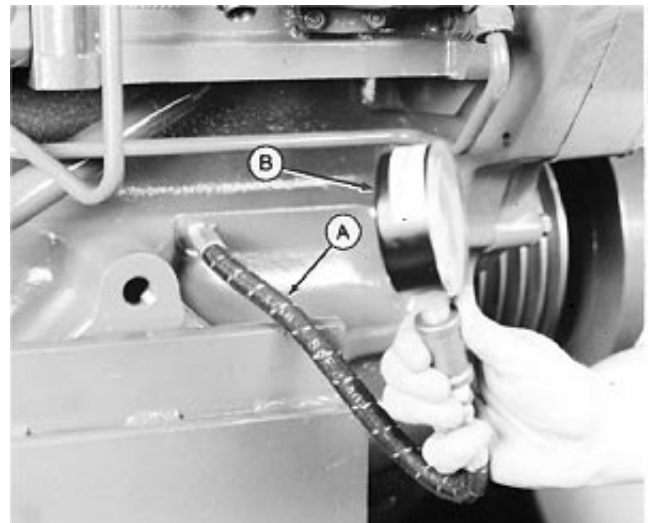
3. Measure oil pressure at slow idle (no load) and rated speed (full load) as specified below.

OIL PRESSURE SPECIFICATIONS

Minimum No Load at 800 rpm (Slow Idle)	103 kPa (1.03 bar) (15 psi)
Maximum Full Load at 2100 rpm (Rated Speed)	414 kPa (4.14 bar) (60 psi)

NOTE: To adjust oil pressure, remove regulating valve spring at filter base and add washers to increase oil pressure and remove washers to decrease oil pressure.

IMPORTANT: Do not use more than a total of five washers.



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-UN-06MAR92

* Part of JT05470 (D15027NU) Universal Pressure Test Kit

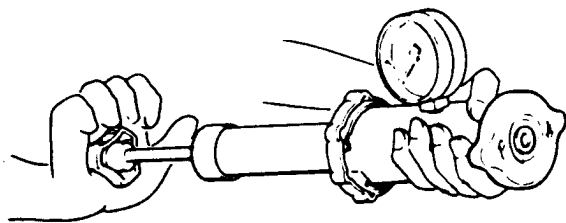
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MEASURE ENGINE CRANKCASE PRESSURE (BLOW-BY)

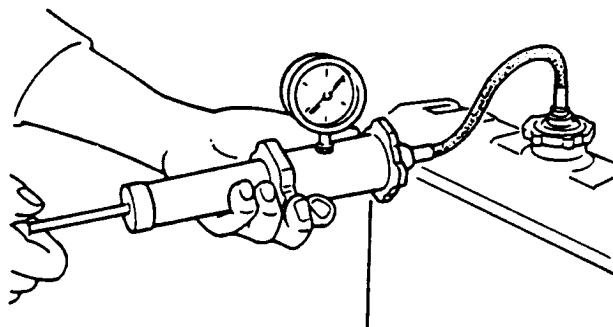
1. Place a hose with a standard gas gauge in end of crankcase vent tube.
2. Run engine at rated speed and load. Engine should be at operating temperature and run-in (with at least 100 operating hours).
3. Measure blow-by over a period of 5 minutes. Multiply figure obtained by 12 (hourly rate) and check against Engine Test Specifications, earlier in this group.
4. If blow-by is lower, there probably is no undue wear between piston rings and liners. If blow-by is higher, there could be excessive wear between piston rings and liners, resulting in loss of engine power. An overhaul of the engine should be considered only after other possible repair options (if any) are evaluated.

CTM8,GR105,16 -19-13MAY93

PRESSURE TEST COOLING SYSTEM AND RADIATOR CAP



RG6557 -UN-20JAN93



RG6558 -UN-20JAN93

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

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

Test Radiator Cap:

1. Remove radiator cap and attach to an approved tester as shown.
2. Pressurize cap to 50 kPa (0.5 bar) (7 psi)*. Gauge should hold pressure for 10 seconds within the normal range if cap is acceptable.

If gauge does not hold pressure, replace radiator cap.

3. Remove the cap from gauge, turn it 180°, and retest cap. This will verify that the first measurement was accurate.

Test Cooling System:

NOTE: Engine should be warmed up to test overall cooling system.

1. Allow engine to cool, then carefully remove radiator cap.
2. Fill radiator with coolant to the normal operating level.

IMPORTANT: DO NOT apply excessive pressure to cooling system, doing so may damage radiator and hoses.

3. Connect gauge and adapter to radiator filler neck. Pressurize cooling system to 50 kPa (0.5 bar) (7 psi)*.
4. With pressure applied, check all cooling system hose connections, radiator, and overall engine for leaks.

If leakage is detected, correct as necessary and pressure test system again.

If no leakage is detected, but the gauge indicated a drop in pressure, coolant may be leaking internally within the system or at the block-to-head gasket. Have your servicing dealer or distributor correct this problem immediately.

INSPECT THERMOSTAT AND TEST OPENING TEMPERATURE

Visually inspect thermostat for corrosion or damage.
Replace as necessary.

- Test thermostat as follows:



CAUTION: DO NOT allow thermostat or thermometer to rest against the side or bottom of container when heating water. Either may rupture if overheated.

1. Suspend thermostat and a thermometer in a container of water.
2. Stir the water as it heats. Observe opening action of thermometer and compare temperatures with specification given in chart below.

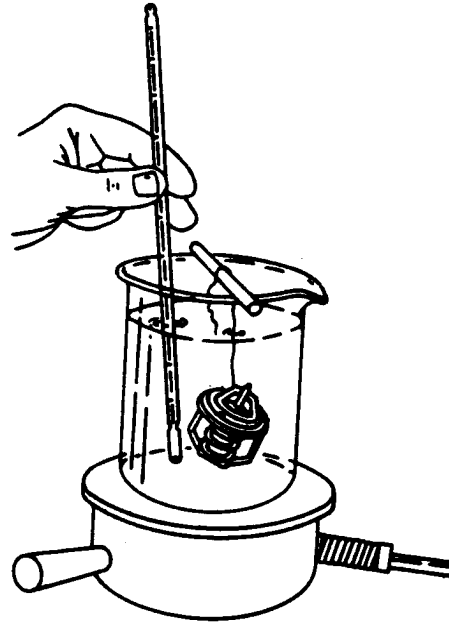
NOTE: Due to varying tolerances of different suppliers, initial opening and full open temperatures may vary slightly from specified temperatures.

THERMOSTAT TEST SPECIFICATIONS

Rating	Initial Opening (Range)	Full Open (Nominal)
71°C (160°F)	69—72°C (156—162°F)	84°C (182°F)
77°C (170°F)	74—78°C (166—172°F)	89°C (192°F)
82°C (180°F)	80—84°C (175—182°F)	94°C (202°F)
89°C (192°F)	86—90°C (187—194°F)	101°C (214°F)
90°C (195°F)	89—93°C (192—199°F)	103°C (218°F)
92°C (197°F)	89—93°C (193—200°F)	105°C (221°F)
96°C (205°F)	94—97°C (201—207°F)	100°C (213°F)
99°C (210°F)	96—100°C (205—212°F)	111°C (232°F)

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

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



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SPECIAL OR ESSENTIAL TOOLS

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

DX,TOOLS -19-05JUN91

A—JT03092 Gauge *

B—JT03017 Hose and Connector *

C—Connector

1/8 in. Pipe Nipple

1/4 in.—1/8 in. Pipe Reducer

1/8 NPT-7/16-20 UNC Adapter

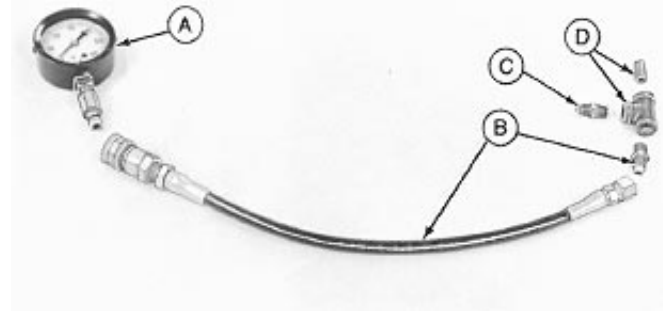
Used with above hose and gauge to check intake manifold pressure at aneroid.

D—"T" Fitting

D—JT03104 Fitting*

Used with above hose and gauge to check intake manifold pressure at aftercooler on 6101A Engines.

* Part of JT05412 Hydraulic Test Kit



RG,CTM61,G110,1-19-17MAR92

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R28266 -UN-15DEC88

AIR INTAKE AND EXHAUST SYSTEM TEST SPECIFICATIONS

NOTE: Specifications given below apply to OEM engines only. For machine applications, consult the appropriate machine technical manual.

ITEM	SPECIFICATION
Intake Manifold Pressure (Turbo Boost) at engine rated speed and rated full load power:	
6101HF Engines	
Standard Governor (2100 rpm)	140—170 kPa (1.4—1.7 bar) (20—25 psi)
Electric (2100 rpm)	140—170 kPa (1.4—1.7 bar) (20—25 psi)
6101AF Engines	
Standard Governor (2100 rpm)	170—180 kPa (1.7—1.8 bar) (25—26 psi)
3—5% Governor (1800 rpm)	170—180 kPa (1.7—1.8 bar) (25—26 psi)
Electric (2100 rpm)	170—180 kPa (1.7—1.8 bar) (25—26 psi)

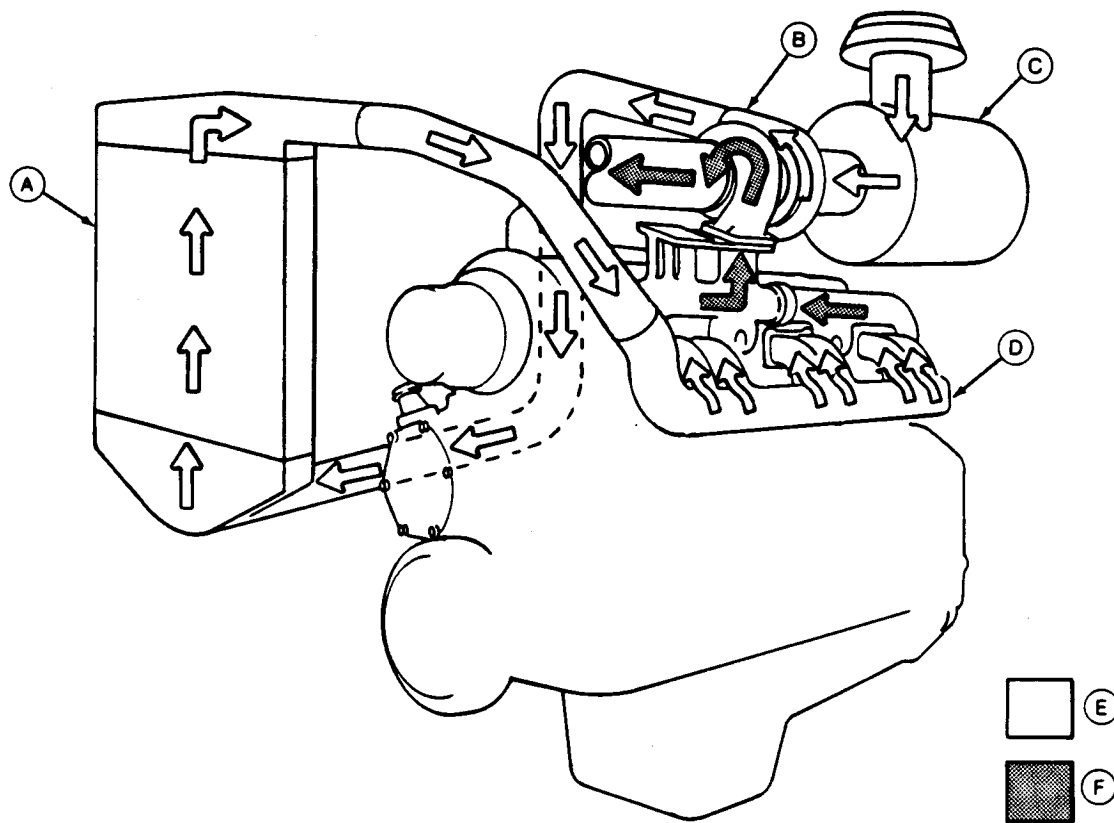
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DIAGNOSING AIR INTAKE MALFUNCTIONS

Symptom	Problem	Solution
Engine Starts Hard or Won't Start	Air leak on suction side of system	Check hose and pipe connections for tightness; repair as required (See Group 30).
Erratic Engine Operation	Air leak on suction side of system	Check hose and pipe connections for tightness; repair as required (See Group 30).
Engine Emits Excessive Black Smoke	Air cleaner element restricted	Clean or replace elements (See operator's manual).
	Turbocharger defective	Repair or replace (See Group 30).
	Air leak in manifold	Check hose and pipe connections for tightness; repair as required (See Group 30).
Engine Idles Poorly	Air leak on suction side of system	Check hose and pipe connections for tightness; repair as required (See Group 30).
Engine Does Not Develop Full Power	Air cleaner restricted	Clean or replace elements (See operator's manual).
	Air leak on suction side of system	Check hose and pipe connections for tightness; repair as required (See Group 30).
	Turbocharger defective	Repair or replace (See Group 30).
	Manifold pressure pipe to aneroid loose or broken	Check hose and pipe connections for tightness; repair as required (See Group 30).
Turbocharger "Screams"	Air leak in manifold	Check intake manifold gasket and manifold; repair as required (See Group 30).

S11.23005,AJ -19-16SEP92

HOW THE AIR INTAKE AND EXHAUST SYSTEM WORKS



RG6234 -UN-17MAR92

A—Heat Exchanger
B—Turbocharger

C—Air Cleaner
D—Intake Manifold

E—Outside Air

F—Exhaust

6101H Engine

Engine suction draws dust-laden outside air (E) through an air inlet stack into the air cleaner (C). Air is filtered through dry type primary and secondary (safety) filter elements in the air cleaner canister. Clean air travels through the air intake hose to the turbocharger (B) and intake manifold (D) to the engine.

Exhaust (F), drives the turbocharger to deliver a larger quantity of air to meet the engine requirements than what could be delivered under naturally aspirated (non-turbocharged) conditions.

On 6101H Engines, an air-to-air aftercooler cools the turbocharger compressor discharge air by routing it through a heat exchanger (A) before it enters the engine. The heat exchanger uses no liquid coolant but relies on air flow to cool the charge air.

On 6101A Engines, the aftercooler functions as a heat exchanger. Engine coolant circulates through the aftercooler core and carries heat out of the aftercooler.

AIR CLEANER OPERATION

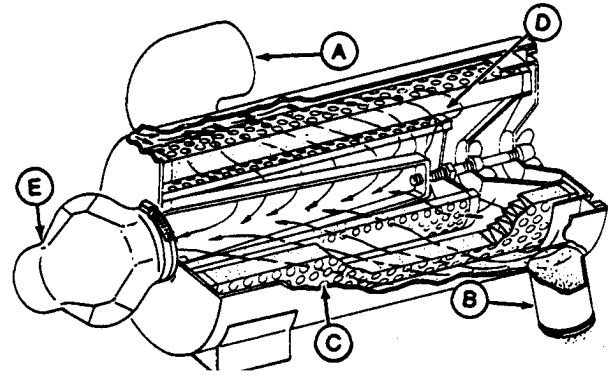
Dust-laden air enters the air cleaner inlet (A) and is forced into a high-speed centrifugal motion.

Most of the dust settles out of the air (before it enters the filter elements) and falls to the bottom of the air cleaner body. It is expelled to the outside of the air cleaner (B) through a rubber valve, which automatically ejects the dust and keeps it from accumulating inside the air cleaner body.

As the intake air is drawn through the primary element (C) and a secondary (safety) element (D), the remaining dust particles are retained in the primary element to permit only clean air to enter the intake manifold.

The safety element retains the dust that would otherwise pass into the engine if the primary element should rupture.

See your operator's manual for recommended service intervals.



A—Air Inlet
B—Dust Outlet
C—Primary Element
D—Secondary (Safety) Element
E—Air Outlet

S11,23005,AO -19-04FEB93

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R28270 -UN-14DEC88

DIAGNOSING TURBOCHARGER MALFUNCTIONS

Before replacing the turbocharger, determine what caused the failure of the defective unit, and correct the condition. This will prevent an immediate repeat failure of the replacement unit. Refer to Air Intake and Exhaust System Group 30 for repair information.

Noise Or Vibration*

Bearings not lubricated (insufficient oil pressure).
Air leak in engine intake or exhaust manifold.
Improper clearance between turbine wheel and turbine housing.
Broken blades (or other wheel failures).

Engine Will Not Deliver Rated Power

Clogged manifold system.
Foreign material lodged in compressor, impeller, or turbine.
Excessive dirt build-up in compressor.
Leak in engine intake or exhaust manifold.
Leak in intake manifold-to-aneroid pipe.
Rotating assembly bearing failure.
Damaged compressor or turbine blades.

Oil On Compressor Wheel Or In Compressor Housing (Oil Being Pushed or Pulled Through Center Housing)

Excessive crankcase pressure.
Air intake restriction.
Drain tube restriction.

Oil In Manifold Or Dripping From Housing

Excessive crankcase pressure.
Air intake restriction.
Drain tube restriction.
Damaged or worn journal bearings.
Unbalance of rotating assembly:
Damage to turbine or compressor wheel or blade.
Dirt or carbon build-up on wheel or blade.
Bearing wear.
Oil starvation or insufficient lubrication.
Shaft seals worn.

Turbine Wheel Drag

Carbon build-up behind turbine wheel caused by coked oil or combustion deposits.
Dirt build-up behind compressor wheel caused by air intake leaks.
Bearing seizure or dirty, worn bearings caused by excessive temperatures, unbalanced wheel, dirty oil, oil starvation, or insufficient lubrication.

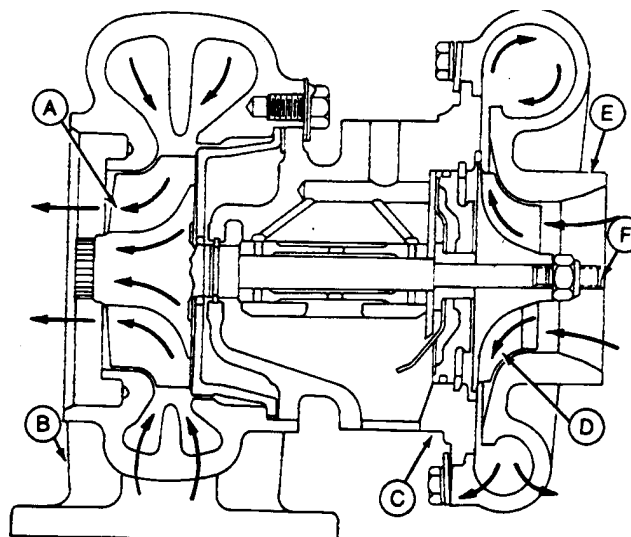
*Do not confuse the whine heard during run down with noise which indicates a bearing failure.

HOW THE TURBOCHARGER WORKS

Exhaust gases from the engine pass through the turbine housing (B) causing the shaft (F) to rotate before the exhaust gas is discharged to the atmosphere.

The compressor wheel (D), also mounted on shaft (F), rotates in the compressor housing (E). Inlet air is drawn into the housing, where it is compressed and delivered to engine cylinders.

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



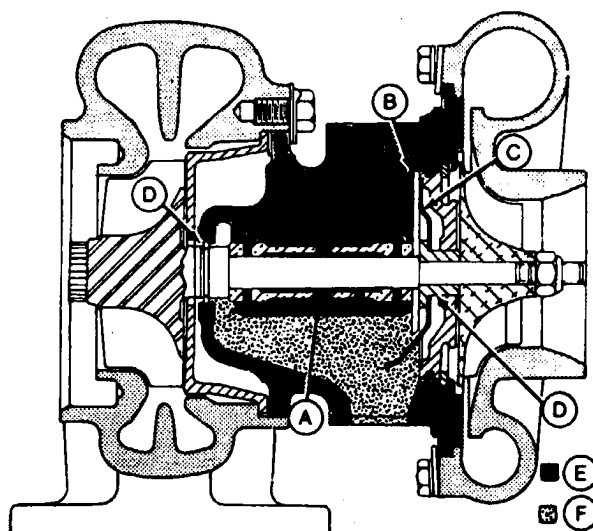
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HOW THE TURBOCHARGER IS LUBRICATED

Engine oil under pressure from the engine lubrication system is pumped through a passage in the bearing housing and directed to the bearing (A), thrust plate (B), and thrust sleeve (C). Oil is sealed from the compressor and turbine by a piston ring (D) at both ends of bearing housing.

The turbocharger contains a single floating bearing. This bearing has clearance between the bearing OD and the housing wall as well as clearance between the bearing ID and the shaft OD. These clearances are lubricated by the oil supply and the bearings are protected by a cushion of oil. Discharge oil drains by gravity from the bearing housing to the engine crankcase.

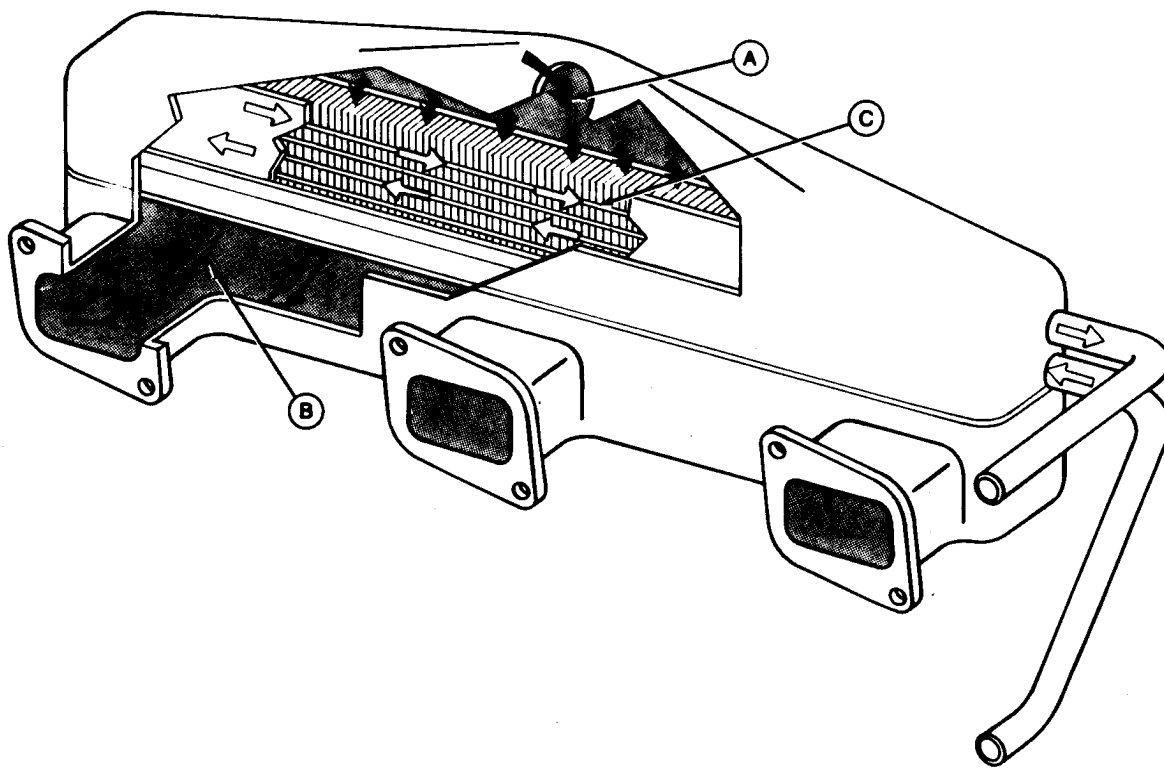
- A—Bearing
- B—Thrust Plate
- C—Thrust Sleeve
- D—Piston Ring
- E—Pressure Oil
- F—Discharge Oil



Turbocharger Lubrication

RG,CTM61,G110,5-19-21APR92

HOW THE AFTERCOOLER WORKS—6101A ENGINES



A—Heated Air

B—Cooled Air

C—Engine Coolant

Air entering intake manifold has been compressed (and heated) by turbocharger. As this heated and compressed air (A) enters intake manifold, it flows around aftercooler before going to engine cylinders.

The aftercooler functions as a heat exchanger, lowering intake air (B) temperature as much as 35°—47°C (95°—116°F). Lowering air temperature makes air more dense, permitting an even greater volume (compared with not having an aftercooler) to be delivered to engine cylinders. This increased volume of air, when combined with a predetermined quantity of additional fuel, enables more power to be produced.

Engine coolant (C) circulates through aftercooler core and carries heat out of aftercooler. Extreme care must be used to insure engine coolant does not leak into intake manifold, resulting in possible damage to engine.

RG5856
-UN-13AUG91

CHECK INTAKE MANIFOLD PRESSURE (TURBO BOOST)

NOTE: For each vehicle application, refer to the appropriate machine technical manual for intake manifold pressure specifications.

Intake manifold pressure (turbo boost) can be checked at intake manifold and aneroid.

IMPORTANT: Engine speed and load should be stabilized before taking readings on gauge. Be sure that gauge works properly.

Pressure checks are only a guide to determine if there is an engine problem (valve leakage, defective nozzles, etc.). Low readings are not a valid reason for increasing injection pump fuel delivery. Pump adjustment should be within specification as established by an authorized repair station.

- If boost pressure is too high, remove and test fuel injection pump for high fuel delivery.
- If boost pressure is too low, check for the following:
 - Restriction in air cleaner.
 - Leak in air intake between turbocharger and cylinder head.
 - Defective turbocharger.
 - Leak in exhaust manifold gasket.
 - Leak in fuel control pipe.
 - Restricted fuel filter elements.
 - Incorrect fast idle adjustment.
 - Incorrect injection pump timing.
 - Faulty fuel supply pump.
 - Low compression pressure.
 - Faulty fuel injection nozzles.
 - Carbon build-up in turbocharger.
 - Turbocharger compressor or turbine wheel rubbing housing.
 - Low fuel injection pump delivery.
 - Restricted exhaust.

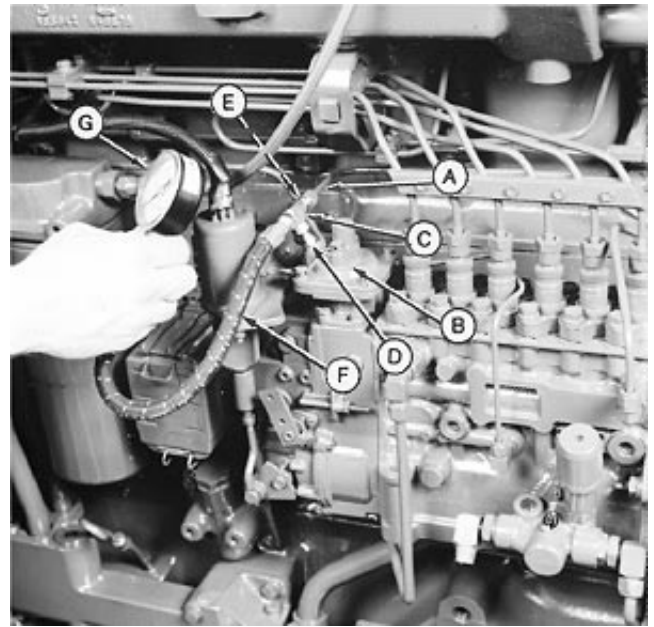
RG,CTM42,110,6 -19-13MAY93

110
9

• **Check Intake Manifold Pressure (Turbo Boost) at Aneroid:**

NOTE: Intake manifold pressure can also be checked at the intake manifold, as described later in this group.

1. Remove aneroid line (A) from aneroid (B).
2. Install a 1/8 in. pipe nipple and "T" fitting (C) into aneroid with pipe adapter (D).
3. Connect aneroid line to "T" fitting.
4. Attach 1/8 in. NPT to 7/16-20 UNC Adapter (E) and JT03017 Hose (F) to JD03092 Pressure Gauge (G).
5. With engine coolant at operating temperature 82—94°C (180—202°F), connect to a dynamometer. Operate engine at full load rated speed.
6. Observe pressure readings. If readings are not within the specified range, check for items addressed earlier in this module.
7. Remove test equipment and reinstall aneroid line.



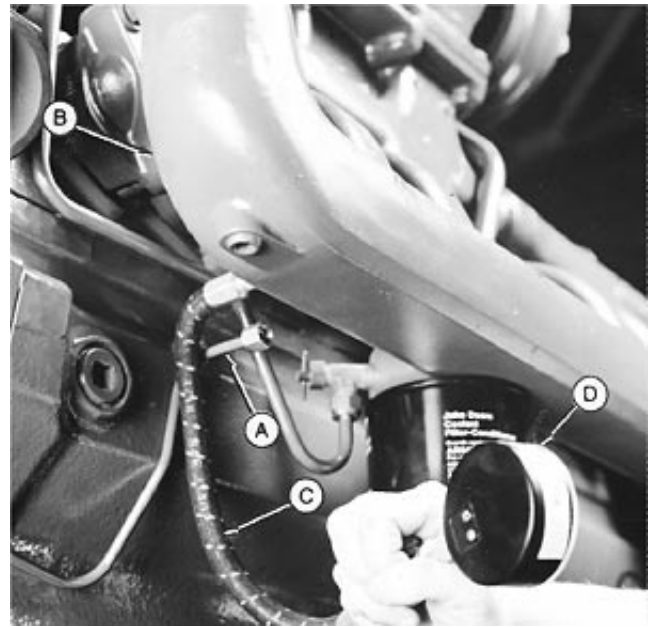
A—Aneroid Line
B—Aneroid
C—T-Fitting
D—Pipe Adapter
E—Adapter
F—JT03017 Hose
G—JT03092 Pressure Gauge

RG,CTM61,G110,3-19-13MAY93

• **Check Intake Manifold Pressure (Turbo Boost) at Intake Manifold:**

NOTE: Intake manifold pressure can also be checked from aneroid line, as described earlier in this group.

1. Remove aneroid line (A) and plug from intake manifold (B).
2. Install JT03017 Hose (C) with an accurate 0—400 kPa (0-4 bar) (0—60 psi) pressure gauge (D).
3. With engine coolant at operating temperature 82—94°C (180—202°F), connect machine to a dynamometer. Operate engine at full load rated speed.
4. Observe pressure reading. If reading is not within the given range, check for items addressed earlier under this major heading.
5. After completing test, remove test equipment and reinstall ether starting aid line, if equipped.



A—Aneroid Line
B—Intake Manifold
C—JT03017 Hose
D—Pressure Gauge

RG,CTM61,G110,4-19-13MAY93

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RG6212
-JUN-06MAR92

SPECIAL OR ESSENTIAL TOOLS

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

DX,TOOLS -19-05JUN91

Flywheel Turning Tool JDE81-1

RG4950

-UN-23AUG88

Rotate engine flywheel. Use with JDE81-4.



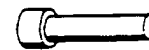
S53,JDE811 -19-07JUL89

Timing Pin JDE81-4

RG5068

-UN-23AUG88

Lock engine at TDC when timing valve train. Use with JDE81-1.



S55,JDE814,B -19-24FEB88

SERVICE EQUIPMENT AND TOOLS

NOTE: Order tools from the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC). Some tools may be available from a local supplier.

Name	Use
Pressure Gauge/0—200 kPa (0—2 bar) (0—30 psi), hose, and fittings.	Measure transfer pump pressure.
	NOTE: Assemble test equipment from JT05470 Universal Pressure Test Kit or any other suitable equipment.

S11,23010,I,Z -19-04MAR87

FUEL SYSTEM TEST SPECIFICATIONS

ITEM	SPECIFICATIONS
Fuel Supply Pump Minimum Operating Pressure	200 kPa (2.0 bar) (29.0 psi)
Hydraulic Aneroid Activator Operating Pressure	100 kPa (1.0 bar) (14.5 psi)
Fuel Injection Pump Timing-to-Engine	TDC
Engine Speeds (RPM)	For each machine application, refer to the appropriate machine technical manual for slow idle, fast idle, and rated speed specifications. For OEM applications, see FUEL INJECTION PUMP SPECIFICATIONS, later in this group.

RG,CTM61,115,1 -19-13MAY93

FUEL SYSTEM TEST SPECIFICATIONS—CONTINUED**TORQUES**

Injection Pump Drive Gear-to-Pump 61 N·m (45 lb-ft)

Injection Pump Drive Gear Cover:

6101HRW10 and 6101HRW11 Engine Applications . . . 68 N·m (50 lb-ft)

All Other Applications 41 N·m (30 lb-ft)

RG,CTM61,115,21-19-13MAY93

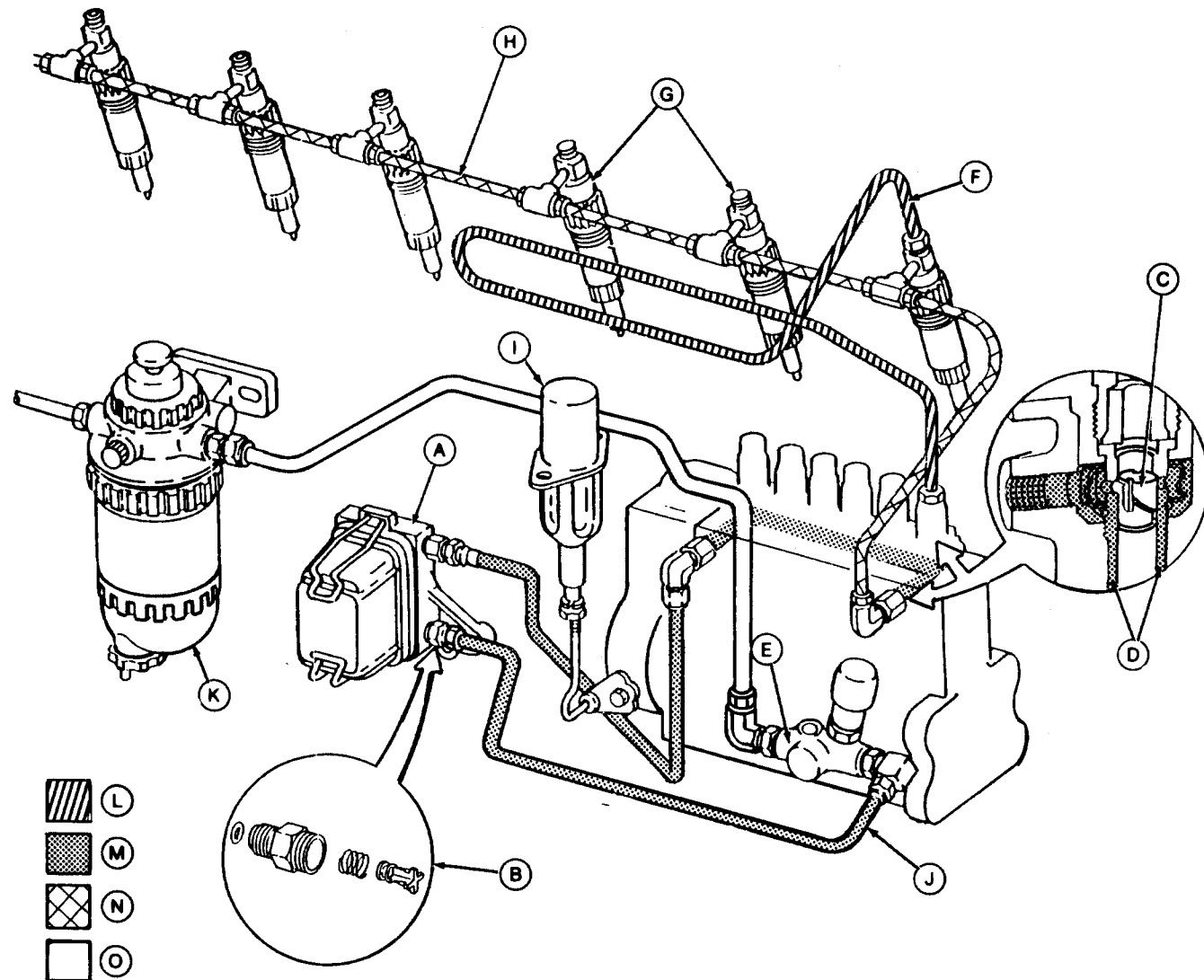
FUEL INJECTION PUMP SPECIFICATIONS*

Engine Model	Option Code	Original (part no.)	Replaced By (part no.)	Governor Regulation	Slow Idle (rpm)	Rated Speed (rpm)	Fast Idle (rpm)
6101HF	1601	RE46178	—	Std.	850	2100	2300
	1612	RE46178	—	Std.	850	2100	2300
	1632	RE42302	—	Electric	850	2100	2300
6101AF	1601	RE46179	—	Std.	850	2100	2300
	1602	RE42225	—	Std.	850	2100	2300
	1610	RE42226	—	3—5%	850	2100	2300
	1611	RE42302	—	Electric	850	1800	2000
	1612	RE46179	—	Std.	850	2100	2300
	1613	RE42225	—	Std.	850	2100	2300
	1614	RE42226	—	3—5%	850	1800	2000
	1632	RE42302	—	Electric	850	2100	2300

**Engine speeds listed are as preset to factory specification. In most cases, slow idle speed will be reset depending upon specific vehicle application requirements. Refer to your machine technical manual for engine speeds that are different from those preset at the factory.*

RG,CTM61,115,22-19-13MAY93

FUEL SYSTEM OPERATION



A—Fuel Filter
B—Check Valve Assembly
C—Pump Plungers
D—Fuel Galley

E—Supply Pump
F—Injection Pressure Lines
G—Nozzles
H—Leak-Off Line

I—Fuel Shut-off Solenoid
J—Supply Pump Outlet
K—Round Primary
Filter/Water Separator

L—Injection Pressure
M—Supply Pump Pressure
N—Fuel Return
O—Gravity Pressure

The supply pump (E) draws fuel from the vented fuel tank through the primary filter/water separator (K).

The supply pump pressurizes the fuel so that it flows through the filter (A) to the injection pump galley (D). Supply pump output pressure will vary depending on load and application.

The galley is kept full by the supply pump. Injection pump plungers (C) further pressurize the fuel. Injection pressure lines (F) route the fuel to the nozzles (G).

The high pressure fuel opens the nozzle valve and forces fuel out the small orifices in the nozzle tip. This atomizes the fuel as it enters the combustion chamber.

There are two sources of excess fuel incorporated into the system. The supply pump supplies more fuel to the pump than is required by the engine, and the nozzle requires excess fuel to lubricate the nozzle valve. A leak-off line (H) returns this excess fuel to the tank from both the pump and nozzles.

RG,CTM61,115,27-19-13MAY93

DIAGNOSE FUEL SYSTEM MALFUNCTIONS

NOTE: The following diagnostics apply to either standard mechanical in-line or rotary fuel pumps, or electronic governor type fuel pumps. See CTM11 for additional electronic pump diagnostics.

Symptom	Problem	Solution
Fuel Not Reaching Injection Nozzles	Fuel filter restricted	Replace fuel filter (See Group 35)
	Fuel line restricted	Clean lines as required
	Fuel too heavy at low temperatures	Use correct grade of fuel (See Group 02)
	Air in system	Correct problem and bleed fuel system (this group)
	Fuel tank valve shut off	Open fuel tank valve
	Low supply pump pressure	Check fuel lines for restrictions; check pump output pressure (this group)
Engine Starts Hard or Won't Start	Fuel too heavy at low temperature	Use correct grade of fuel (See Group 02)
	Injection nozzles faulty or sticking	Repair or replace as required (See Group 35)
	Incorrect timing	Adjust timing (this group)
	Faulty injection pump	Repair or replace
	Water in fuel	Drain water from fuel (or separator if equipped). Install new filter (See Group 35)
	Fuel filter restricted	Replace fuel filters (See Group 35)
	Low supply pump pressure	Check pump output pressure. (See this group)
	Injection pump return fuel line or fittings restricted	Clean lines as required
	Low cetane fuel	Use correct grade of fuel (See Group 02)
	Broken starting fuel control shaft spring	Repair (See Group 35)

Continued on next page

Symptom	Problem	Solution
Engine Starts and Stops	Injection pump drive gear teeth worn or broken	Check timing gear backlash and check for failed crankshaft vibration damper.
	Air in system	Correct problem and bleed fuel system (See this group)
	Fuel filter restricted	Replace fuel filter (See Group 35)
	Fuel lines restricted	Clean lines as required
	Water in fuel	Drain water from fuel, (or separator if equipped). Install new filter (See Group 35)
Erratic Engine Operations	Injection pump return fuel line or fittings restricted	Clean lines as required
	Fuel filter restricted	Replace fuel filter (See Group 35)
	Fuel too heavy at low temperatures	Use correct grade of fuel (See Group 02)
	Injection nozzles faulty or sticking	Repair (See Group 35)
	Fuel lines restricted	Clean as required
	Incorrect timing	Adjust timing (this group)
	Governor faulty	Repair (See Group 35)
	Water in fuel	Drain water from fuel (or separator, if equipped). Install new filter
	Injection pump return fuel line or fittings restricted	Clean lines as required
	Low cetane fuel	Use correct grade of fuel (See Group 02)
Engine Emits Excessive Black Smoke	Injection nozzle return lines restricted	Clean lines as required
	Injection nozzles faulty or sticking	Repair (See Group 35)
	Injection pump timing incorrect	Adjust timing (this group)
	Low cetane fuel	Use correct grade of fuel (See Group 02)

Continued on next page

Symptom	Problem	Solution
Engine Emits Excessive Blue or White Smoke	Over-fueling	Repair and adjust (See Group 35)
	Aneroid defective	Repair and adjust (See Group 35)
	Cranking speed too low	Check batteries and electrical system
	Injection pump timing incorrect	Adjust timing (this group)
	Injection nozzles faulty or sticking	Repair (See Group 35)
	Excessive wear in liners and/or piston rings stuck	See Group 10
	Incorrect cetane fuel for ambient temperature	Use correct grade of fuel (See Group 02)
Engine Idles Poorly	Engine running too "cold"	Check thermostat (See Group 25)
	Injection nozzles faulty or sticking	Repair (See Group 35)
	Incorrect timing	Adjust timing (this group)
	Pump slow idle speed not correctly adjusted	Adjust slow idle speed (this group)
	Fuel lines restricted	Clean as required
	Water in fuel	Drain water from filter, (or separator if equipped). Install new filters (See Group 35)
	Injection pump return lines or fittings restricted	Clean as required
	Injection nozzle return lines clogged	Clean as required
	Low cetane fuel	Use correct grade of fuel (See Group 02)
	Low cetane fuel	Use correct grade of fuel (See Group 02)
Engine Does Not Develop Full Power	Incorrect timing	Adjust timing (this Group)
	Injection pump or governor faulty	Repair (See Group 35)
	Fuel filter clogged	Replace fuel filter (See Group 35)

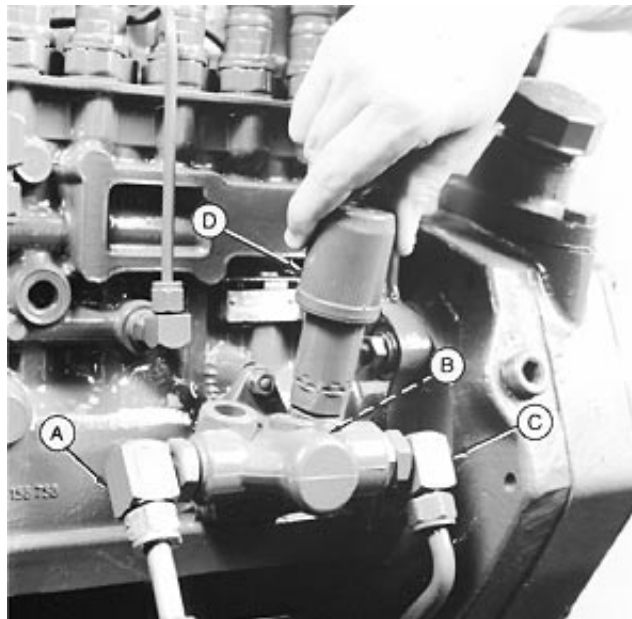
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Symptom	Problem	Solution
Engine Does Not Develop Full Power	Injection nozzles faulty or sticking	Repair (See Group 35)
	Injection pump return fuel line or fittings restricted	Clean as required
	Water in fuel (or gasoline in fuel)	Drain water or replace with clean fuel Install new filters (this Group)
	Incorrect fast idle speed	Adjust speed (this Group)
	Manifold pressure pipe to aneroid loose or broken	Repair as required
	Fuel shut-off cable improperly adjusted	Adjust

RG,CTM42,115,2 -19-28OCT92

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MECHANICAL FUEL SUPPLY PUMP OPERATION



A—Fuel Inlet

B—Plunger

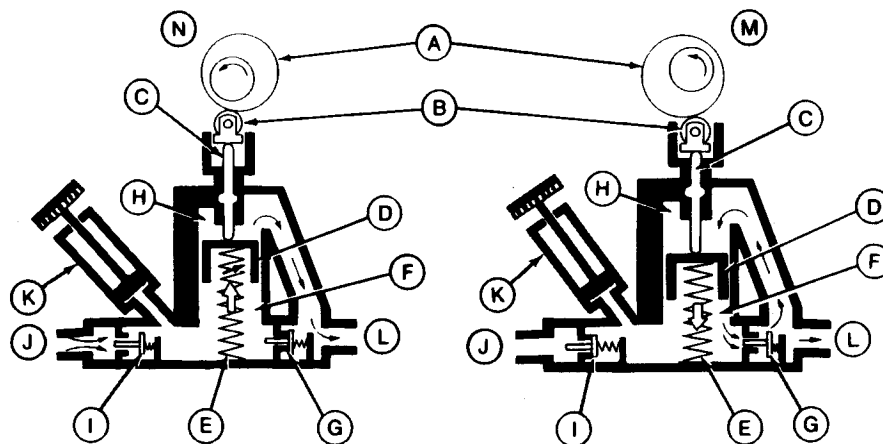
C—Fuel Outlet

D—Hand Primer

The plunger-type Robert Bosch fuel supply pump is used on all 6101 engines. It is mounted on the side of the injection pump housing and is driven by the injection pump camshaft. Fuel enters the supply pump at (A), is pressurized by the plunger (B), and discharged through outlet (C). The hand primer (D) provides manual pump operation for bleeding the fuel system.

RG,CTM61,115,2 -19-13MAY93

MECHANICAL FUEL SUPPLY PUMP OPERATION—(CONTINUED)



RG5787
-UN-06AUG91

A—Camshaft	E—Plunger Spring
B—Roller Tappet	F—Suction Chamber
C—Pressure Spindle	G—Pressure Valve
D—Plunger	H—Pressure Chamber

I—Suction Valve	M—Intermediate Stroke Position
J—Fuel Inlet	N—Suction and Discharge Stroke Position
K—Hand Primer Pump	
L—Fuel Outlet	

As the pump camshaft (A) rotates toward the “high cam” intermediate stroke position (M), the roller tappet (B) and pressure spindle (C) cause the plunger (D) to move against and compress the plunger spring (E).

Plunger movement forces the fuel out of the suction chamber (F), through the pressure valve (G), and into the pressure chamber (H). The amount of fuel discharged from the suction chamber is equal to the amount of fuel delivered for each stroke of the plunger. Towards the end of the intermediate stroke, the spring-loaded pressure valve closes again.

As the camshaft rotates toward the “low cam” or suction and discharge position (N), plunger spring pressure causes the plunger, pressure spindle, and roller tappet to follow the camshaft.

Movement of the plunger pushes the fuel from the pressure chamber, and delivers it to the fuel filters and injection pump. At the same time, plunger suction pressure is permitting fuel to enter the suction chamber through the suction valve (I). With the suction chamber charged with fuel, the pumping cycle begins again.

Fuel is allowed to flow in around the pressure spindle to lubricate the spindle as it moves back and forth in housing. To prevent the fuel from entering the pump crankcase, a rubber O-ring is positioned in the spindle bore of housing at the roller tappet end.

Pulling upward on the on the hand primer pump (K) causes the suction valve to open and fuel to flow into the suction chamber. When the hand plunger is pushed downward, the suction valve closes, and fuel is forced out of the pressure valve.

RG,CTM61,115,3 -19-13MAY93

DIAGNOSING MECHANICAL FUEL SUPPLY PUMP MALFUNCTIONS

IMPORTANT: Visually inspect the fuel inlet fitting and pump filter for possible plugging before disassembling to determine cause of malfunction.

Symptom	Problem	Solution
Low Supply Pump Output Pressure or Pump Not Functioning Correctly	Restriction at fuel inlet fitting.	Thoroughly clean fuel tank, lines, filters, and inlet fitting.
	Worn or pitted valves caused by foreign material lodging in valve.	Replace valves as required.
	Missing or broken spring(s).	Replace spring(s).
	Broken spindle.	Replace pump.
	Out of fuel.	Add fuel to fuel tank.
	Fuel shut off at tank.	Open fuel shut off valve.
	Restricted fuel line.	Clean as required.
	Air leak in fuel line between pump and tank.	Repair as required.
	Loose or damaged fuel line connetions.	Repair.
	Worn or damaged valve assemblies.	Repair or replace.
	Broken valve spring(s)	Repair or replace.
Diesel Fuel Leaking Into Injection Pump Crankcase	Worn spindle and/or pump housing.	Replace pump.
	Defective O-ring seal.	Replace O-ring seal.

RG,CTM61,115,32-19-13MAY93

TEST MECHANICAL FUEL SUPPLY PUMP FOR LEAKS

Fuel delivery pressure should be checked before removing supply pump from injection pump.

1. Connect compressed air line (A) to a pressure gauge (B) and to supply pump inlet fitting. Air line should have a regulating valve to control pressure.
2. Cap or plug supply pump outlet fitting (C).
3. Submerge supply pump in a container of clean diesel fuel. Regulate air pressure to 200 kPa (2.0 bar) (29 psi).
4. Move spindle in and out by hand. No air bubbles should appear around roller tappet or spindle bore.

NOTE: If bubbles appear, it is an indication that either the O-ring seal is defective or spindle or tappet is worn (or possibly both).

IMPORTANT: Serious injection pump or engine damage could occur, if enough diesel fuel leaks past spindle and seal. Fuel leakage past spindle dilutes engine oil.



RG5894 -UN-19AUG91

RG,CTM61,115,23-19-13MAY93

CHECK MECHANICAL FUEL SUPPLY PUMP OPERATION

NOTE: The following procedure can best be performed under moderate air temperature conditions to reduce electrical loads when cranking the engine is required.

1. Make a preliminary inspection of supply pump. Thoroughly clean area around pump. All connections must be tight and not leaking.
2. Start engine and bring to operating temperature. Shut-off engine.

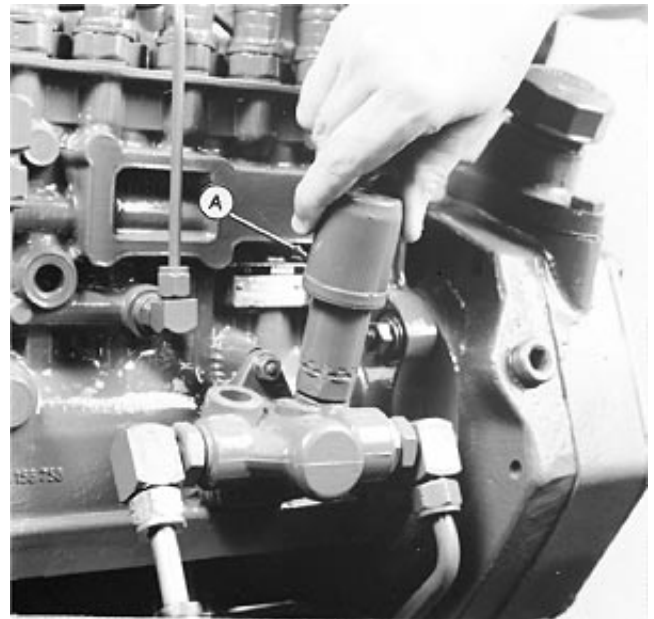
NOTE: Hand primers (A) are spring loaded to remain in the fully extended position. If fuel leaks around the hand primer while in the extended position, replace the hand primer.

• Check operation of hand primer:

1. With engine shut-off, operate hand primer several strokes.

Moderate to heavy leakage of fuel between plunger and barrel indicates seal is defective. Replace hand primer.

NOTE: Appearance of a slight quantity of fuel around the plunger is normal.



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RG6203 -UN-06MAR92

RG,CTM61,115,5 -19-13MAY93

• **Test operation of suction side of pump:**

1. Disconnect suction and discharge lines at pump.
2. Drain all fuel from pump by operating hand primer. Then reconnect suction line to pump.

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NOTE: When operating hand primer, a moderate resistance should be felt. When only a slight resistance (or no resistance) occurs, replace hand primer or repair pump (valves may be defective).

3. Operate hand primer until fuel flows from pump outlet (discharge).

Fuel should flow within 15—25 strokes. If not, the suction line may be obstructed or leaking air, (replace in-line filter when used).

If fuel does not flow and if no leak or obstruction is found, pump is defective. It must be repaired or replaced.

• **Test operation of discharge side of pump:**

1. Suction line must be connected and discharge (pressure) line disconnected.
2. Place injection pump fuel shut-off control in “stop” position to prevent engine from starting.
3. Crank engine with starting motor.

Fuel should flow from pump outlet within 10 seconds. If not, the suction line may be obstructed (replace in-line filter when used), or leaking air.

RG,CTM61,115,6 -19-13MAY93

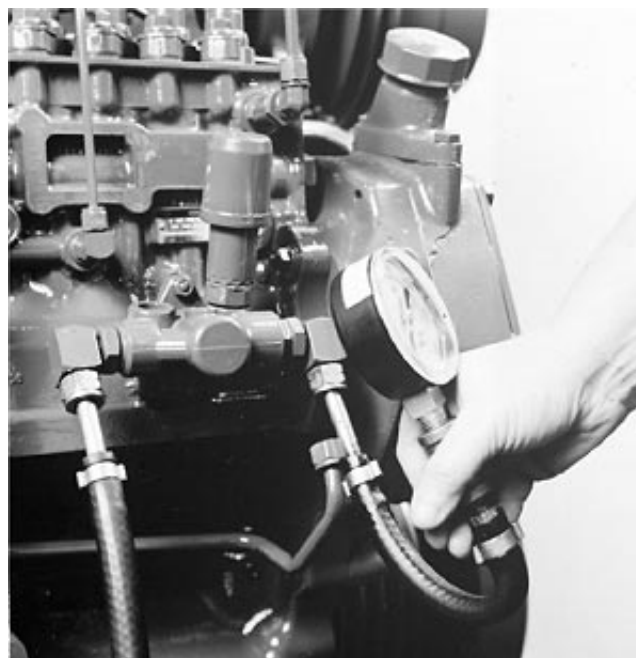
• **Test pump output pressure while cranking engine with starting motor:**

1. Connect a 0—400 kPa (0—4 bar) (0—60 psi) pressure gauge to one end of a pressure hose about 250—300 mm (10—12 in.) long. Connect other end of hose to pump outlet. All air must be out of system.
2. Crank engine for 10 seconds with starting motor (approximately 200 engine rpm). Supply pump minimum outlet pressure should be 200 kPa (2.0 bar) (29.0 psi).

IMPORTANT: The starting motor must crank the engine at normal cranking speed. Use booster batteries if necessary.

3. Compare measured output with the minimum pressure specifications.

If pressure is below the minimum specified and if no obstruction or leak is found, repair or replace the supply pump.



RG6204 -UN-06MAR92

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RG,CTM61,115,8 -19-13MAY93

SERVICE MECHANICAL FUEL SUPPLY PUMP

Gaining access to the valves on the supply pump requires removal and disassembly of the supply pump. (See Group 35).

1. Inspect valves and valve seats for foreign material, wear or pitting. Valve springs must not be cracked or broken.
2. Reassemble parts, open tank shut-off valve, and check operation. If the pump operation is still not normal, the pump will have to be repaired or replaced. (See Group 35.)

RG,CTM61,115,9 -19-13MAY93

FUEL SHUT-OFF SOLENOID OPERATIONAL CHECK

1. Observe fuel shut-off lever (A) when key switch is turned from "OFF" to "START" (engine running at slow idle) and then released to "ON" position.

2. Fuel shut-off lever should move from "NO FUEL" position (B) to "RUN" position (C) when starting motor begins to crank. The lever should remain at the "RUN" position after key switch is released to "ON" position.

If fuel shut-off lever returns to "NO FUEL" position with key switch at "ON" position, check for:

- Loss of battery voltage to fuel shutoff winding. Check voltage and wiring connection to solenoid.
- Binding of fuel shut-off lever, solenoid rod or linkage does not allow solenoid to lock in position. Repair or replace linkage.
- Torn or leaking rubber boot allowing dirt or moisture to enter at spring end of solenoid rod.
- Improperly adjusted fuel shut-off solenoid linkage. See FUEL SHUT-OFF SOLENOID LINKAGE ADJUSTMENT, later in this group.

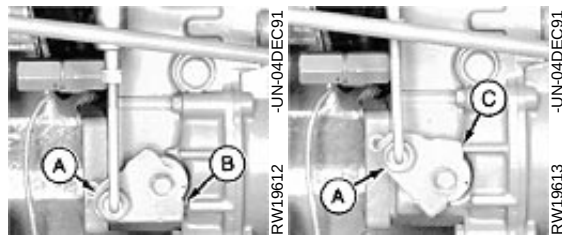
3. Start engine and run at slow idle. Turn key switch to "OFF" position.

4. Fuel shut-off lever should move to "NO FUEL" position and engine should stop.

If the solenoid stops just short of the "NO FUEL" position, slight adjustment of the linkage is required. See FUEL SHUT-OFF SOLENOID LINKAGE ADJUSTMENT, later in this group.

If engine continues to run with key switch at "OFF" position, unplug shut-off solenoid 3-way connector.

- If solenoid moves lever to "NO FUEL" position, problem is in the electrical circuit.
- If solenoid does not shut off fuel to engine, check linkage for binding or excessive tightness. Replacement service kit is available with a swivel rod which is less sensitive to misalignment and binding.



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FUEL SHUT-OFF SOLENOID RESISTANCE TEST

- 1. Disconnect shut-off solenoid 3-way WEATHER PACK™ connector.
- 2. Measure “PULL” coil resistance between black lead wire “C” and white lead wire “B”.
- 3. Measure “HOLD” coil resistance between black lead wire “C” and red lead wire “A”.

Replace solenoid if resistance is not within specification given below.

PULL AND HOLD COIL RESISTANCE SPECIFICATIONS

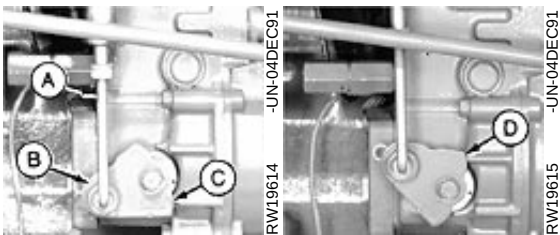
Solenoid Part Number	Pull Coil Resistance (Ohms)	Hold Coil Resistance (Ohms)
12-Volt System:		
RE55674	0.140—0.210	6.63—8.11
24-Volt System:		
RE55675	0.560—0.684	24.35—29.76

WEATHER PACK is a trademark of Packard Electric. RG,CTM61,115,31-19-13MAY93

FUEL SHUT-OFF SOLENOID LINKAGE ADJUSTMENT

Shut-off solenoid linkage is factory adjusted and usually will not require additional field adjustment. ALWAYS check linkage and lever for alignment and binding before making adjustments.

- 1. Thoroughly lubricate all linkage and lever pivot points.
- 2. If necessary, adjust linkage (A) so that lever (B) contacts stop (C) with key switch “OFF” and engine not running.
- 3. Start engine and run at slow idle. Lever should contact stop (D) or nearly contact when the lever is being pushed up.



A—Link
B—Lever
C—Stop
D—Stop

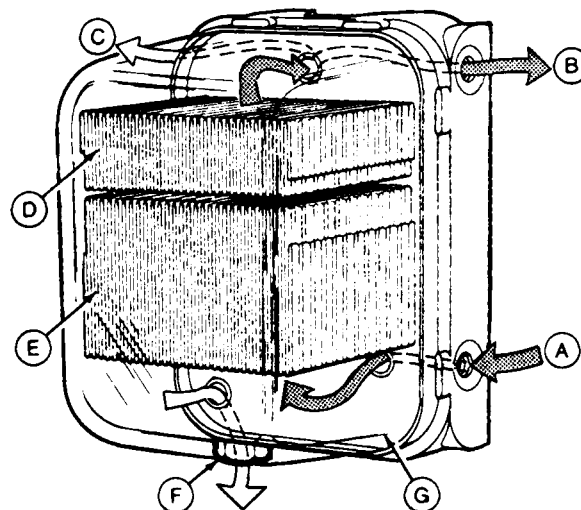
RG,CTM61,115,30-19-13MAY93

RECTANGULAR FINAL FUEL FILTER OPERATION

Fuel enters the filter at (A) and flows through a first stage filtering media (E) and a second stage filtering media (D) before flowing through outlet (B) to the injection pump. The filtering media is housed in the metal sediment bowl (G) and epoxied to the bowl as one assembly.

Since water and other contaminants may settle to the bottom of the sediment bowl, a drain plug (F) is provided to permit their removal.

An air vent (C) enables air in the fuel system to be expelled to the outside through the filters when bleed plug is removed.



- A—Inlet
- B—Outlet
- C—Air Vent
- D—Second Stage Filtering Media
- E—First Stage Filtering Media
- F—Drain Plug
- G—Sediment Bowl

RG,CTM61,115,24-19-13MAY93

-UN-28APR89

R26812

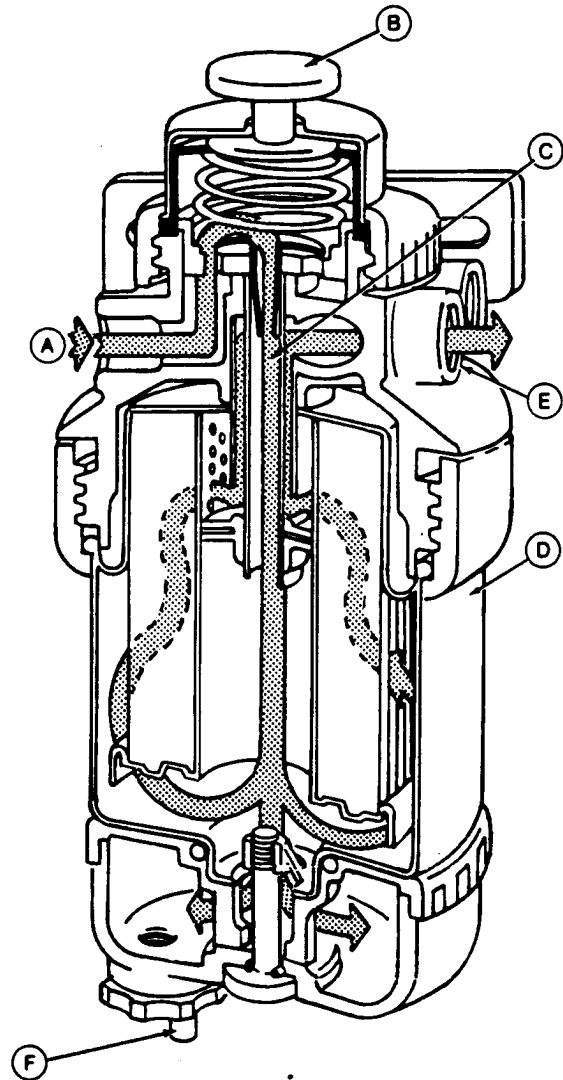
ROUND PRIMARY FUEL FILTER/WATER SEPARATOR OPERATION

The primary fuel filter/water separator is a single-stage filter. Fuel enters the filter at the inlet (A), then flows to the center port (C), travels to the bottom of the filter element (D), onward to the outboard side of the filter, up the sides and back inward through the media before exiting filter through outlet (E) to the fuel injection pump. The filter element is attached to the base with a threaded (detent) ring.

Water and contaminants settle at the bottom of the water separator (clear sediment bowl), a drain plug (F) is provided to drain these contaminants from system.

Air in the system can be expelled by loosening the air bleed screw and pumping the hand primer until fuel free of air bubbles is visible at bleed screw.

- A—Fuel Inlet
- B—Hand Primer
- C—Center Port
- D—Filter Element
- E—Fuel Outlet
- F—Drain Plug



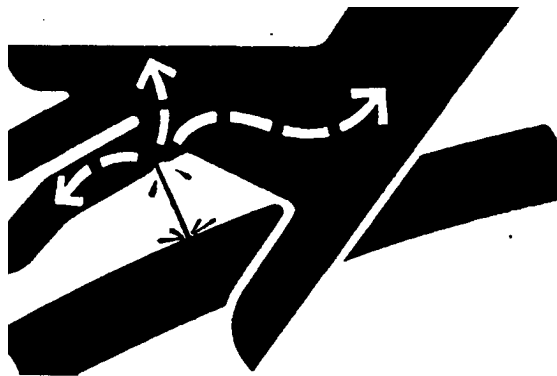
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RG6675 -UN-17MAR93

RG,CTM61,115,25-19-13MAY93

BLEED THE FUEL SYSTEM

CAUTION: Escaping fluid under pressure can penetrate the skin causing serious injury. Relieve pressure before disconnecting fuel or other lines. Tighten all connections before applying pressure. Keep hands and body away from pinholes and nozzles which eject fluids under high pressure. Use a piece of cardboard or paper to search for leaks. Do not use your hand.



If ANY fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type injury or gangrene may result. Doctors unfamiliar with this type of injury may call the Deere & Company Medical Department in Moline, Illinois, or other knowledgeable medical source.

Whenever the fuel system has been opened up for service (lines disconnected or filters removed), it will be necessary to bleed air from the system.

The fuel system may be bled at one of several locations. On some engine applications it may be necessary to consult your operator's manual and choose the location best for your engine/machine application.

S11,0408,AC -19-10MAY93

• At Round Primary Fuel Filter/Water Separator:

1. Drain water and contaminants from clear sediment bowl.
2. Loosen air bleed vent screw (A) on fuel filter base.
3. Operate hand primer (B) until fuel flow is free from air bubbles. Tighten vent screw.

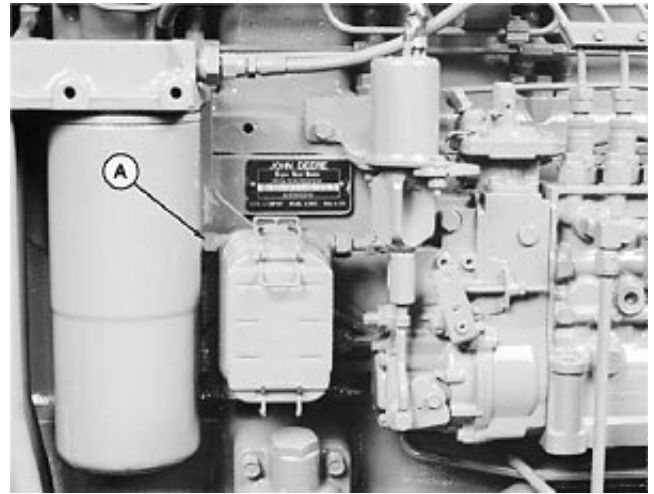


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RG,CTM61,115,26-19-13MAY93

- **At Rectangular Fuel Filter:**

1. Loosen bleed plug (A) on fuel filter base.



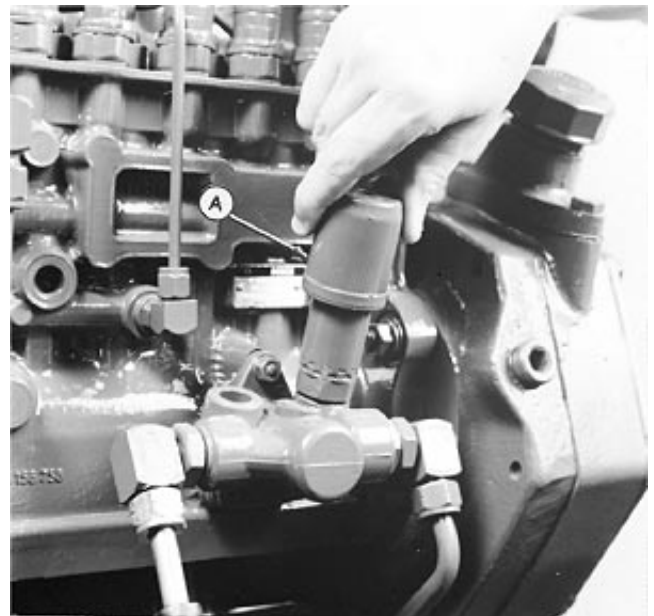
RG,CTM61,G35,3 -19-13MAY93

2. Operate the hand primer (A) on fuel supply pump until a smooth flow of fuel, free of bubbles, comes out of the filter plug hole.

3. Simultaneously stroke the hand primer down and close the filter port plug. This prevents air from entering the system. Tighten plug securely. DO NOT overtighten.

4. Start engine and check for leaks.

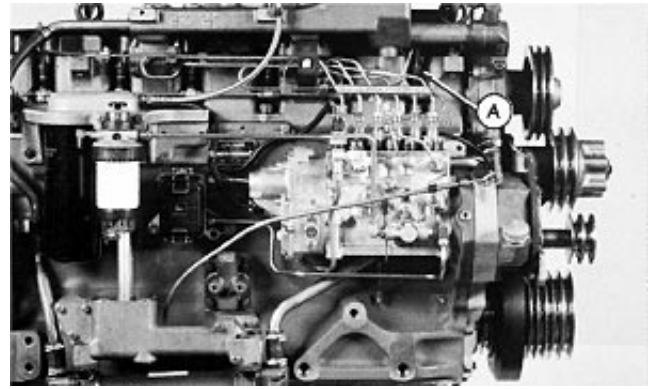
If engine will not start, it may be necessary to bleed air from fuel system at injection nozzles as explained next.



RG,CTM61,115,10-19-13MAY93

• At Fuel Injection Nozzles:

1. Place throttle lever in fast idle position.
2. Loosen fuel line connection at No. 1 injection nozzle (A).
3. Crank engine with starting motor (but do not start engine), until fuel free from bubbles flows out of loosened connections. Retighten connection.
4. Repeat procedure at remaining injection nozzles (if necessary) until all air has been removed from fuel system.



RG6727 -UN-14APR93

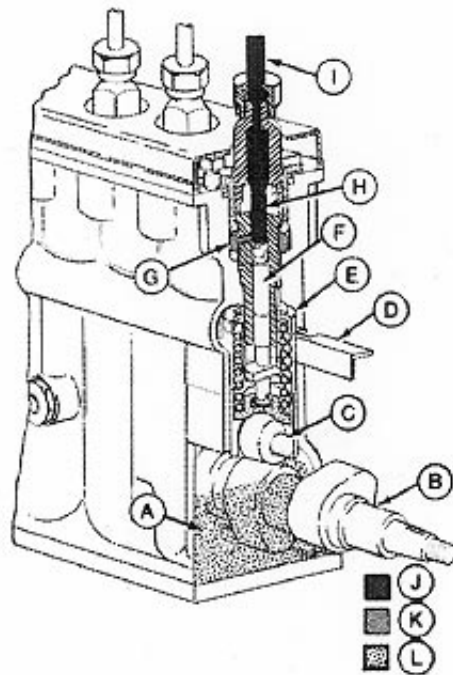
RG,CTM61,115,28-19-13MAY93

IN-LINE FUEL INJECTION PUMP OPERATION

Filtered fuel under pressure by the supply pump fills the injection pump fuel gallery (G). As the camshaft rotates, roller tappets (C) riding on the camshaft (B) lobes operate the plungers (F) to supply high pressure fuel through the delivery valves (H) to the injection nozzles.

A governor-operated control rack (D) is connected to the control sleeves (E) and plungers to regulate the quantity of fuel delivered to the engine.

Engine lubricating oil is piped to the injection pump crankcase (A) to provide splash lubrication of the working parts. Two drain holes at the front end of the pump determine the level of oil maintained in the crankcase. Excess oil drains out these holes and returns back to the engine through the timing gear housing.



RG4650 -UN-14DEC88

- A—Crankcase
- B—Camshaft
- C—Roller Tappet
- D—Control Rack
- E—Control Sleeve
- F—Plunger
- G—Fuel Gallery
- H—Delivery Valve
- I—Delivery Pipe
- J—Injection Pressure
- K—Supply Pump Pressure
- L—Engine Lubricating Oil

S11,23010,GF -19-28OCT92

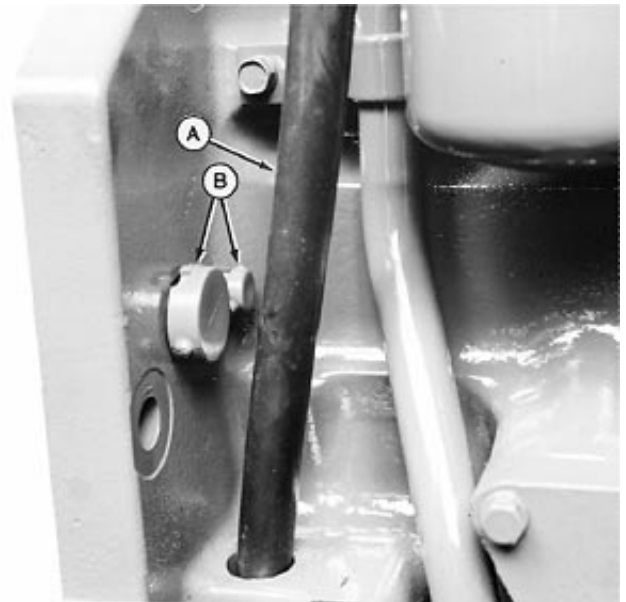
DIAGNOSE IN-LINE FUEL INJECTION PUMP MALFUNCTIONS

Symptom	Problem	Solution
Engine Starts Hard or Won't Start	Incorrect fuel shut-off lever position (pump control rack not moving all the way forward)	Adjust shut-off cable as required.
	Defective injection pump	Remove pump from engine and repair (see Group 35)
	Injection pump not correctly timed	Check pump timing
Slow Idle Speed Irregular	Slow idle stop screw improperly adjusted	Recheck stop screw adjustment
	Supplementary idling spring improperly adjusted	Recheck adjustment
	Defective injection pump	Remove pump from engine and repair (See Group 35)
Engine Horsepower Low	Pump not properly timed	Check timing
	Defective injection pump	Remove pump from engine and repair (See Group 35)

S11,23010,FQ -19-13MAY93

CHECK AND ADJUST INJECTION PUMP TIMING

1. Remove vent tube (A) from in front of plastic plugs (B). Remove two plastic plugs from timing holes.



RG,CTM61,115,11-19-17MAR92

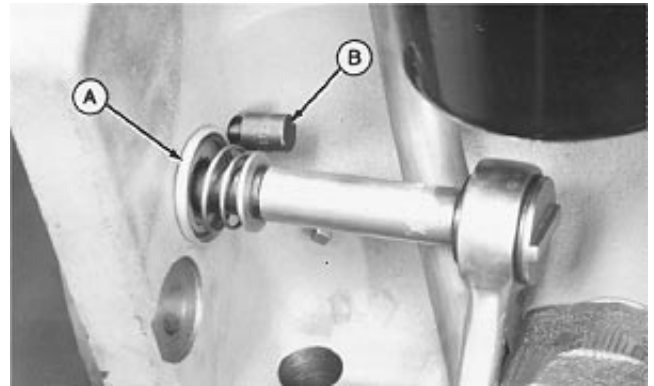
115
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RG6205
-UN-06MAR92

2. Install JDE81-1 Flywheel Rotation Tool (A) and JDE81-4 Timing Pin (B) in their respective timing holes.

3. Position engine at 'TDC' with No. 1 piston on it's compression stroke. (See CHECK AND ADJUST VALVE CLEARANCE in Group 05.)

NOTE: The compression stroke can be determined by removing the rocker arm cover and rotating the engine until both valves are closed (rocker arms loose) on No. 1 cylinder.

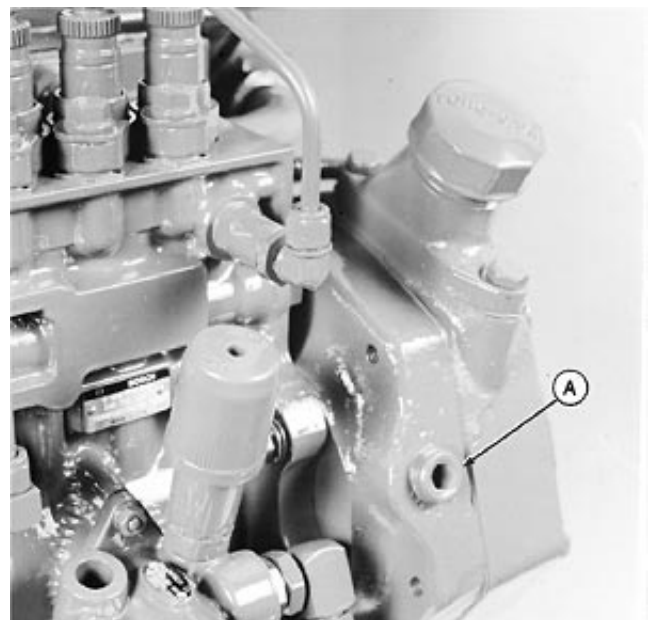


-UN-05JAN90

RG5521

RG,CTM61,115,12-19-21APR92

4. Remove the timing hole plug and look into hole (A). As the flywheel is turned, observe when the pump drive hub mark comes in alignment with the pointer mark. At this position, the JDE81-4 Timing Pin should enter the hole in flywheel.



-UN-24FEB92

RG6171

RG,CTM61,115,13-19-28APR92

IMPORTANT: The normal backlash of gears is enough to throw the pump timing off by several degrees, resulting in poor engine performance. Therefore, it is very important that pump timing be rechecked after it has been installed. To avoid backlash, always approach the timing mark on pointer by rotating crankshaft in direction of normal engine rotation.

NOTE: Normal engine rotation is counter-clockwise, viewed from flywheel end.

5. If the timing marks are not in line when timing pin enters flywheel, remove timing pin from the flywheel. Rotate the flywheel 1-1/2 revolutions opposite direction of normal rotation. Replace the timing pin and rotate in direction of normal rotation until timing pin engages in timing pin hole. If the marks ARE NOT in alignment, loosen four pump drive gear (C) cap screws (B). Rotate pump drive hub nut (A) until pump hub timing marks are aligned. Repeat timing check to be sure marks are aligned. Install timing hole plug.

6. Tighten injection pump drive gear-to-pump hub cap screws to 47 N·m (35 lb-ft).

7. Install injection pump gear cover using a new gasket and tighten cap screws to specification given below.

INJECTION PUMP GEAR COVER TORQUE SPECIFICATIONS

6101HRW10 and 6101HRW11	
Engine Applications	68 N·m (50 lb-ft)
All Other Applications	41 N·m (30 lb-ft)



CHECK FAST IDLE SPEED

1. Remove speed control rod. With the engine running, move governor control lever (A) against the fast idle stop screw (B).

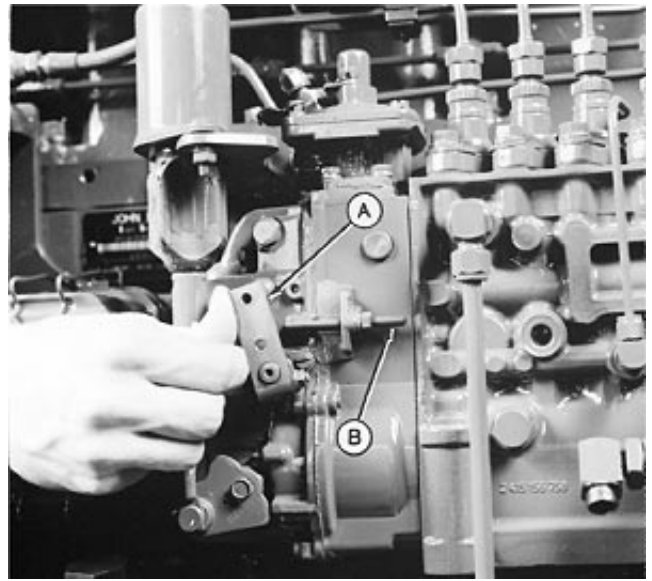
NOTE: The governor control lever on injection pump may be inboard (next to engine block) or outboard (away from engine block), depending upon engine application.

2. Using a tachometer, check fast idle speed to see if it is within specification.

NOTE: For each application, refer to the appropriate machine technical manual for fast idle speed specifications.

If fast idle speed must be adjusted, see your nearest authorized ADS diesel repair station.

NOTE: For some applications, special equipment may be required for fast idle adjustment in conjunction with droop adjustment. See your dealer or John Deere Engine Distributor.



RG6206
-UN-06MAR92

RG,CTM61,115,15-19-21APR92

CHECK AND ADJUST ENGINE SLOW IDLE SPEED

NOTE: Both the slow idle stop screw (A) and the supplementary idling spring screw (B) may be used to adjust the slow idle speed.

IMPORTANT: Minor adjustment of the slow idle speed may be made with the supplementary idling spring screw. However, it should not be used by itself to change engine speed more than 20 rpm, as overspeeding of the engine may result.

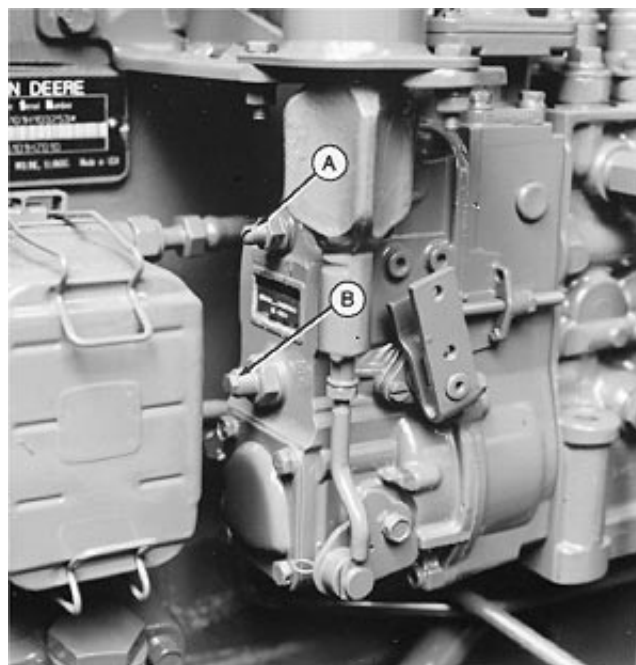
If slow idle stop screw and supplementary idling spring screw are not adjusted according to instruction, engine damage could result because of overspeeding.



CAUTION: ALWAYS STOP ENGINE before making adjustments.

1. With the engine running, pull the governor control lever rearward to the slow idle speed position. Check and adjust slow idle speed to specification.

NOTE: For each application, refer to the appropriate machine technical manual for slow idle speed specifications.



RG6207 -UN-06MAR92

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RG,CTM61,115,16-19-17MAR92

2. Loosen lock nut (C) and back out the supplementary idling spring adjusting screw (B) three turns.

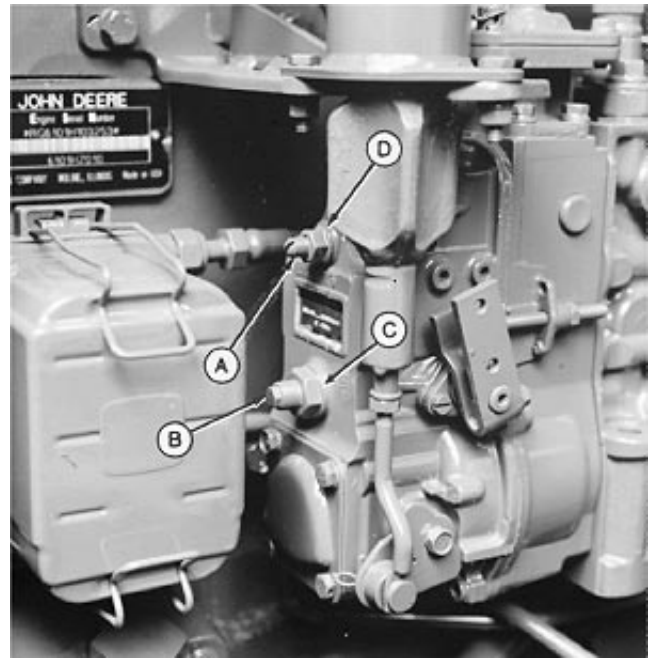
3. Loosen lock nut (D) and adjust slow idle stop screw (A) to obtain an idle speed on the low side of desired slow idle speed setting within 30 rpm.

4. Turn the supplementary idling spring adjusting screw in to increase engine speed a maximum of 30 rpm.

For example, to obtain an 850 rpm slow idle speed, use the slow idle stop screw to set speed at approximately 835 or 840 rpm. Then increase speed to 850 rpm using the supplementary idling spring adjusting screw.

NOTE: Increasing the slow idle speed a slight amount above the specified speed range may help to reduce engine surge (or hunting). If this occurs, use the procedure given above; but do not exceed 850 rpm.

- A—Slow Idle Stop Screw
- B—Supplementary Idling Spring Adjusting Screw
- C—Lock Nut
- D—Lock Nut



RG6208 -JUN-06MAR92

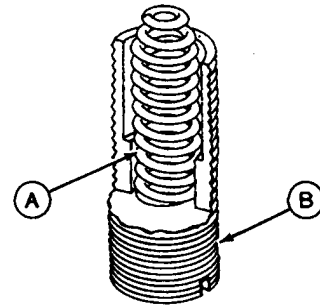
RG,CTM61,115,17-19-17MAR92

5. If engine surging or hunting persists at slow idle, the supplementary idling spring (A) and adjustment screw (B) may need to be replaced with a new one. Remove the pump from the engine and have it repaired by an authorized diesel repair station (ADS shop). See Group 35 for fuel injection pump removal and installation.

6. Again check the fast and slow idle speeds. Readjust, slow idle speed if not correct.

7. Check all adjusting screw lock nuts for tightness.

8. Connect fuel shut-off cable and speed control rod.



R28387N -JUN-14DEC88

RG,CTM61,115,20-19-21APR92

HOW THE ANEROID WORKS—MECHANICAL GOVERNORS ONLY

Intake manifold pressure (created by the turbocharger) enters aneroid at (A). It is directed to upper side of diaphragm chamber (C) and exerts pressure on diaphragm (D).

When the pressure rises to about (100 kPa) (1 bar) 15 psi, or about 1000 engine rpm under moderate to heavy loads, spring pressure (E) is overcome. Diaphragm then moves adjusting shaft screw (F) downward.

Arm (G) has two “legs”. The inner leg bears on the flat surface of adjusting shaft screw (F). The outer leg bears against a block riveted to the control rack (H).

NOTE: Diaphragm adjusting screw (B) regulates the minimum fuel delivery quantity at a specified rpm and zero pressure acting on the diaphragm. The diaphragm spring determines acceleration time (the greater the spring tension, the greater the manifold pressure required to overcome spring tension; hence, a slower acceleration).

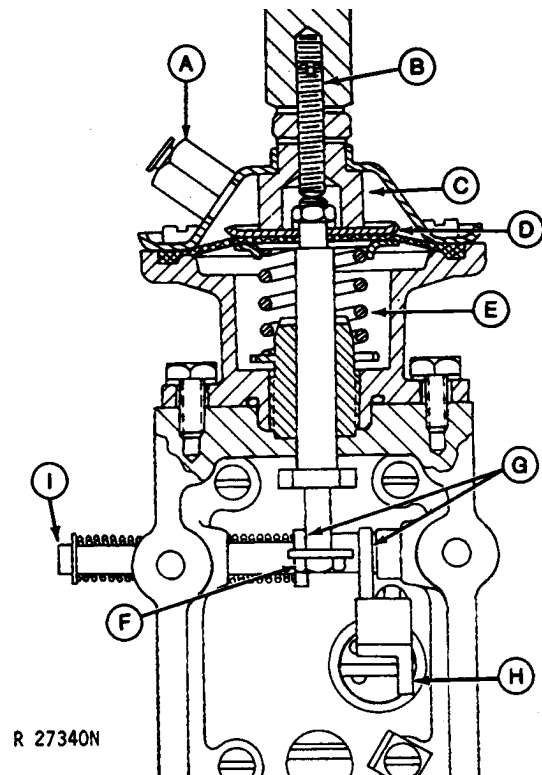
Downward movement of the adjusting shaft causes arm to rotate on starting fuel control shaft (I), permitting control rack to move its normal amount.

If the intake manifold pressure is below 100 kPa (1 bar) (15 psi) because of low engine speed, or is under light load at higher engine speeds, the aneroid spring pressure is greater than the intake manifold pressure. As a result, the control rack travel is limited (therefore, fuel delivery is limited) by the arm and adjusting shaft.

Aneroid control will be in effect until the manifold pressure is high enough to overcome diaphragm spring pressure.

A hydraulic aneroid activator (described in this group) is used to control the lever arm engagement with the control rack by moving the starting fuel control shaft in or out.

During starting, the hydraulic aneroid activator disengages the lever arm from the control rack to permit the rack to move all the way forward to the starting fuel delivery position.



- A—Intake Manifold Pressure Opening
- B—Adjusting Screw
- C—Diaphragm Chamber
- D—Diaphragm
- E—Spring
- F—Adjusting Shaft Screw
- G—Arm
- H—Control Rack
- I—Starting Fuel Shaft

DIAGNOSE ANEROID MALFUNCTION

Symptom	Problem	Solution
Slow Engine Acceleration	Loose pipe or broken connection at inlet fitting	Repair as required. (See Group 35)
	Aneroid cover cracked around inlet fitting	Repair as required. (See Group 35)
	Defective diaphragm	Repair as required. (See Group 35)
	Aneroid not correctly adjusted	Remove injection pump (See Group 35) and adjust on test stand.
Excessive Smoke When Accelerating Engine	Aneroid not correctly adjusted	Remove injection pump. (See Group 35) and adjust on test stand.

S11,23010,IV -19-17MAR92

Use information contained in the chart above to help diagnose aneroid malfunctions.

See Group 35 for instructions on how to repair and adjust the aneroid.

The aneroid controls fuel delivery when intake manifold pressure is about 100 kPa (1 bar) (15 psi) or less. Therefore, all final adjustments are to be made on the test stand with aneroid mounted on injection pump.

IMPORTANT: Correct aneroid adjustments are essential for satisfactory engine performance. Whenever the aneroid has been disassembled or the adjustments have been altered, the injection pump (including aneroid) must be calibrated on the test stand by an authorized diesel injection repair station before releasing the pump for service.

S11,23010,IV1 -19-09SEP91

HOW THE HYDRAULIC ANEROID ACTIVATOR WORKS—MECHANICAL GOVERNORS ONLY

The hydraulic aneroid activator mounts on the inboard side of the governor housing. It has an internal piston (F) that is operated by engine oil pressure to hydraulically move the starting fuel control shaft inward for aneroid control.

Engine lubricating oil is piped from the oil filter body to operate the activator. This oil is then piped to the injection pump housing to lubricate the internal working parts.

Engine oil upon starting the engine is routed to the aneroid activator housing (I) through a banjo connector (A), special screw (B), and an orifice in the capillary valve (E) to head of piston (F).

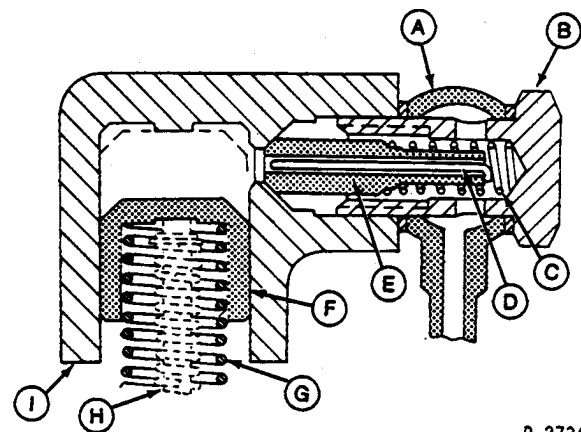
Whenever the engine oil pressure is about (60 kPa) (0.6 bar) 9 psi or higher, the piston will overcome resistance of piston spring (G) and move the starting fuel control shaft (H) inward to provide aneroid control.

Loss of oil pressure permits a return spring on the starting fuel control shaft to hold the lever arm out of engagement with the control rack. This prevents the aneroid from limiting rack travel.

A restrictor wire (D) is inserted in the capillary valve for two reasons.

- (1) To retard engagement of the aneroid when engine is cold.
- (2) To help maintain an open passage in the capillary valve (oil pressure action moves the wire enough to prevent orifice from plugging).

The length of time required to achieve aneroid control depends on the ambient air temperature and the viscosity of the engine oil. Warm ambient air temperatures will permit the aneroid to activate in a few seconds. Cold temperatures may delay activation for several minutes.



- A—Activator Banjo Connector
- B—Special Screw
- C—Capillary Valve Spring
- D—Restrictor Wire
- E—Capillary Valve
- F—Piston
- G—Piston Spring
- H—Starting Fuel Control Shaft
- I—Activator Housing

R 27342N

-UN-14DEC88

R27342N

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The following table gives the approximate ambient temperature-engagement time based on different engine lubricating oil viscosities:

Ambient Temp. °C (°F)	Engine Crankcase Oil	Engagement in Seconds (Approx.)
-1 (30)	SAE 30	86
-18 (1)	10W-20	255
-29 (-20)	5W-20	360

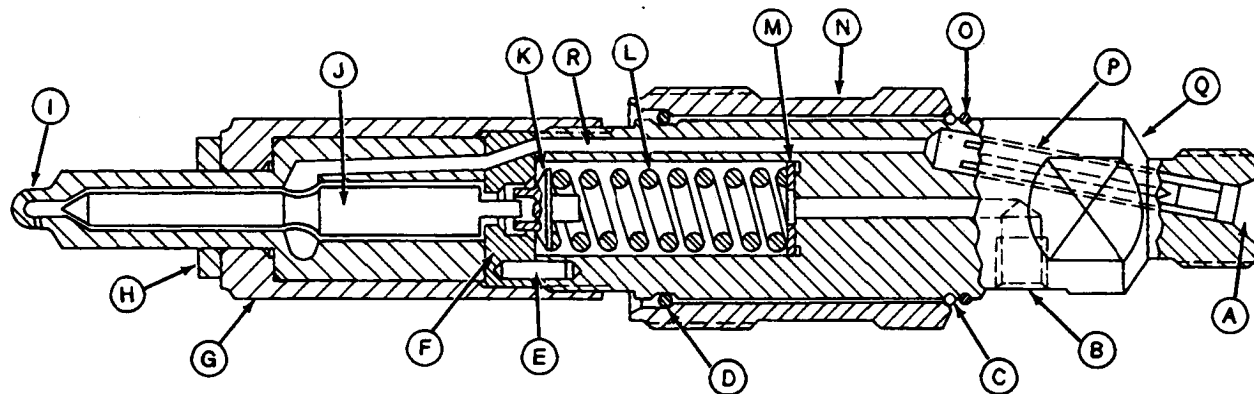
S11,23010,AC -19-19MAY88

DIAGNOSE MALFUNCTIONS—HYDRAULIC ANEROID ACTIVATOR

Symptom	Problem	Solution
Engine Starts Hard	Broken return spring on starting fuel control shaft.	Repair (See Group 35)
	Retaining ring missing from starting fuel control shaft.	Repair (See Group 35)
Excessive Smoke When Accelerating Engine	Check for restriction in oil supply passages to activator piston.	Disassemble activator (See Group 35)

S11,23010,IW -19-28OCT92

FUEL INJECTION NOZZLES—GENERAL INFORMATION



RG2242

RG2242
-UN-14DEC88

A—Fuel Inlet
B—Leak-Off Connection
C—O-Ring
D—Snap Ring
E—Dowel Pin

F—Intermediate Plate
G—Nozzle Retaining Nut
H—Washer
I—Nozzle
J—Valve

K—Spring Seat
L—Spring
M—Shims
N—Gland Nut

O—Snap Ring
P—Edge-Type Filter
Q—Nozzle Holder
R—Fuel Passage

The nozzle valve (J) is held on its seat by a spring (L). Shims (M) are used to regulate the nozzle opening pressure.

The nozzle (I) and valve fit together by precision lapping. These parts are referred to as a nozzle assembly, and are not serviced separately.

Correct alignment of the nozzle assembly with its holder is essential so that the atomized fuel will be sprayed into the combustion chamber at the angle and location intended by design. KDEL holders use an intermediate plate (F) with dowel pins (E) on both sides to insure alignment.

A retaining nut (G) is used to fasten the nozzle assembly to the holder body. The diameter of the holder body is 21 mm, and from this dimension the fuel injection nozzles are known as 21 mm nozzles.

An edge-type filter (P) is placed in the fuel inlet of the nozzle holder. Its purpose is to prevent coarse, foreign particles from damaging the nozzle assembly or plugging the orifices. Finer particles pass through the filter without harm. The filter is not removable.

To provide a seal between the injection nozzle and the engine cylinder head, a steel washer (H) is used at the base of the nozzle retaining nut.

The fuel injection nozzle is fastened to the engine cylinder head by a gland nut (N). The gland nut also functions as a jack screw to raise the injection nozzle out of cylinder head during removal.

S11,23010,AF -19-19SEP91

FUEL INJECTION NOZZLE OPERATION

Fuel lines (A) deliver the fuel to injection nozzles. Fuel enters the injection nozzle inlet (B), and passes through the edge-type filter (C). Coarse foreign particles are retained by the filter.

115
32

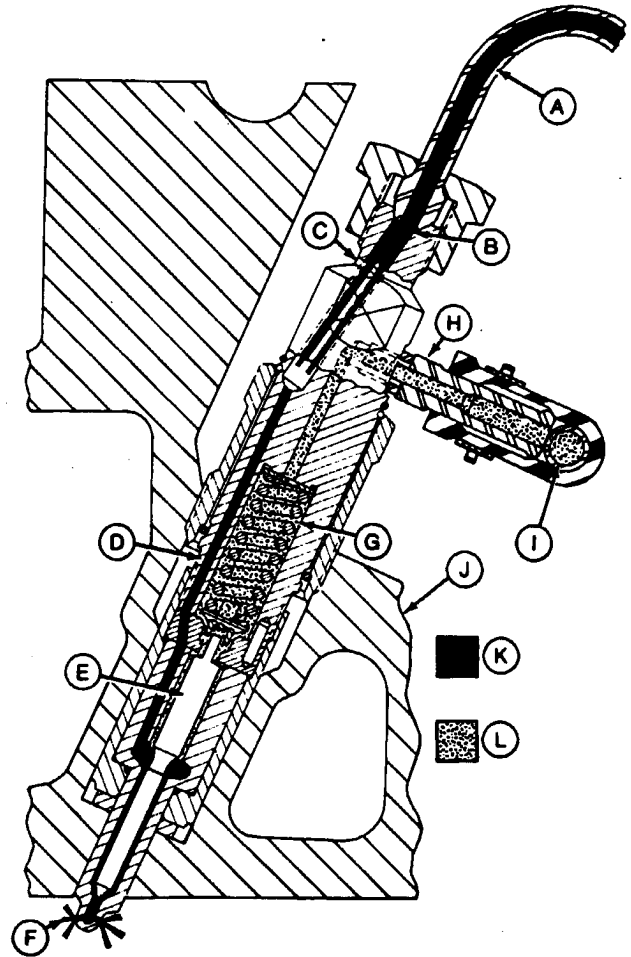
A passage (D) routes fuel through the nozzle holder to the nozzle valve (E). The nozzle valve is lifted instantly off its seat by the high pressure inlet fuel acting on an annulus in the valve.

NOTE: Since the nozzle valve opening pressure is considerably lower than the injection pump output pressure, the inlet fuel pressure easily overcomes the resistance of the nozzle valve spring (G).

When the nozzle valve opens, a definite quantity of fuel (determined by the injection pump output for each plunger stroke) is forced out through orifices (F). The fuel becomes finely atomized as it is sprayed into the combustion chamber at high velocity.

The nozzle assembly is lubricated by a small amount of fuel which seeps between the lapped surfaces of the nozzle and valve which accumulates around the spring (G, refer to previous illustrations).

The leakage fuel is routed out the nozzle holder through a leak-off connector (H) and returned back to the fuel tank by means of a leak-off pipe (I).



Fuel Flow Through KDEL Injection Nozzle

- A—Fuel Delivery Line
- B—Fuel Inlet
- C—Edge-Type Filter
- D—Fuel Passage
- E—Nozzle Valve
- F—Orifices
- G—Nozzle Valve Spring
- H—Leak-Off Connector
- I—Leak-Off Pipe
- J—Engine Cylinder Head
- K—High Pressure Fuel
- L—Low Pressure (Return) Fuel

S55,23010,P -19-17MAR92

RG4651 -UN-14DEC88

DIAGNOSE MALFUNCTIONS—FUEL INJECTION NOZZLE

Fuel injection nozzles are usually removed from the engine when there is a noticeable loss of power or excessive smoking.

Listed in the following chart are various malfunctions which may occur on the 21 mm nozzles. Only possible defects related to these nozzles are listed. Failures in other components of the fuel injection system are listed under their respective headings in this group.

See Group 35 for repair information.

Symptom	Problem	Solution
Engine Has Low Horsepower	Nozzle orifices plugged	Repair (See Group 35)
	Incorrect nozzle valve opening pressure	Adjust (See Group 35)
	Broken or damaged parts	Repair as required (See Group 35)
	a. Broken nozzle valve spring b. Cracked or split nozzle tip c. Cracked or split nozzle body d. Internal leak	
	Wrong nozzle and valve in holder	Install correct nozzle assembly (See Group 35)
	Nozzle loose in cylinder head	Make sure R84472 Steel Washer is installed on tip end of injection nozzle. Tighten to specified torque (See Group 35)
Engine Emits Too Much Smoke	Nozzle orifices plugged	Repair (See Group 35 Diesel Fuel System)
	Broken or damaged parts	Repair as required (See Group 35 Diesel Fuel System)
	a. Broken nozzle valve spring b. Cracked or split nozzle tip c. Cracked or split nozzle body d. Internal leak	
	Wrong nozzle and valve in holder	Install nozzle assembly (See Group 35 Diesel Fuel System)
	Worn nozzle valve seal	Replace nozzle assembly (See Group 35 Diesel Fuel System)

RG,CTM42,115,23-19-28OCT92

TEST FUEL INJECTION NOZZLES (ENGINE RUNNING)

1. Operate engine at intermediate speed and no load.
2. Slowly loosen the fuel pressure line at one of the nozzles until fuel escapes at the connection (fuel not opening nozzle valve).

NOTE: The injection nozzle before and/or after nozzle being checked could be the faulty nozzle.

- If engine speed changes, the injection nozzle is probably working satisfactory.
 - If engine speed does not change, a nozzle is faulty and must be checked and repaired (or replaced).
3. Repeat test for each remaining nozzle assembly.
 4. Remove faulty injection nozzles and repair as required. See Group 35.

S11,23010,HR -19-13MAY93

FUEL DRAIN BACK TEST PROCEDURE

Fuel draining back through the fuel system may cause hard starting. This procedure will determine if air is entering the system at connections and allowing fuel to siphon back to the fuel tank.

1. Disconnect fuel supply line and fuel return line at fuel tank.

IMPORTANT: Fuel return line MUST extend below fuel level in fuel tank before performing this test. Fill fuel tank if necessary.

2. Drain all fuel from the system, including the fuel transfer pump, fuel injection pump, fuel filters, and water separator (if equipped).
3. Securely plug off the end of the fuel return pipe.
4. Using a low pressure air source, pressurize the fuel system at the fuel supply line.



CAUTION: Maximum air pressure should be 100 kPa (1 bar) (15 psi) when performing this test.

5. Apply liquid soap and water solution to all joints and connections in the fuel system and inspect for leaks.

NOTE: Connections may allow air to enter the system without allowing fuel to leak out.

6. If any leaks are found, take necessary steps to repair.
7. Reconnect supply and return lines and prime system.
8. Start engine and run for approximately 10 minutes.
9. Allow engine to sit overnight and try starting the following morning.

S11,23010,JA -19-28OCT92

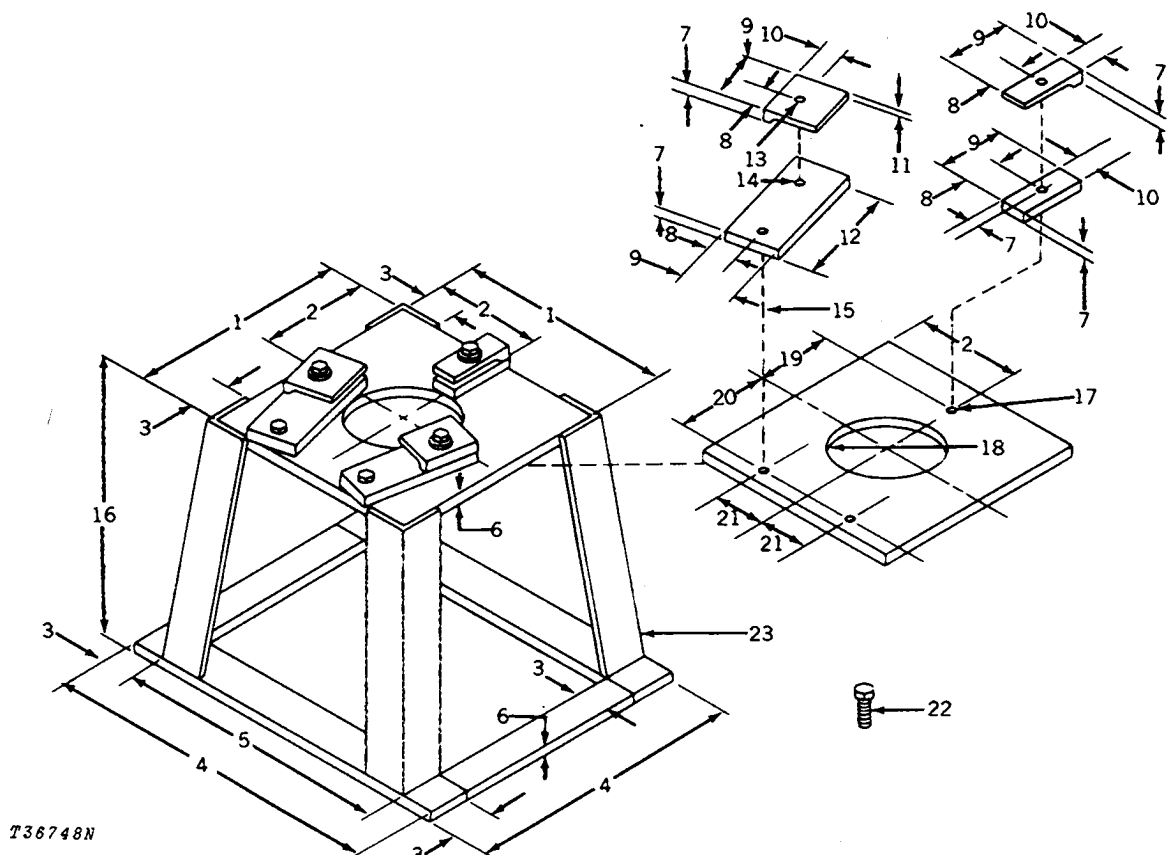
HOW TO MAKE TOOLS

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

S55,DFRG -19-01DEC89

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1

FABRICATED TOOLS—CYLINDER LINER HOLDING FIXTURE



T36748N
-UN-24OCT88

1—254.0 mm (10 in.)	8—31.8 mm (1.25 mm)	15—2 used	20—111.25 mm (4.38 in.)
2—127.0 mm (5 in.)	9—63.5 mm (2.5 in.)	16—304.8 mm (12 in.)	21—60.45 mm (2.38)
3—38.1 mm (1.5 in.)	10—25.4 mm (1 in.)	17—5/16 in.—18 Tap	22—5/16 in. x 1 in. Cap Screw
4—406.4 mm (16 in.)	11—6.35 mm (0.25 in.)	18—69.85 mm (2.75 in.) Radius	23—38.1 mm (1.5 in.) Angle Iron
5—330.2 mm (13 in.)	12—152.4 mm (6 in.)	19—101.6 mm (4 in.)	
6—9.52 mm (0.375 in.)	13—0.328 in. Drill Through		
7—12.7 mm (0.5 in.)	14—5/16 in.—18 Tap		

NOTE: These tools can be made in a service shop using common shop tools and locally obtained materials.

S11,9900,BE -19-14JUN89

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