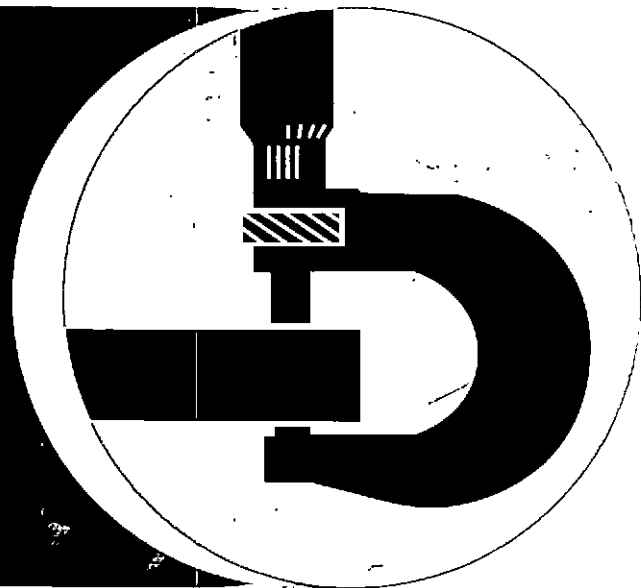


**POWERTECH 8.1L
6081 Diesel Engines**

**COMPONENT
TECHNICAL
MANUAL**



**Deere Power Systems Group
CTM86 (26OCT94)**

LITHO IN U.S.A.
ENGLISH



DEERE
POWER

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

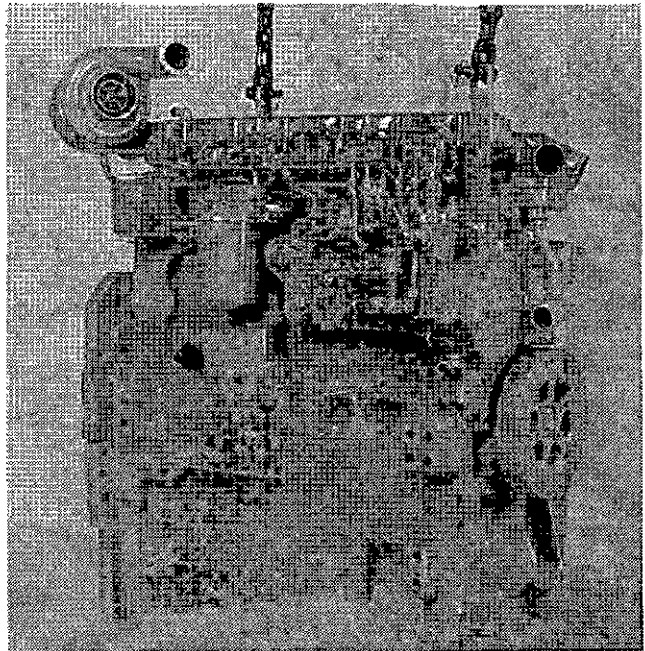
This component technical manual (CTM) covers the recommended repair procedure for 6081, 8.1 L (494 cu. in.) diesel engines produced in Waterloo, Iowa.

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

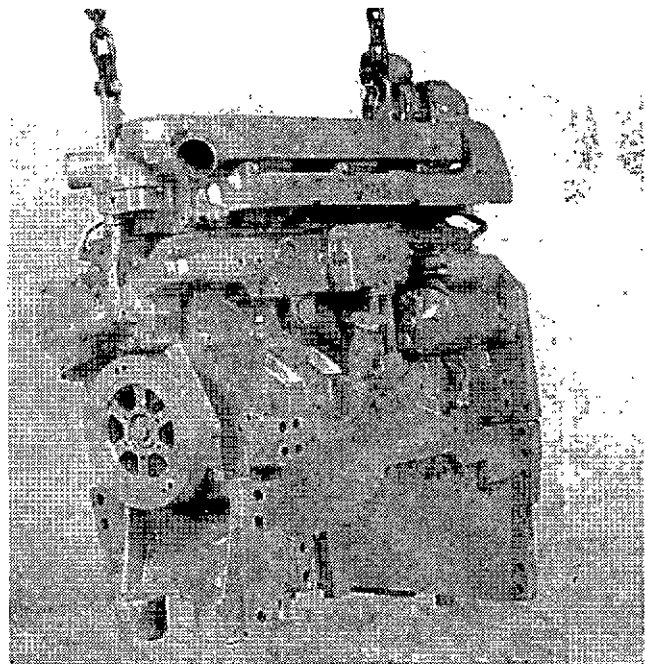
Direction of engine crankshaft rotation in this manual is referenced facing the flywheel looking toward the fan. Front of engine is fan drive end.

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

Read each repair procedure completely before performing any service.



FG7015 -JUN-28/JUL94



FG7016 -JUN-28/JUL94

Contents

	Page		Page
Group 00—Safety	00-1	Group 05—Cylinder Head and Valves	
Group 01—General Information		Special or Essential Tools	05-1
Unified Inch Bolt and Cap Screw Torque Values	01-1	Cylinder Head and Valves Specifications	05-4
Metric Bolt and Cap Screw Torque Values	01-2	Service Equipment and Tools	05-6
Engine Model Designation	01-3	Other Material	05-6
Engine Serial Number Plate Information	01-4	Check and Adjust Valve Clearance	05-7
Engine Application Chart	01-5	Check Valve Lift	05-9
Group 02—Fuels, Lubricants, and Coolant		Remove Cylinder Head	05-10
Diesel Fuel	02-1	Disassemble and Inspect Rocker Arm Shaft Assembly	05-12
Engine Break-In Oil	02-2	Assemble Rocker Arm Shaft Assembly	05-14
Diesel Engine Oil	02-3	Measure Valve Recess	05-14
Oilscan® and Coolscan™	02-4	Preliminary Cylinder Head and Valve Checks	05-15
Grease	02-4	Remove Valve Assembly	05-16
Alternative and Synthetic Lubricants	02-5	Inspect and Measure Valve Springs	05-17
Engine Coolant Requirements	02-5	Inspect Valve Spring Caps and Wear Caps	05-17
Recommended Engine Coolant	02-7	Clean Valves	05-18
Engine Coolant Specifications	02-8	Inspect and Measure Valves	05-18
Replenishing Supplemental Coolant Additives	02-10	Grind (Reface) Valves	05-19
Flush and Service Cooling System	02-11	Inspect and Clean Cylinder Head	05-20
Disposing of Coolant	02-12	Check Cylinder Head Combustion Face Flatness	05-21
Group 03—Engine Mounting		Measure Cylinder Head Thickness	05-22
Engine Repair Stand	03-1	Clean Valve Guides	05-23
Safety Precautions	03-2	Measure Valve Guides	05-23
Install Adapters Onto Engine Repair Stand	03-2	Knurl Valve Guides	05-24
Engine Lifting Procedure	03-3	Clean and Inspect Valve Seats	05-24
Clean Engine	03-3	Measure Valve Seats	05-25
Disconnect Turbocharger Oil Inlet Line	03-4	Grind Valve Seats	05-26
Mount Engine On Repair Stand	03-5	Remove Valve Seat Inserts and Measure Bores	05-27
Group 04—Engine Rebuild Guide		Install Valve Seat Inserts	05-27
6081 Engine Disassembly Sequence	04-1	Inspect and Clean Cylinder Head Nozzle Bore	05-28
Sealant Application Guidelines	04-2	Clean and Inspect Push Rods	05-29
6081 Engine Assembly Sequence	04-3	Inspect and Clean Ventilator Outlet Hose	05-29
		Clean and Inspect Top Deck of Cylinder Block	05-29

Continued on next page

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

CTM86-19-26OCT94

COPYRIGHT® 1994
DEERE & COMPANY
Moline, Illinois
All rights reserved
A John Deere ILLUSTRATION™ Manual

Contents

	Page		Page
00		Measure Cylinder Liner Standout (Height above Block)	05-30
		Assemble Valve Assembly	05-31
01		Install Cylinder Head and Cap Screws	05-32
		Torque-To-Yield Flanged-Head Cap Screws—Grade 180 Marked	
02		—SPECIAL—	05-34
		Install Rocker Arm Assembly	05-35
		Complete Final Assembly on Injection Pump Side of Engine	05-36
03		Complete Final Assembly on Exhaust Manifold Side of Engine	05-37
		Perform Engine Break-In	05-38
04		Group 10—Cylinder Block, Liners, Pistons and Rods	
		Special or Essential Tools	10-1
05		Service Equipment and Tools	10-4
		Other Material	10-4
		Cylinder Block, Liners, Pistons, and Rods Specifications	10-5
10		Preliminary Liner, Piston, and Rod Checks	10-9
		Remove Piston and Connecting Rod Assemblies	10-10
15		Measure Cylinder Liner Standout (Height above Block)	10-14
16		Remove Cylinder Liners	10-15
		Deglazing Cylinder Liners	10-16
		Clean Cylinder Liners	10-17
20		Disassemble Piston/Rod Assembly and Clean Pistons	10-17
		Visually Inspect Pistons	10-19
		Check Piston Ring Groove Wear	10-20
25		Inspect Piston Pin and Pin Piston	10-21
		Visually Inspect Cylinder Liners	10-22
		Cylinder Liner Manufacturing Date Code Explanation	10-23
30		Determine Piston-To-Liner Clearance	10-23
		Measure Liner Flange Thickness	10-25
		Inspect and Measure Connecting Rod Bearings	10-25
35		Inspect Rod and Cap	10-27
		Inspect Piston Pins and Bushings	10-28
100		Remove Piston Pin Bushing, Clean and Inspect Bushing Bore	10-30
		Install Piston Pin Bushing in Connecting Rod	10-31
105		Complete Disassembly of Cylinder Block (If Required)	10-32
		Remove and Clean Piston Cooling Orifices	10-32
		Inspect and Clean Cylinder Block	10-33
		Measure Cylinder Block	10-34
		Install Piston Cooling Orifices and Gallery Plugs	10-35
		Recheck Cylinder Liner Standout (Height above Block)	10-35
		Install Liner Shims—If Required	10-36
		Install Packing on Cylinder Liner and O-Rings in Block	10-36
		Install Cylinder Liners in Block	10-37
		Install Pistons and Connecting Rods	10-39
		TORQUE-TURN Connecting Rod Cap Screws	10-42
		Check Engine Rotation for Excessive Tightness	10-42
		Complete Final Assembly	10-43
		Group 15—Crankshaft, Main Bearings, and Flywheel	
		Special or Essential Tools	15-1
		Service Equipment and Tools	15-4
		Other Material	15-4
		Crankshaft and Main Bearing Failure Analysis	15-5
		Crankshaft, Main Bearings, and Flywheel Specifications	15-6
		Remove Crankshaft Rear Oil Seal and Wear Sleeve (With Oil Seal Housing Installed)	15-9
		Crankshaft Rear Oil Seal and Wear Sleeve Handling Precautions	15-11
		Install Crankshaft Rear Oil Seal and Wear Sleeve (Without Engine Disassembly)	15-12
		Inspect Vibration Damper	15-13
		Check Crankshaft End Play	15-14
		Remove Crankshaft Vibration Damper	15-15
		Replace Front Oil Seal and Wear Sleeve (With Timing Gear Cover Installed on Engine)	15-16
		Remove and Install Timing Gear Cover—Engine Installed in Vehicle	15-20
		Remove Timing Gear Cover—Engine Removed	15-21
		Inspect, Measure and Repair Flywheel	15-21
		Check Flywheel Housing Face Run-Out	15-22
		Check Flywheel Face Flatness	15-22
		Check Pilot Bearing Bore Concentricity	15-23
		Remove Flywheel	15-23

Continued on next page

	Page		Page
Replace Flywheel Ring Gear	15-24	Inspect and Measure Camshaft Followers . . .	16-13
Remove and Install Rear Oil Seal		Visually Inspect Camshaft	16-13
Housing—Engine Installed in Vehicle	15-25	Measure Camshaft Journal OD and	
Remove Rear Oil Seal Housing—Engine		Bushing ID	16-14
Removed	15-26	Measure Camshaft Lobe Lift	16-14
Remove Main Bearing Caps	15-27	Install Camshaft Gears	16-15
Check Main Bearing Oil Clearance	15-28	Service Camshaft Bushings using	
Remove Connecting Rod Caps and		JDG602 Adapter Set	16-16
Remove Crankshaft	15-29	Service Camshaft Bushings using	
Inspect Crankshaft	15-30	JDG606 Adapter Set	16-18
Measure Assembled ID of Bearings And		Install Thrust Washer and Timing Gear	
OD Of Crankshaft Journals	15-31	Cover	16-21
Main Bearing Cap Line Bore		Complete Final Assembly	16-22
Specifications	15-32		
Thrust Bearing New Part Specifications	15-33	Group 20—Lubrication System	
Crankshaft Grinding Guidelines	15-34	Other Material	20-1
Crankshaft Grinding Specifications	15-35	Lubrication System Specifications	20-1
Replace Crankshaft Oil Pump Drive Gear	15-36	Diagnosing Lubrication System	
Replace Crankshaft Gear	15-37	Malfunctions	20-3
Inspect Thrust Bearings	15-38	Oil Filter Base and Pressure Regulating	
Remove and Clean Piston Cooling		Valve Housing Assembly	20-4
Orifices	15-38	Remove and Install Oil filter Base and	
Install Main Bearings and Crankshaft	15-39	Pressure Regulating Valve Housi	20-5
Install Crankshaft Rear Oil Seal Housing	15-41	Engine Oil Cooler Assembly	20-6
Check Oil Seal Housing Runout	15-42	Remove, Inspect, and Install Engine Oil	
Crankshaft Rear Oil Seal And Wear		Cooler	20-7
Sleeve Handling Precautions	15-43	Remove, Inspect, and Install Oil Pressure	
Install Crankshaft Rear Oil Seal and		Regulating Valve,	
Wear Sleeve Assembly	15-44	Oil Filter Bypass Valve, and Oil Cooler	
Install Timing Gear Cover	15-45	Bypass Valve	20-8
Install Front Wear Sleeve	15-46	Remove Engine From Vehicle For Access	
Install Front Oil Seal		to Engine Oil Pump	20-9
(With Timing Gear Cover Installed)	15-47	Check Crankshaft Gear-To-Oil Pump	
Install Vibration Damper	15-47	Drive Gear Backlash	20-9
Install Flywheel	15-48	Remove Engine Oil Pump	20-10
Complete Final Assembly	15-48	Inspect and Clean Oil Pump	20-10
		Check Drive Shaft End Play	20-11
Group 16—Camshaft and Timing Gear Train		Check Drive Shaft Side Movement	20-11
Special or Essential Tools	16-1	Check Pumping Gear Backlash	20-12
Other Material	16-3	Inspect Oil Pump Drive Gear	20-12
Camshaft and Timing Gear Train		Adjust Oil Pump Set Screw	20-13
Specifications	16-4	Install Engine Oil Pump	20-14
Check Valve Lift	16-6	Remove and Install Oil Pump Outlet and	
Check Camshaft End Play and Measure		Oil Cooler Cross-Over Tube Adap	20-15
Gear Backlash	16-7	Tighten Cap Screws on Fornt Frame/Oil	
Remove Vibration Damper and Timing		Sump	20-16
Gear Cover	16-8	Install Engine Into Vehicle After Oil Pump	
Remove Camshaft	16-10	Repair	20-17
Remove Camshaft Gears	16-12		
Measure Thrust Washer Thickness	16-12	Group 25—Cooling System	
		Special or Essential Tools	25-1

Continued on next page

110
115
199
INDX

	Page		Page
Other Material	25-1	Inspect and Repair Fuel Supply Pump	35-12
Cooling System Specifications	25-1	Assemble Fuel Supply Pump	35-13
Diagnosing Cooling System Malfunctions	25-2	Install Fuel Supply Pump	35-13
Inspect Water Pump	25-2	Service Injection Pump Overflow Valve	35-14
Remove Water Pump Assembly	25-3	Remove Fuel Injection Pump	35-15
Install Water Pump Assembly	25-5	Install Fuel Injection Pump	35-18
Replace Bypass Tube in Water Pump Cover	25-6	Remove Fuel Injection Nozzles	35-21
Remove and Test Thermostats	25-6	Diagnose Injection Nozzle Malfunction	35-23
Install Thermostats	25-7	Test Fuel Injection Nozzles	35-25
Remove Water Manifold	25-8	Perform Opening Pressure Test	35-26
Install Water Manifold	25-8	Injection Nozzle Opening Pressure Specifications	35-27
Complete Final Assembly	25-9	Perform Nozzle Leakage Test	35-28
Group 30—Air Intake And Exhaust System		Perform Chatter and Spray Pattern Test	35-29
Other Material	30-1	Disassemble Fuel Injection Nozzle	35-30
Air Intake and Exhaust System Specifications	30-1	Clean and Inspect Fuel Injection Nozzle Assembly	35-32
Extending Turbocharger Life	30-2	Perform Nozzle Slide Test	35-33
Remove Turbocharger	30-5	Clean Spray Orifices	35-33
Turbocharger Failure Analysis	30-6	Inspect Nozzle Holder	35-34
Turbocharger Seven-Step Inspection	30-8	Inspect Gland Nut	35-36
Perform Radial Bearing Clearance Test	30-13	Assemble Fuel Injection Nozzle	35-37
Perform Axial Bearing End Play Test	30-14	Test and Adjust Injection Nozzle Opening Pressure	35-40
Repair Turbocharger	30-14	Inspect and Clean Cylinder Head Nozzle Bore	35-41
Disassemble Turbocharger	30-15	Inspect and Clean Nozzle Seating Surface	35-42
Clean and Inspect Turbine and Compressor Housings	30-16	Install Fuel Injection Nozzles	35-42
Replace Center Housing Assembly and Assemble Turbocharger	30-17	Group 100—Engine Tune-Up and Break-In	
Prelube Turbocharger	30-18	Effects of Altitude and Temperature on Engine Performance	100-1
Install Turbocharger	30-19	Preliminary Engine Testing	100-2
Remove, Inspect, and Install Exhaust Manifold	30-20	General Tune-Up Recommendations	100-3
Remove, Inspect, and Install Intake Manifold	30-21	Dynamometer Test	100-4
Group 35—Fuel System		Engine Break-In Guidelines	100-5
Special or Essential Tools	35-1	Perform Engine Break-In	100-6
Service Equipment and Tools	35-3	Check Crankcase Ventilation System	100-6
Other Material	35-4	Check Air Intake System	100-7
Fuel System Specifications	35-4	Check Exhaust System	100-7
Relieve Fuel System Pressure	35-6	Check and Service Cooling System	100-8
Replace Final (Rectangular) Fuel Filter	35-6	Check Electrical System	100-10
Replace Fuel Check Valve	35-7	Group 105—Engine System Operation and Test	
Replace Primary (Round) Fuel Filter/Water Separator	35-8	Special or Essential Tools	105-1
Remove Fuel Supply Pump	35-9	Engine Test Specifications	105-3
Test Fuel Supply Pump For Leaks	35-10	Engine Cutaway View	105-4
Disassemble Fuel Supply Pump	35-11	General Engine Description	105-5
		How the Lubrication System Works	105-6

Continued on next page

Contents

	Page		Page
How the Cooling System Works	105-8	Diagnose Malfunctions—Fuel Injection Nozzle	115-18
Head Gasket Joint Construction and Operation	105-10	Test Fuel Injection Nozzles (Engine Running)	115-19
Diagnosing Head Gasket Joint Failures . . .	105-12	Fuel Drain Back Test Procedure	115-19
Head Gasket Inspection and Repair Sequence	105-15	 Group 199—Dealer Fabricated Tools	
Diagnosing Engine Malfunctions	105-17	How to Make Tools	199-1
Test Engine Compression Pressure	105-20	Cylinder Liner Holding Fixture	199-1
Check Engine Oil Pressure	105-21	 Index	
Pressure Test Cooling System and Radiator Cap	105-22		
Inspect Thermostats and Test Opening Temperature	105-23		
 Group 110—Air Intake System Operation and Test			
Special or Essential Tools	110-1		
Air Intake and Exhaust System Test Specifications	110-1		
Diagnosing Air Intake Malfunctions	110-2		
How the Air Intake and Exhaust System Works	110-3		
Air Cleaner Operation	110-4		
Air Filter Restriction Indicator Switch Test . .	110-5		
Diagnosing Turbocharger Malfunctions	110-6		
How The Turbocharger Works	110-7		
How The Turbocharger is Lubricated	110-7		
Check Intake Manifold Pressure (Turbo Boost)	110-8		
 Group 115—Fuel System Operation and Tests			
Special or Essential Tools	115-1		
Fuel System Test Specifications	115-1		
Fuel System Operation	115-2		
Diagnose Fuel System Malfunctions	115-3		
Fuel Supply Pump Operation	115-6		
Diagnosing Fuel Supply Pump Malfunctions	115-8		
Check Fuel Supply Pump Operation	115-9		
Service Fuel Supply Pump	115-11		
Rectangular Final Fuel Filter Operation	115-11		
Round (Primary) Fuel Filter/Water Separator Operation	115-12		
Bleed the Fuel System	115-13		
Fuel Injection Pump Operation	115-14		
Diagnose Fuel Injection Pump Malfunctions	115-15		
Fuel Injection Nozzles—General Information	115-16		
Fuel Injection Nozzle Operation	115-17		

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

00
1
-JUN-23AUG88
TS227

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

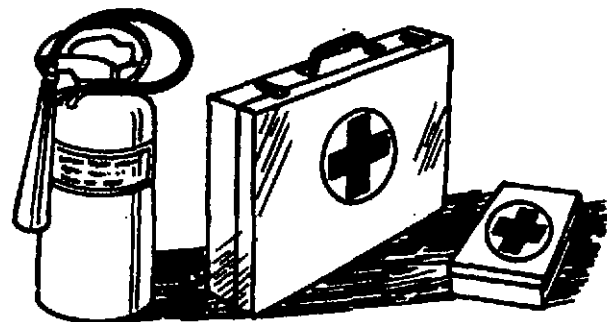
-JUN-23AUG88
TS204

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

-JUN-23AUG88
TS281

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.



-JUN-23AUG88

TS203

DX,POISON -19-21APR93

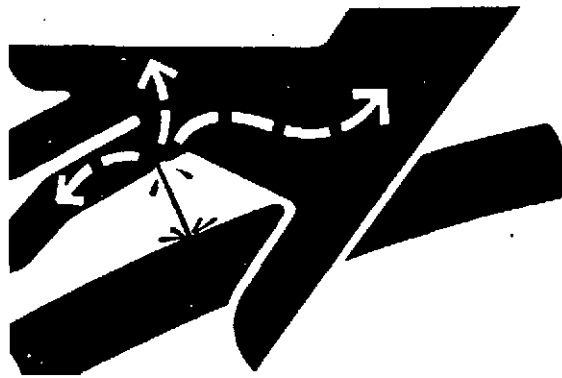
AVOID HIGH-PRESSURE FLUIDS

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

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

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

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



DX,FLUID -19-03MAR93

00
3
-JUN-23AUG88
X9811

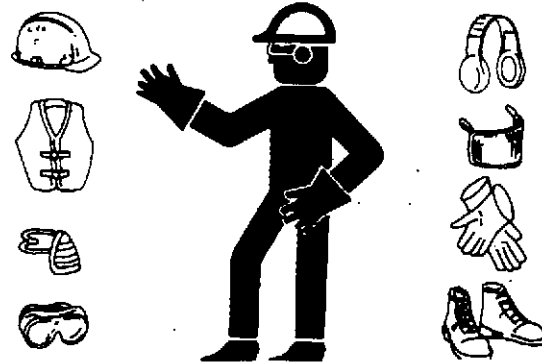
WEAR PROTECTIVE CLOTHING

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

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

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

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



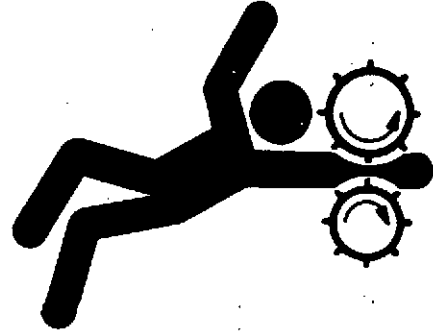
DX,WEAR -19-10SEP90

-JUN-23AUG88
TS206

SERVICE MACHINES SAFELY

Tie long hair behind your head. Do not wear a necktie, scarf, loose clothing, or necklace when you work near machine tools or moving parts. If these items were to get caught, severe injury could result.

Remove rings and other jewelry to prevent electrical shorts and entanglement in moving parts.



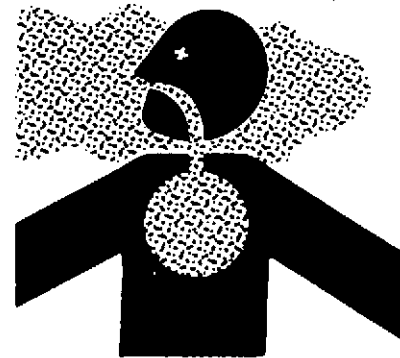
DX, LOOSE -19-04JUN90

TS228 -UN-23AUG88

WORK IN VENTILATED AREA

Engine exhaust fumes can cause sickness or death. If it is necessary to run an engine in an enclosed area, remove the exhaust fumes from the area with an exhaust pipe extension.

If you do not have an exhaust pipe extension, open the doors and get outside air into the area.



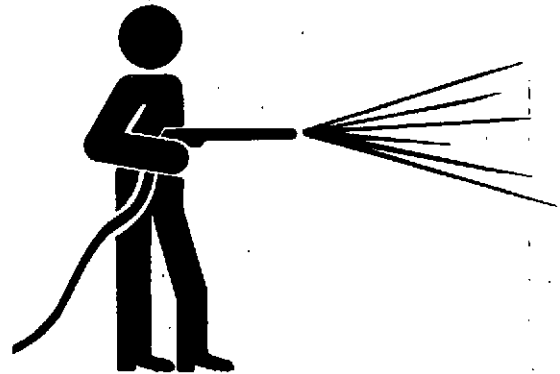
DX, AIR -19-04JUN90

TS220 -UN-29AUG88

WORK IN CLEAN AREA

Before starting a job:

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



DX, CLEAN -19-04JUN90

T6642EJ -UN-18OCT88

REMOVE PAINT BEFORE WELDING OR HEATING

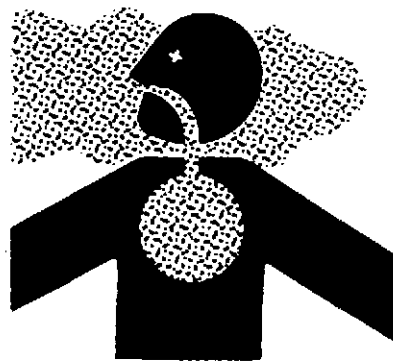
Avoid potentially toxic fumes and dust.

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

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

Remove paint before welding or heating:

- If you sand or grind paint, avoid breathing the dust. Wear an approved respirator.
- If you use solvent or paint stripper, remove stripper with soap and water before welding. Remove solvent or paint stripper containers and other flammable material from area. Allow fumes to disperse at least 15 minutes before welding or heating.



DX,PAINT -19-03MAR93

TS220 -UN-23AUG88

AVOID HEATING NEAR PRESSURIZED FLUID LINES

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



DX,TORCH -19-03MAR93

TS953 -UN-15MAY90

ILLUMINATE WORK AREA SAFELY

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



DX,LIGHT -19-04JUN90

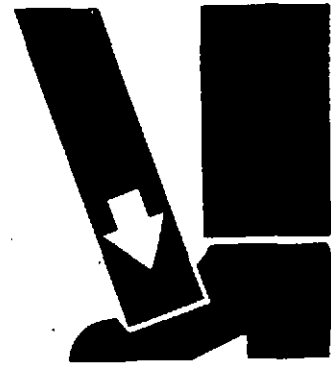
TS223 -UN-23AUG88

USE PROPER LIFTING EQUIPMENT

00
6

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 -JUN-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 -JUN-23AUG88

USE PROPER TOOLS

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

Use power tools only to loosen threaded parts and fasteners.

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

Use only service parts meeting John Deere specifications.



DX,REPAIR -19-04JUN90

00
7
-JUN-08NOV89
TS779

DISPOSE OF WASTE PROPERLY

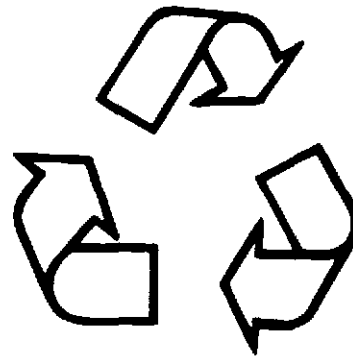
Improperly disposing of waste can threaten the environment and ecology. Potentially harmful waste used with John Deere equipment include such items as oil, fuel, coolant, brake fluid, filters, and batteries.

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

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

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

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



DX,DRAIN -19-03MAR93

-JUN-28NOV90
TS1133

LIVE WITH SAFETY







00
8
Before returning machine to customer, make sure machine is functioning properly, especially the safety systems. Install all guards and shields.



DX,LIVE -19-26SEP92

TS231 -19-07OCT88

UNIFIED INCH BOLT AND CAP SCREW TORQUE VALUES

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

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

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

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

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

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

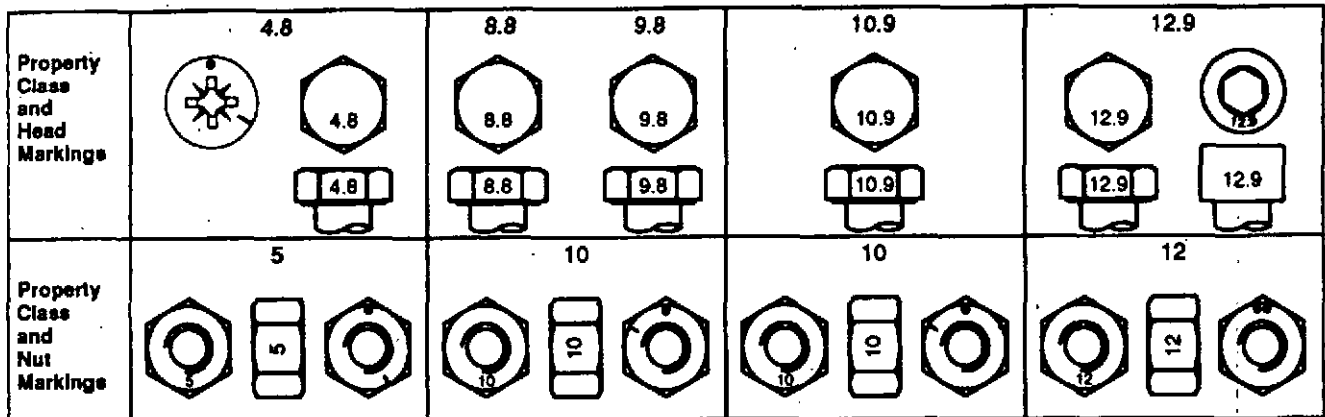
Fasteners should be replaced with the same or higher grade. If higher grade fasteners are used, these should only be tightened to the strength of the original.

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

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

TS1162 -19-04MAR91

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	255	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—6081

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

6081HRW01 Engine

6	.....	Number of cylinders
8.1	.....	Liter displacement
H	.....	Aspiration code
RW	.....	User code
01	.....	Application code

Aspiration Code

H Turbocharged and air-to-air aftercooled

User Code

RW Waterloo Tractor Works

Application Code

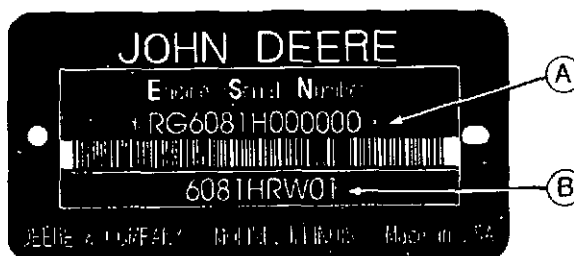
01 8400 Tractor

RG,CTM86,G1,1 -19-12SEP94

01
3

ENGINE SERIAL NUMBER PLATE INFORMATION

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



• Engine Serial Number (A)

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

RG6081H000000

RG Factory code producing engine
 6081H Engine Model Designation
 000000 Sequential Number

Factory Code Producing Engine

RG Waterloo Engine Works

Engine Model Designation

6081H Definition explained previously. (See ENGINE MODEL DESIGNATION.)

Sequential Number

000000 6-digit sequential number.

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

• Engine Application Data (B)

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

-UN-28JUL84

FIG7010

RG,CTM86,G1,2 -19-06SEP94

ENGINE APPLICATION CHART

John Deere Agricultural Equipment Applications

Machine Model No.

Engine Model

~~TRACTORS—WATERLOO~~

8400 6081HRW01

RG,CTM86,G1,3 -19-08FEB94

01
5

01
6

DIESEL FUEL

⚠ CAUTION: Handle fuel carefully. Do not fill the fuel tank when engine is running. DO NOT smoke while you fill the fuel tank or service the fuel system.

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

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

Diesel fuels meeting U.S. Military Specification VV-F-800E are preferred. Diesel fuels specified to EN 590 or ASTM D975 are also recommended.

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

- Cetane Number 40 minimum. Cetane number greater than 50 is preferred, especially for temperatures below -20° C (-4° F) or elevations above 1500 m (5000 ft).
- Cold Filter Plugging Point (CFPP) below the expected low temperature or Cloud Point at least 5° C (9° F) below the expected low temperature.
- Sulfur content:
 - Sulfur content should not exceed 0.5%. Sulfur content less than 0.05% is preferred.
 - If diesel fuel with sulfur content greater than 0.5% is used, reduce the service interval for engine oil and filter changes by 50%.
 - DO NOT use diesel fuel with sulfur content greater than 1.0%.

Bio-diesel fuels with these properties and meeting an appropriate specification (such as Austrian Standard OENORM C1190-RME) may be used.

IMPORTANT: Low sulfur fuels (less than 0.5% sulfur) may not provide adequate lubricity. If fuel of low or unknown lubricity is used, add John Deere All-Season Fuel Conditioner or equivalent at the specified concentration.

RG,FUEL1 -19-21OCT94

ENGINE BREAK-IN OIL

New engines are filled at the factory with John Deere ENGINE BREAK-IN OIL. During the break-in period, add John Deere ENGINE BREAK-IN OIL as needed to maintain the specified oil level.

Change the oil and filter after the first 100 hours of operation of a new or rebuilt engine.

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

If John Deere ENGINE BREAK-IN OIL is not available, use a diesel engine oil meeting one of the following during the first 100 hours of operation:

- API Service Classification CE
- CCMC Specification D4

After the break-in period, use John Deere PLUS-50™ or other diesel engine oil as recommended in this manual.

IMPORTANT: Do not use John Deere PLUS-50 oil or engine oils meeting API CG4, API CF4, or CCMC D5 performance levels during the first 100 hours of operation of a new or rebuilt engine. These oils will not allow the engine to break-in properly.

DX,ENOIL4 -19-17OCT94

DIESEL ENGINE OIL

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

The following oil is preferred.

- John Deere PLUS-50™

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

The following oil is also recommended:

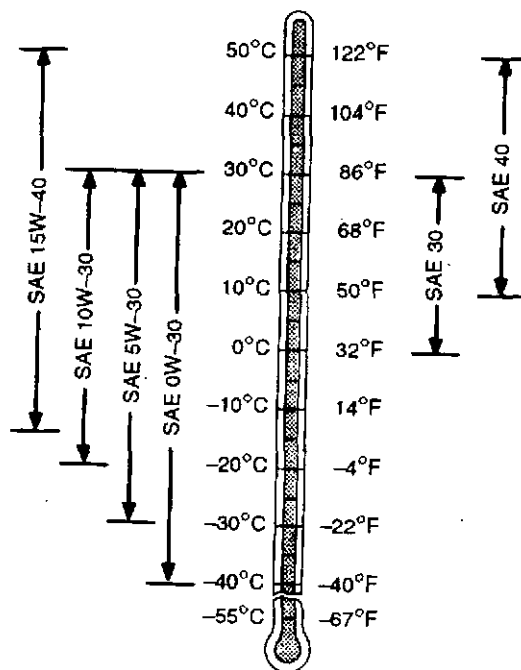
- John Deere TORQ-GARD SUPREME®

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

- John Deere UNI-GARD™
- API Service Classification CG4
- API Service Classification CF4
- API Service Classification CE
- CCMC Specification D5 and Mercedes Benz MB228.3
- CCMC Specification D4 and Mercedes Benz MB228.1

Viscosity grade SAE 15W-40 is preferred.

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



DX,ENOIL

-19-16SEP94

TS1619 -UN-12SEP94

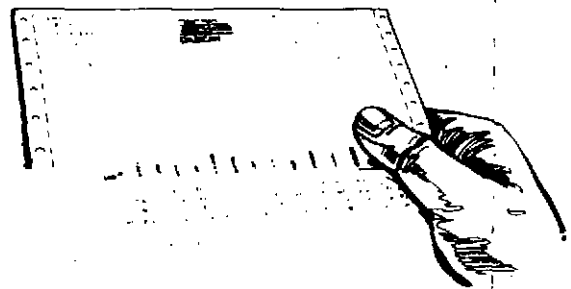
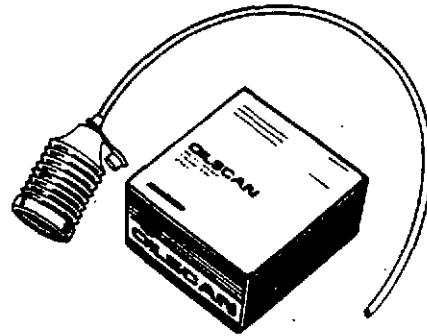
02
3

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

-UN-15JUN89

T6829AB

-UN-18OCT88

T6829AB

GREASE

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

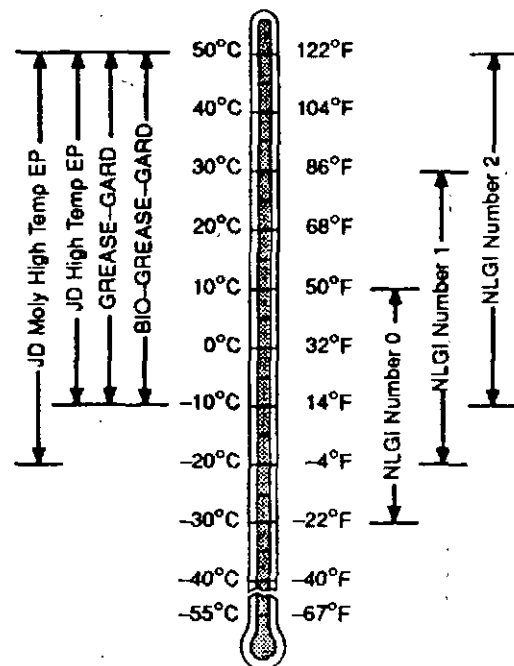
The following greases are preferred:

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

Other greases may be used if they meet the following:

- NLGI Performance Classification GC-LB

Arctic greases (such as Military Specification MIL-G-10924F) may be used at temperatures below -30°C (-22°F).



DX,GREA1 -19-17OCT94

-UN-31JAN84

TS1417

ALTERNATIVE AND SYNTHETIC LUBRICANTS

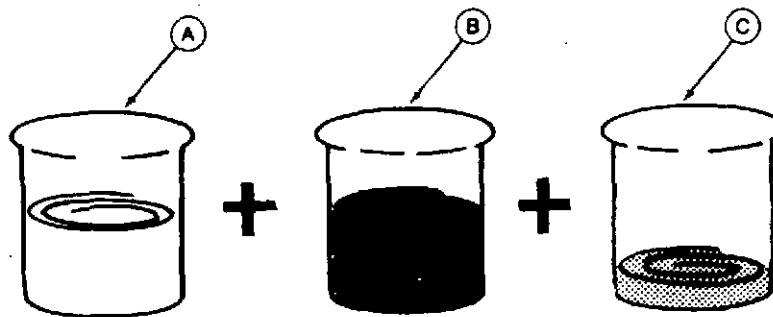
Conditions in certain geographical areas may require lubricant recommendations different from those printed in this manual. Some John Deere lubricants may not be available in your location. Consult your John Deere dealer to obtain information and recommendations.

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

DX,ALTER -19-01FEB94

02
5

ENGINE COOLANT REQUIREMENTS



FG6258 -JUN-22APP82

A—Quality Water

B—Ethylene Glycol Concentrate
(Antifreeze)

C—Supplemental Coolant Additives
(SCA's)

Engine Coolant

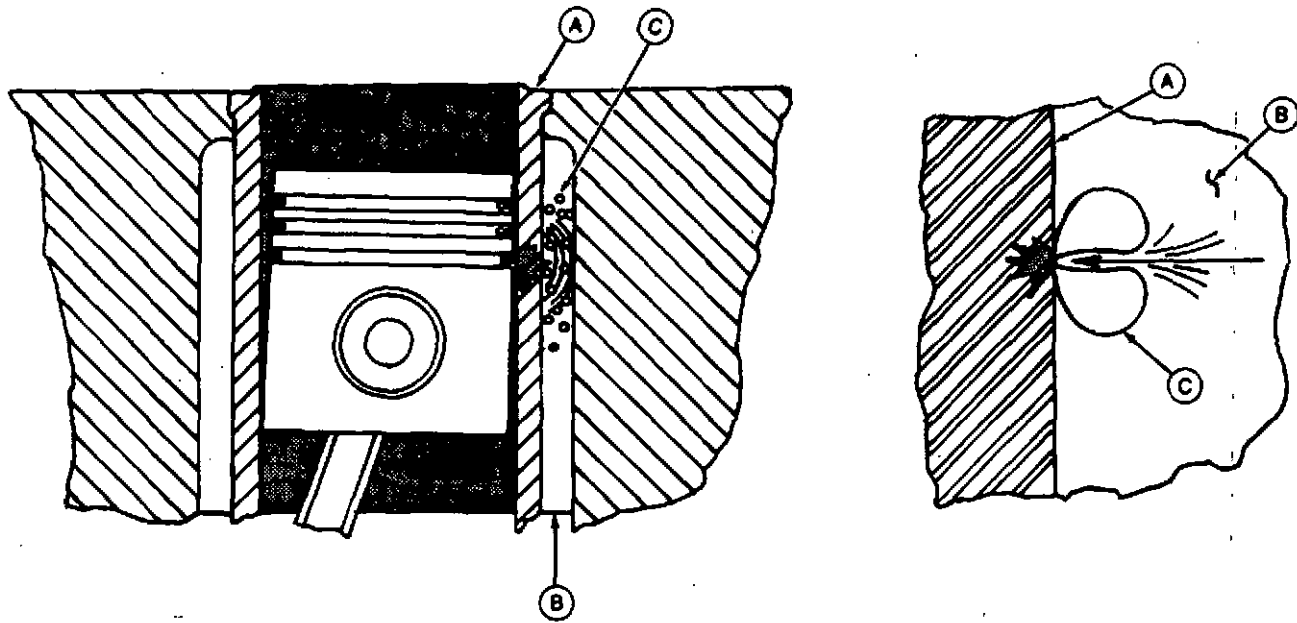
To meet cooling system protection requirements, the coolant **MUST** consist of a 50/50 mixture of quality water and ethylene glycol concentrate (antifreeze). Supplemental coolant additives (SCA's) must be added to this mixture. Add 3% (by volume) TY16004 or TY16005 Liquid Coolant Conditioner. If an equivalent product is used, always follow the supplier's recommendations printed on the container. See ENGINE COOLANT SPECIFICATIONS, later in this section, for further definition.

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.

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.

RG,COOL1 -19-10OCT94

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,COOL1A -19-10OCT94

RECOMMENDED ENGINE COOLANT

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

John Deere Prediluted Antifreeze/Summer Coolant and John Deere Antifreeze/Summer Coolant Concentrate are recommended. John Deere Low Silicate Antifreeze and John Deere COOL-GARD™, where available, may also be used. Supplemental coolant additives **MUST** be added to John Deere Low Silicate Antifreeze.

• JOHN DEERE PREDILUTED ANTIFREEZE/SUMMER COOLANT

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

John Deere Prediluted Antifreeze/Summer Coolant permits extended service life to 1800 hours or 36 months, with replenishment of supplemental coolant additives every 600 hours or 12 months.

• JOHN DEERE ANTIFREEZE/SUMMER COOLANT CONCENTRATE

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

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

John Deere Antifreeze/Summer Coolant Concentrate has a service life of 1200 hours or 24 months, when recommended cooling system maintenance procedures are followed.

• JOHN DEERE COOL-GARD™

In certain geographical areas, John Deere COOL-GARD is marketed for use in the engine cooling system. This product contains all the necessary ingredients that make up the proper coolant solution: chemically pure water, ethylene glycol (low silicate antifreeze), and supplemental coolant additives (SCA's). It is ready to add to cooling system as is; no mixing or supplemental coolant additives required. Contact your John Deere Parts Network for local availability.

John Deere COOL-GARD has a service life of 1200 hours or 24 months, when recommended cooling system maintenance procedures are followed.

RG.COOL2 -19-10OCT94

ENGINE COOLANT SPECIFICATIONS

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

If John Deere coolant products are not used, ethylene glycol concentrate (antifreeze) can be used when mixed with quality water and supplemental coolant additives (SCA's), as described below and later in this section. Use an ethylene glycol concentrate meeting ASTM D5345 (prediluted coolant) or ASTM D4985 (coolant concentrate) mixed 50% with quality water.

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.

Ethylene Glycol Concentrate (Antifreeze):

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

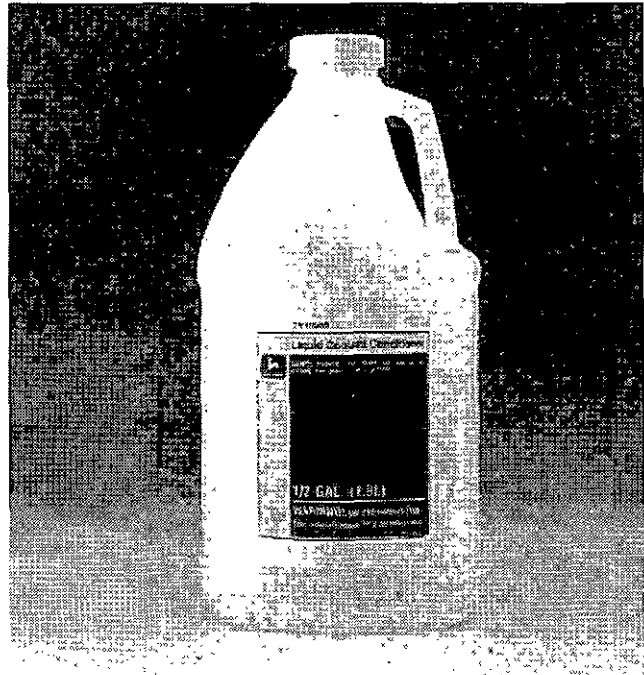
RG,COOL3 -19-10OCT94

ENGINE COOLANT SPECIFICATIONS—CONTINUED



TY16004 Liquid Coolant Conditioner

RG7233
-UN-18SEP94



TY16005 Liquid Coolant Conditioner

RG7234
-UN-08SEP94

Supplemental Coolant Additives (SCA's):

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

NOTE: John Deere Prediluted Antifreeze/Summer Coolant, John Deere Antifreeze/Summer Coolant Concentrate, and John Deere COOL-GARD contain supplemental coolant additives (SCA's). However, as the coolant solution loses its effectiveness, additives will need to be added.

Inhibit the antifreeze-coolant mix with a non-chromate inhibitor such as John Deere Liquid Coolant Conditioner. SCA's guard against rust, corrosion, and liner pitting. ALWAYS follow the supplier's recommendations printed on the container.

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

- TY16004 473 mL (16 oz) container
- TY16005 3.8 L (1 US gal) container

IMPORTANT: Replenish inhibitors between drain intervals by the addition of a supplemental coolant additive every 600 hours or 12 months of operation.

DO NOT use soluble oil.

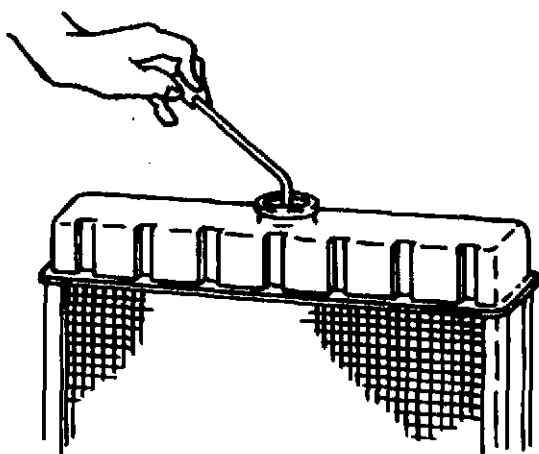
In tropical areas where antifreeze or John Deere COOL-GARD is not available, it is acceptable to use water meeting the quality specifications on the previous page and John Deere Liquid Coolant Conditioner. The recommended concentration of John Deere Liquid Coolant Conditioner must be doubled to 6% (60 mL per Liter of cooling system capacity) by volume when used with water only (no antifreeze).

Additives eventually lose their effectiveness and must be recharged with additional liquid coolant conditioner. See label on container for recommended service intervals and concentration rates. See REPLENISHING SUPPLEMENTAL COOLANT ADDITIVES (SCA'S) BETWEEN COOLANT CHANGES, later in this group.

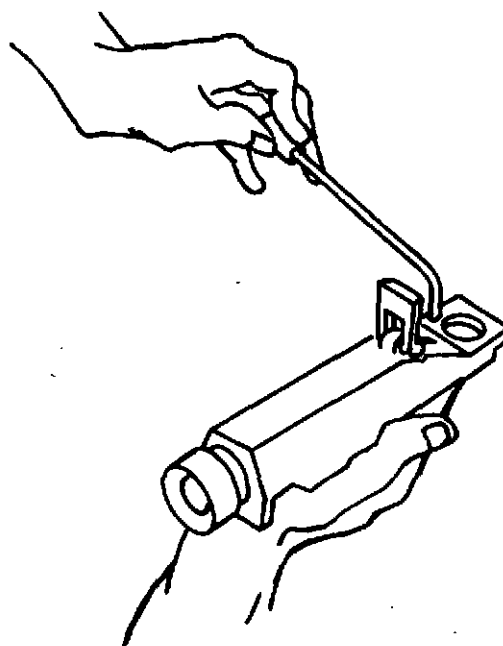
Contact your authorized servicing dealer or engine distributor, if there are further questions.

RG.COOL3A,CTM -19-24OCT94

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



RG6261 -UN-22APR92



RG6262 -UN-22APR92

Through time and use, original additives eventually lose their effectiveness and must be recharged with additional supplemental coolant additives available in the form of liquid coolant conditioner.

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

Perform a CoolScan analysis after 600 hours or 12 months of operation. If a CoolScan analysis is not available, recharge system per instructions printed on label of TY16004 or TY16005 John Deere Liquid Coolant Conditioner.

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

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

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

RG,COOL4,CTM -19-24OCT94

FLUSH AND SERVICE COOLING SYSTEM



JUN-28AUG88

TS281

02
11

⚠ 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.

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: 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 clean water and TY15979 John Deere Heavy-Duty Cooling System Cleaner or an equivalent 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 at 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.RE08B -19-17AUG94

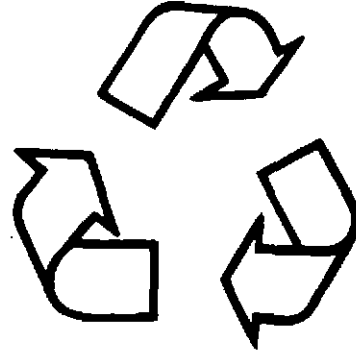
DISPOSING OF COOLANT

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.

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

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

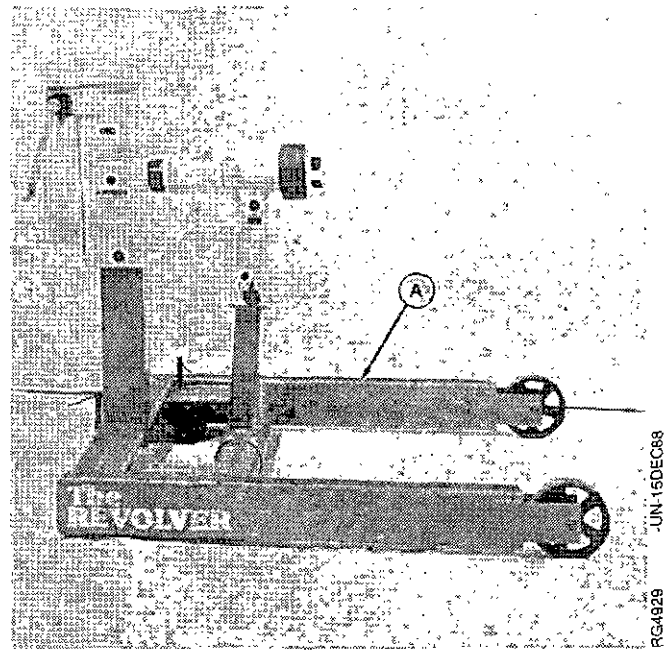


RG.COOL5 -19-01SEP94

TS1133 -JUN-26NOV90

ENGINE REPAIR STAND

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



S11.2000,EM -19-08MAR94

SAFETY PRECAUTIONS

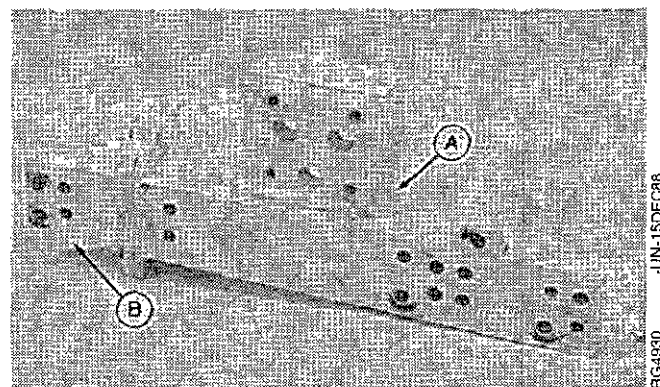
- The engine repair stand should be used only by qualified service technicians familiar with this equipment.
- To maintain shear strength specifications, alloy steel SAE Grade 8 or higher socket head cap screws must be used to mount adapters or engine. Use LOCTITE® 242 Thread Lock and Sealer on cap screws when installing lifting straps on engine. Tighten cap screws to 170 N·m (125 lb-ft).
- For full thread engagement, be certain that tapped holes in adapters and engine blocks are clean and not damaged. A thread length engagement equal to 1-1/2 screw diameters minimum is required to maintain strength requirements.
- To avoid structural or personal injury, do not exceed the maximum capacity rating of 2722 kg (6000 lb). Maximum capacity is determined with the center of the engine located not more than 330 mm (13 in.) from the mounting hub surface of the engine stand.
- To avoid an unsafe off-balance load condition, the center of balance of an engine must be located within 51 mm (2 in.) of the engine stand rotating shaft. Engine center of balance is generally located a few millimeters above the crankshaft.
- To prevent possible personal injury due to engine slippage, recheck to make sure engine is solidly mounted before releasing support from engine lifting device.
- Never permit any part of the body to be positioned under a load being lifted or suspended. Accidental slippage may result in personal injury.
- The lifting jack is to be used when it is necessary to lift the engine for rotation. When working on the engine, the jack should be at its lowest position to keep the center of gravity low and the possibility of tipping low.
- To prevent possible 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.

LOCTITE® is a registered trademark of Loctite Corporation.

S11,2000,DZ -19-14SEP94

INSTALL ADAPTERS ONTO ENGINE 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).



RG,CTM86,G3,1 -19-08FEB94

UN-15DEC88
RG4930

ENGINE LIFTING PROCEDURE

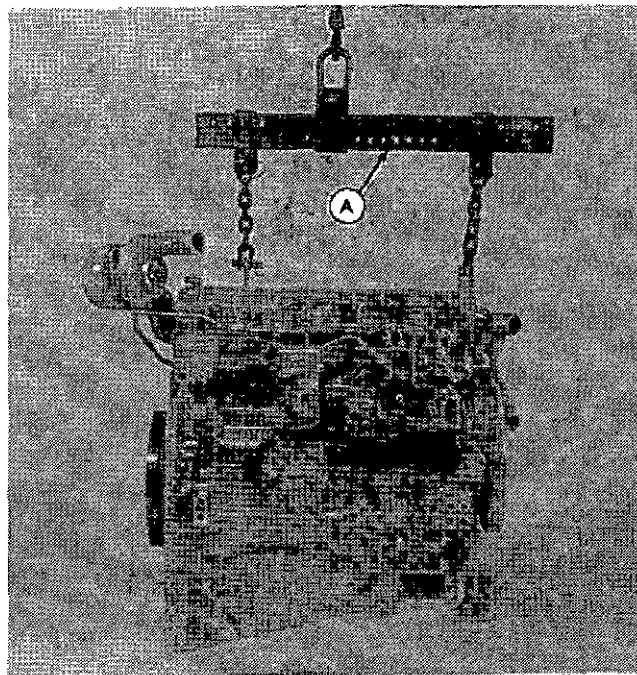
CAUTION: The only recommended method for lifting the 6081 engine is with JDG23 Engine Lifting Sling and safety approved lifting straps that come with engine. Use extreme caution when lifting and NEVER permit any part of the body to be positioned under an engine being lifted or suspended.

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

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

NOTE: If engine does not have lifting straps, they can be procured through service parts or made 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.



03
3
UN-28JUL94
RG7011

RG,CTM86,G3,2 -19-14SEP94

CLEAN ENGINE

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

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

S11,2000,EC -19-20AUG92

DISCONNECT TURBOCHARGER OIL INLET LINE

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

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

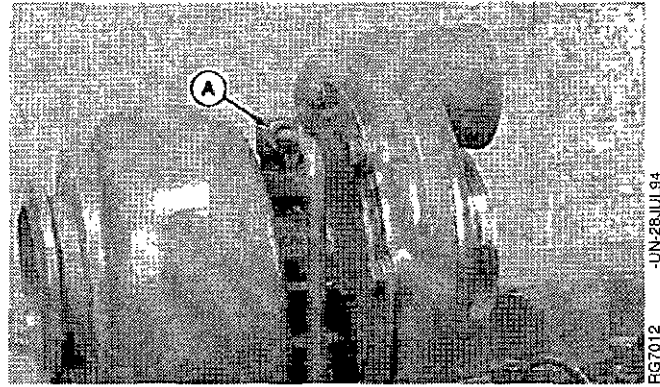


FIG7012 -UN-28JUL94

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 filter base.

RG,CTM86,G3,3 -19-20JUL94

MOUNT ENGINE ON REPAIR STAND

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



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

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

RG,CTM86,G3,4 -19-14SEP94

03
5

03
6

6081 ENGINE DISASSEMBLY SEQUENCE

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

1. Drain all coolant and engine oil. Check engine oil for metal contaminates.
 2. Remove turbocharger oil inlet line and oil return line. Remove turbocharger.
 3. Remove fan pulley and water manifold assembly.
 4. Remove water pump assembly from timing gear cover.
- NOTE: DO NOT damage option code label (if equipped), when removing rocker arm cover.*
5. Remove breather hose from rocker arm cover. Remove rocker arm cover.
 6. Remove rocker arm assembly and push rods. Identify parts for re-assembly.
 7. Remove front crankshaft pulley and damper assembly.
 8. Remove fuel injection lines and injection nozzles.
 9. Remove engine oil filter, filter base, and valve housing.
 10. Remove injection pump gear cover and remove injection pump. Remove fuel filter and mounting base.
 11. Remove engine oil cooler assembly.
 12. Remove front and rear exhaust manifolds.
 13. Remove air intake manifold.

NOTE: ALWAYS bolt down liners when rotating engine flywheel with cylinder head removed.

14. Remove cylinder head with valve assembly. Remove head gasket.
15. On SAE No. 3 flywheel housings, remove flywheel housing and then remove flywheel.
16. On SAE No. 1 and 2 flywheel housings, remove flywheel and then remove flywheel housing.
17. Revolve engine on repair stand and remove engine oil pump assembly.
18. Remove front timing gear cover.
19. Revolve engine to vertical position. Remove pistons and connecting rods. Identify for re-assembly. Perform bearing-to-journal wear checks with PLASTIGAGE™.
20. Remove main bearing caps and remove crankshaft. Perform bearing-to-journal wear checks with PLASTIGAGE™.
21. Remove camshaft and cam followers. Identify for re-assembly.
22. Revolve engine to horizontal position, remove liners, O-rings, and packings. Mark liners for reassembly in same bore from which removed.
23. Remove piston cooling orifices from cylinder block.
24. Remove any sensors/gauges, cylinder block plugs and engine serial number plate, if block is to be put in a "hot tank".
25. Refer to appropriate group for inspection and repair of engine components.

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

RG,CTM86,G4,1 -19-14SEP94

SEALANT APPLICATION GUIDELINES

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

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

• AR31790 SCOTCH-GRIP EC1099 Plastic Adhesive:

AR31790 118 ml (4 oz)

—Rocker arm cover gasket

• 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: fuel filter base, intake manifold, cylinder block (oil galley).

—Capscrews: injection pump access cover, electronic tachometer cover, oil filler inlet, 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

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

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.

• 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.

—Injection pump governor cover fitting (fuel return)

—Threaded nipples and elbows in water pump housing

—Temperature sending unit

—Oil pan (drain hose and drain valve)

—Connectors: turbo line and turbo drain.

—Adapter fitting for turbo oil inlet line

• LOCTITE 609 Retaining Compound (green):

T43515 50 ml. (1.7 oz) bottle

—Wear ring-to-crankshaft

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

TY6299 227 g (8 oz) container

—Rear camshaft bore steel cap plug

• PT569 NEVER-SEEZ® COMPOUND:

PT569 227 g (8 oz) Brush

PT506 453 g (16 oz) Spray

—Cap Screws: turbocharger mounting and turbine housing-to-center housing.

• FEL-PRO® C-670 Molybdenum Disulfide Paste

—Camshaft nose (gear installation)

6081 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., (when applicable) 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 cylinder liners without O-rings and measure liner stand-out. Install liner O-rings in block and packings on liners. Install liners.

NOTE: If new piston and liner kit assemblies are being installed, install the crankshaft first.

4. Install main bearings and crankshaft. Rotate crankshaft to assure correct assembly. Check crankshaft end play.

NOTE: ALWAYS bolt liners down before rotating engine with cylinder head removed.

If installing new piston/liner kits, assemble kits onto the respective connecting rods using NEW snap rings. Bolt liners down as each kit is installed.

5. Install piston and rod assemblies. Bolt liners down after each piston assembly is installed.

6. Install engine oil pump assembly.

7. Install crankshaft rear oil seal housing and check runout. Install rear oil seal and wear sleeve.

8. Install cam followers in hole from which originally removed.

9. Install camshaft. Align timing marks (camshaft-to-crankshaft gears) with No. 1 piston at "TDC" compression stroke.

10. Install fuel injection pump and drive gear.

11. Install engine oil cooler assembly.

12. Install oil filter base, valve housing, and new oil filter.

13. Install engine flywheel and housing, if applicable:

—SAE 3: Flywheel goes on before housing.

— SAE 1 and SAE 2: Housing goes on before flywheel.

14. Install cylinder head, push rods, and rocker arm assembly. Measure valve lift and adjust valve clearance.

15. Install rocker arm cover. Install breather hose.

16. Install front and rear exhaust manifolds.

17. Install air intake manifold.

18. Install timing gear cover. Install front crankshaft wear sleeve and oil seal.

19. Install water pump assembly and water manifold.

20. Install turbocharger. Install turbocharger oil inlet line and oil return line.

21. Install fuel injection nozzles and delivery line assembly.

22. Install fuel filter base, supply lines, and filter.

23. Install front pulley and damper as an assembly.

24. Install fan pulley assembly. Install starting motor.

25. Fill engine with clean oil and the proper coolant. Install dipstick.

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

04
4

Group 05
Cylinder Head and Valves

SPECIAL OR ESSENTIAL TOOLS

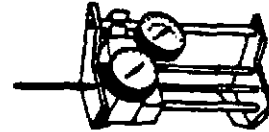
NOTE: Order tools according to information given in the U.S. SERVICE-GARD™ Catalog or in the European Microfiche Tool Catalog (MTC).

DX,TOOLS -19-05JUN91

Spring Compression Tester D01168AA

RG5061 -UN-23AUG88

Test valve spring compression.

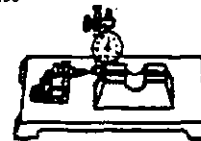


S53,D01168,AA -19-13MAR92

Valve Inspection Center D05058ST

RG5062 -UN-23AUG88

Check valves for out-of round.

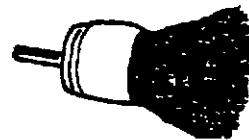


S53,D05058,ST -19-02APR87

End Brush D17024BR

RG5063 -UN-23AUG88

Clean valve seat and bores.



S53,D17024,BR -19-26JAN87

Nozzle Thread Cleaning Brush D17030BR

RG5099 -UN-23AUG88

Used to clean nozzle threads in cylinder head.



S53,D17030,BR -19-16FEB87

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

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



RG,D17526CI -19-29OCT92

Valve Guide Knurler Kit JT05949

RG5064 -UN-23AUG88

Knurl valve guides.



S53,D20002,WI -19-16SEP92

Cylinder Head and Valves

Valve Seat Pilot Driver JDE7

RG5065 -UN-23AUG88

Install replacement valve seat inserts. Use with JDG605.

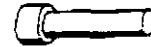


S53,JDE7A -19-04FEB93

Timing Pin JDE81-4

RG5068 -UN-23AUG88

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



RG,JDE814,86 -19-26OCT94

Valve Seat Puller JDE41296

RG5071 -UN-23AUG88

Remove valve seats.



S53,JDE,41296 -19-26JAN87

Tap JDF5

RG5100 -UN-23AUG88

Used to restore nozzle threads in cylinder head.



S53,JDF5 -19-08MAR94

Tap JDG681

RG5100 -UN-23AUG88

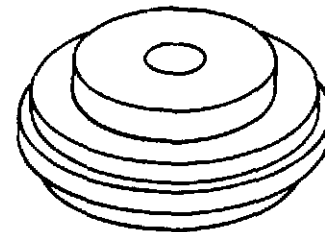
Used to restore threaded holes in cylinder block, for cylinder head cap screws.



RG,JDG681 -19-25MAR91

Valve Seat Installer JDG605

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

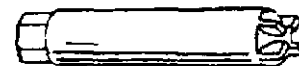


S53,JDG605 -19-25MAR91

Nozzle Seat Reamer JDG609

RG5289 -UN-23AUG88

Used to clean carbon from nozzle seats in cylinder head.



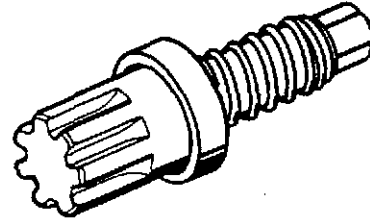
S53,JDG609 -19-02DEC87

05
2

Cylinder Head and Valves

Flywheel Turning Tool JDG820

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



RG7056 -UN-10AUG94

RG,JDG820 -19-04AUG94

05
3

CYLINDER HEAD AND VALVES SPECIFICATIONS

ITEM	SPECIFICATION	WEAR LIMIT
Valve Lift at 0.00 mm (in.) Clearance :		
Intake	13.53—13.71 mm (0.533—0.540 in.)	12.65 mm (0.498 in.)
Exhaust	14.52—14.70 mm (0.572—0.579 in.)	13.64 mm (0.537 in.)
Valve Clearance With Engine Cold (Rocker Arm-to-Valve Tip):		
Intake	0.331—0.431 mm (0.013—0.017 in.)	—
Exhaust	0.661—0.761 mm (0.026—0.030 in.)	—
Valve Spring Compressed Height:		
Valve Closed-Intake	52.5 mm @ 345—399 N (2.07 in. @ 78—90 lb-force)	—
Exhaust	54.5 mm @ 284—338 N (2.15 in. @ 64—76 lb-force)	—
Valve Open-Intake	38.1 mm @ 810—880 N (1.50 in. @ 182—198 lb-force)	—
Exhaust	38.5 mm @ 797—867 N (1.52 in. @ 179—195 lb-force)	—
Valve Head OD:		
Intake	50.87—51.13 mm (2.003—2.013 in.)	—
Exhaust	46.87—47.13 mm (1.845—1.856 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	0.08, 0.38, 0.76 mm (0.003, 0.015, 0.030 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 Face Angle	29.25° ±0.25°	—
Valve Seat Angle	30° ±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 Seat Concentricity with Guide		
	0.051 mm (0.0020 in.)	—
Valve Recess in Cylinder Head:		
Intake	3.35—3.86 mm (0.132—0.152 in.)	4.62 mm (0.182 in.)
Exhaust	1.19—1.70 mm (0.047—0.067 in.)	2.46 mm (0.097 in.)
Maximum Valve Seat Runout	0.051 mm (0.0020 in.)	—
Maximum Valve Face Runout	0.051 mm (0.0020 in.)	—

RG,CTM86,G5,1 -19-04AUG94

CYLINDER HEAD AND VALVES SPECIFICATIONS—CONTINUED

ITEM	SPECIFICATION	WEAR LIMIT
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.)	—
Minimum Acceptable Thickness	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)	60—110AA	—
Maximum Material Removal for Resurfacing Head	0.762 mm (0.0300 in.)	—

RG,CTM86,G5,2 -19-04AUG94

CYLINDER HEAD AND VALVES SPECIFICATIONS—CONTINUED

TORQUES

Cylinder Head-to-Cylinder Block:*

Flanged-Head "SPECIAL" Cap Screws (No Washers)

Step 1	80 N·m (60 lb-ft)
Step 2**	Tighten an additional 90°
Step 3**	Tighten an additional 90°
Step 4**	Tighten an additional 90°
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 *TORQUE-TO-YIELD FLANGED-HEAD CAP SCREWS—GRADE 180 MARKED "SPECIAL"*, later in this group, for proper cap screw tightening sequence.

** Total of three turns *MUST TOTAL* 270° ± 5°.

RG,CTM86,G5,3 -19-14SEP94

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-to-stem runout
JT05893 Heavy-Duty Seat Grinder Set	Grind valve seats

S65,2505,AH -19-08FEB94

OTHER MATERIAL

Name	Use
AR44402 Valve Stem Lubricant	Lubricate valve stems.
PT569 NEVER-SEEZ Compound	Turbocharger-to-exhaust manifold cap screws.
AR31790 SCOTCH-GRIP Plastic Adhesive	Rocker arm cover gasket.

RG,CTM86,G5,4 -19-11OCT94

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.

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

1. Remove rocker arm cover with ventilator tube.

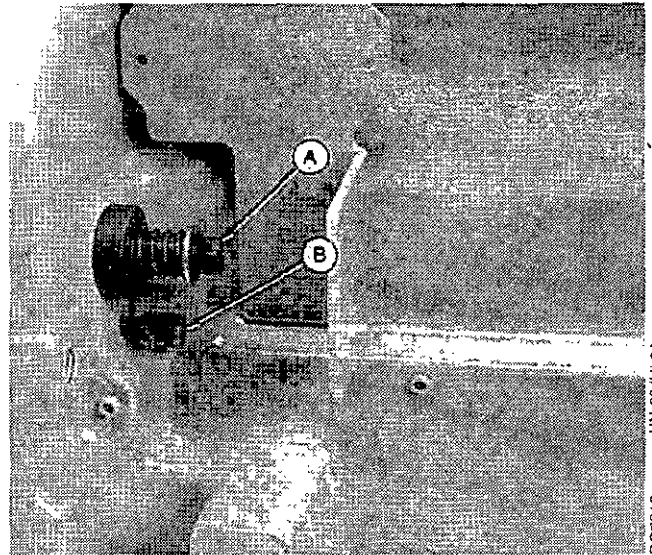
IMPORTANT: Visually inspect contact surfaces of wear caps and rocker arm wear pads. Check all parts for excessive wear, breakage, or cracks. Replace parts that show visible damage.

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

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

If the rocker arms for No. 1 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."



-JUN-28-JUL-94
RG7013

05
7

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

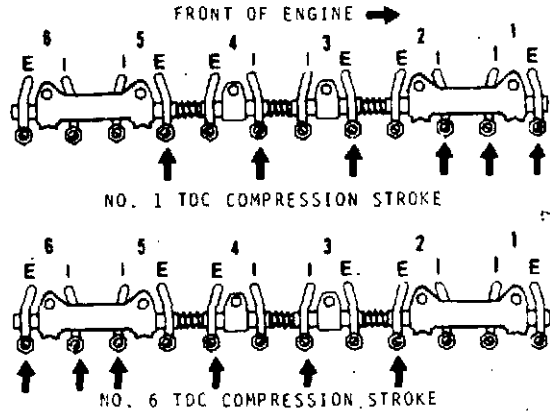
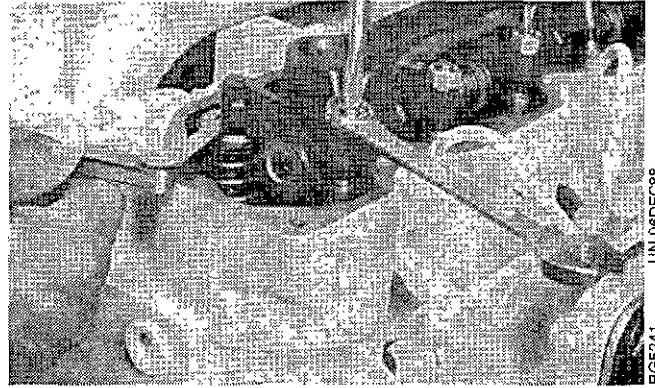
Intake Valves	0.331—0.431 mm (0.013—0.017 in.)
Exhaust Valves	0.661—0.761 mm (0.026—0.030 in.)

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,CTM86.G5.6 -19-11OCT94

CHECK VALVE LIFT

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

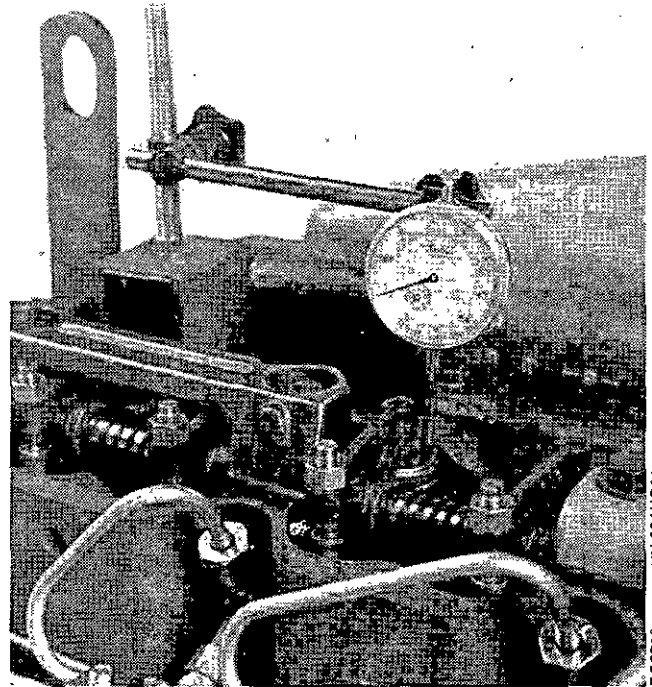
IMPORTANT: For a more accurate measurement, it is recommended that valve lift be measured at 0.00 mm (in.) valve clearance and with engine COLD.

1. Remove turbocharger oil inlet line clamp and rocker arm cover. Loosen locknut on rocker arm. Set valve clearance at 0.00 mm (in.) on valve being checked. 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. Record reading and valve number.

VALVE LIFT SPECIFICATION AT 0.00 MM (IN.) CLEARANCE

Intake	13.53—13.71 mm (0.533—0.540 in.)
Wear Tolerance	12.65 mm (0.498 in.)
Exhaust	14.52—14.70 mm (0.572—0.579 in.)
Wear Tolerance	13.64 mm (0.537 in.)

6. Reset valve clearance to specification after measuring lift. (See CHECK AND ADJUST VALVE CLEARANCE, earlier in this group.)
7. Repeat procedure on all remaining valves.



RG5789 -JUN-09AUG91

05
9

RG,CTM86,G5,7 -19-20JUL94

REMOVE CYLINDER HEAD

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

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

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

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

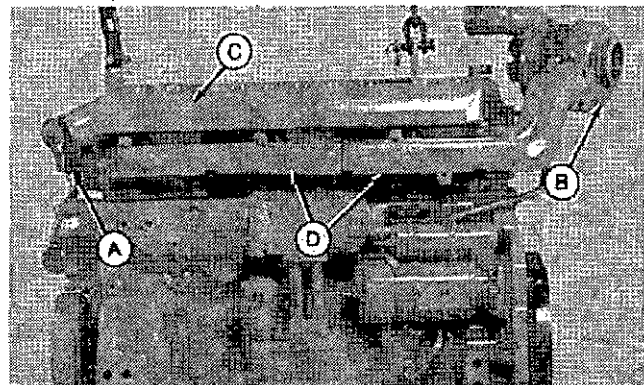
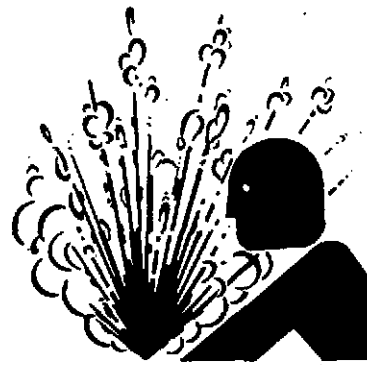
2. Remove water manifold and all coolant piping. (See Group 25, Cooling System.)

3. Remove turbocharger. Remove front and rear exhaust manifold (D). (See Group 30, Air Intake and Exhaust System.)

4. Remove air intake manifold. (Group 30.)

5. Remove fuel injection delivery lines and injection nozzles. (See Group 35, Fuel System.)

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



A—Water Manifold
 B—Turbocharger
 C—Intake Manifold
 D—Exhaust Manifold Assembly

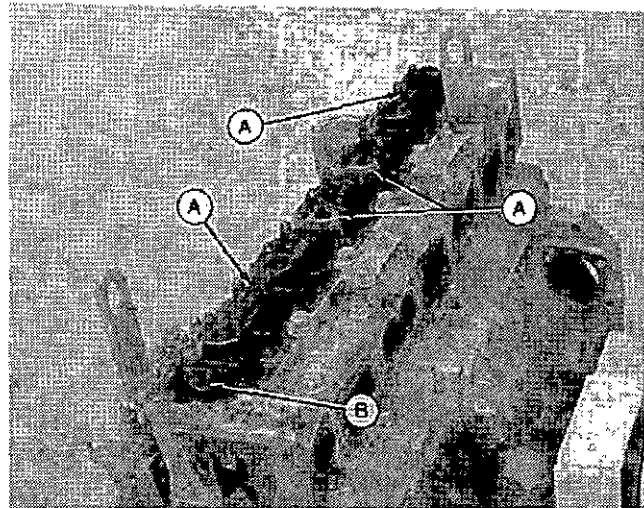
RG,CTM86,G5,8 -19-14SEP94

TS281 -JUN-25AUG88

RG7014 -JUN-28JUL94

05
10

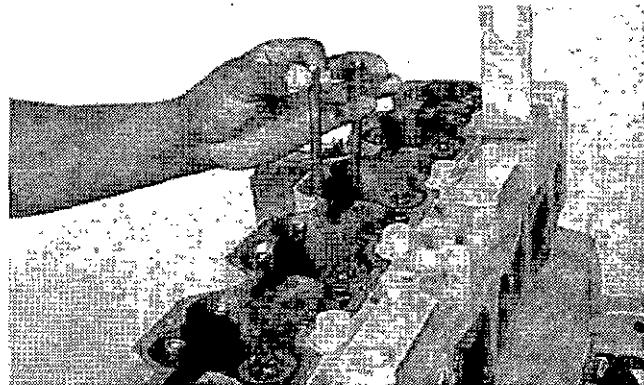
7. Remove six cap screws and remove all four rocker arm shaft clamps (A). Lift rocker arm assembly (B) up and remove. Remove wear caps from valve stems.



RG7017
-JUN-28-JUL-94

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

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



RG7018
-JUN-28-JUL-94

05
11

RG,CTM86,G5,10 -19-14SEP94

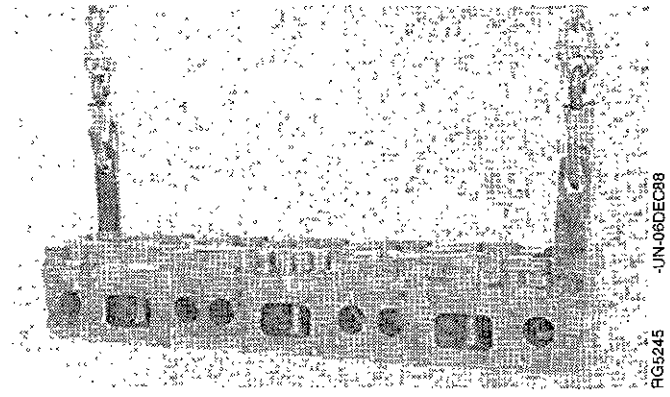
9. Remove all 26 cylinder head cap screws. Discard cap screws, they are not reusable.

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

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

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

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



RG5245
-UN-06DEC88

05
12

RG,CTM86,G5,11 -19-14SEP94

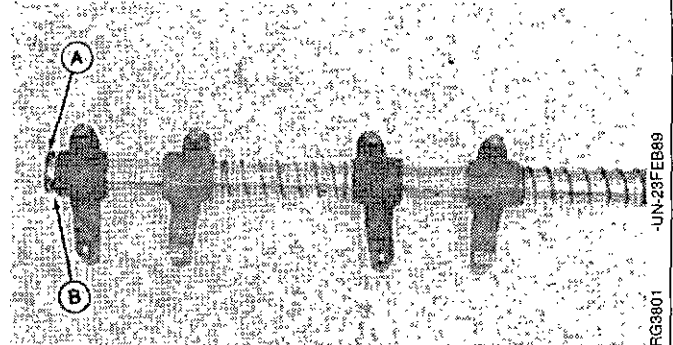
DISASSEMBLE AND INSPECT ROCKER ARM SHAFT ASSEMBLY

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

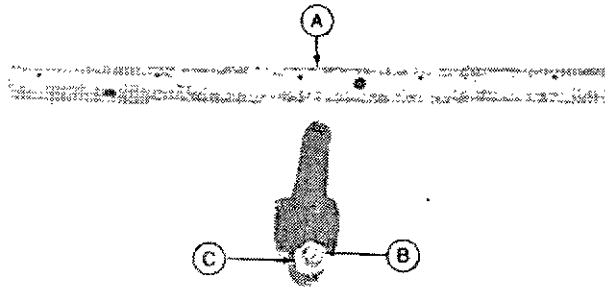
Rocker Arm I.D. 19.07—19.10 mm (0.7507—0.7520 in.)

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.



FG3802 -JUN-23FEB89

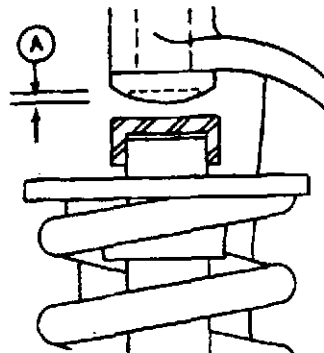
S11,2005,MB -19-28OCT92

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.



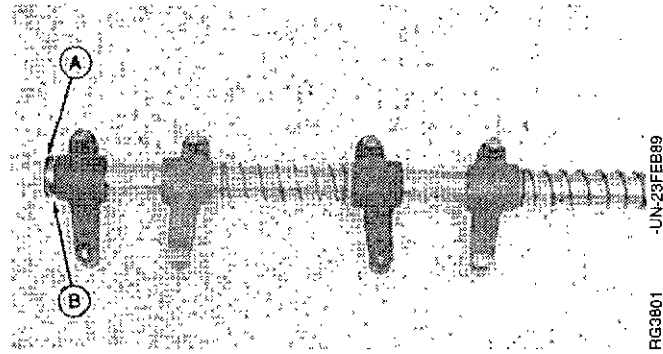
R26131 -JUN-09DEC88

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.



S11.0401.O -19-08MAR94

UN-23FEB89
RG3801

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 and compare measurements to specifications given below.

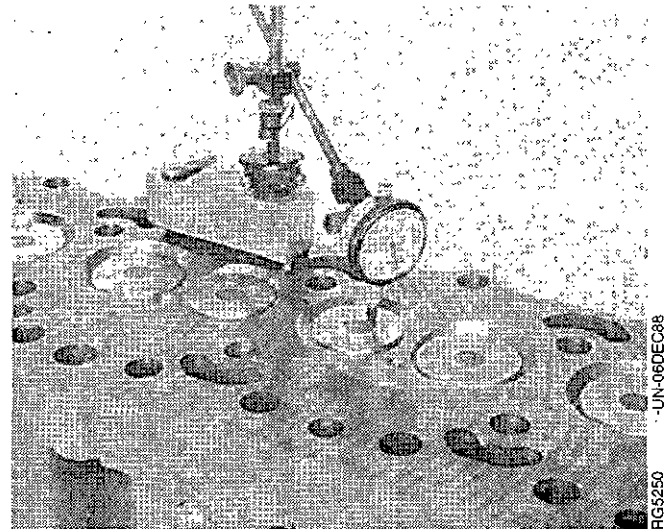
NOTE: Thoroughly clean all gasket material from cylinder head combustion face before measuring.

VALVE RECESS SPECIFICATIONS

Valve Recess Below Cylinder Head:

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

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



UN-06DEC88
RG5250

RG,CTM42,G5,10 -19-28OCT92

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

• Worn or Broken Valve Seats:

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

• Burned, Pitted, Worn, or Broken Valves:

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

• Improper Valve Clearance:

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

• Excessive Recession:

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

05
15

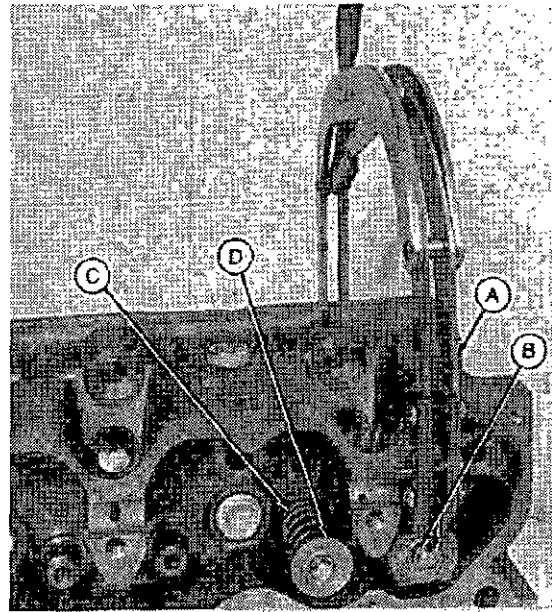
REMOVE VALVE ASSEMBLY

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

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

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

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



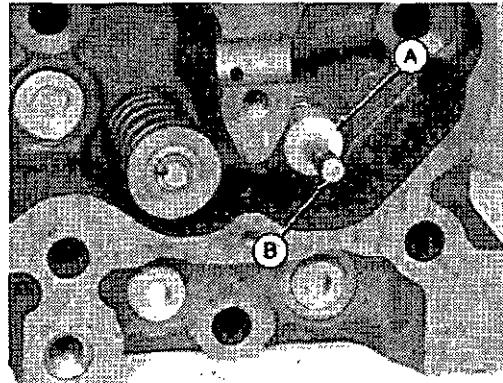
RG7228 -UN-07SEP94

RG,CTM86,G5,15 -19-06SEP94

5. Remove oil shield (A) from exhaust valves. Remove valve (B) from cylinder head. Identify valve for reassembly, if valve is to be reused.

NOTE: Intake valves do not have valve stem seals.

6. Repeat procedure on remaining valves.



RG7229 -UN-07SEP94

RG,CTM86,G5,16 -19-06SEP94

05
16

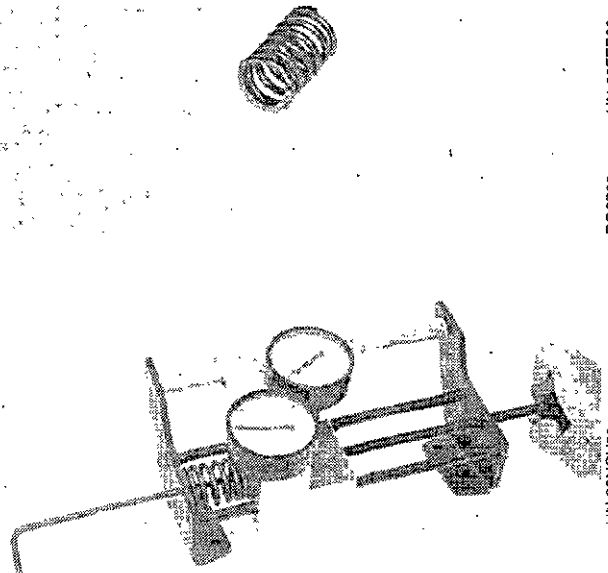
INSPECT AND MEASURE VALVE SPRINGS

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

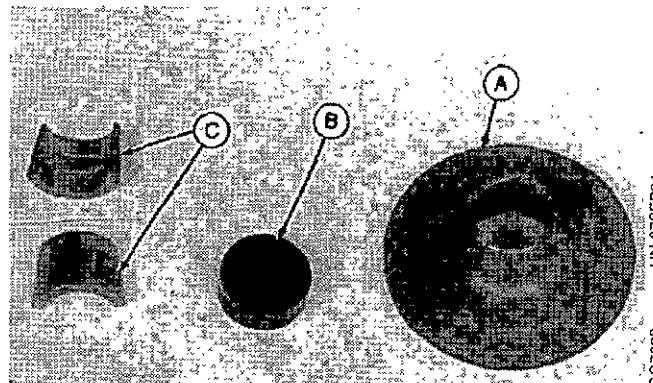
Spring Load	Height
Intake:	
Open: 810—880 N (182—198 lb-force)	38.1 mm (1.50 in.)
Closed: 345—399 N (78—90 lb-force)	52.5 mm (2.07 in.)
Exhaust:	
Open: 797—867 N (179—195 lb-force)	38.5 mm (1.52 in.)
Closed: 284—338 N (64—76 lb-force)	54.5 mm (2.15 in.)



RG,CTM42,G5,11 -19-06SEP94

INSPECT VALVE SPRING CAPS, WEAR CAPS, AND RETAINER LOCKS

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



RG,CTM86,G5,17 -19-12SEP94

CLEAN VALVES

1. Hold each valve firmly against a soft wire wheel on a bench grinder.
2. Make sure all carbon is removed from valve head, face, and stem. Polish valve stem with steel wool or crocus cloth to remove scratch marks left by wire brush.

IMPORTANT: Any carbon left on valve stem will affect alignment in refacer if valves need to be refaced.

RG,CTM86,G5,31 -19-20JUL94

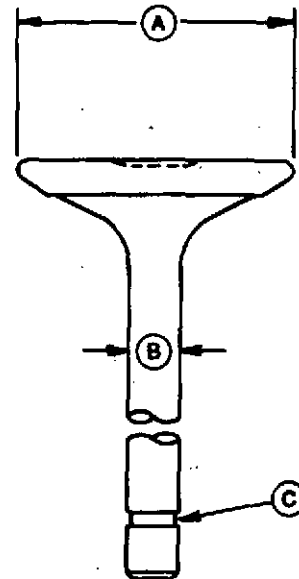
05
18

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.)



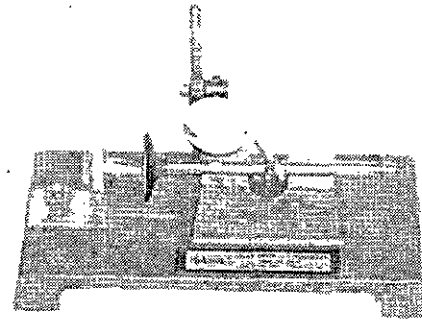
RG,CTM42,G5,12 -19-03MAY93

RG6795 -JUN-12AUG91

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

VALVE FACE RUNOUT SPECIFICATION

Maximum permissible runout of
valve face 0.05 mm (0.002 in.)



RG,CTM86,G5,32 -19-09SEP94

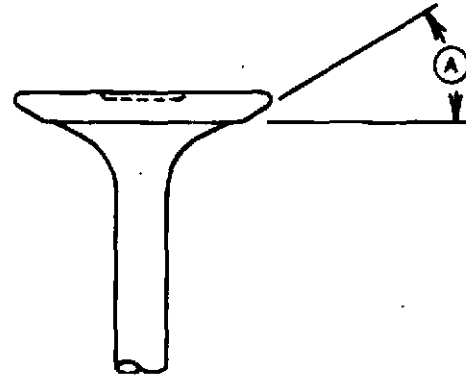
RG4234 -JUN-29FEB89

GRIND (REFACE) VALVES

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

If necessary to reface valve, grind valve face to an angle of $29.25^\circ \pm 0.25^\circ$ (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. Radius all sharp edges after grinding.



S11,2005,MG -19-20JUL94

-JUN-12AUG81 05 19

RG5247

INSPECT AND CLEAN CYLINDER HEAD

1. Inspect combustion face for evidence of physical damage, oil or coolant leakage, or gasket failure prior to cleaning the cylinder head. Repair or replace cylinder head if there is evidence of physical damage; such as cracking, abrasion, distortion, or valve seat "torching". Inspect all cylinder head passages for restrictions.

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

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

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

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

RG,CTM86,G5,37 -19-03OCT94

05
20

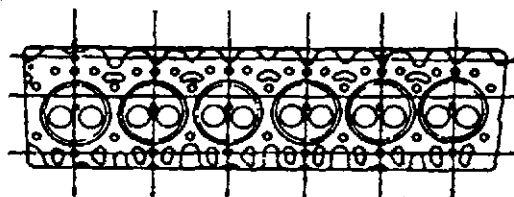
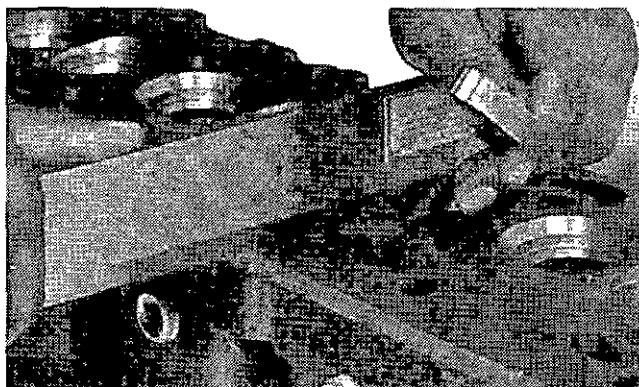
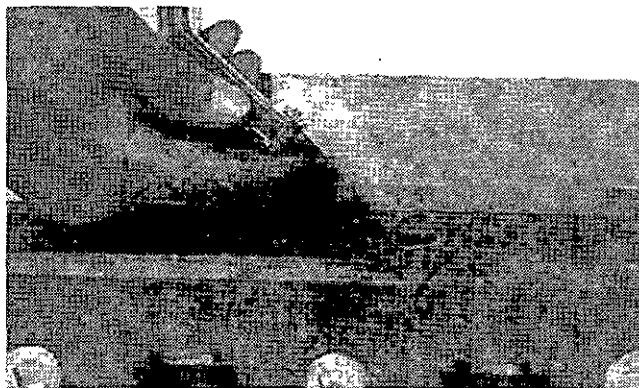
CHECK CYLINDER HEAD COMBUSTION FACE FLATNESS

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 TOP DECK FLATNESS SPECIFICATION

Maximum Out-of-Flat
(Over Entire Length or Width) 0.102 mm (0.0040 in.)
Straightness per any 305 mm
(12 in.) Length 0.025 mm (0.001 in.)



RG.CTM86,G5,35 -19-06SEP94

-UN-07SEP94
RG7231

-UN-07SEP94
RG7232

-UN-06DEC88
RG4629

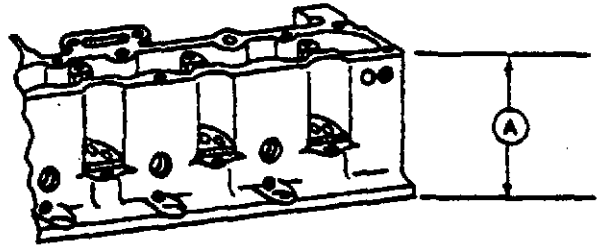
05
21

MEASURE CYLINDER HEAD THICKNESS

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

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

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



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

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

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.)

S11,2005,KZ -19-14SEP94

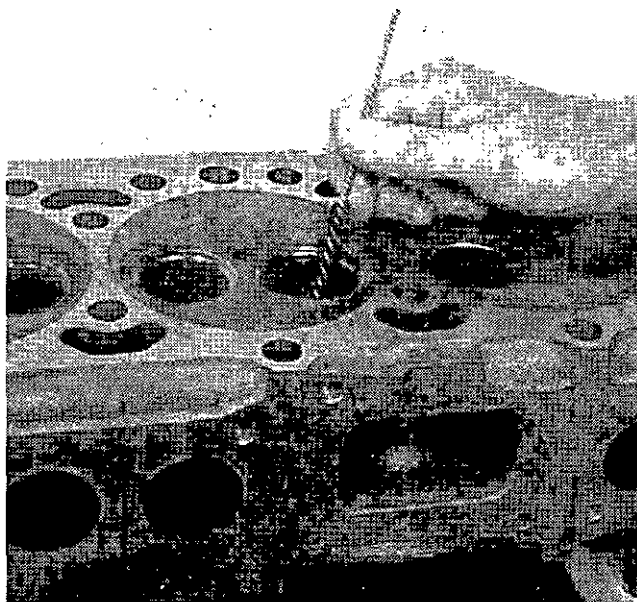
-JUN-23FEB89
RG4421

05
22

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.



S11,2005,MY -19-29OCT92

-UN-06DEC88
R23984

MEASURE VALVE GUIDES

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

VALVE GUIDE SPECIFICATIONS

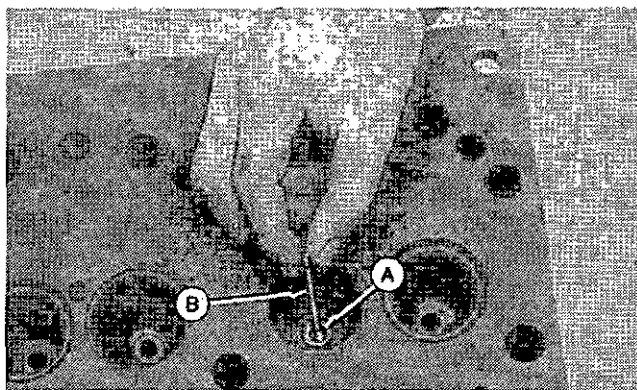
I.D. Guide in a New Head 9.51—9.54 mm
(0.3745—0.3755 in.)

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.)

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

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



S11,2005,MH -19-03MAY93

-UN-09DEC88
R23984

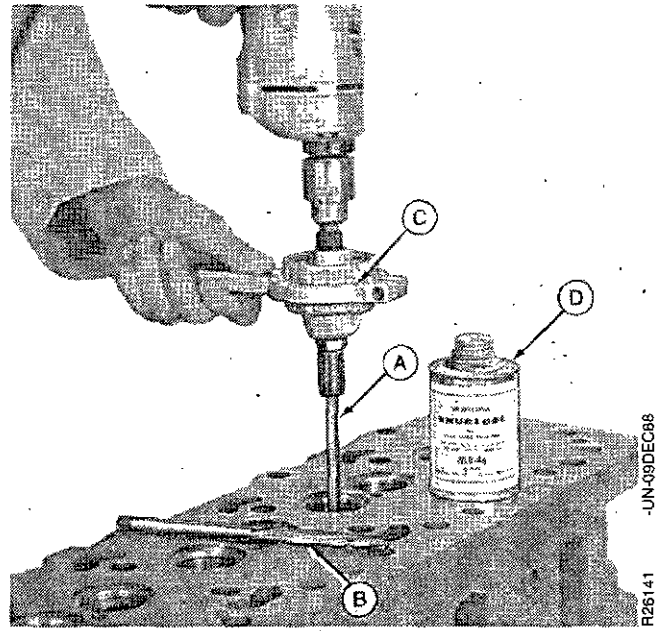
KNURL VALVE GUIDES

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.

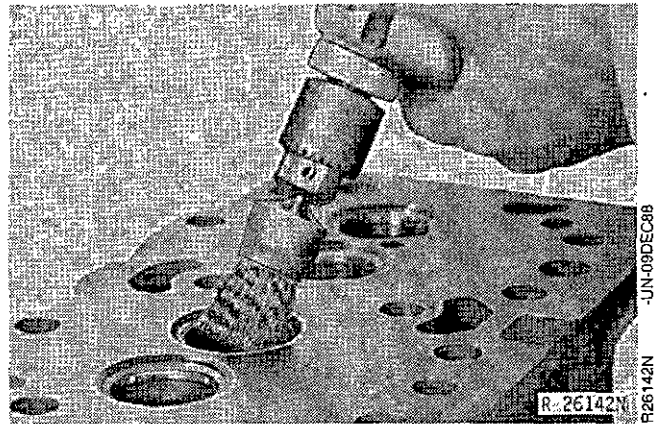
- A—Knurler
- B—Reamer
- C—Speed Reducer
- D—Lubricant



S11,0401,Z -19-08MAR94

CLEAN AND INSPECT VALVE SEATS

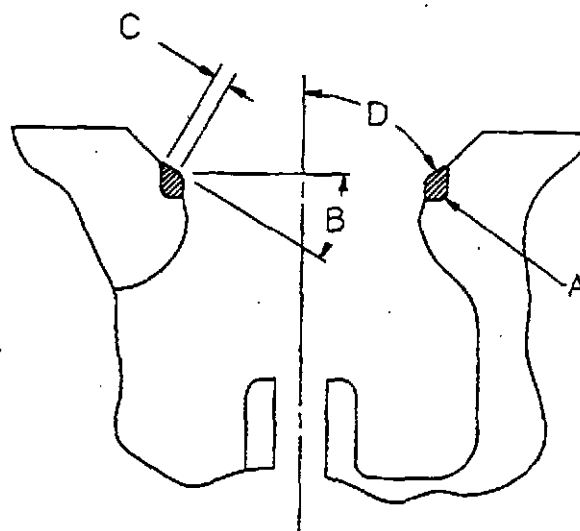
1. Use an electric hand drill with D17024BR Wire Cleaning Brush or equivalent brush to remove all carbon on valve seats.
2. Check seats for cracks, pits, or excessive wear.
3. Check entire combustion face for rust, scoring, pitting or cracks.



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 (D).
3. If valve seat is not within specification, recondition valve seat by grinding or replace valve seat inserts (A) if reconditioning is not possible. (See GRIND VALVE SEATS or INSTALL VALVE SEAT INSERTS, later in this group.)



VALVE SEAT SPECIFICATIONS

Valve Seat Angle (B) 30° ±0.50°

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 0.051 mm (0.0020 in.)

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

S11,2005,MI -19-16SEP94

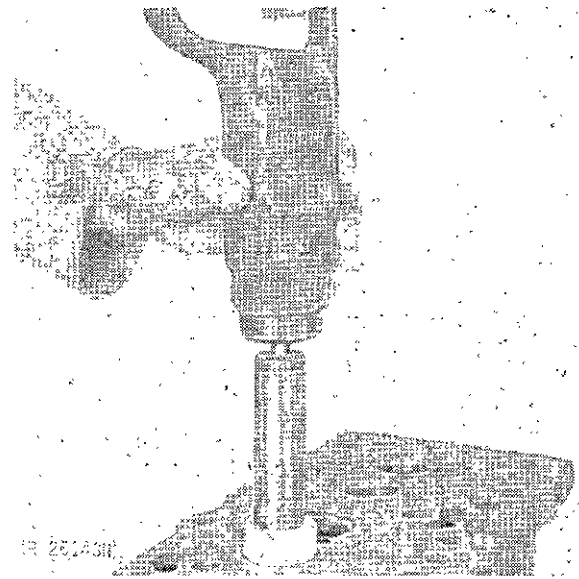
RIG5248 -UN-06DEC88

05
25

GRIND VALVE SEATS

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

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.)



-JUN-09DEC88
R26143N

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

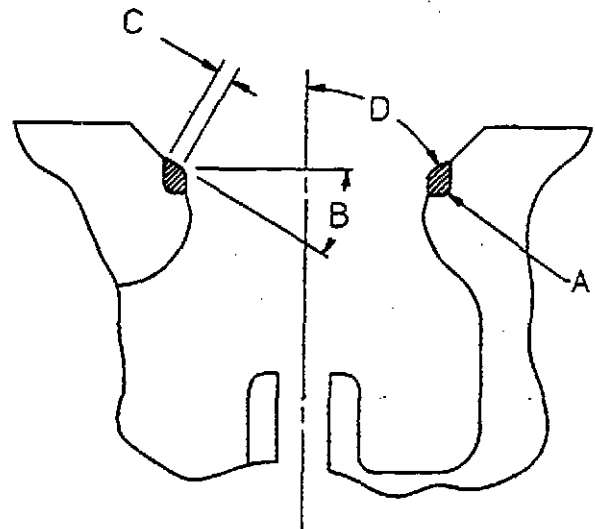
1. Check the seat width (C) and contact pattern between the seat and valve with bluing. Seat width **MUST BE** maintained within specification. Use a vernier caliper or scale to measure seat width. Thoroughly clean seat area after grinding and replace valves and valve seat inserts as necessary.

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

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

VALVE SEAT SPECIFICATIONS

Valve Seat Angle	30° ±0.50°
Exhaust Seat Width	2.0—3.8 mm (0.079—0.150 in.)
Intake Seat Width	1.4—3.8 mm (0.055—0.150 in.)
Maximum Seat Runout (D)	0.051 mm (0.0020 in.)



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

-JUN-06DEC88
R25248

RG,CTM86,G5,33 -19-16SEP94

REMOVE VALVE SEAT INSERTS AND MEASURE BORES IN CYLINDER HEAD

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

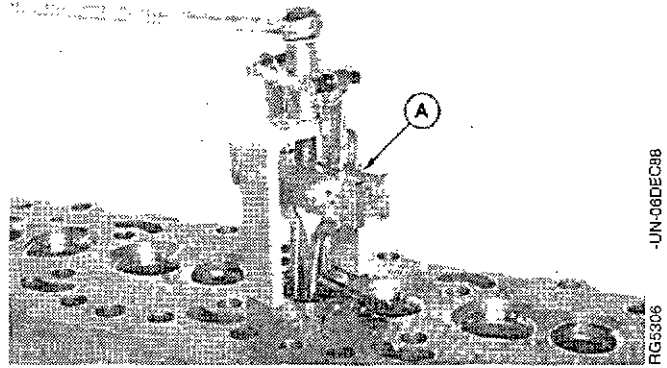
IMPORTANT: Be careful not to damage cylinder head when removing seats.

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

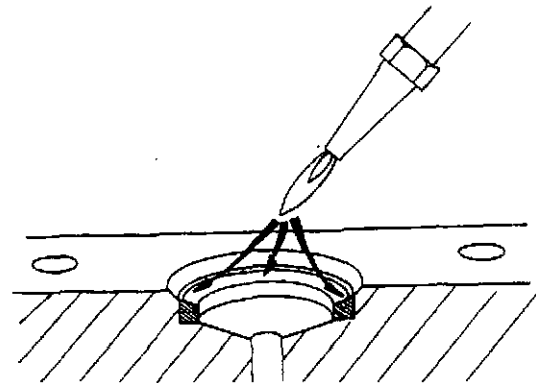
Valve seat inserts may be removed using one of the following methods:

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

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



RG5306 -JUN-06DEC88



RG605 -JUN-17JAN80

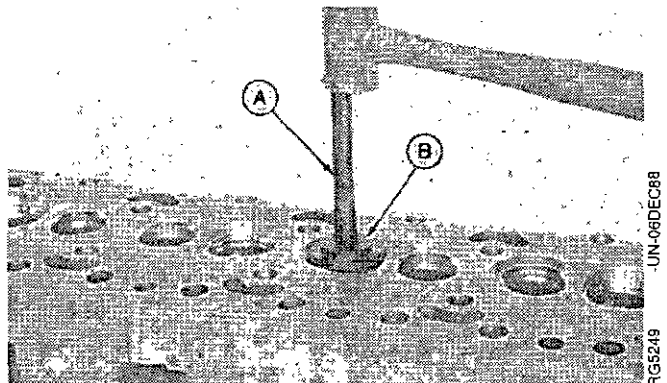
RG,CTM86,G5,34 -19-14SEP94

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. Grind valve seats as required to maintain correct valve recess and valve-to-seat seal. (See GRIND VALVE SEATS, earlier in this group.)



RG5249 -JUN-06DEC88

S11,2005,MM -19-28OCT92

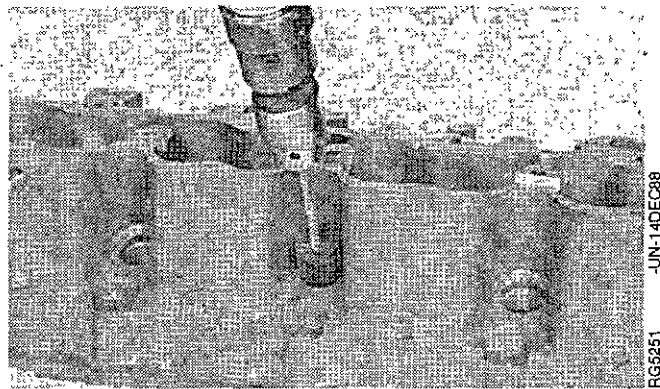
INSPECT AND CLEAN CYLINDER HEAD NOZZLE BORE

1. Inspect condition of threads for gland nut. Threads are metric (M28 x 1.5).
2. Inspect condition of nozzle seating surface in cylinder head.

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

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

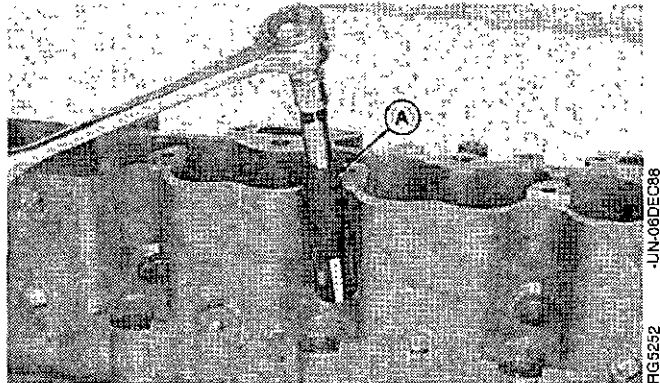
3. Clean threads which have light foreign deposits using a drill and the D17030BR Thread Cleaning Brush. Work brush up and down several times to clean threads.



RG.5251 -JUN-14DEC88

RG.CTM42,G5,14 -19-08FEB94

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

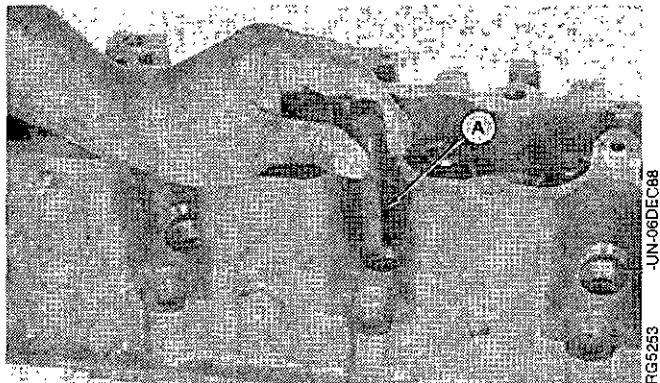


RG.5252 -JUN-06DEC88

RG.CTM42,G5,15 -19-22AUG91

5. Clean nozzle seating surface by using the JDG609 Nozzle Seat Reamer (A) to remove carbon.

6. Blow out debris with compressed air and thoroughly clean all nozzle bores.

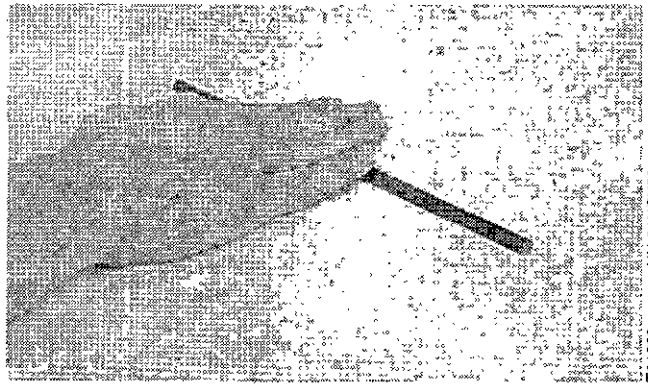


RG.5253 -JUN-06DEC88

S11,2005,NU -19-23AUG91

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.



181233 -JUN-01NOV88

S11,2005,JN -19-24APR92

INSPECT AND CLEAN VENTILATOR OUTLET HOSE

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

05
29

RG,CTM86,G5,12 -19-08FEB94

CLEAN AND INSPECT TOP DECK OF CYLINDER BLOCK

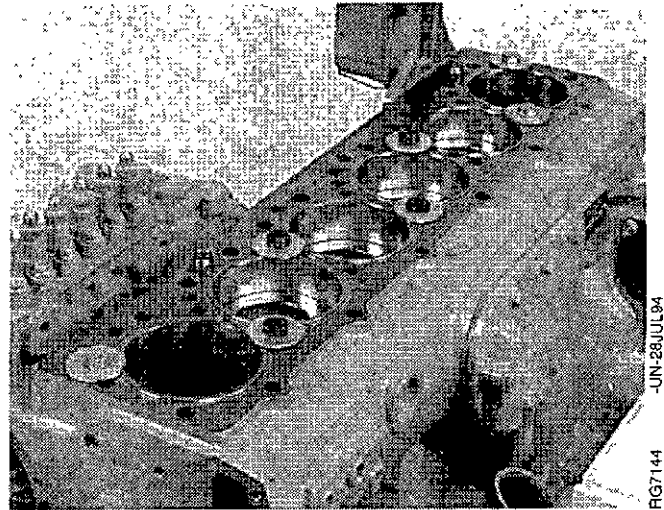
1. Remove gasket material, rust, carbon, and other foreign material from top deck. Gasket surface must be clean.
2. Use compressed air to remove all loose foreign material from cylinders and top deck.
3. Clean all cylinder head mounting cap screw holes using JDG681 or an equivalent 9/16-12 UNC-2A tap 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.
4. Measure top deck flatness. See MEASURE CYLINDER BLOCK in Group 10.

RG,CTM86,G5,13 -19-20JUL94

**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.

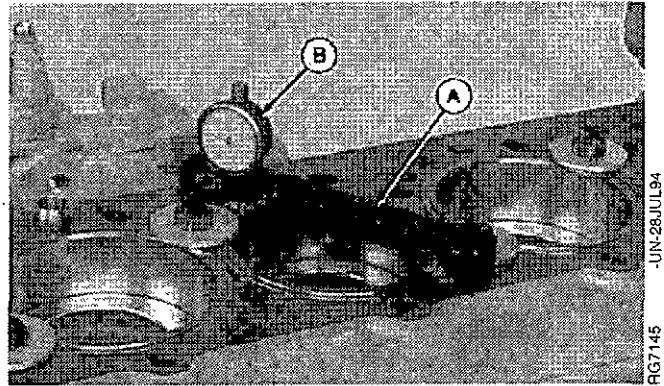
NOTE: Liners having obvious defects must be replaced.



RG7144 -JUN-28JUL94

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

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



RG7145 -JUN-28JUL94

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. (See **INSTALL LINER SHIMS—IF REQUIRED**, in Group 10.)

LINER HEIGHT SPECIFICATIONS

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

RG,CTM86,G5,14 -19-20JUL94

ASSEMBLE VALVE ASSEMBLY

Remember valve stem seals (A) are installed onto exhaust valve stems (B) only.

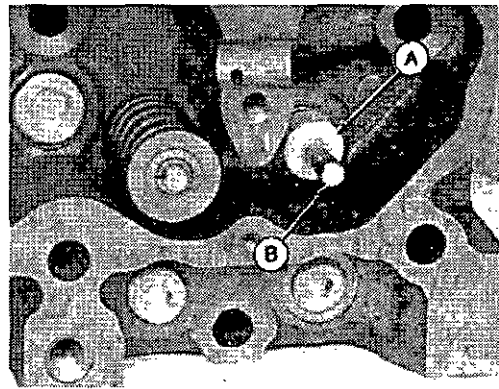
1. Apply AR44402 Valve Stem Lubricant or clean engine oil to valve stems and guides.

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

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

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

3. Install oil shield onto exhaust valve stem until shield bottoms on valve guide tower.



UN-07SEP94
RG7228

RG,CTM86,G5,18 -19-14SEP94

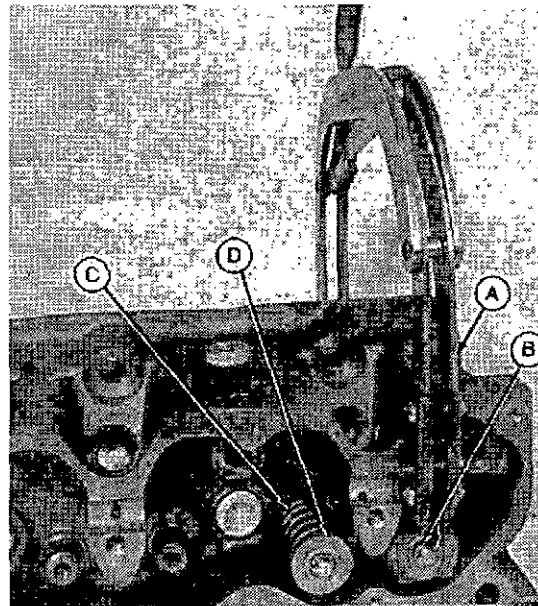
NOTE: There is no top or bottom to valve springs (C); they may be installed either way.

4. Install valve spring and spring cap (D). Spring must seat in machined counterbore of head.

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

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

- A—JDE138 Valve Spring Compressor
- B—Valve Retainer Locks
- C—Valve Spring
- D—Valve Spring Cap



UN-07SEP94
RG7228

RG,CTM86,G5,19-19-14SEP94

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

Repeat procedure for all remaining valves.

7. Measure valve recess in head as directed earlier in this group.

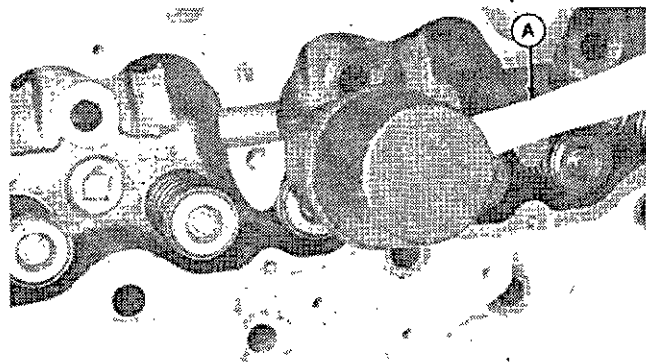


FIG3807 -UN-23FEB89

RG,CTM86,G5,21 -19-06SEP94

INSTALL CYLINDER HEAD AND CAP SCREWS

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

Be sure cylinder head and block gasket surfaces are clean, dry, and free of any oil.

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

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

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

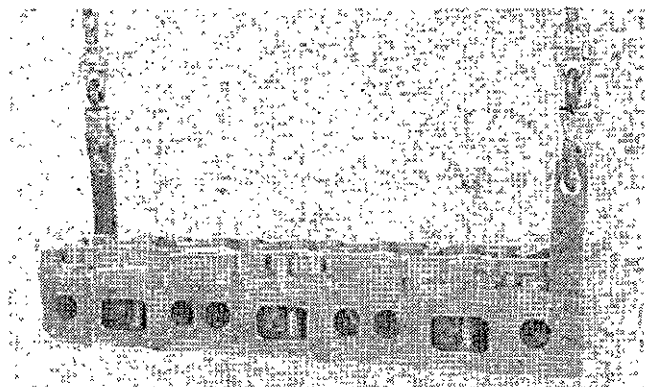


FIG5245 -UN-06DEC88

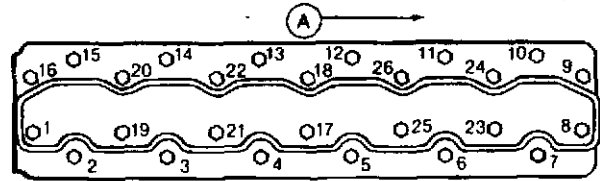
RG,CTM86,G5,22 -19-12SEP94

RG7137 -UN-21FEB94

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



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



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

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

Arrow (A) points toward front of engine.

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

RG,CTM86,G5,23 -19-12SEP94

RG4471 -UN-28FEB94

05
33

TORQUE-TO-YIELD FLANGED-HEAD CAP SCREWS—GRADE 180 MARKED "SPECIAL"

Arrow (A) points toward front of engine.

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

1. Lubricate cap screws with clean SAE30 engine oil and install in their proper locations as outlined previously.

2. Tighten cap screw No. 17 to 80 N·m (60 lb-ft). Sequentially (start at cap screw No. 1 and proceed through cap screw No. 26) tighten all cap screws to 80 N·m (60 lb-ft).

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

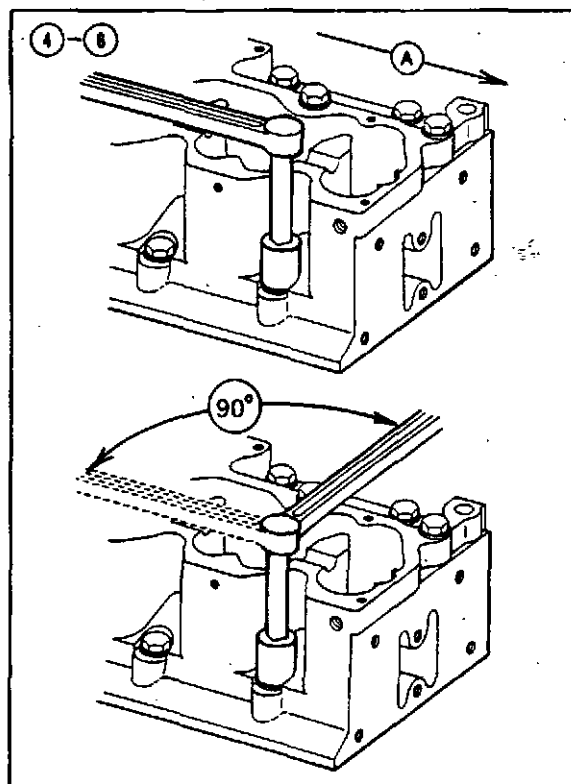
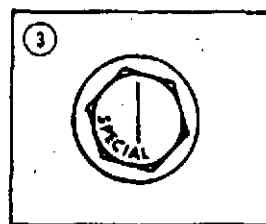
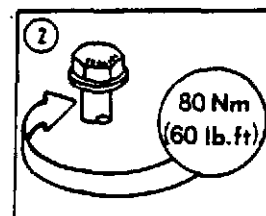
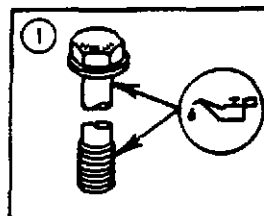
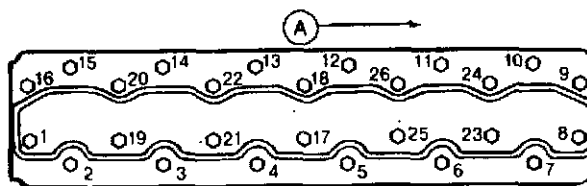
IMPORTANT: If a cap screw is accidentally tightened more than 90° in any one sequence, DO NOT loosen cap screw but make adjustments in the next tightening sequence.

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

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

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

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



JUN-28FEB84

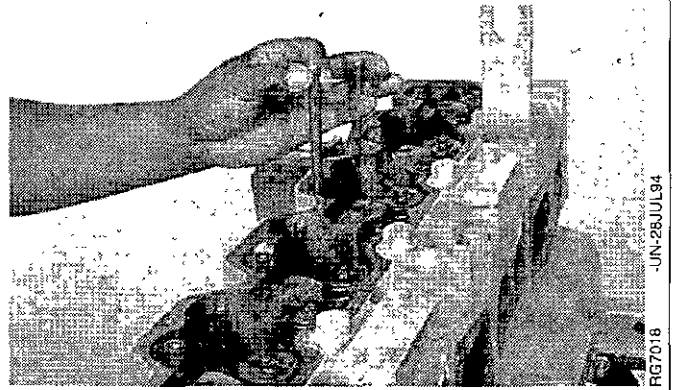
FG471

05
34JUN-01MAY94
FG7139

FG.CTM1.G5.4 -18-09AUG94

INSTALL ROCKER ARM ASSEMBLY

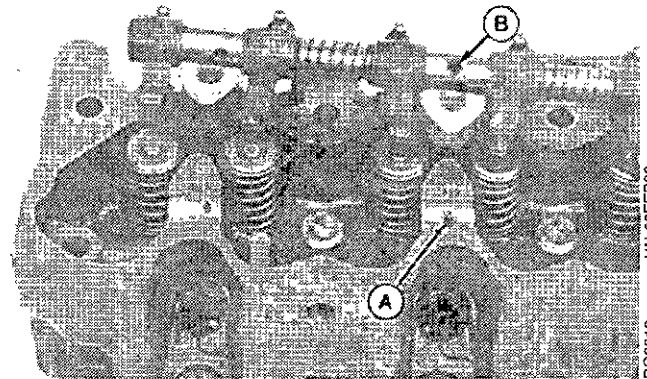
1. Install push rods in holes from which removed.
2. Install wear caps on valve stem tips, make certain caps rotate freely on valve stems.



RG,CTM86,G5,26 -19-20JUL94

RG7018
-JUN-28JUL94

3. Make sure spring pin (A) engages with hole (B) in shaft.
4. Install shaft clamps and all six cap screws. Tighten cap screws to 75 N·m (55 lb-ft).
5. Adjust engine valve clearance. (See CHECK AND ADJUST VALVE CLEARANCE, earlier in this group.)



RG,CTM86,G5,27 -19-20JUL94

RG3810
-JUN-23FEB89

05
35

COMPLETE FINAL ASSEMBLY OF INJECTION PUMP SIDE OF ENGINE

1. Adjust valve clearance, if not previously done.

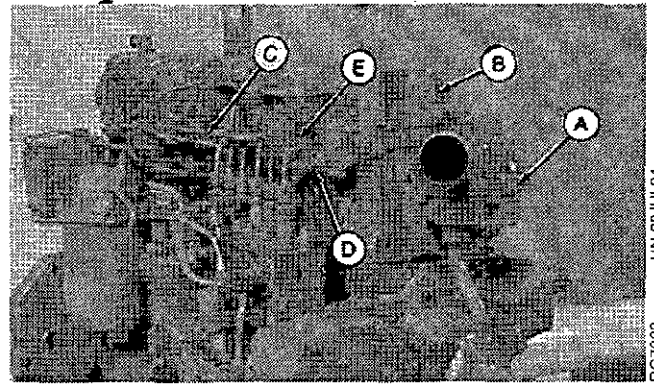
NOTE: Apply AR31790 SCOTCH -GRIP Adhesive or equivalent to seal gasket to rocker arm cover (B). Follow manufacturer's directions on the package for correct application procedure and curing time.

2. Position rocker arm cover gasket on cylinder head and install rocker arm cover. Tighten cap screws to 8 N·m (6 lb-ft) (72 lb-in.).

3. Install fuel injection nozzles (E), fuel leak-off lines (D) and fuel delivery lines (C). (See INSTALL FUEL INJECTION NOZZLES in Group 35.)

4. Connect ventilator outlet hose to adapter on rocker arm cover and tighten clamp securely.

5. Install water manifold (A). (See INSTALL WATER MANIFOLD in Group 25.)



A—Water Manifold
B—Rocker Arm Cover
C—Fuel Delivery (Pressure) Lines
D—Fuel Leak-off Lines
E—Fuel Injection Nozzles

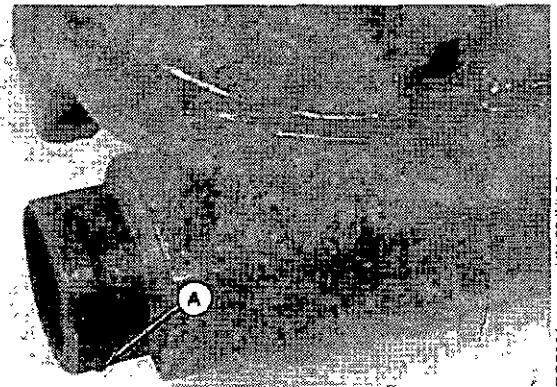
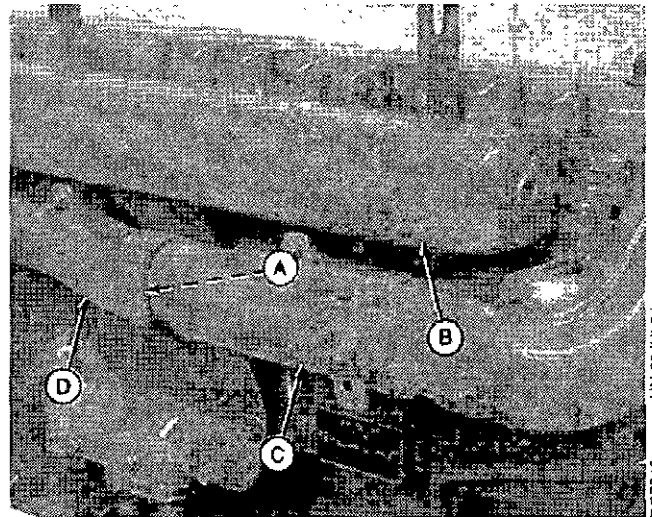
05
36

RG,CTM86,G5,28 -19-20JUL94

COMPLETE FINAL ASSEMBLY ON EXHAUST MANIFOLD SIDE OF ENGINE

NOTE: Apply PT569 NEVER-SEEZ Compound or equivalent to all turbocharger cap screws. NEVER-SEEZ is not needed on exhaust manifold cap screws. Guide studs may be used to aid assembly.

1. Install intake manifold (B) using new gaskets. Tighten cap screws to 47 N·m (35 lb-ft).
2. Install a new sealing ring (A) in groove of rear exhaust manifold (C).
3. Assemble front exhaust manifold (D) and rear exhaust manifold.
4. Install exhaust manifold assembly using new gaskets and guide studs. Tighten cap screws to 47 N·m (35 lb-ft).
5. Install turbocharger using a new metal gasket. Apply PT569 NEVER-SEEZ Compound and tighten cap screws to 24 N·m (18 lb-ft).
6. Connect turbocharger oil return pipe to turbocharger using a new gasket. Tighten cap screws to 27 N·m (20 lb-ft).
7. Connect turbocharger oil inlet line and tighten securely.
8. If engine oil was drained from crankcase, install new oil filter and fill with clean oil of correct grade and viscosity. (See DIESEL ENGINE OIL in Group 02.)
9. Fill cooling system with clean coolant. (See ENGINE COOLANT SPECIFICATIONS in Group 02.)
10. Perform engine break-in. (See PERFORM ENGINE BREAK-IN, later in this group.)



A—Sealing Ring
 B—Intake Manifold
 C—Rear Exhaust Manifold
 D—Front Exhaust Manifold

RG,CTM86,G5,29 -19-16SEP94

PERFORM ENGINE BREAK-IN

1. Run engine at slow idle no load for 2 minutes. Check for liquid leaks.
2. Increase RPM to fast idle, then load down to 50 rpm above rated speed for 20 minutes.

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

3. Recheck valve clearance and adjust as necessary. (See CHECK AND ADJUST VALVE CLEARANCE, earlier in this group.)
4. Install rocker arm cover gasket and cover. Tighten rocker arm cover cap screws to 8 N·m (6 lb-ft) (72 lb-in.). (See COMPLETE FINAL ASSEMBLY OF INJECTION PUMP SIDE OF ENGINE, earlier in this group.)

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

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

RG,CTM6,G05.5 -19-14SEP94

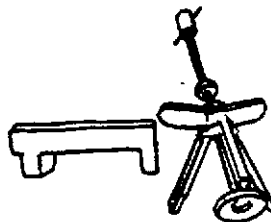
SPECIAL OR ESSENTIAL TOOLS

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 -JUN-29AUG88

Flexible Cylinder Hone D17005BR

Hone cylinder liners.

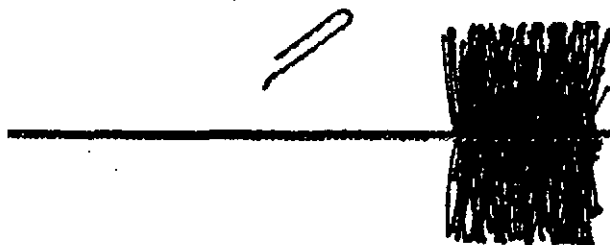


S53,D17005,BR -19-07APR88

RG5074 -JUN-23AUG88

O-Ring Groove Cleaning Brush D17015BR

Clean cylinder liner O-ring groove in block.



S53,D17015,BR -19-25MAR91

RG5075 -JUN-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

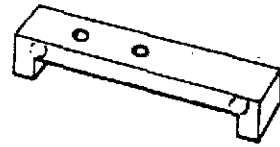
RG5246 -JUN-27MAR92

Cylinder Block, Liners, Pistons and Rods

Piston and Liner Height Gauge JDG451

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.

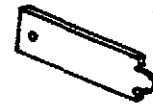


-UN-30SEP94
RG7028

RG,JDG451 -19-28SEP94

No. 1 Ring Groove Wear Gauge JDE55

Check upper compression ring groove wear.

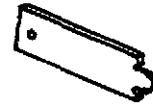


RG5076 -UN-23AUG88

RG,JDE55A -19-04AUG94

No. 2 Ring Groove Wear Gauge JDG852

Check lower compression ring groove wear.



RG5076 -UN-23AUG88

RG,JDG852 -19-04AUG94

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

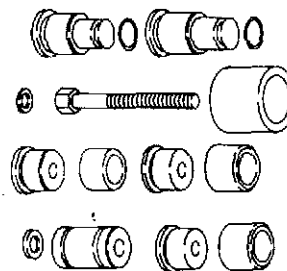
S53,JDE96 -19-25MAR87

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

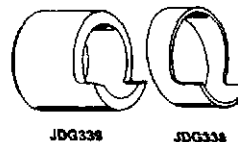


S63,JDE98A -19-16AUG94

RG5078 -UN-16FEB94

Connecting Rod Bushing Service Set JDG337

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



S63,JDG337,A -19-29JUL94

RG5079 -UN-25JUN94

10
3

Tap JDG681

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

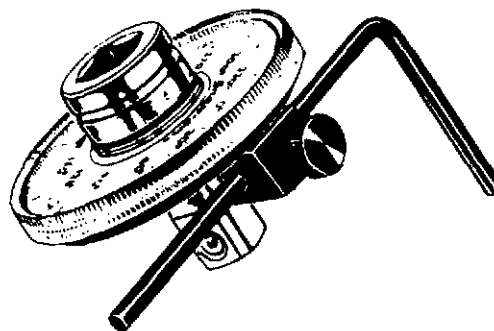


RG,JDG681 -19-25MAR91

RG5100 -UN-23AUG88

Torque Angle Gauge JT05993

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



RG,JT05993 -19-22AUG91

RG5688 -UN-27AUG90

SERVICE EQUIPMENT AND TOOLS

NOTE: Order tools from the U.S. SERVICE-GARD™ 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 -19-04AUG94

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 -19-08AUG94

CYLINDER BLOCK, LINERS, PISTONS, AND RODS SPECIFICATIONS

ITEM	SPECIFICATION	WEAR LIMIT
Cylinder Liner Height Above Block (Liner Standout)	0.051—0.127 mm (0.002—0.005 in.)	— —
Maximum Piston Protrusion Above Block	0.051—0.787 mm (0.002—0.031 in.)	— —
Oil Compression Ring-to-Piston Groove Clearance	0.064—0.102 mm (0.0025—0.0040 in.)	0.165 mm (0.0065 in.)
Piston Compression Ring End Gap No. 1	0.43—0.69 mm (0.017—0.027 in.)	— —
No. 2	1.01—1.27 mm (0.040—0.050 in.)	— —
Piston O.D. 15.16 mm (0.597 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 I.D.	115.865—115.895 mm (4.5616—4.5628 in.)	— —
O.D.	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.)	— —
Liner Flange Counterbore Depth in Block	11.913—11.963 mm (0.469—0.471 in.)	— —

FG,CTM86,G10.1 -19-14SEP94

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

ITEM	SPECIFICATION	WEAR LIMIT
Liner Flange Thickness	11.989—12.039 mm (0.472—0.474 in.)	— —
Liner Flange OD	135.10—135.16 mm (5.319—5.321 in.)	— —
Outer Diameter of Liner at Upper Bore	129.08—129.14 mm (5.082—5.084 in.)	— —
Outer Diameter of Liner at Lower Bore	125.044—125.120 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	47.620—47.630 mm (1.8748—1.8752 in.)	— —
Rod Pin Bushing ID (After Honing)	47.655—47.681 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.)	— —

RG.CTM86.G10.2 -19-04AUG94

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

ITEM	SPECIFICATION	WEAR LIMIT
Crankshaft Rod Journal OD	76.149—76.175 mm (2.9980—2.9990 in.)	— —
Rod Bearing-to-Journal Clearance	0.030—0.110 mm (0.0012—0.0044 in.)	— —
Connecting Rod Cap End Gap		0.254 mm (0.0100 in.)
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	0.100 mm (0.004 in.)	—
Cylinder Block Top Deck Straightness Per Any 305 mm (12.0 in.) Length	0.025 mm (0.001 in.)	—
Centerline of Connecting Rod Pin Journal-to- Centerline of Piston Pin Bore	222.20—222.30 mm (8.748—8.752 in.)	— —

RG.CTM86,G10,3 -19-04AUG94

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.)
---	---------------------------------

Cylinder Liner Cap Screws (for Checking Liner Standout)	68 N·m (50 lb-ft)
--	-------------------

* See *INSTALL PISTONS AND CONNECTING RODS*, later in this group, before tightening cap screws.

FG,CTM86,G10.4 -19-14SEP84

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.

REMOVE PISTON AND CONNECTING ROD ASSEMBLIES

6081HRW01 Engines must be removed from the 8400 Tractor to service the pistons and connecting rods. Refer to machine technical manual: TM1575 (8100, 8200, 8300, and 8400 Tractors—Repair) for engine removal procedure.

⚠ CAUTION: DO NOT drain engine coolant until the temperature is below operating temperature. Then slowly loosen water pump cover drain valve (A) and block drain valve (B) to relieve any pressure.

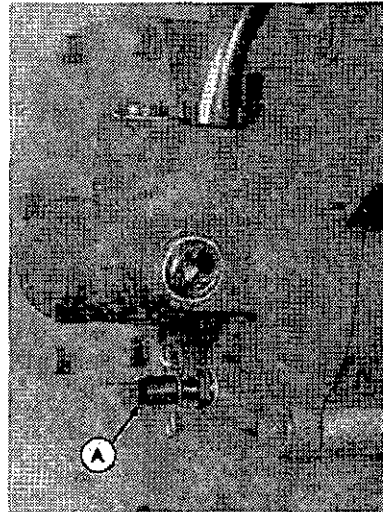
IMPORTANT: Both drain valves must be opened to completely drain engine block.

1. Drain all engine coolant and engine oil.

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

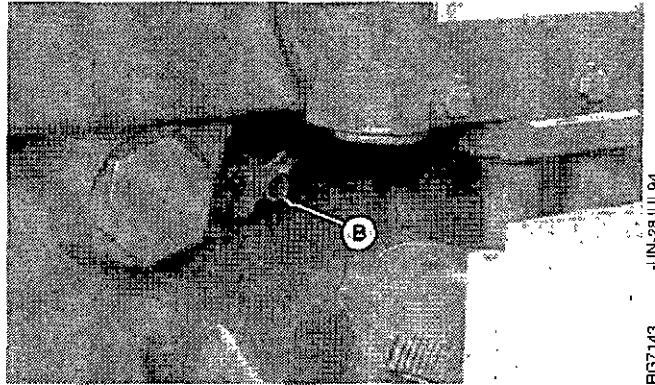
2. Remove cylinder head. (See REMOVE CYLINDER HEAD in Group 05.)

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



-UN-28JUL94

RG7044



-UN-28JUL94

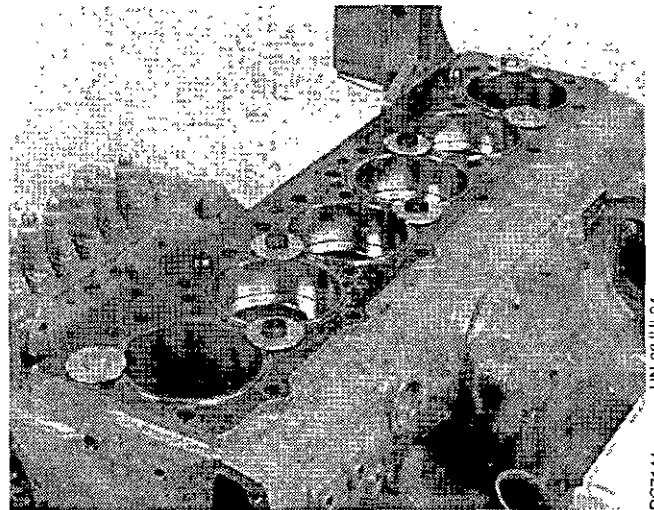
RG7143

RG.CTM86.G10.6 -19-22JUL94

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

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

Cap screws and washers must be tightened to the above specification to achieve an accurate reading when measuring liner standout (height above block). See **MEASURE LINER STANDOUT (HEIGHT ABOVE BLOCK)**, later in this group.



RG7144 -JUN-28JUL94

RG,CTM86,G10,7 -19-22JUL94

10
11

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

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

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

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

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

NOTE: Connecting rod bearing-to-journal oil clearance should be measured before removing piston/rod assembly.

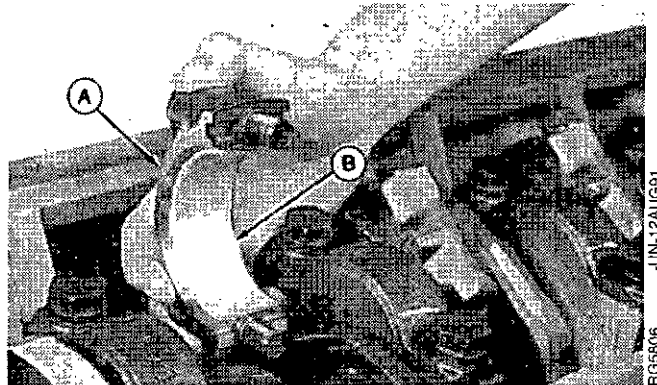
Use PLASTIGAGE as directed by the manufacturer. Remember, the use of PLASTIGAGE will determine bearing-to-journal oil clearance, but will not indicate the condition of either surface.

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

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

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

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



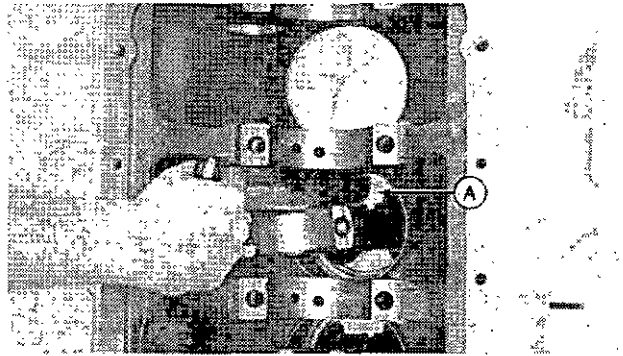
Crankshaft shown removed, piston and rod assembly can be removed with crankshaft installed.

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

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

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

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



-JUN-07DEC88

RG3821

10
13

RG,CTM86,G10,9 -19-14SEP94

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.

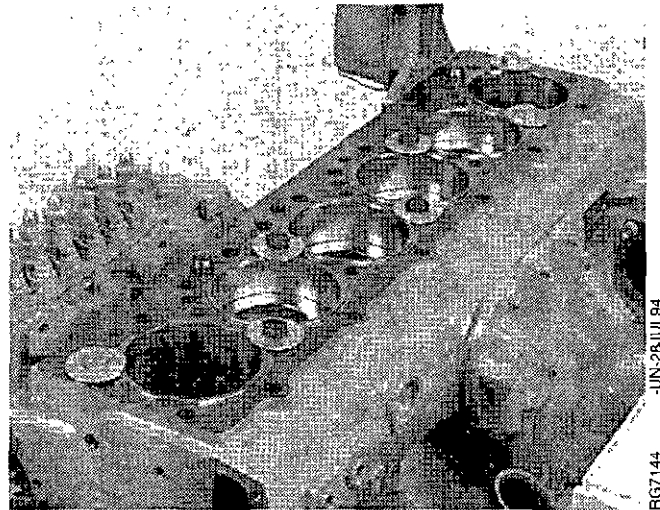
1. Bolt liners down using cap screws and flat washers. Flat washers should be at least 3.18 mm (1/8 in.) thick. Tighten cap screws to 68 N·m (50 lb·ft).

2. Use JDG451 Gauge Block (A) along with D17526C1 (English, in.) or D17527C1 (Metric, mm) Dial Indicator (B) or KJD10123 Gauge to measure the height of bolted down liners that are not obviously defective before removal from block.

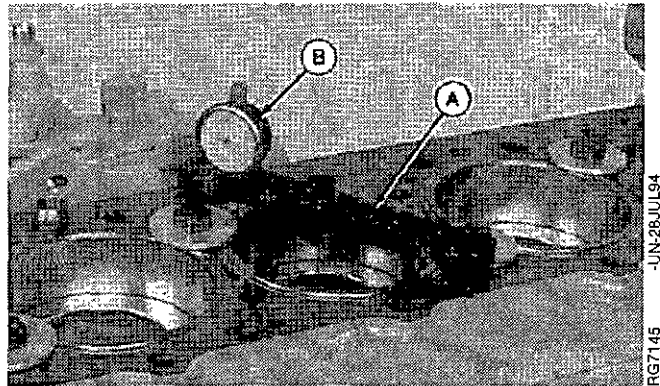
NOTE: Variations in measurement readings may occur within one cylinder and/or between adjacent cylinders.

3. Measure each liner in four places, 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.



RG7144 -JUN-28-JUL94



RG7145 -JUN-28-JUL94

LINER HEIGHT SPECIFICATIONS

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

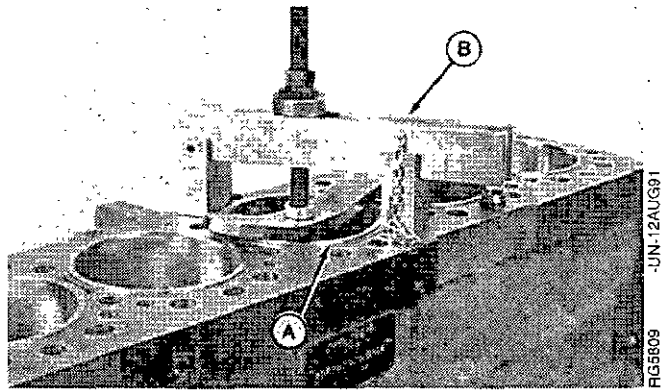
RG,CTM86,G10,10-19-22JUL94

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.

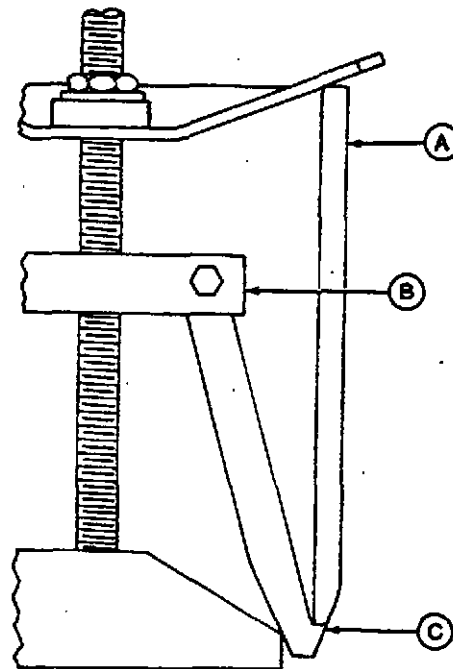
3. Use D01062AA or D01073AA Cylinder Liner Puller (B) to remove cylinder liner (A).



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.

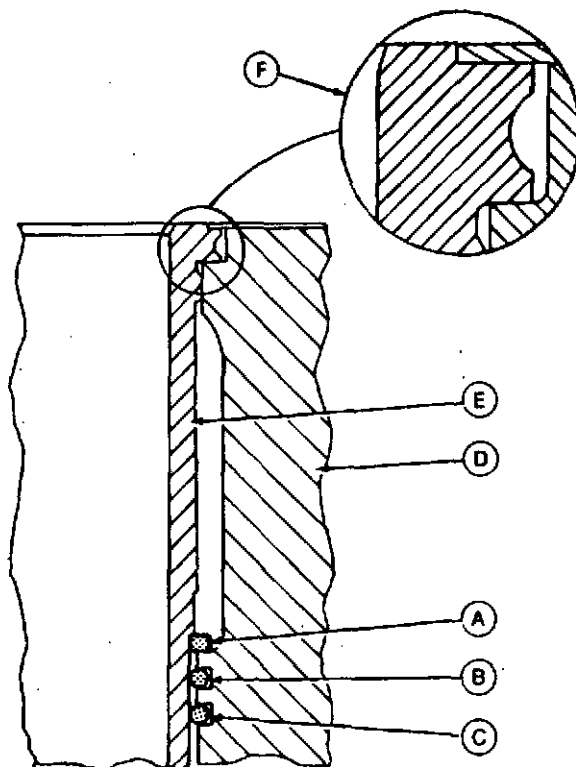


S11,0402,AK -19-02APR93

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

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

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



RG,CTM86,G10,40-19-22JUL94

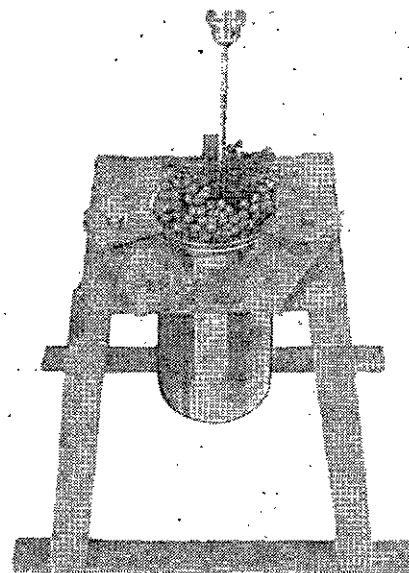
JUN-13MAR93
RG6688

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.

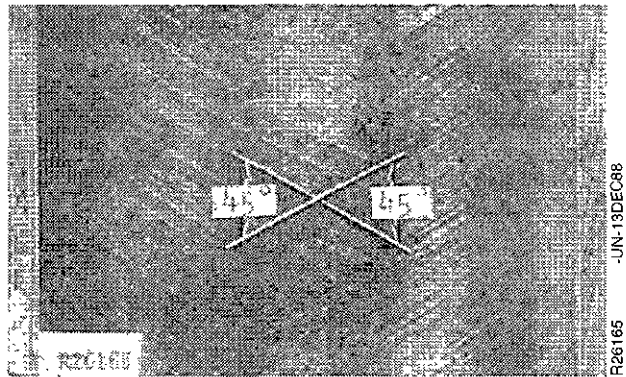


RG,CTM86,G10,18-19-22JUL94

JUN-13DEC88
R26164

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, later in this group, for proper cleaning procedures.



RG,CTM86,G10,19-19-22,JUL94

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.

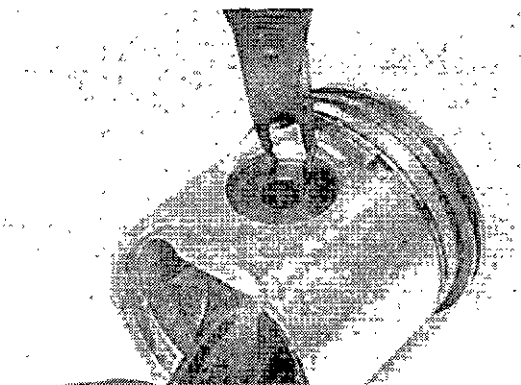
5. Clean liner until a white rag shows no discoloration.

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

DISASSEMBLE PISTON/ROD ASSEMBLY AND CLEAN PISTON

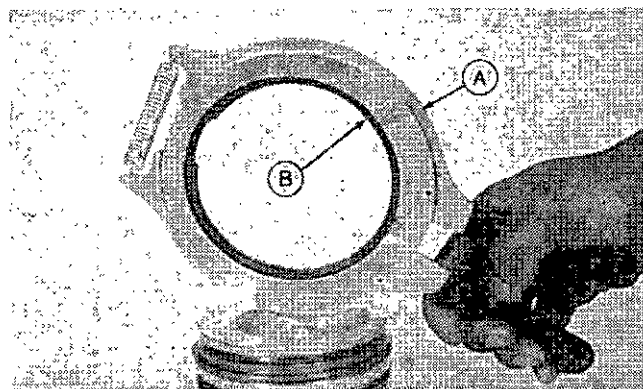
1. Remove piston snap rings. Remove piston pin and connecting rod from piston.

NOTE: Discard snap rings, DO NOT reuse.



RG,CTM86,G10,11-19-22,JUL94

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



RG,CTM86,G10,12-19-22JUL94

UN-13DEC88
RG5229

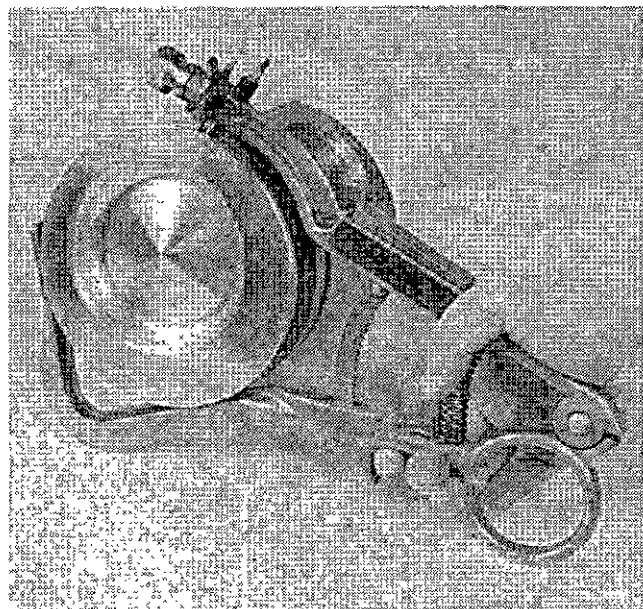
3. Clean piston ring grooves using a piston ring groove cleaning tool.

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.

4. Clean pistons by any of the following methods:

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

If cleaning with hot water and liquid detergent, soak pistons in a 50 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.



RG,CTM86,G10,13-19-22JUL94

UN-27JAN92
RG6086

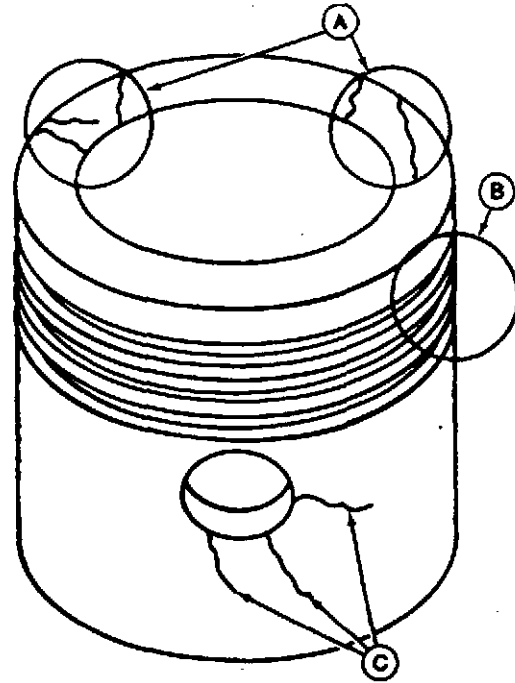
10
18

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)

FIG 9326 -JUN-13DEC88

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

10
19

CHECK PISTON RING GROOVE WEAR

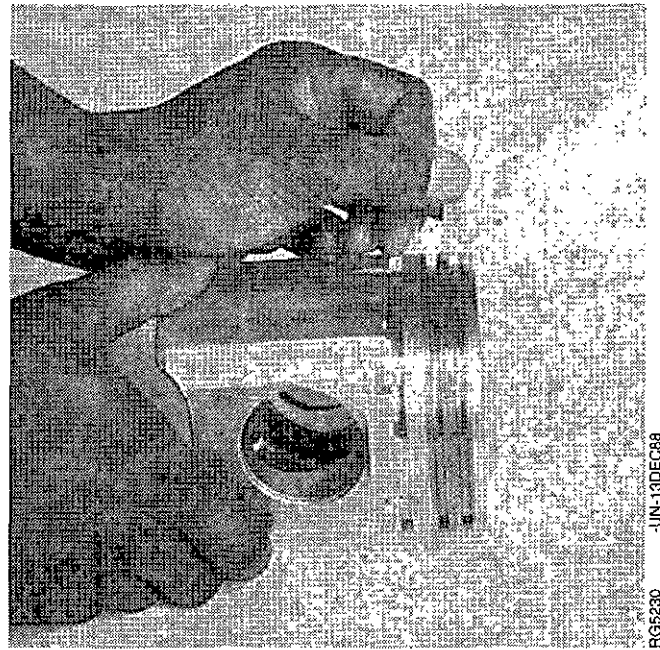
Check grooves at several locations around the circumference of piston.

1. Use the JDE55 Ring Groove Wear Gauge (A) to check wear of top full keystone (compression) ring groove.
2. Use JDG852 Ring Groove Wear Gauge (B) to check wear of middle half-keystone (compression) ring groove.

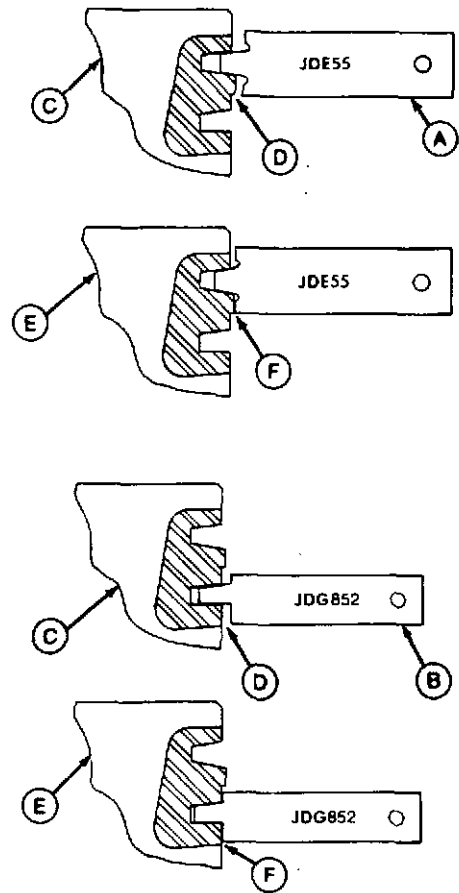
If gauge shoulder contacts ring land of piston, ring groove is worn. Replace piston and liner as a set.

If ring grooves are good (D), proceed with piston inspection.

- A—JDE55 Keystone Ring Groove Wear Gauge
- B—JDG852 Half-Keystone Ring Groove Wear Gauge
- C—Piston With Good Ring Groove
- D—Acceptable Clearance
- E—Piston with Worn Ring Groove
- F—Gauge Shoulder Contacting Piston Ring Land



-JUN-13DEC88
RG5230



-JUN-10AUG84
RG7058

-JUN-10AUG84
RG7059

RG.CTM86,G10,14-19-14SEP94

10
20

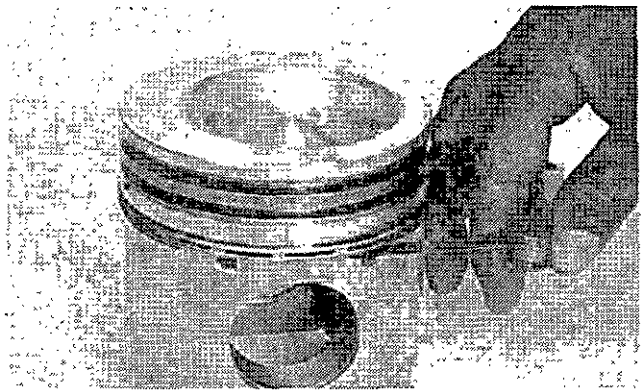
3. Check oil control ring-to-groove clearance by installing a new ring in groove.

4. 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.)
Maximum Serviceable Clearance	0.165 mm (0.0065 in.)

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



UN-13DEC88
RG5234

RG,CTM86,G10,15-19-22JUL94

INSPECT PISTON PIN AND PIN BORE

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

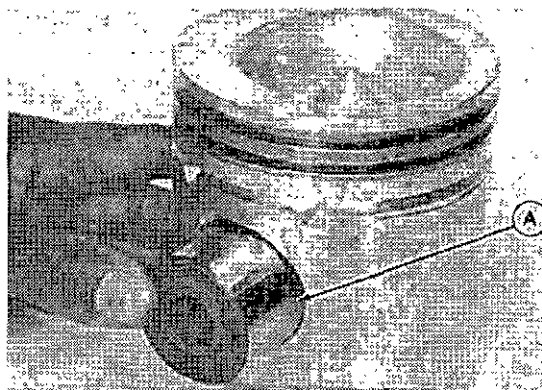
1. Dip piston pin in clean engine oil.
2. Install pin (A) through piston.

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).

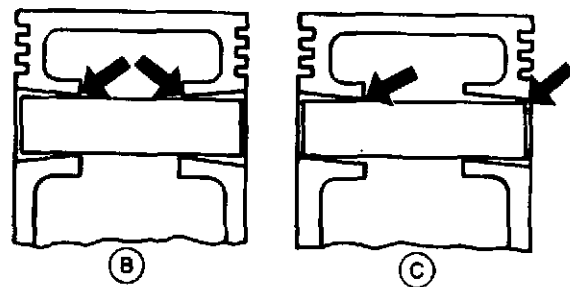
4. Insert pin in piston to check for bore alignment. Pin should not "click" or need to be forced into bore on opposite side (C).

5. Measure piston pin and piston bore specifications. If either are not within specification, replace pin, piston, and liner.



10
21

UN-13DEC88
RG5231



UN-26JUL94
RG4984

PISTON PIN/BORE SPECIFICATIONS

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

RG,CTM86,G10,16-19-22JUL94

VISUALLY INSPECT CYLINDER LINERS

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

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

Replace piston and liner if:

—Pitting depth is one-half liner thickness (C) or more.

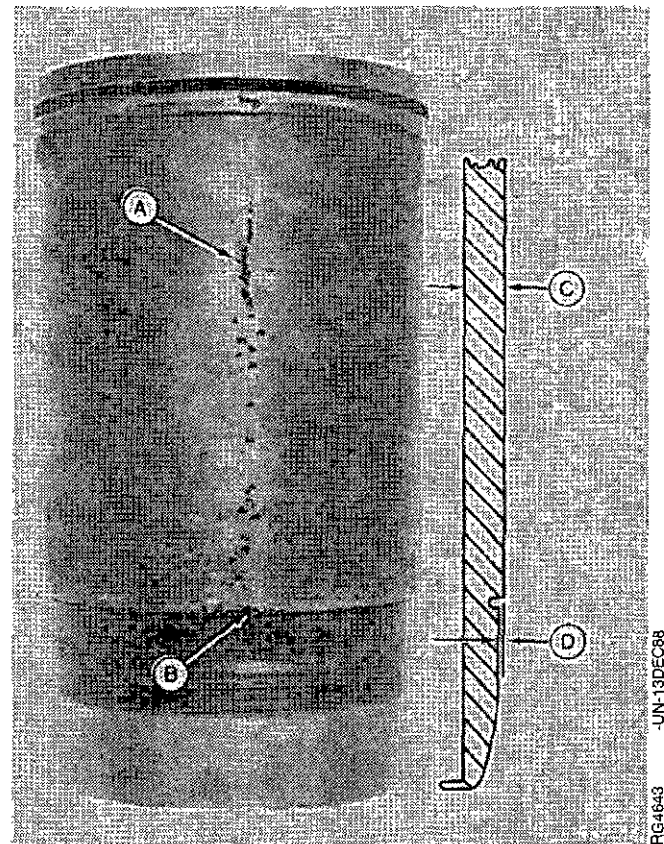
—Erosion depth is one-half packing step (D) or more.

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

RG,CTM42,G10,34-19-22JUL94

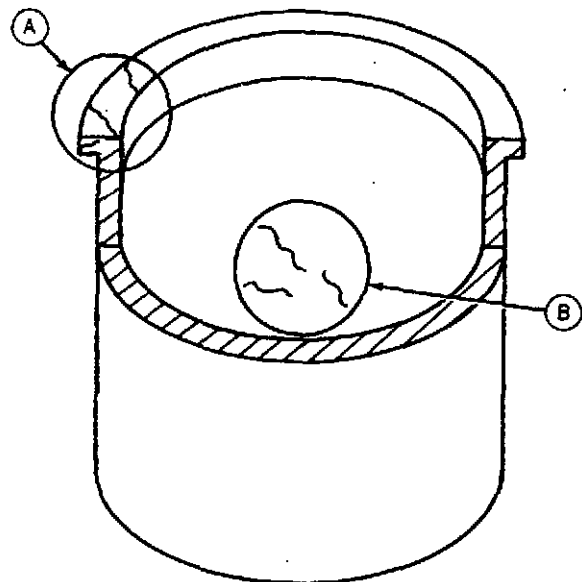
2. Visually examine liner ID. Replace piston and liner if:

— 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,G10,14-19-22JUL94

CYLINDER LINER MANUFACTURING DATE CODE EXPLANATION

A manufacturing four-digit date code will appear on each liner. For example, HJ94 means the liner has a hardened bore and was manufactured in October of 1994.

HJ94

H Liner Material Type
 J Month Liner was Manufactured
 94 Year Liner was Manufactured

Liner Material Specification

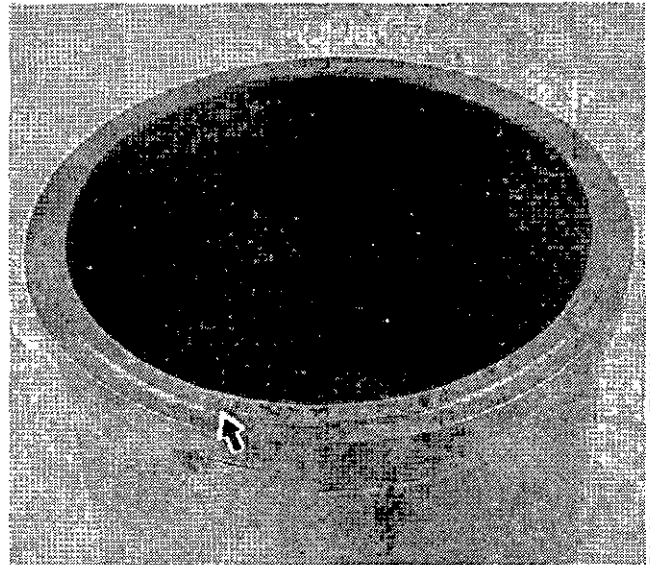
H Hardened Liner Bore

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

94 1994
 95 1995
 etc.



Four-Digit Date Code

-UN-27JAN92
RG6091

10
23

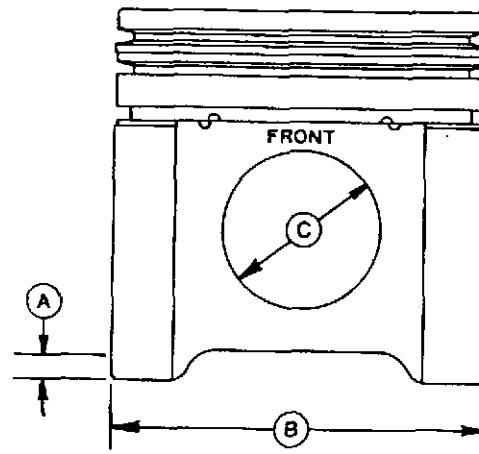
RG,CTM86,G10,21-19-07SEP94

DETERMINE PISTON-TO-LINER CLEARANCE

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

PISTON SKIRT DIAMETER SPECIFICATION

Piston OD 15.16 mm (0.597 in.) from
 Bottom of Piston 115.771—115.789 mm
 (4.5579—4.5586 in.)

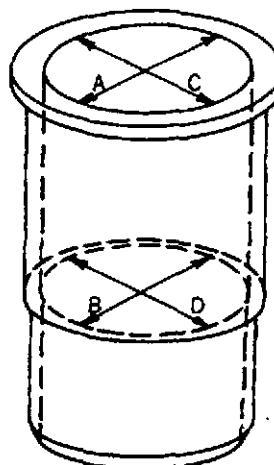


-UN-26JUL94
RG7045

RG,CTM86,G10,17-19-14SEP94

IMPORTANT: ALWAYS measure liners at room temperature.

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



R25922N

-UN-13DEC88

R25922

CYLINDER LINER WEAR SPECIFICATIONS

Liner I.D.	115.865—115.895 mm (4.5616—4.5628 in.)
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.)
New Part Piston-to-Liner Clearance	0.076—0.124 mm (0.0030—0.0049 in.)
Maximum Piston-to-Liner Clearance	0.152 mm (0.0060 in.)

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

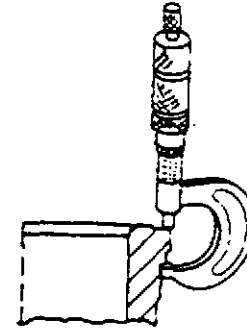
FG.CTM86,G10,20-19-22JUL94

10
24

MEASURE LINER FLANGE THICKNESS

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

If liner flange is not within specification, either use liner shims as needed or replace piston and liner as a set if shims don't bring liner stand-out within specification. (See RECHECK CYLINDER LINER STAND-OUT and INSTALL LINER SHIMS—IF REQUIRED, later in this group.)



LINER FLANGE SPECIFICATION

Flange Thickness 11.989—12.039 mm (0.472—0.474 in.)

RG,CTM86,G10,30-19-14SEP94

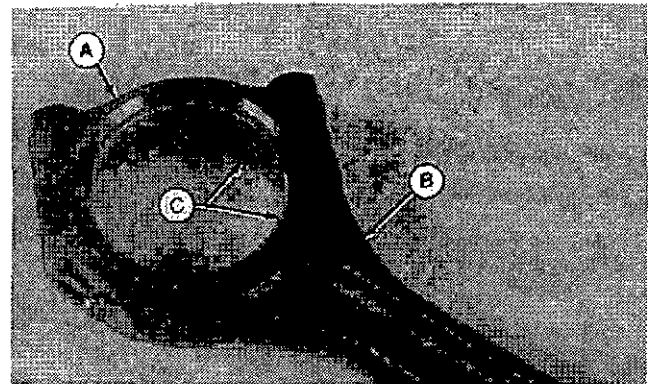
RG4727 -JN-19DEC88

INSPECT AND MEASURE CONNECTING ROD BEARINGS

IMPORTANT: Never use new connecting rod cap screws when checking rod bearing I.D. 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 O.D. of crankshaft journal.

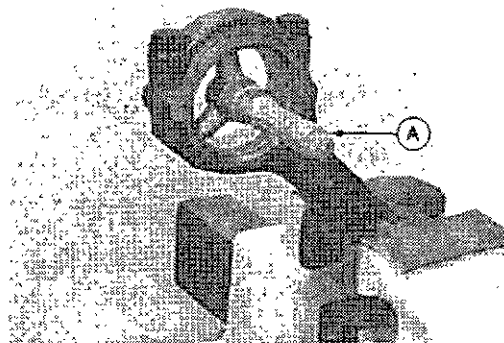
1. With crankshaft removed, measure connecting rod journal O.D. at several points.
2. Carefully clamp rod in a soft jawed vise and install connecting rod cap (A) on rod (B) with bearings (C) in correct position.
3. Initially tighten blind hole cap screw to 27 N-m (20 lb-ft), then, tighten open hole cap screw to same torque.
4. Next, tighten rod 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, described later in this group.)



10
25
RG7046 -JN-28JUL94

RG,CTM86,G10,22-19-22JUL94

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



CONNECTING ROD BEARING AND JOURNAL SPECIFICATIONS

Crankshaft Journal OD	76.150—76.180 mm (2.9980—2.9992 in.)
Assembled Rod Bearing ID	76.210—76.260 mm (3.0005—3.0025 in.)
Oil Clearance (new parts)	0.030—0.110 mm (0.012—0.0044 in.)

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

-JUN-13DEC88
FG3624

FG,CTM86,G10,23-19-14SEP94

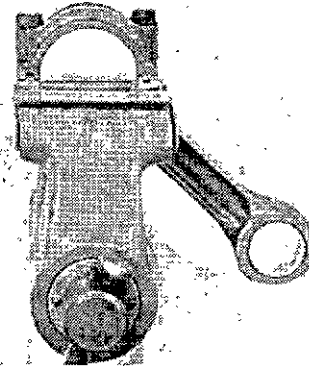
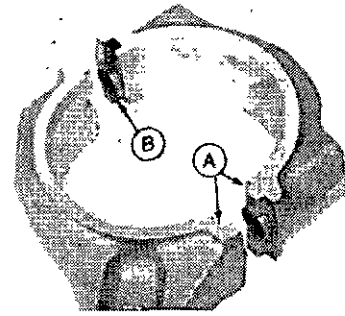
10
26

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.
3. Carefully clamp rod in a soft-jawed vise (cap end upward).
4. Install cap WITHOUT bearing.

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

5. Initially tighten blind hole cap screw to 27 N-m (20 lb-ft), then, tighten open hole cap screw to same torque.
6. Next, tighten rod 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, described later in this group.)



RG3749 -UN-13DEC88

RG4982

-UN-13DEC88

10

27

RG,CTM86,G10,24-19-22,JUL94

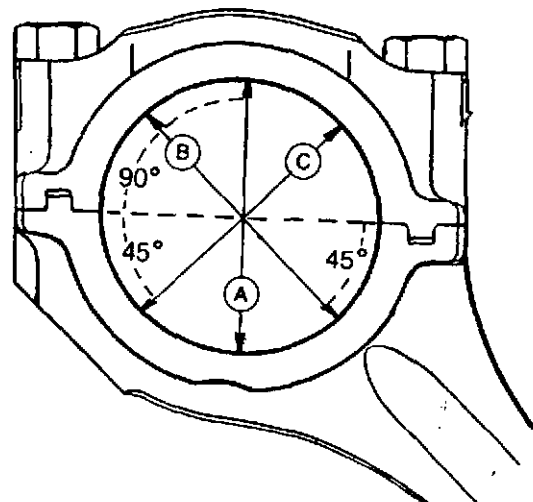
7. Using an inside micrometer, measure rod bore at center of bore and record measurements as follows:

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

ROD BORE SPECIFICATIONS

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

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



-UN-28JUL94

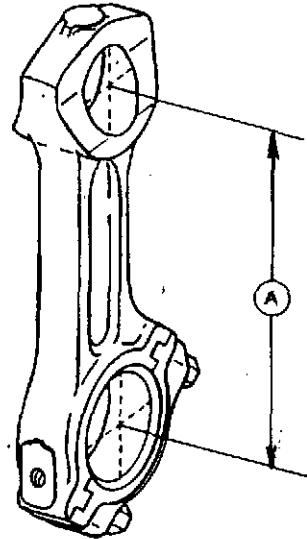
RG7140

RG,CTM86,G10,25-19-22,JUL94

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

CENTERLINE OF PISTON BORE-TO-CRANKSHAFT BORE

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



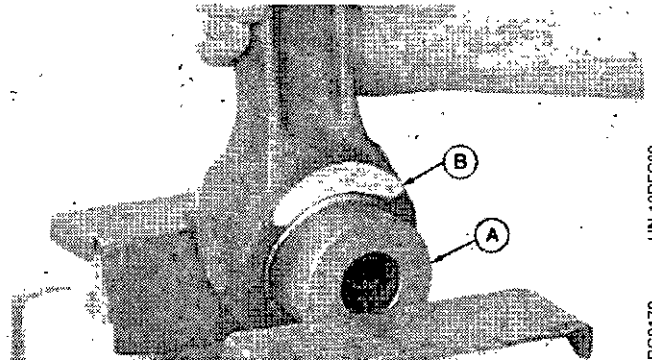
FG,CTM86,G10,26-19-22JUL94

RG7141 JUN-28JUL94

INSPECT PISTON PINS AND BUSHINGS

10
28

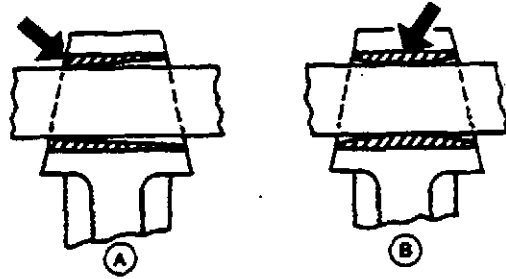
1. Insert piston pin (A) through piston pin bushing and carefully clamp in a soft-jawed vise.
2. Rotate connecting rod (B) back and forth several times to make sure connecting rod moves freely on piston pin.
3. Remove piston pin from vise and connecting rod.



S11,2010,DM -19-08MAR94

RG8172 JUN-13DEC88

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

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

RG4883 -JUN-13DEC88

10
29

S11,2010,JG -19-14SEP94

REMOVE PISTON PIN BUSHING, CLEAN AND INSPECT PIN BORE

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

Use the following tools from the service sets:

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

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

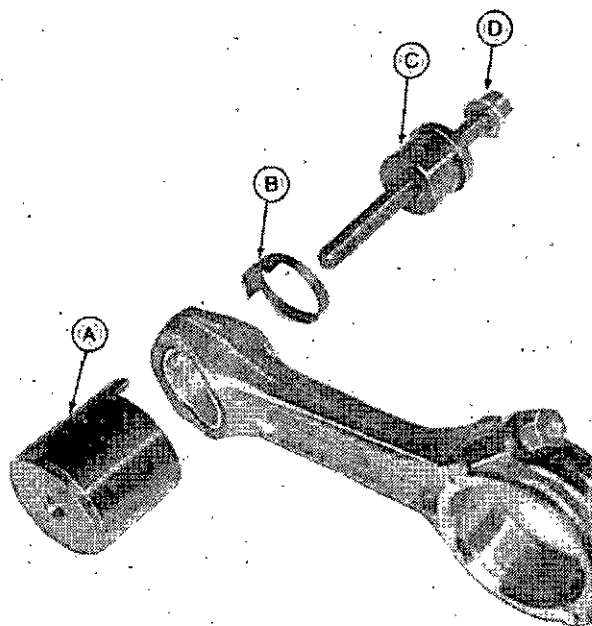
2. Clean rod bushing bore using a medium grit emery cloth, as burrs will distort bushing. Install bushing on opposite side of rod burr.

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

CONNECTING ROD PIN BUSHING SPECIFICATIONS

Rod Pin Bore Diameter Without Bushing	52.354—52.380 mm (2.0612—2.0622 in.)
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 Boring)	47.58—47.63 mm (1.8732—1.8751 in.)
ID of Installed Rod Pin Bushing (After Boring)	47.655—47.681 mm (1.8762—1.8772 in.)

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



UN-13DEC88
FIG.4985

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

INSTALL PISTON PIN BUSHING IN CONNECTING ROD

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

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

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

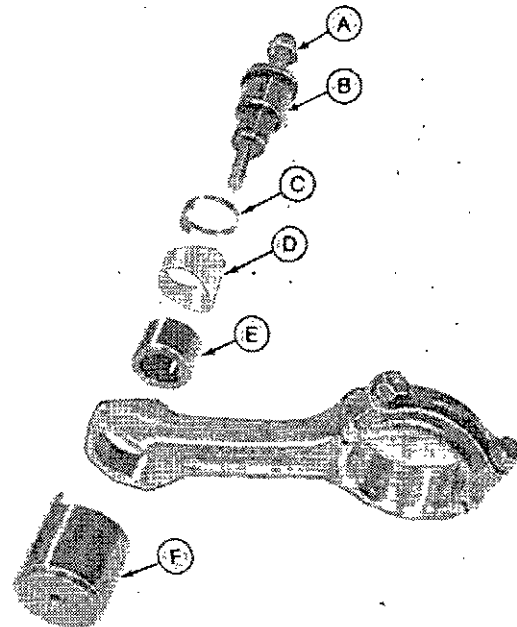
- STD36104 Forcing Screw With Washer (A)
- JDE98A Driver (B)
- JDG338 Adapter (C)
- Service Bushing (D)
- JDE98-3 Pilot (E)
- JDE339 Cup (F)

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

2. Bore ID of newly installed bushing to 47.655—47.681 mm (1.8762—1.8772 in.) after installation. Remove all residue from boring operation.

3. Check distance from centerline of rod's piston pin bore-to-crankshaft journal bore centerline. Distance must be within 222.20—222.30 mm (8.748—8.752 in.).

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



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

FG,CTM86,G10,28-19-13SEP94

-UN-13DEC88

10
31

COMPLETE DISASSEMBLY OF CYLINDER BLOCK (IF REQUIRED)

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

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

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

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

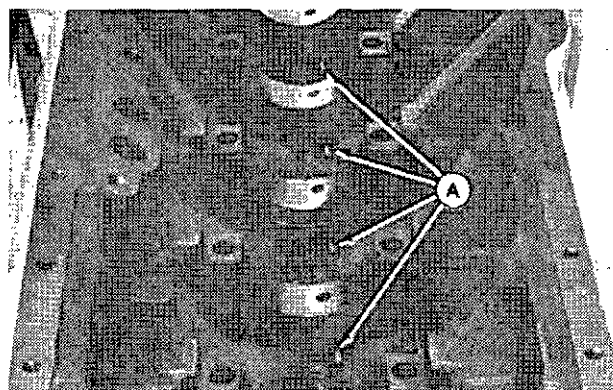
6. If necessary to "Hot Tank" the block, remove oil gallery plugs, water gallery plugs, piston cooling orifices and the engine serial number plate. (See REMOVE AND CLEAN PISTON COOLING ORIFICES, later in this group.)

RG.CTM42,G10.6 -19-22JUL94

REMOVE AND CLEAN PISTON COOLING ORIFICES

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

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



RG3752 -UN-14DEC88

S11.2010,KF -19-13MAR92

10
32

INSPECT AND CLEAN CYLINDER BLOCK

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

1. Use D17015BR O-Ring Bore Cleaning Brush or an equivalent brush to thoroughly clean all debris from cylinder liner O-ring bores.
2. Remove cylinder head locating dowels, if not previously removed. Clean out all threaded holes for cylinder head mounting cap screws in top deck of cylinder block. Use JDG681 Tap or an equivalent 9/16-12 UNC-2A tap approximately 88.9 mm (3.5 in.) long. Use compressed air to remove any debris or fluid which may be present in the cap screw hole.

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

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

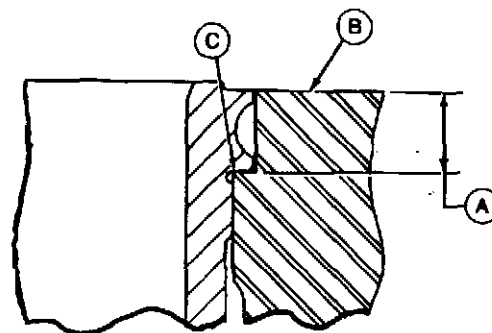
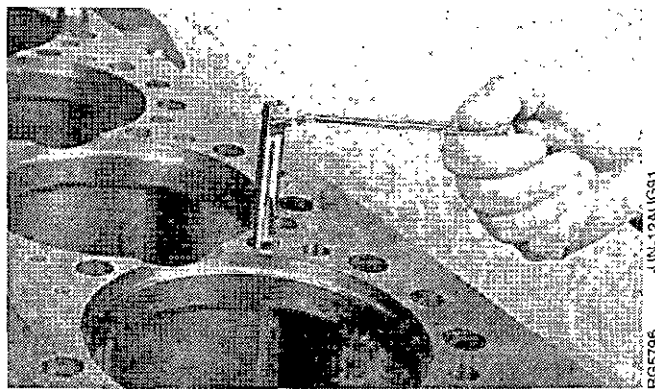
NOTE: DO NOT file liner support flange excessively. Excess filing can damage liner support flange and allow an improper liner fit. Thoroughly clean all filings from cylinder block.

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

BLOCK FLANGE COUNTERBORE DEPTH SPECIFICATION

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

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



RG5796 -UN-12AUG81

-UN-28-JUL84

RG7142

10
33

MEASURE CYLINDER BLOCK

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

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

MAIN AND THRUST BEARING SPECIFICATIONS

Main and Thrust Bearing Bore ID Without Bearing	101.651—101.677 mm (4.0020—4.0030 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	41.81—42.31 mm (1.646—1.666 in.)

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

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

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.

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.)
Camshaft Bushing-to-Journal Clearance	0.063—0.115 mm (0.0025—0.0045 in.)

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

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.)
Straightness per any 305 mm (12.0 in. of length)	0.025 mm (0.001 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.

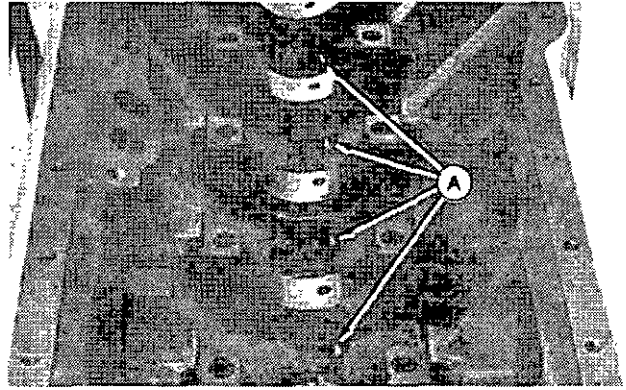
INSTALL PISTON COOLING ORIFICES AND GALLERY PLUGS

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

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

2. Install all six (four shown) piston cooling orifices (A) and tighten to 11 N·m (97 lb-in.)(8 lb-ft).

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



RG3752 JUN-14DEC88

S11,2010,KH -19-22JUL94

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.

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

RG.CTM42,G10,23-19-22JUL94

10
35

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.

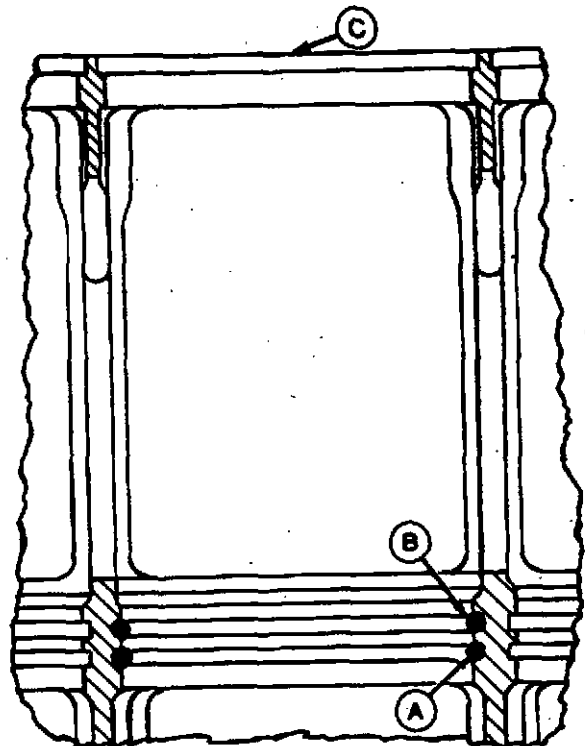
If standout is within specification, proceed to next step.

RG,CTM86,G10,32-19-13SEP94

INSTALL PACKING ON CYLINDER LINER AND O-RINGS IN BLOCK

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



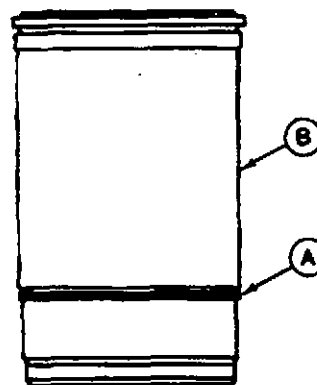
RG3626 -JUN-13DEC88

RG,CTM86,G10,33-19-29MAR94

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.



RG3827 -UN-13DEC88

S11,2010,JT -19-29OCT92

INSTALL CYLINDER LINERS IN BLOCK

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

DO NOT scuff the packing across the upper counterbore.

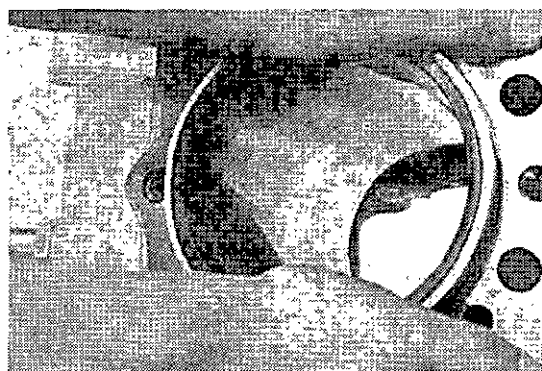
Pitted or eroded liners that meet reuse guidelines should be rotated 90° from their removed position. See VISUALLY INSPECT CYLINDER LINERS, earlier in this group for reuse guidelines.

1. Install liner and packing in block bore with manufacturing date code (stamped on flange) toward front of engine, unless liner OD is pitted or eroded.

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.



10
37
RG32772 -UN-23FEB89

RG,CTM86,G10,34-19-22JUL94

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 been sheared or displaced during liner installation, remove liner and packing assembly. If no damage is found, check packing and O-rings for proper position. Resoap packings and reinstall liner assembly.

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

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

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

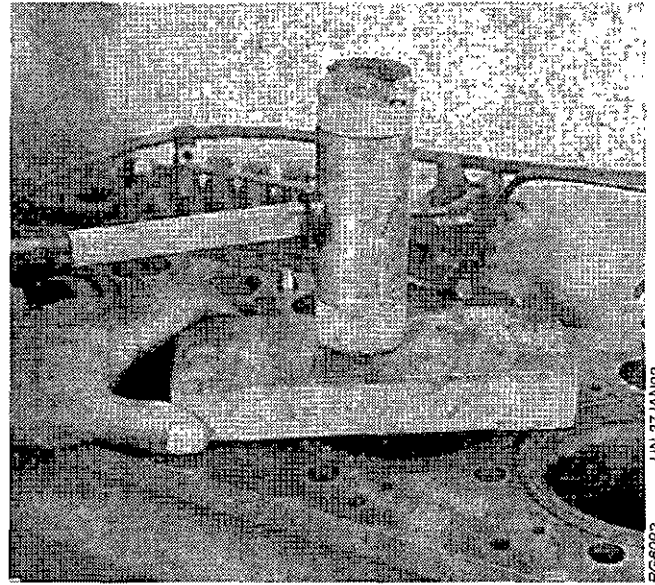


FIG6082 JUN-27-JAN82

10
38

RG,CTM86,G10,35-19-22JUL94

INSTALL PISTONS AND CONNECTING RODS

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

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

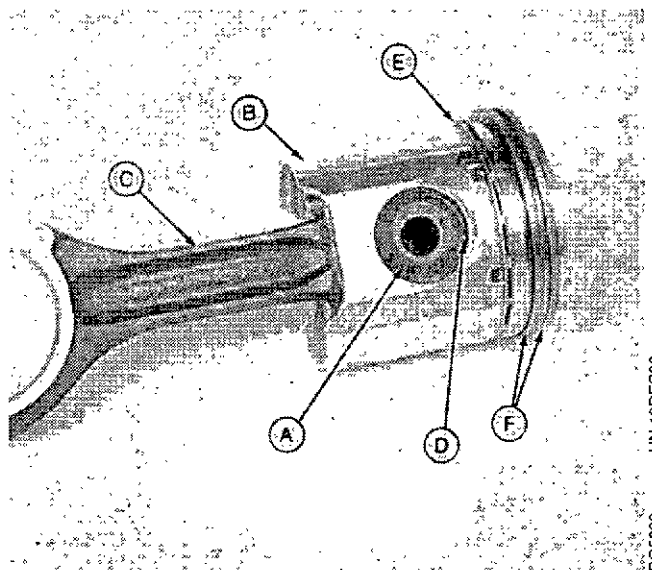
1. Lubricate piston pin (A) and bushing with clean engine oil.
2. Install piston pin through piston (B) and connecting rod (C). Be sure "FRONT" of rod aligns with "FRONT" of piston.
3. Install **NEW** piston pin snap rings (D) in grooves. Make certain snap rings have expanded in grooves of piston.

NOTE: Full keystone compression ring (one "Pip" mark) goes in top piston ring groove and half keystone ring (two "Pip" marks) goes in second ring groove of piston.

4. Use the JDE93 Ring Expander to install compression 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" mark(s) on No. 1 and No. 2 compression rings must face top of piston.



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

-UN-13DEC88
RG6289

10
39

RG,CTM86,G10,36-19-22JUL94

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.

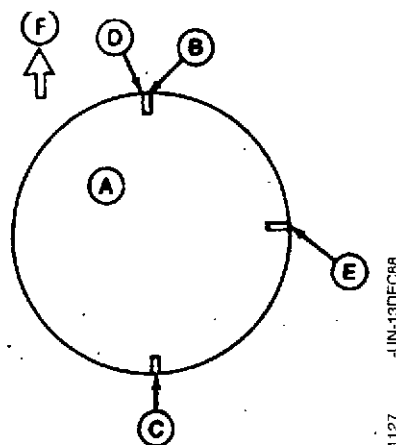
7. Carefully place ring compressor with piston and rod over liner.

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.

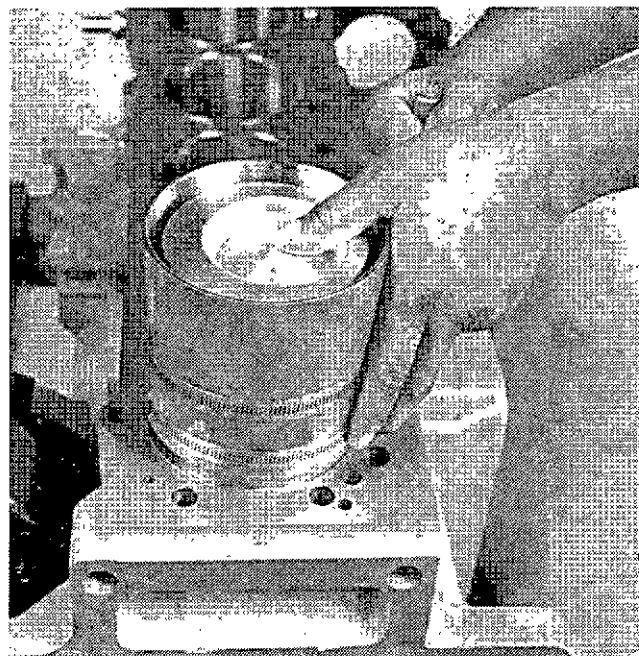
- A—Top of Piston
- B—Top Compression Ring Gap
- C—Oil Control Ring Gap
- D—Expander Ring Gap
- E—Bottom Compression Ring Gap
- F—Front of Engine



R 31127

-JUN-13DEC88

RG1127



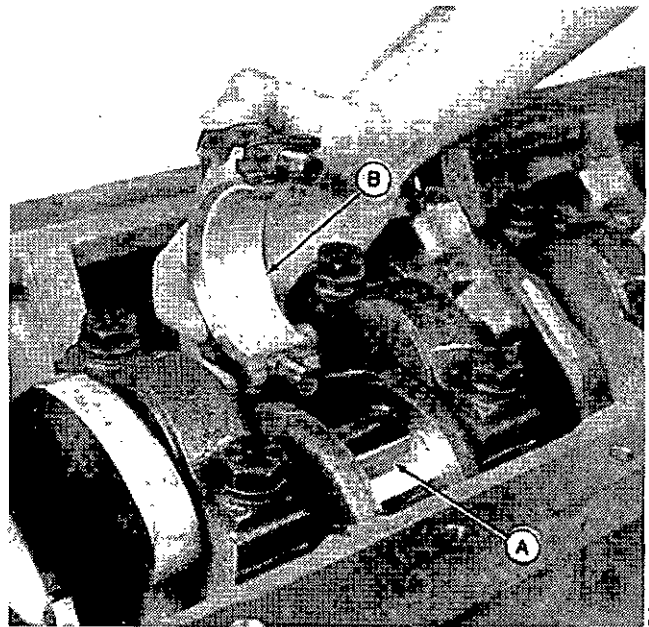
RG5816 -JUN-12AUG91

RG,CTM86,G10,37-19-04AUG94

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.



RG,CTM42,G10,15-18-12APR93

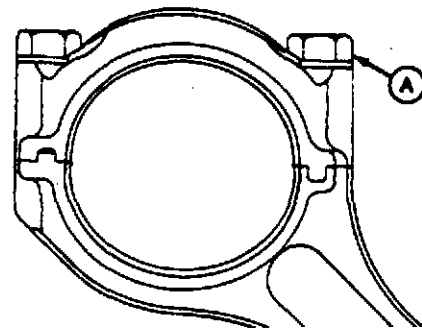
11. Dip NEW cap screws and washers in clean engine oil. Make sure top of cap screws have oil on them also.

IMPORTANT: DO NOT use pneumatic wrenches to install connecting rod cap screws. Doing so may damage threads.

12. Initially, tighten (blind hole) cap screw (A) to 27 N-m (20 lb-ft) before tightening the other (open hole) 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 TORQUE-TURN CONNECTING ROD CAP SCREWS, described next in this group.)

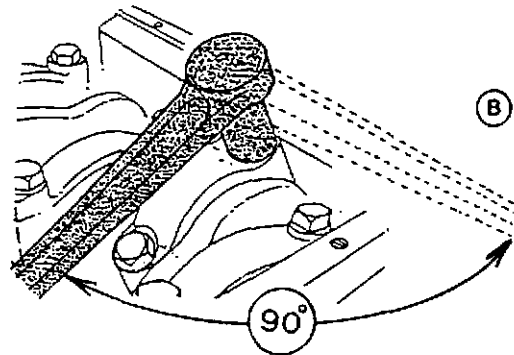
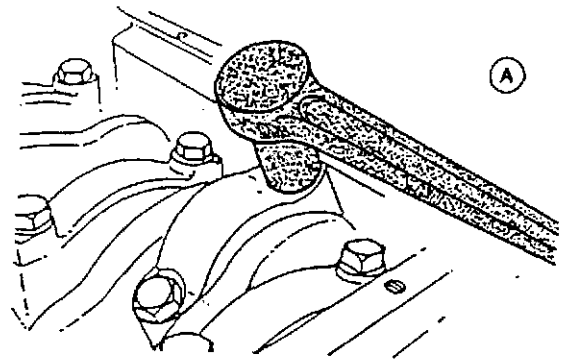


RG,CTM86,G10,38-19-04AUG94

TORQUE-TURN CONNECTING ROD CAP SCREWS

• Using engine axis 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.
2. Position handle of wrench parallel to centerline of engine crankshaft axis (A).
3. Tighten 1/4 turn (90—100°) clockwise until handle of wrench is perpendicular to centerline of engine crankshaft axis (B) as shown.

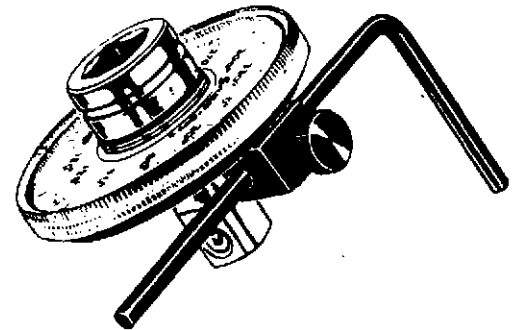


RG,CTM86,G10,41-19-14SEP94

RG7047 -UN-28JUL94

• Using JT05993 Torque Angle Gauge to TORQUE-TURN connecting rod cap screws:

1. After tightening cap screws to 75 N·m (55 lb-ft), follow directions provided with gauge and TORQUE-TURN each cap screw 90°—100°.



JT05993 Torque Angle Gauge

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

RG569B -UN-27AUG90

CHECK ENGINE ROTATION FOR EXCESSIVE TIGHTNESS

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

S11,0402,BK -19-08MAR94

COMPLETE FINAL ASSEMBLY

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

1. Install camshaft and timing gear cover. (Group 16)
2. Install oiling system components. (Group 20)
3. Install cylinder head using a new gasket and cap screws. Install valve train components. (Group 05)
4. Install fuel injection system components. (Group 35)
5. Install thermostat housing and water bypass pipe, if removed. (Group 25)
6. Install vibration damper and crankshaft pulley. (Group 15)
7. Install alternator, fan, and fan belts. (Machine Technical Manual)
8. Install exhaust manifold and intake assembly. (Group 30)
9. Install starting motor.
10. Fill engine with clean oil and proper coolant. (Group 02)
11. Install engine in vehicle (if removed) and perform engine break-in. (Group 05).

RG,CTM86,G10,39-19-22JUL94

10
43

10
44

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).

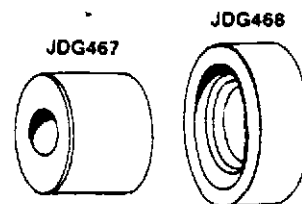
DX,TOOLS -19-05JUN91

Front Wear Sleeve Installer Set JDE3

Install front crankshaft wear sleeve.

Set consists of:

Driver JDG467
Spacer JDG468

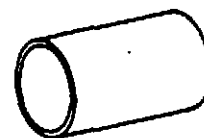


RG,CTM86,G15,1 -19-26JUL94

-UN-04JUL89
RG508

Gear Driver JDH7

Install crankshaft drive gear.



S53,JDH7 -19-04AUG94

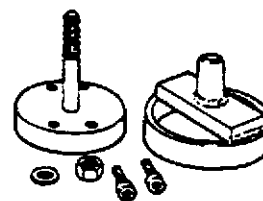
RG5108 -UN-23AUG88

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

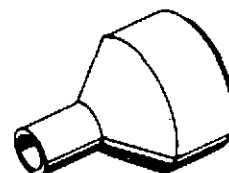
-UN-23AUG88
RG5106

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

-UN-06MAR92
RG6214

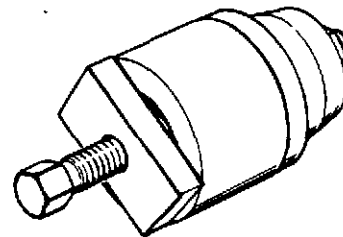
Crankshaft, Main Bearings, and Flywheel

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

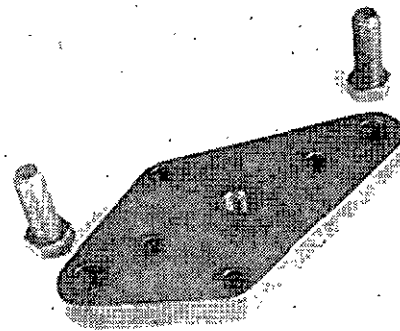


RG,JDG720 -19-01APR93

RG6215 -UN-06MAR92

Hub Puller Kit JDG721

Used with JDG787 Thread Protector to remove vibration damper pulley assembly.

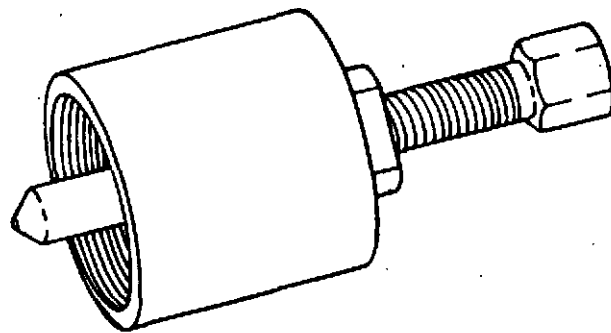


RG,JDG721,A -19-26JUL94

RG5763 -UN-06AUG91

Front Wear Sleeve Puller JDG786

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



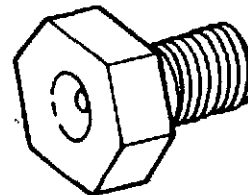
RG,JDG786 -19-29OCT92

RG6428 -UN-13OCT92

Thread Protector JDG787

Used with JDG721 Hub Puller Kit to remove vibration damper pulley assembly.

NOTE: May be used with any puller set where limited space makes it difficult to use puller without a thread protector.



RG,JDG787,A -19-26JUL94

RG6429 -UN-13OCT92

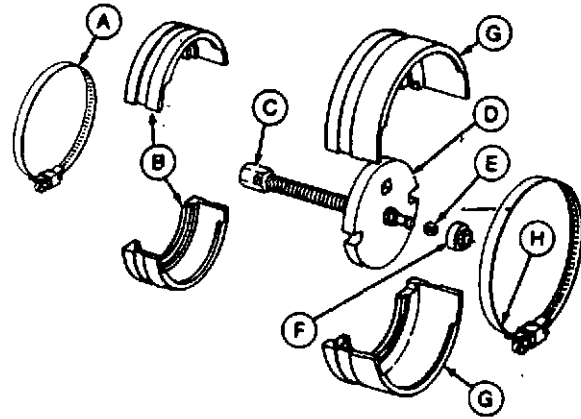
Crankshaft, Main Bearings, and Flywheel

Rear Wear Sleeve Puller Kit JDG790

Used to remove rear wear sleeve with oil seal housing installed on 400, 450, and 500 Series Engines.

Set consists of:

- A—Hose Clamp (500 Series) 219469
- B—Collet Halves (400/450 Series) JDG790-1
- C—Forcing Screw (400/450/500 Series) 35945
- D—Pulling Plate (400/450/500 Series) JDG790-2
- E—Retainer Clip (400/450/500 Series) 13876
- F—Shaft Protector (400/450/500 Series) 215177
- G—Collet Halves (500 Series) JDG790-3
- H—Hose Clamp (400/450 Series) 19311



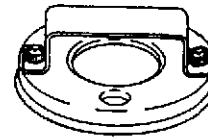
RG,JDG790 -19-03OCT94

RG6457 -UN-22OCT92

Oil Seal Housing Alignment Tool JDG796

Use with oil seal housing casting numbers R115050 and R125027.

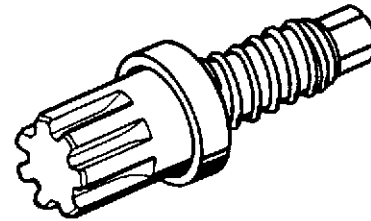
RG6590 -UN-18FEB93



RG,JDG796 -19-08AUG94

Flywheel Turning Tool JDG820

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



RG,JDG820 -19-04AUG94

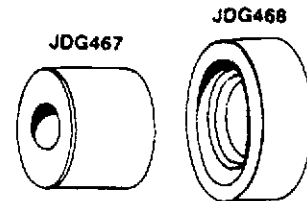
RG7056 -UN-10AUG94

Front Wear Sleeve Installer Set JDE3

Install front crankshaft wear sleeve.

Set consists of:

- Driver JDG467
- Spacer JDG468



RG,CTM86,G15,1 -19-26JUL94

RG5509 -UN-04JUL89

SERVICE EQUIPMENT AND TOOLS

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

Name	Use
D01251AA Puller*	Remove crankshaft gear.

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

RG,CTM61,G15,19-19-02APR93

OTHER MATERIAL

Name	Use
LOCTITE 242 (TY9370) Thread Lock and Sealer	Coat threads of flywheel mounting cap screws.
LOCTITE 515 (TY6304) Flexible Sealant (General Purpose)	Coat trimmed flywheel housing-to-cylinder block gasket.
LOCTITE 609 (TY15969) 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 -19-11OCT94

CRANKSHAFT AND MAIN BEARING FAILURE ANALYSIS

• Scored Main Bearing:

(Diagnosis also applies to connecting rod bearing.)

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

• Galled or "Wiped" Bearings:

Fuel in lubricating oil (incomplete combustion).
Coolant in lubrication system (cracked block, 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.

S11,2015.C -19-29SEP94

15
5

CRANKSHAFT, MAIN BEARINGS, AND FLYWHEEL SPECIFICATIONS

ITEM	SPECIFICATION	WEAR LIMIT
Crankshaft Fillet Radius:		
Thrust Journal (Tangential)	3.56—4.06 mm (0.140—0.160 in.)	—
Main Journals (Tangential)	3.94—4.44 mm (0.156—0.175 in.)	—
Rod Journals (Undercut)	4.01—4.37 mm (0.158—0.172 in.)	—
Engine Stroke	128.5 mm (5.059 in.)	—
Crankshaft End Play	0.038—0.380 mm (0.0015—0.0150 in.)	—
Crankshaft Main Bearing Journal OD	95.201—95.227 mm (3.7480—3.7491 in.)	—
Main Bearing Assembled ID w/Bearing	95.270—95.320 mm (3.7508—3.7528 in.)	—
Main Bearing-to-Journal Clearance	0.030—0.107 mm (0.0012—0.0042 in.)	—
Crankshaft Connecting Rod Journal OD	76.149—76.175 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 Main Bearings Available	0.292, 0.552 mm (0.0115, 0.0217 in.)	—
Undersized Rod Bearings Available	0.292 mm (0.0115 in.)	—
Oversize Thrust Washer Available	0.18 mm (0.007 in.)	—
Main Bearing Cap Bore Specifications:		
ID without Bearing Inserts	101.651—101.677 mm (4.0020—4.0030 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 (Washer Clearance)	37.44—37.54 mm (1.474—1.478 in.)	—
Overall Cap Width	41.81—42.31 mm (1.646—1.666 in.)	—
Base Circle OD for Thrust Washer Clearance Base Circle*	129.286—130.810 mm (5.09—5.15 in.)	—

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

FG,CTM86,G15,2 -19-16SEP94

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.)	—
Maximum Front Oil Seal Installed		
Below Front Face of Seal Bore	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,CTM86,G15,3 -19-14SEP94

CRANKSHAFT, MAIN BEARINGS, AND FLYWHEEL SPECIFICATIONS—CONTINUED**TORQUES**

Vibration Damper-to-Crankshaft	230 N·m (170 lb-ft)
Main Bearing Caps	230 N·m (170 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 (97 lb-in)(8 lb-ft)
Injection Pump Gear Cover-to-Timing Gear Cover	27 N·m (20 lb-ft)
Timing Gear Cover-to-Cylinder Block*	27 N·m (20 lb-ft)
Water Pump Cover-to-Timing Gear Cover:	
5/16-in. Cap Screws	27 N·m (20 lb-ft)
3/8-in. Cap Screws	47 N·m (35 lb-ft)
Hub Drive-to-Flywheel	115 N·m (85 lb-ft)

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

RG,CTM86,G15.4 -19-14SEP94

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.

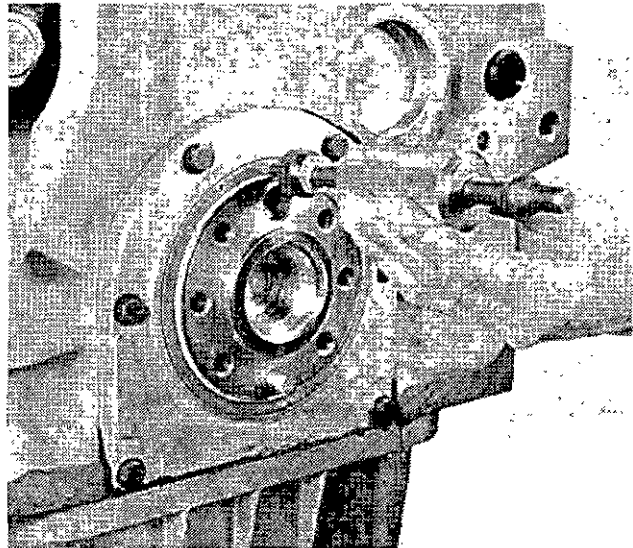
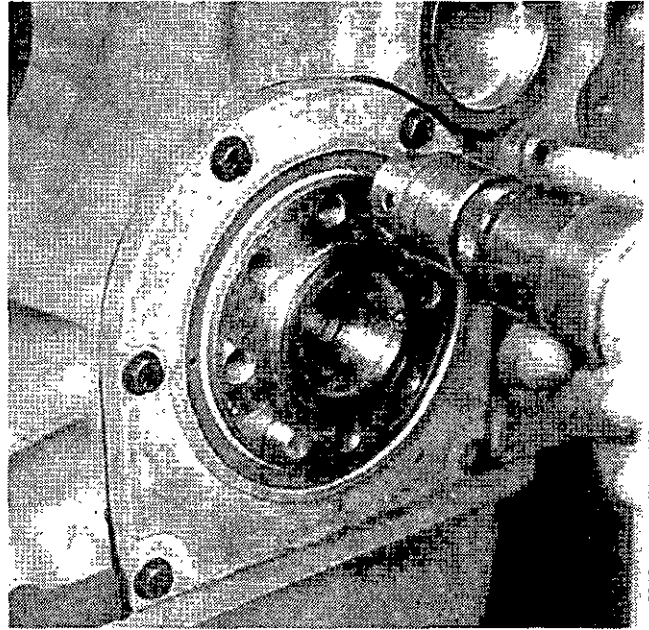
IMPORTANT: If rear oil seal is replaced, also replace rear wear sleeve (as a matched set).

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.

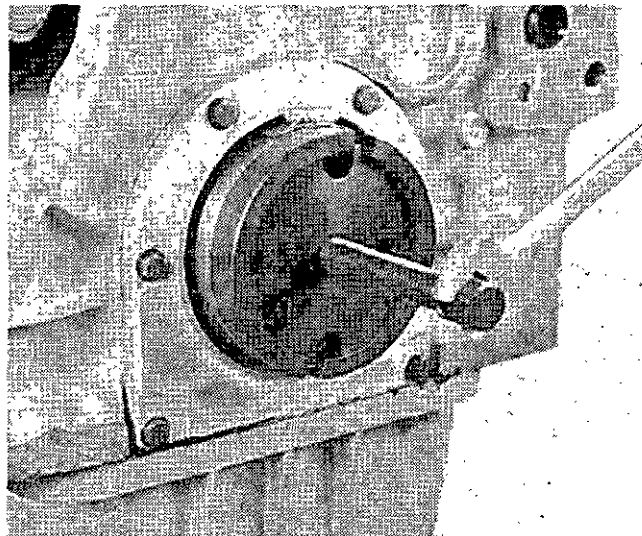
NOTE: It may be necessary to drill a small hole in seal at one or two other locations to aid in removal.

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



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.



RG56468 -JUN-26OCT92

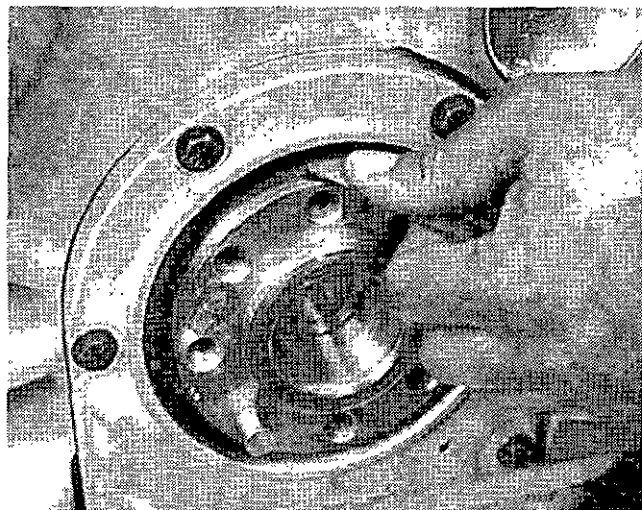
RG.CTM42,G15,50-19-29OCT92

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.)

15
10 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.



RG5622 -JUN-12AUG91

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

CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE HANDLING PRECAUTIONS

Use the following precautions for handling seal and wear sleeve:

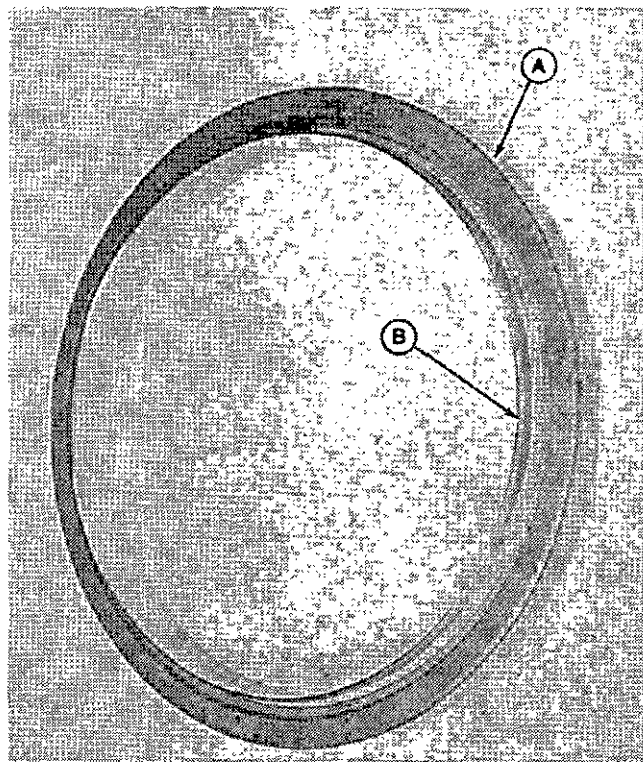
—Seal (A) and wear sleeve (B) are assembled. **DO NOT SEPARATE**. If parts become separated, discard and replace with a new assembly. Attempts to reassemble will cause the wear sleeve to damage the seal allowing engine oil to leak past seal.

—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.



UN-07JUL89
RG5575

S11.2015.GP -19-08MAR94

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.

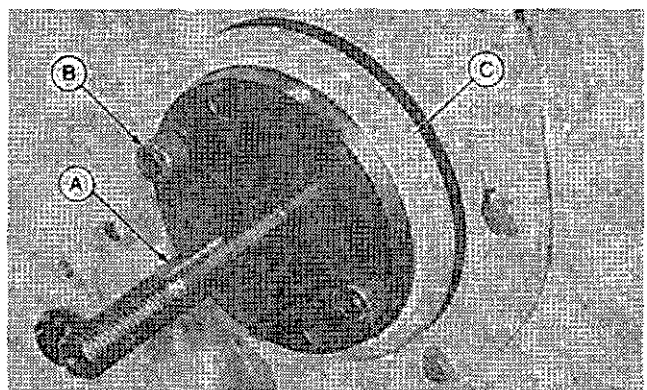


FIG 4639 -JUN-14DEC88

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.

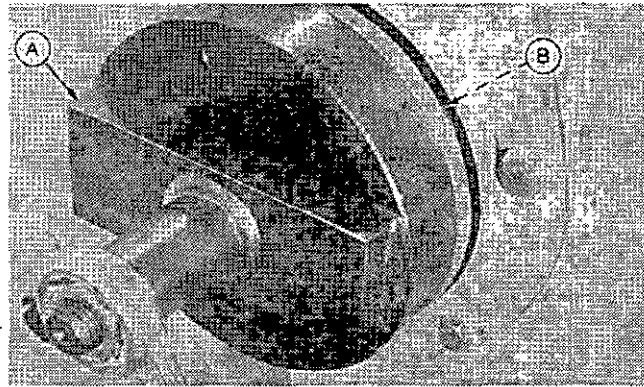
IMPORTANT: When installing the JDG478 Driver on JDG477 (85) Pilot and crankshaft flange to position oil seal/wear sleeve assembly, locate crossbar of installer at right angle (90°) to Allen head cap screws. This allows the crossbar to bottom on pilot, not head of cap screws, assuring correct installation.

S11,2015,GQ -19-16AUG94

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 -UN-14DEC88

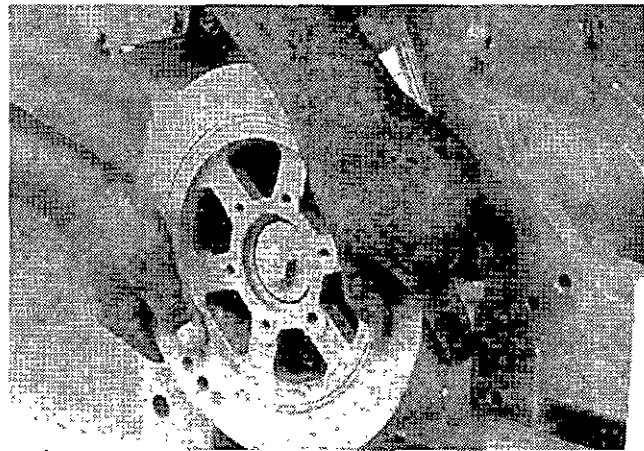
INSPECT VIBRATION DAMPER

IMPORTANT: The damper assembly is not repairable and should be replaced every 5 years or 4500 hours, whichever occurs first. Also, replace damper whenever crankshaft is replaced or major engine overhaul is performed.

Do not immerse the vibration damper or the damper pulley in cleaning solvent. Doing so may damage the rubber portions of this assembly.

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

1. Relieve tension or remove V-belts (shown removed).
2. Grasp vibration damper with both hands and attempt to turn it in both directions. If rotation is felt, damper is defective and should be replaced.



RG,CTM86,G15,5 -19-26JUL94

RG7208 -UN-26JUL94

15
13

3. Check vibration damper radial runout by positioning a dial indicator so preloaded probe (A) contacts damper O.D.

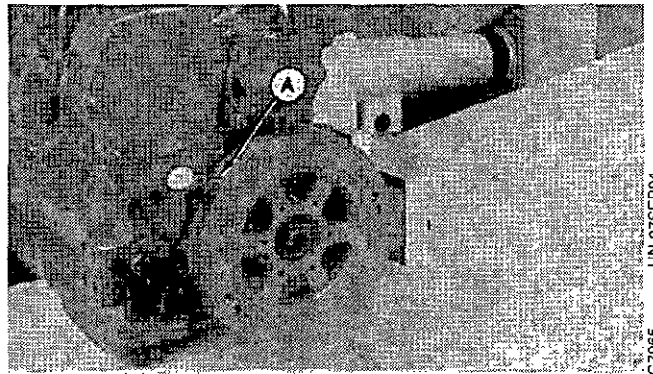
4. Rotate crankshaft using JDE81-1 or JDG820 Flywheel Turning Tool.

5. Note total dial indicator movement. Compare reading with specification below.

DAMPER RADIAL RUNOUT SPECIFICATION

Maximum 1.02 mm (0.040 in.)

If runout exceeds specifications, replace vibration damper.



RG7065 -UN-07SEP94

RG,CTM86,G15,6 -19-02SEP94

CHECK CRANKSHAFT END PLAY

1. Completely engage then release the clutch lever.

2. Place a dial indicator on damper face.

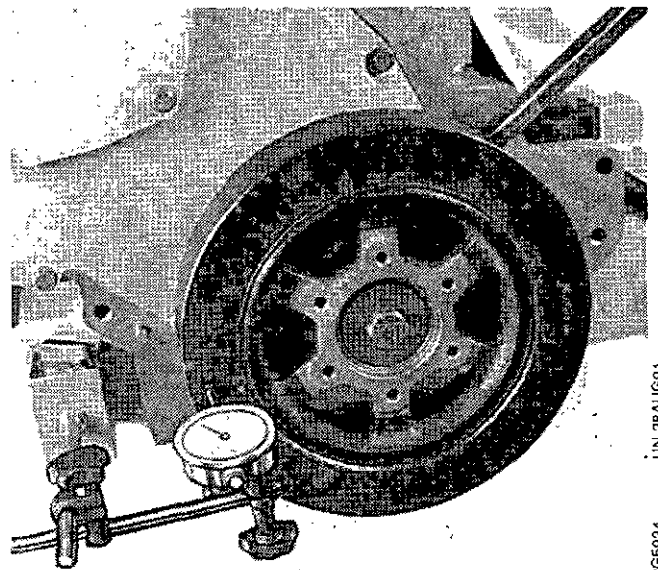
IMPORTANT: Use care not to damage or distort the timing gear cover or bearing inserts when prying. Do not pry on outer intertia ring of damper.

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

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.



RG5934 -UN-28AUG91

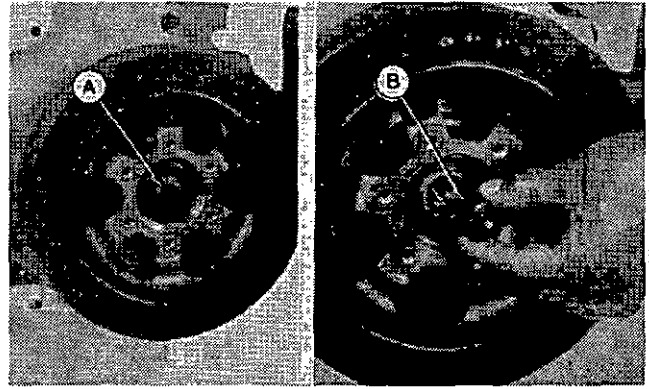
RG,CTM42,G105,8-19-29OCT92

15
14

REMOVE CRANKSHAFT VIBRATION DAMPER

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.

1. Remove pulley from damper, if equipped (shown removed).
2. Remove cap screw (A) and washer securing damper to crankshaft.
3. Install JDG787 Thread Protector (B) in nose of crankshaft.

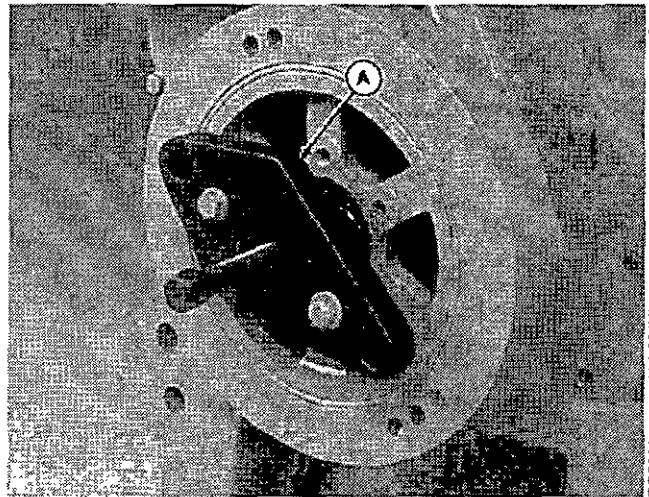


RG,CTM86,G15,7 -19-14SEP94

CAUTION: Plan a safe handling procedure to avoid personal injury or damage to damper.

4. Remove damper from crankshaft using JDG721 Hub Puller (A).

NOTE: D01207AA (OTC518) Puller Set (not shown) may also be used to remove damper.



RG,CTM86,G15,8 -19-26JUL94

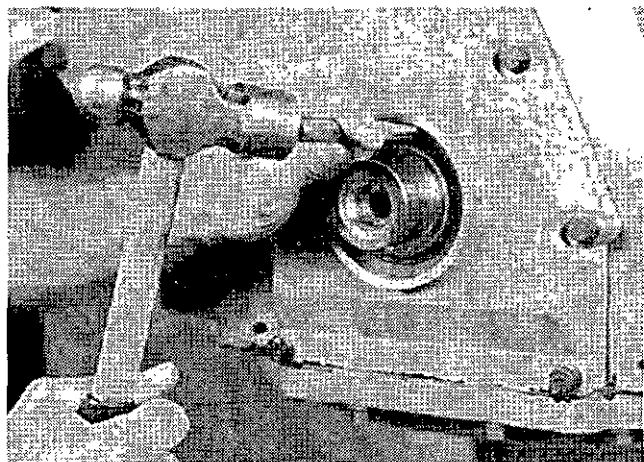
REPLACE CRANKSHAFT FRONT OIL SEAL AND WEAR SLEEVE (WITH TIMING GEAR COVER INSTALLED ON ENGINE)

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 and wear sleeve after timing gear cover is removed.

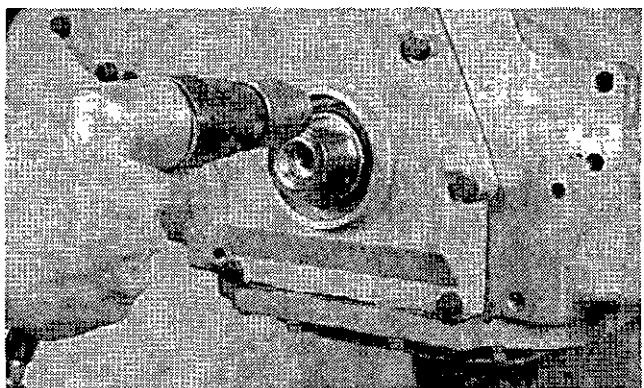
To Remove Front Oil Seal:

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



RG,CTM86,G15,9 -19-26JUL94

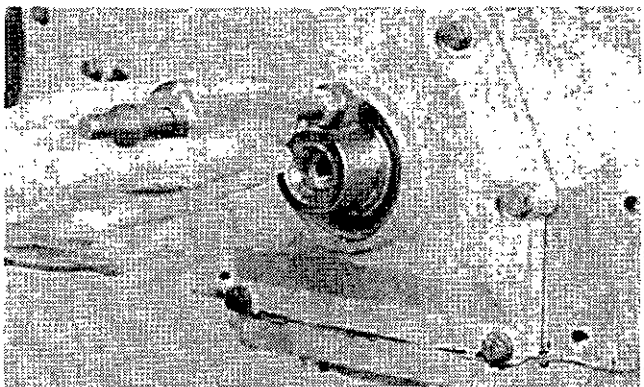
3. Drill 1/8 in. hole in casing.



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

4. Using JDG719 Seal Puller along with JDE38-2 Shank, JDE38-3 Hammer, and metal screw; remove seal.

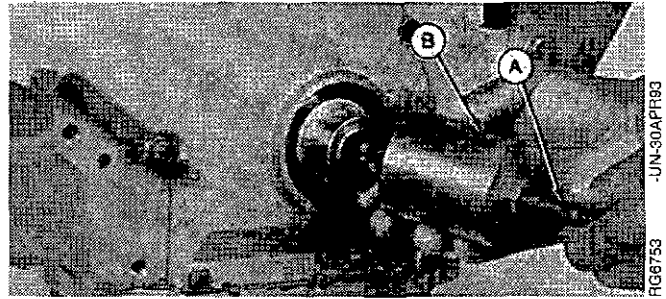
5. Remove keyway from keyslot of crankshaft.



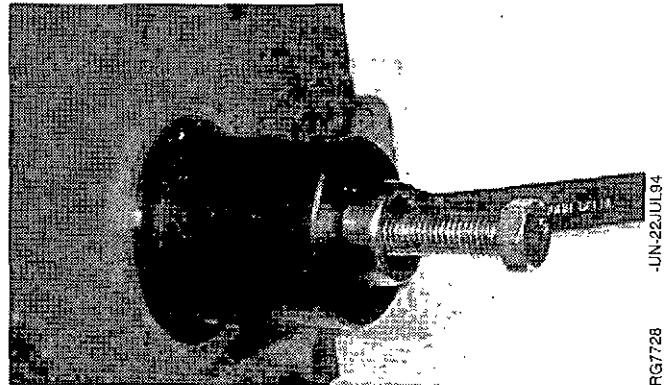
RG,CTM42,G15,40-19-29OCT92

To Remove Wear Sleeve Using JDG786:

1. Start fully threaded centering screw (A) through hex head end of puller (B) from JDG786 Front Wear Sleeve Puller until head of screw is approximately 1/2 in. from hex on puller.
2. Thread centering screw into nose of crankshaft until it bottoms. Back screw out one full turn after it bottoms.
3. Tighten puller until it is securely threaded onto wear sleeve. Back centering screw out one full turn and tighten threaded puller onto wear sleeve again.
4. Remove centering screw from nose of crankshaft and puller.



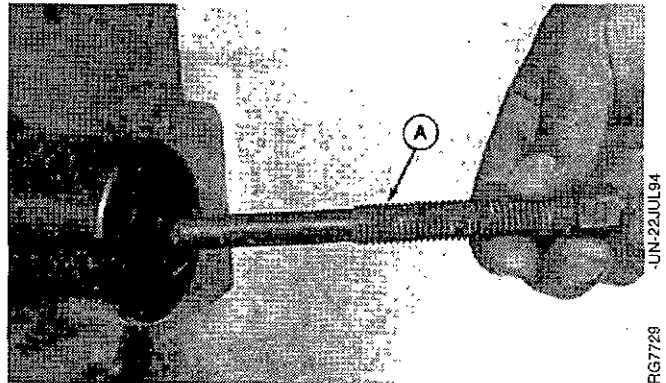
JUN-30AP183
RG6753



JUN-22JUL94
RG7728

RG,CTM86,G15,10-19-26JUL94

5. Install partially threaded forcing screw (A) into puller and tighten until it bottoms in nose of crankshaft. There is no thread engagement in crankshaft; just with puller.
6. Continue to tighten forcing screw until puller and wear sleeve are free from crankshaft flange.
7. Inspect crankshaft flange for nicks or burrs. Clean up flange with a light file and emery cloth.
8. Measure front oil seal bore runout in timing gear cover. Maximum allowable runout is 0.254 mm (0.010 in.)

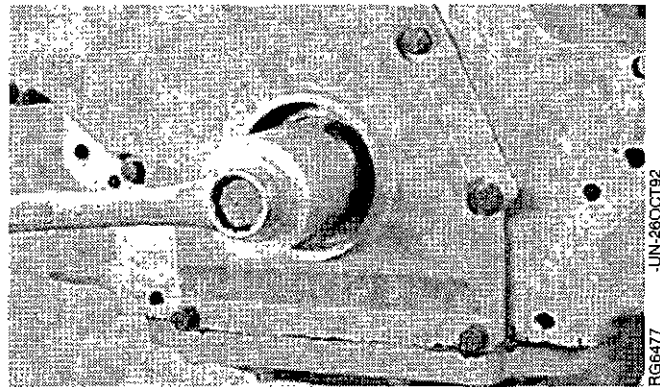
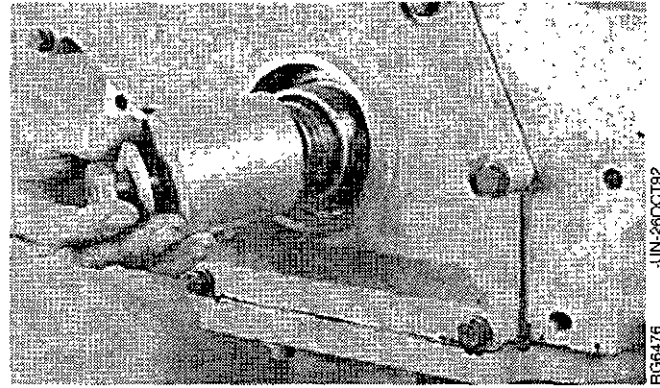


JUN-22JUL94
RG7728

RG,CTM86,G15,23-19-26JUL94

To Install Front Wear Sleeve:

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.



RG,CTM86,G15,11-19-26JUL94

15
18

To Install Front Oil Seal:

1. Place JDG720-2 Seal Protector (A) on nose of crankshaft. Lubricate ID of front oil seal lips with clean engine oil. Slide seal with spring side of seal facing engine onto seal protector. Be careful not to roll oil seal lips.

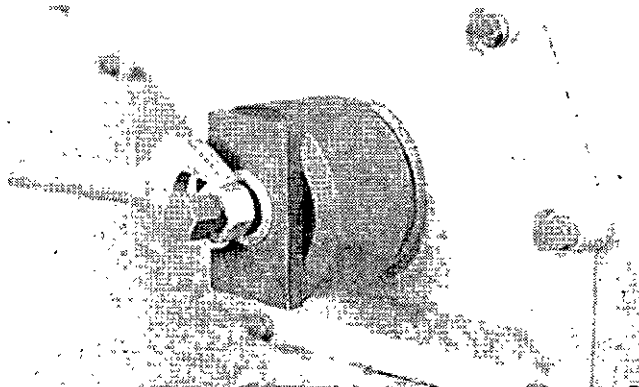
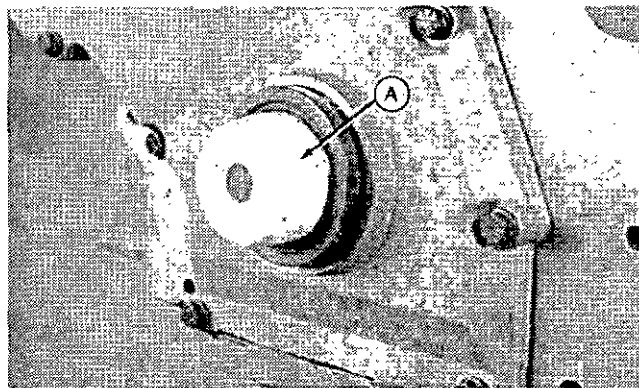
2. Place JDG720-3 Seal Installer onto seal protector against seal. Do not use spacer ring provided with tool set.

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 face of seal bore.



RG66479 -JUN-26OCT92

RG66480 -JUN-26OCT92

15
19

RG,CTM86,G15,12-19-26JUL94

REMOVE AND INSTALL TIMING GEAR COVER—ENGINE INSTALLED IN VEHICLE

6081HRW01 Engines used in 8400 tractors are equipped with front frame/oil sump, refer to TM1575 (8100, 8200, 8300, and 8400 Tractors—Repair) for access to front frame/oil sump-to-engine block cap screws.

To Remove Timing Gear Cover:

1. Remove viscous fan drive, drive housing, and coupler. (Refer to TM1575.)
2. Remove crankshaft vibration damper as detailed earlier in this group.
3. Disconnect water piping and remove water pump cover with water bypass tube. Remove and discard gaskets.
4. Back out all front frame/oil sump-to-engine block cap screws 9.5 mm (0.38 in.)
5. Disconnect engine speed sensor connector from sensor.
6. Remove injection pump drive gear cover.
7. Slowly lift engine block assembly approximately 6.4 mm (0.25 in.) using safety approved lifting equipment.

IMPORTANT: The timing gear cover must not be "dragged" horizontally while in contact with front frame/oil sump gasket. Doing so may damage gasket sealing bead.

8. Remove remaining cap screws and carefully remove timing gear cover with water pump. Remove and discard timing gear cover gasket.

9. Remove front oil seal from timing gear cover and discard seal.

10. Remove front wear sleeve from crankshaft flange and discard sleeve.

To Install Timing Gear Cover:

1. Thoroughly clean all timing gear cover gasket surfaces and front oil seal bore.

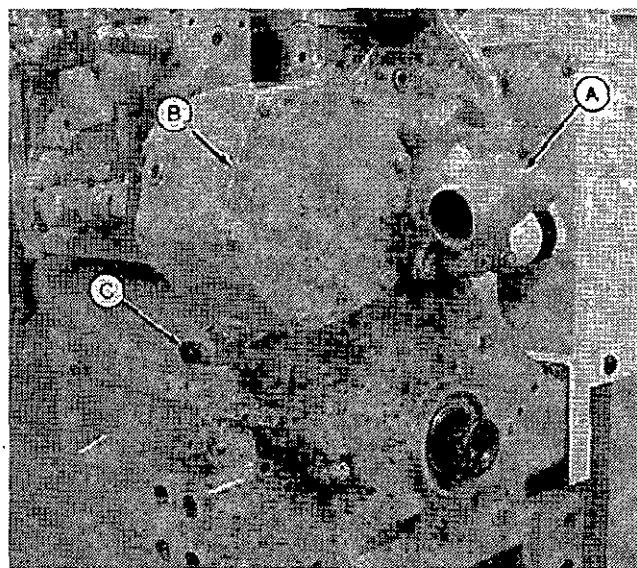
NOTE: Front wear sleeve can be installed with timing gear cover removed or installed.

2. Install a new front wear sleeve on crankshaft flange (See INSTALL FRONT WEAR SLEEVE, later in this group).
3. Install timing gear cover (See INSTALL TIMING GEAR COVER, later in this group).
4. Install front oil seal (See INSTALL CRANKSHAFT FRONT OIL SEAL WITH TIMING GEAR COVER INSTALLED ON ENGINE, later in this group).
5. Install vibration damper (See INSTALL VIBRATION DAMPER, later in this group).
6. Tighten front frame/oil sump cap screws as detailed in Group 20, Lubrication System of this manual (See TIGHTEN CAP SCREWS ON FRONT FRAME/OIL SUMP) or TM1575.
7. Complete final assembly as outlined in TM1575.

RG,CTM86,G15,33-19-27SEP84

REMOVE TIMING GEAR COVER—ENGINE REMOVED

1. Remove engine oil pan. Remove engine oil pump assembly if crankshaft is to be removed.
2. Disconnect engine speed sensor connector (shown disconnected) from sensor (C).
3. Remove injection pump drive gear cover (B).
4. Disconnect water piping and remove water pump cover (A) with water bypass tube. Remove and discard gaskets.
5. Remove remaining cap screws and remove timing gear cover with water pump. Remove and discard gasket.
6. Remove front oil seal from timing gear cover and discard seal.
7. Remove front wear sleeve from crankshaft flange and discard sleeve.



FG,CTM86,G15,13-19-27SEP94

INSPECT AND MEASURE 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.

CHECK FLYWHEEL HOUSING FACE RUNOUT

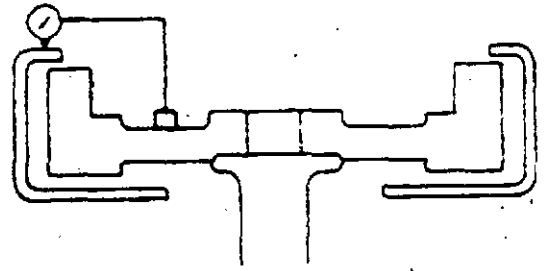
1. Mount dial indicator on flywheel. Set pointer to contact PTO mounting surface on flywheel housing at right angles. Pointer should not contact holes in flywheel housing.

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.)



-JUN-14DEC88
R22212

S55,2015.L -19-29OCT92

15
22

CHECK FLYWHEEL FACE FLATNESS

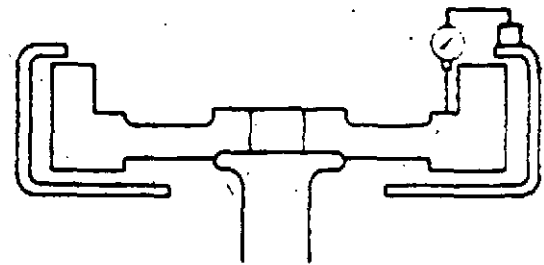
1. Mount dial indicator base on flywheel housing. Position pointer to contact driving ring mounting surface. Do not allow pointer to contact driving ring mounting holes.

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.)



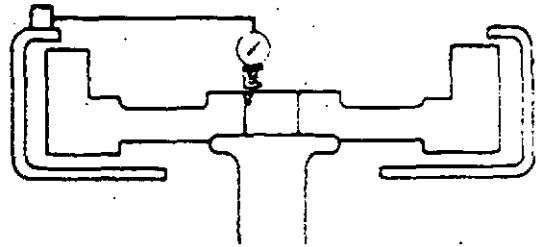
-JUN-14DEC88
R22213

S11,5005.AM -19-02FEB94

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 -19-08MAR94

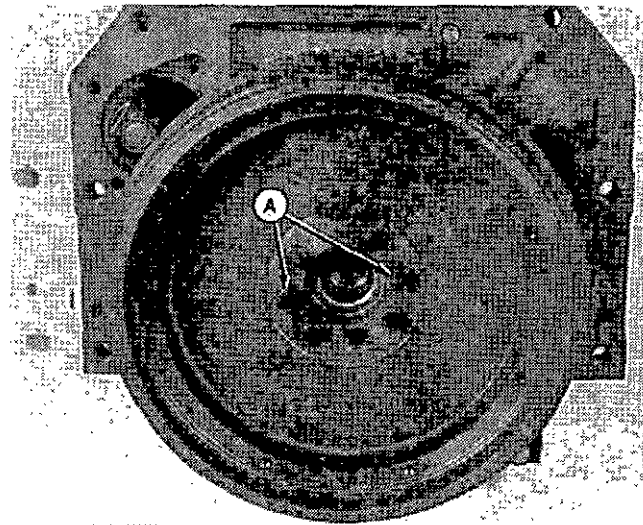
-UN-14DEC88
R22214

REMOVE FLYWHEEL

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

1. Remove two flywheel attaching cap screws (A) that are directly opposite of each other and install two pilot studs in their place, if desired.

2. Remove remaining cap screws and carefully pull flywheel from crankshaft using proper lifting equipment.



RG,CTM86,G15,14-19-27JUL94

15
23

-UN-10AUG94
RG7048

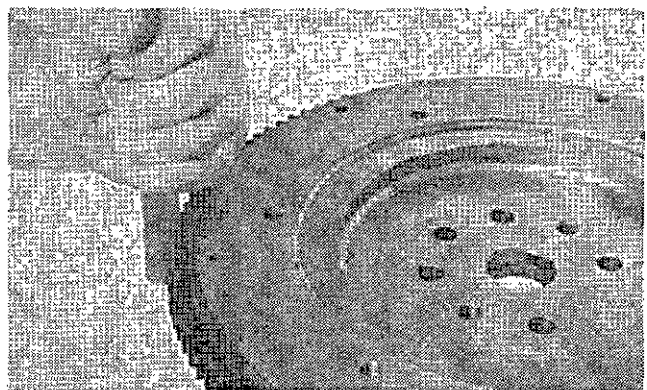
REPLACE FLYWHEEL RING GEAR

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.

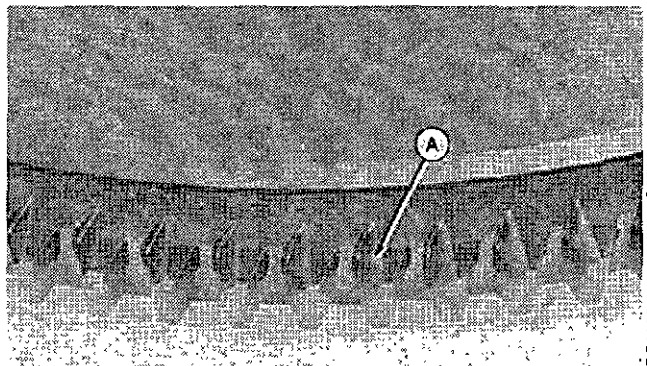
1. If ring gear is damaged, place the flywheel on a solid flat surface.
2. Remove ring gear with a brass drift and hammer.

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.



TS0096 -JUN-14OCT188



RG8836 -JUN-14OCT188

15
24

S11.2015,FX -19-16SEP92

REMOVE AND INSTALL REAR OIL SEAL HOUSING—ENGINE INSTALLED IN VEHICLE

6081HRW01 Engines used in 8400 tractors are equipped with front frame/oil sump, refer to TM1575 (8100, 8200, 8300, and 8400 Tractors—Repair) for access to front frame/oil sump-to-engine block cap screws.

IMPORTANT: Remove rear oil seal housing (A) for replacement purposes only, it is not necessary to remove seal housing for rear seal and wear sleeve replacement.

To Remove Rear Oil Seal Housing:

NOTE: Refer to TM1575 for access to rear crankshaft seal housing area.

1. Remove flywheel cover.
2. Remove transmission input shaft coupler bolts and pry coupler rearward.

NOTE: Use a set screw to separate damper from flywheel, if necessary.

3. Remove torsional damper from flywheel.
4. Remove flywheel from right side of tractor.
5. Back out all front frame/oil sump-to-engine block cap screws 9.5 mm (0.38 in.)
6. Slowly lift engine block assembly approximately 6.4 mm (0.25 in.) using safety approved lifting equipment.

IMPORTANT: The rear oil seal housing must not be “dragged” horizontally while in contact with front frame/oil sump gasket. Doing so may damage gasket sealing bead.

7. Remove rear oil seal housing (A).

8. Remove rear wear sleeve from crankshaft flange with JDG790 Wear Sleeve Puller Kit as detailed earlier in this group. Clean flange with emery cloth.

To Install Rear Oil Seal Housing:

1. Install rear oil seal housing and check runout. (See INSTALL CRANKSHAFT REAR OIL SEAL HOUSING and CHECK OIL SEAL HOUSING RUNOUT, later in this group.)

2. Carefully lower engine onto locating dowels of front frame/oil sump.

3. Tighten front frame/oil sump cap screws as detailed in Group 20, Lubrication System of this manual (See TIGHTEN CAP SCREWS ON FRONT FRAME/OIL SUMP) or TM1575.

4. Install a new rear oil seal and wear sleeve assembly. (See INSTALL CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE, WITHOUT ENGINE DISASSEMBLY, earlier in this group.)

5. Install flywheel. (See INSTALL FLYWHEEL, later in this group.)

6. Install torsional damper onto flywheel. (See TM1575.)

7. Pull transmission input shaft coupler forward, install cap screws and tighten to specified torque. (See TM1575.)

8. Install flywheel cover. (See TM1575.)

9. Start engine and check for leaks.

REMOVE REAR OIL SEAL HOUSING—ENGINE REMOVED

1. Remove rear oil seal housing (A).

IMPORTANT: Whenever rear oil seal is replaced, also replace rear wear sleeve as a matched assembly.

2. Rear oil seal (B) will come off with housing. Use a small punch and hammer to remove oil seal from housing. Discard seal.

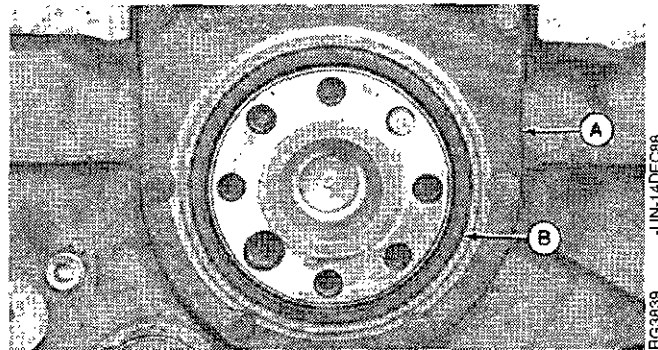
IMPORTANT: The preferred method of removing the rear wear sleeve is with JDG790 Rear Wear Sleeve Puller. If removing wear sleeve with a chisel, DO NOT gouge crankshaft flange. Nicks or burrs should be removed with a medium-grit stone. A polishing cloth (180-grit or finer) may also be used when a stone is not available.

3. Remove rear wear sleeve from crankshaft flange.

Crankshaft rear wear sleeve can be removed using one of the following procedures. However, the preferred method is using JDG790 Wear Sleeve Puller Kit.

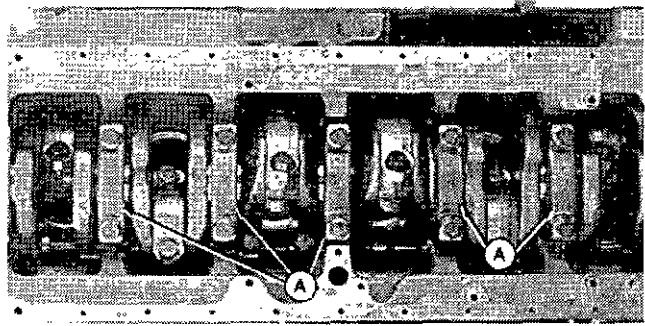
- Use JDG790 Wear Sleeve Puller to remove wear sleeve from crankshaft flange, as described earlier in this group. (See REPLACE CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE (WITH OIL SEAL HOUSING INSTALLED).)
- Use the ball side of a ballpeen hammer and tap wear sleeve across its width in a straight line (to deform and stretch sleeve).
- Score the wear sleeve in several places around OD (but do not cut) with a blunt chisel.

Remove wear sleeve from crankshaft flange. Clean flange with a light file and emery cloth.



REMOVE MAIN BEARING CAPS

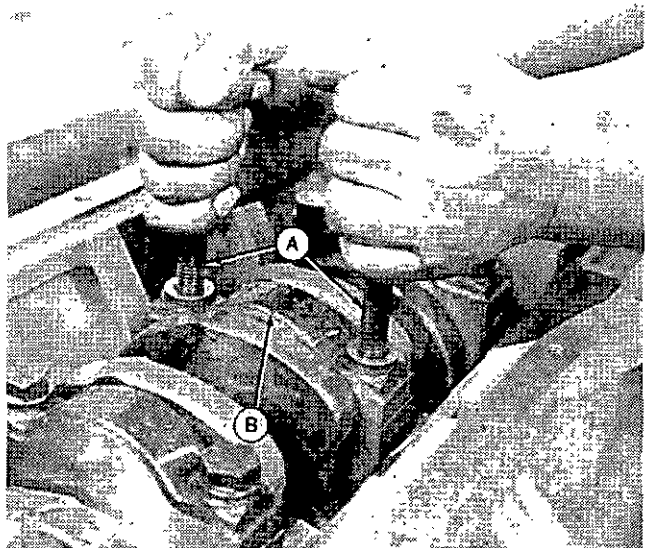
IMPORTANT: Before removing main bearing caps (A), check for proper torque on all main bearings. Also, check each bearing cap to make sure they are numbered for reassembly on the same numbered main bearing bosses. Keep matched bearings with their respective main bearing cap for comparison with crankshaft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

RG,CTM86,G15,16-19-26JUL94

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 OIL CLEARANCE later in this group.



RG,CTM42,G15,17-19-14SEP94

CHECK MAIN BEARING OIL CLEARANCE

The use of PLASTIGAGE will determine bearing-to-journal wear (oil clearance) but will not determine condition of the bearing or journal surfaces.

1. Place a strip of PLASTIGAGE in the center of the main bearing cap (with insert) about three-fourths of the width of the bearing.
2. Use oil (SAE30) on PLASTIGAGE to prevent smearing.
3. Install cap and tighten to 230 N·m (170 lb-ft).
4. Remove cap and compare width of PLASTIGAGE with scale provided on wrapper to determine oil clearance.

MAIN BEARING OIL CLEARANCE SPECIFICATIONS

Main Bearing-to-Journal Clearance 0.030—0.107 mm
(0.0012—0.0042 in.)

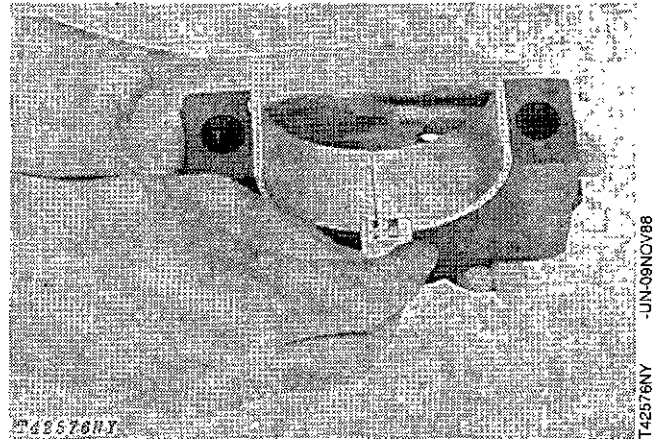


FIG. CTM86, G15, 17-19-14SEP94

REMOVE CONNECTING ROD CAPS AND REMOVE CRANKSHAFT

1. Rotate crankshaft using JDG820 or 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.

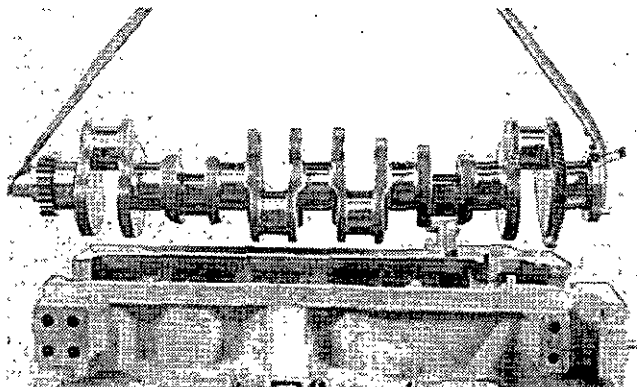
3. Install a cap screw in each end of crankshaft and attach a lifting strap to crankshaft as shown. Using proper lifting equipment, carefully raise crankshaft out of cylinder block.

4. Clean crankshaft, especially oil passages, using solvent and compressed air.

5. Put crankshaft on clean V-blocks.

6. Remove rear wear sleeve from crankshaft flange, if not previously done, using one of the following methods:

- Use JDG790 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 (but do not cut) the wear sleeve in several places around OD with a blunt chisel.



JUN-12AUG91
RG5806

JUN-12AUG91
RG5824

15
29

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 (front) crankshaft gear and (rear) oil pump drive gear for cracks, chipped teeth, or excess wear. Replace gear(s) as required. (See REPLACE FRONT CRANKSHAFT GEAR and 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 inspection.

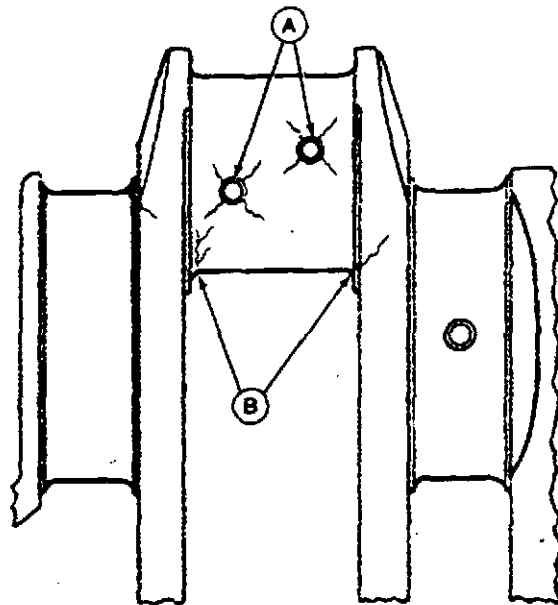


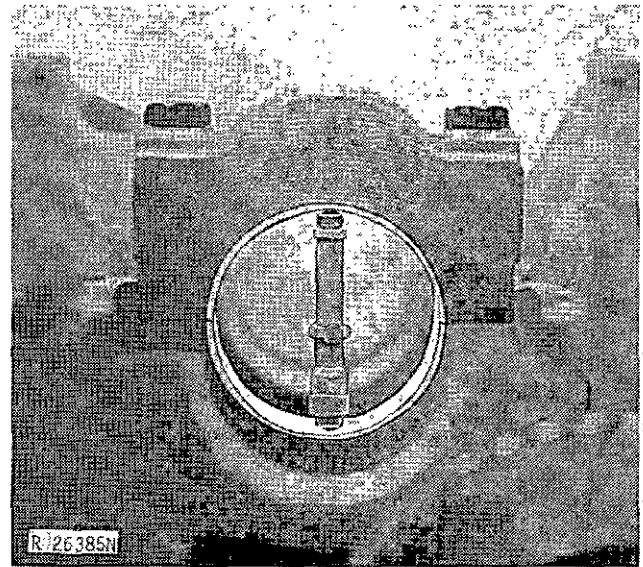
FIG5083 JUN-15DEC88

15
30

MEASURE ASSEMBLED ID OF BEARINGS AND OD OF CRANKSHAFT JOURNALS

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

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 230 N·m (170 lb-ft).
3. Measure I.D. of all assembled bearings with an inside micrometer.



UN-15DEC88
R26385N

MAIN BEARING ID SPECIFICATIONS

With Bearing	95.270—95.320 mm (3.7508—3.7528 in.)
Without Bearing	101.651—101.677 mm (4.0020—4.0030 in.)

RG,CTM86,G15,19-19-04AUG94

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

CRANKSHAFT SPECIFICATIONS

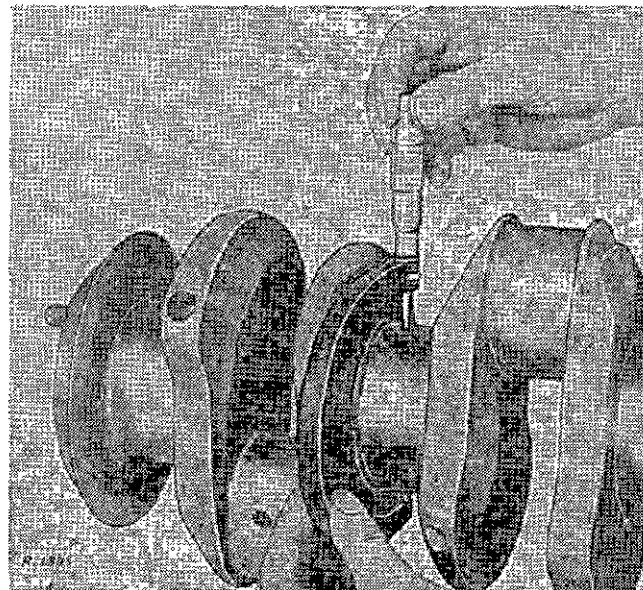
OD of Crankshaft Main Journal	95.201—95.227 mm (3.7480—3.7491 in.)
-------------------------------------	---

NOTE: If engine has previously had a major overhaul and undersized bearing inserts were used, above listed ID and OD dimensions may not be the same as those recorded. However, oil clearance should be within specifications. Oil clearance is 0.030—0.107 mm (0.0012—0.0042 in.). Replace bearings as needed.

Use crankshaft journal OD measurements to determine if journal is out-of-round or tapered.

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.)



UN-14DEC88
RG1806

RG,CTM86,G15,20-19-14SEP94

MAIN BEARING CAP LINE BORE SPECIFICATIONS

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

1. With crankshaft removed from cylinder block, install *main bearing caps without bearing inserts*.
2. Tighten main bearing cap screws to 230 N·m (170 lb-ft).
3. Measure ID of all bearing caps with an inside micrometer. Main bearing cap ID should be 95.270—95.320 mm (3.7508—3.7528 in.)

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

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 (Standard)	101.651—101.677 mm (4.0020—4.0030 in.)
Maximum Bore Diameter Variation	0.013 mm (0.0005 in.)
Maximum Bore Diameter Taper	0.008 mm (0.0003 in.)
Maximum Straightness Variation (Any Bore-to-Adjacent Bore)	0.038 mm (0.0015 in.)
Maximum Straightness Variation (5 Center Bores-to-End Bores)	0.076 mm (0.0030 in.)
Centerline of Bore-to-Top Deck	352.35—352.50 mm (13.872—13.878 in.)

15
32

FG,CTM86,G15,21-19-14SEP94

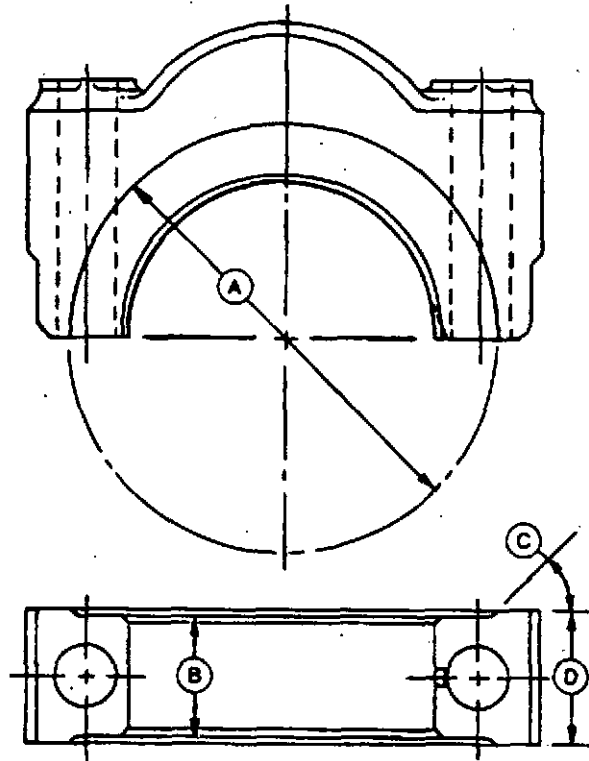
THRUST BEARING NEW PART SPECIFICATIONS

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 Diameter	129.286—130.810 mm (5.09—5.15 in.)
B—Thrust Surface Thickness	
	37.44—37.54 mm (1.474—1.478 in.)
C—Relief Angle	
	45°
D—Bearing Overall Width	
	41.81—42.31 mm (1.646—1.666 in.)

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



RG,CTM86,G15,22-19-14SEP94

RG5269 -JN-14DEC88

CRANKSHAFT GRINDING GUIDELINES

IMPORTANT: Crankshaft grinding should be done **ONLY** be experienced personnel on equipment capable of maintaining crankshaft size and finish specifications.

Crankshaft rod (pin) journals have an undercut fillet radius. DO NOT grind within this undercut area when undersize bearings are used.

In addition to the standard size main bearings, 0.292 mm (0.0115 in.) and 0.552 mm (0.0217 in.) undersize bearings are available for main bearing journals. Rod (pin) journals have only 0.292 mm (0.0115 in.) undersize bearings only. If journals are tapered, out-of-round, scored or damaged, grind the crankshaft and install the proper undersize bearings.

IMPORTANT: If undersize bearings are used, **check bearing clearance after bearing caps have been tightened to specified torque. If undersize bearings are too tight and clearance is not within specifications, the journal and bearing will be wiped clean of all oil. This would result in premature wear of parts.**

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

1. Compare the crankshaft journal measurements taken during inspection and determine the size which the journals are to be reground.

2. Grind all main journals or all connecting rod journals to the same required size.

IMPORTANT: All main journal (tangential) fillets radii must be free of any sharp grind marks or scratches. The fillet must blend smoothly into the journal and crank cheek. Check the radii with a fillet gage.

IMPORTANT: Care must be taken to avoid localized heating which often produces grinding cracks. Cool the crankshaft while grinding by using coolant generously. **DO NOT** crowd the grinding wheel into the work.

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

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

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

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

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

5. Stone the edge of all oil holes in the journal surfaces smooth to provide a radius of approximately 1.50 mm (0.060 in.).

6. When finished grinding, inspect the crankshaft for cracks with the Florescent Magnetic Particle method, or similar method. De-magnetize crankshaft after inspection.

7. Thoroughly clean the crankshaft and oil passages with solvent. Dry with compressed air.

CRANKSHAFT GRINDING SPECIFICATIONS

Item	Specification
Engine Stroke	128.5 mm (5.059 in.)
Main and Rod Journal Surface Finish	Lap 0.20 Um (8 AA)
Thrust Journal Surface Finish	Lap 0.40 Um (16AA)
Rod Journal (Undercut) Fillet Radius	4.10—4.37 mm (0.158—0.172 in.)
Main Journal (Tangential) Fillet Radius	3.94—4.44 mm (0.155—0.175 in.)
Thrust Journal (Tangential) Fillet Radius	3.56—4.06 mm (0.140—0.160 in.)
Thrust Journal Width	44.387—44.487 mm (1.7475—1.7515 in.)

Bearing Sizes Available	Crankshaft Main Journal OD	Crankshaft Rod Journal OD
Standard	95.201—95.227 mm (3.7480—3.7491 in.)	76.149—76.175 mm (2.9980—2.9990 in.)
0.292 mm (0.0115 in.) Undersize	94.909—94.935 mm (3.7366—3.7376 in.)	75.857—75.883 mm (2.9865—2.9875 in.)
0.552 mm (0.0217 in.) Undersize	94.649—94.675 mm (3.7263—3.7274 in.)	

RG,CTM86,G15,24-19-14SEP94

15
35

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.

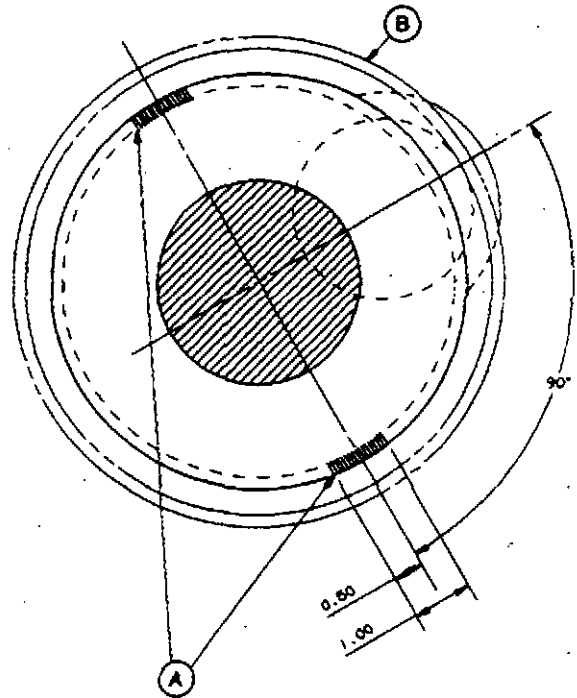
4. Heat new gear to 148°C (300°F) using either heated oil or oven heat.

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 JUN-14DEC88

15
36

S11,2515,BG -19-08AUG94

REPLACE CRANKSHAFT GEAR

NOTE: Remove crankshaft gear for replacement only; it is not necessary to remove gear for crankshaft removal.

1. Install JDG787 Thread Protector in nose of crankshaft.
2. Protect crankshaft wear sleeve surface with masking tape.
3. Remove crankshaft gear using D01251AA* Puller or an equivalent puller.
4. Discard gear after removal.
5. Remove Woodruff key from crankshaft keyway.
6. Remove masking tape.

IMPORTANT: Crankshaft gear must be installed on crankshaft before crankshaft is installed in engine, otherwise damage to thrust bearings could occur.

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

7. Heat crankshaft gear (if removed) to 148°C (300°F), using either heated oil or oven heat.

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

8. Install Woodruff key in crankshaft.
 9. Place gear on crankshaft flange. Be sure key on crankshaft is properly aligned with keyway in gear.
- IMPORTANT: When installing gear, do not gouge or nick crankshaft flange.**
10. Use JDH7 Driver to firmly seat gear against crankshaft flange.
 11. Once gear cools, reseal gear using JDH7 Driver.

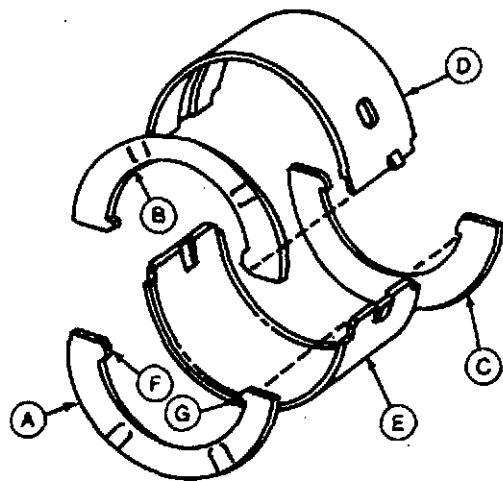
*Part of D01047AA 17-1/2 and 30-Ton Puller Set.

INSPECT 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. Two halves (A) and (C) go on cap side, not block.



- 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 -19-09MAR94

15
38

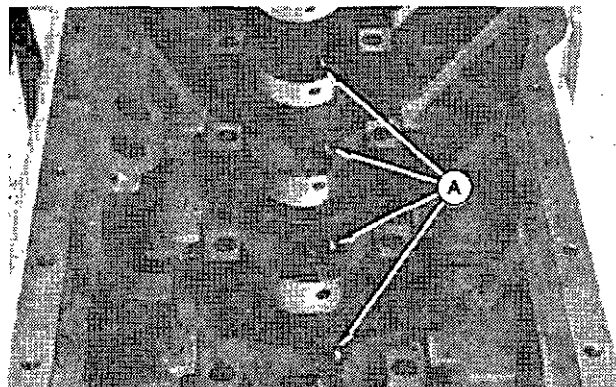
REMOVE AND CLEAN PISTON COOLING ORIFICES

1. Remove all six (four shown) piston cooling orifices (A) and inspect each cooling orifice to make sure it is not plugged or damaged.

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

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

3. Install orifices and tighten to 11 N·m (97 lb-in.).



S11,2015,CN -19-07JUL94

INSTALL MAIN BEARINGS AND CRANKSHAFT

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

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

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

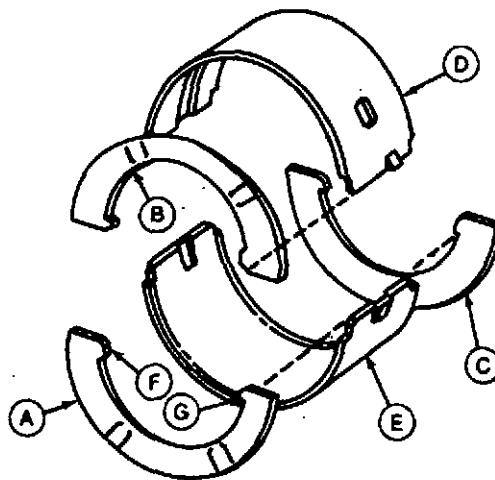
1. Install six main bearing inserts in block except No. 5 thrust bearing insert. Be sure locating tabs on inserts are properly positioned with slot in block web.

IMPORTANT: Thrust washers (A,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.

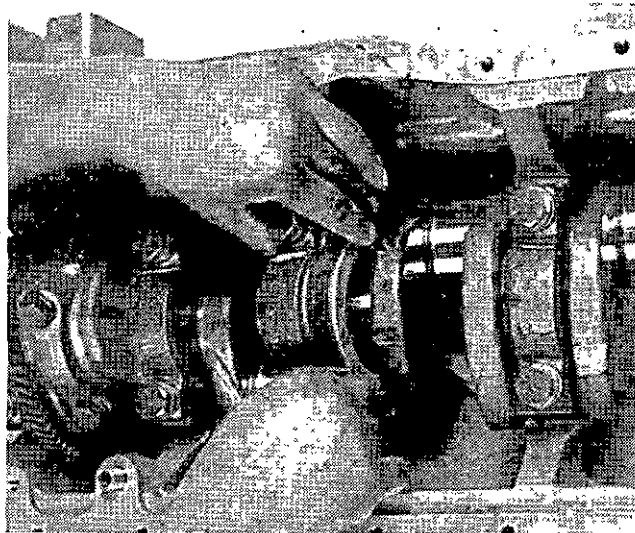
2. Install No. 5 main thrust bearing insert (D) in block. Install upper thrust washer on bearing insert at rear of block web. Be sure tangs on washer are properly positioned on thrust bearing insert.

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

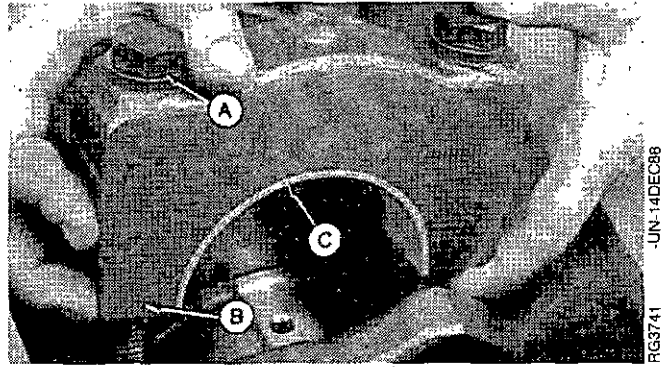
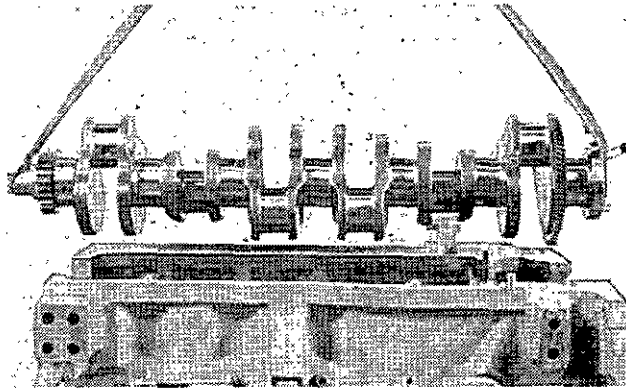
- A—Lower Rear Thrust Washer
- B—Upper Rear Thrust Washer
- C—Lower Front Thrust Washer
- D—Main Bearing Block Thrust Bearing
- E—Main Bearing Cap Thrust Bearing
- F—Large Tang
- G—Small Tang



No. 5 Main Thrust Bearing Assembly



RG,CTM42,G15,21-19-14SEP94



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

4. Carefully position crankshaft onto main bearing inserts using a hoist and lift sling.
5. 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.
6. 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.

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

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

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

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

10. Tighten No. 5 main thrust bearing cap screws to 68 N·m (50 lb-ft).

11. Tighten all main bearing cap screws (including No. 5) to 230 N·m (170 lb-ft).

12. Turn crankshaft by hand. If it does not turn easily, disassemble parts and determine the cause.

13. Install connecting rod bearings and connecting rods caps. See **INSTALL PISTONS AND CONNECTING RODS** in Group 10.

14. Check crankshaft for 0.038—0.380 mm (0.0015—0.0150 in.) end play.

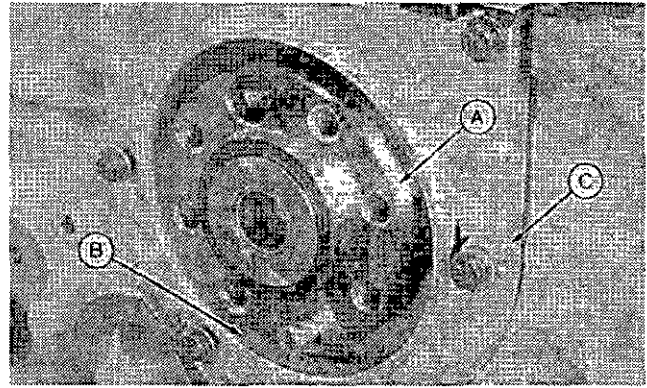
15. Install oil pump and check drive gear-to-crankshaft clearance. See **INSTALL ENGINE OIL PUMP** in Group 20.

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
-UN-14DEC88

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

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

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

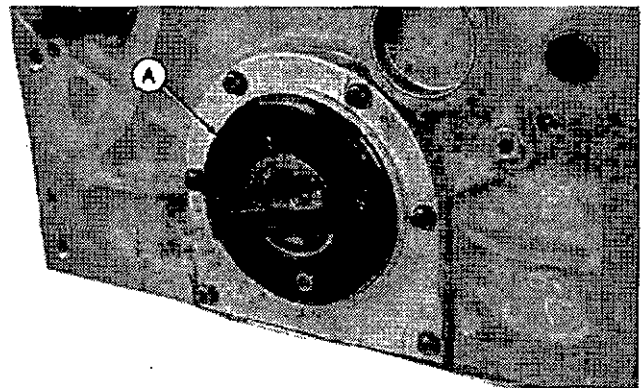
The tool is designed to center the oil seal housing in relation to crankshaft flange. However, measuring the seal housing runout after installation with a magnetic base dial indicator is recommended. Runout should not exceed 0.15 mm (0.006 in.).

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.

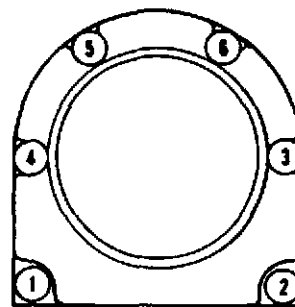
5. Remove alignment tool from end of crankshaft flange.

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

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



RG7049
-UN-10AUG84



RG6427
-UN-13OCT92

RG,CTM82,G15,14-19-14SEP94

CHECK OIL SEAL HOUSING RUNOUT

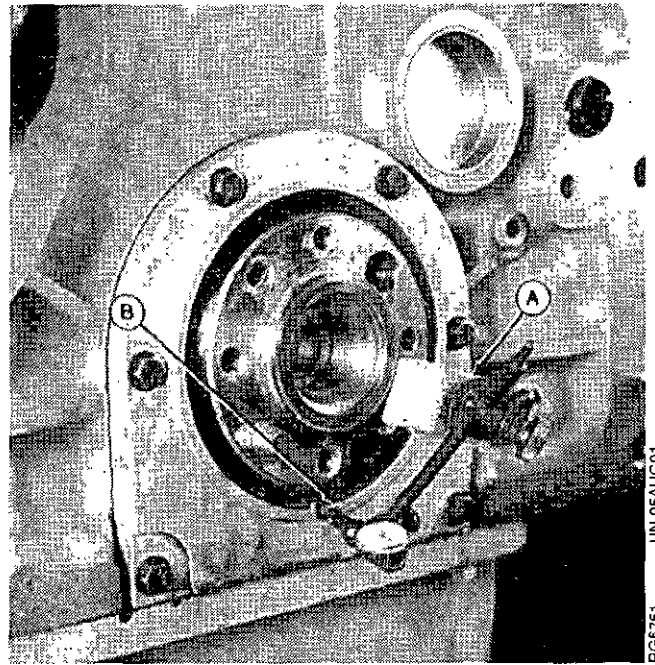
IMPORTANT: On service "short block" assemblies, rear oil seal housing runout is preset at the factory. Do not remove housing from block.

1. Position magnetic base dial indicator (A) on end of crankshaft flange as shown. Preset dial indicator tip on ID of oil seal housing bore (B).

2. Zero dial indicator and rotate crankshaft one full revolution, observe full indicator movement. 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.



15
42

S11,2515,AK -19-16AUG94

CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE HANDLING PRECAUTIONS

Use the following precautions for handling seal and wear sleeve:

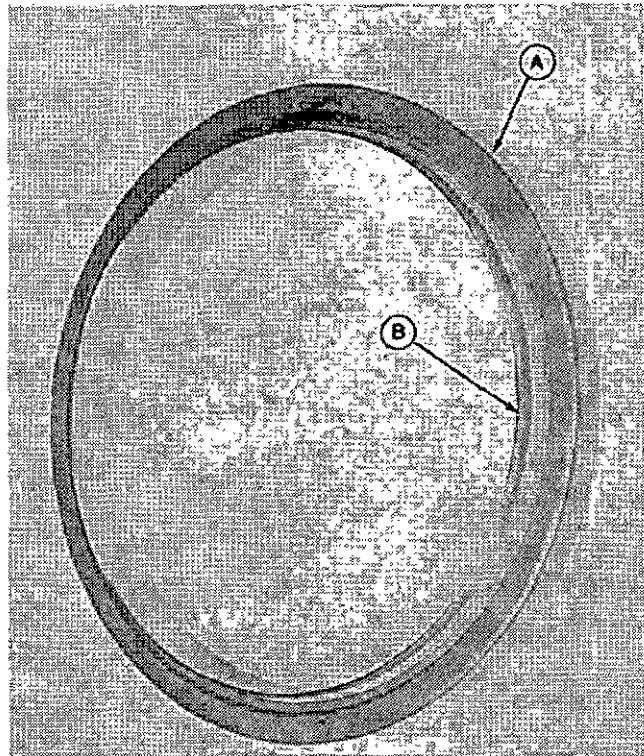
—Seal (A) and wear sleeve (B) are assembled. **DO NOT SEPARATE**. If parts become separated, discard and replace with a new assembly. Attempts to reassemble will cause the wear sleeve to damage the seal allowing engine oil to leak past seal.

—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.



S11,2015,GP -19-08MAR94

15
43

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.

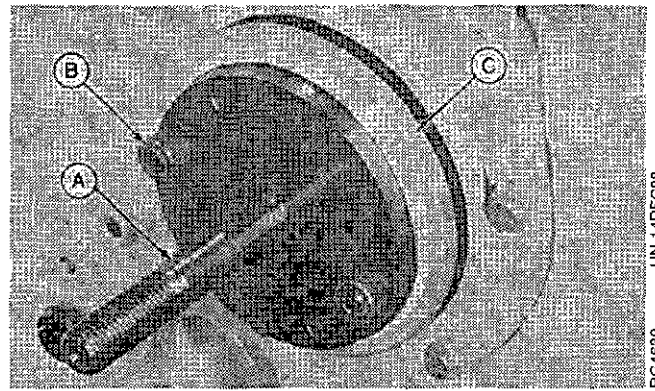
IMPORTANT: DO NOT allow sealant to get on any part of wear sleeve OD or on oil seal.

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.



RG4639 -UN-14DEC88

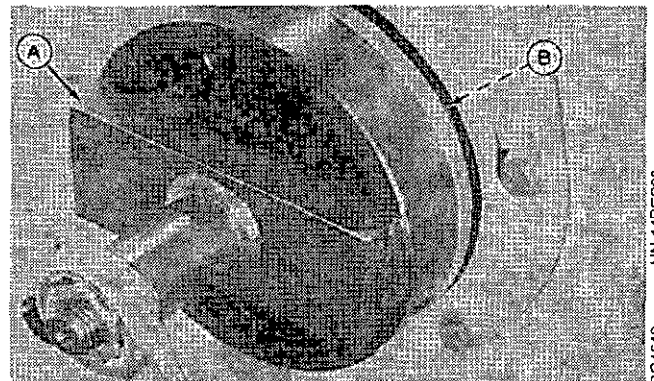
15
44

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.



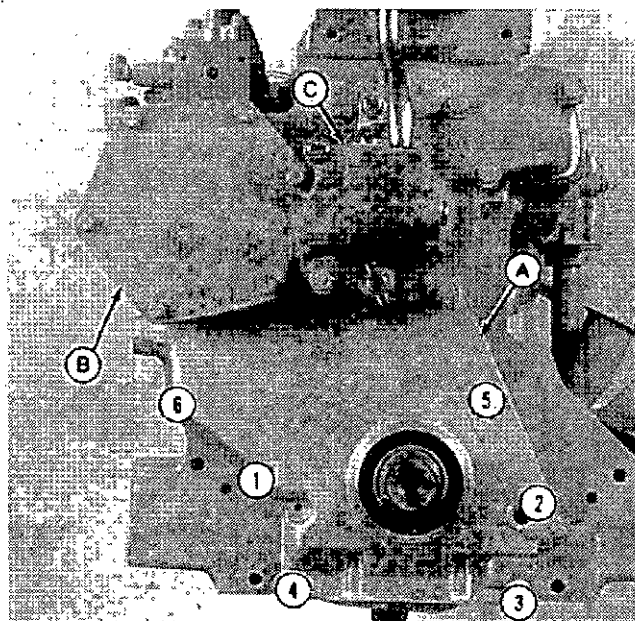
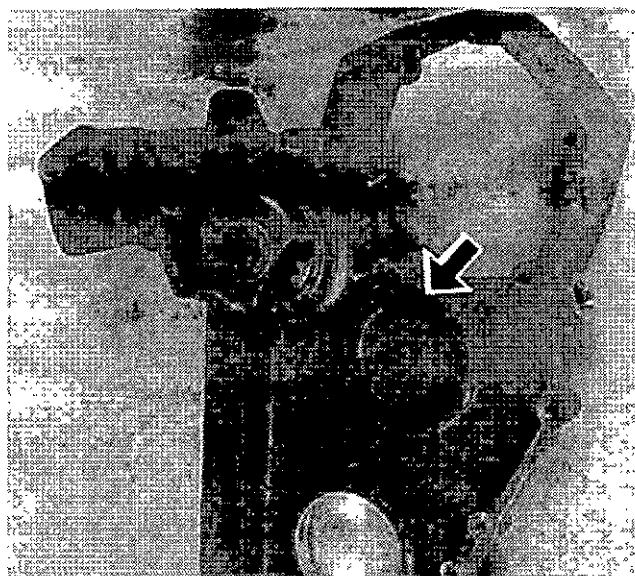
RG4640 -UN-14DEC88

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

INSTALL TIMING GEAR COVER

IMPORTANT: Tightening the timing gear cover (A) cap screws one through six in numerical sequence controls the total runout of the crankshaft flange-to-oil seal bore.

1. Lubricate thrust washer (bold arrow) with TY6333 or TY6347 High Temperature Grease and install in timing gear cover tabs.
2. Install a new gasket on engine block. Apply a light film of grease to the gasket to hold it in place.
3. Install timing gear cover. Tighten cap screws one through six to 27 N·m (20 lb-ft) in numerical sequence, as shown.
4. Install injection pump drive gear cover (B) using a new gasket and tighten cap screws to 27 N·m (20 lb-ft).
5. Install water pump cover using a new gasket. Tighten 5/16-in. cap screws to 27 N·m (20 lb-ft) and 3/8-in. cap screws to 47 N·m (35 lb-ft).
6. Trim timing gear cover gasket flush with oil pan gasket rail.
7. Using a new O-ring, install magnetic speed sensor in timing gear cover, if removed.
8. Install crankshaft front wear sleeve and oil seal. (See INSTALL CRANKSHAFT FRONT OIL SEAL, later in this group.)

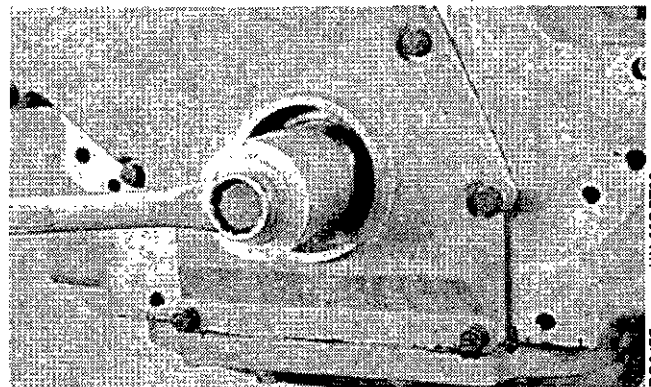
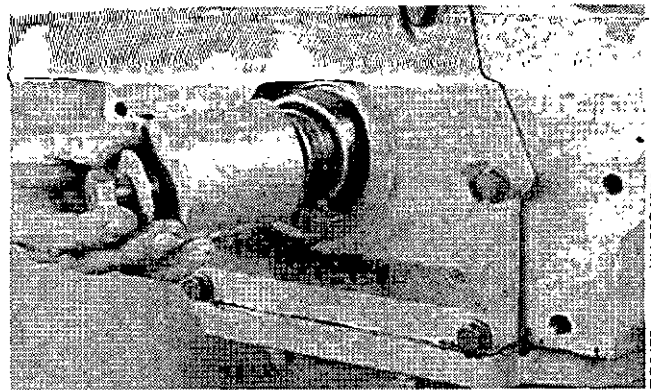


RG,CTM86,G15,27-19-14SEP94

INSTALL FRONT WEAR SLEEVE

NOTE: Front wear sleeve can be installed with timing gear cover removed or installed.

1. Coat I.D. of new wear sleeve with LOCTITE 609 Retaining Compound or equivalent. Position wear sleeve on crankshaft flange.
2. Use the JDG467 Driver (from JDE3 Installer Set), along with large washer and cap screw that secures damper to crankshaft. Tighten cap screw until driver bottoms.
3. Remove installation tools. Clean any sealant from OD of wear and ID of seal bore.



RG,CTM86,G15,28-19-26,JUL94

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.

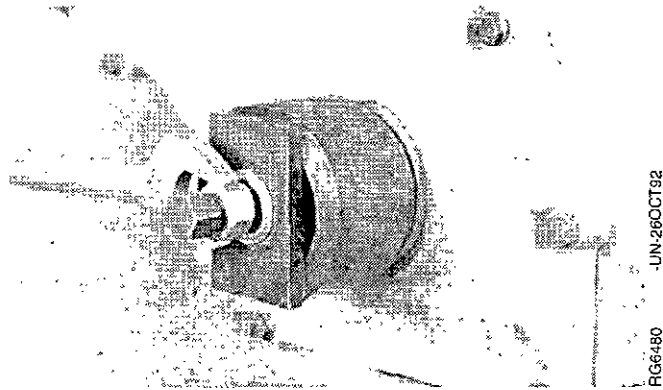
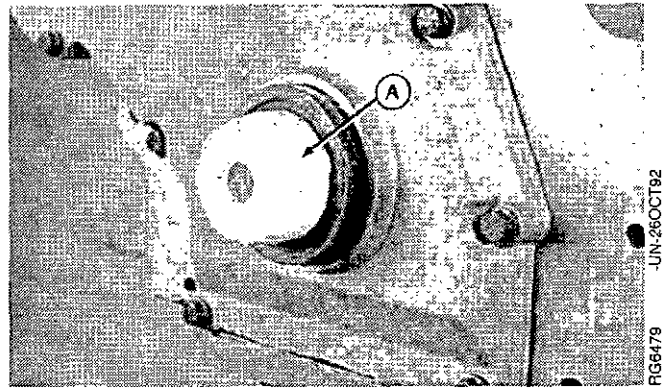
2. Place JDG720-3 Seal Installer onto seal protector against seal. Do not use spacer ring provided with tool set.

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.



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

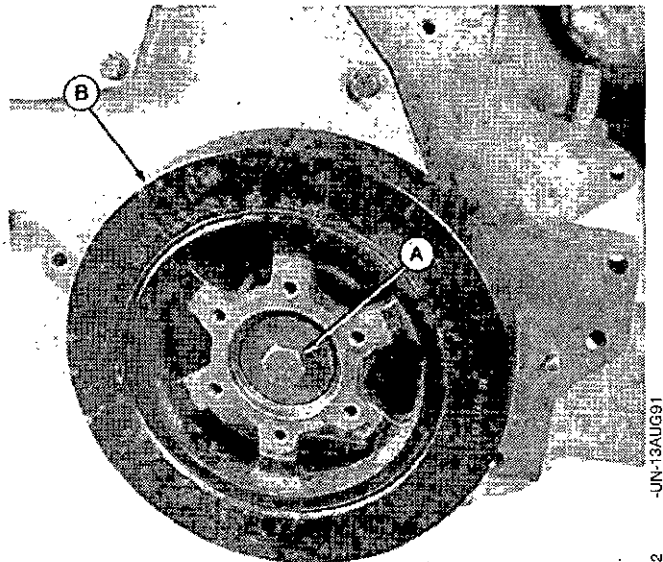
INSTALL VIBRATION DAMPER

1. Install crankshaft Woodruff key with tab facing toward front of engine and key firmly seated in keyway. Position damper (B) 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 (A). Tighten cap screw until it just bottoms out.

3. Remove cap screw and install original cap screw with same hardened washer.

4. Tighten cap screw to 230 N·m (170 lb-ft).



RG,CTM86,G15,29-19-26JUL94

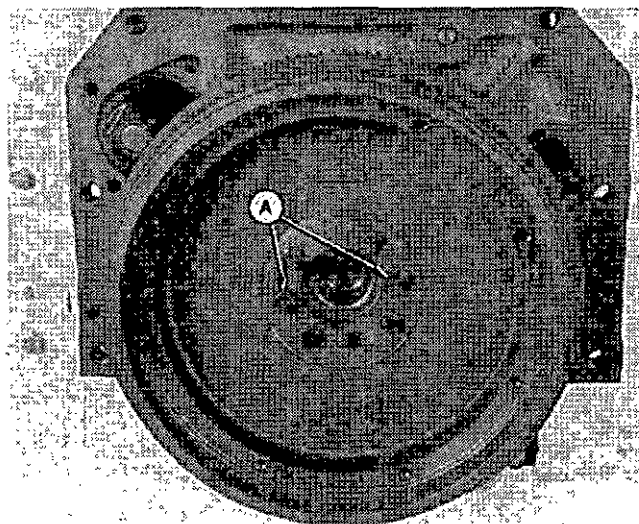
INSTALL FLYWHEEL

Two guide studs may be used at cap screw locations (A) opposite each other to aid in flywheel installation.

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

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

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



RG7046 -JUN-10AUG94

RG,CTM86,G15,30-19-26JUL94

15
48

COMPLETE FINAL ASSEMBLY

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

RG,CTM86,G15,31-19-26JUL94

Group 16 Camshaft and Timing Gear Train

SPECIAL OR ESSENTIAL TOOLS

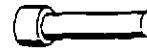
NOTE: Order tools according to information given in the U.S. SERVICE-GARD™ Catalog or in the European Microfiche Tool Catalog (MTC).

DX,TOOLS -19-05JUN91

Timing Pin JDE81-4

RG5068 -UN-23AUG88

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



RG,JDE814,86 -19-26OCT94

Magnetic Follower Holder Kit D15001NU

RG5073 -UN-23AUG88

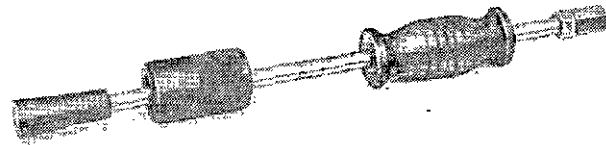
Hold cam followers when removing or installing camshaft.



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.

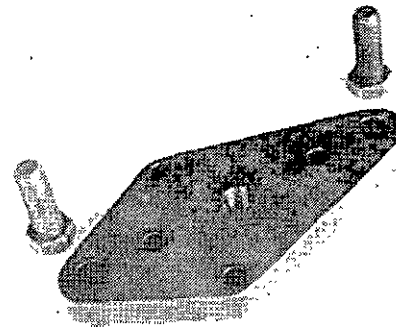


RG78104H1 -UN-15DEC88

S53,D01299,AAA -19-09SEP91

Hub Puller Kit JDG721

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



RG5763 -UN-06AUG81

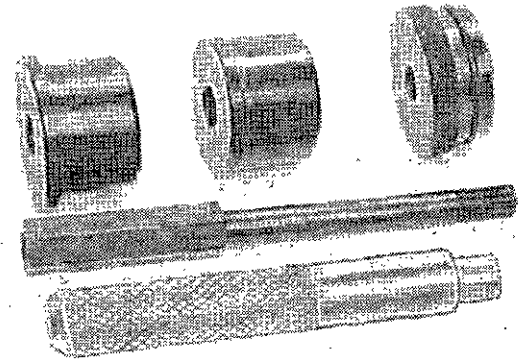
RG,JDG721 -19-03MAY93

Camshaft and Timing Gear Train

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.



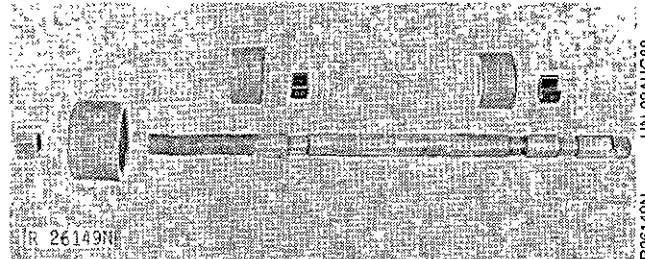
S53_JDG405,A -19-28APR92

RG4228 -UN-27JAN92

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.

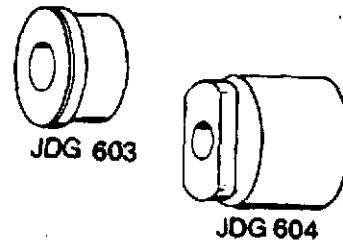


S53_JDE6A -19-09SEP91

R26149N -UN-23AUG88

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.

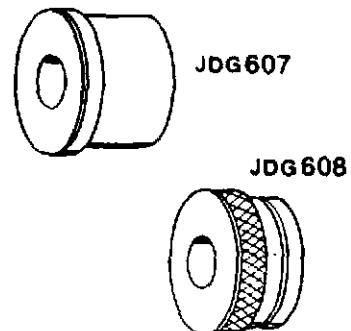


S53_JDG602 -19-09SEP91

RG5336 -UN-23AUG88

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.



S53_JDG606 -19-09SEP91

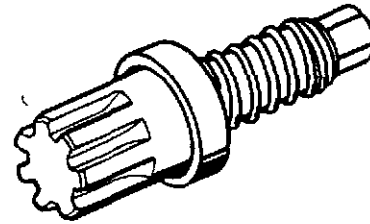
RG5337 -UN-26AUG87

16
2

Camshaft and Timing Gear Train

Flywheel Turning Tool JDG820

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



RG7056 -UN-10AUG94

RG.JDG820 -19-04AUG94

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 installation.
PERMATEX AVIATION (Form-A-Gasket No.3) (TY6299)	Lubricate camshaft bore steel cap plug.

RG.CTM42,G16,1 -19-29OCT92

16
3

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.)	—
Camshaft Gear-to-Injection Pump Drive Gear Backlash	0.051 mm (0.0020 in.) minimum	—
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	7.69—7.79 mm (0.303—0.307 in.)	7.19 mm (0.283 in.)
Exhaust	8.25—8.35 mm (0.325—0.329 in.)	7.75 mm (0.305 in.)
Cam Follower OD	17.33—17.35 mm (0.682—0.683 in.)	—
Cam Follower Bore Diameter in Block	17.384—17.440 mm (0.6845—0.6865 in.)	—
Valve Lift at 0.00 mm (in.) Clearance:		
Intake	13.53—13.71 mm (0.533—0.540 in.)	12.65 mm (0.498 in.)
Exhaust	14.52—14.70 mm (0.572—0.579 in.)	13.64 mm (0.537 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,CTM86,G16.1 -19-15SEP94

CAMSHAFT AND TIMING GEAR TRAIN TORQUES

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)
Injection Pump Drive Gear Cover	27 N·m (20 lb-ft)
Water Pump Cover-to-Timing Gear Cover:	
5/16 in. Cap Screws	27 N·m (20 lb-ft)
3/8 in. Cap Screws	47 N·m (35 lb-ft)

RG,CTM86,G16,2 -19-15SEP94

CHECK VALVE LIFT

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

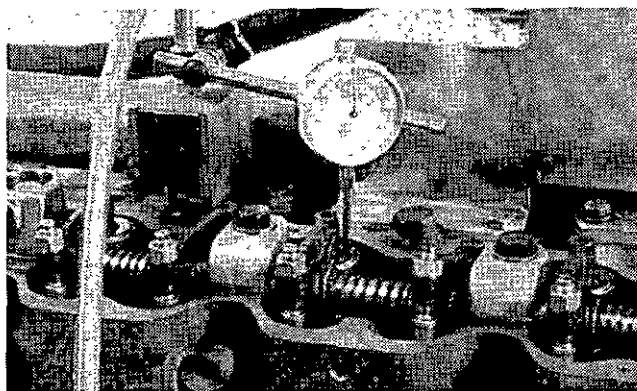
IMPORTANT: For a more accurate measurement, it is recommended that valve lift be measured at 0.00 mm (in.) valve clearance.

1. Remove rocker arm cover. Loosen locknut on rocker arm and 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 tool 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	13.53—13.71 mm (0.533—0.540 in.)
Wear Tolerance	12.65 mm (0.498 in.)
Exhaust	14.52—14.70 mm (0.572—0.579 in.)
Wear Tolerance	13.64 mm (0.537 in.)

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



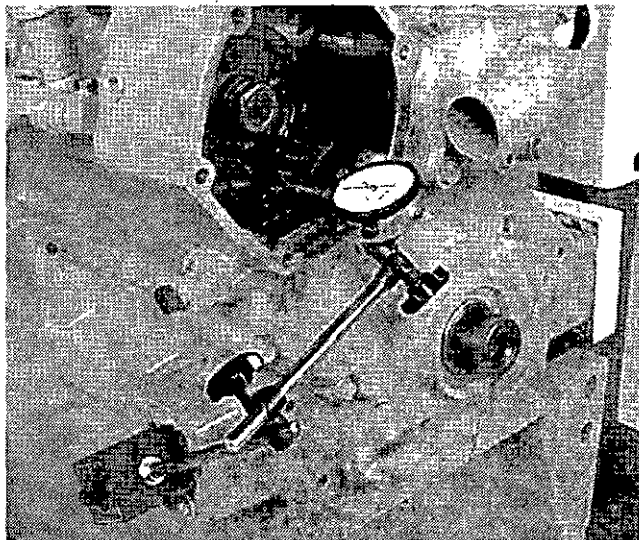
RG6627 JUN-14DEC92

RG,CTM86,G16,3 -19-15SEP94

CHECK CAMSHAFT END PLAY AND MEASURE GEAR BACKLASH

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

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



UN-28JUL94
RG7211

CAMSHAFT END PLAY SPECIFICATIONS

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

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

4. Position indicator plunger tip against camshaft gear tooth with a preload.
5. Measure backlash between camshaft drive gear and crankshaft gear in three (3) different positions around the camshaft gear. Compare readings with specifications given below.

CAMSHAFT DRIVE GEAR-TO-CRANKSHAFT GEAR BACKLASH SPECIFICATION

Camshaft Gear Backlash	0.076 mm (0.003 in.) min.
----------------------------------	---------------------------

Replace gears if backlash is not within specification.

FG,CTM86.G16,4 -19-15SEP94

REMOVE VIBRATION DAMPER AND TIMING GEAR COVER

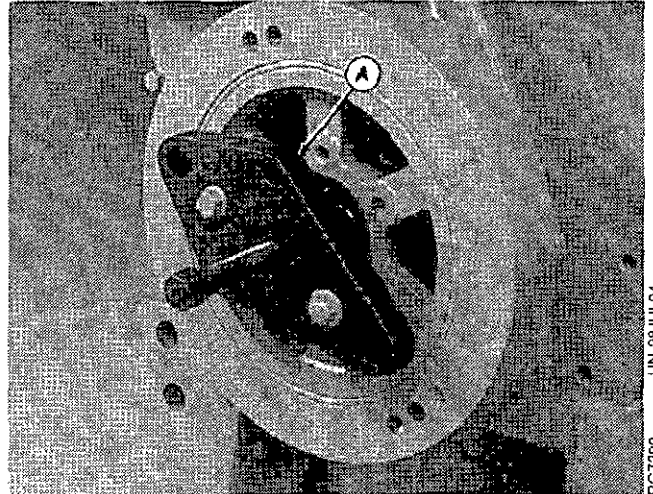
For timing gear cover removal procedure with engine installed in vehicle, refer to REMOVE AND INSTALL TIMING GEAR COVER—ENGINE INSTALLED IN VEHICLE, in group 15.

1. Drain oil (if not previously done), and remove oil pan. Remove oil pump if crankshaft is to be removed.
2. Remove cap screw and washer on damper pulley. Install JDG787 Thread Protector in nose of crankshaft.

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 damper or strike with a hammer.

3. Remove damper from crankshaft using JDG721 Hub Puller (A).

NOTE: D01207AA (OTC518) Puller Set (not shown) may also be used to remove damper.



RG7209
-UN-26JUL94

RG.CTM86,G16,5 -19-27SEP94

Camshaft and Timing Gear Train

4. Disconnect speed sensor wiring connector (C, shown disconnected) and remove injection pump drive gear cover (B).

5. Check camshaft end play. (See CHECK CAMSHAFT ENDPLAY earlier in this group.)

IMPORTANT: Whenever timing gear cover is removed, ALWAYS install a new front oil seal and wear sleeve.

6. Remove water pump cover (A). Remove all remaining cap screws and remove timing gear cover.

7. Remove front oil seal from timing gear cover. Install a new seal after timing gear cover is installed. See **INSTALL FRONT OIL SEAL (WITH TIMING GEAR COVER INSTALLED ON ENGINE)** in Group 15.

8. Remove crankshaft front wear sleeve. (See group 15.)

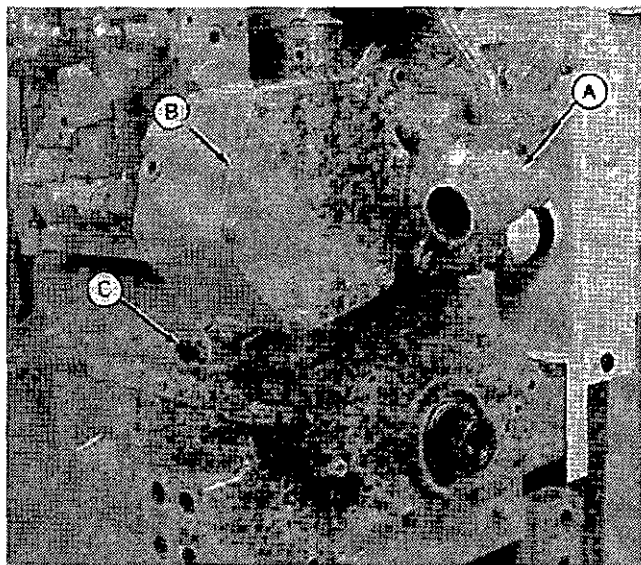


FIG 210
-UN-28JUL94

FG,CTM86,G16,6 -19-15SEP94

REMOVE CAMSHAFT

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

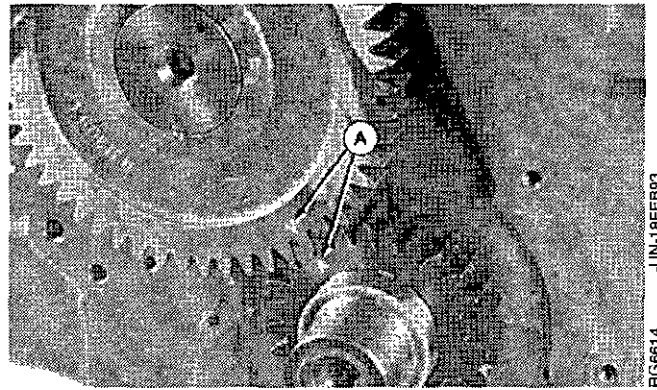
1. Drain engine oil and coolant, if not previously done. Remove timing gear cover as detailed earlier in this group.

2. Rotate engine flywheel with JDE81-1 or JDG820 Flywheel Rotation Tool and lock engine at No. 1 cylinder's "TDC-Compression" stroke with JDE81-4 Timing Pin. Timing marks (A) on camshaft gear and crankshaft gear should be aligned.

If timing marks are not aligned, remove timing pin and continue to rotate engine until marks align. Timing pin should enter hole in flywheel. Engine will be locked at No. 1 "TDC-Compression" stroke.

3. Remove rocker arm cover, rocker arm assembly and push rods. (See Group 05, Cylinder Head and Valves.)

4. When removing camshaft with engine on rollover stand, roll engine to a position where followers fall away from camshaft lobes (oil pan side up) or hold cam followers away from lobes with D15001NU Magnetic Holding Set.

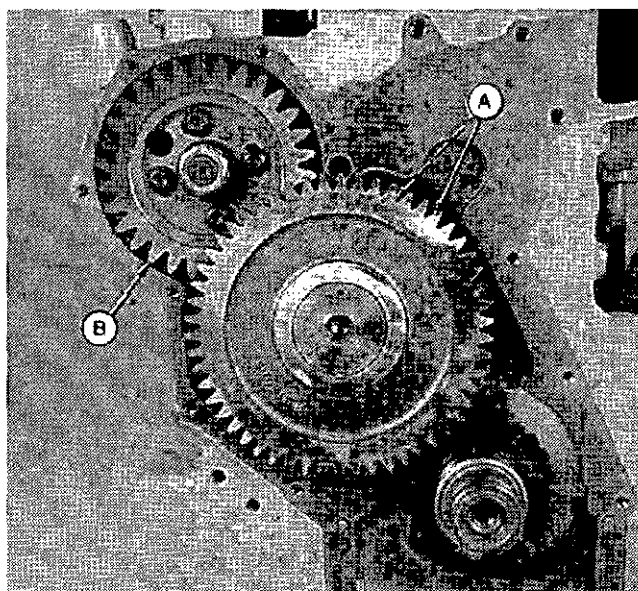


RG.CTM86.G16,7 -19-15SEP94

Camshaft and Timing Gear Train

5. Examine both camshaft gears (A) and injection pump drive gear (B) for worn or damaged gear teeth. Gears should have a minimum backlash of 0.051 mm (0.0020 in.).

NOTE: Timing marks on crankshaft and camshaft gear should be aligned and No. 1 cylinder locked at "TDC Compression" stroke when removing camshaft.



RG7215
-UN-28JUL94

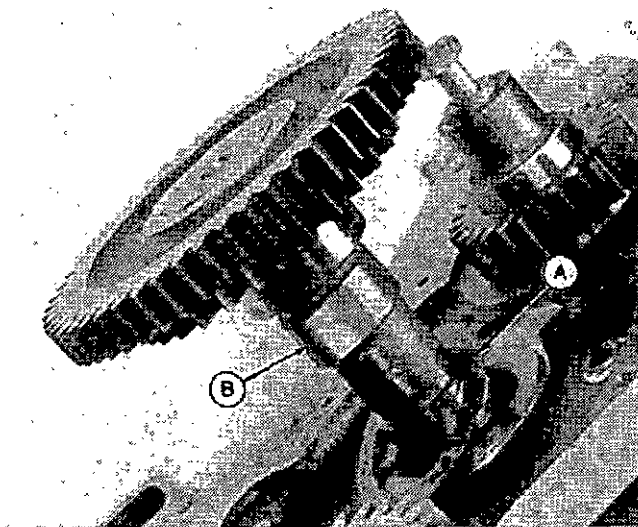
RG.CTM86,G16,9 -19-15SEP94

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

NOTE: Rotate camshaft carefully to aid in removing.

7. Remove thrust washer (A) from behind cam gears.

8. Remove cam followers from cylinder block.



16
11
RG7057
-UN-10AUG94

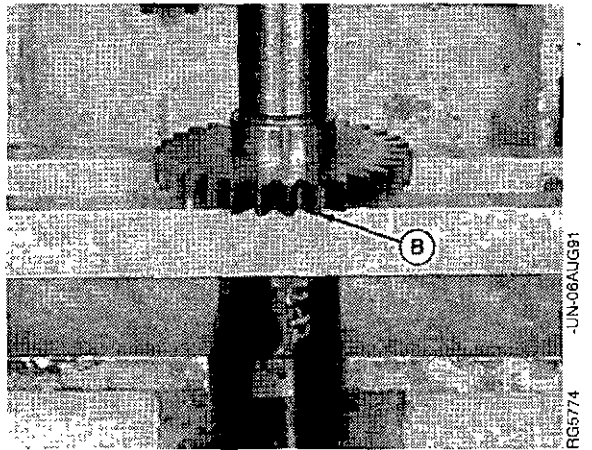
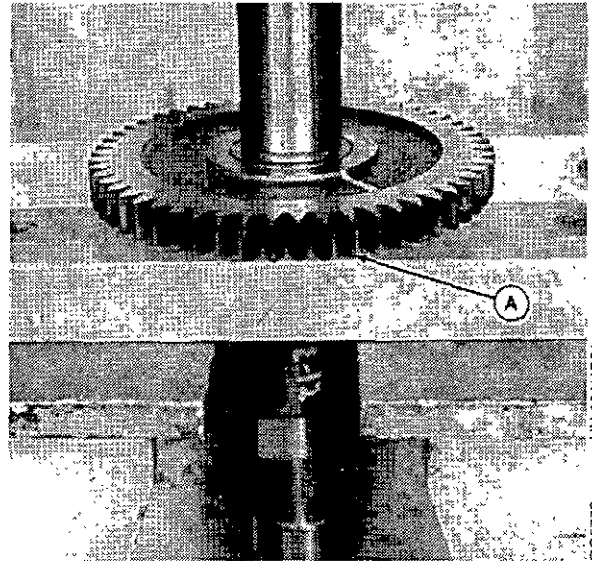
RG.CTM86,G16,10-19-15SEP94

REMOVE CAMSHAFT GEARS

NOTE: Camshaft gears are pressed onto the camshaft. Removal of gears from camshaft will require approximately a 10-ton press.

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

1. Support outer camshaft gear (A) in a press.
2. Remove outer gear from camshaft.
3. Support inner camshaft gear (B) in a press.
4. Remove inner gear from camshaft.
5. Clean camshaft and gears in solvent. Dry with compressed air.



RG,CTM42,G16,17-19-29OCT92

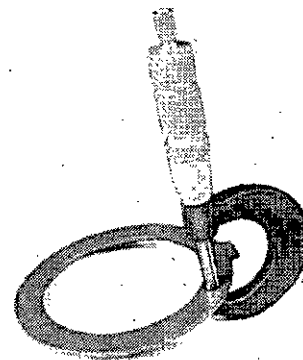
MEASURE THRUST WASHER THICKNESS

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.



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

16
12

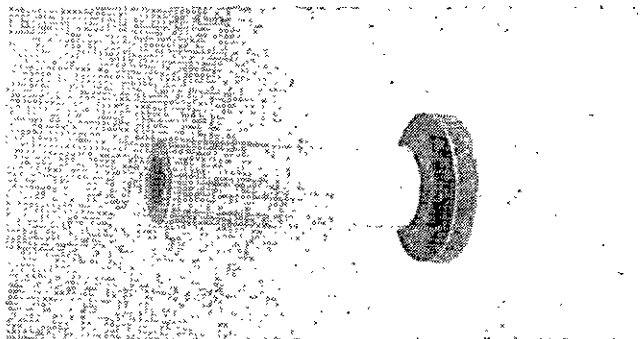
INSPECT AND MEASURE CAMSHAFT FOLLOWERS

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.

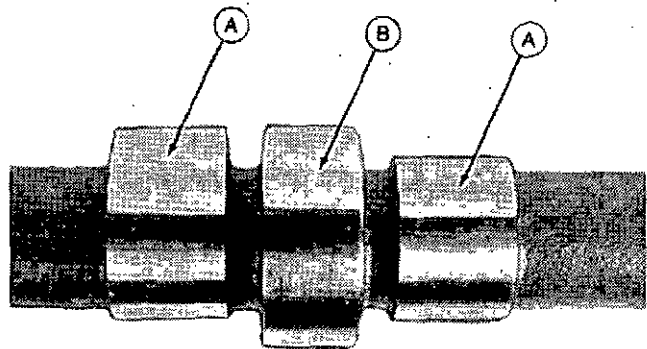


UN-23FEB89
RG2745

RG,CTM42,G16,19-19-15SEP94

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.



16
13
UN-06AUG81
RG3500

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.)

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

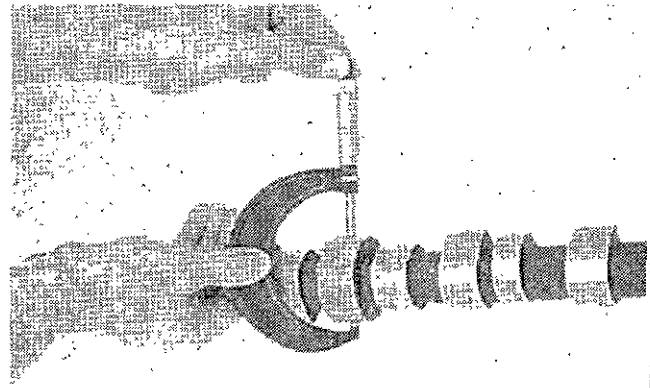
MEASURE CAMSHAFT JOURNAL OD AND BUSHING ID

1. Measure each camshaft journal OD. If camshaft journal OD is not within specification, install a new camshaft.
2. Measure each camshaft bushing ID when installed in cylinder block.

Compare measurements with specs given below.
Replace camshaft and bushings as needed.

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.)



T81260 -JUN-07NOV88

RG,CTM42,G16,21-19-15SEP94

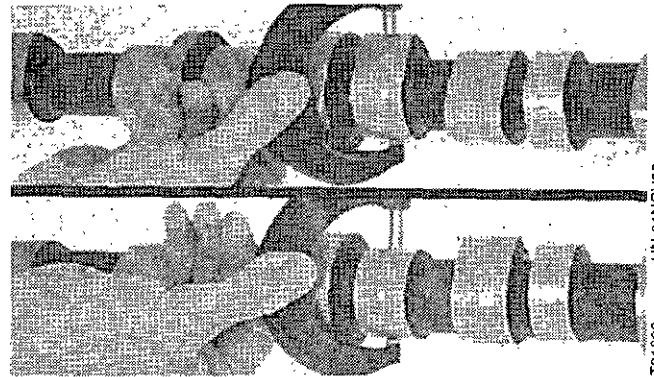
MEASURE CAMSHAFT LOBE LIFT

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	7.69—7.79 mm (0.303—0.307 in.)
Wear Limit	7.19 mm (0.283 in.)
Exhaust Lobe Lift	8.25—8.35 mm (0.325—0.329 in.)
Wear Limit	7.75 mm (0.305 in.)



T81262 -JUN-01NOV88

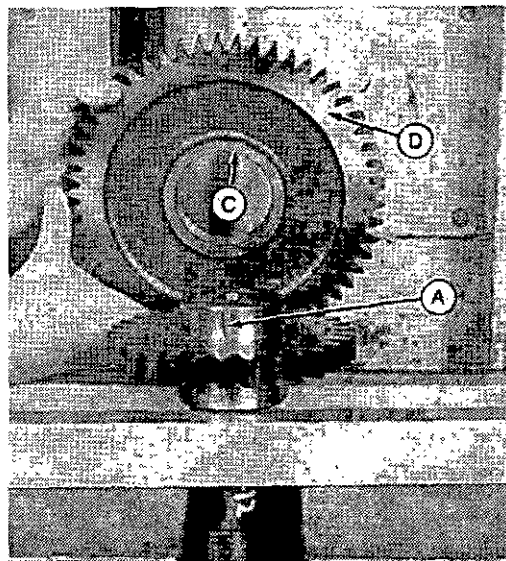
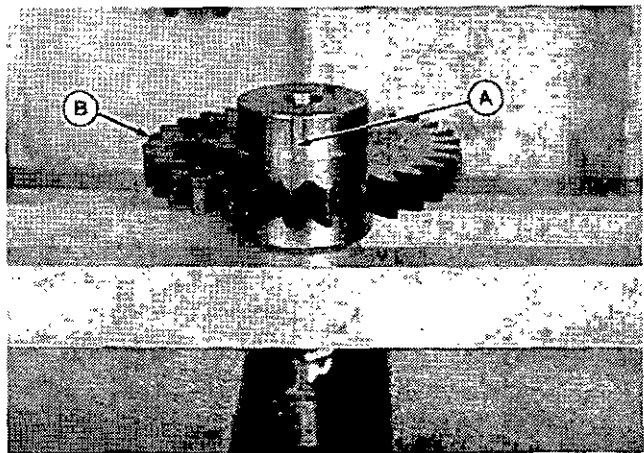
RG,CTM42,G16,22-19-16AUG94

16
14

INSTALL CAMSHAFT GEARS

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

- A—Woodruff Key
- B—Inner Gear
- C—Keyway
- D—Outer Gear



RG,CTM42,G16,23-19-29OCT92

7. Support each end of the camshaft on centers. Use a dial indicator with plunger resting on the thrust surface of the camshaft gears.
8. Check the runout of the inner and outer gear thrust surfaces.

CAMSHAFT GEAR THRUST SURFACE RUNOUT SPECIFICATIONS

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

RG,CTM42,G16,24-19-23SEP91

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.

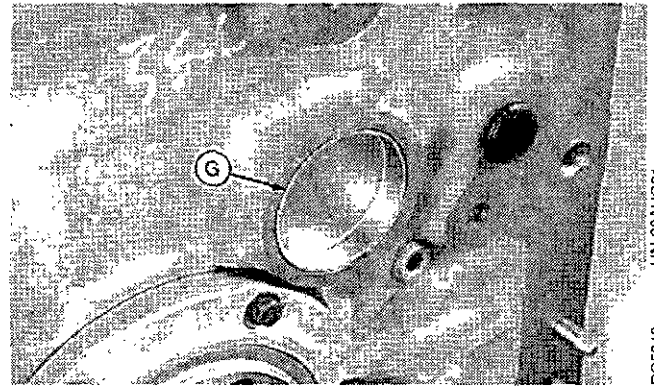
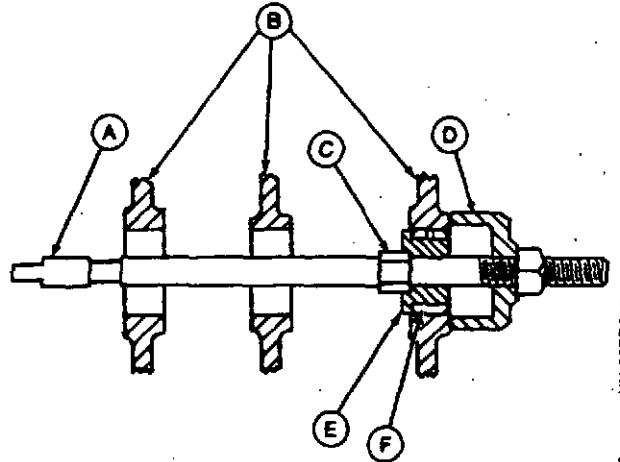
CAMSHAFT JOURNAL AND BUSHING NEW PART SPECIFICATION

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.)

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,G16,30-19-15SEP94

JUN-06DEC88
RG6972
JUN-30AUG91
RG6949

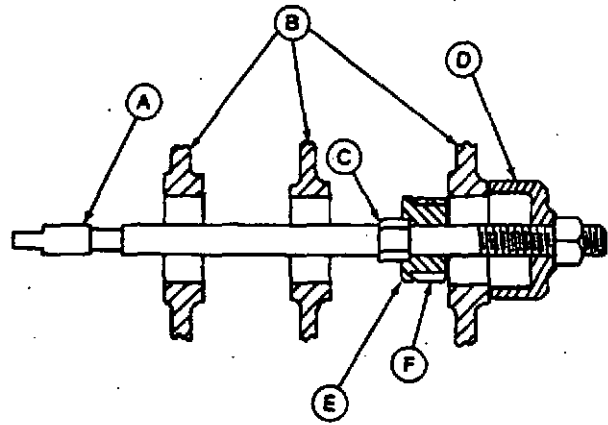
16
16

IMPORTANT: Oil holes in bushings and cylinder block must be aligned after installation or oil starvation will occur. The elongated hole in bushing must be toward the top. After installation, use a small mirror with extension to be sure oil holes are properly aligned.

4. Slide a new camshaft bushing (F) onto JDG603 Bushing Driver (E). Assemble driver and JDG604 Receiver Cup (D) along with components shown from JDE6 Camshaft Bushing Replacement Set (A and C).

5. Be sure bushing is started square in bore and oil holes are aligned with holes in block. Tighten nut to pull bushing in until it is properly positioned in bore.

6. Check bushing-to-cylinder block oil hole alignment using a small mirror with extension.



- A—Bushing Screw (JDE6-1)
- B—Cylinder Block Web
- C—Lock Bushing (No. 25916)
- D—Receiver Cup (JDG604)
- E—Bushing Driver (JDG603)
- F—Camshaft Bushing

S55,2016,N -19-23SEP91

RG5273 -UN-06DEC88

SERVICE CAMSHAFT BUSHINGS USING JDG606 ADAPTER SET

1. Inspect camshaft journals and bushings for wear or damage. Measure cam journals and bushings to determine if proper oil clearance exists. Replace camshaft and/or bushings as necessary.

CAMSHAFT JOURNAL AND BUSHING NEW PART SPECIFICATIONS

Camshaft Bushing Bore in Block	69.987—70.013 mm (2.7554—2.7564 in.)
Journal OD	66.987—67.013 mm (2.6373—2.6383 in.)
Bushing ID	67.076—67.102 mm (2.6408—2.6418 in.)
Oil Clearance	0.063—0.115 mm (0.0025—0.0045 in.)

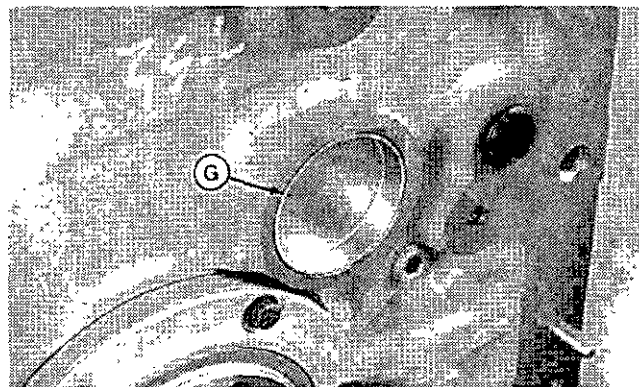
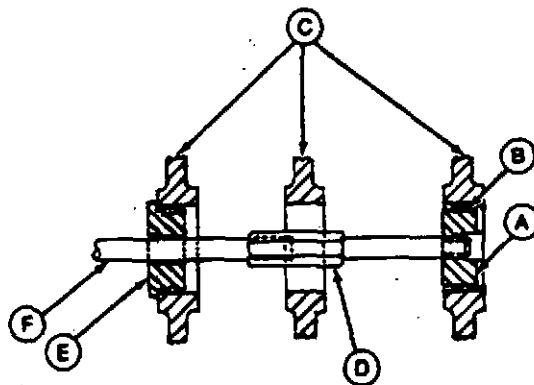
NOTE: The front two bushings can be reached from the front of the engine. The flywheel and rear camshaft bore plug (G) must be removed to reach the other two bushings.

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,G16,31-19-15SEP94

16
18

RG5949 JUN-30AUG91 UN-06DEC88

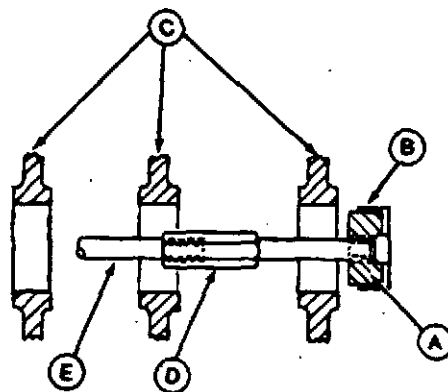
IMPORTANT: Oil holes in bushings and cylinder block must be aligned after installation. The elongated hole in bushing must be toward top. After installation, use a small mirror with extension to be sure oil holes are properly aligned.

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)

-UN-06DEC88

FG5333

S55,2016,P -19-29OCT92

16
19

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 inner gear.

3. Lubricate camshaft lobes with TY6333 or TY6347 High Temperature Grease and bearing journals with clean engine oil.

4. Carefully install camshaft in cylinder block so that camshaft lobes do not drag in bores. Rotate camshaft during installation to avoid obstruction in any bore.

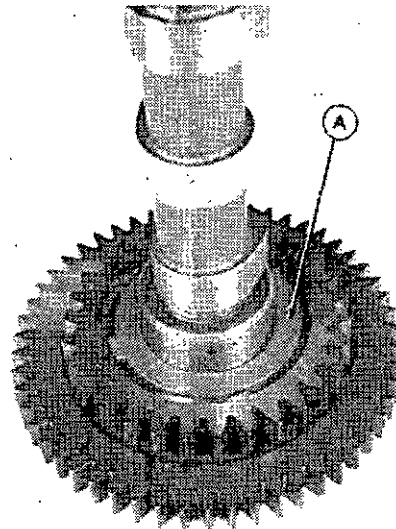


FIG5780 JUN-08AUG91

RG,CTM86,G16,11-19-15SEP94

5. With No. 1 piston on "TDC" compression, align timing marks (A) on camshaft and crankshaft gears. Check injection pump timing.

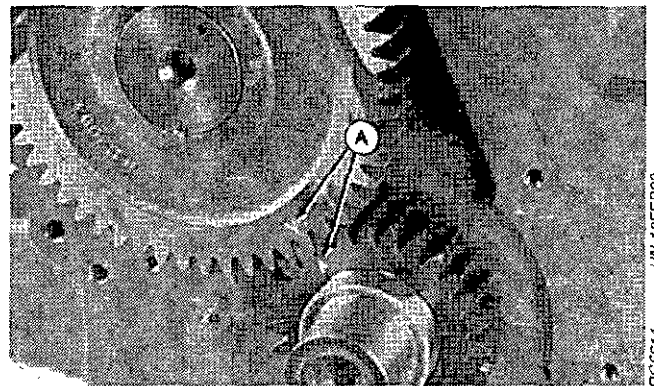


FIG6614 JUN-18FEB93

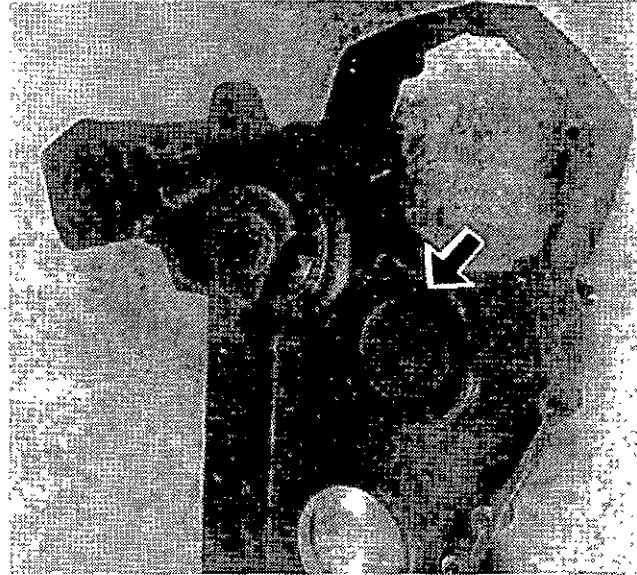
RG,CTM86,G16,12-19-15SEP94

INSTALL THRUST WASHER AND TIMING GEAR COVER

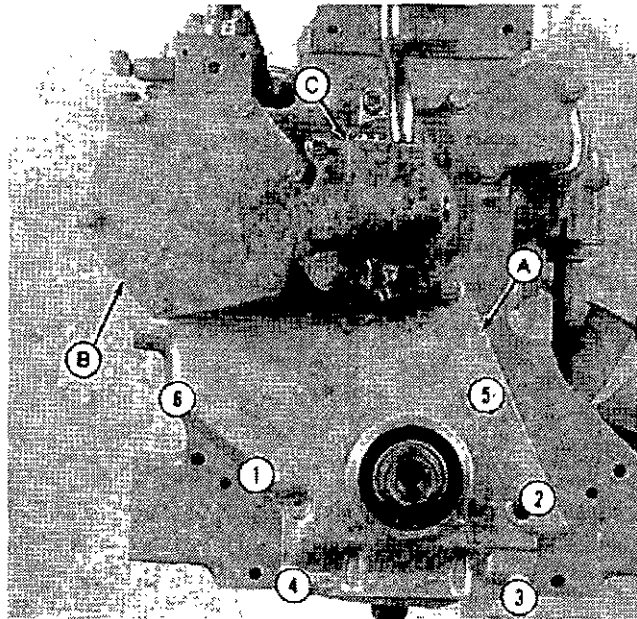
1. Lubricate thrust washer (bold arrow) with TY6333 or TY6347 High Temperature Grease and install inside timing gear cover (A) tabs.
2. Install a new gasket on the engine block. Apply a light film of grease to the gasket to hold it in place.

IMPORTANT: 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 one through six in sequence to 27 N·m (20 lb-ft).
4. Install water pump and cover assembly (C) using a new gasket. Tighten 5/16-in. cap screws to 27 N·m (20 lb-ft). Tighten 3/8-in. cap screws to 47 N·m (35 lb-ft).
5. Check camshaft endplay. (See CHECK CAMSHAFT END PLAY earlier in this group.)
6. Install injection pump drive gear cover using a new gasket and tighten cap screws to 27 N·m (20 lb-ft).
7. Trim timing gear cover gasket flush with oil pan gasket rail.



RG7060 -JUN-10AUG94



RG7060 -JUN-10AUG94

RG.CTM86,G16,13-19-15SEP94

COMPLETE FINAL ASSEMBLY

1. Install a new crankshaft front wear sleeve and oil seal. (See **INSTALL CRANKSHAFT FRONT OIL SEAL (WITH TIMING GEAR COVER INSTALLED ON ENGINE, in Group 15.)**)
2. Connect the magnetic speed sensor wiring lead.
3. Install crankshaft vibration damper. (See **INSTALL VIBRATION DAMPER in Group 15.)**)
4. Install valve train and rocker arm assembly. (See **Group 05, Cylinder Head and Valves.**)
5. Install oil pan using a new gasket or install engine into vehicle if equipped with a structural oil pan. (See **Group 20, Lubrication System.**) Fill engine with clean engine oil.
6. Perform engine break-in as required. (See **PERFORM ENGINE BREAK-IN, Group 05.**)

RG,CTM86,G16,14-19-15SEP94

OTHER MATERIAL

Name	Use
LOCTITE 242 Thread Lock and Sealer (TY9370 or T43512)	Oil filter adapter threads
LOCTITE 592 Pipe Sealant with TEFLON (TY9374/TY9375)	To seal oil sump elbow or drain fitting.

RG,CTM86,G20,15-19-06OCT94

LUBRICATION SYSTEM SPECIFICATIONS

ITEM	SPECIFICATION
Engine Oil Pressure* @ 1800—2000 RPM	280—400 kPa (2.8—4.0 bar) (40—58 psi)
Oil Filter Bypass Valve Operating Pressure	220 kPa (2.2 bar) (32 psi)
Oil Cooler Bypass Valve Operating Pressure	220 kPa (2.2 bar) (32 psi)
Pressure Regulating Valve Starts to Operate	340 kPa (3.4 bar) (49 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 (0.0015 in.)
Maximum Drive Shaft End Play	0.15 mm (0.006 in.)
Maximum Drive Shaft Side Movement	0.17 mm (0.0065 in.)

*—Oil sump temperature 105°C (220°F).

RG,CTM86,G20,1 -19-17OCT94

LUBRICATION SYSTEM SPECIFICATIONS—CONTINUED**TORQUES**

Oil Filter Housing-to-Cylinder Block	61 N·m (45 lb-ft)
Oil Cooler Cover-to-Cylinder Block*	27 N·m (20 lb-ft)
Oil Cooler Tube Adapter-to-Cylinder Block (External)	47 N·m (35 lb-ft)
Oil Pump Outlet and Oil Cooler Cross-Over Tube- to-Cylinder Block Adapter (Internal)	75 N·m (55 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 (Pickup) 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	58 N·m (42 lb-ft)
1/2 in. Cap Screws	133 N·m (98 lb-ft)
Oil Pan Drain Plug:	
Aluminum Pans	102 N·m (75 lb-ft)
Cast Iron Pans	47 N·m (35 lb-ft)

*Refer to REMOVE, INSPECT, AND INSTALL ENGINE OIL COOLER, later in this group for cap screw tightening sequence.

** Initially tighten all 1/2-in. cap screws to 133 N·m (98 lb-ft), then, tighten all 3/8-in. cap screws to 58 N·m (42 lb-ft). Retighten all 3/8-in. cap screws to 58 N·m (42 lb-ft) and all 1/2-in. cap screws to 133 N·m (98 lb-ft).

RG,CTM86,G20,2 -19-17OCT94

DIAGNOSING LUBRICATION SYSTEM MALFUNCTIONS

• Low Oil Pressure:

Low oil level.
Clogged cooler or filter.
Excessive oil temperature.
Incorrect oil.
Oil pressure regulating valve failure.
Excessive main or rod bearing clearance.
Clogged oil pump screen.
Excessive clearance between oil pump gears and cover.
Piston cooling orifice not installed.

• High Oil Pressure:

Improper oil classification.
Clogged oil lines.
Oil pressure regulating valve failure.

• Oil Sludge and Dilution:

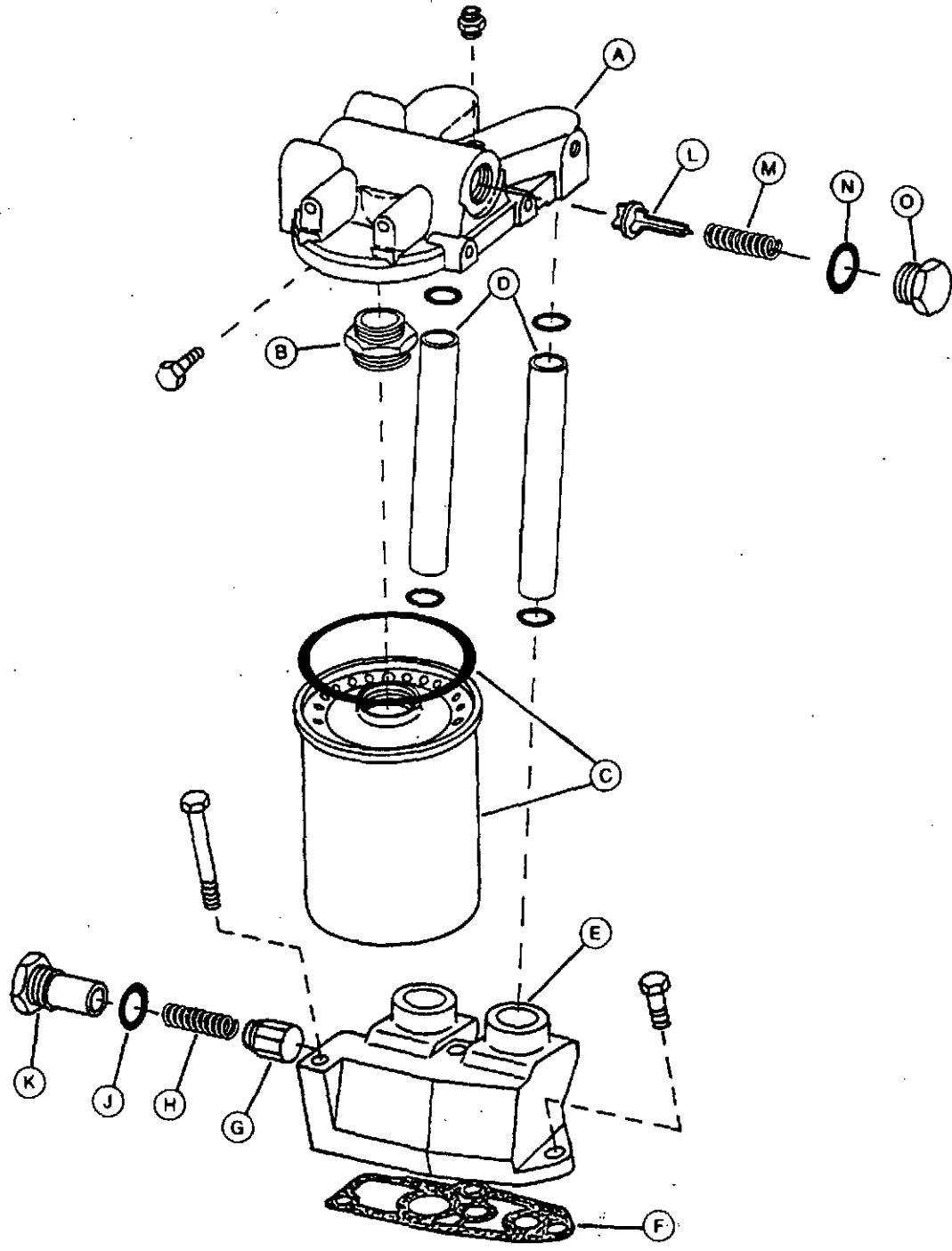
Improper operation and servicing.
Coolant leakage into lubrication system.
Incomplete combustion.
Excessive oil consumption.
Defective injection pump (Failed internal O-ring seals)

• Low Oil Pressure at Slow Idle:

Bypass oil check valve failure.

S11,0404,A -19-08AUG94

OIL FILTER BASE AND OIL PRESSURE REGULATING VALVE HOUSING ASSEMBLY



A—Oil Filter Base
 B—Oil Filter Adapter
 C—Oil Filter With Packing
 D—Oil Tubes

E—Oil Pressure Regulating
 Valve Housing
 F—Gasket
 G—Oil Pressure Regulating
 Valve

H—Spring
 J—O-Ring
 K—Plug
 L—Oil Filter Bypass Valve

M—Spring
 N—O-Ring
 O—Plug

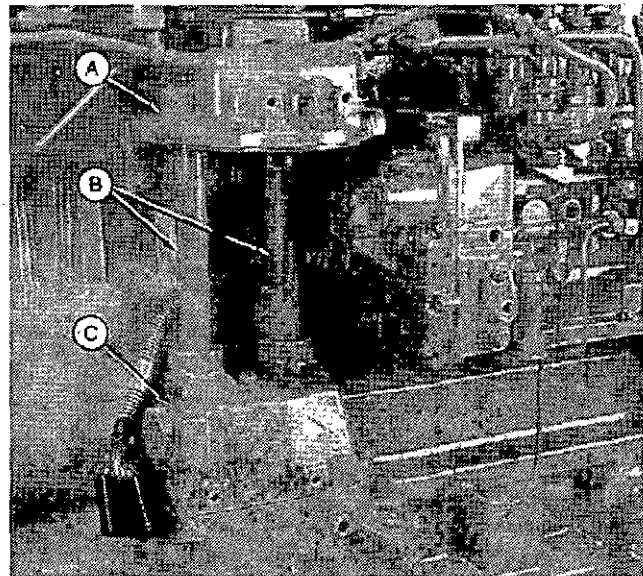
RG7008 -JUN-28JUL94

RG,CTM86,G20,3 -19-15SEP94

REMOVE AND INSTALL OIL FILTER BASE AND OIL PRESSURE REGULATING VALVE HOUSING

• Remove Oil Filter Base and Pressure Regulating Valve Housing:

1. Disconnect turbocharger oil inlet line connector from top of oil filter base (A, shown disconnected).
2. Remove oil filter using a suitable filter wrench (shown removed).
3. Remove two cap screws securing oil filter base to cylinder block. Remove oil filter base and oil tubes (B). Remove and discard four O-rings.
4. Remove three cap screws securing oil pressure regulating valve housing (C) to cylinder block and remove housing. Clean all gasket material from both mating surfaces.

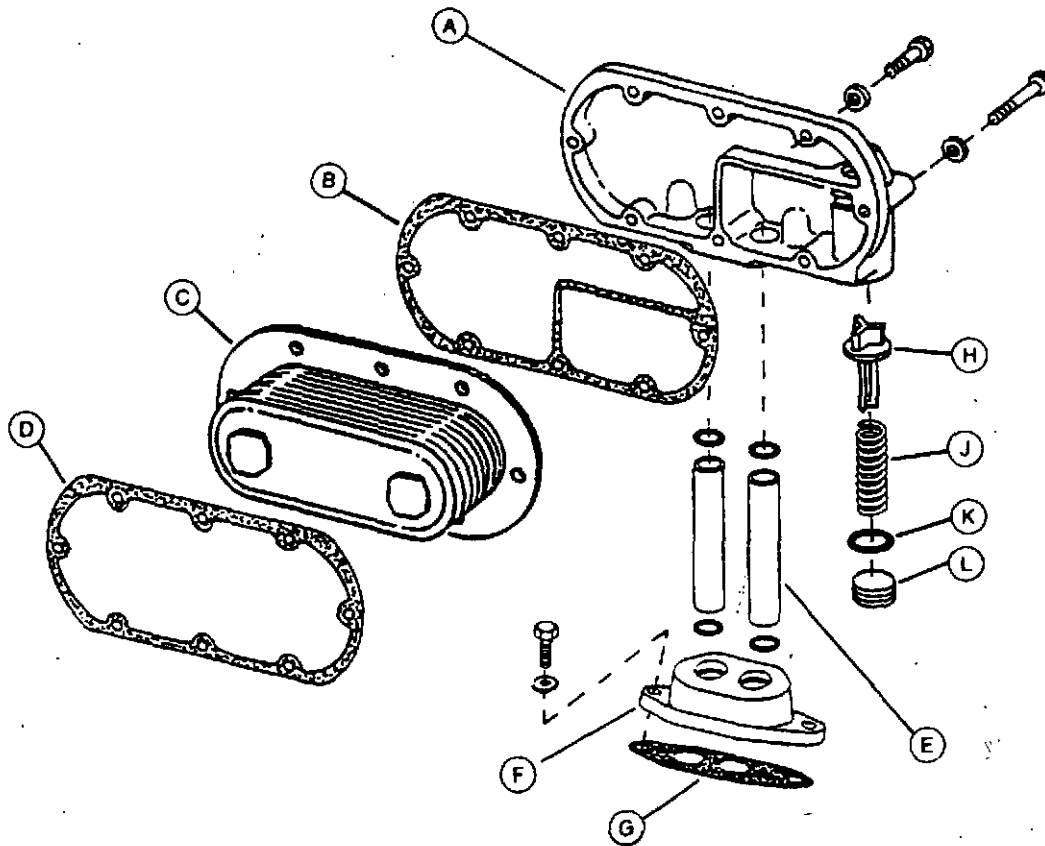


• Install Oil Filter Base and Pressure Regulating Valve Housing:

1. Install oil pressure regulating valve housing using a new gasket. Tighten cap screws to 47 N·m (35 lb-ft).
2. Install new O-ring in housing O-ring bores, lubricate O-rings with clean engine oil, and install oil tubes.
3. Lubricate new O-rings with clean engine oil and install in oil filter base O-ring bores. Install base onto oil tubes.
4. Position filter base on cylinder block, install cap screws, and tighten cap screws to 61 N·m (45 lb-ft).
5. Connect turbocharger oil line connector at top of filter base and tighten securely.
6. Spread a layer of clean engine oil on new filter packing. Install filter and tighten until packing contacts filter base. Tighten an additional 1/2—3/4 turn after packing contacts base. DO NOT overtighten oil filter.

20
5

ENGINE OIL COOLER ASSEMBLY



A—Oil Cooler Cover/Bypass Valve Housing
 B—Cover-to-Cooler Gasket

C—Oil Cooler
 D—Cooler-to-Block Gasket
 E—Oil Cooler Tubes (2 used)

F—Tube Adapter
 G—Adapter-to-Block Gasket
 H—Oil Cooler Bypass Valve

J—Spring
 K—O-Ring
 L—Plug

RG7009 -JUN-28-JUL-94

RG,CTM86,G20,5 -19-15SEP94

20
6

REMOVE, INSPECT, AND INSTALL ENGINE OIL COOLER

Refer to ENGINE OIL COOLER ASSEMBLY, earlier in this group for exploded view of engine oil cooler assembly.

• Remove Oil Cooler Assembly:

1. Remove eight cap screws securing oil cooler cover (A).
2. Remove two cap screws securing oil cooler tube adapter (B). Remove cover, tubes (C), and adapter as an assembly.
3. Remove oil cooler (D) from block bore. Clean all gasket material from mating surfaces.

• Inspect Oil Cooler Assembly:

1. Inspect oil cooler for physical damage, plugging, or leakage which may allow mixing of oil and coolant.
2. Back flush oil cooler to clean all debris from core.
3. Pressure test oil cooler in liquid and compressed air if mixing of oil and coolant is suspected.

Oil cooler should show no leakage when 140—170 kPa (1.4—1.7 bar) (20—25 psi) air pressure is applied for a minimum of 30 seconds.

4. Inspect all remaining parts of oil cooler assembly.

Replace parts as needed. DO NOT attempt to repair oil cooler.

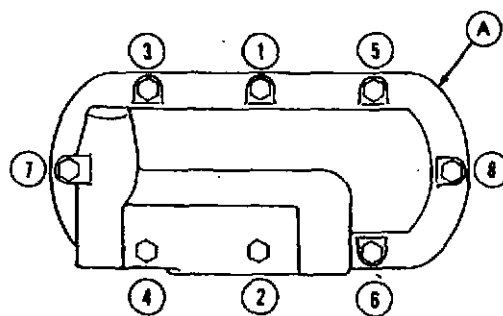
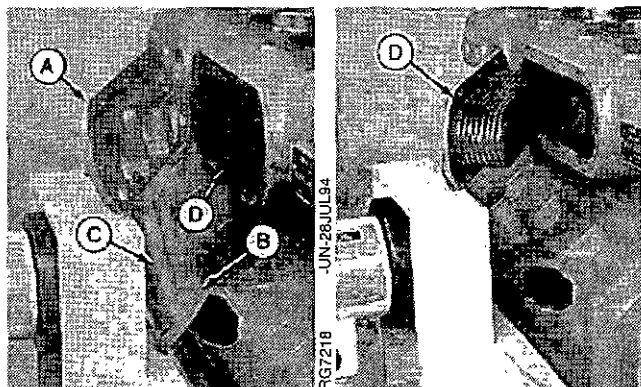
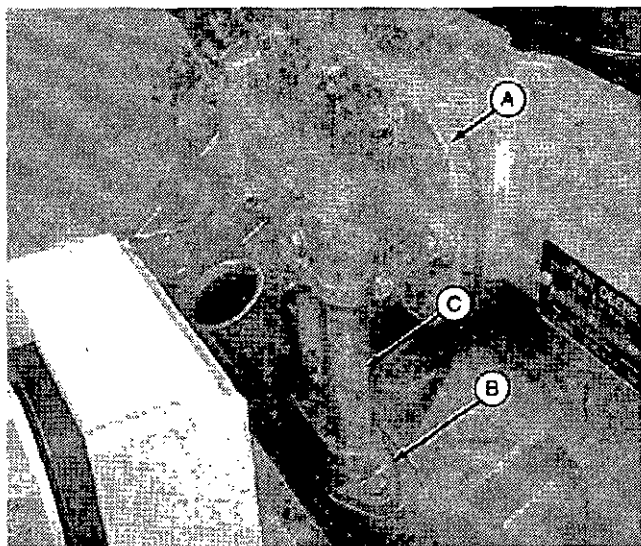
• Install Oil Cooler Assembly:

1. Install oil cooler using a new gasket on each side of cooler. Be sure gaskets are properly aligned with cap screw holes.

NOTE: If cover, tubes, and adapter were disassembled, lubricate new O-rings with clean engine oil.

2. Install a new gasket on cylinder block and install oil cooler cover, tubes, and adapter as an assembly. Tighten adapter cap screws to 47 N·m (35 lb-ft).

3. Sequentially tighten oil cooler cover cap screws one through eight to 27 N·m (20 lb-ft).



A—Oil Cooler Cover/Bypass Valve Housing
 B—Oil Cooler Tube Adapter
 C—Oil Cooler Tubes
 D—Oil Cooler

REMOVE, INSPECT, AND INSTALL OIL PRESSURE REGULATING VALVE, OIL FILTER BYPASS VALVE, AND OIL COOLER BYPASS VALVE

See OIL FILTER BASE AND OIL PRESSURE REGULATING VALVE HOUSING ASSEMBLY and ENGINE OIL COOLER ASSEMBLY, earlier in this group, for illustration of valves.

• Oil Pressure Regulating Valve:

1. Remove plug (K), O-ring (J), spring (H), oil pressure regulating valve (G) from housing (E). Discard O-ring.
2. Inspect valve and valve bore for damage. Replace if necessary.
3. Check spring for proper compression. Replace spring if not within specification.

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.

NOTE: Pressure regulating valve starts to operate at 340 kPa (3.4 bar) (49 psi).

• Oil Filter Bypass Valve:

1. Remove plug (O) with O-ring (N), spring (M), and oil filter bypass valve (L) from oil filter base (A). Discard O-ring.
2. Inspect valve and housing bore for scoring or damage. Replace if necessary.
3. Check spring for proper compression. Replace spring if not within specification.

NEW OIL FILTER BYPASS VALVE SPRING SPECIFICATIONS

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 filter base.
5. Install new O-ring on plug. Install plug and tighten securely.

NOTE: Filter bypass valve operating pressure is 220 kPa (2.20 bar) (32 psi).

• Oil Cooler Bypass Valve:

1. Remove plug (L), O-ring (K), spring (J), and oil cooler bypass valve (I) from oil cooler cover/bypass valve housing (A). 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 spring if not within specification.

NEW OIL COOLER BYPASS VALVE SPRING SPECIFICATIONS

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.)

NOTE: Cooler bypass valve operating pressure is 220 kPa (2.20 bar) (32 psi).

20
8

REMOVE ENGINE FROM VEHICLE FOR ACCESS TO ENGINE OIL PUMP

6081HRW01 Engines used in 8400 Tractors are equipped with a front frame/oil sump which is also a structural member of the vehicle. For access to the engine oil pump, the engine must be removed from the vehicle. Refer to TM1575 (8100, 8200, 8300, and 8400 Tractors—Repair) for engine removal instructions.

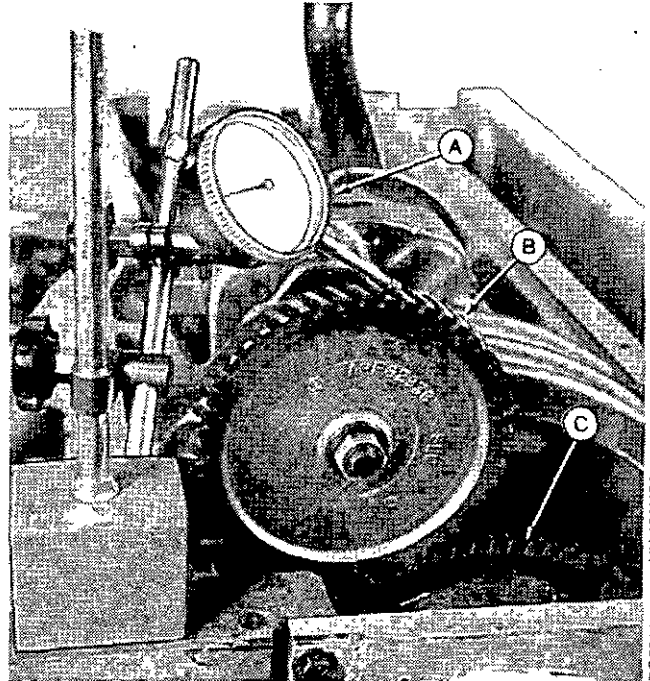
RG.CTM86,G20,8 -19-159EP94

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).

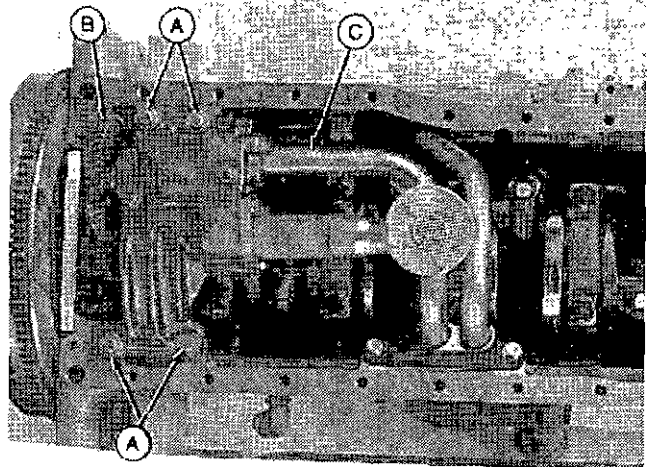
IMPORTANT: Backlash must be at least 0.08 mm (0.003 in.). If backlash is less than 0.08 mm (0.003 in.), replace the oil pump drive gear.



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) and oil pump outlet tube (C) attached.
3. Remove oil pump pickup tube, clean, and inspect as detailed later.



-JUN-28-JUL-94

RG7220

RG,CTM86,G20,9 -19-15SEP94

INSPECT AND CLEAN OIL PUMP

1. Visually inspect oil pump for wear or damage.

IMPORTANT: DO NOT disassemble engine oil pump for flushing, inspection, or performing wear checks. Individual components of oil pump are not available through service parts, Replace pump as a complete assembly.

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.

20
10

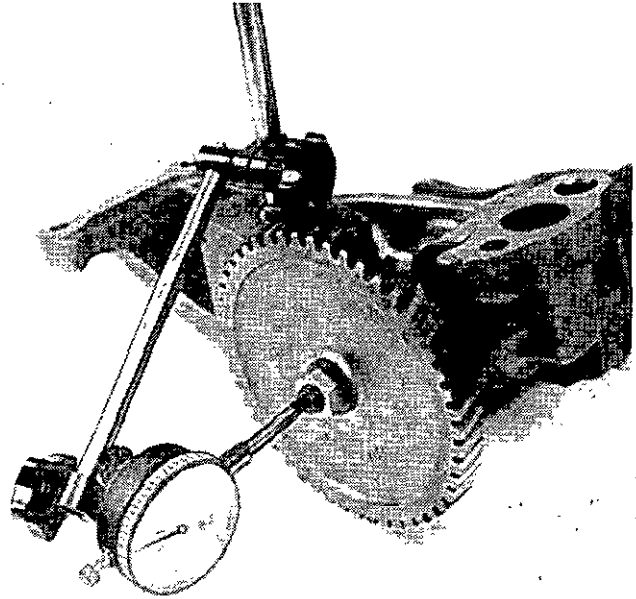
RG,CTM42,G20,18-19-15SEP94

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.).



JUN-16AUG91
RG5916

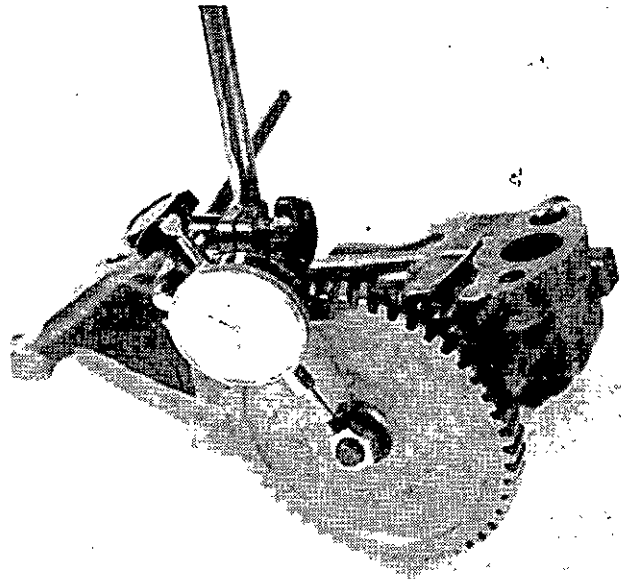
RG,CTM42,G20,19-19-09OCT92

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.).



20
11
JUN-16AUG91
RG5917

RG,CTM42,G20,20-19-09OCT92

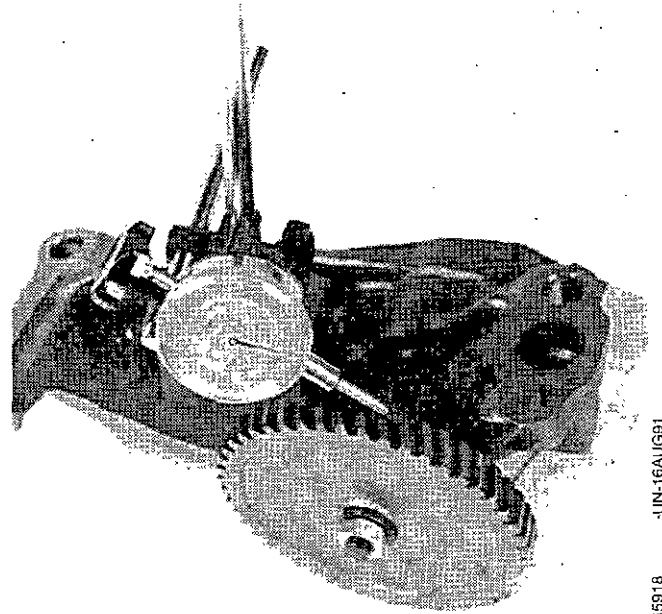
CHECK PUMPING GEAR BACKLASH

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, re-clean gears and check backlash again.

3. Replace oil pump if pumping gear backlash exceeds 2.00 mm (0.079 in.).



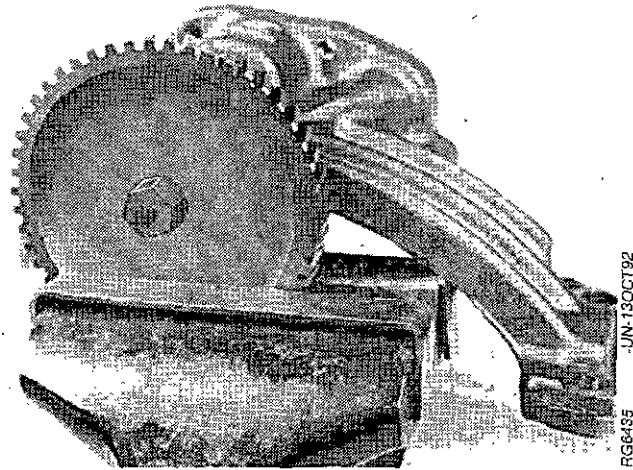
RG5918 -UN-16AUG91

RG,CTM42,G20,21-19-16AUG94

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.



RG6485 -UN-13OCT92

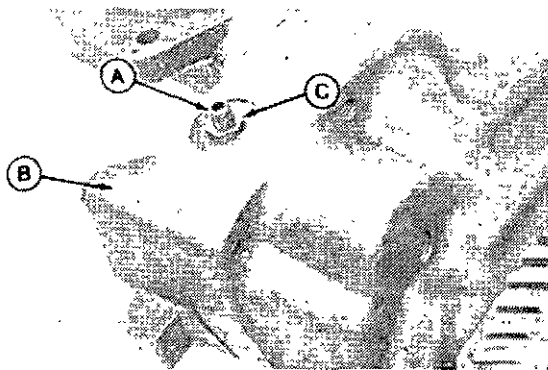
RG,CTM42,G20,31-19-09OCT92

20
12

ADJUST OIL PUMP SET SCREW

IMPORTANT: Normally the set screw (A) should NOT be adjusted; but if the set screw is altered, the following steps should be followed.

1. Assemble drive gear and idler gear into pump housing.
2. Install oil pump cover (B) and tighten cover-to-housing cap screws to 41 N·m (30 lb-ft).
3. Tighten set screw until it contacts idler shaft.
4. Continue to hold set screw and tighten lock nut (C) to 8 N·m (6 lb-ft). Do not overtighten set screw or lock nut.
5. Spin drive gear by hand to assure shaft turns freely in housing. Readjust set screw if shaft does not turn freely.



RG3508
-JUN-28NOV88

RG,CTM86,G20,13-19-28SEP94

20
13

INSTALL ENGINE OIL PUMP

1. Clamp oil pump drive gear (B) in a soft-jawed vise and install drive gear onto oil pump, if removed. Tighten mounting nut to 54 N·m (40 lb-ft).

2. Using a new gasket, install oil pump intake (pickup) tube onto oil pump cover and tighten cap screws to 41 N·m (30 lb-ft), if removed.

NOTE: Lubricate new O-rings with clean engine oil when installing oil pump outlet tube (C) into oil pump and oil cooler (tube) adapter.

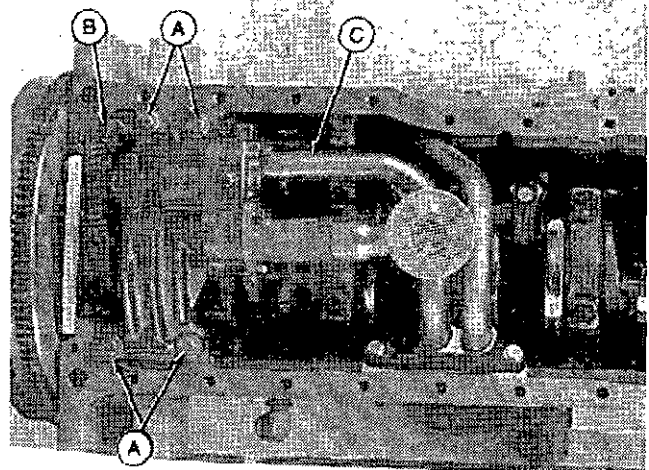
3. Install oil pump-to-oil cooler adapter tube into oil cooler adapter.

4. Install oil pump assembly on other end of oil pump-to-oil cooler adapter tube.

5. Rotate oil pump assembly into position over locating dowels in cylinder block.

6. Seat pump onto dowels using a hard rubber hammer; be sure drive gear is properly meshed with crankshaft gear and oil pump outlet tube is properly positioned in O-ring bores.

7. Tighten oil pump housing-to-cylinder block cap screws (A) to 47 N·m (35 lb-ft).

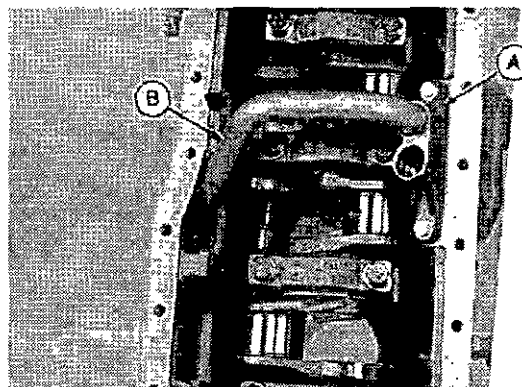


RG7220 -JUN-28JUL84

FG,CTM86,G20,10-19-04OCT94

20
14

REMOVE AND INSTALL OIL PUMP OUTLET TUBE AND OIL COOLER CROSS-OVER TUBE ADAPTER



• Remove Adapter:

1. Remove engine oil pump (shown removed). (See REMOVE ENGINE OIL PUMP, earlier in this group.)
2. Remove two cap screws securing adapter (A) to cylinder block and remove adapter with oil cooler cross-over tube (B).
3. Clean all gasket material from mating surfaces and discard.

• Install Adapter:

1. Lubricate new O-ring with clean engine oil and install adapter (with cross-over tube) using a new gasket. Make sure tubes are properly positioned in each O-ring bore.
2. Tighten cap screws to 75 N·m (55 lb-ft).
3. Install engine oil pump assembly. (See INSTALL ENGINE OIL PUMP, earlier in this group.)

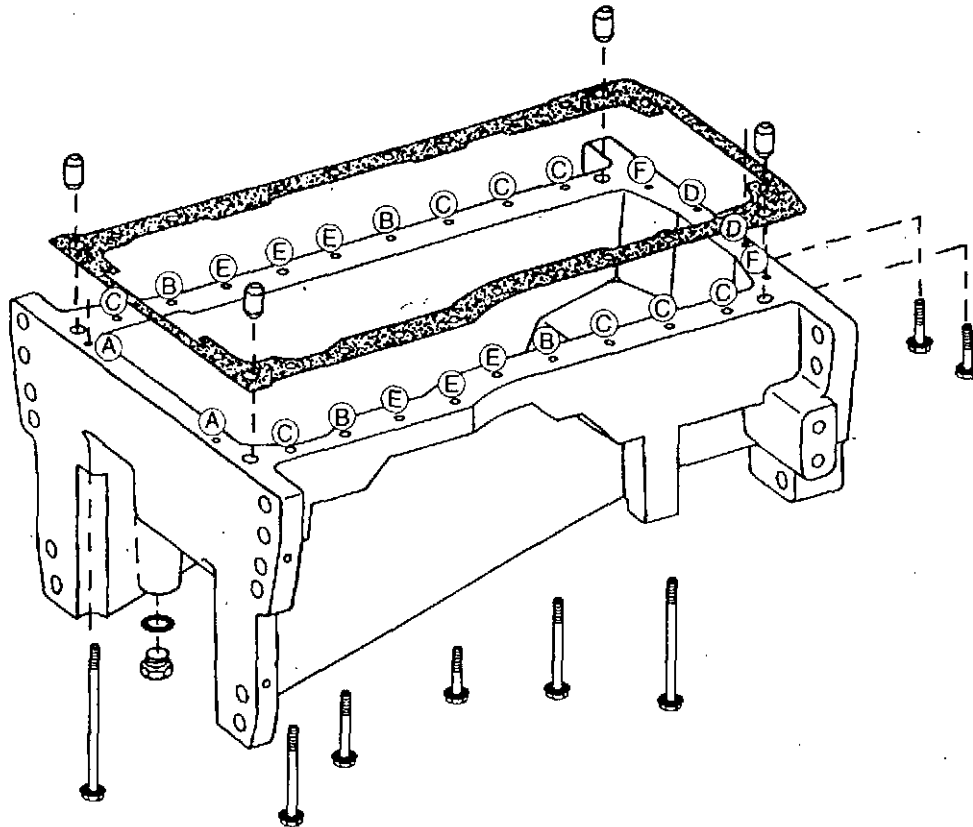
RG,CTM86,G20,11-19-15SEP94

-JUN-28-JUL94

RG7221

20
15

TIGHTEN CAP SCREWS ON FRONT FRAME/OIL SUMP



-JUN-21-JUN94

RG7223

A—0.375 x 7.625 in. (2 used)

B—0.500 x 4.000 in. (4 used)

C—0.500 x 6.000 in. (8 used)

D—0.375 x 2.500 in. (2 used)

E—0.500 x 2.500 in. (6 used)

F—0.375 x 1.875 in. (2 used)

1. Be sure all four sump-to-block locating dowels are in place.

IMPORTANT: DO NOT apply gasket sealant to gasket, front frame/oil sump, trimmed edges of timing gear cover gasket, oil seal housing gasket, or cylinder block mating surfaces. Before installing engine, be sure mating surfaces of engine and front frame/oil sump are clean and dry.

2. Install front frame/oil sump-to-cylinder block gasket.

3. Carefully lower engine block onto front frame/oil sump locating dowels.

4. Install all 3/8 in. and 1/2 in. cap screws in their appropriate locations.

5. Tighten all 1/2 in. cap screws to 133 N·m (98 lb-ft). Tighten all 3/8 in. cap screws to 58 N·m (43 lb-ft).

6. Re-tighten all 3/8 in. cap screws to 58 N·m (43 lb-ft). Re-tighten all 1/2 in. cap screws to 133 N·m (98 lb-ft).

7. Apply clean engine oil to new O-ring for bottom drain plug and install drain plug, if removed.

20
16

**INSTALL ENGINE INTO VEHICLE AFTER OIL
PUMP REPAIR**

1. Refer to TM1575 (8100, 8200, 8300, and 8400 Tractors—Repair) for engine installation instructions after servicing engine oil pump assembly.

RG,CTM86,G20,12-19-15SEP84

20
17

20
18

SPECIAL OR ESSENTIAL TOOLS

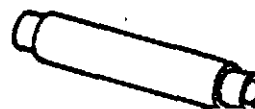
NOTE: Order tools according to information given in the U.S. SERVICE-GARD™ Catalog or in the European Microfiche Tool Catalog (MTC).

DX,TOOLS -19-05JUN91

Water Bypass Tube Seal Driver JDG908

RG5120 -UN-23AUG88

Used to install bypass tube seal in water pump cover.



RG,JDG908 -19-30SEP94

OTHER MATERIAL

Name	Use
LOCTITE 242 (TY9370) Thread Lock and Sealer	Water manifold-to-cylinder head cap screws.
LOCTITE 592 (TY9375) Pipe Sealant with TEFLON	Water pump and block drain valves.

RG,CTM86,G25,1 -19-15SEP94

COOLING SYSTEM SPECIFICATIONS

ITEM	SPECIFICATION
Thermostat Opening Temperature: 82°C (180°F) Thermostat(s)	80—84°C (175—182°F)
TORQUES	
Water Manifold-to-Cylinder Head	20 N·m (15 lb-ft)
Thermostat Cover-to-Water Manifold	20 N·m (15 lb-ft)
Water Pump Cover-to-Timing Gear Cover:	
5/16-in. Cap Screws	27 N·m (20 lb-ft)
3/8-in. Cap Screws	47 N·m (35 lb-ft)
Water Pump Drain Valve-to-Water Pump Cover	27 N·m (20 lb-ft)

RG,CTM86,G25,2 -19-24OCT94

DIAGNOSING COOLING SYSTEM MALFUNCTIONS

• Engine Overheats:

- Loose or broken fan belt
- Dirty radiator
- Low coolant level
- Low oil level
- Engine overloaded
- Defective head gasket
- Incorrect timing (engine/injection pump)
- Faulty thermostats
- Faulty water pump
- Corroded coolant passages
- Improper grade of fuel
- Excessive fuel delivery

• Low Coolant Level:

- Improper maintenance
- Improper operation
- Damaged radiator
- Water pump seal leakage
- Leakage
- Faulty radiator cap

S11.2025,DH -19-17AUG94

VISUALLY INSPECT WATER PUMP

• Inspect Weep Hole:

1. Inspect water pump weep hole (A) in timing gear cover for oil or coolant leakage.

- Oil leakage indicates a damaged rear seal.
- Coolant leakage indicates a damaged front seal.

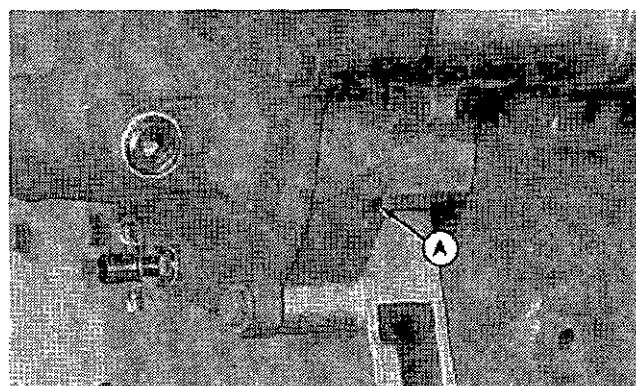
Replace complete water pump assembly if leakage is detected; individual repair parts are not available.

• Inspect For Impeller Contact With Cover:

1. Remove radiator-to-water pump hose from water pump inlet elbow.
2. Using a flashlight, inspect ID of water pump cover for internal impeller contact.

— Impeller contact with cover usually indicates that impeller has moved on shaft or there is a damaged bearing.

Replace water pump assembly and cover as necessary if impeller contact is detected.



JUN-07SEP94
RG7061

25
2

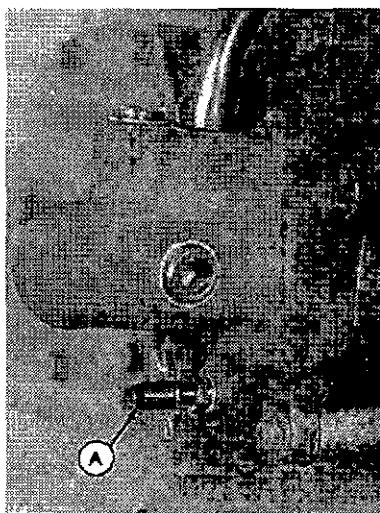
RG,CTM86,G25,3 -19-15SEP94

REMOVE WATER PUMP ASSEMBLY

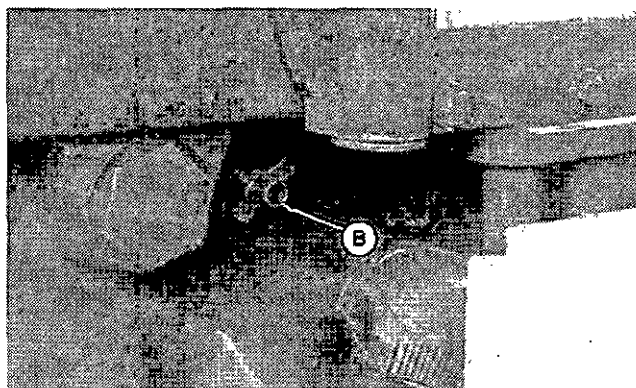
The water pump should be removed from the timing gear cover for replacement purposes only. There are no service parts available to repair water pump, replace as a complete assembly.

⚠ CAUTION: Explosive release of fluids from pressurized cooling system can cause serious burns. Wait until engine coolant is cool enough to touch with bare hands before draining. Slowly loosen radiator cap to first stop to relieve pressure.

1. Open water pump drain valve (A) and block drain valve (B) to drain coolant from engine.



FG7044 -JUN-28JUL94



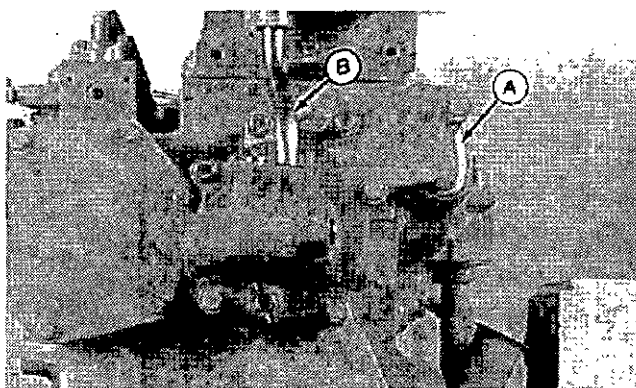
FG7143 -JUN-28JUL94

RG,CTM86,G25,4 -19-15SEP94

2. Remove hose from water pump cover inlet elbow, shown removed.

3. Remove six cap screws securing water pump cover (A) to timing gear cover and remove water pump cover with bypass tube (B).

4. Remove gasket from timing gear cover and discard. Remove bypass tube from cover. Inspect bypass tube seal in water pump cover, replace seal as needed. (See REPLACE BYPASS TUBE SEAL IN WATER PUMP COVER, later in this group.)

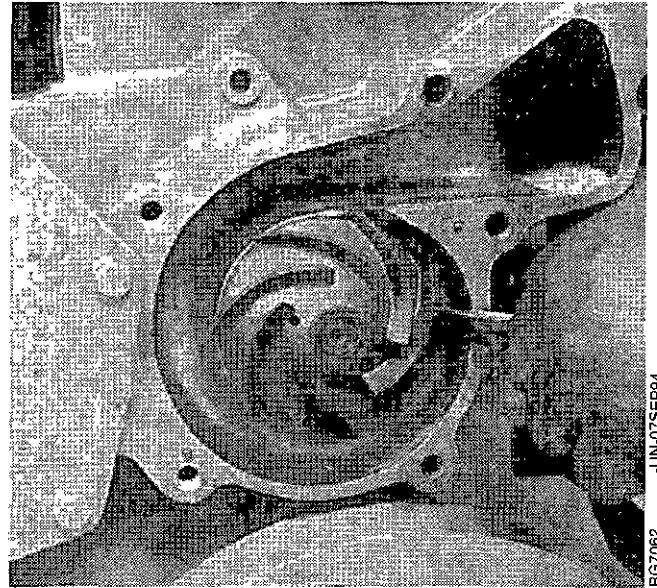


25
3
FG7083 -JUN-08SEP94

RG,CTM86,G25,5 -19-15SEP94

5. Compress retaining ring ends with a small needle-nose pliers as shown.

6. Grasp impeller with a large pliers and pull water pump from timing gear cover using a slight rocking motion until assembly is removed from timing gear cover. Discard water pump assembly.



RG7062 -UN-07SEP94

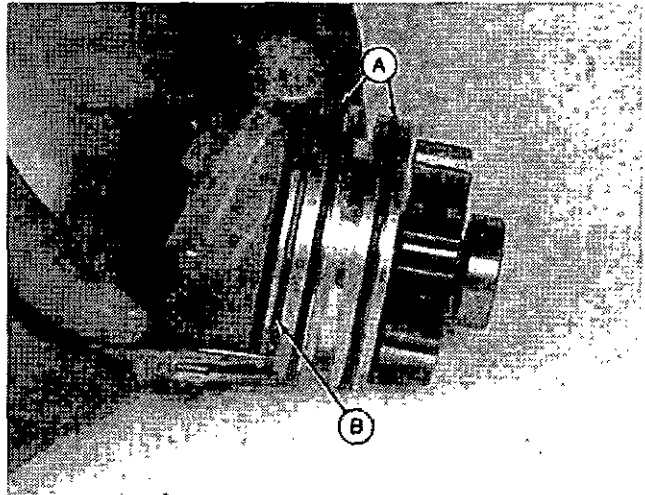
RG.CTM86,G25,6 -19-15SEP94

INSTALL WATER PUMP ASSEMBLY

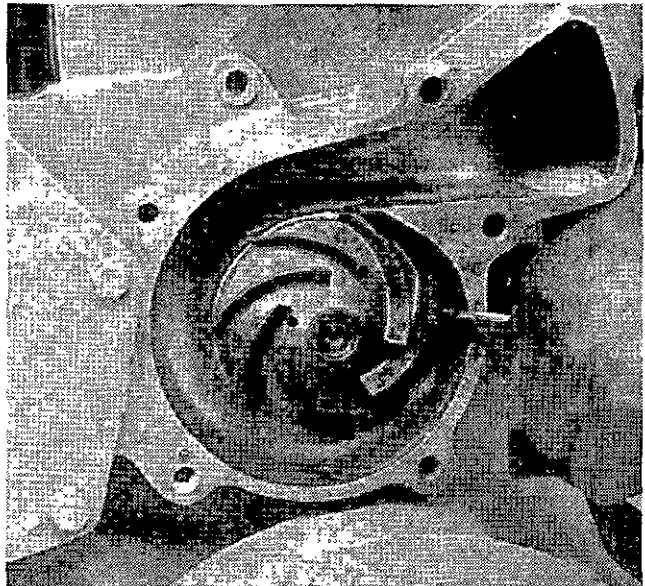
1. Thoroughly clean and inspect water pump mounting bore in timing gear cover before installing pump assembly.
2. Install two new O-rings (A) in rear grooves of water pump housing and apply a light coat of clean engine oil to O-rings.
3. Install a new retaining ring (B) in front (smallest) groove of water pump housing and compress both ends of retaining ring together with a small needle-nose pliers.

NOTE: Retaining ring ends should be at 3 o'clock position and water pump weep hole should align with hole in timing gear cover when installing water pump assembly.

4. Compress retaining ring ends and install water pump assembly into pilot bore of timing gear cover. Make sure that pump drive gear properly meshes with crankshaft gear.
5. Release retaining ring ends and verify that retaining ring is firmly seated in groove of timing gear cover.
6. Install water pump cover with bypass tube using a new gasket. Tighten all 3/8-in. cap screws to 47 N·m (35 lb-ft) and all 5/16-in. cap screws to 27 N·m (20 lb-ft).



RG7227
-UN-07SEP94



RG7062
-UN-07SEP94

RG,CTM86,G25,7 -19-15SEP94

REPLACE BYPASS TUBE SEAL IN WATER PUMP COVER

1. Drain cooling system and remove water pump cover (A) with bypass tube (B). Discard cover gasket.
2. Carefully clamp cover in a soft-jawed vise and remove bypass tube seal. Be careful not to damage machined gasket surface of cover.
3. Install new seal (C) using JDG908 Seal Driver (D). Drive seal into bore until driver bottoms.
4. Remove cover from vise and inspect seal installation and also machined gasket surfaces.

A—Water Pump Cover
 B—Bypass Tube
 C—Bypass Tube Seal
 D—JDG908 Seal Driver

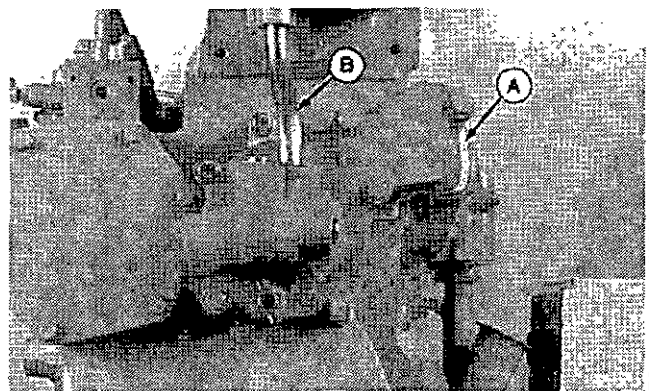


FIG. 7063 -JUN-08SEP94

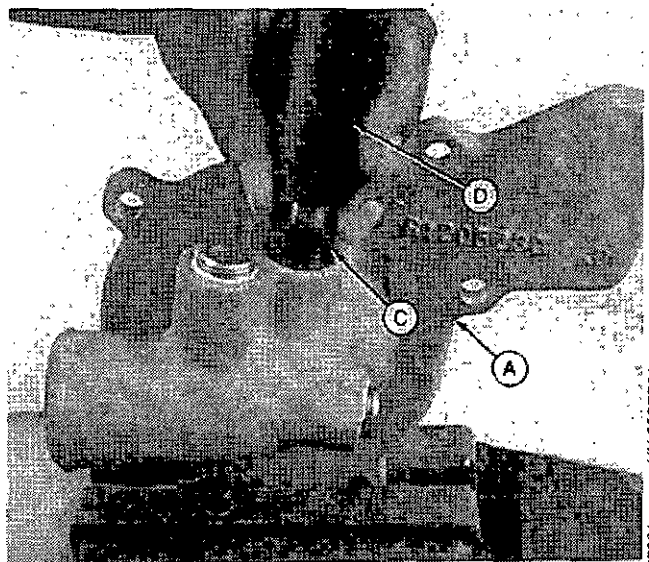


FIG. 7064 -JUN-08SEP94

RG,CTM86,G25,13-19-10OCT94

REMOVE AND TEST THERMOSTATS

CAUTION: Explosive release of fluids from pressurized cooling system can cause serious burns. Do not drain coolant until coolant temperature is below operating temperature. Always loosen cooling system filler cap, radiator cap, or drain valve slowly to relieve pressure.

1. Visually inspect the area around the water manifold for leaks. Partially drain coolant from the cooling system.
2. Remove thermostat cover (A) with gasket. Remove and discard all gasket material.

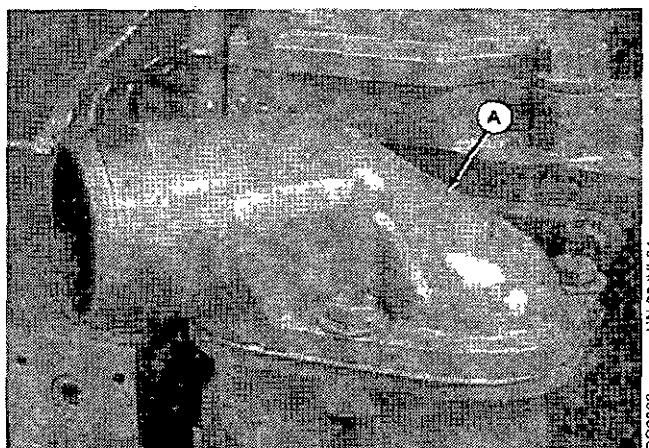


FIG. 6966 -JUN-28JUL94

RG,CTM86,G25,8-19-15SEP94

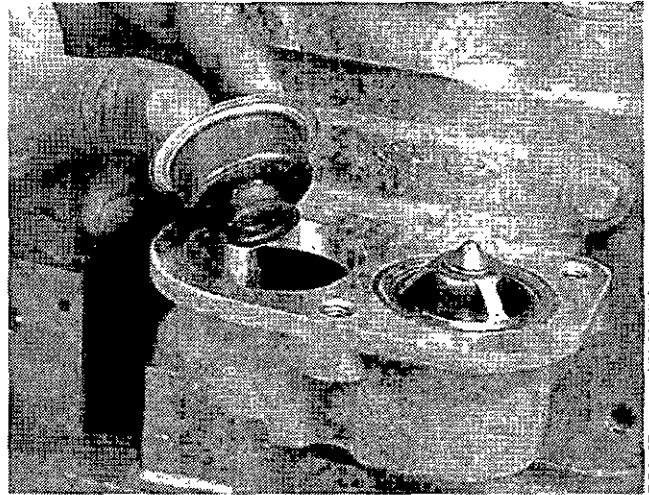
3. Remove thermostats.

4. Inspect thermostats for debris or damage, and test each thermostat using an approved testing procedure. See INSPECT THERMOSTAT AND TEST THERMOSTAT OPENING TEMPERATURE in Group 105 for testing procedure. Thermostats should start to open within the range specified below.

THERMOSTAT OPENING TEMPERATURE SPECIFICATIONS

82°C (180°F) Thermostat(s) 80—84°C (175—182°F)

If either thermostat fails to open within this range, replace both thermostats as a set.



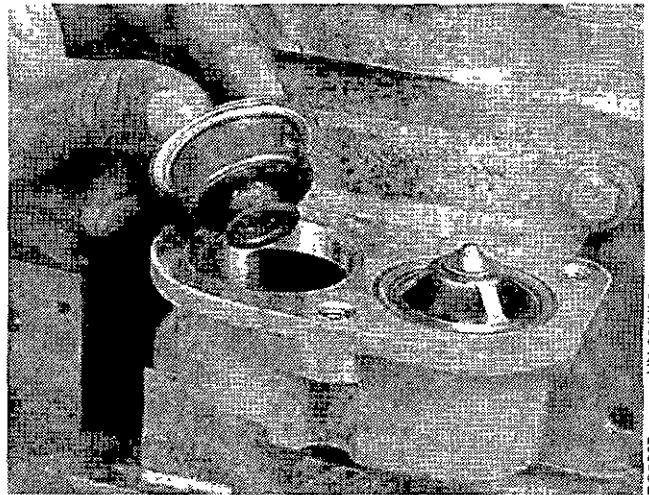
FG.CTM86,G25,9 -19-15SEP94

INSTALL THERMOSTATS

NOTE: Install thermostats in grooves in housing first, then install gasket after thermostat is properly seated in grooves.

1. Install thermostats. Install a new gasket on housing.
2. Install cover and tighten cap screws to 20 N·m (15 lb-ft).

IMPORTANT: Air must be expelled from cooling system when system is refilled. Loosen temperature sending unit fitting at rear of cylinder head or plug in thermostat housing to allow air to escape when filling system. Retighten fitting when all the air has been expelled.



FG.CTM86,G25,10-19-24OCT94

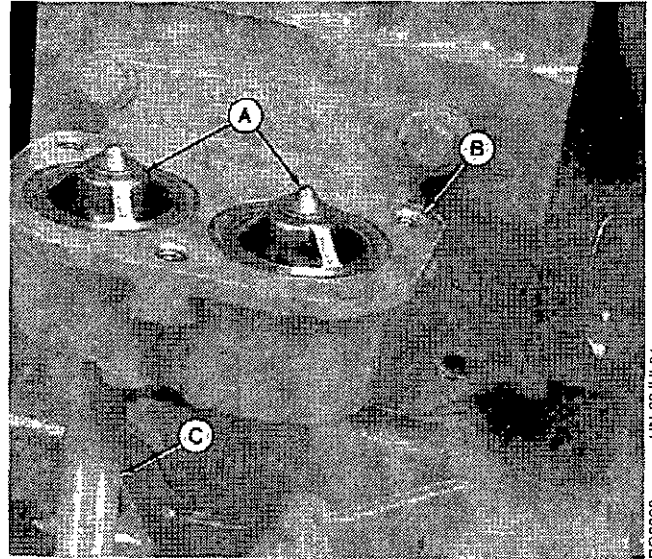
REMOVE WATER MANIFOLD

1. Drain coolant and remove thermostat cover from water manifold (shown removed). Remove thermostats (A).

2. Remove three water manifold-to-cylinder head cap screws, remove water manifold (B) and dislodge water bypass tube as manifold is removed.

NOTE: Pull water manifold straight out (toward front of engine) approximately 6.35 mm (0.25 in.) to disengage from locator (spring) pin, then lift straight up to disengage from bypass tube (C).

3. Remove and discard O-ring from bore of water manifold.



-JUN-28JUL94

FG666B

RG,CTM86,G25,11-19-15SEP94

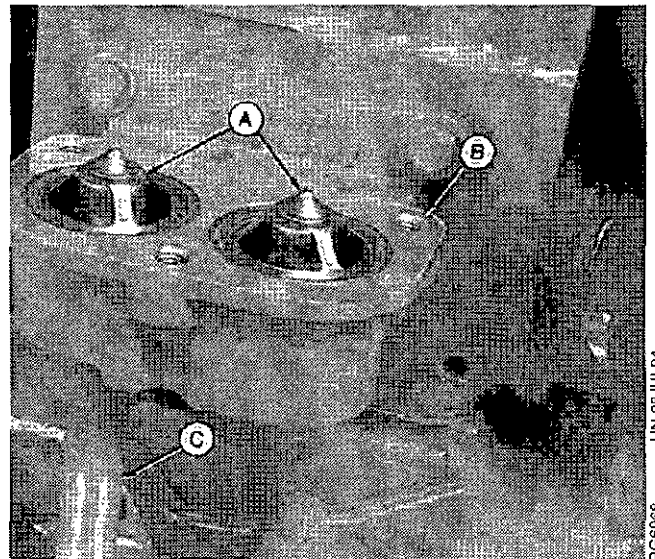
INSTALL WATER MANIFOLD

1. Install a new O-ring into water manifold O-ring bore. Lubricate O-ring with grease to ease bypass pipe installation. Install bypass pipe (C) into bore of water manifold (B). Be careful not to cut O-ring.

2. Install water manifold assembly. Be sure water manifold is properly positioned on spring pin (in front face of cylinder head) and that bypass pipe is fully seated in water manifold and water pump cover bores.

3. Apply LOCTITE 242 Thread Sealer to water manifold-to-cylinder head cap screw threads 360 degrees (except for the leading one to three threads). Tighten water manifold cap screws to 20 N·m (15 lb-ft).

4. Install thermostats and cover. (See INSTALL THERMOSTATS, earlier in this group.)



-JUN-28JUL94

FG666B

RG,CTM86,G25,12-19-24OCT94

25
8

COMPLETE FINAL ASSEMBLY

NOTE: Consult your engine operator's manual or see Group 02 of this CTM for coolant recommendations in your area.

1. Fill cooling system to proper level with the proper coolant.
2. Start engine and run for several minutes to check for leaks in the cooling system.
3. After fan belts cool, check belt tension as detailed in your operator's manual.

RG,CTM42,G25,31-19-15SEP94

25
10

OTHER MATERIAL

Name	Use
PT569 NEVER-SEEZ Compound	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.

RG,CTM86,G30.11-19-16SEP94

AIR INTAKE AND EXHAUST SYSTEM SPECIFICATIONS

ITEM	SPECIFICATION
Total Indicator Reading Limits:	
Radial Bearing Clearance	0.13—0.18 mm (0.005—0.007 in.)
Bearing\Shaft Axial End Play	0.064—0.114 mm (0.0025—0.0045 in.)
TORQUES	
Compressor Housing-to-Backplate	7—8 N·m (60—70 lb-in.)
Turbine Housing-to-Center Housing	15—16 N·m (135—145 lb-in.)
Turbocharger-to-Exhaust Manifold	24 N·m (18 lb-ft)
Turbocharger Oil Return Line	41 N·m (30 lb-ft)
Exhaust Manifold-to-Cylinder Head	47 N·m (35 lb-ft)
Intake Manifold-to-Cylinder Head	47 N·m (35 lb-ft)

RG,CTM86,G30.1-19-15SEP94

30
1

EXTENDING TURBOCHARGER LIFE

Turbochargers are designed to last the life of the engine, but, because they operate at such high speeds (100,000 rpm or more); a moment's carelessness can cause them to fail in seconds.

The major causes of turbocharger failures are 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 -19-06APR94

• 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.

There are two basic causes of over-temperature. The first is restricted air flow and the second is overpowering the engine. In either case the engine has more fuel than available air for proper combustion, this overfueled condition leads to elevated exhaust temperatures.

Causes of restricted air flow can include damaged inlet piping, clogged air filters, excessive exhaust restriction, or operation at extreme altitudes. Overpowering generally is due to improper fuel delivery or injection timing. If overtemperature operation has been identified, an inspection of the air inlet and exhaust systems should be performed. Also, check the fuel delivery and timing.

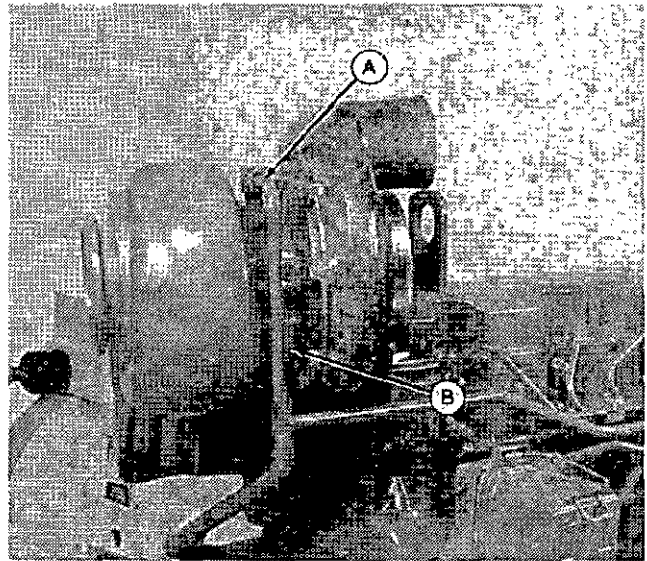
RG,CTM8,G30,R2 -19-19AUG92

REMOVE TURBOCHARGER

CAUTION: After operating engine, allow exhaust system components to cool before removing turbocharger.

Thoroughly clean exterior of turbocharger and surrounding area to prevent entry of dirt into the air intake system during removal.

IMPORTANT: When cleaning turbocharger, do not spray directly into compressor or turbine housings. If turbocharger inspection is required, do not clean exterior prior to removal. Doing so may wash away evidence of a potential failure mode. (See **TURBOCHARGER SEVEN STEP INSPECTION**, later in this group.)



1. Disconnect air intake and exhaust piping from turbocharger (shown disconnected).
2. Disconnect turbocharger oil inlet line (A) from elbow adapter.
3. Disconnect turbocharger oil return (drain) tube (B). Remove and discard gasket.
4. Remove four turbocharger mounting cap screws with washers securing turbocharger to rear exhaust manifold and remove turbocharger.
5. Cap or plug all openings on engine (exhaust and intake manifold related) and place turbocharger on a clean flat table for inspection.
6. Perform turbocharger seven-step inspection, as described later, if failure mode has not been determined.

RG,CTM86,G30,2 -19-15SEP94

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.
	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.
Compressor Wheel Rub	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 injection pump timing.

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.) joints.
	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; Overfueling or Mistimed engine
	Restricted oil drain line.	Inspect and clean oil drain lines as required.
	Operating engine at high speeds and loads immediately after start-up.	Idle engine for a few minutes to allow oil to reach bearings before applying heavy loads.

S11,3005,JG -19-28SEP94

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.
- Turbocharger Bench Test.

NOTE: To enhance the turbocharger inspection, an inspection sheet (Form No. DF-2280 available from Distribution Service Center) can be used that lists the inspection steps in the proper order and shows potential failure modes for each step. Check off each step as you complete the inspection and record any details or problems obtained during inspection. Retain this with the work order for future reference.

S11,3005,IF -19-16AUG94

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.

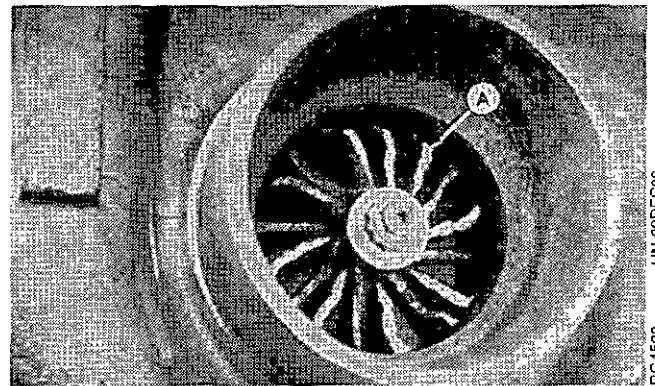
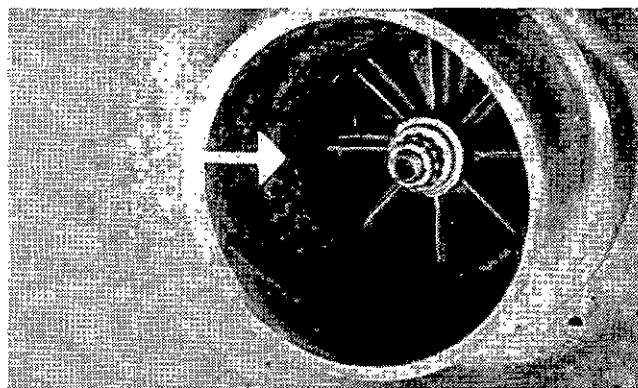


FIG 4523
-JUN-20DEC88

S11,3005,IG -19-07AUG92

NOTE: You will need a good light source for this check.

3. Check compressor inlet for wheel rub on the housing (arrow). Look very closely for any score marks on the housing itself and check the tips of the compressor wheel blades for damage.



S11.3005.IH -19-07AUG92

FIG-4524
-UN-20DEC88

Compressor Housing Outlet

1. Check compressor housing outlet (A). The outlet should be clean and free of dirt or oil.
2. Mark it on your checklist if dirt or oil is found and continue the inspection.



S11.3005.II -19-07AUG92

FIG-4525
-UN-20DEC88

Turbine Housing Inlet

1. Check the turbine housing inlet ports (arrow) for oil in housing, excessive carbon deposit or erosion of center walls.

NOTE: If the inlet is wet with oil, or has excessive carbon deposits, an engine problem is likely. Center wall erosion (cracking or missing pieces), indicate excessive exhaust temperature.

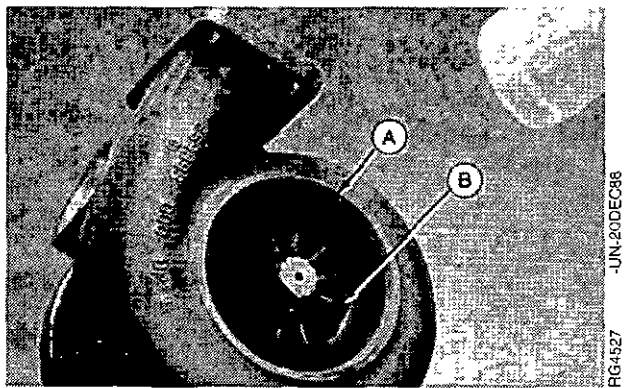


S11.3005.IJ -19-11SEP92

FIG-4526
-UN-20DEC88

Turbine Housing Outlet and Turbine Wheel

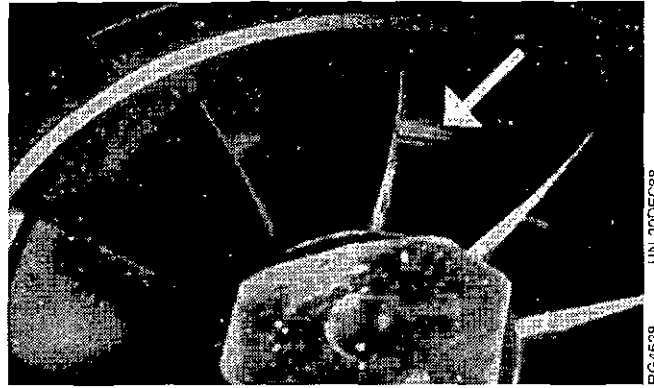
1. Use a flashlight to look up inside the turbine housing outlet (A) and check blades (B) for foreign object damage.



S11.3005.IK -19-11SEP92

FIG-4527
-UN-20DEC88

2. Inspect the wheel blades and housing for evidence of wheel rub (arrow). Wheel rub can bend the tips of the blades with the housing showing wear or damage.



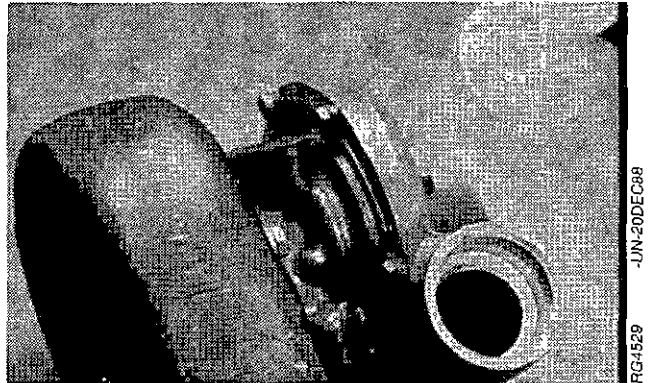
S11,3005,IL -19-11SEP92

RG4528 -UN-20DEC88

External Center Housing and Joints

1. Visually check the outside of the center housing, all connections to the compressor, and turbine housing for oil.

NOTE: If oil is present, make sure it is not coming from a leak at the oil supply or return line.

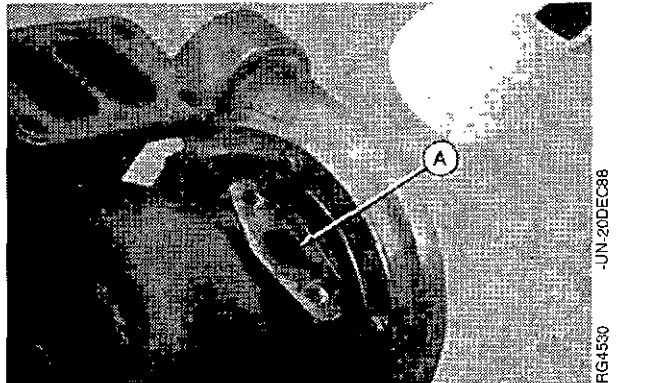


S11,3005,IM -19-07AUG92

RG4529 -UN-20DEC88

Internal Center Housing

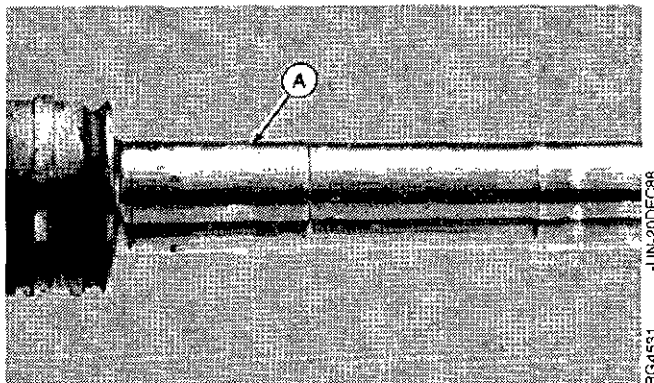
1. Using a flashlight, look through the oil return hole (A), to check the condition of the shaft and/or bearings. There should not be excess carbon deposits on the shaft or in the housing.



S11,3005,IN -19-07AUG92

RG4530 -UN-20DEC88

2. Excessive "blueing" or "coking" of oil along the complete length of the shaft (A) indicates a possible lack of lubrication caused by an engine failure, or improper operation, such as hot shutdowns.



S11,3005,IO -19-07AUG92

RG4531 -UN-20DEC88

30
10

Turbocharger Bench Test

1. Mount the turbocharger in a vise.
2. Rotate the shaft, using both hands, to check rotation and clearance. The shaft should turn freely, however, there may be a slight amount of drag.

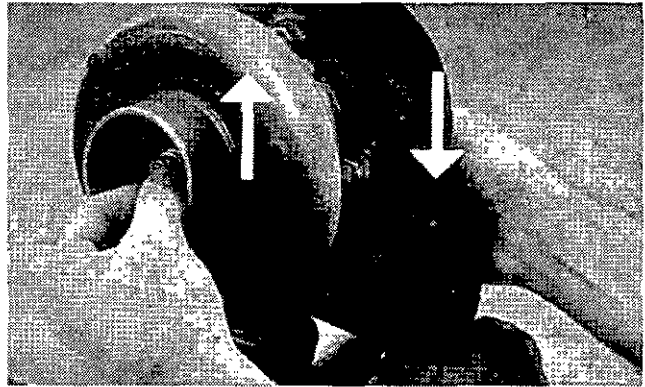


S11,3005,IP -19-29APR93

FG4532
-UN-20DEC88

3. Next, pull up on the compressor end of the shaft and press down on the turbine end while rotating shaft. Neither the compressor wheel nor the turbine wheel should contact the housing at any point.

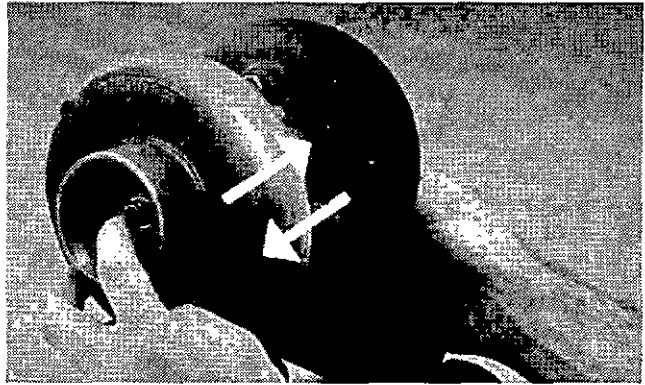
NOTE: There will be some "play" because the bearings inside the center housing are free floating.



S11,3005,IQ -19-07AUG92

FG4533
-UN-20DEC88

4. Next, check shaft endplay by moving the shaft back and forth while rotating. There will be some endplay but not to the extent that the wheels contact the housings.



S11,3005,IR -19-07AUG92

FG4534
-UN-20DEC88

NOTE: These diagnostic procedures will allow you to determine the condition of the turbocharger. If the turbocharger has failed, analysis of your inspection notes should direct you to the specific areas of the engine to correct the problems causing the turbocharger failure (See TURBOCHARGER FAILURE ANALYSIS, outlined earlier in this group). It is not unusual to find that a turbocharger has not failed. If your turbocharger passes all the inspections, the problem lies somewhere else.

IMPORTANT: Before you finalize your conclusion that the turbocharger has not failed, it is strongly recommended that the following procedures of checking radial bearing clearance and axial bearing endplay with a dial indicator be performed. These procedures are not required if a failure mode has already been identified.

S11,3005,JS -19-14OCT94

PERFORM RADIAL BEARING CLEARANCE TEST

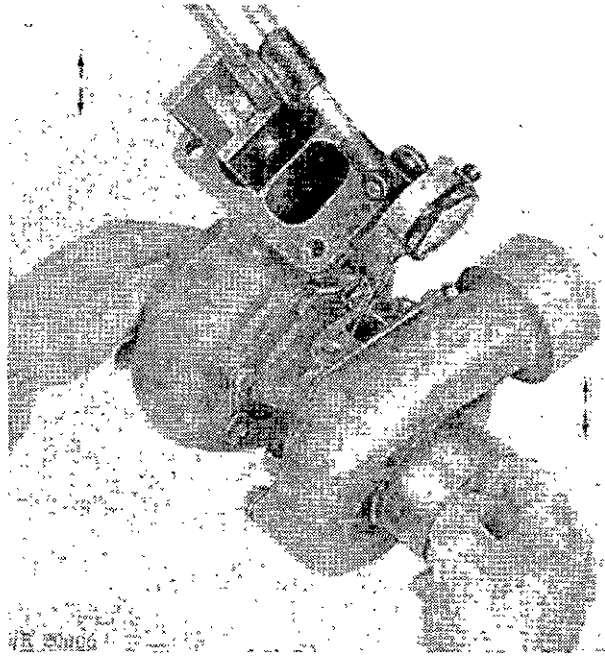
This test will give an indication of the condition of radial bearings within the center housing and rotating assembly.

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.

TURBOCHARGER SHAFT RADIAL MOVEMENT SPECIFICATION

Schwitzer 0.13—0.18 mm (0.005—0.007 in.)

If total indicator reading is not within specification, install a replacement turbocharger or replace center housing and rotating assembly. (See REPLACE CENTER HOUSING ASSEMBLY AND ASSEMBLE TURBOCHARGER, later in this group.)



R20006 -UN-20DEC88

RG,CTM86,G30,3 -19-15SEP94

30
13

PERFORM AXIAL BEARING END PLAY TEST

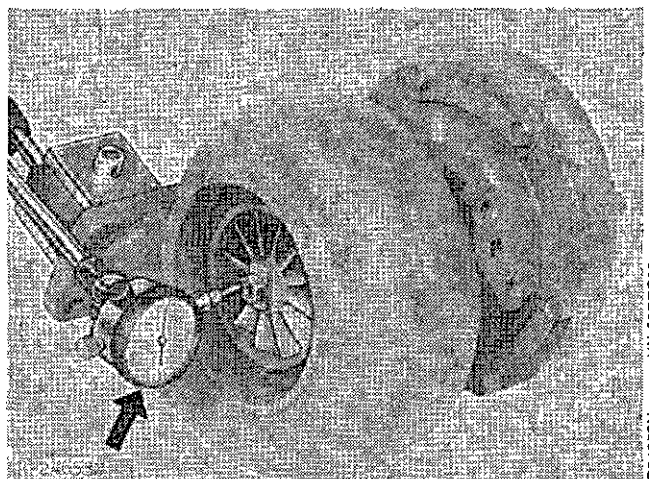
This test will give an indication of the condition of the thrust bearing within the center housing and rotating assembly.

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.

TURBOCHARGER SHAFT AXIAL END PLAY SPECIFICATION

Schwitzer 0.064—0.114 mm (0.0025—0.0045 in.)

If bearing end play is not within specifications, install a replacement turbocharger or replace center housing and rotating assembly. (See REPLACE CENTER HOUSING ASSEMBLY AND ASSEMBLE TURBOCHARGER, later in this group.)



P24653N JUN-20DEC88

RG,CTM86,G30,4 -19-15SEP94

REPAIR TURBOCHARGER

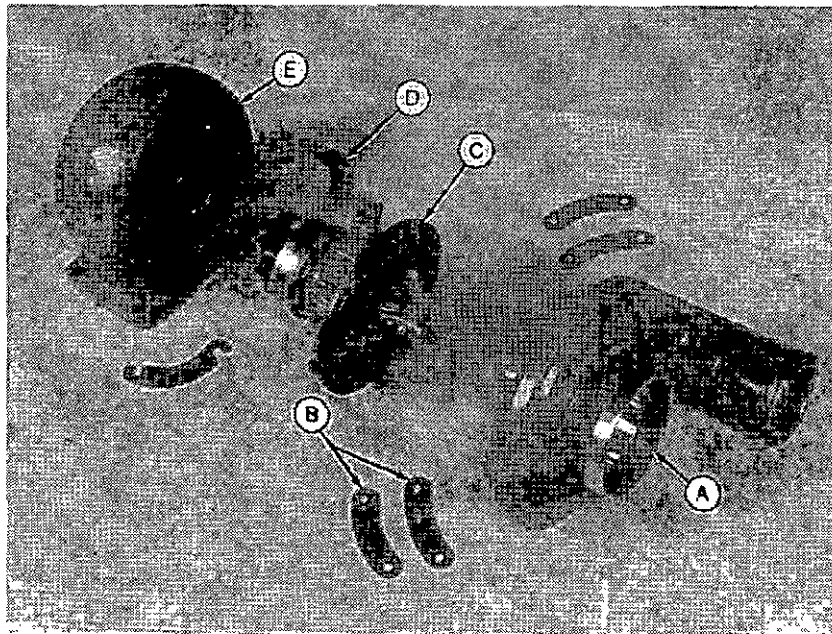
Schwitzer turbochargers used on the engines covered in this manual are available through service parts as a complete remanufactured assembly or as a new center housing and rotating assembly only. When a new center housing and rotating assembly is being installed, thoroughly inspect turbine and compressor housings from existing turbocharger for serviceability. New mounting hardware **MUST** be used. (See CLEAN AND INSPECT TURBINE AND COMPRESSOR HOUSINGS, later in this group.)

30
14

IMPORTANT: Repairing a turbocharger center housing and rotating assembly requires specialized tooling and highly trained personnel, therefore, complete disassembly of turbocharger is not recommended.

RG,CTM86,G30,5 -19-15SEP94

DISASSEMBLE TURBOCHARGER



A—Compressor Housing
B—Compressor Housing
Clamp Plates

C—Center Housing Assembly
D—Turbine Housing Clamp
Plates

E—Turbine Housing

Cap or plug all openings (including exhaust and intake ports) and clean exterior of turbocharger with a pressurized cleaning solvent. Dry turbocharger with compressed air.

IMPORTANT: When cleaning turbocharger do not spray directly into compressor cover or turbine housing. Spinning rotor with high pressure spray may cause bearing damage.

1. Place turbocharger on a clean flat surface.
2. Scribe a location mark on the turbine housing (E), center housing (C), and compressor housing (A) to assure proper indexing of housings when turbocharger is assembled.
3. Remove compressor housing cap screws and clamps (B).
4. Remove compressor housing. Gently tap compressor housing with a soft hammer, if necessary, to remove. Be careful not to damage compressor housing or compressor wheel.
5. Remove turbine housing cap screws and clamps (D).
6. Remove turbine housing. Gently tap turbine housing with a soft hammer, if necessary, to remove. Be careful not to damage turbine housing or turbine wheel.

RG,CTM86,G30,6 -19-15SEP94

30
15

CLEAN AND INSPECT TURBINE AND COMPRESSOR HOUSINGS

1. Thoroughly clean compressor housing (A) and turbine housing (C) using a commercially approved solvent only. Caustic solutions may damage housings. Dry housings with compressed air after cleaning. After a part is cleaned, place it on a clean flat surface and inspect as outlined below.

- **Inspect turbine housing for:**

- Wheel rub damage within the contour area that cannot be polished out with 60-grit silicon carbide abrasive cloth.

- Nicks, dents or warpage that could prevent proper sealing between the turbine housing and center housing.

- Corroded or stripped threaded mounting holes.

- **Inspect compressor housing for:**

- Wheel rub damage within the contour area that cannot be polished out with 80-grit silicon carbide abrasive cloth.

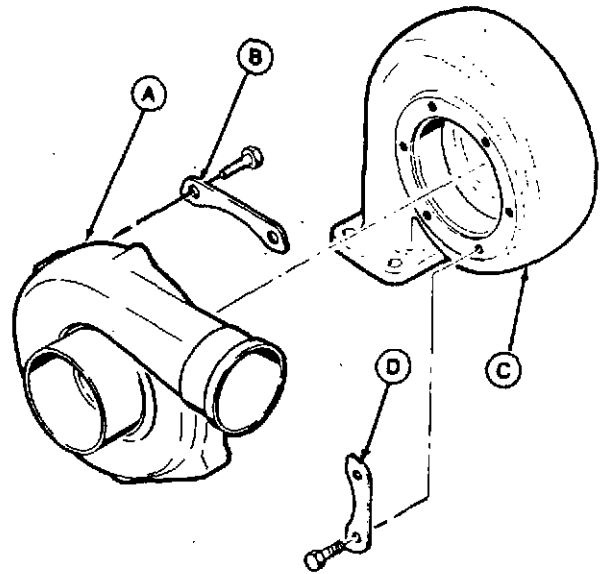
- Nicks, dents, or warpage that could prevent proper sealing between the compressor housing and center housing.

- Corroded or stripped threaded mounting holes.

NOTE: Use new mounting cap screws when turbocharger is reassembled.

2. Clean all threads in housings with a tap.

3. Replace either housing if any of the above defects are found.

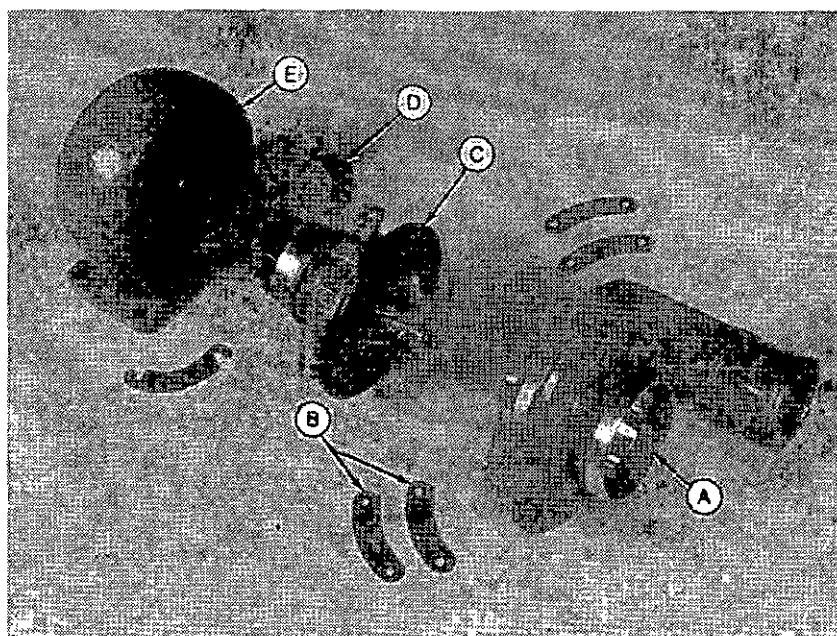


A—Compressor Housing
 B—Compressor Clamp
 C—Turbine Housing
 D—Turbine Clamp

-JUN-05AUG81
 RG5747

RG,CTM42,G30,31-19-15SEP94

REPLACE CENTER HOUSING ASSEMBLY AND ASSEMBLE TURBOCHARGER



A—Compressor Housing
B—Compressor Housing
Clamp Plates

C—Center Housing Assembly
D—Turbine Housing Clamp
Plates

E—Turbine Housing

IMPORTANT: ALWAYS use new cap screws when installing compressor and turbine housings onto center housing assembly.

If reference index marks were not established during turbocharger disassembly, tighten clamp cap screws "finger-tight" until turbocharger is installed on engine and housings are properly indexed with air intake and exhaust piping.

- Carefully transfer the scribed marks from the original center housing (C) to the replacement assembly, if necessary. Use the same procedure for the turbine housing (E) and compressor housing (A), if they are also being replaced.
- Lay turbine housing on outlet side and install center housing assembly into turbine housing. Align scribed reference marks (scribed during disassembly) on turbine housing and center housing.
- Apply a coat of PT569 NEVER-SEEZ Compound to new turbine housing cap screws. Install clamps (D) and cap screws. Tighten cap screws to specification.

4. Position compressor housing onto center housing assembly. Align scribed reference marks (scribed during disassembly) on compressor housing and center housing.

5. Apply a coat of PT569 NEVER-SEEZ Compound to new compressor housing cap screws. Install clamps (B) and cap screws. Tighten cap screws to specification.

TURBOCHARGER CAP SCREW TORQUE SPECIFICATIONS

Turbine Housing-to-Center Housing	15—16 N·m (135—145 lb·in.)
Compressor Housing-to-Backplate	7—8 N·m (60—70 lb·in.)

IMPORTANT: DO NOT spin the rotor assembly with compressed air. Damage to bearings can occur when using compressed air.

- Prelube turbocharger bearings (through oil inlet opening) with clean engine oil before putting turbocharger into service.
- After assembly, spin rotating assembly by hand to check for binding and wheel rub. If either condition exists, disassemble turbocharger and determine the cause.

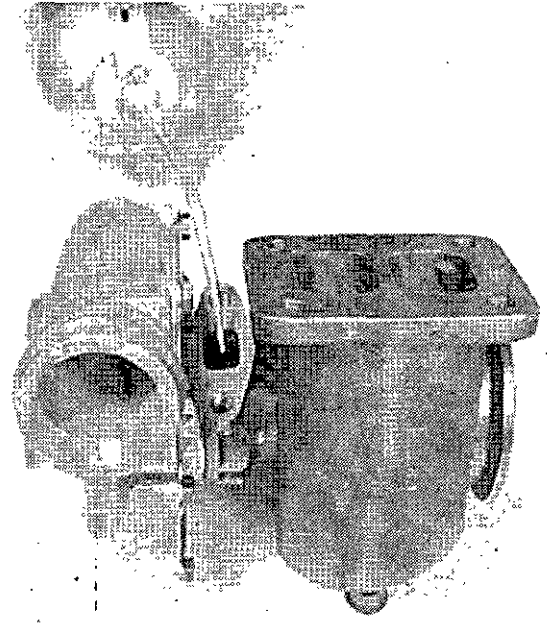
RG,CTM86,G30,7 -19-15SEP94

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.



RG,CTM42,G30,34-19-29OCT92

RG58E8 -UN-13AUG91

INSTALL TURBOCHARGER

IMPORTANT: If turbocharger failed because of foreign material entering the air intake system, be sure to examine the system and clean as required to prevent a repeat failure.

If not previously done, prime (prelube) turbocharger rotating assembly prior to installing turbocharger on engine. Prelube center housing with clean engine oil through oil return (drain) hole as shown. Turn rotating assembly by hand to lubricate bearings.

NOTE: Two threaded guide studs may be used to hold turbocharger-to-exhaust manifold gasket in place and aid turbocharger installation.

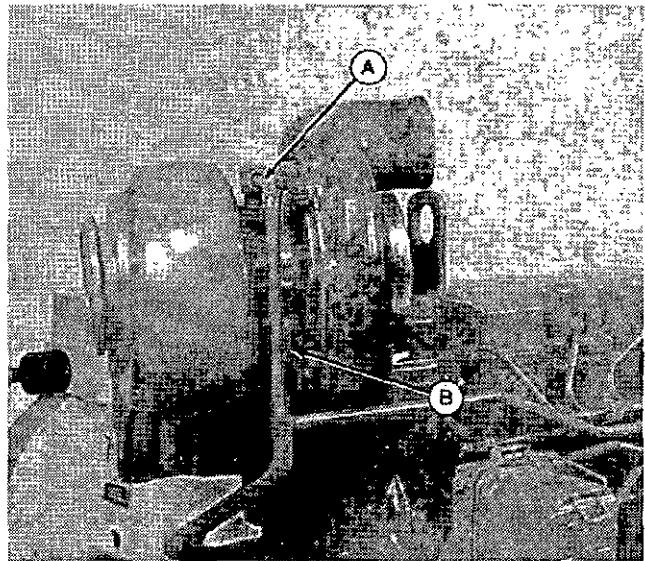
1. Put a new gasket on turbocharger-to-exhaust manifold mounting surface (not shown).
2. Position turbocharger against gasket on exhaust manifold.
3. Apply PT569 NEVER-SEEZ Compound to all turbocharger mounting cap screws. Install cap screws and tighten to 24 N·m (18 lb-ft).

NOTE: Remove all caps or plugs from turbocharger openings.

4. Install turbocharger oil return (drain) tube (B) using a new gasket. Tighten cap screws to 41 N·m (30 lb-ft).
5. Connect oil inlet line (A) to elbow adapter and tighten securely.
6. Refer to your machine technical manual to connect air intake and exhaust piping to turbocharger. Tighten all connections securely to specifications given.

IMPORTANT: BEFORE STARTING an engine with a new or repaired turbocharger, crank the engine over (but do not start) for several seconds to allow engine oil to reach turbocharger bearings. DO NOT crank engine longer than 30 seconds at a time to avoid damaging starting motor.

7. Start and run engine at low idle while checking oil inlet and air piping connections for leaks.



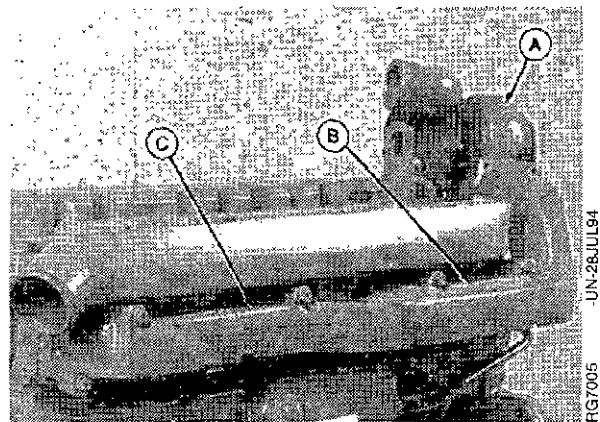
RG7004
-LN-28JUL94

REMOVE, INSPECT, AND INSTALL EXHAUST MANIFOLD

1. Remove turbocharger (A) from exhaust manifold. (See REMOVE TURBOCHARGER, earlier in this group.
2. Remove cap screws and remove rear exhaust manifold (B) and front exhaust manifold (C). Remove manifold gaskets and discard.
3. Remove and discard front-to-rear exhaust manifold sealing ring (D).
4. Remove all residue and gasket material from gasket surfaces.
5. Thoroughly clean passages in exhaust manifolds and exhaust elbow.
6. 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.
7. To install exhaust manifold, reverse removal procedure and use new gaskets.

NOTE: Exhaust manifold cap screws are stainless steel, it is not necessary to use an anti-seize compound during exhaust manifold installation.

8. Tighten exhaust manifold mounting cap screws to 47 N·m (35 lb-ft).



RG7005
UN-28JUL94

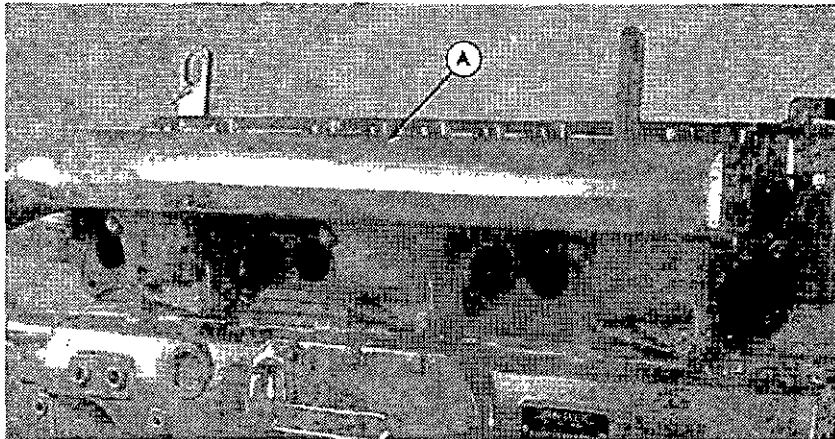


RG7006
UN-28JUL94

- A—Turbocharger
- B—Rear Exhaust Manifold
- C—Front Exhaust Manifold
- D—Sealing Ring

RG.CTM86.G30.9 -19-16SEP94

REMOVE, INSPECT, AND INSTALL INTAKE MANIFOLD



UN-28/JUL94
RG7007

IMPORTANT: All intake manifold connections at the turbocharger and engine cylinder head must be tight to prevent loss of power resulting from insufficient intake manifold pressure.

Intake manifold hose and cap screw connections should be inspected periodically for tightness.

Whenever a tune-up has been performed on the engine, or whenever it is suspected that the horsepower output might be low, the intake manifold pressure (turbo-boost) should be checked. (See Group 110.)

1. Remove exhaust manifold, shown removed. (See REMOVE, INSPECT, AND INSTALL EXHAUST MANIFOLD, earlier in this group.)
2. Remove air intake connections from intake manifold (A) as detailed in machine technical manual.
3. Disconnect ether starting aid line from manifold, if equipped.

4. Remove six cap screws and remove intake manifold from cylinder head. Remove and discard manifold gaskets.

5. Inspect the intake manifold for serviceability. Replace if it is cracked or otherwise damaged.

6. Inspect the machined mating surfaces of cylinder head and intake manifold. Clean, as required, by using a scraper and/or wire brush, and compressed air.

7. To install intake manifold, reverse removal procedures and use new gaskets.

8. Tighten intake manifold cap screws to 47 N·m (35 lb-ft).

9. Install exhaust manifold assembly and turbocharger as detailed earlier in this group.

10. Refer to your machine technical manual to connect all air intake and exhaust piping.

30
21

RG,CTM86,G30,10-19-15SEP94

30
22

SPECIAL OR ESSENTIAL TOOLS

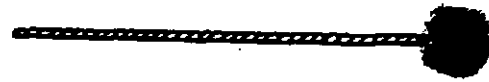
NOTE: Order tools according to information given in the U.S. SERVICE-GARD™ Catalog or in the European Microfiche Tool Catalog (MTC).

DX,TOOLS -19-05JUN91

Nozzle Thread Cleaning Brush D17030BR

RG5099 -UN-23AUG88

Used to clean nozzle threads in cylinder head.

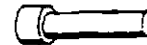


S53,D17030,BR -19-16FEB87

Timing Pin JDE81-4

RG5068 -UN-23AUG88

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



RG,JDE814,86 -19-26OCT94

Serrated Wrench JDE90

RG5290 -UN-15OCT92

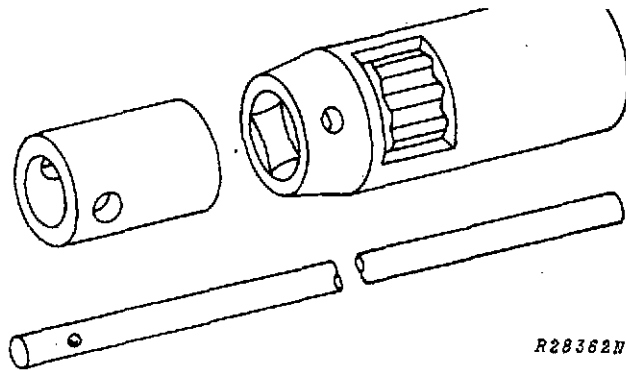
Use to hold injection pump fuel outlet fittings on Bosch "P" pump from turning when loosening and tightening fuel pipe connections.



S54,JDE90 -19-29OCT82

Nozzle Socket JDE92

Used to remove and install 21 mm injection nozzles.



R28362N

S11,3010,OU -19-16AUG94

Tap JDF5

RG5100 -UN-23AUG88

Used to restore nozzle threads in cylinder head.

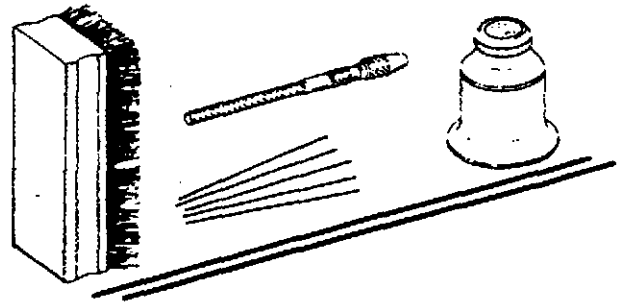


S53,JDF5 -19-08MAR94

Fuel System

Nozzle Cleaning Kit JDF13 (JDE105)

Used to clean injection nozzles.

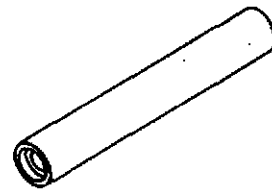


S11,3010,OW -19-09SEP91

RG4953 -UN-14DEC88

Driver JDF15

Used to install spindle seals in fuel supply pumps.



RG2017

S55,3010,BA -19-25JUL91

RG2017 -UN-30NOV88

Crowsfoot Wrench JDF22

Use to loosen and tighten fuel pipes at injection nozzles and at injection pump.



RG5286 -UN-23AUG88

S53,JDF22,1 -19-02DEC87

Nozzle Seat Reamer JDG609

Used to clean carbon from nozzle seats in cylinder head.

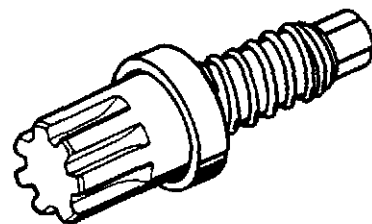


RG5289 -UN-23AUG88

S53,JDG609 -19-02DEC87

Flywheel Turning Tool JDG820

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



RG,JDG820 -19-04AUG94

RG7056 -UN-10AUG94

35
2

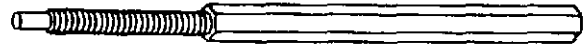
Fuel System

RG7212

-UN-23JUL94

Injection Pump Timing Pin JDG886

Used to set in-line fuel injection pump timing prior to removal of pump.



RG,JDG886 -19-10AUG94

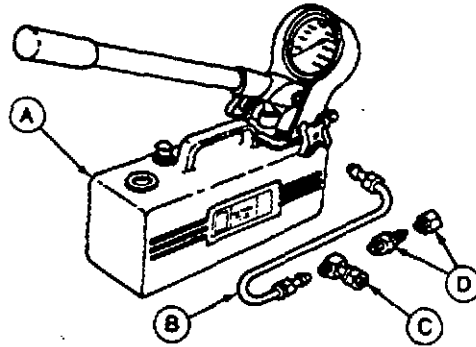
A—Fuel Injection Nozzle Tester D01109AA (Y900)

B—Fuel Line Assembly Y900-2A*

C—Adapter Nut Y900-21**

D—Straight Adapters Y900-7* and Y900-15*

Used to test operational performance and opening pressure of nozzles.



RG-4954 -UN-14DEC88

*Included in D01110AA (Y910A) Adapter Set.

**May be used instead of Y900-7 and Y900-15.

S11,3010,OX -19-09SEP91

SERVICE EQUIPMENT AND TOOLS

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

Name	Use
TORX® T45 Adapter	Injection pump drive gear-to-hub cap screws.

TORX® is a registered trademark of Camcar/Textron.

RG,CTM86,G35,31-19-15SEP94

OTHER MATERIAL

Name	Use
AR54749 Soap Lubricant	Injection pump mounting flange O-ring.
PT569 NEVER-SEEZ Compound	Gland nut threads and fuel injection nozzle barrel.
LOCTITE 242 (TY9370/T43512) Thread Lock and Sealer	Injection pump timing hole plug.
LOCTITE 592 (TY9374/TY9375) Pipe Sealant with TEFLON	Fuel filter drain plug and bleed plug.

RG,CTM42,G35,76-19-15SEP94

FUEL SYSTEM SPECIFICATIONS

ITEM	SPECIFICATION
Injection Pump Type	Bosch P7100 In-line with Electronically-Controlled Governor
Engine Operating Speeds	See Applicable Machine TM
Injection Pump Timing-to-Engine	No. 1 TDC; Compression Stroke
Overflow Valve Opening Pressure	130—180 kPa (1.3—1.8 bar) (19—26 psi)
Fuel Injection Nozzle Type	Bosch 21 mm with 7 mm OD P-Type Nozzle Tip
Nozzle Tip Size	7 Hole x 0.23 mm ID x 148° Spray Angle
New Nozzle Opening Pressure (7 x 0.23 mm)	29 000 kPa (290 bar) (4200 psi)
Used Nozzle Minimum Opening Pressure (7 x 0.23 mm)	26 200 kPa (262 bar) (3800 psi)

RG,CTM86,G35,1 -19-15SEP94

DIESEL FUEL SYSTEM SPECIFICATIONS—CONTINUED

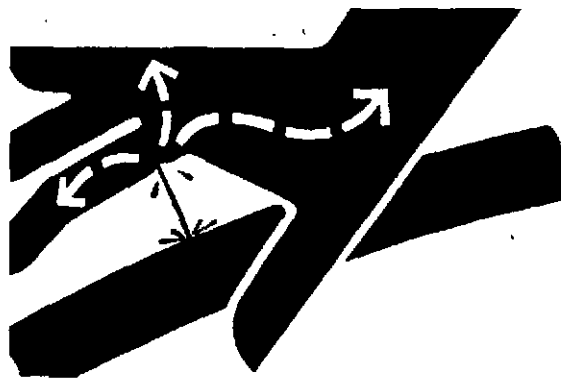
TORQUES

Injection Pump-to-Cylinder Block Stud Nuts	47 N·m (35 lb-ft)
Injection Pump Drive Gear-to-Pump Hub Cap Screws	61 N·m (45 lb-ft)
Fuel Delivery Line Connectors @ Delivery Valves and Nozzles	27 N·m (20 lb-ft)
Nozzle Gland Nut-to-Cylinder Head	88 N·m (65 lb-ft)
Nozzle Retaining Nut	60—80 N·m (44—59 lb-ft)
Supply Pump Mounting Stud Nuts	5—7 N·m (4—5 lb-ft)(45—60 lb-in.)
Leak-off Line-to-Connectors	17 N·m (12 lb-ft)(150 lb-in.) Maximum
Leak-off Connector-to-Nozzle	8 N·m (6 lb-ft)
Fuel Filter Base-to-Cylinder Block	34—54 N·m (25—40 lb-ft)
Fuel Pipe Connections at Filter Base	17 N·m (12 lb-ft)(150 lb-in.) Maximum
Injection Pump Drive Gear Cover Cap Screws	27 N·m (20 lb-ft)
Injection Pump Housing Oil Fill Plug	35 N·m (26 lb-ft)

RG,CTM86,G35,2 -19-15SEP94

RELIEVE FUEL SYSTEM PRESSURE

⚠ CAUTION: Escaping diesel fuel under pressure can have sufficient force to penetrate the skin, causing serious injury. Before disconnecting lines, be sure to relieve pressure. Before applying pressure to the system, be sure ALL connections are tight and lines, pipes and hoses are not damaged. Keep hands and body away from pinholes and nozzles which eject fluid under pressure. Use a piece of cardboard or wood, rather than hands, to search for suspected leaks.



If ANY fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type injury or gangrene may result. Doctors unfamiliar with this type of injury may call the Deere & Company Medical Department in Moline, Illinois, or other knowledgeable medical source.

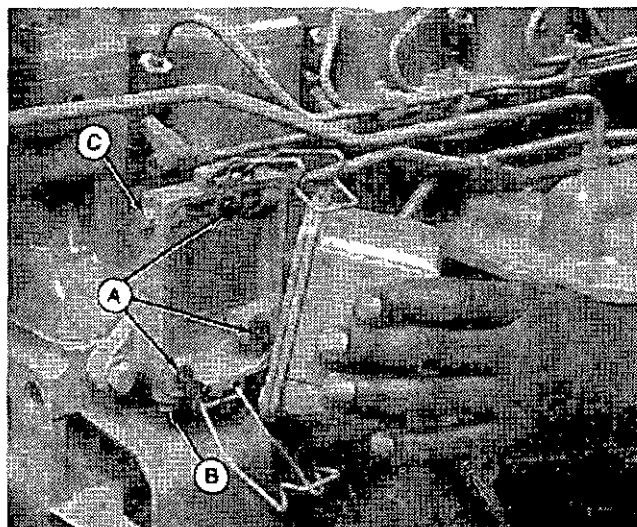
Any time the fuel system has been opened up for service (lines disconnected or filters removed), it will be necessary to bleed air from the system. (See BLEED FUEL SYSTEM in Group 115.)

RG,CTM8,G35,6 -19-29SEP94

REPLACE RECTANGULAR FUEL FILTER ELEMENT

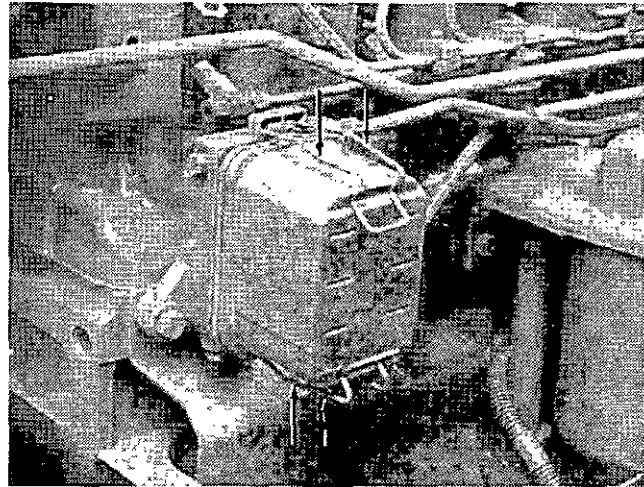
NOTE: Refer to your operator's manual for proper servicing and replacement (hourly) intervals.

1. Close fuel shut-off valve at bottom of fuel tank (not illustrated).
2. Loosen bleed plug (C) and remove drain plug (B). Drain fuel from filter.
3. With fuel filter held firmly against base, lift up on top retaining spring and pull down on bottom retaining spring. Pull fuel filter off guide pins (A) of fuel filter base and discard filter.



RG,CTM86,G35,3 -19-15SEP94

4. Install fuel filter onto guide pins on fuel filter base. Hold filter firmly against base.
5. Secure bottom retaining spring first, then secure top retaining spring.
6. Install drain plug, shown installed. Tighten bleed plug and drain plug securely. Do not overtighten.
7. Open fuel shut-off valve and bleed fuel system. (See BLEED THE FUEL SYSTEM, in Group 115.)

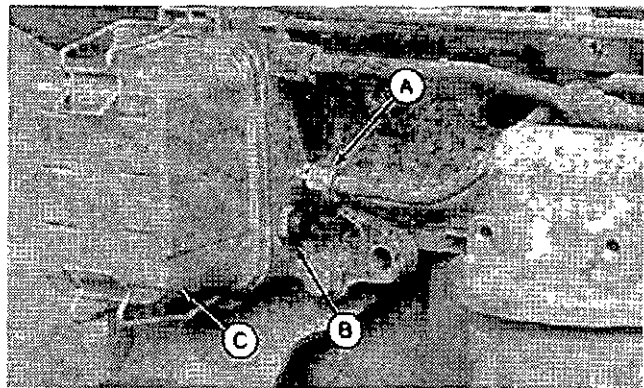


RG7052 -JUN-10AUG94

RG,CTM86,G35,4 -19-15SEP94

REPLACE FUEL FILTER CHECK VALVE

1. Drain and remove fuel filter (C) as described earlier in this group.
2. Remove fuel filter inlet line (A), (shown removed).
3. Inspect and clean fuel filter base (if needed).
4. Remove check valve assembly housing from fuel filter base and discard.
5. Install new check valve assembly and tighten securely.
6. Install fuel inlet line and tighten connection 17 N·m (12 lb-ft) (150 in-lb) maximum. DO NOT overtighten.
7. Install fuel filter and bleed fuel system. (See BLEED THE FUEL SYSTEM, in Group 115.)



RG7074 -JUN-07SEP94

RG,CTM86,G35,5 -19-15SEP94

REPLACE PRIMARY (ROUND) FUEL FILTER/WATER SEPARATOR

NOTE: Refer to your operator's manual for recommended servicing and (hourly) replacement intervals.

1. Thoroughly clean exterior of filter element (E) and mounting base (A). Also clean around filter mounting area.

NOTE: Lifting up on ring as it is rotated helps to get it past retaining detent.

2. Rotate retaining ring (F) counterclockwise (left) 1/4 turn. Remove ring with filter element.

3. Remove water separator (B) from filter element. Drain and clean water separator, dry with compressed air.

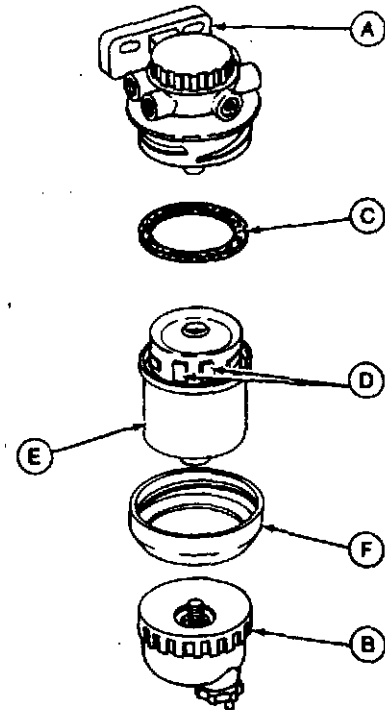
NOTE: Notice indexing keys (D) on filter element. These keys insure proper alignment of filter element to mounting base.

4. Install water separator onto new filter element.

5. Index filter element until longer, vertical keys are oriented away from engine. Insert filter element into mounting base securely. It may be necessary to rotate filter for correct alignment.

6. Install retaining ring to mounting base, making certain dust seal (C) is in place on filter base. Tighten retaining ring until it locks into detent position and a 'click' sound can be heard.

7. Bleed fuel system. See BLEED THE FUEL SYSTEM in Group 115.



A—Mounting Base
 B—Water Separator
 C—Dust Seal
 D—Indexing Keys
 E—Filter Element
 F—Retaining Ring

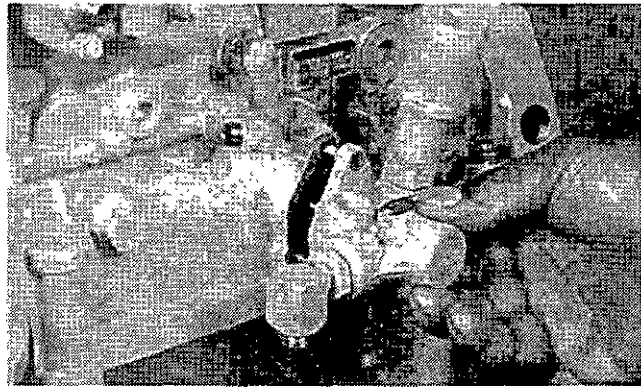
RG7076 -UN-07SEP94

REMOVE FUEL SUPPLY PUMP

NOTE: To diagnose fuel supply pump malfunctions, refer to Group 115.

Thoroughly clean exterior of supply pump. Also clean around supply pump mounting area on injection pump housing.

1. Disconnect fuel inlet line and outlet line, shown disconnected. Cap all line openings so contaminants do not enter fuel system.
2. Remove three supply pump mounting nuts and pull fuel supply pump straight out from mounting studs as shown.
3. Cover supply pump mounting bore so debris cannot enter injection pump housing.



RG7053 -JUN-10AUG94

RG,CTM86,G35,7 -19-15SEP94

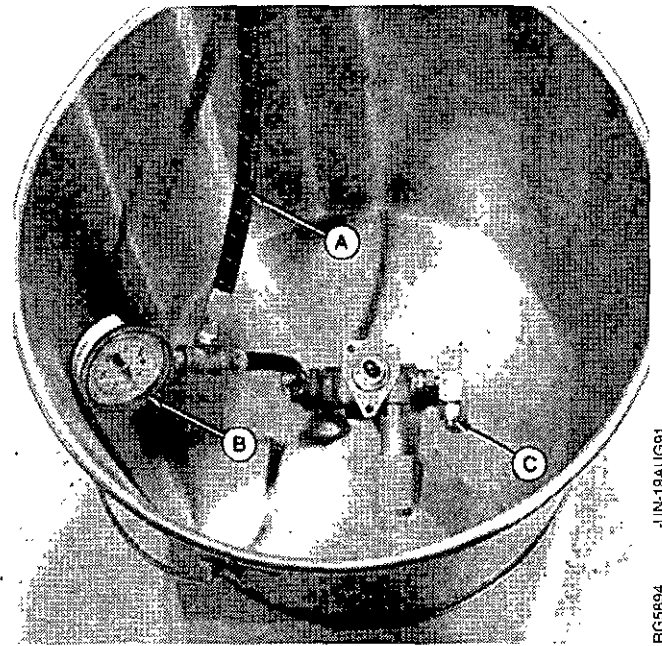
TEST FUEL SUPPLY PUMP FOR LEAKS

Fuel delivery pressure should be checked before removing supply pump from injection pump. See CHECK SUPPLY PUMP OPERATION in Group 115.

1. Connect compressed air line (A) to a pressure gauge (B) and to the supply pump inlet fitting. The air line should have a regulating valve to control pressure.
2. Cap or plug supply pump outlet fitting (C).
3. Submerge supply pump in a container of clean diesel fuel. Regulate air pressure to 200 kPa (2.0 bar) (29 psi).
4. Move spindle in and out by hand. No air bubbles should appear around spindle bore.

NOTE: If bubbles appear, it is an indication that either the spindle seal is defective or that the spindle is worn (or possibly both).

IMPORTANT: If enough diesel fuel leaks past the spindle and seal, serious damage to the injection pump or engine (or both) could occur. Fuel leakage past spindle dilutes engine oil.



RG5694 -JUN-19AUG91

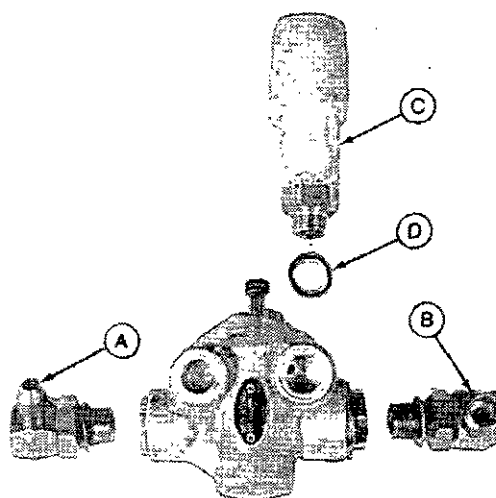
FG.CTM61.G35.6 -19-05APR93

DISASSEMBLE FUEL SUPPLY PUMP

1. Remove inlet elbow fitting (A) and outlet elbow fitting (B) by loosening locknut and unscrewing fittings from pump housing. Remove and discard O-rings.

2. Remove hand primer (C) from housing. Remove and discard copper washer (D).

- A—Inlet Elbow Fitting
- B—Outlet Elbow Fitting
- C—Hand Primer Pump
- D—Copper Washer



RG,CTM61,G35,7 -19-17MAR92

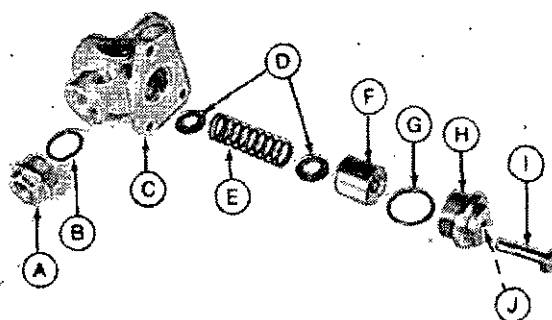
-JUN-19AUG91
RG5909

3. Remove fuel pump outlet valve fitting (A) from pump housing (C). Remove and discard O-ring (B).

4. Remove spindle (I) and spindle guide plug (H) by unscrewing guide plug from pump housing. Remove and discard O-rings (J and G).

5. Remove plunger (F), spring wear plates (D), and spring (E).

- A—Outlet Valve Fitting
- B—O-Ring
- C—Supply Pump Housing
- D—Spring Wear Plates
- E—Spring
- F—Plunger Assembly
- G—O-Ring
- H—Spindle Guide Plug
- I—Spindle
- J—O-Ring



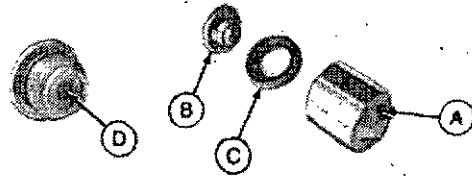
RG,CTM42,G35,64-19-28OCT92

-JUN-28AUG91
RG5912

6. Push inlet valve (B) and seal (C) out of plunger (A) by poking rounded end of a small pin through closed end of plunger.

NOTE: The outlet valve is located in outlet valve fitting (D) and is not removable from fitting.

- A—Plunger
- B—Inlet Valve Seal
- C—Inlet Valve
- D—Outlet Valve and Fitting



RG,CTM42,G35,65-19-03DCT92

-JUN-28AUG91
RG5913

INSPECT AND REPAIR FUEL SUPPLY PUMP

1. Inspect supply pump housing (C) for cracks and wear. Be sure plunger bore is not worn or scored. Check condition of threads for inlet and outlet fittings, hand primer pump, and spindle guide plug (H).

2. Inspect spindle (I) for wear, scoring on OD, and burrs. Check lands that contact plunger and fuel pump cam lobe to be sure they are flat and undamaged. Remove any deposits with a suitable solvent.

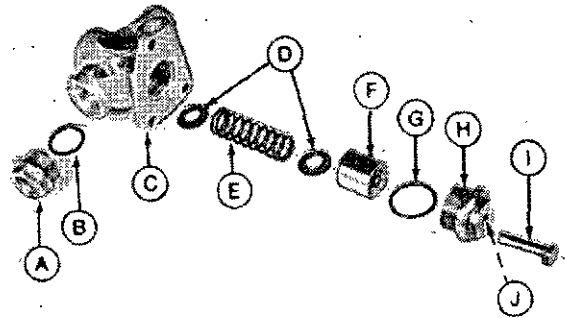
3. Inspect plunger (F) for burrs and pits. Remove any deposits with a suitable solvent.

4. Inspect spring (E) and wear plates (D) for cracks, distortion, and wear.

5. Inspect inlet valve and seal (not shown) for wear, cracks, and broken or missing spring.

6. Inspect outlet valve and fitting (A) for wear, cracks, broken or missing spring, or damaged threads.

If any of the above parts are damaged, worn, or defective, replace as necessary.



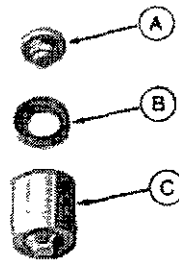
- A—Outlet Valve Fitting
- B—O-ring
- C—Supply Pump Housing
- D—Spring Wear Plates
- E—Spring
- F—Plunger Assembly
- G—O-ring
- H—Spindle Guide Plug
- I—Spindle
- J—O-ring

RG,CTM61,G35,B -19-17MAR92

-JUN-28AUG91
RG5912

ASSEMBLE FUEL SUPPLY PUMP

IMPORTANT: Always use new copper gaskets and O-rings. Dip parts in clean diesel fuel before assembly. Hands should be wet with diesel fuel when assembling internal components of fuel supply pump.



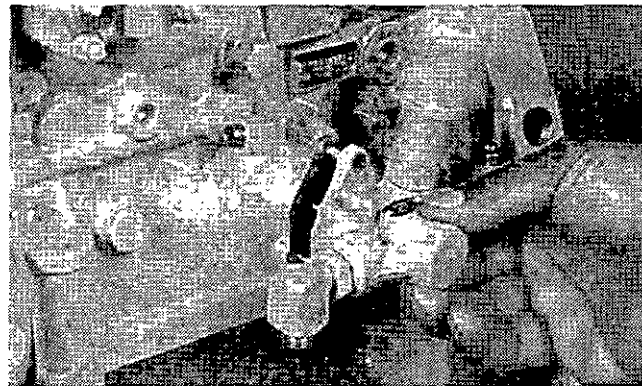
RG5946 -JUN-26AUG91

1. Assemble seal (B) into plunger (C) so that flat side of seal is against the closed end of the plunger. Install inlet valve (A) into plunger so that spring side of valve protrudes through the center of seal and faces toward closed end of plunger.

RG,CTM61,G35,9 -19-17MAR92

INSTALL FUEL SUPPLY PUMP

IMPORTANT: Before installing supply pump, test pump to make sure fuel will not leak around spindle and spindle seal. (See **TEST FUEL SUPPLY PUMP FOR LEAKS**, earlier in this group.)



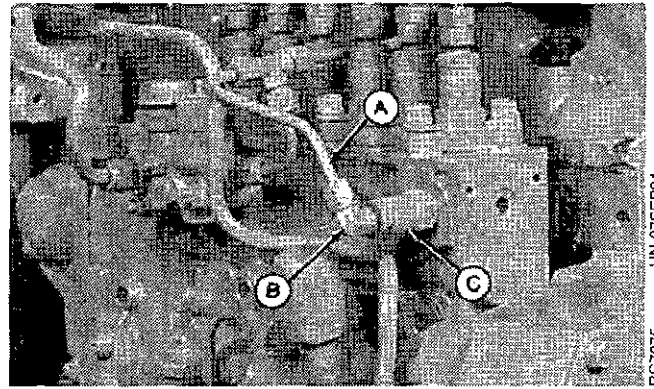
RG7053 -JUN-10AUG94

1. Install a new gasket on supply pump mounting face and position pump over mounting studs.
2. Tighten mounting stud nuts 5—7 N·m (4—5 lb-ft) (45—60 lb-in.).
3. Install fuel inlet and outlet lines and tighten all connections securely.
4. Bleed fuel system. (See **BLEED THE FUEL SYSTEM**, in Group 115.)

RG,CTM86,G35,8 -19-15SEP94

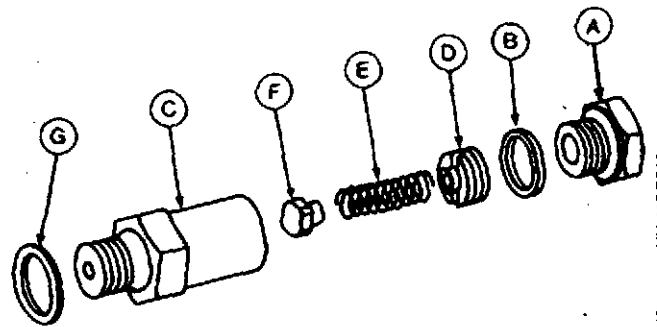
SERVICE INJECTION PUMP OVERFLOW VALVE

1. Remove leak-off line (A) from elbow (B). Remove elbow from overflow valve assembly (C).
2. Remove valve assembly from pump.



RG,CTM86,G35,9 -19-15SEP94

3. Remove reducer (A) and copper washer (B) from valve body (C). Discard copper washer.
4. Unscrew spring seat (D); then remove spring (E) and valve (F).
5. Inspect for foreign material imbedded in seat of nylon valve.
6. Check spring to see that it is not weak or broken.
7. Wash all parts in solvent and air dry.



- A—Reducer
- B—Washer
- C—Valve Body
- D—Spring Seat
- E—Spring
- F—Valve
- G—Washer

NOTE: *There is no adjustment on valve to regulate housing pressure. If suspected that valve is malfunctioning replace valve to restore proper operation.*

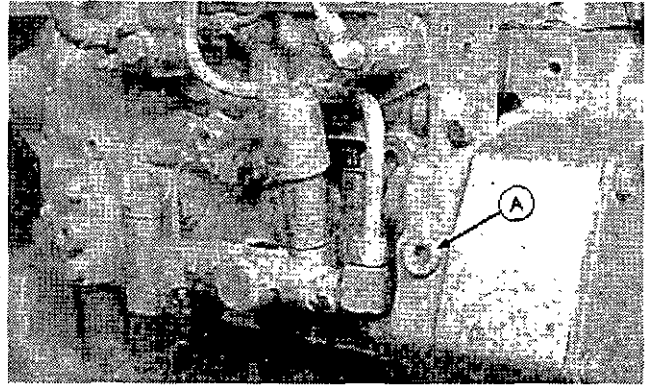
8. Reverse order of removal for reassembly of overflow valve. Install new copper washers.

RG,CTM42,G35,72-19-03OCT92

REMOVE FUEL INJECTION PUMP

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

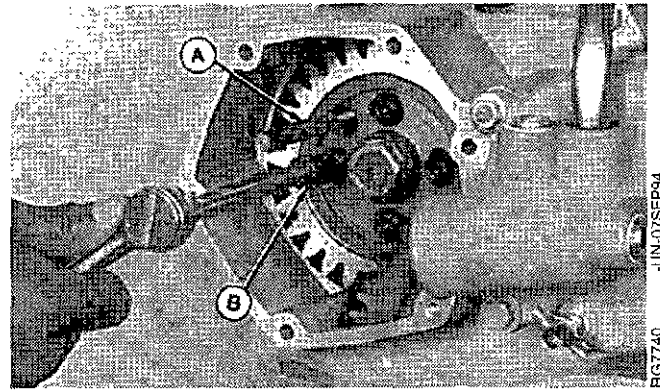
1. Clean injection lines and area around the injection pump with cleaning solvent or a steam cleaner.
2. Remove timing hole plug (A).
3. Rotate engine flywheel (in normal running direction) with JDG820 Flywheel Turning Tool until No. 1 piston is at "TDC" of its compression stroke. At this point, JDE81-4 Timing Pin should enter hole in flywheel.
4. Timing marks on injection pump drive hub and fixed timing pointer should be aligned.



RG7739 -UN-07SEP94

RG,CTM86,G35,10-19-15SEP94

IMPORTANT: To assure that accurate injection pump timing is maintained when pump is removed and reinstalled, it is recommended that JDG886 Injection Pump Timing Pin (A) is used prior to removal and installation of injection pump. If injection pump will be serviced at an authorized repair station, remove timing pin prior to shipping for service.



5. Remove injection pump drive gear cover (shown removed), remove and discard all gasket material.

NOTE: It may be necessary to rotate injection pump drive hub slightly to install timing pin.

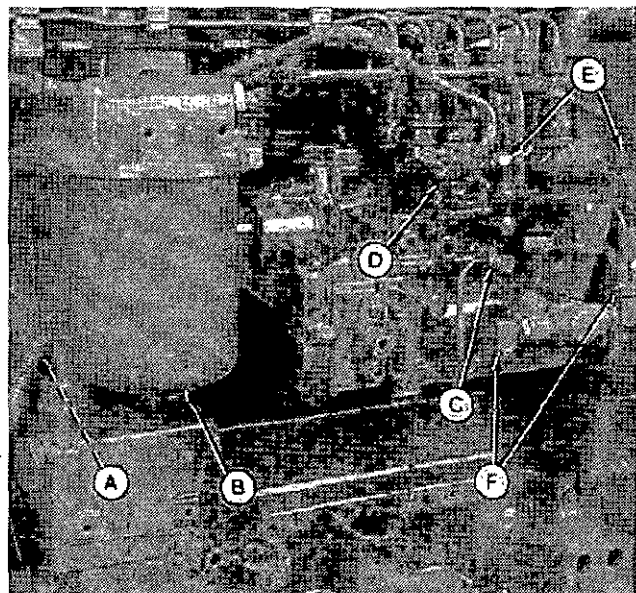
6. Install JDG886 Timing Pin through hole in injection pump drive gear. Thread timing pin into injection pump hub until it bottoms.

7. Remove four injection pump drive gear cap screws using a T45 TORX® adapter (B) and remove drive gear from pump drive hub.

TORX® is a registered trademark of Camcar/Textron.

RG,CTM86,G35,11-19-15SEP94

8. Remove engine oil filter (B) from filter base.
9. Disconnect governor pigtail connectors (A) from main wiring harness. Disconnect fuel shut-off solenoid wiring lead (shown disconnected and capped).
10. Remove injection pump lube line (C) from elbow fitting.
11. Remove fuel inlet line (D) from shut-off solenoid. Remove fuel leak-off line assembly (E).
12. Disconnect fuel supply pump lines (F). (Photo shows outlet line only.)



-JUN-10AUG84
RG7064

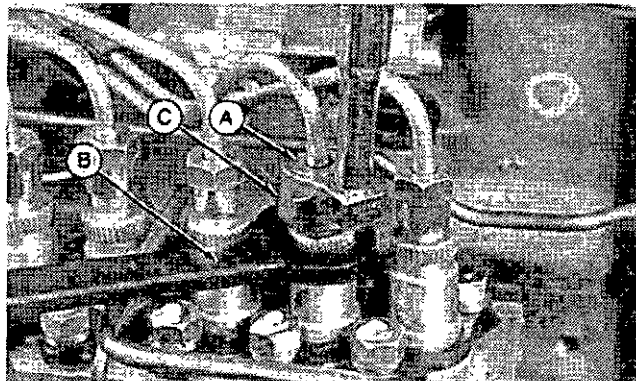
Cap all openings on pump and line connections so contaminants do not enter fuel system.

- A—Governor Pigtail Connectors
- B—Oil Filter
- C—Injection Pump Lube Line
- D—Fuel Inlet Line
- E—Leak-Off Line Assembly
- F—Fuel Supply Pump Lines

RG,CTM86,G35,12-19-15SEP94

IMPORTANT: JDE90 Serrated Wrench (B) MUST BE used to keep delivery valve fittings stationary while loosening line nuts. If a delivery valve and barrel housing rotates while loosening or tightening a fuel line nut, injection pump delivery will be altered. The pump must be recalibrated on a test stand.

13. Remove injection line nuts (A) from injection pump delivery valves using JDE90 Serrated Wrench (B) along with either JDF22 Crowsfoot Wrench (C) or a standard 3/4-in. line wrench.



-JUN-19AUG81
RG5877

14. Remove four injection pump mounting stud nuts.
15. Carefully remove injection pump and place it on a clean flat surface.
16. Cap all delivery valve fittings.

RG,CTM86,G35,13-19-15SEP94

INSTALL FUEL INJECTION PUMP

1. If engine was rotated after injection pump was removed, rotate flywheel until timing pin enters flywheel at No. 1 cylinder's "TDC" compression stroke.

NOTE: When No. 1 cylinder is at "TDC" compression stroke, intake and exhaust valves for No. 1 cylinder will be closed and both rocker arms will be loose.

2. Rotate injection pump drive hub until marks on drive hub (B) and pointer (A) are aligned.

NOTE: It may be necessary to rotate pump hub slightly to get drive hub to enter bearing plate.

3. Thread JDG886 Timing Pin (E) into drive hub, as shown, and tighten until it bottoms against bearing plate (D).

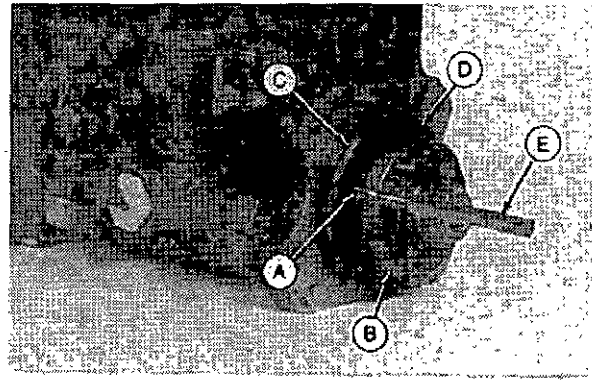
4. Install a new O-ring (C) on pump mounting hub. Lightly lubricate O-ring with JDT308 Soap to aid in pump installation and prevent O-ring damage.

NOTE: Place injection pump drive gear in timing gear housing (if previously removed) with chamfered side of gear toward injection pump. Chamfer is at outer edge of bore for easier installation of gear to pump drive hub.

5. Install injection pump using moderate forward pressure and slight rocking motion to work O-ring into mounting bore.

Injection pump flange should seat solidly against cylinder block and injection pump drive hub nut should be positioned in ID of pump drive gear.

6. Install mounting stud nuts and tighten to 47 N·m (35 lb-ft).



A—Pointer
 B—Drive Hub
 C—O-Ring
 D—Bearing Plate
 E—JDG886 Timing Pin

UN-07SEP94
 RG7741

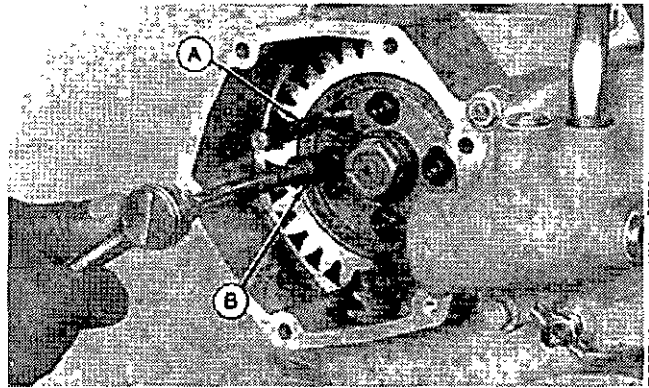
RG,CTM86,G35,14-19-15SEP94

7. Carefully install drive gear on pump drive hub, position gear so mounting cap screws are approximately centered in mounting slots. This will allow for minor adjustment of pump timing, should the need arise.

8. Install four drive gear-to-pump hub cap screws and tighten to 61 N·m (45 lb-ft) using a T45 TORX® adapter (B).

9. Remove JDG886 Timing Pin (A) from injection pump hub. Install timing hole plug using LOCTITE 242 (TY9370) Thread Lock and Sealer, tighten plug securely.

10. Install injection pump drive gear cover using a new gasket. Tighten cap screws to 27 N·m (20 lb-ft).



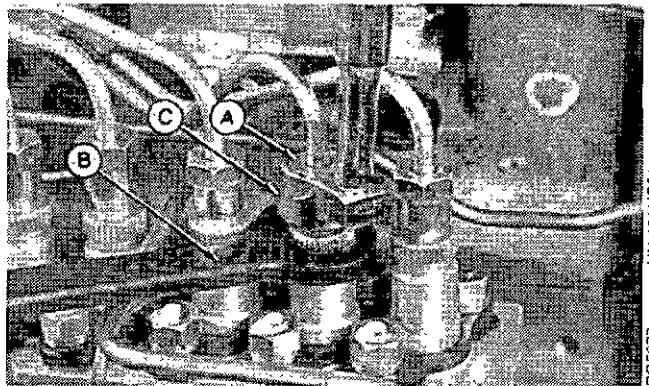
-UN-07SEP94
RG7740

RG,CTM86,G35,15-19-15SEP94

NOTE: Remove protective caps and plugs that were installed on fuel system components during injection pump removal.

11. Connect fuel delivery lines nuts (A) to injection pump delivery valve fittings using JDE90 Serrated Wrench (B) and JDF22 Crowsfoot Wrench (C). Tighten line nuts to 27 N·m (20 lb-ft).

IMPORTANT: DO NOT move delivery valve fittings while tightening line nuts. If delivery valve and barrel housing rotates while tightening a fuel line nut, injection pump fuel delivery will be altered. The injection pump will have to be recalibrated on a test stand by an authorized diesel repair station.



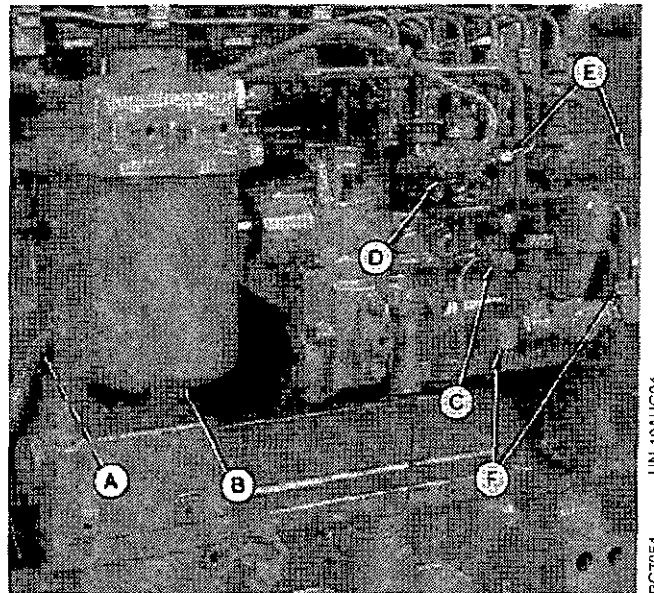
-UN-19AUG91
RG5877

RG,CTM86,G35,16-19-15SEP94

IMPORTANT: Tighten all fuel system connections securely to avoid leakage and air entering system.

12. Install fuel leak-off line assembly (E) onto pump connectors and all connections securely.
13. Connect fuel supply pump lines (F). Connect fuel inlet line (D) at fuel shut-off solenoid.
14. Connect injection pump lube line (C) to cylinder block fitting.
15. Connect governor pigtail connectors (A) to wiring harness.
16. Install engine oil filter (B).

- A—Governor Pigtail Connectors
- B—Oil Filter
- C—Injection Pump Lube Line
- D—Fuel Inlet Line
- E—Leak-off Line Assembly
- F—Supply Pump Lines

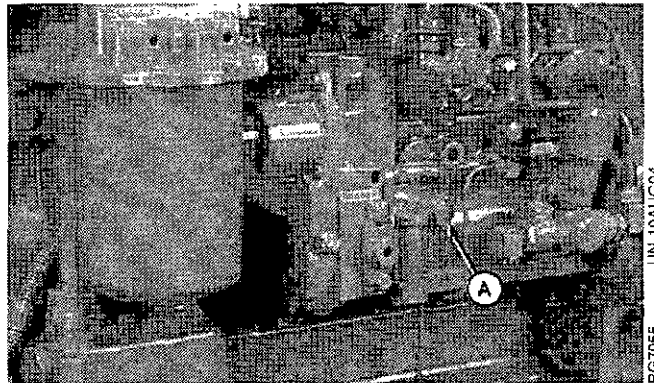


RG7054 -UN-10AUG94

RG,CTM86,G35,17-19-15SEP94

IMPORTANT: NEVER operate injection pump without engine lubricating oil in pump housing. Doing so may cause damage to internal pump rotating parts.

17. Remove oil fill plug (A) and add enough clean engine oil until oil comes out fill hole. Engine should be level when checking oil level.
18. Service fuel filter and water separator as needed.
19. Bleed fuel system. (See BLEED THE FUEL SYSTEM, in Group 115.)



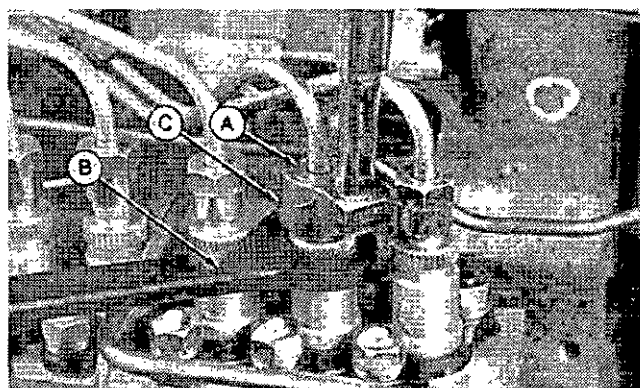
RG7055 -UN-10AUG94

RG,CTM86,G35,18-19-15SEP94

REMOVE FUEL INJECTION NOZZLES



X8811



RG5877

CAUTION: Escaping diesel fuel under pressure can have sufficient force to penetrate the skin, causing serious injury. Before disconnecting lines, be sure to relieve pressure. Before applying pressure to the system, be sure ALL connections are tight and lines, pipes and hoses are not damaged. Keep hands and body away from pinholes and nozzles which eject fluid under pressure. Use a piece of cardboard or wood, rather than hands, to search for suspected leaks.

If ANY fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type injury or gangrene may result. Doctors unfamiliar with this type of injury may call the Deere & Company Medical Department in Moline, Illinois, or other knowledgeable medical source.

IMPORTANT: Cap or plug all fuel lines as they are disconnected to prevent dirt and debris from entering fuel system. Debris in fuel system can plug injectors which affects engine performance.

1. Thoroughly clean area around injection pump and nozzles, including all line connections, using compressed air.

IMPORTANT: JDE90 Serrated Wrench (B) MUST BE used to keep delivery valve fittings stationary while loosening line nuts. If a delivery valve and barrel housing rotates while loosening or tightening a fuel line nut, injection pump delivery will be altered. Pump must be recalibrated on a test stand.

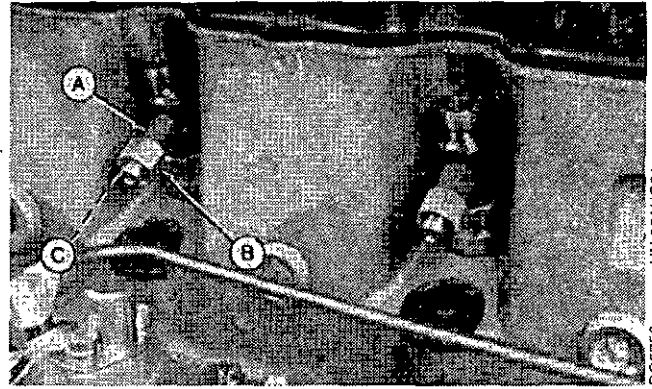
2. Disconnect injection line nuts (A) from injection pump delivery valves using JDF22 Crowsfoot Wrench (C) or a standard 3/4-in. line wrench and JDE90 Serrated Wrench.

3. Disconnect fuel delivery lines from injection nozzles. Lift injection line assembly from engine.

4. Disconnect fuel leak-off line from injection nozzle leak-off connectors. Remove complete leak-off assembly.

5. Remove packing (C) and line nuts (B) from each leak-off connector. Discard packing.

6. Remove leak-off connector (A) with O-ring from each injection nozzle.



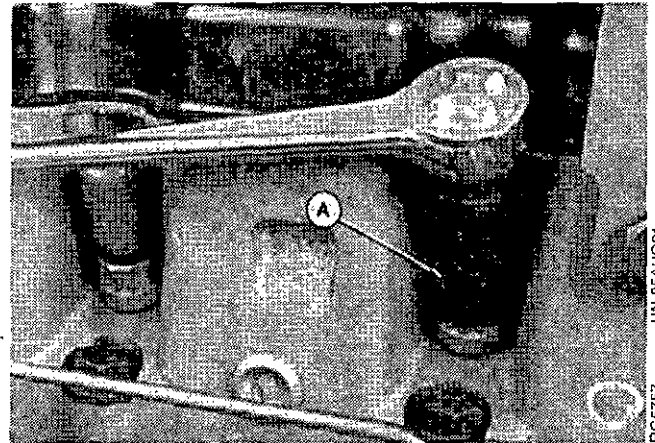
RG,CTM86,G35,20-19-15SEP94

UN-05AUG81
RG5756

NOTE: The socket portion of JDE92 Nozzle Wrench (A) may be used to remove nozzles from cylinder head.

7. If JDE92 Nozzle Wrench is not used, use a 24 mm (15/16 in.) deep socket on nozzle gland nut to remove nozzles. Gland nut will act as a jack screw to raise nozzle out of cylinder head bore. Remove hardened steel washer from injection nozzle bore if it does not come out with nozzle.

8. To prevent debris from entering combustion chamber after nozzles are removed, insert a 12.7 mm (1/2 in.) hardwood dowel in nozzle bore.



RG,CTM86,G35,21-19-15SEP94

UN-05AUG81
RG5757

DIAGNOSE INJECTION NOZZLE MALFUNCTION

Problem	Possible Cause	Suggested Remedy
Failed Hardened Washer	Nozzle replaced without using new washer.	Install new washer.
Incorrect Opening Pressure	Improper adjustment.	Adjust opening pressure.
	Broken spring.	Replace spring.
Nozzle Will Not Open	Plugged orifices.	Clean.
	Chipped orifices.	Replace nozzle.
	Bottomed lift screw.	Adjust lift screw.
Poor Spray Pattern	Plugged orifices.	Clean.
	Chipped orifices.	Replace nozzle.
	Cracked nozzle tip.	Replace nozzle.
Poor Atomization	Plugged orifice.	Clean.
	Chipped orifice.	Replace nozzle.
	Cracked nozzle tip.	Replace nozzle.
	Valve not free.	See "Inconsistent Chatter".
Inconsistent Chatter	Spring components misaligned.	Adjust opening pressure.
	Varnish on valve.	Clean guide area.
	Deposits in seat area.	Clean seat.
	Bent valve.	Replace nozzle.
	Distorted body.	Replace nozzle.

FIG. CTM86, G35, 22-19-15SEP94

35
23

DIAGNOSE INJECTION NOZZLE MALFUNCTION—CONTINUED

Problem	Possible Cause	Suggested Remedy
No Chatter	Spring components misaligned.	Adjust opening pressure.
	Varnish on valve.	Clean guide area.
	Deposits in seat area.	Clean seat.
	Bent valve.	Replace nozzle.
	Valve seat eroded or pitted.	Lap valve to seat. Replace nozzle as necessary.
	Tip seat pitted.	Lap tip to seat. Replace nozzle as necessary.
	Seat interference angle worn.	Replace nozzle.
	Distorted body.	Replace nozzle.
Seat Leakage	Deposits in seat area	Clean seat.
	Valve seat eroded or pitted.	Lap valve to seat. Replace nozzle as necessary.
	Tip seat pitted.	Lap tip to seat. Replace nozzle as necessary.
	Valve not free.	See "Inconsistent Chatter". See "No Chatter".
	Distorted body.	Replace nozzle.
	Cracked tip.	Replace nozzle.
High Leak-Off	Wear or Scratched at Guide	Lap valve to guide. Replace nozzle.
Low Leak-Off	Varnish on valve.	Clean guide area.
	Insufficient clearance.	Clean nozzle. Lap valve to guide. Replace nozzle as necessary.

35
24

TEST FUEL INJECTION NOZZLES

Before disassembling, test injection nozzles with clean filtered fuel to determine its condition.

Test for:

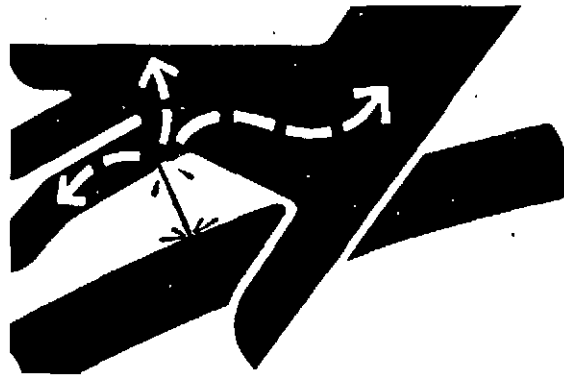
- Opening Pressure
- Leakage
- Chatter
- Spray Pattern



CAUTION: Nozzle tip should always be directed away from operator. Fuel from spray orifices can penetrate skin and clothing, causing serious personal injury. Enclosing nozzle in a transparent cover, or glass beaker is recommended.

Before applying pressure to nozzle tester, be sure all connections are tight and fittings are not damaged. Fuel escaping from a very small hole can be almost invisible. Use a piece of cardboard or wood; rather than your hands, to search for suspected leaks.

If ANY fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type injury or gangrene may result.



X9811 -UN-23AUG88

S11,0408,AL -19-08APR94

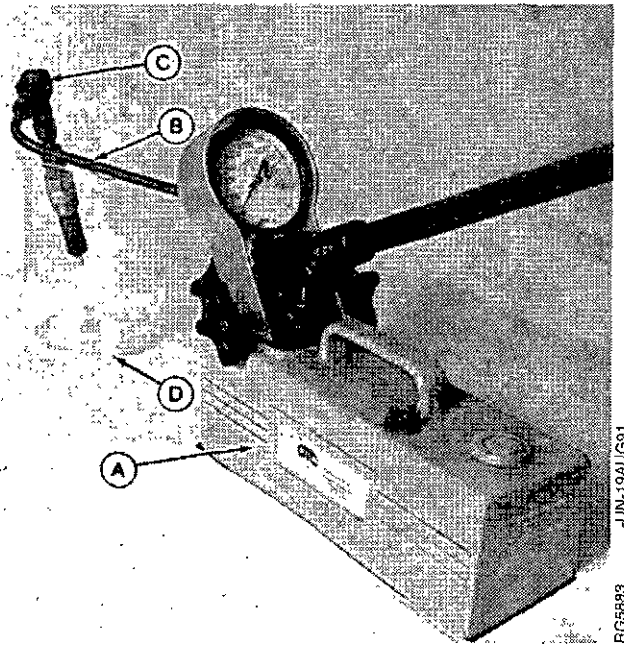
35
25

PERFORM OPENING PRESSURE TEST

1. Connect injection nozzle to D01109AA Nozzle Tester (Y900) (A), using No. Y900-2A Fuel Line (B) and Y900-7 and Y900-15 Straight Adapters (C). Y900-21 90° Adapter may also be used. Place a glass beaker (D) around nozzle.
2. Pump handle several times to flush out nozzle fittings. Tighten fittings.
3. Expel air from nozzle by operating pump handle several strokes. Then raise pressure until valve opens.
4. Recheck by completely releasing pressure, then gradually building pressure until valve opens.

IMPORTANT: Nozzle tester should be checked periodically for accuracy.

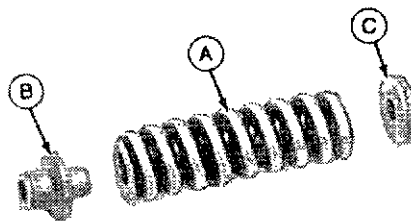
- A—Nozzle Tester
- B—Fuel Line
- C—Adapter
- D—Beaker



RG.CTM42,G35,30-19-03OCT92

INJECTION NOZZLE OPENING PRESSURE SPECIFICATIONS

A new nozzle or a used nozzle with a new spring (A), should open at approximately the following pressures. A used nozzle that has been rebuilt with a new spring and/or valve should be reset to same pressures as a new nozzle. New nozzle opening pressures are:



New Nozzle Opening Pressures (by nozzle tip size)**

7 x 0.23 mm 29 000 kPa (290 bar) (4200 psi)

On nozzles which have been in service, spring and spring seat (B) will have taken a normal set. In this case, opening pressure is satisfactory if it meets or exceeds used nozzle minimum opening pressure given below, but does not exceed new opening pressure given above. Used nozzle minimum opening pressures are:

Used Nozzle Minimum Opening Pressures (by nozzle tip size)**

7 x 0.23 mm 26 200 kPa (262 bar) (3800 psi)

Shims (C) of different thicknesses are available for changing opening pressure adjustment. Each 0.05 mm (0.002 in.) of shim thickness changes opening pressure approximately 700 kPa (7 bar) (100 psi).

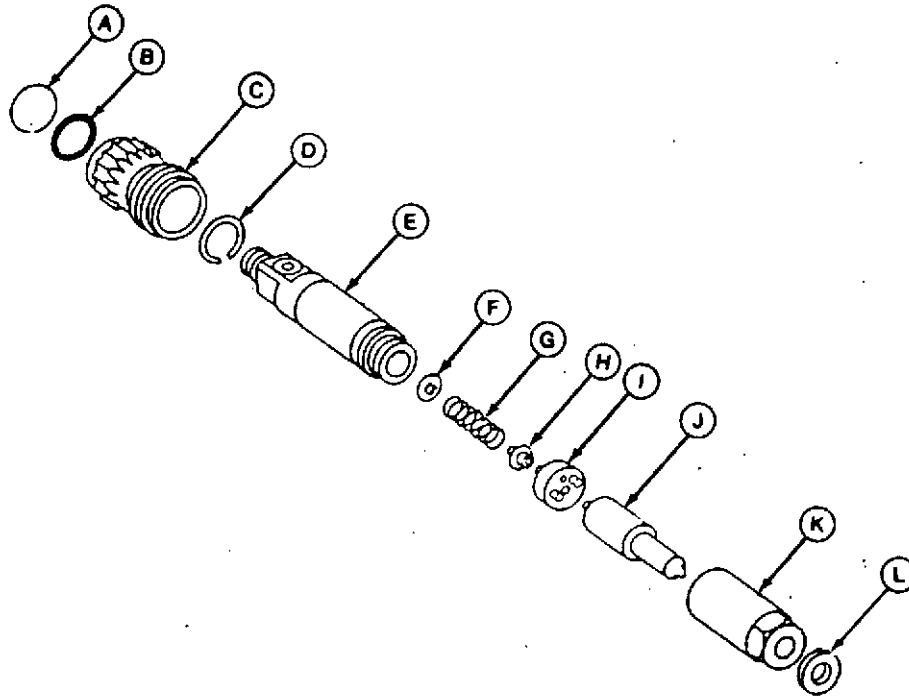
IMPORTANT: Always use John Deere nozzle adjusting shims which are specially hardened. Other shims will not be satisfactory.

If nozzle opening pressures are not correct, disassemble injection nozzles (as described in this group) and change shims until nozzles open at proper new nozzle pressure given above. The difference in nozzle opening pressures between cylinders in an engine should not exceed 350 kPa (3.5 bar) (50 psi).

**See ASSEMBLE FUEL INJECTION NOZZLE later in this group for nozzle tip size identification.

RG3410 -UN-20DEC98

PERFORM NOZZLE LEAKAGE TEST



RG6184 -UN-24FEB92

A—Upper Snap Ring
B—Gland Nut O-Ring
C—Gland Nut

D—Lower Snap Ring
E—Nozzle Holder
F—Shim

G—Nozzle Valve Spring
H—Spring Seat
I—Intermediate Plate

J—Nozzle and Valve
K—Nozzle Retaining Nut
L—Washer

1. Wipe nozzle dry.

2. Bring pressure up slowly to 1970 kPa (20 bar) (285 psi) below the opening pressure. Watch for an accumulation of fuel from spray orifice, indicating a bad seat.

If nozzle drips within 10 seconds, replace nozzle and valve (J).

3. Check for leakage around nozzle retaining nut (K) thread connection with nozzle holder (E).

Leakage indicates a bad seat either between nozzle and intermediate plate (I) or between nozzle holder and intermediate plate.

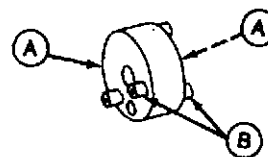
35
28

RG,CTM86,G35,24-19-15SEP94

RG2248

-UN-20APR89

RG2248



IMPORTANT: Do not lap the machined surfaces (A) of the intermediate plate in an attempt to stop fuel leakage at these locations. Dowels (spring pins) (B) in plate have to be removed before surfaces can be lapped. Removing dowels is not recommended as removal is likely to damage them, and replacement dowels are not available as service parts.

If leakage is observed, tighten nozzle retaining nut to a maximum of 79 N·m (58 lb-ft). Replace injection nozzle if leakage continues.

S11,0408,AP -19-08APR94

PERFORM CHATTER AND SPRAY PATTERN TEST

1. Injection nozzle should chatter very softly, and only when hand lever movement is very rapid (four to six downward movements per second). Failure to chatter may be caused by a binding or bent nozzle valve.
2. Until chattering range is reached, the test oil emerges as non-atomized streams. When lever movement is accelerated, sprays should be very broad and finely atomized.

A partially clogged or eroded orifice will usually cause spray to deviate from the correct angle. Spray will also be steady rather than finely atomized.
3. Disassemble nozzle for cleaning or reconditioning if it fails to chatter or spray properly.

RG,CTM42,G35,33-19-03OCT92

35
29

DISASSEMBLE FUEL INJECTION NOZZLE

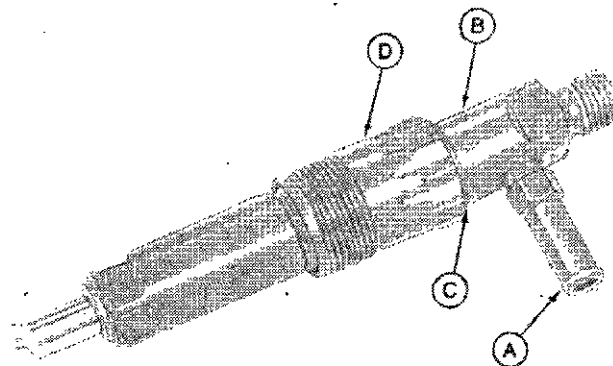
General Nozzle Repair Notes:

NOTE: Disassembly of nozzles is not recommended unless servicing is indicated by nozzle operation and testing.

- Since dirt and water are the worst contaminants in fuel injection system, working area, tools and cleaning materials must be kept spotlessly clean. Whenever possible, work in an isolated, dust-free area.
- Cover workbench with clean paper before disassembly of injection nozzles.
- As parts are disassembled, place them in a pan of clean diesel fuel and leave there until needed. Do not permit parts to strike each other.
- Use a separate pan of clean diesel fuel for washing parts before assembly.

NOTE: Bosch KDEL injection nozzles are of metric design. Only metric tools should be used to service nozzles.

1. Use a 11 mm box or open-end wrench and unscrew leak-off connector (A) (if not removed previously) out of nozzle holder (B).
2. Clamp flats of nozzle holder in a soft-jawed vise. Remove upper snap ring (C) from nozzle holder.
3. Slip gland nut (D) off nozzle holder.

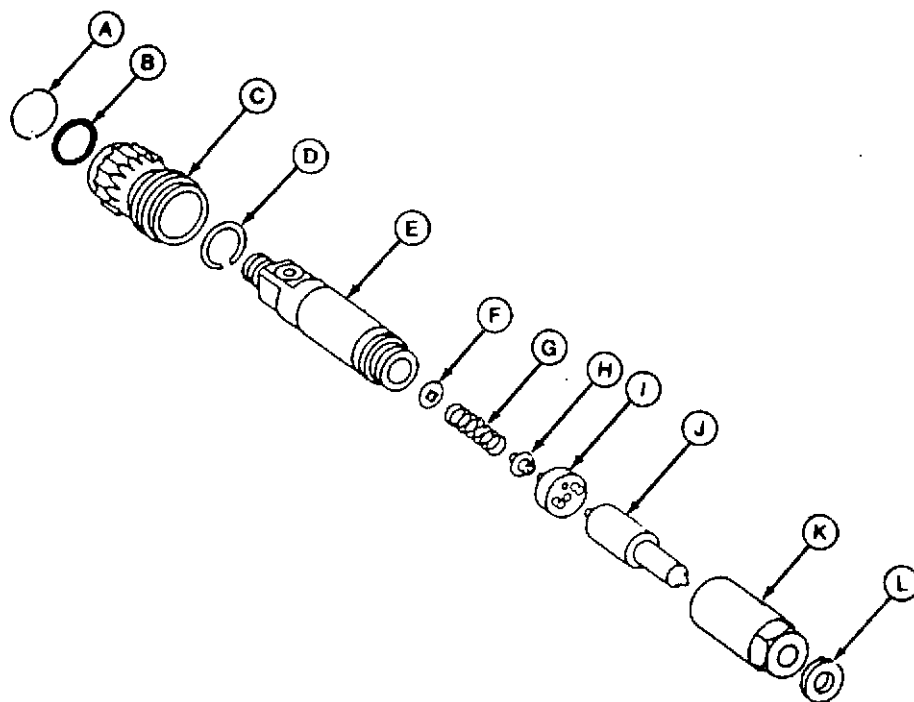


A—Leak-Off Connector
 B—Nozzle Holder
 C—O-Ring and Upper Snap Ring
 D—Gland Nut

-JUN-20DEC88

RG3887

RG,CTM86,G35,25-19-15SEP94



RG6184 JUN-24FEB92

A—Upper Snap Ring
 B—Gland Nut O-Ring
 C—Gland Nut
 D—Lower Snap Ring

E—Nozzle Holder
 F—Shim
 G—Nozzle Valve Spring

H—Spring Seat
 I—Intermediate Plate
 J—Nozzle and Valve Assembly

K—Nozzle Retaining Nut
 L—Washer

4. Remove lower snap ring (D).
5. Clamp the two flats of the nozzle holder (fuel inlet end) in a soft-jawed vise and remove nozzle retaining nut (K), using a 12-point 19 mm wrench.
6. Remove nozzle and valve assembly (J).
7. Pull off intermediate plate (I).
8. Remove spring seat (H), spring (G), and shims (F).
9. Remove gland nut O-ring (B).

10. Withdraw nozzle valve from nozzle. If valve is stuck, it may be necessary to soak nozzle assembly in Bendix cleaner, acetone, or other commercial cleaners sold especially for freeing stuck valves.

⚠ CAUTION: Use nozzle cleaning fluids in accordance with manufacturer's instructions.

Do not permit lapped surfaces of valve and nozzle to come in contact with any hard substance. DO NOT touch valve unless your hands are wet with fuel.

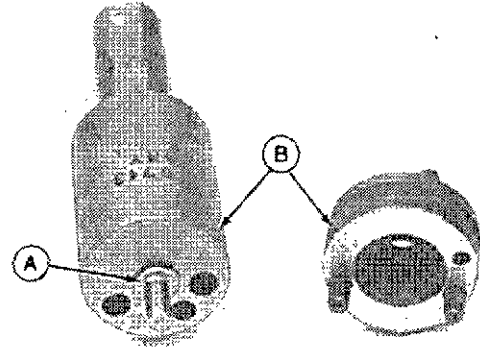
RG,CTM86,G35,26-19-15SEP94

CLEAN AND INSPECT FUEL INJECTION NOZZLE ASSEMBLY

IMPORTANT: Never use a steel brush to clean nozzles. Steel brush may damage injection nozzles.

1. Remove anti-corrosive coating from new or reconditioned nozzles by washing them thoroughly with diesel fuel.
2. Remove carbon from used nozzles and clean by washing them in diesel fuel. If parts are coated with hardened carbon or lacquer, it may be necessary to use a brass wire brush.
3. After removing carbon or lacquer from nozzle exterior, inspect lapped surface for nicks or scratches. Replace if not in good condition.
4. Inspect piston part of nozzle valve (A) to see that it is not scratched or scored. If any of these conditions are present, replace nozzle assembly.
5. Inspect nozzle valve seat, nozzle, and intermediate plate. Contact area of parts (B) must not be scored or pitted. Use inspection magnifier in JDF13 (JDE105) Nozzle Cleaning Kit to aid inspection.

NOTE: A bad nozzle valve seat will cause fuel to drip from nozzle. This condition will usually be noted when making the "Leakage Test".



-UN-20DEC88
RG8411

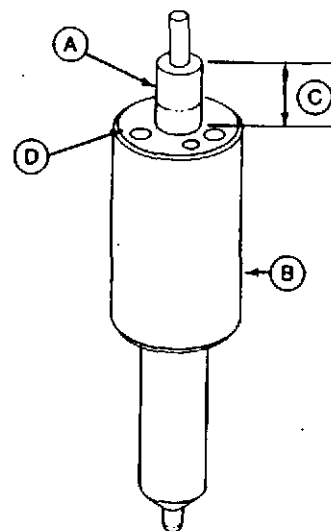
S11,0408,AU -19-08APR94

PERFORM NOZZLE SLIDE TEST

NOTE: DO NOT touch lapped surface (D) unless hands are wet with diesel fuel.

1. Dip nozzle valve (A) in clean diesel fuel.
2. Insert valve in nozzle (B).
3. Hold nozzle vertical and pull valve out about one-third of its engaged length.
4. Release valve. Valve should slide down (C) to its seat by its own weight. Always replace a nozzle assembly if the valve does not fall freely to its seat.

A—Nozzle Valve C—Free-Fall Distance
 B—Nozzle D—Lapped Surface



S11,3010,CZ -19-08APR94

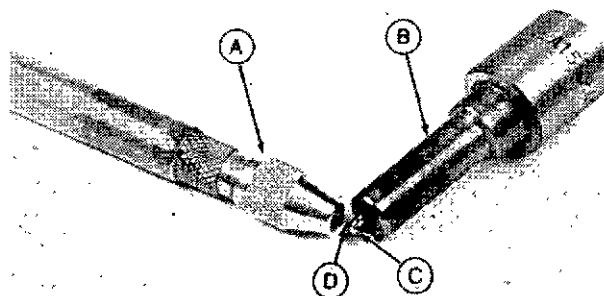
-JUN-12APR83
RG22233

CLEAN SPRAY ORIFICES

1. Begin with cleaning wire (D) 0.07—0.10 mm (0.003—0.004 in.) from JDF13 (JDE105) Nozzle Cleaning Kit.

NOTE: Stoning wire to provide a flat surface on one side will help in reaming carbon from clogged hole.

2. Clamp cleaning wire in pin vise (A). Wire should not protrude from vise more than 0.8 mm (1/32 in.).
3. Insert wire into orifice (C) and rotate.
4. For final cleaning, use cleaning wire 0.03 mm (0.001 in.) smaller than orifice size. Follow previous steps until orifices are clean of any carbon deposits.



A—Pin Vise
 B—Nozzle
 C—Orifice
 D—Cleaning Wire

RG,CTM42,G35,54-19-05APR93

-JUN-30AUG81
RG5954

INSPECT NOZZLE HOLDER

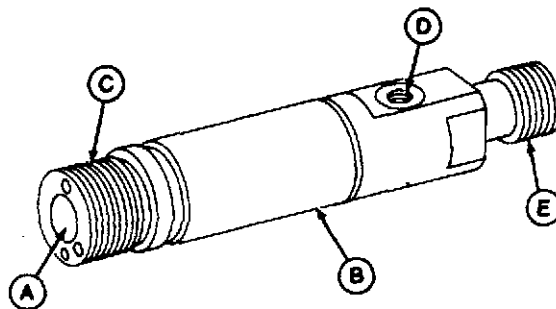
1. Inspect lapped surface (A) on bottom end of nozzle holder (B) for nicks or scratches. Replace holder if not in good condition.

2. Inspect threads M19 x 0.75 (C), M6 x 1 (D), and M14 x 1.5 (E) on nozzle holder for general condition. Threads that are nicked slightly may be "dressed-up." Replace holder if threads cannot be restored to a serviceable condition.

3. Check fuel passages in nozzle holder to make sure they are open. Clean with compressed air.

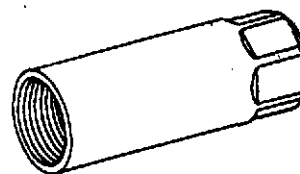
4. Remove carbon deposits on both inner and outer surfaces of nozzle retaining nut.

5. Inspect retaining nut for cracks caused by overtightening or a damaged lower seating surface. A seat may be restored by rubbing surface with emery cloth. Any nozzle nut which cannot be reconditioned, must be replaced.



-UN-20DEC88

RG3413



-UN-20DEC88

RG2247

RG2247

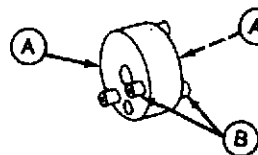
- A—Lapped Surface
- B—Nozzle Holder
- C—M19 x 0.75
- D—M6 x 1
- E—M14 x 1.5

RG,CTM61,G35,30-19-05APR93

6. Examine lapped surfaces on intermediate plate (A) for nicks, scratches, or worn areas which would permit fuel to leak past.

RG2248

-UN-20APR88



RG2248

7. Replace intermediate plate if lapped surfaces are worn or damaged.

IMPORTANT: Do not lap machined surfaces of intermediate plate. Dowel pins (B) in plate have to be removed before surfaces can be lapped. Removing these dowels is not recommended as removal is likely to damage them, and replacement dowels are not available as service parts.

8. Inspect spring seat for splitting, cracking, or excessive wear.

RG2249

-UN-20APR89



Replace seat if any of these conditions are evident.

RG2249

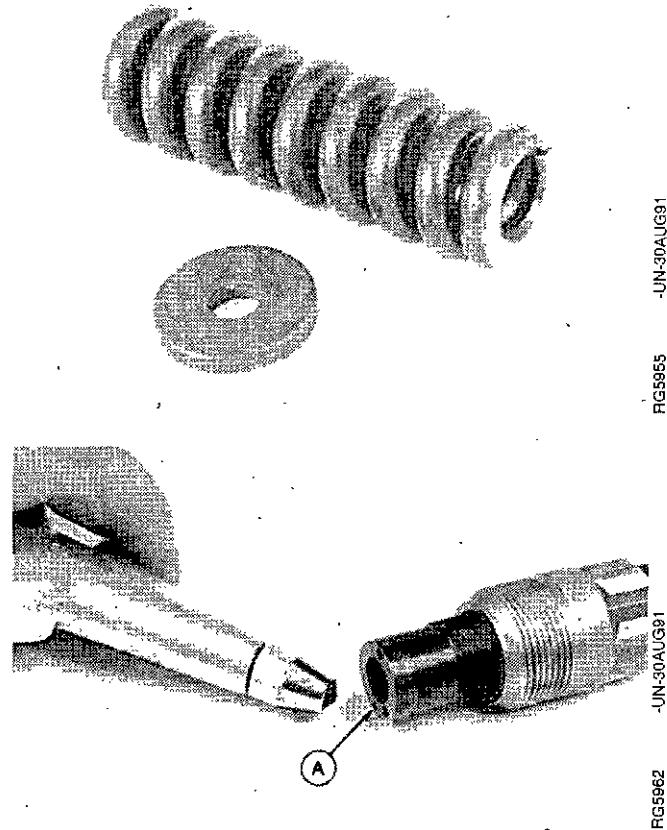
RG,CTM86,G35,32-19-15SEP94

9. Examine spring and shims for pitting or excessive wear.

Replace as necessary.

NOTE: The edge-type filter is pressed into nozzle holder and is not removable for service.

10. Clean filter by applying compressed air to nozzle holder fuel passage (A) at nozzle end.



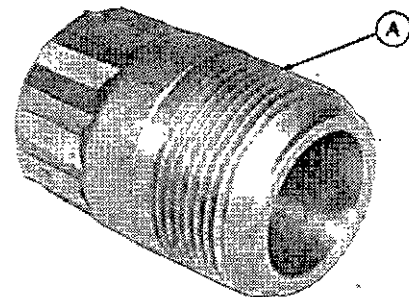
RG,CTM42,G35,56-19-03OCT92

INSPECT GLAND NUT

1. Inspect nozzle holder gland nut for general condition, be sure that it is not cracked or split.

2. Inspect M28 x 1.5 threads (A) for general condition. Threads which are slightly nicked or damaged may be "dressed up."

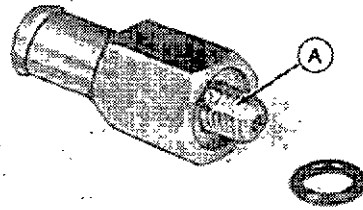
Replace gland nut if unable to restore to a serviceable condition.



RG,CTM42,G35,57-19-05APR93

35
36

3. Check passage in leak-off connector to see that it is open.
4. Blow through connector passage with compressed air.
5. Inspect the M6 x 1 threads (A) for general condition. Replace connector if threads are damaged and cannot be restored to a serviceable condition.



RG.CTM42,G35,34-19-03OCT92

RG5886 -JUN-19AUG91

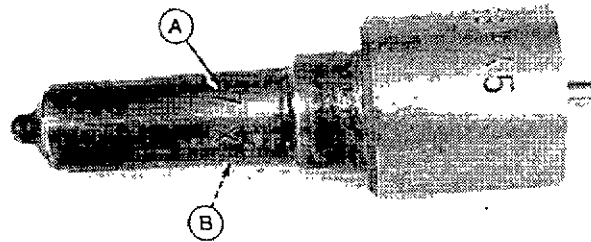
ASSEMBLE FUEL INJECTION NOZZLE

IMPORTANT: Be sure to install correct nozzle assembly on nozzle holder. Do not intermix different size nozzle assemblies.

To help determine correct nozzle assembly for each application, note markings on lower part of nozzle.

The illustration shows a nozzle marked 7 x 0.23. The number "7" (A) indicates the number of orifices and "0.23" (B) indicates the size of each orifice in millimeters.

IMPORTANT: Immerse parts in clean fuel before assembly. DO NOT dry parts with towels or compressed air. Dust particles might collect and stay on pressure faces of nozzle valve and nozzle holder.



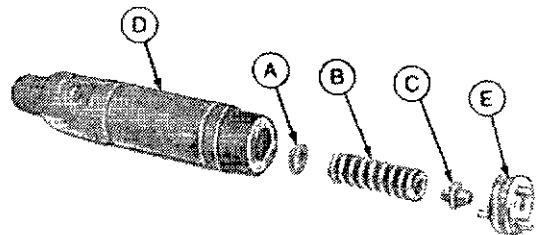
RG.CTM86,G35,27-19-15SEP94

RG5888 -JUN-30AUG91

1. Place shims (A), spring (B), and spring seat (C) in nozzle holder (D) while still wet with diesel fuel.

NOTE: Make sure intermediate plate (E) is free of any foreign material before reassembling.

- A—Shims
- B—Spring
- C—Spring Seat
- D—Nozzle Holder
- E—Intermediate Plate



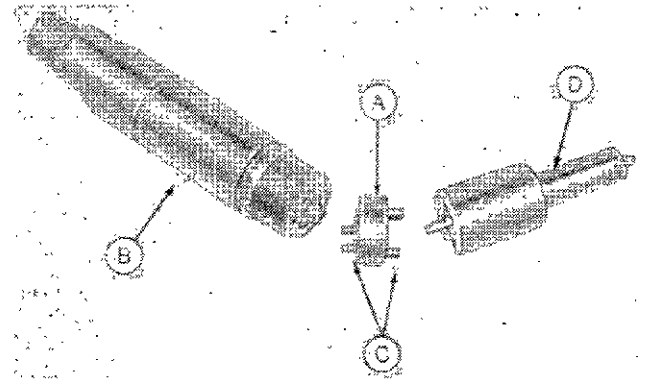
S11.3010,DF -19-19JUL82

RG3415 -JUN-20DEC88

2. Position intermediate plate (A) on nozzle holder (B). Dowel pins (C) in plate will permit installation only one way.

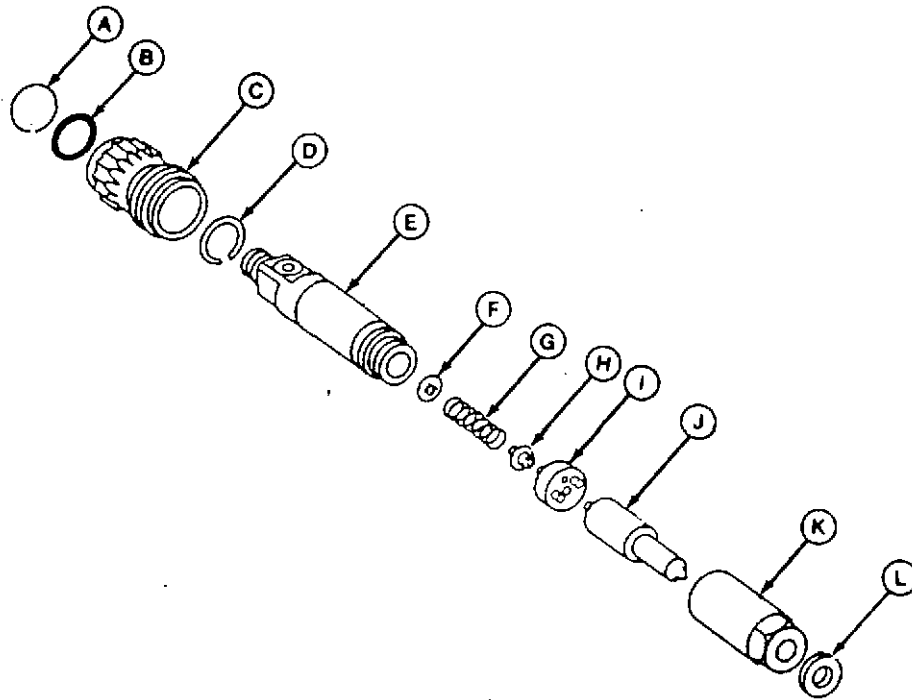
3. Insert nozzle valve into nozzle (D) while holding parts below diesel fuel level in pan.

- A—Intermediate Plate
- B—Nozzle Holder
- C—Dowel Pins
- D—Nozzle and Valve



PG2254 -JUN-23/NOV88

S11,3010,DG -19-08APR94



RG6184 -UN-24FEB92

A—Snap Ring (upper)
B—Gland Nut O-Ring
C—Gland Nut

D—Snap Ring (Lower)
E—Nozzle Holder
F—Shim

G—Nozzle Valve Spring
H—Spring Seat
I—Intermediate Plate

J—Nozzle
K—Nozzle Retaining Nut
L—Washer

4. Install nozzle assembly on nozzle holder (E) and secure with nozzle retaining nut (K).
5. Clamp nozzle holder in a soft-jawed vise. Tighten nozzle retaining nut to 88 N·m (65 lb-ft).
6. Install lower snap ring (D) on nozzle holder.
7. Coat bore of gland nut (C) liberally with PT569 NEVER-SEEZ compound to prevent gland nut from seizing on holder body.

8. Install upper snap ring (A) on nozzle holder and position O-ring (B) against gland nut.
9. Install leak-off connector on nozzle holder using a new washer.

NOTE: Leak-off connector and washer should be installed on nozzle holder even though they will have to be removed to install injection nozzle in cylinder head. This will prevent misplacement of connector and washer before installation on engine.

S55,3010,BJ -19-15SEP94

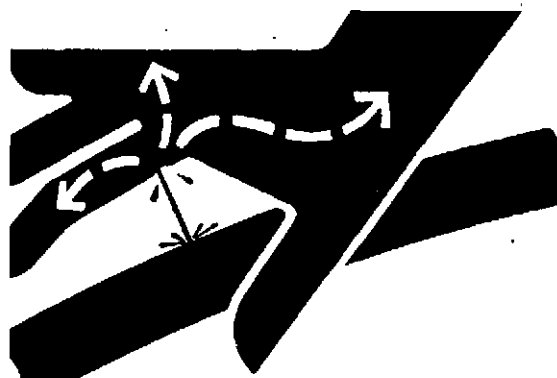
TEST AND ADJUST INJECTION NOZZLE OPENING PRESSURE

CAUTION: Nozzle tip should always be directed away from operator. Fuel from spray orifices can penetrate clothing and skin causing serious personal injury. Enclosing nozzle in a glass beaker is recommended.

Before applying pressure to nozzle tester, be sure all connections are tight, and fittings are not damaged. Fluid escaping from a very small hole can be almost invisible. Use a piece of cardboard or wood, rather than hands, to search for suspected leaks.

If injured by escaping fluid, see a doctor immediately. Any fluid injected into the skin must be surgically removed within a few hours or gangrene may result. Doctors unfamiliar with this type of injury may call the Deere & Company Medical Department in Moline, Illinois, or other knowledgeable medical source.

1. Refer to PERFORM OPENING PRESSURE TEST, earlier in this group to test nozzle opening pressure. Adjust opening pressure as needed.
2. Refer to PERFORM NOZZLE LEAKAGE TEST, earlier in this group to test for leakage. Repair as needed.
3. Refer to PERFORM CHATTER AND SPRAY PATTERN TEST, earlier in this group to test nozzle overall operation. Repair as needed.



-JUN-29AUG88

X9811

RG.CTM86,G35,28-19-15SEP94

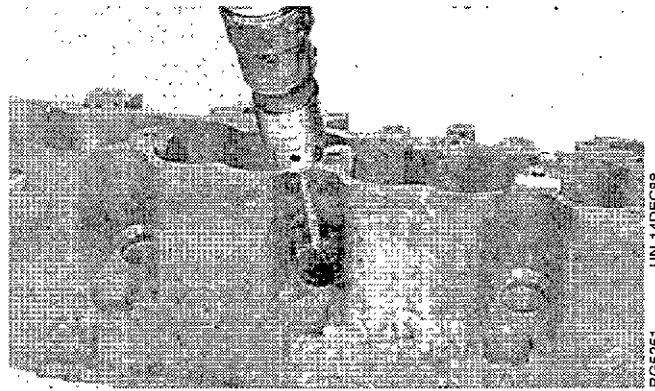
INSPECT AND CLEAN CYLINDER HEAD NOZZLE BORE

1. Inspect condition of threads for gland nut. Threads are metric (M28 x 1.5).
2. Inspect condition of nozzle seating surface in cylinder head.

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

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

3. Clean threads which have light foreign deposits using an electric drill and D17030BR Thread Cleaning Brush. Work brush up and down several times to clean threads.



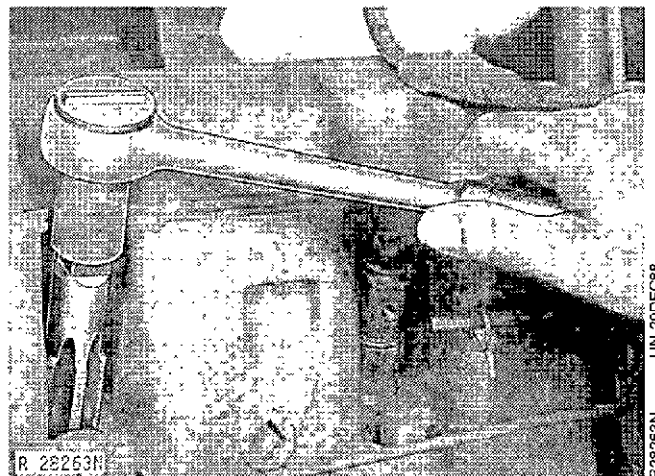
RG5251 -JUN-14DEC88

S55.3010,AU -19-03OCT92

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

5. After cleaning threads, insert a 13 mm (1/2 in.) tapered hardwood dowel to plug nozzle tip bore.

6. Blow out debris from nozzle cavity with compressed air; then remove wood dowel.

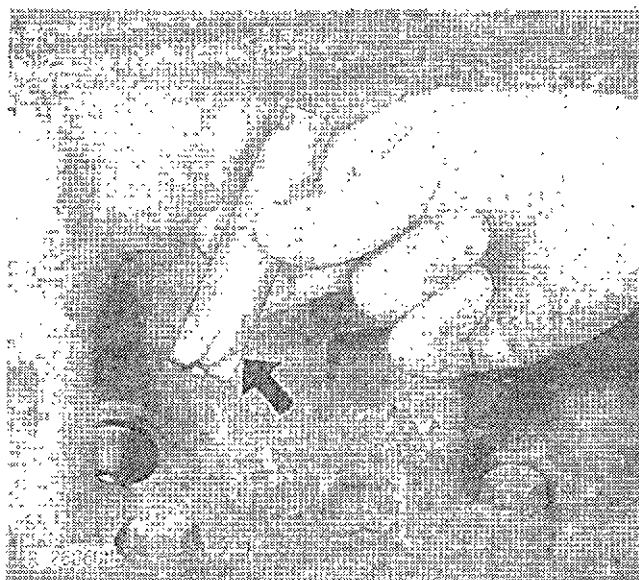


R28263N -JUN-20DEC88

RG,CTM42,G35,37-19-03OCT92

INSPECT AND CLEAN NOZZLE SEATING SURFACE

1. Inspect nozzle seating surface for carbon deposits.
2. If seat is not clean, use the JDG609 Nozzle Seat Reamer to remove carbon. Stop using tool when seat comes clean.
3. Insert a 13 mm (1/2 in.) tapered hardwood dowel to plug the nozzle tip bore.
4. Blow out debris from nozzle cavity with compressed air; then remove wood dowel.



R26860N -JUN-20DEC88

RG,CTM42,G35,36-19-02OCT92

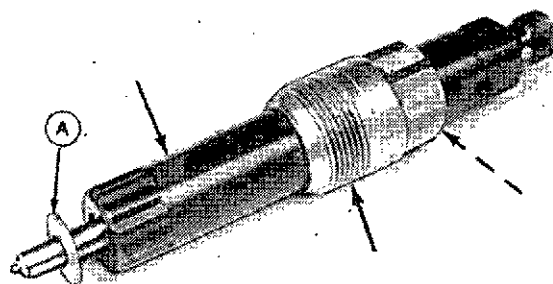
INSTALL FUEL INJECTION NOZZLES

1. Apply PT569 NEVER-SEEZ Compound to gland nut threads and nozzle barrel (arrows). Be sure that NEVER-SEEZ compound was also applied to inside bore of gland nut during assembly.

NOTE: Applying NEVER-SEEZ Compound at these locations will help prevent possible seizure of gland nut to holder body.

2. Install a new special steel washer (A) on tip end of assembled injection nozzle.

IMPORTANT: Do not intermix injection nozzles of different suppliers or different tip sizes within a single engine.



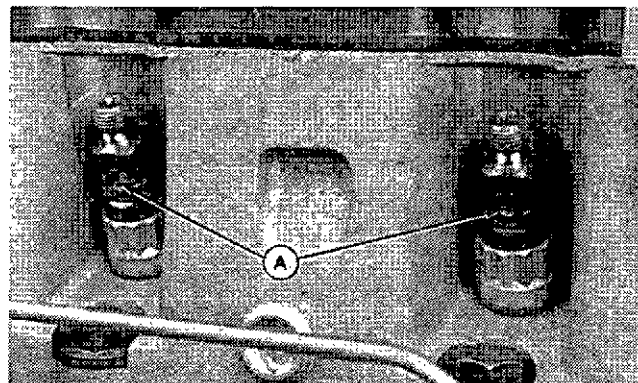
RG5888 -JUN-19AUG91

RG,CTM86,G35,33-19-15SEP94

3. Insert injection nozzle into cylinder head. Turn gland nut by hand to make sure it is threaded straight in cylinder head.

4. Use outer socket of JDE92 Nozzle Socket and turn gland nut down to remove most of the looseness.

5. Rotate nozzle holder so hole for leak-off connector threads (A) are facing straight out from cylinder head.



RG5888 -JUN-19AUG91

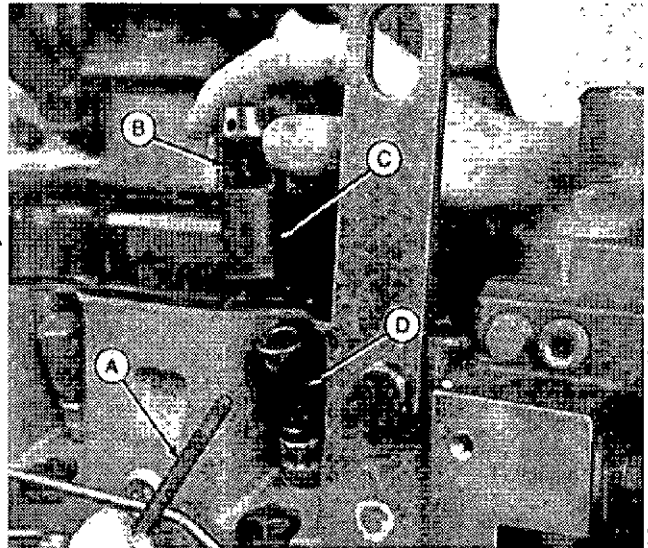
RG,CTM42,G35,41-19-15SEP94

35
42

6. Position inner socket (D) over nozzle holder and engage with flats at top of nozzle holder.
7. Place outer socket (C) portion of JDE92 Nozzle Socket on gland nut with socket "window" (B) facing outward.
8. Insert handle (A) through window into inner socket. Ball detent in handle will keep it secured to inner socket.

NOTE: Handle simulates position of leak-off connector, which must be square with engine to permit proper installation of leak-off lines.

- A—Handle
- B—Window
- C—Outer Socket
- D—Inner Socket



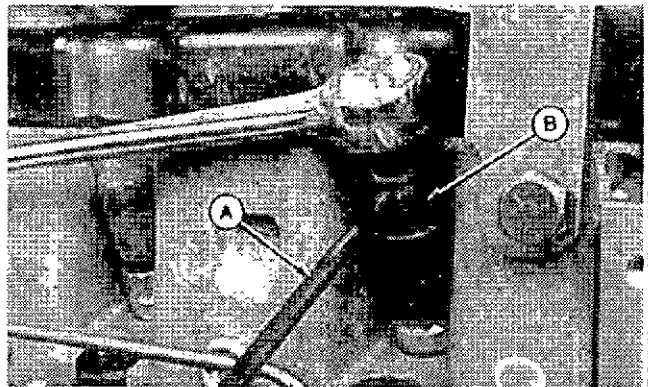
RG,CTM42,G35,42-19-15SEP94

-JUN-05AUG91
RG5758

9. Tighten injection nozzle gland nut to 88 N·m (65 lb-ft). Keep handle (A) pointing straight out while tightening.

Socket window (B) is cut deep enough to obtain a new "bite" without removing inner socket.

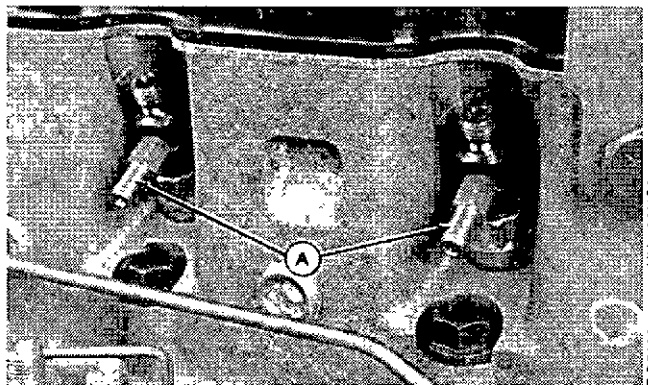
10. Be sure O-ring is positioned against injection nozzle gland nut.



RG,CTM42,G35,43-19-03OCT92

-JUN-05AUG91
RG5759

11. Install leak-off connectors (A) with O-rings on injection nozzles. Tighten securely.



RG,CTM42,G35,44-19-10SEP91

-JUN-19AUG91
RG5890

12. Loosen all leak-off line fittings (A), remove pipes (B), and inspect packings (C). Discard packings that are worn or cut.

NOTE: Mark each leak-off pipe before disassembly to assure assembly in correct location.

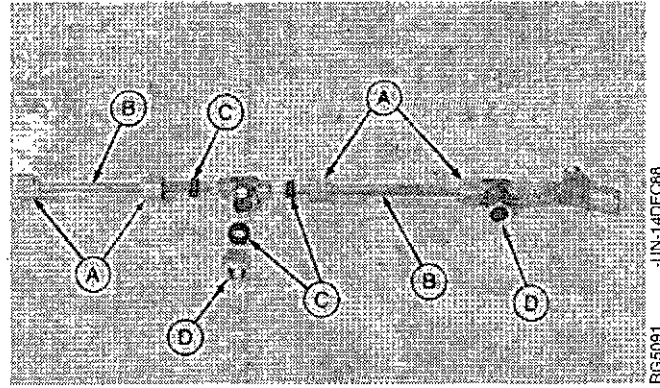
13. Check all pipes and fittings for wear or damage and replace as necessary.

14. Reinstall new packings (if needed), and pipes into T-Fittings. Tighten all connections securely.

15. Install nuts (D) and packings onto leak-off connectors. Install complete assembly over appropriate leak-off line connectors.

16. Tighten all leak-off line connections securely at each injection nozzle.

17. Connect leak-off line at injection pump and tighten securely.



A—Fittings
B—Pipes
C—Packings
D—Nuts

RG,CTM86,G35,29-19-15SEP94

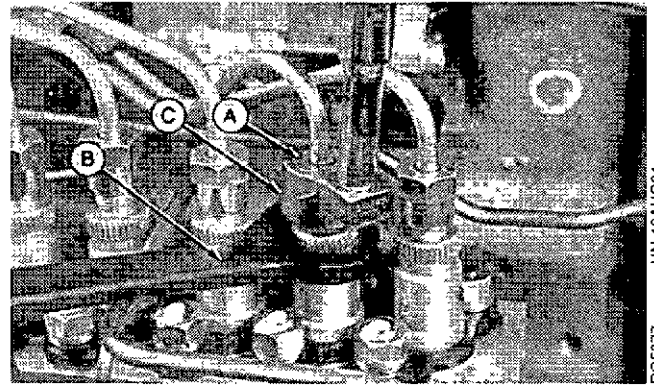
IMPORTANT: Use JDE90 Serrated Wrench (B) to keep delivery valve fittings stationary while tightening fuel line nuts. If a delivery valve and barrel housing rotates while tightening a fuel line nut, injection pump fuel delivery will be altered, and pump will have to be recalibrated on a test stand.

18. Remove protective caps and plugs, that were installed during disassembly, from injection lines, nozzles and delivery valves. Install and connect injection line assembly at each respective injection nozzle and delivery valve.

19. Tighten fuel injection line nozzle nuts (A) to 27 N·m (20 lb-ft).

20. Tighten line nuts at delivery valves to 27 N·m (20 lb-ft) using JDF22 Crowsfoot Wrench (C) or a 3/4 in. line wrench along with JDE90 Serrated Wrench.

21. Bleed the fuel system. (See BLEED THE FUEL SYSTEM, in Group 115.)



A—Fuel Injection Line Nuts
B—JDE90 Serrated Wrench
C—JDF22 Crowsfoot Wrench

RG.CTM86,G35,30-19-15SEP94

RG5877 -JUN-19AUG91

35
46

EFFECTS OF ALTITUDE AND TEMPERATURE ON ENGINE PERFORMANCE

Altitude, fuel temperature, air temperature, and humidity may affect engine performance. As a general rule, atmospheric changes will usually cause a decrease in engine power by the percentages shown in chart below.

ATMOSPHERIC CHANGE	% POWER DECREASE
Fuel Temperature Rise of 1°C (1.8° F) above 40°C (104°F)	0.29
Air Temperature Rise of 5.5° C (10° F) above 25°C (77°F)	0.50
Naturally Aspirated Engines:	
Altitude Rise of 300 m (1000 ft) above 183 m (600 ft)	3.00**
Turbocharged Engines:	
Altitude Rise of 300 m (1000 ft) above 183 m (600 ft)	0.50*
Relative Humidity Rise of 10% above 0%	0.07

If engine required less fuel for acceptable performance at higher elevation, contact your local authorized fuel injection pump repair station for service.

**Engine may have to be defueled when a substantial percentage of operating time occurs at 2250 m (7500 ft) or higher.*

***Engine may have to be defueled when a substantial percentage of operating time occurs at 1500 m (5000 ft) or higher.*

RG.CTM42,G100,6-19-30SEP94

PRELIMINARY ENGINE TESTING

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

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

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

3. Perform a dynamometer test and record power output. See DYNAMOMETER TEST later in this group. Repeat dynamometer test after tune-up. Compare power output before and after tune-up.

4. Perform compression test (See Group 105).

S11,22010,BW -19-08APR94

GENERAL TUNE-UP RECOMMENDATIONS

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

IMPORTANT: Engines that are equipped with electronically-controlled governors have a diagnostic feature that will display detailed codes to alert operator of specific performance problems. Refer to your machine operation and tests manual or CTM68, Electronic Fuel Injection Systems for diagnostic code troubleshooting procedures.

Operation	Detailed Reference
Change engine oil and filters.	Operator's Manual
Lubricate PTO clutch internal levers and linkage, if equipped.	Operator's Manual
Replace fuel filter.	Group 35/Operator's Manual
Clean crankcase vent tube.	This Group/Operator's Manual
Check air intake system. Replace air cleaner elements.	This Group/Operator's Manual
Check exhaust system.	This Group
Check and service engine cooling system.	This Group/Operator's Manual
Check and adjust fan and alternator belts	Operator's Manual
Check electrical system.	This Group
Check crankshaft vibration damper.	Group 15/Operator's Manual
Inspect turbocharger and check turbocharger boost pressure.	Group 110
Check fuel injection system: Check engine-to-injection pump timing, clean injection nozzles, and adjust nozzle opening pressure.	Group 35 and 115
Check engine oil pressure. Correct as necessary.	Group 105
Check engine valve clearance. Adjust if necessary.	Group 05/Operator's Manual
Check engine speeds. Correct as necessary.	Authorized Servicing Dealer
Check engine performance on dynamometer.	This Group

RG,CTM86,G100,1-19-16SEP94

DYNAMOMETER TEST

*NOTE: High elevations may affect engine performance.
See EFFECT OF ALTITUDE AND
TEMPERATURE ON ENGINE PERFORMANCE,
earlier in this group.*

1. Connect engine to dynamometer using manufacturer's instructions.
2. Operate engine at one-half load until coolant and crankcase oil temperatures are up to normal.
3. Run engine at fast idle.
4. Gradually increase load on engine until speed is reduced to rated speed rpm.

NOTE: Refer to the appropriate machine technical manual for average power ratings of specific applications, allow $\pm 5\%$ for minimum and maximum power.

5. Read horsepower on dynamometer and record reading.
6. Compare readings taken with power rating level for your engine application.

RG,CTM86,G100,2-19-16SEP94

ENGINE BREAK-IN GUIDELINES

Engine break-in should be performed when the following repair have been made:

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

RG,CTM61,G105,2-19-29SEP94

PERFORM ENGINE BREAK-IN

Use a dynamometer to perform the following break-in procedure. If necessary, engine break-in can be performed without a dynamometer if under controlled operating conditions.

IMPORTANT: DO NOT use TORQ-GARD SUPREME PLUS-50™ engine oil during break-in period of a new engine or engine that has had a major overhaul. TORQ-GARD SUPREME PLUS-50 oil will not allow a new or overhauled engine to properly wear during this break-in period.

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

Fill engine crankcase with John Deere Break-In oil to proper level for use during the break-in operation. This oil is specifically formulated to enhanced break-in of John Deere diesel engines. Add John Deere Break-In oil as needed to maintain the specified oil level during break-in period.

ENGINE BREAK-IN AFTER MAJOR OVERHAUL

Time	Load	Engine Speed
5 Minutes	No Load	850 rpm
5 Minutes	No Load	1500—2000 rpm
5 Minutes	1/4 Load	1900—2100 rpm
10 Minutes	1/2 Load	1900—2100 rpm
10 Minutes	1/2—3/4 Load	1900—2100 rpm
10 Minutes	3/4—Full Load	Rated Speed

Check and readjust valve clearance as necessary. Cylinder head retorque is not required. (See Group 05, Cylinder Head and Valves.)

Sufficiently load engine during the first 100 hours of operation, but, avoid over-loads, excessive idling, and extended no-load operation.

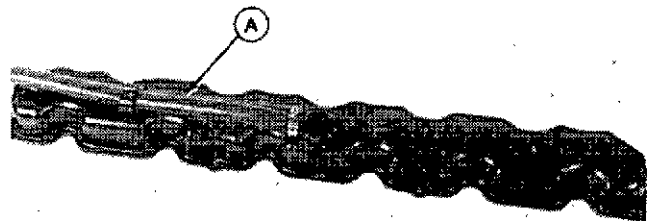
A second 100-hour service interval with John Deere Engine Break-In Oil may be required if the engine is operated under light loads during the first 100-hour break-in period.

After 100 hours maximum, drain break-in oil and change oil filter. Fill crankcase with John Deere TORQ-GARD SUPREME PLUS-50™ or other heavy-duty diesel engine oil within the same service classification as recommended in this manual. See DIESEL ENGINE OIL in Group 02, Fuels, Lubricants, and Coolant.

RG,CTM86,G100,5-19-26OCT94

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.

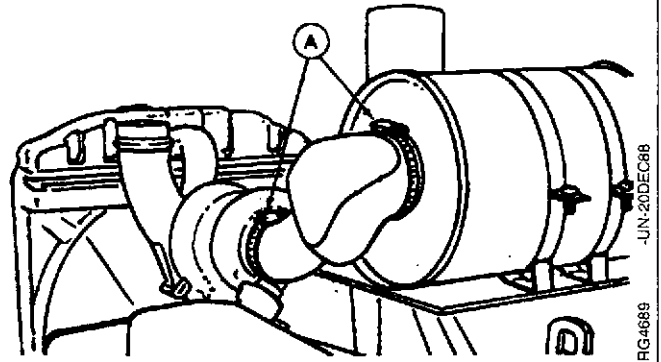


JUN-12AUG91
RG5797

RG,CTM82,100,3 -19-29APR93

CHECK AIR INTAKE SYSTEM

1. Replace air cleaner primary filter element. Replace secondary element if primary element has holes in it.
2. Check condition of air intake hose(s). Replace hoses that are cracked, split, or otherwise in poor condition.
3. Check hose clamps (A) for tightness. Replace clamps that cannot be properly tightened. This will help prevent dust from entering the air intake system which could cause serious engine damage.



S11,22010,CU -19-08APR94

CHECK EXHAUST SYSTEM

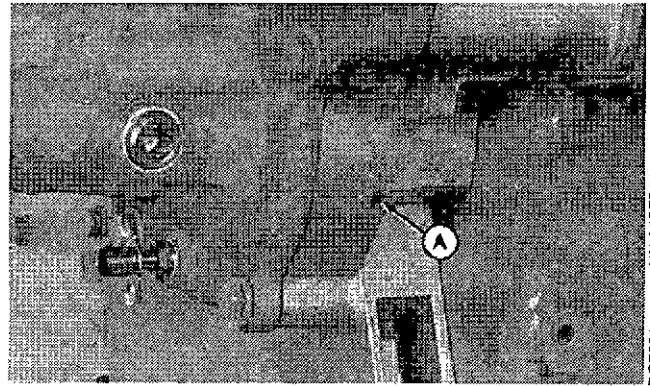
1. Inspect exhaust system for leaks or restrictions. Check manifold for cracks. Repair or replace as necessary.
2. Check that turbocharger-to-exhaust elbow adapter clamps are securely tightened and do not leak.
3. Check exhaust stack for evidence of oil leakage past valve stem seals.

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

S55,22010,C -19-08APR94

CHECK AND SERVICE COOLING SYSTEM

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



RG7061
-JUN-07SEP94

RG.CTM86,G100,3-19-16SEP94

CAUTION: Do not drain coolant until the coolant temperature is below operating temperature. Always loosen water pump drain valve (A) and block drain valve (B) slowly to relieve any excess pressure.

IMPORTANT: Both water pump drain valve and block drain valve must be opened to completely drain 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 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.

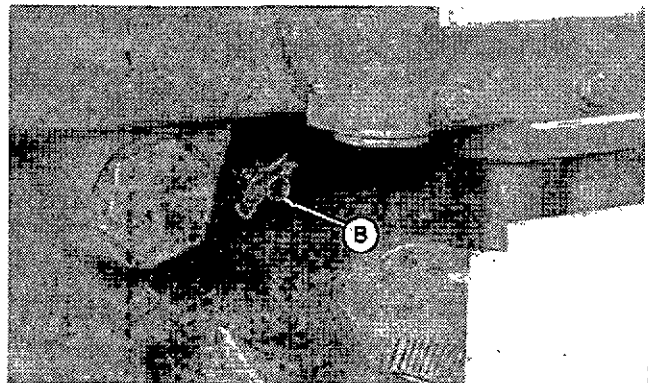
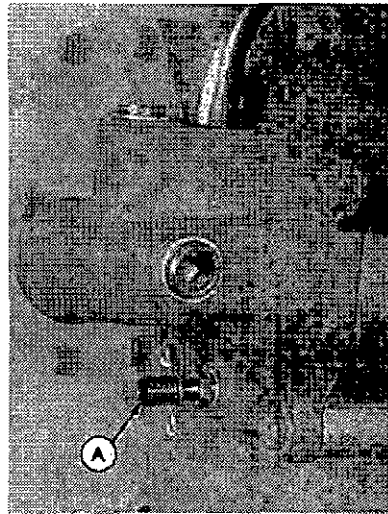
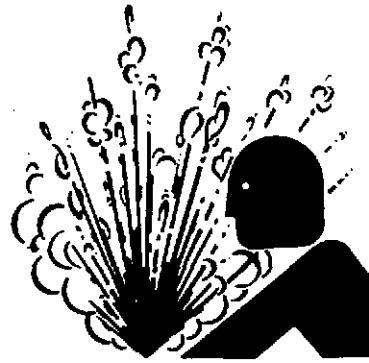
8. Fill cooling system with coolant. Follow recommendations in Group 02.

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 at bottom of radiator filler neck.

11. Check system for holding pressure. See PRESSURE TEST COOLING SYSTEM AND RADIATOR CAP in Group 105.



-JUN-26/JUL-94
RG7044

-JUN-23/AUG88
TS281

-JUN-26/JUL-94
RG7143

RG,CTM86,G100,4-19-16SEP94

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 (-) battery clamp first and replace it last.



1. Clean batteries, and cables with a damp cloth. If corrosion is present, remove it and wash the terminals with a solution of ammonia or baking soda in water. Then flush area with clean water.
2. Coat battery terminals and connectors with petroleum jelly mixed with baking soda to retard corrosion.
3. Test batteries. If batteries are not near full charge, try to find out why.
4. On low-maintenance batteries, check level of electrolyte in each cell of each battery. Level should be to bottom of filler neck. If water is needed, use clean, mineral-free water.

If water must be added to batteries more often than every 250 hours, alternator may be overcharging.

NOTE: Water cannot be added to maintenance-free batteries.

5. If batteries appear to be either undercharged or overcharged, check alternator and charging circuit.
6. Check tension of fan belts. See operator's manual.
7. Check operation of starting motor and gauges.

S11,22010,CZ -19-16SEP94

TS204 -JUN-23AUG88

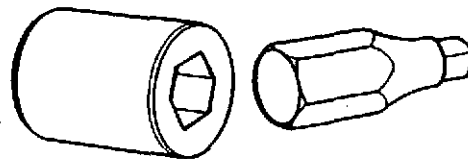
SPECIAL OR ESSENTIAL TOOLS

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

Oil Galley Plug Tool JDG782

Used to remove and install oil galley plug.



-UN-28JAN83

RG6612

RG,JDG782 -19-02APR93

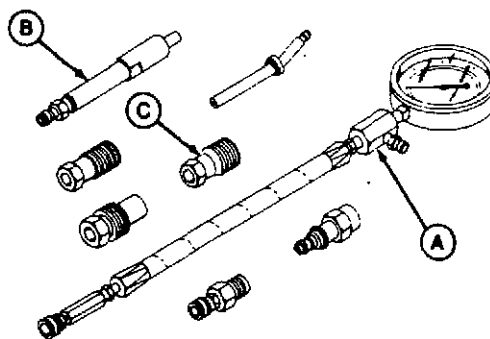
Compression Test Kit JT01674 (D14546BA)

A—Gauge and Hose Assembly JT01682 (D14547BA)

B—Nozzle Adapter JT01675A (D14557BA)

C—Adapter Nut JT01677

Used to test each cylinder's compression pressure.



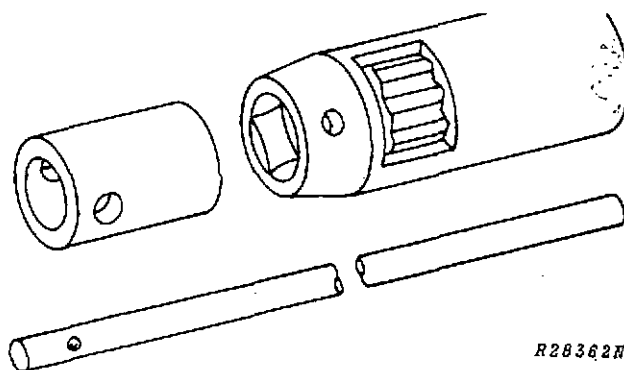
-UN-09AUG91

RG5794

RG,JT01674 -19-17SEP91

Nozzle Socket JDE92

Used to remove and install fuel injection nozzles.



-UN-20DEC88

R28362N

S11,22005,R -19-16AUG94

Universal Pressure Test Kit JT05470 (D15027NU)

Used for testing engine oil pressure.

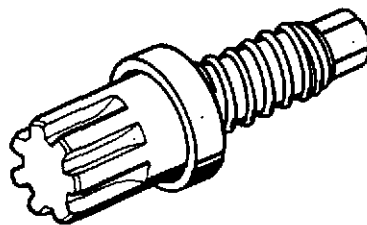


RG5162 -UN-23AUG88

S55,22005,B -19-17SEP91

Flywheel Turning Tool JDG820

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

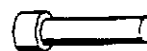


RG7056 -UN-10AUG94

RG,JDG820 -19-04AUG94

Timing Pin JDE81-4

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

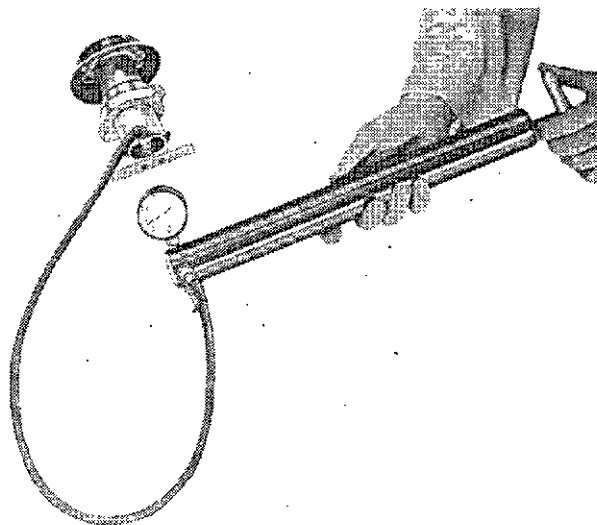


RG5068 -UN-23AUG88

RG,JDE814,86 -19-26OCT94

Cooling System Pressure Pump D05104ST

Used to pressure test radiator cap and cooling system.



RG6406N -UN-28NOV88

S55,22005,C -19-17SEP91

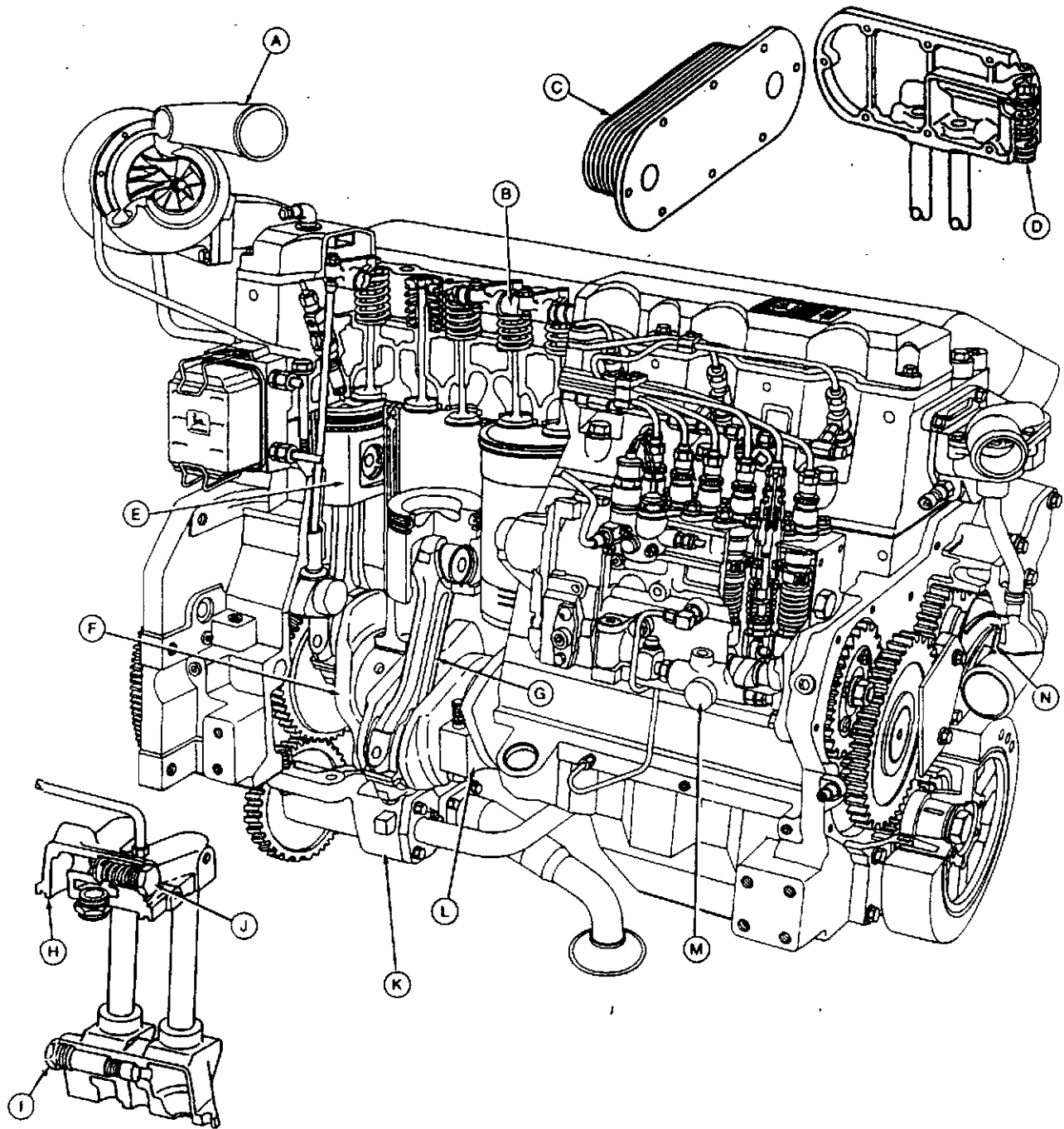
ENGINE TEST SPECIFICATIONS

ITEM	SPECIFICATION
Compression Pressure:	
(at 275—325 RPM cranking speed)	2 380—2 790 kPa (23.8—27.9 bar) (345—405 psi)
Maximum Variation Between Cylinders	340 kPa (3.4 bar) (50 psi)
Oil Pressure at 105°C (220°F):	
Minimum No Load at 850 rpm (Slow Idle)	138 kPa (1.4 bar) (20 psi)
Maximum Full Load at 2200 rpm (Rated Speed)	400 kPa (4.0 bar) (58 psi)
Cooling System Leakage Test Pressure	50 kPa (0.5 bar) (7 psi)*

**Specification given is for Deere OEM cooling systems. Refer to specific machine operation and tests manual for cooling system specifications on specific vehicle applications.*

RG,CTM86,G105.3-19-16SEP94

ENGINE—SECTIONAL VIEW



A—Turbocharger
 B—Rocker Arm Shaft
 C—Oil Cooler
 D—Oil Cooler Relief Valve

E—Piston
 F—Crankshaft
 G—Connecting Rod
 H—Oil Filter Base

I—Oil Pressure Regulating Valve
 J—Oil Filter Relief Valve
 K—Oil Pump Assembly

L—Main Bearing Cap
 M—Fuel Injection Pump
 N—Water Pump

-UN-14SEP94

RG7066

GENERAL ENGINE DESCRIPTION

All 6081 Engines are vertical stroke, in-line, valve-in-head, 6-cylinder diesel engines. The cylinder firing order is 1-5-3-6-2-4.

Direct fuel injection is provided by an in-line injection pump and 21 mm injection nozzles mounted in cylinder head. The pump is driven by an intermediate gear in the timing gear train meshing with the camshaft gear.

The pump has an engine-driven camshaft which rotates at one-half engine speed. Roller cam followers, riding on the camshaft lobes, operate the plungers to supply high-pressure fuel through the delivery valves to the injection nozzles. An electronically-controlled governor has programmable software and a control unit that determine the fuel rack position and fuel delivery based on engine system inputs.

All engines are turbocharged. Operated by exhaust gases, the turbocharger compresses intake air from air cleaner and routes it to each cylinder's combustion chamber.

An air-to-air aftercooler cools the turbocharger compressor discharge air by routing it through a heat exchanger (usually mounted in front of radiator) before it enters the intake manifold. The heat exchanger uses no liquid coolant, but relies on air flow to cool the charge air.

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.

Intake and exhaust valves are operated by cam followers, push rods, and rocker arm assembly. Cylinder heads have replaceable inserts and valves, and have exhaust valve stem seals.

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 individually replaceable.

Pistons are constructed of high-silicone aluminum alloy and have a three ring configuration. The top two rings are compression rings and the lower ring is an oil control ring. A double Ni-Resist ring carrier is cast integrally in the piston to greatly improve the life of the compression ring grooves. A deep "Reentrant" combustion chamber design provides maximum combustion efficiency and lower emissions.

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 pressure 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 spur gear pump driven off the rear of the crankshaft. Oil is filtered in a housing located on the right side of the engine. Oil temperature is limited by an oil cooler located on the left side of engine. 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 gallery.

HOW THE LUBRICATION SYSTEM WORKS

A—Oil Pump	F—Oil Pressure Regulating Valve	K—Connecting Rod Bearings	P—Turbocharger Lube Line
B—Oil Cooler	G—Oil Filter Base	L—Thrust Washer (2 used)	Q—Turbocharger Oil Return
C—Oil Cooler Bypass Valve	H—Crankshaft Main Bearing	M—Main Oil Gallery	R—Camshaft Followers
D—Oil Filter Bypass Valve	I—Piston Cooling Orifices	N—Drill Oil Passage	S—Return Oil
E—Oil Pressure Regulating Valve Housing	J—Camshaft Bushings	O—Rocker Arm Shaft	T—Pressurized Oil

Refer to illustration in foldout.

The engine lubrication system consists of a crank-driven oil pump (A), oil cooler (B), oil filter, oil cooler bypass valve (C), oil filter bypass valve (D), and oil pressure regulating valve (F).

Oil is drawn up from the sump through the oil pump and on to the oil cooler by way of the oil cooler cover which houses the oil cooler bypass valve. Oil proceeds through the oil cooler where it exchanges heat with the engine coolant, unless high restriction is sensed in which case the oil cooler is bypassed. Oil goes to the oil filter base (G) which houses the oil filter bypass valve. Oil passes through the oil filter (not shown), unless high restriction is sensed in which case the oil filter is bypassed.

The oil then moves to the oil pressure regulating valve housing (E) where the regulating valve regulates the main oil gallery (M) pressure and permits excess oil to be returned to the sump. After flowing past the regulating valve, cooled, clean pressurized oil is supplied to the main oil gallery then distributed to the crankshaft main bearings (H) and piston cooling orifices (I) through drilled passages in the cylinder block.

The main bearings work to send oil to the camshaft bushings (J) while passages in the crankshaft allow pressurized oil to also lubricate the connecting rod bearings (K). The piston cooling orifices direct oil onto the piston crown and piston/wrist pin assembly.

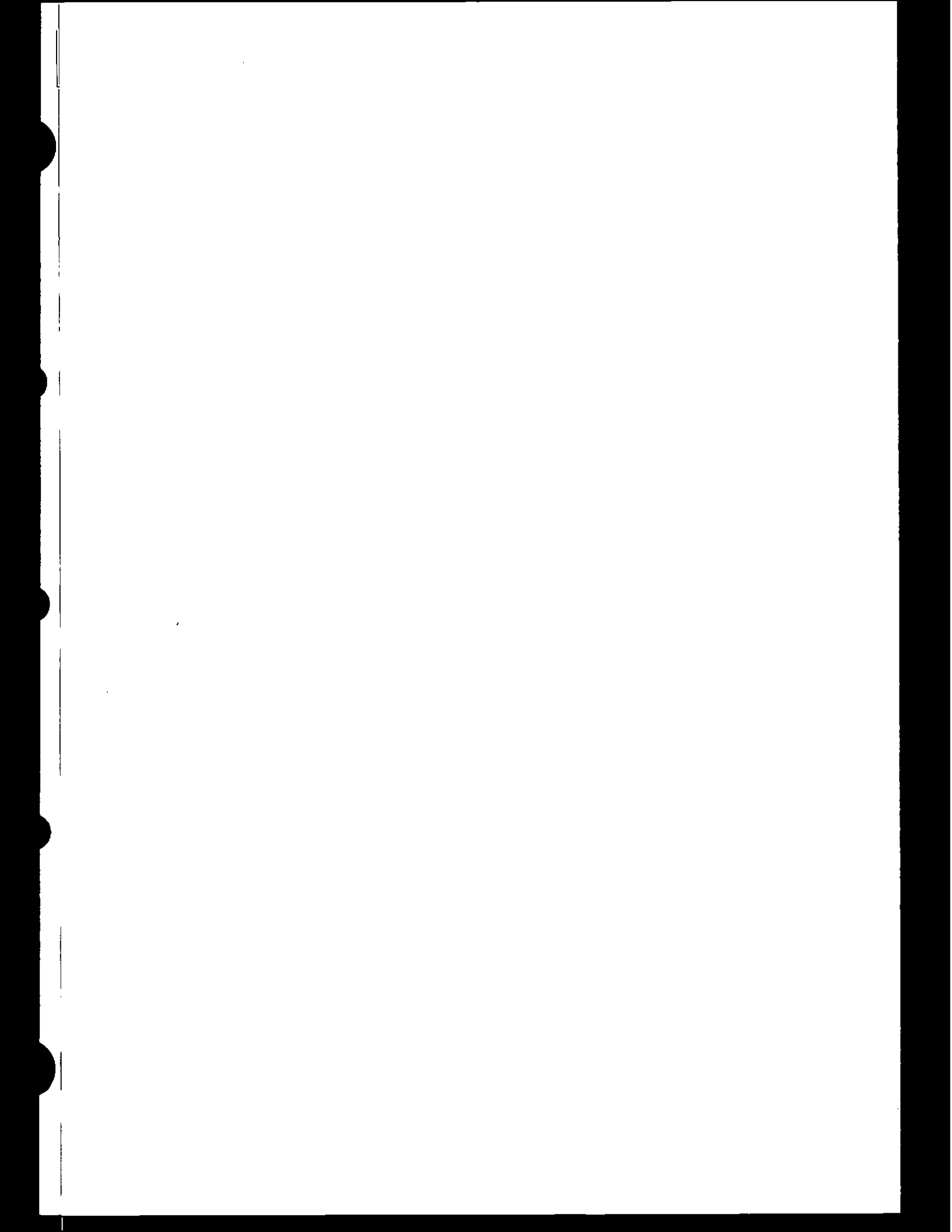
Oil from the front camshaft bushing travels through drilled passages in the camshaft nose to lubricate the camshaft thrust washer (L) and front drive train.

Oil from the rear camshaft bushing feeds through drilled passages (N) in the cylinder block and cylinder head into passages in the rocker arm shaft (O) which lube the rocker arms, which in turn provide oil to the other valve train components as well as the camshaft followers (R).

Some oil is routed from the top of the oil filter base through an external line (P) to the turbocharger and is returned to the cylinder block crankcase through another external line (Q).

The fuel injection pump is pressure lubed by way of an external line which taps into the main oil gallery.

FG,CTM86,G105,2-19-16SEP94



HOW THE COOLING SYSTEM WORKS

A—Radiator
B—Coolant Bypass Tube
C—Water Pump

D—Thermostats (2 used)
E—Thermostat Housing
F—Coolant Manifold

G—Inlet Manifold
H—Engine Oil Cooler
I—Low Temperature Engine Coolant

J—High Temperature Engine Coolant

Refer to illustration in foldout.

The pressurized cooling system consists of a conventional radiator (A), water pump (C), thermostats (D), thermostat housing (E), and cylinder block with coolant cavities.

The pump draws coolant from the bottom of the radiator and discharges it through the lower inlet manifold (G) on the left-hand side of the engine block. The inlet directs coolant to the engine oil cooler (H) and provides the cooling capability from the coolant flow around it. Coolant passes through the oil cooler cavity and enters the upper coolant manifold (F). At this time, the coolant flow will move in one of three directions. Each cylinder is unitized and has a separate flow circuit.

The main coolant passage flows through a rectangular port and around the cylinder liner, then exits the block through a vertical passage into the right-hand side of the cylinder head.

The second circuit involves flowing coolant from the upper coolant manifold through a small vertical passage into the left-hand side of the cylinder head.

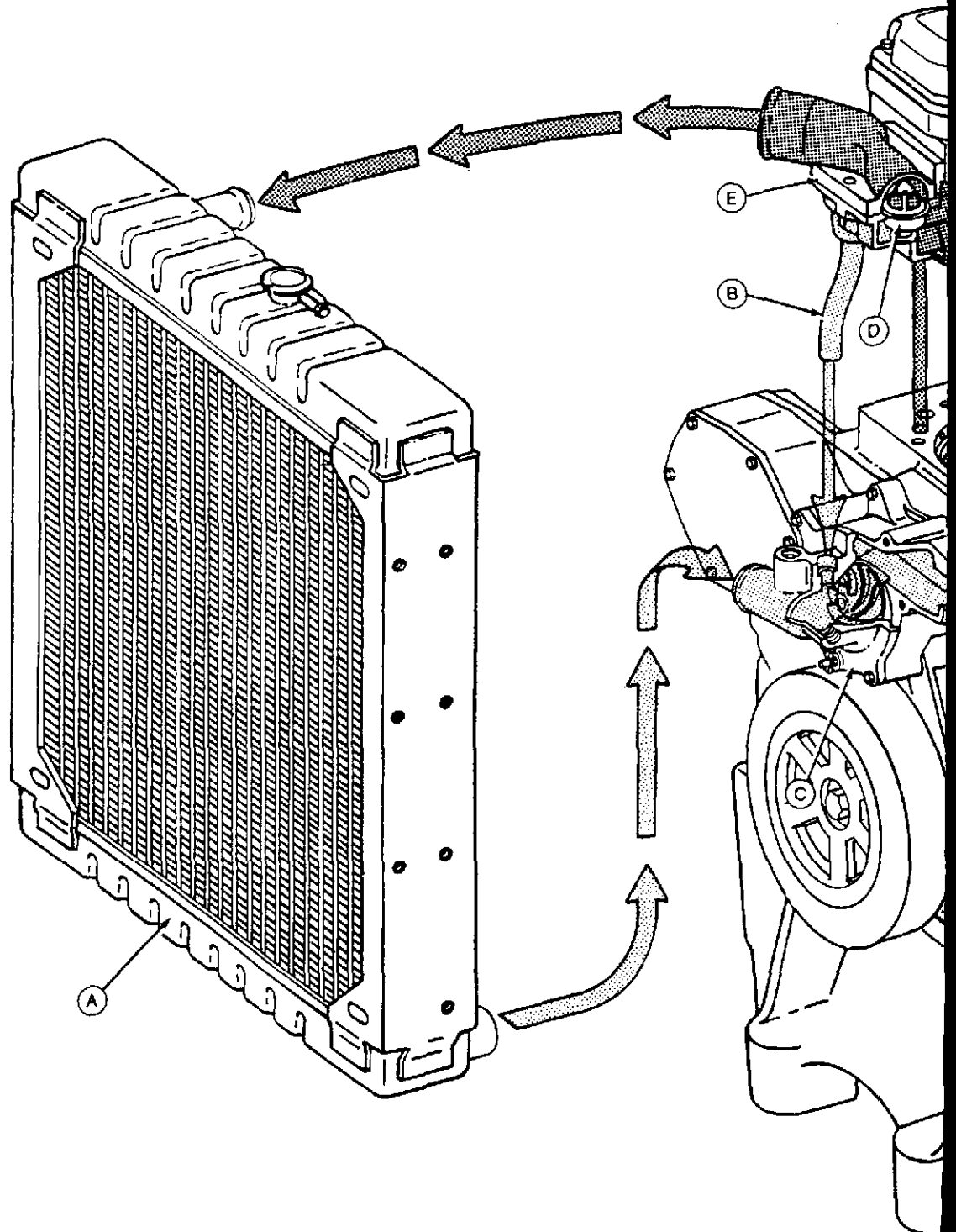
The third circuit is called the "directed cooling" system. Coolant flows through a small port and into a groove at the top of the cylinder liner. Coolant passes around groove in liner, and exits into the vertical passage of the main circuit, then into the right-hand side of the cylinder head.

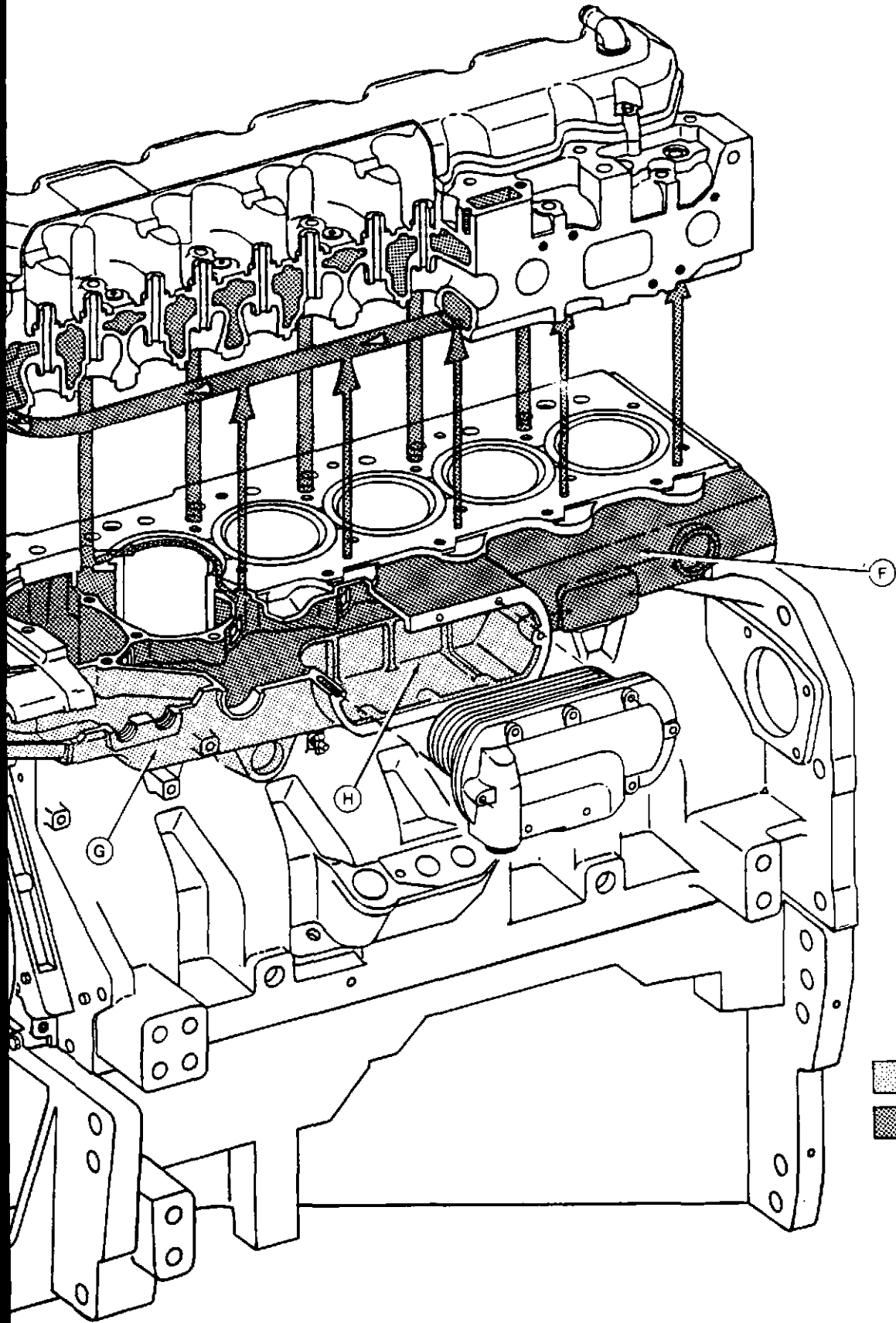
Once the coolant is in the cylinder head, all flow is towards the front. Coolant passes into the thermostat housing, past the two open thermostats (engine at normal operating temperature), and then returns to the radiator.



If the thermostats are closed (as during warm-up periods), coolant is directed back to the pump through the bypass tube (B) to be recirculated. This provides a faster and more uniform warm-up. Some coolant is passing through the bypass tube even while the thermostats are open.

RG,CTM86,G105,1-19-16SEP94

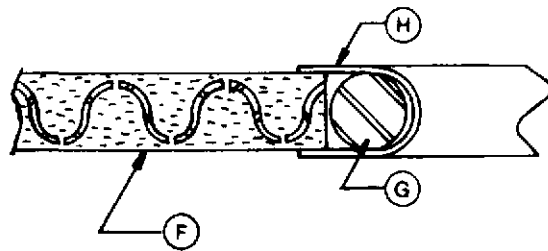
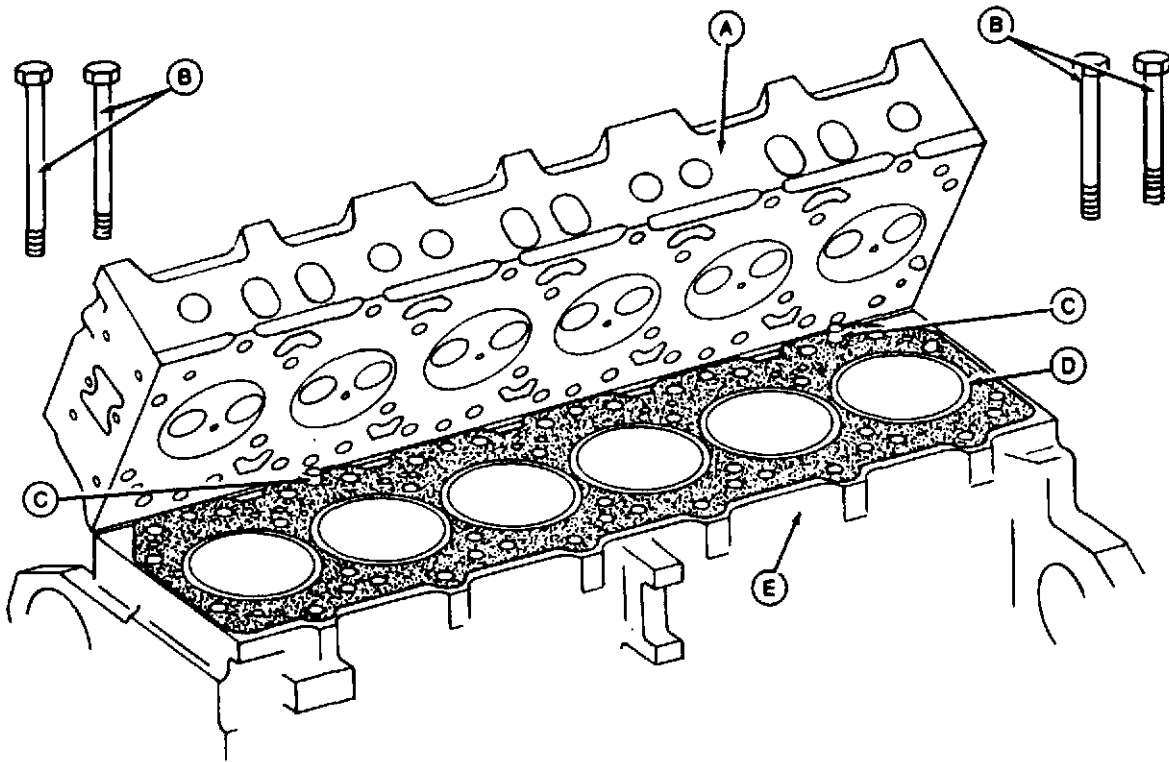
HOW THE COOLING SYSTEM WORKS—CONTINUED





-  I
-  J

HEAD GASKET JOINT CONSTRUCTION AND OPERATION



A—Cylinder Head
B—Cylinder Head Cap
Screws

C—Dowel Pins
D—Cylinder Liners
E—Cylinder Block

F—Gasket Body
G—Fire Ring Combustion
Seal

H—Stainless Steel Flange

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

DIAGNOSING HEAD GASKET JOINT FAILURES

Head gasket failures generally fall into three categories:

- Combustion seal leakage.
- Coolant seal leakage.
- Oil seal leakage.

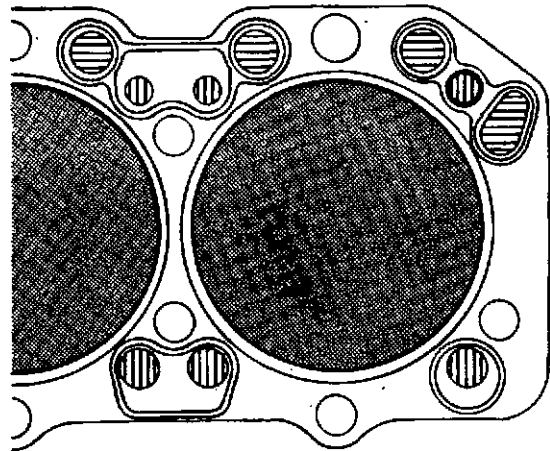
Combustion seal leakage failures occur when combustion gases escape between cylinder head and head gasket combustion flange, or between combustion flange and cylinder liner. Leaking combustion gases may vent to an adjacent cylinder, to a coolant or oil passage, or externally.

Coolant or oil seal leakage failures occur when oil or coolant escapes between cylinder head and gasket body, or between cylinder block and gasket body. The oil or coolant may leak to an adjacent coolant or oil passage, or externally. Since oil and coolant passages are primarily on right hand (camshaft) side of engine, fluid leaks are most likely to occur in that area.

Follow these diagnostic procedures when a head gasket joint failure occurs, or is suspected.

1. Before starting or disassembling engine, conduct a visual inspection of machine, and note any of the following:

- Oil or coolant in head gasket seam, or on adjacent surfaces. Especially right rear corner of gasket joint.
- Displacement of gasket from normal position.
- Discoloration or soot from combustion gas leakage.
- Leaking radiator, overflow tank, or hoses.
- Leaking coolant from water pump weep hole.
- Damaged or incorrect radiator, fan, or shroud.
- Obstructed air flow or coolant flow.
- Worn or slipping belts.
- Damaged or incorrect pressure cap.
- Presence of oil in coolant.
- Low coolant levels.
- Improper coolant.
- Unusually high or low oil levels.
- Oil degradation, dilution, or contamination.
- Correctly specified injection pump.
- Indications of fuel or timing adjustments.
- Unburned fuel or coolant in exhaust system.



- A—Combustion Sealing Areas
- B—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
- Advanced injection pump timing
- Hydraulic or mechanical disturbance of combustion seal

NOTE: Cracked cylinder head or liners may also allow combustion gas leakage into coolant.

RG,CTM8,G105,12-19-16SEP92

Coolant Seal Leakage

Symptoms:

- Coolant discharge from head gasket crevice
- Coolant in crankcase oil
- Low coolant level
- High oil level
- Coolant discharge from crankcase vent

Possible Causes:

- Excessive liner standout
- Excessive liner standout differential between cylinders
- Low head bolt clamping loads
- Out-of-flat/damaged/rough block surface
- Out-of-flat/damaged/rough cylinder head surface
- Oil or coolant overheating
- Cracks/creases in gasket body surfaces
- Damage/voids in elastomer beading

NOTE: Cracked cylinder head, liners, liner packings, defective oil cooler or aftercooler may also allow coolant leakage into crankcase.

RG,CTM8,G105,13-19-13MAY93

Oil Seal Leakage

Symptoms:

- Oil discharge from head gasket crevice
- Oil in coolant
- Low crankcase oil level
- Reduced oil to rocker arms (noisy)

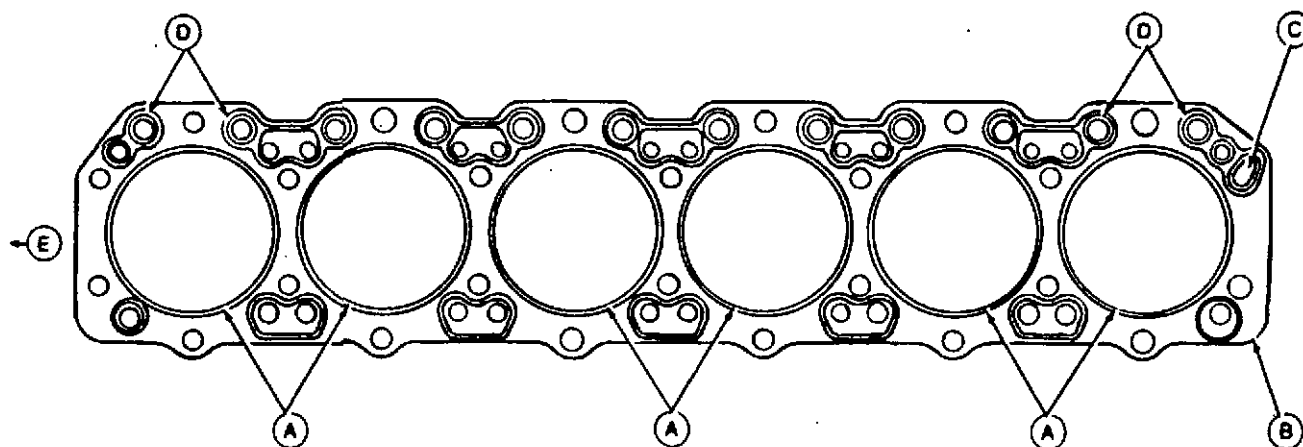
Possible Causes:

- Excessive liner standout
- Excessive liner standout differential between cylinders
- Low head bolt clamping loads
- Out-of-flat/damaged/rough block surface
- Out-of-flat/damaged/rough cylinder head surface
- Oil or coolant overheating
- Cracks/creases in gasket body surfaces
- Damage/voids in elastomer beading
- Damaged/missing O-ring seal at oil port to rocker arms

NOTE: Defective oil cooler may also allow oil leakage into coolant.

RG,CTM8,G105,14-19-16SEP92

HEAD GASKET INSPECTION AND REPAIR SEQUENCE



A—Combustion Seals
(Flanges)

B—Gasket Body
C—Rocker Arm Oil Port

D—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.

RG6448 -UN-13OCT92

7. Clean block, head, liners, and cap screws. (See Groups 05 and 10.)

8. Proceed with the following dimensional checks and visual inspections:

Cylinder Head (See Group 05.)

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

Cylinder Block and Liners (assembled and clamped)
(See Group 05 or 10.)

- Check liner standout at four places on each liner.
- Check liner standout difference between cylinders.

Cylinder Block (See Group 10.)

- Check surface flatness/finish.
- Inspect for surface damage.
- Check liner counterbore depth (if liner is removed).
- Check top deck to crankshaft centerline dimension.
- Inspect cap screw bosses, must be clean/intact.

Cylinder Liner (See Group 10.)

- Check liner flange flatness/finish.
- Check liner flange thickness (if liner is removed).
- Inspect flange for damage.

Cylinder Head Cap Screws (See Group 05.)

- Inspect for corrosion damage.
- Inspect condition of threads.
- Inspect for straightness.
- Check length.

9. When inspections and measurements have been completed, determine most probable causes of joint failure. Make all necessary repairs to joint components, cooling system, and fuel injection system.

10. Reassemble the engine according to procedures and specifications in the repair groups of this manual.

CTM42,G105,18 -19-13MAY93

DIAGNOSING ENGINE MALFUNCTIONS

• Will Not Crank:

Electrical System Malfunction

- Weak battery
- Corroded or loose battery connections
- Defective main switch or start safety switch
- Starter solenoid defective
- Starter defective

• Hard to Start or Will Not Start:

Electrical System Malfunction

- Loose or corroded battery connections
- Weak battery
- Excessive resistance in starter circuit

Fuel System Malfunction - See Group 115

- Empty fuel tank
- Improper fuel
- Fuel shut off at tank
- Water, dirt or air in fuel system
- Plugged fuel filter
- Fuel shut-off cable not pushed in
- Dirty or faulty fuel injection nozzles
- Defective fuel injection pump
- Defective fuel supply pump
- Fuel injection pump incorrectly timed

Service Problem

- Too high viscosity crankcase oil

• Engine Runs Irregularly or Stalls Frequently:

Basic Engine Problem

- Coolant temperature too low
- Improper valve clearance
- Cylinder head gasket leaking
- Worn or broken compression rings
- Valves sticking or burned
- Exhaust system restricted
- Engine compression too low
- Engine overheating
- Worn camshaft lobes

Fuel System Malfunction - See Group 115

- Defective fuel injection pump
- Low fuel supply
- Air in fuel
- Vent on fuel tank cap obstructed
- Fuel injection nozzles defective or leaking
- Fuel filter or fuel lines restricted
- Defective fuel supply pump
- Fuel injection pump incorrectly timed

Service Problem

- Improper fuel

• Engine Misfiring:

Service Problem

- Water in fuel
- Mixture of gasoline and diesel fuel
- Fuel System Malfunction - See Group 115
- Air in fuel system
- Defective fuel injection nozzles
- Defective fuel injection pump
- Fuel injection nozzles improperly installed
- Leaking fuel injection nozzle seals
- Worn or defective fuel supply pump
- Fuel injection pump incorrectly timed

Basic Engine Problem

- Engine overheated
- Lobes of camshaft worn
- Weak valve springs
- Pre-ignition
- Engine compression too low
- Improper valve clearance
- Burnt, damaged or stuck valves

• Lack of Engine Power:

Service Problem

- Air cleaner restricted or dirty
- Excessive resistance in air intake system
- Improper crankcase oil
- Improper fuel
- Restricted exhaust system

Fuel System Malfunction - See Group 115

- Fuel filter restricted
- Defective fuel supply pump
- Defective fuel injection pump
- Fuel injection pump incorrectly timed
- Faulty injection nozzles
- Plugged fuel tank vent

Basic Engine Problem

- Engine overheated
- Engine clutch slipping
- Defective cylinder head gasket
- Lobes of camshaft worn
- Improper valve clearance
- Improper valve timing
- Burnt, damaged or stuck valves
- Weak valve springs
- Piston rings and cylinder liners excessively worn
- Engine compression too low
- Improper coolant temperature

DIAGNOSING ENGINE MALFUNCTIONS—CONTINUED

• Engine Overheats

Service Problem

- Lack of coolant in cooling system
- Radiator core and/or side screens dirty
- Cooling system limed up
- Engine overloaded
- Too low crankcase oil level
- Improper fuel

Basic Engine Problem

- Loose or defective fan belt
- Defective thermostat(s)
- Damaged cylinder head gasket
- Defective water pump
- Defective radiator cap

Fuel System Malfunction - See Group 115

- Fuel injection pump delivers too much fuel
- Fuel injection pump incorrectly timed

• Excessive Oil Consumption

Basic Engine Problem

- Oil control rings worn or broken
- Scored cylinder liners or pistons
- Excessive resistance in air intake system
- Oil flow through oil passages restricted
- Worn valve guides or stems
- Excessive oil pressure
- Piston ring grooves excessively worn
- Piston rings sticking in ring grooves
- Insufficient piston ring tension
- Piston ring gaps not staggered
- Excessive main or connecting rod bearing clearance
- Front and/or rear crankshaft oil seal faulty
- Glazed cylinder liners (insufficient load during engine break-in)

Service Problem

- Too low viscosity crankcase oil
- Crankcase oil level too high
- External oil leaks

• Low Oil Pressure

Service Problem

- Low crankcase oil level
- Improper crankcase oil
- Defective oil pressure warning switch or engine oil pressure indicator light

Basic Engine Problem

- Leakage at internal oil passages
- Defective oil pump
- Excessive main and connecting rod bearing clearance
- Improper regulating valve adjustment
- Piston cooling orifice missing
- Plugged oil pump intake screen

• High Oil Pressure

Basic Engine Problem

- Oil pressure regulating valve bushing loose (wanders)
- Improperly operating regulating valve
- Stuck or damaged filter bypass valve

• Excessive Fuel Consumption

Service Problem

- Improper grade of fuel
- Engine overloaded
- Air cleaner restricted or dirty

Basic Engine Problem

- Compression too low

Fuel System Malfunction - See Group 115

- Leaks in fuel system
- Fuel injection nozzles dirty or faulty
- Fuel injection pump defective (delivers too much fuel)
- Fuel injection pump incorrectly timed
- Improper valve clearance

• Black or Grey Exhaust Smoke

Service Problem

- Excess fuel
- Engine overloaded
- Air cleaner restricted or dirty
- Defective muffler (causing back-pressure)

Fuel System Malfunction - See Group 115

- Fuel injection nozzles dirty or faulty
- Incorrect engine timing

DIAGNOSING ENGINE MALFUNCTIONS—CONTINUED

• White Exhaust Smoke

Basic Engine Problem

- Engine compression too low
- Defective thermostat(s) (does not close)

Fuel System Malfunction - See Group 115

- Defective fuel injection nozzles
- Fuel injection pump incorrectly timed

Service Problem

- Improper fuel

• Coolant in Crankcase

Basic Engine Problem

- Cylinder head gasket defective
- Cylinder head or block cracked
- Cylinder liner seals leaking

• Abnormal Engine Noise

Basic Engine Problem

- Low engine oil level
- Worn main or connecting rod bearings
- Excessive crankshaft end play
- Loose main and connecting rod bearing caps
- Foreign material in combustion chamber
- Worn piston pin bushings and pins
- Scored pistons
- Worn main or connecting rod bearings*
- Worn timing gears
- Incorrect engine timing
- Excessive valve clearance
- Worn cam followers
- Bent push rods
- Worn camshaft
- Worn rocker arm shaft
- Insufficient engine lubrication
- Worn turbocharger bearings
- Crankshaft oil pump drive gear worn or broken
- Crankshaft vibration damper worn or separated

Fuel System Malfunction - See Group 115

- Fuel injection pump incorrectly timed

• Detonation or Pre-Ignition

Basic Engine Problem

- Oil picked up by intake air stream (intake manifold)
- #### Fuel System Malfunction - See Group 115
- Dirty or faulty fuel injection nozzles
 - Incorrect fuel injection pump timing
 - Fuel injection nozzle tip holes enlarged
 - Fuel injection nozzle tips broken
 - Carbon build-up in compression chamber
 - Faulty injection pump

Service Problem

- Improper fuel

• Water Pump Leaking

- Seal ring or pump shaft worn

• Coolant Temperature Below Normal

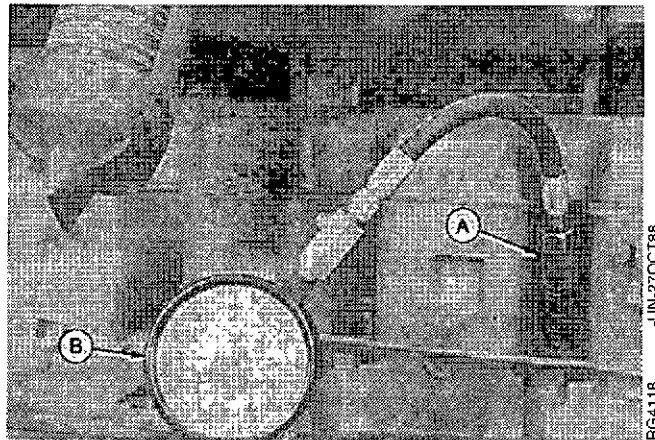
Defective thermostat(s)

- Coolant temperature gauge defective

• Engine Vibrating

- Fan blades bent or broken
- Water pump shaft worn

TEST ENGINE COMPRESSION PRESSURE



RG4118
-JUN-27OCT88

IMPORTANT: Compression pressures are affected by the cranking speed of the engine. Before beginning test, insure that batteries are fully charged and injection nozzle area is thoroughly cleaned.

1. Start engine and run at rated speed until it warms up to normal operating temperature. (From a cold start, operate engine 10—15 minutes at slow idle.)
2. Remove injection lines, leak-off lines, and injection nozzles. See Group 35.
3. Install the JT01675A Nozzle adapter and JT01677 Adapter Nut (A) into injection nozzle bore. Tighten adapter nut to 80 N·m (60 lb-ft).
4. Connect JT01682 Gauge and Hose Assembly (B) to nozzle adapter.
5. Pull fuel shut-off knob all the way out, if equipped, and close fuel shut-off valve.
6. Crank engine over at 275—325 rpm cranking speed and record compression readings.

ENGINE COMPRESSION SPECIFICATION

Engine	Compression Pressure—275—325 rpm
6081	2 380—2 790 kPa (23.8—27.9 bar) (345—405 psi)

NOTE: Pressure given was taken at 300 m (1000 ft) above sea level. A 3.6 percent reduction in gauge pressure will result for each additional 300 m (1000 ft) of altitude.

All cylinders within an engine should have approximately the same pressure. There should be less than 340 kPa (3.4 bar) (50 psi) difference between cylinders.

7. If pressure is much lower than shown, remove gauge and apply oil to ring area of piston through injection nozzle bore. Do not use too much oil and do not get oil on valves.
8. Crank engine over and record compression reading again.

If pressure is higher than 2 790 kPa (27.9 bar) (405 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 2 380 kPa (23.8 bar) (345 psi), it is possible that valves are worn or sticking. Recondition cylinder head as needed. See Group 05.

9. Measure compression pressure in all remaining cylinders and compare readings. Recondition power cylinders and cylinder head as required.

CHECK ENGINE OIL PRESSURE

1. Remove pipe plug from main oil gallery using JDG782 Oil Galley Plug Tool.
2. Install No. 0070 (D1) Fitting, No. 2106 (19-HP) Hose, and JT05472* Gauge (or equivalent).

IMPORTANT: To achieve an accurate oil pressure reading, warm up engine to 105°C (220°F).

3. Start engine, run at speeds given below, measure oil pressure, and compare readings.

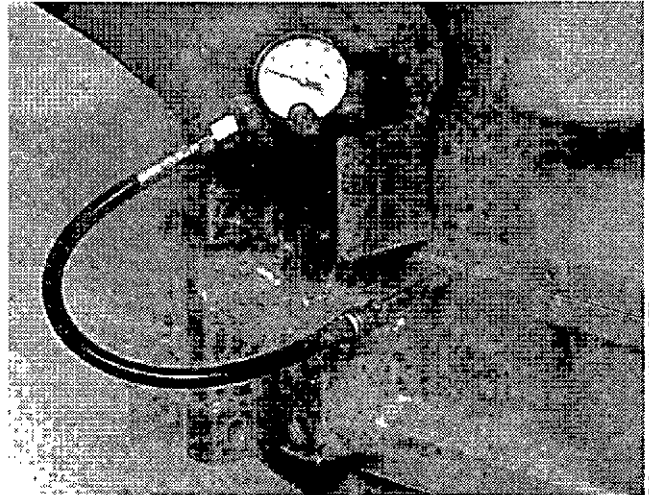
OIL PRESSURE SPECIFICATIONS

Minimum No Load at 850 rpm
(Slow Idle) 138 kPa (1.4 bar) (20 psi)

Maximum Full Load at 2200 rpm
(Rated Speed) 400 kPa (4.0 bar) (58 psi)

NOTE: The oil pressure regulating valve is designed so that adjustment of oil pressure should not be required.

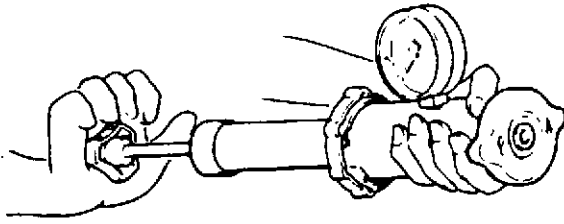
Replace oil pressure regulating valve if oil pressure is not within specified range.



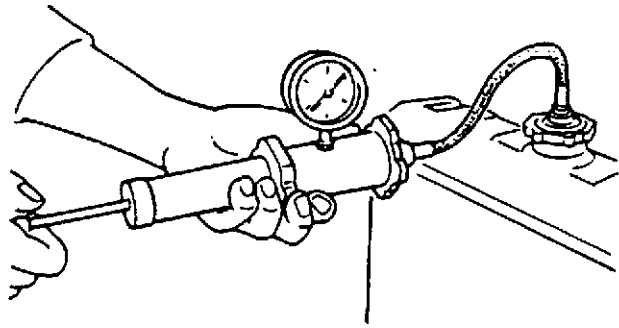
RG7087 -UN-07SEP94

* Part of JT05470 (D15027NU) Universal Pressure Test Kit

PRESSURE TEST COOLING SYSTEM AND RADIATOR CAP



RG6557 -JUN-20JAN93



RG6558 -JUN-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 D05104ST 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.

105 *Test pressures recommended are for all Deere OEM cooling systems.
22 .On specific vehicle applications, test cooling system and pressure cap according to the recommended pressure for that vehicle.

INSPECT THERMOSTAT AND TEST OPENING TEMPERATURE

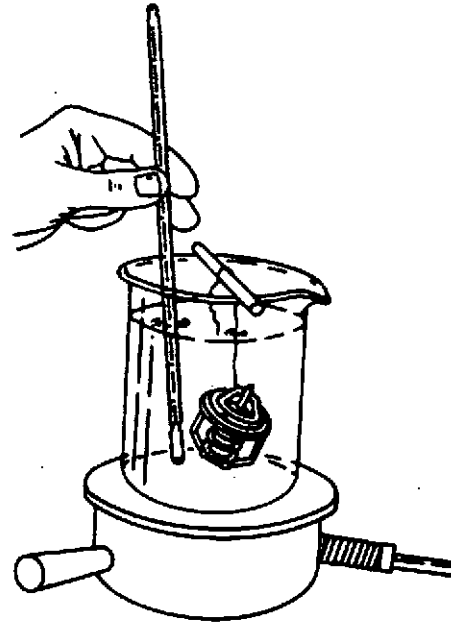
Visually inspect thermostat for corrosion or damage.
Replace as necessary.

- Test thermostat as follows:

⚠ CAUTION: DO NOT allow thermostat or thermometer to rest against the side or bottom of container when heating water. Either may rupture if overheated.

1. Suspend thermostat and a thermometer in a container of water.
2. Stir the water as it heats. Observe opening action of thermometer and compare temperatures with specification given in chart below.

NOTE: Due to varying tolerances of different suppliers, initial opening and full open temperatures may vary slightly from specified temperatures.



THERMOSTAT TEST SPECIFICATIONS

Rating	Initial Opening (Range)	Full Open (Nominal)
71°C (160°F)	69—72°C (156—162°F)	84°C (182°F)
77°C (170°F)	74—78°C (166—172°F)	89°C (192°F)
82°C (180°F)	80—84°C (175—182°F)	94°C (202°F)
89°C (192°F)	86—90°C (187—194°F)	101°C (214°F)
90°C (195°F)	89—93°C (192—199°F)	103°C (218°F)
92°C (197°F)	89—93°C (193—200°F)	105°C (221°F)
96°C (205°F)	94—97°C (201—207°F)	100°C (213°F)
99°C (210°F)	96—100°C (205—212°F)	111°C (232°F)

3. Remove thermostat and observe its closing action as it cools. In ambient air the thermostat should close completely. Closing action should be smooth and slow.
4. If any thermostat is defective on a multiple thermostat engine, replace all thermostats.

CTM42,G105,13 -19-13MAY93

RG5971 JUN-17SEP91

SPECIAL OR ESSENTIAL TOOLS

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

DX,TOOLS -19-05JUN91

A—JT03092 Gauge *

B—JT03017 Hose and Connector *

C—Connector

1/8 in. Pipe Nipple

1/4 in.—1/8 in. Pipe Reducer

1/8 NPT-7/16-20 UNC Adapter

Used with above hose and gauge to check intake manifold pressure at aneroid.

D—"T" Fitting

D—JT03104 Fitting*

Used with above hose and gauge to check intake manifold pressure at aftercooler on 6076A Engines.

* Part of JT05412 Universal Pressure Test Kit



S55,23005,A -19-16SEP94

AIR INTAKE AND EXHAUST SYSTEM TEST SPECIFICATIONS

NOTE: Refer to the appropriate machine technical manual for air intake and exhaust system test specifications.

RG,CTM86,G110,6-19-16SEP94

DIAGNOSING AIR INTAKE MALFUNCTIONS

Symptom	Problem	Solution
Engine Starts Hard or Won't Start	Air leak on suction side of system	Check hose and pipe connections for tightness; repair as required (See Group 30).
	Erratic Engine Operation	Check hose and pipe connections for tightness; repair as required (See Group 30).
Engine Emits Excessive Black Smoke	Air cleaner element restricted	Clean or replace elements (See operator's manual).
	Turbocharger defective	Repair or replace (See Group 30).
	Air leak in manifold	Check hose and pipe connections for tightness; repair as required (See Group 30).
Engine Idles Poorly	Air leak on suction side of system	Check hose and pipe connections for tightness; repair as required (See Group 30).
Engine Does Not Develop Full Power	Air cleaner restricted	Clean or replace elements (See operator's manual).
	Air leak on suction side of system	Check hose and pipe connections for tightness; repair as required (See Group 30).
	Turbocharger defective	Repair or replace (See Group 30).
Turbocharger "Screams"	Air leak in manifold	Check intake manifold gasket and manifold; repair as required (See Group 30).

RG,CTM86,G110,7-19-16SEP94

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 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.

On 6081H Engines, an air-to-air aftercooler cools the turbocharger compressor discharge air by routing it through a heat exchanger before it enters the engine. The heat exchanger uses no liquid coolant but relies on air flow to cool the charge air.

This increased volume of air, when combined with a predetermined quantity of additional fuel, enables more power to be produced.

RG,CTM86,G110,1-19-16SEP94

AIR CLEANER OPERATION

IMPORTANT: Air cleaner information supplied below is for OEM engines using air cleaned kits supplied by John Deere. Refer to the appropriate machine technical manual for specific information detailing air cleaner systems used on all other applications.

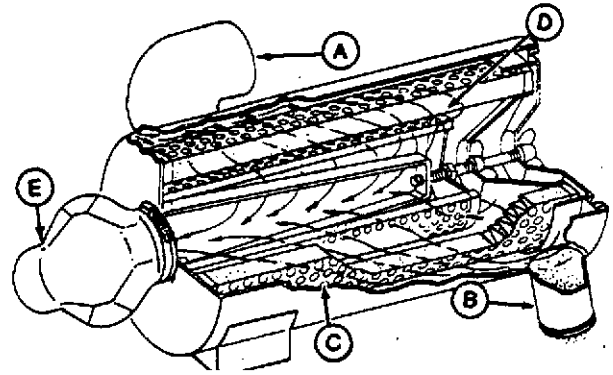
Dust-laden air enters the air cleaner inlet (A) and is forced into a high-speed centrifugal motion.

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 through a rubber valve (B), 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 at outlet (E).

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 and service intervals.



- A—Air Inlet
- B—Dust Outlet
- C—Primary Element
- D—Secondary (Safety) Element
- E—Air Outlet

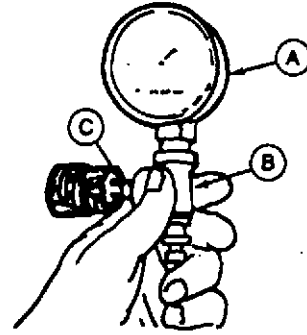
R28270 -JN-14DEC88

RG,CTM86,G110,2-19-16SEP94

AIR FILTER RESTRICTION INDICATOR SWITCH TEST

1. Remove air filter restriction indicator switch from air intake piping.
2. Install pipe nipple (C), tee fitting (B), and gauge (A) from D05022ST Water Vacuum Gauge Kit into air filter restriction indicator hole. Install air filter restriction indicator into tee fitting.
3. Start engine and slowly cover the air cleaner inlet with a piece of paper or cardboard.
4. Air restriction indicator must show red at 5.6—6.8 kPa (56—68 mbar) (22.7—27.3 in. water) (1.6—2.0 in. hg) vacuum.

If air restriction indicator shows red at any other value than listed above, install a new indicator.



RG,CTM6,G110,1 -19-14AUG91

110
5
-JUN-09DEC88
T6188AC

DIAGNOSING TURBOCHARGER MALFUNCTIONS

Before replacing the turbocharger, determine what caused the failure of the defective unit, and correct the condition. This will prevent an immediate repeat failure of the replacement unit. Refer to Air Intake and Exhaust System Group 30 for repair information.

• Noise Or Vibration*:

Bearings not lubricated (insufficient oil pressure).
Air leak in engine intake or exhaust manifold.
Improper clearance between turbine wheel and turbine housing.
Broken blades (or other wheel failures).

• Engine Will Not Deliver Rated Power:

Clogged manifold system.
Foreign material lodged in compressor, impeller, or turbine.
Excessive dirt build-up in compressor.
Leak in engine intake or exhaust manifold.
Leak in intake manifold-to-aneroid pipe.
Rotating assembly bearing failure.
Damaged compressor or turbine blades.

• Oil On Compressor Wheel Or In Compressor Housing (Oil Being Pushed or Pulled Through Center Housing):

Excessive crankcase pressure.
Air intake restriction.
Drain tube restriction.

• Oil In Manifold Or Dripping From Housing:

Excessive crankcase pressure.
Air intake restriction.
Drain tube restriction.
Damaged or worn journal bearings.
Unbalance of rotating assembly:
Damage to turbine or compressor wheel or blade.
Dirt or carbon build-up on wheel or blade.
Bearing wear.
Oil starvation or insufficient lubrication.
Shaft seals worn.

• Turbine Wheel Drag:

Carbon build-up behind turbine wheel caused by coked oil or combustion deposits.
Dirt build-up behind compressor wheel caused by air intake leaks.
Bearing seizure or dirty, worn bearings caused by excessive temperatures, unbalanced wheel, dirty oil, oil starvation, or insufficient lubrication.

*Do not confuse the whine heard during run down with noise which indicates a bearing failure.

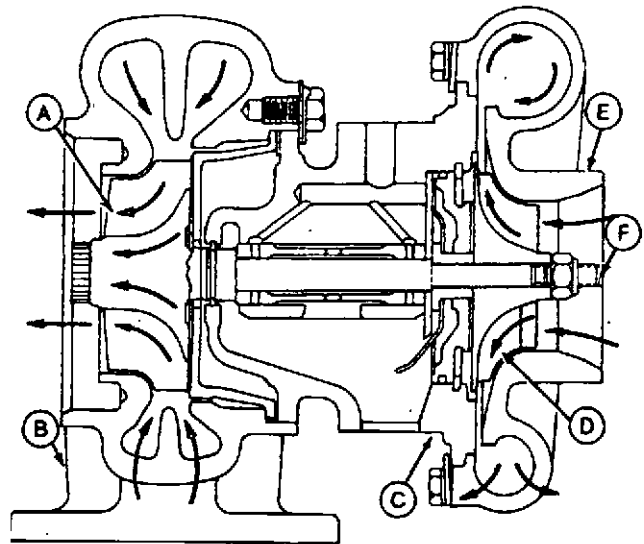
HOW THE TURBOCHARGER WORKS

The turbocharger, which is basically an air pump that is driven by exhaust gases, allows the engine to produce added power without increasing displacement. Turbochargers are specially matched for the power ratio requirements of each specific application.

Exhaust gases from the engine pass through the turbine housing (B) causing the turbine wheel (A) to rotate before the exhaust gas is discharged to the atmosphere. The turbine wheels mounted on a shaft (F) to drive the compressor wheel (D) which is also mounted on the shaft.

As the compressor wheel rotates in the compressor housing (E), an increased volume of (compressed) inlet air is drawn into the housing and delivered to the intake manifold (through an aftercooler or heat exchanger, if so equipped).

All rotating components of the turbocharger are lubricated within the center housing (C).



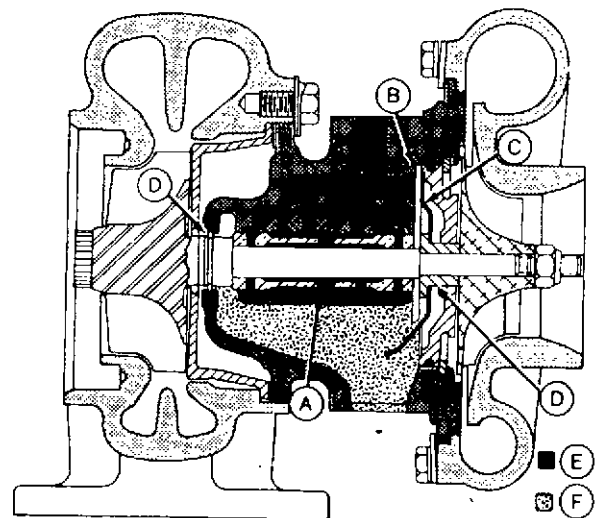
- | | |
|--------------------|----------------------|
| A—Turbine Wheel | E—Compressor Housing |
| B—Turbine Housing | F—Shaft |
| C—Center Housing | |
| D—Compressor Wheel | |

RG,CTM86,G110,3-19-16SEP94

HOW THE TURBOCHARGER IS LUBRICATED

Engine oil under pressure from the engine lubrication system is pumped through a passage in the bearing housing and directed to the bearing (A), thrust plate (B), and thrust sleeve (C). Oil is sealed from the compressor and turbine by a piston ring (D) at both ends of bearing housing.

The turbocharger contains a single floating bearing. This bearing has clearance between the bearing OD and the housing wall as well as clearance between the bearing ID and the shaft OD. These clearances are lubricated by the oil supply and the bearings are protected by a cushion of oil. Discharge oil drains by gravity from the bearing housing to the engine crankcase.



Turbocharger Lubrication

- | |
|-----------------|
| A—Bearing |
| B—Thrust Plate |
| C—Thrust Sleeve |
| D—Piston Ring |
| E—Pressure Oil |
| F—Discharge Oil |

RG,CTM61,G110,5-19-16SEP94

CHECK INTAKE MANIFOLD PRESSURE (TURBO BOOST)

NOTE: For each application, refer to the appropriate machine technical manual for intake manifold pressure specifications.

Intake manifold pressure (turbo boost) should be checked at intake manifold.

IMPORTANT: Engine speed and load should be stabilized before taking a gauge reading. Be sure the gauge works properly and familiarize yourself with the use of the gauge.

Turbo-boost pressure checks are only a guide to determine if there is an engine problem (Valve leakage, faulty nozzle, etc.). Low pressure readings are not a conclusive reason for increasing injection pump fuel delivery. Pump adjustment should be within the specifications as established by an authorized diesel repair station.

- If boost pressure is too high, remove fuel injection pump and have it checked for high fuel delivery by an authorized diesel repair station.

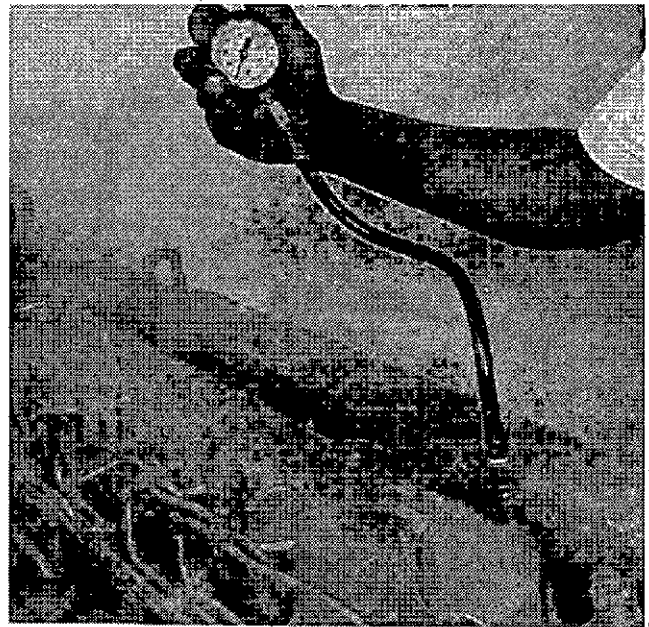
- If boost pressure is too low, check for the following:
 - Restriction in air cleaner.
 - Leak in air intake between turbocharger and cylinder head.
 - Leak in exhaust manifold gasket.
 - Restricted exhaust.
 - Leak in fuel system piping.
 - Restricted fuel filter elements.
 - Incorrect fast idle speed.
 - Incorrect injection pump timing.
 - Low fuel injection pump delivery.
 - Faulty fuel supply pump.
 - Low cylinder compression pressure.
 - Faulty fuel injection nozzles.
 - Carbon build-up in turbocharger.
 - Turbocharger compressor or turbine wheel rubbing housing.

RG,CTM86,G110,4-19-16SEP94

1. Remove ether starting aid assembly adapter or plug from intake manifold cover, however equipped.
2. Connect 0—400 kPa (0—4 bar) (0—60 psi) pressure gauge to intake manifold using JT05412 Industrial Universal Pressure Test Kit. Be sure all connections are tight.
3. With engine at operating temperature, connect machine to a dynamometer or load machine the best way possible. Operate engine at rated full load speed.
4. Record pressure reading and compare with specification.

If reading is not within the specification range, check items addressed earlier under this major heading for possible causes.

5. After completing test, remove test equipment and reinstall ether starting aid line or plug.



110
9

FIG7068
-JUN-07SEP94

RG,CTM86,G110,5-19-16SEP94

110
10

SPECIAL OR ESSENTIAL TOOLS

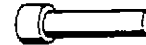
NOTE: Order tools according to information given in the U.S. SERVICE-GARD™ Catalog or in the European microfiche Tool Catalog (MTC).

DX,TOOLS -19-05JUN91

Timing Pin JDE81-4

RG5068 -UN-23AUG88

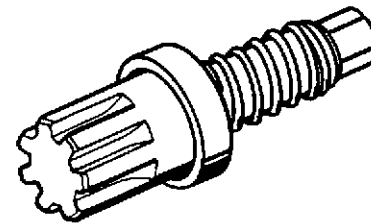
Lock engine at TDC when timing valve train, adjusting valve clearance, and installing fuel injection pump. Use with JDG820 and JDE81-1 Flywheel Turning Tools.



RG,JDE814,86 -19-26OCT94

Flywheel Turning Tool JDG820

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



115
1

-UN-10AUG94
RG7056

RG,JDG820 -19-04AUG94

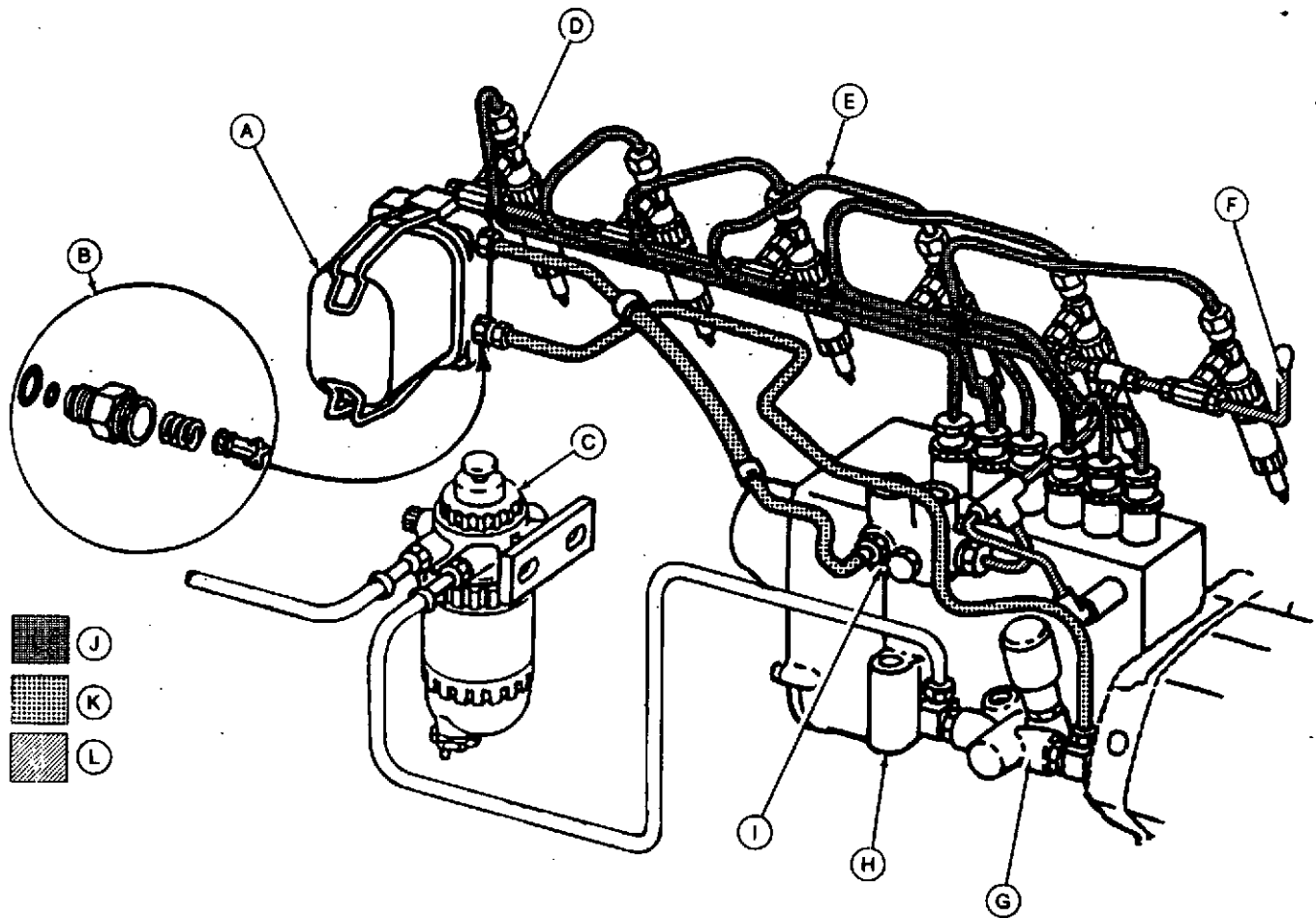
FUEL SYSTEM TEST SPECIFICATIONS

ITEM	SPECIFICATIONS
Fuel Supply Pump Minimum Output Pressure	200 kPa (2.0 bar) (29.0 psi)
Fuel Injection Pump Timing-to-Engine	TDC
Engine Speeds (RPM)*	
TORQUES	
Injection Pump Drive Gear-to-Pump Hub	61 N·m (45 lb-ft)
Injection Pump-to-Cylinder Block Stud Nuts	27 N·m (20 lb-ft)
Injection Pump Drive Gear Cover	27 N·m (20 lb-ft)

** For each application, refer to the appropriate machine technical manual for slow idle, fast idle, and rated speed specifications.*

RG,CTM86,115,1 -19-16SEP94

FUEL SYSTEM OPERATION



A—Final Fuel Filter
 B—Check Valve Assembly
 C—Primary Fuel Filter/Water Separator

D—Injection Nozzles
 E—Injection Pressure Lines
 F—Leak-Off line Assembly
 G—Supply Pump

H—Injection Pump
 I—Fuel Shut-off Solenoid Assembly
 J—Injection Pressure Fuel

K—Supply Pump Pressure Fuel
 L—Return Fuel

The Bosch P-3000 in-line fuel injection pump (H) has an electronically-controlled governor and uses individual pump for each cylinder. The crankshaft-driven injection pump camshaft rotates at one-half engine speed to operate individual pumping units. The fuel rack is electronically-controlled and controls each pumping unit.

The supply pump (G) draws fuel from the vented fuel tank through the pre-filter (not shown) and primary filter/water separator (C). The supply pump pressurizes the fuel so that it flows through the final filter (A), enters the pump through a connection on shut-off solenoid assembly (I), and on to the fuel gallery in the pump housing. Supply pump output pressure will vary depending on load and application.

The gallery is kept full by the supply pump. Injection pump plungers further pressurize the fuel. Injection pressure lines (E) route the fuel to the nozzles (D). The high pressure fuel (J) opens the nozzle valve and forces fuel out the small orifices in the nozzle tip. This atomizes the fuel as it enters the combustion chamber.

There are two sources of excess fuel incorporated into the system. The supply pump supplies more fuel (K) to the pump than is required by the engine, and the nozzle requires excess fuel to lubricate the nozzle valve. A leak-off line assembly (F) returns this excess fuel (L) to the tank from both the pump and nozzles.

RG,CTM86,115,2 -19-16SEP94

DIAGNOSE FUEL SYSTEM MALFUNCTIONS

NOTE: Refer to CTM68 Electronic Fuel Injection Systems and your vehicle technical manual for additional electronic pump diagnostics.

Symptom	Problem	Solution
Fuel Not Reaching Injection Nozzles	Fuel filter restricted	Replace fuel filter (See Group 35)
	Fuel line restricted	Clean lines as required
	Fuel too heavy at low temperatures	Use correct grade of fuel (See Group 02)
	Air in system	Correct problem and bleed fuel system (this group)
	Fuel tank valve shut off	Open fuel tank valve
	Low supply pump pressure	Check fuel lines for restrictions; check pump output pressure (this group)
Engine Starts Hard or Won't Start	Fuel too heavy at low temperature	Use correct grade of fuel (See Group 02)
	Injection nozzles faulty or sticking	Repair or replace as required (See Group 35)
	Incorrect timing	Adjust timing (this group)
	Faulty injection pump	Repair or replace
	Water in fuel	Drain water from fuel filter/water separator. Install new filter (See Group 35)
	Fuel filter restricted	Replace fuel filter (See Group 35)
	Low supply pump pressure	Check pump output pressure. (See this group)
	Injection pump return fuel line or fittings restricted	Clean lines as required
	Low cetane fuel	Use correct grade of fuel (See Group 02)
	Broken starting fuel control shaft spring	Repair (See Group 35)

Continued on next page

115
4

Symptom	Problem	Solution
	Injection pump drive gear teeth worn or broken	Check timing gear backlash and check for failed crankshaft vibration damper.
Engine Starts and Stops	Air in system	Correct problem and bleed fuel system (See this group)
	Fuel filter restricted	Replace fuel filter (See Group 35)
	Fuel lines restricted	Clean lines as required
	Water in fuel	Drain water from fuel filter/water separator. Install new filter (See Group 35)
	Injection pump return fuel line or fittings restricted	Clean lines as required
Erratic Engine Operations	Fuel filter restricted	Replace fuel filter (See Group 35)
	Fuel too heavy at low temperatures	Use correct grade of fuel (See Group 02)
	Injection nozzles faulty or sticking	Repair (See Group 35)
	Fuel lines restricted	Clean as required
	Incorrect timing	Adjust timing (this group)
	Water in fuel	Drain water from fuel (or separator, if equipped). Install new filter
	Injection pump return fuel line or fittings restricted	Clean lines as required
	Low cetane fuel	Use correct grade of fuel (See Group 02)
	Injection nozzle return lines restricted	Clean lines as required
Engine Emits Excessive Black Smoke	Injection nozzles faulty or sticking	Repair (See Group 35)
	Injection pump timing incorrect	Adjust timing (this group)
	Low cetane fuel	Use correct grade of fuel (See Group 02)
	Over-fueling	Repair and adjust (See Group 35)

Continued on next page

Symptom	Problem	Solution
Engine Emits Excessive Blue or White Smoke	Cranking speed too low	Check batteries and electrical system
	Injection pump timing incorrect	Adjust timing (this group)
	Injection nozzles faulty or sticking	Repair (See Group 35)
	Excessive wear in liners and/or piston rings stuck	See Group 10
	Incorrect cetane fuel for ambient temperature	Use correct grade of fuel (See Group 02)
	Engine running too "cold"	Check thermostat (See Group 25)
Engine Idles Poorly	Injection nozzles faulty or sticking	Repair (See Group 35)
	Incorrect timing	Adjust timing (this group)
	Pump slow idle speed not correctly adjusted	Adjust slow idle speed (this group)
	Fuel lines restricted	Clean as required
	Water in fuel	Drain water from fuel filter/water separator. Install new filters (See Group 35)
	Injection pump return lines or fittings restricted	Clean as required
	Injection nozzle return lines clogged	Clean as required
	Low cetane fuel	Use correct grade of fuel (See Group 02)
Engine Does Not Develop Full Power	Low cetane fuel	Use correct grade of fuel (See Group 02)
	Incorrect timing	Adjust timing (this Group)
	Injection pump or governor faulty	Repair (See Group 35)
	Fuel filter clogged	Replace fuel filter (See Group 35)
	Injection nozzles faulty or sticking	Repair (See Group 35)
	Injection pump return fuel line or fittings restricted	Clean as required

Continued on next page

Symptom	Problem	Solution
Engine Does Not Develop Full Power	Water in fuel (or gasoline in fuel)	Drain water or replace with clean fuel. Install new filters (this Group)
	Incorrect fast idle speed	Adjust speed (this Group)

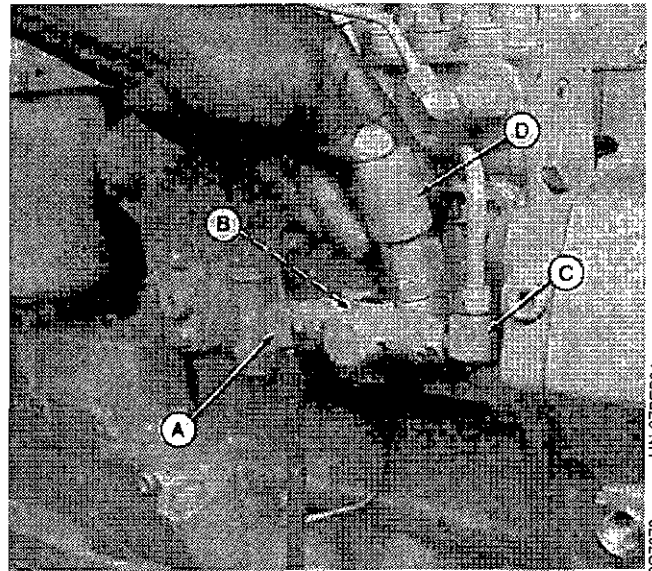
115
6

RG,CTM86,115,3 -19-16SEP94

FUEL SUPPLY PUMP OPERATION

The Robert Bosch plunger-type fuel supply pump is mounted on the side of the injection pump housing and is driven by the injection pump camshaft. Fuel enters the supply pump at (A), is pressurized by the plunger (B), and discharged through outlet (C). The hand primer (D) provides manual pump operation for bleeding air from the fuel system.

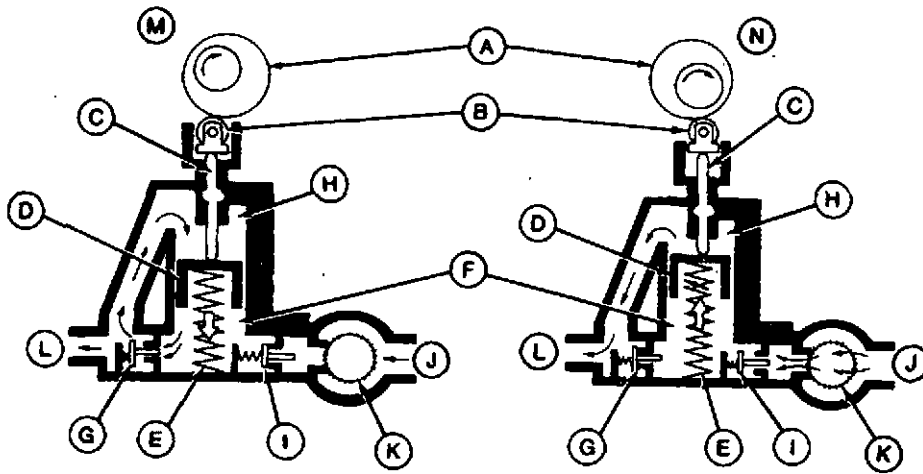
- A—Fuel Inlet
- B—Plunger
- C—Fuel Outlet
- D—Hand Primer



RG7070 -UN-07SEP94

RG,CTM86,115,4 -19-16SEP94

FUEL SUPPLY PUMP OPERATION—CONTINUED



FG2437
-UN-20APR89

A—Camshaft
B—Roller Tappet
C—Pressure Spindle
D—Plunger

E—Plunger Spring
F—Suction Chamber
G—Pressure Valve
H—Pressure Chamber

I—Suction Valve
J—Fuel Inlet
K—Filter
L—Fuel Outlet

M—Intermediate Stroke Position
N—Suction and Discharge Stroke Position

As the pump camshaft (A) rotates toward the "high cam" intermediate stroke position (M), the roller tappet (B) and pressure spindle (C) cause the plunger (D) to move against and compress the plunger spring (E).

Plunger movement forces the fuel out of the suction chamber (F), through the pressure valve (G), and into the pressure chamber (H). The amount of fuel discharged from the suction chamber is equal to the amount of fuel delivered for each stroke of the plunger. Towards the end of the intermediate stroke, the spring-loaded pressure valve closes again.

As the camshaft rotates toward the "low cam" or suction and discharge position (N), plunger spring pressure causes the plunger, pressure spindle, and roller tappet to follow the camshaft.

Movement of the plunger pushes the fuel from the pressure chamber, and delivers it to the fuel filters and injection pump. At the same time, plunger suction pressure is permitting fuel to enter the suction chamber through the suction valve (I). With the suction chamber charged with fuel, the pumping cycle begins again.

Fuel is allowed to flow in around the pressure spindle to lubricate the spindle as it moves back and forth in housing. To prevent the fuel from entering the pump crankcase, a rubber O-ring is positioned in the spindle bore of housing at the roller tappet end.

Pulling upward on the the hand primer pump causes the suction valve to open and fuel to flow into the suction chamber. When the hand plunger is pushed downward, the suction valve closes, and fuel is forced out of the pressure valve.

RG,CTM86,115.5 -19-16SEP94

DIAGNOSING FUEL SUPPLY PUMP MALFUNCTIONS

IMPORTANT: Visually inspect the fuel inlet fitting and pump filter for possible plugging before disassembling to determine cause of malfunction.

Symptom	Problem	Solution
Low Supply Pump Output Pressure or Pump Not Functioning Correctly	Restriction at fuel inlet fitting.	Thoroughly clean fuel tank, lines, filters, and inlet fitting.
	Worn or pitted valves caused by foreign material lodging in valve.	Replace valves as required.
	Missing or broken spring(s).	Replace spring(s).
	Broken spindle.	Replace pump.
	Out of fuel.	Add fuel to fuel tank.
	Fuel shut off at tank.	Open fuel shut off valve.
	Restricted fuel line.	Clean as required.
	Air leak in fuel line between pump and tank.	Repair as required.
	Loose or damaged fuel line connections.	Repair.
	Worn or damaged valve assemblies.	Repair or replace.
Diesel Fuel Leaking Into Injection Pump Crankcase	Broken valve spring(s)	Repair or replace.
	Worn spindle and/or pump housing.	Replace pump.
Supply Pump Will Not Pump	Defective O-ring seal.	Replace O-ring seal.
	Supply pump from A-Series injection pump may have been installed.	Install correct supply pump on injection pump.

RG,CTM86,115,6 -19-16SEP94

CHECK FUEL SUPPLY PUMP OPERATION

NOTE: The following procedure can best be performed under moderate air temperature conditions to reduce electrical loads when cranking the engine is required.

1. Make a preliminary inspection of supply pump. Thoroughly clean area around pump. All connections must be tight and not leaking.
2. Start engine and bring to operating temperature. Turn ignition to "OFF" position.

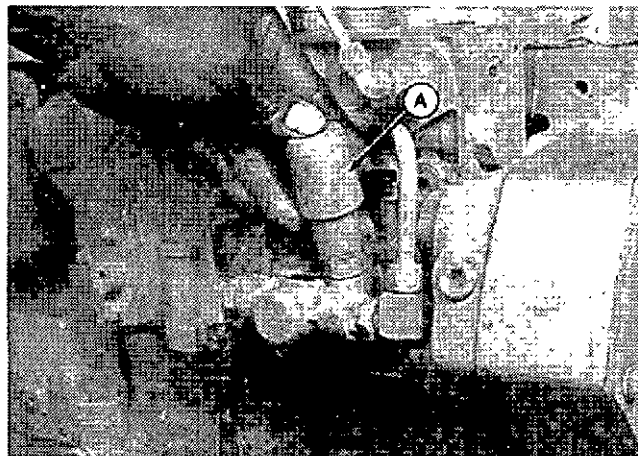
NOTE: Hand primer (A) is spring loaded to remain in the fully extended position. If fuel leaks around a hand primer while seated in the extended position, replace the hand primer.

• Check operation of hand primer:

1. With ignition at "OFF" position, operate hand primer through several strokes.

Moderate to heavy leakage of fuel between plunger and barrel indicates seal is defective. Replace hand primer.

NOTE: Appearance of a slight quantity of fuel around the plunger is normal.



RG7071
-UN-07SEP94

115
9

FIG. CTM86.115.7 -19-16SEP94

• **Test operation of suction side of pump:**

1. Disconnect suction and discharge lines at pump.
2. Drain all fuel from pump by operating hand primer. Then reconnect suction line to pump.

NOTE: When operating hand primer, a moderate resistance should be felt. When only a slight resistance (or no resistance) occurs, replace hand primer or repair pump (valves may be defective).

3. Operate hand primer until fuel flows from pump outlet (discharge).

Fuel should flow within 15—25 strokes. If not, the suction line may be obstructed or leaking air, (replace in-line filter when used).

If fuel does not flow and if no leak or obstruction is found, pump is defective. It must be repaired or replaced.

• **Test operation of discharge side of pump:**

1. Suction line must be connected and discharge (pressure) line disconnected.
2. Place injection pump fuel shut-off control in "STOP" position to prevent engine from starting.
3. Crank engine with starting motor.

Fuel should flow from pump outlet within 10 seconds. If not, the suction line may be obstructed (replace in-line filter when used), or leaking air.

• **Test pump output pressure while cranking:**

1. Connect a 0—400 kPa (0—4 bar) (0—60 psi) pressure gauge to one end of a pressure hose about 250—300 mm (10—12 in.) long. Connect other end of hose to pump outlet. All air must be out of system.

2. Crank engine for 10 seconds with starting motor (approximately 300 engine rpm). Supply pump minimum outlet pressure should be 200 kPa (2.0 bar) (29.0 psi).

IMPORTANT: The starting motor must crank the engine at normal cranking speed. Use booster batteries if necessary.

3. Compare measured output with the minimum pressure specifications.

If pressure is below the minimum specified and if no obstruction or leak is found, repair or replace the pump.

115
10

RG,CTM86,115,8 -19-16SEP94

SERVICE FUEL SUPPLY PUMP

Gaining access to the valves on the supply pump requires removal and disassembly of the supply pump. (See Group 35).

1. Inspect valves and valve seats for foreign material, wear or pitting. Valve springs must not be cracked or broken.
2. Reassemble parts, open tank shut-off valve, and check operation. If the pump operation is still not normal, the pump will have to be repaired or replaced. (See Group 35.)

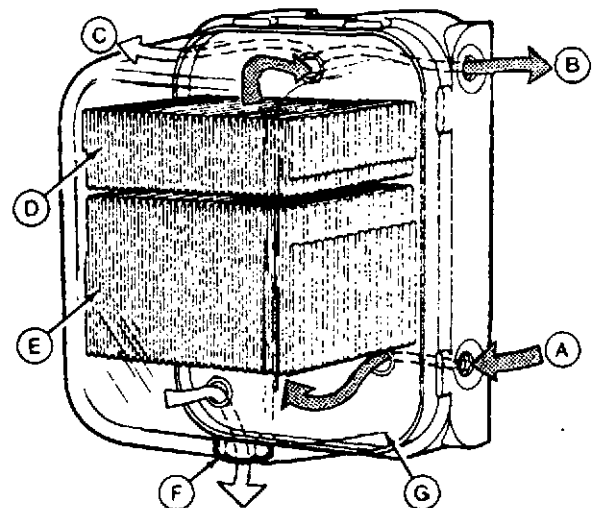
RG,CTM61,115,9 -19-16SEP84

RECTANGULAR FINAL FUEL FILTER OPERATION

Fuel enters the filter at (A) and flows through a first stage filtering media (E) and a second stage filtering media (D) before flowing through outlet (B) to the injection pump. The filtering media is housed in the metal sediment bowl (G) and epoxied to the bowl as one assembly.

Since water and other contaminants may settle to the bottom of the sediment bowl, a drain plug (F) is provided to permit their removal.

An air vent (C) enables air in the fuel system to be expelled to the outside through the filters when bleed plug is removed.



- A—Inlet
- B—Outlet
- C—Air Vent
- D—Second Stage Filtering Media
- E—First Stage Filtering Media
- F—Drain Plug
- G—Sediment Bowl

RG,CTM61,115,24-19-13MAY93

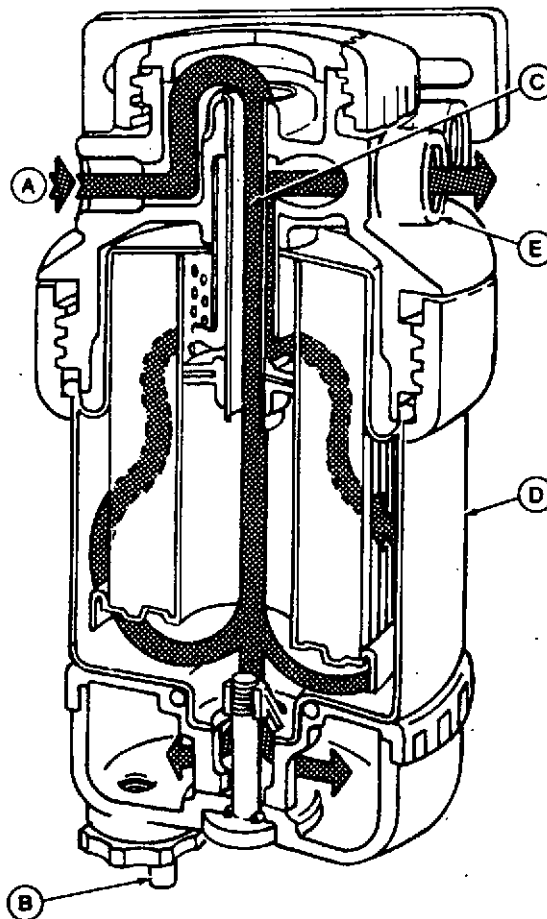
ROUND PRIMARY FUEL FILTER/WATER SEPARATOR OPERATION

115
12

The primary fuel filter/water separator is a single-stage filter. Fuel enters the filter at the inlet (A), then flows to the center port (C), travels to the bottom of the filter element (D), onward to the outboard side of the filter, up the sides and back inward through the media before exiting filter through outlet (E) to the fuel injection pump. The filter element is attached to the base with a threaded (detent) ring.

Water and contaminants settle at the bottom of the water separator (clear sediment bowl). A drain plug (B) is provided to drain these contaminants from system.

- A—Fuel Inlet
- B—Drain Plug
- C—Center Port
- D—Filter Element
- E—Fuel Outlet

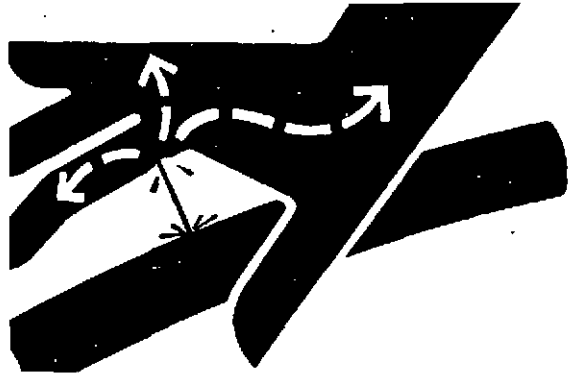


RG,CTM86,115,14-19-16SEP94

RG7073 -UN-07SEP94

BLEED THE FUEL SYSTEM

CAUTION: Escaping fluid under pressure can penetrate the skin causing serious injury. Relieve pressure before disconnecting fuel or other lines. Tighten all connections before applying pressure. Keep hands and body away from pinholes and nozzles which eject fluids under high pressure. Use a piece of cardboard or paper to search for leaks. Do not use your hand.



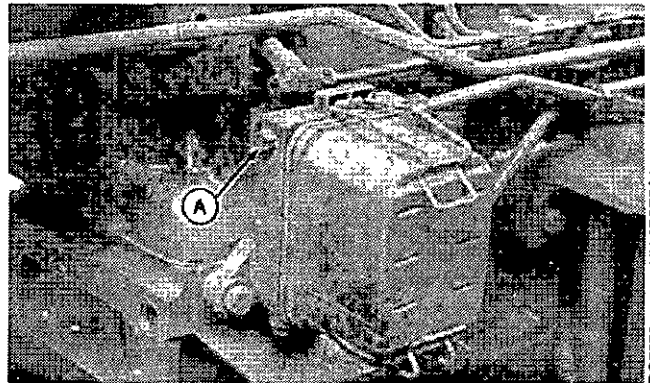
If ANY fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type injury or gangrene may result. Doctors unfamiliar with this type of injury may call the Deere & Company Medical Department in Moline, Illinois, or other knowledgeable medical source.

Whenever the fuel system has been opened up for service (lines disconnected or filters removed), it will be necessary to bleed air from the system.

The fuel system may be bled at one of several locations. On some engine applications it may be necessary to consult your operator's manual and choose the location best for your engine/machine application.

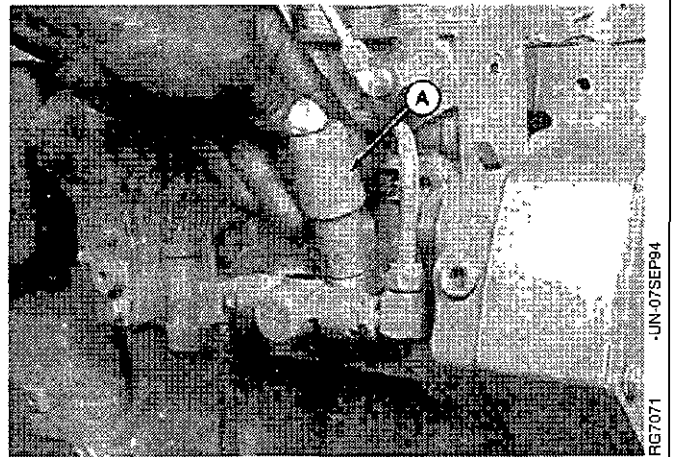
S11,0408,AC -19-18APR94

1. Turn key switch to "ON" position.
2. Loosen bleed plug (A) on side of fuel filter base.



RG,CTM86,115,9 -19-16SEP94

3. Operate the hand primer (A) on fuel supply pump until a smooth flow of fuel, free of bubbles, comes out of the filter plug hole.
4. Tighten bleed plug and start engine.



115
14

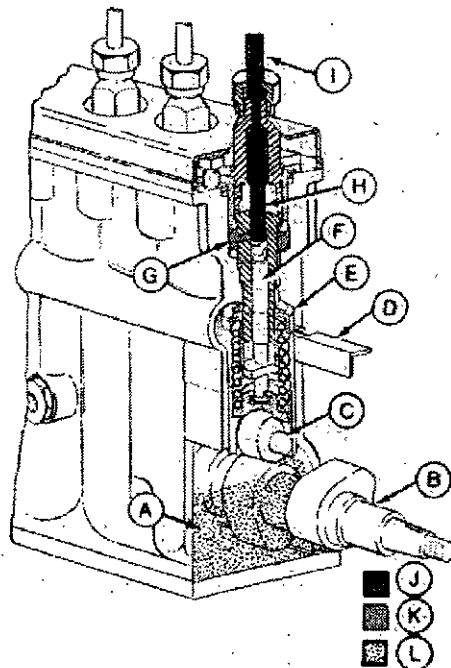
RG,CTM86,115,10-19-16SEP94

FUEL INJECTION PUMP OPERATION

Filtered fuel under pressure by the supply pump fills the injection pump fuel gallery (G). As the camshaft rotates, roller tappets (C) riding on the camshaft (B) lobes operate the plungers (F) to supply high pressure fuel (F) through the delivery valves (H) to the injection nozzles.

An electronically-controlled governor operates control rack (D). The rack is connected to the control sleeves (E) and plungers to regulate the quantity of fuel delivered to the engine.

Engine lubricating (L) oil is piped to the injection pump crankcase (A) to provide splash lubrication of the working parts. Two drain holes at the front end of the pump determine the level of oil maintained in the crankcase. Excess oil drains out these holes and returns back to the engine through the timing gear housing.



- A—Crankcase
- B—Camshaft
- C—Roller Tappet
- D—Control Rack
- E—Control Sleeve
- F—Plunger
- G—Fuel Gallery
- H—Delivery Valve
- I—Delivery Pipe
- J—Injection Pressure
- K—Supply Pump Pressure
- L—Engine Lubricating Oil

RG,CTM86,115,12-19-16SEP94

DIAGNOSE FUEL INJECTION PUMP MALFUNCTIONS

The electronically-controlled fuel injection system has a self-contained engine control unit (ECU) which contains electronic circuitry and a computer program which controls the governor (fuel delivery) and performs diagnostic functions.

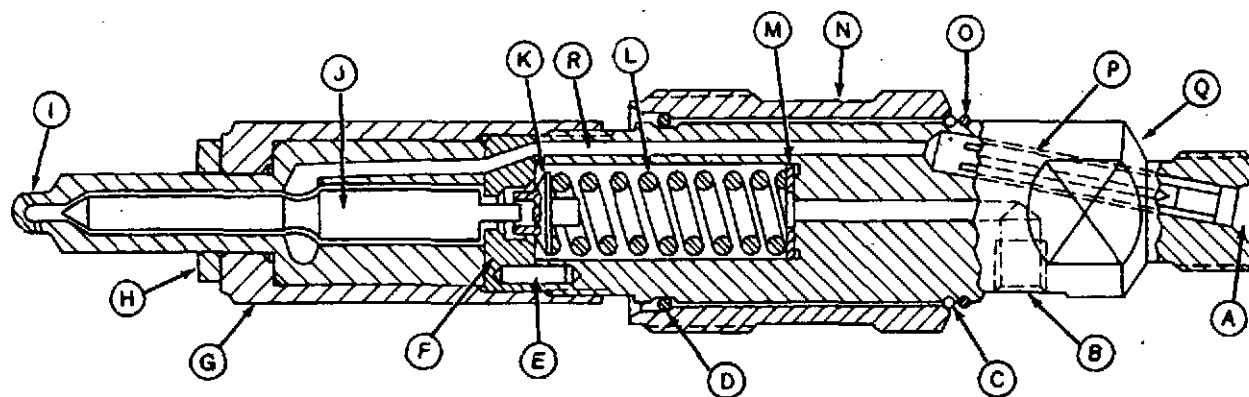
If a problem occurs that can be diagnosed, the controller will switch to a safe operating mode and output an indication of the problem; usually in the form of a diagnostic code. A diagnostic reader or the vehicle digital tachometer may be used to display diagnostic codes.

Refer to specific machine operation and tests manuals or CTM68 Electronic Fuel Injection Systems for detailed diagnostic information.

RG,CTM86,115,13-19-16SEP94

115
15

FUEL INJECTION NOZZLES—GENERAL INFORMATION



RG2242

RG2242 JUN-14DEC88

- | | | | |
|-----------------------|------------------------|---------------|--------------------|
| A—Fuel Inlet | F—Intermediate Plate | K—Spring Seat | O—Snap Ring |
| B—Leak-Off Connection | G—Nozzle Retaining Nut | L—Spring | P—Edge-Type Filter |
| C—O-Ring | H—Washer | M—Shims | Q—Nozzle Holder |
| D—Snap Ring | I—Nozzle | N—Gland Nut | R—Fuel Passage |
| E—Dowel Pin | J—Valve | | |

The nozzle valve (J) is held on its seat by a spring (L). Shims (M) are used to regulate the nozzle opening pressure.

The nozzle (I) and valve fit together by precision lapping. These parts are referred to as a nozzle assembly, and are not serviced separately.

Correct alignment of the nozzle assembly with its holder is essential so that the atomized fuel will be sprayed into the combustion chamber at the angle and location intended by design. KDEL holders use an intermediate plate (F) with dowel pins (E) on both sides to insure alignment.

A retaining nut (G) is used to fasten the nozzle assembly to the holder body. The diameter of the holder body is 21 mm, and from this dimension the fuel injection nozzles are known as 21 mm nozzles.

An edge-type filter (P) is placed in the fuel inlet of the nozzle holder. Its purpose is to prevent coarse, foreign particles from damaging the nozzle assembly or plugging the orifices. Finer particles pass through the filter without harm. The filter is not removable.

To provide a seal between the injection nozzle and the engine cylinder head, a steel washer (H) is used at the base of the nozzle retaining nut.

The fuel injection nozzle is fastened to the engine cylinder head by a gland nut (N). The gland nut also functions as a jack screw to raise the injection nozzle out of cylinder head during removal.

RG,CTM86,115,15-19-16SEP94

FUEL INJECTION NOZZLE OPERATION

Fuel lines (A) deliver the fuel to injection nozzles. Fuel enters the injection nozzle inlet (B), and passes through the edge-type filter (C). Coarse foreign particles are retained by the filter.

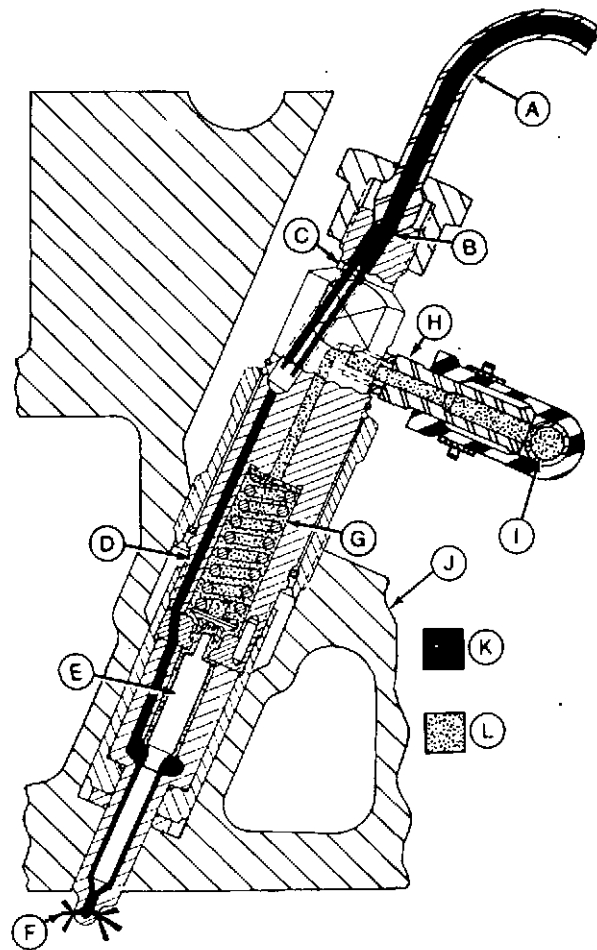
A passage (D) routes fuel through the nozzle holder to the nozzle valve (E). The nozzle valve is lifted instantly off its seat by the high pressure inlet fuel acting on an annulus in the valve.

NOTE: Since the nozzle valve opening pressure is considerably lower than the injection pump output pressure, the inlet fuel pressure easily overcomes the resistance of the nozzle valve spring (G).

When the nozzle valve opens, a definite quantity of fuel (determined by the injection pump output for each plunger stroke) is forced out through orifices (F). The fuel becomes finely atomized as it is sprayed into the combustion chamber at high velocity.

The nozzle assembly is lubricated by a small amount of fuel which seeps between the lapped surfaces of the nozzle and valve which accumulates around the spring (G, refer to previous illustrations).

The leakage fuel is routed out the nozzle holder through a leak-off connector (H) and returned back to the fuel tank by means of a leak-off pipe (I).



Fuel Flow Through KDEL Injection Nozzle

- A—Fuel Delivery Line
- B—Fuel Inlet
- C—Edge-Type Filter
- D—Fuel Passage
- E—Nozzle Valve
- F—Orifices
- G—Nozzle Valve Spring
- H—Leak-Off Connector
- I—Leak-Off Pipe
- J—Engine Cylinder Head
- K—High Pressure Fuel
- L—Low Pressure (Return) Fuel

S55,23010,P -19-16SEP94

15
17
-UN-29AUG94
FIG4651

DIAGNOSE MALFUNCTIONS—FUEL INJECTION NOZZLE

Fuel injection nozzles are usually removed from the engine when there is a noticeable loss of power or excessive smoking.

Listed in the following chart are various malfunctions which may occur on the 21 mm nozzles. Only possible defects related to these nozzles are listed. Failures in other components of the fuel injection system are listed under their respective headings in this group.

See Group 35 for repair information.

Symptom	Problem	Solution
Engine Has Low Horsepower	Nozzle orifices plugged	Repair (See Group 35)
	Incorrect nozzle valve opening pressure	Adjust (See Group 35)
	Broken or damaged parts	Repair as required (See Group 35)
	a. Broken nozzle valve spring b. Cracked or split nozzle tip c. Cracked or split nozzle body d. Internal leak	
	Wrong nozzle and valve in holder	Install correct nozzle assembly (See Group 35)
	Nozzle loose in cylinder head	Make sure steel washer is installed on tip end of injection nozzle. Tighten to specified torque (See Group 35)
Engine Emits Too Much Smoke	Nozzle orifices plugged	Repair (See Group 35)
	Broken or damaged parts	Repair as required (See Group 35)
	a. Broken nozzle valve spring b. Cracked or split nozzle tip c. Cracked or split nozzle body d. Internal leak	
	Wrong nozzle and valve in holder	Install correct nozzle assembly (See Group 35)
	Worn nozzle valve seal	Replace nozzle assembly (See Group 35)

RG,CTM86,115,11-19-16SEP94

TEST FUEL INJECTION NOZZLES (ENGINE RUNNING)

1. Operate engine at intermediate speed and no load.
2. Slowly loosen the fuel pressure line at one of the nozzles until fuel escapes at the connection (fuel not opening nozzle valve).

NOTE: The injection nozzle before and/or after nozzle being checked could be the faulty nozzle.

- If engine speed changes, the injection nozzle is probably working satisfactory.
 - If engine speed does not change, a nozzle is faulty and must be checked and repaired (or replaced).
3. Repeat test for each remaining nozzle assembly.
 4. Remove faulty injection nozzles and repair as required. See Group 35.

S11.23010,HR -19-18APR94

115
19

FUEL DRAIN BACK TEST PROCEDURE

Fuel draining back through the fuel system may cause hard starting. This procedure will determine if air is entering the system at connections and allowing fuel to siphon back to the fuel tank.

1. Disconnect fuel supply line and fuel return line at fuel tank.

IMPORTANT: Fuel return line MUST extend below fuel level in fuel tank before performing this test. Fill fuel tank if necessary.

2. Drain all fuel from the system, including the fuel transfer pump, fuel injection pump, fuel filters, and water separator (if equipped).
3. Securely plug off the end of the fuel return pipe.
4. Using a low pressure air source, pressurize the fuel system at the fuel supply line.



CAUTION: Maximum air pressure should be 100 kPa (1 bar) (15 psi) when performing this test.

5. Apply liquid soap and water solution to all joints and connections in the fuel system and inspect for leaks.

NOTE: Connections may allow air to enter the system without allowing fuel to leak out.

6. If any leaks are found, take necessary steps to repair.
7. Reconnect supply and return lines and prime system.
8. Start engine and run for approximately 10 minutes.
9. Allow engine to sit overnight and try starting the following morning.

S11.23010,JA -19-28OCT92

115
20

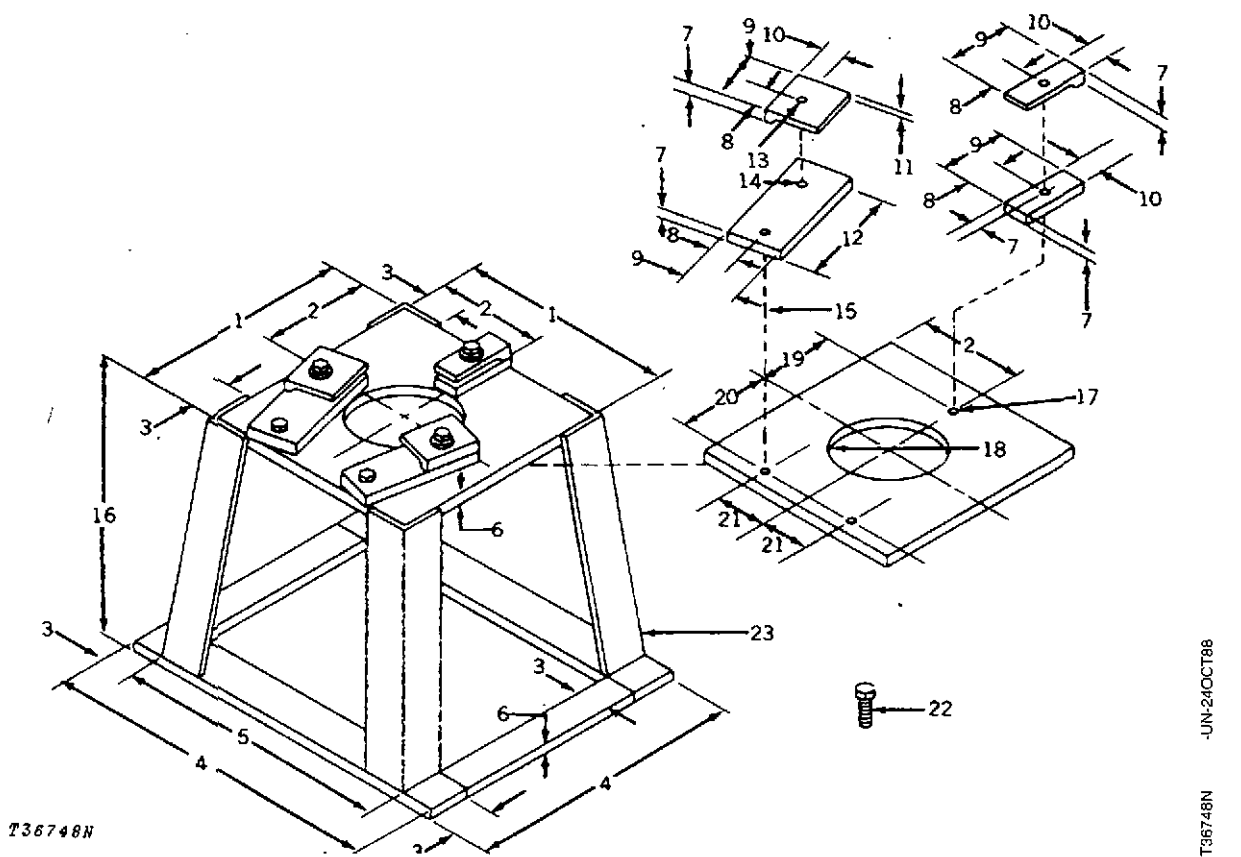
HOW TO MAKE TOOLS

These tools can be made in a service shop using common shop tools and locally obtained materials.

S55,DFRG -19-01DEC89

199
1

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

T36748N -UN-24OCT88

S55,DFRG3 -19-23FEB87

199
2

	Page		Page
Connecting rod		Crankshaft, grinding	
Failure analysis	10-9	Specifications	15-35
Inspect rod and cap	10-27	Crankshaft, journals	
Connecting rod bearings		Measure OD	15-31
Inspect and measure	10-25	Crankshaft, main bearings, flywheel	
Connecting rods		Final assembly	15-48
Install	10-39	Crankshaft, rear oil seal	
Remove	10-10	Remove	15-9
Coolant		Cylinder block	
Additives	02-10	Clean and inspect top deck	05-29
Disposing	02-12	Disassemble	10-32
Products	02-7	Inspect and clean	10-33
Recommended	02-7	Measure	10-34
Requirements	02-5	Cylinder head	
Coolant, engine	02-5	Assemble	05-31
Coolant, engine		Check flatness	05-21
Specifications	02-8	Check valve lift	05-9, 16-6
Cooling orifices		Clean and inspect push rods	05-29
Remove and clean	10-32	Clean and inspect valve seats	05-24
Cooling system		Clean valve guides	05-23
Diagnosing malfunctions	25-2	Disassemble	05-16
Flush	100-8	Failure analysis	05-15
Flush and service	02-11	Final assembly	05-36
How it works	105-8	Grind valve seats	05-26
Pressure test	105-22	Inspect and clean	05-20
Specifications	25-1	Inspect and clean nozzle bore	05-28
Cover, timing gear		Inspect valve springs	05-17
Install	15-21, 15-45	Inspect ventilator outlet hose	05-29
Install with engine installed	15-20	Install	05-32
Remove	15-21	Install rocker arm assembly	05-35
Remove with engine installed	15-20	Measure valve guides	05-23
Crankcase ventilation system		Measure valve recess	05-14
Check	100-6	Measure valve seats	05-25
Crankshaft		Measure valves	05-18
Grinding guidelines	15-34	Preliminary checks	05-15
Inspect	15-30	Remove	05-10
Install	15-39	Remove valve seat inserts	05-27
Remove	15-29	TORQUE-TO-YIELD cap screws	05-34
Crankshaft end play		Valve clearance adjustment	05-7
Check	15-14	Cylinder head gasket	
Crankshaft gear		Failure diagnostics	105-12
Replace	15-37	Joint construction	105-10
Crankshaft gear-to-oil pump drive gear		Joint operation	105-10
Check backlash	20-9	Cylinder liner	
Crankshaft rear oil seal		Manufacturing date code	10-23
Install	15-44	Measure height	05-30, 10-14
Crankshaft rear oil seal & wear sleeve		Measure standout	10-14
Handling precautions	15-11, 15-43	Cylinder liner height	
Install (w/o engine disassembly)	15-12	Recheck	10-35
Crankshaft rear oil seal housing		Cylinder liner O-rings and packings	
Install	15-41	Install	10-36

	Page		Page
Front oil seal		Fuel supply pump—Continued	
Install (timing cover installed)	15-19, 15-47	Disassemble	35-11
Remove (timing cover installed)	15-16	General information	115-6
Front wear sleeve		Inspect	35-12
Install (timing cover installed)	15-18	Install	35-13
Fuel		Service	115-11
Diesel	02-1	Test for leaks	35-10
Fuel filter check valve		Fuel supply pump,	
Replace	35-7	Remove	35-9
Fuel filter, primary		Fuel supply pump, mechanical	
Replace	35-8	Check operation	115-9
Fuel filter, rectangular		Fuel system	
Operation	115-11	Bleed	115-13
Replace	35-6	Diagnostics	115-3
Fuel filter, round primary		Fuel drain back test	115-19
Operation	115-12	General information	115-2
Fuel injection nozzle		Specifications	35-4, 115-1
Clean and inspect seating surface	35-42		
Operation	115-17	G	
Fuel injection nozzle bore		Gasket, head	
Clean and inspect	35-41	Diagnosing failures	105-12
Inspect and clean	05-28	Inspection and repair	105-15
Fuel injection nozzle holder		Joint construction and operation	105-10
Inspect	35-34	Gear	
Fuel injection nozzles		Flywheel ring, replace	15-24
Adjustment	35-40	Gear backlash	
Assemble	35-37	Camshaft-to-crankshaft	16-7
Chatter and spray test	35-29	Gear cover	
Clean	35-32, 35-33	Install	16-21
Diagnostics	115-18	Gear cover, timing	
Disassemble	35-30	Remove	16-8
Inspect	35-32, 35-36	Gear, crankshaft	
Install	35-42	Replace	15-37
Leakage test	35-28	Gear, oil pump drive	
Perform slide test	35-33	Inspect	20-12
Remove	35-21	Gear, Oil Pump Drive (Crankshaft)	
Specifications	35-27	Replace	15-36
Test	35-25	Gears	
Test opening pressure	35-26	Camshaft, remove	16-12
Test, engine running	115-19	Gears, camshaft	
Fuel injection pump		Install	16-15
General information	115-14	Grease	02-4
Service overflow valve	35-14	Grinding, crankshaft	
Fuel injection pump, in-line		Specifications	15-35
Install	35-18	Guides, valve	
Remove	35-15	Clean	05-23
Fuel supply pump		Knurl	05-24
Assemble	35-13	Measure	05-23
Diagnostics	115-8		

	Page		Page
H			
Head, cylinder		Injection nozzles	
Check flatness	05-21	Assemble	35-37
Clean and inspect push rods	05-29	Chatter and spray test	35-29
Clean and inspect valve seats	05-24	Clean	35-32, 35-33
Clean valve guides	05-23	Diagnostics	115-18
Failure analysis	05-15	Disassemble	35-30
Final assembly	05-36	Inspect	35-32, 35-36
Gasket failure diagnostics	105-12	Install	35-42
Gasket joint construction	105-10	Leakage test	35-28
Gasket joint operation	105-10	Perform slide test	35-33
Grind valve seats	05-26	Remove	35-21
Inspect and clean	05-20	Specifications	35-27
Install	05-32	Test	35-25
Install rocker arm assembly	05-35	Test opening pressure	35-26
Measure valve guides	05-23	Test, engine running	115-19
Measure valve recess	05-14	Injection pump	
Measure valve seats	05-25	General information	115-14
Measure valves	05-18	Service overflow valve	35-14
Preliminary checks	05-15	Injection pump, in-line	
Remove	05-10	Install	35-18
Remove valve seat inserts	05-27	Injection pump, in-line fuel	
TORQUE-TO-YIELD cap screws	05-34	Remove	35-15
Valve clearance adjustment	05-7	Inserts, valve seat	
Hose, ventilator outlet		Install	05-27
Inspect	05-29	Replace	05-27
Housing, crankshaft rear oil		Intake manifold	
Install	15-41	Remove, inspect, and install	30-21
Housing, flywheel		Intake system, air	
Check face runout	15-22	Check	100-7
Housing, oil seal		L	
Check runout	15-42	Lift, valve	
Housing, rear oil seal		Check	05-9, 16-6
Remove	15-25, 15-26	Liner flange thickness	
I			
Inch torque values	01-1	Measure	10-25
Injection nozzle		Liner O-rings and packings	
Adjustment	35-40	Install	10-36
Diagnosis	35-23	Liner shims	
Operation	115-17	Install	10-36
Injection nozzle bore		Liner, cylinder	
Clean and inspect	35-41	Failure analysis	10-9
Inspect and clean	05-28	Liner, Cylinder	
Injection nozzle holder		Manufacturing date code	10-23
Inspect	35-34	Liner, cylinder	
Injection nozzle seating surface		Measure height	05-30, 10-14
Clean and inspect	35-42	Measure standout	10-14
		Recheck height	10-35

	Page
Liners, cylinder	
Clean	10-17
Deglaze	10-16
Inspect	10-22
Install	10-37
Measure	10-23
Remove	10-15

Lubricant	
Alternative	02-5
Synthetic	02-5
Lubrication system	
Diagnosing malfunctions	20-3
How it works	105-6

M

Main bearing cap	
Line bore specifications	15-32
Main bearing oil clearance	
Check	15-28
Main bearings	
Install	15-39
Remove	15-27
Main bearings caps	
Remove	15-27
Main bearings, flywheel, crankshaft	
Final assembly	15-48
Manifold, water	
Install	25-8
Remove	25-8
Metric torque values	01-2

N

Nozzle bore	
Clean and inspect	35-41
Nozzle bore, fuel injection	
Inspect and clean	05-28
Nozzle holder	
Inspect	35-34
Nozzle, fuel injection	
Clean and inspect seating surface	35-42
Operation	115-17
Nozzles, fuel injection	
Chatter and spray test	35-29
Clean	35-32
Inspect	35-32
Install	35-42

	Page
Nozzles, fuel injection—Continued	
Leakage test	35-28
Perform slide test	35-33
Remove	35-21
Test, engine running	115-19

O

Oil cooler	
Assembly	20-6
Oil Cooler	
Inspect	20-7
Install	20-7
Oil cooler	
Install cross-over tube adapter	20-15
Oil Cooler	
Remove	20-7
Oil cooler	
Remove corss-over tube adapter	20-15
Oil cooler, assembly	20-6
Oil filter	20-4
Oil filter base	
Assembly	20-4
Install	20-5
Remove	20-5
Oil filter bypass valve	
Remove, inspect, and install	20-8
Oil pressure	
Check	105-21
Oil pressure regulating valve	
Remove, inspect, and install	20-8
Oil pressure regulating valve housing	20-4
Oil pressure regulating valve housing	
Install	20-5
Remove	20-5
Oil pump	
Access	20-9
Adjust set screw	20-13
Check drive shaft endplay	20-11
Check pumping gear backlash	20-12
Check shaft side movement	20-11
Inspect and clean	20-10
Inspect drive gear	20-12
Install	20-14
Install outlet tube adapter	20-15
Remove	20-9, 20-10
Remove outlet tube adapter	20-15
Oil Pump Drive Gear (Crankshaft)	
Replace	15-36
Oil pump drive gear-to crankshaft gear	
Check backlash	20-9

	Page		Page
Oil seal housing runout		Pressure, engine compression	
Check	15-42	Test	105-20
Oil seal housing, crankshaft rear		Pressure, engine oil	
Install	15-41	Check	105-21
Oil seal housing, rear		Pulley assembly, damper	
Remove	15-25, 15-26	Install	15-47
Oil seal, crankshaft rear		Pulley, damper	
Install	15-44	Remove	15-15
Oil seal, front		Pump, fuel injection	
Install (timing cover installed)	15-19, 15-47	Service overflow valve	35-14
Remove (timing cover installed)	15-16	Pump, fuel supply	
Oil seal, rear, and wear sleeve		Remove	35-9
Install (w/o engine disassembly)	15-12	Test for leaks	35-10
Orifices, piston cooling		Pump, in-line fuel injection	
Remove and clean	10-32, 15-38	Remove	35-15
		Pump, oil	
		Adjust set screw	20-13
P		Check drive shaft endplay	20-11
Pilot bearing		Check pumping gear backlash	20-12
Check bore concentricity	15-23	Check shaft side movement	20-11
Pin, piston		Inspect and clean	20-10
Install in piston	10-21	Inspect drive gear	20-12
Piston		Install	20-14
Measure compression ring groove	10-20	Remove	20-10
Measure oil control ring groove	10-20	Pump, water	
Piston cooling orifices		Install	25-5
Remove and clean	10-32, 15-38	Remove	25-3
Piston pin		Push rods	
Install in piston	10-21	Clean and inspect	05-29
Piston pin bushing			
Install	10-31	R	
Piston Pin Bushing		Radiator cap	
Remove	10-30	Pressure test	105-22
Piston pin bushing bore		Radiator, cap	
Clean and inspect	10-30	Pressure test	105-22
Piston ring groove		Rear crankshaft oil seal housing	
Check wear	10-20	Install	15-41
Piston rings		Rear oil seal and crankshaft	
Remove	10-17	Handling precautions	15-11, 15-43
Piston skirt OD		Rear oil seal and wear sleeve	
Measure	10-23	Install (w/o engine disassembly)	15-12
Piston-to-liner clearance		Regulating valve, oil pressure	
Determine	10-23	Remove, inspect, and install	20-8
Pistons		Ring gear, flywheel	
Clean	10-17	Replace	15-24
Failure analysis	10-9	Rings, piston	
Inspect	10-19	Remove	10-17
Inspect pins and bushings	10-28	Rocker arm assembly	
Install	10-39	Install	05-35
Remove	10-10		

INDEX
7

	Page
Rocker arm shaft assembly	
Assemble	05-14
Disassemble and inspect	05-12
Rod bearings	
Inspect and measure	10-25
Rod, connecting	
Inspect rod and cap	10-27
Rods, Connecting	
Install	10-39
Rods, connecting	
Remove	10-10

S

Seal, crankshaft rear oil	
Handling precautions	15-11, 15-43
Install	15-44
Install (w/o engine disassembly)	15-12
Remove	15-9
Seal, front oil	
Install (timing cover installed)	15-19, 15-47
Remove (timing cover installed)	15-16
Seal, rear oil housing	
Remove	15-25, 15-26
Seal, replace	
bypass tube	25-6
Sealant guidelines	04-2
Seats, valve	
Clean and inspect	05-24
Grind	05-26
Measure	05-25
Separator, water	
Operation	115-12
Replace	35-8
Serial Number Plate	01-4
Shaft, rocker arm assembly	
Disassemble and inspect	05-12
Skirt, piston	
Measure OD	10-23
Sleeve, front wear	
Install	15-46
Install (timing cover installed)	15-18
Sleeve, rear wear	
Install	15-44
Sleeve, wear	
Remove	15-25, 15-26
Specifications	
Air intake system	30-1
Block, Liners, Pistons, and Rods	10-5

	Page
Specifications—Continued	
Camshaft and timing gear train	16-4
Coolant	02-8
Cooling system	25-1
Crankshaft	15-6
Crankshaft grinding	15-35
Cylinder Head and Valves	05-4
Exhaust system	30-1
Flywheel	15-6
Fuel injection nozzles	35-27
Fuel system	35-4, 115-1
Intake manifold pressure	110-8
Lubrication System	20-1
Main Bearings	15-6
Specifications,	
Engine test	105-3
Springs, valve	
Inspect	05-17
Supply pump, fuel	
Assemble	35-13
Diagnostics	115-8
Disassemble	35-11
General information	115-6
Inspect	35-12
Install	35-13
Remove	35-9
Service	115-11
Supply pump, mechanical fuel	
Check operation	115-9
Synthetic Lubricants	02-5
System, cooling	
Flush	100-8
System, crankcase ventilation	
Check	100-6
System, electrical	
Check	100-10

T

Temperature compensation	100-1
Test specifications	
Engine	105-3
Thermostat	
Inspect and test	105-23
Thermostats	
Install	25-7
Remove and test	25-6
Thrust bearing	
Specifications	15-33
Thrust washers, camshaft	
Measure	16-12

Index

	Page
Water pump—Continued	
Install	25-5
Remove	25-3
Weep hole, inspect	25-2
Water separator	
Operation	115-12
Replace	35-8
Wear sleeve	
Remove	15-25, 15-26
Wear sleeve, front	
Install	15-46
Install (timing cover installed)	15-18
Wear sleeve, rear	
Install	15-44

INDX
10

