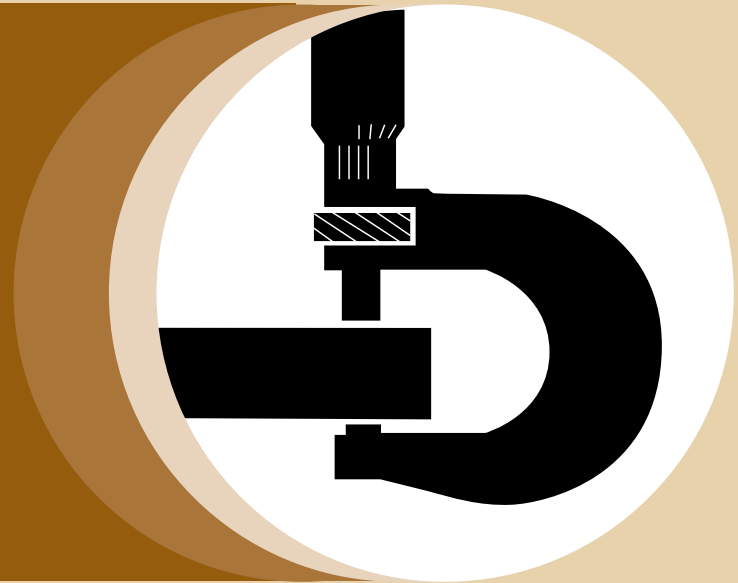


6076 Natural Gas Engines

Serial Number (500000—)

COMPONENT TECHNICAL MANUAL



Deere Power Systems Group
CTM82 (11JUN93)

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 6076, 7.6 L (466 cu. in.) natural gas engines produced in Waterloo, Iowa beginning with Engine Serial No. (500000—).

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

Direction of engine crankshaft rotation in this manual is referenced from the flywheel end looking toward the front. Front of engine is fan drive end.

Read each module completely before performing any service.

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

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TS227

HANDLE NATURAL GAS SAFELY

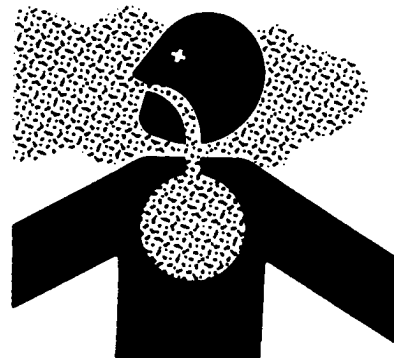
Handle natural gas with care: it is highly flammable. Do NOT smoke while working on or around natural gas equipment.

Natural gas fumes may cause sickness or death. Work in well ventilated area.

Shut off natural gas supply before servicing equipment.

Have a manual valve installed away from the engine to shut off gas supply in case of an emergency.

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



RG,NATGAS,SFTY -19-26FEB93

-UN-23AUG88
TS227
-UN-23AUG88
TS220

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PREVENT BATTERY EXPLOSIONS

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

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

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



DX,SPARKS -19-03MAR93

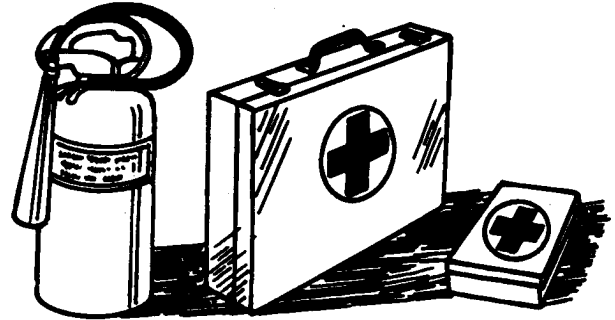
TS204 -UN-23AUG88

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:

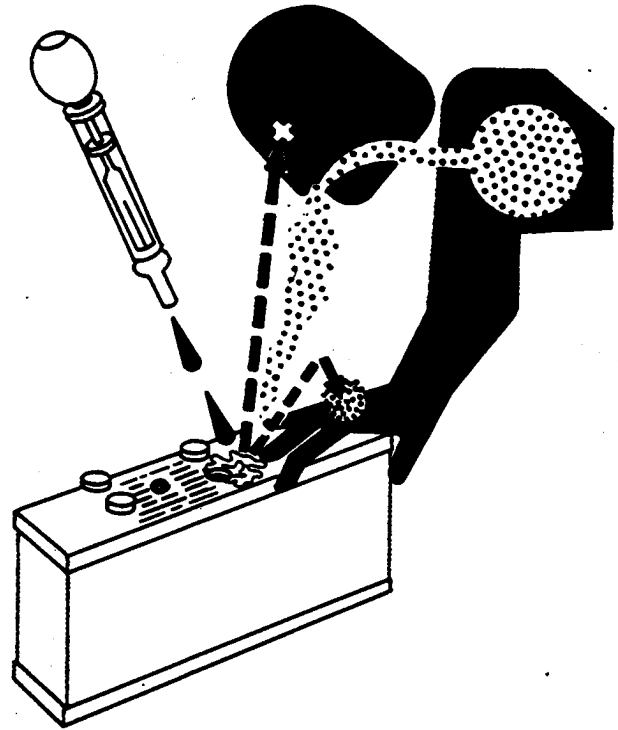
1. Filling batteries in a well-ventilated area.
2. Wearing eye protection and rubber gloves.
3. Avoiding breathing fumes when electrolyte is added.
4. Avoiding spilling or dripping electrolyte.
5. Use proper jump start procedure.

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.



DX,POISON -19-21APR93

TS203 -UN-23AUG88

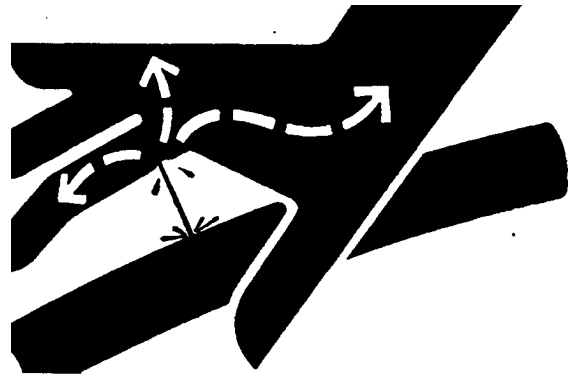
AVOID HIGH-PRESSURE FLUIDS

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.



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DX,FLUID -19-03MAR93

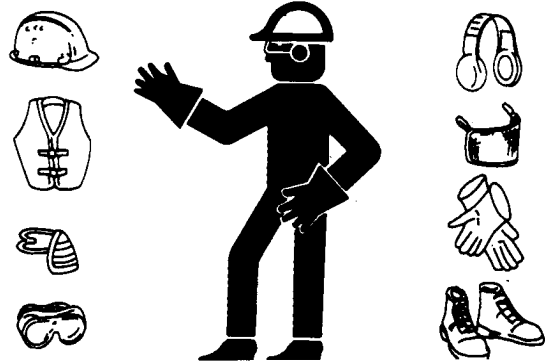
WEAR PROTECTIVE CLOTHING

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.



-UN-23AUG88

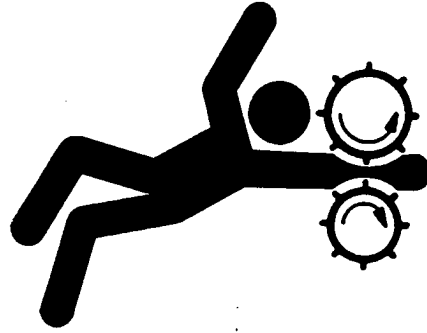
TS206

DX,WEAR -19-10SEP90

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.



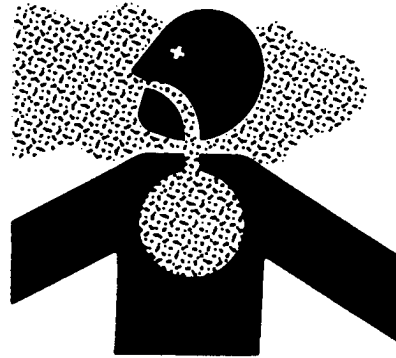
DX, LOOSE -19-04JUN90

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.



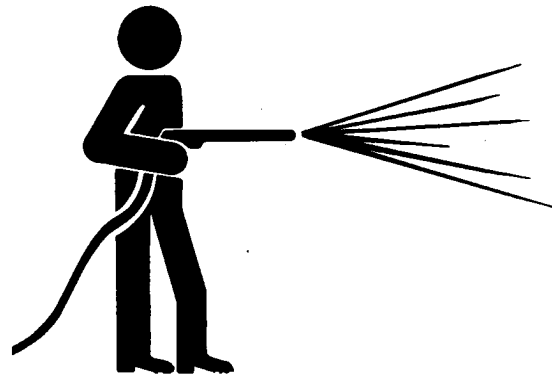
DX, AIR -19-04JUN90

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

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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.



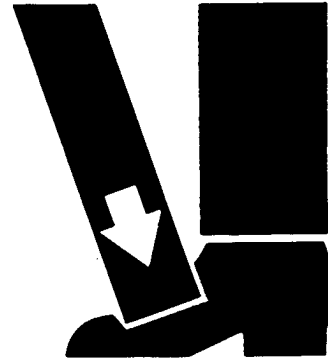
DX,LIGHT -19-04JUN90

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.



TS779 -UN-08NOV89

DX,REPAIR -19-04JUN90

DISPOSE OF WASTE PROPERLY

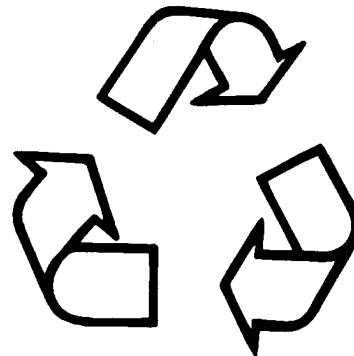
Improperly disposing of waste can threaten the environment and ecology. Potentially harmful waste used with John Deere equipment include such items as oil, fuel, coolant, brake fluid, filters, and batteries.

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

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

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

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



TS1133 -UN-26NOV90

DX,DRAIN -19-03MAR93

LIVE WITH SAFETY

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

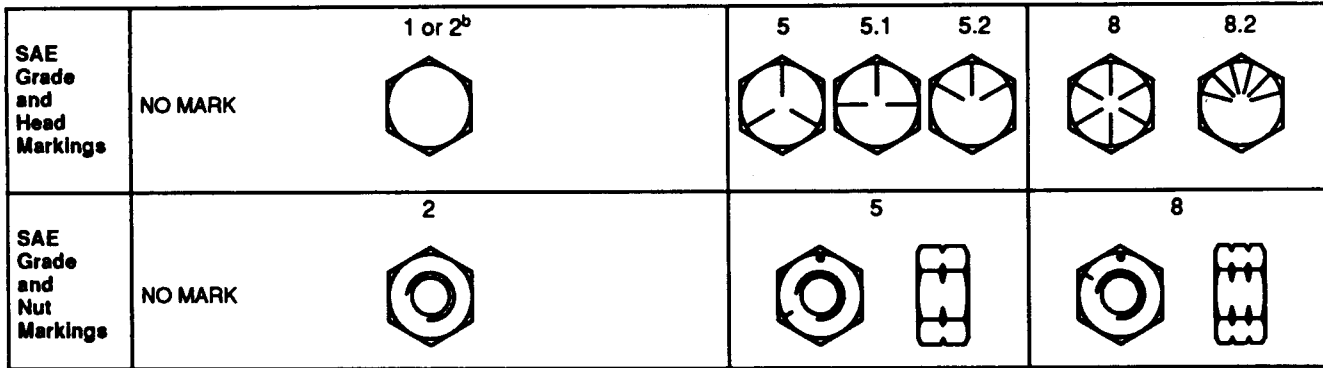


DX,LIVE -19-25SEP92

TS231 -19-07OCT88

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UNIFIED INCH BOLT AND CAP SCREW TORQUE VALUES



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-19-04MAR91
TS1162

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.

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.

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

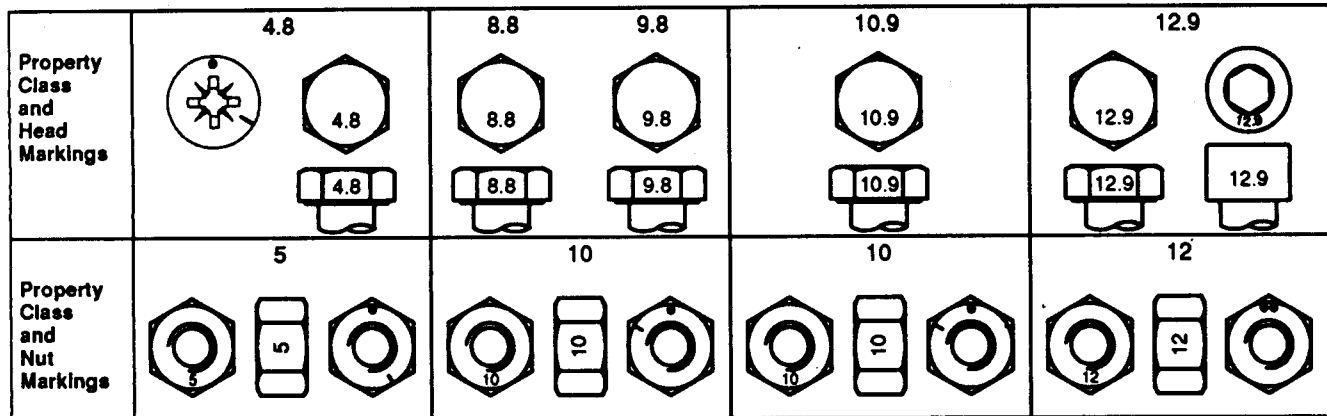
Make sure fasteners threads are clean and that you properly start thread engagement. This will prevent them from failing when tightening.

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.

^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.

METRIC BOLT AND CAP SCREW TORQUE VALUES



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—6076

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

6076AFN30 Engine

6 Number of cylinders
07.6 Liter displacement
A Aspiration code
FN User code
30 Application code

Aspiration Code

A Turbocharged and aftercooled

User Code

FN OEM Natural Gas

Application Code

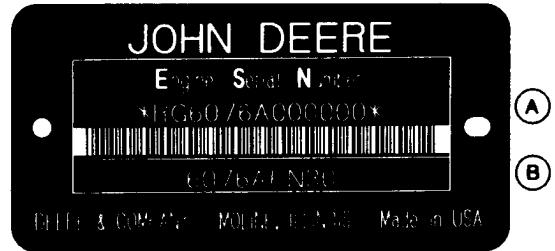
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RG.CTM82,G1,1 -19-04FEB93

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ENGINE SERIAL NUMBER PLATE INFORMATION

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



1. Engine Serial Number (A)

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

RG6076A000000

RG Factory code producing engine
 6076A Engine Model Designation
 000000 Sequential Number

Factory Code Producing Engine

RG Waterloo Engine Works

Engine Model Designation

6076A Definition explained previously. (See ENGINE MODEL DESIGNATION.)

Sequential Number

000000 6-digit sequential number.

The engine serial number plate is located either on the right-hand side of engine between the oil conditioning housing and fuel injection pump (viewed from flywheel end) or on the left-hand side of the block directly above the starting motor.

2. Engine Application Data (B)

The second line of information on the engine serial number plate identifies the engine OEM relationship.

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RG6494

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NATURAL GAS RECOMMENDATIONS

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

Dry natural gas that meets the following specifications is recommended for use in John Deere Natural Gas Engines.

- Maximum Propane Content 5 percent
- Maximum Ethane Content 3 percent
- Maximum Butane Content 1 percent
- Maximum Hydrogen Sulfide (H₂S) Content 10 ppm
- Minimum Octane Rating 118
- Recommended Heating Value (LHV) 33.72 kJ/L
(905 BTU/cu ft)

RG.21881.FLC2 -19-28MAY93

02
1

ENGINE OIL

IMPORTANT: Use of incorrect oil types in John Deere Natural Gas engines could result in damage to internal engine components.

Engine oil must have the proper additive chemistry and controlled sulfated ash level*. If additives are depleted, acids formed during combustion will not be neutralized and will corrode the rings, valves, and liners.

John Deere Torq-Gard Supreme 15W40 engine oil (TBN=8, Sulfated Ash=1%) is recommended for John Deere Natural Gas engines.

Oil and filter must be changed every 400 hours maximum if John Deere Torq-Gard Supreme 15W40 is used.

Oil and filter must be changed every 350 hours for other oils if they meet the following recommendations:

ENGINE OIL SPECIFICATIONS

Viscosity SAE 15W40/SAE 40

Sulfated Ash (% wt.)* 0.45 Min.—1.0 Max.

Total Base Number (TBN)** 5.0 or higher

API Service Classification CE or CD

- SAE 15W40 viscosity oils are preferred. SAE 40 oils may be used when minimum ambient temperature is above 10°C (50°F).
- If sulfated ash level is too high, deposits may form on top of pistons and can cause pre-ignition (“knock”), resulting in piston damage. In addition, deposits may reduce spark plug life.

NOTE: TBN and/or sulfated ash levels are physical properties of oil and are not necessarily an indication of oil performance.

* As measured by ASTM D 874 Test Method.

** As measured by ASTM D 664 Test Method.

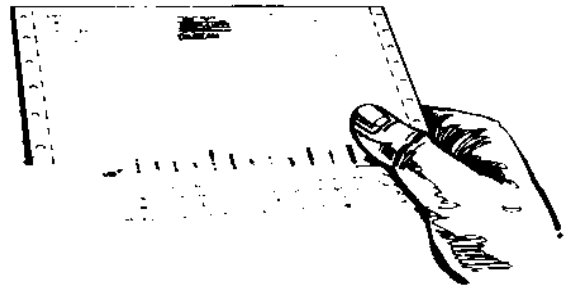
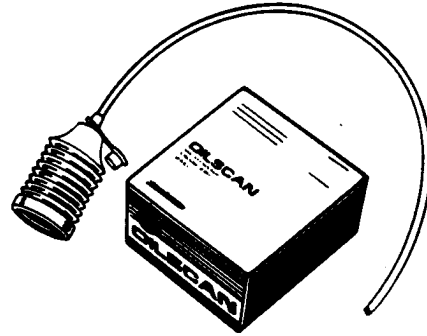
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OILSCAN® AND COOLSCAN™

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

T6829AB -UN-18OCT88

GREASE

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

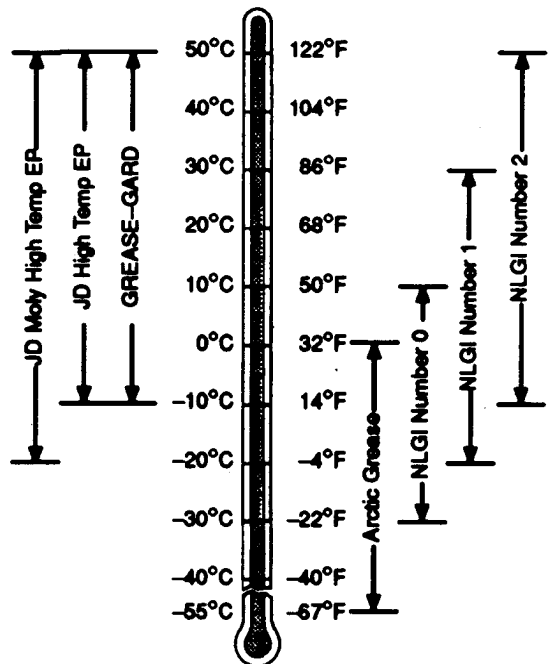
The following greases are preferred:

- 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

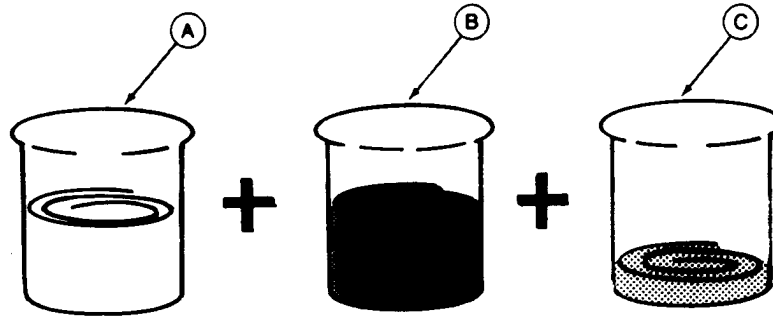
Greases meeting Military Specification MIL-G-10924F may be used as arctic grease.



DX,GREA1 -19-03JUN93

TS1417 -UN-27MAY93

ENGINE COOLANT REQUIREMENTS



A—Quality Water

B—Ethylene Glycol Concentrate
(Antifreeze)

C—Supplemental Coolant Additives
(SCA's)

Engine Coolant

RG6258
-UN-22APR92

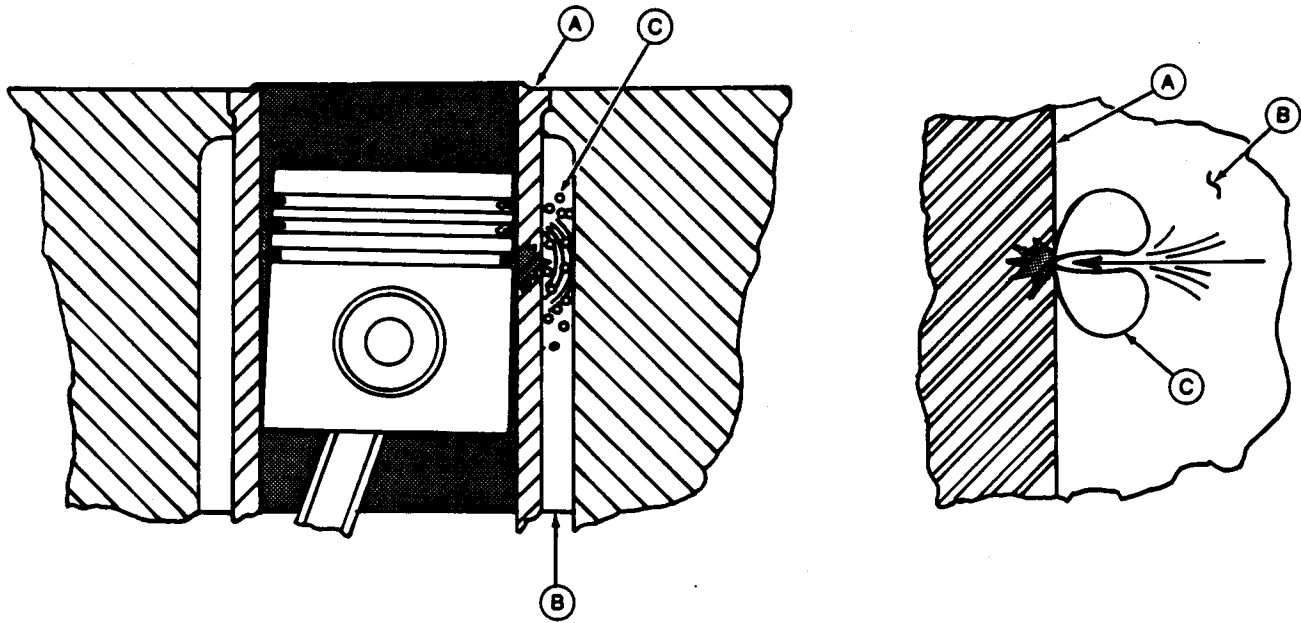
To meet cooling system protection requirements, the coolant **MUST** consist of a 50/50 mixture of quality water and ethylene glycol concentrate (antifreeze). Add to the mixture 3% (by volume) supplemental coolant additives (SCA's). See ENGINE COOLANT SPECIFICATIONS, later in this group, for further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

02

RG6263 -UN-22/APR92

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 JDM H24 or ASTM D 4985.

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ENGINE COOLANT SPECIFICATIONS—CONTINUED



RG4690
-JUN-14DEC88

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.

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 -JUN-14DEC88

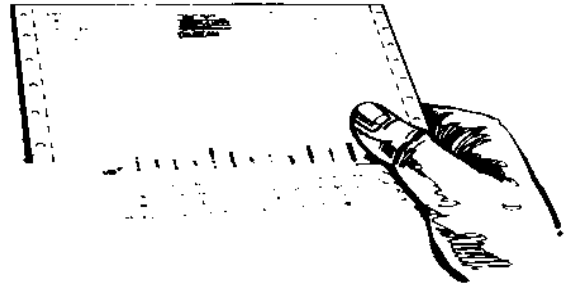
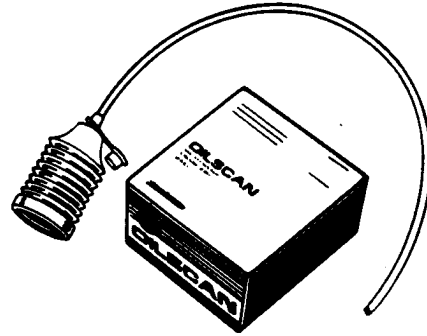
CHECK EFFECTIVENESS OF COOLANT SOLUTION

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.



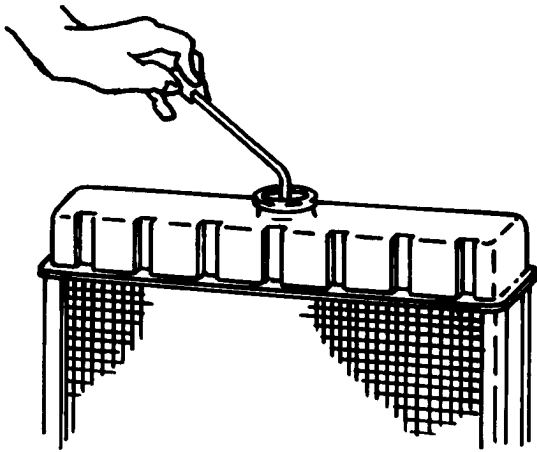
RG.COOL.REQ7 -19-16SEP92

T6829AB -UN-15JUN89

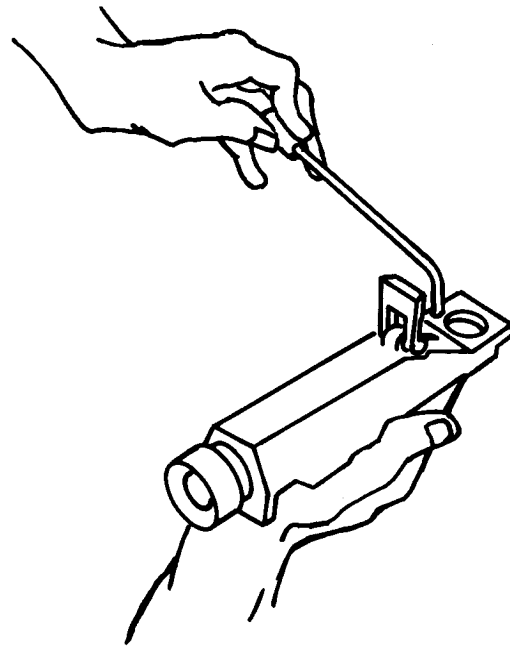
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T6829AB -UN-18OCT88

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.

Perform a COOLSCAN analysis. If a COOLSCAN analysis is not available, recharge system per instructions printed on bottle.

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

IMPORTANT: If frequent coolant make-up is required, the glycol concentration should be checked with JT05460 Refractometer to assure that desired freeze point is maintained. Follow manufacturer's instructions provided with refractometer.

See ENGINE COOLANT SPECIFICATIONS in Fuels, Lubricants, and Coolant section for proper mixing of coolant ingredients before adding to cooling system.

RG,OMCOOL,REQ2 -19-01MAR93

FLUSH AND SERVICE COOLING SYSTEM



TS281
-UN-23AUG88

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 2000 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 operator's manual for a specific 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.REQ8A -19-06APR93

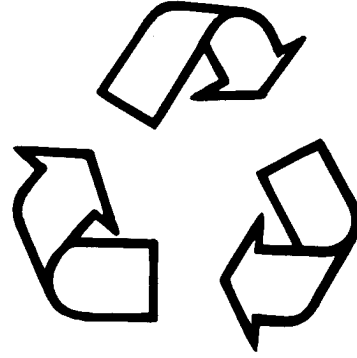
DISPOSING OF COOLANT

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.



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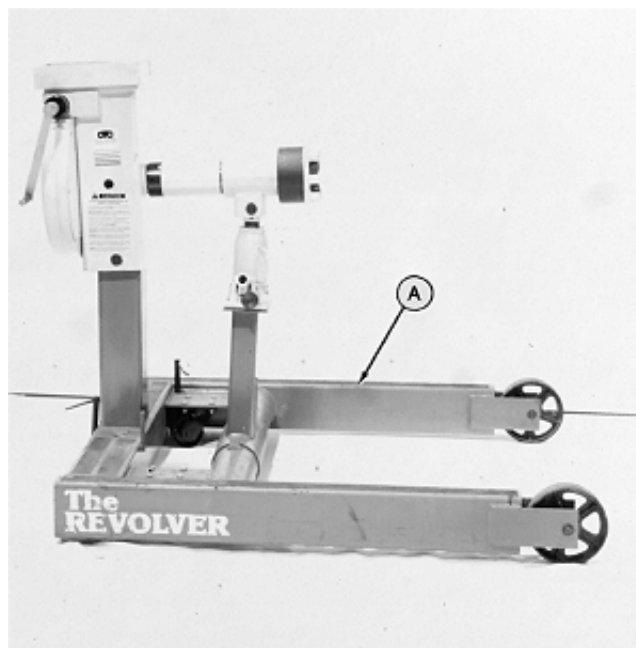
TS1133 -UN-26NOV90

RG,COOL,REQ5 -19-26FEB93

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.



S11.2000.EM -19-31MAR93

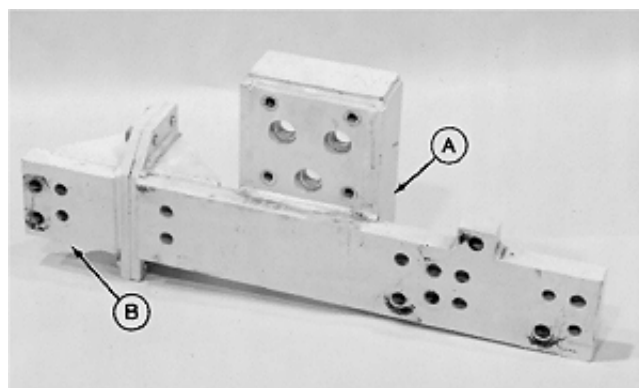
SAFETY PRECAUTIONS

- 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 400 SERIES ADAPTERS ON REPAIR STAND

1. Attach the No. 60581 Engine Adapter (A) to mounting hub of the engine repair stand using SAE Grade 8 socket head screws. Tighten screws to 135 N·m (100 lb-ft).
2. Attach the No. 51400 end adapter (B) to the engine adapter, using four 5/8-11 x 2 in. SAE Grade 8 cap screws. Tighten screws to 135 N·m (100 lb-ft).



S11,2000,FB -19-07AUG91

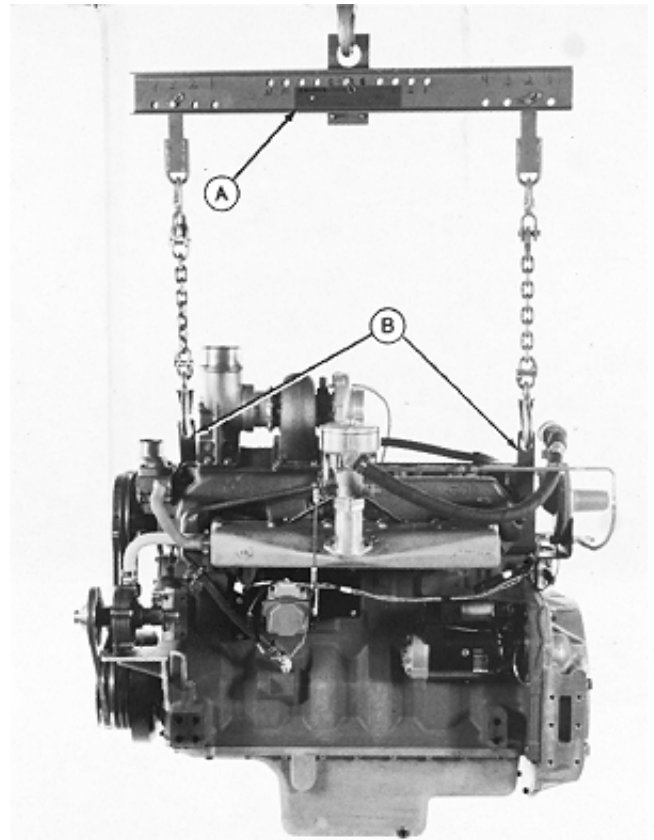
ENGINE LIFTING PROCEDURE

⚠ CAUTION: Use extreme caution when lifting and NEVER permit any part of the body to be positioned under an engine being lifted or suspended.

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

NOTE: If engine does not have lifting straps, they can be procured through service parts or made-up locally. Use of an engine lifting sling (as shown) is the preferred method for lifting engine. However, if a sling is not on hand, engine can be lifted by chain(s) attached to lifting straps and overhead hoist.

2. Carefully lift engine to desired location.



RG,CTM82,G03,1 -19-06APR93

RG6503
-UN-14DEC92

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CLEAN ENGINE

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

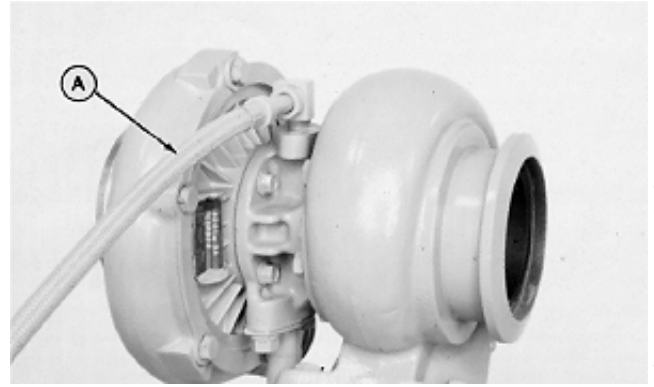
2. Steam-clean engine thoroughly.

RG,CTM82,G03,2 -19-06APR93

DISCONNECT TURBOCHARGER OIL INLET LINE

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

IMPORTANT: When servicing 6076 Engines on a rollover stand, disconnect turbocharger oil inlet line (A) from oil conditioning housing or turbocharger before rolling engine over. Failure to do so may cause a hydraulic lock upon starting engine. Hydraulic lock may cause possible engine failure.



RG5323 -JUN-06DEC88

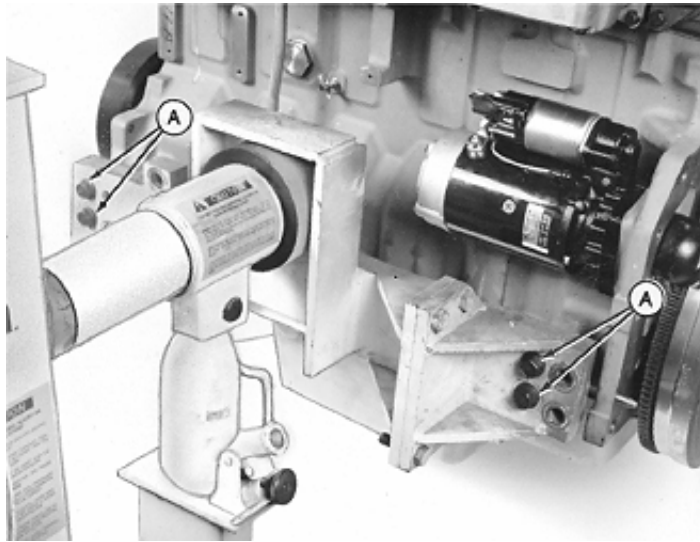
Hydraulic lock occurs when trapped oil in the oil filter housing drains through the turbocharger, the exhaust and intake manifolds, and then into the cylinder head.

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

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

RG,CTM82,G03,3 -19-04FEB93

MOUNT ENGINE ON REPAIR STAND



RG5965
-UN-06SEP91

NOTE: If starting motor is to be removed from engine, remove before mounting engine onto repair stand.

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

1. Mount the starter side of the engine to the engine adapter with four 5/8-11 UNC x 2-3/4 in. cap screws (A).
2. Tighten cap screws to 203 N·m (150 lb-ft).
3. Carefully remove lift sling from engine.

RG,CTM42,G3.2 -19-28OCT92

ENGINE DISASSEMBLY SEQUENCE

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

NOTE: Remove starting motor before mounting engine into repair stand.

1. Drain all coolant and engine oil. Check engine oil for metal contaminates.
2. Remove carburetor, throttle valve, and pressure regulator.
3. Remove turbocharger oil inlet and outlet line and coolant inlet and outlet lines.
4. Remove exhaust elbow and connector. Remove turbocharger.
5. Remove auxiliary water pump and brackets (if equipped). Remove alternator and mounting brackets.
6. Remove fan pulley and water manifold assembly.
7. Remove front crankshaft pulley and damper assembly.
8. Remove ignition wires and spark plugs.
9. Remove ignition control unit, coils, mounting plate, and spacer plate. Remove ignition timing sensor and plate.
10. If equipped, remove electronic governor, throttle actuator, speed sensor, and wiring harness.
11. Remove water pump.
12. Remove engine oil filter and oil conditioning housing.
13. Remove aftercooler and intake manifold assembly, and exhaust manifold.

NOTE: DO NOT damage option code label (if equipped), when removing rocker arm cover.

14. Remove rocker arm cover and breather hose.
 15. Remove rocker arm assembly and push rods. Identify parts for re-assembly.
 16. Remove cylinder head. Remove head gasket.
 17. On SAE No. 3 flywheel housings, remove flywheel then remove flywheel housing.
 18. On SAE No. 1 and 2 flywheel housings, remove flywheel housing and then remove flywheel.
 19. Remove oil pan and engine oil pump assembly.
 20. Remove front timing gear cover.
 21. Remove pistons and connecting rods. Identify for re-assembly. Perform wear checks with PLASTIGAGE™.
- NOTE: Perform wear check on main bearing surfaces with PLASTIGAGE, when removing main bearing caps.*
22. Remove main bearing caps. Remove crankshaft and main bearings. Identify for re-assembly.
 23. Remove camshaft and cam followers. Identify for re-assembly.
 24. Remove liners and their O-ring seals. Mark liners for reassembly in same bore from which removed.
 25. Remove piston cooling orifices.
 26. Remove cylinder block plugs and engine serial number plate, if block is to be put in a "hot tank".
 27. Refer to appropriate group for inspection and repair of engine components.

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

RG,CTM82,G04,1 -19-01JUN93

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 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) bottle

—Plugs and fittings: intake manifold, cylinder block (oil galley).

—Capscrews: ignition sensor plate, ignition coils, ignition control unit, ignition system mounting plate, electronic tachometer cover, oil filler inlet, and flywheel.

—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

• 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

• LOCTITE 515 Flexible Sealant:

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) bottle

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

—Auxiliary water pump drain valve and fittings in separate circuit aftercooler system

—Orifice fitting

—Temperature sending unit

—Oil pan drain plug (drain hose and drain valve)

—Connectors: turbocharger coolant inlet and outlet line pipe fittings

—Adapter fitting for turbocharger oil inlet and outlet lines

—Pipe fittings in natural gas fuel system

• LOCTITE 609 Retaining Compound (green):

TY9372 6 ml. (0.2 oz) tube
T43515 50 ml. (1.7 oz) bottle

—Wear ring-to-crankshaft

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

TY6299 227 g (8 oz) container

—Timing gear cover-to oil pan

—Rear oil seal housing-to-oil pan

—Camshaft bore steel cap plug

SEALANT APPLICATION GUIDELINES—CONTINUED

- **PT569 NEVER-SEEZ®** COMPOUND:

PT569 227 g (8 oz) Brush
PT506 453 g (16 oz) Spray

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

—Pyrometer fitting

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

AR31790 118 ml (4 oz)

—Rocker arm cover gasket

- **FEL-PRO®** C-670 Molybdenum Disulfide Paste

—Camshaft nose (gear and timing wheel installation)

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.

SCOTCH-GRIP® is a registered trademark of 3M Company.

FEL-PRO® is a registered trademark of FEL-PRO.

RG,CTM82,G04,3 -19-01JUN93

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ENGINE ASSEMBLY SEQUENCE

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

1. Install all plugs in cylinder block that were removed to service block. Install engine serial number plate.
2. Install clean piston cooling orifices.
3. Install cam followers in hole from which originally removed.
4. Install camshaft.
5. Install main bearings and crankshaft. Align timing marks (camshaft to crankshaft gears). Rotate crankshaft to assure correct assembly. Check crankshaft end play.
6. Install cylinder liners without O-rings and measure liner stand-out. Install liner O-rings in block and packings on liners. Install liners.
7. Install piston and rod assemblies.
8. Install engine oil pump assembly.
9. Install crankshaft rear oil seal housing, oil seal, and wear sleeve.
10. Install timing gear cover. Install front crankshaft wear sleeve and oil seal.
11. Install oil pan.
12. Install engine oil conditioning assembly.
13. Install water pump.
14. Install flywheel and housing:
 - SAE 1 or SAE 2: Flywheel goes on before housing.
 - SAE 3: Housing goes on before flywheel.
15. Install cylinder head, push rods, and rocker arm assembly. Measure valve lift and adjust valve clearance.
16. Install rocker arm cover. Install breather hose.
17. Install exhaust manifold.
18. Install aftercooler and intake manifold assembly.
19. Install ignition timing sensor, coils, ICU, mounting plate, spacer plate, and wiring harness.
20. Install spark plugs and ignition wires.
21. Install turbocharger, exhaust elbow, coolant inlet and outlet lines, and oil lines.
22. Install carburetor, throttle valve, and pressure regulator.
23. Install crankshaft pulley and damper.
24. Install water manifold and fan pulley assembly.
25. Install alternator and bracket.
26. Install auxiliary water pump (if equipped).
27. If equipped, install electronic governor, throttle actuator, and speed sensor.
28. Fill engine with clean oil and the proper coolant. Install dipstick.
29. Perform engine break-in and standard performance checks.

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4

SPECIAL OR ESSENTIAL TOOLS

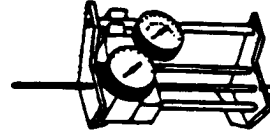
NOTE: Order tools according to information given in the U.S. SERVICE-GARD™ Catalog or in the European Microfiche Tool Catalog (MTC).

DX,TOOLS -19-05JUN91

Spring Compression Tester D01168AA

RG5061 -UN-23AUG88

Test valve spring compression.

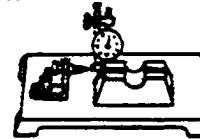


S53,D01168,AA -19-13MAR92

Valve Inspection Center D05058ST

RG5062 -UN-23AUG88

Check valves for out-of round.

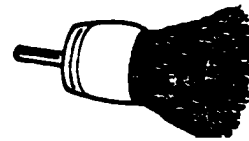


S53,D05058,ST -19-02APR87

End Brush D17024BR

RG5063 -UN-23AUG88

Clean valve seat and bores.



S53,D17024,BR -19-26JAN87

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

RG6246 -UN-27MAR92

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

RG5064 -UN-23AUG88

Knurl valve guides.



S53,D20002,WI -19-16SEP92

Valve Seat Pilot Driver JDE7

RG5065 -UN-23AUG88

Install replacement valve seat inserts. Use with JDG605.



S53,JDE7A -19-04FEB93

Cylinder Head and Valves/Special or Essential Tools

Torque Wrench Adapter JDE37A

RG5072 -UN-23AUG88

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



S53,JDE37A -19-07AUG91

Flywheel Turning Tool JDE81-1

RG4950 -UN-23AUG88

Rotate engine flywheel. Use with JDE81-4.

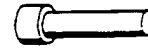


S53,JDE811 -19-07JUL89

Timing Pin JDE81-4

RG5068 -UN-23AUG88

Lock engine at TDC when timing valve train. Use with JDE81-1 or JDE83.

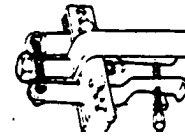


S53,JDE814 -19-06APR90

Valve Seat Puller JDE41296

RG5071 -UN-23AUG88

Remove valve seats.

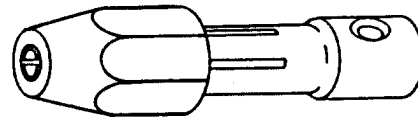


S53,JDE,41296 -19-26JAN87

T-Handle Wrench JDG513

RG6775 -UN-10MAY93

Use with HAN1749 tap and 3/8 in. drive extension to clean damaged spark plug hole threads.



RG,JDG513 -19-04JUN93

Tap (14x1.25) HAN1749

RG5100 -UN-23AUG88

Use with JDG513 T-Handle Wrench to clean damaged spark plug hole threads.



RG,HAN1749 -19-04MAY93

Tap JDG681

RG5100 -UN-23AUG88

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



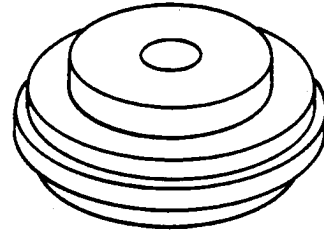
RG,JDG681 -19-25MAR91

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2

Cylinder Head and Valves/Special or Essential Tools

Valve Seat Installer JDG605

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

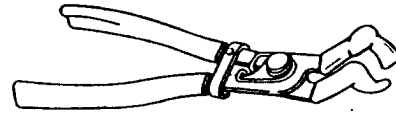


S53,JDG605 -19-25MAR91

RG5240 -UN-23AUG88

Spark Plug Boot Puller Pliers JDG815

Used to remove and install spark plug boots.



RG6720 -UN-27APR93

RG,JDG815 -19-03MAY93

Brush JDG816

Use to clean spark plug hole threads.

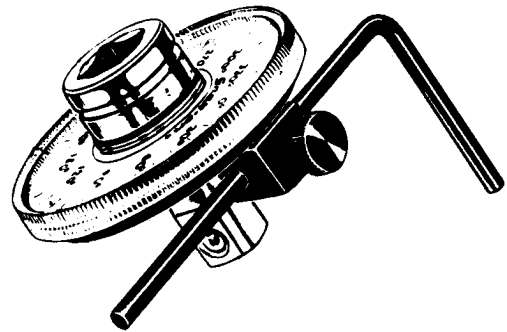


RG6776 -UN-10MAY93

RG,JDG816 -19-04MAY93

Torque Angle Gauge JT05993

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



RG,JT05993 -19-22AUG91

RG5698 -UN-27AUG90

05
3

CYLINDER HEAD AND VALVES SPECIFICATIONS

ITEM	SPECIFICATION	WEAR LIMIT
Valve Lift at 0.00 mm (in.) Clearance		
Exhaust	14.38—14.84 mm (0.566—0.584 in.)	13.49 mm (0.531 in.)
Intake	13.39—13.84 mm (0.527—0.545 in.)	12.50 mm (0.492 in.)
Valve Clearance (Rocker Arm-to-Valve Tip):		
Exhaust	0.51 mm (0.020 in.)	—
Intake	0.38 mm (0.015 in.)	—
Valve Spring Compressed Height:		
Valve Closed-Exhaust	54.5 mm @ 284—338 N (2.15 in. @ 64—76 lb-force)	—
Intake	52.5 mm @ 345—399 N (2.07 in. @ 78—90 lb-force)	—
Valve Open-Exhaust	38.5 mm @ 797—867 N (1.52 in. @ 179—195 lb-force)	—
Intake	38.1 mm @ 810—880 N (1.50 in. @ 182—198 lb-force)	—
Valve Head OD:		
Exhaust	46.87—47.13 mm (1.845—1.856 in.)	—
Intake	50.87—51.13 mm (2.003—2.013 in.)	—
Valve Stem OD:		
Exhaust	9.44—9.46 mm (0.3717—0.3724 in.)	—
Intake	9.46—9.49 mm (0.3724—0.3736 in.)	—
Oversize Valve (Stem) Available	0.38 mm (0.015 in.)	—
Valve Guide ID	9.51—9.54 mm (0.3745—0.3755 in.)	—
Valve Stem-to-Guide Clearance:		
Exhaust	0.051—0.102 mm (0.002—0.004 in.)	—
Intake	0.025—0.076 mm (0.001—0.003 in.)	—
Valve Seat Concentricity with Guide		
	0.051 mm (0.0020 in.)	—
Valve Seat Insert O.D.:		
Exhaust	49.067—49.093 mm (1.9318—1.9328 in.)	—
Intake	52.067—52.093 mm (2.0499—2.0509 in.)	—
Valve Seat Bore I.D.:		
Exhaust	48.987—49.013 mm (1.9286—1.9296 in.)	—
Intake	51.987—52.013 mm (2.0467—2.0477 in.)	—
Valve Seat Bore Depth:		
Exhaust	9.60—9.76 mm (0.378—0.384 in.)	—
Intake	12.21—12.37 mm (0.481—0.487 in.)	—

RG,CTM82,G05,1 -19-01JUN93

CYLINDER HEAD AND VALVES SPECIFICATIONS—CONTINUED

ITEM	SPECIFICATION	WEAR LIMIT
Valve Face Angle	19.25° ±0.25°	—
Valve Seat Angle	20° ±0.50°	—
Valve Seat Width:		
Exhaust	2.0—3.8 mm (0.79—0.150 in.)	—
Intake	1.4—3.8 mm (0.055—0.150 in.)	—
Valve Recess in Cylinder Head:		
Exhaust	0.68—1.20 mm (0.003—0.047 in.)	1.96 mm (0.077 in.)
Intake	2.56—3.08 mm (0.101—0.121 in.)	3.84 mm (0.151 in.)
Maximum Valve Seat Runout	0.051 mm (0.0020 in.)	—
Maximum Valve Face Runout	0.051 mm (0.0020 in.)	—
Cylinder Firing Order	1-5-3-6-2-4	—
Rocker Arm ID	19.07—19.10 mm (0.7507—0.7520 in.)	—
Rocker Arm Shaft OD	19.01—19.05 mm (0.7484—0.7500 in.)	—
Cylinder Head Reconditioning:		
Thickness of Head (Rocker Arm Cover Gasket Rail-to- Combustion Face)	155.45—155.71 mm (6.120—6.130 in.)	154.69 mm (6.09 in.)
Maximum Acceptable Head Out-of-Flat (Entire Length or Width)	0.102 mm (0.0040 in.)	—
Combustion Face Surface Finish (Surface Grind Only) (AA)	0.0015—0.0028 mm (60—110 micro-in.)	—
Maximum Wave Depth	0.008 mm (0.0003 in.)	—
Maximum Material Removal for Resurfacing Head	0.762 mm (0.0300 in.)	—

RG,CTM82,G05,2 -19-11JUN93

05
5

CYLINDER HEAD AND VALVES SPECIFICATIONS—CONTINUED

TORQUES

Cylinder Head-to-Cylinder Block:*

Flanged-Head Cap Screws (no Washers)	
Step 1	100 N·m (75 lb-ft)
Step 2	125 N·m (95 lb-ft)
Step 3	Tighten an Additional 90—100 °
Rocker Arm Shaft Clamps	75 N·m (55 lb-ft)
Rocker Arm Cover-to-Cylinder Head	8 N·m (6 lb-ft) (72 lb-in.)
Intake Manifold-to-Cylinder Head	47 N·m (35 lb-ft)
Exhaust Manifold-to-Cylinder Head	47 N·m (35 lb-ft)
Valve Adjusting Screw Locknut	27 N·m (20 lb-ft)

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

RG,CTM82,G05,3 -19-04FEB93

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6

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

RG,CTM82,G05,23-19-11JUN93

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

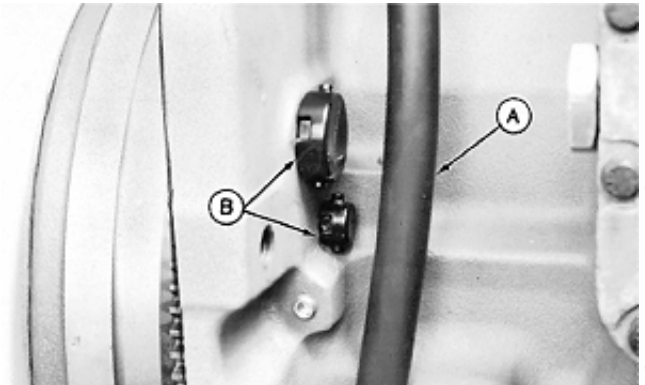
Too little valve clearance throws valves out of time. Valves open too early and close too late. This causes the valves to overheat due to hot combustion gases rushing past valves when out of time. Overheating lengthens valve stems which prevents proper seating of valves. The valves seat so briefly or 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 rocker arm cover and ventilator hose (A).
2. Remove plastic plugs (B).

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

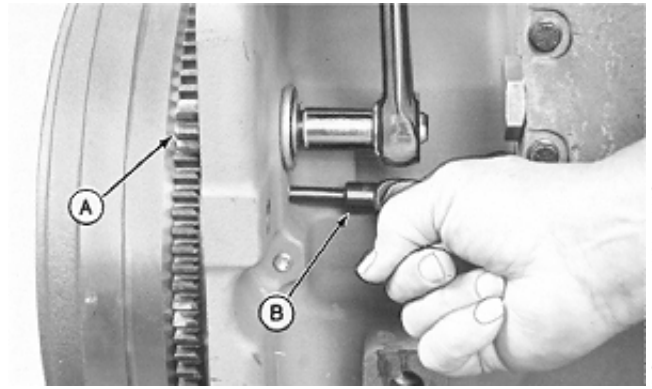


RG5790 -UN-09AUG91 05

RG,CTM42,G5,5 -19-03MAY93

3. Rotate engine with the JDE81-1 Flywheel Turning Tool (A) until JDE81-4 Timing Pin (B) 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."



RG,CTM42,G5,26 -19-07AUG91

-JUN-09AUG91
RG5791

4. With engine lock-pinned at "TDC" of No. 1 piston's compression stroke, check and adjust (as needed) valve clearance on Nos. 1, 3 and 5 exhaust valves and Nos. 1, 2 and 4 intake valves.

VALVE CLEARANCE SPECIFICATIONS

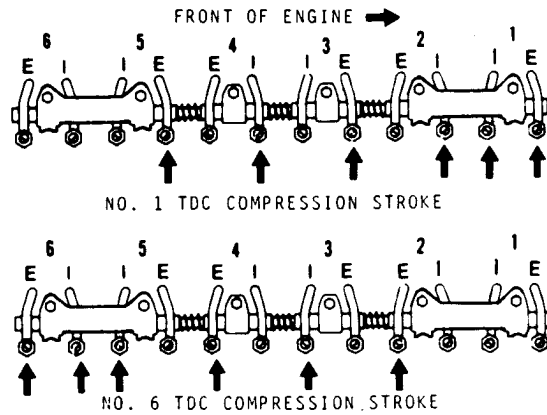
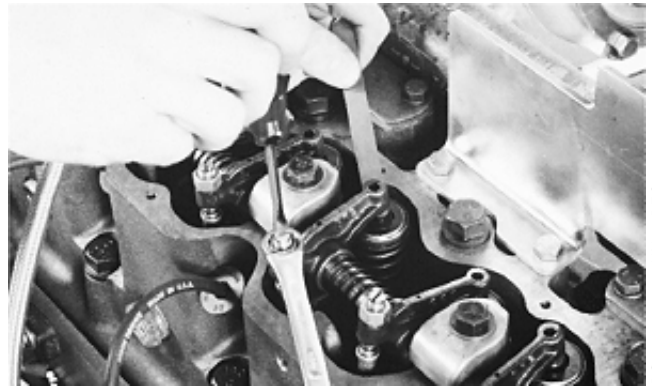
Intake Valves	0.38 mm (0.015 in.)
Exhaust Valves	0.51 mm (0.020 in.)

5. If valve clearance needs to be adjusted, loosen the locknut on rocker arm adjusting screw. Turn adjusting screw until feeler gauge slips with a slight drag. Hold the adjusting screw from turning with screwdriver and tighten locknut to 27 N·m (20 lb-ft). Recheck clearance again after tightening locknut. Readjust clearance as necessary.

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

7. Check and adjust (as needed) valve clearance to the same specifications on Nos. 2, 4 and 6 exhaust and Nos. 3, 5, and 6 intake valves. Tighten valve adjusting screw locknut to 27 N·m (20 lb-ft).

8. Recheck clearance on all valves again after locknut is tightened.



RG,CTM82,G05,4 -19-03MAY93

-JUN-14DEC92
RG6526

-19-21AUG91
RG4295

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8

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.

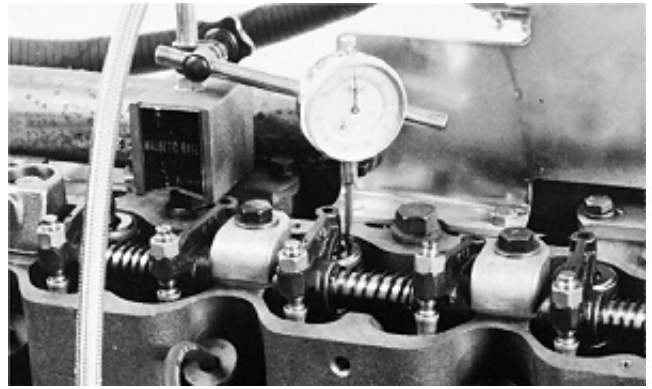
1. Remove rocker arm cover. Loosen locknut on rocker arm. Set valve clearance at 0.00 mm (in.). Tighten locknut.
2. Put dial indicator tip on valve rotator. Be sure that valve is fully closed.
3. Check pre-set on dial indicator. Set dial indicator pointer at zero.
4. Manually turn engine in running direction, using the engine rotation tools previously mentioned for checking valve clearance.
5. Observe dial indicator reading as valve is moved to fully open position.

VALVE LIFT SPECIFICATION AT 0.00 mm (in.) CLEARANCE

Intake 13.39—13.84 mm (0.527—0.545 in.)
 Wear Tolerance 12.50 mm (0.492 in.)

Exhaust 14.38—14.84 mm (0.566—0.584 in.)
 Wear Tolerance 13.49 mm (0.531 in.)

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



-JUN-14DEC92
RG6627

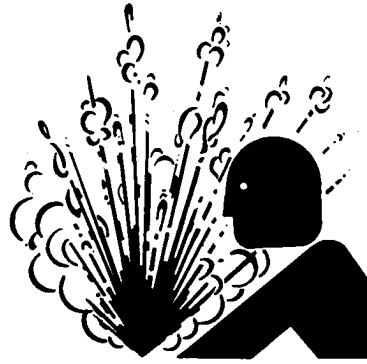
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9

RG,CTM82,G05,5 -19-03MAY93

REMOVE CYLINDER HEAD

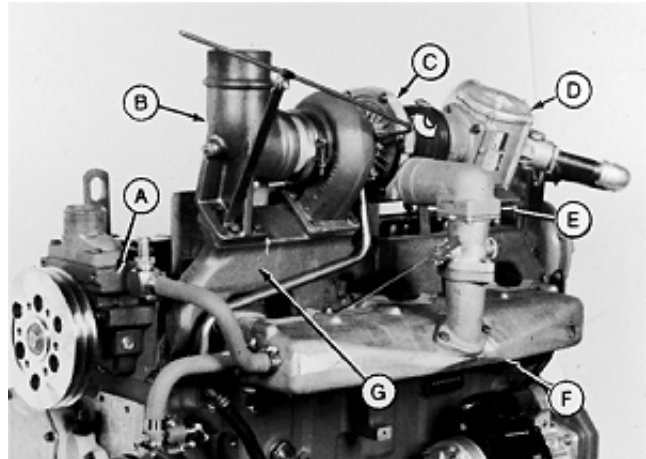
CAUTION: After operating engine, allow exhaust system to cool before removal.

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.



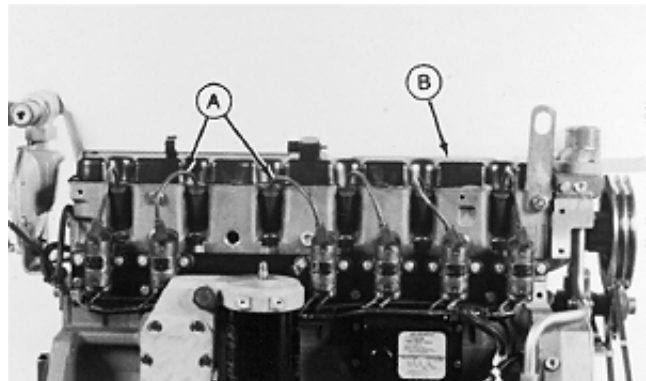
1. Drain all engine oil and coolant.
2. Remove water manifold (A) and all coolant lines. (Group 25).
3. Remove carburetor (D) and throttle valve assembly (E). (Group 35).
4. Remove turbocharger (C) and exhaust elbow (B). (Group 30).
5. Remove aftercooler and intake manifold assembly (F). (Group 30).
6. Remove exhaust manifold (G). (Group 30).

A—Water Manifold
 B—Exhaust Elbow
 C—Turbocharger
 D—Carburetor
 E—Throttle Valve Assembly
 F—Aftercooler Assembly
 G—Exhaust Manifold



RG,CTM82.G05,6 -19-03MAY93

7. Remove ignition wires (A) and spark plugs.
8. Remove rocker arm cover (B) and ventilator hose assembly.



RG,CTM82.G05,7 -19-03MAY93

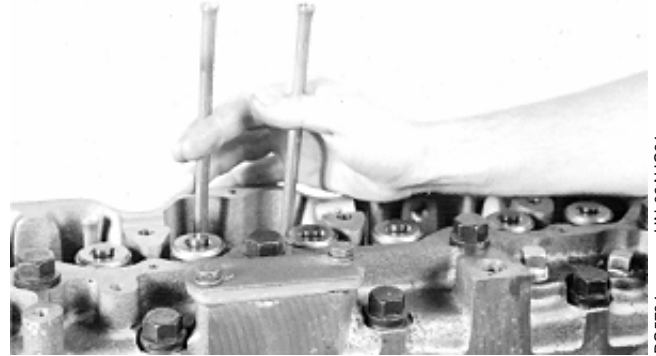
Cylinder Head and Valves/Remove Cylinder Head

9. Remove cap screws (A) from rocker arm clamps (B). Lift rocker arm assembly up and remove. Remove wear caps from valve stems.



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

NOTE: Clean and inspect push rods as explained later in this group.



RG,CTM82,G05,8 -19-03MAY93

11. Remove all 26 cylinder head cap screws.

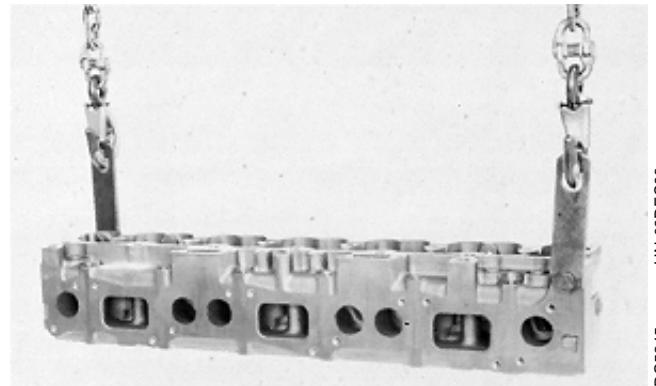
NOTE: If cylinder head gasket failed, check and record each cylinder head cap screw torque before removing.

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

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

12. Remove cylinder head 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 later in this group.



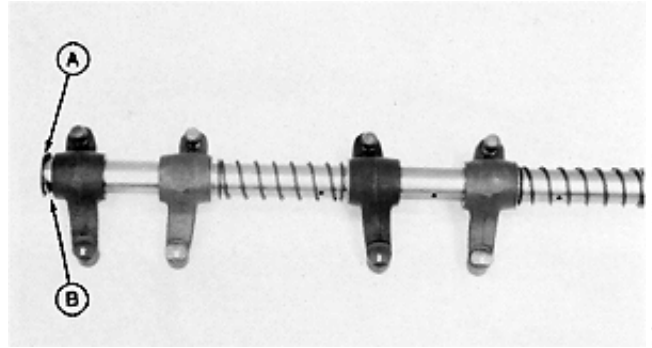
DISASSEMBLE AND INSPECT ROCKER ARM SHAFT ASSEMBLY

NOTE: Make preliminary inspection during disassembly.

Look for:

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

1. Remove plugs (A) and washers (B) from ends of rocker arm shaft.
2. Slide springs, rocker arms, and rocker arm supports off rocker arm shaft identifying their parts for reassembly in the same sequence they were in before disassembly.



RG3801 -UN-23FEB89

S11,2005,HY1 -19-07AUG91

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

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

ROCKER ARM ASSEMBLY SPECIFICATIONS

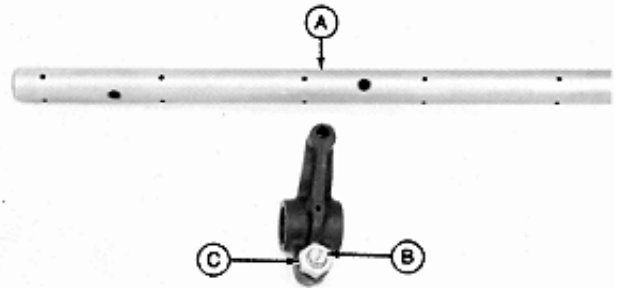
Rocker Arm I.D. 19.07—19.10 mm (0.7507—0.7520 in.)

Rocker Arm Shaft O.D 19.01—19.05 mm (0.7484—0.7500 in.)

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

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

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



RG3802 -UN-23FEB89

S11,2005,MB -19-28OCT92

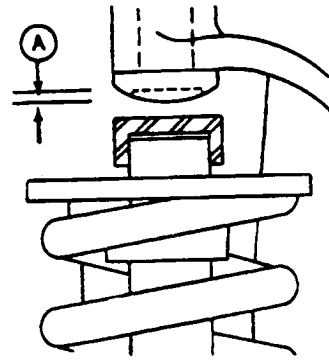
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6. Check for cups or concave wear (A) on ends of rocker arms where they contact wear caps.

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.



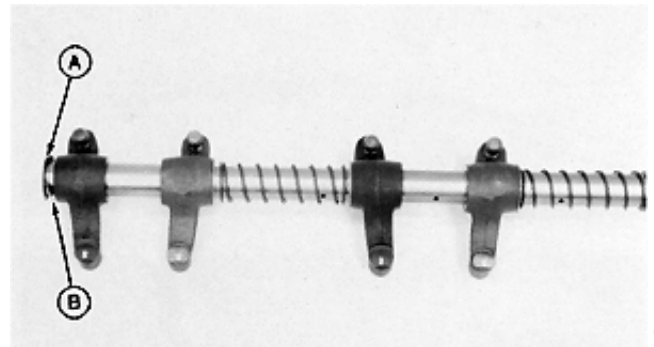
R26131 -UN-09DEC88

S11,0401,N -19-05FEB85

ASSEMBLE ROCKER ARM SHAFT ASSEMBLY

1. Assemble parts on rocker arm shaft opposite removal procedure.

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



RG3801 -UN-23FEB89

S11,0401,O -19-28OCT92

05
13

MEASURE VALVE RECESS

1. Measure and record valve recess dimensions for all valves using JDG451 Gauge with D17526CI (English, in.) or D17527CI (Metric, mm) Dial Indicator or KJD10123 Gauge. Valve recess should be measured at 3.0 mm (0.12 in.) maximum distance in from OD of valve head. Compare measurements to specifications given below.

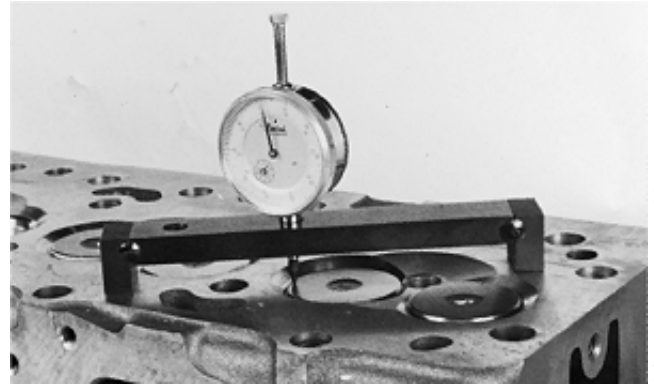
NOTE: Thoroughly clean all gasket material from cylinder head combustion face before measuring.

VALVE RECESS SPECIFICATIONS [3.0 mm (0.12 in.) from valve head OD]

Valve Recess Below Cylinder Head:

Exhaust	0.68—1.20 mm (0.003—0.047 in.)
—Wear Limit	1.96 mm (0.077 in.)
Intake	2.56—3.08 mm (0.101—0.121 in.)
—Wear Limit	3.84 mm (0.151 in.)

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



-JUN-30APR93
RG6748

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14

RG,CTM82,G05,9 -19-01JUN93

PRELIMINARY CYLINDER HEAD AND VALVE CHECKS

Make preliminary inspection of cylinder head and valve assembly during disassembly.

Look for the following conditions:

• Sticking Valves:

Carbon deposits on valve stem.
Worn valve guides.
Scored valve stems.
Warped valve stems.
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.
Incorrect valve or seat installed.

• Burned, Pitted, Worn, or Broken Valves:

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

• Improper Valve Clearance:

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

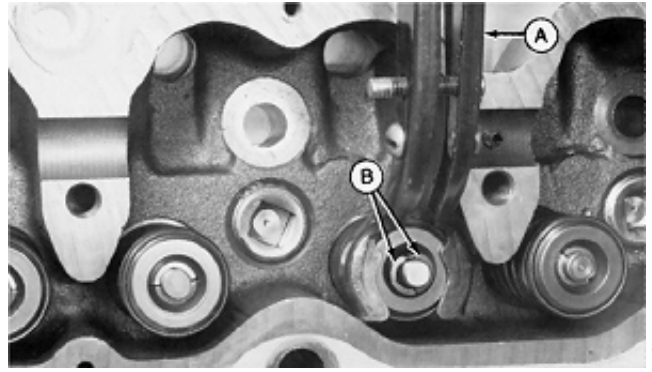
• Excessive Recession:

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

REMOVE VALVE ASSEMBLY

NOTE: Identify all parts for correct reassembly.

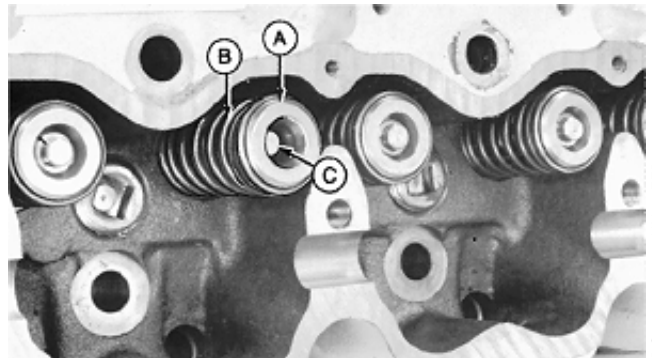
1. Compress JDE138 Valve Spring Compressor (A) over valve.
2. Remove retaining locks (B).
3. Remove valve spring compressor.



S11,0401,Q -19-04JUN93

-JUN-23FEB89
RG3803

4. Remove valve rotators (A) and valve springs (B).
5. Remove exhaust valve stem shields.
6. Remove valves (C) from cylinder head.



RG,CTM42,G5,27 -19-28OCT92

-JUN-23FEB89
RG3804

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16

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.)



-JUN-23FEB89
RG2732

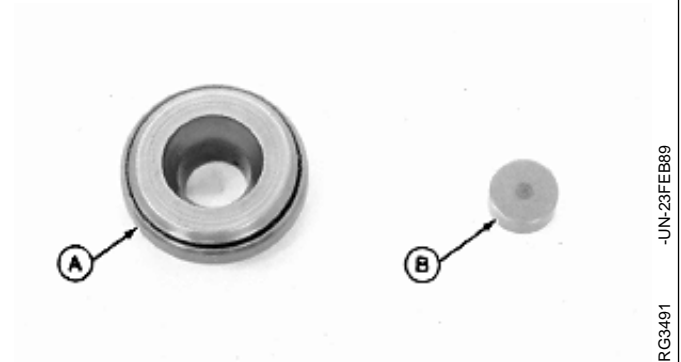


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T82054

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

INSPECT VALVE ROTATORS AND WEAR CAPS

1. Insure that valve rotators (A), if equipped, will turn freely. Replace if defective.
2. Replace valve wear caps (B) if pitted or worn.



RG3491 -UN-23FEB89

S11,0401,T -19-28OCT92

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

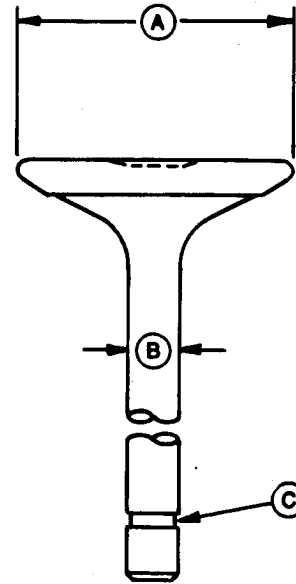
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17

INSPECT AND MEASURE VALVES

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

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

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



VALVE HEAD AND STEM SPECIFICATIONS

A—Valve Head OD:	
Exhaust	46.87—47.13 mm (1.845—1.856 in.)
Intake	50.87—51.13 mm (2.003—2.013 in.)
B—Valve Stem OD:	
Exhaust	9.44—9.46 mm (0.3717—0.3724 in.)
Intake	9.46—9.49 mm (0.3724—0.3736 in.)

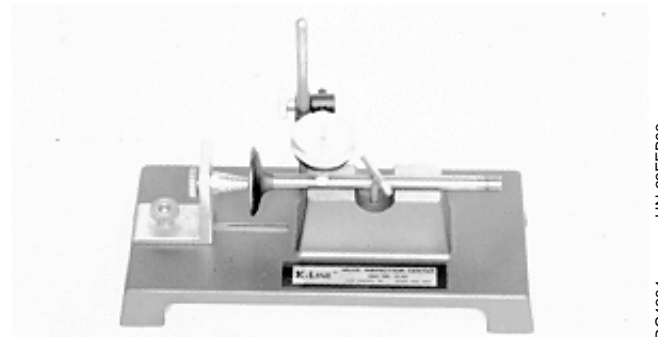
RG,CTM42,G5,12 -19-03MAY93

RG5795 -UN-12AUG91

4. Use D05058ST Valve Inspection Center to determine if valve stem or face are out-of-round, bent, or warped.

VALVE FACE RUNOUT SPECIFICATION

Maximum Permissible Runout of	
Valve Face	0.05 mm (0.002 in.)



S11,2005,IZ -19-29OCT92

RG4234 -UN-23FEB89

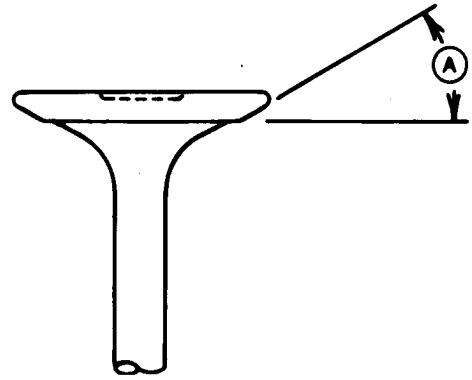
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18

GRIND VALVES

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

If necessary to resurface, grind valve face to a $19.25^\circ \pm 0.25^\circ$ angle (A).

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



RG,CTM82,G05,10-19-11JUN93

RG5247 -JUN-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

05
19

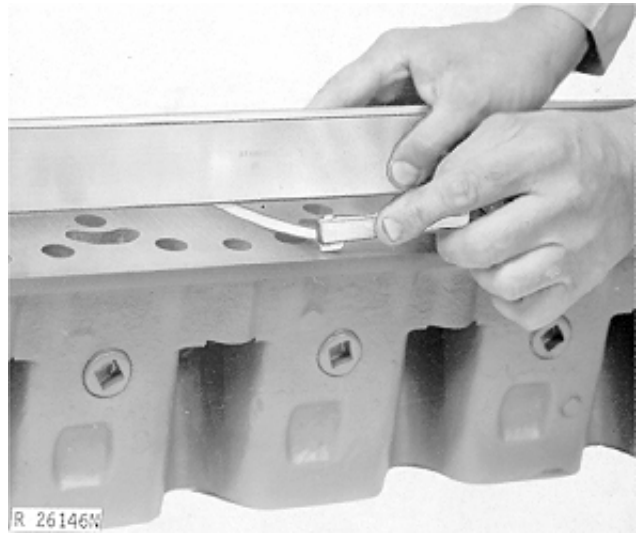
CHECK CYLINDER HEAD COMBUSTION FACE FLATNESS

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

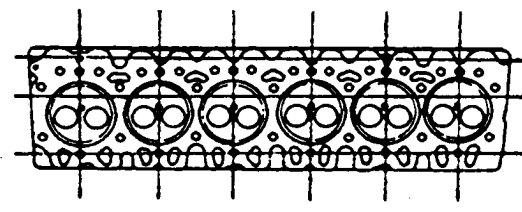
If any measurement exceeds this specification, the cylinder head must be either resurfaced or replaced. (See MEASURE CYLINDER HEAD THICKNESS, later in this group.)

CYLINDER HEAD FLATNESS SPECIFICATION

Maximum Out-of-Flat
(over entire length or width) 0.10 mm (0.004 in.)



-UN-09DEC88
R26146



-UN-06DEC88
RG-4629

S11,2005,KY -19-03MAY93

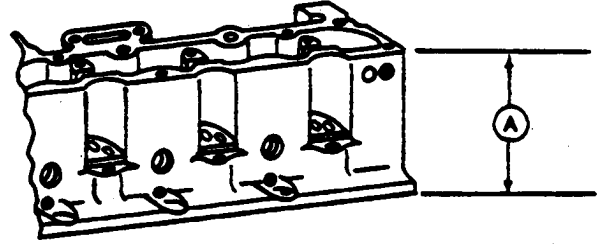
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MEASURE CYLINDER HEAD THICKNESS

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

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

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



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	155.45—155.71 mm (6.120—6.130 in.)
Wear Limit	154.69 mm (6.09 in.)
Combustion Face Surface Finish (AA)	0.015—0.0028 mm (60—110 micro-in.)
Maximum Wave Depth	0.008 mm (0.0003 in.)

-UN-23FEB89
RG4421

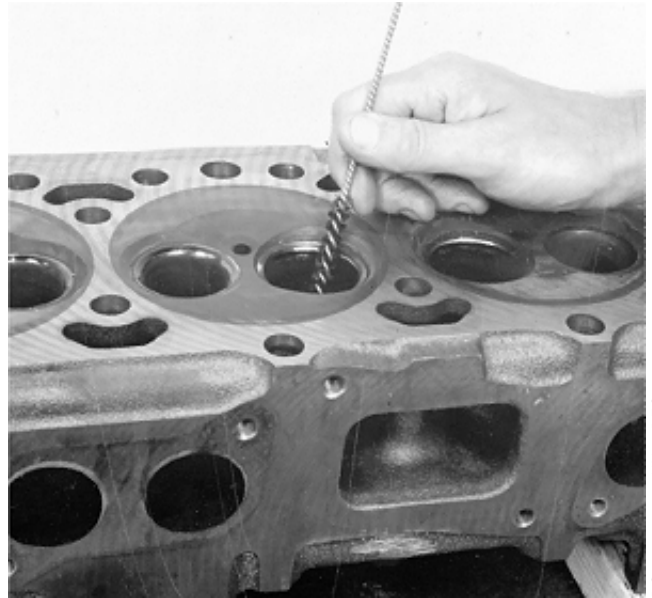
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S11,2005,KZ -19-03MAY93

CLEAN VALVE GUIDES

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

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



-UN-06DEC88
RG5346

S11,2005,MY -19-28OCT92

05
22

MEASURE VALVE GUIDES

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

VALVE GUIDE SPECIFICATIONS

I.D. Guide in a New Head 9.51—9.54 mm
(0.3745—0.3755 in.)

New Guide-to-Valve Stem Clearance:

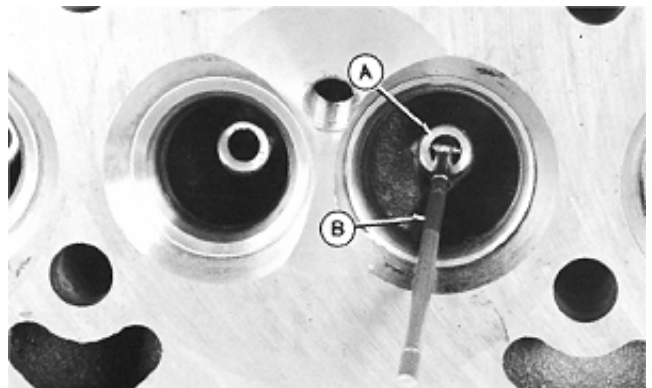
Exhaust 0.051—0.102 mm (0.002—0.004 in.)

Intake 0.025—0.076 mm (0.001—0.003 in.)

Maximum Allowable Clearance 0.15 mm (0.006 in.)

NOTE: Worn guides may be knurled to return them to specified clearance if valve-to-guide clearance is 0.25 mm (0.010 in.) or less. If clearance exceeds 0.25 mm (0.010 in.), install oversize valves.

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



-JUN-14DEC92
RG6528

RG,CTM82,G05,21-19-03MAY93

KNURL VALVE GUIDES

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

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

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

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



S11,0401,Z -19-28OCT92

CLEAN AND INSPECT VALVE SEATS

1. Use an electric hand drill with D17024BR Wire Cleaning 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.



S11,0401,AA -19-28OCT92

MEASURE VALVE SEATS

1. Measure valve seats for proper specifications listed below.
2. Using D11010KW Eccentrimeter, measure valve seat runout.
3. If valve seat is not within specification, replace valve seat insert. (See GRIND VALVE SEATS, or REMOVE VALVE SEAT INSERTS, later in this group.)

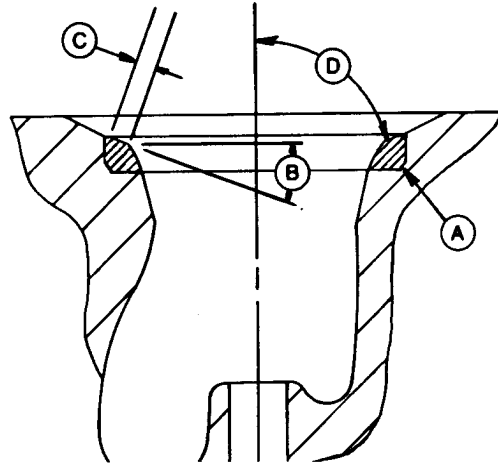
VALVE SEAT SPECIFICATIONS

Valve Seat Angle (B) $20^{\circ} \pm 0.5^{\circ}$

Valve Seat Width (C):

- Exhaust 2.0—3.8 mm (0.079—0.150 in.)
- Intake 1.4—3.8 mm (0.055—0.150 in.)

Maximum Valve Seat Runout (D) 0.051 mm (0.0020 in.)



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

RG6567 -UN-21DEC92

RG,CTM82,G05,11-19-11JUN93

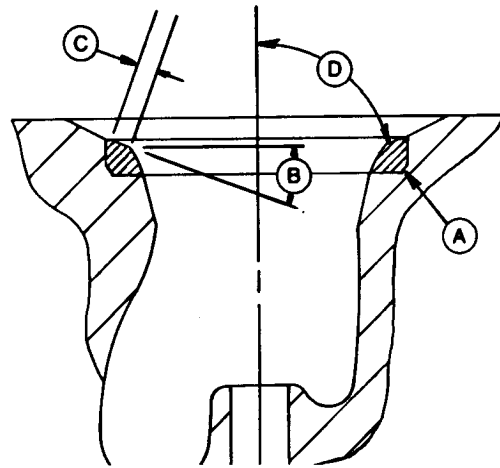
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GRIND VALVE SEATS



-UN-09DEC88

R26143N



-UN-21DEC92

RG6567

A—Valve Seat Insert

B—Seat Angle

C—Seat Width

D—Seat Runout

IMPORTANT: Valve seat grinding should only be done by experienced personnel familiar with equipment and capable of maintaining required specifications. ALWAYS keep work area clean when grinding valve seats.

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 on both intake and exhaust valve seat inserts.

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

1. 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 width changes the fine contact between valve face and seat.

2. ALWAYS measure valve seat runout after grinding using D11010KW Eccentrimeter.

VALVE SEAT SPECIFICATIONS

Valve Seat Angle (B)	20° ±0.5°
Valve Seat Width (C):		
—Exhaust	2.0—3.8 mm (0.079—0.150 in.)
—Intake	1.4—3.8 mm (0.055—0.150 in.)
Max. Valve Seat Runout (D)	0.05 mm (0.002 in.)

IMPORTANT: Blend or radius all sharp edges after grinding valve seats. Always check valve recess in cylinder head after grinding as described later.

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25

REMOVE VALVE SEAT INSERTS

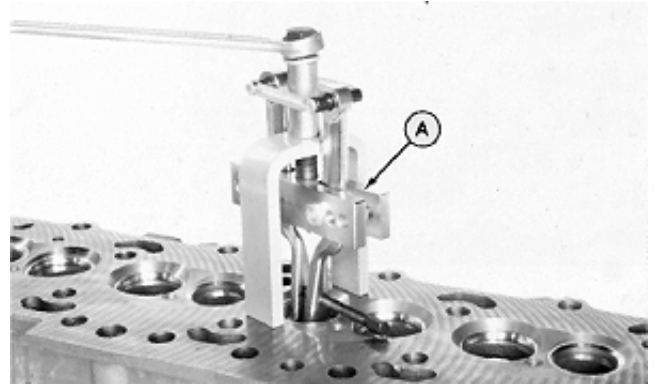
IMPORTANT: Be careful not to damage cylinder head when removing seats.

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

NOTE: On some engines, removal of valve seat inserts with the JDE41296 Puller may not be possible. An alternate removal method is to weld two or three short beads (use an arc welder) equidistant from each other around the face of 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 splatter.

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



RG5306 -JUN-06DEC88

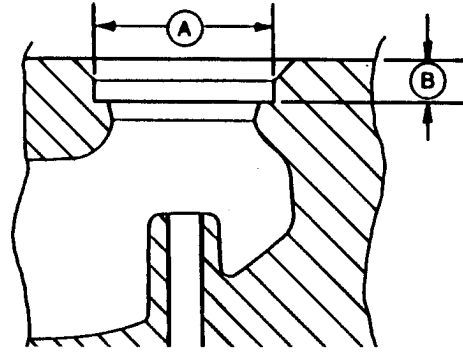
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26

RG,CTM82,G05,13-19-01JUN93

MEASURE VALVE SEAT BORES IN CYLINDER HEAD

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.

1. Measure diameter (A) of valve seat bore.
2. If cylinder head combustion face is to be surfaced, measure depth (B) of bore. Depth must be maintained for proper valve recess.



VALVE SEAT INSERT AND BORE SPECIFICATIONS

Valve Seat Insert O.D. (std.):	
Exhaust	49.067—49.093 mm (1.9318—1.9328 in.)
Intake	52.067—52.093 mm (2.0499—2.0509 in.)
Valve Seat Bore I.D. (std.):	
Exhaust	48.987—49.013 mm (1.9286—1.9296 in.)
Intake	51.987—52.013 mm (2.0467—2.0477 in.)
Valve Seat Bore Depth:	
Exhaust	9.60—9.76 mm (0.378—0.384 in.)
Intake	12.21—12.37 mm (0.481—0.487 in.)

RG,CTM82,G05,25-19-04JUN93

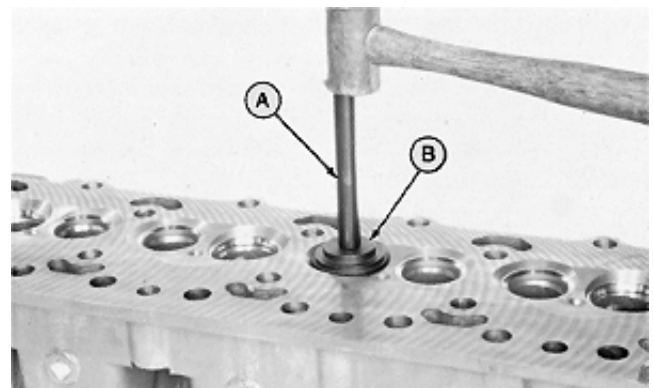
-UN-27MAY93
RG6778

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27

INSTALL VALVE SEAT INSERTS

1. Use the JDE7 Driver (A) along with the JDG605 Valve Seat Installer (B) to drive inserts into place. The larger end of JDG605 Installer is used to install intake valves and the smaller end is used to install exhaust valves.
2. Install new or refaced valves and check valve recess. (See MEASURE VALVE RECESS, earlier in this group.)
3. Check valve seat runout using D11010KW Eccentrimeter. If valve recess or runout is out of specification, replace inserts and check valve seat bore concentricity.

NOTE: New valve seat inserts have a finished seat. Grinding is not recommended.



-UN-06DEC88
RG5249

RG,CTM82,G05,26-19-01JUN93

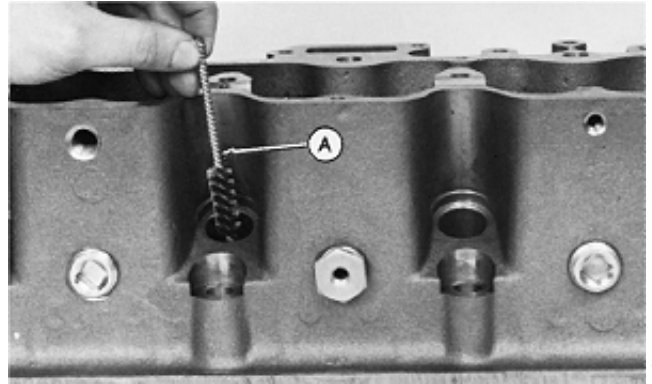
INSPECT AND CLEAN CYLINDER HEAD SPARK PLUG BORE

1. Inspect condition of threads. Threads are M14 x 1.25.
2. Inspect condition of spark plug sealing surface in cylinder head.

Threads and sealing surface must be free of debris and carbon deposits.

IMPORTANT: If the spark plug threads are not clean, a false torque reading may be obtained when the spark plug is installed. This may prevent the plug from seating properly in the cylinder head.

3. Clean threads which have light foreign deposits using a drill and the JDG816 Thread Cleaning Brush (A). Work brush up and down several times to clean threads.

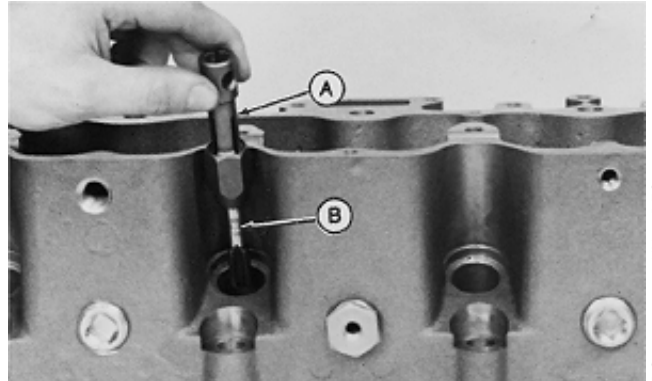


-JUN-30APR93
RG6739

RG,CTM82,G05,14-19-01JUN93

4. Clean threads with heavy foreign deposits or clean up damaged threads using HAN1749 (M14 x 1.25 mm) tap (B) and JDG513 T-handle wrench (A). Be sure to start tap straight to avoid possible cross-threading.

NOTE: If this is done with cylinder head on engine, a light coat of grease on tap will help collect debris on tap and prevent it from falling into the cylinder.

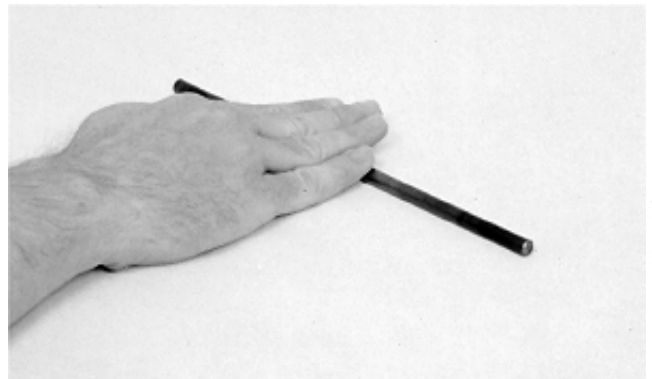


-UN-14DEC92
RG6529

RG,CTM82,G05,15-19-03MAY93

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.

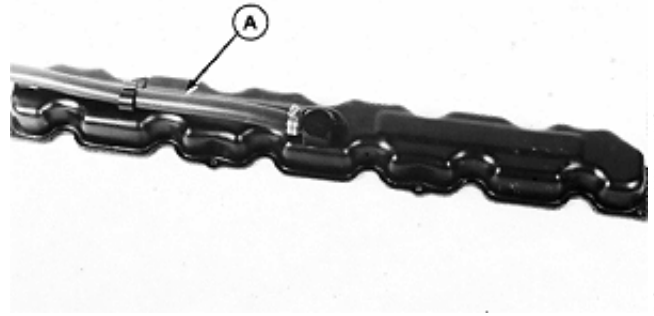


-JUN-01NOV88
TB1233

S11,2005,JN -19-24APR92

INSPECT AND CLEAN VENTILATOR OUTLET HOSE

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

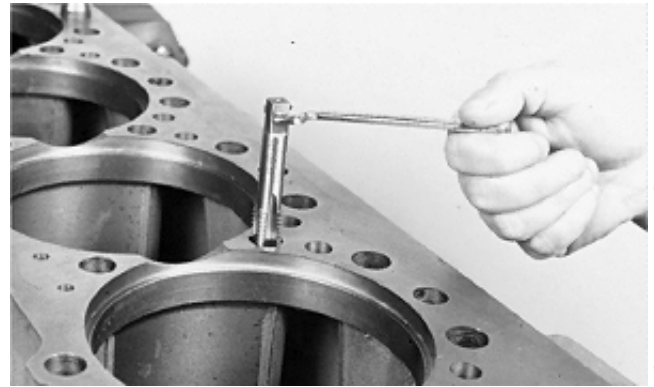


RG,CTM42,G5,9 -19-28OCT92

RG5797
-JUN-12AUG91

CLEAN AND INSPECT TOP DECK OF CYLINDER BLOCK

1. Remove gasket material, rust, carbon, and other foreign material from top deck. Gasket surface must be clean.
2. Use compressed air to remove all loose foreign material from cylinders and top deck.
3. Remove cylinder head locating dowels.
4. Clean all cylinder head mounting cap screw holes using JDG681 or an equivalent 9/16-12 UNC-2A tap about 88.9 mm (3.5 in.) long. Use compressed air to remove debris and any fluids which may be present in the cap screw holes.
5. Measure top deck flatness. See MEASURE CYLINDER BLOCK in Group 10.
6. Install new cylinder head locating dowel pins in cylinder block.



RG,CTM42,G5,17 -19-28OCT92

RG5796
-UN-12AUG91

05
29

MEASURE CYLINDER LINER STANDOUT (HEIGHT ABOVE BLOCK)

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

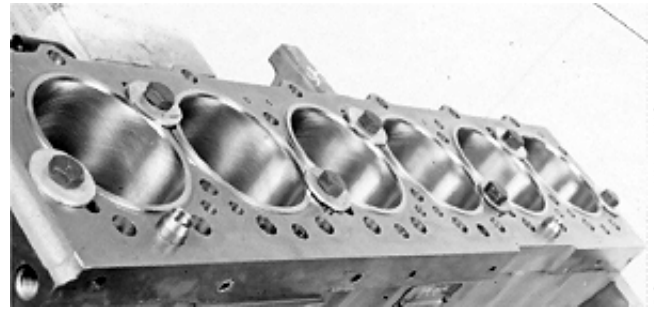
NOTE: Liners having obvious defects must be replaced.

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

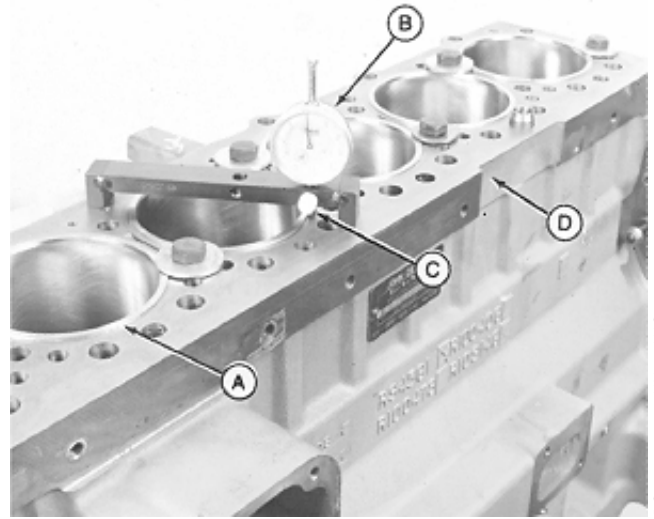
NOTE: Variations in measurement readings may occur within one cylinder and/or between adjacent cylinders.

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

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



RG5829 -UN-12AUG91



RG5813 -UN-12AUG91

LINER HEIGHT SPECIFICATIONS

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

- A—Cylinder Liner
- B—Dial Indicator
- C—Liner Height
- D—Cylinder Block

RG.CTM42,G5,31 -19-28OCT92

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30

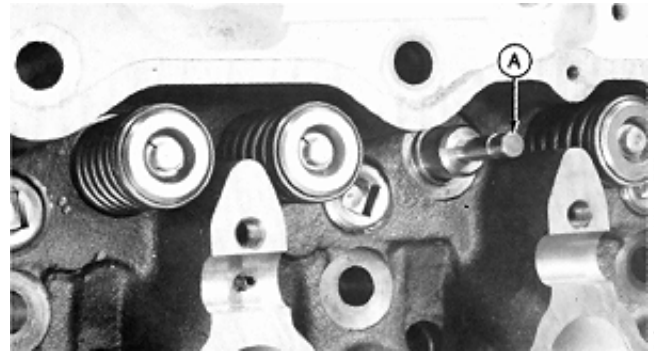
ASSEMBLE VALVE ASSEMBLY

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

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

2. Install reconditioned or new valves (A) in head. If valves are reused, install in same location from which removed.

NOTE: Valves must move freely and seat properly.



-UN-23FEB89
RG3806

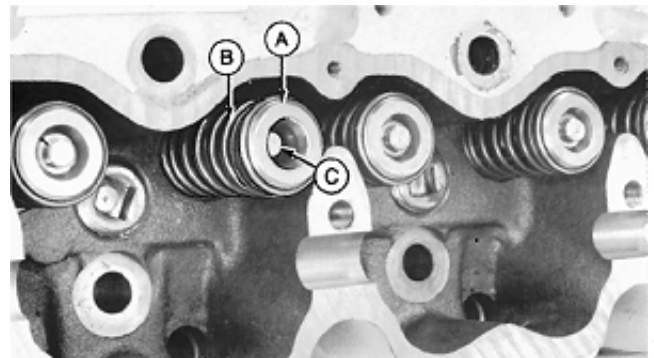
S11,0401,AK -19-28OCT92

NOTE: There is no top or bottom to valve springs; they may be installed either way.

3. Position valve springs (B). End of spring must be in machined counterbore of head. Do not mix valve springs. See INSPECT AND MEASURE VALVE SPRINGS, earlier in this group.

4. Install valve rotators (A) on springs and valves (C).

5. Install valve stem shields on exhaust valve stems.

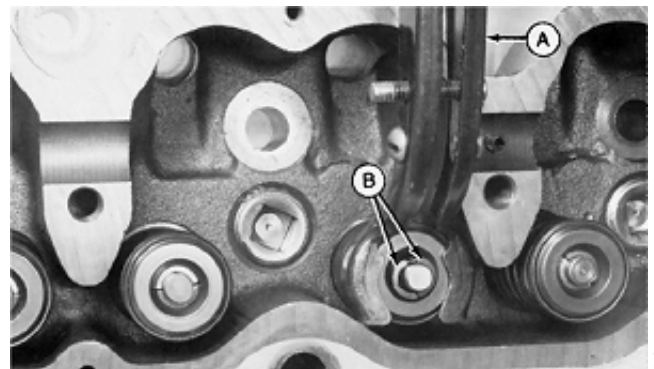


-UN-23FEB89
RG3804

RG,CTM42,G5,28 -19-28OCT92

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

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



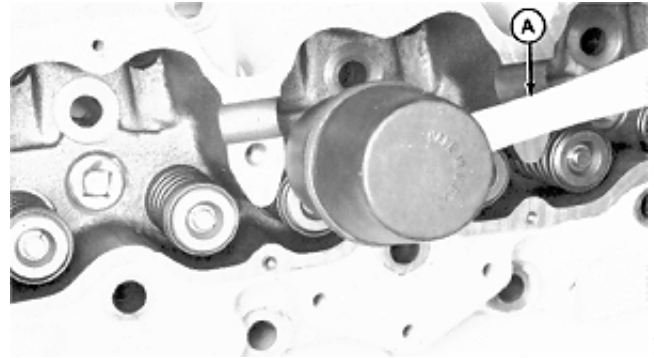
-UN-23FEB89
RG3803

RG,CTM42,G5,29 -19-28OCT92

7. Strike end of each valve with a soft mallet (A) three or four times to insure proper seating of the retainer locks.

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

8. Measure valve recess as directed earlier in this group.



RG3807 -UN-23FEB89

RG,CTM42,G5,30 -19-28OCT92

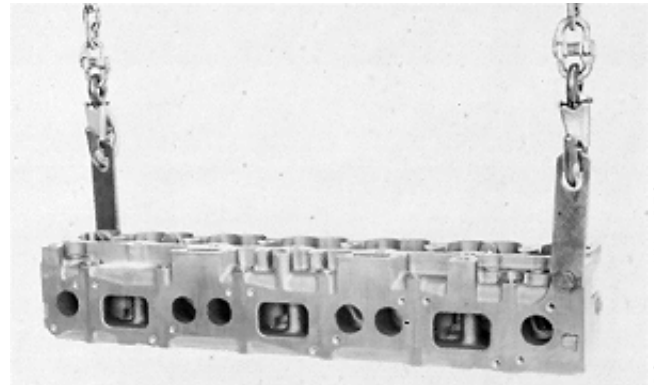
INSTALL CYLINDER HEAD

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

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

IMPORTANT: If cylinder head is lowered onto cylinder block and 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.



RG5245 -UN-06DEC88

RG,CTM42,G5,18 -19-28OCT92

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

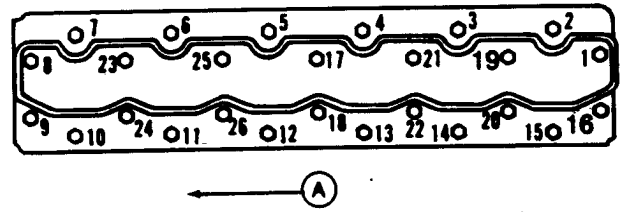
4. Inspect cap screws for corrosion damage and condition of threads. ANY CAP SCREW WITH CORROSION OR OTHER IMPERFECTIONS MUST BE REPLACED.

5. Dip entire cap screw in clean SAE30 engine oil. Remove excess oil.

Arrow (A) points toward front of engine.

6. Install cap screws in proper location.

Use the following cap screws in location as shown:



Cap Screw Length	Location on Cylinder Head
134.1 mm (5.20 in.)	2, 3, 4, 5, 6, 7
149.0 mm (5.87 in.)	17, 19, 21, 23, 25
174.5 mm (6.87 in.)	1, 8, 10, 11, 12, 13, 14, 15
203.0 mm (7.99 in.)	9, 16, 18, 20, 22, 24, 26

-JUN-31/AUG90
RG5699

05
33

TIGHTEN FLANGED-HEAD CYLINDER HEAD CAP SCREWS

NOTE: Flanged-head cap screws DO NOT require washers.

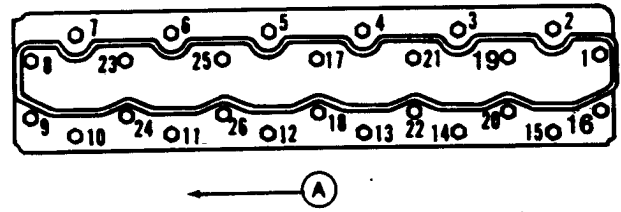
Arrow (A) points toward front of engine.

1. Tighten cap screw No. 17 to 100 N·m (75 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 100 N·m (75 lb-ft), including cap screw No. 17.

3. Beginning with cap screw No. 1, retighten all cap screws in the same numerical sequence to 125 N·m (95 lb-ft).

4. 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.)

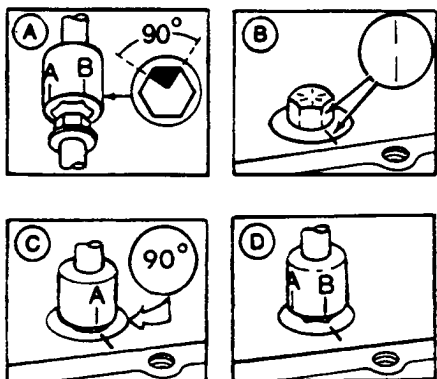


-JUN-31/AUG90
RG5699

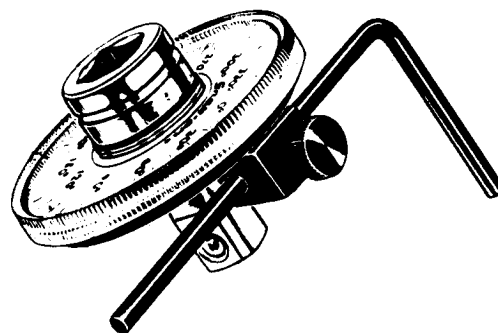
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RG,CTM6,G05.3 -19-28OCT92

TORQUE-TURN FLANGED-HEAD CYLINDER HEAD CAP SCREWS



Line Scribe Method



JT05993 Torque Angle Gauge

RG5563 -UN-04JUL89

RG5698 -UN-27AUG90

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 125 N·m (95 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° (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°) 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 125 N·m (95 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.

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

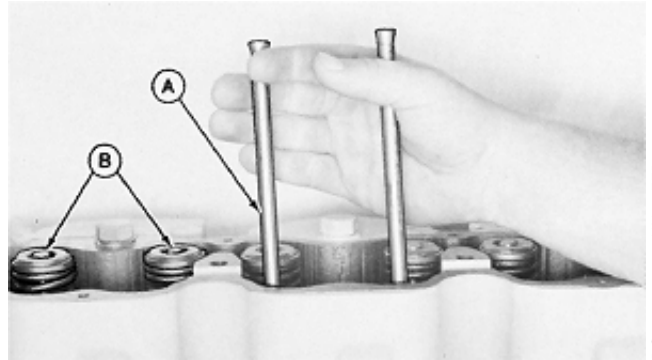
IMPORTANT: Retorque of cylinder head cap screws after engine run-in is not required when using flanged-head cap screws and the recommended TORQUE-TURN tightening procedure.

RG,CTM6,G05.4 -19-28OCT92

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35

INSTALL ROCKER ARM ASSEMBLY

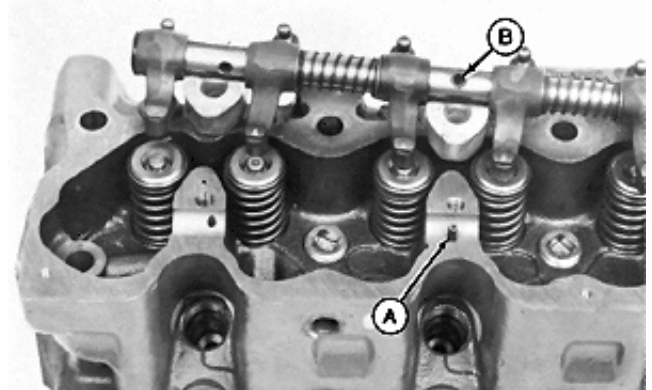
1. Install push rods (A) in holes from which removed.
2. Install wear caps (B) on valves, making certain caps rotate freely.



RG3809 -UN-23FEB89

S11,2005,HT -19-28OCT92

3. Make sure spring pin (A) engages with hole (B) in shaft.



RG3810 -UN-23FEB89

RG5793 -UN-09AUG91

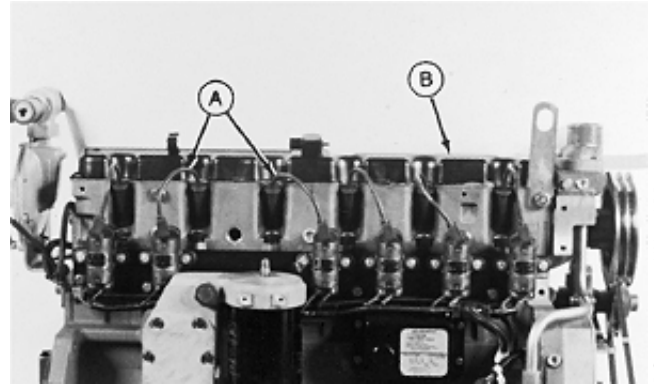
4. Install shaft clamps (B) and all six cap screws (A). Tighten cap screws to 75 N·m (55 lb-ft).



RG,CTM82,G05,16-19-04FEB93

COMPLETE FINAL ASSEMBLY OF WATER PUMP SIDE

1. Adjust valve clearance as directed earlier in this group.
2. Apply AR31790 SCOTCH-GRIP Adhesive or equivalent to new gasket, and seal gasket to rocker arm cover (B). Be sure to follow the manufacturer's directions on the package for correct application procedures and curing times.
3. Install cover and tighten cap screws to 8 N·m (6 lb-ft) (72 lb-in.).
4. Install spark plugs (D) and ignition wires (C). Tighten plugs to 38 N·m (28 lb-ft).
5. Connect crankcase ventilator hose. Tighten clamp securely.
6. Install water manifold (A).



RG6747 -JUN-30APR93

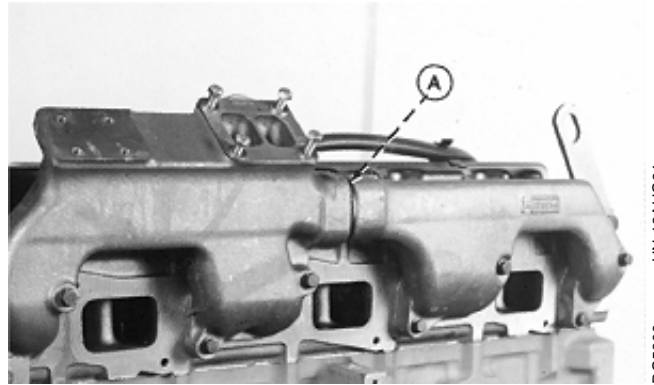
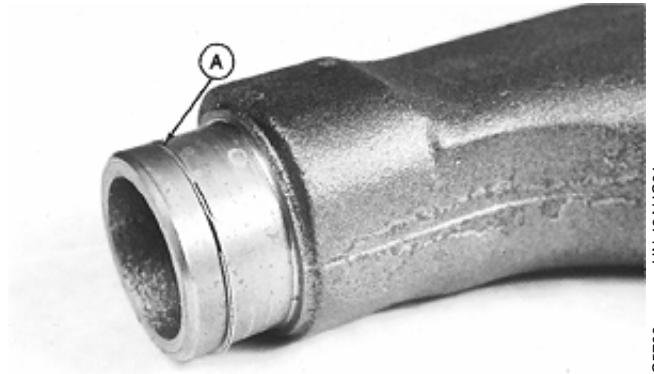
RG.CTM82.G05,17-19-03MAY93

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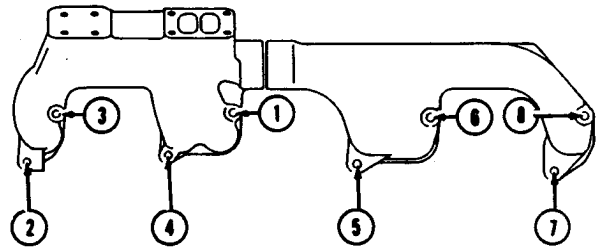
COMPLETE FINAL ASSEMBLY ON EXHAUST MANIFOLD SIDE

NOTE: Apply PT569 NEVER-SEEZ Compound or equivalent to all exhaust manifold cap screws.

1. Install front exhaust manifold using new gaskets. Do not tighten cap screws until sealing ring (A) and rear exhaust manifold is installed.
2. Install rear exhaust manifold using new gaskets and sealing ring.



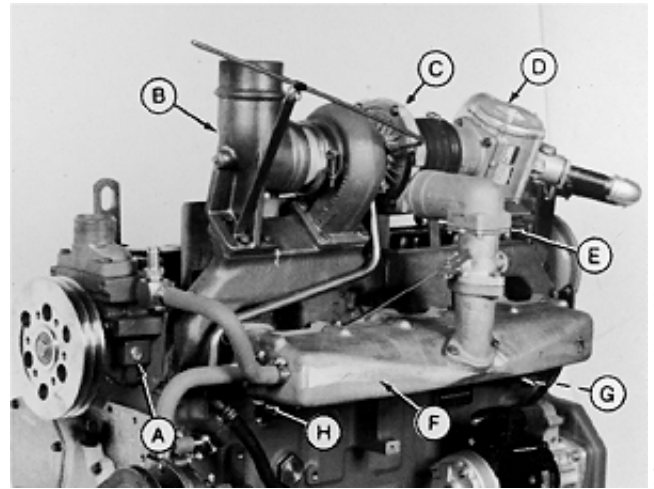
3. Tighten cap screws in sequence shown in bottom illustration to 47 N·m (35 lb-ft).



RG,CTM82,G05,24-19-03MAY93

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38

4. Install aftercooler and intake manifold assembly (F). Tighten cap screws to 47 N·m (35 lb-ft).
5. Install water manifold (A). (See INSTALL WATER MANIFOLD in Group 25).
6. Install turbocharger (C), exhaust elbow (B), and turbocharger oil and coolant lines. (See Group 30).
7. Connect MAP sensor (H) and CATS switch (G), if equipped.
8. Install carburetor (D) and throttle valve assembly (E). (See Group 35).
9. If engine oil was drained from crankcase, install new oil filter and fill with clean oil of correct grade and viscosity. (See ENGINE OIL in Group 02.)
10. Fill cooling system with clean coolant. (See ENGINE COOLANT SPECIFICATIONS in Group 02.)
11. Perform engine break-in as outlined later in this group. (See PERFORM ENGINE BREAK-IN.)



- A—Water Manifold
- B—Exhaust Elbow
- C—Turbocharger
- D—Carburetor
- E—Throttle Valve Assembly
- F—Aftercooler Assembly
- G—CATS Switch
- H—MAP Sensor

RG6749 -UN-30APR93

05
39

RG,CTM82,G05,20-19-01JUN93

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 method for engine break-in.

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 WATER PUMP SIDE, earlier in this group.)

NOTE: 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,CTM82,G05,22-19-03MAY93

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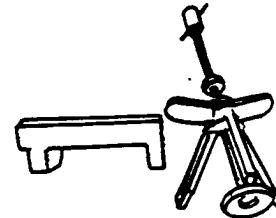
SPECIAL OR ESSENTIAL TOOLS

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

Cylinder Liner Puller D01062AA
(or D01073AA)

Remove cylinder liners.



S53,D01062,AA -19-07AUG91

RG5019 -UN-23AUG88

Flexible Cylinder Hone D17005BR

Hone cylinder liners.

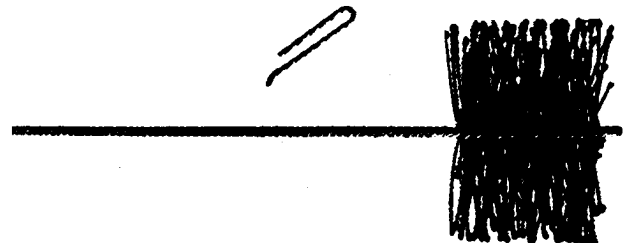


RG5074 -UN-23AUG88

S53,D17005,BR -19-07APR88

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

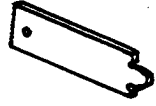
Use with JDG451 to measure valve recess and cylinder liner height-to-cylinder block top deck.





RG,D17526CI -19-29OCT92

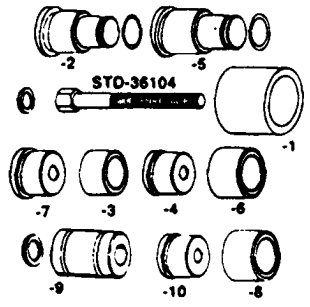
RG6246 -UN-27MAR92

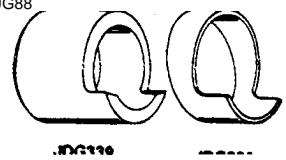
Cylinder Block, Liners, Pistons and Rods/Special or Essential Tools

Ring Groove Wear Gauge JDE55 Check wear of keystone ring groove on pistons.	RG5076	-UN-23AUG88	
			S53,JDE55 -19-25MAR91

Piston Ring Expander JDE93 Remove and install piston rings.	RG5077	-UN-23AUG88	
			S53,JDE93 -19-17FEB87

Piston Ring Compressor JDE96 Compress rings while installing pistons.	RG5031	-UN-23AUG88	
			S53,JDE96 -19-25MAR87

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	RG5078	-UN-23AUG88	
			S53,JDE98A -19-13MAR92

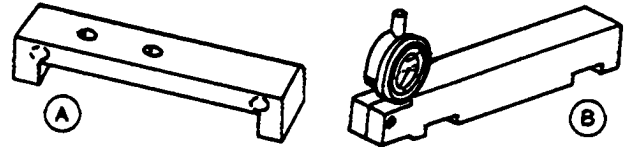
Connecting Rod Bushing Service Set JDG337 Use with JDE98A Bushing Service Set to remove and install connecting rod bushings.	RG5079	-UN-23AUG88	
			S53,JDG337,A -19-24NOV87

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-UN-23AUG88
RG5078

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

RG5103 -UN-23AUG88



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 JDG681

RG5100 -UN-23AUG88

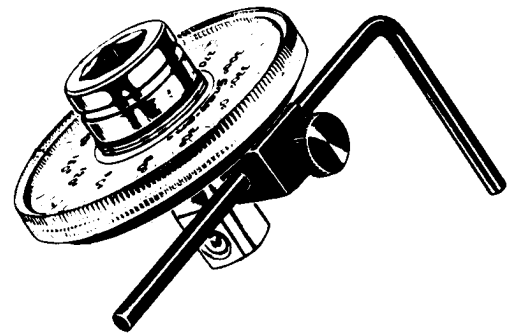


Used to restore threaded holes in cylinder block for cylinder head cap screws.

RG,JDG681 -19-25MAR91

Torque Angle Gauge JT05993

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



RG,JT05993 -19-22AUG91

10
3
-UN-27AUG90
RG5698

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
Cylinder Liner Height		
Above Block	0.025—0.102 mm (0.001—0.004 in.)	— —
Maximum Piston Protrusion Above Block	0.051—0.787 mm (0.002—0.031 in.)	— —
Piston Oil Control Ring-to- Groove Clearance	0.064—0.102 mm (0.0025—0.0040 in.)	0.165 mm (0.0065 in.)
Piston Oil Control Ring End Gap		
No. 1	0.43—0.69 mm (0.017—0.027 in.)	— —
No. 2	0.63—0.89 mm (0.025—0.035 in.)	— —
Piston OD:		
—19.1 mm (0.75 in.) from Bottom of Skirt	115.771—115.789 mm (4.5579—4.5586 in.)	—
Piston-to-Liner Clearance at Bottom of Skirt	0.076—0.124 mm (0.0030—0.0049 in.)	0.152 mm (0.0060 in.)
Cylinder Liner ID	115.865—115.895 mm (4.5616—4.5628 in.)	— —
Cylinder Liner OD	127.94—128.24 mm (5.037—5.049 in.)	— —
Cylinder Liner Thickness	6.05—6.15 mm (0.238—0.242 in.)	— —
Cylinder Liner Packing Step Dimension	1.45—1.55 mm (0.057—0.061 in.)	— —
Cylinder Liner Maximum Taper	0.051 mm (0.0020 in.)	— —
Cylinder Liner Maximum Out-of-Round	0.051 mm (0.0020 in.)	— —
Cylinder Liner Counterbore Depth	8.105—8.155 mm (0.319—0.321 in.)	— —

RG,CTM82,G10,1 -19-12APR93

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

ITEM	SPECIFICATION	WEAR LIMIT
Liner Flange Thickness	8.175—8.225 mm (0.322—0.324 in.)	— —
Liner Flange OD	135.105—135.130 mm (5.319—5.321 in.)	— —
Outer Diameter of Liner at Upper Bore	129.085—129.135 mm (5.082—5.084 in.)	— —
Outer Diameter of Liner at Lower Bore	125.042—125.122 mm (4.923—4.926 in.)	— —
Upper Bore Diameter in Block For Seating Liners	129.155—129.205 mm (5.085—5.087 in.)	— —
Lower Bore Diameter in Block for Seating Liners	125.133—125.183 mm (4.9265—4.9285 in.)	— —
Liner-to-Block Clearance at Upper Bore	0.026—0.126 mm (0.001—0.005 in.)	— —
Liner-to-Block Clearance at Lower Bore	0.012—0.140 mm (0.0005—0.0055 in.)	— —
Liner Shim Thickness	0.05 mm (0.002 in.)	— —
Piston Pin OD	47.60—47.61 mm (1.8739—1.8745 in.)	— —
Piston Pin Bore ID in Piston	47.62—47.63 mm (1.8748—1.8752 in.)	— —
Rod Pin Bushing ID (After Honing)	47.65—47.68 mm (1.8762—1.8772 in.)	— —
Rod Pin Bore Diameter Without Bushing	52.354—52.380 mm (2.0612—2.0622 in.)	— —
Rod Pin-to-Bushing Oil Clearance	0.042—0.084 mm (0.0017—0.0033 in.)	0.102 mm (0.0040 in.)
Rod-to-Pin Bushing Press Fit Specification	0.084—0.147 mm (0.0033—0.0058 in.)	— —
Connecting Rod Bore Without Bearings	81.051—81.077 mm (3.191—3.192 in.)	— —
Connecting Rod Bearing Assembled ID	76.21—76.26 mm (3.0004—3.0024 in.)	— —

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RG,CTM42,G10,29-19-29OCT92

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

ITEM	SPECIFICATION	WEAR LIMIT
Crankshaft Rod Journal OD	76.15—76.18 mm (2.9980—2.9992 in.)	— —
Bearing-to-Journal Clearance	0.030—0.110 mm (0.0012—0.0044 in.)	0.152 mm (0.0060 in.)
Maximum Connecting Rod/Cap Gap	0.254 mm (0.0100 in.)	—
Maximum Connecting Rod Out-of-Round	0.025 mm (0.0010 in.)	—
Centerline of Main Bearing Bore-to- Top Deck of Cylinder Block	352.35—352.50 mm (13.872—13.878 in.)	— —
Camshaft Bushing Bore in Block	69.987—70.013 mm (2.7554—2.7564 in.)	— —
Maximum Runout of Camshaft Bushing Bore in Block	0.038 mm (0.0015 in.)	—
New Camshaft Bushing-to-Journal Clearance	0.063—0.115 mm (0.0025—0.0045 in.)	— —
Camshaft Bushing ID	67.076—67.102 mm (2.6408—2.6418 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	222.20—222.30 mm (8.748—8.752 in.)	— —

RG.CTM42,G10,20-19-04JUN93

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

TORQUES

Connecting Rod Cap Screws:

Initial *	27 N·m (20 lb-ft)
Final (All Cap Screws)	75 N·m (55 lb-ft) Plus 90—100°

Piston Cooling Orifices into Cylinder Block	9.6—12.4 N·m (85—110 lb-in.)
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Cylinder Liner Cap Screws (for Checking Liner Standout)	68 N·m (50 lb-ft)
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* See *INSTALL PISTONS AND CONNECTING RODS*, later in this group, before tightening cap screws.

RG,CTM42,G10,39-19-29OCT92

PRELIMINARY LINER, PISTON, AND ROD CHECKS

Scuffed or Scored Pistons:

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

Worn or Broken Compression Rings:

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

Clogged Oil Control Ring:

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

Stuck Rings:

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

Cylinder Liner Wear and Distortion:

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

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.

Dull Satin Finish and Fine Vertical Scratches on Rings:

Dirt and abrasive in air intake system.

Damaged Piston

Extended operation with incorrect timing (knock).

Poor fuel quality (sulfur, low heat value).

Incorrect spark plug

Corroded liners and piston rings

Low coolant temperatures (thermostats bad, acid formation).

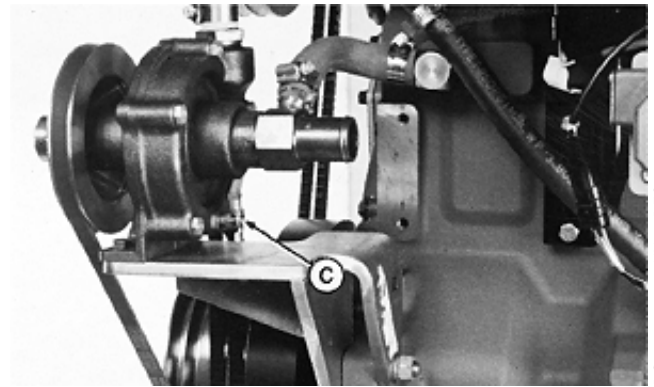
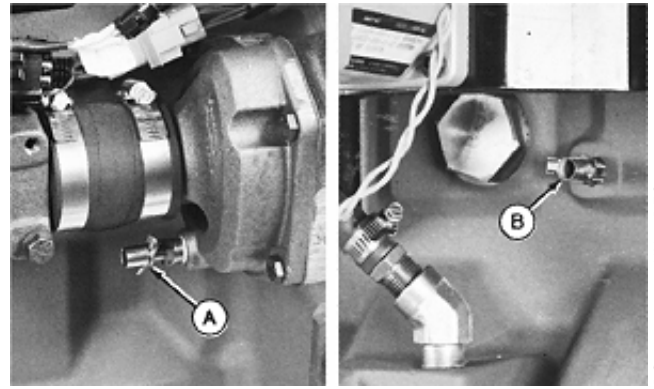
Sour gas.

REMOVE PISTONS AND CONNECTING RODS

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

IMPORTANT: Water pump drain valve (A), block drain valve (B), and auxiliary water pump drain valve (C) must be opened to completely drain both sides of the engine.

1. Drain all coolant and engine oil. Disconnect turbocharger oil inlet line at turbocharger or oil conditioning housing.



RG,CTM82,G10,2 -19-12APR93

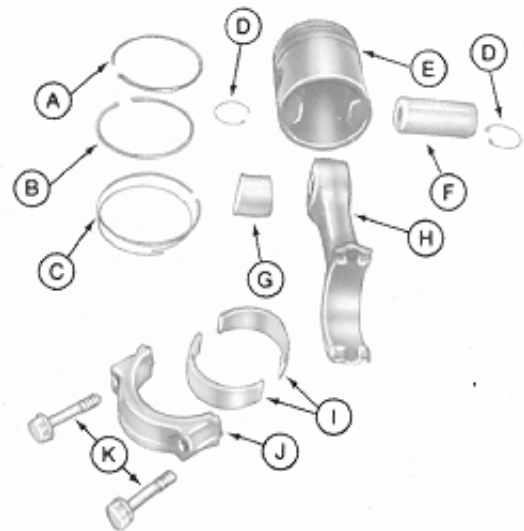
NOTE: If engine is to be completely disassembled, follow **DISASSEMBLY SEQUENCE** in Group 04.

2. Remove cylinder head. (See REMOVE CYLINDER HEAD in Group 05.)

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

4. Remove crankshaft (if desired). (See REMOVE CRANKSHAFT in Group 15.)

- | | |
|----------------------------------|----------------------|
| A—#1 Keystone Compression Ring | E—Piston |
| B—#2 Keystone Compression Ring | F—Piston Pin |
| C—Oil Control Ring with Expander | G—Piston Pin Bushing |
| D—Snap Ring (2 used) | H—Connecting Rod |
| | I—Bearings |
| | J—Connecting Rod Cap |
| | K—Special Cap Screw |

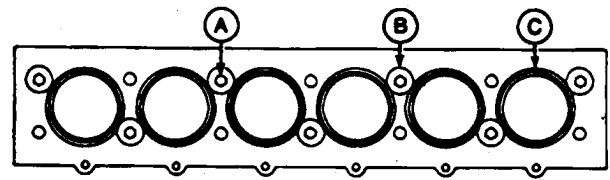


RG,CTM42,G10,30-19-24SEP91

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), later in this group.



-UN-07DEC88

RG3819

S11,2010,EV -19-07AUG91

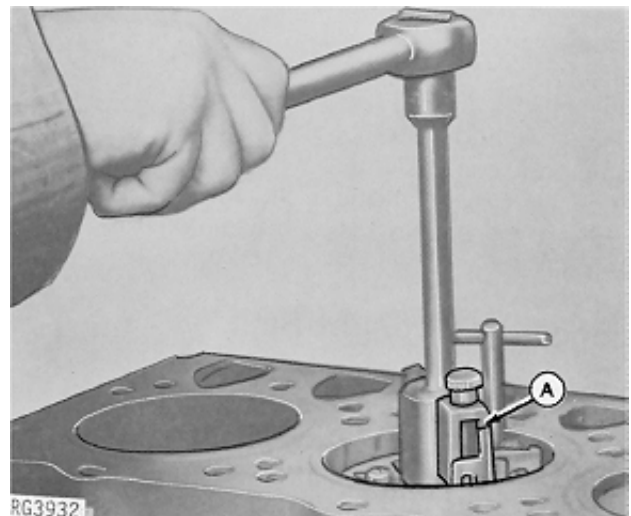
6. Remove carbon from liner bore with a scraper or ridge reamer (A) before removing pistons. Use compressed air to remove loose material from cylinders.

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

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

B—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.



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11

-UN-07DEC88

RG3932

S11,2010,IV -19-29OCT92

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. Remember, the use of PLASTIGAGE will determine bearing journal clearance, but will not indicate the condition of either surface.

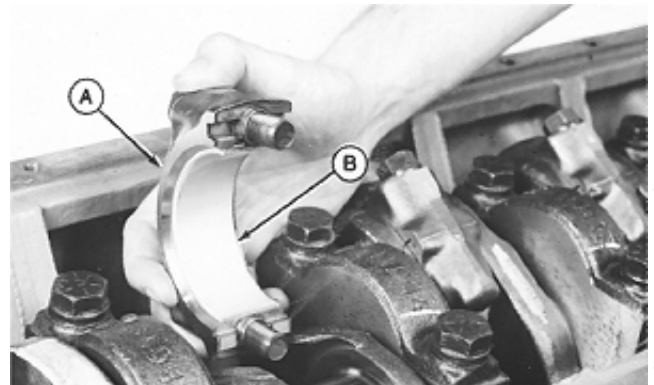
IMPORTANT: Using pneumatic wrenches may cause thread damage.

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).



RG5807
-UN-12AUG91



RG5806
-UN-12AUG91

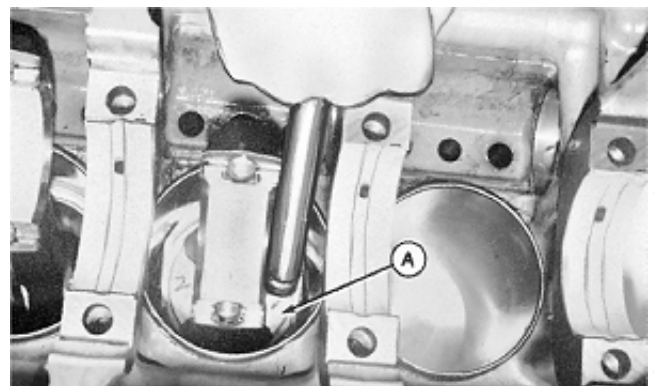
RG,CTM42,G10,2 -19-22AUG91

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

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

IMPORTANT: If liners 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.

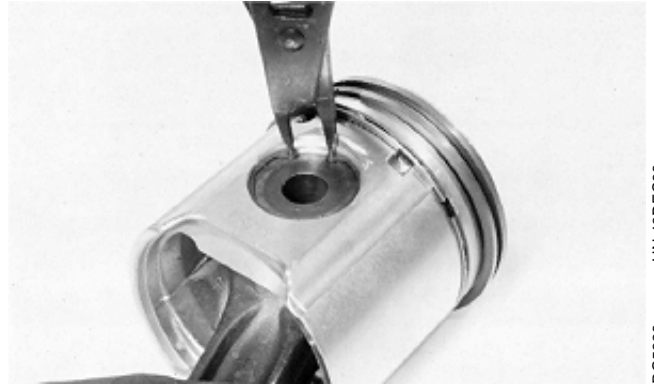


RG5808
-UN-12AUG91

RG,CTM42,G10,3 -19-29OCT92

9. Remove piston snap rings. Remove piston pins and connecting rods from pistons.

NOTE: Discard snap rings. DO NOT reuse.



RG5228 -JUN-13DEC88

S11,2010,IW1 -19-25MAR91

MEASURE CYLINDER LINER STANDOUT (HEIGHT ABOVE BLOCK)

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

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

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

2. Use JDG451 Gauge along with D17526CI (English, in.) or D17527CI (Metric, mm) Dial Indicator (B) or KJD10123 Gauge to measure the height (C) of bolted down liners (A) that are not obviously defective before removal from block (D). Cap screws must be tightened to 68 N·m (50 lb-ft) to achieve an accurate reading.

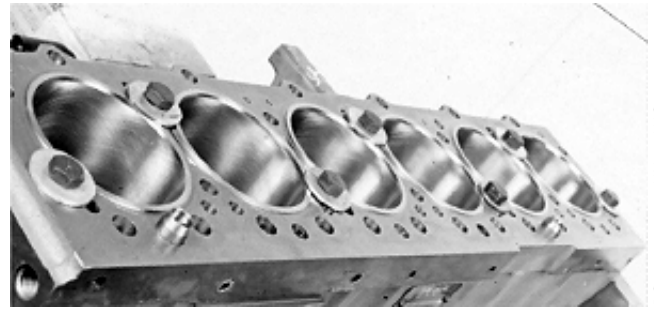
NOTE: Variations in measurement readings may occur within one cylinder and/or between adjacent cylinders.

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

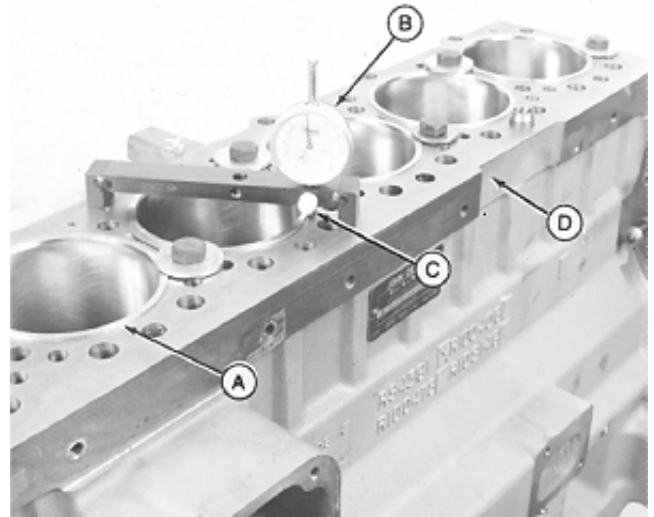
4. Remove any liner that does not meet standout specification at any location and measure liner flange thickness, as explained later in this group. Use liner shims or replace piston/liner sets as necessary.

LINER HEIGHT SPECIFICATIONS

Liner Height Above Block	0.025—0.102 mm (0.001—0.004 in.)
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RG5829 -UN-12AUG91



RG5813 -UN-12AUG91

A—Cylinder Liner
B—Dial Indicator
C—Liner Height
D—Cylinder Block

RG.CTM42.G10.21-19-29OCT92

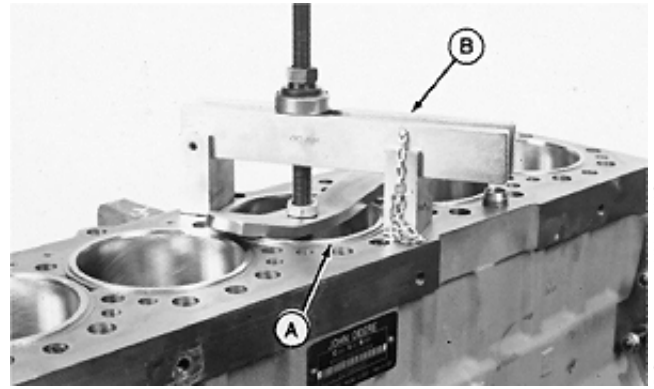
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14

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.

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

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

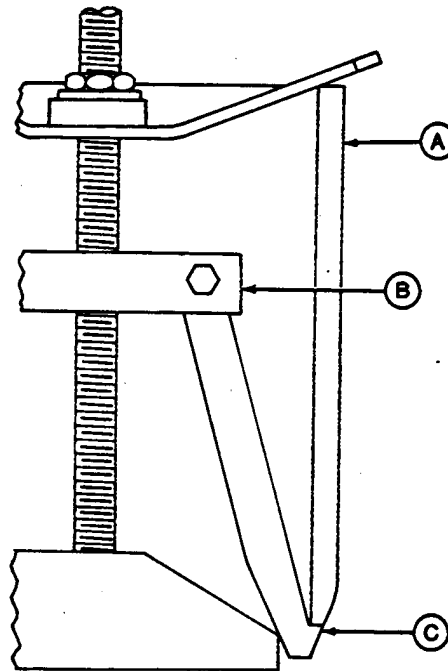


RG5809 -JUN-12AUG91

RG.CTM42,G10,4 -19-12APR93

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.



RG-1179 -JUN-13DEC88

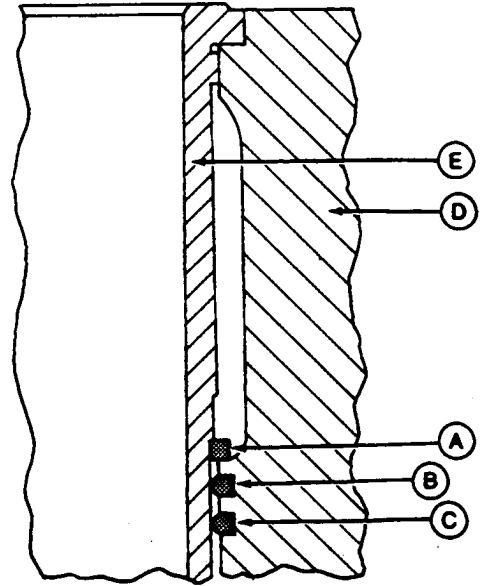
S11,0402,AK -19-02APR93

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15

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—Liner



RG.CTM42,G10,5 -19-07AUG91

RG3825 -JUN-13DEC88

REMOVE PISTON RINGS

10
16

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



RG.CTM82,G10,3 -19-12APR93

RG6534 -JUN-14DEC92

CLEAN PISTONS

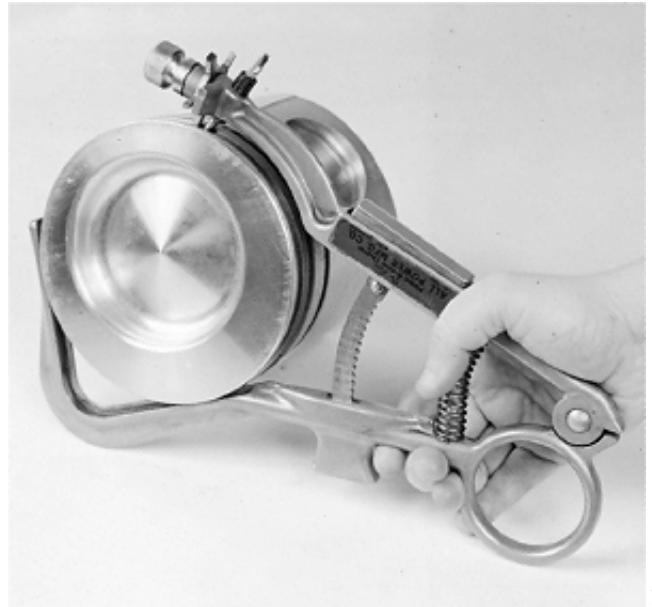
1. Clean piston ring grooves using a piston ring groove cleaning tool.

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

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—NOT A WIRE BRUSH—to loosen carbon residue. Dry with compressed air.



RG6088 -UN-27JAN92

RG,CTM82,G10,4 -19-04FEB93

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17

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.

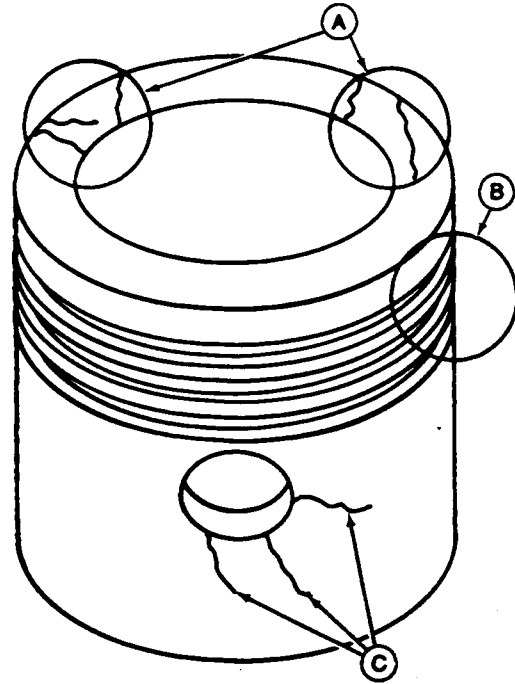
RG,CTM61,G10,9 -19-02APR93

VISUALLY INSPECT 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)

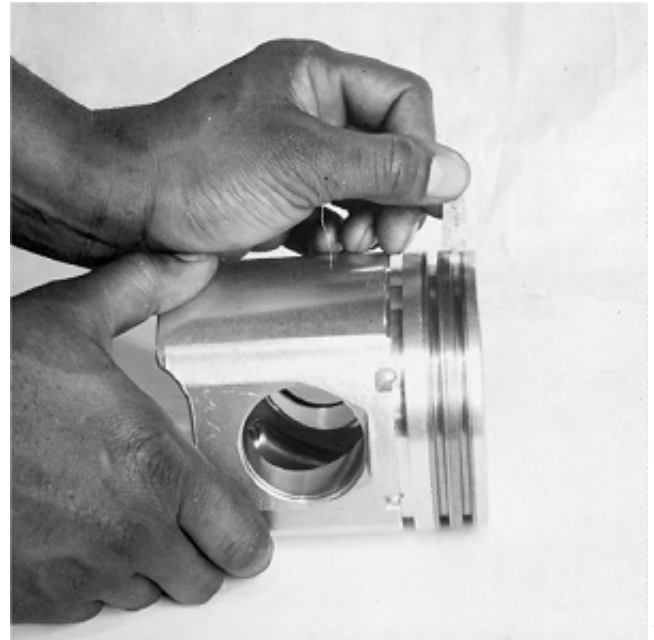
RG3326 -UN-13DEC88

RG,CTM82,G10,5 -19-04FEB93

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18

CHECK PISTON RING GROOVE WEAR

1. Use the JDE55 Ring Groove Wear Gauge to check wear of keystone ring grooves. Check each groove at several locations.

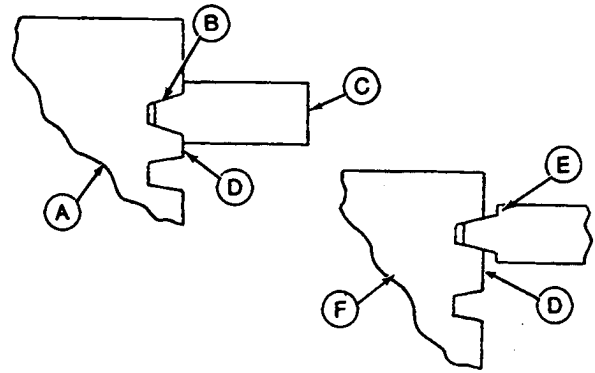


RG5230 -UN-13DEC88

RG,CTM82,G10,6 -19-04FEB93

Gauge shoulders should not contact ring land (D) of piston. If ring grooves are worn, replace piston and liner as a set. If ring grooves are good, 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



R 24201K

S11,2010,DG -19-17FEB87

-JUN-13DEC88
R24201

INSTALL PISTON PIN IN PISTON

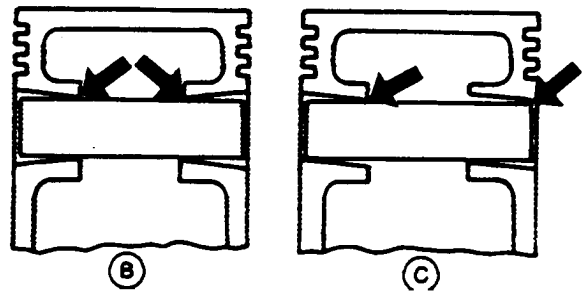
NOTE: Piston pin must be in good condition and not worn beyond specification given below.

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	47.60—47.61 mm (1.8739—1.8745 in.)
Piston Pin Bore ID in Piston	47.62—47.63 mm (1.8748—1.8752 in.)



RG,CTM82,G10,7 -19-12APR93

VISUALLY INSPECT CYLINDER LINERS

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

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

Replace piston and liner if:

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

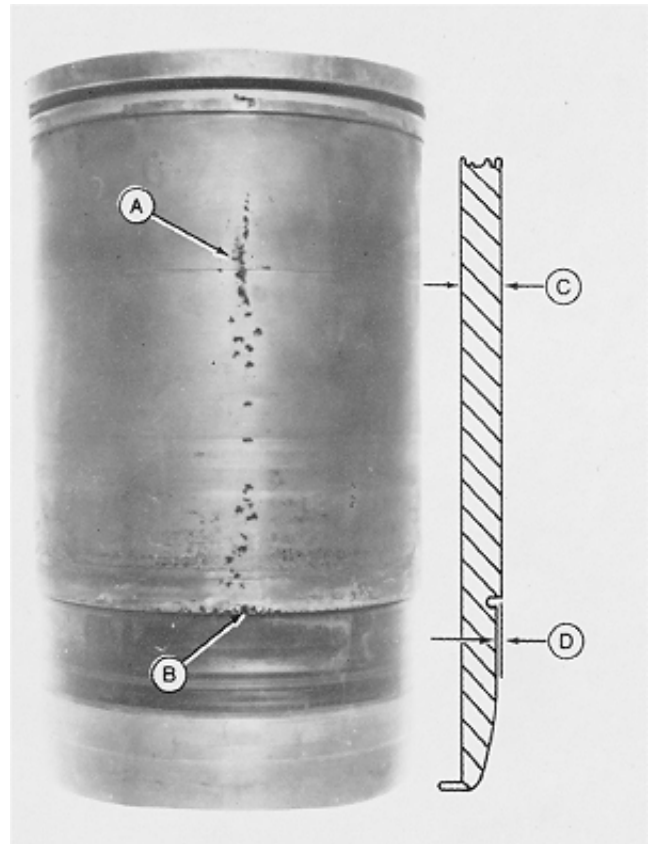
—Depth of erosion is one-half or more of the packing step (D).

CYLINDER LINER SPECIFICATIONS

Cylinder Liner Thickness 6.05—6.15 mm
(0.238—0.242 in.)

Packing Step Dimension 1.45—1.55 mm
(0.057—0.061 in.)

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



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

RG,CTM42,G10,34-19-29OCT92

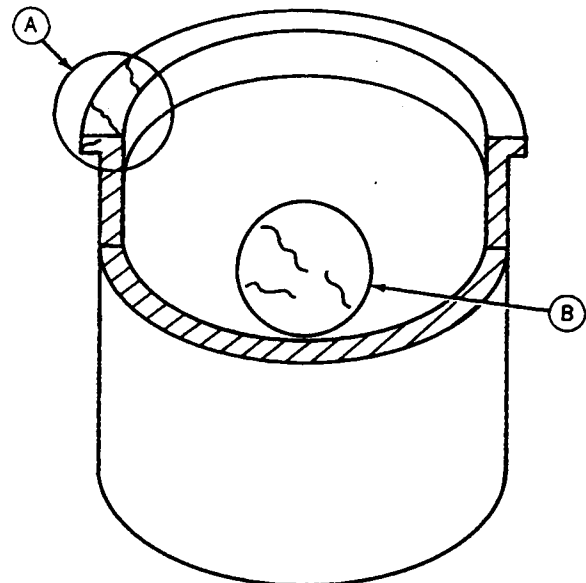
RG4643 -UN-13DEC88

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

RG1188 -UN-13DEC88

RG1188

MEASURE PISTON SKIRT OD

1. Measure piston skirt diameter (B) at right angles to piston pin bore (C) the following distance from the bottom of the piston (A):

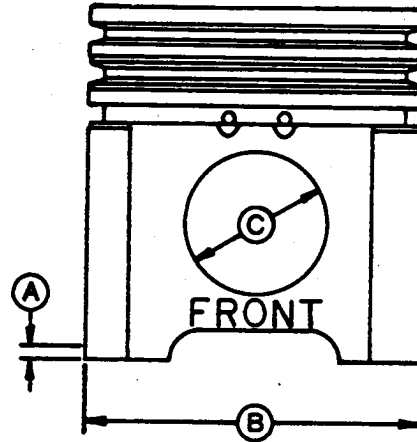
—19.1 mm (0.75 in.)

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

PISTON SKIRT DIAMETER SPECIFICATION

Piston OD:

—19.1 mm (0.75 in.) from
 Bottom of Skirt 115.771—115.789 mm
 (4.5579—4.5586 in.)



RG,CTM82,G10,8 -19-12APR93

RG5232 -UN-13DEC88

DETERMINE PISTON-TO-LINER CLEARANCE

1. Place piston (without rings) in matched liner.

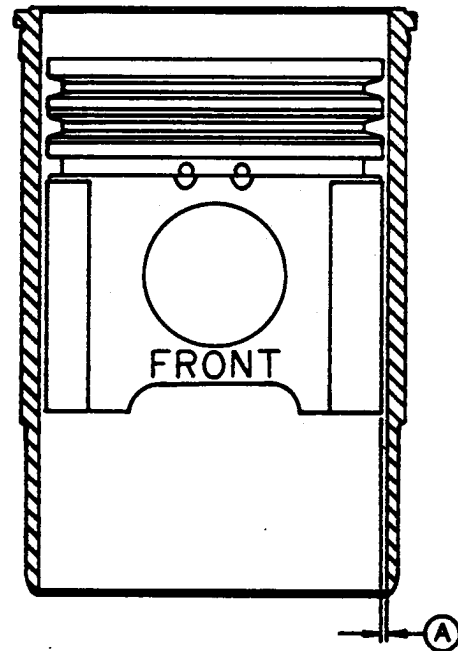
2. Compare liner ID measurement with piston skirt OD measurement to determine piston-to-liner clearance (A).
 Piston-to-liner clearance specifications are:

PISTON-TO-LINER CLEARANCE

New Part 0.076—0.124 mm
 (0.0030—0.0049 in.)
 Wear Limit 0.152 mm
 (0.0060 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 0.051 mm (0.0020 in). See MEASURE CYLINDER LINERS, later in this group.



RG,CTM82,G10,9 -19-12APR93

RG5233 -UN-13DEC88

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21

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	0.064—0.102 mm (0.0025—0.0040 in.)
Wear Limit	0.165 mm (0.0065 in.)

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



RG6533 -UN-14DEC92

RG,CTM82,G10,10-19-12APR93

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 pin 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 ID with matched piston OD.

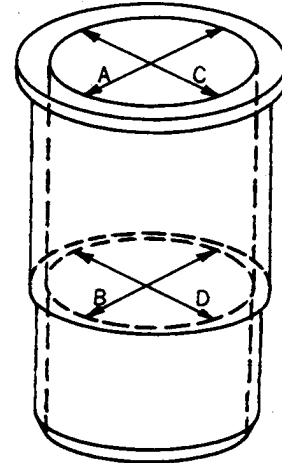
CYLINDER LINER WEAR SPECIFICATIONS

Maximum Wear or Taper in Ring Travel Area 0.051 mm
(0.0020 in.)

Maximum Liner Out-of-Round 0.051 mm
(0.0020 in.)

Maximum Piston-to-Liner Clearance 0.152 mm
(0.0060 in.)

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



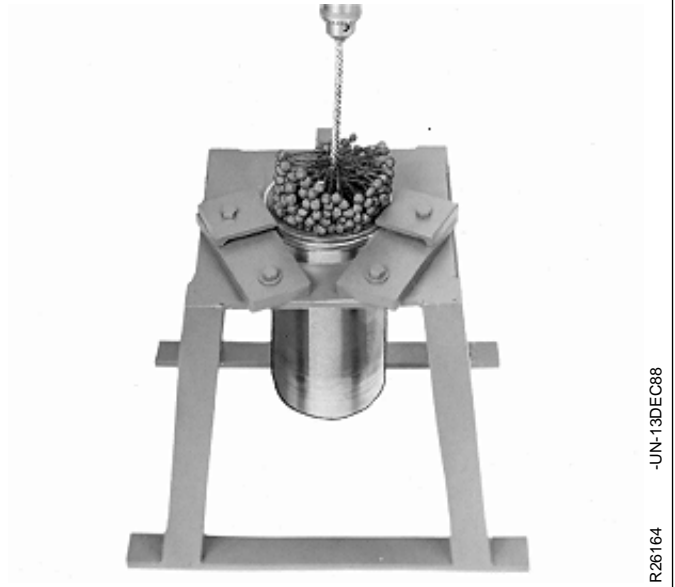
R25922N

R25922 -JUN-13DEC88

DEGLAZE CYLINDER LINERS

1. Secure cylinder liner in a holding fixture. (See Dealer Fabricated Tools, Group 199 for assembly of holding fixture.)
2. Use D17005BR Flexible Cylinder Hone to deglaze cylinder liner.

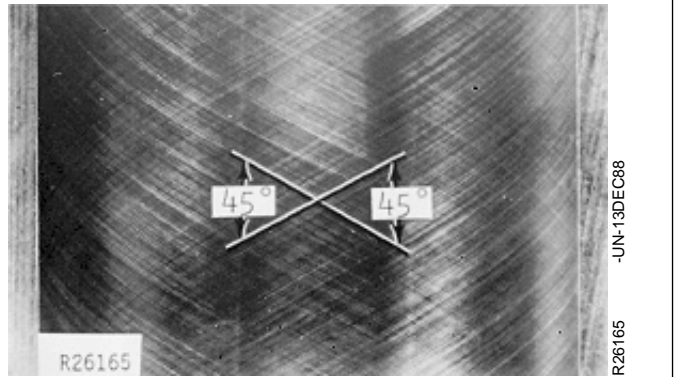
NOTE: Use honing oil along with flex hone when deglazing liners.



S11,0402,AS -19-29OCT92

3. Use D17005BR Hone according to instructions supplied with tool to obtain a 45° cross-hatch pattern.

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



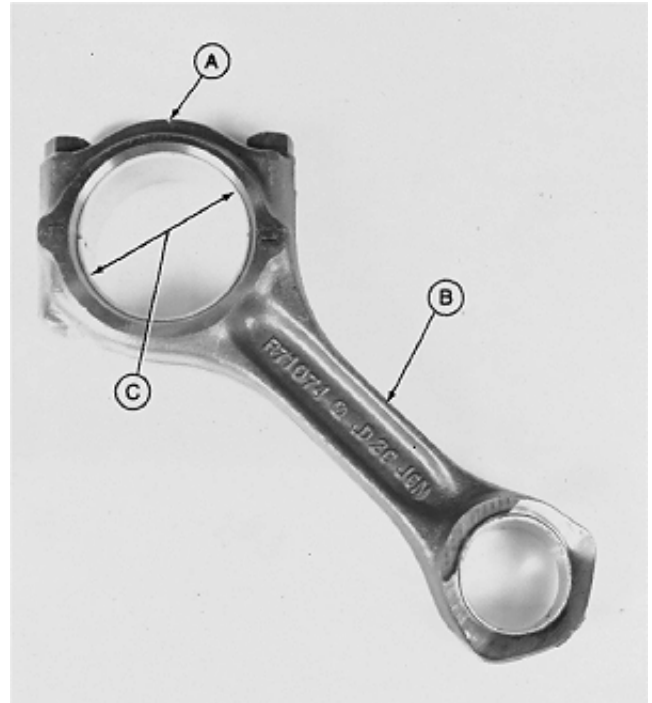
S11,0402,AT -19-12APR93

INSPECT AND MEASURE CONNECTING ROD BEARINGS

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, described later in this group.)



RG5705 -UN-01APR91

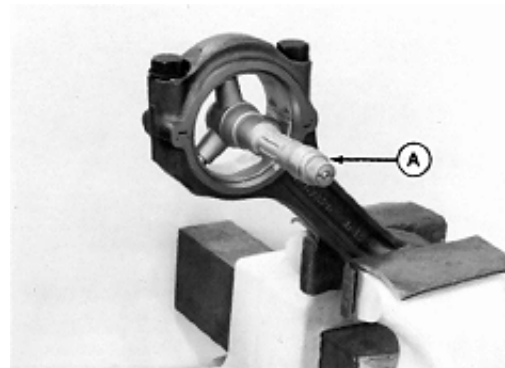
RG.CTM42.G10,40-19-29OCT92

4. Using an inside micrometer (A) measure ID of bearing.
5. Subtract OD of crankshaft journals from ID of rod bearings to obtain oil clearance.
6. Compare measurements with the following specifications.

CONNECTING ROD BEARING AND JOURNAL SPECIFICATIONS

Crankshaft Journal OD	76.15—76.18 mm (2.9980—2.9992 in.)
Assembled Rod Bearing ID	76.21—76.26 mm (3.0005—3.0025 in.)
Oil Clearance (new parts)	0.030—0.110 mm (0.0012—0.0044 in.)
Wear Limit	0.152 mm (0.0060 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.

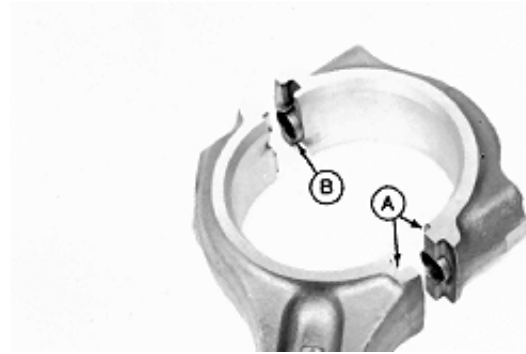


RG3824 -UN-13DEC88

S11,2010,JR -19-12APR93

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.



S11,0402,AE -19-13MAR92

RG3749 -JUN-13DEC88

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.)



S11,2010,JS -19-23AUG91

RG4982 -JUN-13DEC88

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° left of measurement "A".
- C. At 45° right of measurement "A".

ROD BORE SPECIFICATIONS

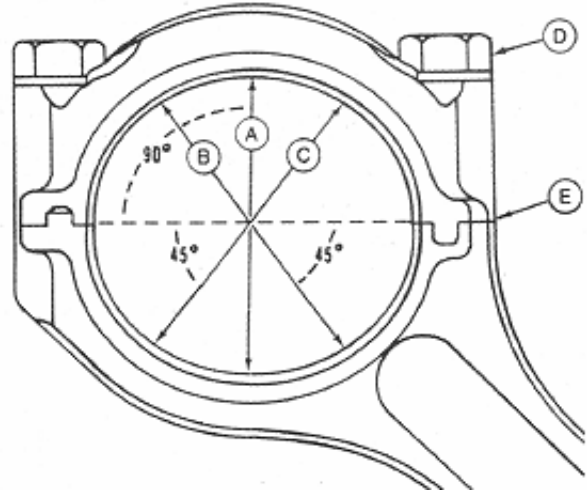
Rod Bore ID 81.051—81.077 mm
(3.191—3.192 in.)

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

8. Remove cap screw (D). Using a feeler gauge, measure gap at rod/cap joint (E). If gap is excessive, mating surfaces of rod and cap are worn and must be replaced.

ROD CAP SPECIFICATION

Maximum End Gap 0.25 mm (0.010 in.)

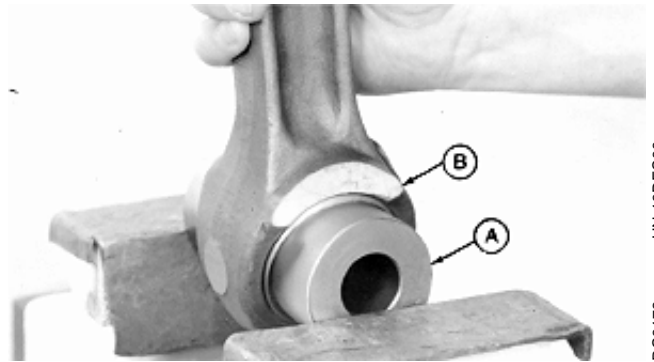


RG6661 -UN-11MAR93

S11,2010,JU -19-12APR93

INSPECT PISTON PINS AND BUSHINGS

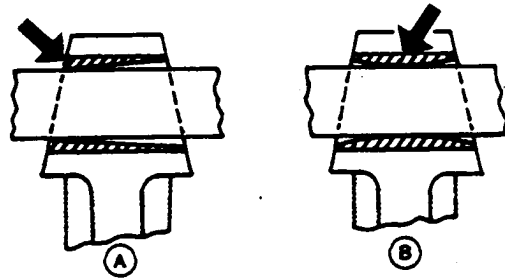
1. Insert piston pin (A) through piston pin bushing and carefully clamp in a soft-jawed vise.
2. Rotate connecting rod (B) back and forth several times to make sure connecting rod moves freely on piston pin.
3. Remove piston pin from vise and connecting rod.



RG3172 -UN-13DEC88

S11,2010,DM -19-12APR93

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

PISTON PIN BORE SPECIFICATIONS

OD of Piston Pin	47.60—47.61 mm (1.8739—1.8745 in.)
ID of Pin Bore in Piston	47.62—47.63 mm (1.8748—1.8752 in.)
ID of Installed Rod Pin Bushing (After Honing)	47.65—47.68 mm (1.8762—1.8772 in.)
Rod Pin-to-Bushing Oil Clearance	0.042—0.084 mm (0.0017—0.0033 in.)
Wear Limit	0.102 mm (0.0040 in.)

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

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28

RG4983 -JUN-13DEC88

REMOVE PISTON PIN BUSHING

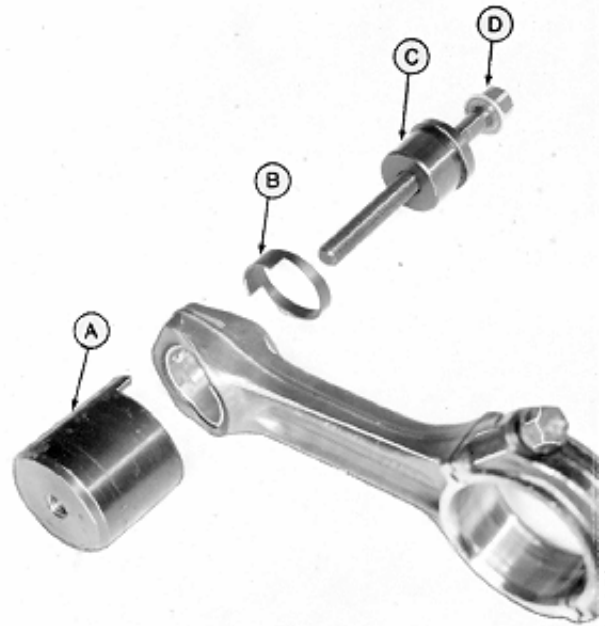
IMPORTANT: Do not use any power tool to remove or install piston pin bushing.

1. If necessary, remove pin bushing with the JDG337 Connecting Rod Bushing Service Set.

Use the following tools from the service set:

- A—JDG339 Cup
- B—JDG338 Adapter
- C—JDE98-4 Driver
- D—STD36104 Forcing Screw with Washer

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



RG4985 -UN-13DEC88

S11,2010,J1 -19-12APR93

CLEAN AND INSPECT CONNECTING ROD PIN BORE

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

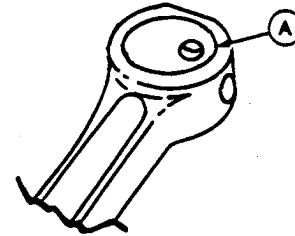
2. If necessary, file a slight chamfer (A) around bore to remove any sharp edges. Chamfer will also aid in bushing installation.

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

CONNECTING ROD PIN BORE SPECIFICATIONS (Bushing Removed)

ID of Rod Pin Bore 52.354—52.380 mm
(2.0612—2.0622 in.)

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



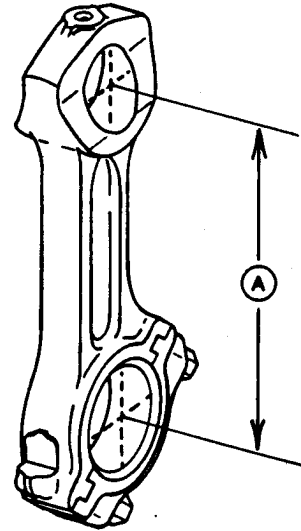
RG5227 -UN-13DEC88

S11,2010,JJ -19-12APR93

4. Measure connecting rod 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

New part 222.20—222.30 mm (8.748—8.752 in.)



RG,CTM42,G10,37-19-12APR93

RG6455 -UN-22OCT92

INSTALL PISTON PIN BUSHING IN ROD

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

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

- A—STD36104 Forcing Screw With Washer
- B—JDE98A Driver
- C—JDG338 Adapter
- D—Service Bushing
- E—JDE98-3 Pilot
- F—JDE339 Cup

IMPORTANT: Be sure oil hole in service bushing and connecting rod are properly aligned.

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



2. Precision bore and hone bushing to the specified dimensions.

CONNECTING ROD PIN BORE AND BUSHING SPECIFICATIONS

Rod Pin Bore-to-Bushing Press Fit Specification	0.084—0.147 mm (0.0033—0.0058 in.)
ID of Installed Service Rod Pin Bushing (Before Honing)	47.58—47.63 mm (1.8732—1.8751 in.)
ID of Installed Rod Pin Bushing (After Honing)	47.65—47.68 mm (1.8762—1.8772 in.)
Bearing Bore-to-Pin Bushing Bore (Center-to-Center) Length	222.20—222.30 mm (8.748—8.752 in.)

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

S11,2010,JK -19-12APR93

RG4986 -UN-13DEC88

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, auxiliary water pump, and all remaining cooling system components. (Group 25)

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

5. Remove ignition system and electronic governor system. (Group 40)

6. If necessary to "Hot Tank" the block, remove oil gallery plugs, water gallery plugs, piston cooling orifices and the engine serial number plate.

RG,CTM82,G10,11-19-12APR93

INSPECT AND CLEAN CYLINDER BLOCK

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

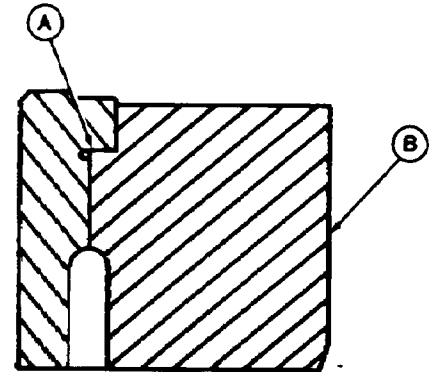
1. Clean block thoroughly using cleaning solvent, pressure steam, or a hot tank.

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

RG,CTM42,G10,38-19-29OCT92

2. 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.

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



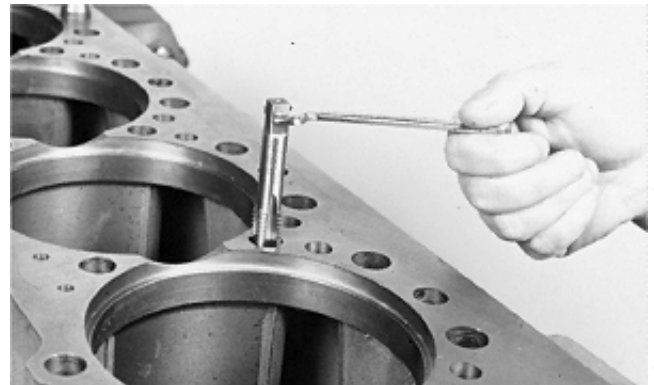
3. Carefully inspect block for cracks or damage. If a cracked block is suspected, pressure-test the block. A procedure for pressure testing is outlined in FOS (Fundamentals of Service) Manual-ENGINES. Replace cracked or damaged block.

COUNTERBORE DEPTH AND LINER FLANGE SPECIFICATIONS

Cylinder Liner Counterbore Depth	8.105—8.155 mm (0.319—0.321 in.)
Liner Flange Thickness	8.175—8.225 mm (0.322—0.324 in.)

4. When determined that the cylinder block is serviceable, remove cylinder head locating dowels. Clean out all threaded holes for cylinder head cap screws in top deck of cylinder block. Use JDG681 Tap or an equivalent 9/16-12 UNC-2A tap approximately 88.9 mm (3.5 in.) long. Use compressed air to remove any debris or fluid which may be present in the cap screw hole.

5. Install new locating dowel pins in cylinder block.



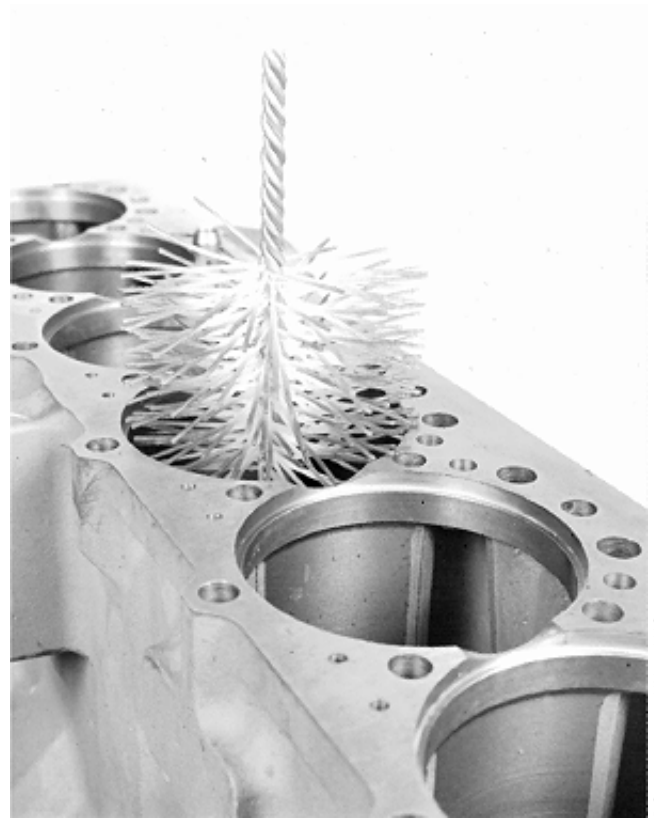
RG3329 -JUN-13DEC68

RG5796 -JUN-12AUG91

CLEAN CYLINDER LINER O-RING BORE

1. Use D17015BR O-Ring Bore Cleaning Brush to thoroughly clean all debris from O-ring bore.

NOTE: Use brush exactly as directed by the manufacturer.



-JUN-12AUG91
RG5812

RG,CTM42,G10,9 -19-12APR93

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MEASURE CYLINDER BLOCK

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

MAIN AND THRUST BEARING SPECIFICATIONS

Main and Thrust Bearing Bore ID	
Without Bearing	92.125—92.151 mm (3.627—3.628 in.)
Main Bearing Surface Width	36.28—36.78 mm (1.428—1.448 in.)
Thrust Bearing (No. 5 Main)	
Surface Width	37.44—37.54 mm (1.474—1.478 in.)
Overall Thrust Bearing Cap Width	39.16—39.66 mm (1.542—1.561 in.)

If any main or thrust bearing cap assembled ID is not within specification, blank (generic) bearing caps are available and must be lined bored to specification. (See Group 15-Crankshaft, Main Bearings, and Flywheel.)

S11,2010,JH -19-29OCT92

2. Measure cam follower bore diameter at all bore locations. Record measurements by bore location.

CAMSHAFT FOLLOWER AND BORE SPECIFICATIONS

Cam Follower Bore ID	17.384—17.440 mm (0.6845—0.6865 in.)
Cam Follower OD	17.33—17.35 mm (0.682—0.683 in.)
Maximum Cam Follower-to-Bore Clearance	0.114 mm (0.0045 in.)

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

S11,2010,JV -19-12APR93

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

CAMSHAFT BUSHING AND BORE SPECIFICATION

Camshaft Bushing Installed ID	67.076—67.102 mm (2.6408—2.6418 in.)
Camshaft Bushing Bore in Block	69.987—70.013 mm (2.7554—2.7564 in.)
Maximum Runout of Camshaft Bushing Bore in Block	0.038 mm (0.0015 in.)
New Camshaft Bushing-to-Journal Clearance	0.063—0.115 mm (0.0025—0.0045 in.)
Maximum Clearance	0.152 mm (0.0060 in.)

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



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RG5830 -UN-12AUG91

RG,CTM42,G10,22-19-29OCT92

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

CYLINDER BLOCK TOP DECK SPECIFICATIONS

Maximum Out-of-Flat
(over entire length or width) 0.10 mm
(0.004 in.)

Minimum Main Bearing Bore Centerline-to-
Top Deck Distance 352.35 mm
(13.872 in.)

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

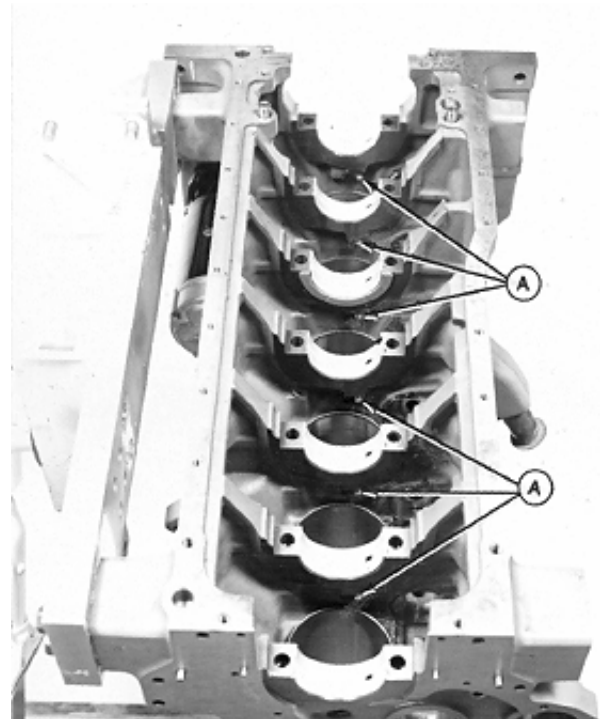
S11,2010,JW -19-01JUN93

INSTALL PISTON COOLING ORIFICES AND GALLERY PLUGS

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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 piston cooling orifices (A) and tighten to 11 N-m (97 lb-in.).
2. Install new oil and water gallery plugs as required, if removed.



RG5811 -JUN-12AUG91

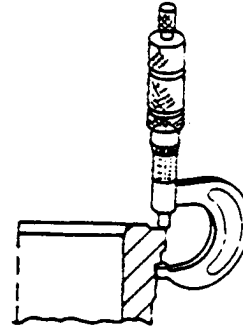
RG,CTM42,G10,10-19-29OCT92

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 SPECIFICATIONS

Flange Thickness 8.175—8.225 mm (0.322—0.324 in.)



S11,2510,AV -19-29OCT92

RG4727 -JUN-13DEC88

RECHECK CYLINDER LINER STANDOUT (HEIGHT ABOVE BLOCK)

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

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

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

RG,CTM42,G10,23-19-29OCT92

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INSTALL LINER SHIMS—IF REQUIRED

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

The liner shim is 0.05 mm (0.002 in.) thick. A maximum of two liner shims may be used per cylinder, as required. Shims have tangs in the I.D. to help hold them in place against bottom of liner flange during liner installation.

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

Liner standout **MUST NOT** exceed 0.102 mm (0.004 in.) after shim installation.

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

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

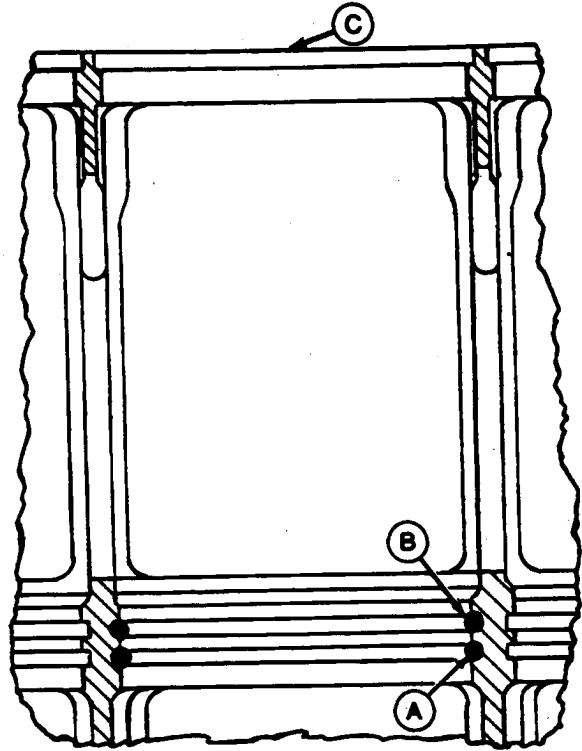
If standout is within specification, proceed to next step.

RG,CTM6,G10.2 -19-29OCT92

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.



S11.0402,BA -19-04JUN93

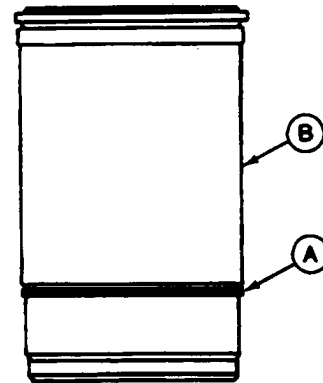
RG3826 -UN-13DEC88

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

NOTE: Make sure the square packing is not twisted.

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



S11.2010,JT -19-29OCT92

RG3827 -UN-13DEC88

CYLINDER LINER MANUFACTURING DATE CODE EXPLANATION



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

HL90

H Liner Material Type
 L Month Liner was Manufactured
 90 Year Liner was Manufactured

Liner Material Specification

H 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

90 1990
 91 1991
 etc.

When installing new liners, the liner manufacturing date code should be toward the front of the engine. This will help with future repairs in knowing whether the liners have been moved or not during a previous repair.

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INSTALL CYLINDER LINERS

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

DO NOT scuff liner packing across upper counterbore.

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

1. Install liner and packing in block bore with mark toward front of engine, unless liner OD is pitted or eroded.

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

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

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



RG5814 -JUN-12AUG91

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41

RG,CTM42,G10,12-19-12APR93

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

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

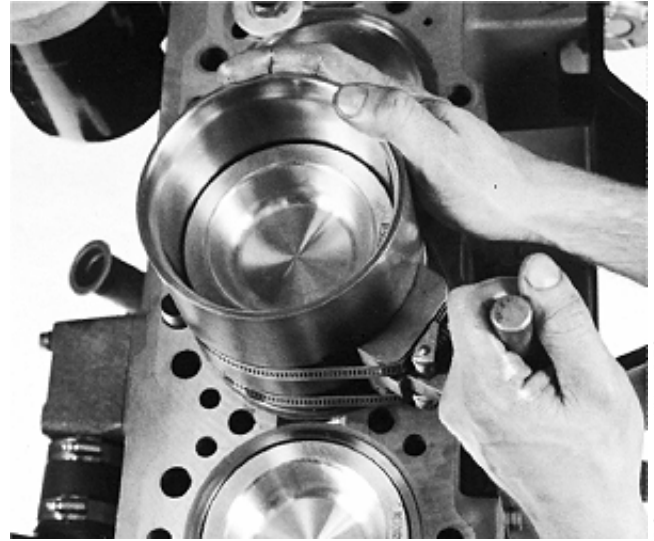
NOTE: Cylinder liner will protrude over top of cylinder block more than normal due to uncompressed packings and O-rings.

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

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

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

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



RG6635
-JUN-14DEC92

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RG,CTM42,G10,13-19-12APR93

INSTALL PISTONS AND CONNECTING RODS

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

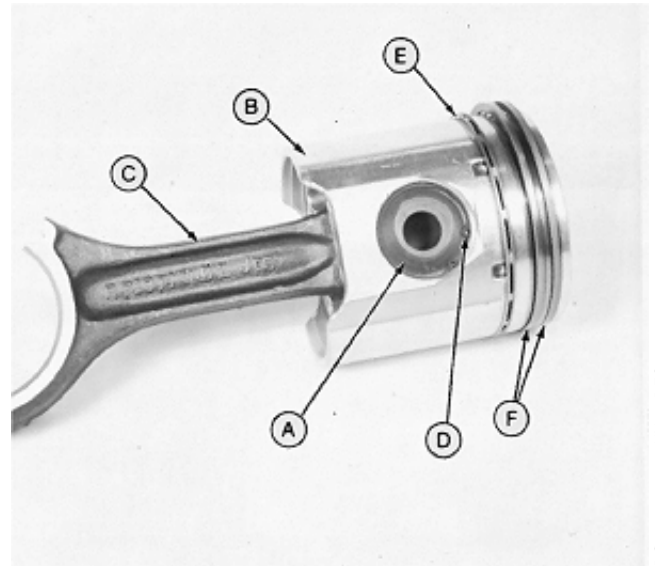
If a new piston and liner assembly is to be installed, **DO NOT** remove piston from liner. Push piston out of liner bottom only far enough to install piston pin.

1. Use the JDE93 Ring Expander to install piston rings (F) and oil control ring with expander ring (E).

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

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

2. Lubricate piston pin (A) and bushing with clean engine oil.
3. Install piston pin through piston (B) and connecting rod (C). Be sure front of rod aligns with front of piston.
4. Install NEW piston pin snap rings (D) in grooves. Make certain snap rings have expanded in grooves of piston.



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

RG5239 -UN-13DEC88

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43

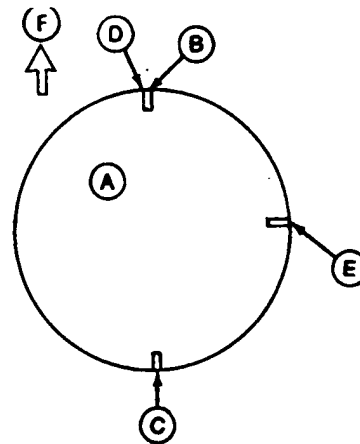
RG,CTM82,G10,12-19-04FEB93

5. Stagger ring gap on pistons as shown.

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

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

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



R 31127

R31127 -UN-13DEC88

S11,2010,JW1 -19-07AUG91

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

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

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

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



RG5816 -JUN-12AUG91

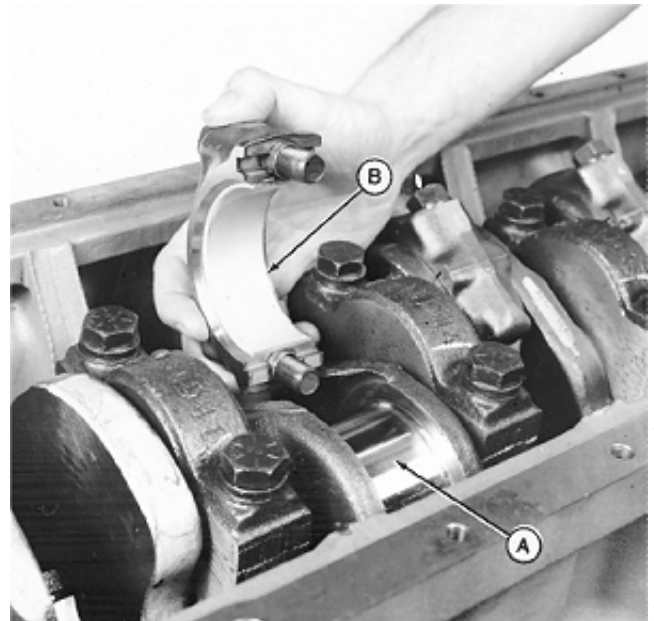
RG,CTM82,G10,13-19-04FEB93

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

IMPORTANT: NEVER use connecting rod cap screws more than once for final engine assembly. Once rod cap screws have been tightened, they cannot be reused for final assembly.

10. Install connecting rod caps.



RG5817 -JUN-12AUG91

RG,CTM42,G10,15-19-12APR93

11. 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.

12. Initially tighten cap screw (A) to 27 N·m (20 lb-ft) before tightening the other cap screw.

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

14. Finally TORQUE-TURN all cap screws 90—100°. (See USE TORQUE-TURN METHOD FOR PROPER TORQUE, described next in this group.)



RG5818 -UN-12AUG91

RG,CTM42,G10,16-19-29OCT92

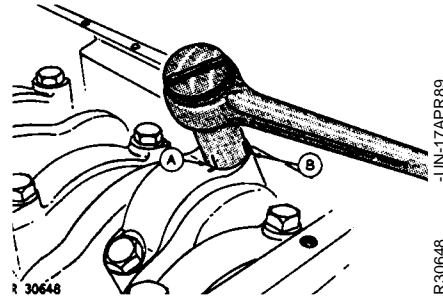
USE TORQUE-TURN METHOD FOR PROPER TORQUE

• 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.



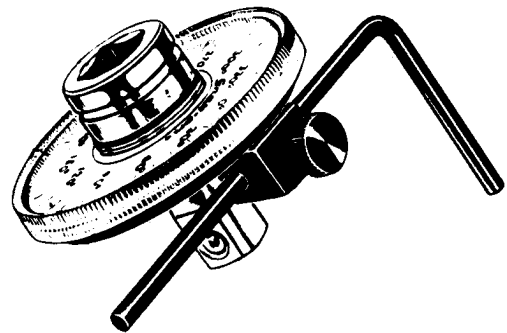
-UN-17APR89

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°.



RG5698 -UN-27AUG90

JT05993 Torque Angle Gauge

RG,CTM6,G10,4 -19-22AUG91

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

COMPLETE FINAL ASSEMBLY

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

1. Install camshaft and timing gear cover. (Group 16)
2. Install lubrication system components. (Group 20)
3. Install cylinder head with new head gasket. Install valve train. (Group 05)
4. Install exhaust manifold and intake assembly. (Group 30)
5. Install turbocharger and exhaust elbow.
6. Install throttle valve assembly, carburetor, and regulator. (Group 40)
7. Install water pump. (Group 25)
8. Install ignition system. (Group 40)
9. Install crankshaft damper and pulley. (Group 15)
10. Install water manifold and water bypass pipe. (Group 25)
11. Install alternator, fan, and fan belts.
12. Install starting motor.
13. Install auxiliary water pump bracket and belt (if equipped).
14. Install electronic governor system (if equipped).
15. Fill engine with clean oil and proper coolant. (Group 02)
16. Perform engine break-in. (Group 05)

RG,CTM82,G10,14-19-12APR93

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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

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

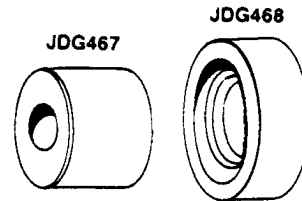
-UN-27MAR92
RG6246

Front Wear Sleeve Installer Set JDE3

Install front crankshaft wear sleeve.

Set consists of:

- Driver JDG467
- Spacer JDG468



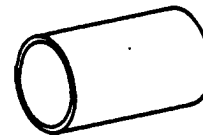
S53,JDE3A -19-16MAR92

-UN-04JUL89
RG5508

Gear Driver JDH7

RG5108 -UN-23AUG88

Install gear on crankshaft.



S53,JDH7 -19-23FEB87

Flywheel Turning Tool JDE81-1

RG4950 -UN-23AUG88

Rotate engine flywheel. Use with JDE81-4.

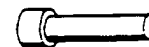


S53,JDE811 -19-07JUL89

Timing Pin JDE81-4

RG5068 -UN-23AUG88

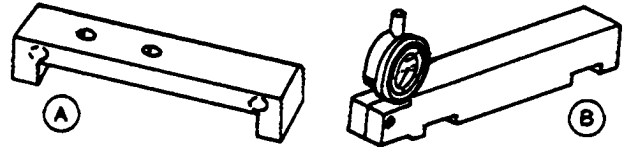
Lock engine at TDC when timing valve train. Use with JDE81-1 or JDE83.



S53,JDE814 -19-06APR90

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

RG5103 -UN-23AUG88



Measure piston and liner heights.

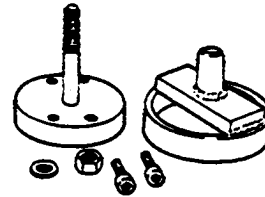
NOTE: A dial indicator is not supplied with JDG451. Use D17526CI (English, in.) or D17527CI (Metric, mm) Dial Indicator with JDG451.

RG,JDG451 -19-29OCT92

Seal and Wear Sleeve Installer JDG476(85)

Used to simultaneously install the new teflon unitized oil seal and wear sleeve on the rear crankshaft flange. Use with JDG796 Alignment Tool to install rear oil seal housing eliminating need for dial indicator to measure runout.

Consists of:
JDG477(85) Pilot
JDG478 Driver



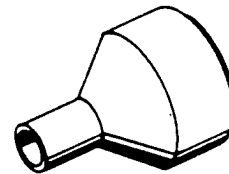
S11,2515,BW -19-03MAY93

RG5106 -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



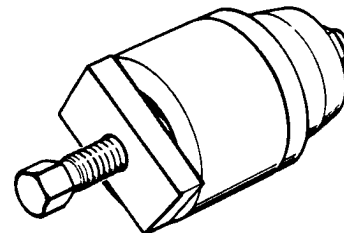
RG,JDG719 -19-29OCT92

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

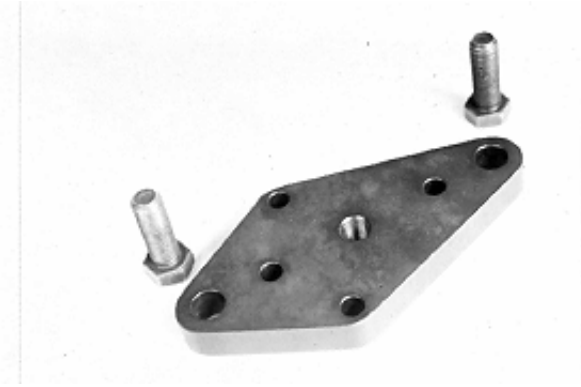


RG,JDG720 -19-01APR93

RG6215 -UN-06MAR92

Hub Puller Kit JDG721

Used with JDG787 Thread Protector to remove vibration damper pulley assembly on some engine applications.

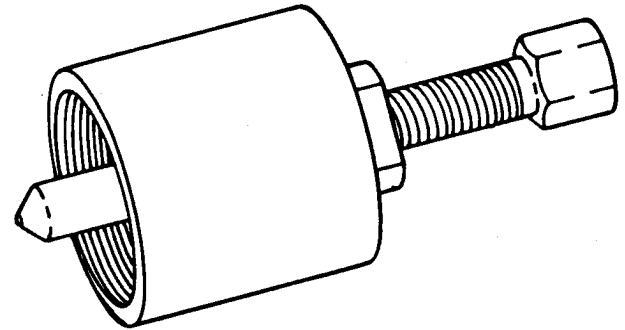


RG,JDG721 -19-03MAY93

RG5763 -UN-06AUG91

Front Wear Sleeve Puller JDG786

Used to remove front crankshaft wear sleeve with timing gear cover installed.

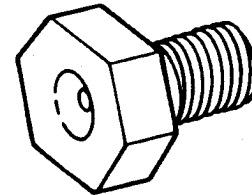


RG,JDG786 -19-29OCT92

RG6428 -UN-13OCT92

Thread Protector JDG787

Used with any puller set to remove vibration damper pulley assembly.



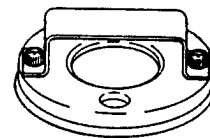
RG,JDG787 -19-03FEB93

RG6429 -UN-13OCT92

Seal Housing Alignment Tool JDG796

Use with JDG476 Seal and Wear Sleeve Installer.

RG6590 -UN-18FEB93



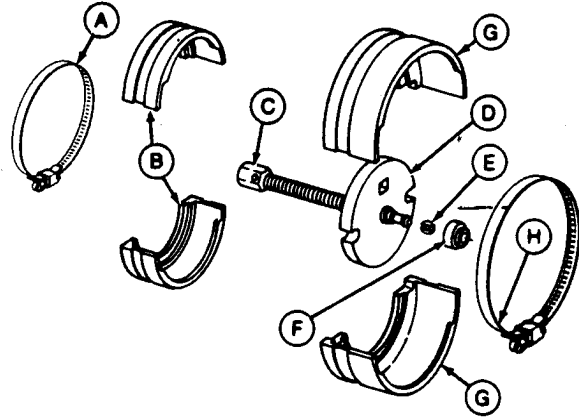
RG,JDG796 -19-04JUN93

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



RG6457 -JUN-22OCT92

RG,JDG790 -19-02APR93

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*	Used to remove crankshaft gear.

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

RG,CTM42,G15,32-19-11JUN93

OTHER MATERIAL

Name	Use
LOCTITE 242 (TY9370/T43512) Thread Lock & Sealer	Coat threads of flywheel mounting cap screws.
LOCTITE 609 (T43515) Retaining Compound	Coat OD of crankshaft flange for installation of rear oil seal/wear sleeve.
PLASTIGAGE	Check main bearing-to-crankshaft journal oil clearance during engine disassembly.
Brake Kleen or Ignition Cleaner and Drier	Remove sealant from crankshaft flange.

S11,2015,EE -19-03MAY93

CRANKSHAFT, MAIN BEARINGS, AND FLYWHEEL SPECIFICATIONS

ITEM	SPECIFICATION	WEAR LIMIT
Crankshaft Fillet Radius:		
Pin Journal	3.94—4.44 mm (0.156—0.175 in.)	—
Thrust Journal	3.56—4.06 mm (0.140—0.160 in.)	—
Main Journal	3.94—4.44 mm (0.156—0.175 in.)	—
Crankshaft End Play	0.038—0.380 mm (0.0015—0.0150 in.)	—
Main Bearing Journal OD	85.65—85.67 mm (3.372—3.373 in.)	—
Main Bearing Assembled ID	85.70—85.76 mm (3.3742—3.3762 in.)	—
Main Bearing-to-Journal Clearance	0.030—0.108 mm (0.0012—0.0042 in.)	0.152 mm (0.0060 in.)
Connecting Rod Journal OD	76.15—76.18 mm (2.9980—2.9990 in.)	—
Crankshaft Rear Oil Seal- to-Housing Maximum Runout	0.152 mm (0.0060 in.)	—
Journal Taper per 25.4 mm (1.00 in.) Length	0.0025 mm (0.0001 in.)	—
Journal Out-of-Roundness	0.025 mm (0.0010 in.)	—
Undersized Bearings Available	0.05, 0.25, 0.51 and 0.76 mm (0.002, 0.010, 0.020, and 0.030 in.)	—
Oversize Thrust Washer Available	0.18 mm (0.007 in.)	—
Main Bearing Cap Bore Specifications:		
ID without Bearing Inserts	92.125—92.151 mm (3.6270—3.6280 in.)	—
Maximum Bore Diameter Taper	0.008 mm (0.0003 in.)	—
Maximum Bore Diameter Variation	0.013 mm (0.0005 in.)	—
Maximum Straightness Variation (Any Bore-to-Adjacent Bores)	0.038 mm (0.0015 in.)	—
Maximum Straightness Variation (5 Center Bores-to-End Bores)	0.076 mm (0.0030 in.)	—
Centerline of Bore-to-Top Deck of Block	352.35—352.50 mm (13.872—13.878 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)	37.44—37.54 mm (1.474—1.478 in.)	—
Overall Cap Width	39.16—39.66 mm (1.542—1.561 in.)	—
Base Circle OD for Thrust Washer Clearance*	123.70—125.30 mm (4.87—4.93 in.)	—

* Thrust (washer) surfaces on bearing cap must be flat in respect to mating thrust (washer) surfaces in cylinder block.

CRANKSHAFT, MAIN BEARINGS, AND FLYWHEEL SPECIFICATIONS—CONTINUED

ITEM	SPECIFICATION	WEAR LIMIT
Crankshaft OD for Front Pulley	47.650—47.676 mm (1.8785—1.876 in.)	—
Front Pulley ID	47.594—47.630 mm (1.8738—1.8752 in.)	—
Damper Pulley Radial Runout (Maximum)	1.02 mm (0.040 in.)	—
Front Oil Seal Housing Install Below Front of Timing Gear Cover (Maximum) . . .	8.4 mm (0.33 in.)	—
Oil Pump Drive Gear-to-Crankshaft Clearance	0.38 mm (0.015 in.)	—
Maximum Rear Oil Seal Housing Runout	0.15 mm (0.006 in.)	—
Flywheel Housing Face Runout Maximum Variation	0.20 mm (0.008 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.)	—

RG.CTM42,G15,1 -19-29OCT92

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CRANKSHAFT, MAIN BEARINGS, AND FLYWHEEL SPECIFICATIONS—CONTINUED

TORQUES

Flywheel Housing-to-Cylinder Block	407 N·m (300 lb-ft)
Vibration Damper-to-Crankshaft	230 N·m (170 lb-ft)
Main Bearing Caps	203 N·m (150 lb-ft)
Rear Crankshaft Oil Seal Housing	27 N·m (20 lb-ft)
Flywheel-to-Crankshaft	115 N·m (85 lb-ft)
Piston Cooling Orifices	11 N·m (8 lb-ft)
Front Crankshaft Pulley-to-Damper	41 N·m (30 lb-ft)
Ignition Timing Wheel Access Cover-to-Timing Gear Cover	27 N·m (20 lb-ft)
Ignition Timing Indicator-to-Timing Gear Cover	27 N·m (20 lb-ft)
Timing Gear Cover-to-Cylinder Block*	27 N·m (20 lb-ft)

* See *INSTALL TIMING GEAR COVER*, later in this group, for proper cap screw tightening sequence.

RG,CTM82,G15,1 -19-01JUN93

FAILURE ANALYSIS

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

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

• **Galled or “Wiped” Bearings:**

Coolant in lubrication system (cracked block, liner seal failure, or leaking water pump seal with plugged hole).
Insufficient bearing oil clearance.
Parts not lubricated prior to engine operation.
Wrong bearing size.

• **Inconsistent Wear Pattern:**

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

• **Broken Main Bearing Caps:**

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

• **Cracked, Chipped or Broken Bearings:**

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

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RG,CTM82,G15,2 -19-04FEB93

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 JDG719, JDE38-2, and JDE38-3 are not available, JDG22 Seal Remover can be used to remove the seal. Follow same procedure for both pullers.

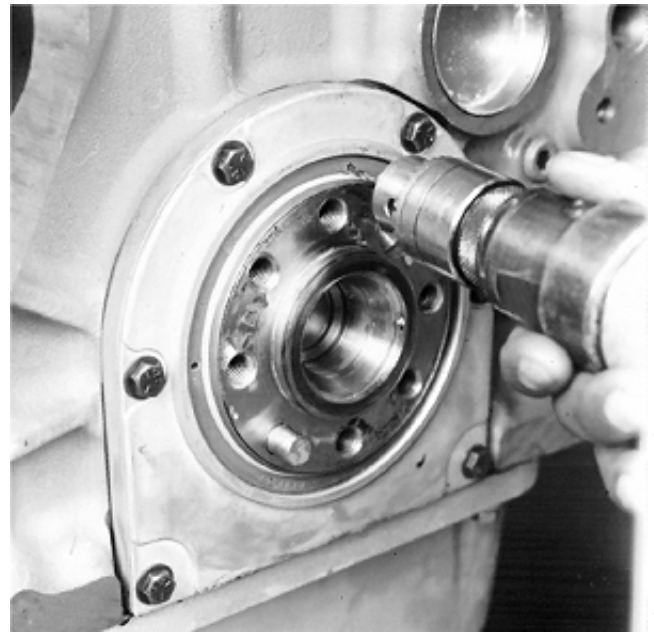
IMPORTANT: If rear oil seal is replaced, also replace rear wear sleeve (as a matched set).

NOTE: If oil seal housing is to be removed, remove seal and wear sleeve after housing is removed. See REMOVE REAR OIL SEAL HOUSING AND WEAR SLEEVE (WITH ENGINE DISASSEMBLED), later in this group.

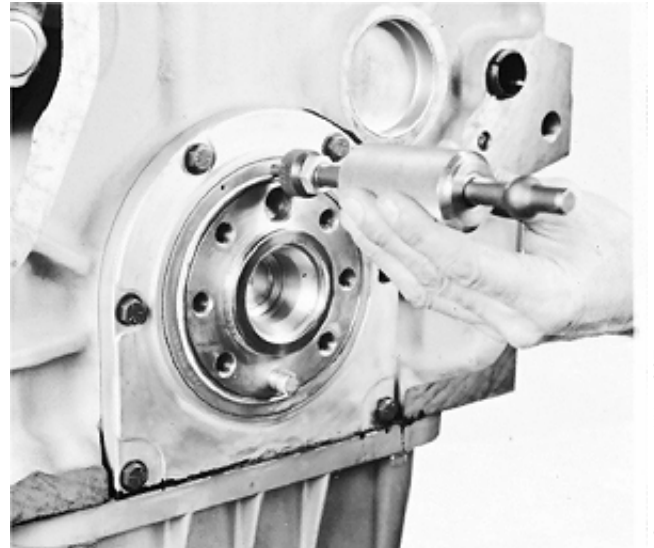
1. Remove rear drive hub (if equipped) and flywheel. See REMOVE FLYWHEEL later in this group.
2. Drill two small holes approximately 20° apart in bottom of seal casing. Install sheet metal screws in seal casing with JDG22 Seal Remover attached.

NOTE: It may be necessary to drill a small hole in seal at one or two other locations to aid in removal.

3. Cock seal at 6 O'clock position (180° opposite drilled hole) using a small punch and carefully pull seal from housing.



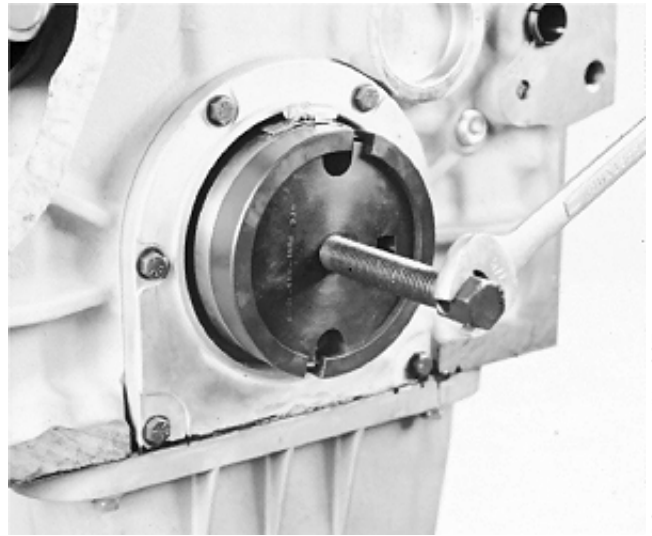
RG5819 -UN-12AUG91



RG6467 -UN-26OCT92

RG.CTM42.G15.2 -19-03MAY93

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.



RG6468 -UN-26OCT92

RG,CTM42,G15,50-19-29OCT92

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.)

Look for nicks or burrs on wear ring surface and bore in flywheel housing. If necessary, use a polishing cloth.

Finish cleaning by wiping flange with a clean rag. Any small nicks should be removed with 180-grit or finer polishing cloth.

Check oil seal housing runout as explained later in this group.

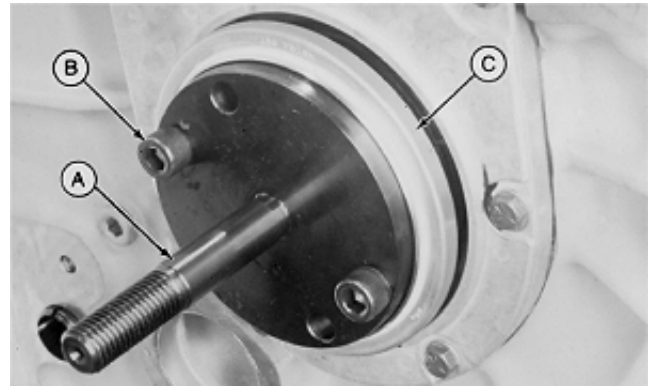


RG5822 -UN-12AUG91

RG,CTM42,G15,4 -19-29OCT92

INSTALL CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE (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.



RC4639 -JUN-14DEC88

1. Apply a light coating of LOCTITE 609 Retaining Compound, or equivalent, completely around the leading edge of crankshaft flange. Wipe away any sealant that may have gotten on ID of seal housing bore.

2. Install JDG477(85) Pilot (A) on end of crankshaft using the Allen head cap screws (B) supplied with tool set. Tighten cap screws securely.

IMPORTANT: Handle seal and wear sleeve assembly carefully. If assembly becomes separated, discard these parts and install a new assembly. (See CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE HANDLING PRECAUTIONS, later in this group.)

3. Carefully start oil seal/wear sleeve assembly (C) over JDG477(85) Pilot and crankshaft flange with open side of seal toward engine.

IMPORTANT: When installing the JDG478 Driver on JDG477(85) Pilot and crankshaft flange to position oil seal/wear sleeve assembly, locate crossbar of installer at right angle (90°) to Allen head cap screws. This allows the crossbar to bottom on pilot, not head of cap screws, assuring correct installation.

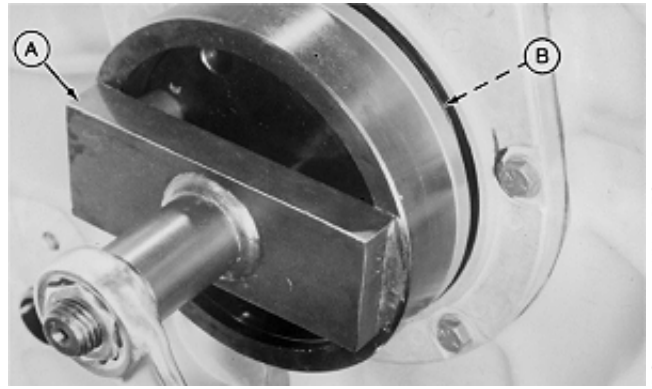
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S11.2015.GQ -19-29OCT92

4. Position JDG478 Driver (A) so that hole in the cross plate goes over threaded stud of pilot. Install washer and nut on stud.

5. Tighten nut to draw JDG478 Driver in until crossbar bottoms on JDG477(85) Pilot. When the tool bottoms, seal and wear ring assembly (B) will be correctly positioned.

6. Remove JDG476(85) Tool Set from engine.



S11,2015,GR -19-11JUN93

RG4640 -JUN-14DEC88

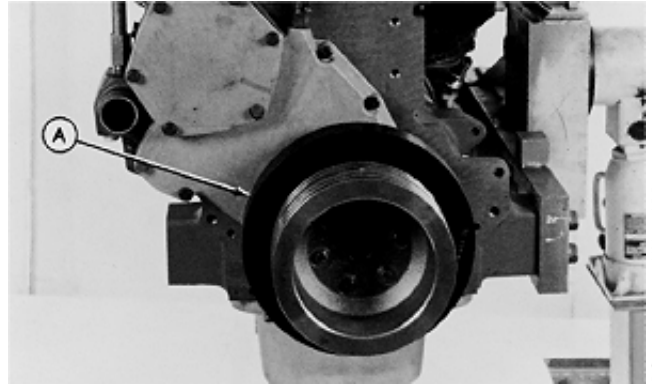
INSPECT VIBRATION DAMPER

IMPORTANT: Do not immerse the vibration damper or the damper pulley in cleaning solvent. Doing so may damage the rubber portions of these components.

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

The damper assembly is not repairable and should be replaced every 5 years or 4500 hours, whichever occurs first.

1. Remove fan belts (shown removed).
2. Grasp vibration damper (A) with both hands and attempt to turn it in both directions. If rotation is felt, damper is defective and should be replaced.

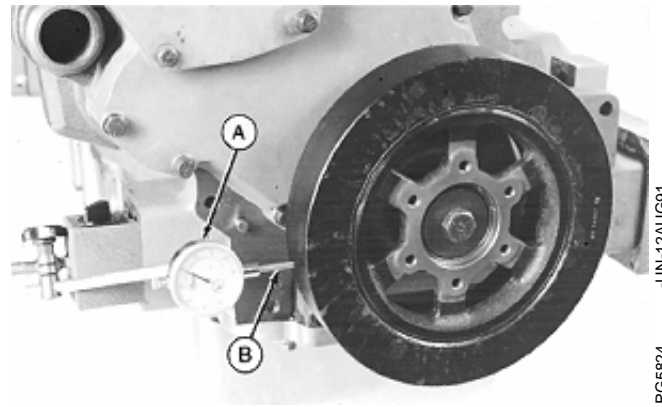


RG,CTM82,G15,3 -19-03MAY93

RG6733 -JUN-27APR93

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11

3. Check vibration damper radial runout by positioning a dial indicator (A) so probe (B) contacts damper O.D.
4. Rotate crankshaft using JDE81-1 Flywheel Turning Tool.
5. Note dial indicator reading.



RG5824 -UN-12AUG91

DAMPER RADIAL RUNOUT SPECIFICATION

Maximum 1.02 mm (0.040 in.)

If runout exceeds specifications, replace vibration damper.

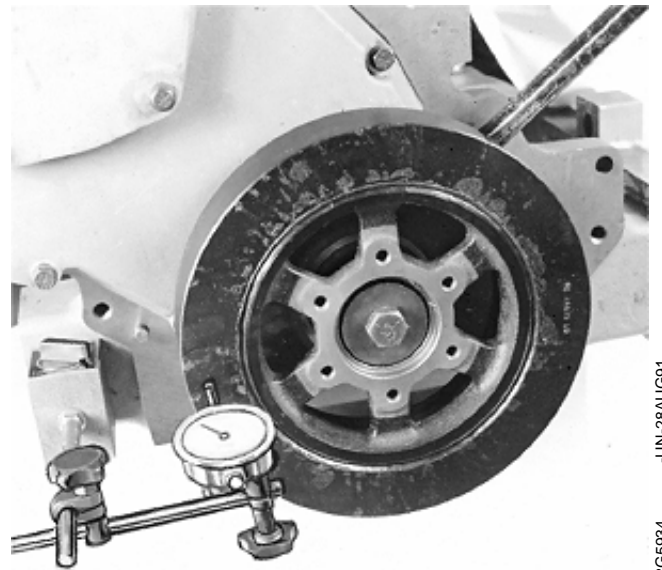
RG.CTM42,G15,6 -19-29OCT92

CHECK CRANKSHAFT END PLAY

1. Completely engage then release the clutch lever.
2. Place a dial indicator on damper face.

IMPORTANT: Use care not to damage or distort the timing gear cover or bearing inserts when prying. Do not pry on outer interia ring of damper.

3. Pry with flat bar between the damper pulley and timing gear cover.



RG5934 -UN-28AUG91

CRANKSHAFT END PLAY SPECIFICATIONS

End Play 0.038—0.380 mm
(0.0015—0.0150 in.)

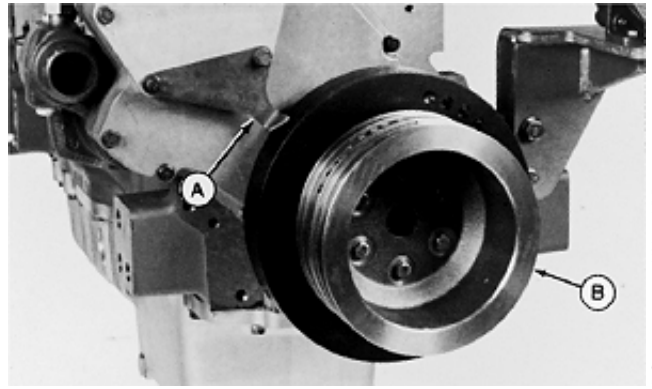
NOTE: New thrust bearings will usually restore proper end play.

RG.CTM42,G105,8-19-29OCT92

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12

REMOVE DAMPER PULLEY

1. Remove timing indicator (A).
2. Remove pulley (B) from damper.

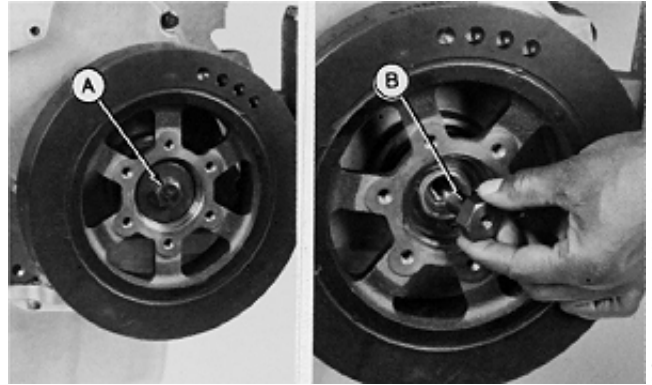


RG,CTM82,G15,11-19-04JUN93

RG6750
-UN-30APR93

IMPORTANT: DO NOT use a jaw-type puller to remove vibration damper. Damage could result to the damper. Never apply thrust on outer ring of damper. Do not drop or hammer on damper.

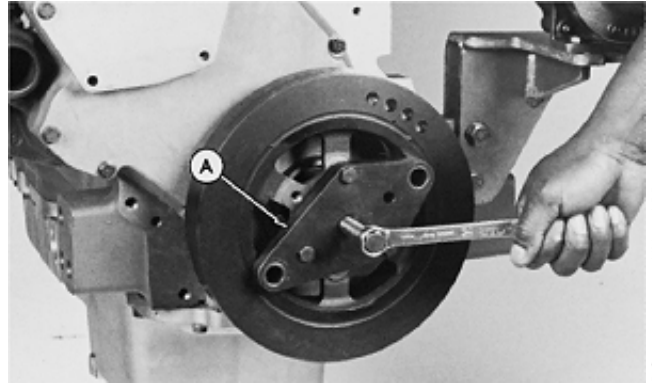
3. Remove cap screw (A) and washer.
4. Install JDG787 Thread Protector (B).



RG,CTM82,G15,4 -19-03MAY93

RG6751
-UN-30APR93

5. Remove damper using JDG721 Hub Puller (A).



RG,CTM82,G15,20-19-03MAY93

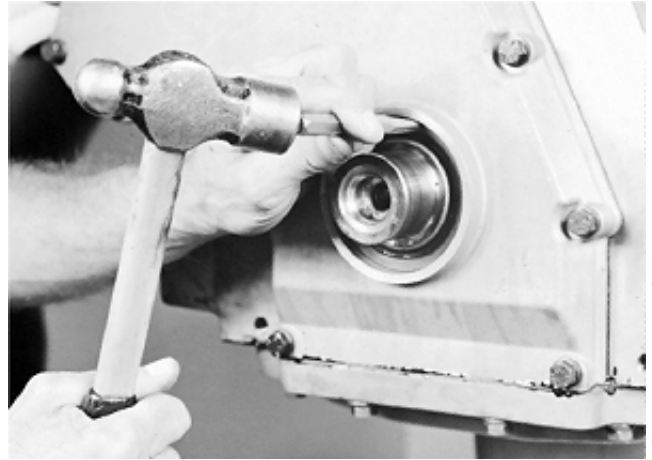
RG6752
-UN-30APR93

REMOVE CRANKSHAFT FRONT OIL SEAL (WITH TIMING GEAR COVER INSTALLED ON ENGINE)

IMPORTANT: Whenever front oil seal is replaced, the wear sleeve must also be replaced.

NOTE: If timing gear cover is going to be removed from engine, remove front seal after timing gear cover is removed.

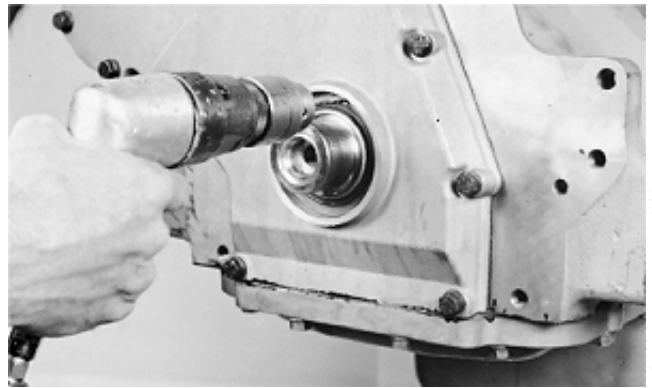
1. Check oil seal and wear sleeve for wear, damage, or leakage.
2. Center punch seal casing at 12 O'clock position.



RG6471
-UN-26OCT92

RG,CTM42,G15,38-19-03MAY93

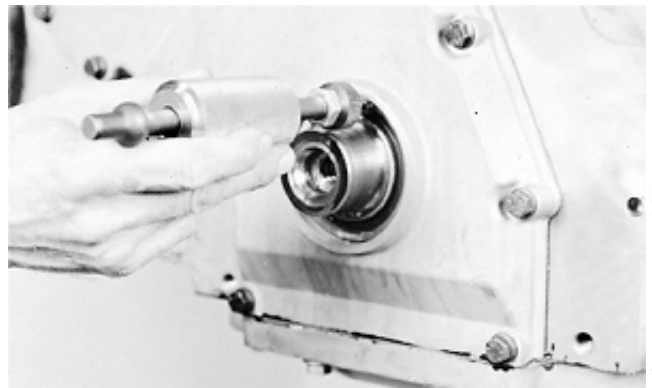
3. Drill 1/8 in. hole in casing.



RG6472
-UN-26OCT92

RG,CTM42,G15,39-19-29OCT92

4. Using JDG719 Seal Puller along with JDE38-2 Shank, JDE38-3 Hammer, and metal screw; remove seal.
5. Remove keyway from keyslot of crankshaft.

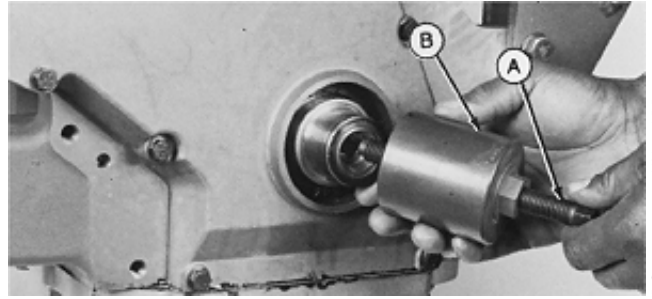


RG6473
-UN-26OCT92

RG,CTM42,G15,40-19-29OCT92

• **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 until it bottoms.
3. Tighten puller until it is securely threaded onto wear sleeve.
4. Remove centering screw from nose of crankshaft and puller.



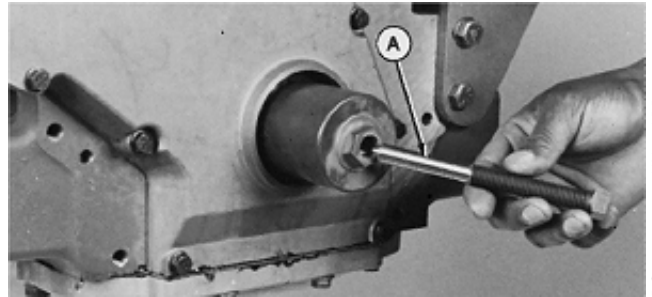
-UN-30APR93
RG6753



-UN-30APR93
RG6754

RG,CTM82,G15,18-19-03MAY93

5. Install partially threaded forcing screw (A) into puller and tighten until it bottoms in nose of crankshaft. There is no thread engagement in crankshaft; just with puller.
6. Continue to tighten forcing screw until puller and wear sleeve are free from crankshaft flange.
7. Inspect crankshaft flange for nicks or burrs.
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.).



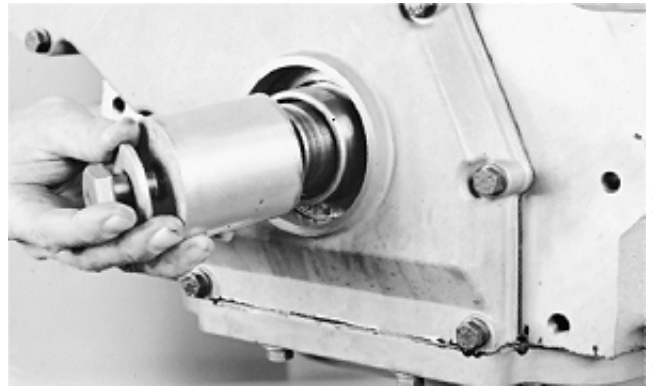
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RG,CTM82,G15,19-19-03MAY93

INSTALL CRANKSHAFT FRONT WEAR SLEEVE

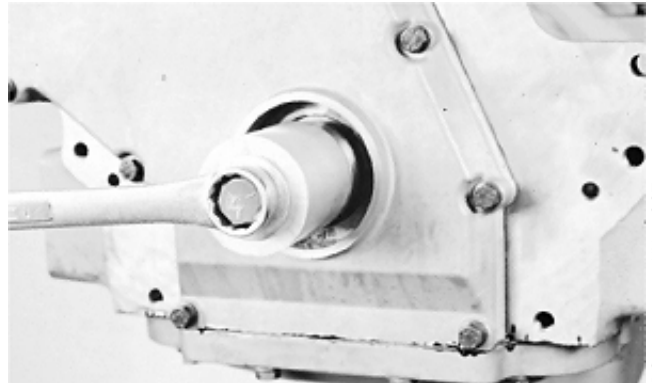
NOTE: Wear sleeve can also be installed with timing gear cover removed, but seal must be installed with timing gear cover installed.

1. Coat ID of new wear sleeve with LOCTITE 609 Retaining Compound.
2. Using JDG467 Driver from JDE3 Installer along with washer and 5/8-11 UNC x 3 in. cap screw that secures damper pulley assembly to crankshaft. Tighten cap screw until driver bottoms.
3. Remove installation tools and clean any sealant from OD of wear sleeve or ID of seal bore.



-JUN-26OCT92

RG6476



-JUN-26OCT92

RG6477

RG,CTM42,G15,42-19-11JUN93

INSTALL CRANKSHAFT FRONT OIL SEAL (WITH TIMING GEAR COVER INSTALLED ON ENGINE)

IMPORTANT: Whenever front oil seal is replaced, the wear sleeve MUST be replaced also.

1. Place JDG720-2 Seal Protector (A) on nose of crankshaft. Lubricate ID of front oil seal lips with clean engine oil. Slide seal with spring side of seal facing engine onto seal protector. Be careful not to roll oil seal lips.
2. Place JDG720-3 Seal Installer onto seal protector against seal. Do not use spacer ring provided with tool set.
3. With nut and washer installed onto JDG720-1 Forcing Screw, thread forcing screw into nose of crankshaft until it bottoms.
4. Tighten nut against crossplate of installer until installer bottoms onto front face of timing gear cover.
5. Remove installation tools. Verify seal is installed square in bore and that seal lips are not rolled on wear sleeve.

Oil seal should be 8.4 mm (0.33 in.) below front lip of seal bore.



RG6479 -JUN-26OCT92

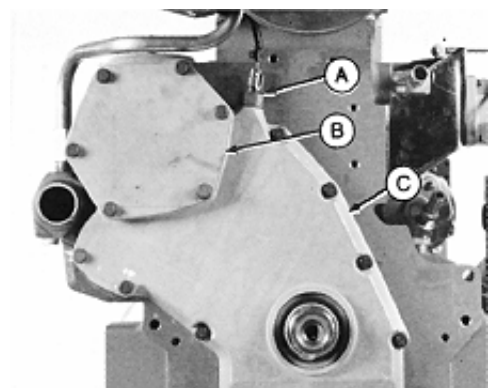


RG6480 -JUN-26OCT92

RG,CTM42,G15,43-19-03MAY93

REMOVE TIMING GEAR COVER

1. Remove magnetic pick-up (A, if equipped) and access cover (B). Discard gasket.
2. Remove oil pan.
3. Remove oil pump if crankshaft is to be removed.
4. Remove timing gear cover (C). Discard gasket.
5. Remove oil seal from cover and discard.



RG6537 -JUN-14DEC92

RG,CTM82,G15,5 -19-03MAY93

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

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CHECK FLYWHEEL HOUSING FACE RUNOUT

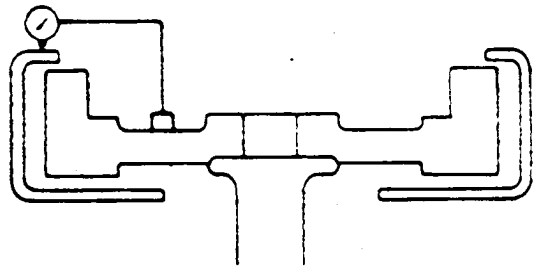
1. Mount dial indicator on flywheel. Set pointer to contact PTO mounting surface on flywheel housing at right angles. Pointer should not contact holes in flywheel housing.

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.)

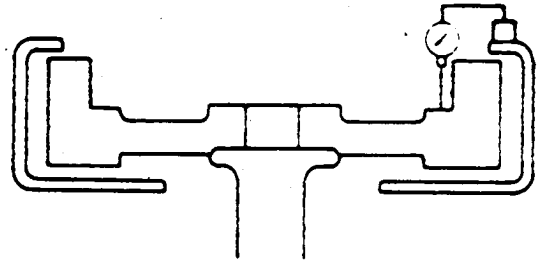


R22212 -UN-14DEC88

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

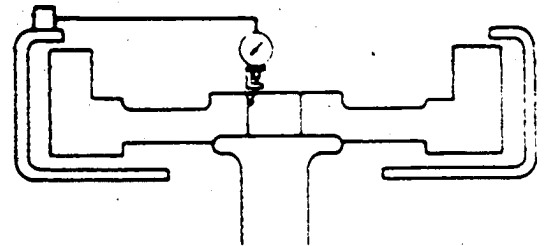
Maximum Variation 0.23 mm (0.009 in.)
Maximum Variation per 25 mm
(1.0 in.) of Travel 0.013 mm (0.0005 in.)

S11,5005,AM -19-29OCT92

R22213 -UN-14DEC88

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.)

S55,2015,M -19-29OCT92

R22214 -UN-14DEC88

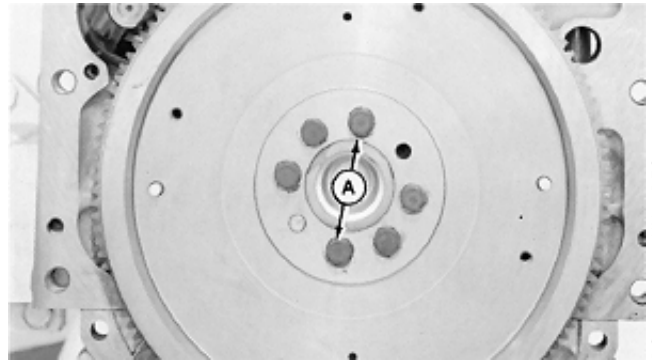
REMOVE FLYWHEEL

IMPORTANT: If equipped with electronic governor, remove speed pickup from flywheel housing before removing flywheel.

NOTE: SAE 1 and SAE 2 flywheel housings **MUST BE** removed before flywheel can be removed from engine. See **REMOVE SAE 1 AND SAE 2 FLYWHEEL HOUSING**, later in this group.

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

1. Remove two flywheel attaching cap screws (A), and install two pilot studs in their place.
2. Remove remaining cap screws and carefully pull flywheel from crankshaft.



RG3836
-UN-14DEC88

RG.CTM82.G15.12-19-03MAY93

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REMOVE SAE 1 AND SAE 2 FLYWHEEL HOUSING

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

IMPORTANT: If equipped with electronic governor, remove speed pickup before removing housing.

1. Remove attaching cap screws.
2. Remove flywheel housing.
3. Inspect mounting holes in flywheel housing for thread damage.

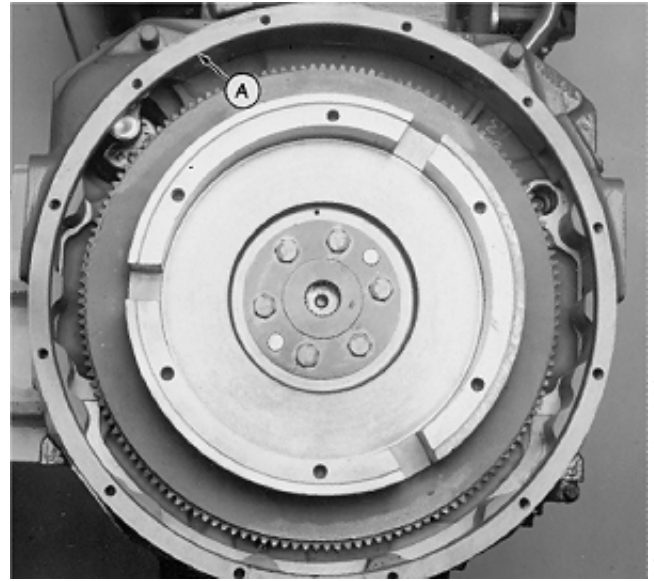
RG.CTM82.G15.13-19-03MAY93

REMOVE SAE 3 FLYWHEEL HOUSING

NOTE: The flywheel **MUST** be removed before removing the SAE 3 flywheel housing. See **REMOVE FLYWHEEL** earlier in this group.

CAUTION: Flywheel housing (A) is heavy. Plan a proper lifting procedure to avoid personal injury.

1. Remove flywheel housing attaching cap screws.
2. Remove flywheel housing.
3. Inspect mounting holes in flywheel housing for thread damage.



RG5005
-UN-14DEC88

S11.2015.GO -19-29OCT92

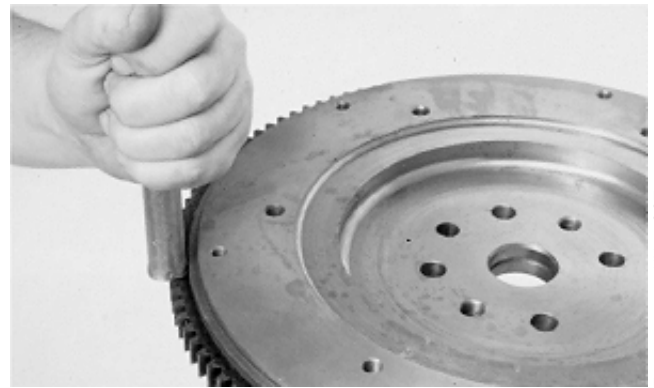
REPLACE FLYWHEEL RING GEAR

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.

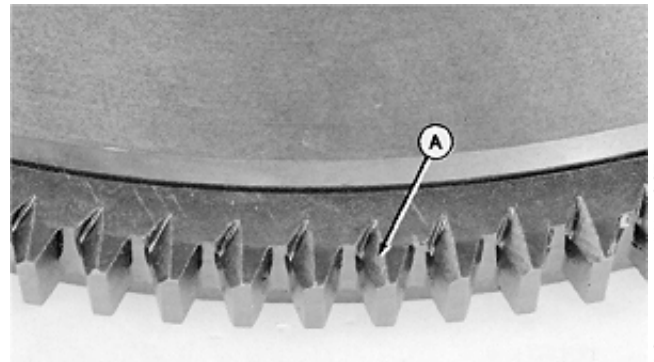
1. If ring gear is damaged, place the flywheel on a solid flat surface.
2. Remove ring gear with a brass drift and hammer.

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

S11.2015,FX -19-16SEP92

REMOVE REAR OIL SEAL HOUSING AND WEAR SLEEVE (WITH ENGINE DISASSEMBLED)

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 (WITH OIL SEAL HOUSING INSTALLED), 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 rear wear sleeve. The 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.



RG3839 -UN-14DEC88

RG,CTM42,G15,14-19-29OCT92

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.

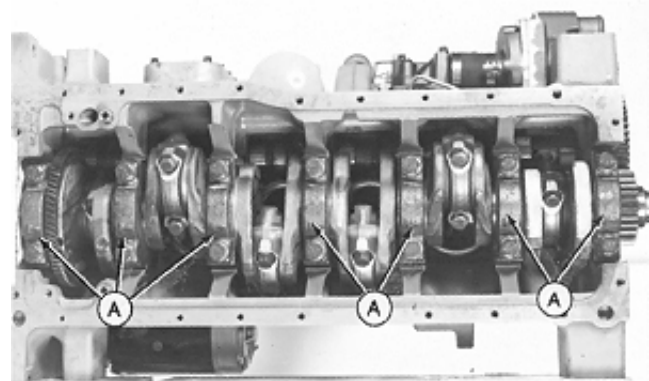
RG,CTM42,G15,54-19-02APR93

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REMOVE CRANKSHAFT MAIN BEARINGS

IMPORTANT: Before removing main bearing caps (A), check for proper torque on all main bearings. Also, check each bearing cap to make sure they are numbered for reassembly on the same numbered main bearing bosses. Keep matched bearing inserts with their respective main bearing cap for comparison with crankshaft journal (surface) from which removed.

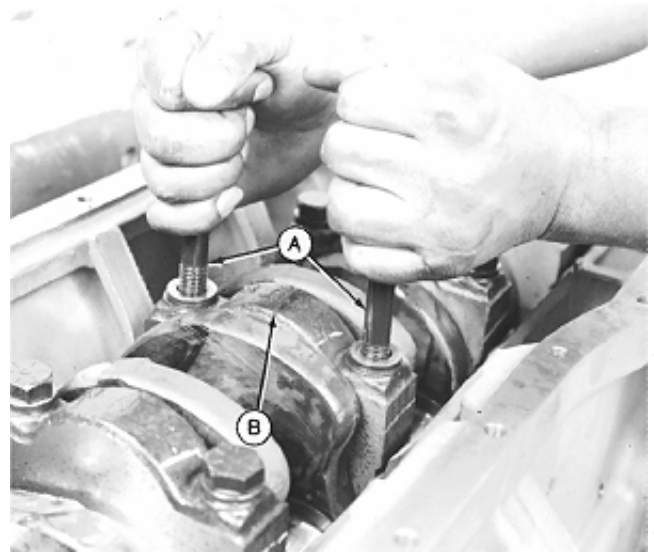
NOTE: When removing main bearings and caps, leave No. 1 and 7 main bearing caps installed until all of the connecting rod caps have been removed.



-UN-12AUG91
RG5832

RG,CTM42,G15,16-19-29OCT92

1. Loosen main bearing cap screws and washers.
2. 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.
3. Use PLASTIGAGE to measure oil clearance on each main bearing as they are removed. See CHECK MAIN BEARING CLEARANCE later in this group.



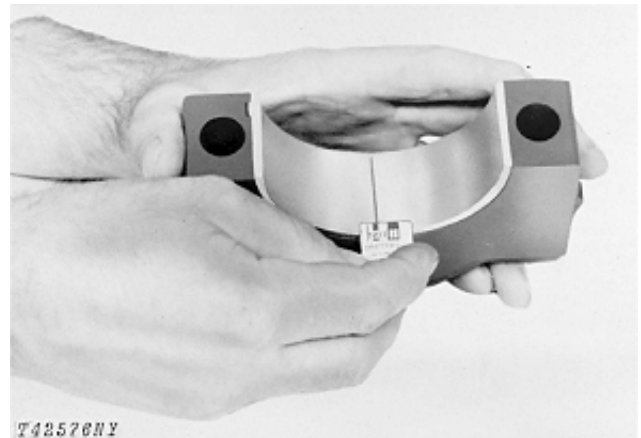
-UN-12AUG91
RG5833

RG,CTM42,G15,17-19-29OCT92

CHECK MAIN BEARING CLEARANCE

The use of PLASTIGAGE will determine wear but will not determine condition of the bearing or journal surfaces.

1. Put a strip of PLASTIGAGE in the center of the main bearing cap (with insert) about three-fourths of the width of the bearing.
2. Use oil (SAE30) on PLASTIGAGE to prevent smearing.
3. Install cap and tighten to 203 N-m (150 lb-ft).
4. Remove cap and compare width of PLASTIGAGE with scale provided on wrapper to determine oil clearance.



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T42576NY

MAIN BEARING CLEARANCE SPECIFICATIONS

Main Bearing-to-Journal Clearance	0.030—0.108 mm (0.0012—0.0042 in.)
Wear Limit	0.152 mm (0.0060 in.)

S11,0403.Z -19-03MAY93

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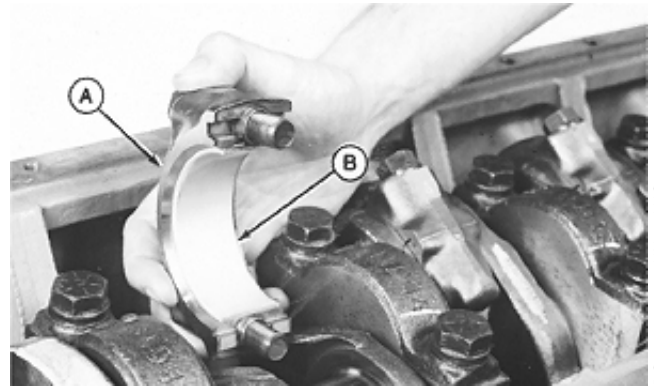
REMOVE CRANKSHAFT

1. Rotate crankshaft using 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 (A) with bearings (B), then remove No. 1 and 7 main bearing caps and bearings. See REMOVE PISTONS AND CONNECTING RODS in Group 10.

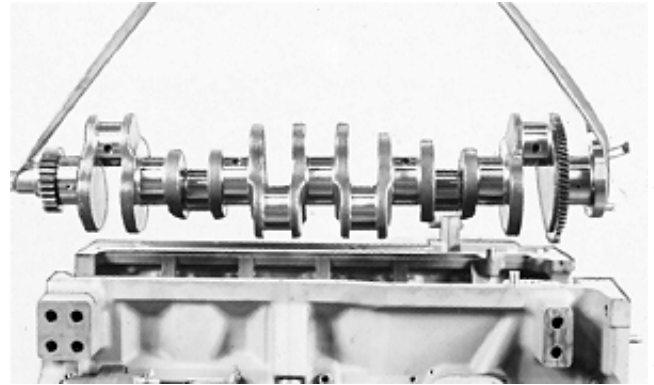
⚠ CAUTION: Crankshaft is very heavy. Plan a proper handling procedure to avoid injury.

NOTE: Install a screw on each end of crankshaft to aid in lifting crankshaft.

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.



RG5806
-JUN-12AUG91

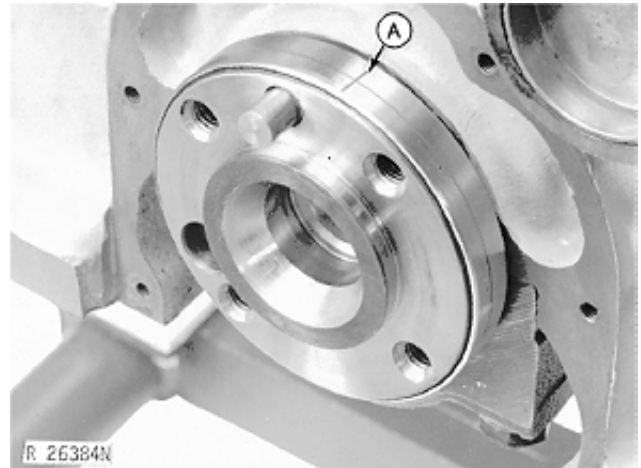


RG5834
-JUN-12AUG91

RG,CTM42,G15,18-19-29OCT92

If wear sleeve has not been removed from crankshaft, the following procedures may be used. However, removing wear sleeve using JDG790 Wear Sleeve Puller Kit while crankshaft is installed in engine is the preferred method.

- Use JDG790 Wear Sleeve Puller to remove wear sleeve from crankshaft, as described earlier in this group. Position crankshaft rod journals in V-blocks so that crankshaft does not rotate while removing wear sleeve.
- Use the ball side of a ballpeen hammer and tap wear sleeve across its width in a straight line (to deform and stretch sleeve).
- Score (A), but do not cut, the wear sleeve in several places around OD with a blunt chisel.



RG.CTM42.G15.55-19-06NOV92

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REMOVE AND INSPECT 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.

*Part of D01047AA 17-1/2 and 30-Ton Puller Set.

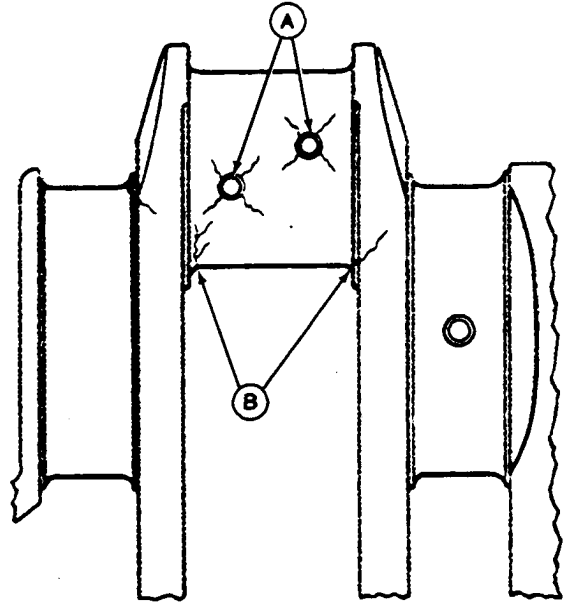
S11,0403,Q -19-03MAY93

INSPECT CRANKSHAFT

NOTE: If the crankshaft damper damage was discovered during teardown, it is recommended that the crankshaft be magna-fluxed. This will verify whether or not it has microscopic cracks or fissures. (See INSPECT VIBRATION DAMPER, earlier in this group.)

1. Thoroughly clean crankshaft. Clear restrictions from all oil passages.
2. Inspect crankshaft for signs of load stress, cracks, or scratches on journals. Also check each journal for evidence of excessive overheating or discoloration. If either condition exists, replace crankshaft since heat treatment has probably been destroyed.
3. Inspect crankshaft gear and oil pump drive gear for cracks, chipped teeth, or excess wear. Replace gear as required. (See REPLACE CRANKSHAFT OIL PUMP DRIVE GEAR, later in this group.)
4. Inspect the keyway for evidence of cracks or wear. Replace crankshaft as necessary.
5. Carefully inspect the rear hub of the crankshaft in the area of the wear sleeve contact surface for evidence of a rough or grooved condition. Any imperfections in this area will result in oil leakage. Slight ridges may be cleaned up with emery cloth and crocus cloth.
6. Check each journal for evidence of excessive overheating or discoloration. If either condition exists, replace crankshaft since heat treatment has probably been destroyed.
7. Carefully check the crankshaft for cracks in the area of rod journal oil holes (A) and at journal fillets (B). Replace crankshaft if any cracks are found.

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



RG5093 -UN-15DEC88

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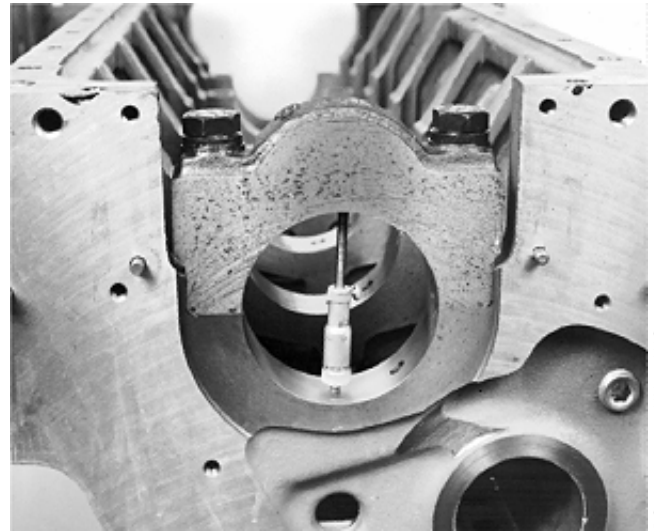
MEASURE ASSEMBLED ID OF BEARINGS AND OD OF CRANKSHAFT JOURNALS

1. With crankshaft removed from engine, install main bearing inserts and caps (be sure inserts are installed correctly).
2. Tighten main bearing cap screws to 203 N-m (150 lb-ft).
3. Measure I.D. of all bearings with an inside micrometer.

MAIN BEARING ID SPECIFICATIONS

With Bearing	85.70—85.76 mm (3.3742—3.3762 in.)
Without Bearing	92.125—92.151 mm (3.627—3.628 in.)

NOTE: Inspect and measure assembled ID of connecting rod bearings. Compare measurements with connecting rod journal OD on crankshaft. (See Group 10.)



RG5835 -JUN-12AUG91

RG,CTM42,G15,34-19-29OCT92

4. Measure OD of all respective crankshaft journals at several points around journal.

CRANKSHAFT SPECIFICATIONS

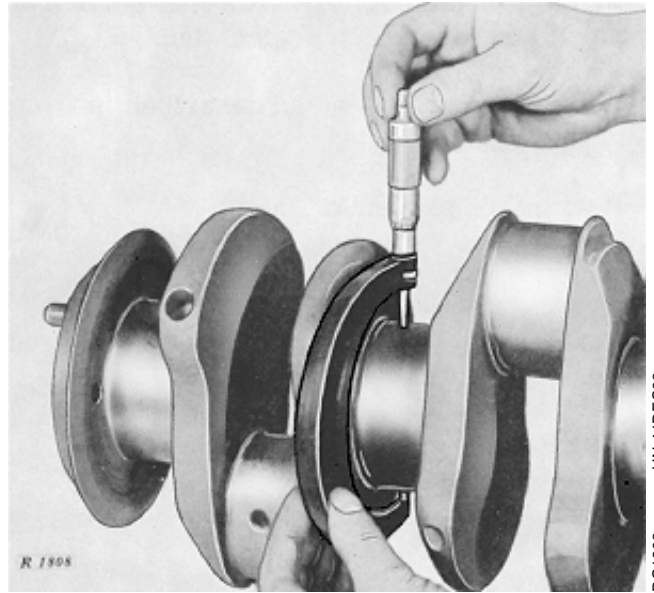
OD of Main Bearing Journal	85.65—85.67 mm (3.372—3.373 in.)
Crankshaft-to-Main Bearing Oil Clearance	0.030—0.108 mm 0.0012—0.0042 in.)
Wear Limit	0.152 mm (0.0060 in.)

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.

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.) Length	0.0025 mm (0.0001 in.)
Journal Out-of-Roundness	0.025 mm (0.0010 in.)



S11,0403,AD -19-03MAY93

MAIN BEARING CAP LINE BORE SPECIFICATIONS

1. With crankshaft removed from cylinder block, install main bearing caps without bearing inserts.
2. Tighten main bearing cap screws to 203 N-m (150 lb-ft).
3. Measure ID of all bearing caps with an inside micrometer.

If any main bearing cap assembled ID is not within specification, blank (generic) bearing caps are available and must be line bored to specification. Replace individual bearing caps as needed.

IMPORTANT: Main bearing cap line boring should be done ONLY by experienced personnel on equipment capable of maintaining bore specifications.

MAIN BEARING CAP BORE SPECIFICATIONS

ID Without Bearings (Std.)	92.125—92.151 mm (3.627—3.628 in.)
Max. Bore Diameter Variation	0.013 mm (0.0005 in.)
Max. Bore Diameter Taper	0.008 mm (0.0003 in.)
Max. Straightness Variation (Any Bore-to-Adjacent Bore)	0.038 mm (0.0015 in.)
Max. Straightness Variation (5 Center Bores-to-End Bores)	0.08 mm (0.003 in.)
Centerline of Bore-to-Top Deck	352.35—352.50 mm (13.872—13.878 in.)

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S11,2515,BY -19-03MAY93

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.

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 counterclockwise, as viewed from the front end of crankshaft. Lap or polish journals in opposite direction of grinding.

5. Polish or lap the ground surfaces to the specified finish to prevent excessive wear of the journals.

NOTE: Production crankshafts are induction hardened and shotpeened at the factory. Field shotpeening is not recommended due to the equipment required and part geometry.

6. If the thrust surfaces of the crankshaft are worn or grooved excessively, regrind and polish. Maintain the specified radius between each thrust surface and the bearing journal. An oversize thrust washer set containing one standard washer and two 0.18 mm (0.007 in.) oversize washers is available. (See THRUST BEARING NEW PART SPECIFICATIONS, later in this group.)

NOTE: When thrust surfaces are reground and an oversize washer is used, crankshaft end play specification must be maintained to within 0.038—0.380 mm (0.0015—0.0150 in.) (See CHECK CRANKSHAFT END PLAY, earlier in this group.)

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.

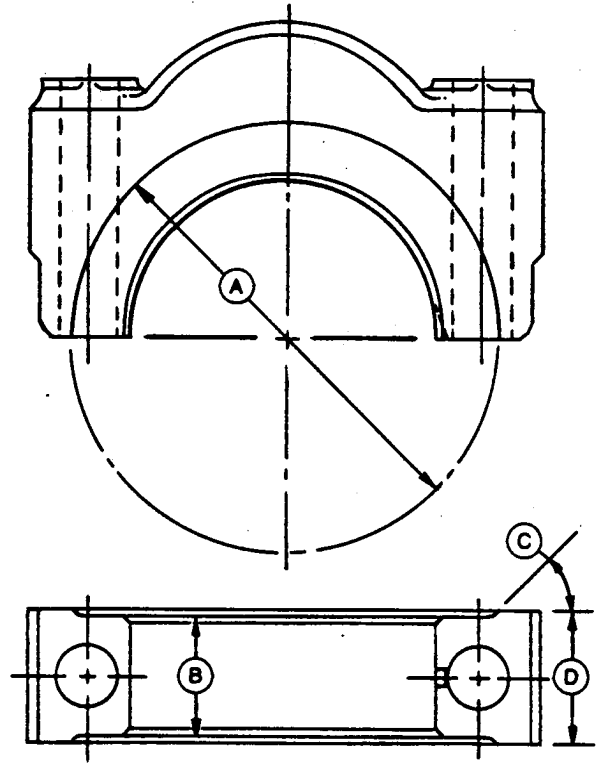
THRUST BEARING NEW PART SPECIFICATIONS

IMPORTANT: Install thrust bearing in cylinder block and tighten to specification before regrinding 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	123.70—125.30 Dia. (4.87—4.93 in.)
B—Thrust Surface Thickness	
	37.44—37.54 mm (1.474—1.478 in.)
C—Relief Angle	
	45°
D—Bearing Overall Width	
	39.16—39.66 mm (1.542—1.561 in.)

Maximum runout for thrust surface is 0.025 mm (0.0010 in.).



S55,2015,P -19-29OCT92

RG5269 -JN-14DEC88

CRANKSHAFT GRINDING SPECIFICATIONS

Item	Specification
Engine Stroke	121 mm (4.75 in.)
Main and Rod Journal Surface Finish	Lap 0.20 Um (8 AA)
Thrust Journal Surface Finish	Lap 0.40 Um (16AA)
Rod Journal Fillet Radius	3.94—4.44 mm (0.155—0.175 in.)
Main Journal Fillet Radius	3.94—4.44 mm (0.155—0.175 in.)
Thrust Journal Fillet Radius	3.56—4.06 mm (0.140—0.160 in.)
Thrust Journal Width	44.387—44.487 mm (1.7475—1.7515 in.)

Bearing Size	Crankshaft Main Journal OD	Crankshaft Rod Journal OD
Standard	85.65—85.67 mm (3.3720—3.3730 in.)	76.15—76.18 mm (2.9980—2.9990 in.)
0.05 mm (0.002 in.) Undersize	85.60—85.62 mm (3.3700—3.3710 in.)	76.10—76.13 mm (2.9960—2.9970 in.)
0.25 mm (0.010 in.) Undersize	85.40—85.42 mm (3.3620—3.3630 in.)	75.90—75.93 mm (2.9880—2.9890 in.)
0.51 mm (0.020 in.) Undersize	85.14—85.16 mm (3.3520—3.3530 in.)	75.64—75.67 mm (2.9780—2.9790 in.)
0.76 mm (0.030 in.) Undersize	84.89—84.91 mm (3.3420—3.3430 in.)	75.39—75.42 mm (2.9680—2.9690 in.)

S11,2015,HG -19-29OCT92

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REPLACE CRANKSHAFT OIL PUMP DRIVE GEAR

IMPORTANT: Protect all machined surfaces of crankshaft from grinding debris and weld spatter when removing old gear and installing new gear. **DO NOT** use a cutting torch to remove failed gear.

1. Using a rotary grinding wheel or parting 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.

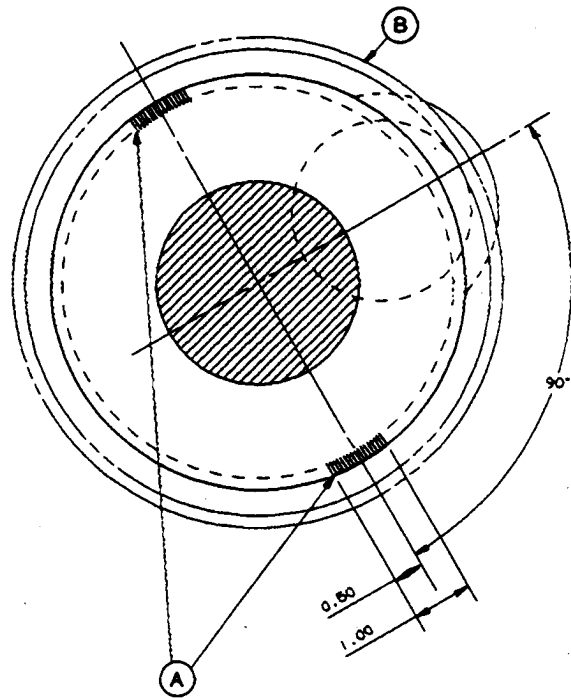
4. Heat new gear to 148°C (300°F) using either heated oil or oven heat.

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

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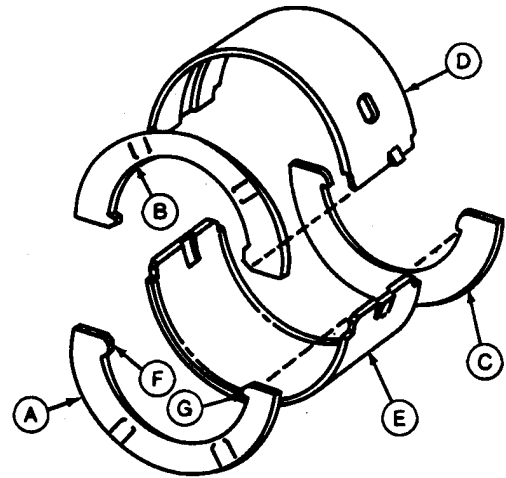
INSPECT THRUST BEARINGS

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

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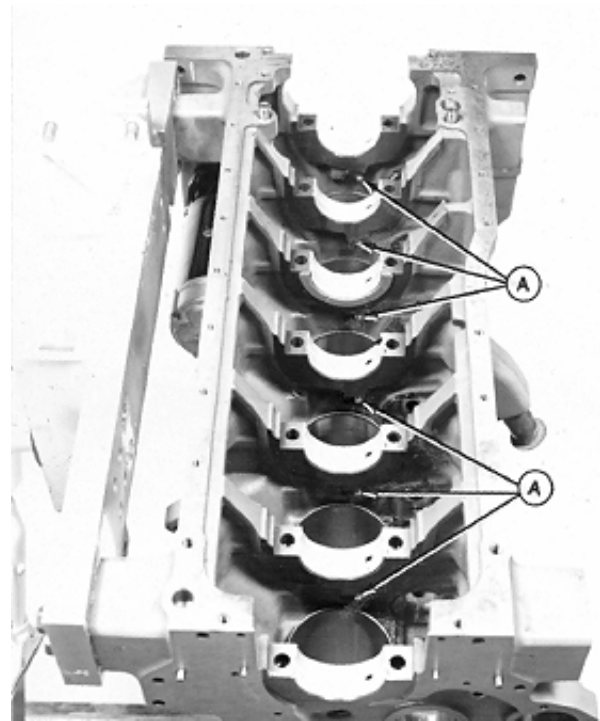
REMOVE AND CLEAN PISTON COOLING ORIFICES

1. Remove all six 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) (96 lb-in.).



UN-12AUG91
RG5811

RG,CTM42,G15,20-19-29OCT92

INSTALL CRANKSHAFT MAIN BEARINGS

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

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

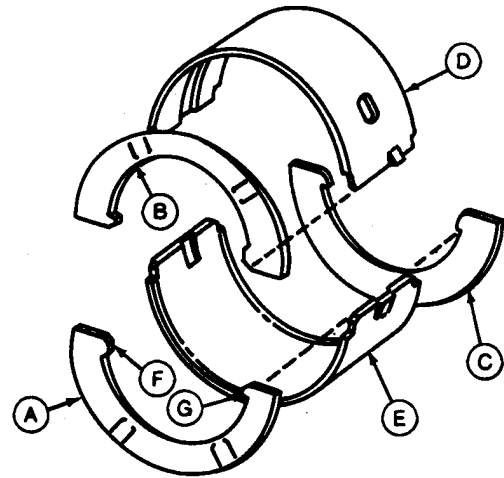
- All main bearing webs in block
- Both sides of main bearing inserts, thrust bearing inserts, and thrust washers
- Entire OD of crankshaft main bearing journal

1. Install six main bearing inserts in block except No. 5 thrust bearing insert. Be sure locating tabs on inserts are properly positioned with slot in block web.

IMPORTANT: Thrust washers (A,C) go on both sides of bearing cap and thrust washer (B) on rear side of block web only with the slots facing the crankshaft.

2. Install No. 5 main thrust bearing insert (D) in block. Install upper thrust washer on bearing insert at rear of block web. Be sure tangs on washer are properly positioned on thrust bearing insert.

3. Check to make sure that oil holes in main bearing web are properly aligned with oil holes in bearing inserts.



No. 5 Main Thrust Bearing Assembly

- A—Lower Rear Thrust Washer
- B—Upper Rear Thrust Washer
- C—Lower Front Thrust Washer
- D—Main Bearing Block Thrust Bearing
- E—Main Bearing Cap Thrust Bearing
- F—Large Tang
- G—Small Tang


RG,CTM42,G15,21-19-03MAY93

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INSTALL CRANKSHAFT GEAR

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.

1. 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.

2. Install Woodruff key in crankshaft.

3. Place gear on crankshaft flange. Be sure key on crankshaft is properly aligned with keyway in gear.

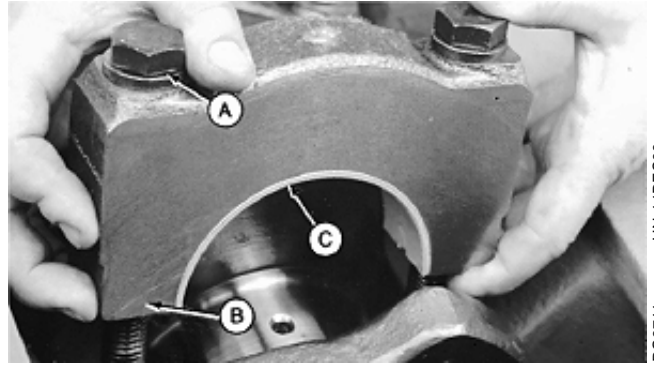
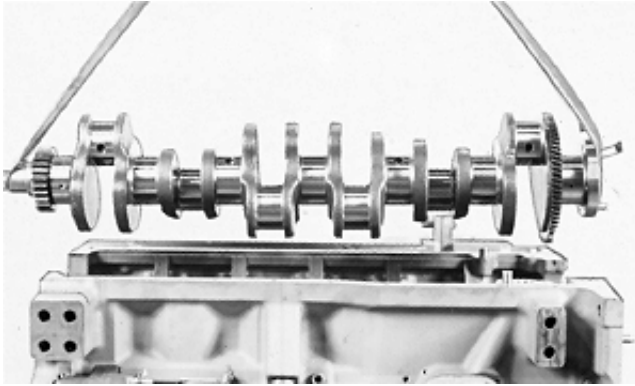
IMPORTANT: When installing gear, do not gouge or nick crankshaft flange.

4. Use JDH7 Driver to firmly seat gear against crankshaft flange.

5. Once gear cools, reseal gear using JDH7 Driver.

S11,0403,AQ -19-03MAY93

INSTALL CRANKSHAFT



CAUTION: Crankshaft is heavy. Plan a proper lifting procedure to avoid injuries.

- Carefully position crankshaft onto main bearing inserts using a hoist and lift sling.
- 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.
- 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 be on the camshaft side of the block pointing towards the front of the engine. If bearing caps have been rebored, make sure bearing caps have numbers stamped on them.

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

- Before tightening cap screws on main bearing caps, align upper and lower thrust flanges on main thrust bearings. Using a soft-face hammer, tap crankshaft to the rear and then to the front to line up thrust bearing flanges.

- Tighten No.'s 1, 2, 3, 4, 6 and 7 main bearing cap screws to 68 N·m (50 lb-ft). Hand-tighten No. 5 main thrust bearing cap screws.

- Gently pry crankshaft rearward and then forward to align thrust washers on No. 5 main thrust bearing.

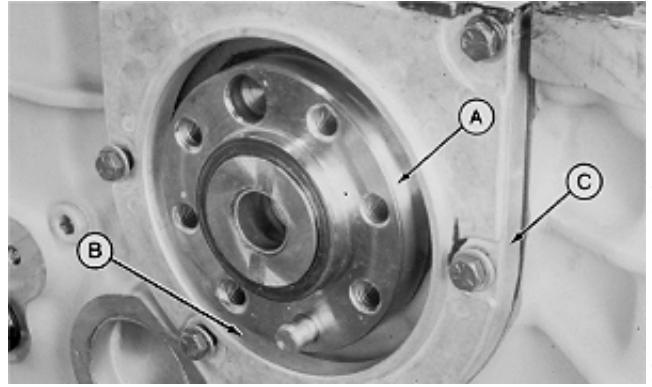
NOTE: DO NOT PRY crankshaft on No. 5 main thrust bearing.

- Tighten No. 5 main thrust bearing cap screws to 68 N·m (50 lb-ft).
- Tighten all main bearing cap screws (including No. 5) to 203 N·m (150 lb-ft).
- Turn crankshaft by hand. If it does not turn easily, disassemble parts and determine the cause.
- Install connecting rod bearings and connecting rods caps. See **INSTALL PISTONS AND CONNECTING RODS** in Group 10.
- Check crankshaft for 0.038—0.380 mm (0.0015—0.0150 in.) end play.
- Install oil pump and check drive gear-to-crankshaft clearance. See **INSTALL ENGINE OIL PUMP** in Group 20.

INSTALL CRANKSHAFT REAR OIL SEAL HOUSING

These instructions are for when oil seal housing and oil pan have been removed from cylinder block.

1. Make sure the OD of crankshaft flange (A) and ID of seal housing (B) are free from nicks or burrs. Restore damage surfaces with a fine file or emery cloth. Clean with compressed air.
2. Install oil seal housing (C) on cylinder block using a new gasket. Install all six cap screws with washers, and tighten finger tight.



RG4637 -JUN-14DEC88

RG,CTM42,G15,24-19-29OCT92

IMPORTANT: Installation tools must be clean to assure proper positioning on crankshaft flange and to hold runout within specification so oil seal does not fail prematurely.

3. Slip the JDG796 Alignment Tool over crankshaft flange and into seal housing bore to center oil seal housing.

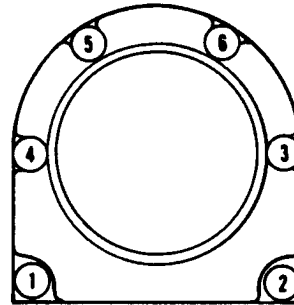
The driver is designed to center the oil seal housing in relation to crankshaft flange. However, the use of a magnetic base dial indicator is still recommended to measure the seal housing runout. Runout should not exceed 0.15 mm (0.006 in.).

4. Position bottom of oil seal housing flush with cylinder block-to-oil pan mating surface. Tighten seal housing cap screws to 27 N-m (20 lb-ft), using sequence shown in bottom illustration, beginning with cap screw No. 1.

5. Remove driver from end of crankshaft flange.

6. Check oil seal housing runout with a magnetic base dial indicator. (See CHECK OIL SEAL HOUSING RUNOUT, later in this group.)

7. Trim off excess gasket material extending below bottom of oil seal housing.



RG6427 -JUN-13OCT92

RG6427

RG,CTM82,G15,14-19-04JUN93

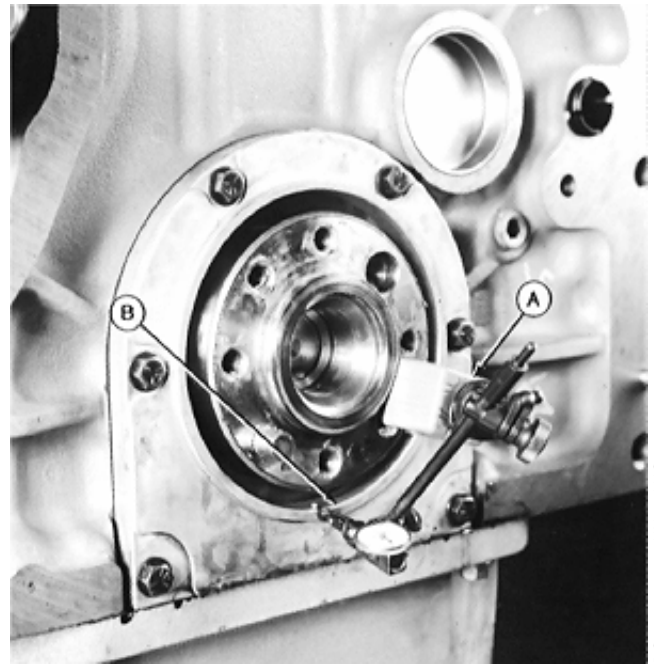
CHECK OIL SEAL HOUSING RUNOUT

IMPORTANT: On service “shortblock” assemblies, rear oil seal housing runout is preset at the factory. Do not remove housing from block.

1. Position magnetic base dial indicator (A) on end of crankshaft flange as shown. Preset dial indicator tip on ID of oil seal housing bore (B).
2. Zero dial indicator and rotate crankshaft one full revolution, observe full indicator movement. The maximum oil seal housing bore runout is 0.15 mm (0.006 in.).

If runout exceeds specification, loosen cap screws and adjust housing to obtain an acceptable runout while keeping bottom of seal housing flush with oil pan mating surface.

3. Recheck oil seal housing bore runout. If runout still exceeds specification, oil seal housing bore is possibly distorted and should be replaced. See INSTALL CRANKSHAFT REAR OIL SEAL HOUSING, earlier in this group.



RG5751 -UN-05AUG91

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S11,2515,AK -19-29OCT92

CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE HANDLING PRECAUTIONS

Use the following precautions for handling seal and wear sleeve:

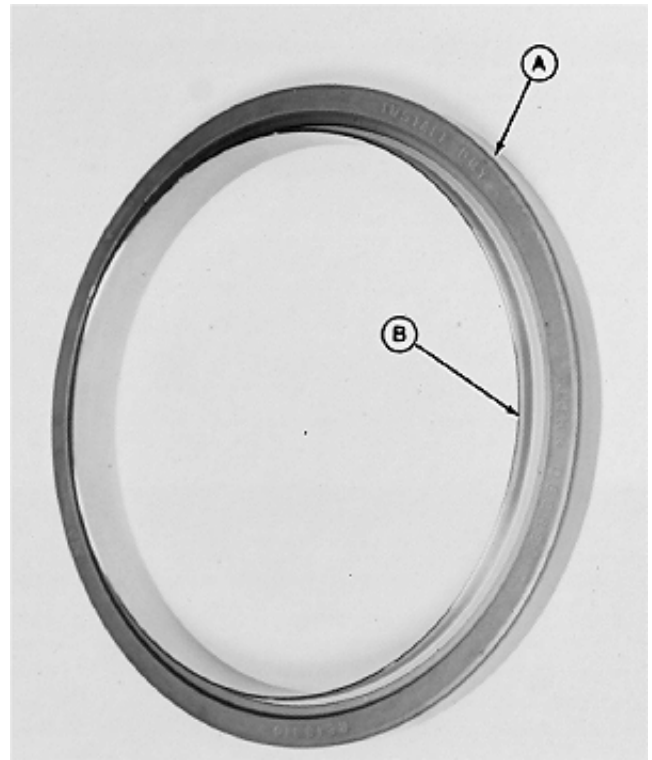
—Seal (A) and wear sleeve (B) are assembled. DO NOT SEPARATE. If parts become separated, discard and replace with a new assembly. Attempts to reassemble will cause the wear sleeve to damage the seal allowing engine oil to leak past seal.

—Always install seal and wear sleeve assembly immediately after removal from plastic bag to avoid possible dirt contamination.

—No lubrication of any kind is to contact seal when installing. Use of a lubricant may result in premature seal failure.

—Install oil seal/wear sleeve assembly with the open side of seal and wear sleeve ID chamfer toward the engine. If seal is reversed, engine oil may be lost because grooves in oil seal lip would be incorrect with respect to direction of crankshaft rotation.

—Oil seal/wear sleeve assembly MUST be installed with the JDG476(85) Crankshaft Rear Oil Seal Installation Tool Set. Tool set consists of JDG477(85) Pilot and JDG478 Driver.



RG5575 -UN-07-JUL89

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S11,2015,GP -19-29OCT92

INSTALL CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE ASSEMBLY

1. Apply a light coating of LOCTITE 609 Retaining Compound, or equivalent, completely around the leading edge of crankshaft flange. Wipe away any sealant that may have gotten on seal housing bore.

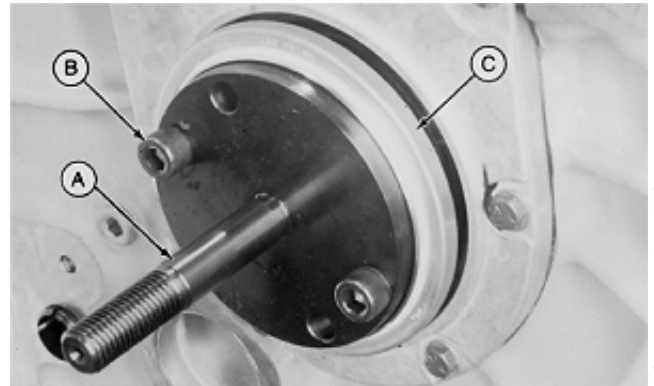
IMPORTANT: DO NOT allow sealant to get on any part of wear sleeve OD or on oil seal.

2. Install JDG477(85) Pilot (A) on end of crankshaft using the Allen head cap screws (B) supplied with tool set. Tighten cap screws securely.

IMPORTANT: Handle seal and wear sleeve assembly carefully. If assembly becomes separated, discard these parts and install a new assembly.

3. Carefully start oil seal/wear sleeve assembly (C) over JDG477(85) Pilot and crankshaft flange with open side of seal toward engine.

IMPORTANT: When installing the JDG478 Driver on JDG477(85) Pilot and crankshaft flange to position oil seal/wear sleeve assembly, locate crossbar of installer at right angle (90°) to Allen head cap screws. This allows the crossbar to bottom on pilot, not head of cap screws, assuring correct installation.



-JUN-14DEC88

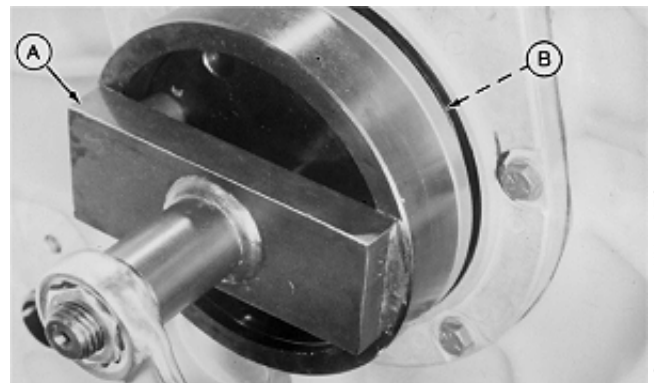
RG4639

RG,CTM42,G15,26-19-29OCT92

4. Position JDG478 Driver (A) so that hole in the cross plate goes over threaded stud of pilot. Install washer and nut on stud.

5. Tighten nut to draw JDG478 Driver in until crossbar bottoms on JDG477(85) Pilot. When the tool bottoms, seal and wear ring assembly (B) will be correctly positioned.

6. Remove JDG476(85) Tool Set from engine.



-JUN-14DEC88

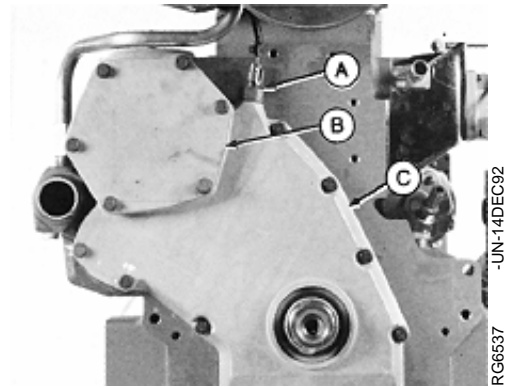
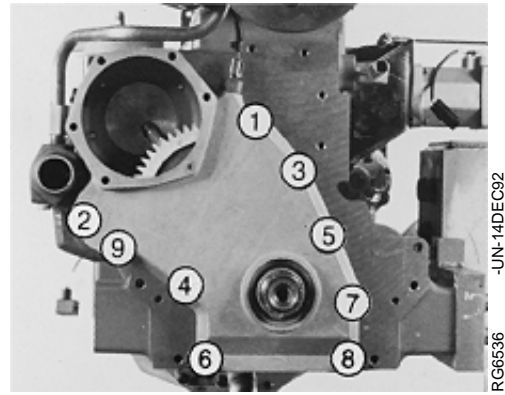
RG4640

RG,CTM42,G15,27-19-11JUN93

INSTALL TIMING GEAR COVER

IMPORTANT: Tightening the timing gear cover cap screws in numerical sequence controls the total runout of the front crankshaft oil seal.

1. Install a new gasket on the engine block. Lightly grease the gasket to hold it in place. Install timing gear cover (C). Tighten cap screws in sequence one through nine (as shown) to 27 N·m (20 lb-ft).
2. Trim timing gear cover gasket flush with oil pan gasket rail.
3. Lightly grease and install a new timing wheel access cover gasket on timing gear cover. Install cover (B). Tighten cap screws to 27 N·m (20 lb-ft).
4. Using a new O-ring, install magnetic pickup (A, if equipped) in timing gear cover and tighten securely.
5. Install crankshaft front wear sleeve and seal. (See **INSTALL CRANKSHAFT FRONT WEAR SLEEVE**, earlier in this group.)



INSTALL SAE 3 FLYWHEEL HOUSING

On SAE 1 and SAE 2 flywheel housings, the flywheel housing is installed AFTER the flywheel.

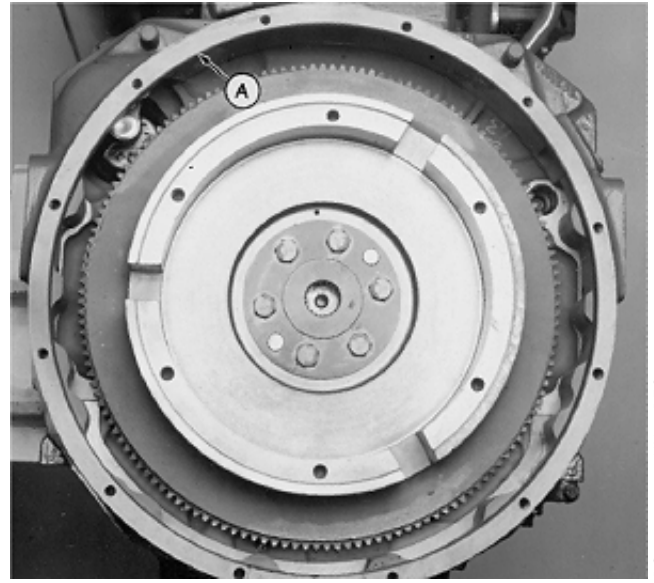
⚠ CAUTION: Flywheel housing (A) is heavy. Plan a proper lifting procedure to avoid personal injury.

1. On engines requiring a gasket between block and flywheel housing, inspect cylinder block and flywheel housing gasket surfaces to see that they are clean. Scrape off all old gasket material. Install a new gasket (without sealant) between block and flywheel housing.
2. Install flywheel housing on cylinder block.

NOTE: Use new cap screws when installing flywheel housing.

3. Dip threads of cap screw in engine oil before installing. Install and tighten cap screws to 407 N-m (300 lb-ft).

NOTE: If equipped, install electronic governor magnetic speed sensor after flywheel is installed.



RG5005 -JUN-14DEC88

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RG,CTM82,G15,15-19-03MAY93

INSTALL FLYWHEEL

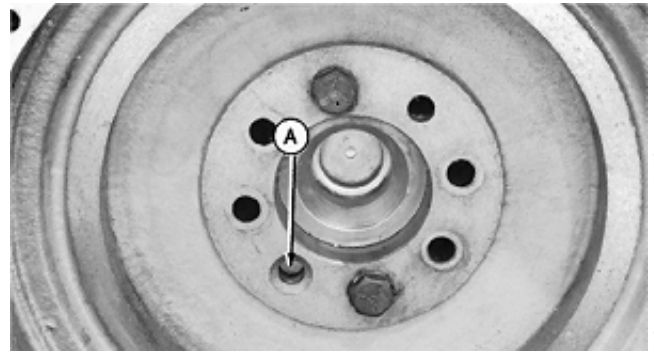
Two guide studs may be used to aid in flywheel installation.

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

NOTE: ALWAYS use new cap screws when installing flywheel. Flywheel must be clean and free of oil before installing.

1. Coat threads of flywheel attaching cap screws with LOCTITE 242 Thread Lock & Sealer.
2. Position flywheel over dowel pin (A) and install drive hub (if equipped). Start four cap screws. Remove guide studs and install remaining cap screws.
3. Install remaining flywheel attaching cap screws.
4. Tighten flywheel attaching cap screws to 115 N·m (85 lb-ft).

NOTE: If equipped, install electronic governor speed sensor in flywheel housing after flywheel and housing are both installed. (See REMOVE AND INSTALL ELECTRONIC GOVERNOR SPEED SENSOR, in Group 40.)



RG4383 -UN-14DEC88

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RG,CTM82,G15,16-19-04JUN93

INSTALL SAE 1 AND SAE 2 FLYWHEEL HOUSING

On SAE 3 flywheel housings, the housing **MUST** be installed **BEFORE** installing flywheel.



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

1. Scrape off all old gasket material. Install a new gasket without sealant between block and flywheel housing, if equipped.
2. Install flywheel housing on cylinder block.

NOTE: ALWAYS use new cap screws when installing flywheel housing.

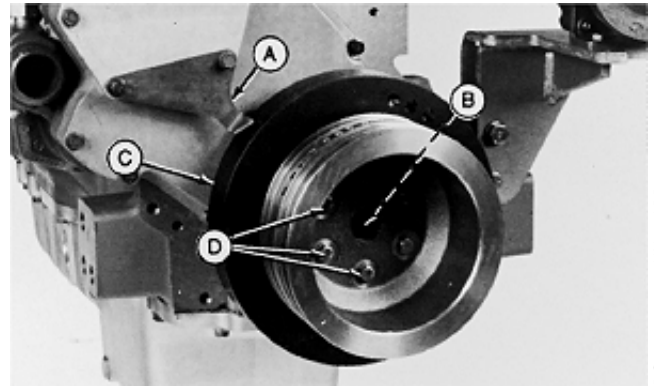
3. Dip threads of cap screw in engine oil before installing. Install and tighten cap screws to 407 N-m (300 lb-ft).
4. If equipped, install electronic governor speed sensor in flywheel housing. (See REMOVE AND INSTALL ELECTRONIC GOVERNOR SPEED SENSOR, in Group 40.)

RG,CTM82,G15,17-19-04JUN93

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INSTALL DAMPER PULLEY ASSEMBLY

1. Make sure crankshaft Woodruff key is in place. Position damper (C) onto crankshaft.
2. Use hardened washer (part of damper assembly) and insert a cap screw that is 25 mm (1 in.) longer than original cap screw (B). Tighten cap screw until it just bottoms out.
3. Remove cap screw and insert original cap screw with same hardened washer.
4. Tighten cap screw to 230 N·m (170 lb-ft).
5. Install pulley. Tighten cap screws (D) to 41 N·m (30 lb-ft).
6. Lock engine at "TDC" of No. 1 cylinder.
7. Install timing indicator (A) so indicator as aligned with 0° mark on damper. Tighten cap screws to 27 N·m (20 lb-ft).



RG6756 -JUN-30APR93

- A—Timing Indicator
B—Vibration Damper Cap Screw
C—Vibration Damper
D—Pulley Cap Screws

RG,CTM82,G15,9 -19-01JUN93

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COMPLETE FINAL ASSEMBLY

1. Install fan assembly.
2. Install oil pan and fill with clean engine oil.
3. Fill cooling system with proper coolant and perform engine break-in. (See PERFORM ENGINE BREAK-IN in Group 05.)

RG,CTM82,G15,10-19-03MAY93

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.

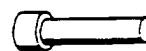


S53,JDE811 -19-07JUL89

Timing Pin JDE81-4

RG5068 -UN-23AUG88

Used to lock flywheel at "TDC" when timing engine and adjusting valves.



S53,JDE814,A -19-09SEP91

Magnetic Follower Holder Kit D15001NU

RG5073 -UN-23AUG88

Hold cam followers when removing or installing camshaft.



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.



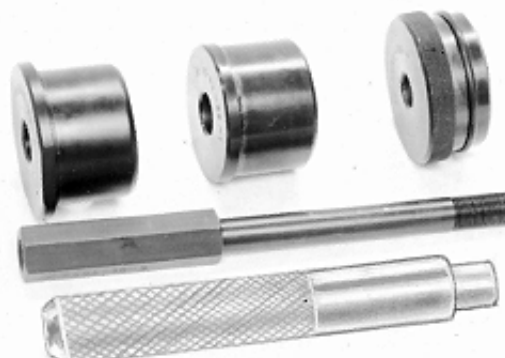
RG78104H1 -UN-15DEC88

S53,D01299,AAA -19-09SEP91

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.



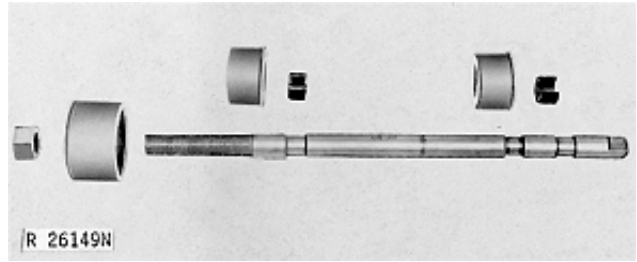
RG4228 -UN-27JAN92

S53,JDG405,A -19-28APR92

Camshaft Bushing 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.

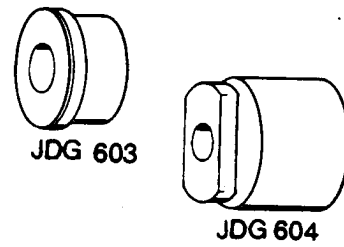


R26149N -UN-23AUG88

S53,JDE6A -19-09SEP91

Camshaft Bushing Adapter Set JDG602

Used with JDE6 Camshaft Bushing Service Set to service camshaft bushings. JDG602 consists of JDG603 Driver and JDG604 Receiver Cup.

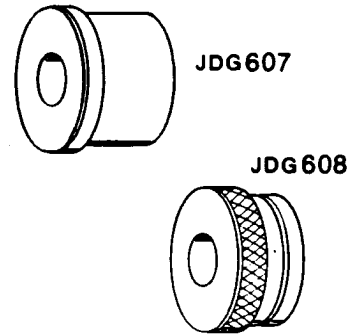


RG5336 -UN-23AUG88

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

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2

OTHER MATERIAL

Name	Use
High Temperature Grease (TY6333 OR TY6347)	Lubricate camshaft lobes and thrust washers before camshaft installation.
FEL-PRO® C-670 Molybdenum Disulfide Paste	Lubricate camshaft nose to provide lubrication to aid in camshaft gear and timing wheel installation.
PERMATEX AVIATION (Form-A-Gasket No.3) (TY6299)	Lubricate camshaft bore steel cap plug.

RG,CTM82,G16.1 -19-04FEB93

CAMSHAFT AND TIMING GEAR TRAIN SPECIFICATIONS

ITEM	SPECIFICATION	WEAR LIMIT
Camshaft End Play	0.0130—0.5000 mm (0.0005—0.0200 in.)	0.65 mm (0.026 in.)
Camshaft Thrust Washer Thickness	2.24—2.34 mm (0.088—0.092 in.)	—
Camshaft Journal OD	66.987—67.013 mm (2.6373—2.6383 in.)	—
Camshaft Bushing ID	67.076—67.102 mm (2.6408—2.6418 in.)	—
Camshaft Bushing-to-Journal Clearance	0.063—0.115 mm (0.0025—0.0045 in.)	0.152 mm (0.0060 in.)
Camshaft Bushing Bore in Block (without bushings)	69.987—70.013 mm (2.7554—2.7564 in.)	—
Maximum Runout of Camshaft Bore	0.038 mm (0.0015 in.)	—
Maximum Runout of Camshaft Gear Thrust Surfaces	0.10 mm (0.004 in.)	—
Camshaft Drive Gear-to-Crankshaft Gear Backlash	0.076 mm (0.0030 in.) minimum	—
Camshaft Lobe Lift:		
Intake	7.61—7.87 mm (0.300—0.310 in.)	7.11 mm (0.280 in.)
Exhaust	8.17—8.43 mm (0.322—0.332 in.)	7.67 mm (0.302 in.)
Cam Follower OD	17.33—17.35 mm (0.682—0.683 in.)	—
Cam Follower Bore ID in Block	17.384—17.440 mm (0.6845—0.6865 in.)	—
Valve Lift at 0.00 mm (in.) Clearance:		
Intake	13.39—13.84 mm (0.527—0.545 in.)	12.50 mm (0.492 in.)
Exhaust	14.38—14.84 mm (0.566—0.584 in.)	13.49 mm (0.531 in.)
Crankshaft Front Oil Seal Bore Runout	0.254 mm (0.010 in.) maximum	—
Crankshaft Front Oil Seal Installed Depth (below front face of cover)	8.4 mm (0.33 in.)	—

RG,CTM82,G16,2 -19-04JUN93

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CAMSHAFT AND TIMING GEAR TRAIN SPECIFICATIONS—CONTINUED

TORQUES

Rocker Arm Shaft Clamps	75 N·m (55 lb-ft)
Rocker Arm Cover-to-Cylinder Head	8 N·m (6 lb-ft) (72 lb-in.)
Timing Gear Cover-to-Cylinder Block	27 N·m (20 lb-ft)
Ignition Timing Wheel Access Cover	27 N·m (20 lb-ft)
Ignition Timing Sensor	22 N·m (16 lb-ft)

RG,CTM82,G16,3 -19-03MAY93

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.

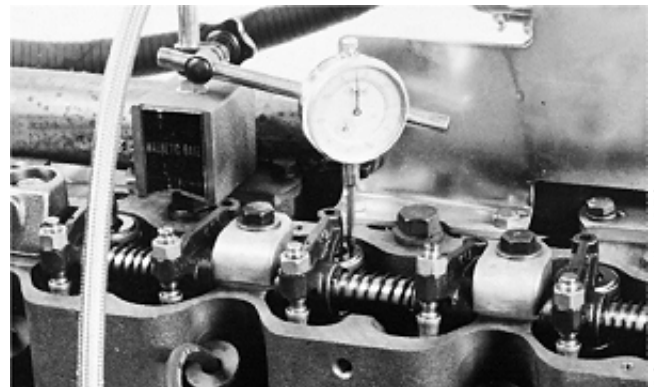
1. Remove rocker arm cover. Loosen locknut on rocker arm. Set valve clearance at 0.00 mm (in.). Tighten locknut.
2. Put dial indicator tip on valve rotator. Be sure that valve is fully closed.
3. Check pre-set on dial indicator. Set dial indicator pointer at zero.
4. Manually turn engine in running direction using JDE81-1 Rotation Tool.
5. Observe dial indicator reading as valve is moved to fully open position.

VALVE LIFT SPECIFICATION AT 0.00 mm (in.) CLEARANCE

Intake 13.39—13.84 mm (0.527—0.545 in.)
 Wear Tolerance 12.50 mm (0.492 in.)

Exhaust 14.38—14.84 mm (0.566—0.584 in.)
 Wear Tolerance 13.49 mm (0.531 in.)

6. Follow same procedure for all remaining valves and adjust valve clearance to specification. (See CHECK AND ADJUST VALVE CLEARANCE in Group 05.)



RG6527 -UN-14DEC92

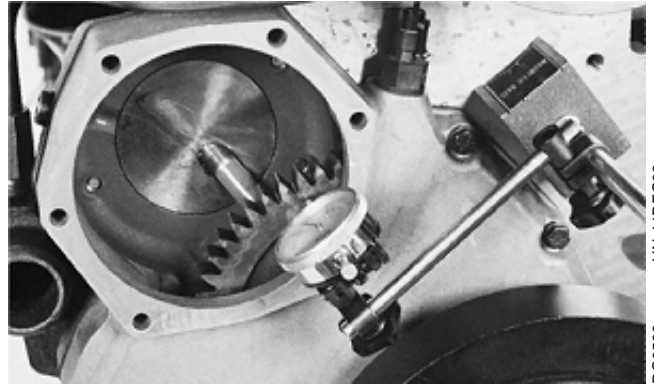
16
5

RG,CTM82,G16,4 -19-03MAY93

CHECK CAMSHAFT END PLAY

NOTE: Camshaft end play must be measured before removing timing gear cover, as thrust washer in back side of timing gear cover limits camshaft end play.

1. Remove ignition timing wheel access cover (shown removed).
2. Install magnetic base dial indicator on front face of cylinder block.
3. Position dial indicator tip on front face of camshaft gear, as shown. Set dial indicator to zero.
4. Move camshaft gear back and forth and observe end play reading. Compare reading with specification given below.



-JUN-14DEC92
RG6539

CAMSHAFT END PLAY SPECIFICATIONS

Camshaft End Play (NEW)	0.013—0.500 mm (0.0005—0.0200 in.)
Wear Limit	0.65 mm (0.0260 in.)

If end play is excessive, remove timing gear cover and camshaft and measure thickness of thrust washers.

RG,CTM82,G16,5 -19-04JUN93

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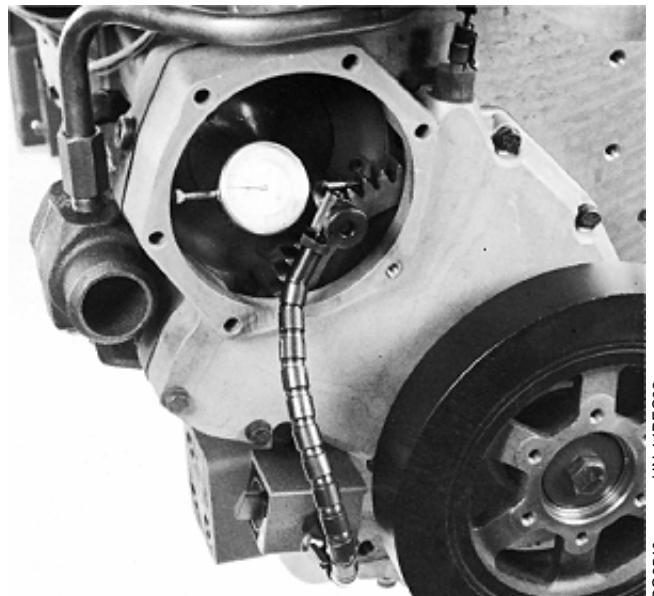
MEASURE CAMSHAFT DRIVE GEAR-TO-CRANKSHAFT GEAR BACKLASH

Measure backlash between camshaft drive gear and crankshaft gear in three (3) different positions around the camshaft gear. Use a magnetic base dial indicator with indicator plunger resting on camshaft gear tooth.

CAMSHAFT DRIVE GEAR-TO-CRANKSHAFT GEAR BACKLASH SPECIFICATION

Minimum Camshaft Gear Backlash	0.076 mm (0.003 in.)
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Replace gears if backlash is not within specification.

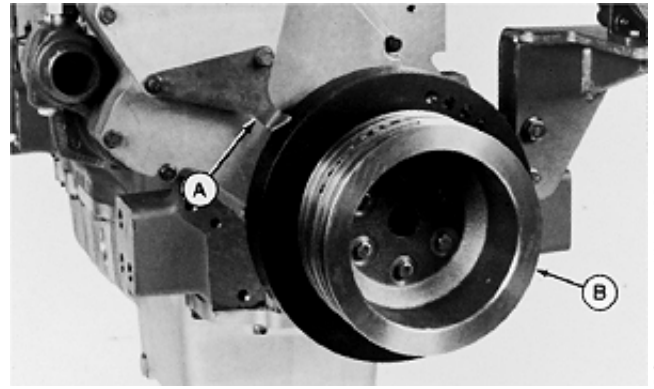


-JUN-14DEC92
RG6540

RG,CTM82,G16,8 -19-03MAY93

REMOVE TIMING GEAR COVER

1. Drain oil (if not previously done).
2. Remove timing indicator (A).
3. Remove pulley (B) and damper. (See REMOVE DAMPER PULLEY, in Group 15.)



RG,CTM82,G16,6 -19-03MAY93

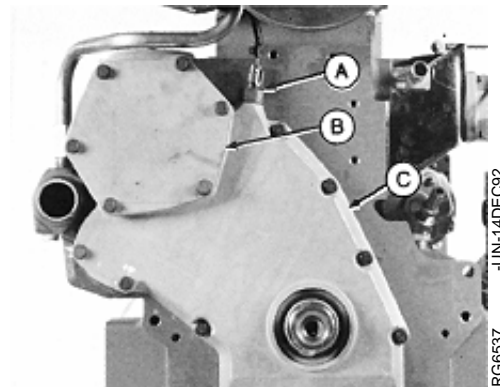
RG6750
-JUN-30APR93

4. Remove magnetic pick-up (A, if equipped) and ignition timing wheel access cover (B).
5. Check camshaft end play. (See CHECK CAMSHAFT ENDPLAY, earlier in this group.)
6. Remove oil pan.

IMPORTANT: Whenever timing gear cover is removed, ALWAYS install a new front oil seal. Whenever front oil seal is replaced, wear sleeve must also be replaced.

7. Remove timing gear cover (C).
8. Remove front oil seal from timing gear cover.

NOTE: Install new wear sleeve and oil seal after timing gear cover is installed. See Group 15.



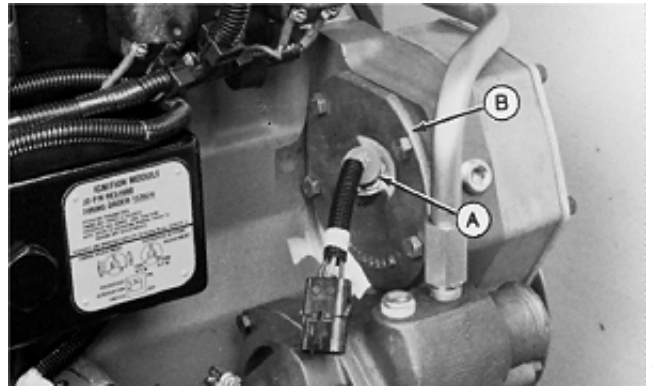
RG,CTM82,G16,7 -19-04JUN93

RG6537
-JUN-14DEC92

REMOVE CAMSHAFT

NOTE: It is not necessary to remove cylinder head from engine for camshaft removal. If push rods are bent or show excessive scuffing, it may be necessary to remove cylinder head for inspection of block, head, camshaft lobes and camshaft followers.

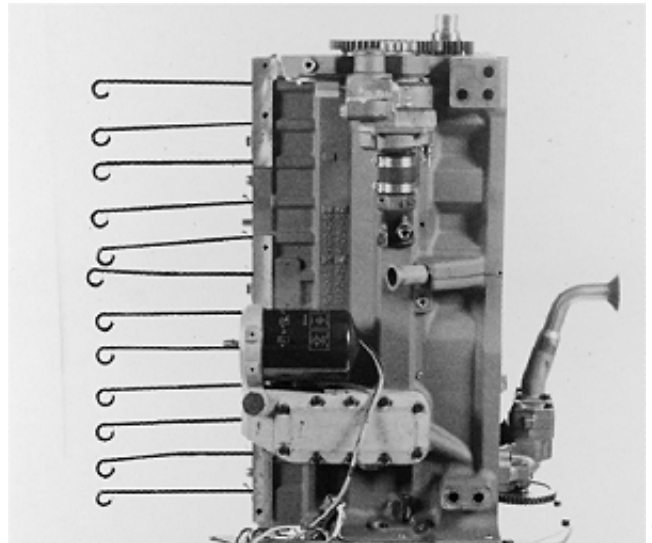
1. Drain engine oil and coolant, and remove timing gear cover, if not previously done.
2. Disconnect turbocharger oil inlet line at turbocharger or oil conditioning housing.
3. Disconnect ignition timing sensor (A) and remove from sensor plate (B) to prevent damaging sensor during camshaft removal. (See Group 40.)
4. Remove rocker arm cover, rocker arm assembly and push rods. Remove cylinder head, if desired. (See Group 05, Cylinder Head and Valves.)



RG66757 -JUN-30APR93

RG,CTM82,G16,9 -19-04JUN93

5. When removing camshaft with engine on rollover stand, roll engine to a vertical position and hold camshaft followers away from camshaft lobes with D15001NU Magnetic Holding Set.



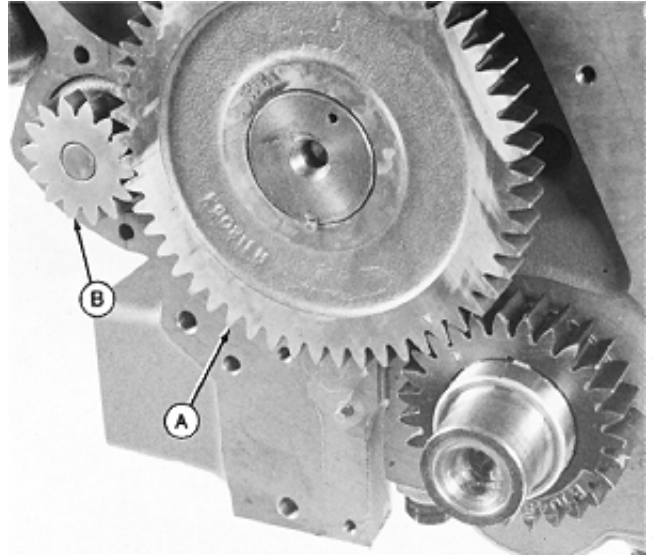
RG66571 -UN-30APR93

RG,CTM82,G16,10-19-04JUN93

16
8

Camshaft and Timing Gear Train/Remove Camshaft

6. Examine camshaft gear (A) and water pump drive gear (B) for worn or damaged gear teeth.



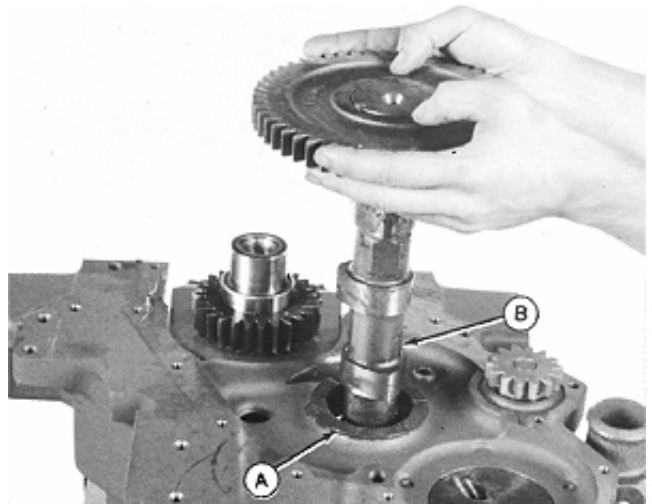
RG,CTM82,G16,11-19-03MAY93

7. Carefully remove camshaft (B) from cylinder block so that camshaft lobes do not drag in bores.

NOTE: Rotate camshaft carefully to aid in removing.

8. Remove thrust washer (A) from behind camshaft gear.

9. Remove camshaft followers.



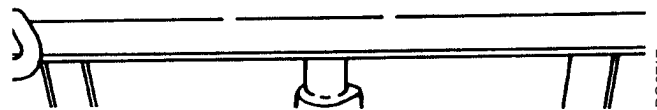
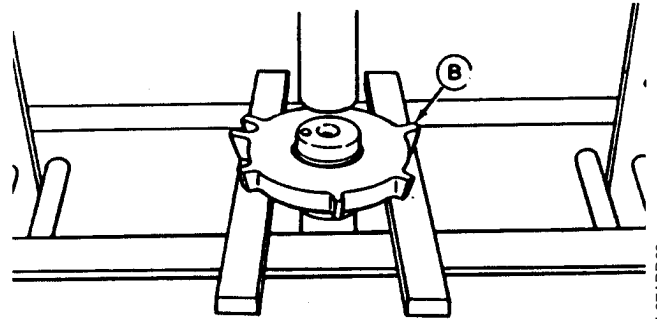
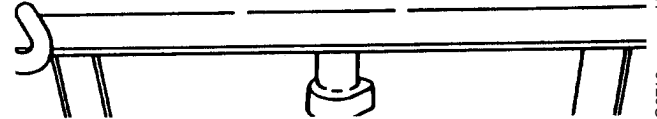
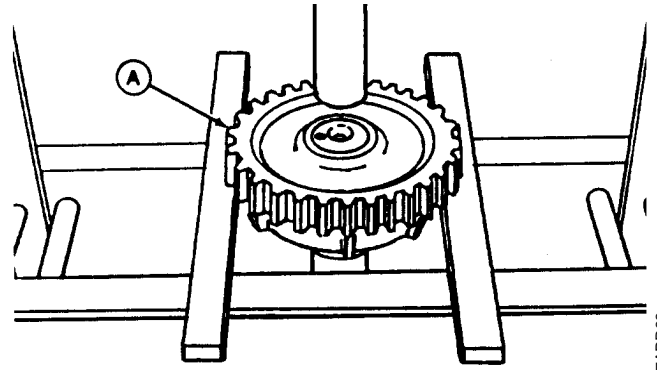
RG,CTM82,G16,12-19-04JUN93

REMOVE CAMSHAFT GEAR AND IGNITION TIMING WHEEL

NOTE: Camshaft gear and timing wheel are pressed onto the camshaft. Removal from camshaft will require approximately a 10-ton press.

IMPORTANT: Prevent camshaft from striking floor when pushing camshaft nose out of gear and timing wheel. Camshaft may be damaged if it is allowed to fall to the floor.

1. Support camshaft gear (A) in a press.
2. Remove gear from camshaft.
3. Support timing wheel (B) in a press.
4. Remove timing wheel from camshaft.
5. Clean camshaft, gear, and timing wheel.
6. Check thrust surfaces and timing wheel teeth for nicks or other damage.



-UN-27APR93

RG6716

-UN-27APR93

RG6717

RG,CTM82,G16,13-19-01JUN93

MEASURE THRUST WASHER THICKNESS

1. After removal of camshaft, check the two thrust washers individually for proper thickness.

THRUST WASHER THICKNESS SPECIFICATIONS

Thrust Washer Thickness 2.24—2.34 mm
(0.088—0.092 in.)

2. Replace washers if worn or damaged.



-UN-06AUG91

RG5775

RG,CTM42,G16,18-19-29OCT92

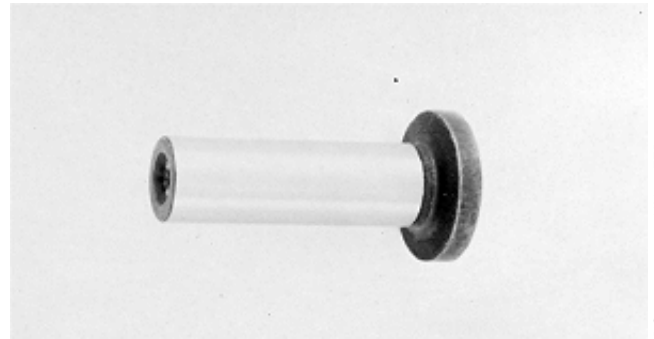
INSPECT AND MEASURE CAMSHAFT FOLLOWERS

1. Inspect camshaft followers for uneven wear or damage. Also inspect corresponding camshaft lobe for wear or damage. Replace as necessary.
2. Measure follower OD and follower bore ID in cylinder block.

CAMSHAFT FOLLOWER AND BORE SPECIFICATIONS

Camshaft Follower OD	17.33—17.35 mm (0.682—0.683 in.)
Camshaft Follower Bore ID in Block	17.384—17.440 mm (0.6845—0.6865 in.)

Replace cam followers that are not within specification. Replace cylinder block if any one cam follower bore is not within specification.



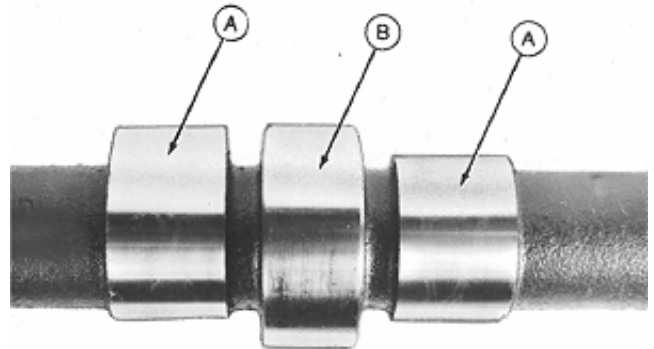
RG2745 -UN-23FEB89

RG,CTM42,G16,19-19-29OCT92

VISUALLY INSPECT CAMSHAFT

1. Clean camshaft in solvent. Dry with compressed air.
2. Visually inspect camshaft lobes (A) and journals (B) for wear or damage. Replace as necessary. New camshaft followers can be used with old camshaft (if camshaft is serviceable). DO NOT reuse old cam followers with a new camshaft.

NOTE: Very light score marks may be found, but are acceptable if valve lift is within specification. Pitting or galling dictates replacement. (See CHECK VALVE LIFT earlier in this group.)



RG3500 -UN-06AUG91

RG,CTM42,G16,20-19-29OCT92

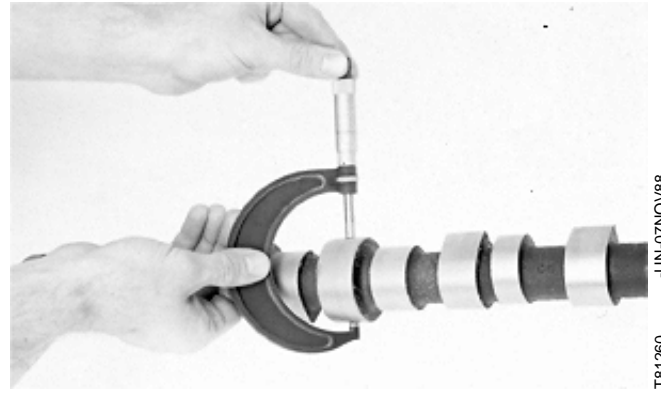
MEASURE CAMSHAFT JOURNAL OD AND BUSHING ID

1. Measure each camshaft journal OD. If camshaft journal OD is not within specification, install a new camshaft.

CAMSHAFT JOURNAL AND BUSHING SPECIFICATIONS

Camshaft Journal Diameter (NEW)	66.987—67.013 mm (2.6373—2.6383 in.)
Camshaft Bushing ID (NEW)	67.076—67.102 mm (2.6408—2.6418 in.)
Bushing-to-Journal Clearance (MAXIMUM)	0.152 mm (0.0060 in.)

2. Measure each camshaft bushing ID when installed in cylinder block.



T81260 -JUN-07NOV88

RG,CTM42,G16,21-19-29OCT92

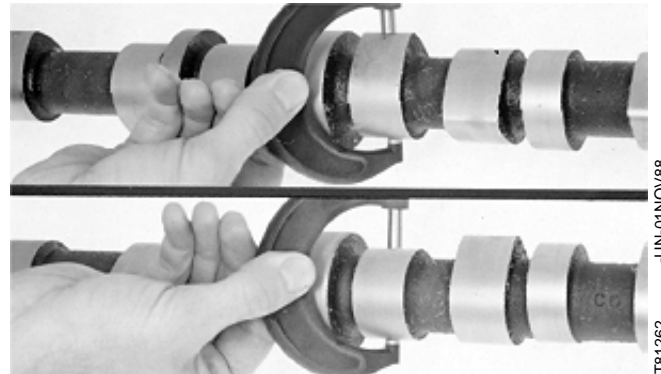
MEASURE CAMSHAFT LOBE LIFT

1. Measure each camshaft lobe at its highest point and at its narrowest point. Subtract narrowest dimension from highest dimension to find camshaft lobe lift.

If camshaft lobe lift is not within the wear specification on any one lobe, install a new camshaft.

CAM LOBE LIFT NEW PART SPECIFICATION

Intake Lobe Lift	7.61—7.87 mm (0.2996—0.3098 in.)
Wear Limit	7.11 mm (0.280 in.)
Exhaust Lobe Lift	8.17—8.43 mm (0.322—0.332 in.)
Wear Limit	7.67 mm (0.302 in.)



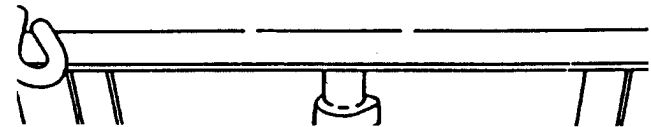
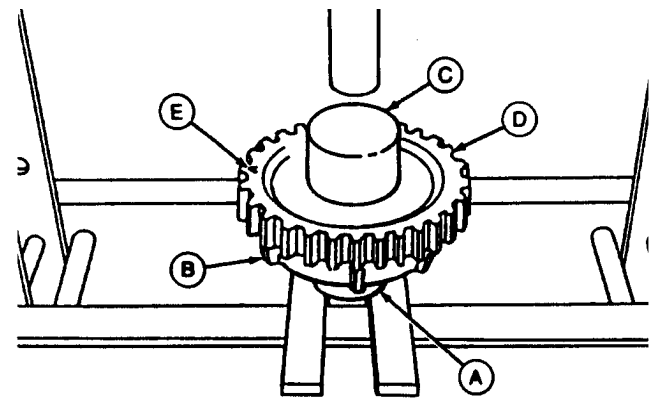
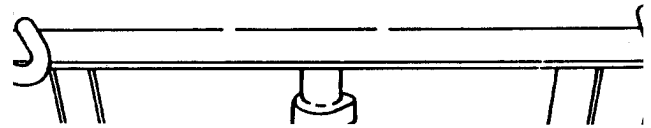
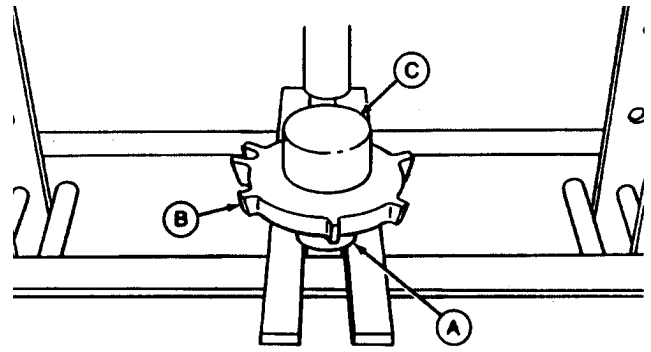
T81262 -JUN-01NOV88

RG,CTM42,G16,22-19-03MAY93

INSTALL CAMSHAFT GEAR AND IGNITION TIMING WHEEL

1. Support camshaft under first bearing journal (A) in a hydraulic press.
2. Install Woodruff key. Lubricate camshaft nose with FEL-PRO® C-670 Molybdenum Disulfide Paste.
3. Set timing wheel (B) on camshaft with thrust washer surface (short side of teeth) to the inside (toward the camshaft). Align Woodruff key and keyway.
4. Using a suitable driver, such as JD320, push wheel onto camshaft until tight against the camshaft bearing journal.
5. Set gear (D) on camshaft with timing mark upward (away from the camshaft). Align Woodruff key and keyway of gear.
6. Push gear onto camshaft nose until tight against timing wheel.

- A—Bearing Journal
- B—Timing Wheel
- C—Driver (JD320)
- D—Camshaft Gear
- E—Timing Mark



RG,CTM82,G16,14-19-28MAY93

7. Support each end of the camshaft on centers. Use a dial indicator with plunger resting on the thrust surfaces of the gear and timing wheel.

8. Check the runout of the inner and outer thrust surfaces.

CAMSHAFT THRUST SURFACE RUNOUT SPECIFICATIONS

Maximum Camshaft Thrust Surface Runout 0.10 mm
(0.004 in.)

RG,CTM82,G16,15-19-03MAY93

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.

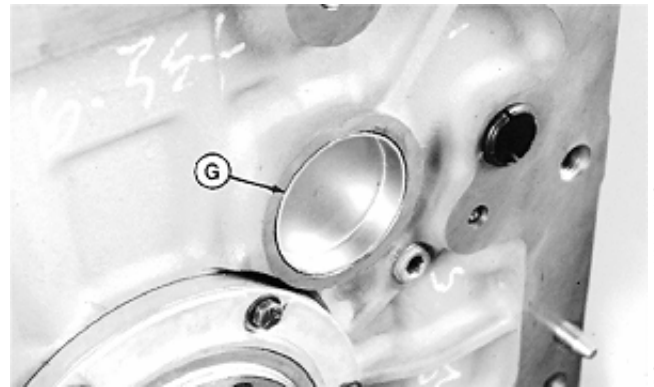
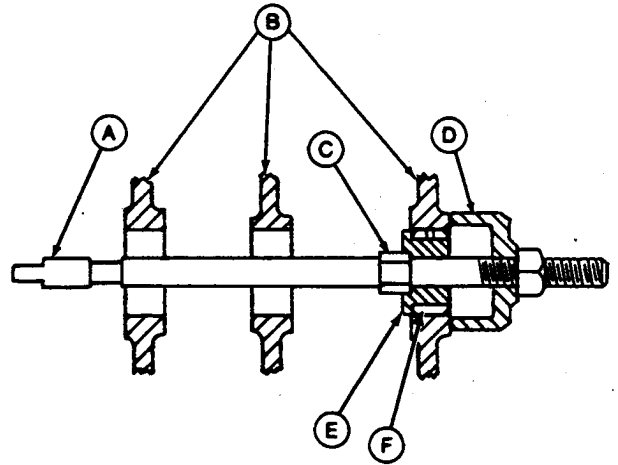
CAMSHAFT JOURNAL AND BUSHING NEW PART SPECIFICATION

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	0.063—0.115 mm (0.0025—0.0045 in.)
Maximum Worn 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 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 Plug

RG,CTM42,G16,30-19-29OCT92

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14

-UN-06DEC88

RG5272

-UN-30AUG91

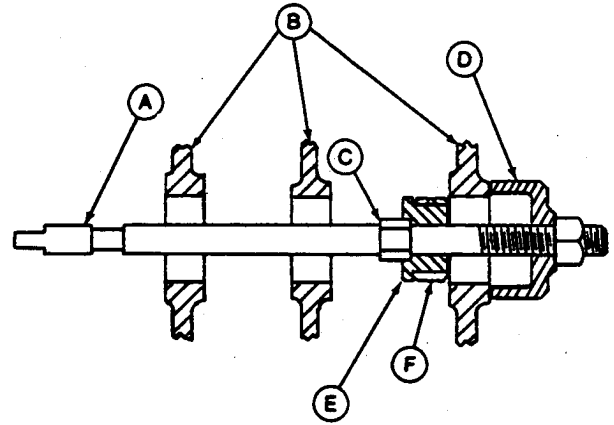
RG5949

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

RG5273 -UN-06DEC88

S55,2016.N -19-23SEP91

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	0.063—0.115 mm (0.0025—0.0045 in.)
Wear Limit	0.152 mm (0.0060 in.)

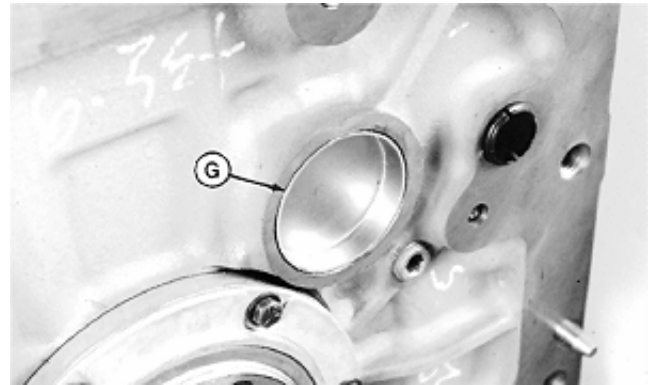
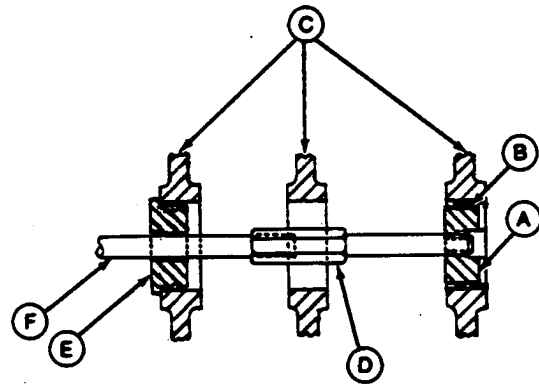
NOTE: The front two bushings can be reached from the front of the engine. The flywheel and rear camshaft bore plug (G) must be removed to reach the other two bushings.

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 Plug

RG,CTM42,G16,31-19-04JUN93

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RG5332

-UN-30AUG91

RG5949

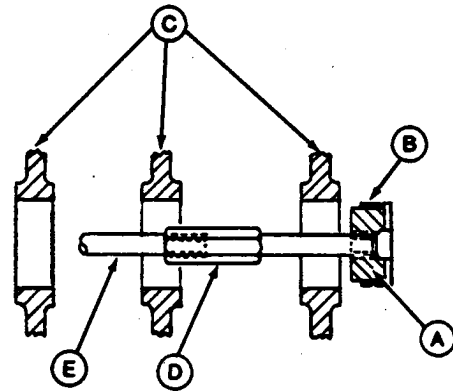
IMPORTANT: Oil holes in bushings and cylinder block must be aligned after installation. The elongated hole in bushing must be toward top. After installation, use a small mirror with extension to be sure oil holes are properly aligned.

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

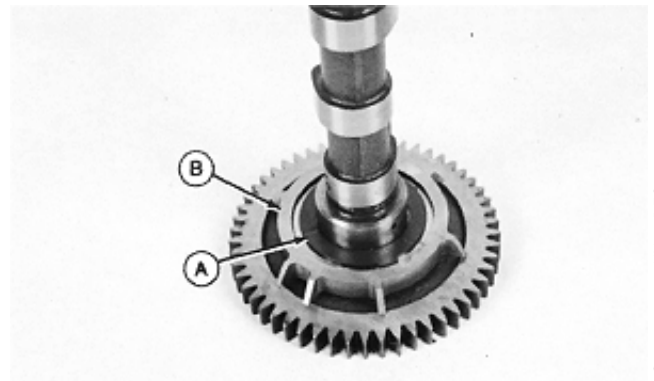
IMPORTANT: Set engine at TDC of No. 1 piston's compression stroke before installing camshaft so timing marks on camshaft and crankshaft gears will be aligned.

1. If camshaft followers were removed with engine on a rolover stand, reinstall followers but do not obstruct camshaft bore. Roll engine to an angle where followers fall away from camshaft bores.

NOTE: If D15001NU Magnetic Holding Tool Set is used, hold camshaft followers away from camshaft bore until camshaft is installed.

2. Lubricate thrust washer (A) with TY6333 or TY6347 High Temperature Grease and install on camshaft behind timing wheel (B).

3. Lubricate camshaft lobes with TY6333 or TY6347 High Temperature Grease and bearing journals with clean engine oil.



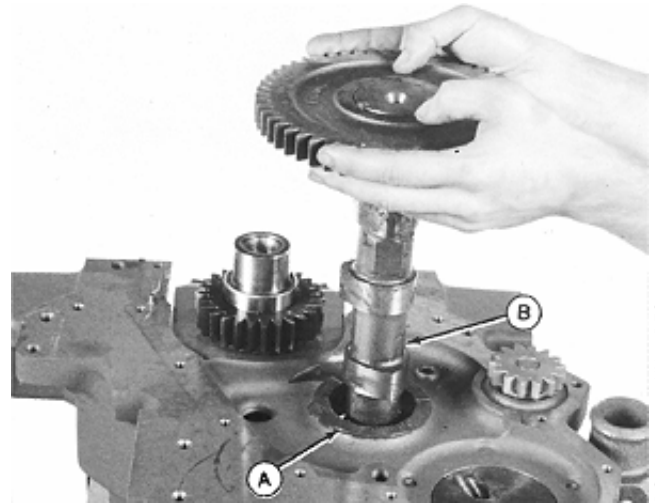
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RG6543 -UN-14DEC92

RG,CTM82,G16,16-19-03MAY93

Camshaft and Timing Gear Train/Install Camshaft

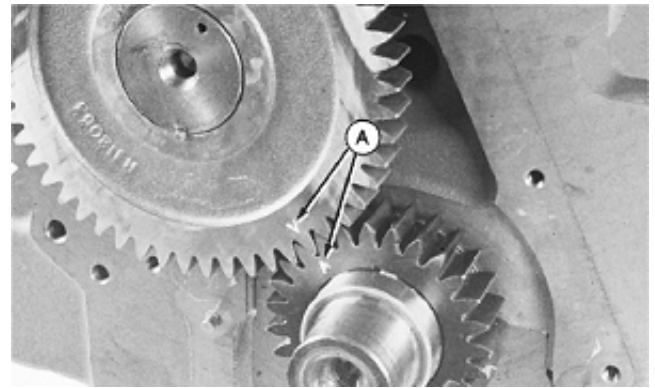
4. Carefully install camshaft (A) in cylinder block so that camshaft lobes do not drag in bores. Rotate camshaft during installation to avoid obstruction in any bore.



RG6542 -UN-14DEC92

RG,CTM82,G16,17-19-03MAY93

5. With No. 1 piston at "TDC," align timing marks (A) on camshaft and crankshaft gears.



RG6614 -UN-18FEB93

RG,CTM82,G16,18-19-03MAY93

INSTALL THRUST WASHER AND TIMING GEAR COVER

1. Lubricate thrust washer (A) with TY6333 or TY6347 High Temperature Grease and install in timing gear cover.

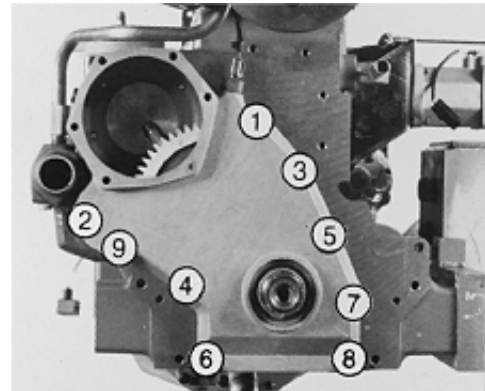
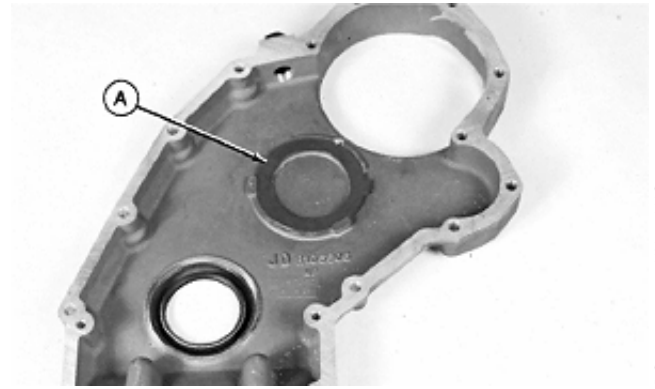
2. Install a new gasket on the engine block. Apply a light film of grease to the gasket to hold it in place.

NOTE: Tightening the timing gear cover cap screws in proper sequence controls the total runout for the front crankshaft oil seal.

3. Install timing gear cover. Tighten cap screws in sequence one through nine (as shown) to 27 N·m (20 lb-ft).

4. Trim timing gear cover gasket flush with oil pan gasket rail.

5. Check camshaft endplay. (See CHECK CAMSHAFT END PLAY, earlier in this group.)



-JUN-06AUG91

RG5782

-JUN-14DEC92

RG6536

RG,CTM82,G16,19-19-04JUN93

COMPLETE FINAL ASSEMBLY

1. Install crankshaft front wear sleeve and seal. (See INSTALL CRANKSHAFT FRONT WEAR SLEEVE, in Group 15.)
2. Install the magnetic pickup assembly in timing gear cover (if equipped).
3. Install vibration damper, pulley assembly, and timing indicator. (See Group 15, Crankshaft, Main Bearings and Flywheel.)
4. Install ignition timing sensor (if removed). Tighten to 22 N·m (16 lb-ft).
5. Install ignition timing wheel access cover, gasket, and timing indicator. Tighten the six cap screws to 27 N·m (20 lb-ft).
6. Install cylinder head (if removed), valve train, and rocker arm assembly. (See Group 05, Cylinder Head and Valves.)
7. Install oil pan and new gasket. (See Group 20, Lubrication System.) Fill engine with clean engine oil.
8. Perform engine break-in as required. (See PERFORM ENGINE BREAK-IN, in Group 05.)

OTHER MATERIAL

Name	Use
PERMATEX AVIATION (Form-A-Gasket No. 3) (TY6299)	To seal gasket surfaces.
LOCTITE 592 Pipe Sealant with TEFLON (TY9374/TY9375)	To seal oil pan elbow drain fitting.
High Temperature Grease (TY6343 or TY6347)	To lubricate oil pump components.

RG,CTM42,G20,1 -19-09OCT92

LUBRICATION SYSTEM SPECIFICATIONS

ITEM	SPECIFICATION
Oil Filter Bypass Valve Operating Pressure	210 kPa (2.1 bar) (30 psi)
Oil Pressure Regulating Valve Spring:	
Compressed Length	43.0 mm @ 66—74 N (1.69 in. @ 15—17 lb-force)
Free Length	85.0 mm (3.35 in.)
Oil Filter Bypass Valve Spring:	
Compressed Length	30.0 mm @ 64—78 N (1.18 in. @ 14—18 lb-force)
Free Length	44.0 mm (1.73 in.)
Oil Cooler Bypass Valve Spring:	
Compressed Length	30.0 mm @ 64—78 N (1.18 in. @ 14—18 lb-force)
Free Length	44.0 mm (1.73 in.)
Oil Pump:	
Crankshaft Gear-to-Oil Pump Drive Gear	
Minimum Backlash	0.08 mm (0.003 in.)
Pump Gear Backlash	0.33—2.00 mm (0.013—0.079 in.)
Oil Pump Drive Gear-to-Crankshaft Throw	
Minimum Clearance	0.38 mm (0.015 in.)
Maximum Drive Shaft End Play	0.15 mm (0.006 in.)
Maximum Drive Shaft Side Movement	0.17 mm (0.0065 in.)

RG,CTM42,G20,2 -19-07JUN93

20
1

LUBRICATION SYSTEM SPECIFICATIONS—CONTINUED

TORQUES

Oil Conditioning Housing-to-Cylinder Block: *

Step 1	20 N·m (15 lb-ft)
Step 2	37 N·m (27 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)
Intake Tube-to-Cover	41 N·m (30 lb-ft)
Pump Housing-to-Cylinder Block	47 N·m (35 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 Drain Plug	101 N·m (75 lb-ft)
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* Refer to *INSTALL OIL FILTER AND OIL CONDITIONING HOUSING*, later in this group, for proper cap screw tightening 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.

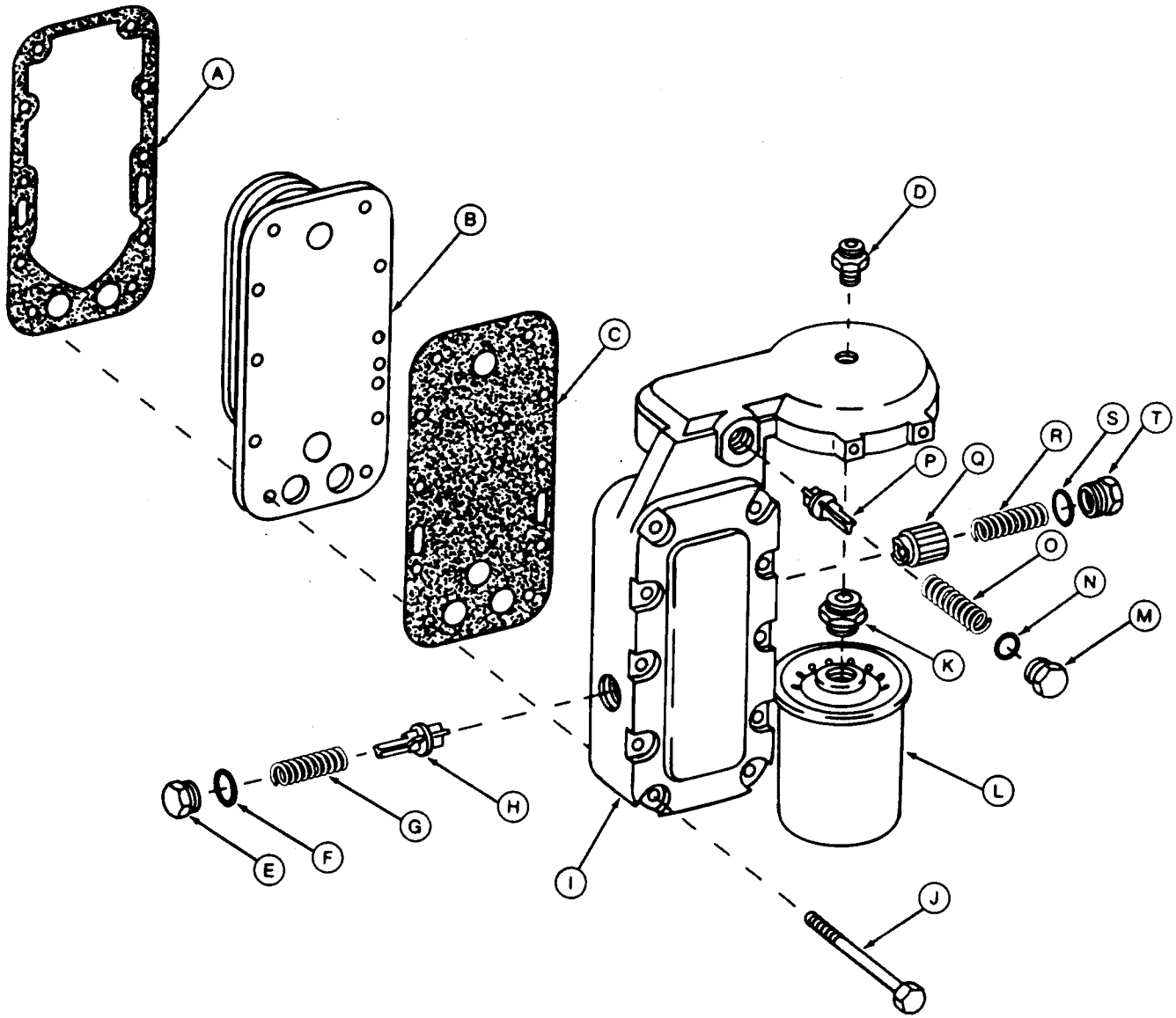
RG,CTM42,G20,32-19-03JUN93

DRAIN ENGINE OIL AND REMOVE OIL PAN

1. Drain engine coolant.
2. Disconnect turbocharger oil inlet line at turbocharger or oil conditioning housing. (See **DISCONNECT TURBOCHARGER OIL INLET LINE**, in Group 03.)
3. Drain engine oil.
4. Remove oil level sight gauge (if equipped).
5. Remove oil pan and discard gasket.

S11,0404.C -19-04JUN93

OIL FILTER AND OIL CONDITIONING HOUSING ASSEMBLY



A—Gasket
 B—Oil Cooler
 C—Gasket
 D—Fitting
 E—Plug
 F—O-Ring

G—Spring
 H—Oil Cooler Bypass Valve
 I—Oil Conditioning Housing
 J—Cap Screw (10 Used)
 K—Adapter

L—Oil Filter
 M—Plug
 N—O-Ring
 O—Spring
 P—Oil Filter Bypass Valve

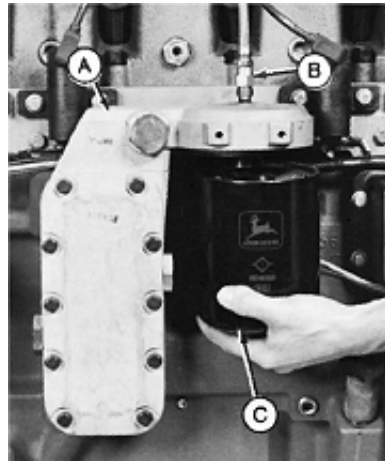
Q—Oil Pressure Regulating Valve
 R—Spring
 S—O-Ring
 T—Plug

RG5886 -UN-16AUG91

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3

REMOVE OIL FILTER AND OIL CONDITIONING HOUSING

1. Disconnect turbocharger oil inlet line (B) from oil conditioning housing (A).
2. Turn oil filter (C) counterclockwise and remove filter from housing.
3. Remove cap screws securing oil conditioning housing to cylinder block and remove housing.



RG,CTM82,G20,1 -19-12APR93

REMOVE, INSPECT, AND INSTALL OIL PRESSURE REGULATING VALVE, OIL FILTER BYPASS VALVE, AND OIL COOLER BYPASS VALVE

See OIL FILTER AND OIL CONDITIONING HOUSING ASSEMBLY, earlier in this group, for illustration of valves.

• Oil Pressure Regulating Valve

1. Remove plug (T), O-ring (S), spring (R), oil pressure regulating valve (Q) from housing (I). Discard O-ring.
2. Inspect valve and valve bore for damage. Replace if necessary.
3. Check spring for proper compression.

NEW PRESSURE REGULATING VALVE SPRING SPECIFICATION

Working Load at 66—74 N 43.0 mm
(15—17 lb force) (1.69 in.)

Spring Free Length 85.0 mm (3.35 in.)

4. Dip all parts in clean engine oil, insert valve and spring in housing.
5. Install plug using a new O-ring and tighten securely.

• Oil Filter Bypass Valve

1. Remove plug (M) with O-ring (N), spring (O), and oil filter bypass valve (P) from oil conditioning housing (I). Discard O-ring.
2. Inspect valve and housing bore for scoring or damage. Replace if necessary.
3. Check spring for proper compression. Replace if necessary.

NEW OIL FILTER BYPASS VALVE SPRING SPECIFICATION

Working Load at 64—78 N 30.0 mm
(14—18 lb force) (1.18 in.)

Spring Free Length 44.0 mm (1.73 in.)

4. Dip all parts in clean engine oil, insert valve and spring in housing.
5. Install new O-ring on plug. Install plug and tighten securely.

NOTE: Filter bypass valve operating pressure is 210 kPa (2.10 bar) (30 psi).

• Oil Cooler Bypass Valve

1. Remove plug (E), O-ring (F), spring (G), and oil cooler bypass valve (H) from oil conditioning housing (I). Discard O-ring.
2. Check housing for clogged passages and all other parts for scale build-up.
3. Clean all parts with a stiff bristle brush and solvent, if necessary. Dry with compressed air.
4. Inspect bypass valve for damage. Replace if necessary.
5. Check bypass valve spring for proper specifications. Replace if not within specifications.

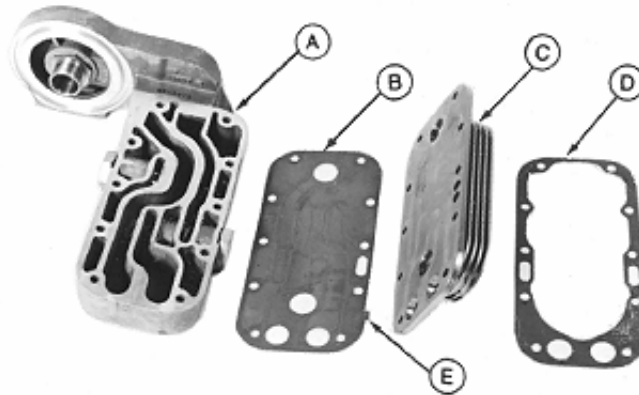
NEW OIL COOLER BYPASS VALVE SPRING SPECIFICATION

Working Load at 64—78 N 30.0 mm
(14-18 lb force) (1.18 in.)

Spring Free Length 44.0 mm (1.73 in.)

20
5

INSTALL OIL FILTER AND OIL CONDITIONING HOUSING



RG5904 -JUN-20AUG91

A—Oil Conditioning Housing
B—Gasket

C—Oil Cooler

D—Gasket

E—Tab

1. Remove all gasket material from cylinder block and oil conditioning housing (A).

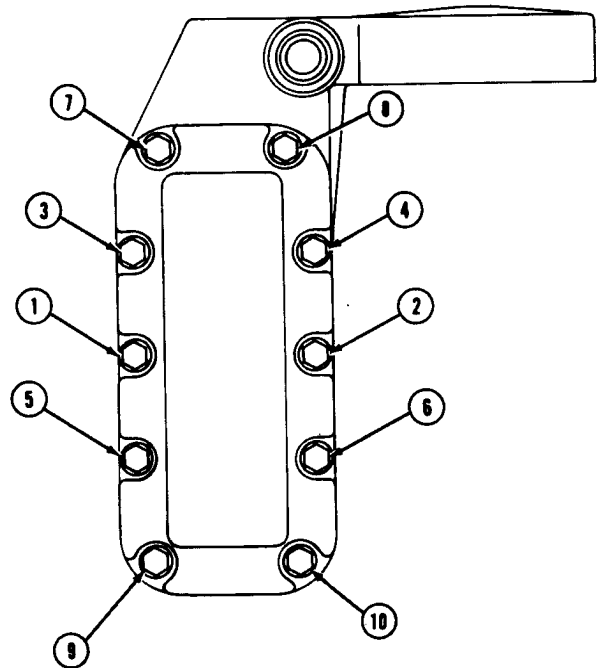
2. Install gasket (D), engine oil cooler (C), gasket (B), and oil conditioning housing onto cylinder block using 5/16 x 3 in. studs. Tab (E) on gasket with silicone bead should be downward and to the right.

RG,CTM42,G20,9 -19-09OCT92

3. Tighten cap screws to 20 N·m (15 lb-ft) following sequence shown in diagram.

4. Retighten cap screws to 37 N·m (27 lb-ft) following same sequence.

NOTE: It may be helpful to put an ink mark on each cap screw after tightening each time to assure all cap screws have been tightened.



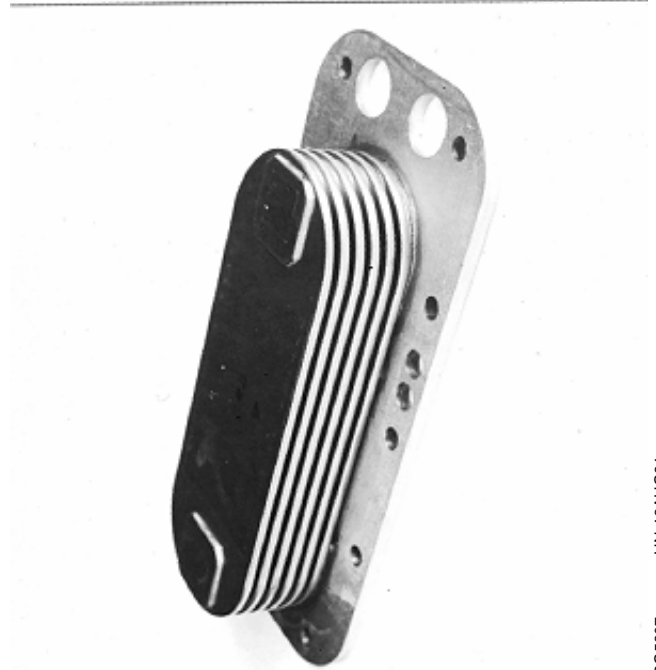
RG5905 -JUN-16AUG91

RG,CTM42,G20,10-19-09OCT92

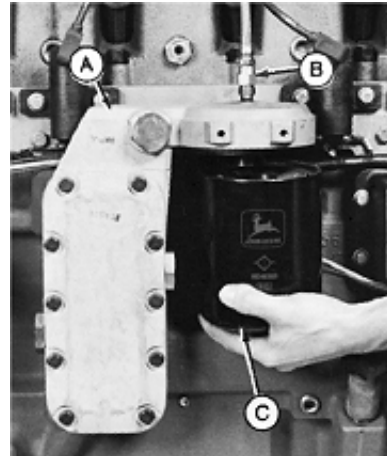
REMOVE ENGINE OIL COOLER

6076 engines are equipped with a 6-plate engine oil cooler.

1. Remove oil filter (C), turbocharger oil line (B), and cover (A).
2. Remove oil cooler.



6-plate oil cooler



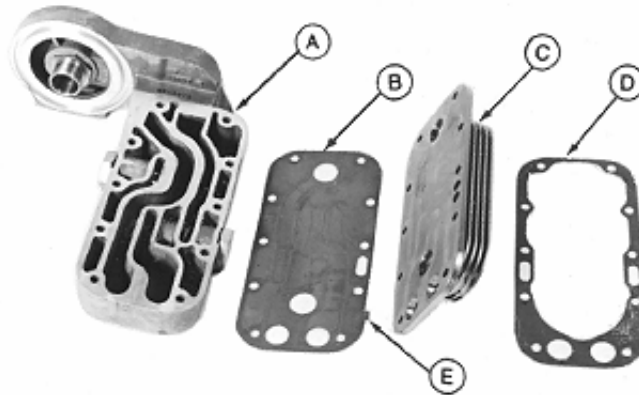
RG6544 -UN-14DEC92

RG5907 -UN-16AUG91

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RG,CTM82,G20,2 -19-04JUN93

CLEAN, INSPECT, AND INSTALL ENGINE OIL COOLER



RG5904
-JUN-20AUG91

A—Oil Conditioning Housing

B—Gasket

C—Oil Cooler

D—Gasket

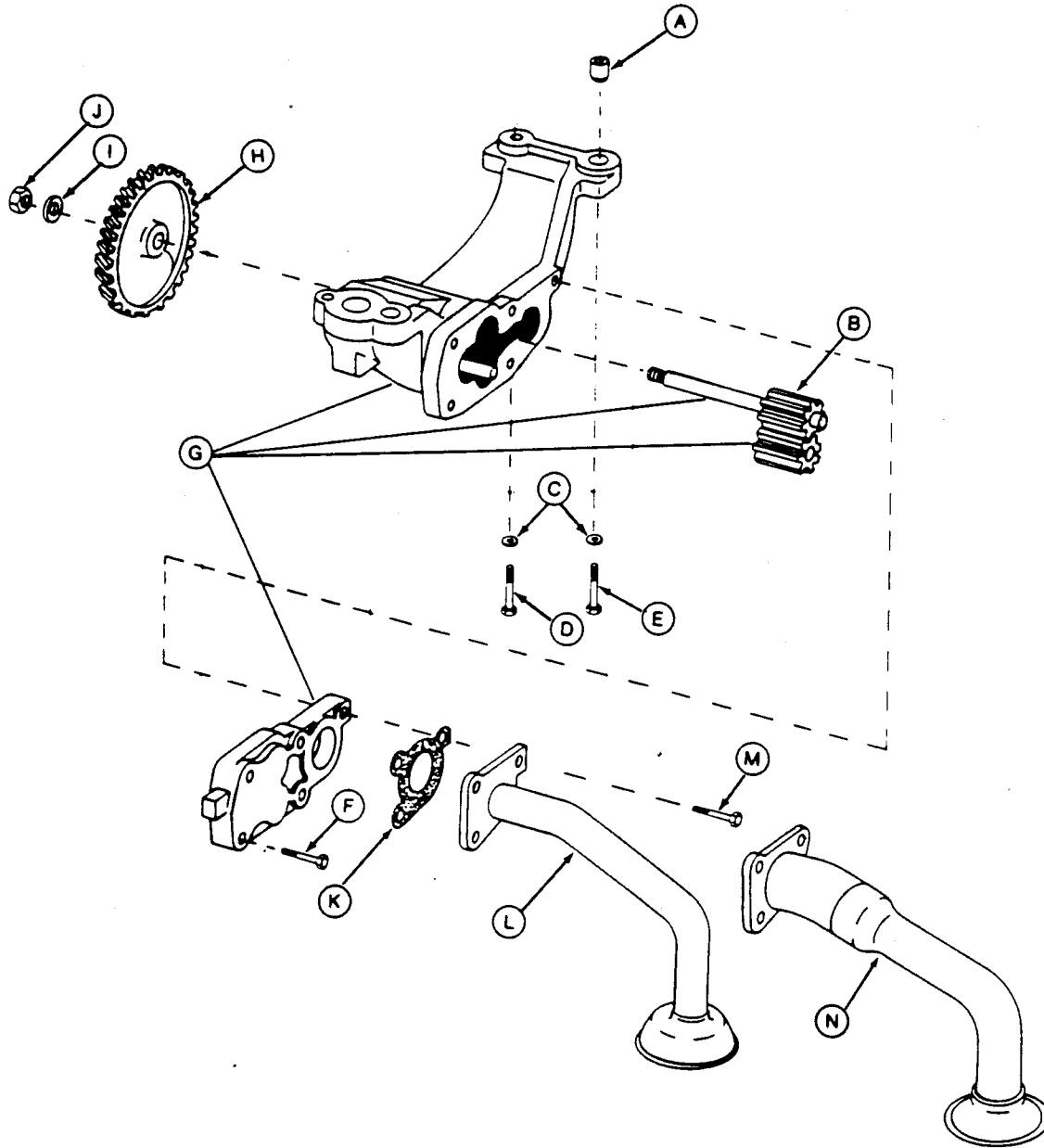
1. Once oil cooler is removed, scrape off all old gasket material from cooler and block.
2. Clean all parts with clean solvent and a brass wire brush. Dry with compressed air.
3. Inspect all parts for serviceability. Replace parts as necessary.

NOTE: If mixing of oil and coolant is suspected, pressure test oil cooler in liquid 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. Using new gaskets install oil cooler/oil conditioning housing. See INSTALL OIL FILTER AND OIL CONDITIONING HOUSING, earlier in this group.

RG,CTM42,G20,12-19-09OCT92

ENGINE OIL PUMP ASSEMBLY



A—Bushing (2 Used)
 B—Oil Pump Gears
 C—Washer (4 Used)
 D—Cap Screw (2 Used)

E—Cap Screw (2 Used)
 F—Cap Screw (2 Used)
 G—Oil Pump Assembly
 H—Oil Pump Drive Gear

I—Washer
 J—Nut
 K—Gasket

L—Oil Pump Intake*
 M—Cap Screw (4 Used)
 N—Oil Pump Intake**

* Used on deep sump oil pan applications only.

** Used on standard sump oil pan applications only to lower oil pump intake and improve off-level capability.

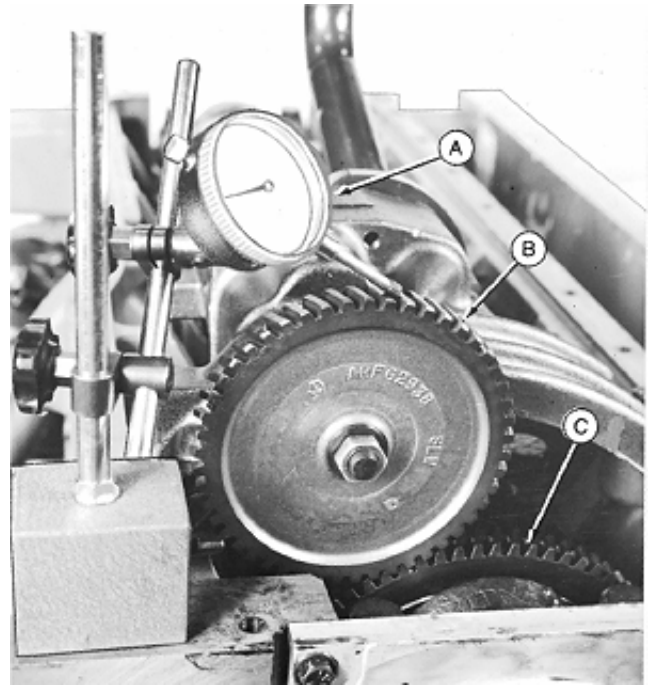
RG6434 -JUN-13OCT92

CHECK CRANKSHAFT GEAR-TO-OIL PUMP DRIVE GEAR BACKLASH

Before removing oil pump, determine if there is adequate backlash between oil pump and crankshaft drive gears.

1. Mount dial indicator (A) and measure backlash between pump drive gear (B) and crankshaft gear (C).

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.

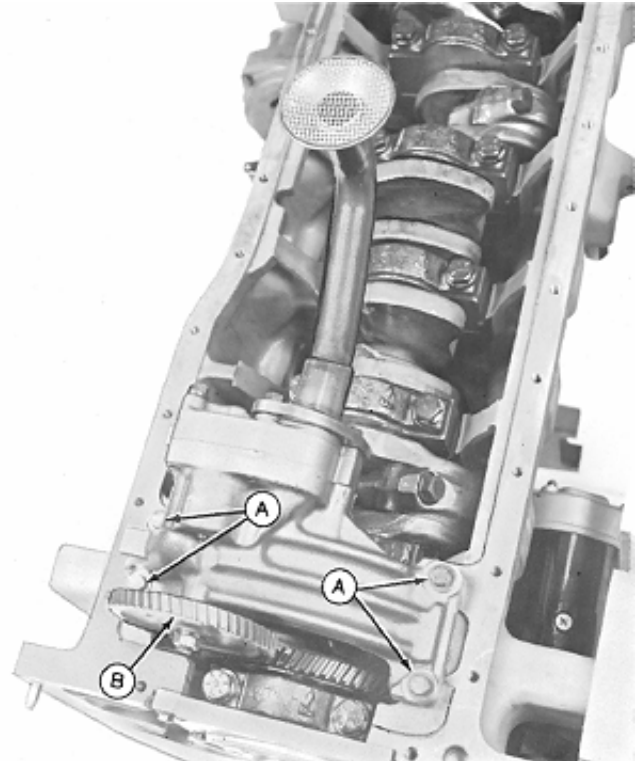


RG5914 -JUN-16AUG91

RG,CTM42,G20,16-19-09OCT92

REMOVE ENGINE OIL PUMP

1. Remove four oil pump housing cap screws (A).
2. Remove oil pump assembly with drive gear (B) attached.



RG5915 -JUN-16AUG91

RG,CTM42,G20,17-19-09OCT92

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.

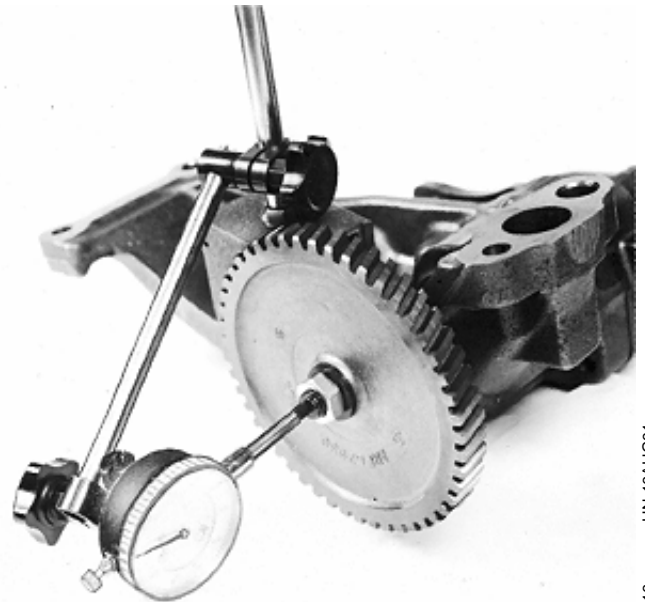
RG,CTM42,G20,18-19-09OCT92

CHECK DRIVE SHAFT END PLAY

1. Mount dial indicator with indicator plunger resting against end of pump drive shaft.
2. Move shaft toward and away from indicator.

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.).



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11
-UN-16AUG91
RG5916

RG,CTM42,G20,18-19-09OCT92

CHECK DRIVE SHAFT SIDE MOVEMENT

1. Mount dial indicator with indicator plunger resting on one of the hex nut flats.
2. Move shaft from side-to-side.

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

RG,CTM42,G20,20-19-09OCT92

CHECK PUMPING GEAR BACKLASH

1. Mount dial indicator with indicator plunger resting against side of gear tooth.
2. Hold idler gear stationary. Slowly rotate drive gear back and forth until contact with idler gear is felt.

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

RG,CTM42,G20,21-19-09OCT92

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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

INSTALL ENGINE OIL PUMP

1. Lubricate bottom surface of oil pump housing gear pocket bores, idler shaft, gear teeth on drive shaft with gear and oil pump cover ends of both gears with TY6343 or TY6347 High Temperature Grease.

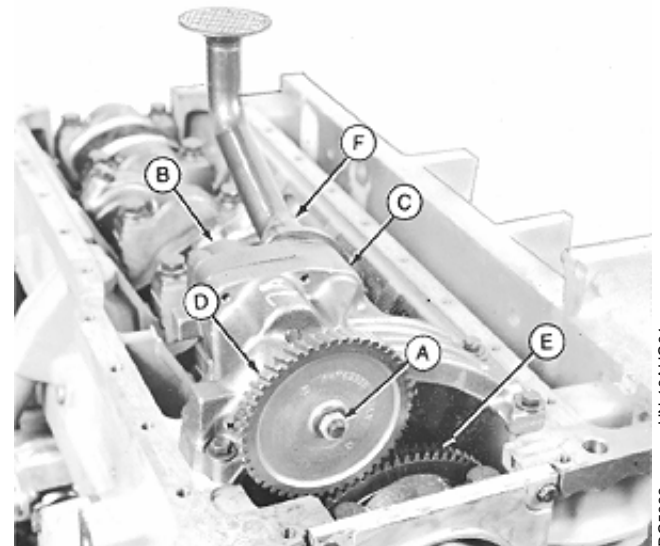
2. Tighten oil pump drive gear-to-drive shaft nut (A) to 54 N-m (40 lb-ft). Install oil pump cover (B)-to-oil pump housing (C).

3. Using a new gasket, install oil pump intake (F)-to-oil pump cover and tighten cap screws to 41 N-m (30 lb-ft).

NOTE: Oil pump gears must turn freely after installation of oil pump cover and intake.

4. Install oil pump assembly over hollow dowel pin in cylinder block. Tighten oil pump housing-to-cylinder block cap screws to 47 N-m (35 lb-ft).

NOTE: Make sure oil pump drive gear (D) meshes properly with crankshaft gear (E).

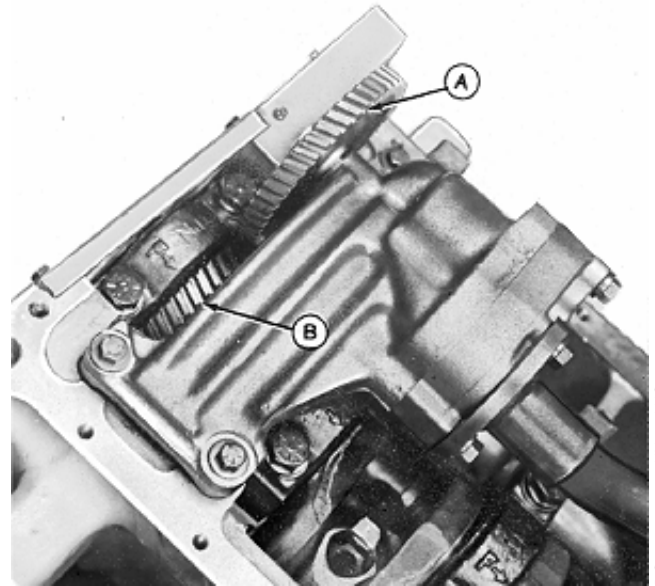


RG5922 -UN-16AUG91

- A—Shaft Nut
- B—Oil Pump Cover
- C—Oil Pump Housing
- D—Oil Pump Drive Gear
- E—Crankshaft Gear
- F—Oil Pump Intake

RG,CTM42,G20,23-19-09OCT92

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 bearings 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.



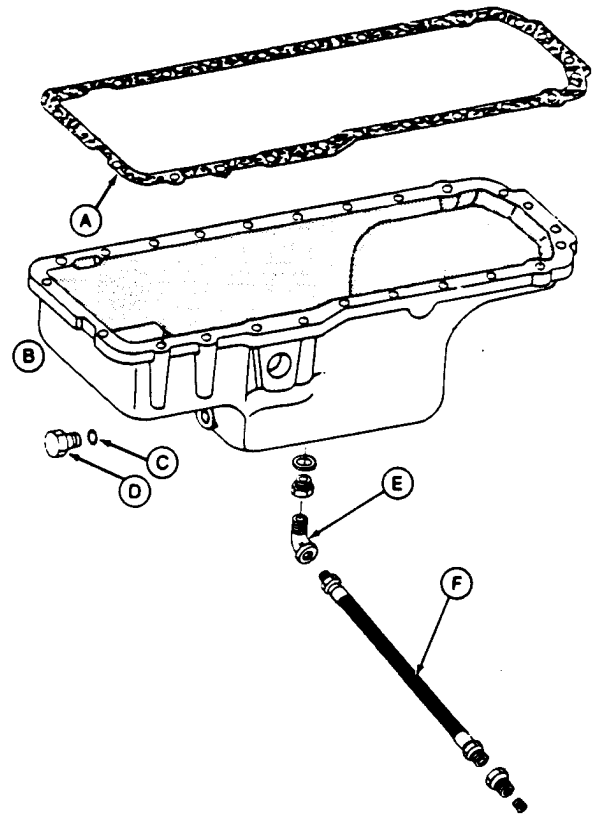
RG,CTM42,G20,24-19-22AUG91

-JUN-20AUG91
RG5923

INSTALL OIL PAN

Before installing oil pan, remove old gasket and sealant material from pan and cylinder block mating surfaces. Guide studs may be used if desired.

1. Apply a thin layer of PERMATEX AVIATION (Form-A-Gasket No. 3) across entire front and rear gasket rail of block. Install gasket (A) onto cylinder block and apply a layer of sealant to gasket across front and rear gasket face. If multi-piece gasket is used, apply sealant to mating joints. Install oil pan.
 2. Insert all cap screws in their appropriate hole location.
 3. Proceeding counterclockwise from flywheel end (B), tighten all cap screws to 54 N·m (40 lb-ft).
 4. Repeat sequence by tightening all 3/8 in. cap screws to 68 N·m (50 lb-ft).
 5. Complete sequence by tightening counterclockwise all 1/2 in. cap screws to 156 N·m (115 lb-ft).
 6. Recheck torque on all 3/8 in. cap screws.
 7. Oil pan drain plug (D) uses either an aluminum washer or rubber O-ring (C) for sealing. Apply a light coat of engine oil to new rubber O-rings. Install aluminum washer on drain plug so raised center contacts head of plug.
- Some engines may be equipped with an elbow fitting (E) and drain hose (F).
8. Install drain plug and tighten to 101 N·m (75 lb-ft). Fill engine crankcase with correct engine oil.
 9. If equipped with elbow fittings and drain hose, the threads and sealing surfaces must be free of any oil film to insure an effective seal. Apply a light coat of LOCTITE 592 Pipe Sealant with TEFLON to fittings except for the leading one to three threads. Tighten fittings securely.



- A—Oil Pan Gasket
- B—Flywheel End
- C—O-Ring or Aluminum Washer
- D—Drain Plug
- E—Elbow Fitting
- F—Drain Hose

RG6669 -JUN-15/MAR93

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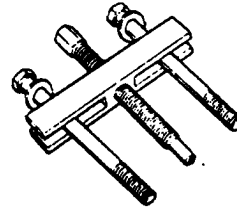
SPECIAL OR ESSENTIAL TOOLS

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

Push Puller D01206AA

Used to remove water pump impeller from water pump and to remove fan pulley from shaft pressed into water manifold. Also used with D01217AA to remove water pump drive gear from water pump.

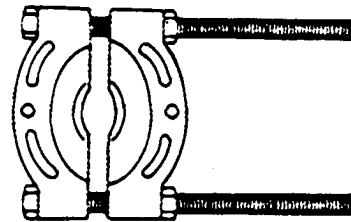


RG,CTM42,G25,33-19-10SEP91

-UN-23AUG88
RG5097

Bearing Puller* D01217AA

Used with D01206AA to remove water pump drive gear from water pump.



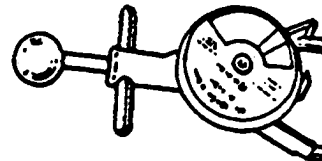
RG,CTM42,G25,34-19-10SEP91

-UN-06APR89
RG4981

* Part of D01212AA Step Plate Adapter Set

Belt Tension Gauge JDG529

Used to check and adjust fan belt tension.



S53,JDG529 -19-09SEP91

-UN-23AUG88
RG5082

Belt Tension Gauge JDST28

Used with a straightedge to check fan belt tension.

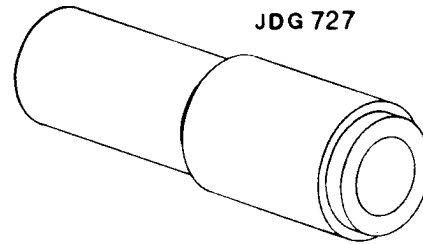


RG5588 -UN-13SEP89

RG,CTM61,G25,26-19-17MAR92

Bearing Driver JDG727

Used to remove and install water pump bearing assembly in water pump housing. Installs new bearing to the correct depth.



RG,CTM42,G25,35-19-10SEP91

RG5963 -JUN-03SEP91

OTHER MATERIAL

Name	Use
LOCTITE 515 (TY6304) Flexible Sealant	Water pump, thermostat cover and water manifold gaskets.
LOCTITE 242 (TY9370) Thread Lock and Sealer	Water outlet manifold-to-cylinder head cap screws.
LOCTITE 592 (TY9375) Pipe Sealant with TEFLON	Water pump, block, auxiliary water pump fittings, drain valves, and water bypass tube fitting.

RG,CTM82,G25,1 -19-12APR93

COOLING SYSTEM SPECIFICATIONS

ITEM	SPECIFICATION
Water Pump:	
Impeller Bore ID	15.849—15.875 mm (0.624—0.625 in.)
Shaft OD Impeller End	15.905—15.917 mm (0.626—0.627 in.)
Bearing Bore in Water Pump Housing	38.041—38.067 mm (1.498—1.499 in.)
Bearing OD	38.087—38.100 mm (1.499—1.500 in.)
Drive Gear Bore ID	18.90—18.92 mm (0.744—0.745 in.)
Shaft OD Drive Gear End	18.948—18.960 mm (0.746—0.747 in.)
Water Pump Seal Installed Height	10.16—10.42 mm (0.400—0.410 in.)
Impeller Installed Depth Below Gasket Surface	2.75—3.50 mm (0.108—0.138 in.)
Bearing Installed Depth Below Pump Housing Nose	6.75—7.00 mm (0.266—0.276 in.)
Thermostat Opening Temperature:	
89°C (192°F) Thermostat(s)	87—91°C (188—195°F)
Water Manifold Mounted, Fixed Fan Drive*:	
Shaft Installed Dimension From Manifold	
Mounting Face-to-End of Shaft	33.31—33.57 mm (1.311—1.322 in.)
Fan Pulley Bore ID	47.576—47.612 mm (1.8731—1.8745 in.)
Bearing OD (Pulley End)	47.612—47.625 mm (1.8745—1.8750 in.)
Shaft OD (Manifold End)	25.387—25.400 mm (0.9995—1.0000 in.)
Manifold Bore ID	25.336—25.362 mm (0.9975—0.9985 in.)
Standard V-Belt Tension Using JDG529 Gauge:	
Auxiliary Water Pump Belt:	
New Belts	178 N (40 lb _f)
Belts in Service (minimum 10-minutes use)	89—178 N (20—40 lb _f)
Fan/Alternator Belts**:	
New Belts	423—463 N (95—104 lb _f)
Belts in Service (minimum 10-minutes use)	378—423 N (85—95 lb _f)

* Specifications apply only to fan drives supplied by John Deere Factory. Refer to manufacturers specifications for other fan drives.

** Check tension on front belt only. Measure tension on long part of belt.

RG,CTM82,G25,2 -19-12APR93

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COOLING SYSTEM SPECIFICATIONS—CONTINUED

TORQUES

Water Pump-to-Cylinder Block Cap Screw	27 N·m (20 lb-ft)
Inlet Manifold Elbow-to-Cylinder Block	27 N·m (20 lb-ft)
Water Manifold-to-Cylinder Head	60 N·m (45 lb-ft)
Thermostat Cover-to-Water Manifold	47 N·m (35 lb-ft)
Water Pump Cover-to-Water Pump Housing	30 N·m (22 lb-ft)
Water Pump Drain Valve-to-Water Pump Cover	27 N·m (20 lb-ft)
Fan-to-Fan Pulley*	40 N·m (30 lb-ft)
Auxiliary Water Pump Bracket-to-Cylinder Block	102 N·m (75 lb-ft)
Auxiliary Water Pump-to-Bracket	41 N·m (30 lb-ft)

* Applies only to fans provided by the John Deere factory. See manufacturer's recommendations for torque specifications on OEM supplied fans.

RG,CTM82,G25,4 -19-12APR93

SERVICE EQUIPMENT AND TOOLS

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

Name	Use
D01217AA Bearing Pulling Attachment	Support gear during removal.
D01206AA Gear and Pulley Puller	Remove gear from water pump shaft.

RG,CTM42,G25,38-19-12APR93

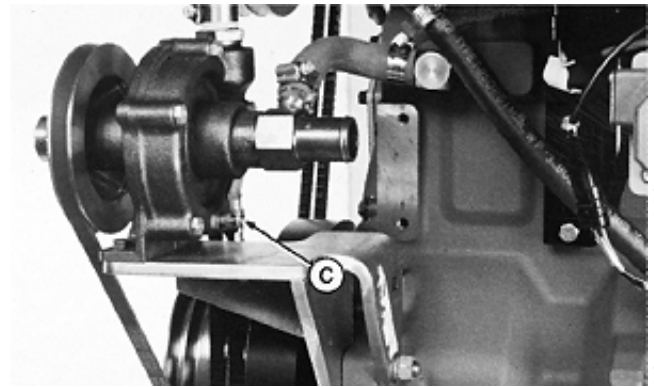
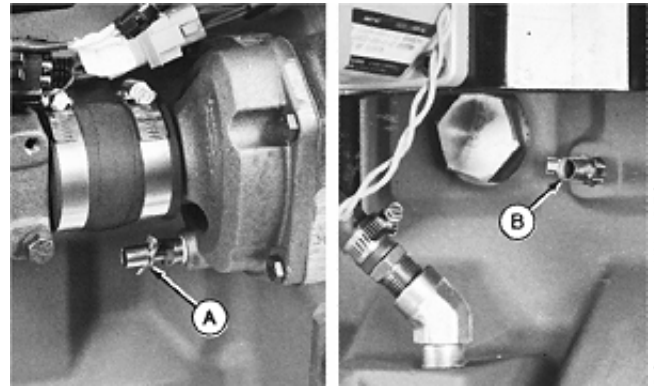
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REMOVE ENGINE WATER PUMP

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.

IMPORTANT: Water pump, block, and auxiliary water pump (if equipped) drain valves must be opened to completely drain both sides of the engine.

1. Open water pump drain valve (A), block drain valve (B), and auxiliary water pump drain valve (C) to drain coolant from engine.



RG,CTM82,G25,5 -19-12FEB93

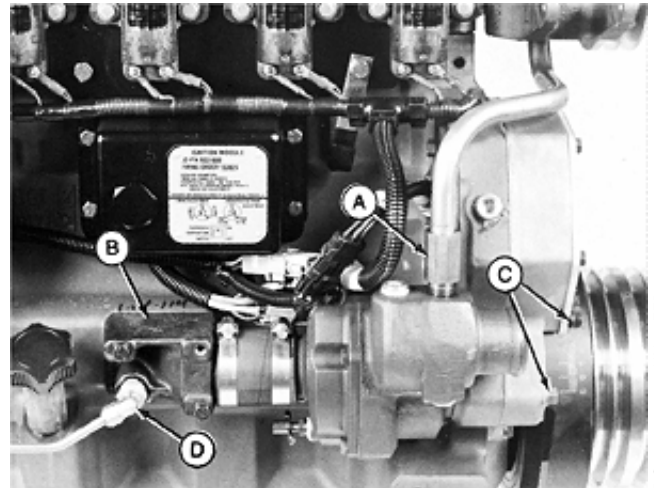
2. Remove fitting (A) and water bypass tube from water pump housing.

3. Remove turbocharger coolant supply line (D).

4. Remove water inlet manifold elbow (B) cap screws and water pump mounting cap screws (C).

NOTE: Oil dipstick may have to be removed to provide clearance for water pump removal. Rotate water pump inlet downward and lift inlet manifold elbow up between block and dipstick tube while sliding water pump to the rear. Some applications may be different.

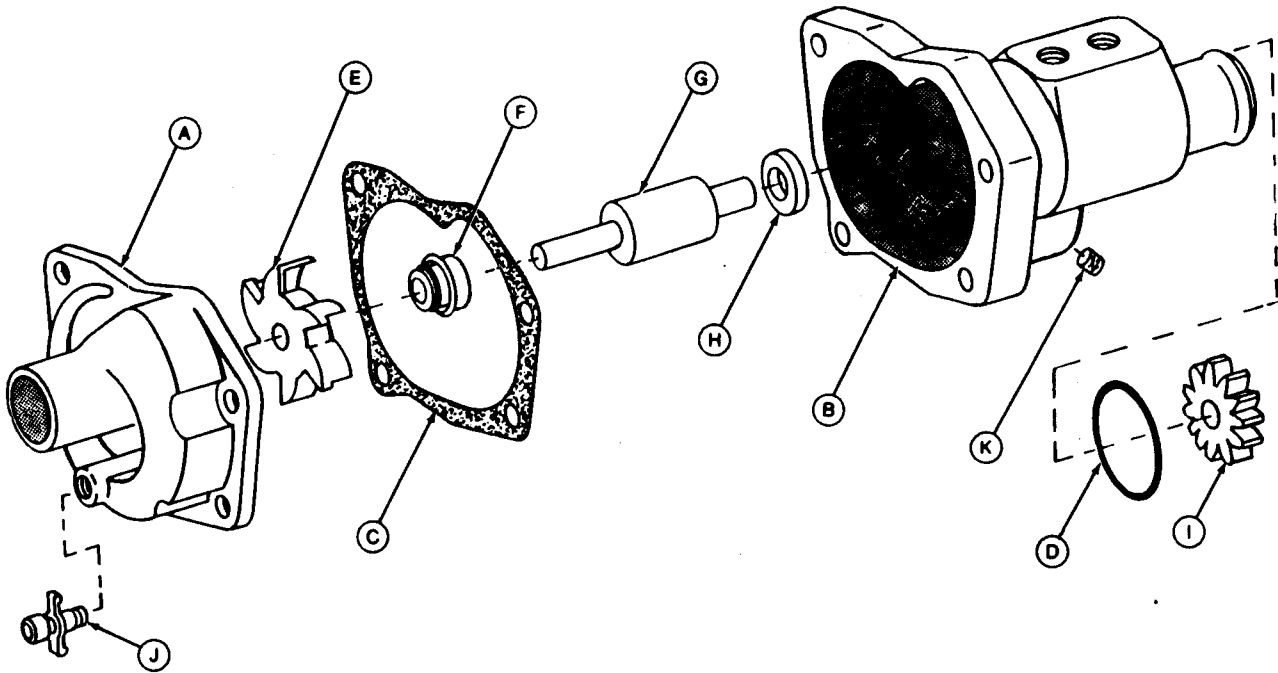
5. Slide water pump nose out of cylinder block flange bore. Remove O-ring.



A—Water Bypass Tube Fitting
 B—Water Inlet Manifold
 C—Water Pump Mounting Cap Screws
 D—Turbocharger Coolant Supply Line

RG,CTM82,G25,6 -19-23FEB93

DISASSEMBLE ENGINE WATER PUMP



A—Cover
B—Housing
C—Gasket

D—O-Ring
E—Impeller
F—Seal (Water Pump)

G—Bearing
H—Seal (Oil)
I—Drive Gear

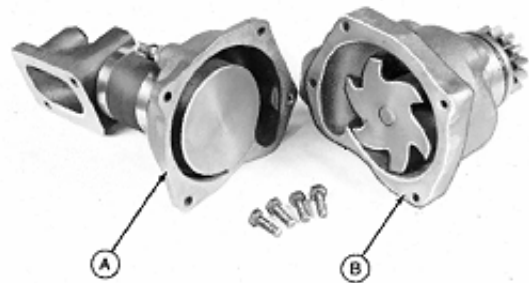
J—Drain Valve
K—Weep Hole Filters (2 used)

RG,CTM42,G25,13-19-23FEB93

RG5847 -JUN-13AUG91

1. Remove four cap screws and remove cover (A) from housing (B).

2. Remove and discard gasket. Scrape all gasket material from cover and housing face.

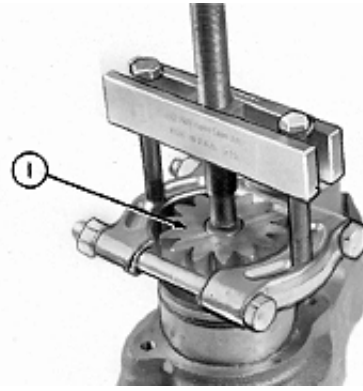


RG,CTM42,G25,14-19-12SEP91

RG5851 -JUN-13AUG91

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3. Remove the water pump gear (I) by supporting the back side of the gear with D01217AA Bearing Puller and using D01206AA Puller to pull the gear off of the bearing shaft.



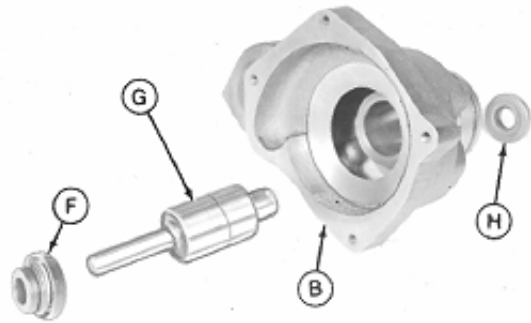
RG,CTM42,G25,16-19-12SEP91

RG5840 -UN-13AUG91

4. Roll oil seal lip (H) using a punch and hammer. Using needle nose pliers, remove and discard oil seal.

5. Using a press, remove bearing (G), water pump seal (F), and impeller (not shown). Support pump housing (B) on gasket surface so that impeller will clear the supports and press on the outer race of the bearing from the gear end with JDG727 Bearing Driver. Discard bearing, seal, and impeller.

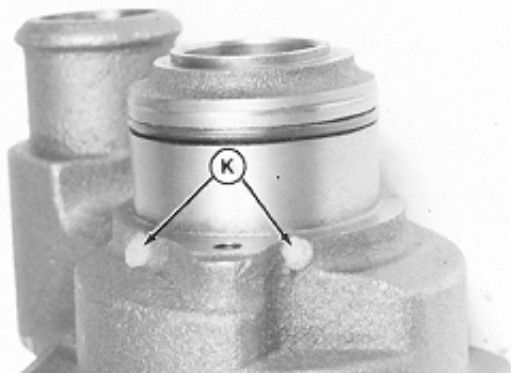
NOTE: It is not recommended that bearing and impeller be reused once they have been removed from the water pump. A new bearing, water pump seal, and impeller are provided in water pump overhaul kit.



RG,CTM42,G25,17-19-29OCT92

RG5841 -UN-13AUG91

6. Remove and discard foam weep hole filters (K).



RG,CTM42,G25,36-19-12SEP91

RG5842 -UN-13AUG91

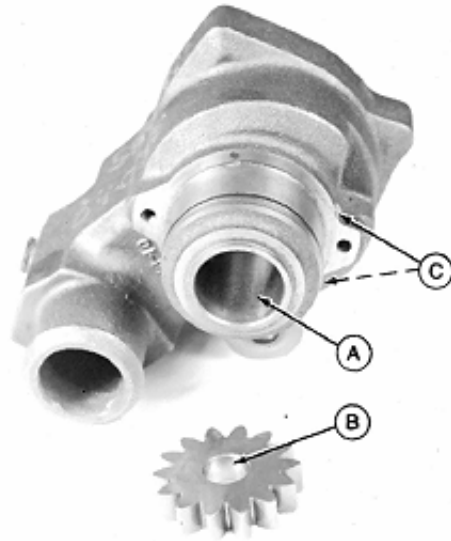
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7

INSPECT WATER PUMP PARTS

1. Measure water pump housing bore ID (A) and drive gear ID (B). Replace parts if worn, damaged, cracked, or not within specifications.

WATER PUMP SPECIFICATIONS

Impeller Bore ID	15.849—15.875 mm (0.624—0.625 in.)
Shaft OD Impeller End	15.905—15.917 mm (0.626—0.627 in.)
Bearing Bore in Water Pump Housing	38.041—38.067 mm (1.498—1.499 in.)
Bearing OD	38.087—38.100 mm (1.499—1.500 in.)
Drive Gear Bore ID	18.90—18.92 mm (0.744—0.745 in.)
Shaft OD Drive Gear End	18.948—18.960 mm (0.746—0.747 in.)
Water Pump Seal Installed Height	10.16—10.42 mm (0.400—0.410 in.)
Impeller Installed Depth Below Gasket Surface	2.75—3.50 mm (0.108—0.138 in.)
Bearing Installed Depth Below Pump Housing Nose	6.75—7.00 mm (0.266—0.276 in.)



2. Clean gear and housing with clean solvent and dry with compressed air.

3. Inspect water pump housing for debris, cracks, or damage. Be sure the “weep holes” in the housing are cleaned and foam filters (C) are removed from weep holes while pump is disassembled.

NOTE: Make sure all gasket material is removed from pump.

RG5843 -UN-13AUG91

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RG,CTM82,G25,18-19-23FEB93

ASSEMBLE ENGINE WATER PUMP

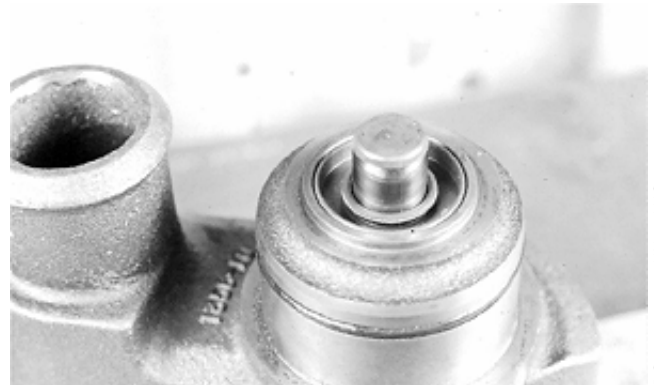
IMPORTANT: When installing water pump bearing into housing, press only on outer bearing race. Do NOT press on bearing shaft as this will damage the bearing.

1. Support pump housing on gasket surface. Using JDG727 Bearing Driver, press a new bearing into drive gear end of pump housing until outer race is 6.75—7.00 mm (0.266—0.276 in.) below nose of housing. Press only on outer race. Bearing driver will bottom against nose of housing, leaving bearing at correct depth.

2. Apply a light film of clean engine oil to the drive gear end of shaft and to the oil seal lip. Install the new oil seal with spring loaded lip facing outward toward gear end of bearing shaft. Seal should be installed flush with housing nose.



-UN-13AUG91
RG5844

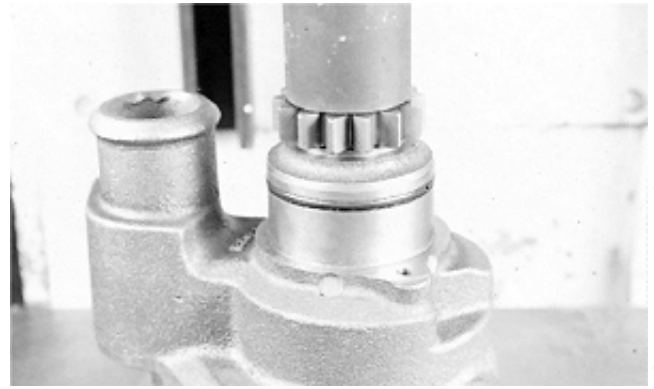


-UN-13AUG91
RG5845

RG,CTM42,G25,19-19-23FEB93

IMPORTANT: When installing drive gear, support impeller end of shaft so pressing load is transmitted through the shaft. Bearing damage will result if load is transmitted through the outer bearing race.

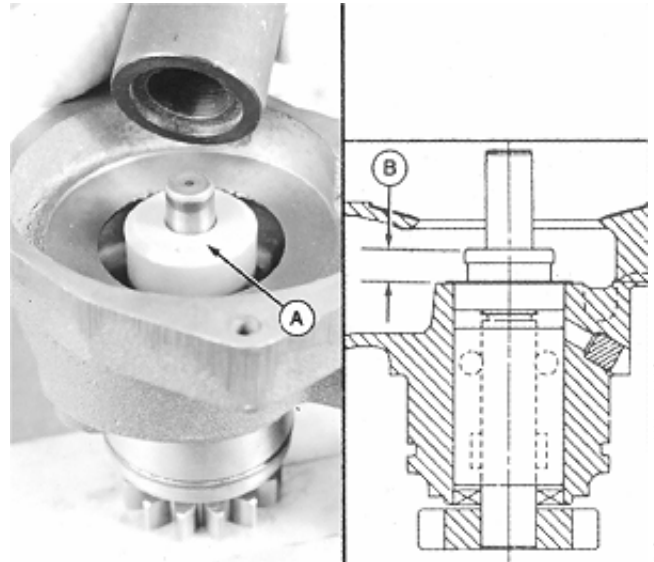
3. Support water pump on impeller end of bearing shaft. Press drive gear onto shaft until gear is flush with end of shaft.



RG5846 -JUN-13AUG91

IMPORTANT: When installing water pump seal, support drive gear end of shaft so pressing load is transmitted through the shaft.

4. Support water pump on gear end of bearing shaft and use R113749 Seal Driver (A) (supplied with water pump overhaul kit) and JDG727 Water Pump Bearing Driver to install a new water pump seal. Seal height (B) should be 10.16—10.42 mm (0.400—0.410 in.) when properly installed. R113749 Seal Driver will install seal to proper height.

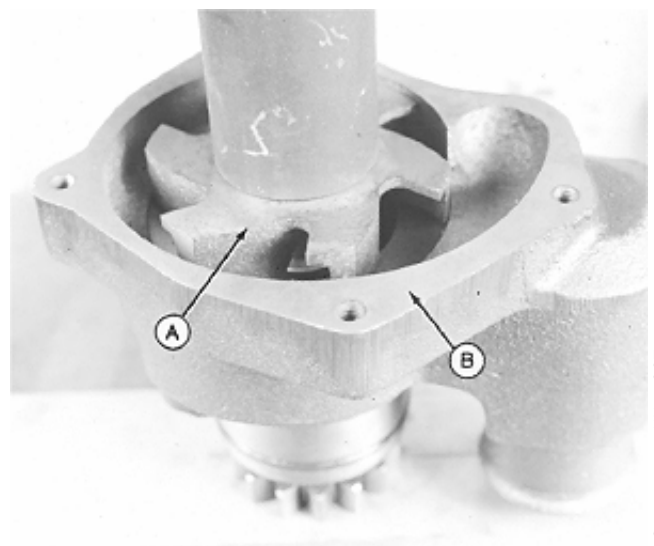


RG5848 -JUN-13AUG91

RG,CTM42,G25,37-19-04FEB93

IMPORTANT: When installing impeller, support drive gear end of shaft so pressing load is transmitted through the shaft. Bearing damage will result if load is transmitted through the outer bearing race.

5. Support water pump on gear end of bearing shaft and press new impeller (A) onto shaft until impeller face is 2.97—3.23 mm (0.117—0.127 in.) below gasket surface (B). Use straightedge and dial caliper from bottom of straightedge to impeller to measure depth specification. Pump impeller must rotate freely. Disassemble and correct problem if interference is felt.



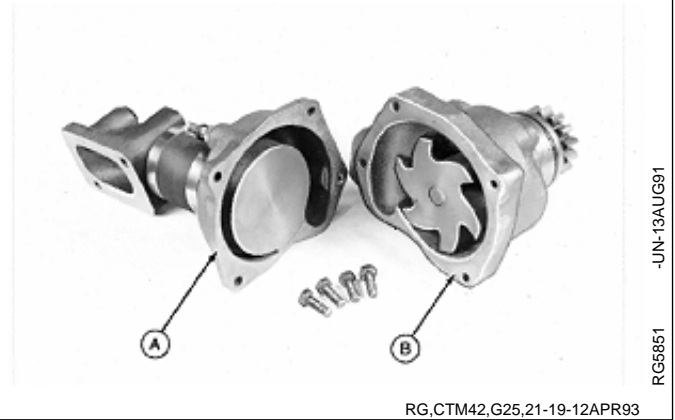
RG5849 -JUN-15OCT92

RG,CTM42,G25,20-19-29OCT92

6. Apply a coat of LOCTITE 515 Flexible Sealant to the gasket surfaces (A and B). Install a new gasket and pump cover. Tighten the four cover cap screws to 30 N·m (22 lb-ft).

7. If drain valve is removed, apply LOCTITE 592 Pipe Sealant to threads and tighten drain valve to 27 N·m (20 lb-ft).

8. Install new weep hole filters and a new O-ring on the pump housing pilot.



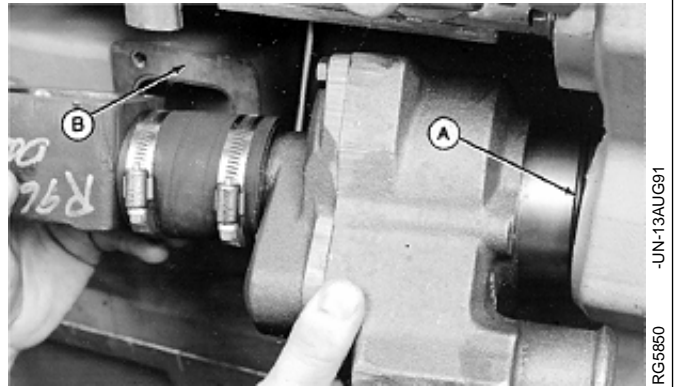
RG,CTM42,G25,21-19-12APR93

RG5851 -JUN-13AUG91

INSTALL ENGINE WATER PUMP

1. Apply a light coat of engine oil to water pump housing O-ring (A). Install pump into pilot bore in block making sure that pump drive gear properly meshes with camshaft gear.

2. Install a new gasket (B) between water inlet manifold elbow and cylinder block.



RG,CTM82,G25,19-19-12APR93

RG5850 -JUN-13AUG91

3. Install water pump mounting cap screws (C) and tighten to 27 N·m (20 lb-ft).

4. Install two 5/16 in. inlet manifold elbow cap screws and tighten to 27 N·m (20 lb-ft).

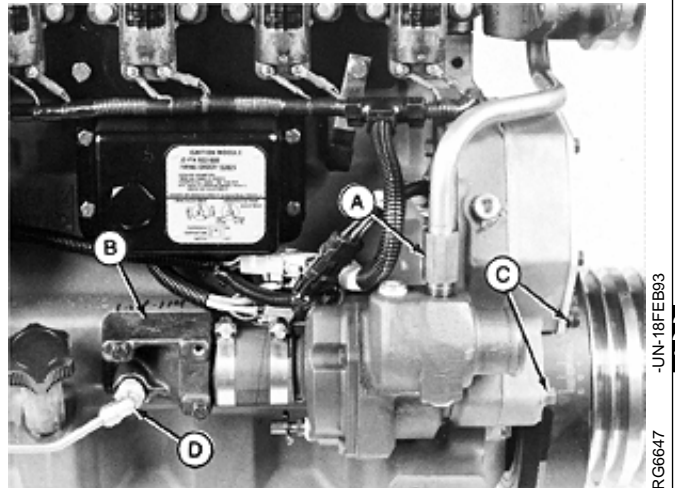
5. Install a new O-ring into bore of water outlet manifold. Lubricate O-ring with engine oil and install bypass pipe into manifold bore.

6. Install new O-ring in water bypass tube fitting (A). Lubricate O-ring with engine oil and install fitting onto pump end of bypass pipe.

7. Apply LOCTITE 592 Pipe Sealant with TEFLON to fitting threads and screw fitting into water pump housing. Tighten securely.

8. Install J-clamp with "J" of clamp toward rear of engine on inside-upper timing wheel access cover cap screw.

9. Install turbocharger coolant supply line (D) into water inlet manifold (B). Tighten securely.



A—Water Bypass Tube Fitting
B—Water Inlet Manifold
C—Water Pump Mounting Cap Screw
D—Turbocharger Coolant Supply Line

RG,CTM82,G25,7 -19-12APR93

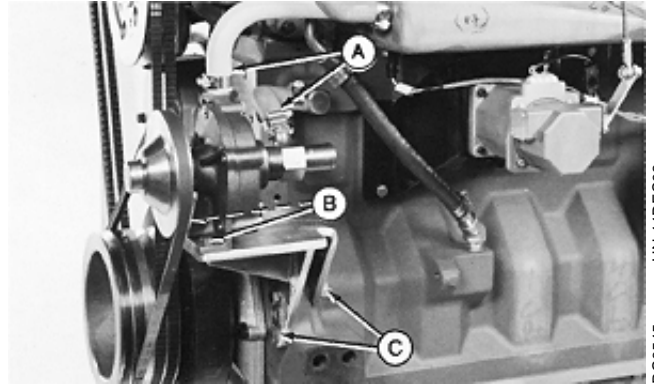
RG6647 -JUN-18FEB93

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REMOVE AND INSTALL AUXILIARY WATER PUMP—IF EQUIPPED

⚠ CAUTION: Explosive release of fluids from pressurized cooling system can cause serious burns. Do not drain coolant until coolant temperature is below operating temperature. Always loosen cooling system filler cap, radiator cap, or drain cock slowly to relieve pressure.

NOTE: Auxiliary water pump is used only on 150 kW (200 Hp) engines with separate circuit aftercooler and auxiliary heat exchanger.



-JUN-14DEC92
RG66545

1. Open block and auxiliary water pump drain valves. Drain coolant from engine and separate circuit heat exchanger.
2. Remove coolant hoses (A) from auxiliary water pump.
3. Loosen bracket cap screws (C) and remove belt.
4. Remove pump mounting cap screws (B) and remove pump.
5. Remove bracket cap screws and bracket (if necessary).
6. Install pump bracket on engine. Tighten cap screws to 102 N·m (75 lb-ft).
7. Install pump on bracket. Tighten cap screws to 41 N·m (30 lb-ft).
8. Install coolant hoses. Tighten hose clamps securely and close drain valves.
9. Install and tighten water pump belt.

AUXILIARY WATER PUMP BELT TENSION SPECIFICATIONS

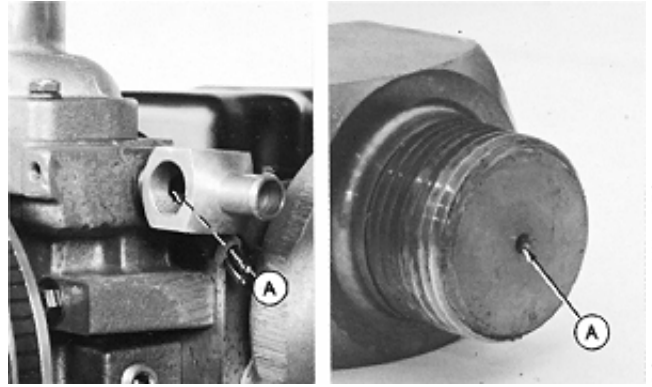
New Belt	178 N (40 lb _f)
Used Belt*	89—178 N (20—40 lb _f)

* 10 minutes use (minimum)

INSPECT AND CLEAN AFTERCOOLER ORIFICE FITTING

NOTE: Orifice fitting is used only on 150 kW (200 Hp) engines to bleed air from separate aftercooler circuit when filling cooling system.

1. Partially drain cooling system.
2. Remove aftercooler hose and heat exchanger hose.
3. Check orifice (A) for plugging or restriction. Orifice is 1.59 mm (0.063 in.) diameter. If plugged or restricted, use a small drill bit or wire to clean it out.
4. Install coolant hoses and refill cooling system with proper coolant.



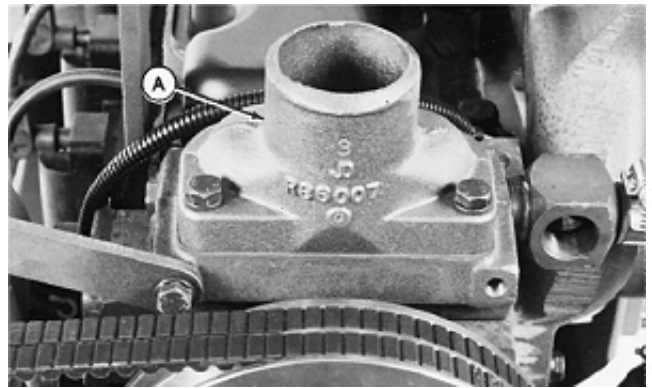
RG6546 -JUN-14DEC92

RG,CTM82,G25,15-19-12APR93

REMOVE AND TEST THERMOSTATS

⚠ CAUTION: Explosive release of fluids from pressurized cooling system can cause serious burns. Do not drain coolant until coolant temperature is below operating temperature. Always loosen cooling system filler cap, radiator cap, or drain cock slowly to relieve pressure.

1. Visually inspect the area around the water manifold for leaks. Partially drain coolant from the cooling system.
2. Remove thermostat cover (A).



RG6547 -JUN-14DEC92

RG,CTM82,G25,8 -19-12FEB93

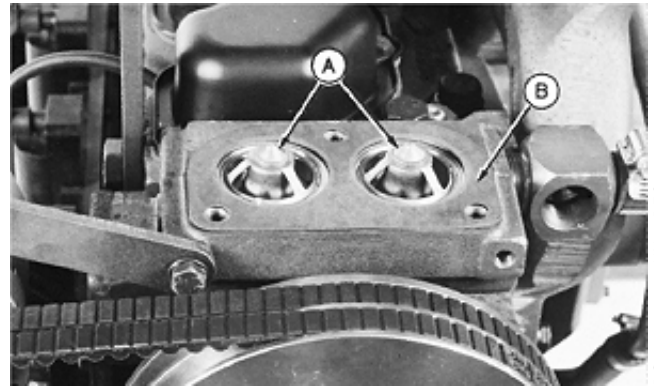
3. Remove thermostats (A). Discard gasket (B).

4. Inspect thermostats for debris or damage, and test each thermostat using an approved thermostat testing procedure. (See INSPECT THERMOSTAT AND TEST THERMOSTAT OPENING TEMPERATURE, in Group 105 for thermostat testing procedure.) Thermostats should start to open within the range specified.

THERMOSTAT OPENING TEMPERATURE SPECIFICATIONS

89°C (192°F) Thermostat(s) 87—91°C (188—195°F)

If either thermostat fails to open within this range, replace both thermostats.



RG6548 -JUN-14DEC92

RG,CTM82,G25,9 -19-04JUN93

INSTALL THERMOSTATS

1. Apply LOCTITE 515 Flexible Sealant on water manifold-to-thermostat cover mating surface.

NOTE: Install thermostats in thermostat housing first, then install gasket after thermostat is properly seated.

2. Install thermostats (A) and a new gasket (B).

3. Install cover and tighten cap screws to 47 N-m (35 lb-ft).



RG6549 -JUN-14DEC92

RG,CTM82,G25,10-19-12APR93

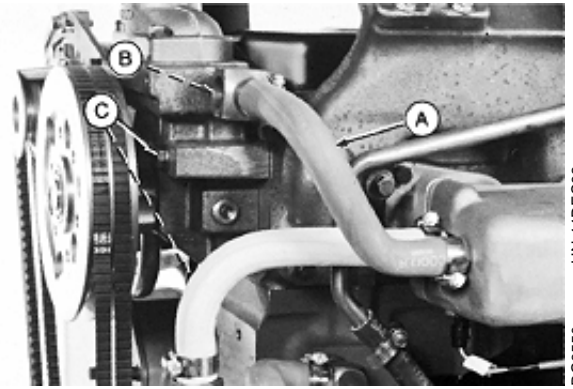
REMOVE WATER MANIFOLD

1. Remove alternator adjusting strap from water manifold and remove alternator. Remove alternator support bracket from side of water manifold.
2. Remove water manifold-to-aftercooler hose (A) and water manifold-to-auxiliary heat exchanger hose from fitting (B, shown removed).
3. Remove "J" clamp from bypass tube (E). Remove bypass tube from water pump fitting and remove other end tube from water manifold.
4. Remove three water manifold-to-cylinder head cap screws (C) and remove water manifold assembly.

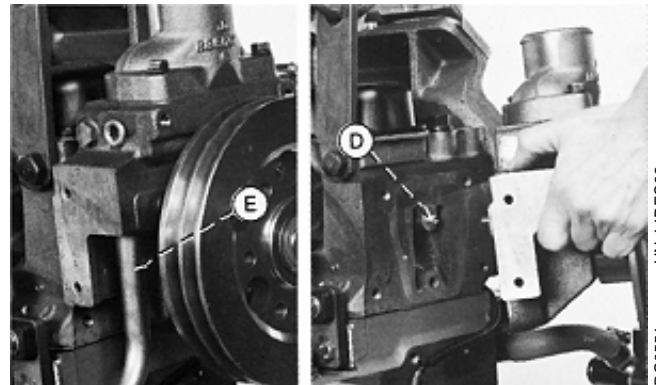
NOTE: Pull water manifold straight ahead (away from engine) approximately 6.4 mm (0.25 in.) to disengage from locator (spring) pin (D).

5. Remove and discard O-rings from bore of water manifold and from water pump fitting.

- A—Water Manifold-to-Aftercooler Tube
- B—Auxiliary Heat Exchanger Hose Fitting
- C—Cap Screws
- D—Locating Spring Pin
- E—Bypass Pipe



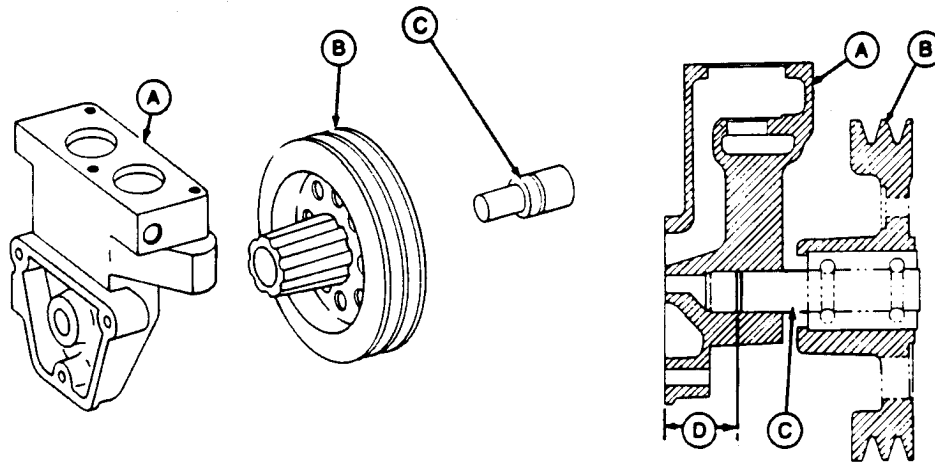
RG6650
-JUN-14DEC92



RG6651
-JUN-14DEC92

RG,CTM82,G25,11-19-12APR93

REPLACE BEARINGS IN WATER MANIFOLD MOUNTED, FIXED FAN DRIVE ASSEMBLY



RG6643 -JUN-18FEB93

A—Water Manifold

B—Fan Pulley

C—Bearing

D—Bearing Shaft Installed Dimension

1. Remove water manifold, if not previously done. See REMOVE WATER MANIFOLD, earlier in this group.
2. Support front face of water manifold (A) and use a press to push bearing (C) and pulley (B) out of manifold.
3. Support front face of fan pulley and push bearing out of pulley. Discard bearing.
4. Thoroughly inspect water manifold and pulley for cracks or damage. Measure parts and compare readings with specifications given below. Replace parts as necessary.

IMPORTANT: Support fan pulley on a flat, firm surface and press on bearing outer race to prevent damage to the bearing.

5. Install new bearing into pulley until outer race bottoms in bore of pulley. End of shaft will extend through bearing stop.

IMPORTANT: Support water manifold on machined mounting surface and press on inner shaft to prevent damage to the bearing.

6. Press bearing shaft into water manifold until end of shaft is 33.31—33.47 mm (1.311—1.318 in.) from manifold mounting surface (D). Hold water manifold firmly and turn fan pulley by hand to assure bearings rotate freely.

7. Install water manifold. (See INSTALL WATER MANIFOLD, later in this group.)

WATER MANIFOLD MOUNTED, FIXED FAN DRIVE SPECIFICATIONS

Shaft OD	25.387—25.400 mm (0.9995—1.0000 in.)
Bearing OD	47.612—47.625 mm (1.8745—1.8750 in.)
Pulley ID	47.576—47.612 mm (1.8731—1.8745 in.)
Manifold ID	25.336—25.362 mm (0.9975—0.9985 in.)
Shaft Installed Dimension from Manifold Mounting Face-to-End of Shaft	33.31—33.47 mm (1.311—1.318 in.)

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INSTALL WATER MANIFOLD

1. Install a new O-ring into water manifold and water pump fitting bores. Lubricate O-rings with grease to ease bypass pipe installation. Install bypass pipe (E) into bore of water manifold, be careful not to cut O-ring.

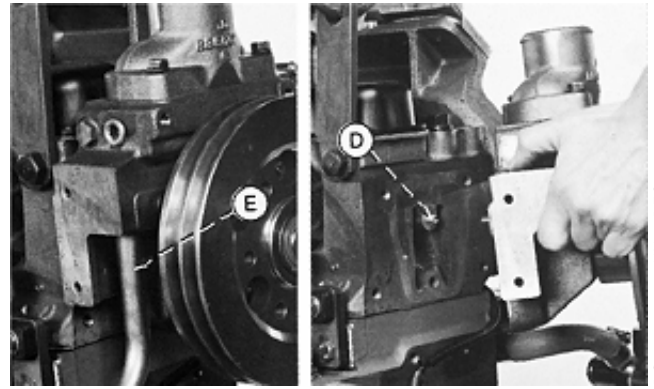
2. Using LOCTITE 515 Flexible Sealant and a new gasket, install water manifold assembly. Be sure water manifold is properly positioned on spring pin (D, in front face of cylinder head) and that bypass pipe is fully seated in water manifold and water pump fitting bores.

3. Apply LOCTITE 242 Thread Sealer to water manifold-to-cylinder head cap screw (C) threads 360 degrees (except for the leading one to three threads). Tighten water manifold cap screws to 61 N·m (45 lb-ft).

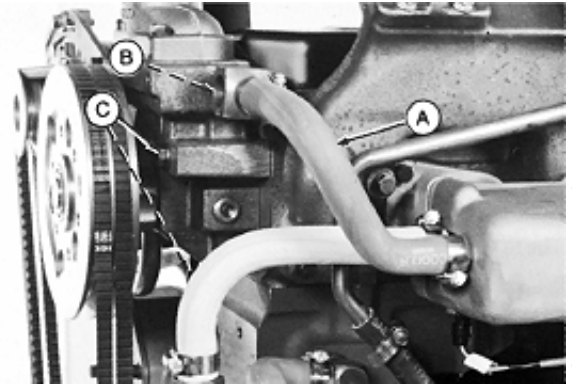
4. Install bypass pipe "J" clamp to inside-upper ignition timing wheel access cover cap screw and tighten to 27 N·m (20 lb-ft).

5. Install water manifold-to-aftercooler hose (A) and water manifold-to-auxiliary heat exchanger hose to fitting (B, shown removed).

- A—Water Manifold-to-Aftercooler Tube
- B—Auxiliary Heat Exchanger Hose Fitting
- C—Cap Screws
- D—Locating Spring Pin
- E—Bypass Pipe



-UN-14DEC92
RG6551

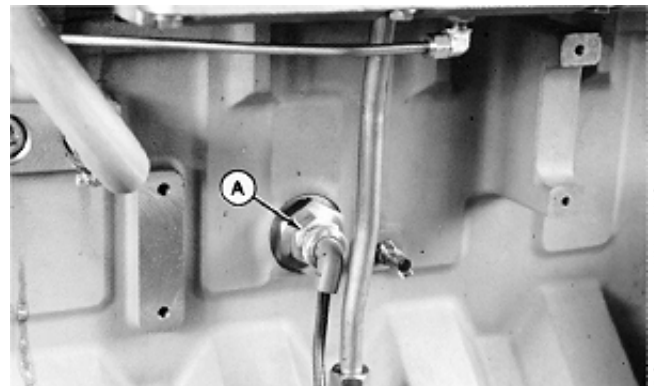


-UN-14DEC92
RG6550

RG,CTM82,G25,12-19-12APR93

REMOVE COOLANT HEATER—IF EQUIPPED

1. Unplug heater (A) from electrical power source.
2. Drain cooling system.
3. Remove electrical cord, loosen nut, and pull heater element out of block.



-UN-30AUG91
RG5948

RG,CTM42,G25,29-19-29OCT92

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.

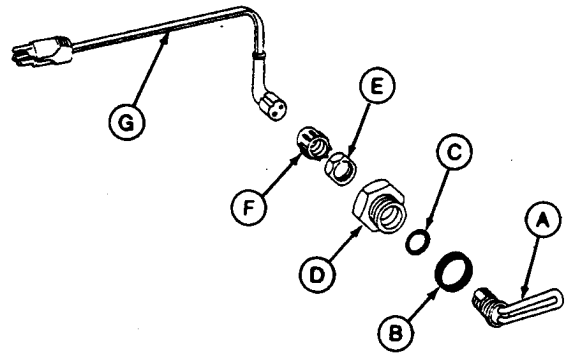
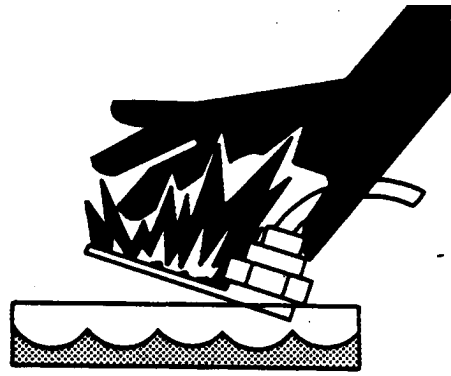
Only plug coolant heater into electrical power if heater element is immersed in coolant. Sheath could burst and result in personal injury.

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 groove of flange nut (D). Install 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

RG.CTM42.G25.30-19-05MAY93

-UN-23AUG88
TS210

-UN-14DEC88
RG5275

COMPLETE FINAL ASSEMBLY

NOTE: Consult your engine operator's manual or see Group 02 of this CTM for coolant recommendations.

IMPORTANT: Air must be expelled from cooling system when system is refilled. Loosen temperature sending unit fitting at rear of cylinder head, bleed plug or petcock at top front of cylinder head, and plug in thermostat housing to allow air to escape when filling system. Retighten fitting or plug when all the air has been expelled.

1. Fill cooling system to proper level with the proper coolant. (See ENGINE COOLANT REQUIREMENTS in Group 02.)
2. Start engine and run for several minutes to check for leaks in the cooling system.
3. After belts cool, check belt tension.

RG,CTM82,G25,13-19-12APR93

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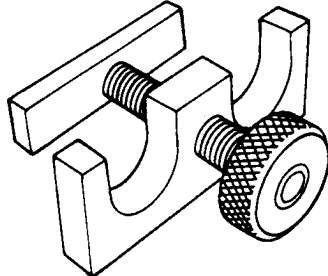
SPECIAL OR ESSENTIAL TOOLS

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

Sealing Ring Compression Tool JDG683

Used to compress aftercooler sealing ring for cover-to-intake manifold alignment during assembly.



RG5571 -UN-04JUL89

RG,JDG683 -19-09SEP91

OTHER MATERIAL

Name	Use
PT569 NEVER-SEEZ Compound	Exhaust manifold cap screws, turbocharger-to-exhaust manifold cap screws, and aftercooler cover-to-intake manifold cap screws.
LOCTITE 592 (TY9374/TY9375) Pipe Sealant with TEFLON	Turbocharger oil supply and drain lines, and coolant supply and drain lines.

RG,CTM82,G30,1 -19-04FEB93

AIR INTAKE AND EXHAUST SYSTEM SPECIFICATIONS

ITEM	SPECIFICATION
Total Indicator Reading Limits:	
Radial Bearing Clearance	0.08—0.15 mm (0.003—0.006 in.)
Bearing End Play	0.03—0.10 mm (0.001—0.004 in.)
Exhaust Adapter End Play	1.59 mm (0.063 in.)

RG,CTM82,G30,2 -19-12APR93

AIR INTAKE AND EXHAUST SYSTEM SPECIFICATIONS—CONTINUED

TORQUES

Compressor Housing-to-Center Housing	15.3—18.7 N·m (11—14 lb-ft) (135—165 in.-ft)
Turbine Housing-to-Center Housing	15.8—19.2 N·m (11—14 lb-ft) (140—170 in.-ft)
Turbocharger-to-Exhaust Manifold	24 N·m (18 lb-ft)
Exhaust Elbow-to-Exhaust Manifold	24 N·m (18 lb-ft)
Exhaust Adapter V-Band Clamp	20 N·m (15 lb-ft)
Heat Shield-to-Cylinder Head	34 N·m (25 lb-ft)
Exhaust Manifold-to-Cylinder Head	47 N·m (35 lb-ft)
Intake Manifold-to-Cylinder Head	47 N·m (35 lb-ft)
Aftercooler Cover-to-Intake Manifold	34 N·m (25 lb-ft)
Aftercooler Intake Adapter-to-Aftercooler Cover	27 N·m (20 lb-ft)
Throttle Valve-to-Aftercooler Intake Adapter	27 N·m (20 lb-ft)
Intake Coupling-to-Throttle Valve (4 psi system)	15 N·m (11 lb-ft)
Carburetor-to-Throttle Valve (20 psi system)	15 N·m (11 lb-ft)
Throttle Valve Support Strap-to-Intake Manifold	15 N·m (11 lb-ft)
Aftercooler Coolant Inlet and Outlet Hose Clamps	4 N·m (35 lb-in.)
Intake Hose Clamps	9—13 N·m (7—10 lb-ft) (80—115 lb-in.)

RG.CTM82,G30,21-19-07JUN93

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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 turbocharger's spinning shaft and bearings, it also carries away heat. When oil flow stops or is reduced, heat is immediately transferred from the hot turbine wheel to the bearings, which are also heating up because of the increased friction due to the lack of oil. This combination causes the turbocharger shaft temperature to increase rapidly.

If oil flow does not increase and the process continues, bearings will fail. Once the bearings fail (which can happen in just seconds) seals, shaft, turbine and compressor wheels can also be damaged.

The principle causes of turbocharger bearing lubrication problems are low oil pressure, a bent, plugged or undersized oil lube supply line, plugged or restricted oil galleries in the turbocharger, or improper machine start-up and shutdown procedure.

Oil levels and pressure should always be closely monitored and all worn hoses and lines should be replaced. The turbocharger oil supply line should be checked frequently to make sure it is not kinked or bent and it should always be replaced with a line of equal size, length and strength.

The easiest way to damage a turbocharger is through improper start-up and shutdown procedures. Always idle the engine for at least 30 seconds (no load) after start-up and before shutdown. Warming the engine up before applying a load allows oil pressure to build up and lines to fill with oil.

Idling the engine before shutdown allows the engine and turbocharger to cool. "Hot" shutdowns can cause the turbocharger to fail because after high-speed operation the turbocharger will continue to rotate long after the engine has been shut off and oil pressure has dropped to zero. This will cause heat to build up and possible bearing damage. It can also cause carbon and varnish deposits to form.

S55,3005,F -19-04JUN93

• **Oil Contamination**

A second cause of turbocharger failures is contaminated oil. It can be caused by a worn or damaged oil filter or not changing the lube oil at recommended intervals. Expecting the oil filter to remove dirt, sand, metal chips, etc. from the oil before they reach the engine or turbocharger can be a costly mistake because contaminated oil may completely bypass the engine oil filter if the oil filter or oil cooler is clogged, if the filter element is improperly installed, or if the oil is thick during cold weather.

Four good ways of avoiding oil contamination are:

- Always inspect the engine thoroughly during major overhaul. Look especially for any sludge or debris left in lube oil galleries.
- Change lube oil at recommended intervals. Analysis of oil samples at filter change periods can help identify potentially harmful contaminants in the oil.
- Clean the area around the oil fill cap before adding oil.
- Use a clean container when adding oil.

S11,3005,MK -19-04JUN93

• **Ingestion of Foreign Objects**

The third cause of turbocharger damage is the ingestion of foreign objects. Foreign objects or particles can be ingested and cause damage to the turbocharger on both compressor and turbine sides. This is easy to avoid.

On the compressor side, foreign objects usually take the form of dust, sand, or shreds of air cleaner element that enter through improperly installed air cleaner elements. Leaky air inlet piping (loose clamps or torn rubber joints) or torn pleats in dry-type air cleaner elements also create problems.

The result is erosion of compressor blades that can cause the delicately balanced wheel to wobble.

IMPORTANT: Whenever an internal engine failure (valve, valve seat, piston) occurs, a thorough inspection of the turbocharger MUST BE performed before returning engine to service.

S11,3005,ML -19-04JUN93

• **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 leads to longer turbocharger life.

RG,CTM8,G30,R1 -19-04JUN93

- **Abnormally High Exhaust Temperatures**

A fifth cause of turbocharger damage is abnormally high exhaust temperatures. Elevated exhaust temperatures cause coking of oil which can lead to bearing failure. Extreme over-temperature operation can cause wheel burst.

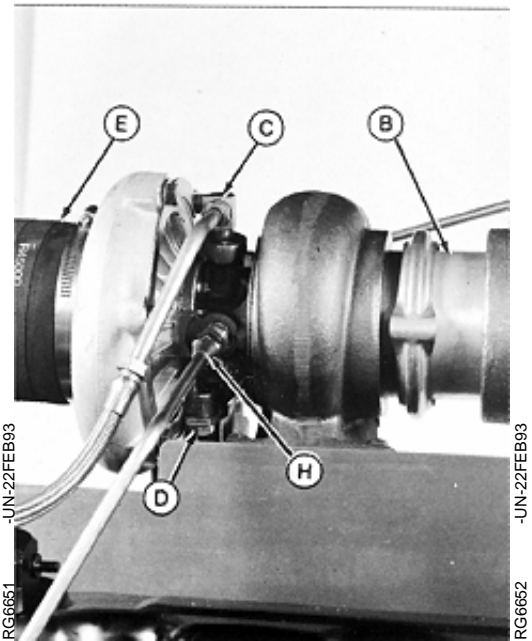
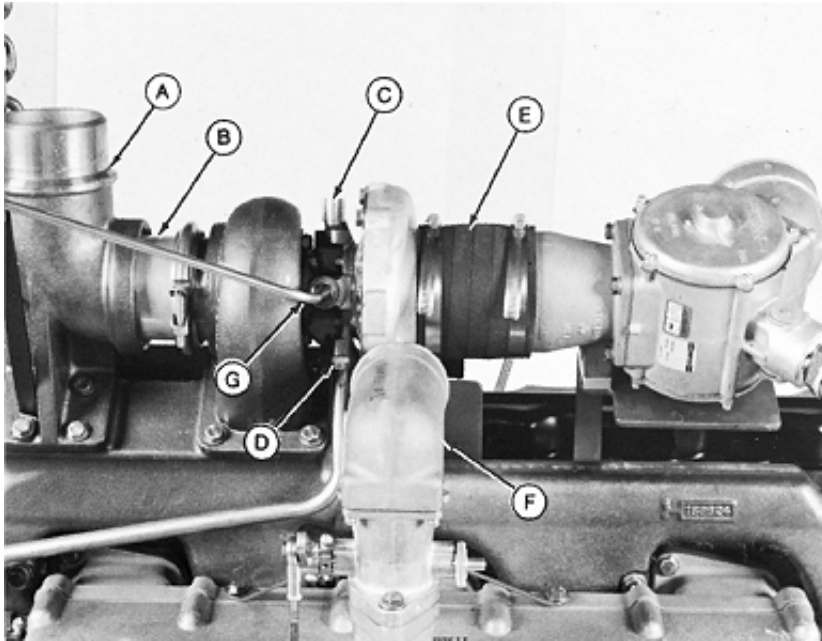
Over-temperature on a natural gas engine can result from a rich air/fuel mixture, overpowering the engine, or restricted air flow. With a rich air/fuel mixture or restricted air flow, the engine is burning more fuel than necessary to produce the desired power level. The excess energy exits through the exhaust system in the form of heat.

6076 Natural gas engines are lean-burn engines, so more air than necessary is available for combustion. Higher efficiency and lower exhaust temperatures will result with a leaner air/fuel mixture. The turbocharger center housing on natural gas engines is water-cooled to protect the turbocharger bearings from extreme exhaust temperatures.

If over-temperature operation is identified, check air inlet and exhaust systems, coolant lines, engine load, air/fuel adjustment, and ignition timing.

RG,CTM82,G30,4 -19-16FEB93

REMOVE TURBOCHARGER



A—Exhaust Elbow
B—Exhaust Adapter

C—Oil Inlet Line
D—Oil Return Tube

E—Air Intake Hose
F—Intake Coupling

G—Coolant Return Line
H—Coolant Inlet Line

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

Thoroughly clean exterior of turbocharger and surrounding area to prevent entry of dirt into the air intake system during removal.

IMPORTANT: When cleaning turbocharger, do not spray directly into compressor cover or turbine housing. If turbocharger inspection is required, do not clean exterior prior to removal. Doing so may wash away evidence of a potential failure mode. (See **TURBOCHARGER SEVEN STEP INSPECTION**, later in this group.)

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. Partially drain cooling system.

2. Remove band clamp from exhaust adapter (B). Remove air intake hose (E) from turbocharger compressor housing inlet.
3. Disconnect coolant inlet (H) and return (G) lines, oil inlet line (C), and return tube (D). Discard gasket.
4. Remove intake coupling (F, on 4 psi system) or carburetor (on 20 psi system). (See **REMOVE AND INSTALL 20 PSI CARBURETOR**, in Group 35.)
5. Remove four turbocharger mounting cap screws with washers and lift turbocharger from exhaust manifold.
6. Remove exhaust adapter from exhaust elbow (A).
7. Cap or plug all exhaust and intake manifold openings.
8. Place turbocharger on a clean flat table. Perform turbocharger seven-step inspection, as described later, if failure mode has not been determined.

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TURBOCHARGER FAILURE ANALYSIS

The following is a guide for diagnosing the cause of turbocharger failures after removal from the engine.

COMPRESSOR HOUSING INLET DEFECTS

Problem	Possible Cause	Suggested Remedy
Foreign Object Damage	Objects left in intake system.	Disassemble and inspect intake system for foreign objects (this group). Inspect engine for internal damage.
	Leaking and/or defective intake system.	Inspect air intake system connections including air filter; repair as required (this group). Inspect air intake related engine components.
Compressor Wheel Rub	Bearing failure.	Determine if engine and/or operator contributed to lack of lubrication, contaminated lubrication, excessive temperature, or debris generating engine failure in progress. Correct as required.
	Manufacturing defects.	Correct as required.

COMPRESSOR HOUSING OUTLET DEFECTS

Oil and/or Dirt in Housing	Restricted air intake system.	Inspect and clean air cleaner.
	Prolonged periods of low RPM engine idling.	Check with operator to confirm conditions. (See 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.
	Oil leaking from compressor housing seal.	Verify that oil is in compressor housing and refer to "Compressor Housing Outlet Defects" as listed earlier in this chart.
Center Wall Deteriorated	Excessive operating temperature.	Check for restricted air intake.
		Check engine for overfueling.
		Check ignition.

TURBINE HOUSING OUTLET DEFECTS

Problem	Possible Cause	Suggested Remedy
Turbine Wheel Rub	Bearing failure.	Determine if engine and/or operator contributed to lack of lubrication, contaminated lubrication, excessive temperature, or debris generating engine failure in progress. Correct as required.
	Manufacturing defect.	Correct as required (this group).
Foreign Object Damage	Internal engine failure.	Inspect and repair engine as required.
	Objects left in intake system.	Disassemble and inspect air intake system, (this group).
	Leaking air intake system.	Correct as required, (this group).
Oil and/or Excessive Carbon	Internal engine failure.	Verified by oil in turbine housing. Correct as required.
	Turbine seal failure.	Inspect for excessive heat from overfueling and/or restricted air intake.
	Prolonged periods of low RPM engine idling.	Verify with operator to run engine under load or a higher 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).
	Defective gasket.	Verify that leaks are not occurring at gasket joints.
Leaks from Joints	Loose attaching screws.	Tighten to specifications in CTM, (this group).
	Defective gasket.	Inspect and repair as required.

INTERNAL CENTER HOUSING DEFECTS

Excessive Carbon Build up in Housing or on Shaft	Hot engine shut-down.	Review proper operation with operator as shown in Operator's manual.
	Excessive operating temperature.	Restricted air intake, air/fuel mixture too rich, overfueling, or mistimed engine.
	Restricted oil drain line.	Inspect and clean oil drain lines as required.
	Operating engine at high speeds & loads immediately after start-up.	Idle engine for a few minutes to allow oil to reach bearings before applying heavy loads.

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.

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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.

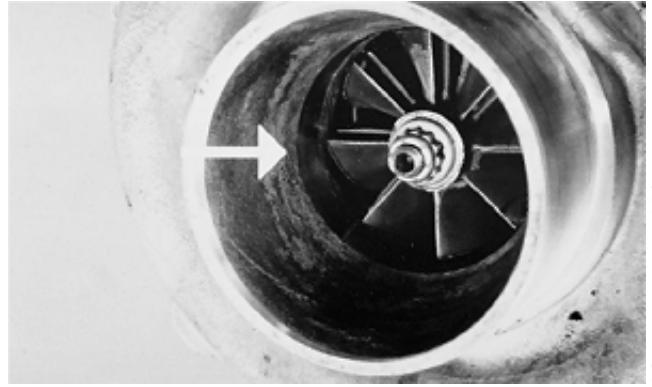


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NOTE: You will need a good light source for this check.

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.

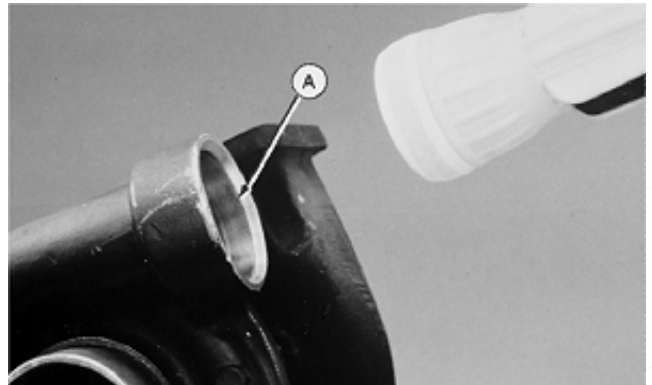


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Compressor Housing Outlet

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.



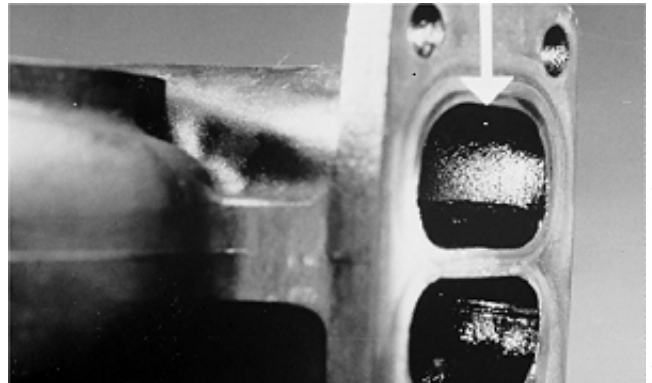
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Turbine Housing Inlet

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.



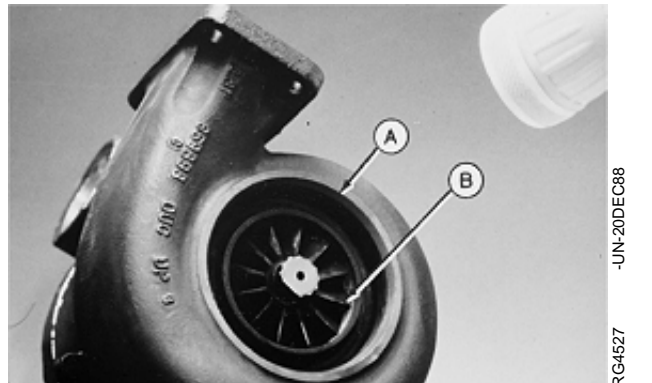
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Turbine Housing Outlet and Turbine Wheel

1. Use a flashlight to look up inside the turbine housing outlet (A) and check blades (B) for foreign object damage.



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2. Inspect the wheel blades and housing for evidence of wheel rub (arrow). Wheel rub can bend the tips of the blades with the housing showing wear or damage.



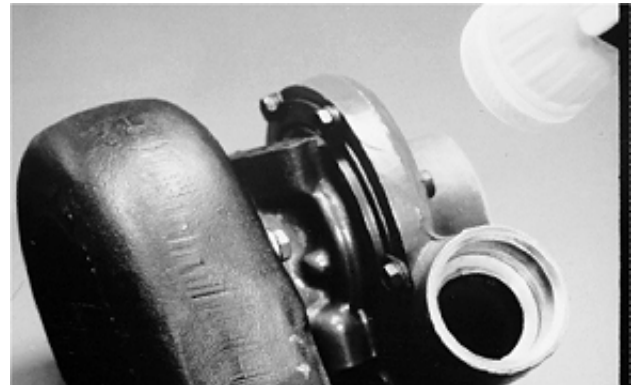
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External Center Housing and Joints

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.

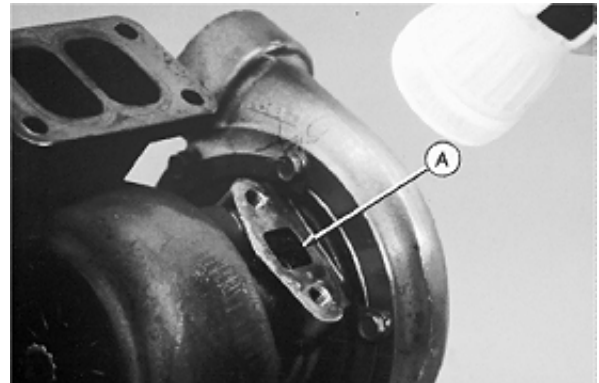


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Internal Center Housing

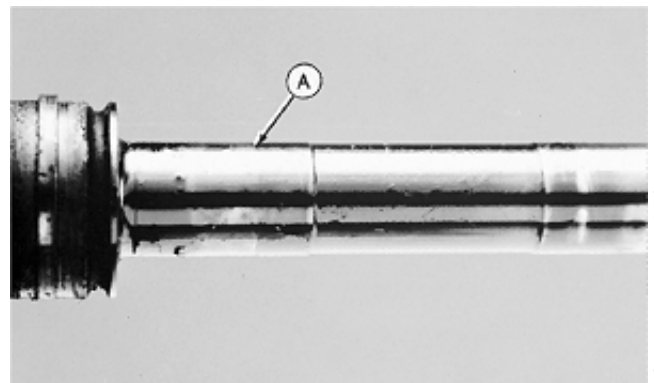
1. Using a flashlight, look through the oil return hole (A), to check the condition of the shaft and/or bearings. There should not be excess carbon deposits on the shaft or in the housing.



RG4530

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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.

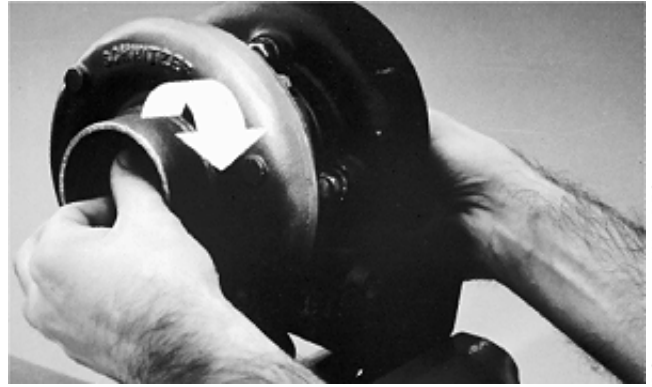


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Turbocharger Bench Test

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.

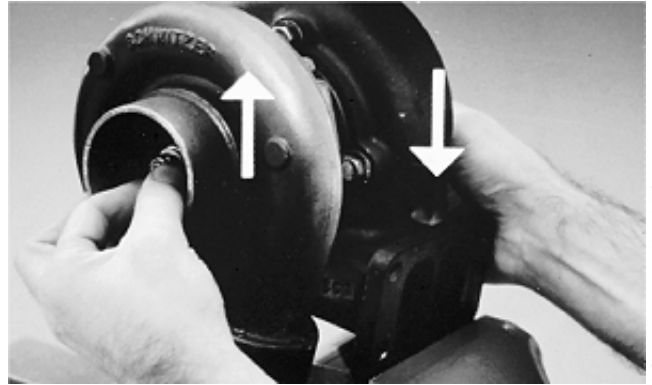


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3. Next, pull up on the compressor end of the shaft and press down on the turbine end while rotating shaft. Neither the compressor wheel nor the turbine wheel should contact the housing at any point.

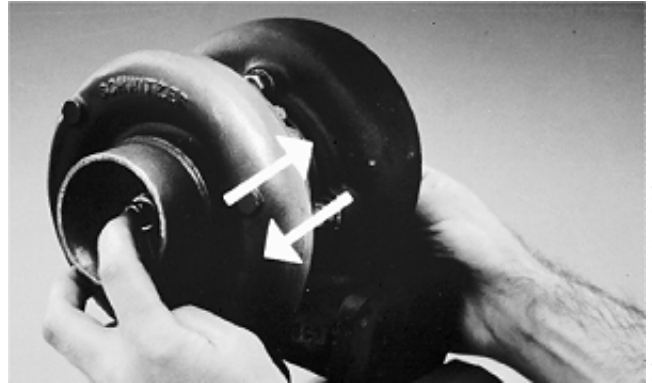
NOTE: There will be some "play" because the bearings inside the center housing are free floating.



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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.



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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.

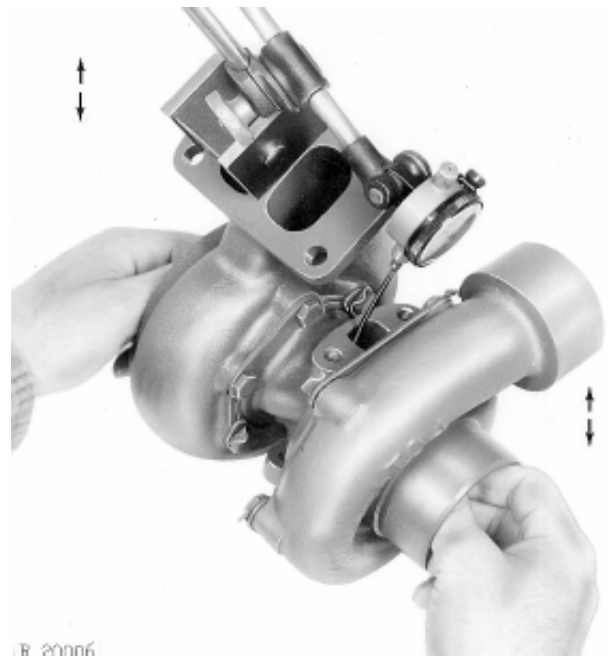
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PERFORM RADIAL BEARING CLEARANCE TEST

This test will give an indication of the condition of radial bearings within the center housing and rotating assembly.

1. Fasten a magnetic base (plunger-type) dial indicator to the turbocharger mounting base. Assemble an extension adapter and indicator extension rod onto dial indicator.
2. Position indicator tip (through 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 movement. Total indicator movement should be within 0.08—0.15 mm (0.003—0.006 in.)

If radial bearing clearance is not within specification, replace turbocharger. (See **REMOVE TURBOCHARGER**, earlier in this group and **INSTALL TURBOCHARGER**, later in this group.)



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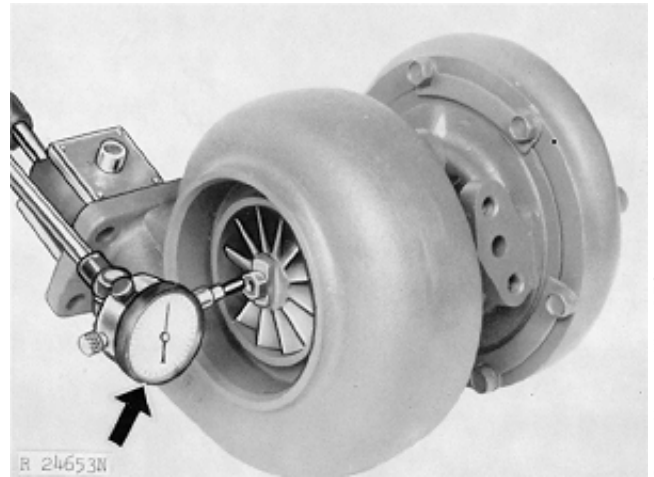
RG,CTM82,G30,9 -19-23FEB93

PERFORM AXIAL BEARING END PLAY TEST

This test will give an indication of the condition of the thrust bearing within the center housing and rotating assembly.

1. Mount magnetic base dial indicator (arrow) so indicator tip rests on flat surface on turbine end of shaft. Preload indicator tip and zero dial on indicator.
2. Move shaft axially back and forth by hand.
3. Observe and record total dial indicator movement. Total indicator movement should be within 0.03—0.10 mm (0.001—0.004 in.).

If axial bearing end play is not within specifications, replace turbocharger. (See REMOVE TURBOCHARGER, earlier in this group and INSTALL TURBOCHARGER, later in this group.)



RG,CTM82,G30,10-19-23FEB93

REPAIR TURBOCHARGER

AiResearch/Garrett turbochargers used on the engines covered in this manual are available through service parts as a complete assembly only, no individual repair parts are available.

IMPORTANT: Repairing a turbocharger center housing and rotating assembly requires specialized tooling and highly trained personnel and thus it is not recommended that the turbocharger be disassembled for repair.

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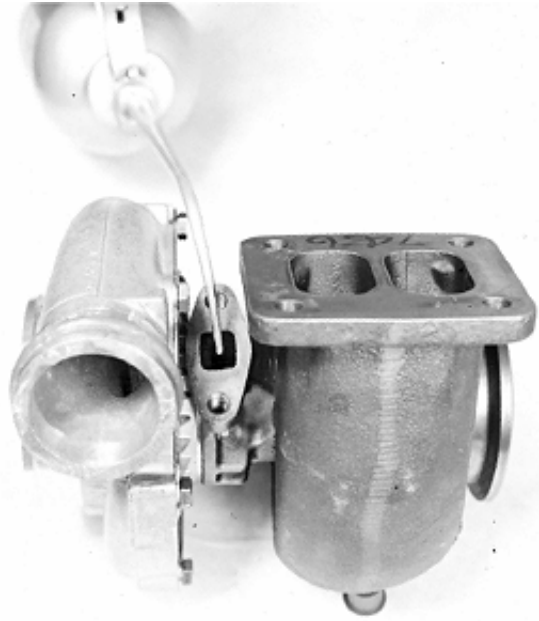
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PRELUBE TURBOCHARGER

IMPORTANT: DO NOT spin the rotor assembly with compressed air. Damage to bearings can occur when using compressed air.

Fill oil return (drain) port with clean engine oil and spin rotating assembly by hand to properly lubricate bearings.

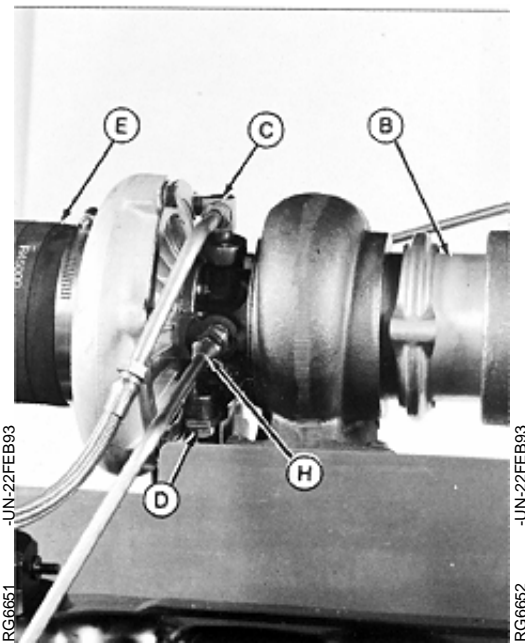
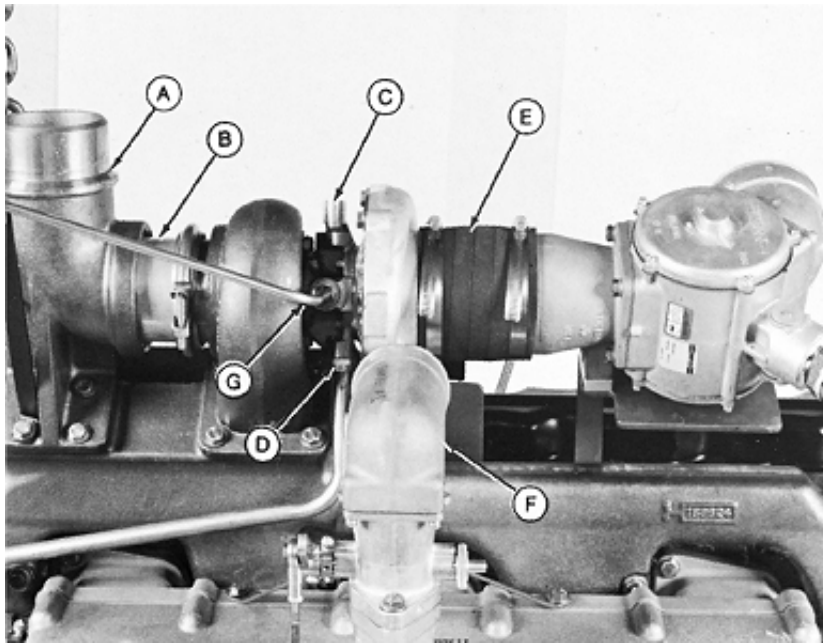
If turbocharger is to be stored for an extended period of time, lubricate internally and install protective covers on all openings.



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INSTALL TURBOCHARGER



A—Exhaust Elbow
B—Exhaust Adapter

C—Oil Inlet Line
D—Oil Return Tube

E—Air Intake Hose
F—Intake Coupling

G—Coolant Return Line
H—Coolant Inlet Line

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.

1. Using guide studs, install new turbocharger mounting gasket on exhaust manifold.
2. Install exhaust adapter (B) onto exhaust elbow (A).
3. Mount turbocharger on exhaust manifold. Apply PT569 NEVER-SEEZ Compound to all turbocharger mounting cap screws and tighten to 24 N-m (18 lb-ft).
4. Apply a coat of grease to O-rings and install on compressor housing outlet and intake coupling (F).
5. Using a new gasket, install intake coupling (F, on 4 psi system) or carburetor (on 20 psi system) onto throttle valve and compressor outlet. Tighten cap screws to 15 N-m (11 lb-ft).

6. Using a new gasket, install oil drain tube (D) and tighten cap screws securely. Install and tighten oil inlet line (C).

7. Install exhaust adapter V-band clamp and tighten mounting screw to 20 N-m (15 lb-ft).

8. Install air intake hose (E) and tighten hose clamps securely.

9. Connect coolant inlet (H) and outlet (G) lines to turbocharger center housing. Tighten lines securely.

IMPORTANT: BEFORE STARTING an engine with a new turbocharger, crank the engine over (but do not start) for several seconds to allow engine oil to reach turbocharger bearings. DO NOT crank engine longer than 30 seconds at a time to avoid damage to starting motor.

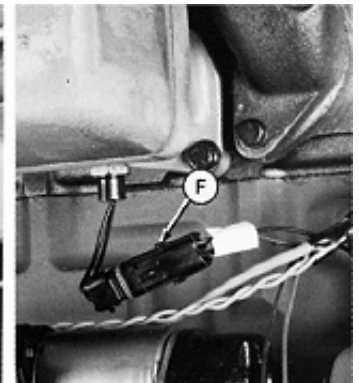
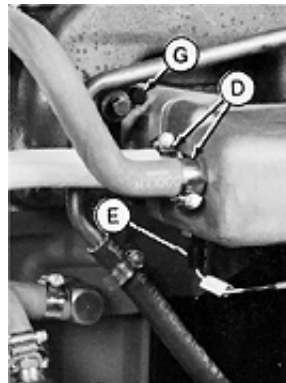
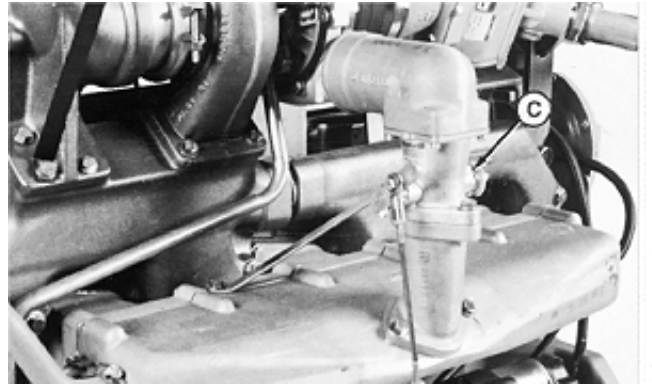
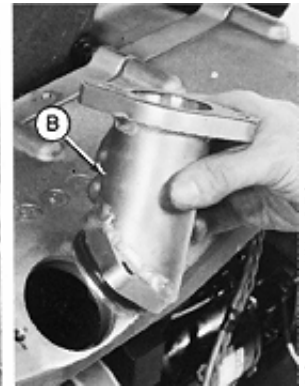
10. Start and run engine at low idle while checking oil inlet and air piping connections for leaks.

REMOVE AFTERCOOLER ASSEMBLY

⚠ CAUTION: Explosive release of fluids from pressurized cooling system can cause serious burns. Wait until engine coolant is cool enough to touch with bare hands before draining. Slowly loosen radiator cap to first stop to relieve pressure.

1. Drain engine coolant.
2. Thoroughly clean exterior of turbocharger, aftercooler assembly, and carburetor to prevent entry of dirt into engine when parts are removed.
3. Remove throttle valve and intake coupling or carburetor. (See REMOVE AND INSTALL 20 PSI CARBURETOR, in Group 35.)
4. Remove aftercooler intake adapter (B) from aftercooler cover.
5. Loosen clamps (D) on coolant inlet and outlet hoses. Remove coolant hoses from aftercooler.
6. Disconnect MAP sensor (E) and charge air temperature switch (F, if equipped).
7. Remove top three intake manifold cap screws (G) and install guide studs in these locations. Remove remaining cap screws.
8. Remove intake manifold and aftercooler assembly.
9. Remove and discard intake manifold gaskets.

A—Carburetor (20 psi system)
 B—Aftercooler Intake Adapter
 C—Throttle Valve
 D—Clamps
 E—Manifold Absolute Pressure (MAP) Sensor
 F—Charge Air Temperature Switch (CATS)
 G—Cap Screws



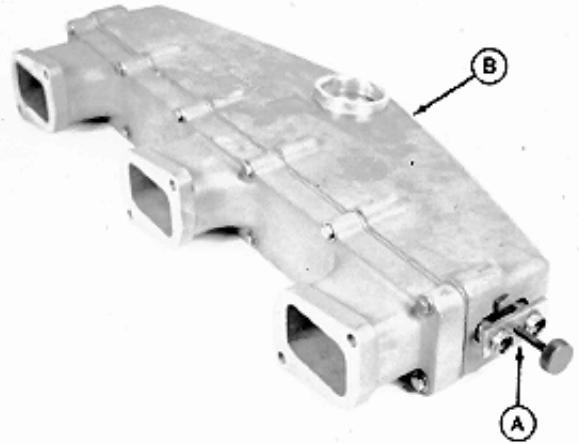
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10. Install JDG683 Sealing Ring Compression Tool (A) onto aftercooler coolant tubes with cross bar across slot.
11. Remove 12 cap screws and remove aftercooler cover (B).
12. Remove JDG683 tool from aftercooler tubes. Remove aftercooler core from aftercooler cover.
13. Inspect aftercooler end seal and replace as needed.
14. Inspect and repair aftercooler. (See INSPECT AND REPAIR AFTERCOOLER, later in this group.)

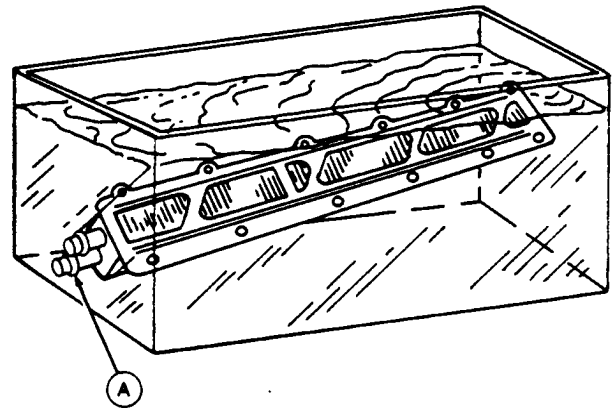


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INSPECT AND REPAIR AFTERCOOLER

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.



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IMPORTANT: Coolant leakage from the aftercooler may cause severe engine damage.

A minor leak that is accessible may be repaired. However, if the condition of the core is questionable, replace the aftercooler.

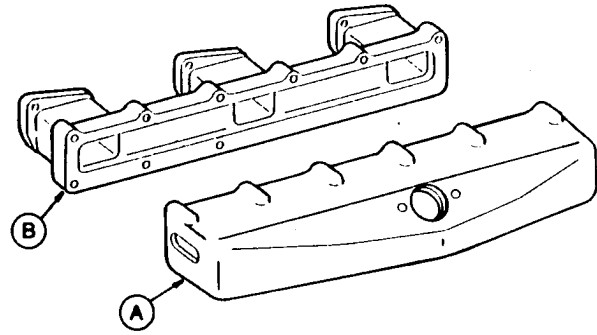
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INSPECT AND REPAIR INTAKE MANIFOLD AND AFTERCOOLER COVER

1. Inspect aftercooler cover (A) for cracks or damage. Replace as necessary.
2. Check intake manifold (B) for damage. Inspect machined mounting surfaces for burrs or other defects which might prevent gaskets from sealing properly. Repair as required.
3. Thoroughly steam clean interior of intake manifold and cover.

IMPORTANT: Do not use a hot tank to clean aluminum parts as damage and severe deterioration can occur.

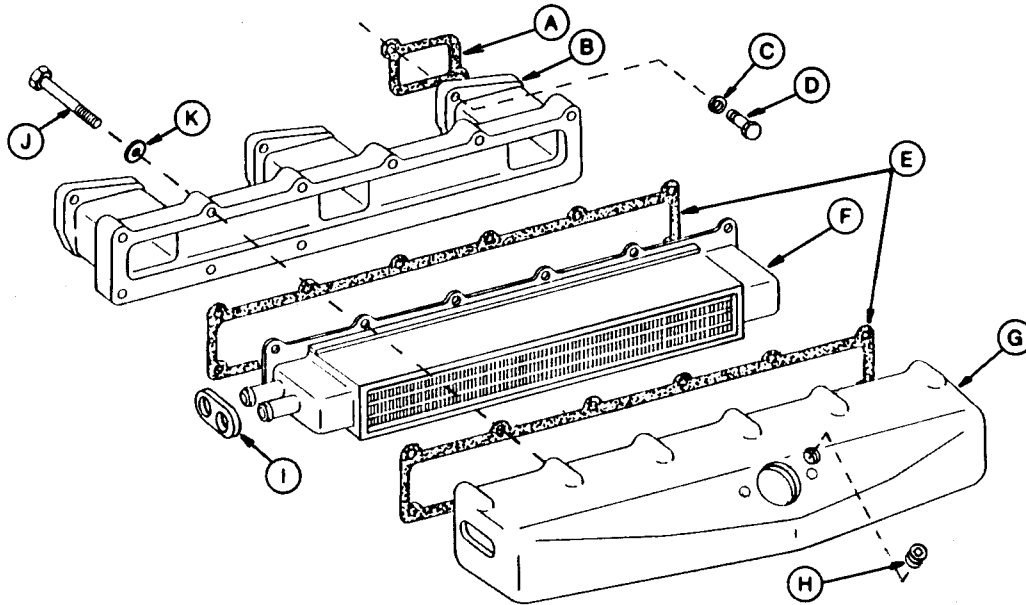
4. Scrape all gasket material from cylinder head and intake manifold mounting surfaces.



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ASSEMBLE AND INSTALL AFTERCOOLER ASSEMBLY



A—Gasket (3 Used)
B—Intake Manifold
C—Washer (6 Used)

D—Cap Screw (6 Used)
E—Gasket (2 Used)
F—Aftercooler Core

G—Aftercooler Cover
H—Pipe Plug
I—End Seal

J—Cap Screw (12 Used)
K—Washer (12 Used)

IMPORTANT: Improperly seated or crimped aftercooler end seal can result in loss of power and possible engine damage. Make sure end seal is properly seated.

1. Install aftercooler end seal on coolant tubes.

IMPORTANT: Debris left in intake manifold can cause engine damage. Make sure that inside of manifold is clean before assembly.

2. Position aftercooler core into aftercooler cover using new gaskets.

3. Install JDG683 Sealing Ring Compression Tool onto aftercooler coolant tubes with cross bar across slot.

4. Tighten tool until aftercooler cover cap screw holes are aligned with holes in gaskets, aftercooler, and intake manifold. Use guide studs as needed to hold alignment.

5. Apply PT569 NEVER-SEEZ Compound to all aftercooler cover-to-intake manifold cap screws. Tighten cap screws to 34 N·m (25 lb-ft). Remove seal ring compression tool.

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6. Install three guide studs (A) in locations shown.

IMPORTANT: All intake manifold connections must be tight to prevent loss of power resulting from lower manifold pressure, and possible engine damage.

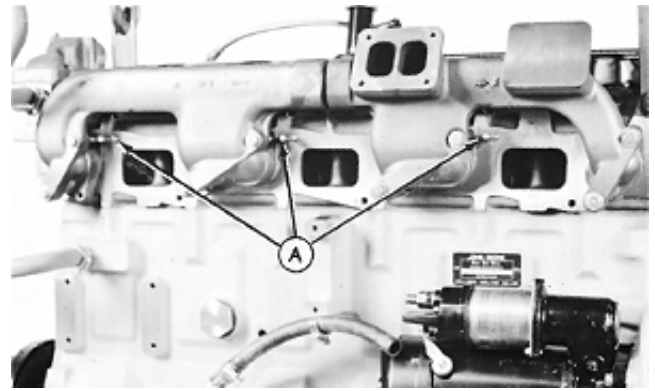
7. Using new gaskets, install aftercooler assembly to cylinder head. Tighten cap screws to 47 N·m (35 lb-ft).

8. Install and tighten aftercooler coolant inlet and outlet hoses.

9. Connect MAP sensor and charge air temperature switch, if equipped.

10. Install aftercooler intake adapter onto aftercooler cover. Tighten cap screws to 27 N·m (20 lb-ft).

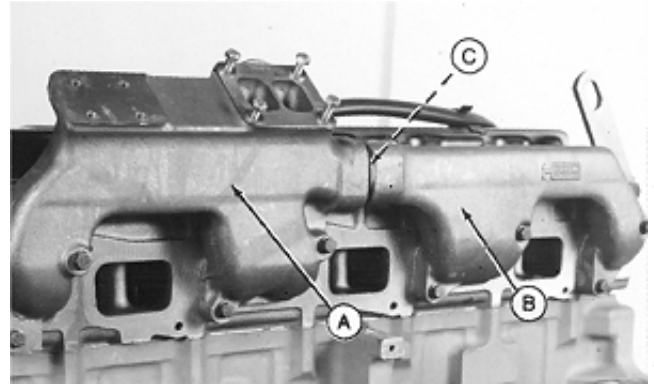
11. Install throttle valve and intake coupling or carburetor, as equipped. Tighten throttle valve-to-aftercooler intake adapter cap screws to 27 N·m (20 lb-ft). (See REMOVE AND INSTALL 20 PSI CARBURETOR, in Group 35.)



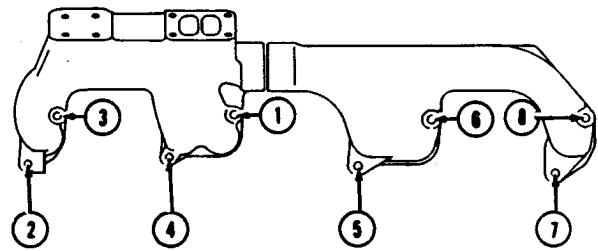
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REMOVE, INSPECT, AND INSTALL EXHAUST MANIFOLD

1. Remove turbocharger and air intake assembly as described earlier in this group.
2. Remove turbocharger oil return pipe (D).
3. Remove cap screws and lift off front exhaust manifold (A) and rear exhaust manifold (B).
4. Remove and discard front-to-rear exhaust manifold sealing ring (C).
5. Remove all residue and gasket material from gasket surfaces.
6. Thoroughly clean passages in exhaust manifolds and exhaust elbow.
7. Inspect each exhaust manifold for cracks or damage. Inspect machined mounting surfaces for burrs or other defects which might prevent gaskets from sealing properly. Replace parts as necessary.
8. To install exhaust manifold, reverse removal procedure and use new gaskets.
9. Coat exhaust manifold cap screws with PT569 NEVER-SEEZ Compound and tighten to 47 N·m (35 lb-ft) in sequence as shown.



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- A—Front Exhaust Manifold
- B—Rear Exhaust Manifold
- C—Sealing Ring
- D—Turbocharger Oil Return Pipe

RG,CTM42,G30,53-19-12APR93

OTHER MATERIAL

Name	Use
PT569 NEVER-SEEZ Compound	Regulator seat ring in union body.
LOCTITE 242 (TY9370/T43512) Thread Lock and Sealer	Throttle valve mounting screws.
LOCTITE 592 (TY9374/TY9375) Pipe Sealant with TEFLON	All threaded pipe connections.
TY6299 PERMATEX® Form-A-Gasket No. 3	Regulator repair kit gaskets.

RG,CTM82,G35,1 -19-04JUN93

FUEL SYSTEM SPECIFICATIONS

ITEM	SPECIFICATION
Carburetor Type	Impco 200 Series
Regulated Differential Gas Pressure	51—102 mm (2—4 in.) H ₂ O
Natural Gas Supply Pressure (Regulator Inlet):	
28 kPa (4 psi) System	13—55 kPa (2—8 psi)
138 kPa (20 psi) System	124—207 kPa (18—30 psi)

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FUEL SYSTEM SPECIFICATIONS—CONTINUED

TORQUES

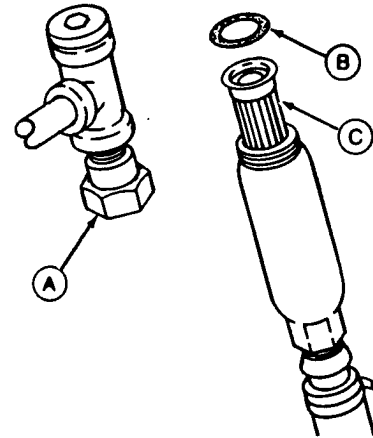
Throttle Valve-to-Aftercooler Intake Adapter	27 N·m (20 lb-ft)
Throttle Valve Support Strap-to-Intake Manifold	15 N·m (11 lb-ft)
Carburetor Support Bracket-to-Outlet Adapter (4 PSI)	15 N·m (11 lb-ft)
Carburetor-to-Air Inlet and Outlet Adapter (4 PSI)	20 N·m (15 lb-ft)
Carburetor-to-Throttle Valve (20 PSI)	15 N·m (11 lb-ft)
Regulator Spring Case-to-Diaphragm Case	8 N·m (6 lb-ft)

RG,CTM82,G35,3 -19-07JUN93

REPLACE NATURAL GAS FILTER

⚠ CAUTION: Natural gas is highly flammable. DO NOT smoke while working on or near natural gas equipment. Natural gas fumes may cause sickness or death. Work in well ventilated area and shut off natural gas supply before servicing equipment.

1. Shut off gas supply at manual shut-off valve.
2. Loosen natural gas filter outlet fitting (A) and remove using a backup wrench on inlet end of filter housing.
3. Remove gasket (B) and filter element (C) from housing. Remove housing and clean if needed.
4. Install new filter element and gasket in housing.
5. Tighten fitting securely using a backup wrench.
6. Start engine and check filter assembly for leaks.



RG6655 -UN-22FEB93

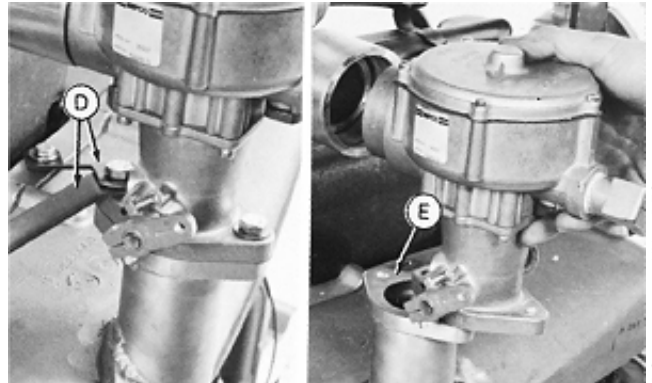
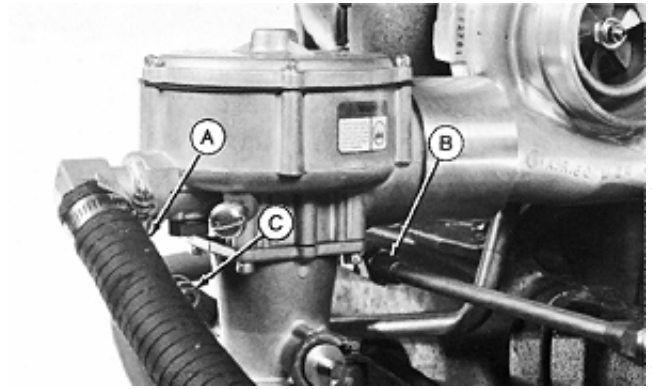
RG,CTM82,G35,5 -19-01JUN93

REMOVE AND INSTALL 20 PSI CARBURETOR

⚠ CAUTION: Natural gas is highly flammable. DO NOT smoke while working on or near natural gas equipment. Natural gas fumes may cause sickness or death. Work in well ventilated area and shut off natural gas supply before servicing equipment.

Carburetor Removal:

1. Shut off gas supply at manual shut-off valve.
2. Loosen hose clamp and remove regulated supply line (A).
3. Disconnect balance tube (B). Disconnect throttle linkage (C).
4. Remove throttle valve-to-aftercooler intake adapter cap screws. Loosen support strap (D) cap screws on intake manifold and remove carburetor with throttle valve.
5. Plug air intake opening to keep debris out of system. Remove gasket (E) and clean mounting surface.



Carburetor Installation:

1. Place a new gasket on intake adapter. Apply grease to turbocharger adapter O-ring.
2. Apply LOCTITE 242 (TY9370/T43512) Thread Lock and Sealer to cap screw threads. Install throttle valve and carburetor assembly onto air intake adapter. Be sure carburetor inlet is properly seated in turbocharger adapter.
3. Install support straps. Tighten throttle valve-to-aftercooler intake adapter cap screws to 27 N·m (20 lb-ft). Tighten support strap-to-intake manifold cap screws to 15 N·m (11 lb-ft).
4. Connect throttle linkage and tighten securely.
5. Install balance tube and regulated supply line.

Refer to Group 115 for necessary adjustments.

A—Regulated Supply Line
 B—Balance Tube
 C—Throttle Linkage
 D—Support Strap
 E—Gasket

-JUN-14DEC92
RG6613

-JUN-14DEC92
RG6614

REMOVE AND INSTALL 4 PSI CARBURETOR

⚠ CAUTION: Natural gas is highly flammable. DO NOT smoke while working on or near natural gas equipment. Natural gas fumes may cause sickness or death. Work in well ventilated area and shut off natural gas supply before servicing equipment.

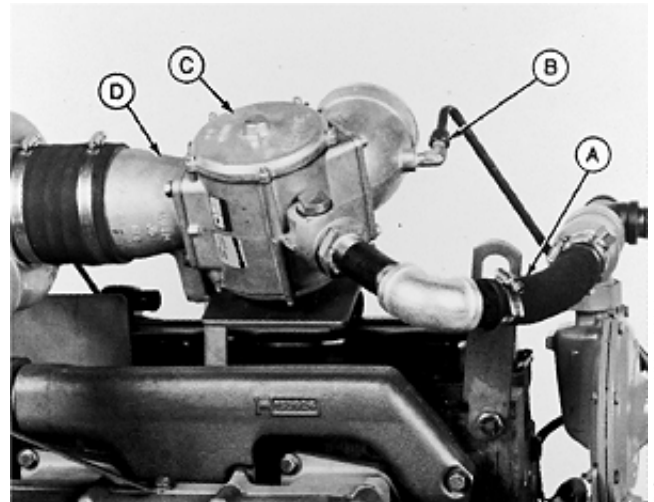
Carburetor Removal:

1. Shut off gas supply at manual shut-off valve.
2. Loosen hose clamp and remove regulated supply line (A) from fitting.
3. Disconnect balance tube (B) from elbow fitting.
4. Remove air inlet piping (shown removed) from carburetor (C).
5. Remove four cap screws securing carburetor to outlet adapter (D). Remove carburetor.
6. Clean gasket material from mounting surfaces. Plug air and fuel inlet openings to keep debris out of system.

Carburetor Installation:

1. Install carburetor onto adapter using a new gasket. Tighten cap screws to 20 N·m (15 lb-ft).
2. Connect air inlet piping. Tighten mounting hardware securely.
3. Install regulated supply line and balance tube.

Refer to Group 115 for necessary adjustments.



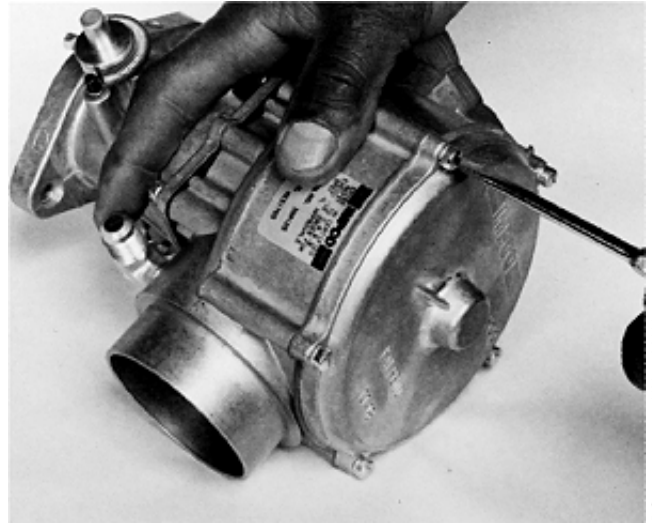
A—Regulated Supply Line
B—Balance Tube
C—Carburetor
D—Outlet Adapter

RG6758 -UN-10MAY93

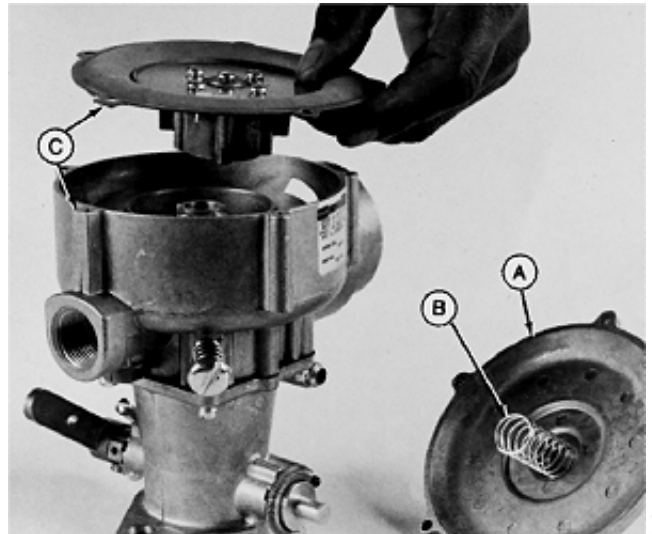
REPLACE DIAPHRAGM(S) IN CARBURETOR

NOTE: 20 PSI carburetor shown, 4 PSI similar. 20 PSI carburetors has only one diaphragm and 4 PSI carburetors have two diaphragms. The 20 PSI diaphragm can be replaced without removing carburetor from engine.

1. Remove carburetor from engine if necessary. (See REMOVE AND INSTALL 4 PSI CARBURETOR or REMOVE AND INSTALL 20 PSI CARBURETOR, earlier in this group.)
2. Place carburetor on a clean, flat table and remove five screws from cover (A). Remove cover and spring (B).
3. Remove diaphragm and gasket assembly. Clean both mounting surfaces of gasket material.
4. Install a new diaphragm and gasket assembly. Be sure that square tab (C) on diaphragm gasket is properly indexed with square tab on (20 PSI) carburetor housing.
5. Install spring and cover, tighten screws securely.
6. On 4 PSI carburetors, replace diaphragm assembly at other end of carburetor following the same procedure. Clean carburetor as needed.
7. Install carburetor on engine and tighten all connections securely, if removed.



RG6761 -UN-10MAY93



RG6762 -UN-10MAY93

RG.CTM82,G35,11-19-04JUN93

SERVICE NATURAL GAS REGULATOR

Regulator parts are subject to normal wear and must be inspected and replaced as necessary. The frequency of inspection and replacement of parts depends on the severity of service conditions, applicable codes, and government regulations.

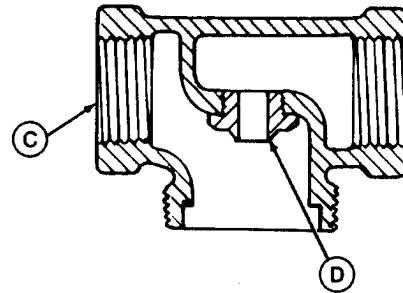
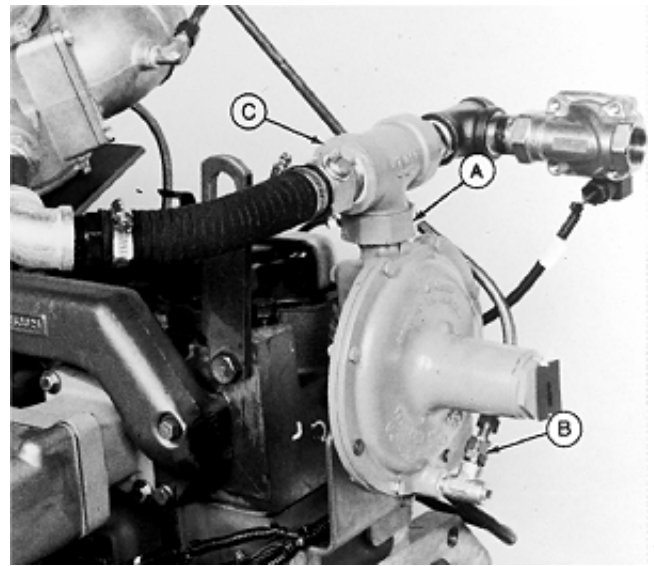
⚠ CAUTION: Natural gas is highly flammable. DO NOT smoke while working on or near natural gas equipment. Natural gas fumes may cause sickness or death. Work in well ventilated area and shut off natural gas supply and relieve internal regulator pressure before servicing equipment.

Startup and Adjustment:

The spring loaded regulator has been adjusted at the factory to provide specified reduced pressure. The regulator pressure setting may be adjusted as necessary if pressure is not within specification. (See ADJUST REGULATOR DIFFERENTIAL GAS PRESSURE, in Group 115.)

Install Regulator Repair Kit and Replace Seat Ring:

1. Shut off natural gas supply and relieve internal regulator gas pressure.
2. Unscrew union nut (A), be careful not to lose split rings.
3. Disconnect balance tube (B) from fitting.
4. Remove four lower cap screws with nuts and remove regulator from support plate. Be careful not to damage pilot tube when removing regulator.
5. Inspect and replace seat ring (D) in union body (C), if necessary. Coat threads of replacement ring with PT569 NEVER-SEEZ Compound and tighten to 47 N·m (35 lb-ft).



A—Union Nut
B—Balance Tube
C—Union Body
D—Seat Ring

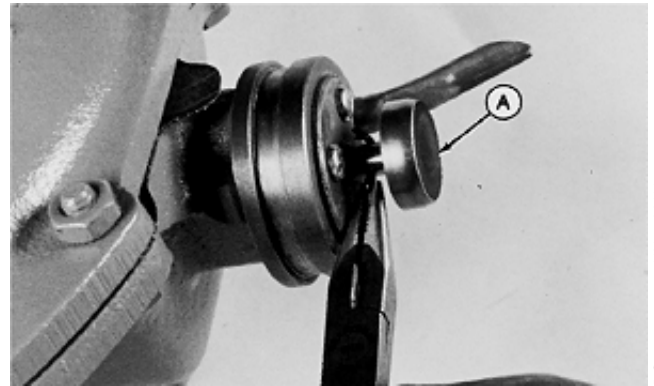
-UN-10MAY93

RG6763

-UN-10MAY93

RG6764

6. Remove cotter pin and replace disc holder assembly (A). Secure assembly with new cotter pin provided in kit.



-JUN-10MAY93

RG6767

RG,CTM82,G35,14-19-18MAY93

7. Remove closing cap (A) from spring case (J). Turn adjusting screw (C) counterclockwise until all compression is removed from spring.

8. Remove remaining cap screws and nuts securing spring case to diaphragm case (K) and separate regulator assembly.

9. Remove the diaphragm (I) assembly by tilting assembly so that pusher post (G) slips off lever assembly (F).

10. Remove cap screw from pusher post to disassemble diaphragm assembly.

NOTE: Coat top surface of pusher post with TY6299 PERMATEX® Form-A-Gasket No. 3 before assembly.

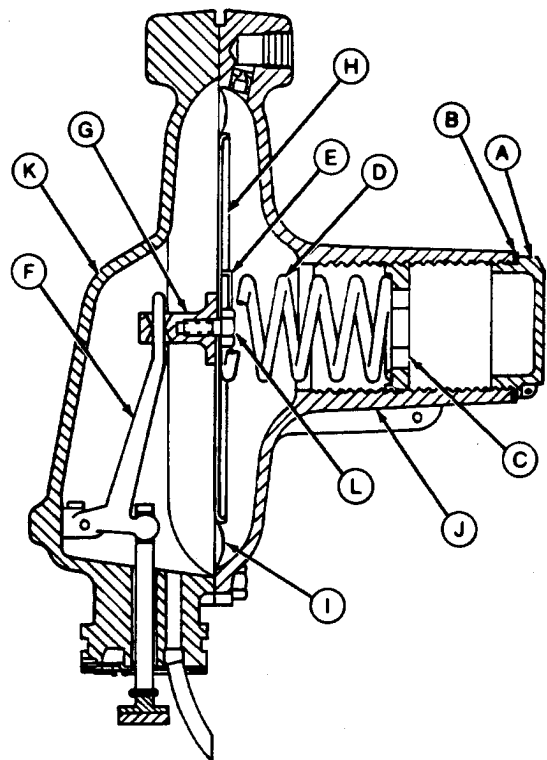
11. Install cap screw on control spring seat (E), diaphragm plate (H), new diaphragm, and pusher post. Tighten cap screw 5 N·m (4 lb-ft).

12. Install the spring case and control spring on the diaphragm case assembly. Install cap screws with hex nuts and tighten finger tight at this time.

13. Turn adjusting screw clockwise until control spring force is the same as before disassembly.

14. Finish tightening the cap screws and hex nuts to 8 N·m (6 lb-ft) using a crisscross pattern.

15. Install closing cap using a new gasket (B) and tighten securely.



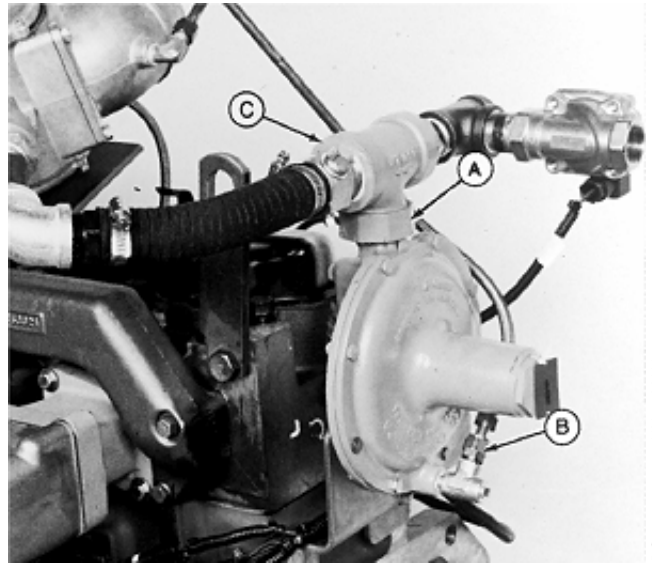
-JUN-10MAY93

RG6774

- A—Closing Cap
- B—Cap Gasket
- C—Adjusting Screw
- D—Control Spring
- E—Control Spring Seat
- F—Lever Assembly
- G—Pusher Post
- H—Diaphragm Plate
- I—Diaphragm
- J—Spring Case
- K—Diaphragm Case
- L—Cap Screw

RG,CTM82,G35,15-19-18MAY93

16. Slide union nut (A) as far as it will go onto the regulator's diaphragm case assembly.
17. Install a new body gasket at end of diaphragm case.
18. Install both halves of the split ring into slots of diaphragm case assembly and secure them by sliding the union nut up onto the split rings.
19. Install the diaphragm case assembly with split rings, body gasket and union nut so that the pilot tube fits into the outlet of the body.
20. Tighten union nut until the diaphragm case assembly is secure on union body.
21. Install regulator-to-bracket mounting screws and tighten nuts securely.
22. Install and securely tighten balance tube (B).
23. Open gas supply valve.
24. Adjust regulator to desired outlet pressure setting. (See ADJUST REGULATOR DIFFERENTIAL GAS PRESSURE, in Group 115.)



RG6763 -JUN-10MAY93

RG,CTM82,G35,16-19-04JUN93

SPECIAL OR ESSENTIAL TOOLS

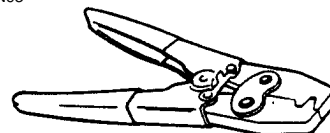
NOTE: Order tools according to information given in the U.S. SERVICE-GARD™ Catalog or in the European Microfiche Tool Catalog (MTC).

DX,TOOLS -19-05JUN91

Crimping Tool JDG708

RG6785 -UN-04JUN93

Use to crimp WEATHER PACK terminals.



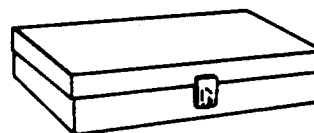
RG,CTM82,G40,19-19-01JUN93

Electrical Repair Tool Kit JDG155

RG6784 -UN-04JUN93

Consists of:

- Holding Plate JDG107
- Contact Insertion Tool JDG139
- Contact Extraction Tool JDG140
- Contact Extraction Tool JDG141
- Contact Extraction Tool JDG142
- Contact Extraction Tool JDG143
- Crimping Pliers JDG144
- Electrician's Pliers JDG145
- Carry Case JDG146



Use for repair and installation of wires into electrical connectors.

RG,JDG155 -19-03JUN93

WEATHER PACK Extraction Tool JDG364

RG6783 -UN-04JUN93

Use to replace terminal contact in WEATHER PACK connector body.

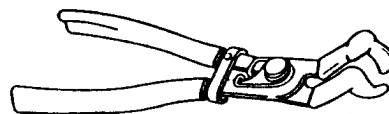


RG,JDG364 -19-01JUN93

Spark Plug Boot Puller Pliers JDG815

RG6720 -UN-27APR93

Used to remove and install spark plug boots.



RG,JDG815 -19-03MAY93

OTHER MATERIAL

Name	Use
Silicon Dielectric Grease (AT66865)	Spark plug terminal and boot.
LOCTITE 242 Thread Lock & Sealer (TY9370/T43512)	Ignition sensor plate-to-block cap screws.
LOCTITE 592 Pipe Sealant with TEFLON (TY9374/TY9375)	Charge Air Temperature Switch (CATS) and Manifold Absolute Pressure (MAP) sensor pipe threads.
Electrical Connector and Wire Service Kit (RE11154)	Repair wiring harnesses on John Deere engines

RG,CTM82,G40,1 -19-04JUN93

IGNITION SYSTEM AND ELECTRONIC GOVERNOR SPECIFICATIONS

ITEM	SPECIFICATION
Ignition timing @ 1800 rpm, MAP sensor unplugged	21.5 BTDC
Spark plug gap	0.38 mm (0.015 in.)
Electronic governor speed sensor-to-ring gear clearance	1/2—1 turn CCW from top of tooth

RG,CTM82,G40,2 -19-28MAY93

IGNITION SYSTEM AND ELECTRONIC GOVERNOR SPECIFICATIONS—CONTINUED

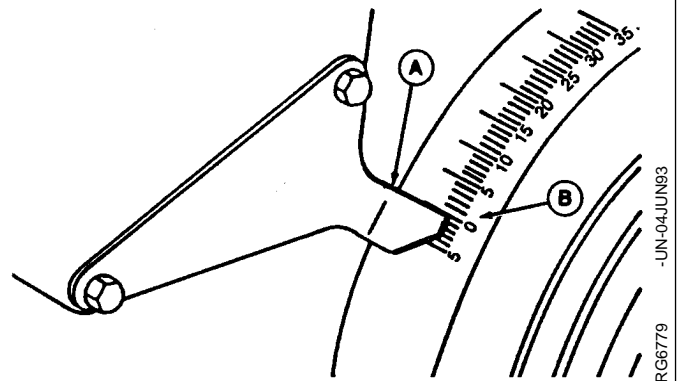
TORQUES

Ignition timing wheel access cover	27 N·m (20 lb-ft)
Ignition timing indicator	27 N·m (20 lb-ft)
Ignition timing sensor plate-to-block	34 N·m (25 lb-ft)
Ignition timing sensor	22 N·m (16 lb-ft)
Ignition control unit-to-mounting plate	16 N·m (12 lb-ft)
Ignition coil-to-mounting plate	16 N·m (12 lb-ft)
Ignition system mounting plate-to-block	54 N·m (40 lb-ft)
Spark plugs	38 N·m (28 lb-ft)
Electronic governor speed sensor lock nut	22 N·m (16 lb-ft)
Throttle actuator-to-bracket	10 N·m (7 lb-ft)
Throttle actuator bracket-to-block:	
7.92 mm (0.312 in.) cap screws	20 N·m (15 lb-ft)
9.53 mm (0.375 in.) cap screws	34 N·m (25 lb-ft)
Throttle actuator linkage	10 N·m (7 lb-ft)

RG,CTM82,G40,3 -19-11JUN93

CHECK IGNITION TIMING INDICATOR ALIGNMENT

1. Lock engine at "TDC" of No. 1 cylinder, using a timing pin.
2. Check alignment of timing indicator (A) and timing marks (B) on vibration damper.
3. If indicator is not aligned with the 0° timing mark, loosen timing indicator cap screws and adjust as necessary. Tighten indicator cap screws to 27 N·m (20 lb-ft).



RG6779 -UN-04JUN93

RG,CTM82,G40,20-19-28MAY93

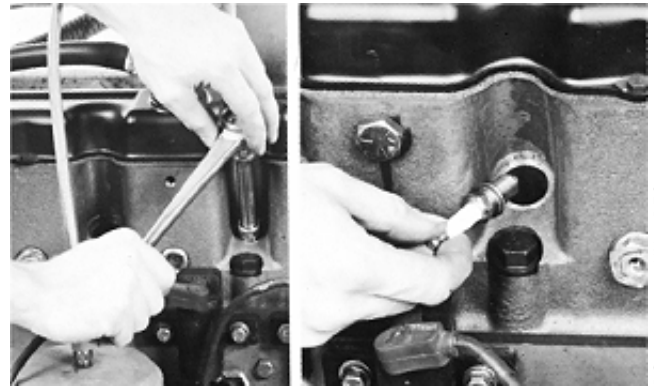
REMOVE AND INSTALL SPARK PLUGS AND WIRES

CAUTION: Electrical shock may occur if you contact live electrical components. Disconnect power before servicing ignition system.

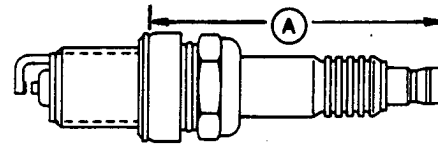
IMPORTANT: Avoid damage to spark plug boots. Pull straight out on boots when removing.

1. Use JDG815 Puller Pliers to remove plug wires from plug bores.
2. Check plug bore for water or debris. If present, use compressed air to remove debris. Replace plug wire if necessary.
3. Check spark plug. (See INSPECT, CLEAN, AND ADJUST SPARK PLUGS, later in this group.)
4. Tighten plugs to 38 N-m (28 lb-ft).
5. Apply silicon dielectric grease to spark plug terminal, ignition coil terminal, and OD of boot. Install plug wire.

NOTE: Spark plug dimension (A) must be 56 mm (2.2 in.) for the boot to properly seat in the plug bore.



RG6730 -UN-27APR93



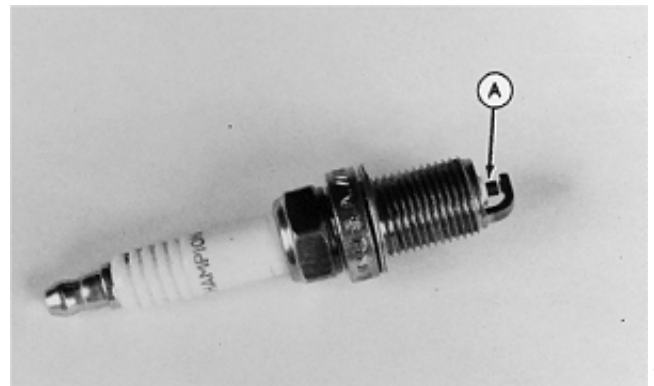
RG6522 -UN-14DEC92

RG,CTM82,G40,4 -19-28MAY93

INSPECT, CLEAN, AND ADJUST SPARK PLUGS

IMPORTANT: Always check new spark plugs for proper gap. Excessive spark plug gap can cause pre-ignition (knocking).

1. Check spark plug for damage. (See FOS Manual-ELECTRICAL SYSTEMS for spark plug inspection.)
2. Use small file to file electrode (A) flat and smooth.
3. Set gap to 0.38 mm (0.015 in.).



RG6644 -UN-30APR93

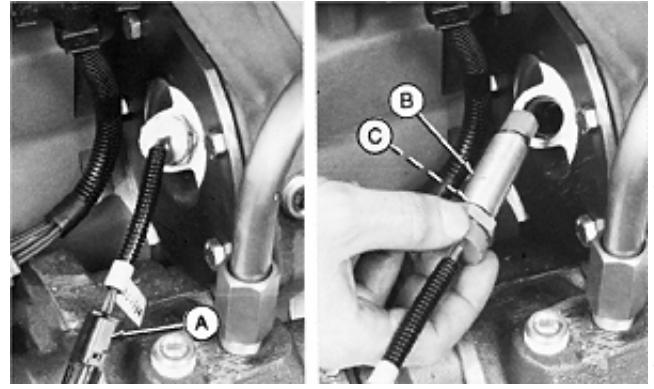
RG,CTM82,G40,5 -19-11JUN93

REMOVE AND INSTALL IGNITION TIMING SENSOR

1. Disconnect wiring (A).
2. Remove ignition timing sensor (B) from ignition sensor plate.
3. Inspect O-ring (C). Replace if necessary.

IMPORTANT: DO NOT overtighten sensor. Sensor may be damaged during operation.

4. Install sensor. Tighten to 22 N·m (16 lb-ft).
5. Connect wiring harness.

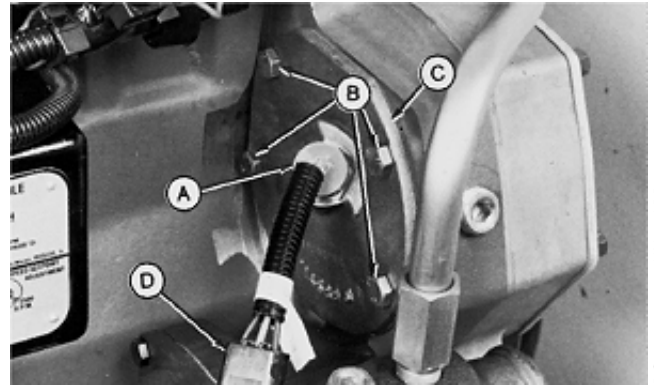


RG6654 -JUN-21DEC92

RG,CTM82,G40,6 -19-28MAY93

REMOVE AND INSTALL IGNITION SENSOR PLATE

1. Remove ignition timing sensor (A). (See REMOVE AND INSTALL IGNITION TIMING SENSOR, earlier in this group.)
2. Remove cap screws (B), plate (C), and gasket. Discard gasket.
3. Clean gasket surfaces.
4. Install plate with new gasket. Tighten cap screws to 34 N·m (25 lb-ft).
5. Install ignition sensor. (See REMOVE AND INSTALL IGNITION TIMING SENSOR, earlier in this group.)



RG6741 -JUN-30APR93

A—Ignition Sensor
B—Cap Screws
C—Sensor Plate
D—Wire Harness

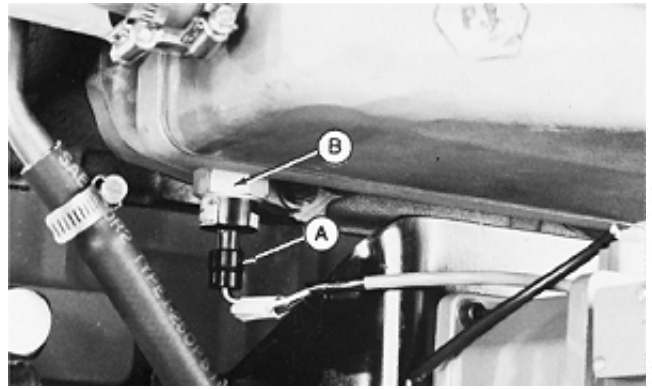
RG,CTM82,G40,12-19-28MAY93

REMOVE AND INSTALL MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR

1. Disconnect wiring (A).
2. Remove MAP sensor (B).

IMPORTANT: DO NOT allow sealant to enter pressure sensing hole in sensor.

3. Apply LOCTITE 592 Pipe Thread Sealant with TEFLON to sensor threads except first 1—3 threads.
4. Install MAP sensor in intake manifold and tighten.
5. Connect wiring harness.



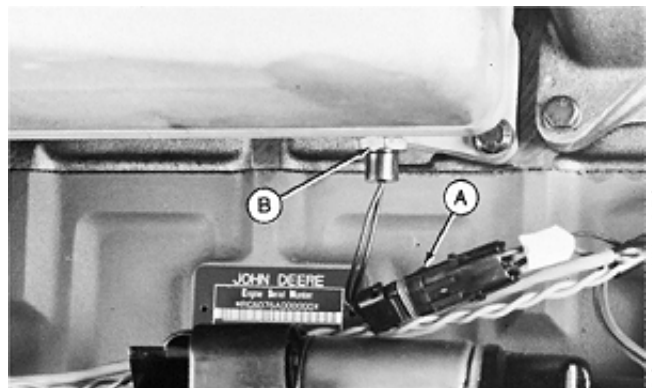
RG6555 -JUN-21DEC92

RG.CTM82.G40,7 -19-28MAY93

REMOVE AND INSTALL CHARGE AIR TEMPERATURE SWITCH (CATS)

NOTE: 112kW (150 Hp) engines are not equipped with a CATS switch.

1. Disconnect wiring (A).
2. Remove CATS switch (B).
3. Apply LOCTITE 592 Pipe Thread Sealant with TEFLON to switch threads except first 1—3 threads.
4. Install CATS switch in intake manifold and tighten.
5. Connect wiring harness.



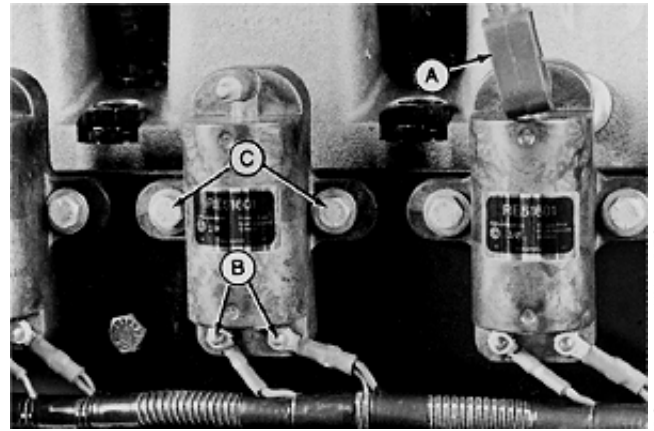
RG6556 -JUN-21DEC92

RG.CTM82.G40,8 -19-28MAY93

REMOVE AND INSTALL IGNITION COILS

⚠ CAUTION: Electrical shock may occur if you contact live electrical components. Disconnect power before servicing ignition system.

1. Remove plug wires (A) at the ignition coil terminal.
2. Disconnect primary and ground wires (B) from coils.
3. Remove cap screws (C).
4. Apply LOCTITE 242 Thread Lock to threads of cap screws. Install coil to plate. Tighten cap screws to 16 N·m (12 lb-ft).
5. Install primary and ground wires to terminals.
6. Apply silicon dielectric grease to coil output terminals. Install plug wires onto coils.



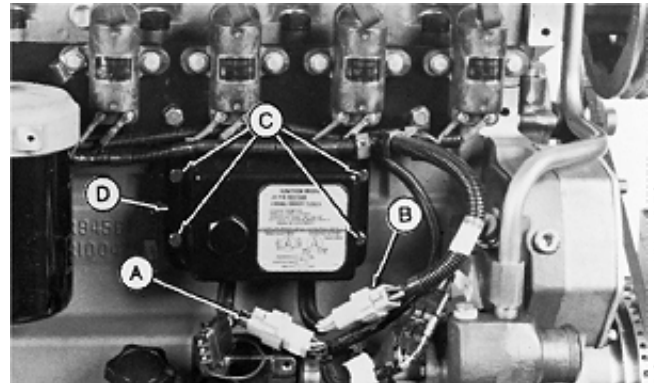
RG6559
-UN-21DEC92

RG,CTM82,G40,9 -19-28MAY93

REMOVE AND INSTALL IGNITION CONTROL UNIT (ICU)

1. Disconnect wire harness connectors (A) and (B).
2. Remove cap screws (C) and remove ICU (D) from mounting plate.
3. Apply LOCTITE 242 Thread Lock to threads of cap screws. Install ICU and tighten cap screws to 16 N·m (12 lb-ft).
4. Connect wire harness.

NOTE: See Group 120 for ignition timing procedure and specifications.



RG6560
-UN-21DEC92

A—Connector
B—Connector
C—Cap Screws
D—ICU

RG,CTM82,G40,10-19-28MAY93

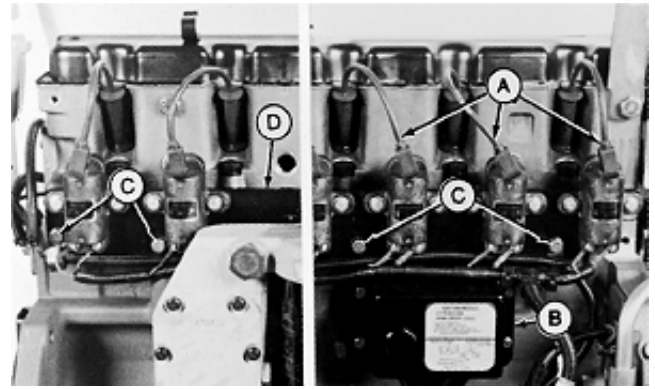
REMOVE AND INSTALL IGNITION SYSTEM MOUNTING PLATE

NOTE: The ignition system mounting plate (D) can be removed without removing ICU or coils.

1. Disconnect spark plug wires (A) from ignition coils.
2. Disconnect wire harness connectors from ICU.
3. Remove four cap screws (C). Lift plate and spacer from block.

NOTE: J-clamps are used on front and rear cap screws.

4. Apply LOCTITE 242 Thread Lock to threads of cap screws. Install spacer, plate, and wire J-clamps. Tighten cap screws to 54 N·m (40 lb-ft).
5. Connect wire harness connectors to ICU.

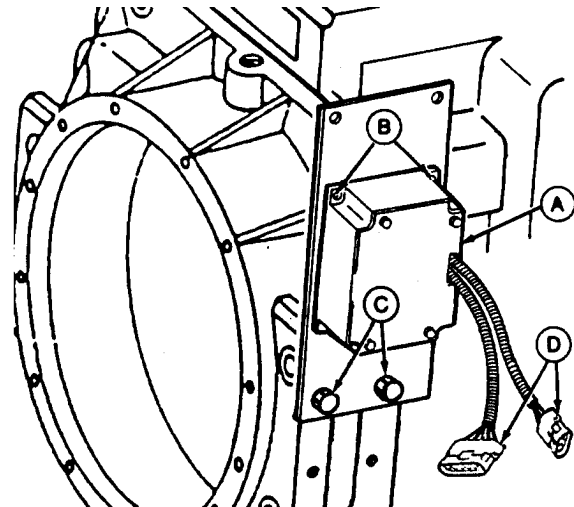


A—Spark Plug Wires
B—ICU
C—Cap Screws
D—Plate

RG.CTM82.G40.11-19-03MAY93

REMOVE AND INSTALL ELECTRONIC GOVERNOR—IF EQUIPPED

1. Disconnect wiring harness connectors (D).
2. Remove governor mounting cap screws (B) and governor (A).
3. Remove bracket-to-flywheel housing cap screws (C) and bracket (if necessary).
4. Install governor bracket. Tighten cap screws to 81 N·m (60 lb-ft).
5. Install governor onto bracket and tighten cap screws.
6. Connect wire harness connector.



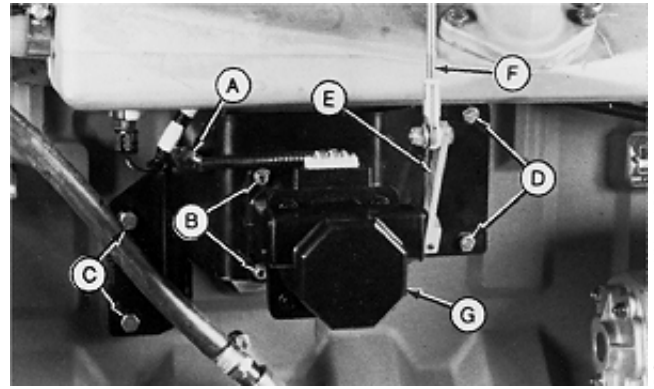
A—Governor
B—Mounting Cap Screws
C—Bracket-to-Flywheel Housing Cap Screws
D—Connectors

RG.CTM82.G40.13-19-28MAY93

REMOVE AND INSTALL THROTTLE ACTUATOR—IF EQUIPPED

NOTE: If replacing actuator lever only, it is not necessary to remove actuator from engine.

1. Disconnect wire harness connector (A) and throttle linkage (F).
2. Remove throttle actuator-to-bracket cap screws (B) and actuator (G).
3. Remove bracket cap screws (C and D) and bracket.
4. If replacing actuator, remove actuator lever (E). Note position of lever before removal.
5. Install actuator bracket. Tighten 3/8 in. cap screws (C) to 34 N·m (25 lb-ft), and 5/16 in. cap screws (D) to 20 N·m (15 lb-ft).
6. Install actuator onto bracket. Tighten cap screws to 10 N·m (7 lb-ft).
7. Install lever at same position as removed. Install throttle linkage.
8. Connect wire harness connector.
9. Check linkage for proper throttle travel. If throttle lever will not go to full throttle or slow idle, adjust linkage and/or reposition the actuator lever one tooth in the proper direction.



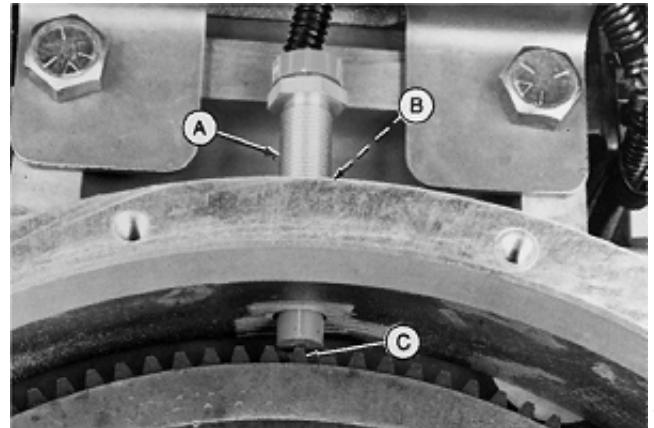
- A—Wire Harness
- B—Actuator-to-Bracket Screws
- C—3/8 in. Bracket Cap Screws
- D—5/16 in. Bracket Cap Screws
- E—Actuator Lever
- F—Throttle Linkage
- G—Actuator

RG.CTM82,G40,14-19-11JUN93

RG6743
-JUN-30APR93

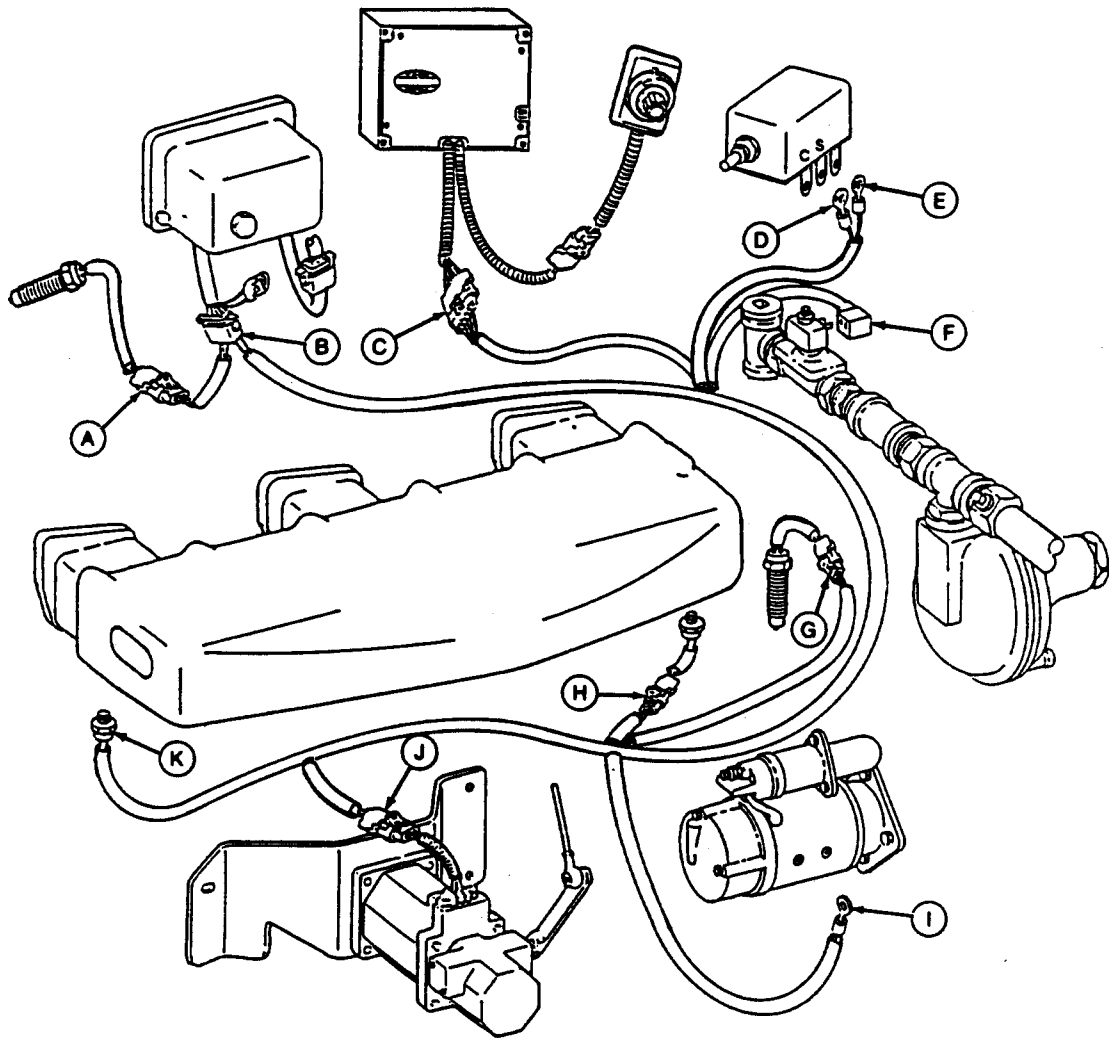
REMOVE AND INSTALL ELECTRONIC GOVERNOR SPEED SENSOR—IF EQUIPPED

1. Disconnect wire harness.
2. Loosen lock nut (B) and turn sensor (A) out of flywheel housing.
3. Rotate flywheel until a ring gear tooth (C) is directly under the sensor hole in flywheel housing.
4. Install sensor into flywheel housing until sensor touches ring gear. Turn sensor out 1/2—1 turn to provide proper sensor-to-gear clearance.
5. Tighten lock nut to 22 N-m (16 lb-ft).
6. Connect wire harness.



RG.CTM82.G40,15-19-28MAY93

REMOVE AND INSTALL ELECTRONIC GOVERNOR AND IGNITION SYSTEM WIRING HARNESS



RG6745 -JUN-30APR93

A—Ignition Timing Sensor
B—ICU
C—Electronic Governor

D—Safety Switch (C term.)
E—Safety Switch (S term.)
F—Electric Shutoff Valve

G—Governor Speed Sensor
H—CATS Switch
I—Ground Connection

J—Throttle Actuator
K—MAP Sensor

1. Disconnect harness from:
 - Ignition Control Unit (ICU)
 - Ignition timing sensor
 - Electric shutoff valve
 - Instrument panel (safety switch)
 - Charge Air Temperature Switch (CATS)
 - Manifold Absolute Pressure (MAP) sensor
 - Electronic governor
 - Throttle actuator
 - Governor speed sensor
 - Ground at starter stud

2. Remove wire harness from J-clamps.
3. Install wire harness using the same routing as when removed. Install in J-clamps.
4. Reconnect all connectors to proper components.

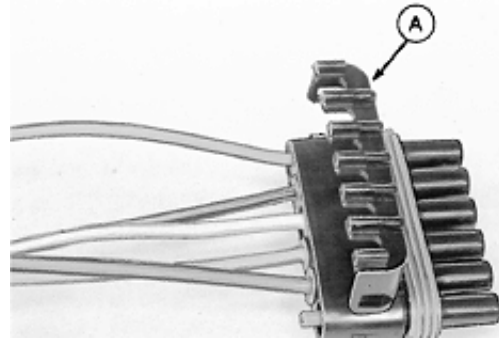
NOTE: Star tooth washer should not be directly against ring terminal.

40
11

REPLACE WEATHER PACK™ CONNECTOR

IMPORTANT: Identify wire color locations with connector terminal letters.

1. Open connector body (A).

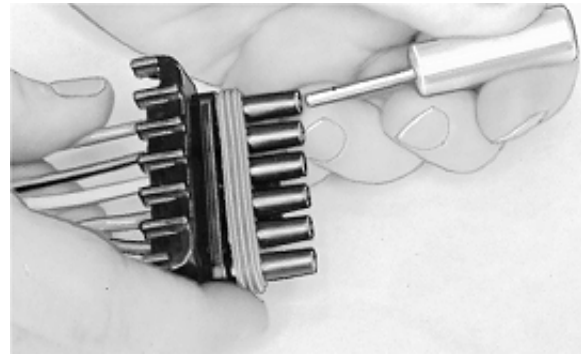


TS0127 -UN-23AUG88

WEATHER PACK is a trademark of PACKARD ELECTRIC

DX,ECONN,O -19-04JUN90

2. Insert JDG364 Extraction Tool over terminal contact in connector body.

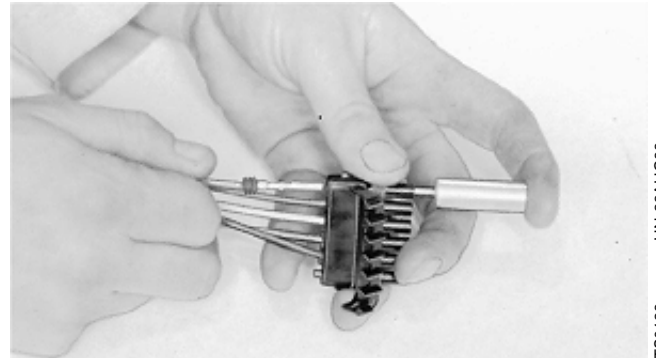


TS0128 -UN-23AUG88

DX,ECONN,P -19-04JUN90

3. Hold extractor tool fully seated and pull wire from connector body.

NOTE: If terminal cannot be removed, insert wire or nail through extractor tool handle and push terminal contact from connector.



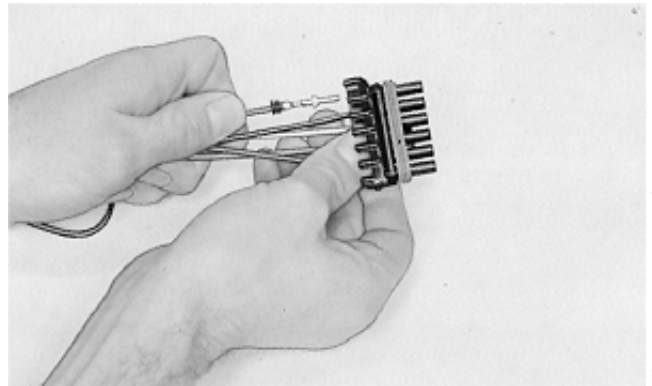
TS0129 -UN-23AUG88

DX,ECONN,Q -19-04JUN90

IMPORTANT: Carefully spread contact lances to assure good seating on connector body.

NOTE: Connector bodies are “keyed” for proper contact mating. Be sure contacts are in proper alignment.

4. Push contact into new connector body until fully seated.
5. Pull on wire slightly to be certain contact is locked in place.
6. Transfer remaining wires to correct terminal in new connector.
7. Close connector body.



TS0130 -UN-23AUG88

DX,ECONN,R -19-04JUN90

INSTALL WEATHER PACK CONTACT

NOTE: Cable seals are color coded for three sizes of wire:

- a) Green - 18 to 20 gauge wire
- b) Gray - 14 to 16 gauge wire
- c) Blue - 10 to 12 gauge wire

1. Slip correct size cable seal on wire.
2. Strip insulation from wire to expose 6 mm (1/4 in.) and align cable seal with edge of insulation.



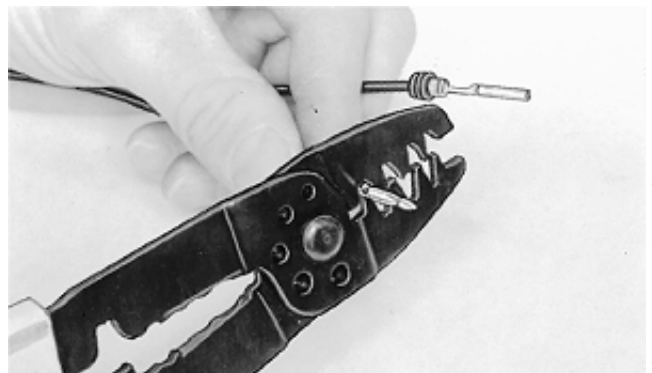
TS0136 -UN-23AUG88

DX,ECONN,AA -19-04JUN90

NOTE: Contacts have numbered identification for two sizes of wire:

- a) #15 for 14 to 16 gauge wire
- b) #19 for 18 to 20 gauge wire

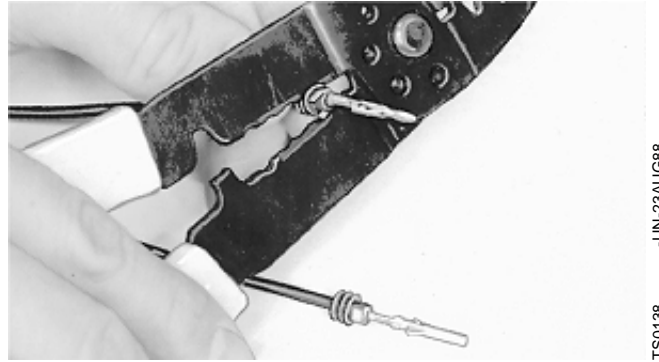
3. Place proper size contact on wire and use JDG144 Terminal Applicator to crimp contact in place with a “W” type crimp.



TS0137 -UN-23AUG88

DX,ECONN,AB -19-04JUN90

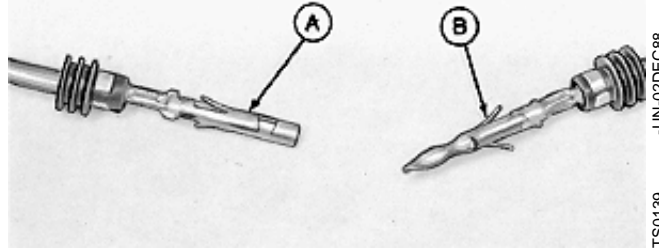
4. Use JDG144 Terminal Applicator to secure cable seal to contact as shown.



TS0138 -UN-23AUG88

DX,ECONN,AC -19-04JUN90

IMPORTANT: Proper contact installation for “sleeve” (A) and “pin” (B) is shown.



TS0139 -UN-02DEC88

DX,ECONN,AD -19-04JUN90

ALTITUDE COMPENSATION GUIDELINE

High elevations may affect engine performance. As a general rule, this guideline will apply.

One and one-half percent reduction in power rating per 300 m (1000 ft) rise in elevation above 183 m (600 ft). For every 5.5°C (10°F) above 25°C (77°F), a one percent reduction in power may be experienced. Engine may have to be defueled when a substantial

percentage of operating time occurs at 2250 m (7500 ft) or higher.

As altitude increases, air gets thinner and engine runs richer; exhaust temperatures rise and power drops. Reduce load on engine and lean out A/F (Air/Fuel) mixture to keep exhaust temperatures at 1100°F or below.

RG,CTM82,100,2 -19-28MAY93

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. Perform compression test (See Group 105).
2. 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.

3. 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.

4. 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.

S11,22010,BW -19-28MAY93

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
Change engine oil and filters.	Operator's Manual
Lubricate PTO clutch internal levers and linkage.	Operator's Manual
Replace natural gas filter.	Group 35/Operator's Manual
Clean crankcase vent tube.	This Group/Operator's Manual
Check air intake system. Replace air cleaner elements.	This Group/Operator's Manual
Check exhaust system.	This Group
Check and service engine cooling system.	This Group/Operator's Manual
Check and adjust fan and alternator belts.	Operator's Manual
Check and adjust auxiliary water pump belt, if equipped.	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 electrical fuel shutoff valve operation.	Group 115
Check regulator differential pressure; check air/fuel mixture.	Group 115/Operator's Manual
Check electronic governor operation.	Group 120/Operator's Manual
Check ignition system operation/check spark plug wires.	Group 120/Operator's Manual
Clean and gap or replace spark plugs.	Group 40/Operator's Manual
Check engine oil pressure.	Group 105
Adjust engine valve clearance.	Group 05/Operator's Manual
Check engine performance on dynamometer.	Group 105

DYNAMOMETER TEST

IMPORTANT: Consult the appropriate machine technical manual for a recommended method of loading engine for dynamometer testing and engine specifications.

If possible, test the engine on a dynamometer and record horsepower output before it is tuned. This test gives the horsepower output and fuel consumption of the engine as is. This will help determine if a tune-up can restore engine power or whether an overhaul is needed. Test engine on a dynamometer after tune-up and horsepower output with reading obtained before tune-up.

Satisfactory engine performance depends on these basic things listed below:

- An adequately balanced supply of clean air and fuel.
- Good compression pressure.
- Proper valve train timing for good combustion.
- Proper air temperatures.
- Proper fuel setting for altitude level at which engine is operated. (See ALTITUDE COMPENSATION GUIDELINES, earlier in this group.)

RG,CTM82,100,9 -19-11JUN93

ENGINE BREAK-IN GUIDELINES

Engine break-in should be performed when the following repair have been done:

- 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 has been replaced. (Primary objective is to see if oil seal leaks.)
- Cylinder head has been removed. Check and reset valve clearance.

RG,CTM82,100,8 -19-28MAY93

ENGINE BREAK-IN INSTRUCTIONS

After a MAJOR engine overhaul, 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 engine break-in.

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.

TIME	LOAD	ENGINE SPEED*	REMARKS
5 Minutes	No Load	850 rpm	Check oil pressure, coolant, temperature, and leakage.
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.)

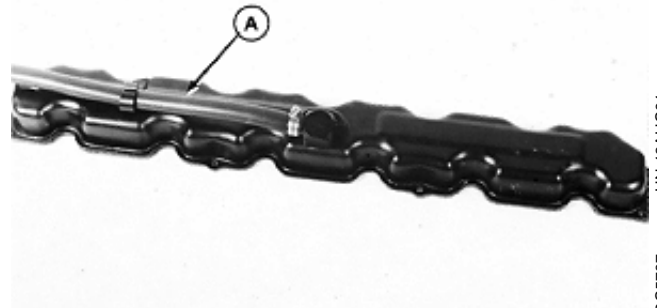
During the first 100 hours of operation, avoid over-loads, excessive idling, and no-load operation.

After 100 hours maximum, drain crankcase oil and change oil filter. Fill crankcase with oil of proper viscosity and service classification. John Deere TORQ-GARD SUPREME 15W40 engine oil is recommended. (See ENGINE OIL, in Group 02.)

RG,CTM82,100,10-19-11JUN93

CHECK CRANKCASE VENTILATION SYSTEM

1. Inspect crankcase ventilation system for restrictions. 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.
2. Clean crankcase vent tube (A) with solvent and compressed air if restricted. Install and tighten hose clamps securely.

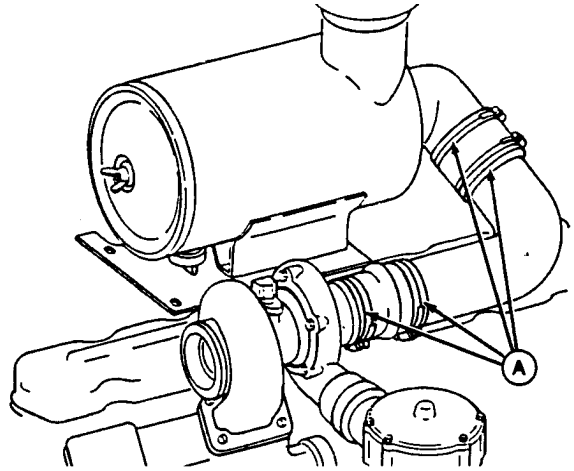


-JUN-12AUG91
RG5797

RG,CTM82,100,3 -19-29APR93

CHECK AIR INTAKE SYSTEM

1. Replace air cleaner primary and secondary filter elements.
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.



RG6511 -UN-03MAR93

RG,CTM82,100,4 -19-29APR93

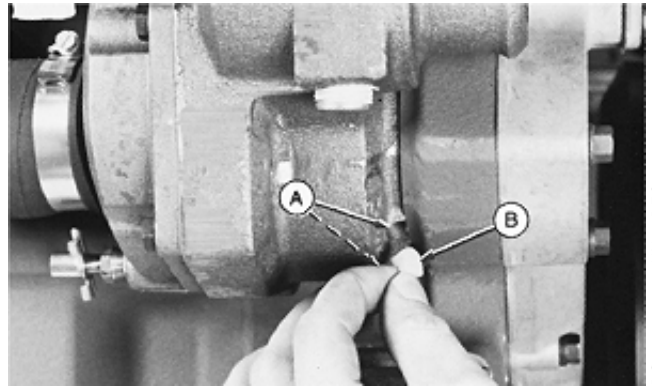
CHECK EXHAUST SYSTEM

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.

RG,CTM82,100,5 -19-04FEB93

CHECK AND SERVICE COOLING SYSTEM

1. Remove trash that has accumulated on or near radiator.
2. Visually inspect entire cooling system and all components for leaks or damage. Repair or replace as necessary.
3. Remove the foam filters (B) from weep holes (A) located in the bottom of water pump housing. Inspect the weep holes for any restrictions.
4. Insert a heavy gauge wire deep into weep holes to make sure holes are open.
5. Install new foam filters flush with pump housing in each weep hole, if pump assembly passes inspection.



RG,CTM82,100,6 -19-29APR93

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

IMPORTANT: Water pump, block, and auxiliary water pump (if equipped) drain valves (A, B, & C) must be opened to completely drain both sides of the engine.



6. Remove and check thermostats. (See REMOVE AND TEST THERMOSTATS in Group 25.)

7. Drain and flush cooling system. (See FLUSHING AND SERVICING COOLING SYSTEM in Group 02.)

IMPORTANT: Air must be expelled from cooling system when system is refilled. Loosen temperature sending unit fitting at rear of cylinder head, bleed plug or petcock at top front of cylinder head, or plug in thermostat housing to allow air to escape when filling system. Retighten fitting or plug when all the air has been expelled.

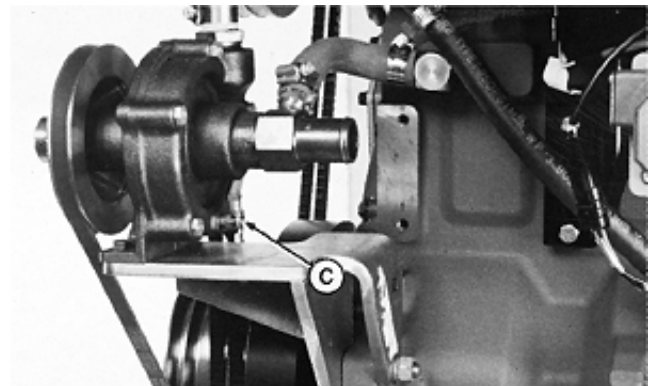
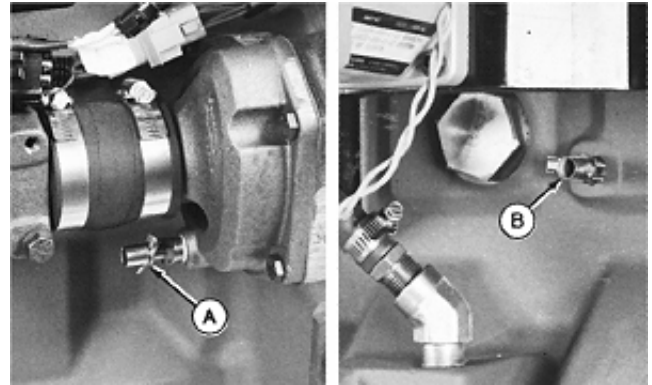
8. Fill cooling system with coolant. (See ENGINE COOLANT RECOMMENDATIONS in Group 02.)

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

10. After engine cools, check coolant level.

NOTE: Coolant level should be approximately 19 mm (3/4 in.) below bottom of radiator filler neck.

11. Check system for holding pressure. (See PRESSURE TEST COOLING SYSTEM AND RADIATOR CAP in Group 105.)



A—Water Pump Drain Valve
B—Block Drain Valve
C—Auxiliary Water Pump Drain Valve

TS281 -UN-23AUG88

RG6530 -UN-14DEC92

RG6531 -UN-14DEC92

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.



TS204 -UN-23AUG88

RC4694 -UN-15DEC88

S11.22010,CZ -19-13MAY93

SPECIAL OR ESSENTIAL TOOLS

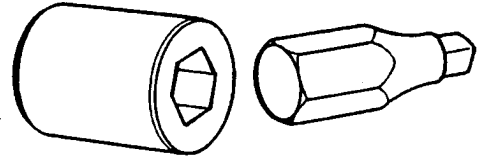
NOTE: Order tools according to information given in the U.S. SERVICE-GARD™ Catalog or in the European Microfiche Tool Catalog (MTC).

DX,TOOLS -19-05JUN91

105

Oil Galley Plug Tool JDG782

Used to remove and install oil galley plug.

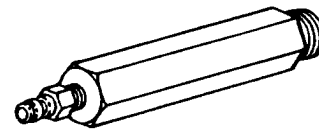


RG6612 -UN-29JAN93

RG,JDG782 -19-02APR93

Compression Test Adapter JDG814

Used with JT01682* (D14547BA**) Gauge and Hose Assembly to test compression pressure.



RG6759 -UN-30APR93

*Part of JT01674 (D14546BA) Compression Test Kit.

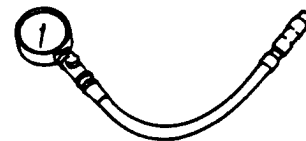
**Use with JT01681 Special Adapter for quick coupler connection.

RG,JDG814 -19-01JUN93

Compression Test Kit JT01674 (D14546BA)

Gauge and Hose Assembly . . . JT01682 (D14547BA)

Used with JDG814 Compression Test Adapter to test compression pressure.



RG6760 -UN-30APR93

RG,JT01674,NG -19-30APR93

Cooling System Pressure Pump D05104ST

Used to pressure test radiator cap and cooling system.



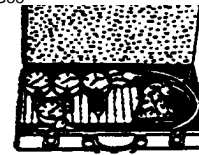
S55.22005.C -19-17SEP91

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R26406N -UN-29NOV88

Universal Pressure Test Kit JT05470 (D15027NU)

Used for testing engine oil pressure.



RG5162 -UN-23AUG88

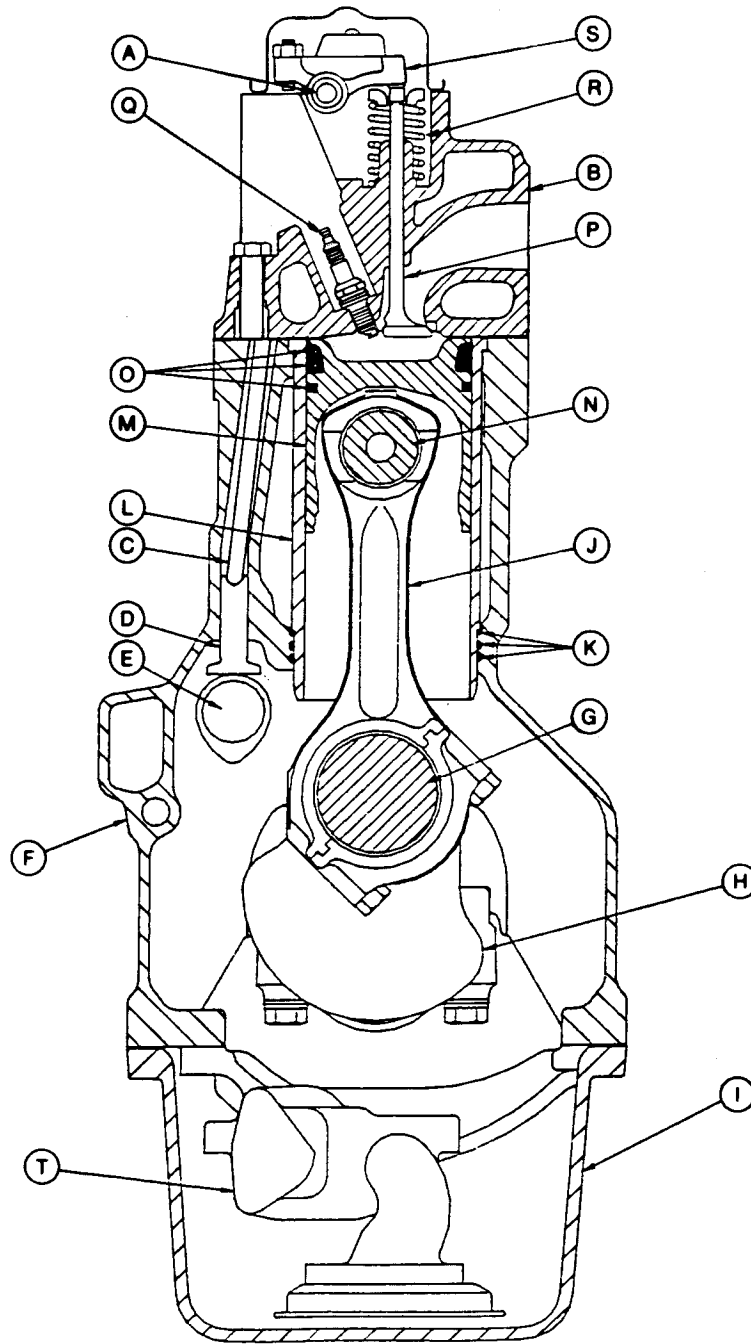
S55.22005.B -19-17SEP91

ENGINE TEST SPECIFICATIONS

ITEM	SPECIFICATION
Compression Pressure: (Wide Open Throttle & 275—325 RPM cranking speed with 11:1 Compression Ratio)	1517—1724 kPa (15.1—17.2 bar) (220—250 psi)
Oil Pressure [105°C (220°F) Sump Temperature]: Minimum (No Load/Slow Idle)	138 kPa (1.4 bar) (20 psi)
Maximum (Full Load/Rated Speed)	400 kPa (4.0 bar) (58 psi)
Cooling System Leakage Test Pressure	120 kPa (1.2 bar) (17 psi)

RG.CTM82,105,1 -19-04JUN93

ENGINE—SECTIONAL VIEW



RG6566 -UN-21DEC92

A—Rocker Arm Shaft
 B—Cylinder Head
 C—Push Rod
 D—Cam Follower
 E—Camshaft

F—Cylinder Block
 G—Crankshaft
 H—Crankshaft Counterweight
 I—Oil Pan
 J—Connecting Rod

K—Liner Packing Rings
 L—Cylinder Liner
 M—Piston
 N—Piston Pin
 O—Piston Rings

P—Valve
 Q—Spark Plug
 R—Valve spring
 S—Rocker Arm
 T—Oil Pump

GENERAL ENGINE DESCRIPTION

6076 Natural Gas Engines are vertical stroke, in-line, valve-in-head, 6-cylinder spark ignited engines. The cylinder firing order is 1-5-3-6-2-4.

Natural gas is mixed with intake air by a carburetor. Depending on fuel supply pressure available, the carburetor will be located either before the turbocharger, or between turbocharger and aftercooler. The fuel is supplied to the carburetor at the proper pressure level by a regulator. Regulator outlet pressure varies with intake air pressure. Intake air is controlled by a throttle plate between turbocharger and aftercooler.

Ignition is provided by a non-waste spark ignition system with adjustable timing and overspeed protection features. Engine position and speed, indicated by a timing wheel behind the camshaft gear, trigger the ignition system to fire each cylinder at the proper time.

All natural gas engines are turbocharged. Operated by exhaust gases, the turbocharger compresses intake air from air cleaner and routes it to each cylinder's combustion chamber. Natural gas turbochargers use a water-cooled center housing to maintain lower bearing temperatures and enhance turbocharger life.

An aftercooler cools the turbocharger compressor discharge air before it enters the intake manifold. The aftercooler uses liquid coolant to cool the charge air.

On higher horsepower engines, separate circuit aftercooler system is used to maintain charge air temperature at an acceptable level.

Intake and exhaust valves are operated by cam followers, push rods, and rocker arm assembly. Cylinder heads have replaceable inserts and valves, and have positive rotators for both intake and exhaust valves.

The camshaft and followers are made of chilled iron. The cam lobes are individually flame hardened to provide excellent wear characteristics. Spherically ground followers riding on tapered cam lobes help insure positive follower rotation.

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 piston and liner kit.

Pistons are constructed of high-grade cast aluminum alloy and are cam ground. A double Ni-Resist ring carrier is cast integrally in the piston to greatly improve the life of the two ring grooves. Pistons have a three ring combination. The top two rings are compression rings and the lower ring is an oil control ring.

The highly polished, hardened piston pins are fully-floating and held in position by means of snap rings. Spray jets (piston cooling orifices) in cylinder block direct pressurized oil to lubricate piston pins and cool pistons.

Connecting rods are of forged steel and have replaceable bushing and bearing inserts. They are weight controlled (by machining) on both ends to minimize engine vibration.

The engine is supplied with lubricating oil by a gear pump driven off the rear of the crankshaft. Oil is conditioned in a housing located on the right side of the engine. Oil temperature is limited by an oil cooler and filtered by a full flow oil filter. Individual cooler and filter bypass valves protect the system and ensure engine lubrication during times of high restriction; such as cold starts. Oil pressure is controlled by a pressure regulating valve located before the main oil gallery.

Coolant flow is supplied by a gear-driven water pump located on the right side of the engine. The water pump is driven off of the camshaft gear.

HOW THE LUBRICATION SYSTEM WORKS

NOTE: Refer to illustrations on the following two pages.

The engine lubrication system consists of a gear-driven (crankshaft), positive displacement pump (A), oil cooler (C), oil filter (F), cooler bypass valve (I), filter bypass valve (H), and oil pressure regulating valve (E).

Oil is drawn up from the oil pan through the oil pump. After it leaves the oil pump, oil flows to the oil cooler through a machined passage in the cylinder block. The oil conditioning housing (D) contains the oil cooler bypass valve, oil filter bypass valve, oil pressure regulating valve, and the engine oil filter. Oil then proceeds through the oil cooler where it exchanges heat with the coolant.

If high restriction is sensed, such as during a cold start, oil bypasses the oil cooler through the cooler bypass valve and goes directly to the oil filter. If excessively high restriction is sensed at the filter, oil is routed directly to the regulating valve. After flowing past the regulating valve; pressurized, cooled, filtered oil is supplied to the main oil gallery (B). Oil is then distributed, under pressure, to each main bearing (T) and piston cooling orifice (Q). Oil from the piston cooling orifices lubricates the piston pin and bushing (P) through a hole in the top of the connecting rod. The regulating valve permits excess oil to be diverted back to the oil pan.

From the main oil gallery, cooled and filtered oil is pressure fed to the main and rod bearings (R), piston cooling orifices, and camshaft bushings (S). Oil from the front camshaft bushing is fed through a drilled hole in the camshaft nose and lubricates the camshaft thrust washer and splash lubes the front gears.

Oil from the rear camshaft bushing is fed through a drilling in the cylinder block and cylinder head and up to the rocker arm shaft (N). Oil from the shaft is distributed to the rocker arms. Oil from the rocker arms lubricates the other valve train components and camshaft followers.

Clean oil from the oil filter goes to the turbocharger oil inlet line (G) and is returned through the turbocharger oil return tube (O). Oil completes the circuit by returning to the oil pan.

RG,CTM82,105,4 -19-28MAY93

HOW THE LUBRICATION SYSTEM WORKS—CONTINUED



105
7

RG06721 -JUN-

A—Engine Oil Pump
B—To Main Oil Gallery
C—Engine Oil Cooler
D—Oil Conditioning Housing
E—Oil Pressure Regulating Valve
F—Oil Filter

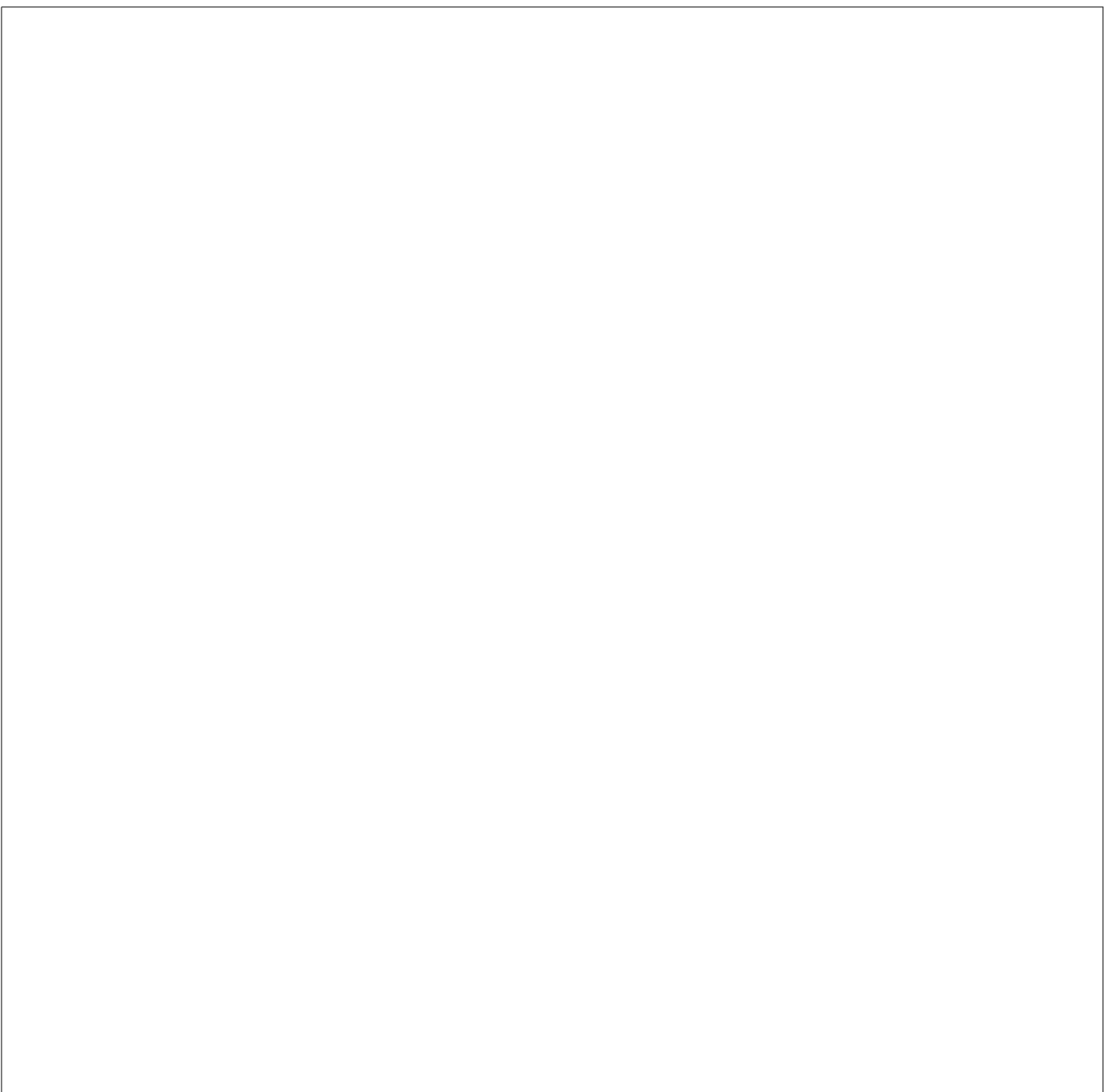
G—Turbocharger Oil Inlet Line
H—Filter Bypass Valve
I—Oil Cooler Bypass Valve
J—From Oil Cooler
K—To Oil Cooler
L—From Oil Pump

M—Main Oil Gallery
N—Rocker Arm Shaft
O—Turbocharger Oil Return Tube
P—Piston Pin and Bushing
Q—Piston Cooling Orifices
R—Connecting Rod Bearings

S—Camshaft Bushings
T—Main Bearings
U—Low Pressure Engine Oil
V—High Pressure Engine Oil
W—To Oil Pan*
X—To Turbocharger*

*Not shown on this artwork, refer to artwork on following page.

RG.CTM82,105,5 -19-03JUN93



RG.C6722 -JUN-

- | | | | |
|---------------------------------|--------------------------------|---------------------------------|----------------------------|
| A—Engine Oil Pump* | G—Turbocharger Oil Inlet Line* | M—Main Oil Gallery* | S—Camshaft Bushings* |
| B—To Main Oil Gallery | H—Filter Bypass Valve | N—Rocker Arm Shaft* | T—Main Bearings* |
| C—Engine Oil Cooler* | I—Oil Cooler Bypass Valve | O—Turbocharger Oil Return Tube* | U—Low Pressure Engine Oil |
| D—Oil Conditioning Housing | J—From Oil Cooler | P—Piston Pin and Bushing* | V—High Pressure Engine Oil |
| E—Oil Pressure Regulating Valve | K—To Oil Cooler | Q—Piston Cooling Orifices* | W—To Oil Pan |
| F—Oil Filter | L—From Oil Pump | R—Connecting Rod Bearings* | X—To Turbocharger |

Oil Conditioning Assembly

* Not shown on this artwork, refer to previous page.

HOW THE COOLING SYSTEM WORKS

Refer to illustration on the following pages.

The pressurized cooling system consists of either a conventional radiator, or a surge tank and heat exchanger, a water pump (B), thermostats (K), and water outlet manifold (L).

The pump draws low temperature coolant from the bottom of radiator or heat exchanger and discharges it through the water inlet manifold elbow (D), into main coolant gallery (E) on right-hand side of engine. Coolant from the main coolant gallery flows into lower end of engine oil cooler cavity (F), circulates around oil cooler plates to cool engine oil, then flows out upper end of oil cooler cavity and into cylinder block coolant jacket.

Coolant enters coolant jacket near rear of engine, and flows around the cylinder liners progressing upward toward cylinder head and forward from No. 6 cylinder toward No. 1 cylinder. As coolant circulates around the liners, it carries excess heat away from the liners.

Coolant flows through block deck passages and cylinder head gasket into the cylinder head. Coolant passages in block deck, cylinder head gasket, and cylinder head are sized to provide even coolant flow in all parts of the head. Upon entering the head, coolant circulates through cavities around intake and exhaust ports, spark plugs, valve guides and valve seats to keep all parts of the head at acceptable temperature levels. Coolant then flows toward front end of cylinder head where it passes through the outlet cavity and into water outlet manifold and thermostat housing.

If coolant temperature in thermostat housing is below thermostat opening temperature, thermostats will remain closed (during warm-up periods), causing coolant to be directed back through bypass pipe (N) and into water pump inlet to be recirculated through the engine. This provides a faster, more uniform warm-up.

If coolant temperature in thermostat housing is above thermostat opening temperature, thermostats will be open (engine at normal operating temperature) and coolant will flow through thermostats and thermostat cover and into radiator top tank or surge tank.

Higher horsepower engines use a separate circuit aftercooler system [aftercooler (I), auxiliary water pump (T), and external heat exchanger] to maintain a low charge air temperature. When filling cooling system, coolant enters the aftercooler system through fitting (R) in upper left cylinder block and air bleeds out through orifice fitting (V) in water manifold. During engine operation, the orifice fitting limits exchange of coolant between engine circuit and aftercooler circuit. This allows coolant flowing through the separate aftercooler circuit to be cooled lower than normal engine coolant temperature.

Lower horsepower engines that do NOT use a separate circuit aftercooler system, coolant is taken from upper left cylinder block and routed into aftercooler (I) where it circulates through the aftercooler core and back out to the thermostat housing. Coolant circulating through the aftercooler absorbs heat from compressed intake air and carries heat back to engine cooling system to be dissipated through the radiator.

The turbocharger is water cooled to protect bearings from high exhaust temperatures and prevent coking of oil in the bearings. Inlet line (G) supplies coolant to turbocharger from inlet manifold elbow (D). Outlet line (H) carries coolant from turbocharger to surge tank or radiator. When engine is shut down, coolant circulates through turbocharger by convection to reduce the degree of heat soak.

Two locations are provided for draining coolant. Block drain valve (M) is located in center of left-hand side of block, and is used to drain left side of engine. Water pump drain valve (C) is located on bottom rear of water pump, and is used to drain right side of engine (water pump, oil cooler, main coolant gallery). An additional drain is located on auxiliary water pump for draining separate circuit aftercooler system.

- | | | | |
|--------------------------------------|---------------------------------------|--------------------------------------|------------------------------------|
| A—From Radiator | H—Turbocharger Coolant
Outlet Line | N—Coolant Bypass Pipe | S—From External Heat
Exchanger* |
| B—Water Pump | I—Aftercooler | O—Low Temperature Engine
Coolant | T—Auxiliary Water Pump* |
| C—Water Pump Drain Valve | J—To Radiator | P—High Temperature Engine
Coolant | U—To External Heat
Exchanger* |
| D—Water Inlet Manifold
Elbow | K—Thermostats (2 used) | Q—Charge Air* | V—Orifice (Bleed) Fitting* |
| E—Main Coolant Gallery | L—Water Outlet Manifold | R—Cylinder Block (Fill)
Fitting* | |
| F—Engine Oil Cooler Cavity | M—Block Drain Valve | | |
| G—Turbocharger Coolant
Inlet Line | | | |

* Not shown on this artwork, refer to following page.

RG,CTM82,105,8 -19-03JUN93

- | | | | |
|---------------------------------------|--|--------------------------------------|-----------------------------------|
| A—From Radiator* | H—Turbocharger Coolant
Outlet Line* | N—Coolant Bypass Pipe* | S—From External Heat
Exchanger |
| B—Water Pump* | I—Aftercooler | O—Low Temperature Engine
Coolant | T—Auxiliary Water Pump |
| C—Water Pump Drain Valve* | J—To Radiator* | P—High Temperature Engine
Coolant | U—To External Heat
Exchanger |
| D—Water Inlet Manifold
Elbow* | K—Thermostats (2 used)* | Q—Charge Air | V—Orifice (Bleed) Fitting |
| E—Main Coolant Gallery* | L—Water Outlet Manifold* | R—Cylinder Block (Fill)
Fitting | |
| F—Engine Oil Cooler Cavity* | M—Block Drain Valve* | | |
| G—Turbocharger Coolant
Inlet Line* | | | |

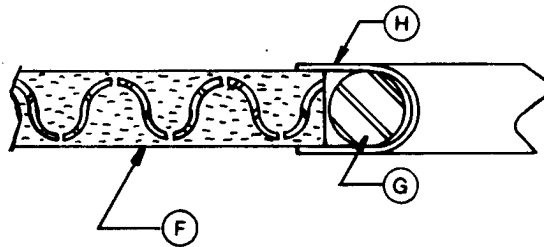
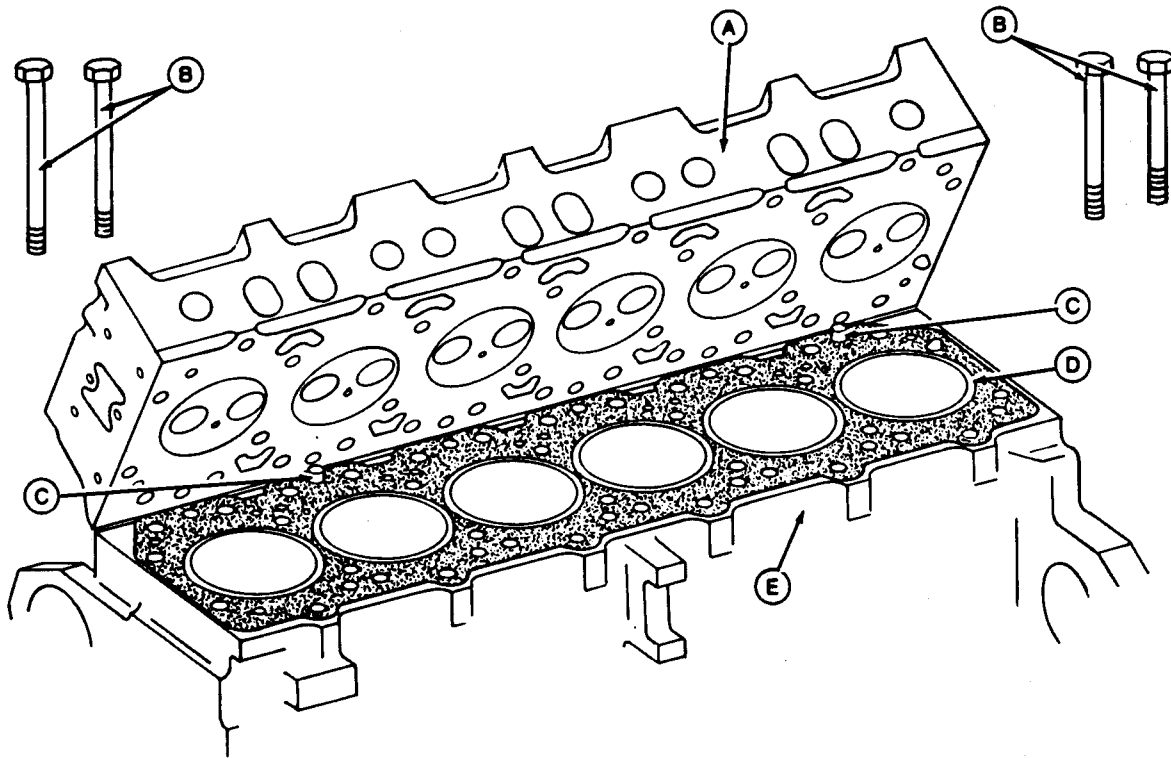
Separate Circuit Aftercooler

* Not shown on this artwork, refer to previous page.

RG.CTM82,105,18-19-03JUN93

HEAD GASKET JOINT CONSTRUCTION AND OPERATION

105
14



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

The head gasket joint consists of:

- Cylinder head gasket
- Cylinder head (A)
- Cylinder block (E)
- Cylinder liners (C)
- Cylinder head cap screws (B)

RG6447 -UN-13OCT92

RG6430 -UN-17SEP92

Refer to illustration on previous page.

The head gasket must form an air-tight seal between cylinder liners and cylinder head that can withstand the temperatures and pressures of the combustion process. The gasket must also form a liquid-tight seal between the cylinder head and cylinder block to retain coolant and oil in their respective passages. The gasket is constructed of thin, formed sheets of steel-inserted, non-asbestos material (F). 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. Dowels (D) 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.

CTM42,G105,26 -19-29OCT92

105
15

DIAGNOSING HEAD GASKET JOINT FAILURES

105
16

Head gasket failures generally fall into three categories:

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

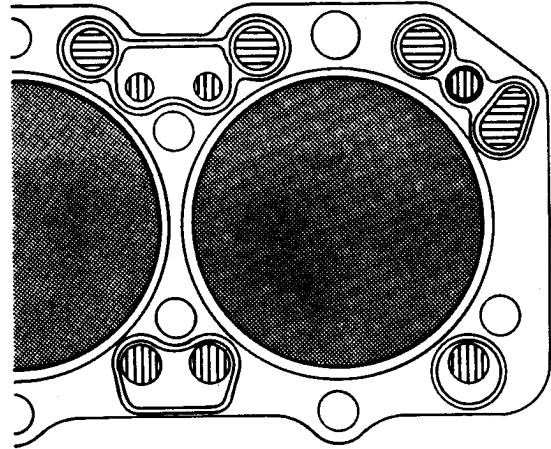
Combustion seal leakage failures occur when combustion gases escape between cylinder head and head gasket combustion flange, or between combustion flange and cylinder liner. Leaking combustion gases may vent to an adjacent cylinder, to a coolant or oil passage, or externally.

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.
- Indications of fuel or timing adjustments.
- Unburned fuel or coolant in exhaust system.



- A—Combustion Sealing Areas
- B—Oil Sealing Areas (Push Rod)
- C—Coolant Sealing Areas
- D—Cylinder Head Cap Screws

-UN-13OCT92

RG6449

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
- Hydraulic or mechanical disturbance of combustion seal

NOTE: Cracked cylinder head or liners may also allow combustion gas leakage into coolant.

RG,CTM82,105,17-19-30APR93

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)

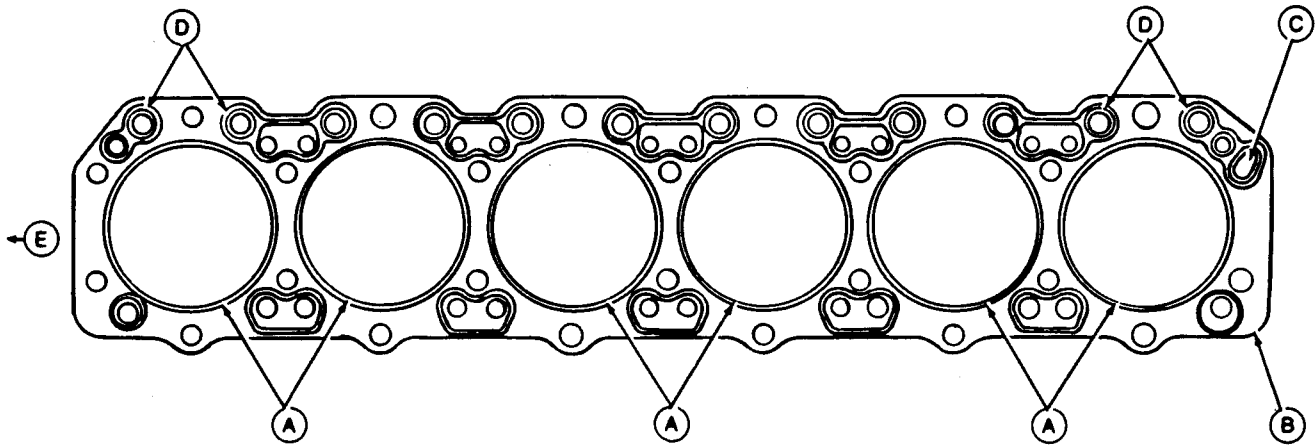
Possible Causes:

- 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—Elastomer Beading Strips E—Front of Engine

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

1. Review historical data relating to machine operation, maintenance and repair, along with diagnostic observations. Note all areas requiring further inspection and analysis.
2. Remove rocker arm cover and check for presence of coolant in the oil.
3. Record head cap screw torques prior to removal. Upon removal, check cap screw length differences.
4. Remove cylinder head using appropriate lifting devices to prevent handling damage to head gasket. See REMOVE CYLINDER HEAD in 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).
- Elastomer missing/damaged in port areas (D).
- Oil or coolant paths from port areas.
- Localized areas of low compression.

6. Before cleaning components, inspect head, block, and liners for evidence of combustion gas and fluid leakage. Inspect cylinders and valve ports for unusual deposits.

7. Clean block, head, liners, and cap screws. (See Groups 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.

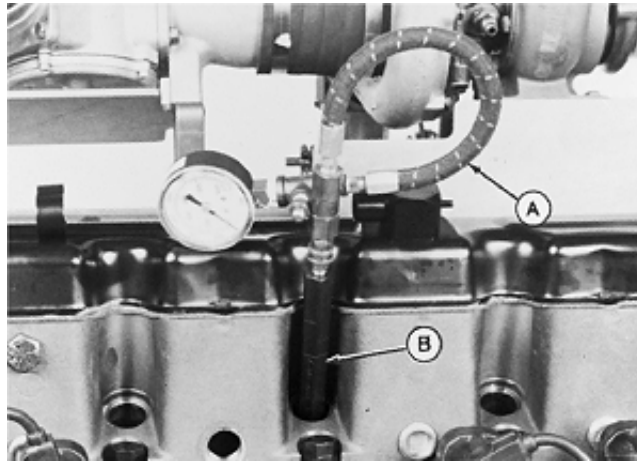
Cylinder Head Cap Screws (See Group 05.)

- 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.

TEST ENGINE COMPRESSION PRESSURE



IMPORTANT: Compression pressures are affected by the cranking speed of the engine. Before beginning test, insure that batteries are fully charged and spark plug 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 all spark plugs. (See Group 40.)

IMPORTANT: Inspect O-ring on JDG814 Compression Test Adapter (B) before measuring compression on each cylinder. Replace O-ring as needed.

3. Install the adapter into spark plug bore. Tighten to 7 N·m (5 lb-ft).

4. Connect JT01682 Gauge and Hose Assembly (A) to adapter.

5. Disconnect gas shut-off solenoid and close manual natural gas shut-off valve.

6. Crank engine over at 275—325 rpm cranking speed and record compression readings.

COMPRESSION PRESSURE SPECIFICATIONS (wide open throttle)

6076AFN (11:1 C/R) 1517—1724 kPa (15.1—17.2 bar)
(220—250 psi)

NOTE: Specified pressure 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.

7. If pressure is much lower than shown, remove gauge and apply oil to ring area of piston through spark plug bore. Do not use too much oil and do not get oil on valves.

8. Crank engine over and record compression reading again.

If pressure is higher than 1724 kPa (17.2 bar) (250 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 1517 kPa (15.1 bar) (220 psi), it is possible that valves are worn or sticking. Recondition cylinder as needed. See Group 05.

9. Measure compression pressure in all remaining cylinders and compare readings. Recondition cylinders and valves, or replace rings and liners, as required.

CHECK ENGINE OIL PRESSURE

1. Remove plug from hole (A) using JDG782 Oil Galley Plug Tool.
2. Install JT05487 Fitting (B), JT05498 Hose (C), JT01609* Coupler (D), JT07034 Gauge (E), and JT03220 Quick Connect Coupler (F).

IMPORTANT: To achieve an accurate oil pressure reading, warm up engine until engine oil is 105°C (220°F).

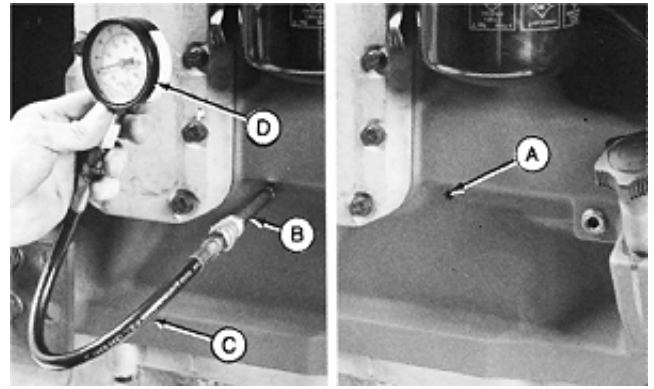
3. Measure oil pressure at slow idle (no load) and rated speed (full load) as specified below.

OIL PRESSURE SPECIFICATIONS

Minimum (No Load at 900 rpm)
(Slow Idle) 138 kPa (1.4 bar) (20 psi)

Maximum (Full Load at 1800 rpm)
(Rated Speed) 400 kPa (4.0 bar) (58 psi)

NOTE: The regulating valve is designed so that adjustment of oil pressure should not be required.



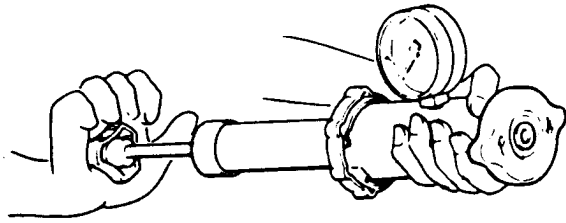
- A—Plug
- B—JT05487 Fitting
- C—JT05498 Hose
- D—JT01609 Coupler
- E—JT07034 Gauge
- F—JT03220 Quick Connect

105
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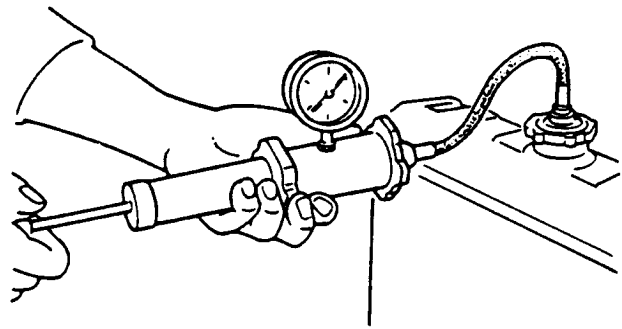
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RG6563

* Part of JT05470 (D15027NU) Universal Pressure Test Kit

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.

Test pressures recommended are for all Deere OEM cooling systems. On specific vehicle applications, test cooling system and pressure cap according to the recommended pressure for that vehicle.

RG18293,6 -19-13MAY93

INSPECT THERMOSTAT AND TEST OPENING TEMPERATURE

105
24

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.

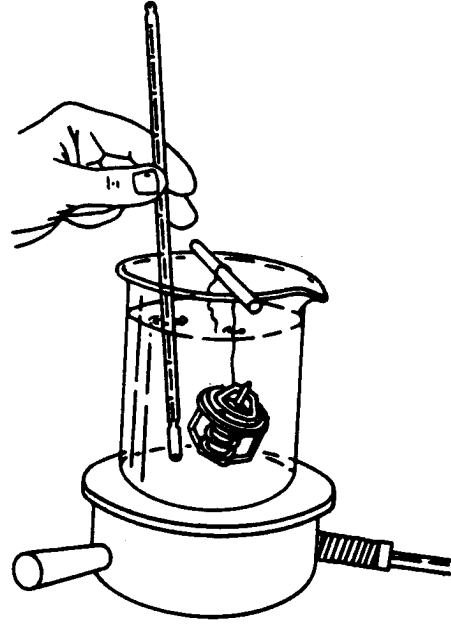
1. Suspend thermostat and a thermometer in a container of water.
2. Stir the water as it heats. Observe opening action of thermometer and compare temperatures with specification given in chart below.

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)
89°C (192°F)	86—90°C (187—194°F)	101°C (214°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 either thermostat is defective on a multiple thermostat engine, replace all thermostats.



RG5971 -UN-17SEP91

RG,CTM82,105,19-19-04JUN93

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).

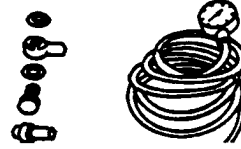
DX,TOOLS -19-05JUN91

Manifold Pressure Tester JDE147

RG5163

-UN-23AUG88

Use with JDG51 Inlet Air Adapter* for testing intake manifold pressure.



* JDG51 is a part of JDE147 Manifold Tester Kit.

RG,JDE147 -19-03MAY93

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
JT05697 U-Tube Manometer Kit	Used to check air intake restriction.

RG,CTM82,110,8 -19-03MAY93

AIR INTAKE AND EXHAUST SYSTEM TEST SPECIFICATIONS

ITEM	SPECIFICATION
Maximum Air Intake Restriction	381 mm H ₂ O (15 in. H ₂ O)
Maximum Allowable Exhaust Temperature (shutdown temperature)	649°C (1200°F)
Maximum Allowable Charge Air Temperature (200 Hp only) (shutdown temperature)	88°C (190°F)
Intake Manifold Pressure (Turbo Boost) @ 1800 rpm Wide Open Throttle (W.O.T.) and Full Load:	
149 kW (200 Hp)	89 kPa (0.9 bar) (13 psi)
112 kW (150 Hp)	70 kPa (0.7 bar) (10 psi)

RG,CTM82,110,1 -19-28MAY93

HOW THE AIR INTAKE AND EXHAUST SYSTEM WORKS

Engine suction draws dust-laden outside air through an air inlet stack into the air cleaner. 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, carburetor, throttle valve, and intake manifold to the engine.

Exhaust, as it is expelled out the exhaust elbow, 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.

Intake air, which has been compressed (and heated) by the turbocharger, flows around the aftercooler and lowers the air temperature up to 10°C (50°F) without separate circuit aftercooler 112 kW (150 Hp) engine or up to 50°C (120°F) with separate circuit aftercooler 149 kW (200 Hp) engine before entering the engine cylinders. Lowering the air temperature makes the air more dense and permits an even greater volume of air to be delivered to the cylinders for combustion. Lower intake air temperatures also make the engine more resistant to detonation (knocking).

The increased volume of air, when combined with a predetermined quantity of additional fuel, enables more power to be produced.

RG,CTM82,110,3 -19-28MAY93

AIR CLEANER OPERATION

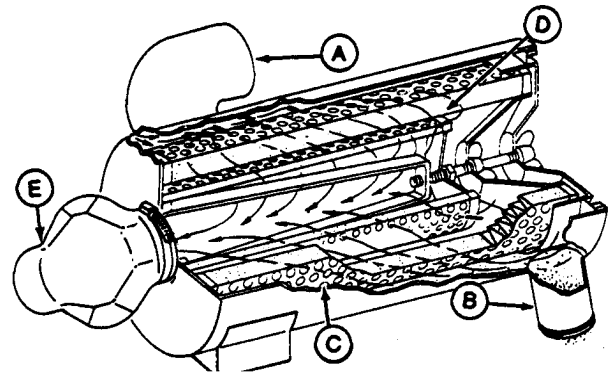
Dust-laden air enters the air cleaner inlet (A) and is forced into a high-speed centrifugal motion.

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

R28270 -UN-14DEC88

RG,CTM82,110,9 -19-03MAY93

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-to-regulator balance line.
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.

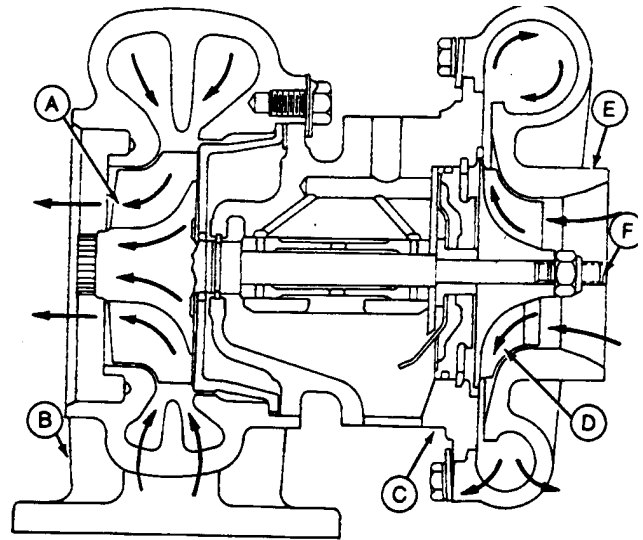
*Do not confuse the whine heard during run down with noise which indicates a bearing failure.

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



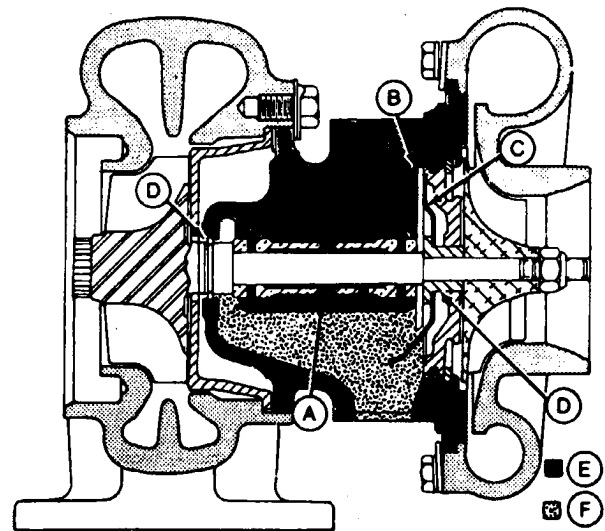
S11,23005.L -19-17MAR92

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R28273

HOW THE TURBOCHARGER IS LUBRICATED

Engine oil under pressure from the engine lubrication system is pumped through a passage in the bearing housing and directed to the bearings (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 the bearing housing.

The Garrett/AiResearch turbocharger contains two floating bearings and the Schwitzer turbocharger contains a single floating bearing. These bearings have clearance between the bearing OD and the housing bore as well as clearance between the bearing ID and the shaft OD. These clearances are lubricated by the oil supply (E) and the bearings are protected by a cushion of oil. Discharge oil (F) drains by gravity from the bearing housing to the engine crankcase.



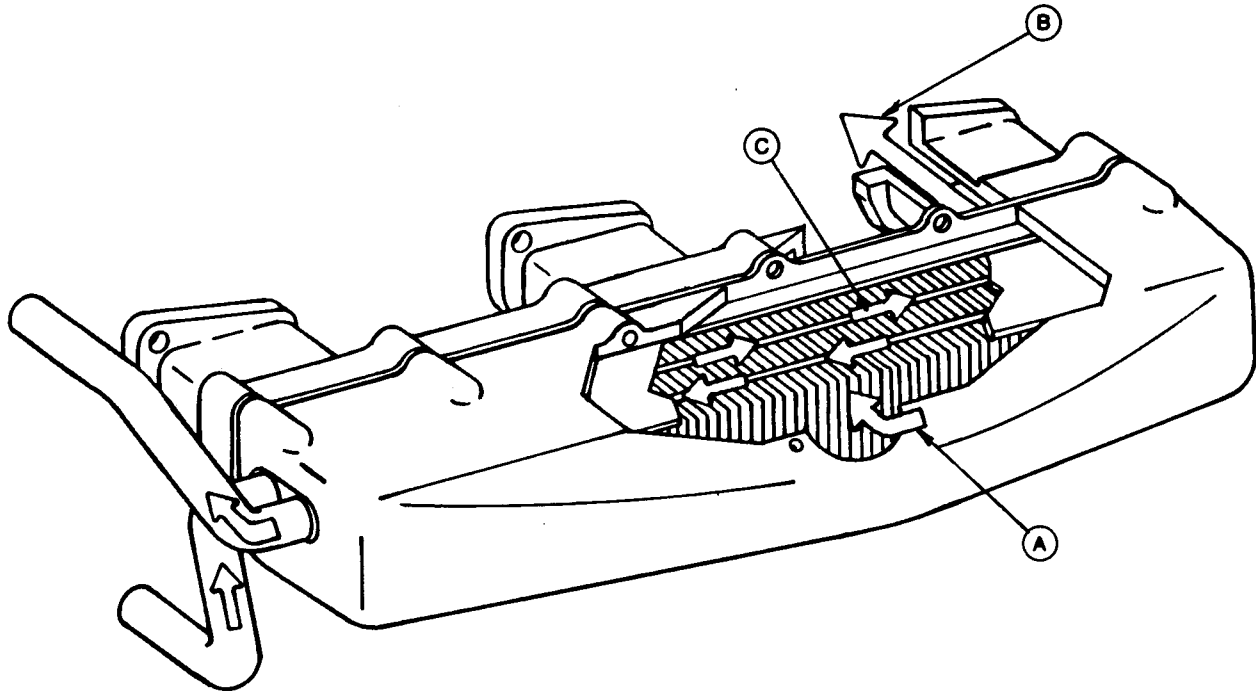
Schwitzer Turbocharger Lubrication

- A—Bearing(s)
- B—Thrust Plate
- C—Thrust Sleeve
- D—Piston Ring
- E—Pressure Oil
- F—Discharge Oil

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RG4646

HOW THE AFTERCOOLER WORKS



A—Heated Air

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 core before going to engine cylinders.

The aftercooler functions as a heat exchanger, lowering intake air (B) temperature as much as 10°C (50°F) without separate circuit aftercooler [112 kW (150 Hp) engines] or up to 50°C (120°F) with separate circuit aftercooler [149 kW (200 Hp) engines].

B—Cooled Air

Lowering air temperature makes air more dense, permitting a greater volume of air to be delivered to engine cylinders. This increased volume of air when combined with additional fuel, enables more power to be produced and increases resistance to detonation (knocking).

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.

C—Engine Coolant

RG,CTM82,110,5 -19-28MAY93

110
5

RG6670 -JUN-21DEC92

CHECK INTAKE MANIFOLD PRESSURE (TURBO BOOST)

Intake manifold pressure (turbo boost) can be checked at intake manifold at 1800 rpm and full rated load.

- If boost pressure is too high, check for overloading and overfueling (rich A/F mixture).

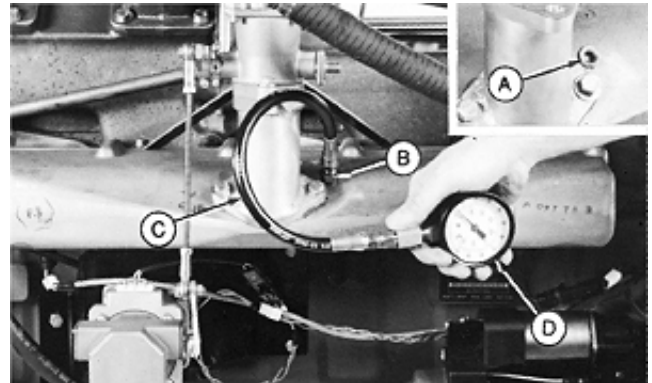
- If boost pressure is too low, check for the following:

- Engine not fully loaded.
- Rich A/F mixture (throttle valve not very far open).
- Restriction in air cleaner.
- Leak in air intake between turbocharger and cylinder head.
- Defective turbocharger.
- Leak in exhaust manifold gasket.
- Leak in regulator balance line.
- Restricted fuel filter elements.
- Faulty or misadjusted pressure regulator.
- Low compression pressure.
- Incorrect ignition timing.
- Carbon build-up in turbocharger.
- Turbocharger compressor or turbine wheel rubbing housing.
- Restricted exhaust.

RG,CTM82,110,6 -19-03MAY93

- **Use JDE147:**

1. Remove pipe plug (A) from intake manifold cover.
2. Install JDG51 Fitting (B) into cover.
3. Install JDG115 Hose (C) with an accurate pressure gauge (D).
4. With engine at operating temperature, connect machine to a dynamometer. Operate engine at rated full load speed. Observe pressure reading.



-UN-21DEC92
RG6561

- A—Pipe Plug
- B—JDG51 Fitting
- C—JDG115 Hose
- D—JDG108 Gauge

INTAKE MANIFOLD PRESSURE SPECIFICATIONS

149 kW (200 Hp)	89 kPa (0.9 bar) (13 psi)
112 kW (150 Hp)	70 kPa (0.7 bar) (10 psi)

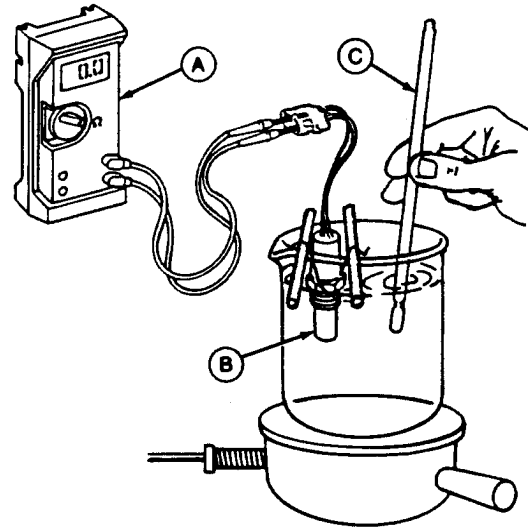
5. Remove test equipment and install plug.

RG,CTM82,110,7 -19-03MAY93

TROUBLESHOOT CHARGE AIR TEMPERATURE SWITCH (CATS)

1. Remove CATS switch (B) from intake manifold.
2. Connect a multimeter (A) between connector pins A and B to measure continuity. Switch should be open (infinite resistance). If switch is closed (0 Ohms resistance) at room temperature, the switch is defective.
3. Suspend sensor end of switch in a container of water.
4. While monitoring water temperature with a thermometer (C), slowly warm the water until switch closes. The switch should close at 85—91°C (185—196°F).
5. As the water cools, monitor the water temperature until the switch opens. The switch should open at 74—80°C (165—176°F).

A—Multimeter
B—CATS Switch
C—Thermometer

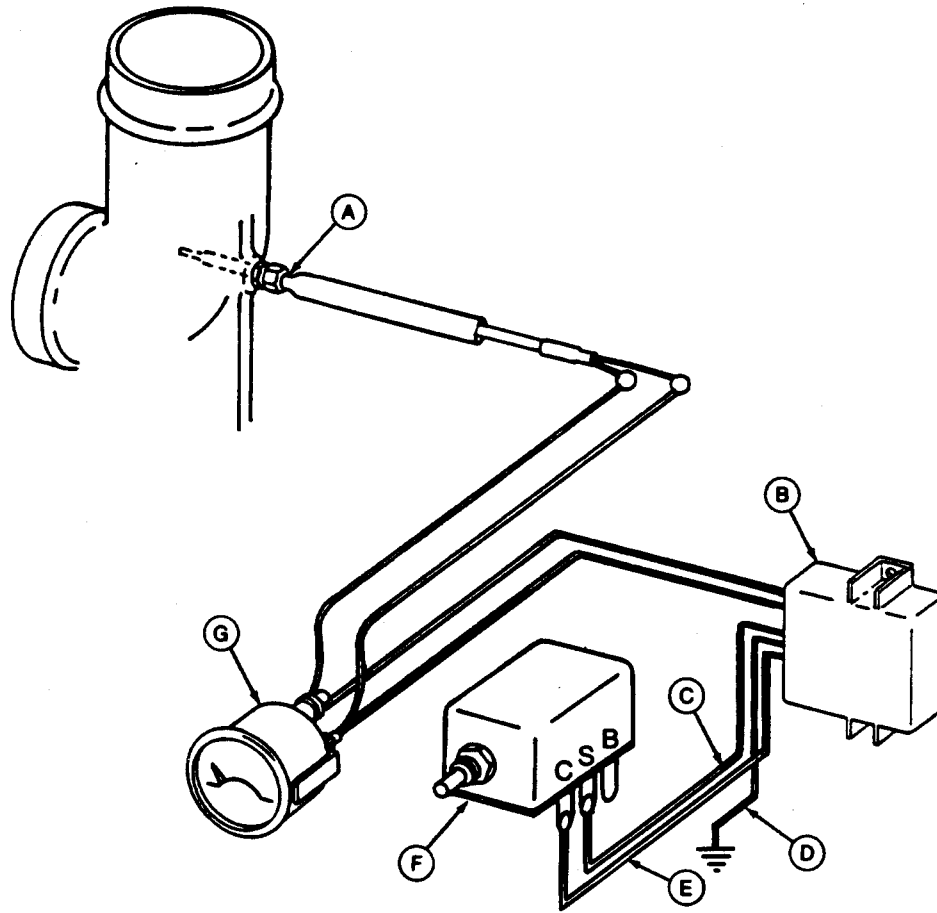


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RG6769 -UN-10MAY93

HOW THE PYROMETER SHUTDOWN WORKS



A—Thermocouple
B—Shutdown Control Box

C—Shutdown Signal Wire
D—Ground Wire

E—Power Supply
F—Safety Reset Switch

G—Pyrometer Gauge

The pyrometer thermocouple (A) senses exhaust temperature at the exhaust elbow. As exhaust temperature rises, the thermocouple sends a signal to the exhaust temperature gauge (G) and pyrometer shutdown control box (B). The trip point of the pyrometer control box is calibrated to 649°C (1200°F). If exhaust temperature reaches the trip point, the

control box connects the shutdown signal wire (C) to ground. The shutdown signal trips the safety reset switch (F) and shuts the engine down. As soon as the thermocouple temperature drops below 649°C (1200°F), the control box resets and the engine can be restarted.

RG,CTM82,110,11-19-28MAY93

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RG6736
-JUN-27APR93

ADJUST PYROMETER SHUTDOWN TEMPERATURE

1. Remove pyrometer thermocouple from exhaust elbow.
2. Disconnect all wires from "S" terminal of safety reset switch, except for pyrometer shutdown signal wire.
3. Turn electrical power on and reset safety switch.

IMPORTANT: DO NOT overheat thermocouple. To avoid melting or damaging thermocouple, heat evenly over length of thermocouple probe.

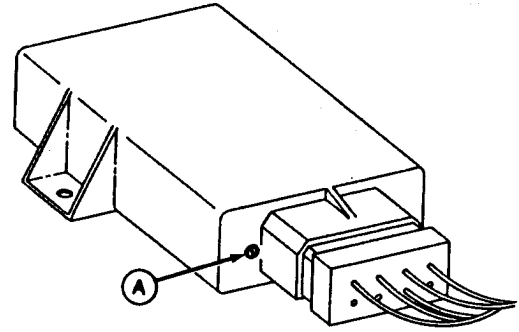
4. While watching pyrometer gauge, slowly heat thermocouple until safety switch is tripped. Note temperature at which safety switch is tripped.

IMPORTANT: DO NOT exceed 649°C (1200°F) shutdown temperature. Higher exhaust temperatures may cause engine damage.

5. Turn pyrometer shutdown adjusting screw (A) clockwise to increase or counterclockwise to decrease shutdown temperature.

NOTE: Adjusting screw rate is approximately 33°C (60°F) per revolution of the adjusting screw.

6. Repeat steps 3, 4, and 5 as necessary to reach a 649°C (1200°F) shutdown temperature.
7. Install thermocouple probe in exhaust elbow.
8. Reconnect wires to "S" terminal of safety reset switch.



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
JT05697 U-Tube Manometer	Check and adjust natural gas regulator differential pressure.

RG.CTM82,115,1 -19-30APR93

115
1

FUEL SYSTEM TEST SPECIFICATIONS

ITEM	SPECIFICATIONS
Regulator Differential Gas Pressure	51—102 mm-H ₂ O (2—4 in.-H ₂ O)
Natural Gas Supply Pressure (Regulator Inlet):	
28 kPa (4 psi) System	13—55 kPa (2—8 psi)
138 kPa (20 psi) System	124—207 kPa (18—30 psi)

RG.CTM82,115,2 -19-11JUN93

HOW THE FUEL SYSTEM WORKS

Natural gas supply pressure (I) enters the fuel system through a manual shutoff valve (not shown). Gas flows through the natural gas filter (F) and electric shutoff valve (E) into the pressure regulator (H).

Using carburetor air inlet pressure in balance line (D) as a reference, the pressure regulator reduces gas pressure to the proper differential pressure.

NOTE: Differential pressure is the difference between air pressure at the carburetor inlet (C), and regulated gas pressure. Gas pressure must be 51—102 mm-H₂O (2—4 in.-H₂O) above air inlet pressure under all operating conditions to enable carburetor to maintain a consistent air/fuel mixture.

Gas then flows through the regulated supply line (G), to the carburetor (B). In the carburetor, the gas mixes with air to form the air/fuel mixture. The air/fuel mixture flows from the carburetor, through the throttle valve (A), and into the engine where it is burned.

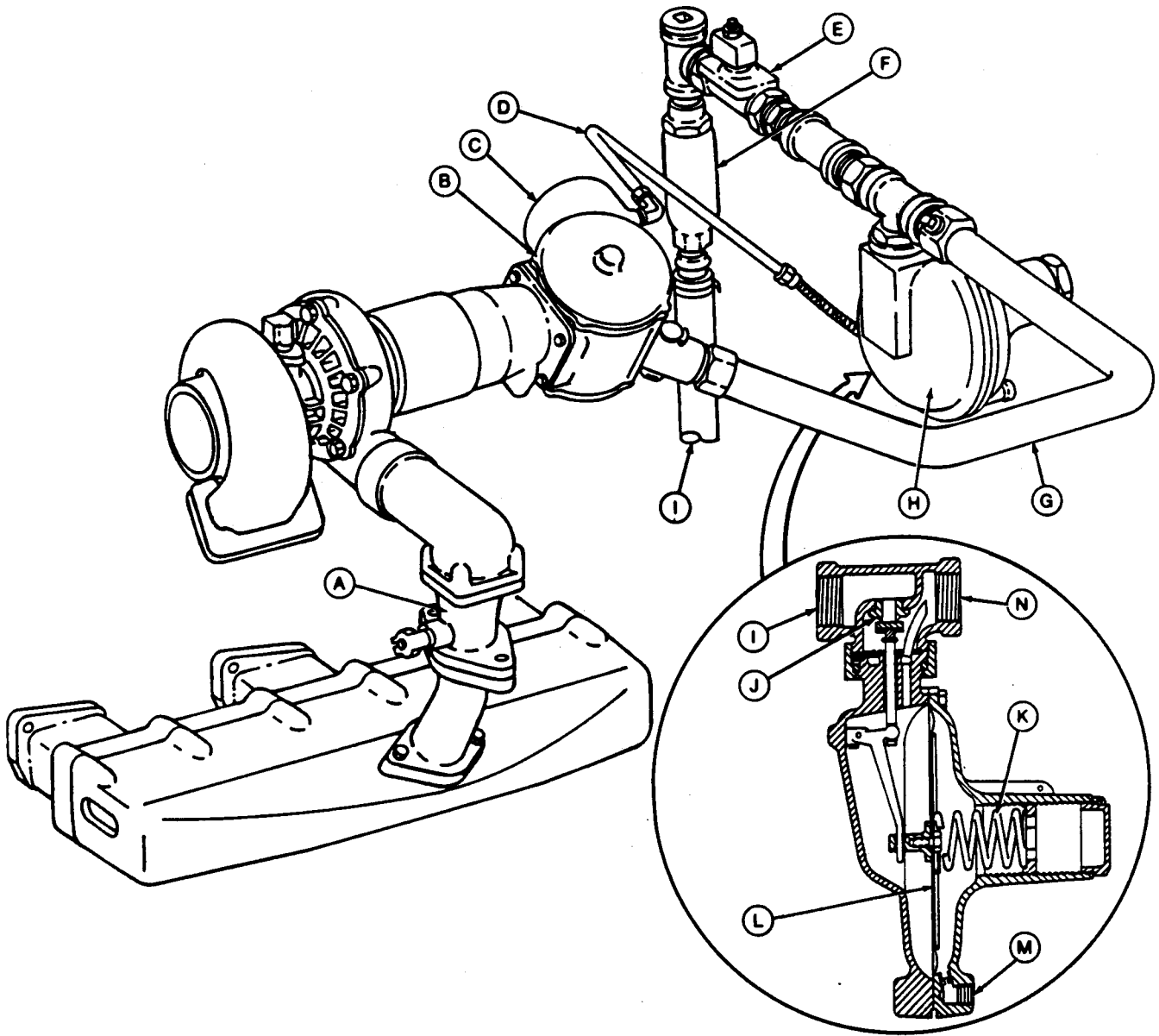
The volume of air and fuel flowing through the carburetor is controlled by the throttle valve. As the throttle valve opening increases, more air/fuel mixture flows to the engine, and engine speed increases.

The regulator uses a diaphragm (L) linked to a ring valve (J) to control the flow of gas into the regulator. Gas pressure is regulated by controlling gas flow.

The regulator adjusting spring (K) and air intake pressure (M, from the balance line) apply a force on one side of the diaphragm. This force is opposed by regulated gas pressure (N) on the opposite side of the diaphragm. A change in pressure on either side of the diaphragm causes the diaphragm to move, resulting in a corresponding adjustment of the ring valve. The ring valve is continuously adjusted to keep the pressure on each side of the diaphragm in equilibrium.

RG,CTM82,115,3 -19-30APR93

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2



A—Throttle Valve
 B—Carburetor
 C—Air Inlet
 D—Balance Line

E—Electric Shutoff Valve
 F—Gas Filter
 G—Regulated Supply Line
 H—Natural Gas Regulator

I—Supply Pressure
 J—Ring Valve
 K—Adjusting Spring

L—Diaphragm
 M—Air Intake Pressure
 N—Regulated Gas Pressure

HOW THE FUEL SYSTEM WORKS—CONTINUED

As intake air (F) is pulled through the carburetor, low pressure on the outlet side of the carburetor equalizes on the back side of the diaphragm (I) through the bleed holes (J) in the metering valve. As pressure on the back side of the diaphragm is reduced, the pressure differential across the diaphragm overcomes spring force. As the spring (G) is compressed, the metering valve (H) is lifted off of its seat, and air and fuel is allowed to mix (C).

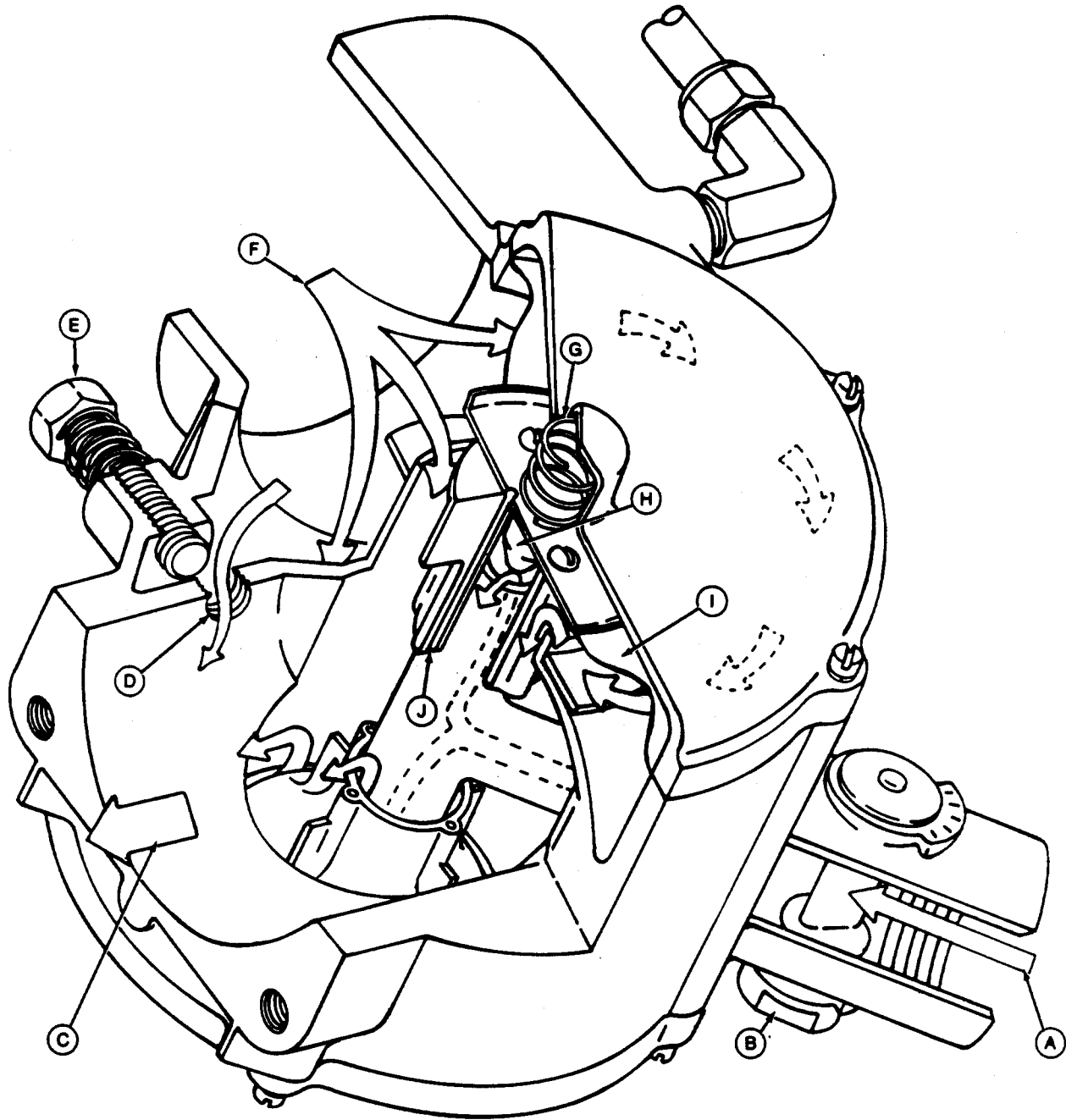
At low idle, the throttle valve is nearly closed allowing only a small amount of air to be pulled through the carburetor. Since fuel flow at idle is limited by the position of the metering valve, the air/fuel mixture is controlled by limiting the amount of air that flows through the metering valve. Turning the idle mixture screw (E) out allows more air to bypass the metering valve through the idle air passage (D). As a result,

the metering valve does not open as far and less fuel is metered, causing the mixture to be leaner. Turning the idle screw in allows less air to bypass the metering valve. As a result, the metering valve opens further, more fuel is metered, and the idle mixture becomes richer.

Under full load, the throttle valve is nearly wide open allowing a large amount of air to be pulled through the carburetor. Since the metering valve is open wide to allow the large volume of air to flow, the air/fuel mixture is controlled by restricting fuel flow at the power valve (B). As the power valve is closed, fuel flow is restricted. With less fuel flowing into the carburetor, the mixture becomes leaner. As the valve is opened, more fuel flows into the carburetor and the mixture becomes richer.

115
4

RG,CTM82,115,4 -19-28MAY93



A—Regulated Gas Supply
 B—Power Valve
 C—Air/Fuel Mixture

D—Idle Air Passage
 E—Idle Mixture Screw
 F—Intake Air

G—Spring
 H—Metering Valve

I—Diaphragm
 J—Bleed Holes

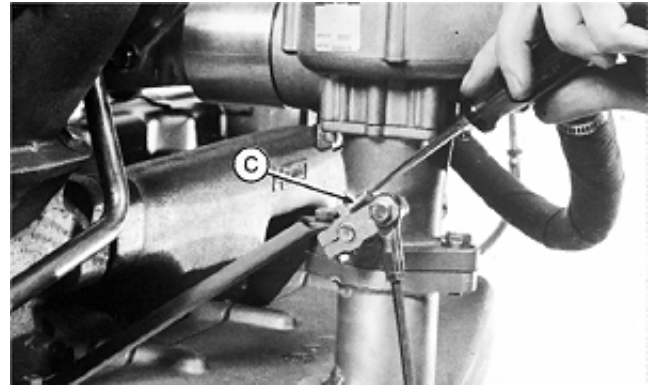
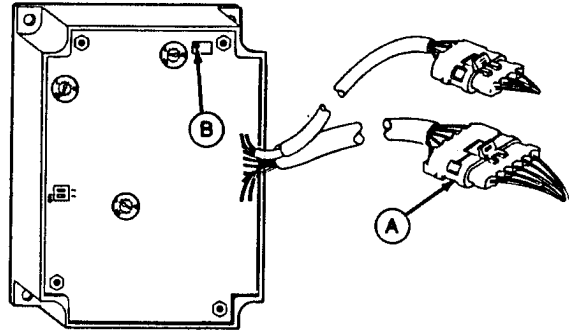
Carburetor (4 psi Gas System)

ADJUST LOW IDLE SPEED

1. With engine warmed up and running at low idle, unplug governor at connector (A). If not equipped with electronic governor, loosen manual throttle cable from throttle lever.
2. Adjust set screw (C) on throttle lever to desired low idle speed.
3. Reconnect electronic governor or throttle cable.
4. If equipped with electronic governor, idle speed may increase slightly when governor is reconnected. If speed increases too far beyond desired idle speed, the speed set screw (B) on electronic governor can be turned counterclockwise to reduce the idle speed.

NOTE: Adjustment of speed set screw will affect maximum attainable RPM.

- A—Governor Connector
- B—Governor Speed Set Screw
- C—Low Idle Speed Set Screw



RG,CTM82,115,6 -19-30APR93

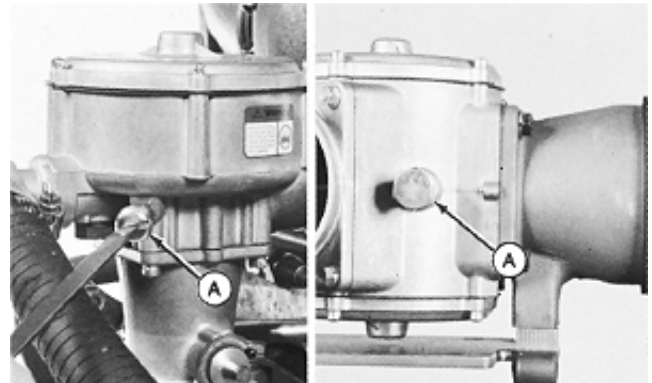
RG6523 -UN-10MAY93

RG6524 -UN-14DEC92

ADJUST LOW IDLE FUEL MIXTURE

With engine running at low idle speed, adjust idle mixture screw (A) until engine idles smoothly.

NOTE: This is not a critical adjustment.



RG,CTM82,115,7 -19-30APR93

RG6565 -UN-21DEC92

ADJUST AIR/FUEL MIXTURE

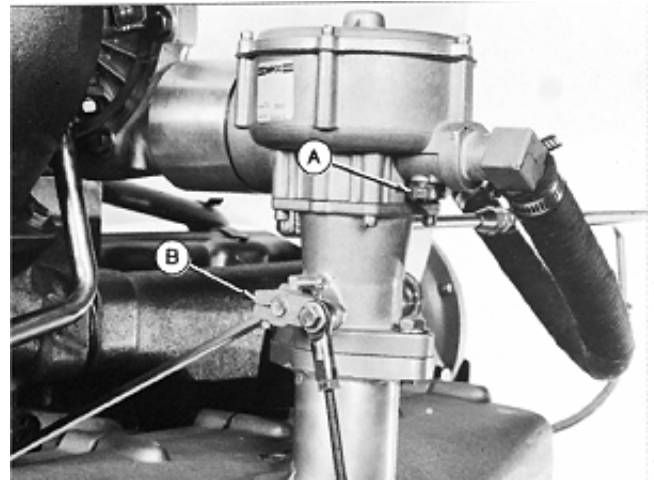
NOTE: Engine will operate at higher efficiency and lower exhaust temperatures with a leaner fuel mixture. If too lean, engine will not make full power, or could begin to misfire.

1. Operate engine at full load condition for the application.
2. Slowly turn the power valve (A) leaner. As fuel mixture is leaned, throttle opening must be increased to maintain engine speed.

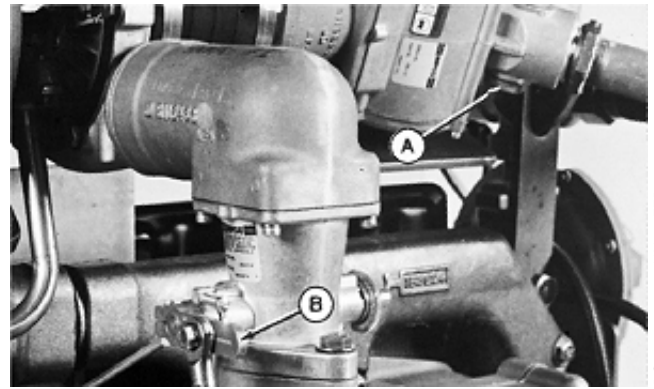
If equipped with a manual throttle, use an interactive process of mixture adjustment and throttle adjustment to maintain constant speed.

If equipped with an electronic governor, the governor will automatically adjust the throttle to maintain constant speed.

3. Continue adjusting the power valve until throttle lever (B) is at least horizontal, if possible.
4. Reduce load on engine and reapply to ensure that mixture setting is not too lean. If engine will not pick up the load, adjust power valve to provide a slightly richer air/fuel mixture.



20 psi system



4 psi system

RG66504 -JUN-14DEC92

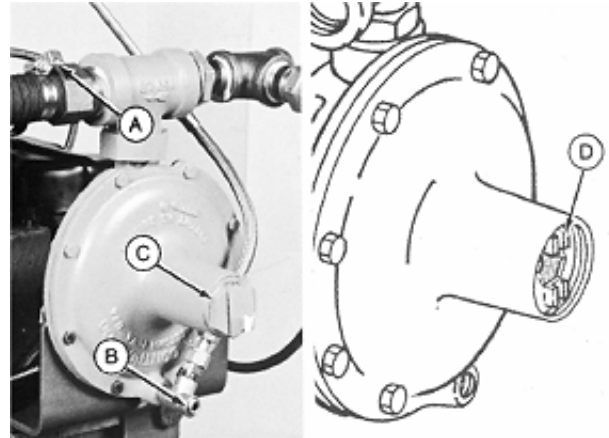
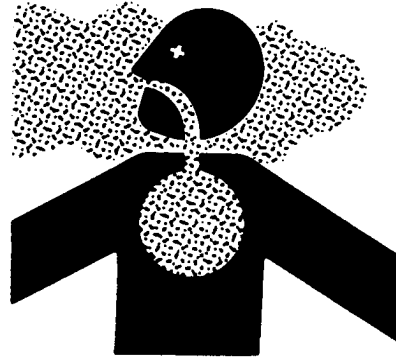
RG66624 -JUN-18FEB93

ADJUST REGULATOR DIFFERENTIAL GAS PRESSURE

CAUTION: Natural gas is highly flammable. Do NOT smoke while working on or around natural gas equipment. Natural gas fumes may cause sickness or death. Work in a well ventilated area.

Differential pressure between the entering air stream and the mixer gas inlet is preset at the factory. If further adjustment is necessary, use the following procedure.

1. Attach water manometer (JT05697) to balance line fitting (B) and regulated supply line fitting (A) between regulator and carburetor.
2. Start engine and read differential pressure on manometer. Pressure should be 51—102 mm-H₂O (2—4 in.-H₂O).
3. If pressure is incorrect, shut engine off and remove cap (C). Turn adjusting screw (D) clockwise to increase pressure, counterclockwise to reduce pressure.
4. Repeat steps 2 and 3 until correct differential pressure is obtained.
5. Shut engine off. Install cap on regulator, remove manometer, and install plugs.



RG.CTM82,115,9 -19-30APR93

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SPECIAL OR ESSENTIAL TOOLS

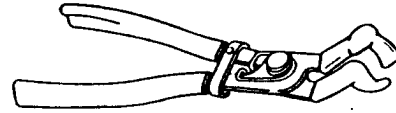
NOTE: Order tools according to information given in the U.S. SERVICE-GARD™ Catalog or in the European Microfiche Tool Catalog (MTC).

DX,TOOLS -19-05JUN91

Spark Plug Boot Puller Pliers JDG815

RG6720 -UN-27APR93

Used to remove and install spark plug boots.



RG,JDG815 -19-03MAY93

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
Inductive Timing Light	Checking ignition timing and troubleshooting ignition system.
Multimeter (JT05791)	Checking voltage and resistance. Troubleshooting electrical system.
0—207 kPa (0—30 psi) Pressure Regulator and Gauge.	Pressurize Manifold Absolute Pressure (MAP) sensor.

RG,CTM82,120,1 -19-28MAY93

120

HOW THE IGNITION SYSTEM WORKS

The ignition system consists of:

- Ignition control unit (ICU) (A)
- Manifold absolute pressure (MAP) sensor (I)
- Ignition timing sensor (K)
- Ignition timing wheel (L)
- Ignition coils (H)
- Spark plug wires (G)
- Spark plugs (F)
- Primary ignition harness (E)

The ignition system is a microprocessor based, camshaft referenced, non-waste spark, capacitive discharge system. Being a non-waste spark system, each cylinder has its own ignition coil, and the coil fires on the combustion stroke only.

The overall operation of the ignition system is controlled by the ignition control unit (ICU). Firing interval and timing schedules are programmed into the ICU. As the ICU receives engine speed, position, and load information from the ignition timing sensor and MAP sensors, it uses these schedules to determine precisely when each cylinder should fire. The ICU then signals the proper ignition coil to discharge.

The timing sensor sends a signal to the ICU each time a trigger finger passes by the end of the sensor. The ignition timing wheel on the camshaft has six trigger fingers (M) precisely spaced at 60° to provide timing interval signals, and a seventh finger (J) to provide a position (reset) signal. The timing interval signals indicate how fast the engine is running and when each cylinder should fire. The reset signal triggers the ICU to reset to the beginning of the firing order (5-3-6-2-4-1-RESET). Since the reset signal is between cylinder No. 1 & 5, No. 5 cylinder will be the first cylinder to fire after the reset signal. However, the timing marks on the vibration damper are relative to No. 1 cylinder.

When starting the engine, the ICU will go through one complete revolution of the timing wheel before it fires any of the cylinders. This ensures that the ignition system is correctly oriented with the engine.

The manifold absolute pressure (MAP) sensor sends a signal to the ICU to indicate manifold (boost) pressure. The ICU interprets this signal as an indication of load on the engine.

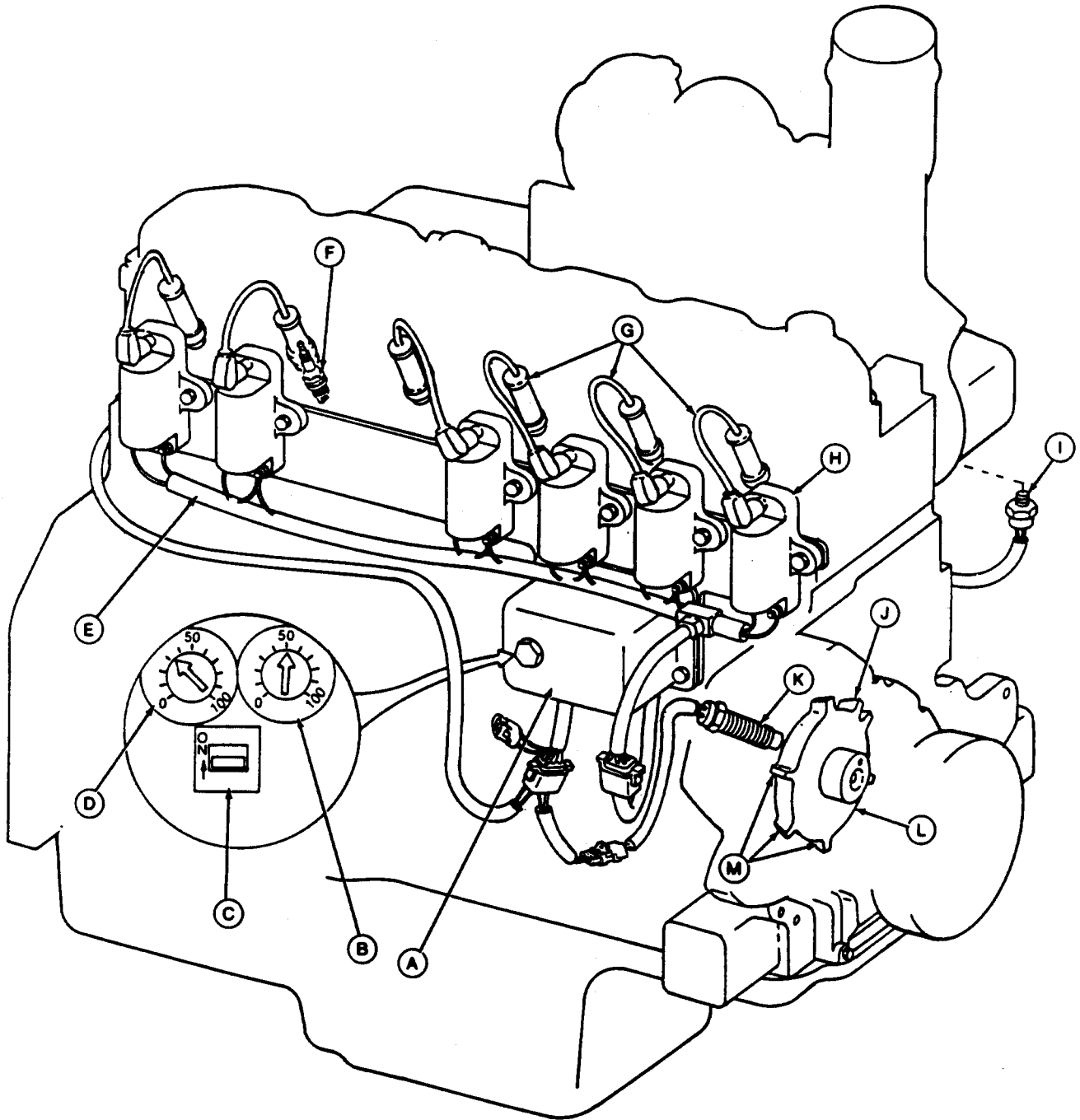
The ICU uses the speed signal from the timing sensor to select the base timing, then uses the load signal to determine how much timing advance to apply to the base timing. The ICU then sends a low voltage, high current primary charge through the primary harness to the appropriate ignition coil.

The ignition coil consists of a primary coil and a secondary coil. The primary coil receives the primary charge from the ICU and induces a high voltage, low current charge in the secondary coil. This secondary charge discharges through the ignition coil output terminal, spark plug wire, and into the spark plug where it ignites the air/fuel mixture.

The ICU is provided with a manual timing adjustment potentiometer (D) to allow fine tuning of the ignition system by the operator if knocking or detonation is heard from the engine.

The ICU also provides overspeed protection for the engine. If engine speed reaches the preselected shutdown speed, the ICU will automatically shut the engine down. The ICU is equipped with an overspeed adjustment potentiometer (B) and half-speed verify switch (C). This allows operator to adjust shutdown speed between 1800—2500 rpm and verify the shutdown speed without actually overspeeding the engine.

A self-diagnostic feature is provided that allows the ICU to run a self-diagnostic test on the ignition system.



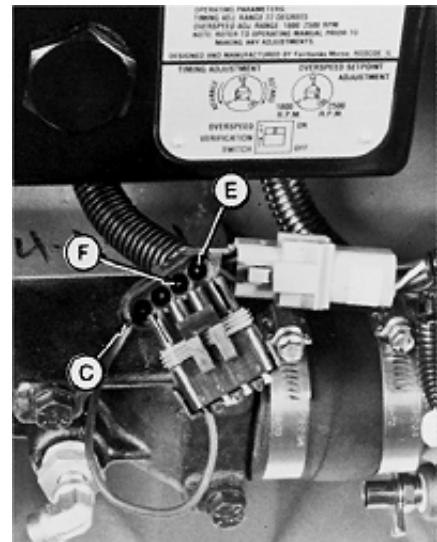
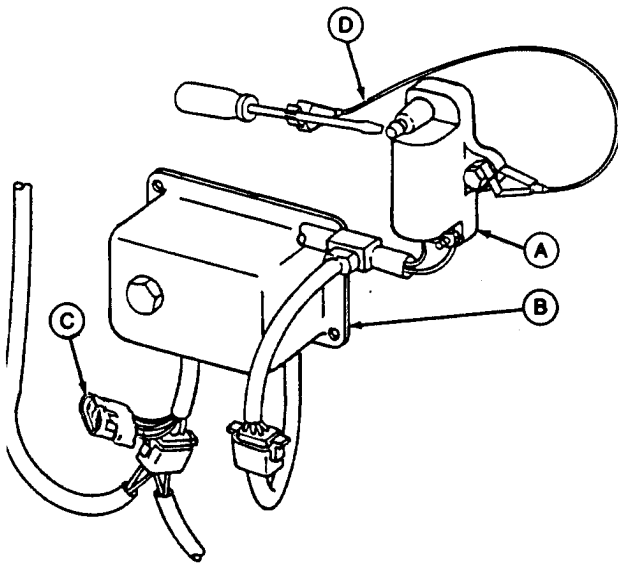
A—Ignition Control Unit (ICU)
 B—Overspeed Adjustment Potentiometer
 C—1/2 Speed Verify Switch

D—Timing Adjustment Potentiometer
 E—Primary Ignition Harness
 F—Spark Plug

G—Spark Plug Wires
 H—Ignition Coils
 I—Manifold Absolute Pressure (MAP) Sensor

J—Position (Reset) Signal
 K—Ignition Timing Sensor
 L—Ignition Timing Wheel
 M—Ignition Timing Signals

IGNITION CONTROL UNIT SELF-DIAGNOSTIC TEST



120
4

RG6737
-UN-27APR93

RG6738
-UN-27APR93

A—Ignition Coil
B—Ignition Control Unit

C—Diagnostic Connector
D—Grounded Lead

E—Diagnostic Pin A

F—Diagnostic Pin B

CAUTION: To avoid possible backfire, disconnect plug wires from spark plugs, or close gas valve and purge all gas from engine, before performing self-test.

Electrical shock may occur if you contact live electrical components. Avoid contact with spark plug wires or ignition coils.

This test verifies operation of ICU, primary ignition harness, and ignition coils.

1. Disconnect spark plug wires from ignition coils (A).
2. With electrical power disconnected, use a jumper lead to connect diagnostic connector pin A (E) to pin B (F).

3. Turn electrical power ON. Hold reset button in, or disconnect wires from "S" terminal of safety reset switch.

NOTE: Once powered, ignition coils will discharge sequentially.

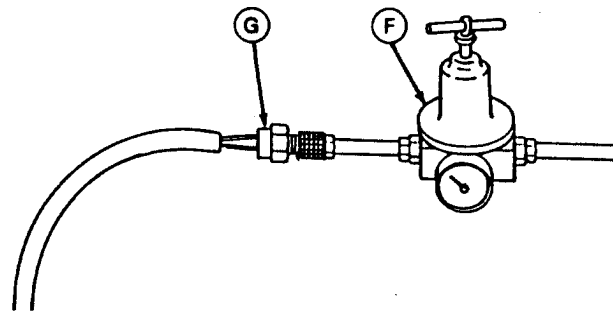
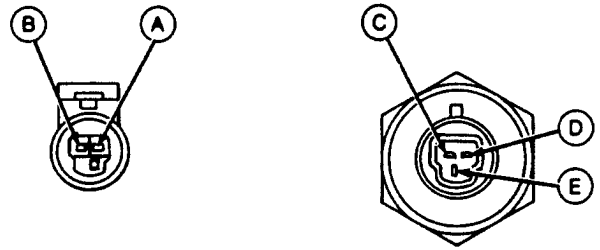
4. Use a grounded lead (D) to check spark jump and verify that each ignition coil is firing consistently. Replace any weak coils, indicated by poor spark or short jump range. (See TROUBLESHOOTING PRIMARY AND SECONDARY IGNITION SYSTEM if any coils are misfiring.)

5. Disconnect jumper from diagnostic connector. Turn power OFF to discontinue self-test.

RG,CTM82,120,4 -19-28MAY93

TROUBLESHOOT MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR

1. Connect a 0—207 kPa (0—30 psig) regulated air supply (F) to the manifold absolute pressure (MAP) sensor (G), using a 1/4-18 NPT fitting. Set gauge pressure at 0 kPa (0 psi) initially.
2. Initiate the ICU self-diagnostic test. (See IGNITION CONTROL UNIT SELF-DIAGNOSTIC TEST, earlier in this group.)
3. Increase MAP sensor pressure between 0—207 kPa (0—30 psi). As MAP sensor pressure increases, ignition discharge rate should increase. This will verify that the MAP sensor is working.
4. If ICU does not respond to changes in MAP sensor pressure, disconnect MAP sensor from wiring harness connector.
5. With the power supply “ON”, use a multimeter to check voltage levels at MAP sensor connector. Ground pin (A) should read 0VDC, and voltage supply pin (B) should read approximately +5VDC.
6. If voltages are at the correct levels, use jumper wires to connect MAP sensor voltage input terminal (D) to connector voltage supply pin (B), and MAP sensor ground terminal (C) to connector ground pin (A).
7. Measure signal voltage at the output terminal (E) of the MAP sensor while increasing gauge pressure over a range of 0—207 kPa (0—30 psi). At 25°C (77°F), output voltage should read approximately 1.6 VDC at 0 kPa (0 psi), and approximately 4.1 VDC at 207 kPa (30 psi).
8. If MAP sensor output voltage is incorrect, or does not change with pressure, replace the MAP sensor.



- A—Connector Ground Pin
- B—Connector Voltage Input Pin
- C—Sensor Ground Terminal
- D—Sensor Voltage Input Terminal
- E—Sensor Output Terminal
- F—Regulated Air Pressure
- G—MAP Sensor

RG,CTM82,120,5 -19-28MAY93

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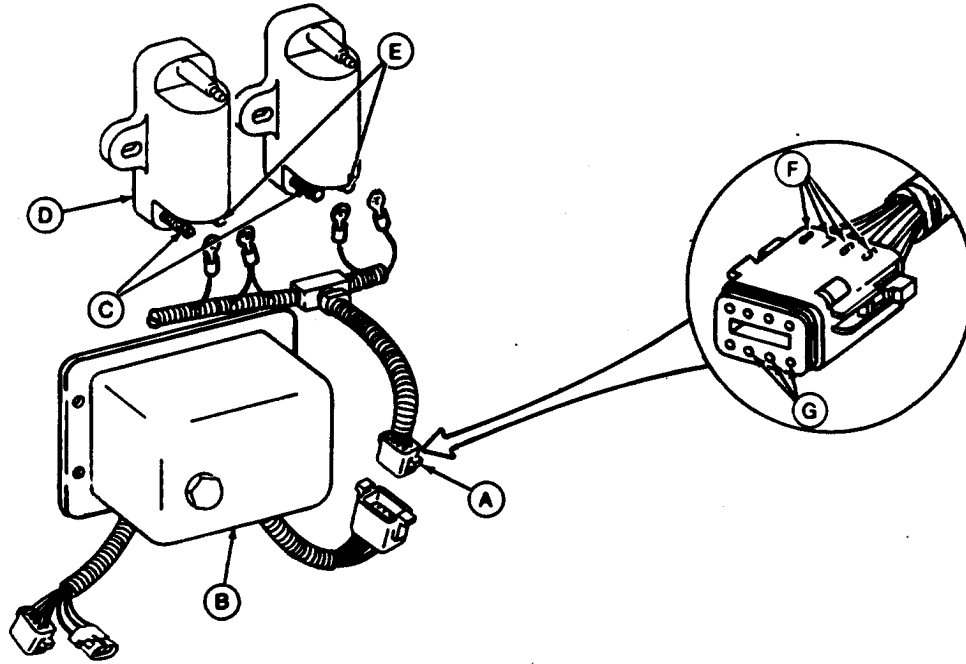
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RG6781

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TROUBLESHOOT PRIMARY AND SECONDARY IGNITION SYSTEM



RG6735 -UN-27APR93

A—Primary Ignition Harness Connector

B—Ignition Control Unit (ICU)
C—Primary Terminal

D—Ignition Coil
E—Ground Terminal

F—Pin Location Identifiers
G—Connector Pins

⚠ CAUTION: Electrical shock may occur if you contact live electrical components. Avoid contact with spark plug wires or ignition coils.

1. Use a spark plug firing indicator or inductive timing light to determine which cylinders are not firing.

NOTE: Brightness of firing indicator is not an indication of ignition output strength.

2. Stop the engine. Disconnect primary ignition harness connector (A) from ICU (B). Determine which connector pin (G) is connected to problem cylinder.

3. Use an ohmmeter to measure resistance between connector pin and a good ground.

- If resistance is 0.7—0.9 Ohms, primary circuit is not defective. Check secondary circuit. (See step 6.)

- If resistance is below 0.7 Ohms or above 0.9 Ohms, primary circuit is defective.

4. Disconnect wire from ignition coil primary terminal (C). Measure resistance between primary terminal and a good ground.

- If resistance is 0.7—0.9 Ohms, primary harness or connector is defective.

- If resistance is below 0.7 Ohms or above 0.9 Ohms, defect is in ignition coil (D) or ground wire.

5. Measure resistance between primary terminal and ground terminal (E) of ignition coil.

- If resistance is 0.7—0.9 Ohms, defect is in ground wire connections. Tighten connections or replace primary harness.

- If resistance is below 0.7 Ohms or above 0.9 Ohms, defect is in ignition coil. Replace ignition coil.

CONNECTOR PIN IDENTIFICATION

Pin No. (F)	1	2	3	4	5	6	7	8
Cyl. No.	1	5	3	6	2	4	GROUND	NOT USED

RG,CTM82,120,6 -19-28MAY93

6. Remove spark plug wire from coil. Measure resistance between ignition coil output terminal (C) and a good ground.

If resistance is 6000—7500 Ohms, ignition coil and ground wire connections are good. Check spark plug wire resistance. (See Step 8.)

If resistance is below 6000 Ohms or above 7500 Ohms, defect is in ignition coil or ground wire connections.

7. Measure resistance between ignition coil output terminal and ignition coil ground terminal (D).

If resistance is 6000—7500 Ohms, defect is in ground wire or ground connections.

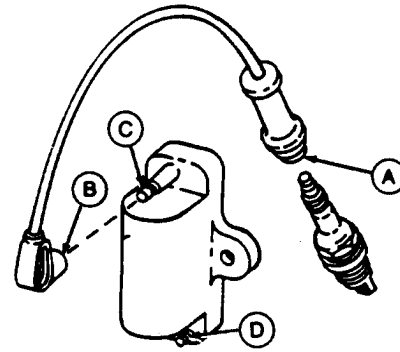
If resistance is below 6000 Ohms or above 7500 Ohms, defect is in ignition coil. Replace ignition coil.

8. Remove spark plug wire from engine. Measure resistance across ends (A & B) of plug wire.

If resistance is greater than 400 Ohms, replace spark plug wire.

If resistance is less than 400 Ohms, inspect spark plug boot for cracks that would allow arching to cylinder head. Replace damaged wires. Clean plug wire and ignition coil connections and install plug wire.

9. Inspect and/or replace spark plug in troubled cylinder.



A—Spark Plug End of Plug Wire
B—Coil End of Plug Wire
C—Ignition Coil Output Terminal
D—Ground Terminal

RG,CTM82,120,7 -19-04JUN93

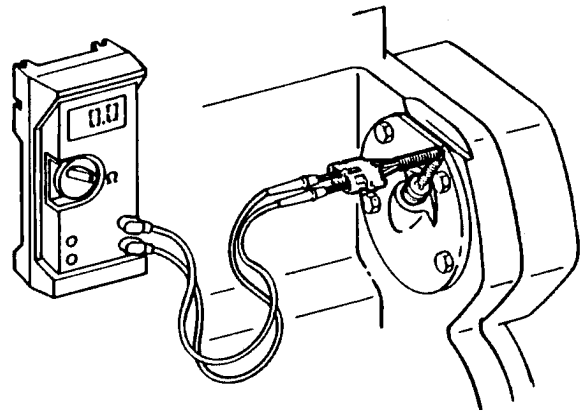
RG6731 -JUN-27/APR93

120

TROUBLESHOOT IGNITION TIMING AND GOVERNOR SPEED SENSORS

NOTE: Identical sensors are used for engine speed and ignition timing.

1. If a sensor fault is suspected, verify that the sensor is correctly installed. (See Group 40.)
2. Disconnect sensor from wiring harness connector.
3. Check resistance across sensor connector pins A and B. Resistance must be 2700—3300 Ohms at 20°C (68°F).
4. If resistance is not within specification, replace sensor.



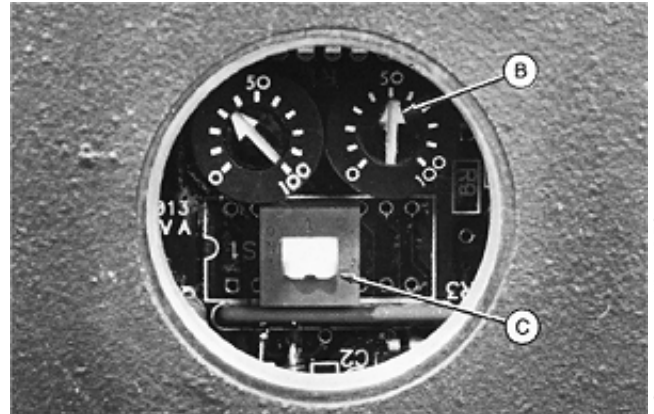
RG6732 -UN-27APR93

RG,CTM82,120,8 -19-11JUN93

ADJUST OVERSPEED SHUTDOWN

The ignition control unit (ICU) is equipped with overspeed protection. The ICU will shut the engine down if engine speed reaches a preset limit. The shutdown speed is factory set to 2000 rpm. Shutdown speed is operator adjustable to the desired speed (in the range 1800 to 2500 rpm) by using the 1/2 speed verify switch and overspeed adjustment potentiometer.

1. Remove hexagon cover (A) on ICU.
 2. Turn overspeed potentiometer (B) fully clockwise, and turn 1/2 speed switch (C) to "ON".
 3. Set engine speed at 1/2 the desired overspeed shutdown set point. For example, set engine speed at 1000 rpm for a 2000 rpm shutdown.
 4. Turn overspeed potentiometer slowly counterclockwise until engine stalls.
 5. Turn 1/2 speed switch to "OFF" and record dial reading.
- NOTE: If switch is not turned to "OFF", engine will continue to shutdown at 1/2 the desired shutdown speed.*
6. Replace hexagon cover.
 7. Cycle ignition switch off and on before attempting to restart the engine.



A—ICU Cover
 B—Overspeed Adjustment Potentiometer
 C—1/2 Speed Verify Switch

RG,CTM82,120,9 -19-05MAY93

-JUN-14DEC92
RG6498

-JUN-14DEC92
RG6499

ADJUST IGNITION TIMING

CAUTION: Electrical shock may occur if you contact live electrical components. Use care when making adjustments to electrical components. Avoid contact with spark plug wires or ignition coils.

The ignition system contains no moving parts, therefore timing will not change with use. The ignition timing adjustment, in the ICU, enables operator to eliminate “knock” or detonation that may occur while operating under load.

Timing is factory set at 21.5° BTDC at 1800 rpm with MAP sensor disconnected. This setting is for good quality fuel. Timing can be adjusted 2° advance to 20° retard from factory setting.

1. Remove hexagon cover (A) from ICU, and unplug MAP sensor (B).
2. With engine running at 1800 rpm, connect an inductive timing light to No. 1 spark plug wire.
3. Turn timing adjustment potentiometer (C) clockwise to retard timing, counterclockwise to advance timing. Set timing at 21.5° BTDC as indicated by timing light (D) and timing marks (E) on vibration damper.

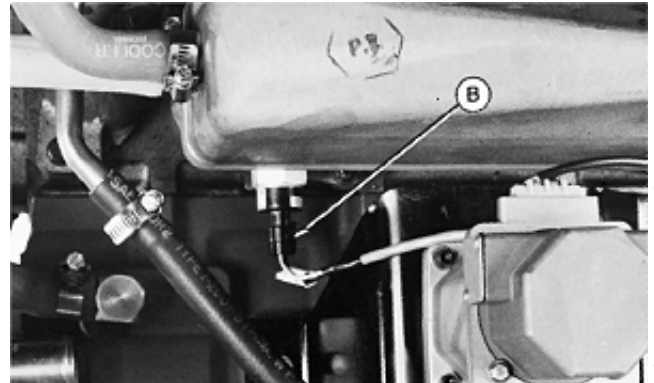
IMPORTANT: Adjust timing **ONLY** as far as necessary for optimum engine performance. Continuously operating with “knock” or detonation (timing too advanced), will result in serious engine damage. Operating with timing too retarded will result in high exhaust temperatures and reduced efficiency.

4. Connect MAP sensor and load the engine. Listen for a knocking sound from the engine. If a slight knock is heard, timing is too advanced for the gas quality. Retard timing (with MAP sensor connected) until the knock stops.
5. When “knock” is eliminated, retard timing an additional 2°. Install hexagon cover on ICU, and record timing for your records.

- A—ICU Cover
- B—MAP Sensor
- C—Timing Adjustment Potentiometer
- D—Inductive Timing Light
- E—Timing Marks



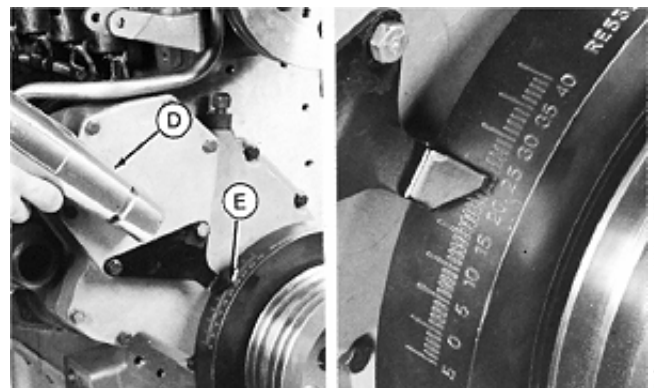
RG6498 -UN-14DEC92



RG6501 -UN-14DEC92

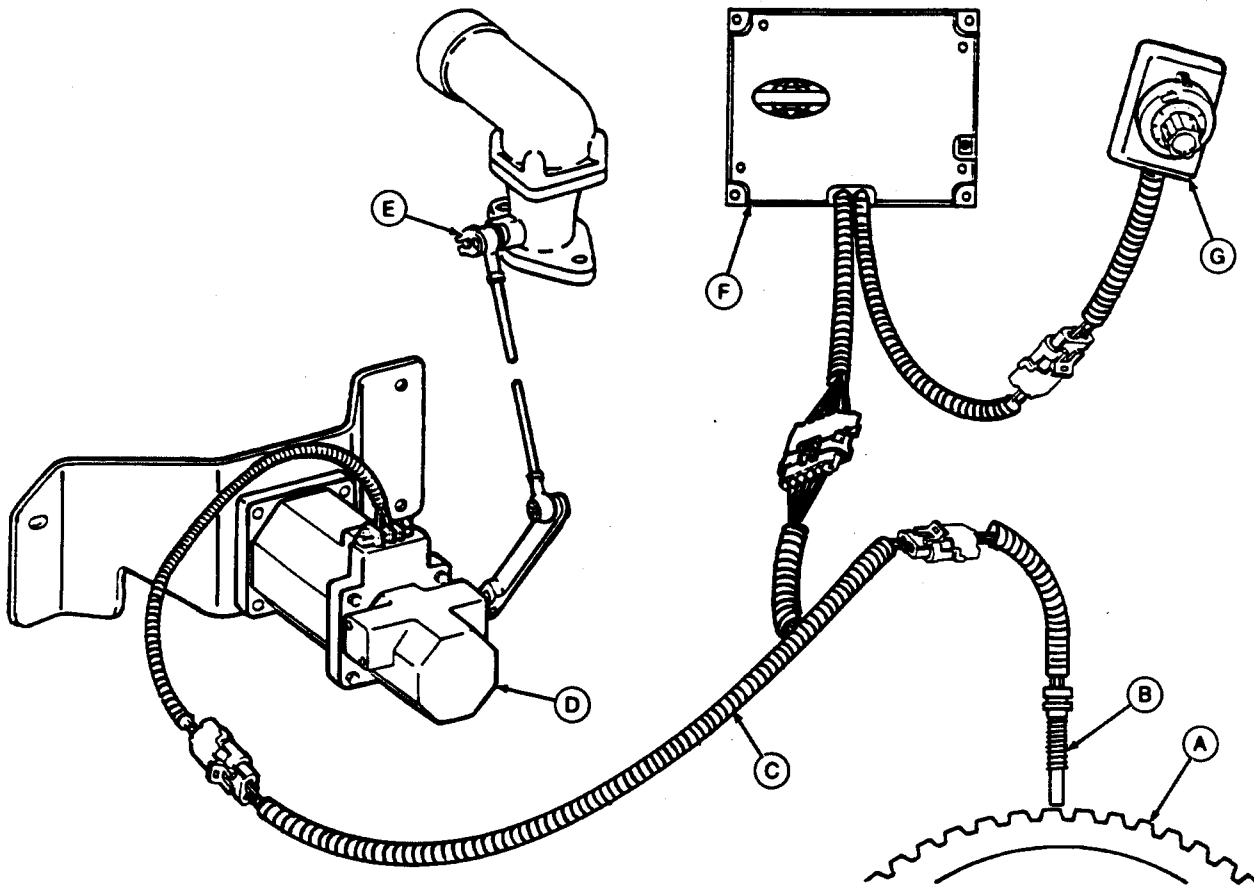


RG6502 -UN-14DEC92



RG6625 -UN-18FEB93

HOW THE ELECTRONIC GOVERNOR WORKS



A—Flywheel Ring Gear
B—Speed Sensor

C—Wiring Harness
D—Throttle Actuator

E—Throttle Valve
F—Governor Control Module

G—Remote Speed Potentiometer

The electronic governor is an all-speed governor that can be adjusted to operate in isochronous or droop mode. The governor consists of:

- Governor control module (F)
- Throttle actuator (D)
- Speed sensor (B)
- Remote speed potentiometer (speed dial) (G)
- Wiring Harness (C)

Desired engine speed is selected by adjusting the speed dial. As the dial is adjusted, voltage across the remote potentiometer changes. The governor translates this into "desired speed".

The speed sensor in flywheel housing senses actual engine speed from flywheel ring gear (A) and sends a speed signal to the governor. The governor receives the signal and compares actual speed to

desired speed. If actual speed is higher than desired, the governor sends a signal to throttle actuator to reduce opening of throttle valve (E) thereby reducing engine speed. If actual speed is lower than desired, the governor signals actuator to increase throttle opening thereby increasing engine speed.

Once the engine reaches desired speed, the governor regulates throttle valve to maintain constant speed. As engine load changes, engine speed is affected. The governor reacts to these speed changes and quickly adjusts throttle to bring engine back to desired speed. If the governor reacts too slowly or over-reacts, engine speed may oscillate above and below desired speed or may overshoot desired speed. The GAIN and INTEGRATION potentiometers can be adjusted to reduce or eliminate engine surging or overshoot.

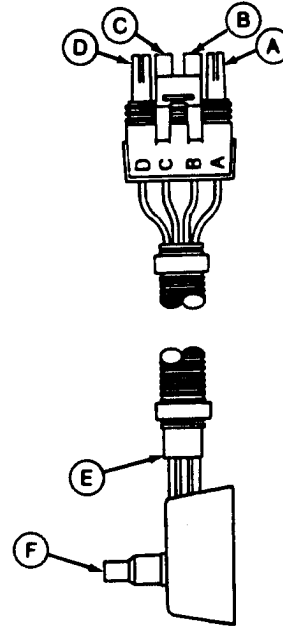
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-JUN-27/APR93
RG6734

TROUBLESHOOT REMOTE SPEED POTENTIOMETER

1. Disconnect remote speed potentiometer from governor.
2. Using a multimeter, measure resistance across potentiometer connector pins A and B. Resistance should be 4500—5500 Ohms.
3. Turn potentiometer fully counterclockwise.
4. Measure resistance across pins A and C. Resistance should be 4500—5500 Ohms.
5. Slowly turn potentiometer dial (F) clockwise. Resistance across pins A and C should decrease to 0 Ohms when turned fully clockwise.
6. Measure resistance from pin D to potentiometer end of shield wire (E). Resistance should be approximately 0 Ohms

A—Pin A
B—Pin B
C—Pin C
D—Pin D
E—Shield Wire
F—Potentiometer Dial



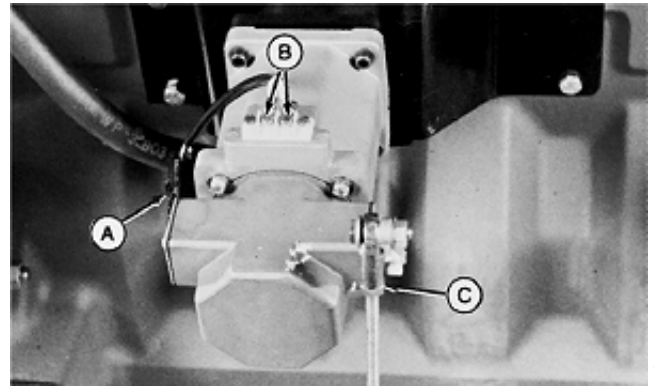
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RG6766 -JUN-10MAY93

RG,CTM82,120,15-19-05MAY93

TROUBLESHOOT THROTTLE ACTUATOR

1. Disconnect actuator connector from wiring harness.
2. Using a multimeter, measure resistance across actuator terminals (B). Resistance should be approximately 0.55—0.95 Ohms for a 12 Volt unit, or 1.9—2.7 Ohms for a 24 Volt unit.
3. Measure resistance across connector (A) terminals. Resistance should be same as in step 2 above.
4. Check for continuity between each actuator terminal and actuator case. There should be no continuity.
5. Disconnect throttle linkage (C) from actuator lever. Apply battery voltage to actuator terminals. Actuator lever should move to its full travel position.
6. Disconnect electrical power. Manually move the actuator lever through its full range of travel. Lever should move smoothly with no binding.



A—Connector
B—Actuator Terminals
C—Throttle Linkage

RG6768
-JUN-10MAY93

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RG,CTM82,120,16-19-05MAY93

ADJUST ELECTRONIC GOVERNOR

Governors are preset for most applications. Adjustment of the electronic governor may be required if engine speed oscillates during steady state operation, overshoots steady state operating speed excessively during acceleration, or if response time is too slow.

NOTE: New engines may be unstable at no-load due to tight throttle linkage. Gain can be reduced to stop oscillation. As linkage wears in, engine will become more stable and accept more gain.

The electronic governor is preset to the following values:

GAIN (A)	40
I (B)	40
DROOP (C)	0
S1	ON
S2	OFF

1. Start engine. With engine unloaded, adjust speed dial (D) to the desired operating speed.

2. Remove governor cover and adjust GAIN potentiometer clockwise until engine speed begins to oscillate.

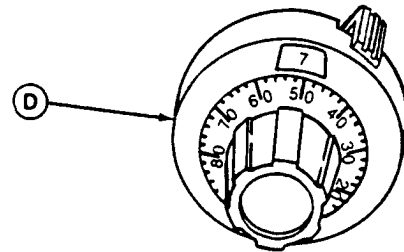
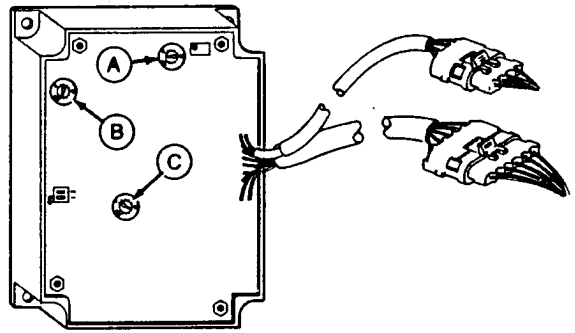
NOTE: If engine remains stable at 100% GAIN, disrupt the actuator linkage by hand.

3. Turn GAIN potentiometer counterclockwise until engine speed stabilizes.

NOTE: A warm engine is more stable than a cold engine. If governor is adjusted on a warm engine, turn adjustment potentiometers 1/2 division (5%) counterclockwise to ensure engine is stable when cold.

4. Repeat Steps 2 and 3 to adjust "I" potentiometer setting.

5. If engine speed changed during governor adjustment, readjust to desired speed.



- A—Gain Potentiometer
- B—I Potentiometer
- C—Droop Potentiometer
- D—Remote Speed Potentiometer (Speed Dial)

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-UN-10MAY93

RG6518

-UN-18FEB93

RG6631

6. Conduct the following test with engine operating at normal operating speed.

- Disconnect throttle actuator wiring connector to lower engine speed.
- When engine slows to approximately half of normal operating speed, reconnect throttle actuator.
- As engine speed recovers, observe the overshoot.

7. If overshoot is too great, turn "I" potentiometer (A) clockwise to reduce overshoot.

If engine speed oscillates during steady state operation, turn "I" potentiometer counterclockwise slightly until stable.

NOTE: In some cases, a slight overshoot may be acceptable.

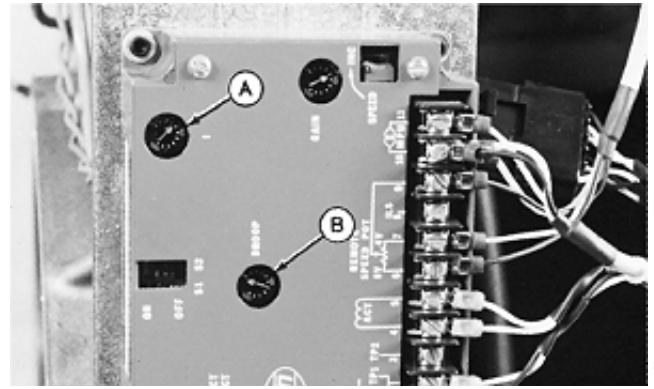
8. Operate engine at various loads, if possible, to ensure stable operation.

9. For isochronous operation (zero droop), set DROOP potentiometer (B) counterclockwise to minimum position. Engine will operate at a constant speed regardless of load.

For DROOP operation, turn DROOP potentiometer clockwise to obtain desired amount of droop from no-load to full load.

NOTE: As droop is increased, high idle must be increased to provide full load at 1800 rpm.

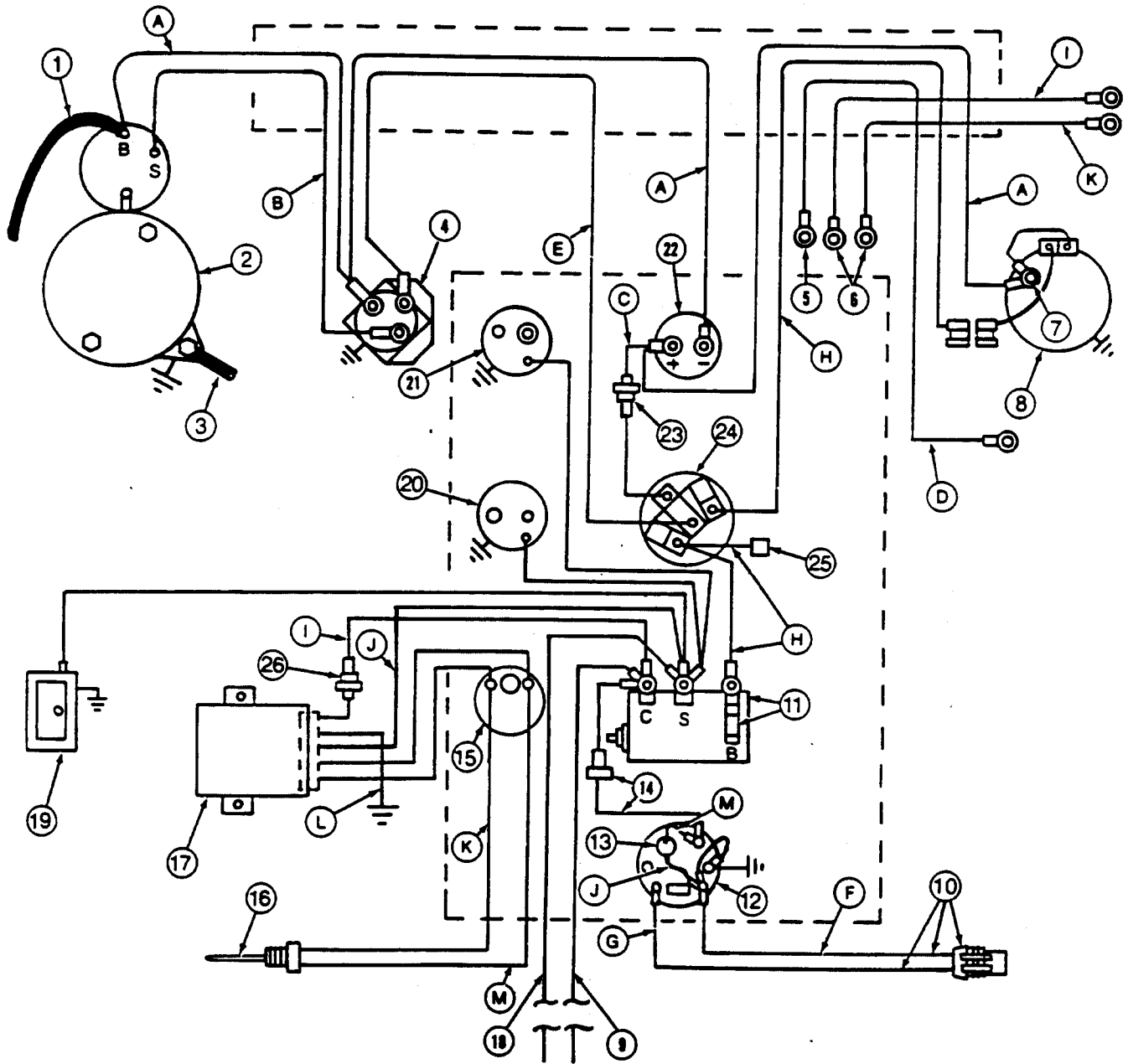
10. Install cover on electronic governor.



RG6637 -JUN-18FEB93

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INSTRUMENT PANEL WIRING DIAGRAM



- 1—Positive Battery Cable
- 2—Starting Motor
- 3—Negative Battery Cable
- 4—Starter Circuit Relay
- 5—Fuel Shutoff Lead (not used)
- 6—Tach. Leads (not used)
- 7—Alternator Output
- 8—Alternator
- 9—Power to Ignition and Gov. Harness

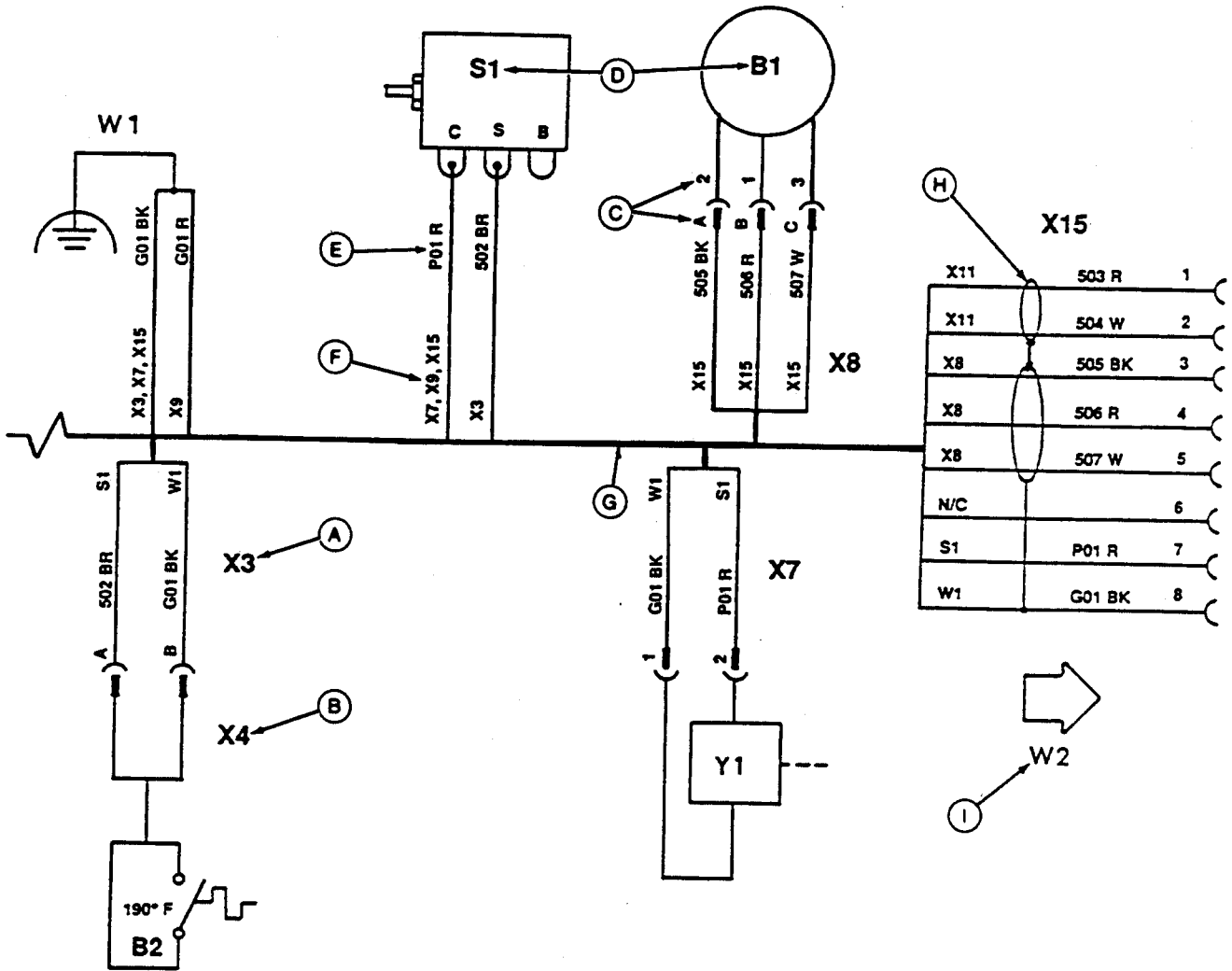
- 10—Tachometer Harness
- 11—Safety Switch/14-Amp SFE Fuse
- 12—Tachometer/Hour Meter
- 13—Light
- 14—3-Amp MDX Fuse
- 15—Pyrometer Gauge
- 16—Pyro. Sensor
- 17—Pyro. Shutdown Box
- 18—CATS Shutdown Signal
- 19—Oil Level Sight Gauge

- 20—Water Temp. Gauge
- 21—Oil Pressure Gauge
- 22—Ammeter
- 23—25-Amp MDL Fuse
- 24—Ignition/Key Switch
- 25—Terminal (not used)
- 26—8-Amp 3AG Fuse
- *A—8 Gauge—Red or Brown
- B—10 Gauge—White
- C—12 Gauge—Red or Brown
- D—14 Gauge—Dark Blue

- E—14 Gauge—White
- F—16 Gauge—Black
- G—16 Gauge—Orange
- H—16 Gauge—Purple
- I—18 Gauge—Black or Black With White Stripe
- J—18 Gauge—Brown
- K—18 Gauge—Red
- L—18 Gauge—White
- M—18 Gauge—Yellow

RG,CTM82,120,19-19-05MAY93

READING A WIRING DIAGRAM



A—Harness Connector Identification
 B—Component Connector Identification

C—Connector Pin Numbers or Letters
 D—Component Identification

E—Wire Number and Color
 F—Wire Routing Number
 G—Wiring Harness

H—Shielded Wires
 I—Harness Connection Designation

Wiring harnesses (G) are drawn showing components, connectors, and wires.

Wire routing numbers/letters (F) indicate connector or component destination of each wire.

Each component is represented by a schematic symbol and is identified by a letter/number designation (D) and description.

Harness connectors (A) and component connectors (B) are identified by a letter/number designation.

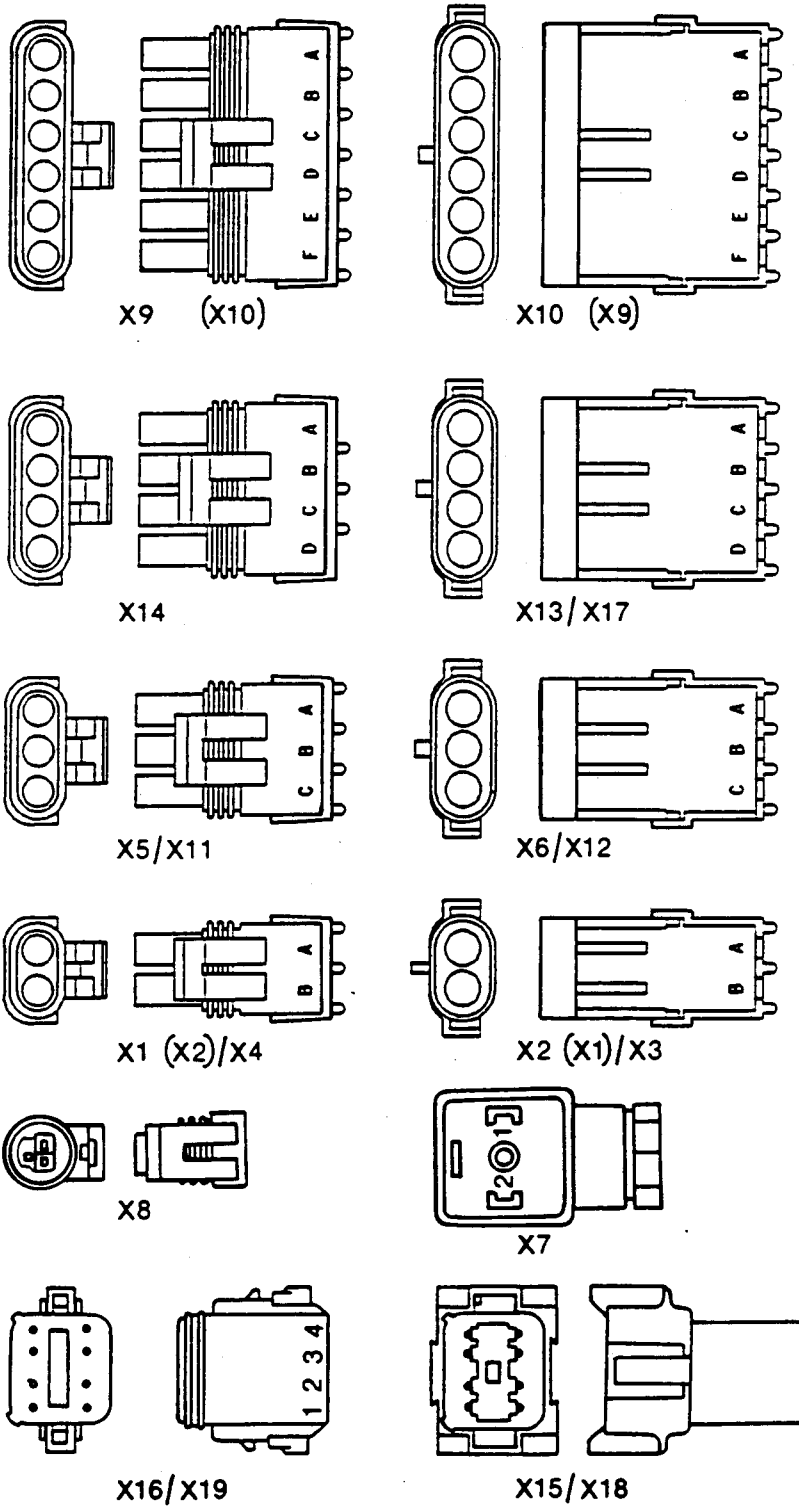
Connector pin numbers or letters (C) are indicated as they are marked on the connector.

Harness connection designation (I) indicates which harnesses connect together.

Wires attached to each connector pin are identified by a number and/or color designation (E).

Shielded wires (H) are wrapped with a grounded sheath to protect against electromagnetic interference.

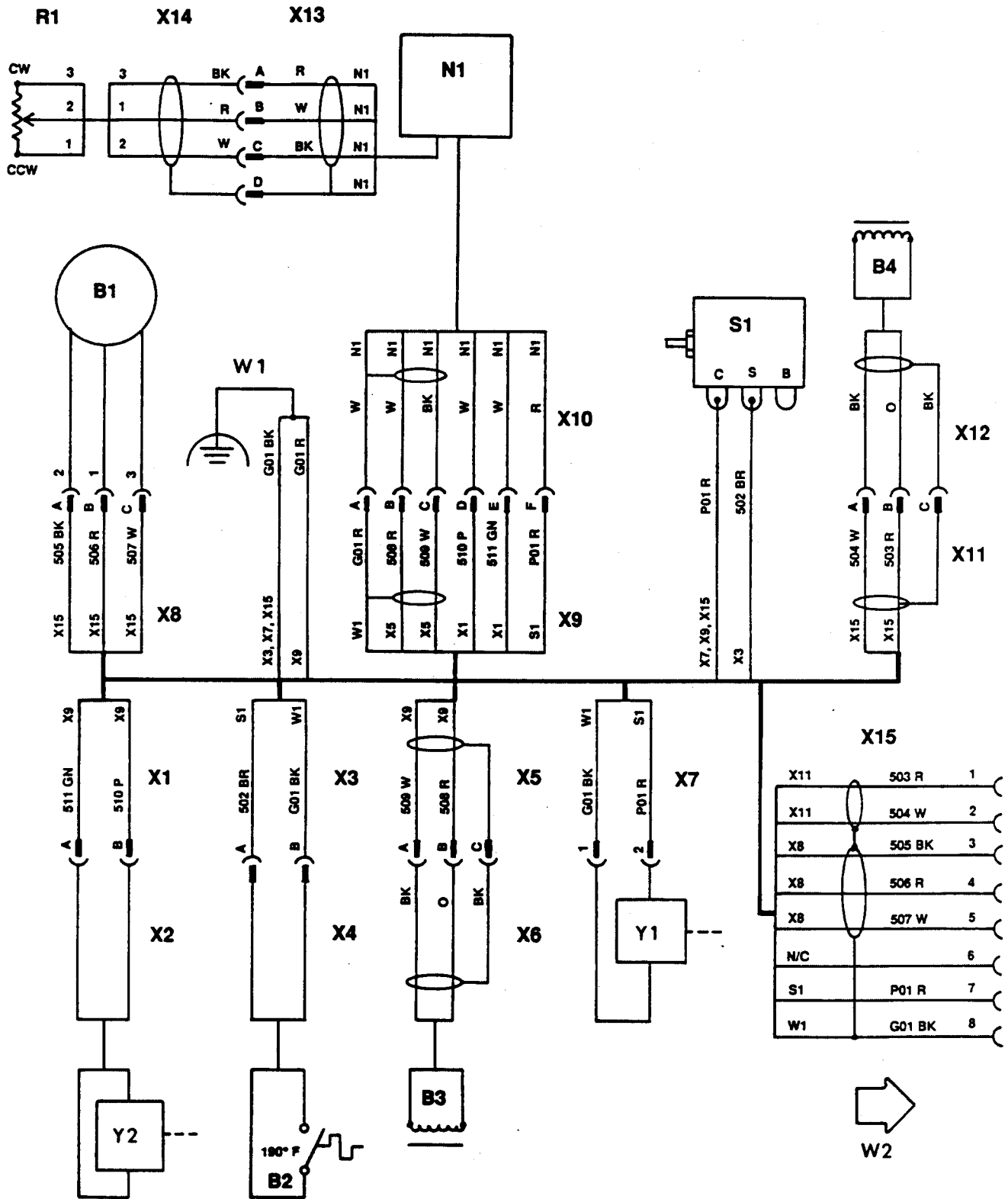
WIRING HARNESS CONNECTORS



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18

RG6771 -UN-10MAY93

IGNITION SYSTEM AND ELECTRONIC GOVERNOR WIRING DIAGRAM

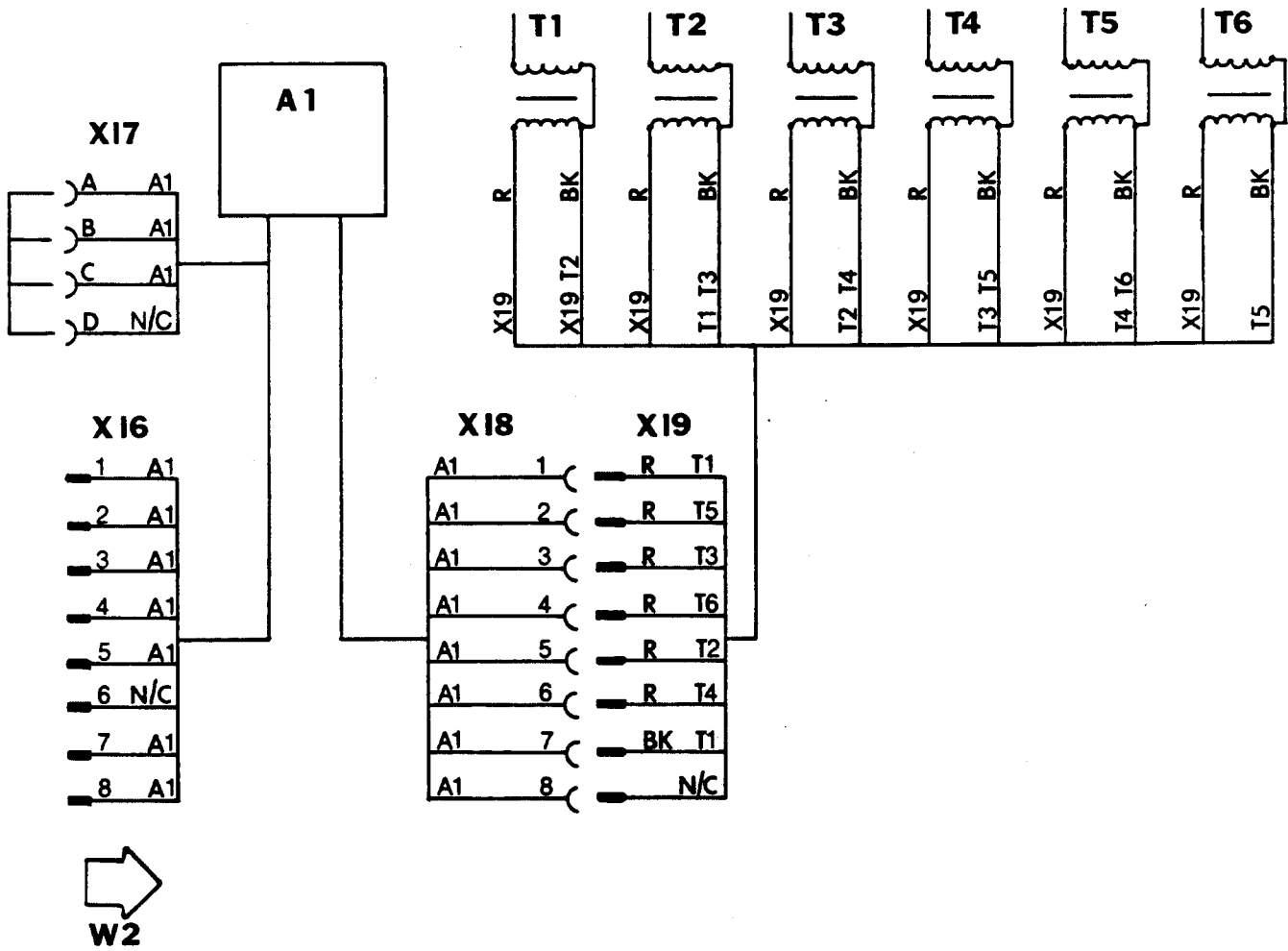


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RG6772 -UN-14MAY93

RG,CTM82,120,18-19-19MAY93

PRIMARY IGNITION SYSTEM WIRING DIAGRAM



- A1—Ignition Control Unit
- B1—MAP Sensor
- B2—CATS Switch
- B3—Governor Speed Sensor
- B4—Ignition Timing Sensor
- N1—Electronic Governor
- N/C—No Connection
- R1—Remote Speed Pot.
- S1—Safety Reset Switch
- T1—No. 1 Ignition Coil
- T2—No. 2 Ignition Coil
- T3—No. 3 Ignition Coil
- T4—No. 4 Ignition Coil
- T5—No. 5 Ignition Coil
- T6—No. 6 Ignition Coil
- W1—Ground Connection
- W2—Ignition System and Gov. To Primary Ignition
- X1/X2—Throttle Actuator Connector (12 Volt)
- (X1)/(X2)—Throttle Actuator Connector (24 Volt)

- X3/X4—CATS Connector
- X5/X6—Governor Speed Sensor Connector
- X7—Electric Shutoff Valve Connector
- X8—MAP Sensor Connector
- X9/X10—Governor Connector (12 Volt)
- (X9)/(X10)—Governor Connector (24 Volt)
- X11/X12—Ignition Timing Sensor Connector
- X13/X14—Speed Potentiometer Connector
- X15/X16—Ignition System and Gov. Harness-to-ICU Connector
- X17—ICU Diagnostic Connector
- X18/X19—ICU-to-Primary Ignition Harness Connector
- Y1—Electric Shutoff Valve
- Y2—Throttle Actuator
- BK—Black
- BR—Brown
- O—Orange
- P—Purple
- R—Red
- W—White

RG,CTM82,120,17-19-19MAY93

DIAGNOSE ENGINE MALFUNCTIONS

⚠ CAUTION: DO NOT attempt to perform any gas repairs or plumbing changes if there is not a manual gas shut-off valve prior to any defective parts. Contact the local gas company for assistance.

Symptom	Problem	Solution
Engine cranks but will not start or hard to start	Improper starting procedure.	Review starting procedure.
	Slow starter speed.	Weak battery.
		Loose or corroded battery connections.
		Excessive resistance in starter circuit.
		Starter defective.
		Check battery voltage.
		Check electrical system for cause of low voltage.
		Open manual supply valve.
		Reinstall wires. Replace wires, if necessary.
		Clean out wells. Replace plug wires, if necessary.
		Clean and regap plugs, or replace if necessary.
		Check for proper plug type.
		Check voltage and ground at connector. Replace valve if necessary. See Group 120.
		Inspect supply line for damage, leakage, and recommended size.
	Check in-line gas filter for plugging. Replace filter if necessary.	

Continued on next page

Symptom	Problem	Solution
		Check pressure with gauge. If low, contact gas company.
	Regulator differential pressure too low or high.	Check balance line for damage. See ADJUST REGULATOR DIFFERENTIAL GAS PRESSURE, in Group 115.
	Idle mixture too rich or lean.	See ADJUST IDLE FUEL MIXTURE, in Group 115.
	Improper ignition timing.	See ADJUST IGNITION TIMING, in Group 120.
	Carburetor diaphragm valve leaking or sticking.	Check diaphragm plate for warpage. Clean or replace carburetor diaphragm valve and check for leakage. See Group 35. Replace diaphragm.
	Restricted air intake.	Check and service air intake system.
	Restricted exhaust system.	Check exhaust restriction. Replace muffler if plugged.
	Air leak on suction side of carburetor	Check hose and pipe connections for tightness. Repair as required. (See Group 30).
	Ignition timing sensor damaged or loose.	Check timing sensor for proper installation. See TROUBLESHOOT IGNITION TIMING SENSOR, in Group 120.
	Ignition timing wheel damaged.	Check timing wheel for damaged teeth.
	Ignition control unit damaged.	Check for input voltage higher than 32VDC.

Continued on next page

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Symptom	Problem	Solution
		Perform diagnostic self-test. (See IGNITION CONTROL UNIT SELF-DIAGNOSTIC TEST.)
	Poor quality gas.	Check gas composition with gas company.
Engine starts and stops.	1/2 speed verify switch in ICU left in "ON" position.	Move switch to "OFF" position.
	Manual gas supply valve not fully open.	Open manual valve.
	Gas filter restricted.	Replace filter.
	Regulator sticking.	Repair regulator.
Erratic engine operation	Regulator differential pressure too high or low.	Adjust differential pressure.
	Improper air/fuel mixture.	Adjust air/fuel mixture.
	Carburetor diaphragm valve leaking or sticking.	Clean and repair carburetor. See Group 35.
		Check diaphragm plate for warpage.
		Replace diaphragm.
		Check for broken diaphragm spring.
	Poor gas quality.	Check gas composition with gas company.
	Ignition timing does not change with load.	MAP sensor not functioning properly. (See TROUBLESHOOT MAP SENSOR in Group 120.)
Engine starts, but cannot increase speed.	Throttle linkage broken, disconnected, or incorrectly adjusted.	Check and repair throttle linkage.
	Restricted fuel supply.	Check in-line fuel filter for plugging. Replace filter element.
		Check supply line for damage, kinks, etc.

Continued on next page

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Symptom	Problem	Solution
	Improper ignition timing.	See ADJUST IGNITION TIMING, in Group 120.
	Speed dial spinning on potentiometer shaft.	Tighten set screws in dial knob.
	No electrical power to governor. Check voltage at governor connector.	Check wiring and connections from governor to safety reset switch.
	Open speed dial circuit, or defective potentiometer.	Check wiring and connections from governor to speed dial. Check resistance across potentiometer. Replace as necessary. (See TROUBLESHOOT REMOTE SPEED POTENTIOMETER, in Group 120.)
	No signal from speed sensor.	Check for proper installation of speed sensor. Check for defective speed sensor. (See TROUBLESHOOT IGNITION TIMING AND GOVERNOR SPEED SENSORS, in Group 120.) Check wiring and connections from governor to speed sensor.
	No signal to throttle actuator.	Check wiring and connections from governor to actuator.
	Throttle actuator not responding to governor signal.	Check for faulty or stuck actuator. (See TROUBLESHOOT THROTTLE ACTUATOR, in Group 120.) Check for shorted actuator coils. (See TROUBLESHOOT THROTTLE ACTUATOR.)
Engine does not idle properly.	Improper idle mixture.	See ADJUST IDLE FUEL MIXTURE, in Group 115.
	Loose spark plug wire.	Reinstall wire. Replace wire, if necessary.
	Water in spark plug wells.	Clean out wells. Replace plug wires, if necessary.

Continued on next page

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4

Symptom	Problem	Solution
	Worn or bad spark plugs.	Clean and regap plugs, or replace if necessary.
	Wrong spark plug type.	Install correct plugs.
	Improper ignition timing.	See ADJUST IGNITION TIMING, in Group 120.
	No spark from ignition system to one or more cylinders.	Check for low input voltage to ignition control unit. Lower than 10VDC. See IGNITION CONTROL UNIT SELF-DIAGNOSTIC TEST, in Group 120. See TROUBLESHOOT PRIMARY AND SECONDARY IGNITION SYSTEM, in Group 120.
	Air leak on suction side of carburetor	Check for air leaks under load. Replace any leaking gaskets and O-rings.
	Regulator differential pressure too high.	Check balance line for leaks or damage. See ADJUST REGULATOR DIFFERENTIAL GAS PRESSURE, in Group 115.
	Throttle linkage sticking.	Clean any paint or dirt off swivel ends and adjust as needed to prevent binding.
	Electronic governor unstable. (Unplug actuator to check.)	Adjust governor. See ADJUST ELECTRONIC GOVERNOR, in Group 120.
	Carburetor sticking, leaking, or not operating properly.	Clean and repair carburetor. Check diaphragm plate for warpage. Replace diaphragm, if necessary. Check for broken diaphragm spring.
	Radio interference/EMI (noise) problem.	Check all ground wires and connections for continuity.

Continued on next page

Symptom	Problem	Solution
		Check all shielded wires and drain lines for good connections to ground.
	Poor gas quality.	Check gas composition with gas company.
Engine knocks (pre-ignition)	Ignition timing too advanced.	Retard timing. See ADJUST IGNITION TIMING, in Group 120.
	Excessive spark plug gap.	Set spark plug gap to correct specification. See CLEAN, INSPECT, AND ADJUST SPARK PLUGS, in Group 40.
	Charge air temperature too high (200 Hp model).	Check charge air temperature with thermocouple.
		Check operation of auxiliary water pump and heat exchanger.
	Engine overheating.	See "Engine Overheats".
	Poor gas quality.	Check gas composition with gas company.
		Retard ignition timing.
		Reduce load on engine.
	Low crankcase oil level.	Add oil as needed.
Engine misses or vibrates under load, or throttle arm very erratic.	Improper air/fuel mixture.	See ADJUST AIR/FUEL MIXTURE, in Group 115.
	Throttle linkage sticking.	Clean any paint or dirt off swivel ends and adjust as needed to prevent binding.
	Loose spark plug wire.	Reinstall wire. Replace wire, if necessary.
	Water in spark plug wells.	Clean out wells. Replace plug wires, if necessary.
	Worn or bad spark plugs.	Clean and regap plugs, or replace if necessary.
	Wrong spark plug type.	Install correct plug type.

Continued on next page

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Symptom	Problem	Solution
	Regulator differential pressure too high.	See ADJUST REGULATOR DIFFERENTIAL GAS PPRESSURE, in Group 115.
	Electronic governor unstable.	Adjust governor. See ADJUST ELECTRONIC GOVERNOR, in Group 120.
	Improper ignition timing.	See ADJUST IGNITION TIMING, in Group 120.
	No spark from ignition system to one or more cylinders.	Check for low input voltage to ignition control unit. Lower than 10VDC. See IGNITION CONTROL UNIT SELF-DIAGNOSTIC TEST, in Group 120. See TROUBLESHOOT PRIMARY AND SECONDARY IGNITION SYSTEM, in Group 120.
	Poor gas quality.	Check gas composition with gas company.
	Carburetor sticking, leaking, or not operating properly.	Clean and repair carburetor. Check diaphragm plate for warpage. Replace diaphragm, if necessary. Check for broken diaphragm spring.
	Air leak on vacuum side of carburetor	Check for air leaks under load. Replace any leaking gaskets and O-rings.
	Radio interference/EMI (noise) problem.	Check all ground wires and connections for continuity. Check all shielded wires and drain lines for good connections to ground.
Engine misses on one or more cylinders.	No spark from ignition system to one or more cylinders.	Check for low input voltage to ignition control unit. Lower than 10VDC.

Continued on next page

Symptom	Problem	Solution
Engine speed varies greatly.		See IGNITION CONTROL UNIT SELF-DIAGNOSTIC TEST, in Group 120.
		Use inductive timing light to locate problem cylinder. See TROUBLESHOOT PRIMARY AND SECONDARY IGNITION SYSTEM, in Group 120.
	Water in spark plug wells.	Remove water and check spark plug boots for proper fit.
	Spark plug wire loose or damaged.	Reinstall or replace plug wire.
	Spark plugs fouled, corroded, damaged, or wrong type.	Clean or replace spark plugs.
	Throttle linkage sticking or binding.	Clean any paint or dirt off swivel ends and adjust as needed to prevent binding.
	Load changing.	Check PTO clutch adjustment and check load device.
	Electronic governor unstable or improperly adjusted.	Adjust governor. (See ADJUST ELECTRONIC GOVERNOR, in Group 120.)
	Speed sensor in flywheel housing improperly adjusted, or loose connection.	Check and adjust height of speed sensor. (See REMOVE AND INSTALL ELECTRONIC GOVERNOR SPEED SENSOR, in Group 40.)
		Check for faulty speed sensor or bad connections. (See TROUBLESHOOT IGNITION TIMING AND GOVERNOR SPEED SENSORS, in Group 120.)
Faulty ground wires or connections.	Check wires and ground connections for good continuity.	
Radio interference/EMI (noise) problem.	Check all ground wires and connections for continuity.	

Continued on next page

Symptom	Problem	Solution
Engine shuts down.		Check all shielded wires and drain lines for good connections to ground.
	Instrument panel fault.	Check wiring and safety relay.
	Safety shutdown tripped.	Check oil level and pressure.
		Check coolant and exhaust temperatures.
		Check charge air temperature switch. (200 HP model)
	Engine speed exceeds overspeed shutdown setting.	Check for cause of engine overspeed.
		Check adjustment of overspeed shutdown setting. (See ADJUST OVERSPEED SHUTDOWN, in Group 120.)
		Check setting of 1/2 speed verify switch in ICU. Move to "OFF" position.
	Electronic governor unstable.	Adjust governor. (See ADJUST ELECTRONIC GOVERNOR, in Group 120.)
	Charge air temperature too high (200 Hp model). Must be below 88°C (190°F).	Check charge air temperature with thermocouple.
	Check operation of auxiliary water pump and external heat exchanger.	
Charge air temperature switch defective.	See TROUBLESHOOT CHARGE AIR TEMPERATURE SWITCH, in Group 110.	
Exhaust temperature too high. Must be below 649°C (1200°F).	Check air intake restriction. Replace air cleaner element.	
	Check exhaust restriction. Replace muffler.	

Continued on next page

Symptom	Problem	Solution
		Turbocharger defective. Inspect turbocharger and replace if necessary.
		Check for leak in air system.
	Engine overloaded.	Check load on engine. Reduce load if necessary.
	Gas supply interrupted.	Contact gas company.
	Electric shutoff valve closed.	Check voltage and ground at shutoff valve terminals.
		Check electrical wire and connections.
	Ignition input voltage lower than 10VDC.	Check electrical system for cause of low voltage.
	Timing input fault.	Check for open, shorted, or grounded timing sensor.
		Check condition of ignition timing sensor. (See TROUBLESHOOT IGNITION TIMING AND GOVERNOR SPEED SENSORS, in Group 120.)
		Check ignition timing wheel for damaged.
	ICU damaged.	Check for input voltage higher than 32VDC.
		Perform diagnostic test. (See IGNITION CONTROL UNIT SELF-DIAGNOSTIC TEST, in Group 120.)
	Remote speed potentiometer malfunctioning.	Check all wiring for loose connections. (See TROUBLESHOOT REMOTE SPEED POTENTIOMETER, in Group 120.)
	Throttle actuator malfunctioning.	Check throttle actuator coil. (See TROUBLESHOOT THROTTLE ACTUATOR, in Group 120.)

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Symptom	Problem	Solution	
Coolant temperature below normal	Faulty thermostat.	Remove and check thermostats.	
	Faulty temperature gauge or sender.	Check gauge, sender, and connections.	
Engine overheats [89°C (192°F) thermostats are standard.]	Low coolant level.	Fill radiator to proper level, check radiator and hoses for loose connections or leaks.	
	Faulty radiator cap or leaking cooling system.	Pressure test radiator and cap. (See PRESSURE TEST COOLING SYSTEM AND RADIATOR CAP, in Group 105.)	
	Loose or defective fan belts. (Radiator cooled engines only.)	Adjust belt tension. Replace as required.	
	Low engine oil level.	Check oil level. Add oil as required.	
	Cooling system needs flushing.	Flush cooling system. Check radiator or heat exchanger for plugging.	
	Faulty thermostats.	Remove and check thermostats. (See INSPECT THERMOSTATS AND TEST OPENING TEMPERATURE, in Group 105.)	
	Faulty temperature gauge or sender.	Check gauge and sender.	
	Engine overloaded.	Reduce load on engine.	
	Exhaust temperature above 649°C (1200°F).	Air/fuel mixture too rich.	Adjust mixture. (See ADJUST AIR/FUEL MIXTURE, in Group 115.)
		Improper ignition timing. Too retarded.	See ADJUST IGNITION TIMING, in Group 120.
Faulty carburetor.		Repair or replace carburetor.	
Engine overloaded.		Reduce load on engine.	
Engine misfiring.		See "Engine misses or vibrates under load".	
Air intake restriction too high.		Check intake system. Replace air filter, if necessary.	

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Symptom	Problem	Solution
Engine does not develop full power.	Leak in air system.	Check for air leaks under load. Replace any leaking gaskets and O-rings.
	Restricted exhaust system.	Check exhaust system. Replace muffler if necessary.
	Turbocharger not functioning properly.	See Group 30.
	Air/Fuel mixture too lean.	Adjust mixture. (See ADJUST AIR/FUEL MIXTURE, in Group 115.)
	Throttle linkage improperly adjusted.	Adjust linkage so throttle can travel freely over full range of movement.
	Gas supply pressure too low.	Check for plugged gas filter. Replace if necessary. Check supply pressure with a gauge. Contact gas company if low.
	Engine overloaded.	Reduce load on engine.
	Intake air restriction too high.	Check air intake system. Service air cleaner.
	Regulator differential pressure too low.	Adjust regulator. (See ADJUST REGULATOR DIFFERENTIAL GAS PRESSURE, in Group 115.)
	Overheated engine.	See "Engine Overheats".
	Improper valve clearance.	Adjust valve clearance. (See CHECK AND ADJUST VALVE CLEARANCE, in Group 05.)
	Leak in air system.	Check for air leaks under load. Replace any leaking gaskets and O-rings.
	Turbocharger not functioning properly.	See Group 30.
	Leaking exhaust manifold gasket.	Replace gaskets.
Restricted exhaust system.	Check muffler. Replace if necessary.	

Continued on next page

Symptom	Problem	Solution
	Droop setting too high.	Increase high idle speed or decrease droop to obtain correct rated speed.
	Restricted gas filter.	Replace filter.
	Regulated supply line to carburetor kinked, restricted, or leaking.	Replace hose.
	Poor gas quality.	Check gas composition with gas company.
Low oil pressure	Low oil level.	Add oil as needed.
	Improper type of oil.	Drain, fill crankcase with oil of proper viscosity and quality.
	High engine oil temperature.	Check operation of cooling system and oil cooler.
High oil consumption	Crankcase oil too light.	Use proper viscosity oil.
	Oil leaks.	Check for leaks in lines, gaskets and drain plug.
	Restricted crankcase vent tube.	Clean vent tube.
	Faulty turbocharger.	See Group 30.
	High intake vacuum/low load operation	Increase load, or lean out fuel/air mixture to increase throttle valve opening.
Engine smokes (blue).	Excessive idling or low load operation.	Increase load on engine.
	Turbocharger oil seal leaking.	Replace turbocharger. Avoid hot shutdowns. See Group 30.
	Excessive valve guide clearance.	Knurl guides or install oversize valves. See Group 05.
	Worn engine components.	Repair or replace components as needed.
High fuel consumption	Air intake restricted	Check air intake system. Service air cleaner.
	Engine overloaded.	Reduce load.

Continued on next page

Symptom	Problem	Solution
	Improper air/fuel mixture.	Adjust mixture. (See ADJUST AIR/FUEL MIXTURE, in Group 115.)
	Poor quality gas. Low BTU gas.	Check gas composition with gas company.
	Improper valve clearance.	Adjust valve clearance. See Group 05.
	Incorrect ignition timing.	Adjust timing. (See ADJUST IGNITION TIMING, in Group 120.)
	Faulty turbocharger.	Replace turbocharger. See Group 30.
	Low engine temperature.	Check thermostats. (See INSPECT THERMOSTATS AND TEST OPENING TEMPERATURE, in Group 105.)
Turbocharger "Screams"	Air leak in manifold/aftercooler	Repair air leak. (See Group 30).
Fuel not reaching carburetor	Manual shutoff valve not open.	Open manual valve.
	Gas filter restricted.	Replace filter.
	Gas line restricted or leaking.	Check for damage, kinks, leaks. Repair as necessary.
	Pressure regulator malfunctioning.	Check regulator operation and adjustment. Replace if necessary.
	Electric shutoff valve not opening. Listen to hear valve open when electrical power is turned "ON".	Check electrical connections. Verify voltage and ground at shutoff valve connector. Replace valve if necessary.
	Low gas supply pressure.	Check supply pressure with a gauge. Contact gas company if low.
	Gas supply interrupted.	Contact gas company.

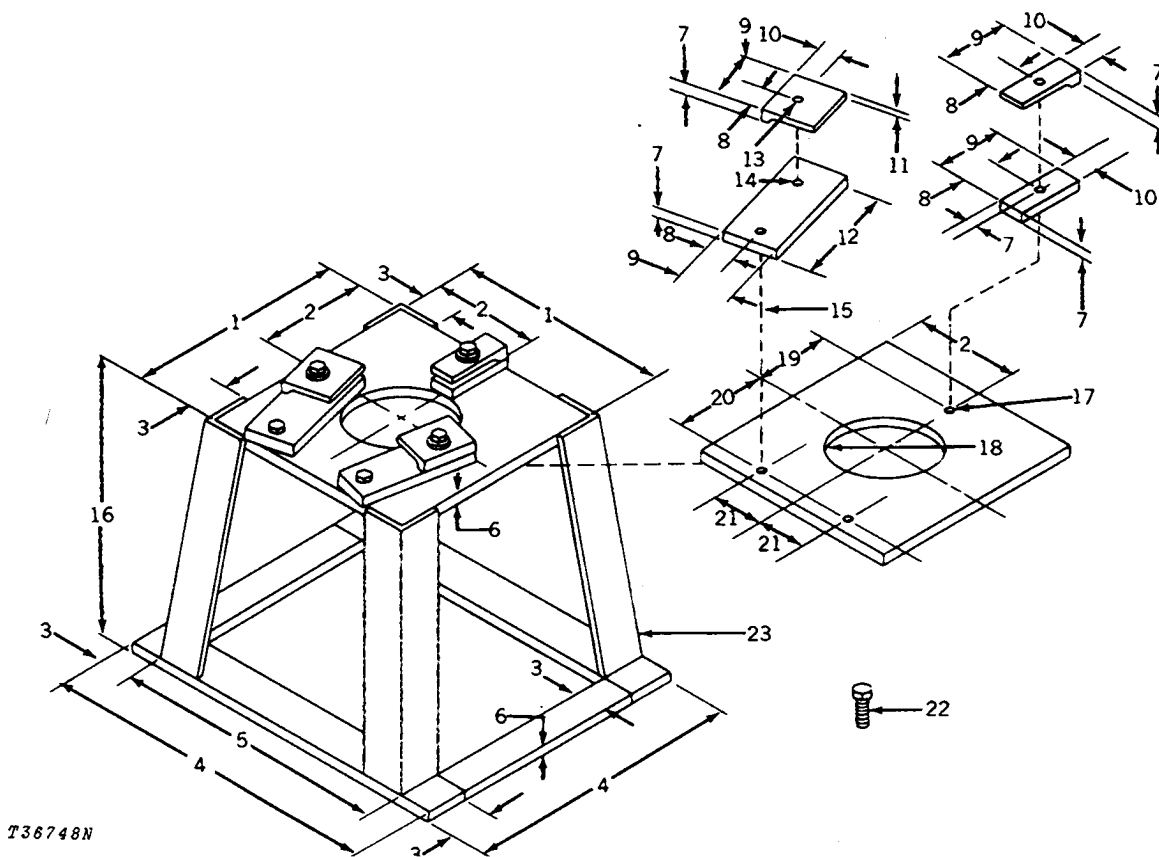
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HOW TO MAKE TOOLS

These tools can be made in a service shop using common shop tools and locally obtained materials.

S55,DFRG -19-01DEC89

DFRG3—CYLINDER LINER HOLDING FIXTURE



- 1—254.0 mm (10 in.)
- 2—127.0 mm (5 in.)
- 3—38.1 mm (1.5 in.)
- 4—405.4 mm (16 in.)
- 5—330.2 mm (13 in.)
- 6—9.52 mm (0.38 in.)
- 7—12.7 mm (0.5 in.)

- 8—31.8 mm (1.25 in.)
- 9—63.5 mm (2.5 in.)
- 10—25.4 mm (1 in.)
- 11—6.35 mm (0.25 in.)
- 12—152.4 mm (6 in.)
- 13—0.328 in. Drill Through
- 14—5/16 in.—18 Tap

- 15—2 used
- 16—304.8 mm (12 in.)
- 17—5/16 in.—18 Tap
- 18—69.85 mm (2.75 in.) Radius
- 19—101.6 mm (4 in.)

- 20—111.25 mm (4.38 in.)
- 21—60.45 mm (2.38 in.)
- 22—5/16 in. x 1 in. Cap Screw
- 23—38.1 mm (1.5 in.) Angle Iron

S55,DFRG3 -19-23FEB87

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