

John Deere Series 220 Diesel Engines

COMPONENT TECHNICAL MANUAL

**John Deere
Lawn & Grounds Care Division**

**CTM3 (10AUG93)
Replaces CTM3 (28NOV89)**

Litho in U.S.A.

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.

Use this component technical manual in conjunction with the machine technical manual. An application listing in the Specifications and General Information section 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 organized so that all the information on a particular engine is kept together in a single section.

Information in each section 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, other materials needed to do the job and service parts kits. All specifications, wear tolerances, and torque values appear at the beginning of each section.

This manual is part of a total product support program.

FOS MANUALS—REFERENCE

TECHNICAL MANUALS—MACHINE SERVICE

COMPONENT MANUALS—COMPONENT SERVICE

Fundamentals of Service (FOS) Manuals cover basic theory of operation, fundamentals of troubleshooting, general maintenance, and basic type of failures and their causes. FOS Manuals are for training new personnel and for reference by experienced technicians.

Technical Manuals are concise guides for specific machines. Technical manuals are on-the-job guides containing only the vital information needed for diagnosis, analysis, testing and repair.

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

JOHN DEERE DEALERS

IMPORTANT: The changes listed below make your current CTM obsolete. Discard CTM3, dated 28 NOV 89. Please remove this page and route through your service department.

- The format or “style” of the book has been changed. The familiar “modular” layout has been replaced by a two-column “floating text” format. Also, a heavy emphasis on the use of “exploded” line art, to illustrate specific yet “simple” procedures, is used.
- The layout of the book also changed. It has been completely reorganized to cover a different engine “family” in its own section, similar to how a Technical manual is layed out, using sections and groups.
 - Sections 1 through 4 cover engine service. This includes; engine teardown, diagnosis, checks, tests, adjustments and operational tests.
 - Section 10 covers removal/installation and repair of accessories, primarily on Series 220 OEM Power Unit engines.
 - Section 20 covers Theory of Operation of the various engine systems.
 - Section 21 covers Electrical System component location and schematics for Series 220 OEM Power Unit engines.
- Turbocharger analysis, inspection and repair information has been added. See Accessories - Series 220 Power Unit Engines.
- Information/model designation for Series 220 engines (3009, 3011, 3014 and 4019) have been added wherever applicable.
- Engine application charts have been updated to include the latest product models. See Specifications and General Information section.
- The book’s title. The title was changed from “3TN and 4TN Series Yanmar Diesel Engines” to “John Deere 220 Series Diesel Engines”, to include information pertaining to the OEM Stand-alone power packs.
- A safety section, fuels, lubricants and coolant information and an alphabetical index have also been added.
- A nominal or “standard” specification has been added and listed with the “wear limit” specification.

ABOUT THIS MANUAL

This Component Technical Manual (CTM3) covers the recommended repair and adjustment procedures for the following engines:

- 3 and 4TN Series Diesel Engines used in John Deere Lawn and Grounds Care and small Industrial products.
- Series 220 Diesel Engines offered as OEM units. Three different configurations are available: Base industrial engine, industrial power unit or a generator drive unit.

Before beginning repair of an engine, clean the engine and mount on a repair stand.

This manual contains SI Metric units of measure, followed immediately by the U.S. customary units of measure.

Direction of engine crankshaft rotation in this manual is referenced facing the flywheel looking toward the water pump. Front of engine is water pump 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 story completely before performing service to check engine model differences in procedure or specifications.

Each section will be identified with a symbol, letter or a number.

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.

Safety	S
Specifications and General Information	G
3TN66, 3TNA72 (3009)	1
3TN75, 3TN78, 3TNC78 (3011), 3TN82, 3TNA82, 3TN84 (3014)	2
4TN78T, 4TN82, 4TN84(T) (4019)	3
4TN100	4
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Introduction

RECOGNIZE SAFETY INFORMATION



T81389

This is the safety-alert symbol. When you see this symbol on your engine or in this manual, be alert to the potential for personal injury.

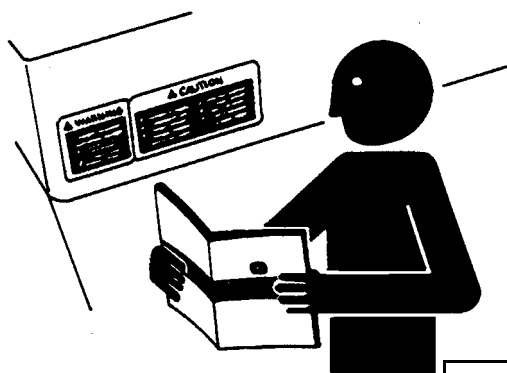
Follow recommended precautions and safe servicing practices.

Understand Signal Words

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

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

REPLACE SAFETY SIGNS

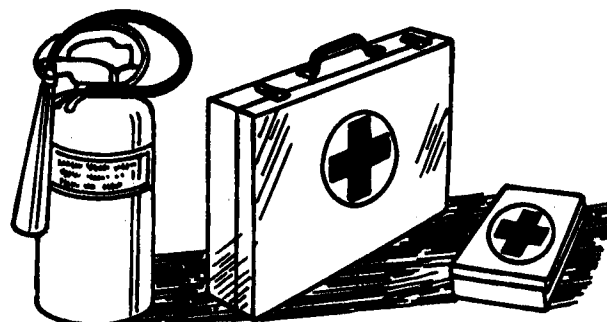


TS201

Replace missing or damaged safety signs. See the machine operator's manual for correct safety sign placement.

HANDLE FLUIDS SAFELY-AVOID FIRES

Be Prepared For Emergencies



TS291



TS227

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 engine is clean of trash, grease, and debris.

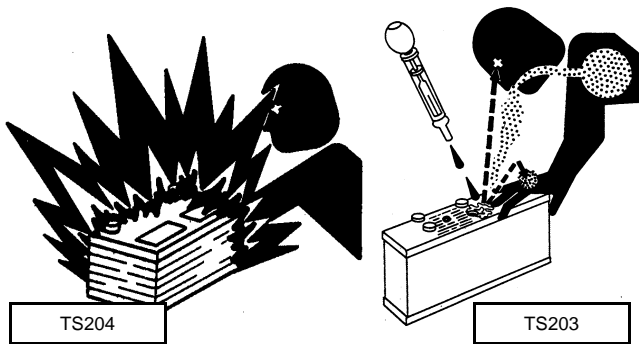
Do not store oily rags; they can ignite and burn spontaneously.

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.

S USE CARE IN HANDLING AND SERVICING BATTERIES



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).

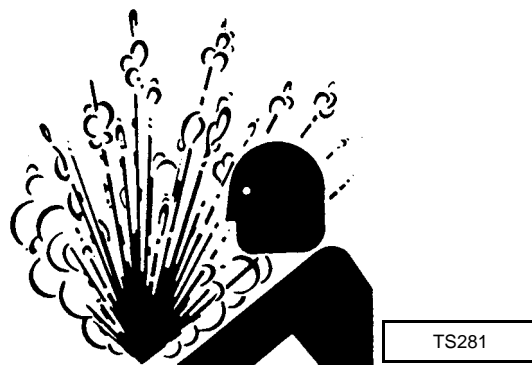
Prevent Acid Burns

- 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 acid burns 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.
 4. 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 1.9 L (2 quarts).
3. Get medical attention immediately.

SERVICE COOLING SYSTEM SAFELY



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

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

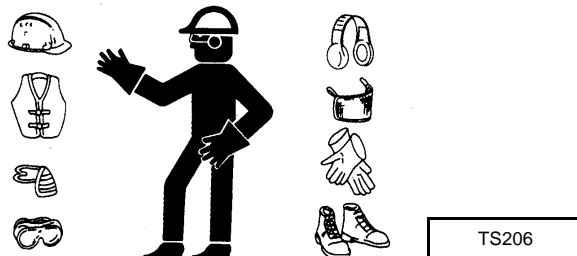
USE SAFE SERVICE PROCEDURES

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.

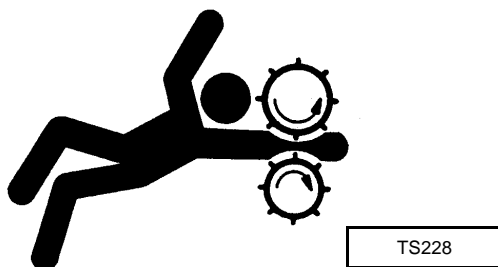
Operating equipment safely requires the full attention of the operator. Do not wear radio or music headphones while operating engine.



Service Engines 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.

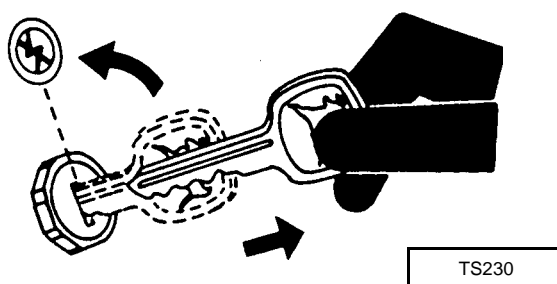
Remove rings and other jewelry to prevent electrical shorts and entanglement in moving parts.



Use Proper Tools

Use tools appropriate to the work. Makeshift tools 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. Use only service parts meeting John Deere specifications.

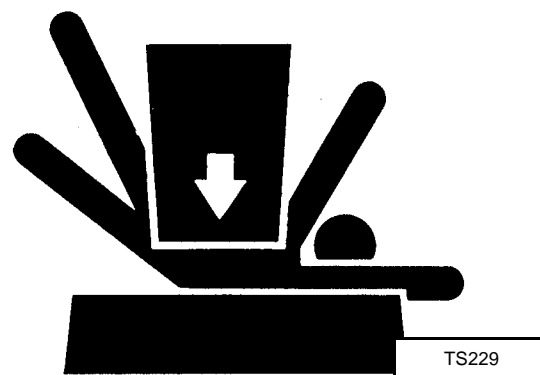
Shut Down Engine



- **Before working on the engine:**

1. Stop the engine and remove the key.
2. Disconnect the battery ground strap.
3. Hang a “DO NOT OPERATE” tag on the instrument panel.

Support Engine Properly and Use Proper Lifting Equipment



If you must work on a lifted engine, securely support the engine.

Do not support the engine on cinder blocks, hollow tiles, or props that may crumble under continuous load. Do not work under an engine that is supported solely by a jack. Follow recommended procedures in this manual.

Lifting heavy components incorrectly can cause severe injury or engine damage. Follow recommended procedure for removal and installation of components in the manual.

Work In A Clean Area

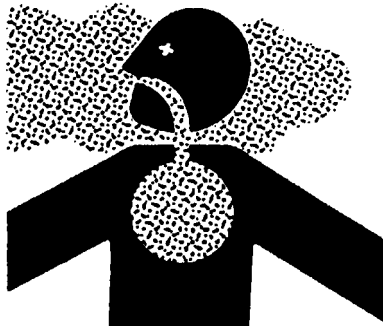
- **Before starting a job:**

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

Illuminate Your Work Area Safely

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

S Work In A 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.

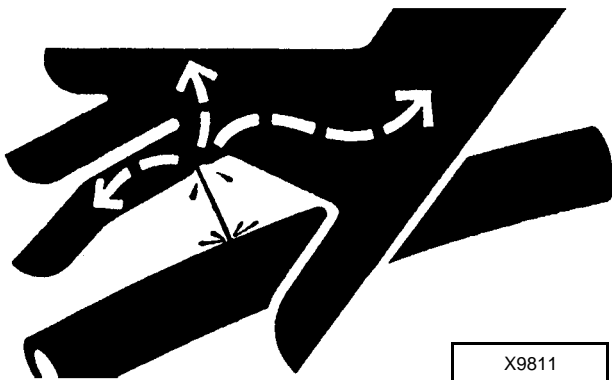
If you do not have an exhaust pipe extension, open the doors and get outside air into the area.

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.

USE CARE AROUND HIGH-PRESSURE FLUID LINES

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.

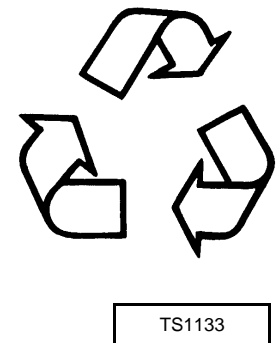
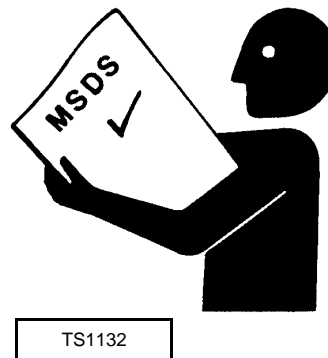
If an accident occurs, see a doctor immediately. Any fluid injected into the skin must be surgically removed within a few hours or gangrene may result. Doctors unfamiliar with this type of injury should reference a knowledgeable medical source. Such information is available from Deere & Company Medical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

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.

HANDLE CHEMICAL PRODUCTS SAFELY



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

A Material Safety Data Sheet (MSDS) provides specific details on chemical products: physical and health hazards, safety procedures, and emergency response techniques. Check the MSDS before you start any job using a hazardous chemical. That way you will know exactly what the risks are and how to do the job safely. Then follow procedures and recommended equipment.

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

LIVE WITH SAFETY



TS231

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

S

SPECIFICATIONS AND GENERAL INFORMATION

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G

ENGINE SERIAL NUMBER PLATE

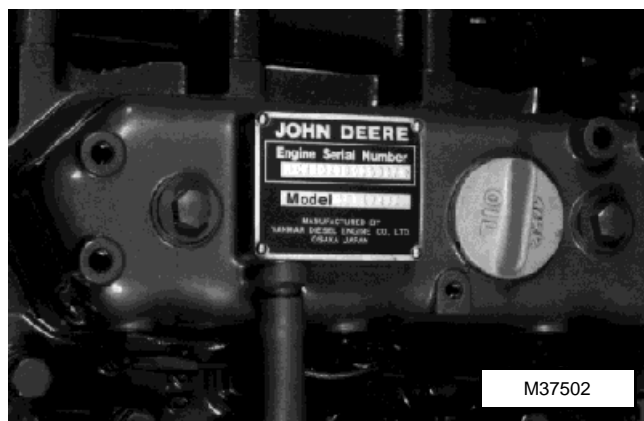
NOTE: The engine serial number plate can be easily destroyed. Before "hot tank" cleaning the block, remove the plate or record the information elsewhere.

Location

All except 4TN100: The engine serial number plate is located on the rocker arm cover.

4TN100: The engine serial number plate is located on the side of the engine, under exhaust manifold.

Refer to the engine model designation on your engine's serial number plate to identify as to which section to use for repair information.



Engine Serial Number Information

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 are examples:

3TN and 4TN Series Engines

CH3029D000000

CH..... Factory producing engine (Yanmar)
 3029D Engine model designation
 000000 Sequential serial number

Series 220 OEM Engines

CH3009D000000

CH..... Factory producing engine
 3009D Engine model designation
 000000 Sequential serial number

Factory Code

CH..... Yanmar

Engine Model Designation

3009D Definition explained following. (See "Engine Model Designation".)

Sequential Number

000000 6-digit sequential serial number

Engine Model Designation - 3TN and 4TN Series Engines

John Deere engine model designation includes number of cylinders, usage, engine type, bore diameter, fuel injection (type) and application. For example:

3TNA72UJK Engine

3 Number of cylinders
 T Usage (tractor)
 NA Engine type
 72 Bore diameter
 U Fuel Injection (Type)
 JK Application

Engine Type

NA..... Diesel
 G Gasoline

Fuel Injection (Type)

U Indirect injection
 R Direct injection

Application

JK John Deere
 E-SP Export - Sperry Company

General Information

Engine Model Designation -Series 220 OEM Engines

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

3009DF001 Engine

3Number of cylinders
 0.9..... Liter designation
 D Aspiration code
 F0 User code
 01 Application code

Aspiration Code

D Naturally aspirated
 T Turbocharged

User Code

F0 OEM

Application Code

01 Bare industrial engine
 05 Industrial power pack
 06 Gen set power pack

ENGINE APPLICATION CHART - LAWN AND GROUNDS CARE EQUIPMENT

Machine Model No.	Engine Model
LAWN AND GARDEN TRACTORS	
330	3TN66UJ
332	3TN66UJ
430	3TNA72UJ*
455	3TNA72UJ3
FRONT MOWERS	
F915	3TN66UJ
F925	3TNA72UJ
F935	3TNA72UJ
F1145	3TN75RJ
COMPACT UTILITY TRACTORS	
655	3TN66UJ
670	3TNA72UJK
755	3TNA72UJ
770	3TNA82RJK
855	3TN75RJ
870	3TN84RJK
955	3TN84UJ
970	4TN82RJK
1070	4TN84RJK
SKID STEER LOADERS	
375	3TN66E-SP
575	3TN82E-SP
675	4TN82E-SP
GOLF AND TURF	
756 Compact Utility Tractor	3TNA72UJ
856 Compact Utility Tractor	3TN75RJ
3325 Professional Turf Mower	4TN82RJE
3365 Professional Turf Mower	4TN82RJE

* 430 Lawn and Garden Tractors were built with two slightly different versions of 3TNA72UJ engines. In this manual, 3TNA72UJ engines, Serial Numbers (- 5000), are referred to as “Early 3TNA72”. Engines with Serial Numbers (5001 -) are referred to as “Later 3TNA72”.

ENGINE APPLICATION CHART - INDUSTRIAL EQUIPMENT

Machine Model No.	Engine Model
EXCAVATORS	
15	3TNA72UJB
25	3TN78RJB
30	3TN82RJB
50	4TN78TRJB
LOADERS	
84	4TN100RJF
244E	4TN100LFB



ENGINE APPLICATION CHART - OEM APPLICATION

Machine Model No.	Engine Model
3009	3TNA72
3011	3TNC78
3014	3TN84
4019D	4TN84
4019T	4TN84T

General Engine Specifications

BASIC ENGINE SPECIFICATIONS

G

GENERAL	UNIT OF MEASURE	3TN66	3TNA72 (3009)	3TN75	3TN78
Number of Cylinders	----	3	3	3	3
Bore	mm (in.)	66 (2.60)	72 (2.83)	75 (2.95)	78 (3.07)
Stroke	mm (in.)	64.2 (2.53)	72 (2.83)	75 (2.95)	86 (3.39)
Displacement	L (cu in.)	0.658 (40.15)	0.879 (53.64)	0.994 (60.70)	1.232 (75.20)
Compression Ratio	----	23:1	22.3:1	17.8:1	17.75:1
Horsepower*	kW (hp)	10.4 - 12.7 (14 - 17)	12.7 - 16.4 (17 - 22)	17.9 (24)	17 (23)
Firing Order	----	1-3-2	1-3-2	1-3-2	1-3-2
Combustion System	----	Indirect Injection	Indirect Injection	Direct Injection	Direct Injection
Aspiration	----	Natural	Natural	Natural	Natural
Weight (dry)	kg (lbs)	85 (187)	118 (260)	160 (353)	123 (271)
Starter	----	Hitachi 0.8 kW	Nippondenso 1.0 kW (Hitachi 0.8 kW on 3009)	Nippondenso 1.0 kW	Hitachi 2.0 kW
Alternator	----	Kokosan 20A, Nippondenso 35 or 40A	Kokosan 20A, Nippondenso 35 or 40A	Nippondenso 35 or 40A	Hitachi 25A

* Engine horsepower will vary by application. Refer to machine technical manual or operator's manual for specific engine horsepower.

General Engine Specifications

GENERAL	UNIT OF MEASURE	3TNC78 (3011)	3TN82	3TNA82	3TN84 (3014)
Number of Cylinders	----	3	3	3	3
Bore	mm (in.)	78 (3.07)	82 (3.23)	82 (3.23)	84 (3.31)
Stroke	mm (in.)	80 (3.15)	86 (3.39)	86 (3.39)	86 (3.39)
Displacement	L (cu in.)	1.146 (69.90)	1.362 (83)	1.362 (83)	1.429 (87.2)
Compression Ratio	----	18:1	18.06:1	18.1:1	17.8:1
Horsepower*	kW (hp)	16.9 - 20.2 (22.7 - 27.1)	18 - 24.6 (24 - 33)	17.2 (24)	20.9 - 24.9 (28 - 33.5)
Firing Order	----	1-3-2	1-3-2	1-3-2	1-3-2
Combustion System	----	Direct Injection	Direct Injection	Direct Injection	Direct Injection
Aspiration	----	Natural	Natural	Natural	Natural
Weight (dry)	kg (lbs)	160 (353)	190 (419)	190 (419)	153 (337)
Starter	----	Nippondenso 1.0 kW	Hitachi 2.0 kW, Nippondenso 1.4 kW	Nippondenso 1.0 or 1.2 kW	Nippondenso 1.0 or 1.2 kW
Alternator	----	Nippondenso 40A	Hitachi 25A, Nippondenso 35 or 40A	Kokosan 20A, Nippondenso 35A	Kokosan 20A, Nippondenso 35 or 40A

* Engine horsepower will vary by application. Refer to machine technical manual or operator's manual for specific engine horsepower.

General Engine Specifications

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GENERAL	UNIT OF MEASURE	4TN78T	4TN82	4TN84 (4019D)	4TN84T (4019T)
Number of Cylinders	----	4	4	4	4
Bore	mm (in.)	78 (3.07)	82 (3.23)	84 (3.31)	84 (3.31)
Stroke	mm (in.)	86 (3.39)	86 (3.39)	86 (3.39)	86 (3.39)
Displacement	L (cu in.)	1.643 (100)	1.816 (110.8)	1.906 (116.3)	1.906 (116.3)
Compression Ratio	----	17.75:1	18.1:1	17.8:1	17.8:1
Horsepower*	kW (hp)	29 (39)	24.6 - 28 (33 - 38)	28.1 - 33.4 (37.7 - 44.8)	34.4 - 40.3 (46.1 - 54)
Firing Order	----	1-3-4-2-1	1-3-4-2-1	1-3-4-2-1	1-3-4-2-1
Combustion System	----	Direct Injection	Direct Injection	Direct Injection	Direct Injection
Aspiration	----	Turbocharged	Natural	Natural	Turbocharged
Weight (dry)	kg (lbs)	230 (507)	220 (485)	194 (428)	199 (439)
Starter	----	Hitachi 0.8 kW	Nippondenso 1.0 or 1.4 kW, Hitachi 2.0 kW	Nippondenso 1.0 or 1.4 kW	Nippondenso 1.4 kW
Alternator	----	Hitachi 25A	Kokosan 20A, Nippondenso 35 or 40A	Kokosan 20A, Nippondenso 40A	Nippondenso 40A

* Engine horsepower will vary by application. Refer to machine technical manual or operator's manual for specific engine horsepower.

General Engine Specifications



GENERAL	UNIT OF MEASURE	4TN100
Number of Cylinders	----	4
Bore	mm (in.)	100 (3.90)
Stroke	mm (in.)	110 (4.30)
Displacement	L (cu in.)	3.5 (211)
Compression Ratio	----	N/A
Horsepower*	kW (hp)	38.8 - 44 (52 - 59)
Firing Order	----	1-3-4-2-1
Combustion System	----	Direct Injection
Aspiration	----	Natural or Turbocharged
Weight (dry)	kg (lbs)	332 (731)
Starter	----	Nippondenso 1.4 kW
Alternator	----	Hitachi 25A

* Engine horsepower will vary by application. Refer to machine technical manual or operator's manual for specific engine horsepower.

DIESEL FUEL

Use either Grade No. 1-D or Grade No. 2-D fuel as defined by ASTM Designation D975 for diesel fuels. In European countries, use ISO 1585 commercial diesel fuel.

NOTE: At altitudes above 1500 m (5000 ft) use Grade 1-D for all temperatures. If engine is operated under "stand-by" conditions, use grade 1-D for all temperatures.

If engine is operated at temperatures of -40° to -57°C (-40° to -70°F), Grade DF-A arctic fuel is recommended.

Fuel sulfur content of less than 0.5 percent is preferred, to prevent higher wear from corrosive combustion products.

IMPORTANT: If fuel sulfur content exceeds 0.5 percent, the engine oil drain interval must be reduced by 50 percent.

Cetane number should be no less than 40 to assure satisfactory starting and overall performance. At low temperatures and/or high altitude, a cetane number of more than 45 is recommended.

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

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

DIESEL ENGINE OIL

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

IMPORTANT: John Deere TORQ-GARD SUPREME PLUS-50™ engine oil is not recommended during engine break-in (first 100 hours on a new or overhauled engine). The superior lubricating properties of this oil will not allow the engine to properly wear during break-in period. Use SAE 10W 30.

John Deere TORQ-GARD SUPREME PLUS-50™ engine oil is recommended at all other times. This oil is specially formulated to provide superior protection against high temperature thickening and wear as well as exceptional cold weather starting

performance; these properties may result in longer engine life.

NOTE: When John Deere TORQ-GARD SUPREME PLUS-50™ engine oil and a John Deere oil filter are used, the change interval may be extended by 50 hours. ALWAYS follow recommendations in the operator's manual.

John Deere TORQ-GARD SUPREME® engine oil is also recommended but standard operator's manual oil change intervals must be maintained. Other oils may be used if they meet one or more of the following specifications:

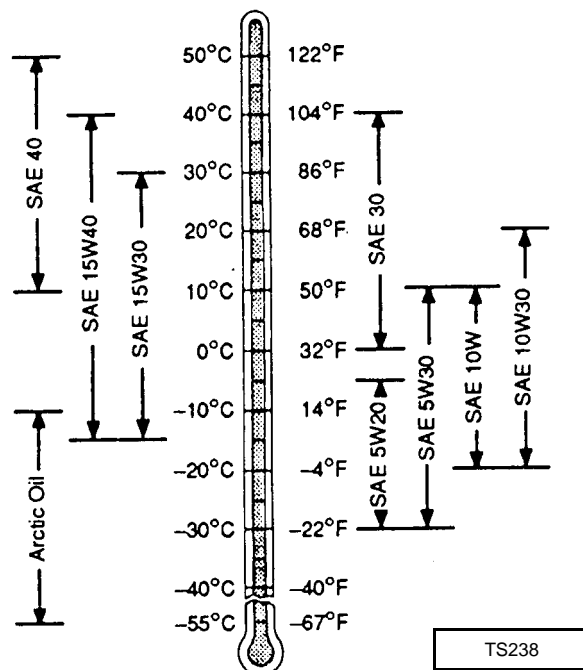
- API Service Classification CE or CD
- Military Specification MIL-L-2104E or MIL-L-2104D or MIL-L-2104C

In European countries, oils meeting CCMC Specification D4 or D5 may be used.

SAE 5W20, SAE 5W30, and arctic oil viscosity grades meeting API Service Classification CC may be used, but oil and filter must be changed at one-half the normal interval.

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

NOTE: Some increase in oil consumption may be expected when low viscosity oils are used. Check oil levels more frequently.

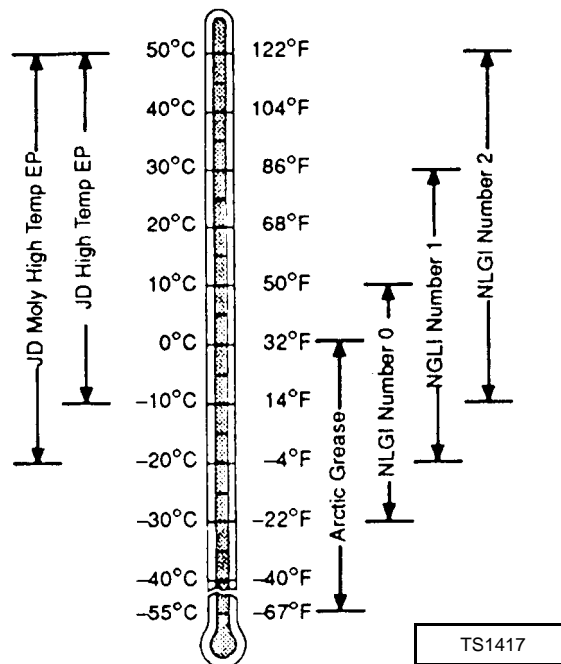
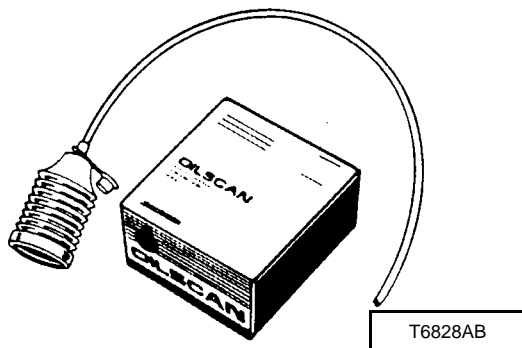


OILSCAN® AND COOLSCAN™

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.



GREASE

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

The following greases are preferred:

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

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

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

Grease meeting Military Specification MIL-G-10294F may be used as arctic grease.

ENGINE COOLANT RECOMMENDATIONS

CAUTION

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

Shut off engine. Remove the radiator filler cap only when the cap is cool enough to touch with bare hands. Slowly loosen cap to first stop to relieve pressure before removing completely.

- Always maintain engine coolant at correct level.
- Coolant make-up should be mixed at same concentrations as original coolant, including inhibitors.

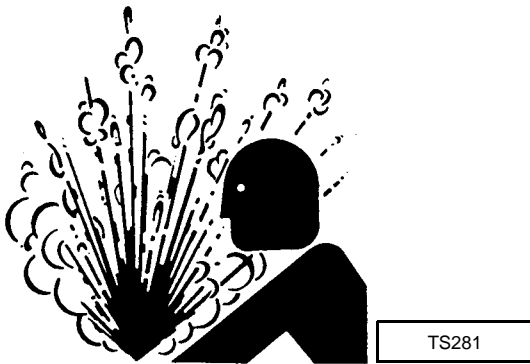
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- In tropical areas where antifreeze of John Deere Cooling Fluid is not available, use water meeting quality specifications outlined in this group and John Deere RE23182 Liquid Coolant Conditioner. The liquid coolant conditioner should be added in the amount recommended on the label for your cooling system capacity.

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

In certain geographical areas where water quality is unacceptable, John Deere Engine Cooling Fluid is marketed for use in the engine cooling system. It protects the engine from corrosion and freezing down to -37°C (-35°F).

John Deere Engine Cooling Fluid or John Deere Low Silicate Antifreeze are recommended for all John Deere Diesel Engines. John Deere Cooling Fluid is ready to use as it is without dilution or mixing. John Deere Low Silicate Antifreeze is concentrated and should be mixed minimum 40% - maximum 60% antifreeze and distilled to deionized water. Consult your John Deere Parts Network for local availability.



ENGINE COOLANT SPECIFICATIONS

Water Quality

Distilled, de-ioned, 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 methyl alcohol or methoxy propanol base concentrate. This concentrate is not compatible with additives used in supplemental coolant additives. Damage can occur to rubber seals on cylinder liners which are in contact with coolant.

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

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

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

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

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

- TY6377 - 208 L (55 U.S. Gal) container
- TY15886 - 3.8 L (1 U.S. Gal) container

Contact your John Deere Parts Network for local availability.

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

Supplemental Coolant Additives (SCA's)

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

CAUTION

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

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- John Deere Liquid Coolant Conditioner

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

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

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

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

Contact your John Deere Parts Network for availability.

Other approved SCA's are:

- NALCOOL 3000®
- FLEETGARD®-DCA008-78L DCA2 in 473 mL (16 oz) container
- FLEETGARD®-DCA60-78L DCA4 in 473 mL (16 oz) container

NALCOOL 3000® is a registered trademark of the NALCO Company.

FLEETGARD® is a registered trademark of the Cummins Engine Company.

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

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

JOHN DEERE ENGINE COOLING FLUID

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

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

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

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

Contact your John Deere Parts Network for local availability.

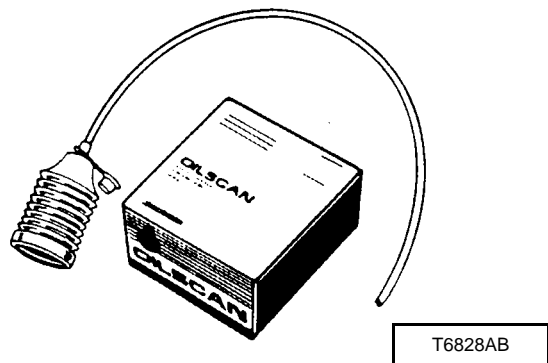
CHECK EFFECTIVENESS OF COOLANT SOLUTION

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

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

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

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



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

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

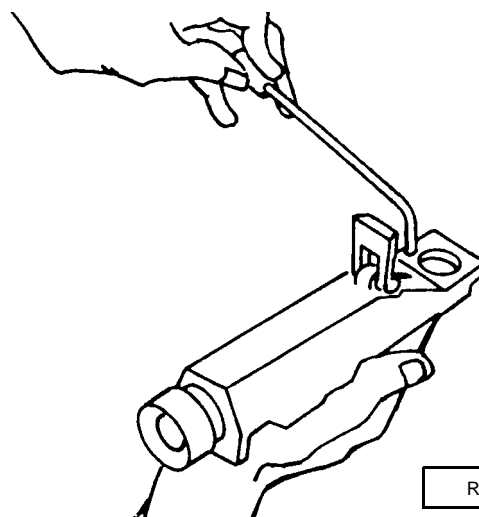
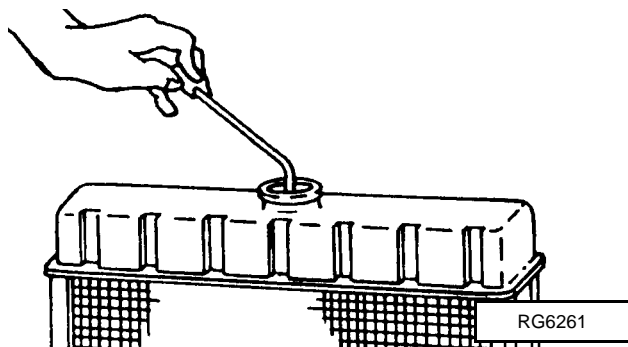
NOTE: Service intervals listed are a recommended engineering guideline. Refer to your vehicle operator's manual for a specific service interval.

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

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

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

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



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

FLUSHING AND SERVICING COOLING SYSTEM



CAUTION

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

Shut off engine. Remove the radiator filler cap only when the cap is cool enough to touch with bare hands. Slowly loosen cap to first stop to relieve pressure before removing completely.

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

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

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

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

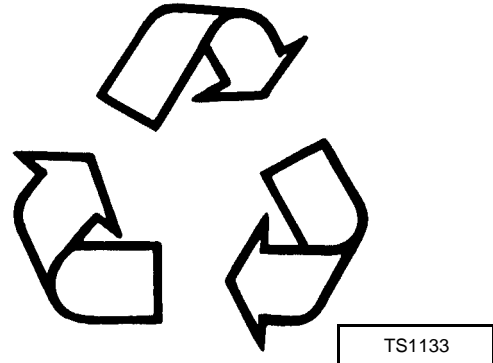
At 1200 hours/2-year service interval, flush cooling system and replace thermostats as described in your operator's manual. Clean cooling system with a heavy duty cooling system cleaner such as FLEETGARD® RESTORE™. Follow the instructions provided with cleaner. Refill cooling system with the appropriate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

IMPORTANT: NEVER overfill the system. A pressurized system needs space for heat expansion without overflowing at the top of the radiator. Coolant level should be approximately 19 mm (3/4 in.) below bottom of radiator filler neck.

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

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

DISPOSING OF COOLANT



Improperly disposing of coolant can threaten the environment and ecology.

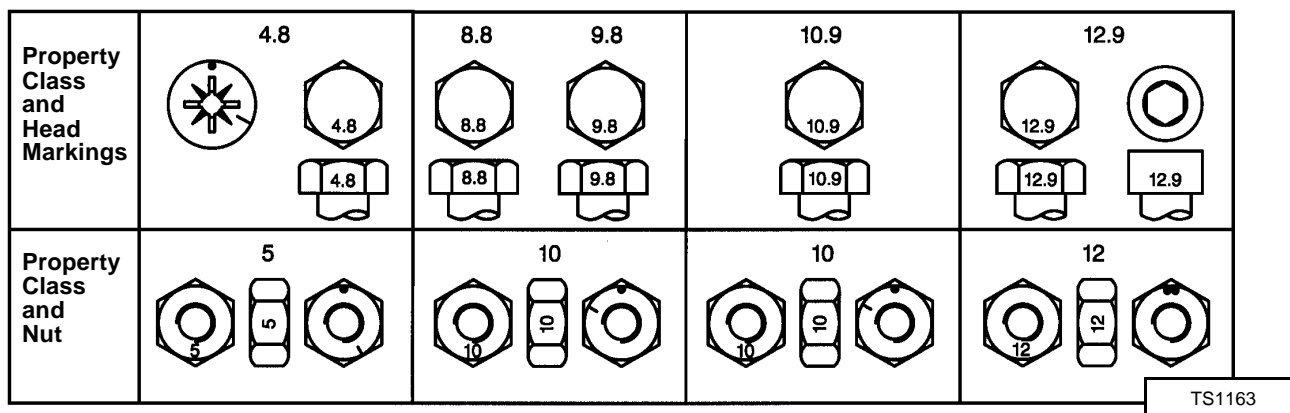
Use leakproof containers when draining fluids. Do not use food or beverage containers that may mislead someone into drinking from them.

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

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

*FLEETGARD® is a registered trademark of the Cummins Engine Company.
RESTORE™ is a registered trademark of FLEETGARD®.*

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

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

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

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.

^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.

Repair Information

UNIFIED INCH BOLT AND CAP SCREW TORQUE VALUES

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SAE Grade and Head Markings	No Marks	1 or 2 ^b 	5 	5.1 	5.2 	8 	8.2 
	No Marks	2 	5 		8 		

TS1162

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

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

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

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.

- ^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.

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.

DISCONNECT TURBOCHARGER OIL INLET LINE

1. Drain all engine oil and coolant.

IMPORTANT: When servicing turbocharged engines on a rollover stand, disconnect turbocharger oil inlet line before rolling engine over. Failure to do so may cause a hydraulic lock upon starting engine. Hydraulic lock may cause severe engine damage.

Hydraulic lock occurs when trapped oil in the oil filter housing drains through the turbocharger, into exhaust and intake manifolds, and cylinder head. After starting the engine, trapped oil in the manifold and head is released into the cylinder(s) filling them with oil causing hydraulic lock and severe engine damage.

2. Disconnect turbocharger oil inlet line at turbocharger.

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3TN66 AND 3TNA72 (3009) ENGINES

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Section 1

ENGINE SPECIFICATIONS - 3TN66

Rocker Arm Cover	
Special Nut Torque	18 N•m (160 lb-in.)
Rocker Arm Assembly	
Mounting Cap Screw and Nut Torque	26 N•m (226 lb-in.)
Rocker Arm Shaft O.D.	
Standard	9.97 - 9.99 mm (0.3925 - 0.3933 in.)
Wear Limit	9.95 mm (0.3920 in.)
Rocker Arm and Shaft Support I.D.'s	
Clearance	0.14 mm (0.005 in.)
Standard	10.00 - 10.02 mm (0.3937 - 0.3945 in.)
Wear Limit	10.09 mm (0.3972 in.)
Push Rod Length	
Standard	114 - 115 mm (4.488 - 4.528 in.)
Push Rod Bend	
Wear Limit	0.08 mm (0.003 in.)
Cylinder Head and Valves	
Mounting Cap Screw Torque	
First	11 N•m (97 lb-in.)
Second	22 N•m (195 lb-in.)
Final	34 N•m (25 lb-ft)
Cylinder Head Distortion	
Standard	0.05 mm (0.002 in.) or less
Wear Limit	0.15 mm (0.006 in.)
Maximum Amount of Metal to be Removed	0.20 mm (0.008 in.)
Valve Seat Width	
Intake Valve	
Standard	1.15 mm (0.045 in.)
Wear Limit	1.65 mm (0.065 in.)
Exhaust Valve	
Standard .....	.41 mm (0.056 in.)
Wear Limit	1.91 mm (0.075 in.)
Intake and Exhaust Valves	
Valve Faces	
Minimum Margin	0.51 mm (0.020 in.)
Exhaust Angle	45°
Intake Angle	30°
Valve Stem O.D.	
Distance A. ....	.20 mm (0.787 in.)
Distance B. ....	.40 mm (1.575 in.)
Intake Valve	
Standard	5.46 - 5.48 mm (0.2149 - 0.2157 in.)
Wear Limit	5.40 mm (0.2126 in.)
Exhaust Valve	
Standard	5.44 - 5.46 mm (0.2142 - 0.2149 in.)
Wear Limit	5.40 mm (0.2126 in.)
Valve Recession	
Intake Valve	0.40 mm (0.016 in.)
Exhaust Valve	0.85 mm (0.033 in.)

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Specifications

Valve Guides

Valve Guide I.D.

Maximum Clearance 0.20 mm (0.008 in.)

Standard 5.50 - 5.52 mm (0.216 - 0.217 in.)

Wear Limit 5.58 mm (0.220 in.)

Valve Guide Height 7 mm (0.276 in.)

Valve Springs

Spring Free Length

Wear Limit 28 mm (1.102 in.)

Maximum Spring Inclination 0.80 mm (0.032 in.)

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Exhaust Manifold

Mounting Cap Screw and Nut Torque 11 N•m (97 lb-in.)

Intake Manifold

Mounting Cap Screw Torque 11 N•m (97 lb-in.)

Valve Seat Angles

Valve Seat Surface

Exhaust Valve 45°

Intake Valve 30°

Lower Seat Surface 70°

Upper Seat Surface 15°

Piston-to-Cylinder Head Clearance 0.59 - 0.74 mm (0.023 - 0.029 in.)

Piston and Connecting Rod Cap Screw Torque 23 N•m (203 lb-in.)

Connecting Rod Bearing I.D.

Clearance 0.16 mm (0.006 in.)

Standard 36 - 36.042 mm (1.417 - 1.419 in.)

Wear Limit 37.07 mm (1.459 in.)

Piston Ring Groove Clearance

First Compression Ring

Standard 0.065 - 0.100 mm (0.0026 - 0.0039 in.)

Wear Limit 0.20 mm (0.0079 in.)

Second Compression Ring

Standard 0.030 - 0.065 mm (0.0012 - 0.0026 in.)

Wear Limit 0.20 mm (0.0079 in.)

Oil Ring

Standard 0.020 - 0.055 mm (0.0008 - 0.0022 in.)

Wear Limit 0.20 mm (0.0079 in.)

Piston End Ring Gap

Standard

First Compression Ring and Oil Ring 0.15 - 0.35 mm (0.006 - 0.014 in.)

Second Compression Ring 0.25 - 0.40 mm (0.010 - 0.016 in.)

Wear Limit 1.50 mm (0.0591 in.)

Piston Pin

Pin O.D.

Standard 19.991 - 20.00 mm (0.787 - 0.788 in.)

Wear Limit 19.975 mm (0.786 in.)

Bore I.D.

Clearance 0.045 mm (0.0018 in.)

Standard 20.00 - 20.008 mm (0.787 - 0.788 in.)

Wear Limit 20.02 mm (0.788 in.)

Piston Pin, continued

Bushing I.D.

Clearance	0.110 mm (0.0043 in.)
Standard	20.025 - 20.038 mm (0.788 - 0.789 in.)
Wear Limit	20.10 mm (0.781 in.)

Piston O.D.

Distance A.	.5 mm (0.197 in.)
-------------	-------------------

Standard Size Piston

Standard	65.927 - 65.957 mm (2.596 - 2.597 in.)
Wear Limit	65.85 mm (2.593 in.)

0.25 mm (0.010 in.) Oversize Piston

Standard	66.18 - 66.21 mm (2.606 - 2.607 in.)
Wear Limit	66.10 mm (2.602 in.)

0.50 mm (0.020 in.) Oversize Piston

Standard	66.43 - 66.46 mm (2.615 - 2.616 in.)
Wear Limit	66.35 mm (2.612 in.)

Cylinder Bore I.D.

Standard Size Bore

Clearance	0.25 mm (0.010 in.)
Standard	66.00 - 66.03 mm (2.599 - 2.600 in.)
Wear Limit	66.20 mm (2.606 in.)

0.25 mm (0.010 in.) Oversize Bore

Standard	66.25 - 66.28 mm (2.609 - 2.610 in.)
Wear Limit	66.45 mm (2.616 in.)

0.50 mm (0.020 in.) Oversize Bore

Standard	66.50 - 66.53 mm (2.619 - 2.620 in.)
Wear Limit	66.70 mm (2.626 in.)

 Degalzing 30 - 40° cross-hatch pattern

 Reboring 30 - 40° cross-hatch pattern

Crankshaft Rear Oil Seal

Seal Case-to-Block Cap Screw Torque	11 N•m (96 lb-in.)
Oil Pan-to-Seal Case Cap Screw Torque	9 N•m (78 lb-in.)

Crankshaft and Main Bearings

 Main Bearing Cap Screw Torque 54 N•m (40 lb-ft)

 Crankshaft Maximum Bend 0.02 mm (0.0007 in.)

Connecting Rod Journal O.D.

Standard	35.97 - 35.98 mm (1.4161 - 1.4165 in.)
Wear Limit	35.92 mm (1.414 in.)

Main Bearing Journal O.D.

Standard	39.97 - 39.98 mm (1.5736 - 1.5740 in.)
Wear Limit	39.92 mm (1.572 in.)

Main Bearing I.D.

Clearance	0.15 mm (0.0059 in.)
Standard	40.00 - 40.042 mm (1.575 - 1.577 in.)
Wear Limit	40.07 mm (1.578 in.)

Stub Shaft (330/332 LGT, F915 FM)

 Stub Shaft-to-Flywheel Cap Screw Torque 59 N•m (44 lb-ft)

 Cover-to-Block Cap Screw Torque 49 N•m (36 lb-ft)

 Cover-to-Plate Cap Screw Torque 26 N•m (226 lb-in.)

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Specifications

Flywheel

Maximum Distortion	0.02 mm (0.0008 in.)
Mounting Cap Screw Torque	83 N•m (61 lb-ft)
Flywheel Plate Mounting Cap Screw Torque	49 N•m (36 lb-ft)

Camshaft

Mounting Cap Screw Torque	11 N•m (96 lb-in.)
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Camshaft Side Gap

Standard	0.05 - 0.15 mm (0.0020 - 0.0060 in.)
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Wear Limit	0.40 mm (0.016 in.)
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Maximum Camshaft Bend	0.02 mm (0.001 in.)
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Lobe Height

Standard	29.97 - 30.03 mm (1.180 - 1.182 in.)
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Wear Limit	29.75 mm (1.171 in.)
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Journal O.D.

Gear Housing and Flywheel Ends

Standard	35.94 - 35.96 mm (1.4150 - 1.4157 in.)
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Wear Limit	35.85 mm (1.4114 in.)
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Intermediate

Standard	35.91 - 35.94 mm (1.4138 - 1.4150 in.)
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Wear Limit	35.85 mm (1.4114 in.)
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Bushing I.D.

Clearance	0.18 mm (0.007 in.)
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Standard	36.00 - 36.065 mm (1.417 - 1.420 in.)
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Wear Limit	36.10 mm (1.421 in.)
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Bore I.D.

Clearance	0.18 mm (0.007 in.)
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Standard	36.00 - 36.025 mm (1.417 - 1.418 in.)
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Wear Limit	36.10 mm (1.421 in.)
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Cam Followers

O.D.

Standard	17.950 - 17.968 mm (0.7067 - 0.7074 in.)
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Wear Limit	17.93 mm (0.706 in.)
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Bore I.D.

Clearance	0.032 - 0.068 mm (0.0013 - 0.0027 in.)
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Standard	18.00 - 18.018 mm (0.7087 - 0.7094 in.)
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Wear Limit	18.05 mm (0.711 in.)
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Timing Gear Cover

Fan Mounting Cap Screw Torque	11 N•m (96 lb-in.)
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Cover Mounting Cap Screw Torque	9 N•m (78 lb-in.)
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Crankshaft Pulley Cap Screw Torque	115 N•m (85 lb-ft)
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Idler Gear

Shaft O.D

Standard	19.959 - 19.980 mm (0.786 - 0.787 in.)
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Wear Limit	19.93 mm (0.785 in.)
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Bushing I.D.

Clearance	0.15 mm (0.0059 in.)
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Standard	20.00 - 20.021 mm (0.787 - 0.788 in.)
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Wear Limit	20.08 mm (0.791 in.)
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Timing Gear Housing Cap Screw Torque	
Aluminum Housing-to-Block	9 N•m (78 lb-in.)
Cast Iron Housing-to-Block	11 N•m (96 lb-in.)
Oil Pan and Strainer Mounting Cap Screw Torque	
Oil Pan-to-Block	11 N•m (96 lb-in.)
Oil Pan-to-Seal Case	9 N•m (78 lb-in.)
Oil Pan-to-Timing Gear Housing	9 N•m (78 lb-in.)
Oil Strainer-to-Block	11 N•m (96 lb-in.)
Oil Pump	
Mounting Cap Screw Torque	25 N•m (18 lb-ft)
Rotor Shaft O.D.-to-Backing Plate I.D. Clearance	
Standard	0.015 - 0.048 mm (0.0006 - 0.0035 in.)
Wear Limit	0.20 mm (0.0078 in.)
Rotor Recess	
Wear Limit	0.25 mm (0.010 in.)
Outer Rotor-to-Pump Body Clearance	
Standard	0.03 - 0.09 mm (0.0011 - 0.0035 in.)
Wear Limit	0.13 mm (0.0057 in.)
Inner-to-Outer Rotor Clearance	
Wear Limit	0.15 mm (0.0059 in.)
Oil Pressure Regulating Valve	
Spring	
Compressed Length	14.70 mm (0.580 in.) @12 N (2.7 lb-force)
Free Length	21.90 - 24.50 mm (0.860 - 0.960 in.)
Housing-to-Valve Body Retaining Nut Torque	30 N•m (22 lb-ft)
Thermostat	
Thermostat Cover Cap Screw Torque	9 N•m (78 lb-in.)
Water Pump	
Mounting Cap Screw Torque	26 N•m (226 lb-in.)
Fan Mounting Cap Screw Torque	11 N•m (96 lb-in.)
Plate-to-Housing Screw Torque	9 N•m (78 lb-in.)
Fuel Injection Pump	
Mounting Nut Torque	20 N•m (180 lb-in.)
Fuel Injection Pump Camshaft	
Bearing Retaining Screw Torque	20 N•m (180 lb-in.)
Minimum Lobe Height	30.90 mm (1.217 in.)
Fuel Control and Governor Linkage	
Governor Shaft O.D. (Minimum)	7.90 mm (0.311 in.)
Governor Shaft Bore I.D.	
Wear Limit	8.15 mm (0.321 in.)
Clearance	0.18 mm (0.007 in.)
Sleeve I.D. (Maximum)	8.20 mm (0.323 in.)
Injection Pump Camshaft O.D.	
Clearance	0.15 mm (0.006 in.)
Wear Limit	7.90 mm (0.311 in.)
Fuel Injection Nozzles	
Mounting Nut Torque	40 N•m (30 lb-ft)
Nozzle Fitting Torque	40 N•m (30 lb-ft)
Nozzle Torque	50 N•m (37 lb-ft)
Separator Plate Nozzle Contact Surface Maximum Wear	0.10 mm (0.0039 in.)

Specifications

Starter - Hitachi 0.8 kW

Cover Bushing (Reamed Out)	12.50 - 12.53 mm (0.492 - 0.493 in.)
Minimum Brush Length	7.70 mm (0.303 in.)

Alternator - Kokosan 20A (375 SSL, 330/332 LGT, F915 FM)

Flywheel Assembly-to-Coil Plate Assembly Nut Torque	27 N•m (20 lb-ft)
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Alternator - Nippondenso 35A (655 CUT)

Attaching Screw Torque	4 N•m (31 lb-in.)
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Rotor Assembly

Pulley Nut Torque	54 N•m (40 lb-ft)
Retainer-to-Front Frame Screw Torque	2 N•m (16 lb-in.)
Stator-to-Rectifier Lead Wire Distance	33.50 mm (1.300 in.)
Minimum Brush Length	5.50 mm (0.220 in.)

Alternator - Nippondenso 40A (655 CUT)

Minimum Rotor Slip Ring O.D.	14 mm (0.550 in.)
Retainer-to-Front Frame Screw Torque	2 N•m (16 lb-in.)
Sheave Nut Torque	69 N•m (51 lb-ft)
Brush Length	
New	10.50 mm (0.410 in.)
Wear Limit	4.50 mm (0.170 in.)

Checks, Tests and Adjustments

Valve Clearance20 mm (0.008 in.)
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Connecting Rod Side Play

Standard Clearance	0.20 - 0.40 mm (0.0079 - 0.0157 in.)
Wear Limit	0.55 mm (0.0217 in.)

Connecting Rod Bearing Clearance

Standard Clearance	0.020 - 0.072 mm (0.0008 - 0.0028 in.)
Wear Limit	0.15 mm (0.0059 in.)

Crankshaft End Play

Standard Clearance	0.090 - 0.271 mm (0.004 - 0.011 in.)
Wear Limit	0.33 mm (0.0129 in.)

Crankshaft Main Bearing Clearance

Main Bearing Cap Cap Screw Torque	54 N•m (40 lb-ft)
Standard Clearance	0.020 - 0.072 mm (0.0008 - 0.0028 in.)
Wear Limit	0.15 mm (0.0059 in.)

Valve Lift (Intake and Exhaust)	7.5 mm (0.300 in.)
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Camshaft End Play

Standard Clearance	0.05 - 0.20 mm (0.0020 - 0.0079 in.)
Wear Limit	0.40 mm (0.016 in.)

Timing Gear Backlash

Standard Backlash	
All Except Crankshaft Gear-to-Oil Pump Gear	0.04 - 0.12 mm (0.0016 - 0.0047 in.)
Crankshaft Gear-to-Oil Pump Gear	0.11 - 0.19 mm (0.0043 - 0.0075 in.)
Wear Limit	0.20 mm (0.0079 in.)

Fuel Injection Nozzle

Opening Pressure	11722 ± 480 kPa (1700 ± 70 psi)
Leakage at 11032 kPa (1600 psi)	Minimum of 10 Seconds
Chatter and Spray Pattern at 11722 ± 480 kPa (1700 ± 70 psi)	
Slow Hand Lever Movement	Chatter Sound
Slow Hand Lever Movement	Fine Stream Spray Pattern
Fast Hand Lever Movement	Fine Atomized Spray Pattern

Thermostat	
Begin Opening	71° C (160°F)
Fully Open	85° C (184° F)
Minimum Lift Height .....	.8 mm (0.310 in.)
Coolant Temperature Sensor Continuity	107-113° C (225-235° F)
Starter No-Load Amp Draw/RPM	
Maximum Starter Amperage	
Hitachi 0.8 kW .....	.60 Amps at 7000 rpm
Minimum Starter RPM	
Hitachi 0.8 kW	7000
Fuel Injection Pump Static Timing	
Injection Pump Timing	13° BTDC (Before Top Dead Center)
Distance on Outer Surface of Crankshaft Pulley for	
Every 0.1 mm (0.004 in.) of Shim Thickness	1° or 1 mm (3/64 in.)
Engine Crankshaft Position	No. 1 Cylinder on TDC Compression Stroke
Total Shim Pack Thickness (New Shims)	0.5 mm (0.020 in.)
Delivery Valve Fitting Torque	42 N•m (31 lb-ft)
Fan/Alternator Drive Belt Tension	
Applied Force	98 N (22 lb-force)
Deflection	10 - 15 mm (0.400 - 0.600 in.)
Operational Tests	
Radiator, Bubble Test	
Maximum Air Pressure Into Cylinder	2448 kPa (355 psi)
Cooling System	
Maximum Pressure	117 kPa (17 psi)
Minimum Pressure after 15 Seconds	90 kPa (13 psi)
Radiator Cap	
Valve Opening Pressure	97 kPa (14 psi)
Cylinder, Compression Pressure	
Compression Pressure	2448 kPa (355 psi)
Maximum Difference Between Cylinders	490 kPa (71 psi)
Engine Oil Pressure	
375 SSL	
Idle Speed	
Fast	3625 ± 25 rpm
Slow	1450 ± 50 rpm
Engine Oil Pressure .....	.294 - 392 kPa (43 - 57 psi)
330/332 LGT	
Idle Speed	
Fast	3350 ± 100 rpm
Slow	1450 ± 50 rpm
Engine Oil Pressure .....	.294 - 440 kPa (43 - 64 psi)
655 CUT	
Fast Idle	3425 ± 25 rpm
Engine Oil Pressure .....	.365 ± 69 kPa (53 ± 10 psi)
F915 FM	
Idle Speed	
Fast	3635 ± 35 rpm
Slow	1450 ± 50 rpm
Engine Oil Pressure .....	.294 - 440 kPa (43 - 64 psi)
Air Intake System Holding Pressure .....	.34 - 69 kPa (5 - 10 psi)
Fuel Supply Pump Pressure (Maximum)	103 kPa (15 psi)

Specifications

ENGINE SPECIFICATIONS - 3TNA72 (3009)

Rocker Arm Cover

Special Nut Torque 18 N•m (160 lb-in.)

Rocker Arm Assembly

Mounting Cap Screw and Nut Torque 26 N•m (226 lb-in.)

Rocker Arm Shaft O.D.

Standard 11.96 - 11.98 mm (0.4711 - 0.4718 in.)

Wear Limit 11.95 mm (0.4706 in.)

Rocker Arm and Shaft Support I.D.'s

Clearance 0.14 mm (0.005 in.)

Standard 12.00 - 12.02 mm (0.4724 - 0.4732 in.)

Wear Limit 12.09 mm (0.4759 in.)

Push Rod Length

Standard 141 - 142 mm (5.550 - 5.590 in.)

Push Rod Bend

Wear Limit 0.08 mm (0.003 in.)

Cylinder Head and Valves

Mounting Cap Screw Torque

First 19 N•m (168 lb-in.)

Second 38 N•m (28 lb-ft)

Final 61 N•m (45 lb-ft)

Cylinder Head Distortion

Standard 0.05 mm (0.002 in.) or less

Wear Limit 0.15 mm (0.006 in.)

Maximum Amount of Metal to be Removed 0.20 mm (0.008 in.)

Valve Seat Width

Intake Valve

Standard 1.44 mm (0.057 in.)

Wear Limit 1.98 mm (0.078 in.)

Exhaust Valve

Standard 1.77 mm (0.070 in.)

Wear Limit 2.27 mm (0.089 in.)

Intake and Exhaust Valves

Valve Faces

Minimum Margin 0.51 mm (0.020 in.)

Exhaust Angle 45°

Intake Angle 30°

Valve Stem O.D.

Distance A 25 mm (0.984 in.)

Distance B 45 mm (1.772 in.)

Intake and Exhaust Valves

Standard 6.94 - 6.96 mm (0.2732 - 0.2740 in.)

Wear Limit 6.90 mm (0.2717 in.)

Valve Recession

Exhaust Valve 0.85 mm (0.033 in.)

Intake Valve 0.50 mm (0.020 in.)

Valve Guides

Valve Guide I.D.

Maximum Clearance 0.20 mm (0.008 in.)

Standard 7.00 - 7.02 mm (0.275 - 0.276 in.)

Wear Limit 7.08 mm (0.279 in.)

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Valve Guides, continued	
Valve Guide Height	.9 mm (0.354 in.)
Valve Springs	
Spring Free Length	
Wear Limit	37.40 mm (1.472 in.)
Maximum Spring Inclination	1.00 mm 0.040 in.)
Exhaust Manifold	
Mounting Cap Screw and Nut Torque	26 N•m (30 lb-in.)
Intake Manifold	
Mounting Cap Screw Torque	11 N•m (97 lb-in.)
Valve Seat Angles	
Valve Seat Surface	
Exhaust Valve	45°
Intake Valve	30°
Lower Seat Surface	70°
Upper Seat Surface	15°
Piston and Connecting Rod Cap Screw Torque	
	23 N•m (203 lb-in.)
Piston-to-Cylinder Head Clearance	
	.061 - 0.79 mm (0.024 - 0.031 in.)
Connecting Rod Bearing I.D.	
Clearance	0.16 mm (0.006 in.)
Standard	40.00 - 40.042 mm (1.575 - 1.577 in.)
Wear Limit	40.07 mm (1.578 in.)
Piston Ring Groove Clearance	
First Compression Ring	
Standard	0.075 - 0.110 mm (0.0030 - 0.0043 in.)
Wear Limit	0.20 mm (0.0079 in.)
Second Compression Ring	
Standard	0.030 - 0.065 mm (0.0012 - 0.0026 in.)
Wear Limit	0.20 mm (0.0079 in.)
Oil Ring	
Standard	0.020 - 0.055 mm (0.0008 - 0.0022 in.)
Wear Limit	0.20 mm (0.0079 in.)
Piston Ring End Gap	
Standard	
First Compression Ring	0.10 - 0.25 mm (0.004 - 0.010 in.)
Second Compression Ring	0.25 - 0.40 mm (0.010 - 0.016 in.)
Oil Ring	0.15 - 0.35 mm (0.006 - 0.014 in.)
Wear Limit	1.50 mm (0.0591 in.)
Piston Pin	
O.D.	
Standard	20.991 - 21.00 mm (0.826 - 0.827 in.)
Wear Limit	20.975 mm (0.825 in.)
Bore I.D.	
Clearance	0.045 mm (0.0018 in.)
Standard	21.00 - 21.009 mm (0.8268 - 0.8271 in.)
Wear Limit	21.02 mm (0.828 in.)
Bushing I.D.	
Clearance	0.110 mm (0.0043 in.)
Standard	21.025 - 21.038 mm (0.8278 - 0.8282 in.)
Wear Limit	21.10 mm (0.831 in.)

Specifications

Piston O.D.

Distance A.	8 mm (0.315 in.)
Standard Size Piston	
Standard	71.922 - 71.952 mm (2.832 - 2.833 in.)
Wear Limit	71.81 mm (2.827 in.)
0.25mm (0.10 in.) Oversize Piston	
Standard	72.17 - 72.20 mm (2.841 - 2.842 in.)
Wear Limit	72.06 mm (2.837 in.)
0.50 mm (0.020 in.) Oversize Piston	
Standard	72.42 - 72.45 mm (2.851 - 2.852 in.)
Wear Limit	72.31 mm (2.847 in.)

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Cylinder Bore I.D.

Standard Size Bore	
Clearance	0.28 mm (0.011 in.)
Standard	72.00 - 72.03 mm (2.835 - 2.836 in.)
Wear Limit	72.20 mm (2.843 in.)
0.25 mm (0.010 in.) Oversize Bore	
Standard	72.25 - 72.28 mm ((2.845 - 2.846 in.)
Wear Limit	72.45 mm (2.852 in.)
0.50 mm (0.020 in.) Oversize Bore	
Standard	72.50 - 72.53 mm (2.855 - 2.856 in.)
Wear Limit	72.70 mm (2.862 in.)
Degalzing	30 - 40° cross-hatch pattern
Reboring	30 - 40° cross-hatch pattern

Crankcase Extension Housing

Mounting Cap Screw Torque	
Flywheel Housing/Plate-to-Extension	49 N•m (36 lb-ft)
Seal Case-to-Extension	26 N•m (226 lb-in.)
Extension-to-Block	27 N•m (20 lb-ft)
Extension-to-Timing Gear Housing	22 N•m (195 lb-in.)

Crankshaft Rear Oil Seal

Seal Case-to-Block Cap Screw Torque	11N•m (96 lb-in.)
Oil Pan-to-Seal Case Cap Screw Torque (430 LGT, 455 LGT, 755/56 CUT, F925/35 FM)	9 N•m (78 lb-in.)
Seal Case-to-Extension Cap Screw Torque (15 EX, 670 CUT, 3009 OEM)	9 N•m (78 lb-in.)

Crankshaft and Main Bearings

Main Bearing Cap Screw Torque	79 N•m (58 lb-ft)
Crankshaft Maximum Bend	0.02 mm (0.0007 in.)
Connecting Rod Journal O.D.	
Standard	39.97 - 39.98 mm (1.5736 - 1.5740 in.)
Wear Limit	39.92 mm (1.572 in.)
Main Bearing Journal O.D.	
Standard	43.97 - 43.98 mm (1.7311 - 1.7315 in.)
Wear Limit	43.92 mm (1.729 in.)

Main Bearing I.D.

Clearance	0.15 mm (0.0059 in.)
Standard	44.00 - 44.042 mm (1.732 - 1.734 in.)
Wear Limit	44.07 mm (1.735 in.)

Stub Shaft (430 LGT, F925/35 FM)

Stub Shaft-to-Flywheel Cap Screw Torque	59 N•m (44 lb-ft)
Cover-to-Block Cap Screw Torque	49 N•m (36 lb-ft)
Nut Torque	88 N•m (65 lb-ft)
Cover-to-Plate Cap Screw Torque	26 N•m (226 lb-in.)

Flywheel

Maximum Distortion	0.02 mm (0.0008 in.)
Mounting Cap Screw Torque	83 N•m (61 lb-ft)

Flywheel Housing/Plate Mounting Cap Screw Torque	49 N•m (36 lb-ft)
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Camshaft

Mounting Cap Screw Torque	11 N•m (96 lb-in.)
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Camshaft Side Gap

Standard	0.05 - 0.15 mm (0.0020 - 0.0060 in.)
Wear Limit	0.40 mm (0.016 in.)
Maximum Camshaft Bend	0.02 mm (0.001 in.)

Lobe Height

Standard	33.95 - 34.05 mm (1.337 - 1.341 in.)
Wear Limit	33.75 mm (1.329 in.)

Journal O.D.

Gear Housing and Flywheel Ends

Standard	39.94 - 39.96 mm (1.5724 - 1.5732 in.)
Wear Limit	39.85 mm (1.5689 in.)

Intermediate

Standard	39.91 - 39.94 mm (1.5713 - 1.5724 in.)
Wear Limit	39.85 mm (1.5689 in.)

Bushing I.D.

Standard	40.00 - 40.065 mm (1.575 - 1.577 in.)
Clearance	0.18 mm (0.007 in.)
Wear Limit	40.10 mm (1.579 in.)

Bore I.D.

Clearance	0.18 mm (0.007 in.)
Standard	40.00 - 40.025 mm (1.575 - 1.576 in.)
Wear Limit	40.10 mm (1.579 in.)

Cam Followers

O.D.

Standard	20.927 - 20.960 mm (0.8239 - 0.8252 in.)
Wear Limit	20.93 mm (0.824 in.)

Bore I.D.

Clearance	0.040 - 0.094 mm (0.0016 - 0.0037 in.)
Standard	21.00 - 21.021 mm (0.8268 - 0.8276 in.)
Wear Limit	21.05 mm (0.829 in.)

Timing Gear Cover

Fan Mounting Cap Screw Torque	11 N•m (96 lb-in.)
Cover Mounting Cap Screw Torque	9 N•m (78 lb-in.)
Crankcase Extension Housing-to-Cover Cap Screw Torque	22 N•m (195 lb-in.)
Crankshaft Pulley Cap Screw Torque	
Early 3TNA72 (430 LGT)	88 N•m (65 lb-ft)
Later 3TNA72	115 N•m (85 lb-ft)

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Specifications

Idler Gear

Shaft O.D.

Standard 19.959 - 19.980 mm (0.786 - 0.787 in.)

Wear Limit 19.93 mm (0.785 in.)

Bushing I.D.

Clearance 0.15 mm (0.0059 in.)

Standard 20.00 - 20.021 mm (0.787 - 0.788 in.)

Wear Limit 20.08 mm (0.791 in.)

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Timing Gear Housing Cap Screw Torque

Aluminum Housing-to-Block 9 N•m (73 lb-in.)

Cast Iron Housing-to-Block 11 N•m (96 lb-in.)

Crankcase Extension-to-Housing (670 CUT, 15 EX, 3009 OEM). 22 N•m (195 lb-in.)

Oil Pan and Strainer Mounting Cap Screw Torque

Oil Pan/Plate-to-Extension Housing (670 CUT) 11 N•m (96 lb-in.)

Oil Pan-to-Block (All Except 670 CUT) 11 N•m (96 lb-in.)

Oil Pan-to-Seal Case (All Except 670, 15 EX, 3009 OEM). 9 N•m (78 lb-in.)

Oil Pan-to-Timing Gear Housing (All Except 670, 15 EX, 3009 OEM) 9 N•m (78 lb-in.)

Oil Strainer-to-Block 11 N•m (96 lb-in.)

Oil Pump - Early 3TNA72 (430 LGT)

Mounting Cap Screw and Nut Torque 9 N•m (78 lb-in.)

Governor Shaft Torque 49 N•m (36 lb-ft)

Gear Housing End Cover Cap Screw Torque 9 N•m (78 lb-in.)

Oil Pump Gear Lock Nut Torque 27 N•m (20 lb-ft)

Outer Rotor Bore Depth-to-Outer Rotor Thickness Clearance

Standard 0.08 - 0.15 mm (0.003 - 0.006 in.)

Wear Limit 0.25 mm (0.010 in.)

Outer Rotor-to-Bore Diameter Clearance

Standard 0.10 - 0.15 mm (0.004 - 0.006 in.)

Wear Limit 0.25 mm (0.010 in.)

Inner Rotor-to-Outer Rotor Clearance

Standard 0.10 - 0.15 mm (0.004 - 0.006 in.)

Wear Limit 0.25 mm (0.010 in.)

Rotor Shaft O.D.

Standard 12.670 - 12.685 mm (0.4988 - 0.4990 in.)

Wear Limit 12.650 mm (0.4980 in.)

Rotor Shaft Bore I.D.

Standard 12.700 - 12.718 mm (0.5000 - 0.5007 in.)

Wear Limit 0.100 mm (0.0039 in.)

Rotor Shaft-to-Bore Clearance

Standard 0.015 - 0.048 mm (0.006 - 0.0019 in.)

Wear Limit 0.100 mm (0.0039 in.)

Oil Pump - Later 3TNA72

Mounting Cap Screw Torque 25 N•m (18 lb-ft)

Rotor Recess

Wear Limit 0.25 mm (0.010 in.)

Rotor Shaft O.D.-to-Backing Plate I.D. Clearance

Standard 0.015 - 0.048 mm (0.0006 - 0.0035 in.)

Wear Limit 0.20 mm (0.0078 in.)

Oil Pump - Later 3TNA72, continued	
Outer Rotor-to-Pump Body Clearance	
Standard	0.03 - 0.09 mm (0.0011 - 0.0035 in.)
Wear Limit	0.13 mm (0.0057 in.)
Inner-to-Outer Rotor Clearance	
Wear Limit	0.15 mm (0.0059 in.)
Oil Pressure Regulating Valve -Early 3TNA72 (430 LGT)	
Spring	
Compressed Length	30 mm (1.180 in.) @ 29.4 ± 3.1 N (6.6 ± 0.7 lb-force)
Free Length	39.50 - 40.50 mm (1.550 - 1.590 in.)
Oil Pressure Regulating Valve - Later 3TNA72	
Spring	
Compressed Length	27.50 mm (1.080 in.) @ 20.5 N (4.6 lb-force)
Free Length	43.50 - 48.50 mm (1.710 - 1.910 in.)
Housing-to-Valve Body Retaining Nut Torque	30 N•m (22 lb-ft)
Housing-to-Engine Block Cap Screw Torque	27 N•m (20 lb-ft)
Thermostat	
Thermostat Cover Cap Screw Torque	26 N•m (226 lb-in.)
Water Pump	
Mounting Cap Screw Torque	26 N•m (226 lb-in.)
Fan Mounting Cap Screw Torque	11 N•m (96 lb-in.)
Plate-to-Housing Cap Screw Torque	9 N•m (78 lb-in.)
Fuel Supply Pump - (670 CUT, 3009 OEM)	
Mounting Nut Torque	11 N•m (96 lb-in.)
Fuel Injection Pump	
Mounting Nut Torque	20 N•m (180 lb-in.)
Fuel Injection Pump Camshaft	
Bearing Retaining Screw Torque	20 N•m (180 lb-in.)
Gear-to-Camshaft Lock Nut Torque - Early 3TNA72 (430 LGT)	88 N•m (65 lb-ft)
Minimum Lobe Height	30.90 mm (1.217 in.)
Fuel Control and Governor Linkage - Early 3TNA72 (430 LGT)	
Gear Housing End Cover Cap Screw Torque	9 N•m (78 lb-in.)
Governor Shaft O.D. (Minimum)	7.90 N•m (0.311 in.)
Governor Shaft Torque	49 N•m (36 lb-ft)
Governor Shaft Bore I.D.	
Clearance	0.18 mm (0.007 in.)
Wear Limit	8.15 mm (0.321 in.)
Sleeve I.D. (Maximum)	
	9.20 mm (0.362 in.)
Oil Pump Rotor Shaft O.D.	
Clearance	0.15mm (0.006 in.)
Wear Limit	8.90 mm (0.350 in.)
Fuel Control and Governor Linkage - Later 3TNA72	
Governor Shaft O.D. (Minimum)	7.90 mm (0.311 in.)
Governor Shaft Bore I.D.	
Wear Limit	8.15 mm (0.321 in.)
Clearance	0.18 mm (0.007 in.)
Sleeve I.D. (Maximum)	8.20 mm (0.323 in.)
Injection Pump Camshaft O.D.	
Wear Limit	7.90 mm (0.311 in.)
Clearance	0.15 mm (0.006 in.)

Specifications

Fuel Injection Nozzles

Mounting Nut Torque	40 N•m (30 lb-ft)
Nozzle Fitting Torque	40 N•m (30 lb-ft)
Nozzle Torque	50 N•m (37 lb-ft)
Separator Plate Nozzle Contact Surface Maximum Wear	0.10 mm (0.0039 in.)

Starter - Hitachi 0.8 kW (3009 OEM)

Cover Bushing (Reamed Out)	12.50 - 12.53 (0.492 - 0.493 in.)
Minimum Brush Length	7.70 mm (0.303 in.)

1 Starter Motor - Nippondenso 1.0 kW (All Except 3009 OEM)

Minimum Brush Length	8.5 mm (0.300 in.)
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Alternator - Kokosan 20A (670 CUT, 15 EX)

Flywheel Assembly-to-Coil Plate Assembly Nut Torque	27 N•m (20 lb-ft)
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Alternator - Nippondenso 35A (430 LGT, 670 CUT, 755/56 CUT, F925/35 FM)

Attaching Screw Torque	4 N•m (31 lb-in.)
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Rotor Assembly

Retainer-to-Front Frame Screw Torque	2 N•m (16 lb-in.)
Pulley Nut Torque	54 N•m (40 lb-ft)
Stator-to-Rectifier Lead Wire Distance	33.50 mm (1.300 in.)
Minimum Brush Length	5.50 mm (0.220 in.)

Alternator - Nippondenso 40A (455 LGT, 755/56 CUT, 3009 OEM)

Sheave Nut Torque	69 N•m (51 lb-ft)
Retainer-to-Front Frame Screw Torque	2 N•m (16 lb-in.)
Minimum Rotor Slip Ring O.D.	14 mm (0.550 in.)
Brush Length	
New	10.50 mm (0.410 in.)
Wear Limit	4.50 mm (0.170 in.)

Checks, Tests and Adjustments

Valve Clearance	0.20 mm (0.008 in.)
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Connecting Rod Side Play

Standard Clearance	0.20 - 0.40 mm (0.0079 - 0.0157 in.)
Wear Limit	0.55 mm (0.0217 in.)

Connecting Rod Bearing Clearance

Standard Clearance	0.020 - 0.072 mm (0.0008 - 0.0028 in.)
Wear Limit	0.15 mm (0.0059 in.)

Crankshaft End Play

Standard Clearance	0.090 - 0.271 mm (0.004 - 0.011 in.)
Wear Limit	0.33 mm (0.0129 in.)

Crankshaft Main Bearing Clearance

Main Bearing Cap Cap Screw Torque	79 N•m (58 lb-ft)
Standard Clearance	0.020 - 0.072 mm (0.0008 - 0.0028 in.)
Wear Limit	0.15 mm (0.0059 in.)

Valve Lift (Intake and Exhaust)	7.5 mm (0.300 in.)
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Camshaft End Play

Standard Clearance	0.05 - 0.20 mm (0.0020 - 0.0079 in.)
Wear Limit	0.40 mm (0.016 in.)

Timing Gear Backlash - Early 3TNA72 (430 LGT)

Standard Backlash	
Fuel Injection Pump Gear-to-Oil Pump Gear	0.11 - 0.19 mm (0.0043 - 0.0075 in.)
All Except Fuel Injection Pump Gear-to-Oil Pump Gear	0.04 - 0.12 mm (0.0016 - 0.0047 in.)
Wear Limit	0.20 mm (0.0079 in.)

Timing Gear Backlash - Later 3TNA72	
Standard Backlash	
Crankshaft Gear-to-Oil Pump Gear	0.11 - 0.19 mm (0.0043 - 0.0075 in.)
All Except Crankshaft Gear-to-Oil Pump Gear	0.04 - 0.12 mm (0.0016 - 0.0047 in.)
Fuel Injection Nozzle	
Opening Pressure	11722 ± 480 kPa (1700 ± 70 psi)
Leakage at 11032 kPa (1600 psi)	Minimum of 10 Seconds
Chatter and Spray Pattern at 11722 ± 480 kPa (1700 ± 70 psi)	
Slow Hand Lever Movement	Chatter Sound
Slow Hand Lever Movement	Fine Stream Spray Pattern
Fast Hand Lever Movement	Fine Atomized Spray Pattern
Thermostat	
Begin Opening	71° C (160°F)
Fully Open	85° C (184° F)
Minimum Lift Height	8 mm (0.310 in.)
Coolant Temperature Sensor Continuity	107-113° C (225-235° F)
Starter No-Load Amp Draw/RPM	
Maximum Starter Amperage	
Hitachi 0.8 kW	60 Amps at 7000 rpm
Nippondenso 1.0 kW	90 Amps at 3000 rpm
Minimum Starter RPM	
Hitachi 0.8 kW	7000
Nippondenso 1.0 kW	3000
Fuel Injection Pump Static Timing Adjustment - Early 3TNA72 (430 LGT)	
Injection Pump Timing	15° BTDC (Before Top Dead Center)
Engine Crankshaft Position	No. 1 Cylinder on TDC Compression Stroke
Distance On Outer Surface of Crankshaft Pulley for	
Every 0.1 mm (0.004 in.) of Shim Thickness	1° or 1 mm (3/64 in.)
Delivery Valve Fitting Torque	42 N•m (31 lb-ft)
Fuel Injection Pump Static Timing Adjustment - Later 3TNA72	
Injection Pump Timing	13° BTDC (Before Top Dead Center)
Engine Crankshaft Position	No. 1 Cylinder on TDC Compression Stroke
Distance on Outer Surface of Flywheel Per 1° of Rotation	2.62 mm (0.100 in.)
Total Shim Pack Thickness (New Shims)	0.5 mm (0.020 in.)
Delivery Valve Fitting Torque	42 N•m (31 lb-ft)
Fan/Alternator Drive Belt Tension	
Applied Force	98 N (22 lb-force)
Deflection	10 - 15 mm (0.400 - 0.600 in.)
Operational Tests	
Radiator, Bubble Test	
Maximum Air Pressure Into Cylinder	
3009 OEM	2455 kPa (356 psi)
All Except 3009 OEM	2448 kPa (355 psi)
Cooling System	
15 EX, 670 CUT, 3009 OEM	
Maximum Pressure	97 kPa (14 psi)
Minimum Pressure after 15 Seconds	88 kPa (12.8 psi)
430 LGT, 455 LGT, 755/56 CUT, F925/35 FM	
Maximum Pressure	117 kPa (17 psi)
Minimum Pressure after 15 seconds	90 kPa (13 psi)

Specifications

Radiator Cap

Valve Opening Pressure

15 EX, 3009 OEM	88 kPa (12.8 psi)
670 CUT	55 kPa (8 psi)
430 LGT, 455 LGT, 655 CUT, 755/56 CUT, F925/35 FM	97 kPa (14 psi)

Cylinder, Compression Pressure

Compression Pressure

All Except 3009 OEM	2448 kPa (355 psi)
3009 OEM	2455 kPa (356 psi)

Maximum Difference Between Cylinders	490 kPa (71 psi)
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Engine Oil Pressure

F925/35 FM

Idle Speed

Fast	3635 ± 35 rpm
Slow	1450 ± 50 rpm

Engine Oil Pressure	294 - 440 kPa (43 - 64 psi)
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455 LGT

Idle Speed

Fast	3350 ± 100 rpm
Slow	1650 ± 50 rpm

Engine Oil Pressure	294 - 440 kPa (43 - 64 psi)
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430 LGT, 755/56 CUT, 670 CUT

Fast Idle Speed	3425 ± 25 rpm
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Engine Oil Pressure	365 ± 69 kPa (53 ± 10 psi)
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15 EX

Idle Speed

Fast	2425 ± 25 rpm
Slow	800 ± 25 rpm

Engine Oil Pressure	117 - 345 kPa (17 - 50 psi)
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3009 OEM

Low Idle Speed	1300 rpm
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Engine Oil Pressure	147 kPa (21 psi)
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Air Intake System Holding Pressure	34 - 69 kPa (5 - 10 psi)
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Minimum Fuel Supply Pump Pressure (670 CUT, 3009 OEM)	29 kPa (4.3 psi)
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Fuel System Holding Pressure (Maximum)	103 kPa (15 psi)
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SPECIAL OR ESSENTIAL TOOLS

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

JDG504 Valve Guide Driver

Use to remove and install valve guides in cylinder head on 3TN66 engine.

JDE118 Valve Guide Driver

Use to remove and install valve guides in cylinder head on 3TNA72 (3009) engine.

D-20018WI Valve Guide Knurler

Use to knurl inside diameter of valve guides on 3TNA72 (3009) engine.

D-20020WI Valve Guide Reamer

Use to ream out new valve guides on 3TNA72 (3009) engine.

SERVICE PARTS KITS

The following kits are available through your parts catalog:

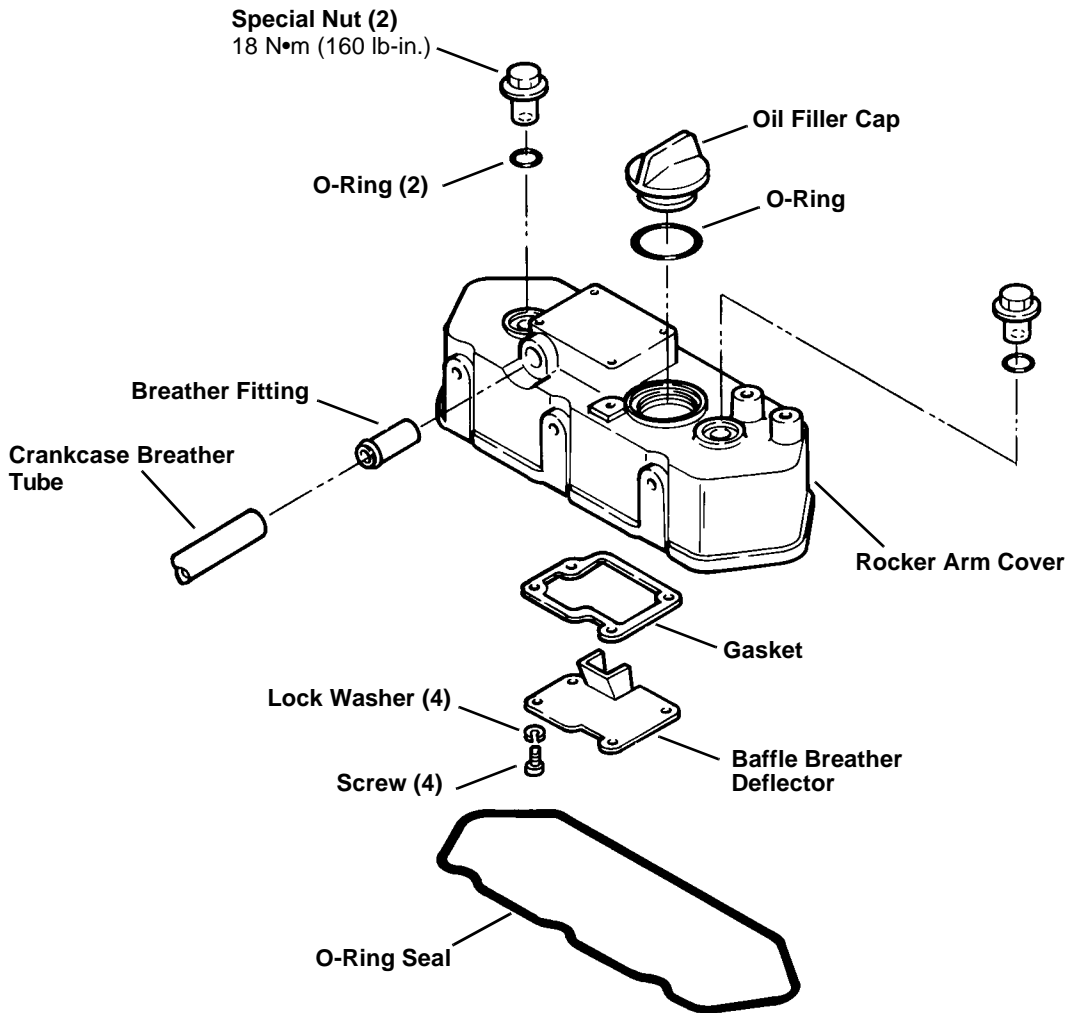
- Cylinder Head Gasket Kit

Cylinder Head, Valves and Manifolds

ROCKER ARM COVER

NOTE: Some models may be equipped with an oil fill extension and/or adaptor with an o-ring.

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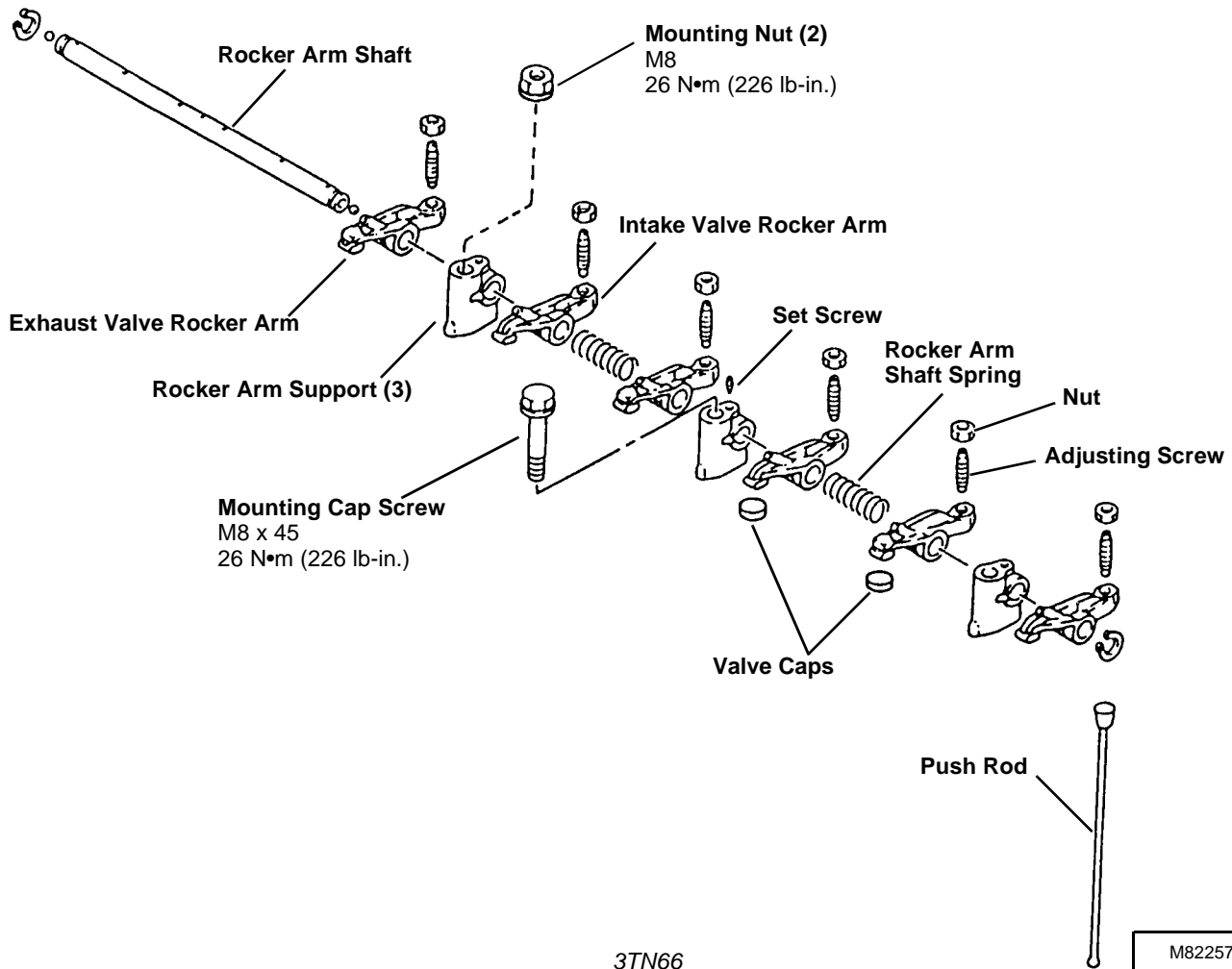
ROCKER ARM ASSEMBLY

Removal/Installation and Disassembly/Assembly

1. Remove rocker arm cover. (See procedure in this group.)
 - Inspect all parts for wear or damage. (See *Inspection* procedures.)

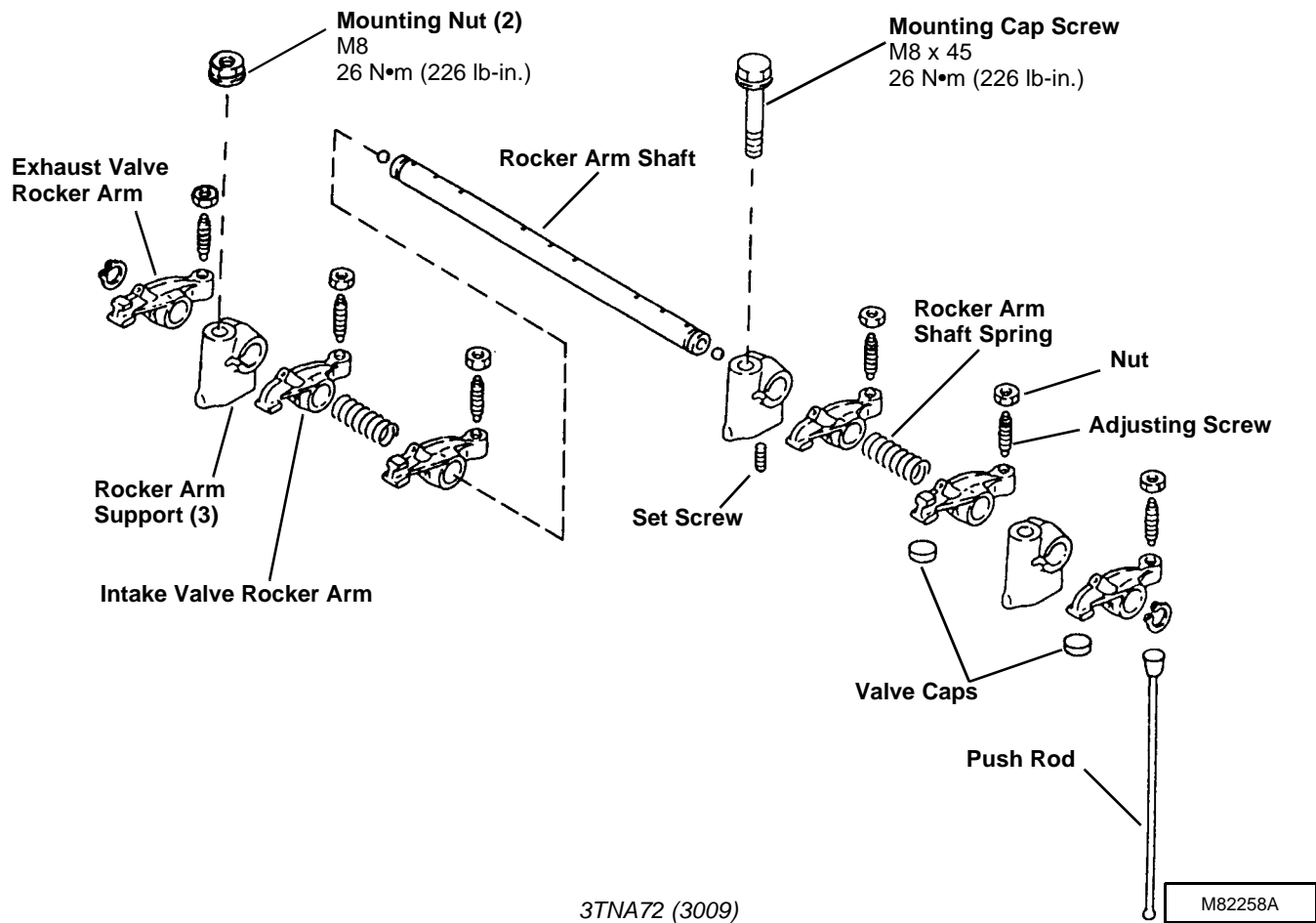
IMPORTANT: Install center rocker arm support on shaft, aligning set screw hole in support with center hole in shaft.

- Lubricate all parts with clean oil during assembly.
- Adjust valve clearance. (See *Checks, Tests and Adjustments* in this section.)



Cylinder Head, Valves and Manifolds

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3TNA72 (3009)

Inspection

- Measure outer diameter of rocker arm shaft at each rocker arm location.



Rocker Arm Shaft O.D. - 3TN66:

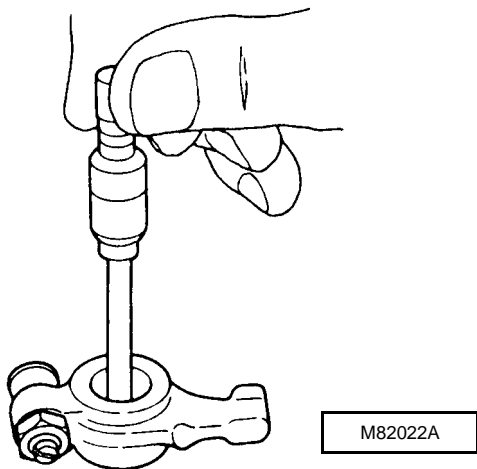
Standard 9.97 - 9.99 mm
 (0.3925 - 0.3933 in.)
 Wear Limit..... 9.95 mm (0.3920 in.)

Rocker Arm Shaft O.D. - 3TNA72 (3009):

Standard 11.96 - 11.98 mm
 (0.4711 - 0.4718 in.)
 Wear Limit..... 11.95 mm (0.4706 in.)

Replace rocker arm shaft if less than wear limit.

- Measure inner diameters of rocker arms and supports.



Rocker Arm and Shaft Support I.D.'s - 3TN66:

Standard 10.00 - 10.02 mm
 (0.3937 - 0.3945 in.)
 Wear Limit..... 10.09 mm (0.3972 in.)
 Clearance..... 0.14 mm (0.005 in.)

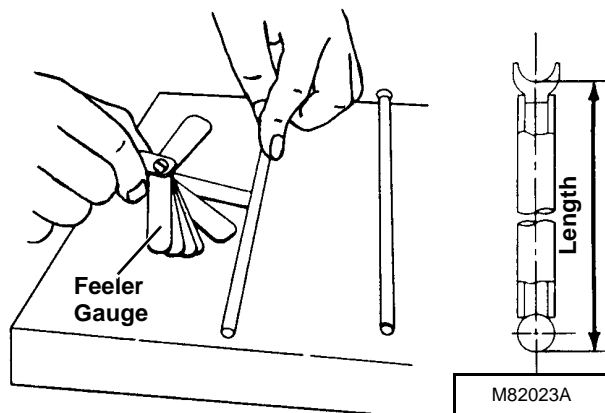
Rocker Arm and Shaft Support I.D.'s - 3TNA72 (3009):

Standard 12.00 - 12.02 mm
 (0.4724 - 0.4732 in.)
 Wear Limit..... 12.09 mm (0.4759 in.)
 Clearance..... 0.14 mm (0.005 in.)

Replace rocker arms or supports if I.D. is more than wear limit.

If shaft and support/arm clearance (support/arm I.D. minus shaft O.D.) exceed wear limit, replace all parts.

- Measure length and bending of push rod.



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Push Rod Length:

3TN66..... 114 - 115 mm
 (4.488 - 4.528 in.)
 3TNA72 (3009) 141 - 142 mm
 (5.550 - 5.590 in.)

Push Rod Bend:

Wear Limit..... 0.08 mm (0.003 in.)

Replace push rod if not within specifications.

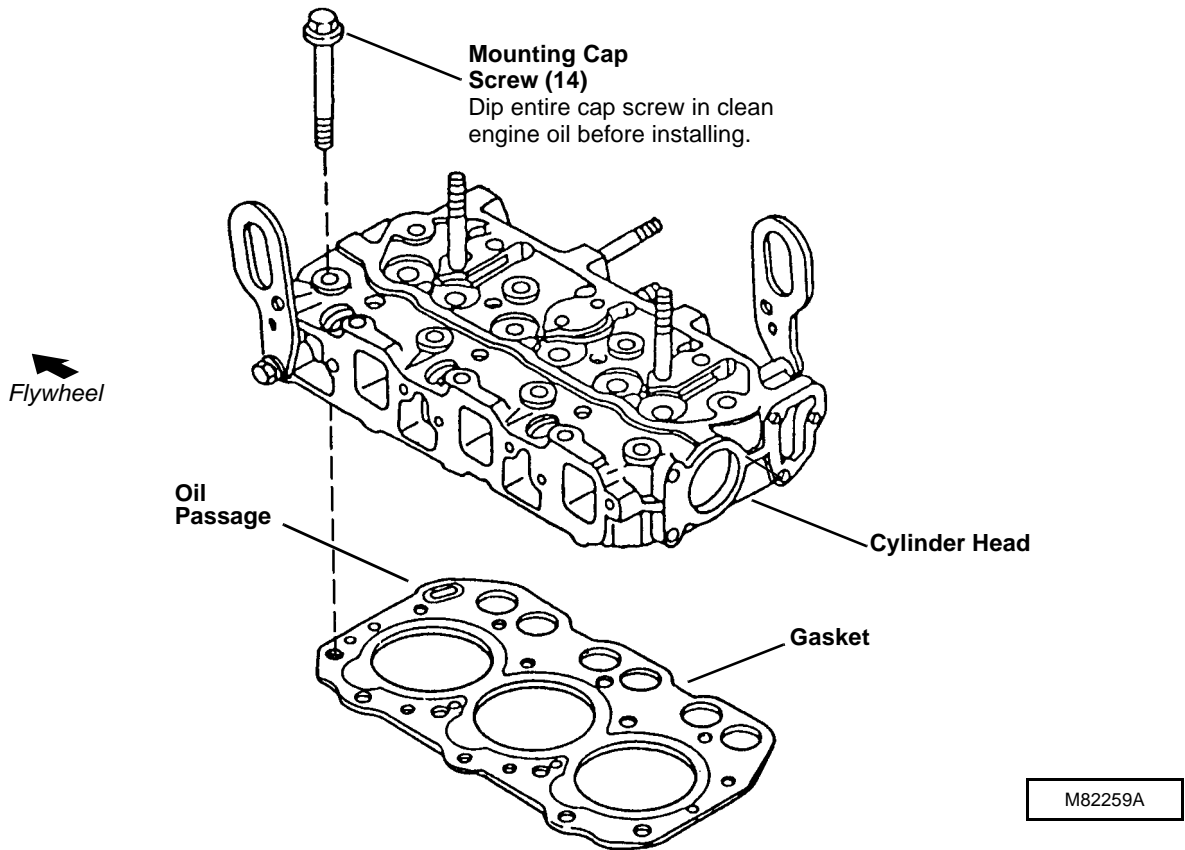
CYLINDER HEAD AND VALVES

Removal/Installation

1. Remove rocker arm assembly, push rods and valve caps. (See procedure in this group.)
2. Remove exhaust and intake manifolds. (See procedures in this group.)
3. Remove water pump. (See *Cooling System* in this section.)

Cylinder Head, Valves and Manifolds

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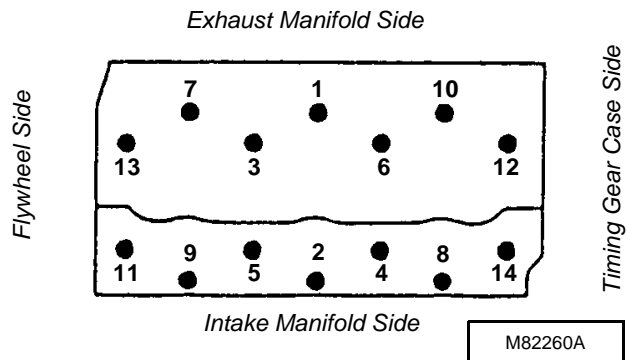


4. Remove fuel injection nozzles. (See *Fuel System* in this section.)
5. Remove glow plugs. (See procedure in *ACCESSORIES - SERIES 220 POWER UNIT ENGINES* section.)
6. Disassemble and inspect cylinder head and valves. (See *Disassembly/ Assembly and Inspection/Replacement* procedures.)

IMPORTANT: Oil passage in gasket must be located over oil passage in cylinder block. Install gasket as shown.

7. Tighten mounting cap screws, in the sequence shown, in three stages of gradually-increasing torque.

IMPORTANT: Cylinder head mounting cap screws must be checked for proper torque after 50 hours of engine operation.



Torque Specifications - 3TN66:

- First 11 N•m (97 lb-in.)
- Second 22 N•m (195 lb-in.)
- Final 34 N•m (25 lb-ft)

Torque Specifications - 3TNA72 (3009):

- First 19 N•m (168 lb-in.)
- Second 38 N•m (28 lb-ft)
- Final 61 N•m (45 lb-ft)

Disassembly/Assembly

NOTE: Size and shape of lifting brackets will vary due to numerous engine applications.

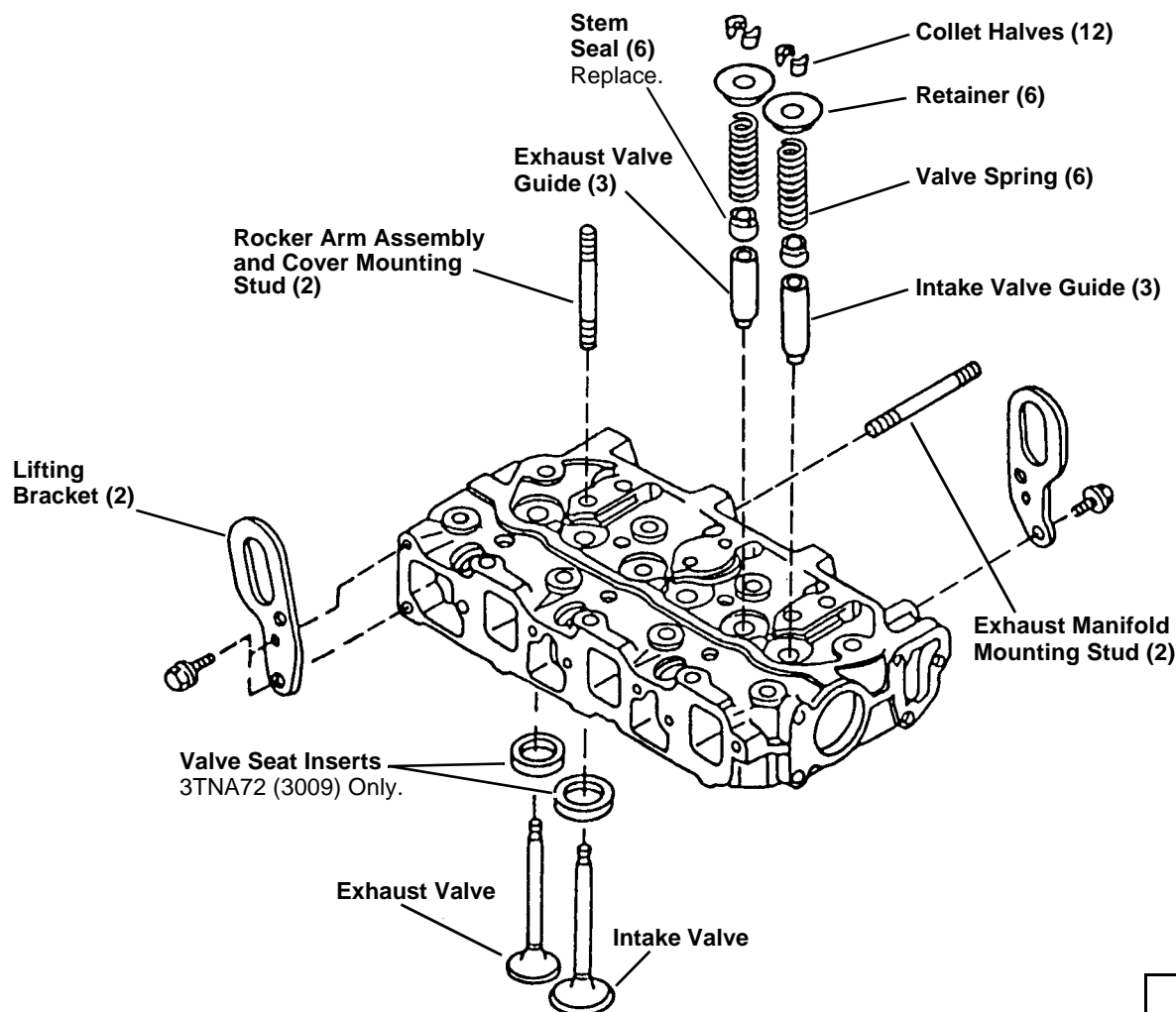
- Compress valve springs using a valve spring compressor.
- Intake and exhaust valve guides are press fit. Remove guides only if replacement is necessary. (See *Inspection/Replacement* procedures.)
- On 3TNA72 (3009), intake and exhaust valve seat inserts are press fit. Remove inserts only if replacement is necessary.
- Inspect all parts for wear or damage. (See *Inspection/Replacement* procedures.)

IMPORTANT: Do not reuse stem seals if removed. Used seals will leak.

- Apply clean engine oil on intake and exhaust valve stems during assembly.
- Install springs with smaller pitch end or paint mark toward cylinder head.

*NOTE: If new valves are installed, measure valve recession. (See *Inspection/Replacement* procedures.)*

After each valve has been assembled, tap on top of valve stem with a plastic hammer to seat retainer.



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Cylinder Head, Valves and Manifolds

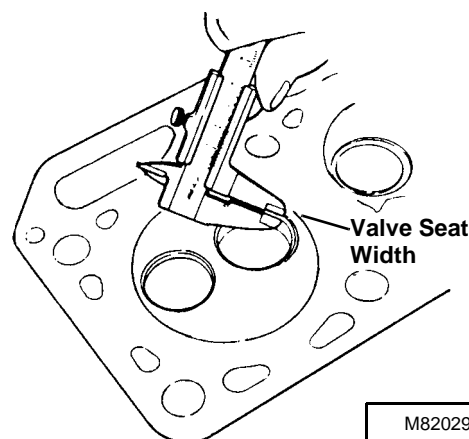
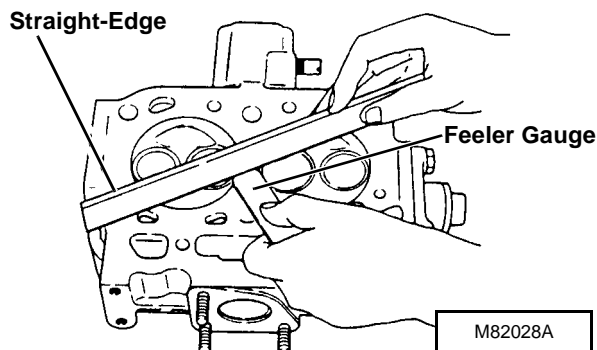
Inspection/Replacement

Before inspection, thoroughly clean all components of carbon or dirt.

Cylinder Head:

- Measure cylinder head flatness. Place a straight-edge along each of the four sides and each diagonal. Measure clearance between straight edge and combustion surface with a feeler gauge.

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Valve Seat Width - 3TN66:

Intake Valve

Standard 1.15 mm (0.045 in.)
Wear Limit..... 1.65 mm (0.065 in.)

Exhaust Valve

Standard 1.41 mm (0.056 in.)
Wear Limit..... 1.91 mm (0.075 in.)

Cylinder Head Distortion:

Standard 0.05 mm (0.002 in.) or less
Wear Limit..... 0.15 mm (0.006 in.)

If distortion exceeds the wear limit, resurface or replace cylinder head. Remove only enough metal to make cylinder head flat; but do not remove more than **0.20 mm (0.008 in.)**.

If cylinder head was resurfaced:

- Measure piston-to-cylinder head clearance. (See procedure in this group.)
- Measure valve recession. (See procedure in this group.)
- Measure valve seat width.

Valve Seat Width - 3TNA72 (3009):

Intake Valve

Standard 1.44 mm (0.057 in.)
Wear Limit..... 1.98 mm (0.078 in.)

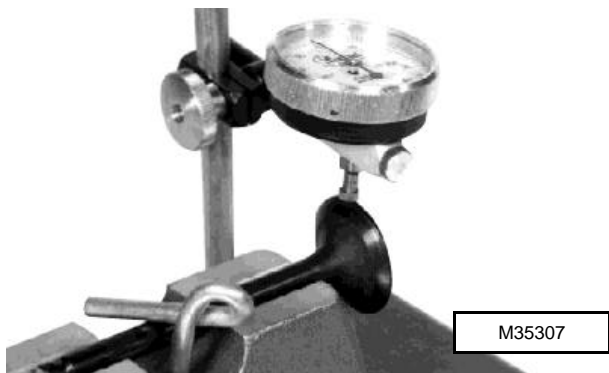
Exhaust Valve

Standard 1.77 mm (0.070 in.)
Wear Limit..... 2.27 mm (0.089 in.)

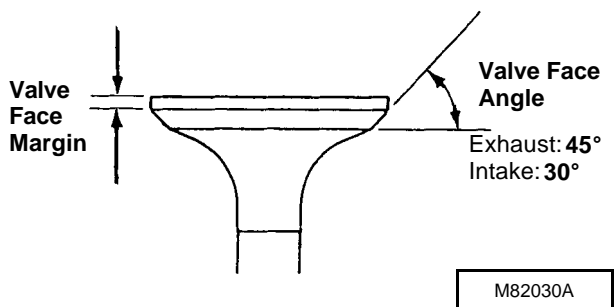
If necessary, grind valve seats to meet specifications. (See *GRIND VALVE SEATS* procedure.)

Intake and Exhaust Valves:

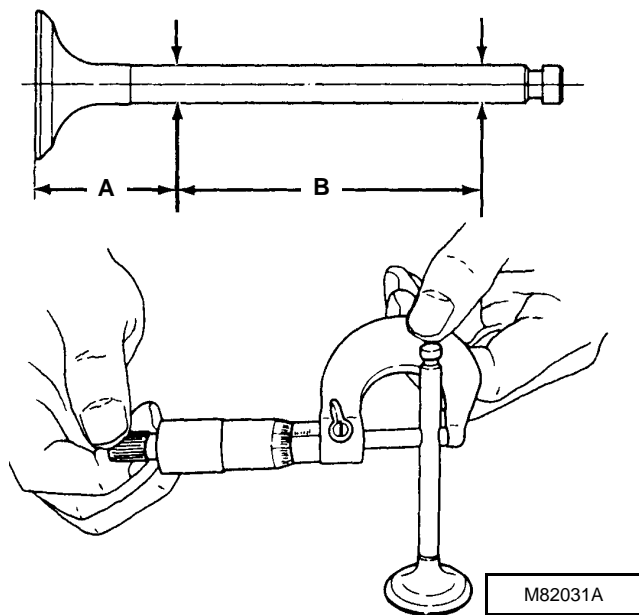
- Check valve for out-of-round, bent or warped condition using a valve inspection center. Replace valve if necessary.



If valve faces are worn, burned or pitted, grind valves to proper face angle. If valve face margin is less than **0.51 mm (0.020 in.)** after grinding, replace valve.



- Measure valve stem diameter at two locations shown. Replace valve if measurement exceeds wear limit.



Valve Stem O.D. - 3TN66:

Distance A20 mm (0.787 in.)

Distance B40 mm (1.575 in.)

Intake Valve

Standard5.46 - 5.48 mm

.....(0.2149 - 0.2157 in.)

Wear Limit.....5.40 mm (0.2126 in.)

Exhaust Valve

Standard5.44 - 5.46 mm

.....(0.2142 - 0.2149 in.)

Wear Limit.....5.40 mm (0.2126 in.)

Valve Stem O.D. - 3TNA72 (3009):

Distance A25 mm (0.984 in.)

Distance B45 mm (1.772 in.)

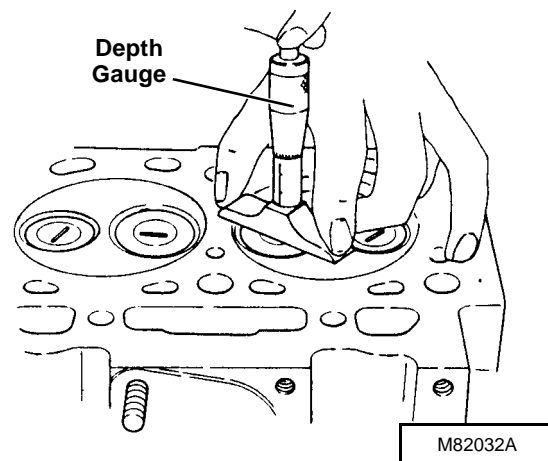
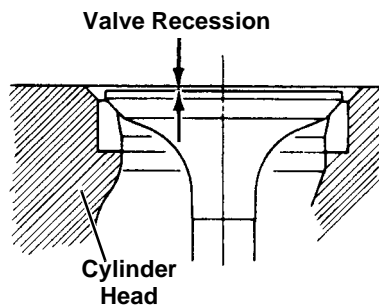
Intake and Exhaust Valves

Standard6.94 - 6.96 mm

.....(0.2732 - 0.2740 in.)

Wear Limit.....6.90 mm (0.2717 in.)

- Measure valve recession using a depth gauge. Replace valve or cylinder head if measurement exceeds specification.



Cylinder Head, Valves and Manifolds

Valve Recession - 3TN66:

Intake Valve 0.40 mm (0.016 in.)

Exhaust Valve 0.85 mm (0.033 in.)

Valve Recession - 3TNA72 (3009):

Intake Valve 0.50 mm (0.020 in.)

Exhaust Valve 0.85 mm (0.033 in.)

1 Valve Guides:

- Clean valve guides using a valve guide brush.
- Measure valve guide inside diameter.

Valve Guide I.D. - 3TN66:

Standard 5.50 - 5.52 mm

. (0.216 - 0.217 in.)

Wear Limit. 5.58 mm (0.220 in.)

Valve Guide I.D. - 3TNA72 (3009):

Standard 7.00 - 7.02 mm

. (0.275 - 0.276 in.)

Wear Limit. 7.08 mm (0.279 in.)

If diameter exceeds wear limit, knurl or replace guide.

If diameter is less than wear limit, determine guide-to-stem clearance (guide diameter minus stem diameter).

If clearance exceeds **0.15 mm (0.006 in.)** but is less than **0.20 mm (0.008 in.)**, knurl valve guides.

- Knurl valve guides using:
 - 3TN66: 5.50 mm Valve Guide Knurler
 - 3TNA72 (3009): D-20018WI Valve Guide Knurler

If clearance exceeds **0.20 mm (0.008 in.)**, replace valve guides.

- Replace valve guides using:
 - 3TN66: JDG504 Valve Guide Driver
 - 3TNA72 (3009): JDE118 Valve Guide Driver

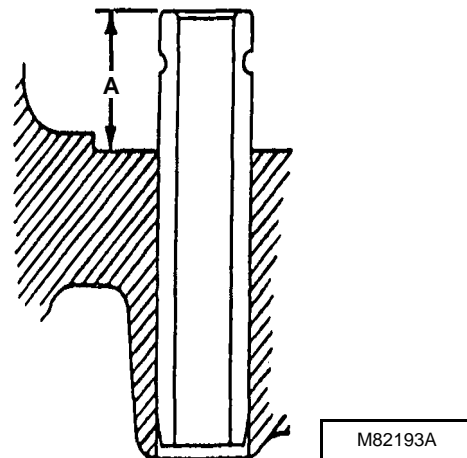
Intake and exhaust valve guides are different. The exhaust valve guide has one groove and the intake valve guide has none. Install valve guides with tapered ends down. Push valve guides down until top of valve guides are a specified distance (A) from top of cylinder head.

Valve Guide Height "A":

3TN66 7 mm (0.276 in.)

3TNA72 (3009) 9 mm (0.354 in.)

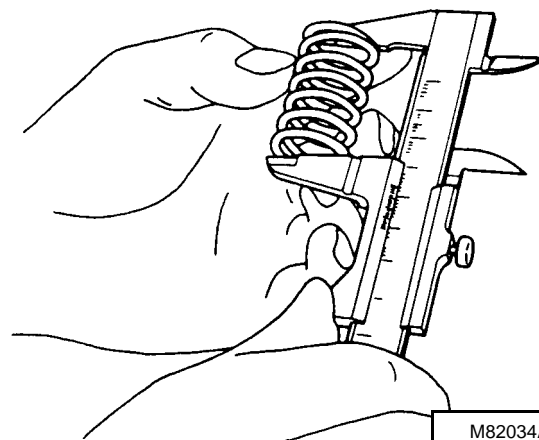
- Ream inside diameter of valve guides using:
 - 3TN66: 5.50 mm Valve Guide Reamer
 - 3TNA72 (3009): D-20020WI Valve Guide Reamer



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Valve Springs:

- Measure spring free length. Replace spring if measurement exceeds specification.



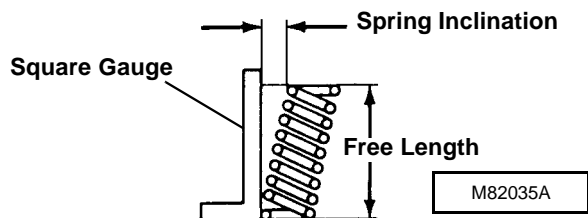
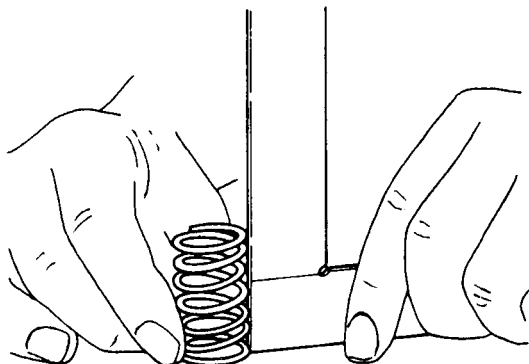
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Spring Free Length:

3TN66.....28 mm (1.102 in.)

3TNA72 (3009) 37.40 mm (1.472 in.)

- Measure spring inclination. Replace spring if measurement exceeds specification.



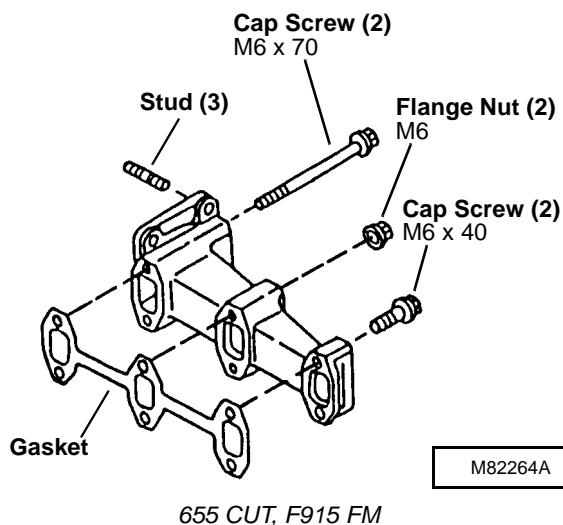
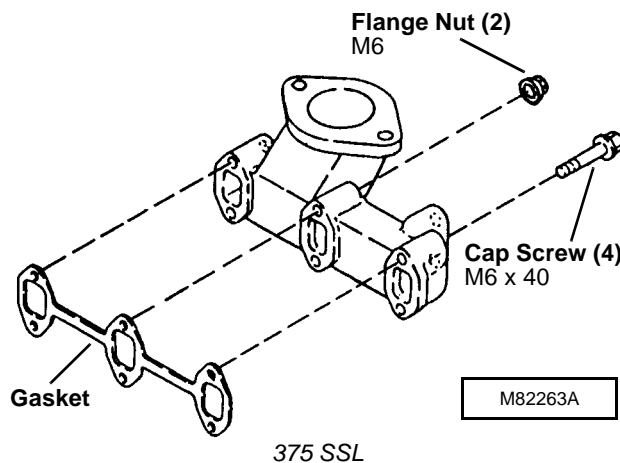
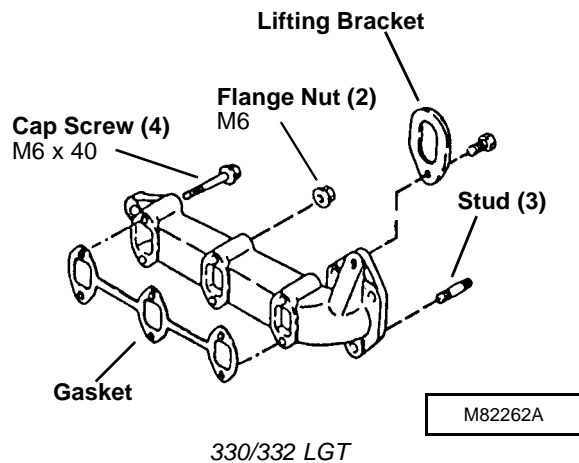
Spring Inclination:

3TN66..... 0.80 mm (0.032 in.)

3TNA72 (3009) 1.00 mm (0.040 in.)

EXHAUST MANIFOLD - 3TN66

- Remove muffler and gasket, if equipped.
- Tighten all mounting hardware to **11 N•m (97 lb-in.)**.



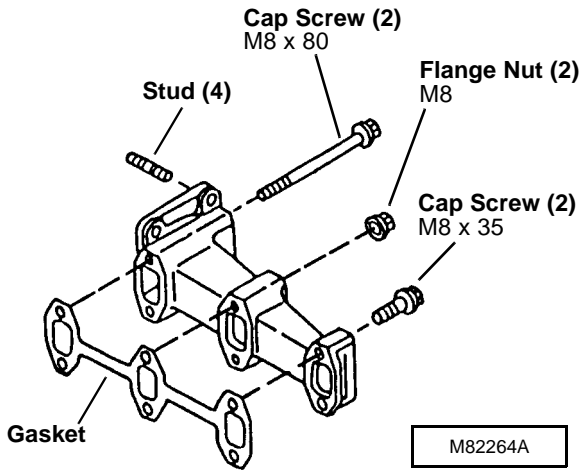
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Cylinder Head, Valves and Manifolds

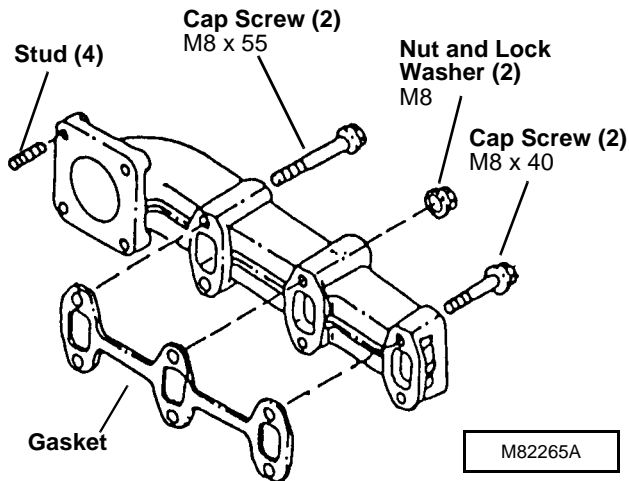
EXHAUST MANIFOLD - 3TNA72 (3009)

- Remove muffler and gasket, if equipped.
- Remove extension/elbow and gasket, if equipped.
- Tighten all mounting hardware to **26 N•m (230 lb-in.)**.

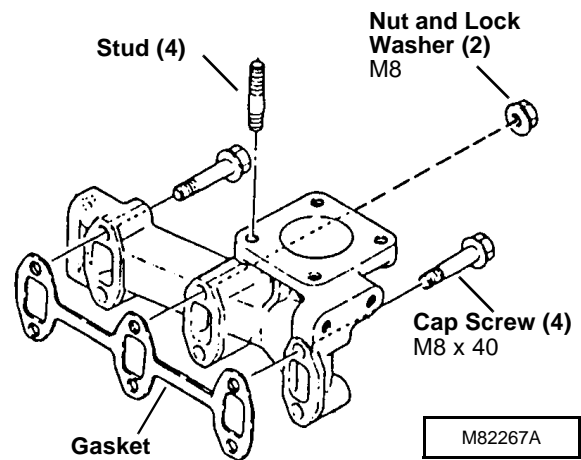
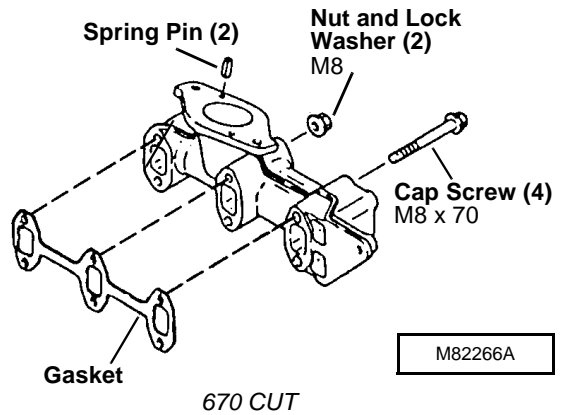
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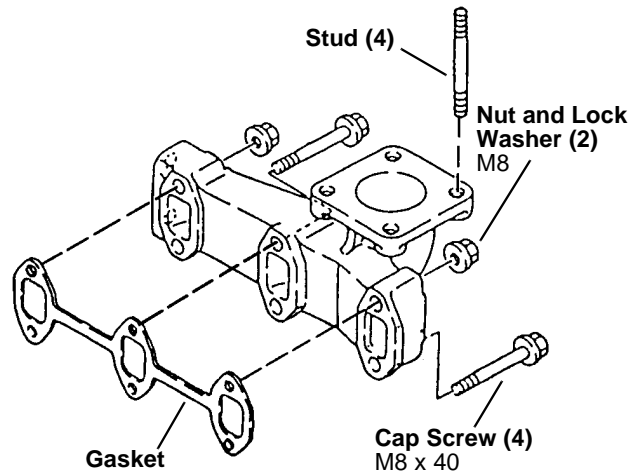
430 LGT (Early), 755/56 CUT, F925/35 FM



430 LGT (Later)



15 EX, 455 LGT

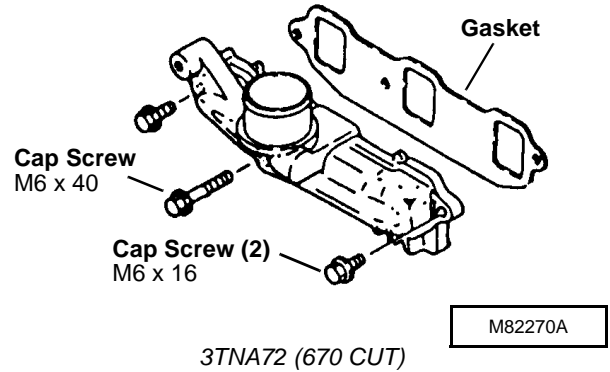
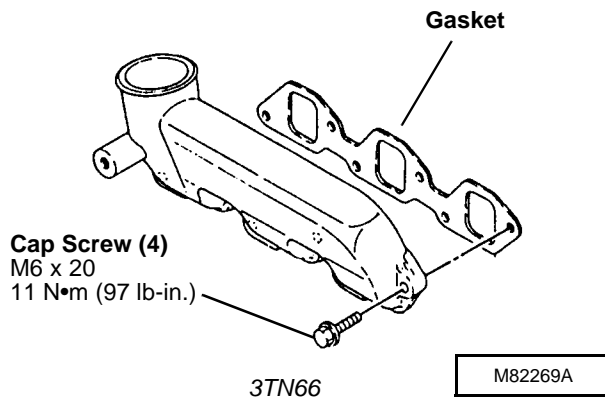


3009 OEM

INTAKE MANIFOLD - 3TN66

NOTE: On 375 SSL engine application, mounting cap screws are 22 mm long.

1. Remove fuel filter assembly mounting cap screw(s), if equipped.
2. Remove fuel injection lines, if necessary. (See *Fuel System* in this section.)



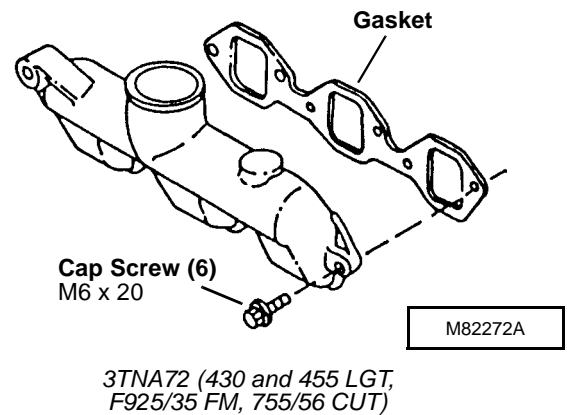
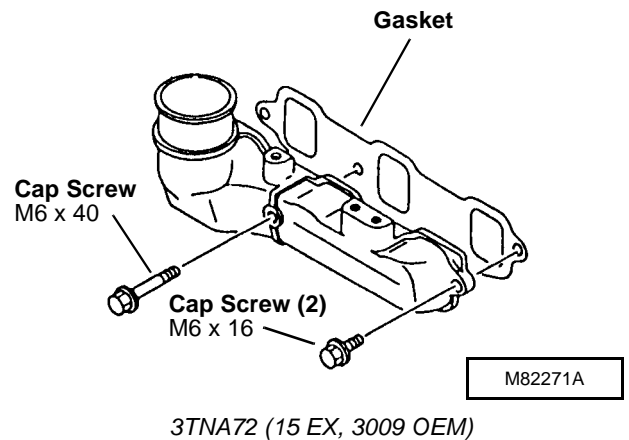
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INTAKE MANIFOLD - 3TNA72 (3009)

1. Remove fuel filter assembly mounting cap screw(s), if equipped.
2. Remove fuel injection lines. (See *Fuel System* in this section.)
3. OEM Power Unit engine (3009):
 - Remove air cleaner and mount bracket.
 - Remove instrument panel and bracket.

(See procedures in *ACCESSORIES - SERIES 220 POWER UNIT ENGINES* section.)

- Tighten all mounting cap screws to **11 N•m (97 lb-in.)**.



Cylinder Head, Valves and Manifolds

GRIND VALVE SEATS

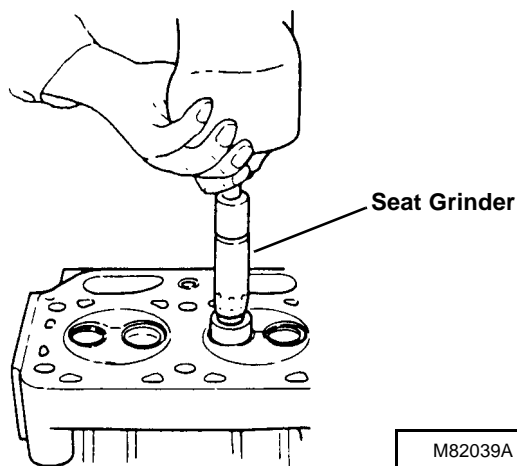
IMPORTANT: Valve seats should never be cut.

Cutting a valve seat can damage its sealing surface, which may result in leaks or valve/seat failure. Valve seats should be ground and lapped.

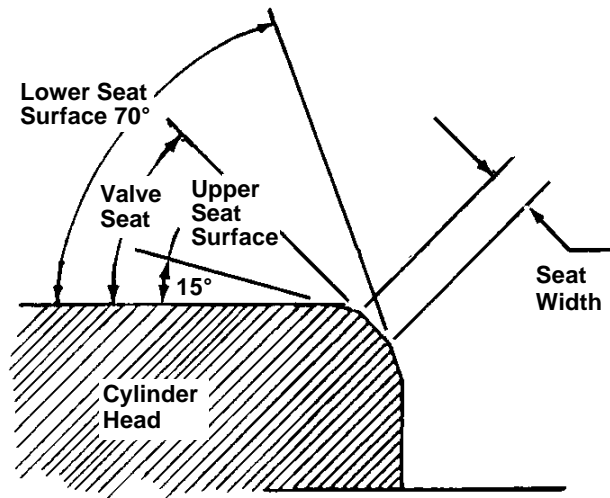
NOTE: LIGHTLY grind valve seats for a few seconds only to avoid excessive valve seat width.

1

1. Grind intake valve seat using a 30° seat grinder and exhaust valve seat using a 45° seat grinder. Follow tool manufacturers instructions.



2. Measure valve seat width after grinding.
3. If seat is too wide after grinding, grind lower seat surface using a 70° seat grinder until seat width is close to specifications.
4. Grind upper seat surface using a 15° seat grinder until seat width is narrowed to specifications.
5. If valve seats are ground, measure valve recession and check contact pattern between the seat and valve with bluing dye.
6. Lap valves. (See procedure in this group.)



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

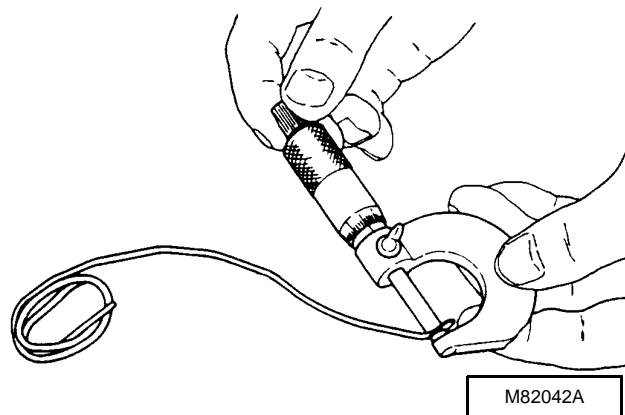
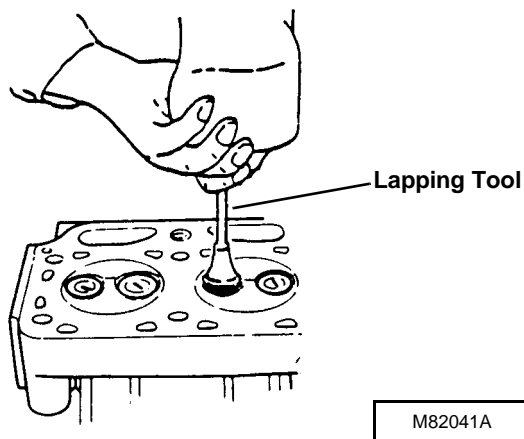
NOTE: Valve seat inserts are available for 4TN78T engine only.

LAP VALVES

NOTE: Use a rubber type lapping tool for valves without a lapping tool groove slit.

If seat does not make proper contact, lap the valve into the seat:

1. Apply small amount of fine lapping compound to face of valve.
2. Turn valve to lap valve to seat.
3. Lift valve from seat every 8 to 10 strokes. Lap until a uniform ring appears around the surface of the valve face.
4. Wash all parts in solvent to remove lapping compound. Dry parts.
5. Check position of lap mark on valve face. Lap mark must be on or near center of valve face.



MEASURE PISTON-TO-CYLINDER HEAD CLEARANCE

1. Place three 10 mm (0.400 in.) long pieces of 1.50 mm (0.060 in.) diameter soft wire in three positions on the flat part of the piston head.
2. Install cylinder head and old gasket. Install cylinder head cap screws and tighten in proper sequence to specified torque. (See *CYLINDER HEAD AND VALVES - Removal/Installation* in this group.)
3. Slowly turn crankshaft one complete revolution.
4. Remove cylinder head and gasket.
5. Measure thickness of flattened section of each piece of wire. Calculate average thickness of wires to obtain piston-to-cylinder head clearance specification.

Piston-to-Cylinder Head Clearance:

3TN66.....	0.59 - 0.74 mm
.....	(0.023 - 0.029 in.)
3TNA72 (3009)	0.61 - 0.79 mm
.....	(0.024 - 0.031 in.)

If clearance is less than specifications, replace cylinder head.

Pistons, Rods and Cylinder Block

SERVICE PARTS KITS

The following kits are available through your parts catalog:

- Cylinder Block Gasket Kit
- Cylinder Head Gasket Kit
- Oversized Pistons and Rings
- Undersized Connecting Rod Bearing Inserts

1

PISTON AND CONNECTING ROD

Removal

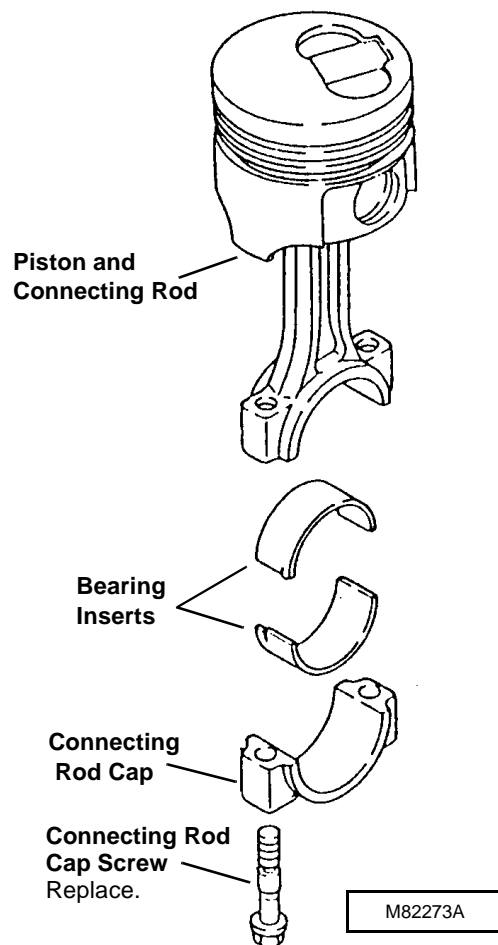
1. Remove oil pan and strainer tube. (See *Lubrication System* in this section.)
2. Remove cylinder head. (See *Cylinder Head, Valves and Manifolds* in this section.)
3. Check cylinder bore for ridges. These ridges can cause damage to piston if ridge is not removed.
4. If necessary, remove ridge from top of cylinder bore using a ridge reamer.
5. Measure connecting rod side play. (See *Checks, Tests and Adjustments* in this section.)
6. Measure connecting rod bearing clearance. (See *Checks, Tests and Adjustments* in this section.)

IMPORTANT: Keep connecting rods and caps together. Rods and caps are a matched set. Note alignment marks on each part.

7. Remove two cap screws, connecting rod cap and bearing inserts.

IMPORTANT: Pistons and cylinders are matched. Pistons must be installed in the cylinders from which they are removed.

8. Note connecting rod alignment mark in relation to the cylinders. Starting at flywheel end with cylinder number one, then two, etc.
9. Push piston and connecting rod out of cylinder bore using a wooden dowel.
10. Disassemble and inspect all parts for wear or damage. (See *Disassembly and Inspection/Replacement* procedures.)



Installation

- Apply clean engine oil on all parts during installation.
- Never reuse connecting rod cap screws, replace with new.

IMPORTANT: Pistons must be installed in cylinders from which they were removed and in the same direction. Be careful not to damage crankshaft rod journal while installing piston.

1. If new piston rings were installed, deglaze cylinder bore. (See procedure in this group.)
2. Install piston and connecting rod into the cylinder from which it was removed, with piston recess on top of piston toward fuel injection pump.

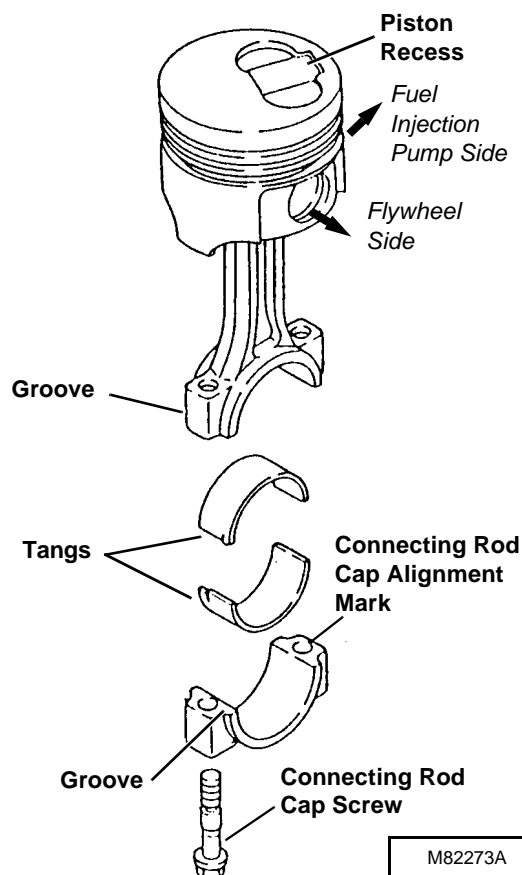
Pistons, Rods and Cylinder Block

IMPORTANT: Do not touch bearing insert surfaces. Oil and acid from your finger will corrode the bearing surface.

3. Install bearing inserts on connecting rod and rod cap, aligning tangs with grooves.

IMPORTANT: Connecting rod caps must be installed on the same connecting rods they were removed from.

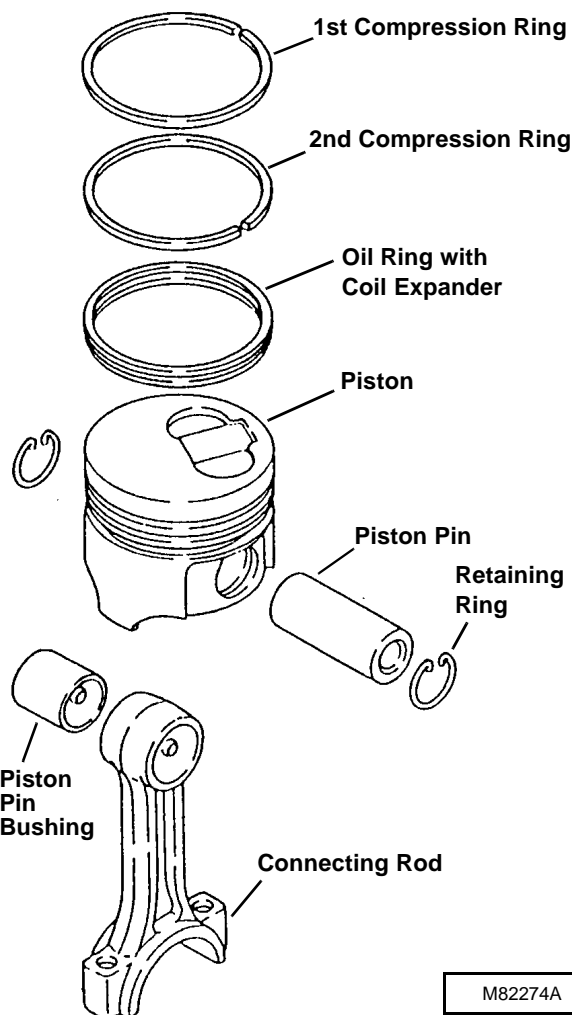
- 1 4. Match the connecting rods to caps using alignment marks. Install caps.
5. Dip entire connecting rod cap screws in clean engine oil. Install new cap screws and tighten to 23 N•m (203 lb-in.).
6. If a new piston and connecting rod were installed, stamp a number corresponding to the cylinder number on the connecting rod cap and connecting rod.



Disassembly

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

- Put a mark on each piston and connecting rod to aid in assembly.
- Piston pin bushing is press fit in connecting rod. Remove bushing only if replacement is necessary. (See *Inspection/Replacement* procedures.)
- Inspect all parts for wear or damage. Replace as necessary. (See *Inspection/Replacement* procedures.)



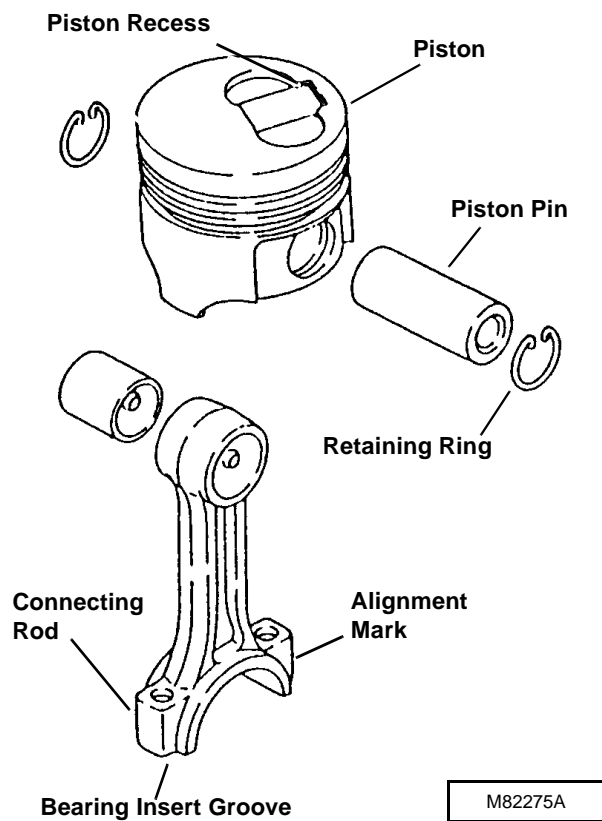
7. Install cylinder head. (See *Cylinder Head, Valves and Manifolds* in this section.)
8. Install oil pan and strainer tube. (See *Lubrication System* in this section.)

Assembly

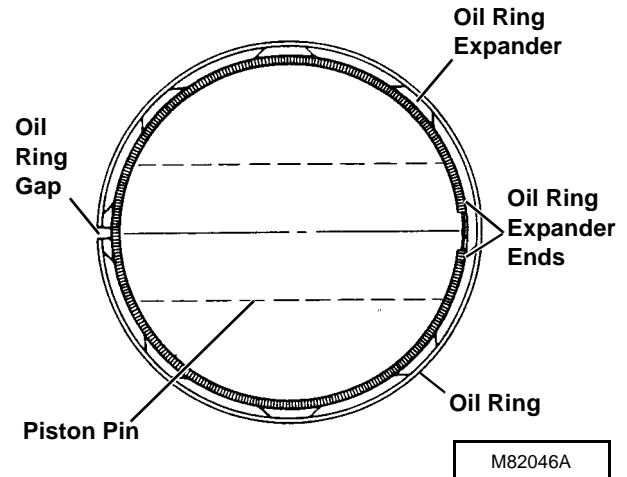
- Apply clean engine oil to all parts during assembly.

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

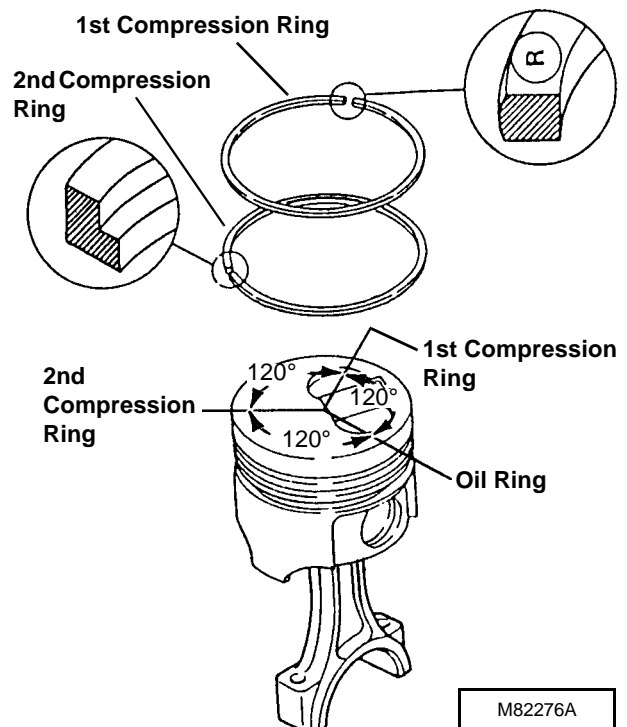
1. Assemble piston to connecting rod with piston recess on same side as connecting rod “punched” alignment mark. If a new connecting rod is used, assemble piston to connecting rod with piston recess opposite connecting rod bearing insert groove.
2. Install piston pin and snap rings.



3. Install oil ring expander in bottom ring groove of piston with ends above either end of piston pin.
4. Install oil ring over expander with ring gap opposite (180°) of expander ends.



5. Install second compression ring, with chamfer toward top of piston, in middle groove. Turn ring until gap is 120° away from oil ring gap.
6. Install first compression ring (chrome plated), with manufacturer's mark “T”, “R” or “RN” (near ring gap) toward top of piston, in top groove. Turn ring until gap is 120° away from second ring gap.

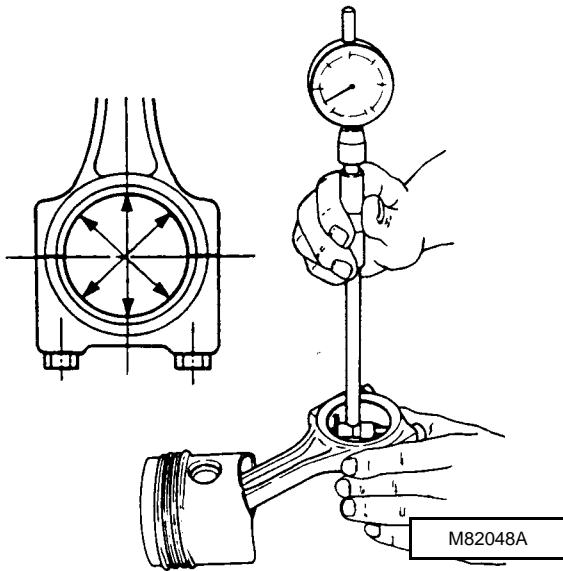


Pistons, Rods and Cylinder Block

Inspection/Replacement

1. Inspect all parts for wear or damage. Replace as necessary.
2. Measure crankshaft connecting rod journal diameter. (See *Crankshaft, Main Bearings and Flywheel* in this section.)
3. Install connecting rod cap and bearing inserts on connecting rod. Install old connecting rod cap screws and tighten to **23 N•m (203 lb-in.)**.
4. Measure connecting rod bearing diameter.

1



Connecting Rod Bearing I.D. - 3TN66:

Standard 36.00 - 36.042 mm
 (1.417 - 1.419 in.)
 Wear Limit..... 37.07 mm (1.459 in.)
 Clearance..... 0.16 mm (0.006 in.)

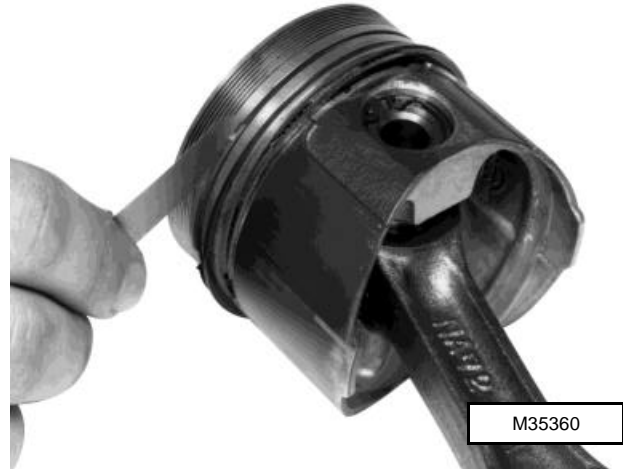
Connecting Rod Bearing I.D. - 3TNA72 (3009):

Standard 40.00 - 40.042 mm
 (1.575 - 1.577 in.)
 Wear Limit..... 40.07 mm (1.578 in.)
 Clearance..... 0.16 mm (0.006 in.)

If bearing diameter exceeds wear limit, replace bearing inserts.

If bearing clearance (bearing I.D. minus crankshaft journal O.D.) exceeds specification, grind crankshaft connecting rod journals and install undersized bearing inserts, or replace bearing inserts and crankshaft.

5. With rings installed on piston, measure piston ring groove clearance. Measure several places around each piston.



Piston Ring Groove Clearance - 3TN66:

First Compression Ring

Standard 0.065 - 0.100 mm
 (0.0026 - 0.0039 in.)
 Wear Limit..... 0.20 mm (0.0079 in.)

Second Compression Ring

Standard 0.030 - 0.065 mm
 (0.0012 - 0.0026 in.)
 Wear Limit..... 0.20 mm (0.0079 in.)

Oil Ring

Standard 0.020 - 0.055 mm
 (0.0008 - 0.0022 in.)
 Wear Limit..... 0.20 mm (0.0079 in.)

Piston Ring Groove Clearance - 3TNA72 (3009):

First Compression Ring

Standard 0.075 - 0.110 mm
 (0.0030 - 0.0043 in.)
 Wear Limit..... 0.20 mm (0.0079 in.)

Second Compression Ring

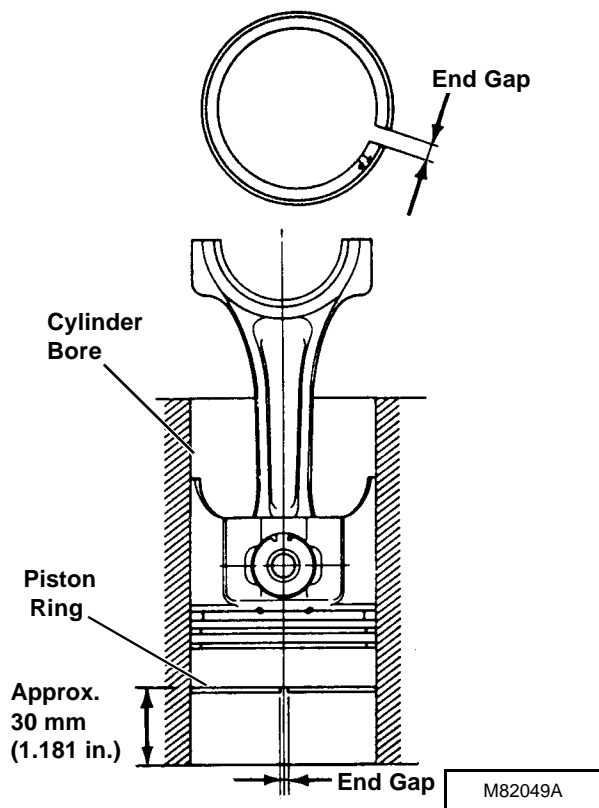
Standard 0.030 - 0.065 mm
 (0.0012 - 0.0026 in.)
 Wear Limit..... 0.20 mm (0.0079 in.)

Oil Ring

Standard 0.020 - 0.055 mm
 (0.0008 - 0.0022 in.)
 Wear Limit..... 0.20 mm (0.0079 in.)

If clearance exceeds wear limit, replace rings or piston.

6. Measure piston ring end gap. Push ring into cylinder bore, using a piston, until ring is approximately **30 mm (1.181 in.)** from bottom of cylinder bore.



Piston Ring End Gap - 3TN66:

Standard

First Compression Ring and Oil Ring 0.15 - 0.35 mm
 (0.006 - 0.014 in.)
Second Compression Ring .. 0.25 - 0.40 mm
 (0.010 - 0.016 in.)
Wear Limit..... 1.50 mm (0.0591 in.)

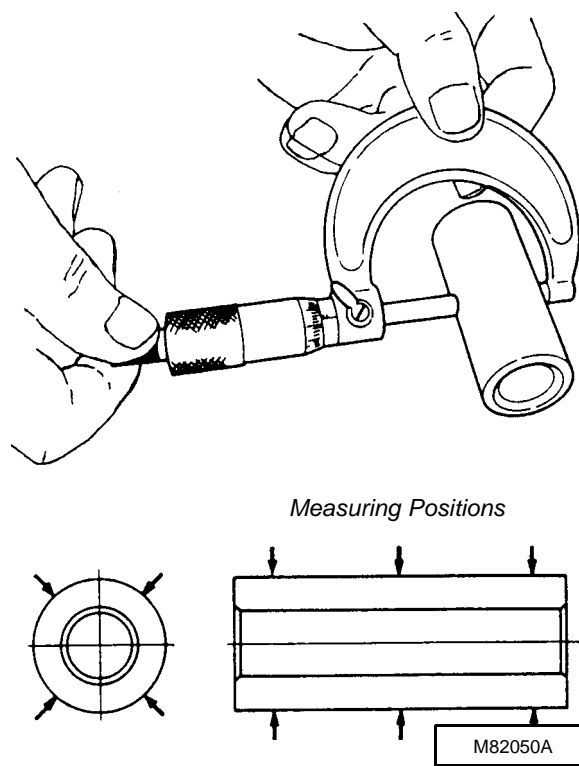
Piston Ring End Gap - 3TNA72 (3009):

Standard

First Compression Ring 0.10 - 0.25 mm
 (0.004 - 0.010 in.)
Second Compression Ring .. 0.25 - 0.40 mm
 (0.010 - 0.016 in.)
Oil Ring 0.15 - 0.35 mm
 (0.006 - 0.014 in.)
Wear Limit: 1.50 mm (0.0591 in.)

If end gap exceeds wear limit, replace rings.

7. Measure piston pin diameter. Measure diameter at six places.



Pistons, Rods and Cylinder Block

Piston Pin O.D. - 3TN66:

Standard 19.991 - 20.00 mm
.....(0.787 - 0.788 in.)
Wear Limit..... 19.975 mm (0.786 in.)

Piston Pin O.D. - 3TNA72 (3009):

Standard 20.991 - 21.00 mm
.....(0.826 - 0.827 in.)
Wear Limit..... 20.975 mm (0.825 in.)

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If pin diameter is less than wear limit, replace pin.

8. Measure piston pin bore diameter in piston.



M37683

Piston Pin Bore I.D. - 3TN66:

Standard 20.00 - 20.008 mm
.....(0.787 - 0.788 in.)
Wear Limit..... 20.02 mm (0.788 in.)
Clearance..... 0.045 mm (0.0018 in.)

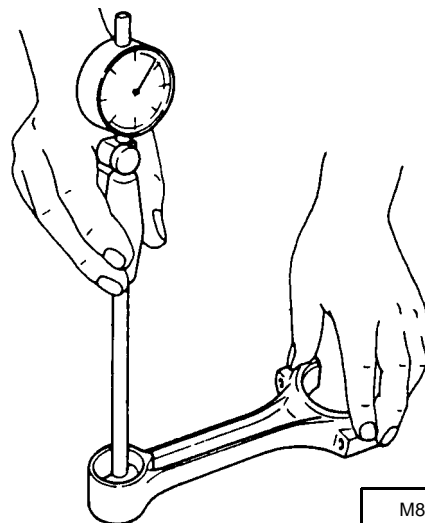
Piston Pin Bore I.D. - 3TNA72 (3009):

Standard 21.00 - 21.009 mm
.....(0.8268 - 0.8271 in.)
Wear Limit..... 21.02 mm (0.828 in.)
Clearance..... 0.045 mm (0.0018 in.)

If piston pin bore exceeds wear limit, replace piston.

If bore clearance (bore I.D. minus pin O.D.) exceeds specification, replace piston, piston pin or both.

9. Measure piston pin bushing diameter in connecting rod.



M82051A

Piston Pin Bushing I.D. - 3TN66:

Standard 20.025 - 20.038 mm
.....(0.788 - 0.789 in.)
Wear Limit..... 20.10 mm (0.781 in.)
Clearance..... 0.11 mm (0.0043 in.)

Piston Pin Bushing I.D. - 3TNA72 (3009):

Standard 21.025 - 21.038 mm
.....(0.8278 - 0.8282 in.)
Wear Limit..... 21.10 mm (0.831 in.)
Clearance..... 0.11 mm (0.0043 in.)

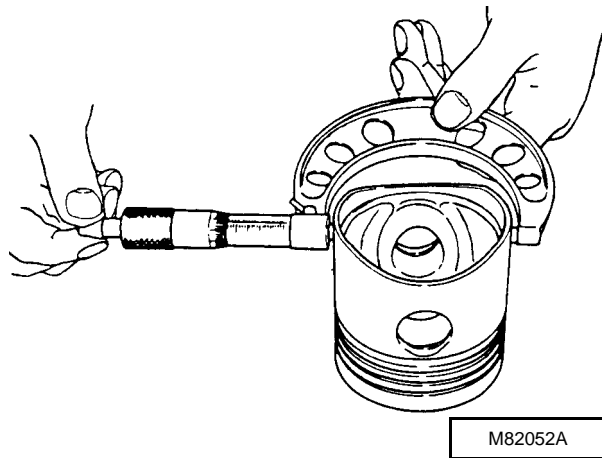
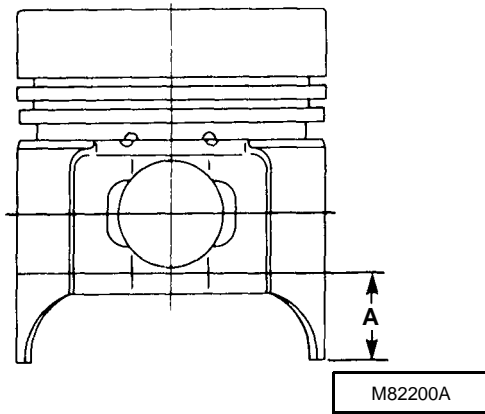
If bushing diameter exceeds wear limit, replace bushing.

If bushing clearance (bushing I.D. minus pin O.D.) exceeds specification, replace bushing, piston pin or both.

Piston pin bushing is press fit. Replace bushing using a driver set. When installing bushing, make sure to align oil hole in bushing with hole in connecting rod.

10. Measure piston diameter perpendicular to piston pin bore at distance A.

NOTE: If engine has had a previous major overhaul, oversize pistons and rings may have been installed. Pistons and rings are available in 0.25 mm (0.010 in.) and 0.50 mm (0.020 in.) oversize.



Piston O.D. - 3TN66:

Distance A5 mm (0.197 in.)

Standard Size Piston

Standard 65.927 - 65.957 mm
.....(2.596 - 2.597 in.)

Wear Limit..... 65.85 mm (2.593 in.)

0.25 mm (0.010 in.) Oversize Piston

Standard 66.18 - 66.21 mm
.....(2.606 - 2.607 in.)

Wear Limit..... 66.10 mm (2.602 in.)

0.50 mm (0.020 in.) Oversize Piston

Standard 66.43 - 66.46 mm
.....(2.615 - 2.616 in.)

Wear Limit..... 66.35 mm (2.612 in.)

Piston O.D. - 3TNA72 (3009):

Distance A8 mm (0.315 in.)

Standard Size Piston

Standard 71.922 - 71.952 mm
.....(2.832 - 2.833 in.)

Wear Limit..... 71.81 mm (2.827 in.)

0.25 mm (0.010 in.) Oversize Piston

Standard 72.17 - 72.20 mm
.....(2.841 - 2.842 in.)

Wear Limit..... 72.06 mm (2.837 in.)

0.50 mm (0.020 in.) Oversize Piston

Standard 72.42 - 72.45 mm
.....(2.851 - 2.852 in.)

Wear Limit..... 72.31 mm (2.847 in.)

If piston diameter is less than wear limit, install a new piston.

11.Measure cylinder bore diameter. (See procedure in this group.)

1

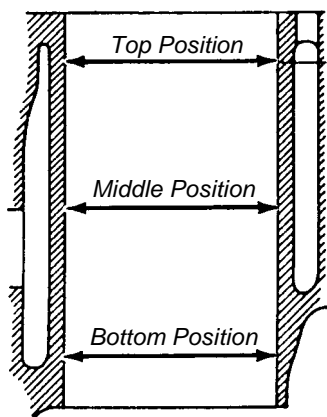
Pistons, Rods and Cylinder Block

CYLINDER BORE

Inspection

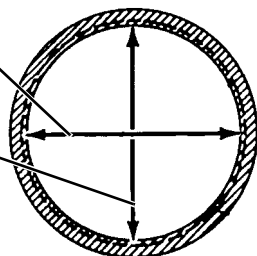
Measure cylinder bore diameter at three positions; top, middle and bottom. At these three positions, measure in both directions; along crankshaft center line and direction of crankshaft rotation.

1 *NOTE: If engine has had a previous major overhaul, oversize pistons and rings may have been installed.*



Direction of Crankshaft Rotation

Direction of Crankshaft Centerline



M82053A

Cylinder Bore I.D. - 3TN66:

Standard Size Bore

Standard 66.00 - 66.03 mm
..... (2.599 - 2.600 in.)
Wear Limit 66.20 mm (2.606 in.)
Clearance 0.25 mm (0.010 in.)

0.25 mm (0.010 in.) Oversize Bore

Standard 66.25 - 66.28 mm
..... (2.609 - 2.610 in.)
Wear Limit 66.45 mm (2.616 in.)

0.50 mm (0.020 in.) Oversize Bore

Standard 66.50 - 66.53 mm
..... (2.619 - 2.620 in.)
Wear Limit 66.70 mm (2.626 in.)

Cylinder Bore I.D. - 3TNA72 (3009):

Standard Size Bore

Standard 72.00 - 72.03 mm
..... (2.835 - 2.836 in.)
Wear Limit 72.20 mm (2.843 in.)
Clearance 0.28 mm (0.011 in.)

0.25 mm (0.010 in.) Oversize Bore

Standard 72.25 - 72.28 mm
..... (2.845 - 2.846 in.)
Wear Limit 72.45 mm (2.852 in.)

0.50 mm (0.020 in.) Oversize Bore

Standard 72.50 - 72.53 mm
..... (2.855 - 2.856 in.)
Wear Limit 72.70 mm (2.862 in.)

If cylinder bore exceeds wear limit, replace cylinder block or have cylinder rebored. (See *Reboring* procedure.)

If cylinder is rebored, oversize pistons and rings must be installed. Pistons and rings are available in 0.25 mm (0.010 in.) and 0.50 mm (0.020 in.) oversize.

If clearance (cylinder bore I.D. minus piston O.D.) exceeds specification, replace cylinder block, piston or both; or rebore cylinder and install oversize piston and rings.

Deglazing

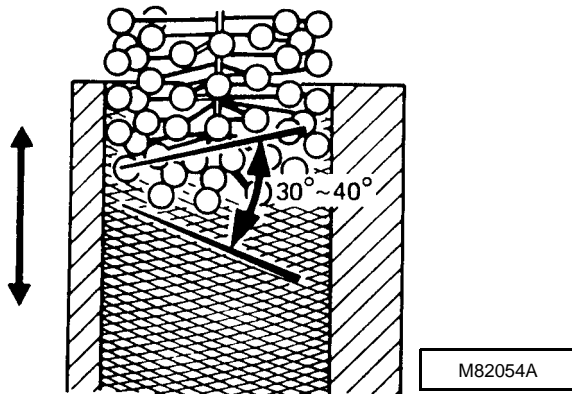
IMPORTANT: If cylinder bores are to be deglazed with crankshaft installed in engine, put clean shop towels over crankshaft to protect journal and bearing surfaces from any abrasives.

1. Deglaze cylinder bores using a flex-hone with 180 grit stones.

- Use flex-hone as instructed by manufacturer to obtain a **30 - 40° cross-hatch pattern** as shown.

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

- Remove excess abrasive residue from cylinder walls using a clean dry rag. Clean cylinder walls using clean white rags and warm soapy water. Continue to clean cylinder until white rags show no discoloration.



Reboring

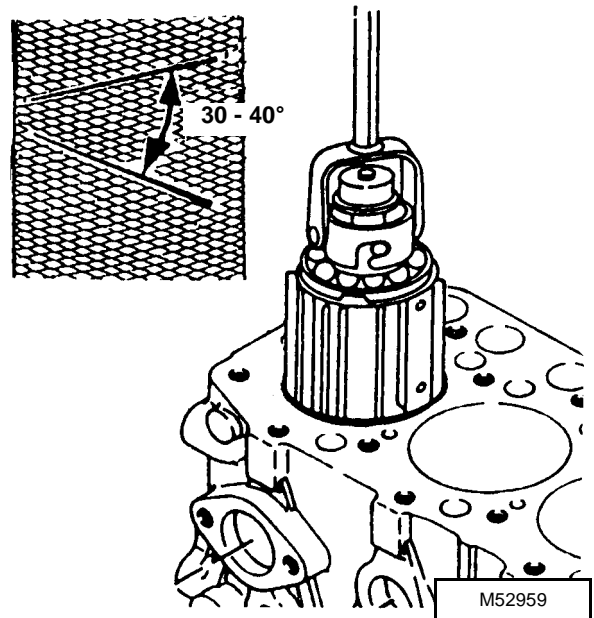
NOTE: The cylinder block can be rebored to use oversize pistons and rings. Pistons and rings are available in 0.25 mm (0.010 in.) and 0.50 mm (0.020 in.) oversize. (See this group for cylinder bore I. D. specifications.)

- Align center of bore to drill press center.

IMPORTANT: Check stone for wear or damage. Use a rigid hone with 300 grit stones.

- Adjust hone so lower end is even with lower end of cylinder bore.
- Adjust rigid hone stones until they contact narrowest point of cylinder.
- Coat cylinder with honing oil. Hone should turn by hand. Adjust if too tight.

- Run drill press at about 250 RPM. Move hone up and down in order to obtain a **30 - 40° crosshatch pattern**.



NOTE: Measure bore when cylinder is cool.

- Stop press and check cylinder diameter.

NOTE: Finish should not be smooth. It should have a 30 - 40° crosshatch pattern.

- Remove rigid hone when cylinder is within 0.03 mm (0.001 in.) of desired size.
- Use a flex hone with 180 grit stones for honing to final size.
- Check bore for size, taper and out-of-round. (See *Inspection* procedures.)

IMPORTANT: Do not use solvents to clean cylinder bore. Solvents will not remove all metal particles and abrasives produced during honing.

- Clean cylinder thoroughly using warm soapy water until clean white rags show no discoloration.
- Dry cylinder and apply engine oil.

Crankshaft, Main Bearings and Flywheel

OTHER MATERIALS

Number	Name	Use
LOCTITE® PRODUCTS U.S./ Canadian/ LOCTITE No.		
1 TY15130/ NA/ #395	John Deere Form-In-Place Gasket	Seals rear oil seal case, crankcase extension housing, (3TNA72 - 670 CUT, 15 EX, 3009 OEM) and flywheel housing (3TNA72 - 15 EX, 3009 OEM) to engine block.

SERVICE PARTS KITS

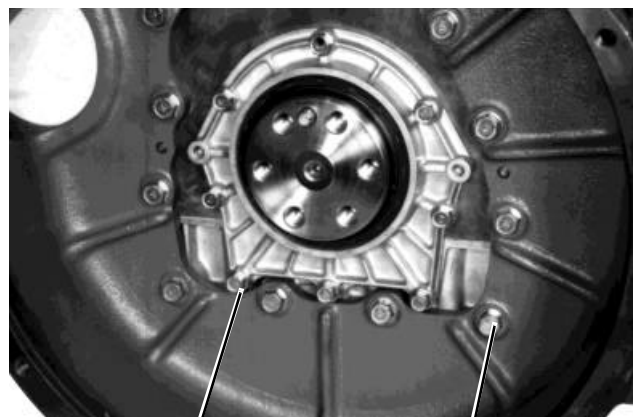
The following kits are available through your parts catalog:

- Cylinder Block Gasket Kit
- Undersized Main Bearing Inserts

®LOCTITE is a registered trademark of the Loctite Corp.

CRANKCASE EXTENSION HOUSING - 3TNA72 (670 CUT)

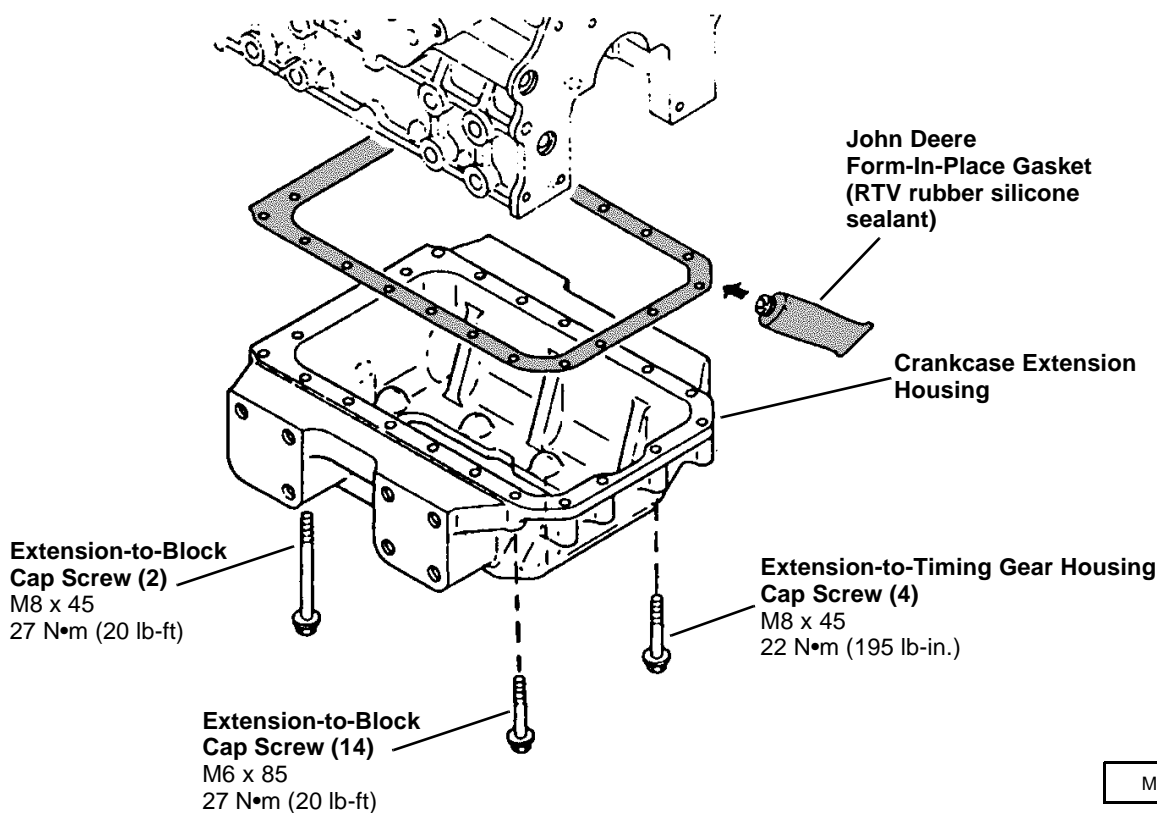
1. Remove flywheel. (See procedure in this group.)
2. Remove oil pan and oil strainer. (See *Lubrication System* in this section.)



Cap Screw (4)
M6 x22
26 N•m (226 lb-in.)

Cap Screw (3)
M10 x 20
49 N•m (36 lb-ft)

M82056



M82277A

Crankshaft, Main Bearings and Flywheel

CRANKCASE EXTENSION HOUSING - 3TNA72 (15 EX and 3009 OEM)

1. Remove flywheel. (See procedure in this group.)
2. Remove oil pan and oil strainer. (See *Lubrication System* in this section.)

1

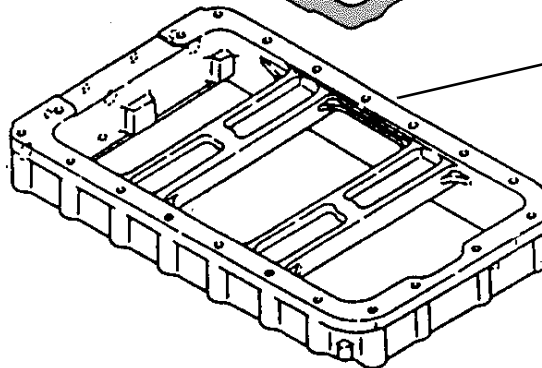
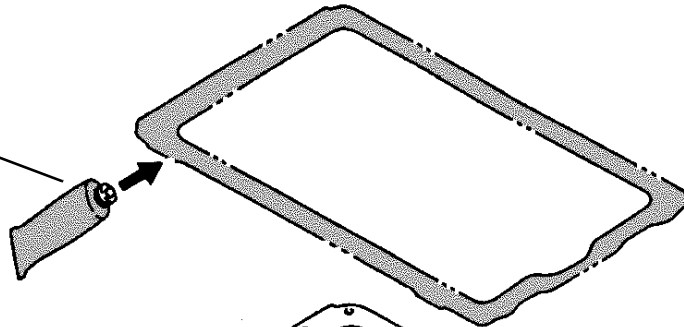


Cap Screw (4)
M6 x 22
26 N•m (226 lb-in.)

Cap Screw (3)
M10 x 28
49 N•m (36 lb-ft)

M82056

John Deere
Form-In-Place Gasket
(RTV rubber silicone
sealant)



Crankcase Extension
Housing

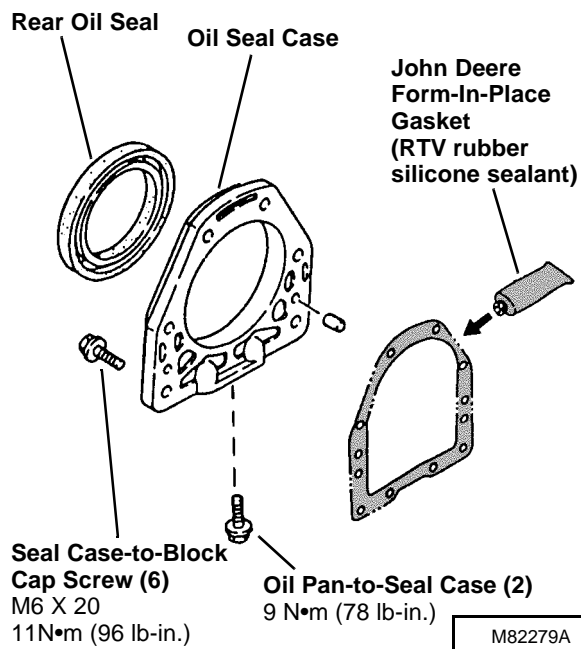
M82202A

CRANKSHAFT REAR OIL SEAL - 3TN66 AND 3TNA72 (430 LGT, 455 LGT, 755/56 CUT, F925/35 FM)

Replacement

1. Remove flywheel plate. (See procedure in this group.)
 - Replace oil seal using a driver set. Install seal, with lip toward cylinder block. Install seal flush with surface of oil seal case.

NOTE: If crankshaft is grooved at oil seal contact point, seal can be installed 3 mm (0.120 in.) farther into oil seal case.

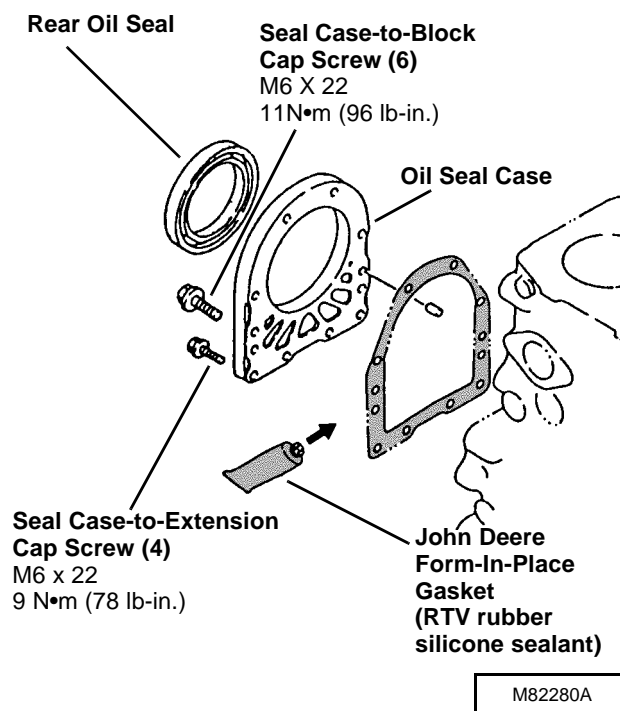


CRANKSHAFT REAR OIL SEAL - 3TNA72 (15 EX, 670 CUT, 3009 OEM)

Replacement

1. Remove flywheel. (See procedure in this group.)
 - Replace oil seal using a driver set. Install seal, with lip toward cylinder block. Install seal flush with surface of oil seal case.

NOTE: If crankshaft is grooved at oil seal contact point, seal can be installed 3 mm (0.120 in.) farther into oil seal case.



1

Crankshaft, Main Bearings and Flywheel

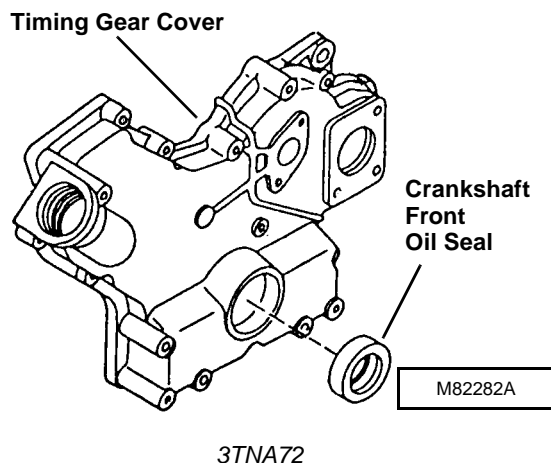
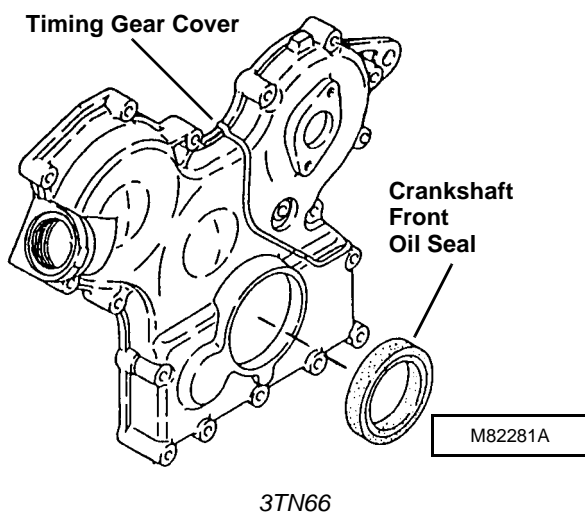
CRANKSHAFT FRONT OIL SEAL

Replacement

NOTE: Timing gear covers are similar. The most common applications are shown.

- Remove timing gear cover. (See *Camshaft and Timing Gear Train* in this section.)
- Replace oil seal using a driver set. Install seal with lip toward inside of gear housing cover. Install seal flush with surface of cover.

1



CRANKSHAFT AND MAIN BEARINGS

Removal

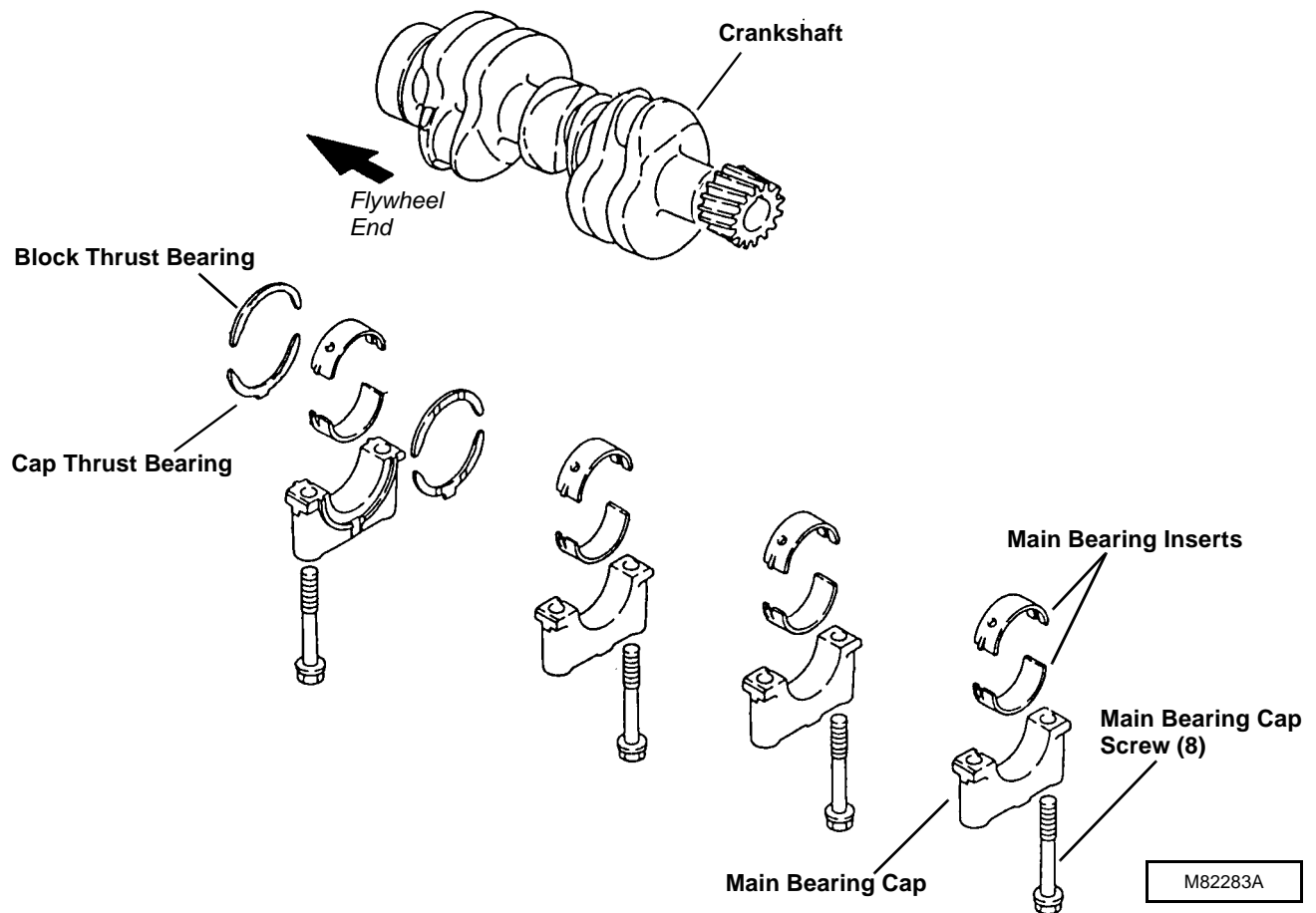
1. Check crankshaft end play. (See *Checks, Tests and Adjustments* in this section.)
2. Remove rear oil seal. (See procedure in this group.)
3. Remove flywheel housing, if equipped. (See procedure in this group.)
4. Remove crankcase extension housing, if equipped. (See procedure in this group.)
5. Remove timing gear housing. (See *Camshaft and Timing Gear Train* in this section.)
6. Check crankshaft bearing clearance. (See *Checks, Tests and Adjustments* in this section.)

IMPORTANT: Connecting rod end caps must be installed on the same connecting rods from which they were removed. Note alignment marks on caps and rods.

7. Remove connecting rod cap screws and end caps.
8. Push pistons and connecting rods away from crankshaft.

IMPORTANT: Main bearing caps must be installed on the same main bearings from which they were removed.

9. Remove main bearing cap screws, caps and cap thrust bearings.
10. Remove crankshaft.
11. Remove block thrust bearings and main bearing inserts.
12. Inspect all parts for wear or damage. (See *Inspection/Replacement* procedures.)



Installation

- Apply clean engine oil on all parts during installation.

IMPORTANT: Do not touch bearing insert surfaces. Oil and acid from your finger will corrode the bearing surface.

1. Install grooved bearing inserts in crankshaft bearing bores, aligning tangs with slots in bores.
2. Install block thrust bearings with oil grooves facing away from engine block.

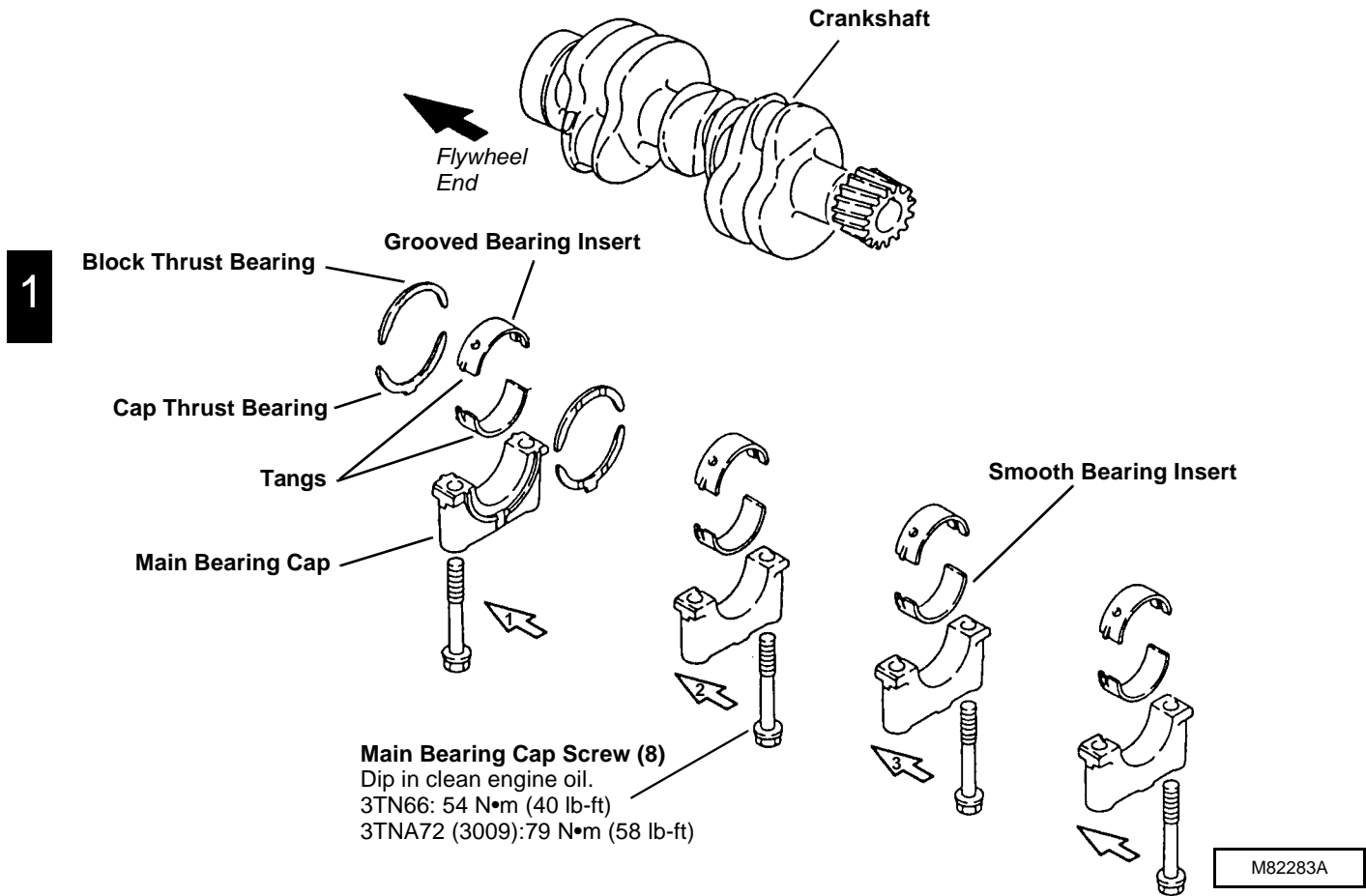
NOTE: Main bearing caps have “raised arrows” that are stamped with numbers. Both correspond to their location on the engine block. The number “1” main bearing bore is at flywheel end. Install bearing caps beginning with number 1, then 2, etc. The main bearing cap at gear train end does not have a number. Also install bearing caps with the “arrow” toward the flywheel end.

3. Install crankshaft.
4. Install smooth bearing inserts in main bearing caps, aligning tangs with slots in caps.
5. Install cap thrust bearings, with oil grooves facing away from cap, in the number “1” main bearing cap.
6. Install main bearing caps in their original locations with arrows pointing toward flywheel side of engine.

IMPORTANT: DO NOT use high speed power tools or air wrenches to tighten main bearing cap screws.

7. Dip entire main bearing cap screws in clean engine oil. Install cap screws and tighten. DO NOT tighten to specifications.
8. Using a soft-faced hammer, tap the front end of the crankshaft then the rear end of the crankshaft to align the thrust bearings.

Crankshaft, Main Bearings and Flywheel



9. Tighten main bearing cap screws to specifications. When tightening, start at center main bearing cap and work your way out, alternating to the ends. Turn crankshaft by hand. If it does not turn easily, disassemble the parts and find the cause.

IMPORTANT: Connecting rod caps must be installed on the same connecting rods they were removed from.

Never reuse connecting rod cap screws, replace with new.

10. Match the connecting rod caps to the rods using alignment marks. Install caps.

11. Dip entire connecting rod cap screws in clean engine oil. Install new cap screws and tighten to **23 N•m (203 lb-in.)**.

12. Install timing gear housing. (See *Camshaft and Timing Gear Train* in this section.)

13. Install crankcase extension housing, if equipped. (See procedure in this group.)

14. Install flywheel housing, if equipped. (See procedure in this group.)

15. Install rear oil seal. (See procedure in this group.)

Inspection/Replacement

1. Inspect crankshaft gear for chipped or broken teeth. Replace if necessary.

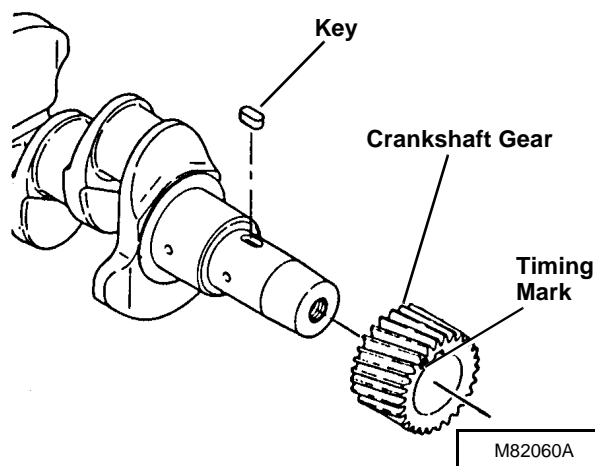
To replace gear:

Remove gear from crankshaft using a knife-edge puller and a press.

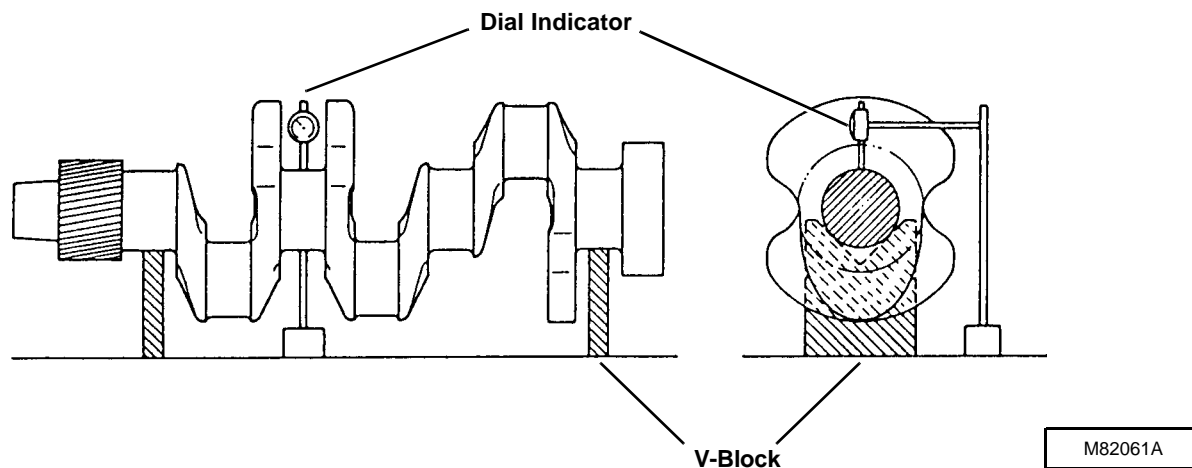
CAUTION

DO NOT heat oil over 182° C (360° F). Oil fumes or oil can ignite above 193° C (380° F). Use a thermometer. Do not allow a flame or heating element to come in direct contact with the oil. Heat the oil in a well-ventilated area. Plan a safe handling procedure to avoid burns.

Heat gear to approximately 150°C (300°F). Install gear with timing mark "A" toward press table. Align slot in gear with key in shaft. Press crankshaft into gear until gear is tight against crankshaft shoulder.



2. Inspect crankshaft for bend using v-blocks and a dial indicator. Turn crankshaft slowly and read variation on indicator. If variation is greater than 0.02 mm (0.0007 in.), replace crankshaft.

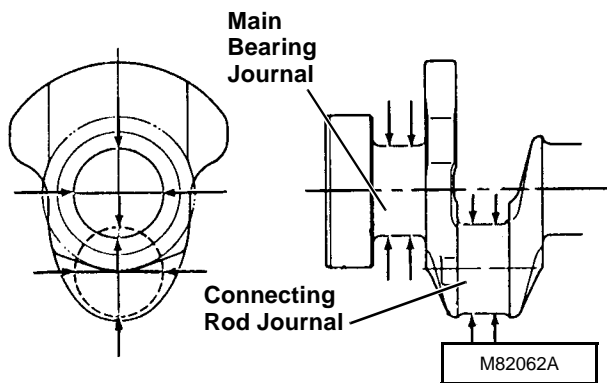


Crankshaft, Main Bearings and Flywheel

3. Measure crankshaft connecting rod journal and main bearing journal diameters. Measure several places around each journal.

NOTE: If engine has had a previous major overhaul, journals may have been ground and undersized bearing inserts installed.

1



Connecting Rod Journal O.D. - 3TN66:

Standard 35.97 - 35.98 mm
 (1.4161 - 1.4165 in.)
Wear Limit..... 35.92 mm (1.414 in.)

Connecting Rod Journal O.D. - 3TNA72 (3009):

Standard 39.97 - 39.98 mm
 (1.5736 - 1.5740 in.)
Wear Limit..... 39.92 mm (1.572 in.)

Main Bearing Journal O.D. - 3TN66:

Standard 39.97 - 39.98 mm
 (1.5736 - 1.5740 in.)
Wear Limit..... 39.92 mm (1.572 in.)

Main Bearing Journal O.D. - 3TNA72 (3009):

Standard 43.97 - 43.98 mm
 (1.7311 - 1.7315 in.)
Wear Limit..... 43.92 mm (1.729 in.)

If journal diameter is less than wear limit, replace crankshaft or have journals ground undersize by a qualified machine shop.

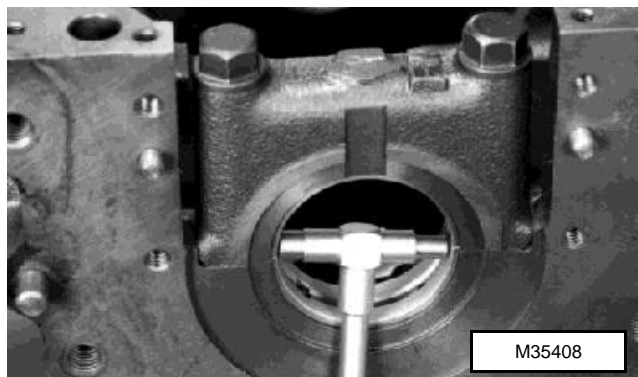
If journals are ground, undersize bearing inserts must be installed. Bearing inserts are available in 0.25 mm (0.010 in.) undersize.

4. Install bearing inserts and main bearing cap on main bearing. Tighten main bearing cap screws to specifications.

Main Bearing Cap Screw Torque Specifications:

3TN66..... 54 N•m (40 lb-ft)
3TNA72 (3009) 79 N•m (58 lb-ft)

5. Measure main bearing diameter.



Main Bearing I.D. - 3TN66:

Standard 40.00 - 40.042 mm
 (1.575 - 1.577 in.)
Wear Limit..... 40.07 mm (1.578 in.)
Clearance..... 0.15 mm (0.0059 in.)

Main Bearing I.D. - 3TNA72 (3009):

Standard 44.00 - 44.042 mm
 (1.732 - 1.734 in.)
Wear Limit..... 44.07 mm (1.735 in.)
Clearance..... 0.15 mm (0.0059 in.)

If bearing diameter exceeds wear limit, replace bearing inserts.

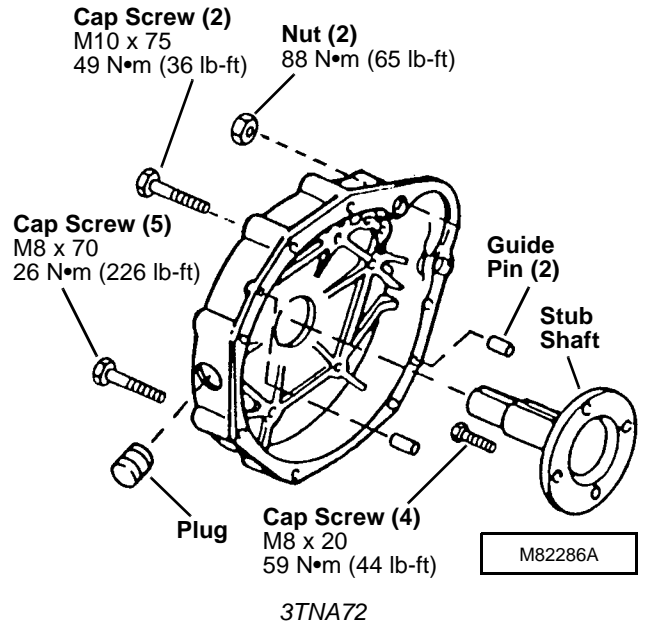
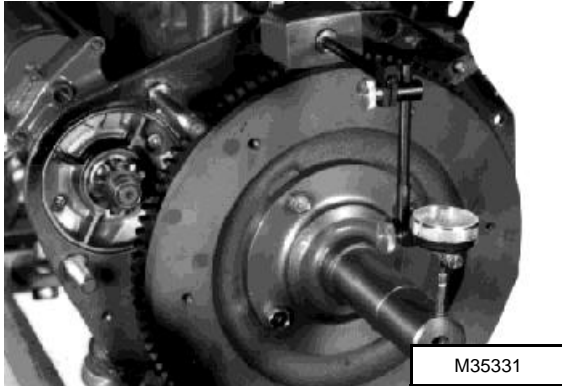
If bearing clearance (bearing I.D. minus crankshaft main bearing journal O.D.) exceeds specification, replace bearing inserts and crankshaft or have crankshaft journals ground undersize by a qualified machine shop and install undersized bearing inserts.

Bearing inserts are available in 0.25 mm (0.010 in.) undersize.

6. Clean and inspect oil passages in main bearing journals, connecting rod journals and main bearing bores in cylinder block.
7. Inspect crankshaft for cracks or damage. Replace if necessary.

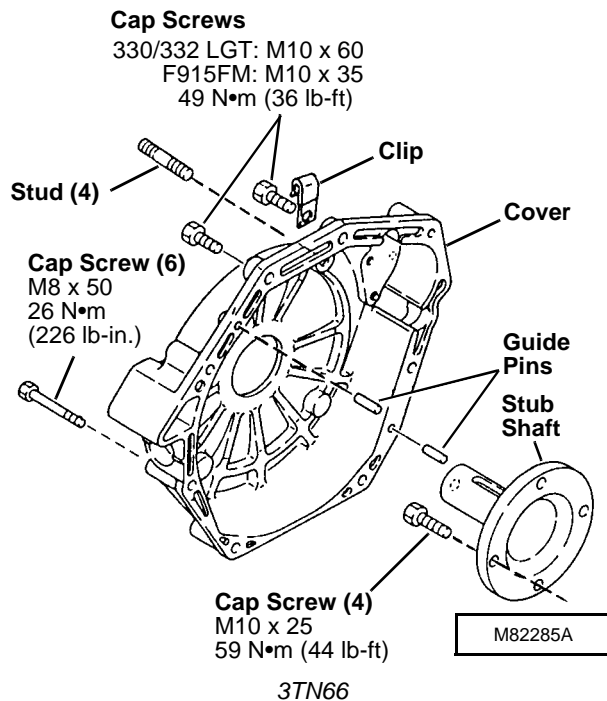
STUB SHAFT - 3TN66 (330/332 LGT, F915 FM) AND 3TNA72 (430 LGT, F925/35 FM)

1. Remove electric clutch. (See procedure in Machine Technical Manual.)
2. Remove cover.
3. Measure stub shaft TIR (total indicated runout) using a dial indicator. If TIR exceeds **(0.20 mm (0.008 in.))**, replace stub shaft.



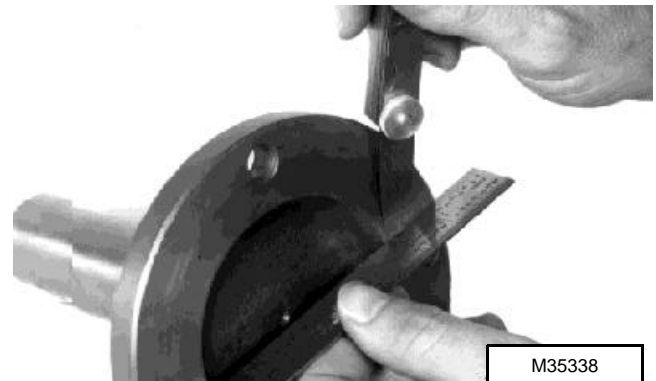
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4. Remove stub shaft.



5. Measure stub shaft mounting flange flatness. Place a straight edge across stub shaft mounting surface. Measure clearance between straight edge and mounting surface with a feeler gauge. If clearance exceeds **0.05 mm (0.002 in.)**, replace stub shaft.

Installation is done in reverse order of removal.



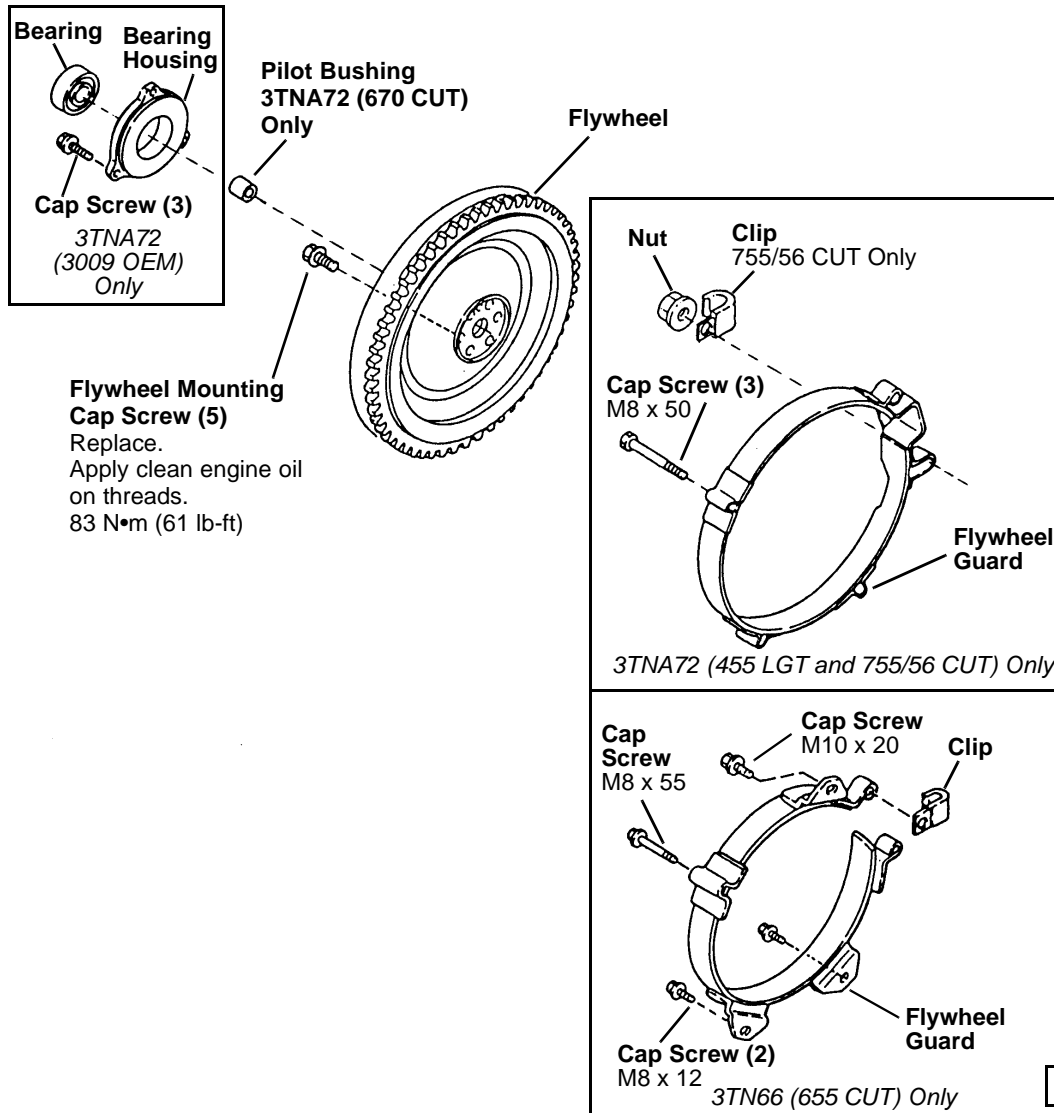
Crankshaft, Main Bearings and Flywheel

FLYWHEEL

1. 3TN66 (330/332 LGT and F915 FM) and 3TNA72 (430 LGT and F925/35 FM). Remove stub shaft. (See procedure in this group.)
 - 3TN66 (655 CUT) and 3TNA72 (455 LGT and 755/56 CUT): Remove starter and flywheel guard.

- 3TNA72 (3009 OEM): Remove bearing housing.
- 3TN66 (375 SSL) and 3TNA72 (15 EX): Remove center flex coupler. (See procedure in Machine Technical Manual.)

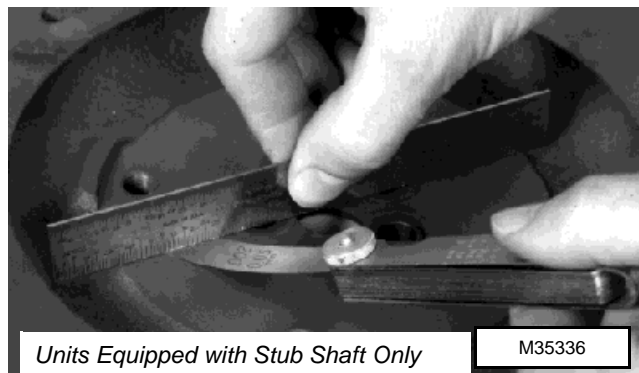
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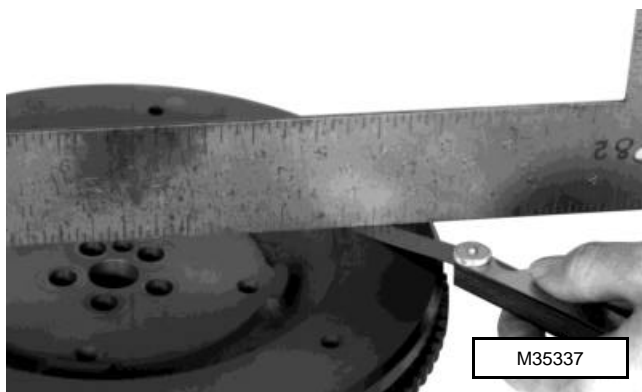
2. Remove mounting cap screws and flywheel.

IMPORTANT: Never reuse flywheel mounting cap screws. Always install new.

- Inspect pilot bushing, if equipped, for wear or damage. Replace if necessary using a driver set. Install bushing flush with flywheel surface.
- Measure flywheel flatness. Place a straight edge across flywheel surface opposite of ring gear. Measure clearance between straight edge and flywheel surface with a feeler gauge. If clearance exceeds **0.02 mm (0.0008 in.)**, replace flywheel.



1



FLYWHEEL HOUSING - 3TNA72 (15 EX, 3009 OEM)

1. Remove flywheel. (See procedure in this group.)
2. Remove starter.

**Housing-to-Block
Cap Screw (6)**
M10 x 25
49 N•m (36 lb-ft)

Flywheel Housing

**John Deere Form-In-Place Gasket
(RTV rubber silicone sealant)**

Plug

**Housing-to-Extension
Cap Screw (3)**
M10 x 28
49 N•m (36 lb-ft)

M82288A

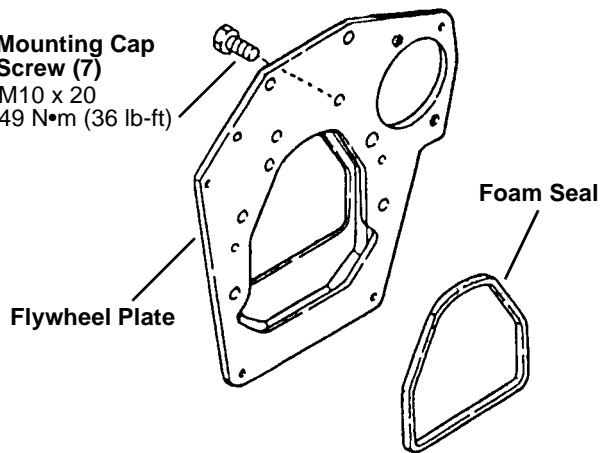
Crankshaft, Main Bearings and Flywheel

FLYWHEEL PLATE - 3TN66 AND 3TNA72 (All Except 15 EX and 3009 OEM)

1. Remove flywheel. (See procedure in this group.)
2. Remove starter.

1

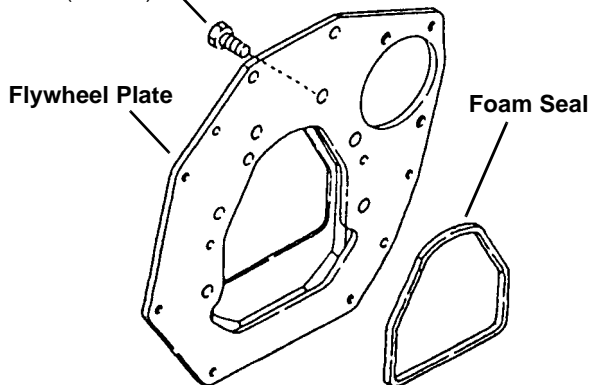
Mounting Cap Screw (7)
M10 x 20
49 N•m (36 lb-ft)



3TN66 (655 CUT)

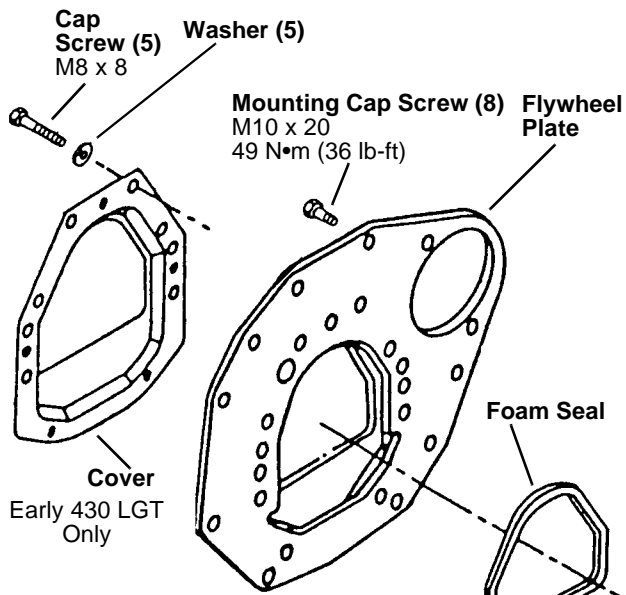
M82289A

Mounting Cap Screw (6)
M10 x 20
49 N•m (36 lb-ft)



3TN66 (375 SSL, 330/332 LGT, F915 FM)

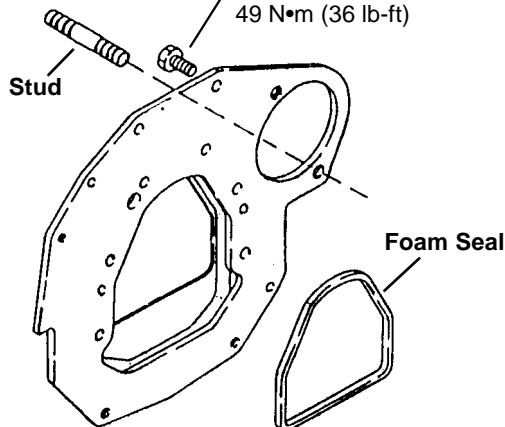
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3TNA72 (430 LGT, F925/35 FM)

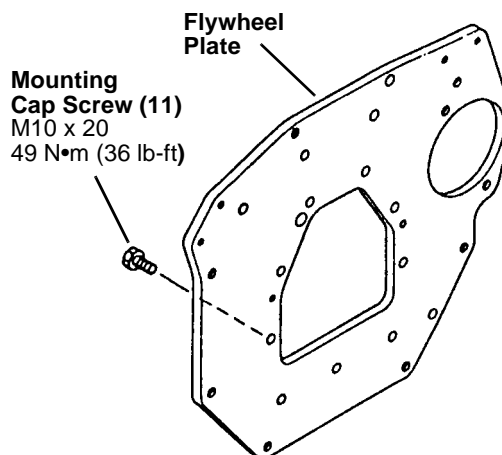
M82357A

Mounting Cap Screw (7)
M10 x 20
49 N•m (36 lb-ft)



3TNA72 (455 LGT, 755/56 CUT)

M82358A



3TNA72 (670 CUT)

M82359A

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).

D15001NU Magnetic Follower Holder Kit

Hold cam followers when removing and installing camshaft.

OTHER MATERIALS

Number	Name	Use
LOCTITE® PRODUCTS		
U.S./		
Canadian/		
LOCTITE No.		
TY15130/ NA/ #395	John Deere Form-In-Place Gasket	Seals camshaft plug, timing gear cover and housing to engine block.
TY9370/ TY9477/ #242	Thread Lock and Sealer (Medium Strength)	Apply to threads of crankshaft pulley cap screw.
TY9369/ NA/ #222	Thread Lock and Sealer (Low Strength)	Apply to threads of studs in timing gear housing.

SERVICE PARTS KITS

The following kits are available through your parts catalog:

- Cylinder Head Gasket Kit
- Cylinder Block Gasket Kit

® LOCTITE is a registered trademark of the Loctite Corp.

Camshaft and Timing Gear Train

CAMSHAFT

Removal

1. Remove rocker arm assembly and push rods. (See *Cylinder Head, Valves and Manifolds* in this section.)
2. Remove timing gear cover. (See procedure in this group.)
3. Check camshaft end play. (See *Checks, Tests and Adjustments* in this section.)
4. Check backlash of timing gears. (See *Checks, Tests and Adjustments* in this section.)

NOTE: If a magnetic follower holder kit is not available, turn engine until oil pan is upward, to hold cam followers away from camshaft.

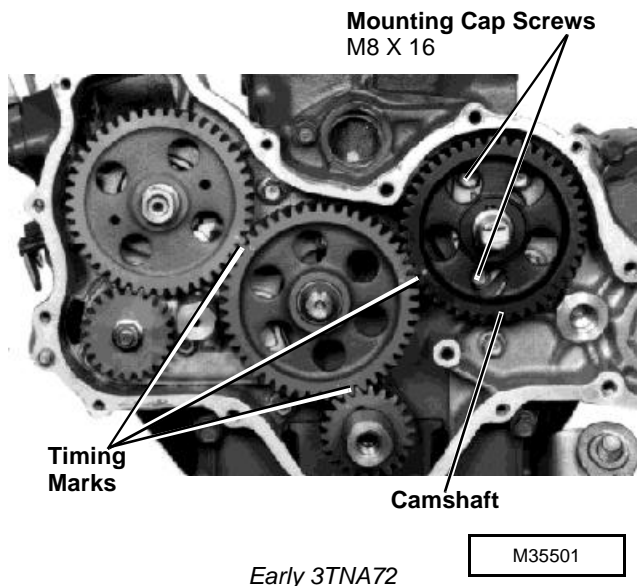
5. Hold cam followers away from camshaft using a magnetic follower holder kit such as D15001NU.

NOTE: Due to the odd number of teeth on the idler gear, timing marks will only align periodically.

6. Rotate crankshaft and align timing marks.

IMPORTANT: DO NOT allow camshaft lobes to hit bearing surfaces while removing camshaft. Machined surfaces can be damaged.

7. Remove two cap screws and camshaft.
8. Inspect all parts for wear or damage. (See *Inspection/Replacement* procedures.)

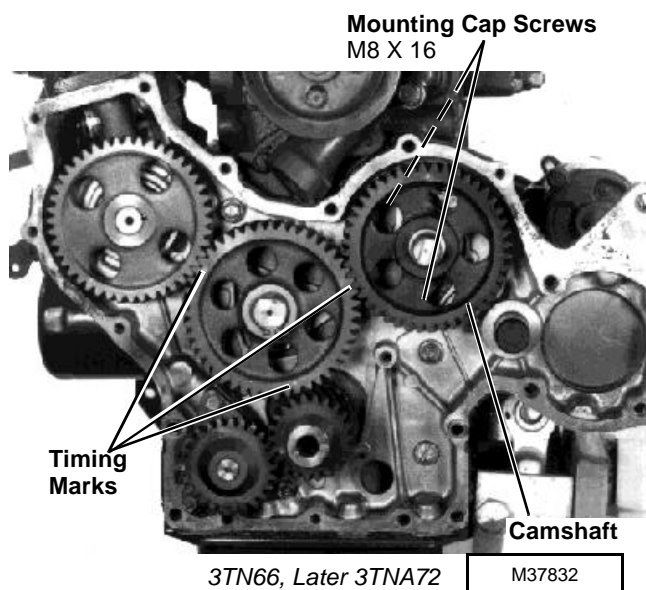


Installation

- Apply clean engine oil on all parts during installation.

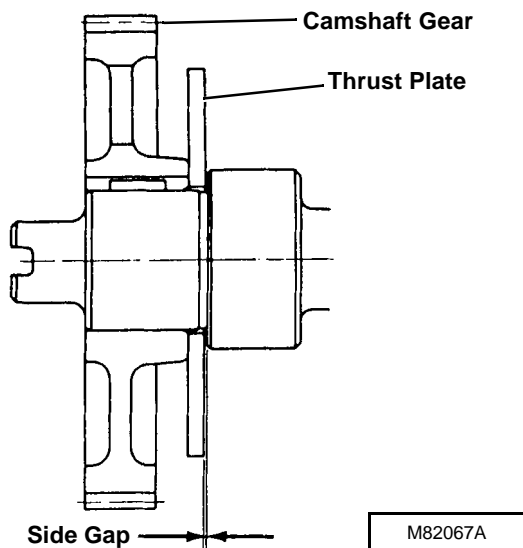
IMPORTANT: DO NOT allow camshaft lobes to hit bearing surfaces while installing camshaft. Machined surfaces can be damaged.

1. Rotate crankshaft to align timing marks.
2. Install camshaft.
3. Install and tighten mounting cap screws to **11 N•m (96 lb-in.)**.
4. Install timing gear cover. (See procedure in this group.)
5. Install push rods and rocker arm assembly. (See *Cylinder Head, Valves and Manifolds* in this section.)



Inspection/Replacement

1. Check camshaft side gap using a feeler gauge.



Camshaft Side Gap:

Standard 0.05 - 0.15 mm
 (0.0020 - 0.0060 in.)

Wear Limit..... 0.40 mm (0.016 in.)

If side gap is at wear limit, remove gear and replace thrust plate.

2. Inspect gear for chipped or broken teeth. Replace if necessary.

To remove/replace gear:

Remove gear from camshaft using a knife-edge puller and a press.

CAUTION

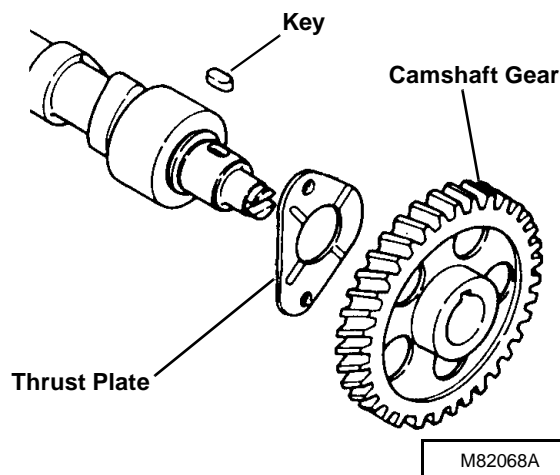
DO NOT heat oil over 182° C (360° F). Oil fumes or oil can ignite above 193° C (380° F). Use a thermometer. Do not allow a flame or heating element to come in direct contact with the oil. Heat the oil in a well-ventilated area. Plan a safe handling procedure to avoid burns.

Heat gear to approximately 150°C (300°F).

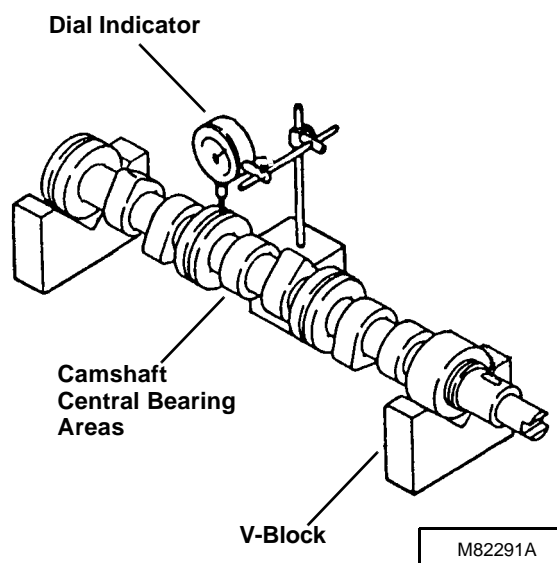
IMPORTANT: Be sure thrust plate is not between camshaft gear and camshaft shoulder while installing gear.

Install thrust plate if removed. Install gear with timing mark "C" side toward press table. Align slot in gear with key in shaft. Press camshaft into gear until gear is tight against camshaft shoulder.

Thrust plate must spin freely on camshaft.

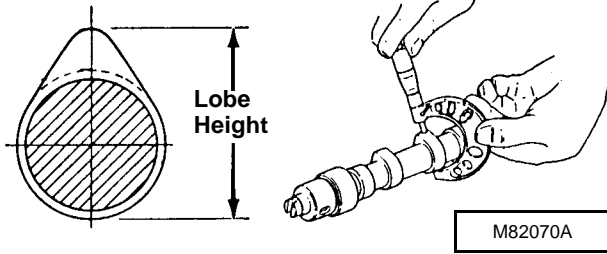


3. Inspect camshaft for bend using v-blocks and a dial indicator. Turn camshaft slowly and read variation on indicator. If variation is greater than 0.02 mm (0.001 in.), replace camshaft.



4. Measure camshaft lobe height.

Camshaft and Timing Gear Train



1 Lobe Height - 3TN66:

Standard 29.97 - 30.03 mm
 (1.180 - 1.182 in.)

Wear Limit..... 29.75 mm (1.171 in.)

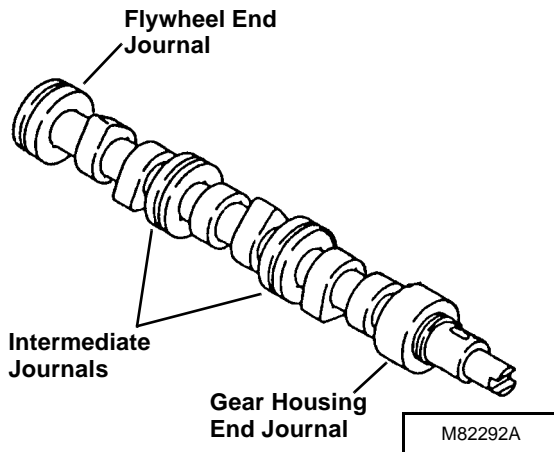
Lobe Height - 3TNA72 (3009):

Standard 33.95 - 34.05 mm
 (1.337 - 1.341 in.)

Wear Limit..... 33.75 mm (1.329 in.)

If lobe height is less than wear limit, replace camshaft.

5. Measure camshaft end and intermediate journal diameters.



Camshaft Journal O.D. - 3TN66:

Gear Housing and Flywheel Ends

Standard 35.94 - 35.96 mm
 (1.4150 - 1.4157 in.)

Wear Limit..... 35.85 mm (1.4114 in.)

Intermediate

Standard 35.91 - 35.94 mm
 (1.4138 - 1.4150 in.)

Wear Limit..... 35.85 mm (1.4114 in.)

Camshaft Journal O.D. - 3TNA72 (3009):

Gear Housing and Flywheel Ends

Standard 39.94 - 39.96 mm
 (1.5724 - 1.5732 in.)

Wear Limit..... 39.85 mm (1.5689 in.)

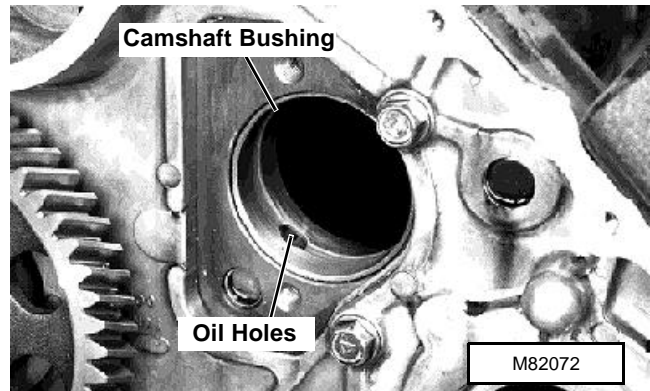
Intermediate

Standard 39.91 - 39.94 mm
 (1.5713 - 1.5724 in.)

Wear Limit..... 39.85 mm (1.5689 in.)

If journal diameters are less than wear limit, replace camshaft.

6. Measure camshaft bushing diameter at gear housing end.



Camshaft Bushing I.D. - 3TN66:

Standard 36.00 - 36.065 mm
 (1.417 - 1.420 in.)

Wear Limit..... 36.10 mm (1.421 in.)

Clearance..... 0.18 mm (0.007 in.)

Camshaft Bushing I.D. - 3TNA72 (3009):

Standard 40.00 - 40.065 mm
 (1.575 - 1.577 in.)

Wear Limit..... 40.10 mm (1.579 in.)

Clearance..... 0.18 mm (0.007 in.)

If bushing diameter exceeds wear limit, replace bushing.

If bushing clearance (bushing I.D. minus camshaft journal O.D.) exceeds specification, replace bushing, camshaft or both.

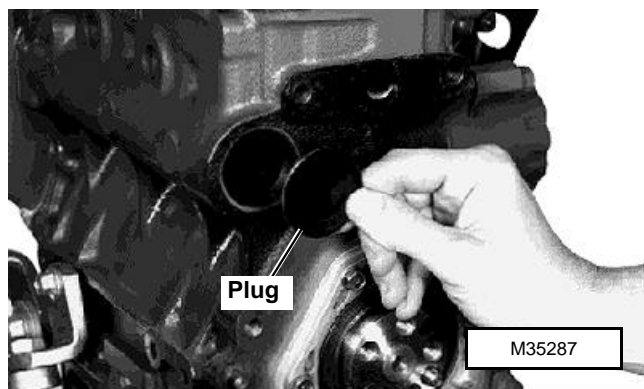
To replace bushing:

Remove bushing using a chisel. Be careful not to push bushing inside of engine. Align oil holes in new bushing and cylinder block. Install bushing using a driver set.

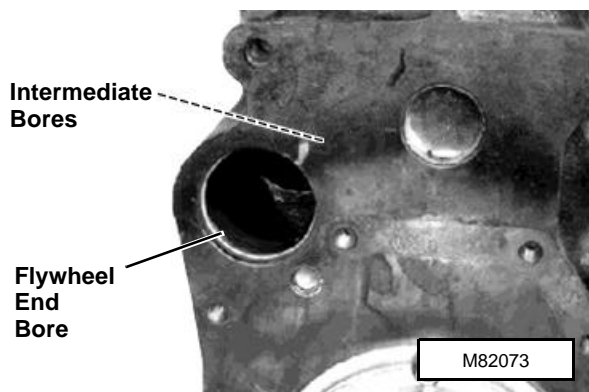
NOTE: Flywheel housing/plate must be removed to measure camshaft intermediate and flywheel end bearing diameters.

7. Measure intermediate and flywheel end camshaft bore diameters using the following procedures:

- Remove flywheel housing/plate. (See *Crankshaft, Main Bearings and Flywheel* in this section.)
- Remove plug using a long wooden dowel. Insert wooden dowel through gear housing side.



- Measure intermediate and flywheel end camshaft bore diameters.



Camshaft Bore I.D. - 3TN66:

Standard 36.00 - 36.025 mm
..... (1.417 - 1.418 in.)

Wear Limit..... 36.10 mm (1.421 in.)

Clearance..... 0.18 mm (0.007 in.)

Camshaft Bore I.D. - 3TNA72 (3009):

Standard 40.00 - 40.025 mm
..... (1.575 - 1.576 in.)

Wear Limit..... 40.10 mm (1.579 in.)

Clearance..... 0.18 mm (0.007 in.)

1

If bore diameter exceeds wear limit, replace cylinder block.

If bore clearance (bore I.D. minus camshaft journal O.D.) exceeds specification, replace camshaft, cylinder block or both.

- Apply John Deere Form-In Place Gasket, or an equivalent, on outer edge of plug. Install plug until it bottoms in bore.
- Install flywheel housing/plate.

CAM FOLLOWERS

Removal/Installation

1. Remove cylinder head. (See *Cylinder Head, Valves and Manifold* in this section.)

IMPORTANT: Cam followers must be installed in the same bores from which they were removed.

2. Put a mark on each cam follower and cylinder block bore to aid in installation.
3. Remove cam followers.
4. Inspect all parts for wear or damage. (See *Inspection* procedures.)
5. Apply clean engine oil on all parts during installation.

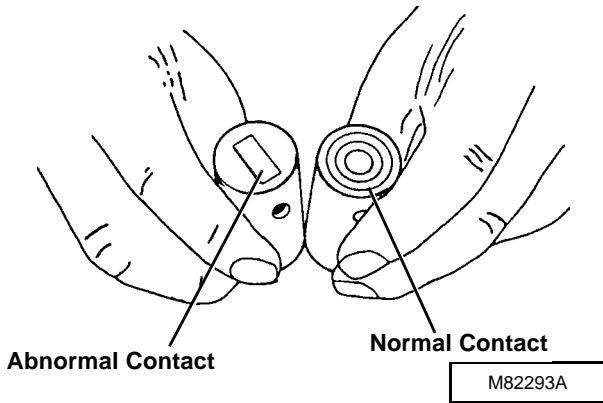
Installation is done in the reverse order of removal.

Camshaft and Timing Gear Train

Inspection

- Inspect cam follower contact surface for abnormal wear. Replace if necessary.

1



- Measure cam follower diameter.



Cam Follower O.D. - 3TN66:

Standard 17.950 - 17.968 mm
 (0.7067 - 0.7074 in.)

Wear Limit..... 17.93 mm (0.706 in.)

Cam Follower O.D. - 3TNA72 (3009):

Standard 20.927 - 20.960 mm
 (0.8239 - 0.8252 in.)

Wear Limit..... 20.93 mm (0.824 in.)

If diameter is less than wear limit, replace cam follower.

- Measure cam follower bore diameter in cylinder block.

Cam Follower Bore I.D. - 3TN66:

Standard 18.00 - 18.018 mm
 (0.7087 - 0.7094 in.)

Wear Limit..... 18.05 mm (0.711 in.)

Clearance..... 0.032 - 0.068 mm
 (0.0013 - 0.0027 in.)

Cam Follower Bore I.D. - 3TNA72 (3009):

Standard 21.00 - 21.021 mm
 (0.8268 - 0.8276 in.)

Wear Limit..... 21.05 mm (0.829 in.)

Clearance..... 0.040 - 0.094 mm
 (0.0016 - 0.0037 in.)

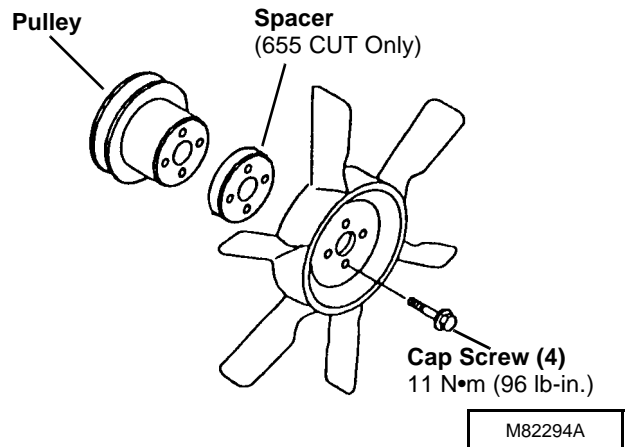
If cam follower bore diameter exceeds wear limit, replace cylinder block.

If bore clearance (bore I.D. minus follower stem O.D.) exceeds specification, replace cam follower, cylinder block or both.

TIMING GEAR COVER - 3TN66

Removal/Installation

- Remove alternator and belt.
- Remove fan, spacer, if equipped, and pulley.
- Remove crankshaft pulley cap screw and washer.
- Remove crankshaft pulley using a two-jaw puller kit.
- Remove tachometer, if equipped.



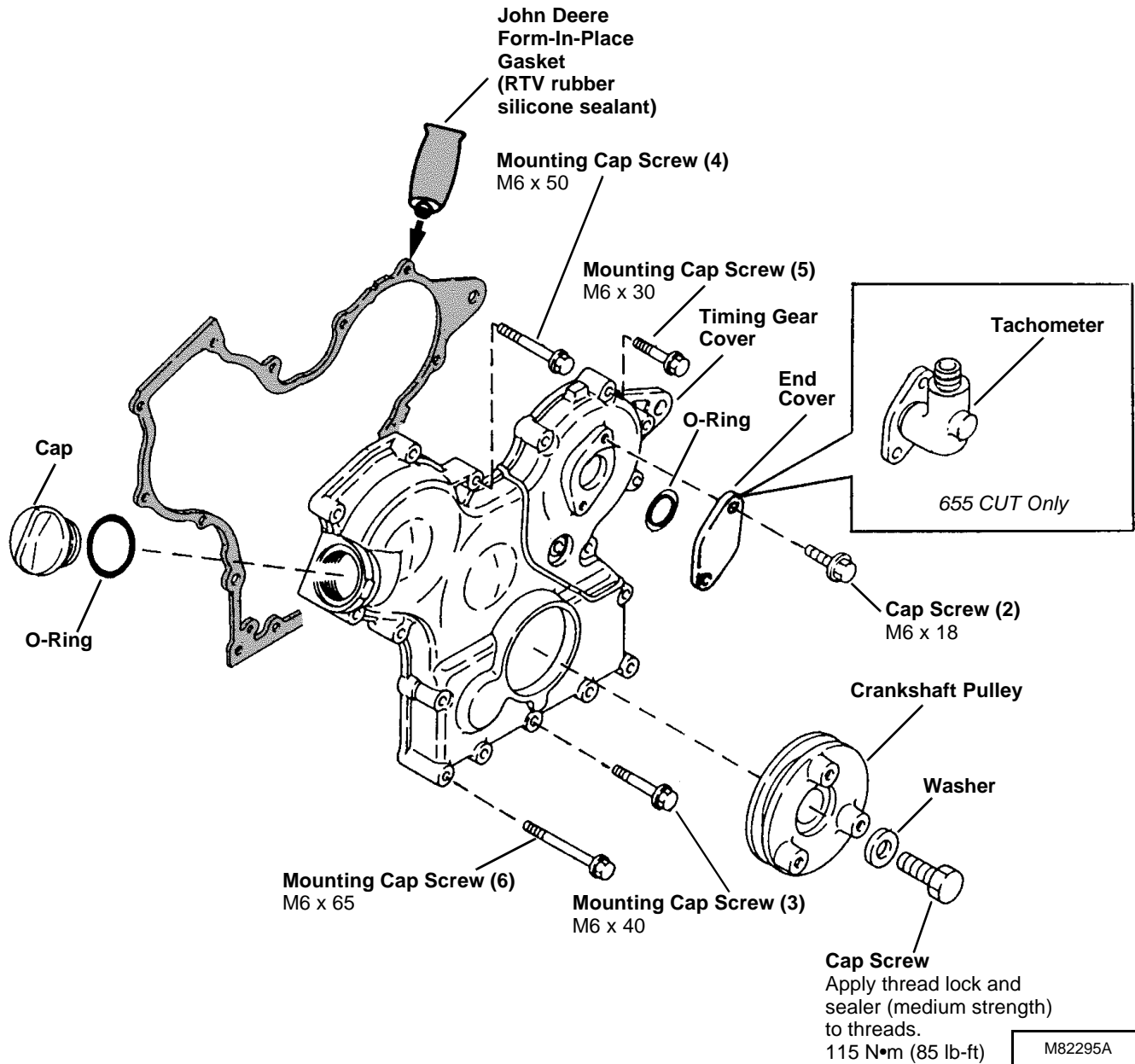
Camshaft and Timing Gear Train

NOTE: It is not necessary to remove end cover and o-ring to remove timing gear cover.

6. Remove 18 mounting cap screws and timing gear cover.

Installation is done in the reverse order of removal.

- Tighten all mounting cap screws to **9 N•m (78 lb-in.)**
- Adjust fan/alternator drive belt tension. (See *Checks, Tests and Adjustments* in this section.)



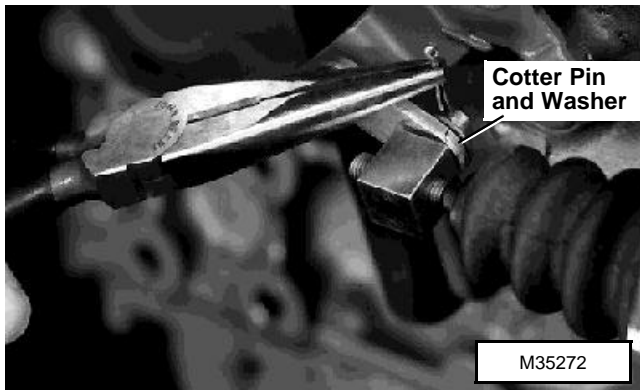
1

Camshaft and Timing Gear Train

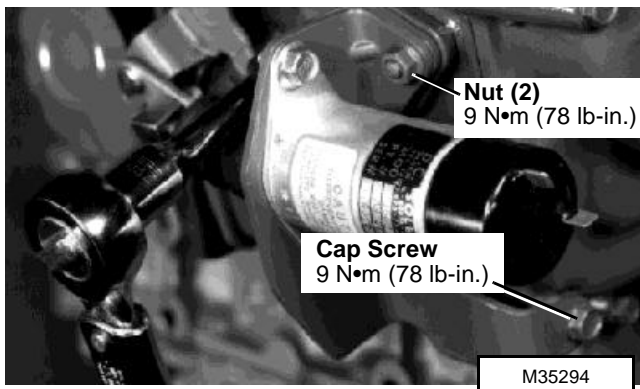
TIMING GEAR COVER - EARLY 3TNA72 (430 LGT)

Removal/Installation

1. Remove alternator and belt.
2. Remove crankshaft pulley cap screw and washer.
3. Remove crankshaft pulley using a two-jaw puller kit.
4. Remove cotter pin and washer to disconnect fuel shutoff solenoid linkage.



5. Remove two nuts and one cap screw to remove bracket and fuel shutoff solenoid.

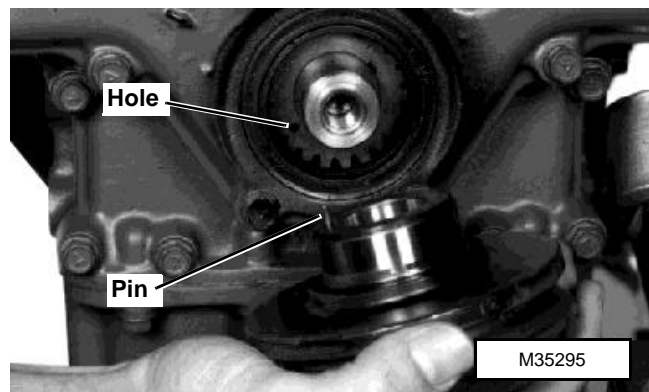


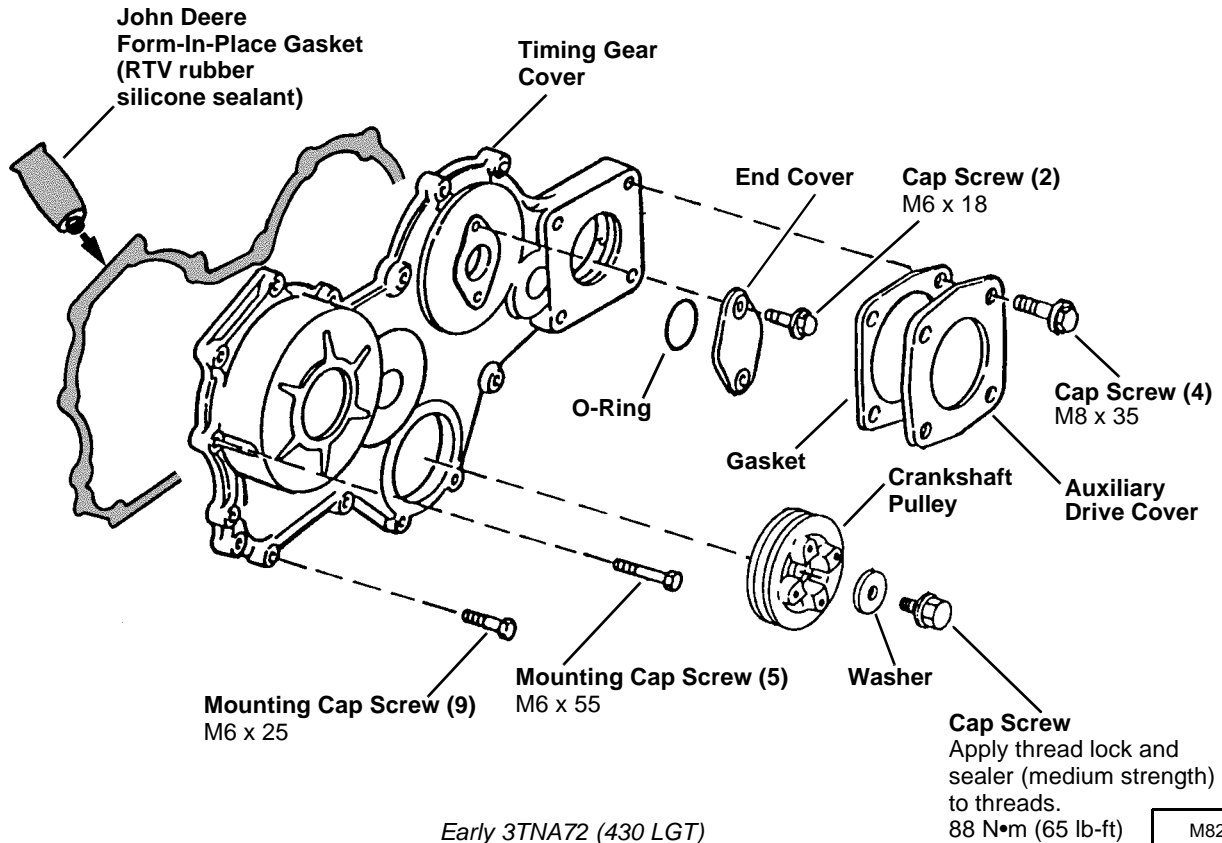
NOTE: It is not necessary to remove auxiliary drive cover and gasket, if equipped, or end cover and o-ring to remove timing gear cover.

6. Remove 14 mounting cap screws and timing gear cover.

Installation is done in the reverse order of removal.

- Tighten all mounting cap screws to **9 N•m (78 lb-in.)**.
- Align pin in crankshaft pulley with hole in crankshaft gear. Install crankshaft pulley.
- Adjust alternator drive belt tension. (See *Checks, Tests and Adjustments* in this section.)





Early 3TNA72 (430 LGT)

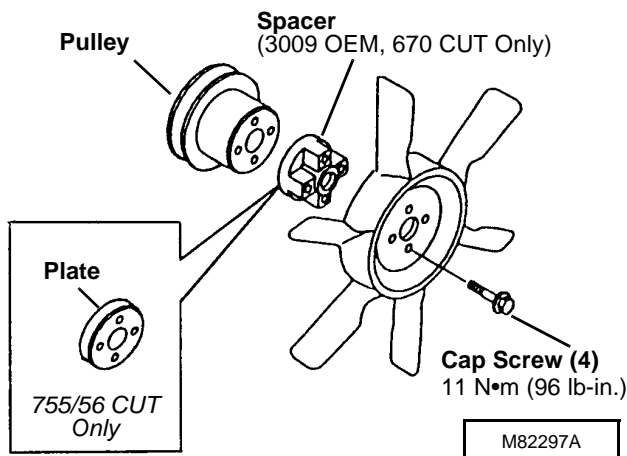
TIMING GEAR COVER - LATER 3TNA72

Removal/Installation

1. Remove alternator and belt.

NOTE: 430 LGT (Later) and F925/35 FM application is not equipped with a fan. Alternator belt pulley does not have to be removed to access timing gear cover.

2. Remove fan, spacer/plate, if equipped, and pulley.



3. Remove crankshaft pulley cap screw and washer.
4. Remove crankshaft pulley using a two-jaw puller kit.
5. Remove tachometer, if equipped.
6. 670 CUT: Remove hydraulic pump and steering pump, if equipped. (See procedures in Machine Technical Manual.)

NOTE: It is not necessary to remove auxiliary drive cover and gasket, if equipped, or end cover and o-ring to remove timing gear cover.

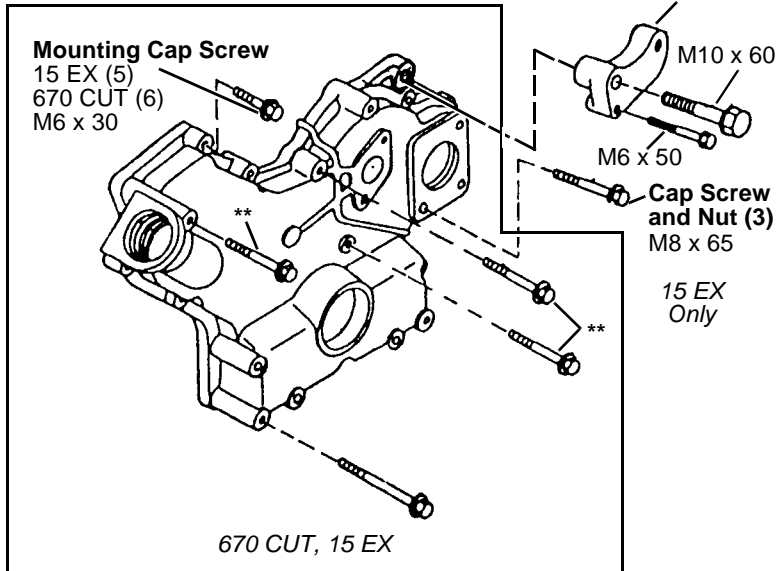
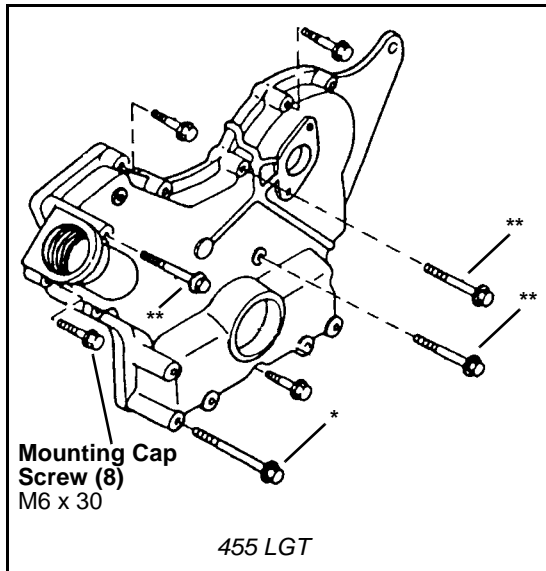
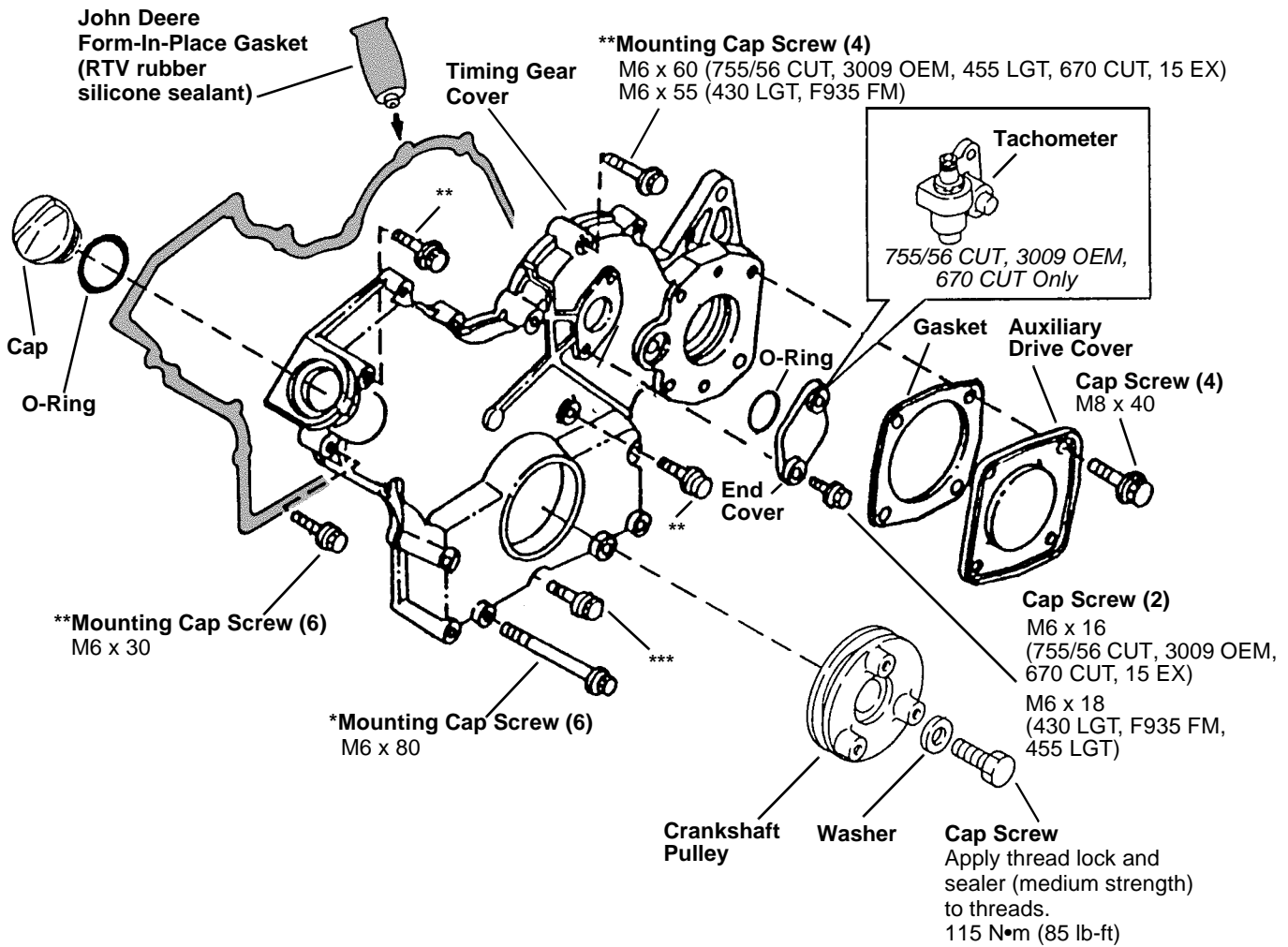
7. Remove mounting cap screws and timing gear cover.

Installation is done in the reverse order of removal.

- Tighten all mounting cap screws to **9 N•m (78 lb-in.)**
- Adjust fan/alternator drive belt tension. (See *Checks, Tests and Adjustments* in this section.)

Camshaft and Timing Gear Train

1



Later 3TNA72

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IDLER GEAR - EARLY 3TNA72 (430 LGT)

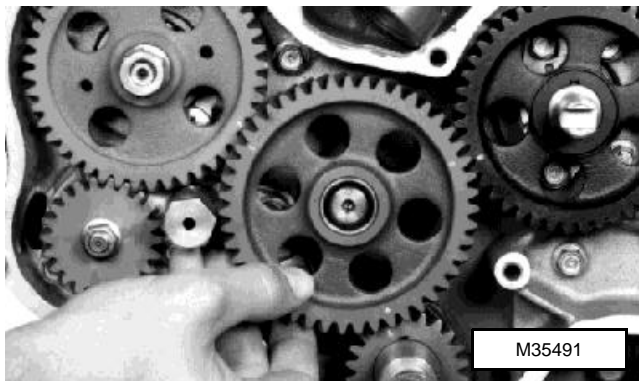
Removal/Installation

1. Remove timing gear cover. (See procedure in this group.)
2. Check backlash of timing gears. (See *Checks, Tests and Adjustments* in this section.)

NOTE: Due to the odd number of teeth on the idler gear, timing marks will only align periodically. When all timing marks on gears are aligned, the piston closest to the water pump is at TDC on compression stroke. Number one cylinder is closest to the flywheel.

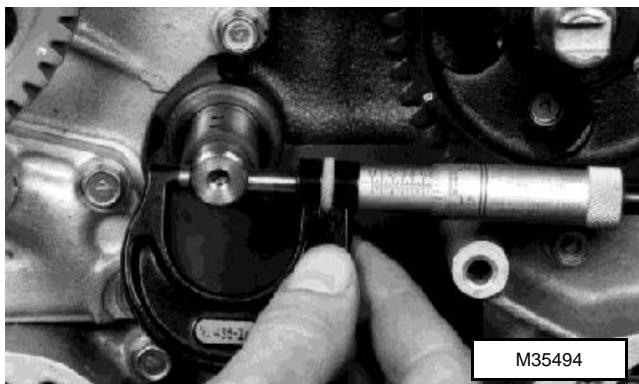
3. Rotate crankshaft and align timing marks.
4. Remove idler gear.
5. Inspect gear and shaft for wear or damage. (See *Inspection/Replacement* procedures.)

Installation is done in the reverse order of removal.



Inspection/Replacement

- Inspect gear for chipped or broken teeth. Replace if necessary.
- Measure idler gear shaft diameter.



Idler Gear Shaft O.D.:

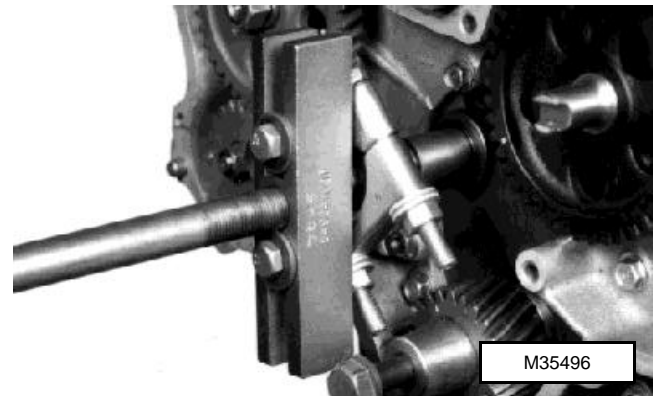
Standard 19.959 - 19.980 mm
..... (0.786 - 0.787 in.)

Wear Limit 19.93 mm (0.785 in.)

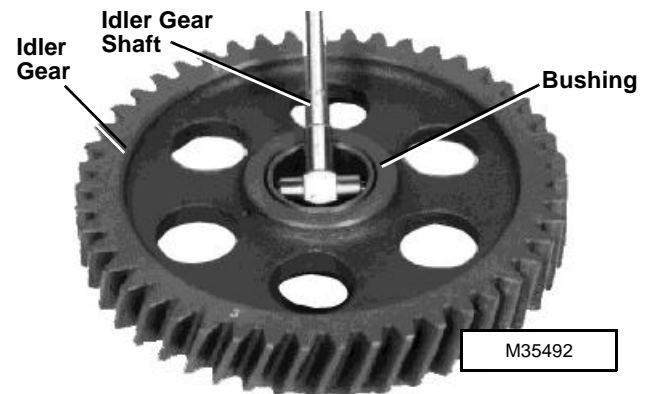
If shaft diameter is less than wear limit, replace idler gear shaft.

To replace shaft:

- Remove set screw in end of shaft. Install a gear cover mounting cap screw with washer into threaded hole. Remove idler shaft using a slide hammer and puller.
- Install shaft with flange toward cylinder block. Install shaft tight against block using a soft-faced hammer. Install set screw.



- Measure idler gear bushing diameter.



Idler Gear Bushing I.D.:

Standard 20.00 - 20.021 mm
..... (0.787 - 0.788 in.)

Wear Limit 20.08 mm (0.791 in.)

Clearance 0.15 mm (0.0059 in.)

If bushing diameter exceeds wear limit, replace bushing.

Camshaft and Timing Gear Train

To replace bushing:

Replace bushing using a driver set. Align oil holes in bushing and idler gear. Install bushing flush with surface of idler gear.

If bushing clearance (bushing I.D. minus shaft O.D.) exceeds specification, replace bushing, shaft or both.

1 IDLER GEAR - 3TN66 AND LATER 3TNA72

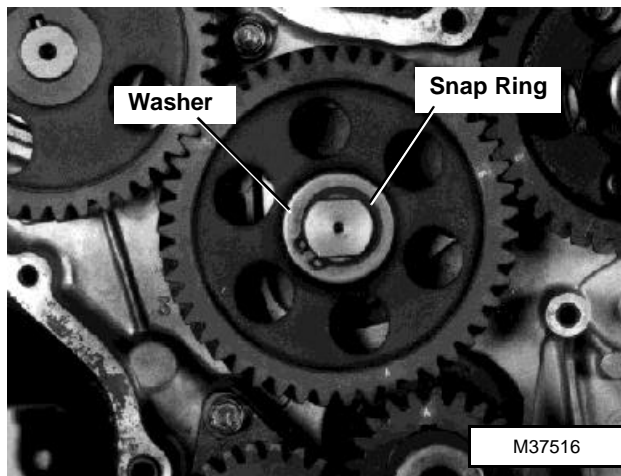
Removal/Installation

1. Remove timing gear cover. (See procedure in this group.)
2. Check backlash of timing gears. (See *Checks, Tests and Adjustments* in this section.)

NOTE: Due to the odd number of teeth on the idler gear, timing marks will only align periodically. When all timing marks on gears are aligned, the piston closest to the water pump is at TDC on compression stroke. Number one cylinder is closest to the flywheel.

3. Rotate crankshaft and align timing marks.
4. Remove snap ring, washer and gear.
5. Inspect all parts for wear or damage. (See *Inspection/Replacement* procedures.)

Installation is done in the reverse order of removal.



Inspection/Replacement

- Inspect gear for chipped or broken teeth. Replace if necessary.
- Measure idler gear shaft diameter.



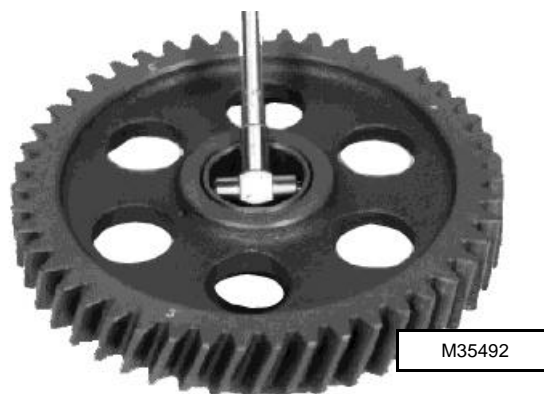
Idler Gear Shaft O.D.:

Standard 19.959 - 19.980 mm
. (0.786 - 0.787 in.)

Wear Limit. 19.93 mm (0.785 in.)

If shaft diameter is less than wear limit, remove three cap screws and replace idler gear shaft.

- Measure idler gear bushing diameter.



Idler Gear Bushing I.D.:

Standard 20.00 - 20.021 mm
. (0.787 - 0.788 in.)

Wear Limit. 20.08 mm (0.791 in.)

Clearance 0.15 mm (0.0059 in.)

If bushing diameter exceeds wear limit, replace bushing.

To replace bushing:

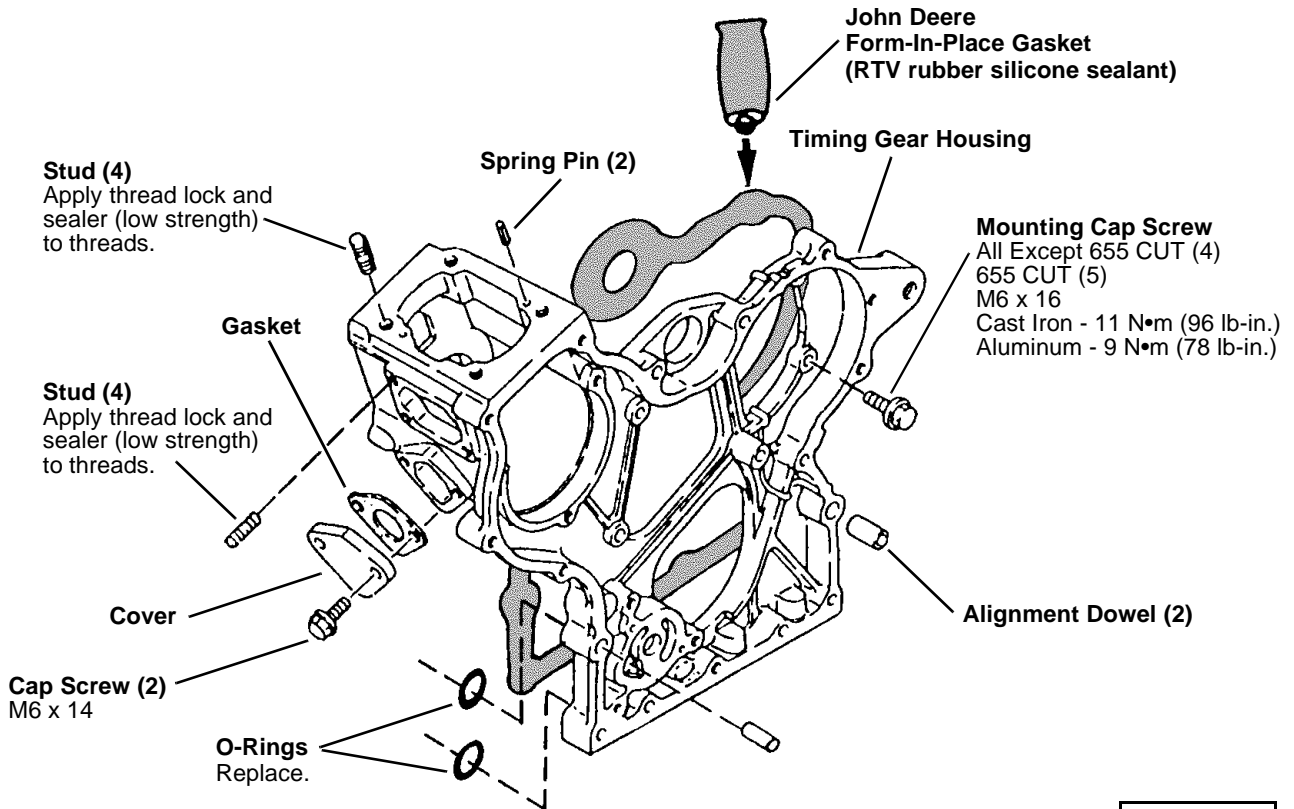
Replace bushing using a driver set. Align oil holes in bushing and idler gear. Install bushing flush with surface of idler gear.

If bushing clearance (bushing I.D. minus shaft O.D.) exceeds specification, replace bushing, shaft or both.

TIMING GEAR HOUSING - 3TN66

Removal/Installation

1. Remove idler gear. (See procedure in this group.)
 2. Remove injection pump camshaft. (See *Fuel System* in this section.)
 3. Remove engine camshaft. (See procedure in this group.)
 4. Remove oil pump. (See *Lubrication System* in this section.)
 5. Remove water pump. (See *Cooling System* in this section.)
 6. Remove mounting cap screws and housing.
 7. Replace o-rings.
- Installation is done in the reverse order of removal.



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Camshaft and Timing Gear Train

TIMING GEAR HOUSING - EARLY 3TNA72

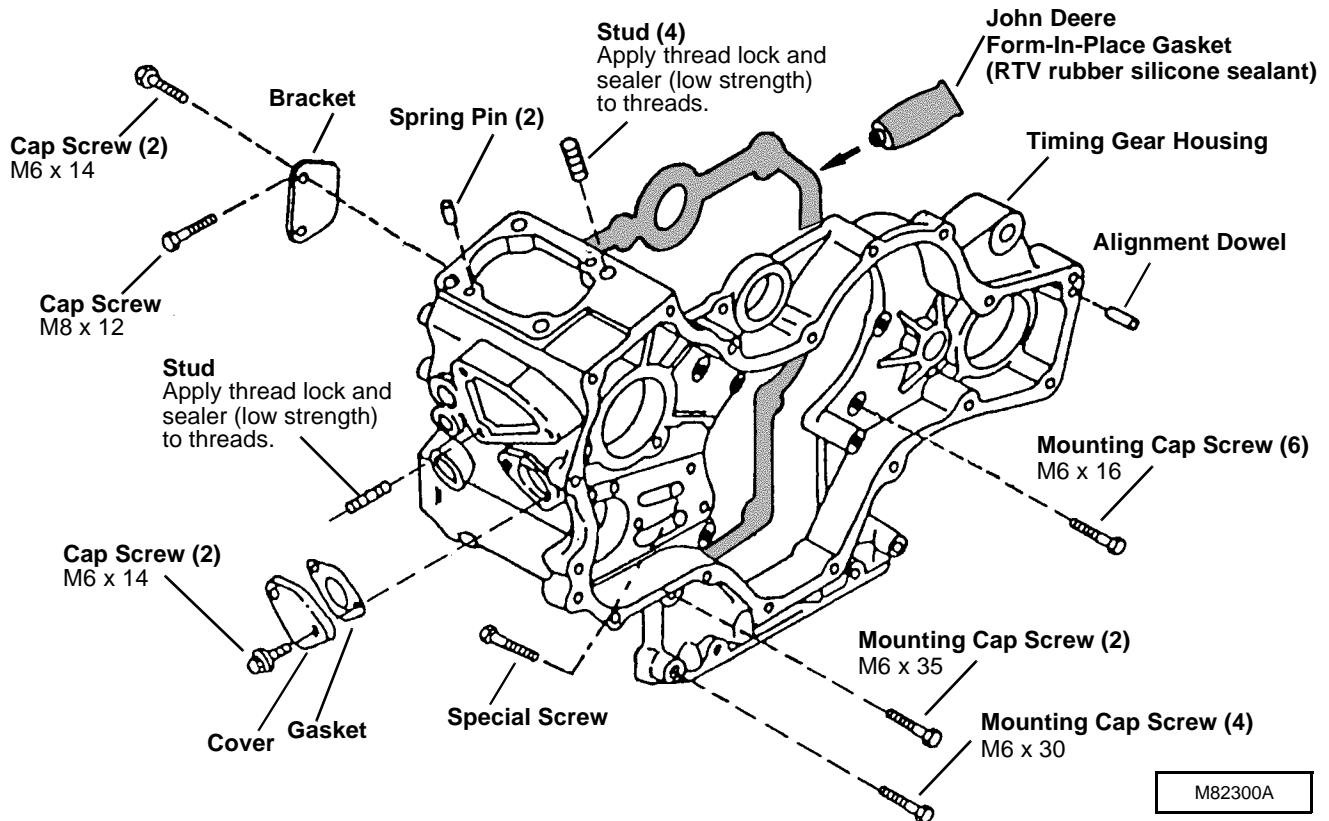
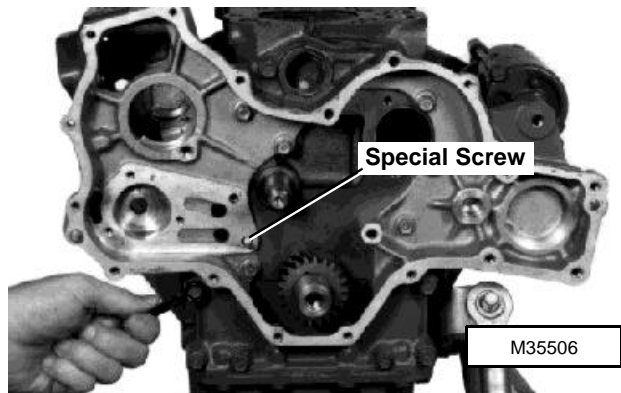
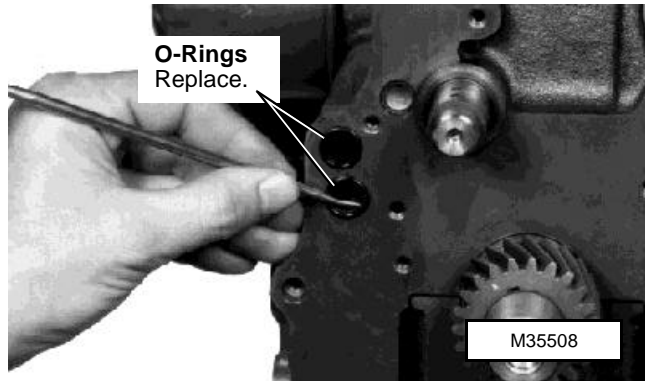
Removal/Installation

1. Remove fuel control and governor linkage. (See *Fuel System* in this section.)
2. Remove idler gear. (See procedure in this group.)
3. Remove injection pump camshaft. (See *Fuel System* in this section.)
4. Remove engine camshaft. (See procedure in this group.)
5. Remove water pump. (See *Cooling System* in this section.)
6. Remove oil pump. (See *Lubrication System* in this section.)
7. Remove bracket.
8. Remove mounting cap screws and housing.
9. Replace o-rings

Installation is done in reverse order.

- Install special screw before installing gear housing.

- Tighten all mounting cap screws to:
 - Cast Iron..... 11 N•m (96 lb-in.)
 - Aluminum..... 9 N•m (73 lb-in.)



TIMING GEAR HOUSING - LATER 3TNA72

Removal/Installation

1. Remove idler gear. (See procedure in this group.)
2. 670 CUT and 3009 OEM: Remove fuel supply pump. (See procedure in *ACCESSORIES - SERIES 220 POWER UNIT ENGINES* Section.)
3. Remove fuel injection pump camshaft. (See *Fuel System* in this section.)
4. Remove engine camshaft. (See procedure in this group.)
5. Remove oil pump. (See *Lubrication System* in this section.)
6. Remove water pump. (See *Cooling System* in this section.)
7. Remove mounting cap screws and housing.
8. Replace o-rings.

Installation is done in reverse order of removal.

1

Camshaft and Timing Gear Train

1

John Deere Form-In-Place Gasket (RTV rubber silicone sealant)

Cap Screw (4)
M8 x 12

Cover
All Except 455 LGT, 15 EX, 670 CUT, 3009 OEM

Gasket

Stud (4)
Apply thread lock and sealer (low strength) to threads.

Spring Pin (2)

Timing Gear Housing

Mounting Cap Screw (7)
M6 x 16
Cast Iron - 11 N•m (96 lb-in.)
Aluminum - 9 N•m (78 lb-in.)

Stud (4)
Apply thread lock and sealer (low strength) to threads.

Gasket

Cover

Alignment Dowel (2)

Cap Screw (2)
M6 x 14

O-Ring (2)
Replace.

Crankcase Extension-to-Housing Cap Screw (4)
(670 CUT, 15 EX, 3009 OEM Only)
M6 x 45 (15 EX, 3009 OEM)
M8 x 45 (670 CUT)
22 N•m (195 lb-in.)

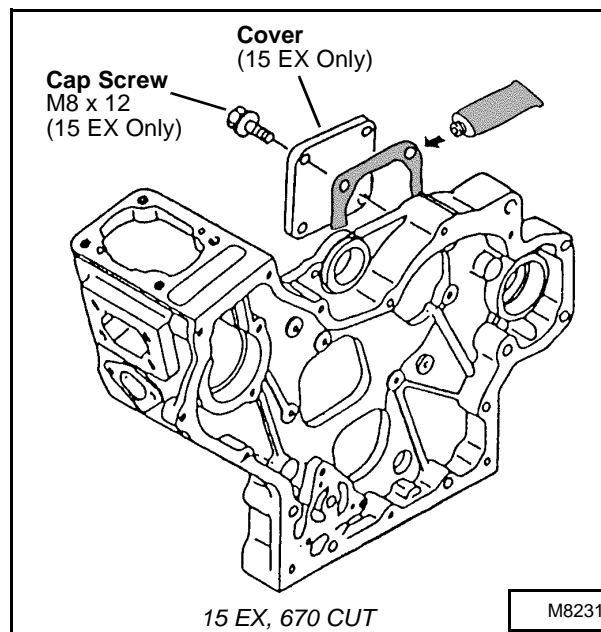
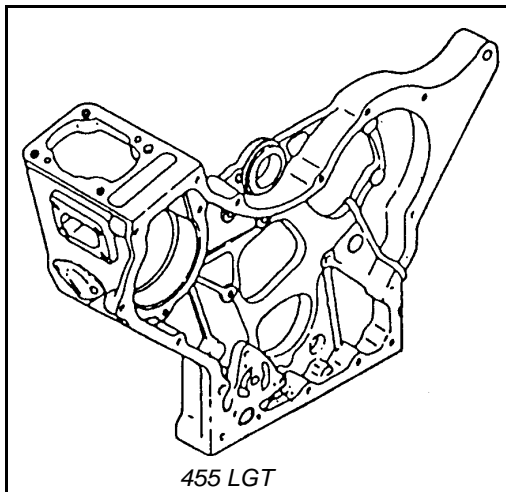
Fuel Supply Pump

Cap Screw (2)
M6 x 20

670 CUT, 3009 OEM

Cover
(15 EX Only)

Cap Screw
M8 x 12
(15 EX Only)



M82310A

OTHER MATERIALS

Number	Name	Use
LOCTITE® PRODUCTS U.S./ Canadian/ Loctite No.	John Deere Form-In-Place Gasket	Seals oil pan/plate to crankcase extension housing and/or block.
TY15130/ NA/ #395		

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®LOCTITE is a registered trademark of the Loctite Corp.

Lubrication

OIL PAN AND STRAINER - 3TN66

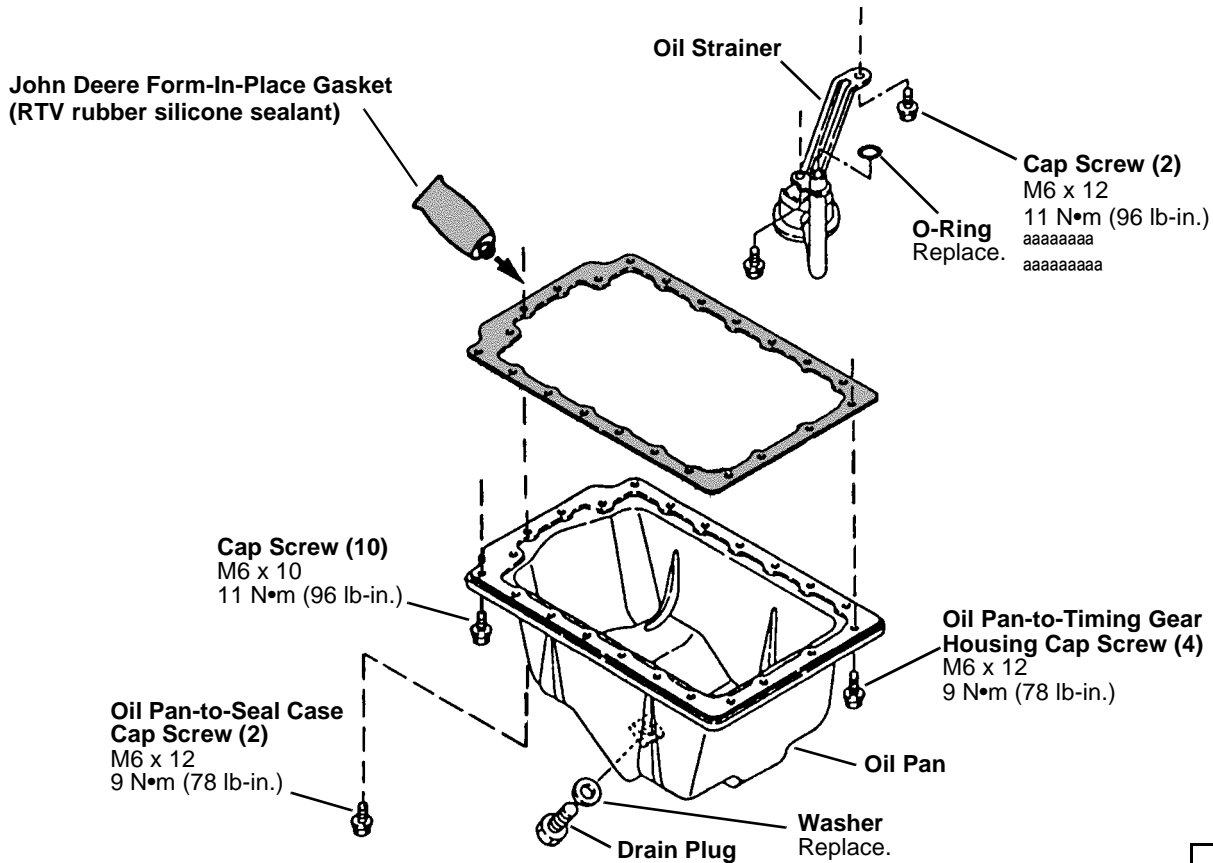
Removal/Installation

- Approximate crankcase oil capacity is 2.5 L (2.6 qt).

NOTE: On 655 CUT; Engine serial number (- 012269), uses an aluminum oil pan. Engine serial number (012270 -) uses a sheet metal oil pan. Size and quantity on mounting cap screws are different.

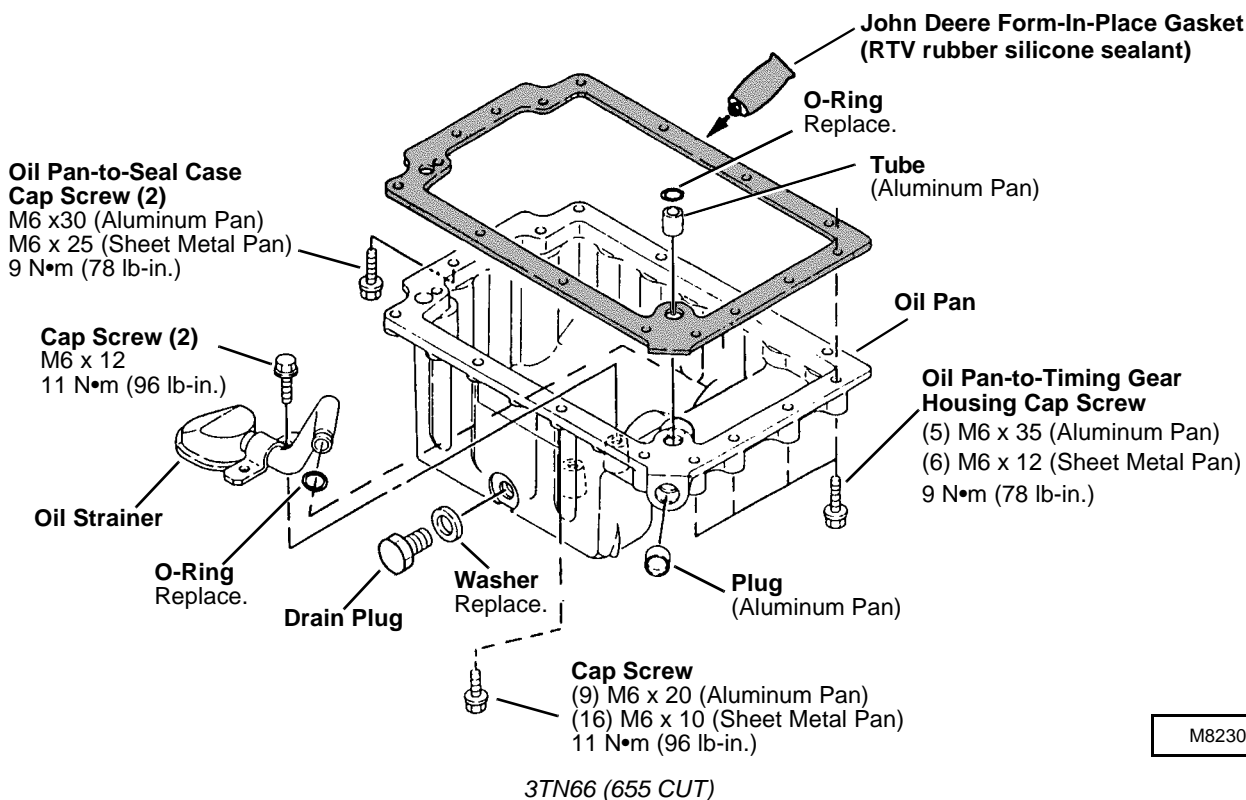
- Fill engine with proper engine oil. (See *SPECIFICATIONS AND GENERAL INFORMATION* section.)

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M82302A

3TN66 (375 SSL, 330/332 LGT, F915 FM)

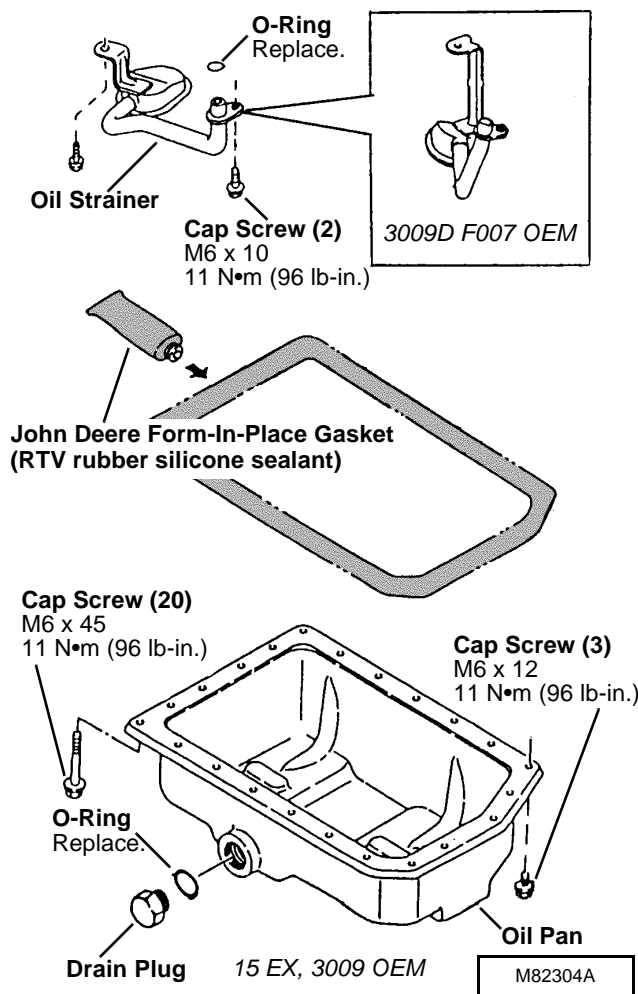


OIL PAN AND STRAINER - 3TNA72

Removal/Installation

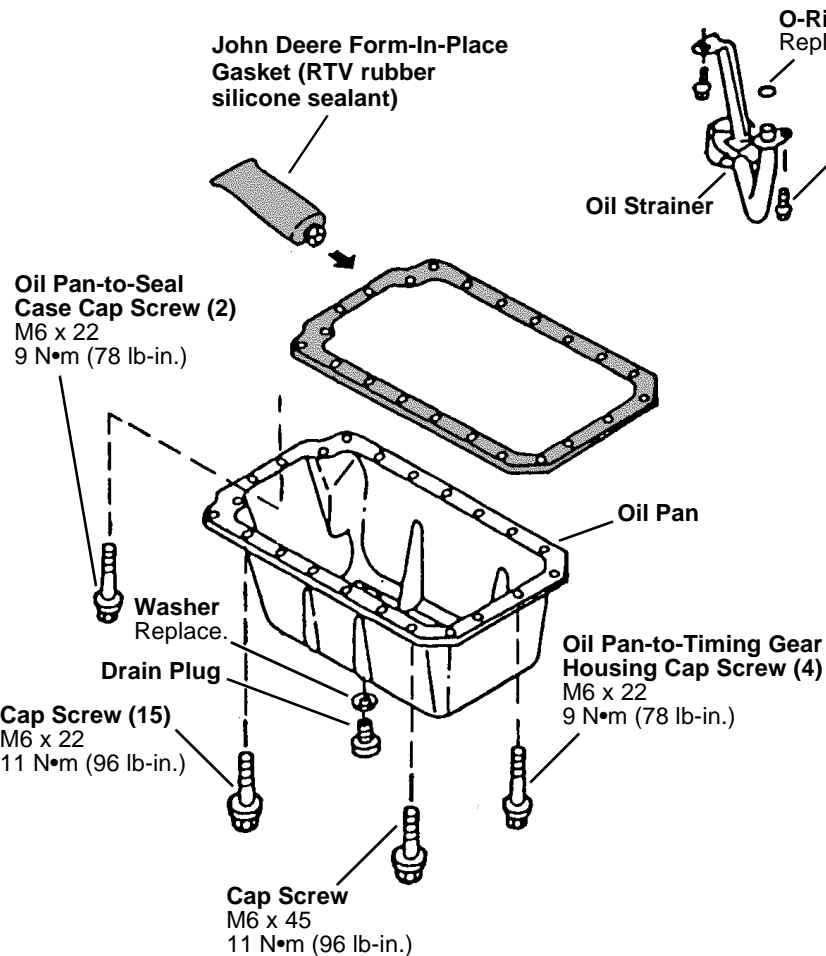
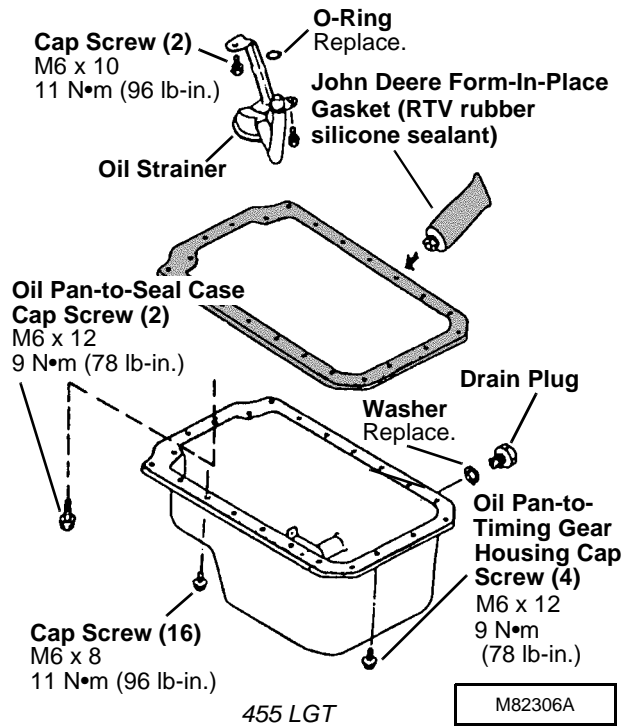
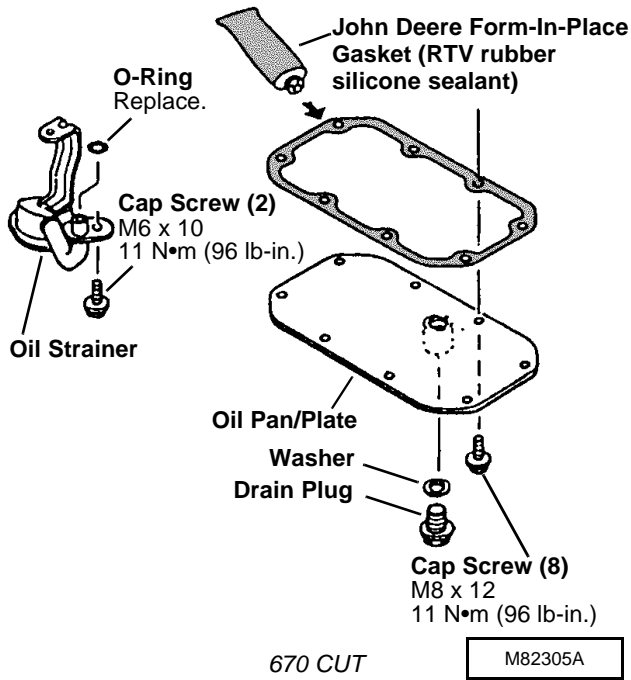
- Approximate crankcase oil capacity is:

15 EX	1.9L (2 qt)
430 LGT, 455 LGT.....	2.8L (3 qt)
670 CUT	2.6L (2.7 qt)
755/56 CUT	3.2L (3.4 qt)
F925/35 FM	3.5L (3.6 qt)
3009 OEM	
F001 and 005	2.9L (3.1 qt)
F007	3.8L (3.9 qt)
- Fill engine with proper engine oil. (See *SPECIFICATIONS AND GENERAL INFORMATION* section.)



Lubrication

1



430 LGT, F925/35 FM, 755/56 CUT

OIL PUMP - EARLY 3TNA72 (430 LGT)

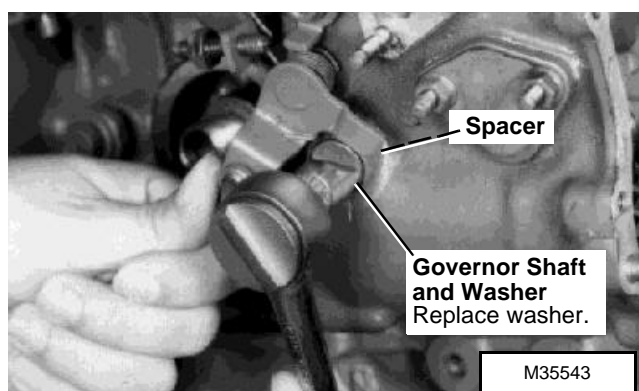
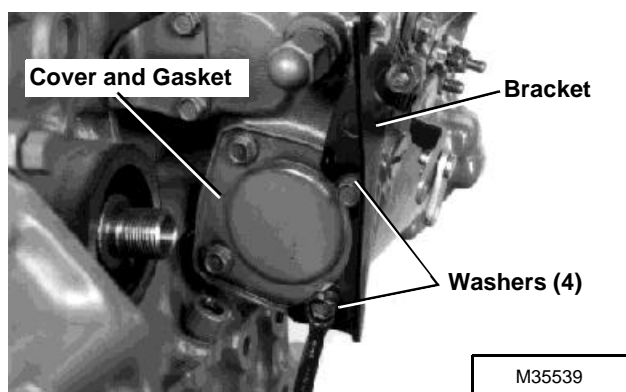
Removal

1. Remove idler gear, (See *Camshaft and Timing Gear Train* in this section.)
2. Loosen oil pump gear lock nut.
3. Remove fuel injection pump camshaft. (See *Fuel System* in this section.)
4. Remove oil filter and oil dipstick tube.
5. Remove two cap screws, bracket and four washers.
6. Remove two cap screws, cover and gasket.



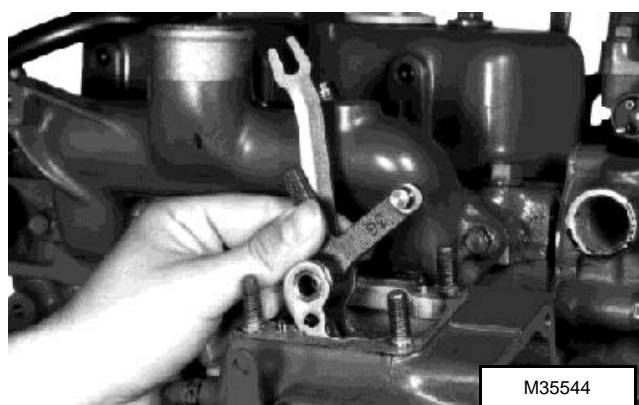
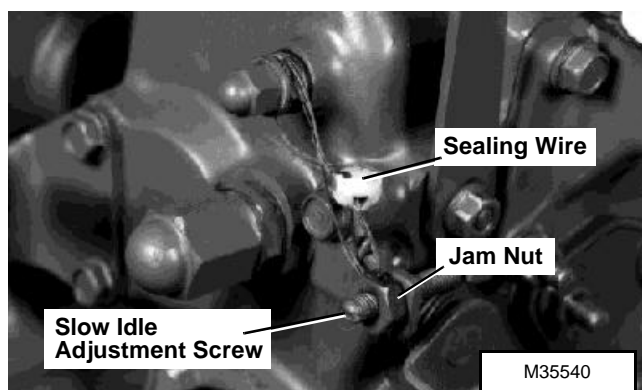
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10. Remove governor shaft, washer and spacer.



7. Remove sealing wire.
8. Loosen jam nut. Turn slow idle adjustment screw counterclockwise several turns.

11. Remove governor linkage assembly.



9. Disconnect spring from governor linkage.

12. Remove oil pump gear lock nut.

NOTE: Oil pump gear is press fit on rotor shaft.

13. Remove oil pump gear using a three-jaw puller.

Lubrication

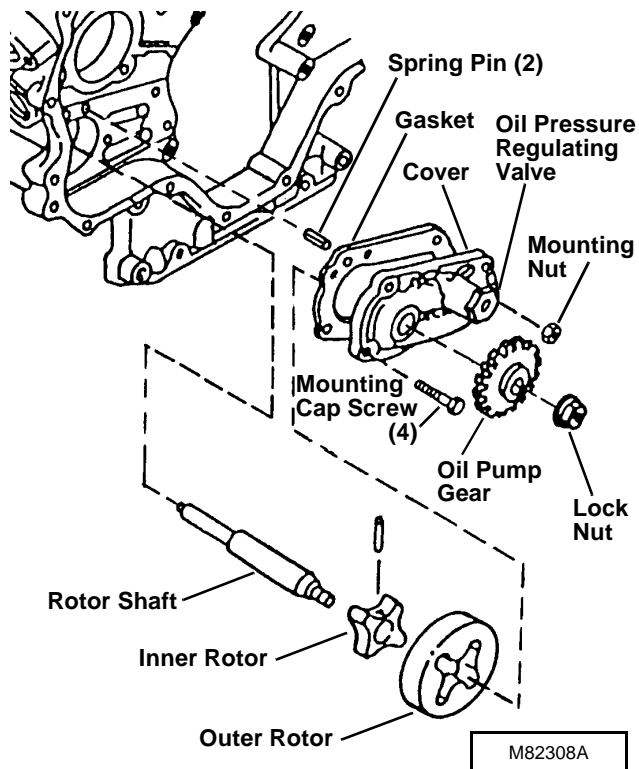
14. Remove four cap screws, nut cover and gasket.

15. Remove oil pump assembly.

NOTE: See OIL PRESSURE REGULATING VALVE if service is necessary.

16. Inspect all parts for wear or damage. (See *Inspection* procedures.)

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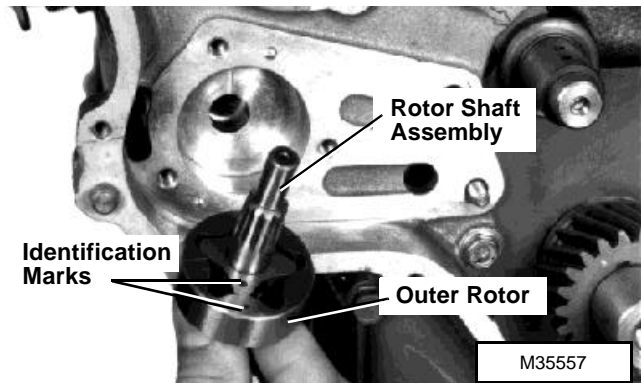


Installation

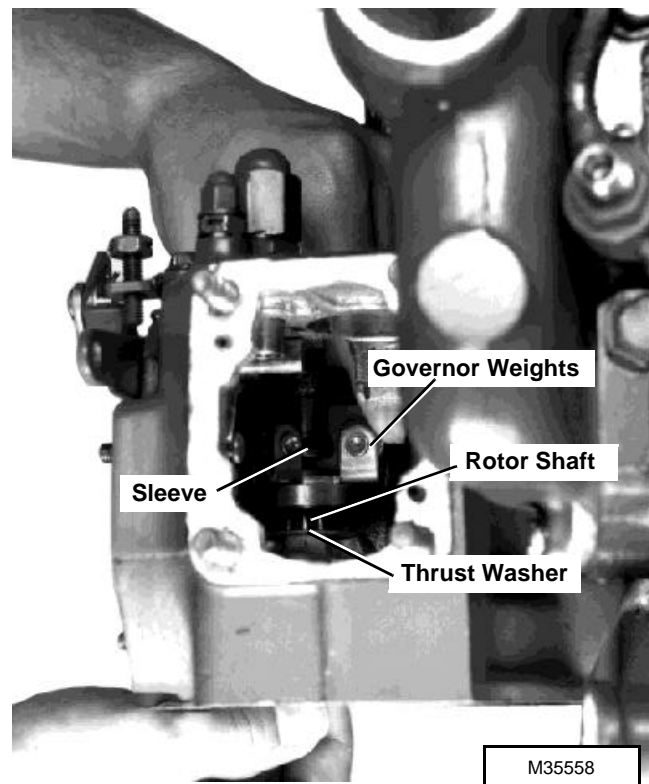
1. Apply clean engine oil on all parts during installation.

IMPORTANT: Oil pump assembly must be installed with identification marks on rotors facing toward gear housing.

2. Install rotor shaft assembly and outer rotor in gear housing with identification marks facing gear housing.

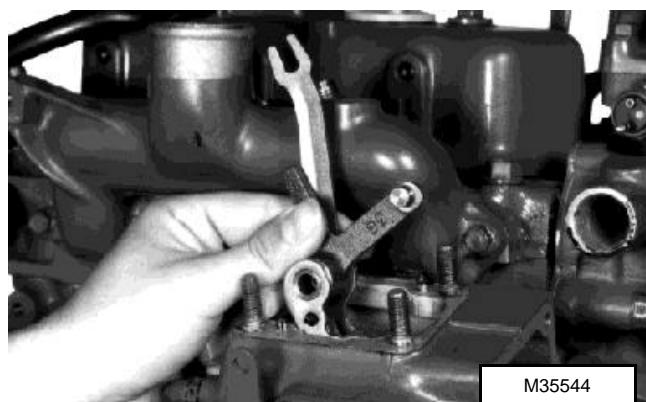


3. Align splines on rotor shaft with splines in thrust washer and governor weights. Install thrust washer, governor weights and sleeve on rotor shaft.

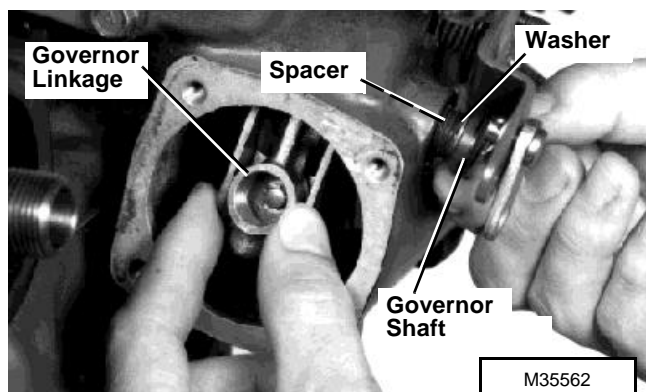


4. Install oil pump gasket and cover.
5. Install four cap screws and nut. Tighten to **9 N•m (78 lb-in.)**.
6. Install oil pump gear and lock nut. Leave nut loose.
7. Install spacer and new washer on governor shaft.

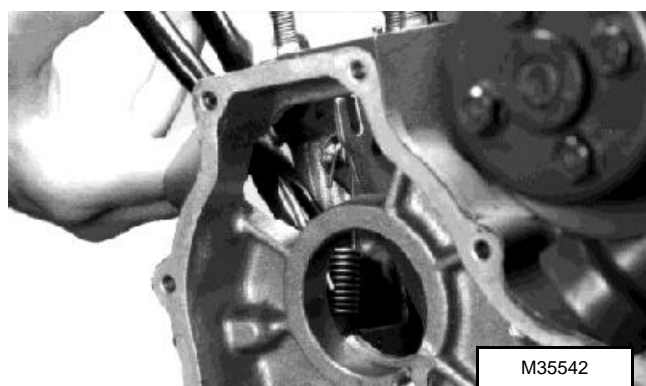
8. Install governor linkage assembly.



9. Insert governor shaft through linkage assembly. Tighten shaft to **49 N•m (36 lb-ft)**.

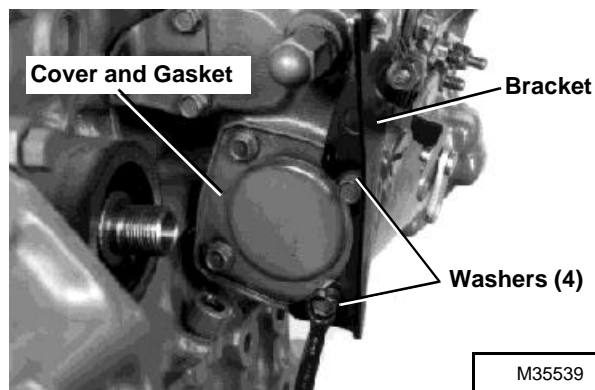


10. Connect spring to internal lever, then to governor assembly.



11. Install gasket, cover and two cap screws.

12. Install four washers (two each hole location), bracket and two cap screws. Tighten all four cap screws to **9 N•m (78 lb-in.)**.



1

13. Install oil dipstick tube and oil filter.

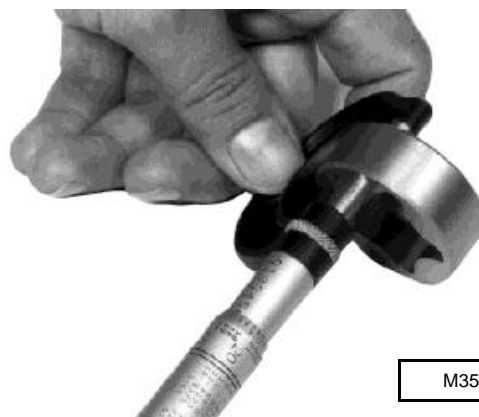
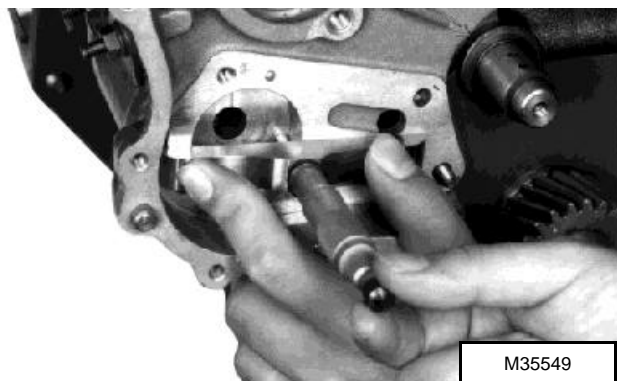
14. Install fuel injection pump camshaft. (See *Fuel System* in this section.)

15. Tighten oil pump gear lock nut to **27 N•m (20 lb-ft)**.

16. Install idler gear. (See *Camshaft and Timing Gear Train* in this section.)

Inspection

- Measure outer rotor bore depth and outer rotor thickness.



Lubrication

Outer Rotor-to-Bore Clearance:

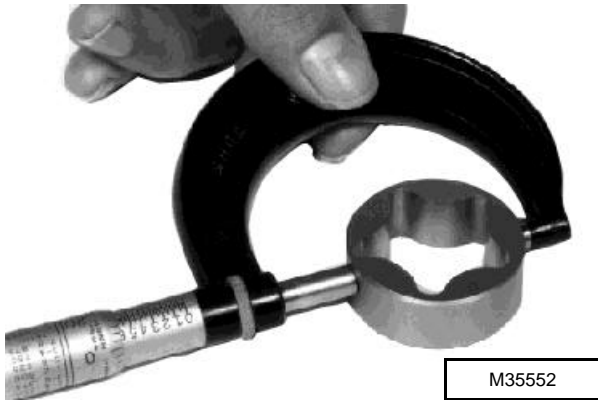
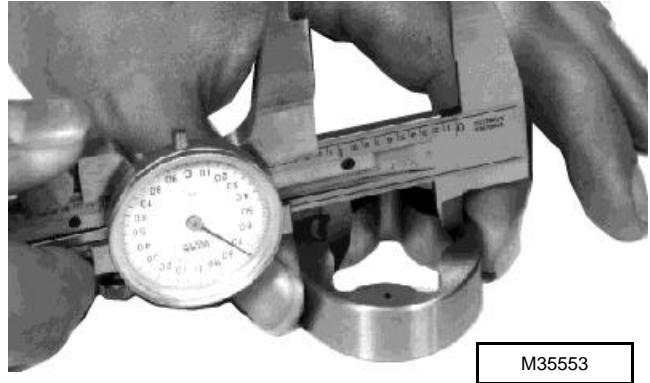
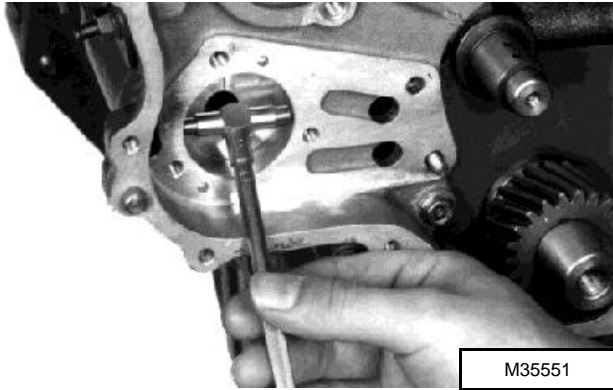
Standard 0.08 - 0.15 mm
..... (0.003 - 0.006 in.)

Wear Limit..... 0.25 mm (0.010 in.)

If clearance (bore depth minus rotor thickness) is more than wear limit, replace timing gear housing.

1

- Measure outer rotor bore and outer rotor diameters.



Inner Rotor-to-Outer Rotor Clearance:

Standard 0.10 - 0.15 mm
..... (0.004 - 0.006 in.)

Wear Limit..... 0.25 mm (0.010 in.)

If clearance (outer rotor I.D. minus inner rotor O.D.) is more than wear limit, replace oil pump assembly.

- Measure rotor shaft diameter.

Outer Rotor-to-Bore Diameter Clearance:

Standard 0.10 - 0.15 mm
..... (0.004 - 0.006 in.)

Wear Limit..... 0.25 mm (0.010 in.)

If clearance (bore I.D. minus rotor O.D.) is more than wear limit, replace timing gear housing.

- Measure inner rotor O.D. and outer rotor I.D.

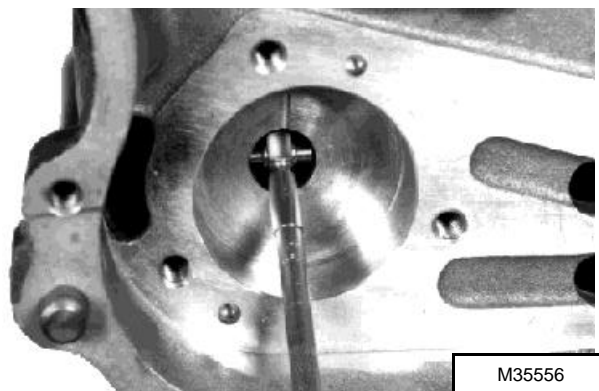


Rotor Shaft Diameter:

- Standard 12.670 - 12.685 mm
.....(0.4988 - 0.4990 in.)
- Wear Limit..... 12.650 mm (0.4980 in.)

If shaft diameter is less than wear limit, replace oil pump assembly.

- Measure rotor shaft bore diameter.



Rotor Shaft Bore Diameter:

- Standard 12.700 - 12.718 mm
.....(0.5000 - 0.5007 in.)
- Wear Limit..... 12.80 mm (0.504 in.)
- Clearance
- Standard 0.015 - 0.048 mm
.....(0.006 - 0.0019 in.)
- Wear Limit..... 0.100 mm (0.0039 in.)

If bore diameter is more than wear limit, replace timing gear housing.

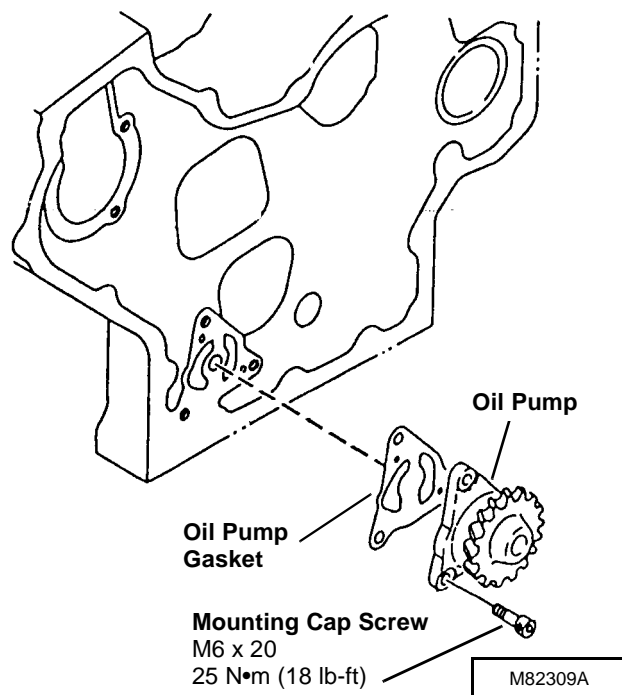
If rotor shaft clearance (bore I.D. minus shaft O.D.) is more than wear limit, replace timing gear housing and oil pump assembly.

OIL PUMP - 3TN66 and LATER 3TNA72

Removal/Installation

1. Remove timing gear cover. (See *Camshaft and Timing Gear Train* in this section.)
2. Check oil pump gear backlash. Replace entire oil pump assembly if backlash is more than **0.25 mm (0.010 in.)**.
3. Remove four mounting cap screws, oil pump and gasket.
4. Inspect all parts for wear or damage. (See *Disassembly/Assembly* procedures).

1



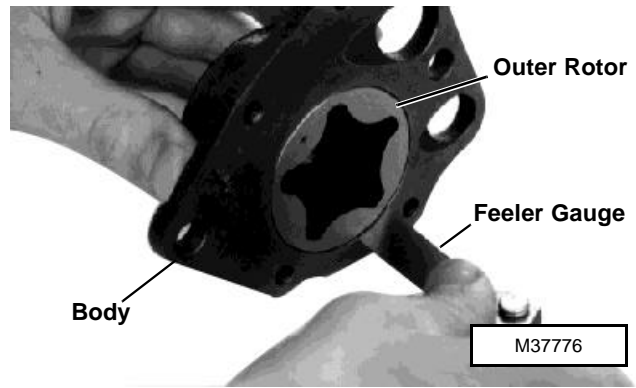
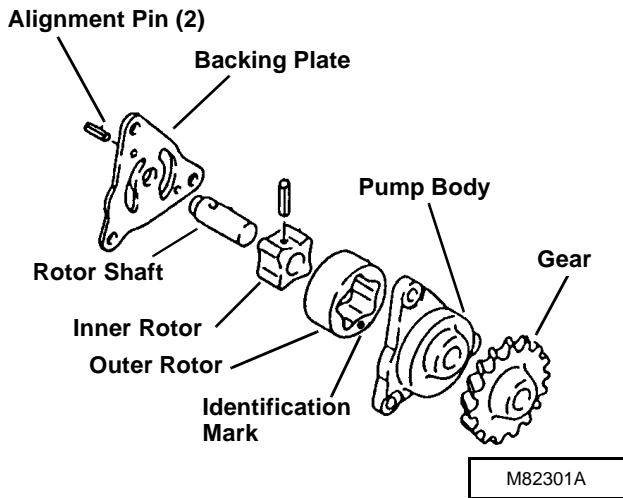
Disassembly/Assembly

- Gear is press fit on rotor shaft. Remove gear using a knife edge puller and a press.
- Inspect parts for wear or damage. (See *Inspection* procedures.)
- Coat all parts with clean engine oil.

Lubrication

- Install outer rotor with identification mark facing toward rotor shaft assembly.

1



Outer Rotor-to-Pump Body Clearance:

Standard 0.03 - 0.09 mm

.....(0.0011 - 0.0035 in.)

Wear Limit..... 0.13 mm (0.0051 in.)

- Check inner-to-outer rotor clearance. If clearance is more than **0.15 mm (0.0059 in.)**, replace rotor assembly.

Inspection

- Check rotor shaft outer diameter and the shaft hole diameter in backing plate. If clearance is more than wear limit, replace entire assembly.

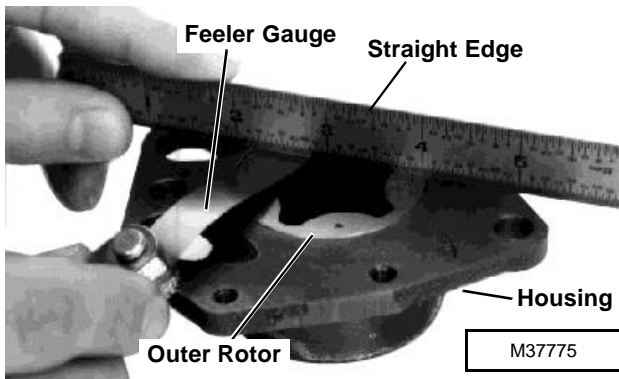
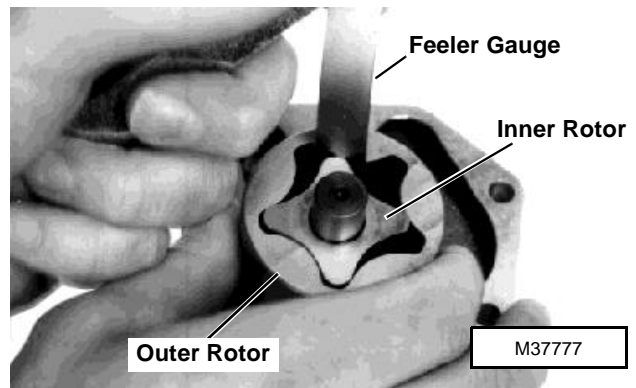
Rotor Shaft and Plate Clearance:

Standard 0.015 - 0.048 mm

.....(0.0006 - 0.0035 in.)

Wear Limit..... 0.20 mm (0.0078 in.)

- Check rotor recess. If rotors are below face of pump housing more than **0.25 mm (0.010 in.)**, replace rotor assembly.



- Check outer rotor-to-pump body clearance. If clearance is more than wear limit, replace entire assembly.

OIL PRESSURE REGULATING VALVE - 3TN66

Removal/Installation

1. Remove oil filter and o-ring.
2. Remove retaining nut and valve assembly.
3. If adjusting pressure only, remove cap and add shims. Each 1 mm (0.039 in.) of shim thickness increases oil pressure 13.8 kPa (2 psi).

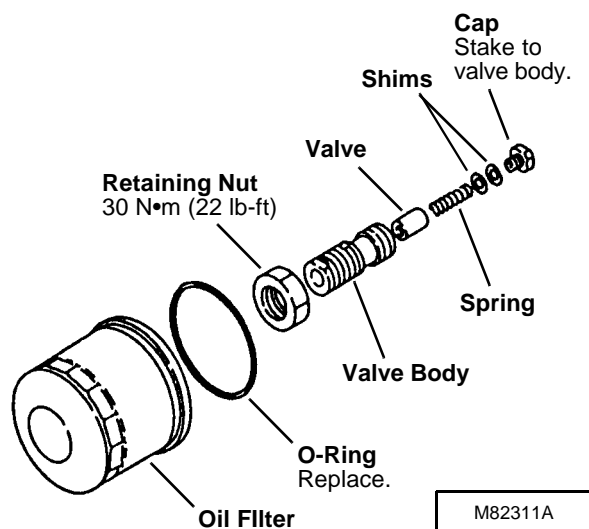
NOTE: Valve components are not serviced individually. Replace complete regulating valve if any components are defective.

4. Inspect all parts for wear or damage. Replace complete valve if necessary.
5. Check spring free and compressed lengths.

Spring Specifications:

Free Length 21.90 - 24.50 mm
 (0.860 - 0.960 in.)
 Compressed Length ... 14.70 mm (0.580 in.)
 @12 N (2.7 lb-force)

Installation is done in the reverse order of removal.

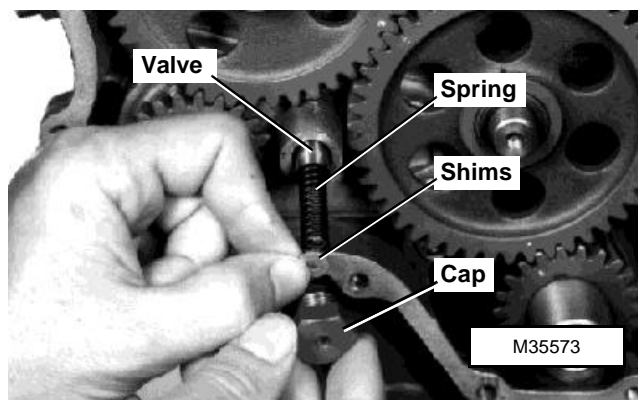


OIL PRESSURE REGULATING VALVE - EARLY 3TNA72 (430 LGT)

Removal/Installation

1. Remove timing gear cover. (See *Camshaft and Timing Gear Train* in this section.)
2. Remove cap, shims, if equipped, spring and valve.

3. Inspect all parts for wear or damage. Replace as necessary.



4. Check spring free and compressed lengths.

Spring Specifications:

Free Length 39.50 - 40.50 mm
 (1.550 - 1.590 in.)
 Compressed Length 30 mm (1.180 in.)
 @ 29.4 ± 3.1 N (6.6 ± 0.7 lb-force)

IMPORTANT: If oil pressure regulating valve was disassembled to be cleaned, the same number and thickness of shims must be installed.

NOTE: Shims are available in 0.20 mm (0.080 in.) and 0.30 mm (0.012 in.) sizes.

5. If adjusting oil pressure only, add shims as necessary. Each 0.20 mm (0.080 in.) of shim thickness increases oil pressure 6 kPa (0.85 psi). Each 0.30 mm (0.012 in.) shim thickness increases oil pressure 9 kPa (1.30 psi).

Installation is done in the reverse order of removal.

Lubrication

OIL PRESSURE REGULATING VALVE - LATER 3TNA72

Removal/Installation

1. Remove oil filter.
2. Remove three cap screws, valve assembly and gasket.

1 *NOTE: If adjusting engine oil pressure, retaining nut need not be removed.*

3. If adjusting pressure only, remove cap and add shims. Each 1 mm (0.039 in.) of shim thickness increases oil pressure 10.9 kPa (1.6 psi).

NOTE: Valve components are not serviced individually. Replace complete regulating valve if any components are defective.

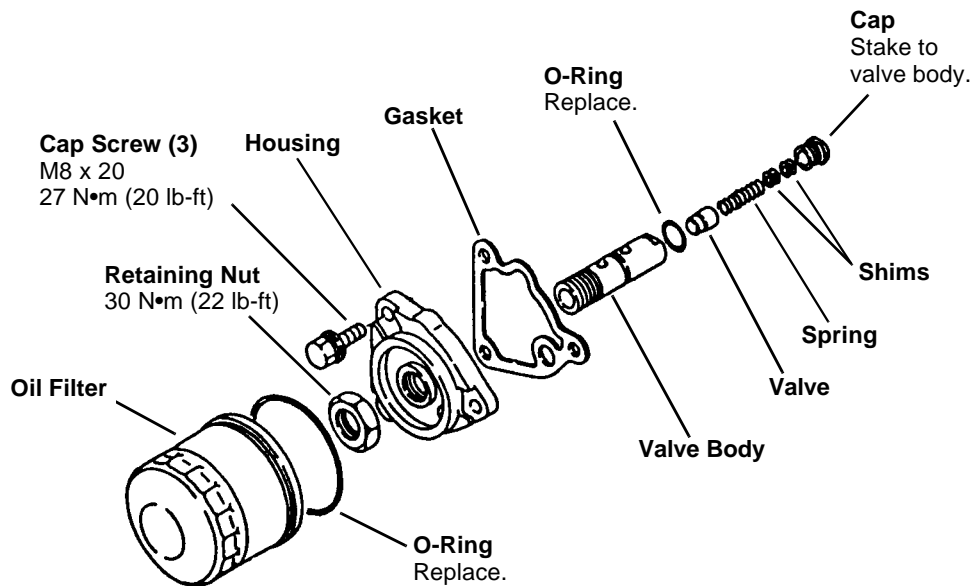
4. Inspect all parts for wear or damage. Replace complete valve if necessary.
5. Check spring free and compressed lengths.

Spring Specifications:

Free Length 43.50 - 48.50 mm
.....(1.710 - 1.910 in.)

Compressed Length . . . 27.50 mm (1.080 in.)
..... @ 20.5 N (4.6 lb-force)

Installation is done in the reverse order of removal.



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OTHER MATERIALS

Number	Name	Use
LOCTITE® PRODUCTS U.S./ Canadian/ LOCTITE No.	John Deere Pipe Sealant with TEFLON®	3TNA72 (15 EX, 755/56 CUT): Apply to threads of plug in water pump housing.

1

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®TEFLON is a registered trademark of the Du Pont Company.

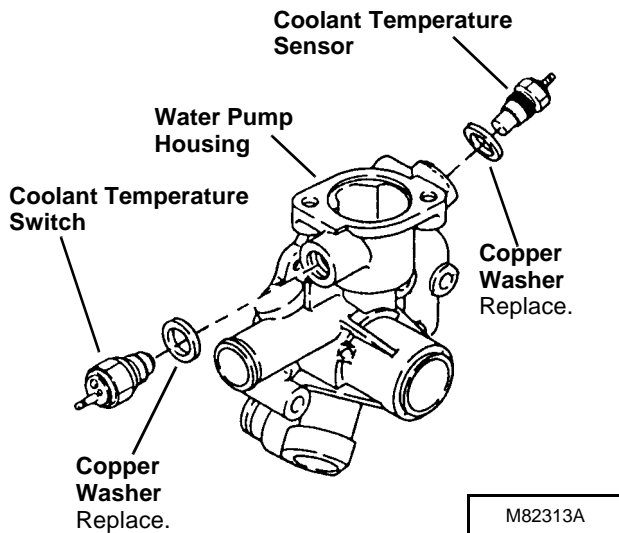
Cooling System

COOLANT TEMPERATURE SENSOR Replacement

NOTE: Some engines may also be equipped with a coolant temperature switch. Switch is located opposite of sensor in water pump housing. Replacement procedures are the same.

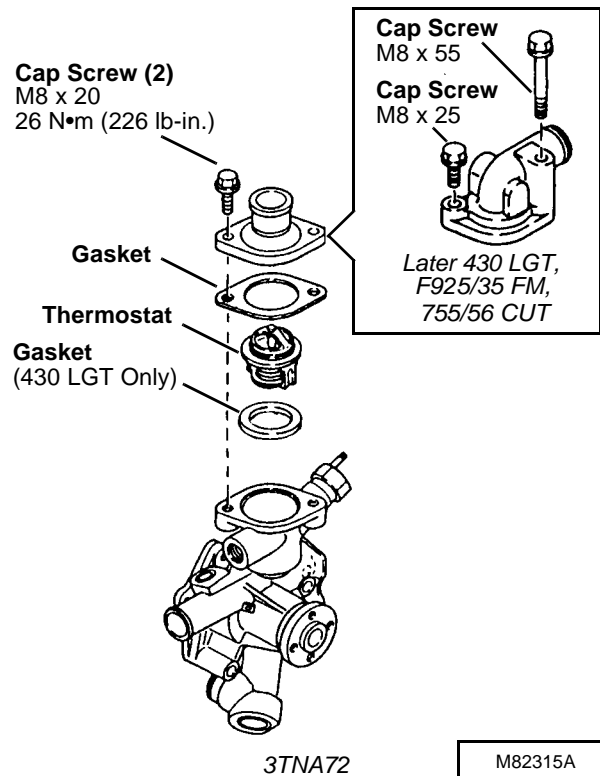
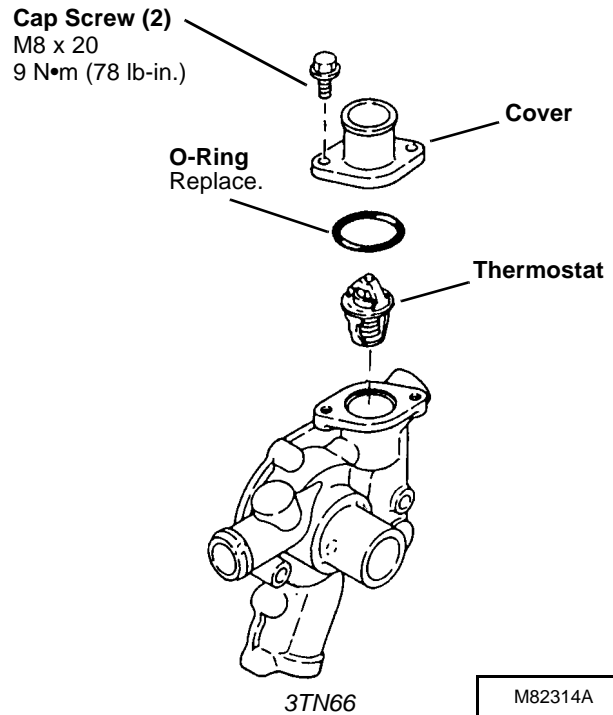
1. Disconnect wiring lead, if equipped.
2. Open engine drain valve to drain coolant.
3. Remove sensor and washer.
4. Test sensor. (See *Checks, Tests and Adjustments* in this section.)

Installation is done in reverse order of removal.



THERMOSTAT

- Replace gaskets.
- Test thermostat. (See *Checks, Tests and Adjustments* in this section.)



WATER PUMP - 3TN66

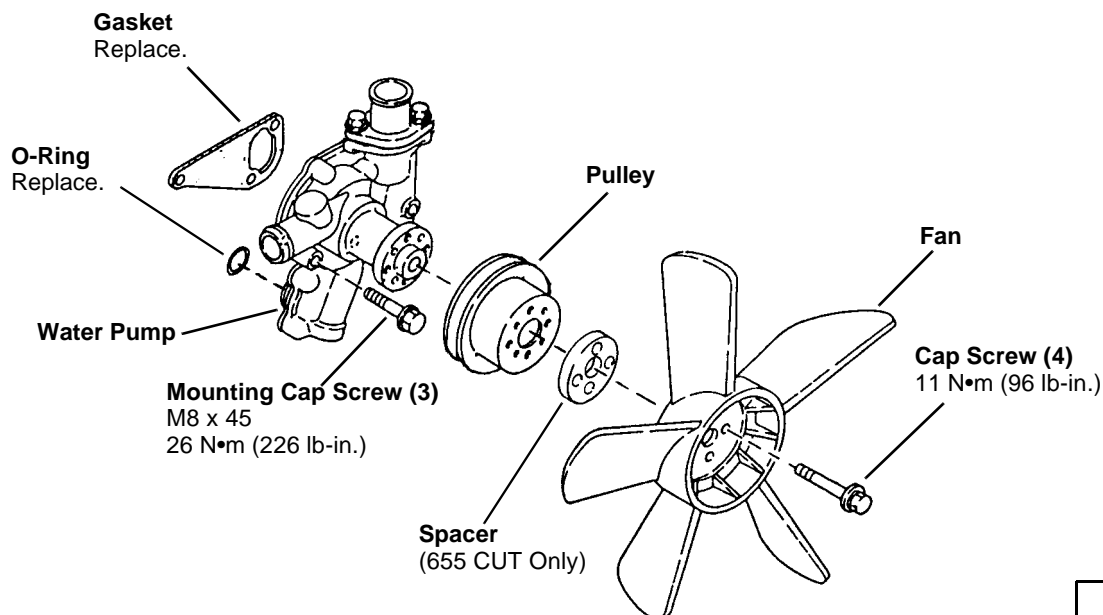
Removal/Installation

1. Open engine drain valve to drain coolant.
2. Remove fan/alternator drive belt.
3. Remove fan, spacer, if equipped, and pulley.

4. Remove three mounting cap screws, pump and gasket.
5. Inspect all parts for wear or damage. (See *Disassembly/Assembly* procedures.)

Installation is done in the reverse order of removal.

- Adjust fan/alternator drive belt tension. (See *Checks, Tests and Adjustments* in this section.)



1

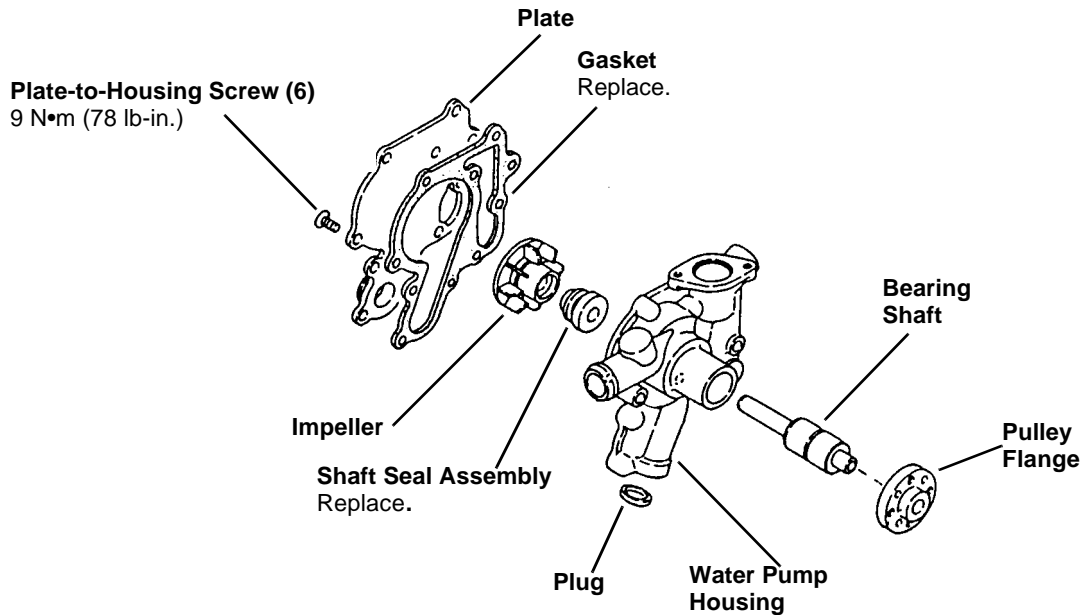
Cooling System

Disassembly

1. Remove thermostat. (See procedure in this group.)

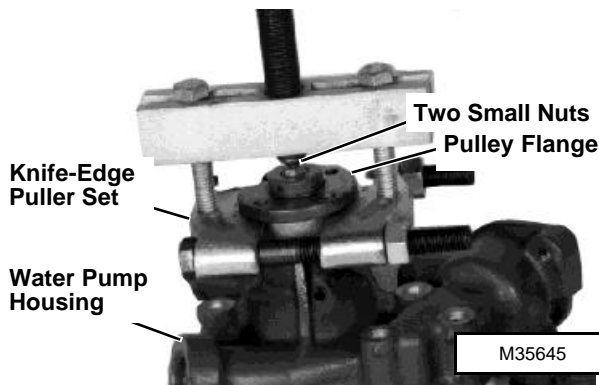
2. Remove coolant temperature sensor. (See procedure in this group.)
3. Apply heat to six plate-to-housing screws. Remove screws, plate and gasket.

1



4. Apply extreme heat to pulley flange. Remove flange using a knife-edge puller set and two small nuts.

IMPORTANT: Impeller bore is tapered. When pressing bearing shaft from impeller, allow enough clearance between cap screw and impeller bore to prevent cap screw from binding.



6. Remove impeller from bearing shaft using a knife-edge puller, a 3/8 in. cap screw and a press.
7. Remove shaft seal assembly; (seal, ceramic seal and seal cup).
8. Inspect all parts for wear or damage. Replace as necessary.

5. Place water pump assembly on a press table. Install supports under water pump housing, staying clear of impeller. Press bearing shaft assembly through water pump housing using a piece of pipe or a deep socket.

Assembly

1. Install bearing shaft into pump housing, long end down, using a piece of pipe or deep socket and a press. Press shaft into pump housing until bearing surface is flush with pump housing surface.
2. Install new shaft seal over impeller side of bearing shaft, rubber seal side away from pump housing. Push shaft seal into pump housing, until it stops, using a 25 mm or 1 in. socket and a press.

IMPORTANT: Support pump housing on bearing shaft only. DO NOT support on housing or damage to housing will occur.

3. Place water pump housing on a press table. Support housing on bearing shaft using a driver disk. Install pulley flange onto shaft with straight hub facing away from housing.

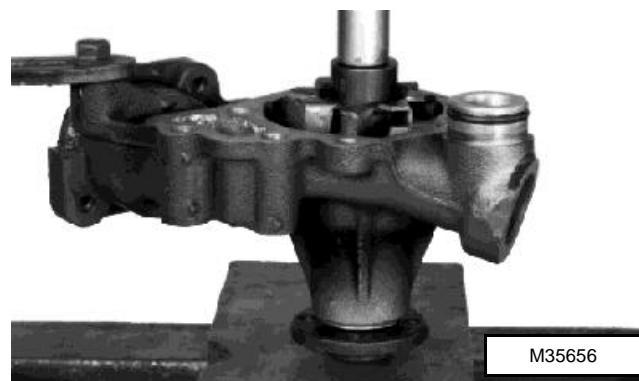
Press pulley flange onto bearing shaft until flange is flush with end of shaft.

IMPORTANT: DO NOT touch lapped sealing surface of ceramic seal with bare hands. It must be clean and dry.

4. Install seal cup and ceramic seal in impeller.

5. Install a knife-edge puller around bearing shaft, between pulley flange and pump housing. Place pump housing, with knife-edge puller down, on a press table. Install impeller with ceramic seal toward shaft seal.

Press impeller on bearing shaft until top of impeller is even with end of shaft.



6. Install new gasket, plate and six screws. Tighten to specifications.
7. Install coolant temperature sensor. (See procedure in this group.)
8. Install thermostat. (See procedure in this group.)

Cooling System

WATER PUMP - 3TNA72

Removal/Installation

1. Open engine drain valve to drain coolant.
2. Remove fan/alternator drive belt.

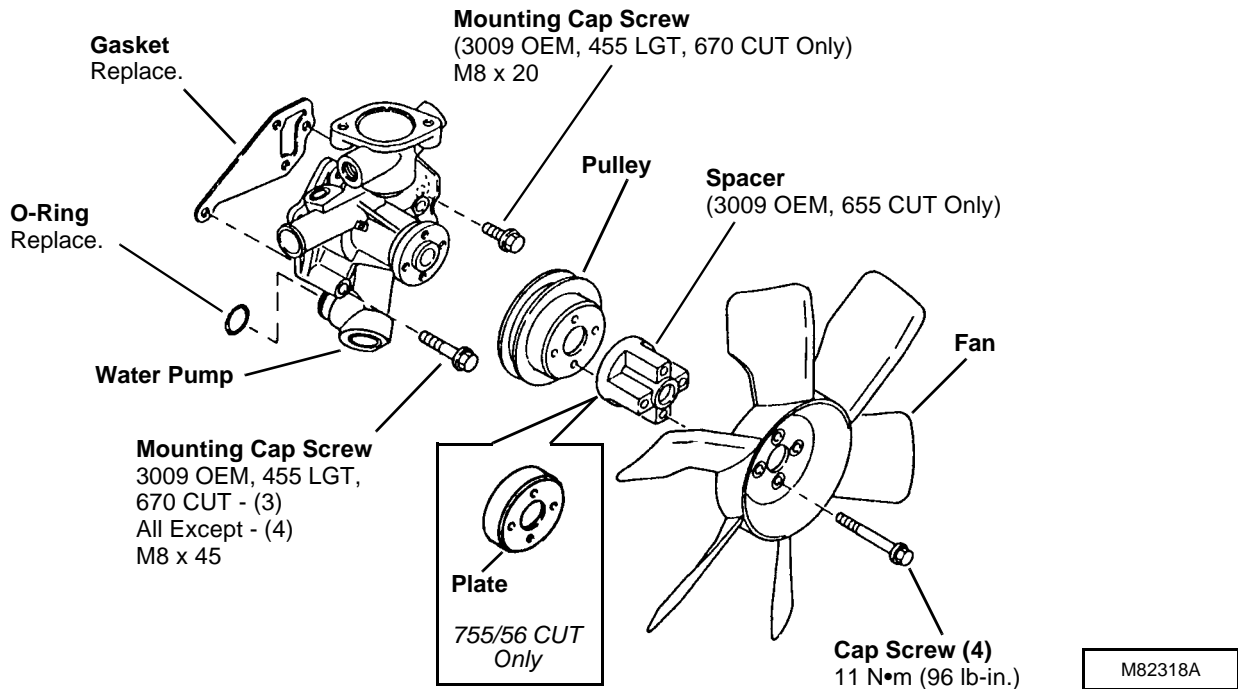
NOTE: 430 LGT and F925/35 FM application is not equipped with a fan.

- 1 3. Remove fan and spacer/plate, if equipped, and pulley.

4. Remove three mounting cap screws, pump and gasket.
5. Inspect all parts for wear or damage. (See *Disassembly/Assembly* procedures.)

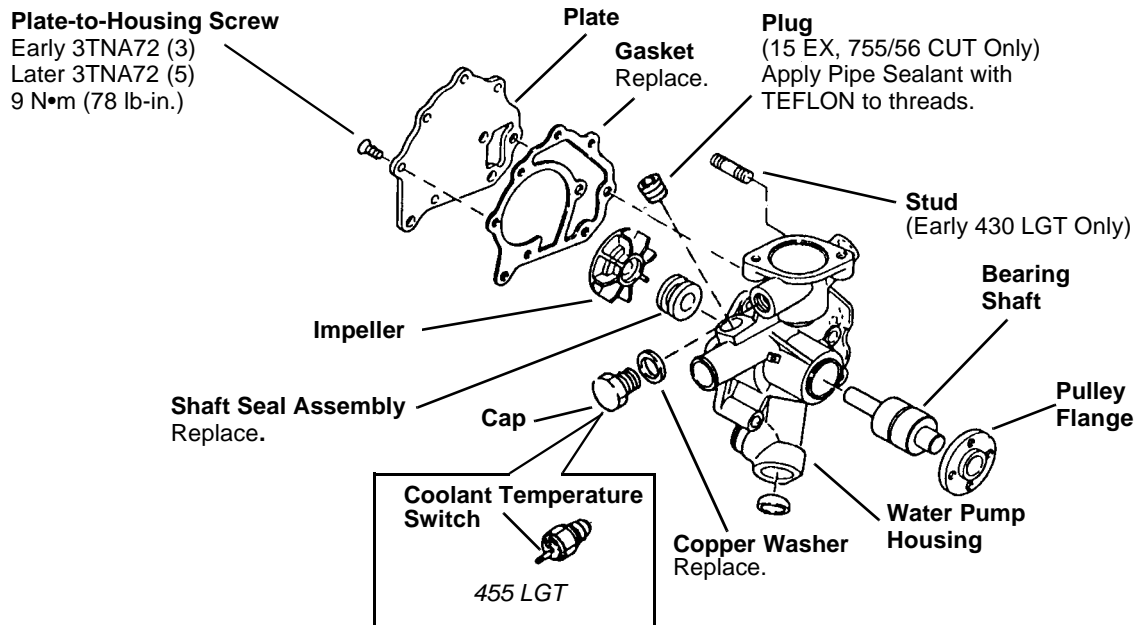
Installation is done in the reverse order of removal.

- Adjust fan/alternator drive belt tension. (See *Checks, Tests and Adjustments* in this section.)
- Tighten mounting cap screws to **26 N•m (226 lb-in.)**.



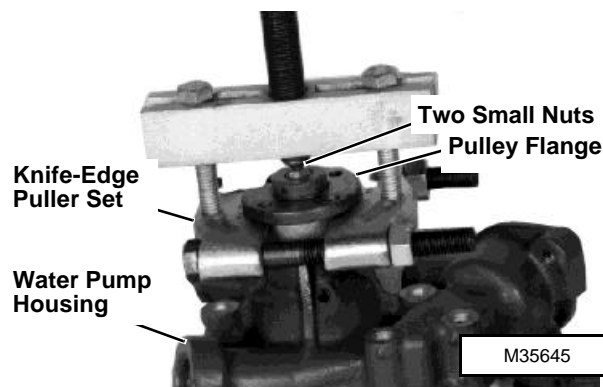
Disassembly

1. Remove thermostat. (See procedure in this group.)
2. Remove coolant temperature sensor. (See procedure in this group.)
3. Apply heat to plate-to-housing screws. Remove screws, plate and gasket.



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4. Apply extreme heat to pulley flange. Remove flange using a knife-edge puller set and two small nuts.



IMPORTANT: Impeller bore is tapered. When pressing bearing shaft from impeller, allow enough clearance between cap screw and impeller bore to prevent cap screw from binding.

6. Remove impeller from bearing shaft using a knife-edge puller, a 3/8 in. cap screw and a press.
7. Remove shaft seal assembly; (seal, ceramic seal and seal cup).
8. Inspect all parts for wear or damage. Replace as necessary.

5. Place water pump assembly on a press table. Install supports under water pump housing, staying clear of impeller. Press bearing shaft assembly through water pump housing using a piece of pipe or a deep socket.

Cooling System

Assembly

1. Install bearing shaft into pump housing, long end down, using a piece of pipe or deep socket and a press. Press shaft into pump housing until bearing surface is flush with pump housing surface.
2. Install new shaft seal over impeller side of bearing shaft, rubber seal side away from pump housing. Push shaft seal into pump housing, until it stops, using a 25 mm or 1 in. socket and a press.

IMPORTANT: Support pump housing on bearing shaft only. DO NOT support on housing or damage to housing will occur.

3. Place water pump housing on a press table. Support housing on bearing shaft using a driver disk. Install pulley flange onto shaft with straight hub facing away from housing.

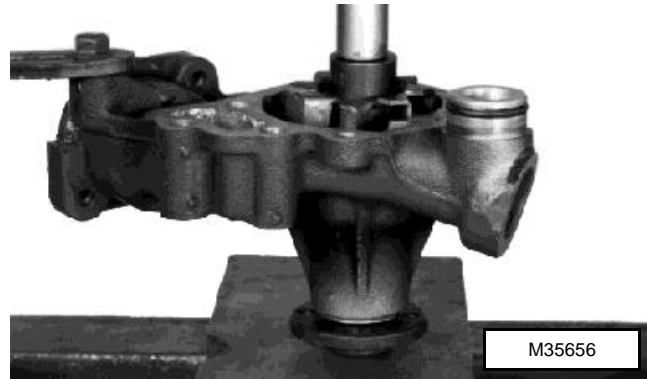
Press pulley flange onto bearing shaft until flange is flush with end of shaft.

IMPORTANT: DO NOT touch lapped sealing surface of ceramic seal with bare hands. It must be clean and dry.

4. Install seal cup and ceramic seal in impeller.

5. Install a knife-edge puller around bearing shaft, between pulley flange and pump housing. Place pump housing, with knife-edge puller down, on a press table. Install impeller with ceramic seal toward shaft seal.

Press impeller on bearing shaft until top of impeller is even with end of shaft.



6. Install new gasket, plate and screws. Tighten to specifications.
7. Install coolant temperature sensor. (See procedure in this group.)
8. Install thermostat. (See procedure in this group.)

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).

JDF13 Nozzle Cleaning Kit

Use to clean fuel injection nozzles.

OTHER MATERIALS

Number	Name	Use
LOCTITE® PRODUCTS U.S./ Canadian/ LOCTITE No.		
TY9369/ NA/ #222	Thread Lock and Sealer (Low Strength)	Apply to threads of fuel shutoff lever set screw.

1

SERVICE PARTS KITS

The following kits are available through your parts catalog:

- Cylinder Block Gasket Kit
- Fuel Injection Nozzle Shim Pack

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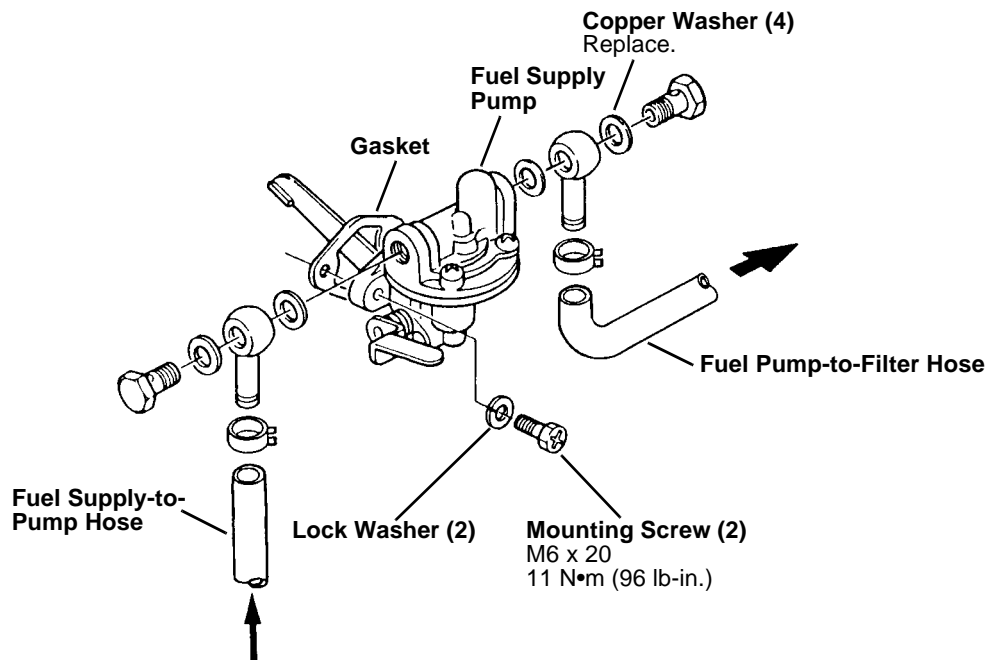
Fuel System

FUEL SUPPLY PUMP - 3TNA72 (670 CUT, 3009 OEM)

Replacement

IMPORTANT: Replace all copper washers.
Damaged or used washers may leak.

1



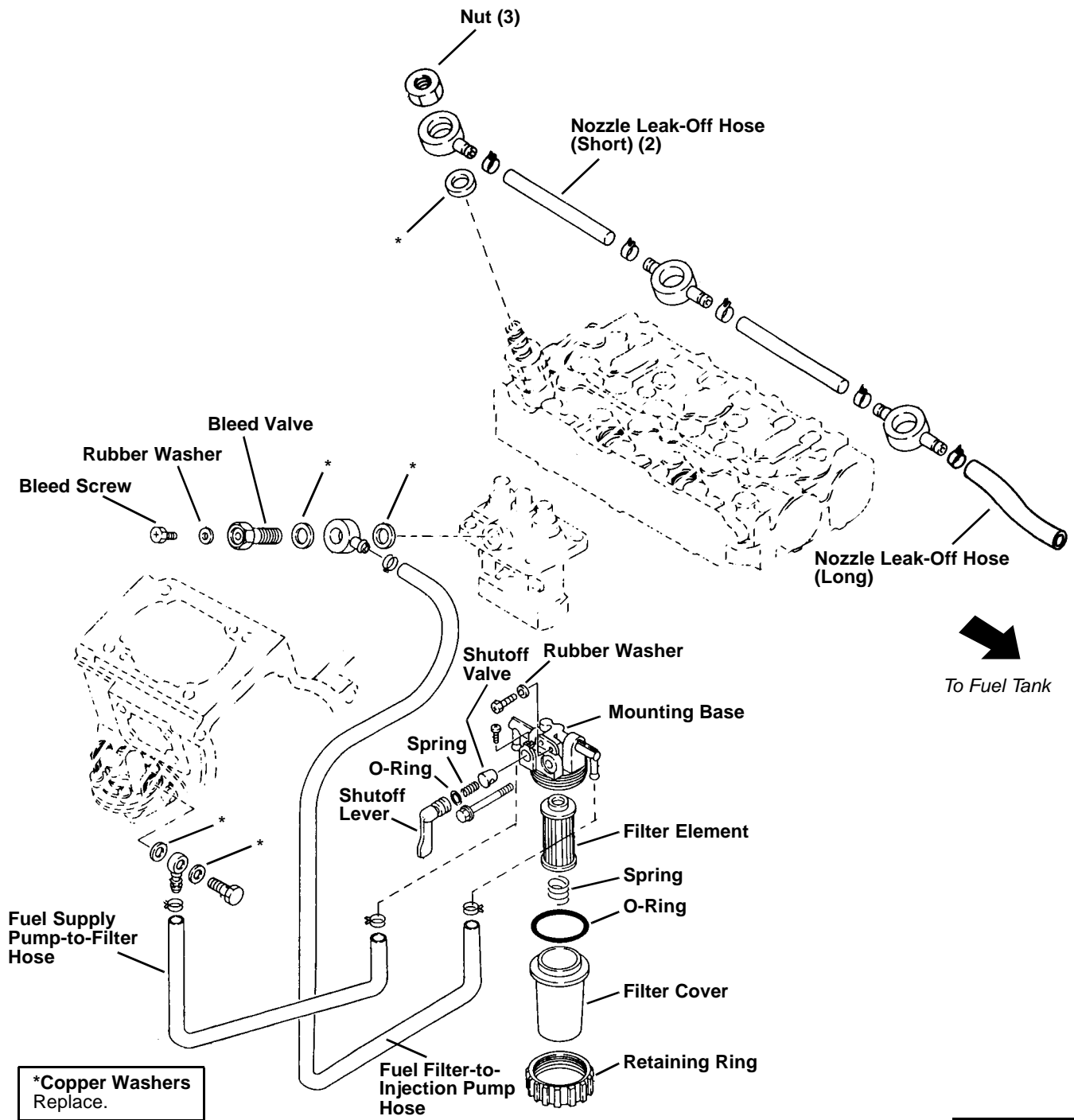
M82135A

FUEL FILTER ASSEMBLY - IF EQUIPPED

IMPORTANT: Replace all copper washers.
Damaged or used washers may leak.

NOTE: As a result of the various engine applications for each engine model, fuel filter assemblies may or may not be mounted on the engine. Fuel filters and line routing will be different. 3TNA72 (3009 OEM) shown.

1



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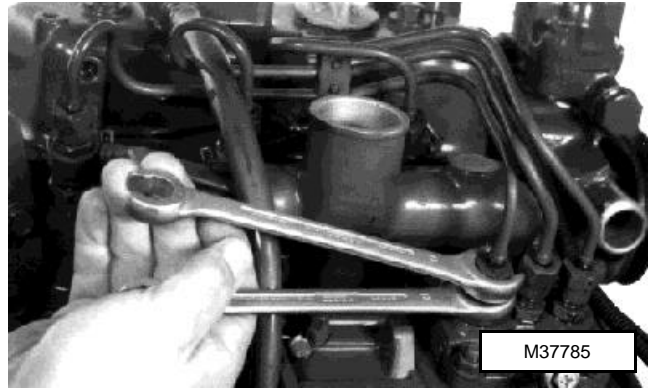
FUEL INJECTION PUMP

Removal

CAUTION

Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.

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



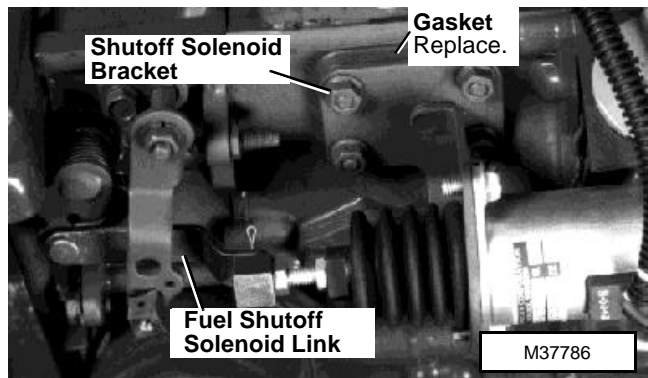
4. Disconnect hose from fuel filter or supply pump (670 CUT, 3009 OEM), if equipped.
5. Disconnect leak-off hoses to/from injection pump.
6. 375 SSL, 655 CUT, F915 FM, 455 LGT, 755/56 CUT:
 - Disconnect fuel shutoff solenoid link.
 - Remove four nuts, shutoff solenoid bracket and gasket.

IMPORTANT: Never steam clean or pour cold water on injection pump while the pump is running or warm. Doing so can damage the pump.

1. Clean the injection pump lines and area around the pump using a parts cleaning solvent or steam cleaner.

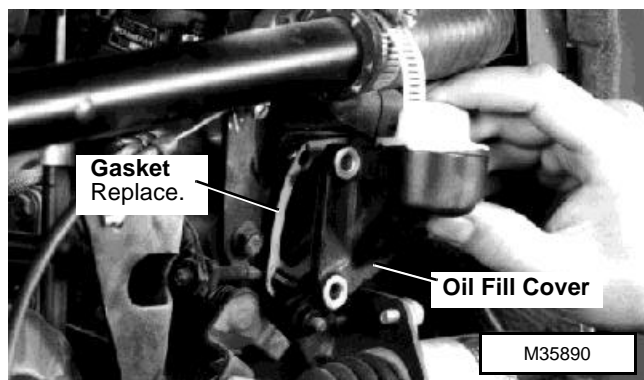
IMPORTANT: When removing injection lines, **DO NOT** turn pump delivery valve fittings. Turning fittings may damage pump internally.

2. Loosen fuel injection line connectors slightly to release pressure in the fuel system. When loosening connectors, use another wrench to keep delivery valves from loosening.
3. Loosen line clamp and remove fuel injection lines.



430 LGT (Early):

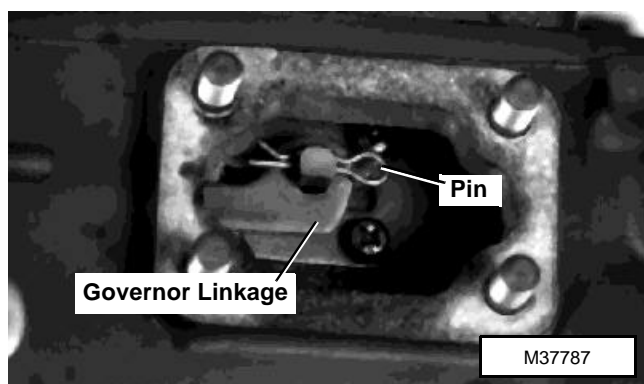
- Remove two cap screws, nut, oil fill cover and gasket.



330/332 LGT, 15 EX, 430 LGT (Later), 670 CUT, F925/35 FM, 3009 OEM:

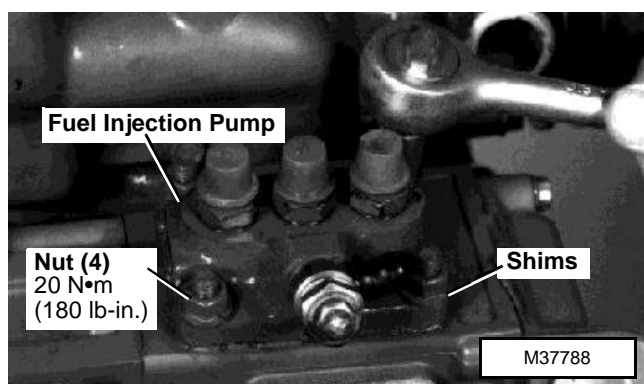
- Remove four nuts, cover and gasket.

7. 3TN66 and Later 3TNA72: Remove pin and washer, if equipped. Disconnect governor linkage.



IMPORTANT: If injection pump is being removed to be serviced or replaced, the same number and thickness of new shims must be installed when pump is assembled.

8. Remove four nuts to remove fuel injection pump and shims.



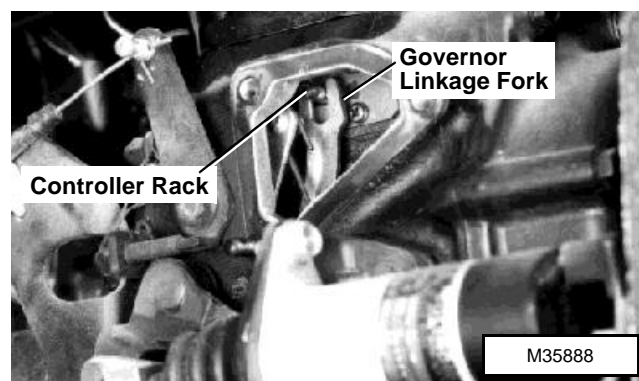
DO NOT attempt to service the injection pump except for fuel delivery valves. If unit is in need of repair, it must be serviced by a qualified fuel injection repair shop. If replacement is necessary, replace entire unit.

Installation

Installation is done in the reverse order of removal.

IMPORTANT: If a serviced or replacement fuel injection pump is installed, measure old shim thickness and install new shims of the same thickness.

- Early 3TNA72: When installing fuel injection pump into housing, align controller rack with governor linkage fork.



NOTE: 3TN66 and Later 3TNA72: Governor linkage may have two holes. Connect governor linkage to injection pump rack using hole closest to injection pump gear.

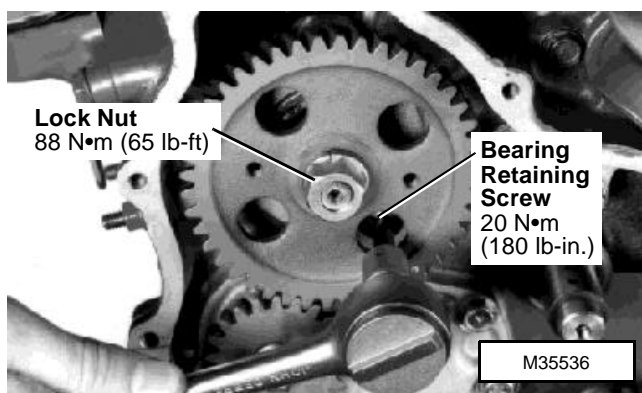
- 3TN66 and Later 3TNA72: When connecting governor linkage to injection pump rack, attach link to rack at hole closest to injection pump gear.
- Bleed the fuel system. (See *Operational Tests* in this section.)
- If new injection pump is being installed, check and adjust injection pump timing. (See *Checks, Tests and Adjustments* in this section.)

Fuel System

FUEL INJECTION PUMP CAMSHAFT - EARLY 3TNA72 (430 LGT)

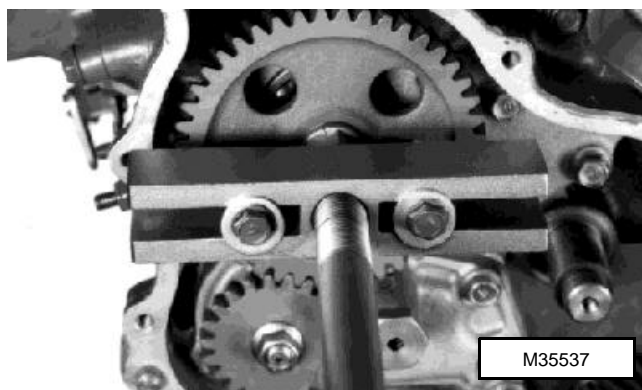
Removal

1. Remove fuel injection pump. (See procedure in this group.)
2. Remove idler gear. (See *Camshaft and Timing Gear Train* in this section.)
3. Put a shop towel between oil pump and injection pump gears. Loosen injection pump gear lock nut.
4. Remove bearing retaining screw.



IMPORTANT: DO NOT allow fuel injection pump camshaft lobes to hit bearing surfaces while removing camshaft. Machined surfaces may be damaged. ^{a a}

5. Remove fuel injection pump camshaft assembly using a slide hammer, puller set and two mounting cap screws from gear housing cover.

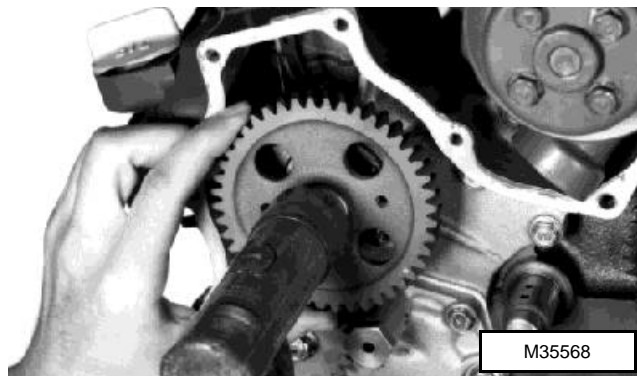


6. Disassemble and inspect all parts for wear or damage. (See *Disassembly and Inspection* procedures.)

Installation

Installation is done in the reverse order of removal.

- After installing camshaft assembly into housing, tap on end of camshaft gear with a plastic hammer to seat bearings in bores.

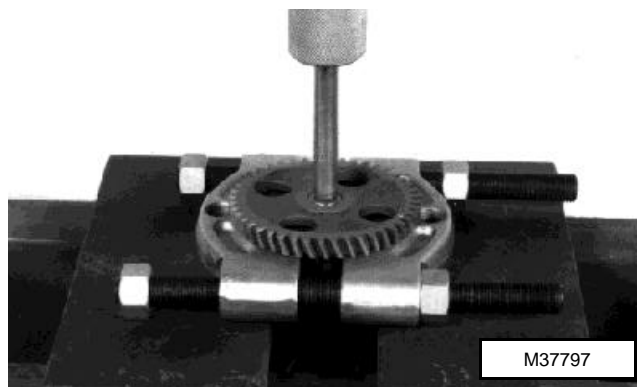


Disassembly

NOTE: Injection pump camshaft is tapered on gear end. Gear and bearings are press fit on shaft.

IMPORTANT: Hold camshaft while removing gear and bearings. Shaft can be damaged if dropped.

1. Remove lock nut and lock washer.
2. Remove gear using a knife edge puler and a press.
3. Remove key.



4. Remove bearings using a knife edge puller and a press.
5. Inspect all parts for wear or damage. (See *Inspection* procedures.)

Assembly

NOTE: Install large bearing on gear end.

1. Install bearings on ends of camshaft using a 3/4 in. deep well socket and a press. Press until bearing races bottom on camshaft shoulders.
2. Install key.
3. Put camshaft gear on a flat surface and press camshaft assembly into gear. Press until gear face is flush with end of shaft.
4. Install lock washer and lock nut. Leave nut loose.

Inspection

- Measure height of each camshaft lobe. Replace camshaft if lobe height is less than **30.90 mm (1.217 in.)**.



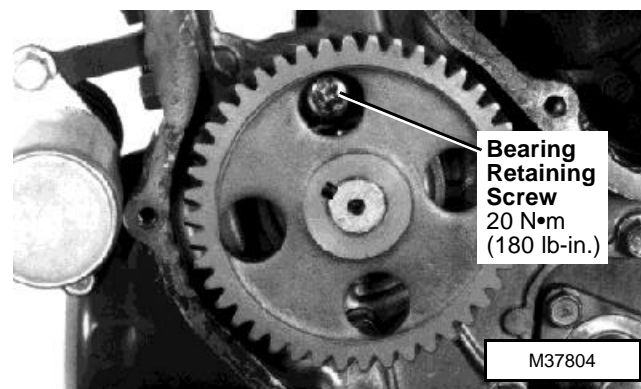
- Inspect camshaft bearing supports in timing gear housing. Check for cracks, damage or indications that bearings have spun in support. Replace timing gear housing if bearing bores are damaged. (See *Camshaft and Timing Gear Train* in this section.)
- Inspect all parts for wear or damage. Replace as necessary.

FUEL INJECTION PUMP CAMSHAFT - 3TN66 AND LATER 3TNA72

Removal

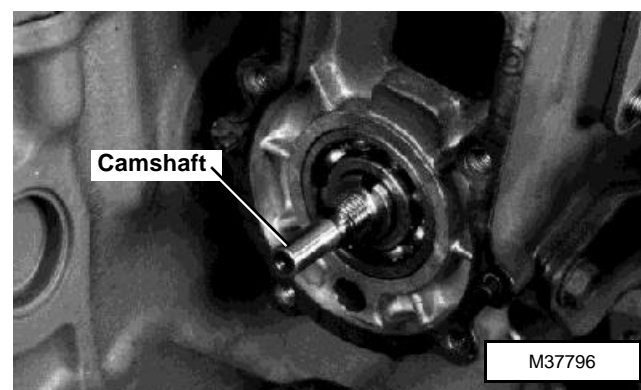
1. Remove fuel injection pump. (See procedure in this group.)

2. 670 CUT and 3009 OEM: Remove fuel supply pump. (See procedure in this group.)
3. Remove fuel control and governor linkage. (See procedure in this group.)
4. Remove idler gear. (See *Camshaft and Timing Gear Train* in this section.)
5. Remove bearing retaining screw.



IMPORTANT: DO NOT allow fuel injection pump camshaft lobes to hit bearing surfaces while removing camshaft. Machined surfaces may be damaged.

6. Tap the rear of camshaft with plastic hammer to remove from housing.



7. Disassemble and inspect all parts for wear or damage. (See *Disassembly and Inspection* procedures.)^{a a}

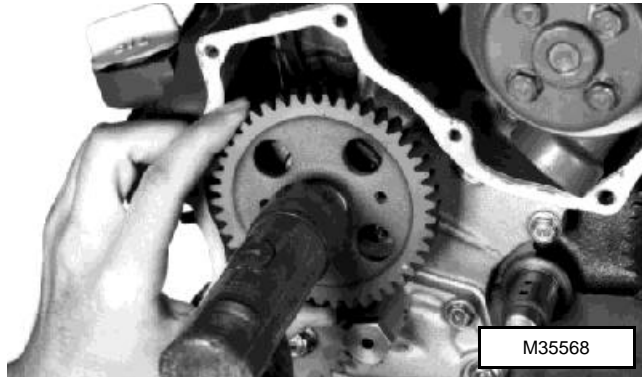
Fuel System

Installation

Installation is done in reverse order of removal.

- After installing camshaft assembly into housing, tap on end of camshaft gear with a plastic hammer to seat bearings in bores.

1

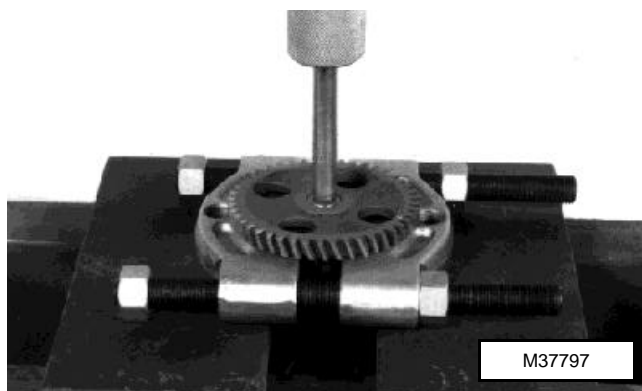


Disassembly

NOTE: Gear and bearings are press fit on shaft.

IMPORTANT: Hold camshaft while removing gear and bearings. Shaft can be damaged if dropped.

1. Remove gear using knife edge puller and a press.
2. Remove key.



3. Remove bearings using a knife edge puller and a press.
4. Inspect all parts for wear or damage. (See *Inspection* procedures.)

Assembly

NOTE: Install large bearing on gear end.

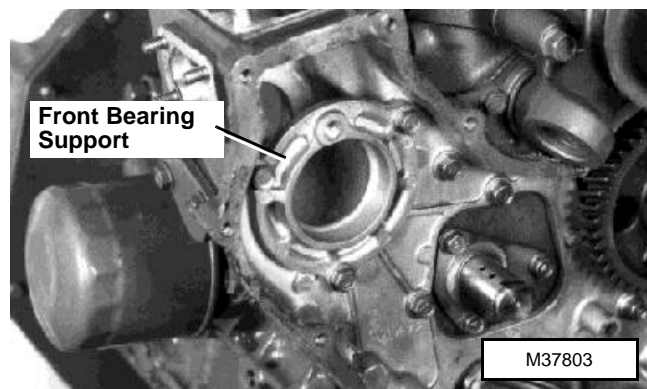
1. Install bearings on ends of camshaft using a 3/4 in. deep well socket and a press. Press until bearing races bottom on camshaft shoulders.
2. Install key.
3. Put camshaft gear on a flat surface and press camshaft assembly into gear. Press until gear face is flush with end of shaft.

Inspection

- Measure height of each camshaft lobe. Replace camshaft if lobe height is less than **30.90 mm (1.217 in.)**.



- Inspect camshaft bearing supports in timing gear housing. Check for cracks, damage or indications that bearings have spun in support.
 - If rear bearing bore is damaged, replace timing gear housing. (See *Camshaft and Timing Gear Train* in this section.)
 - If front bearing bore is damaged, remove three cap screws and replace support.

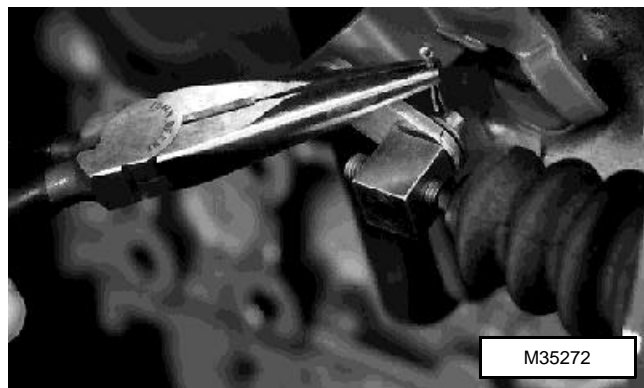


- Inspect all parts for wear or damage. Replace as necessary.

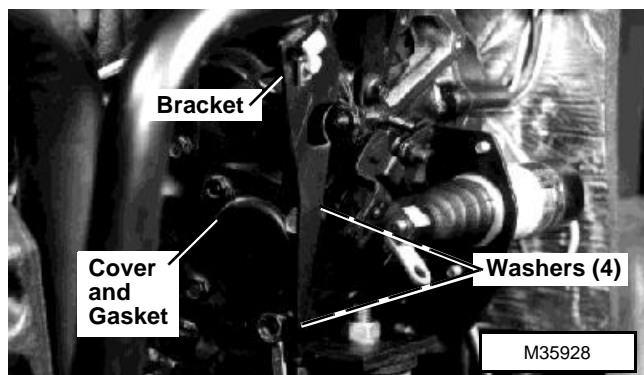
FUEL CONTROL AND GOVERNOR LINKAGE - EARLY 3TNA72 (430 LGT)

Removal

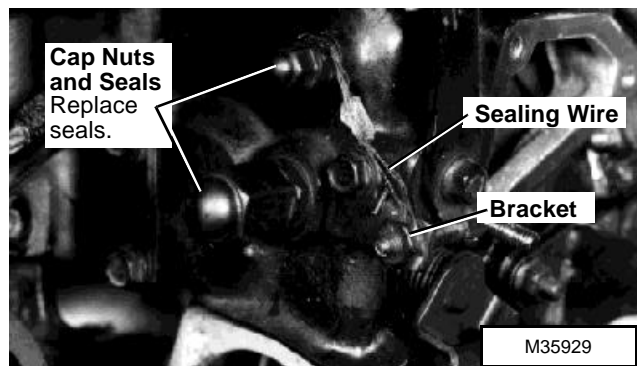
1. Remove fuel injection pump. (See procedure in this group.)
2. Remove cotter pin and washer to disconnect fuel shutoff solenoid linkage.



3. Remove oil filter and dipstick tube.
4. Remove two cap screws, bracket and four washers.
5. Remove two cap screws, cover and gasket.

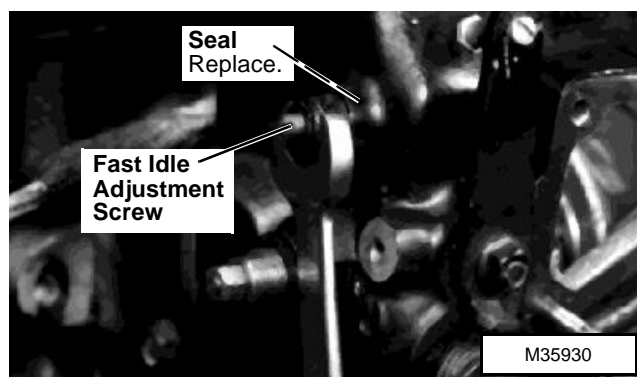


6. Remove sealing wire.
7. Remove cap screw and slow idle screw bracket.
8. Remove cap nuts and seals.

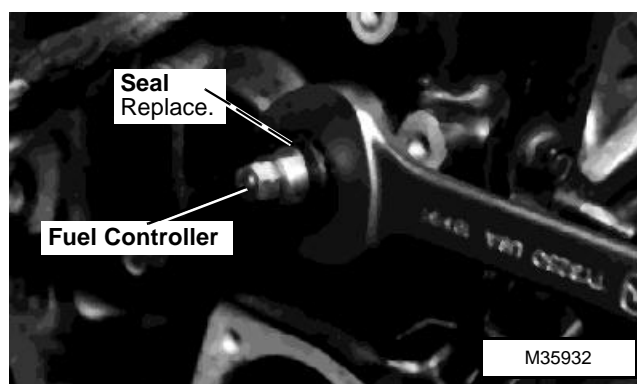


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9. Loosen lock nut and remove fast idle adjustment screw and seal.



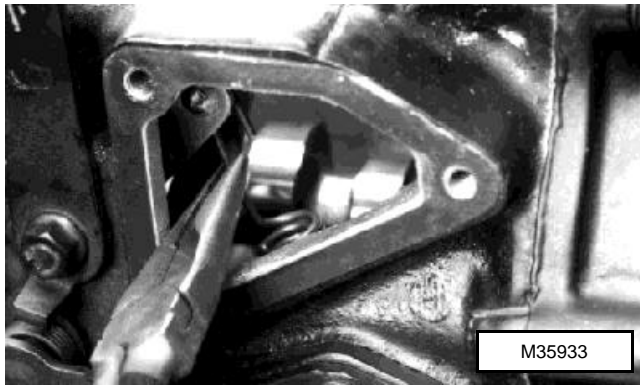
10. Loosen lock nut and remove fuel controller and seal.



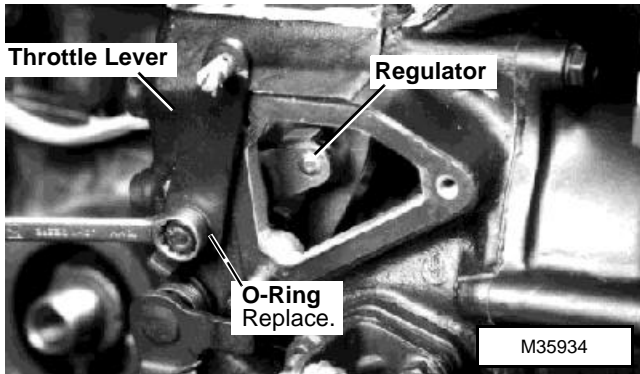
Fuel System

11. Disconnect spring from throttle lever regulator.

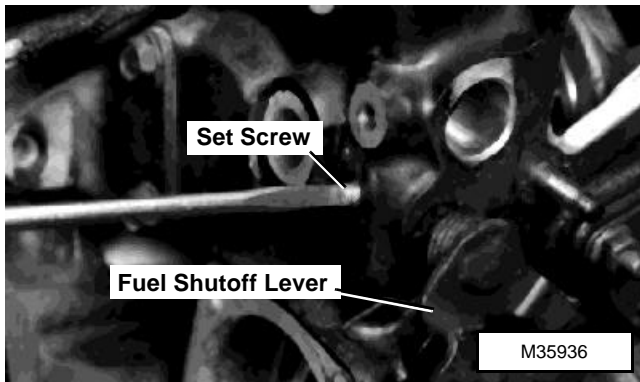
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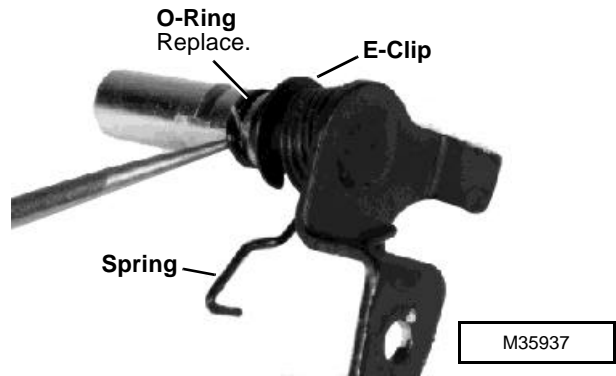
12. Remove nut, throttle lever, regulator and o-ring.



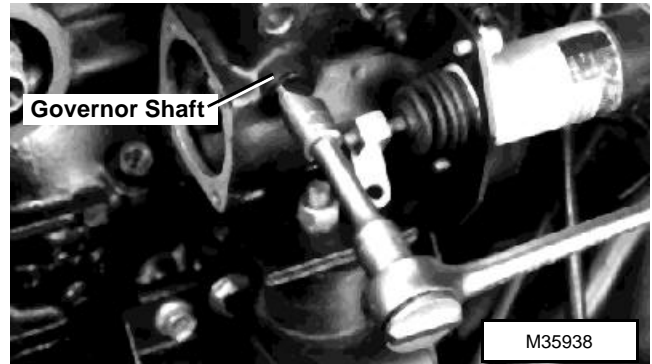
13. Remove set screw and fuel shutoff lever.



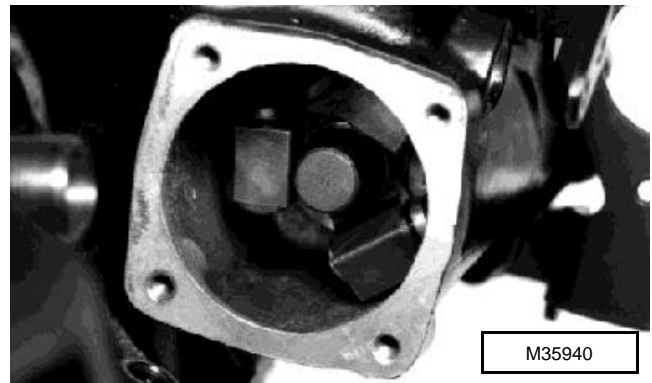
14. Remove o-ring, e-clip and spring.

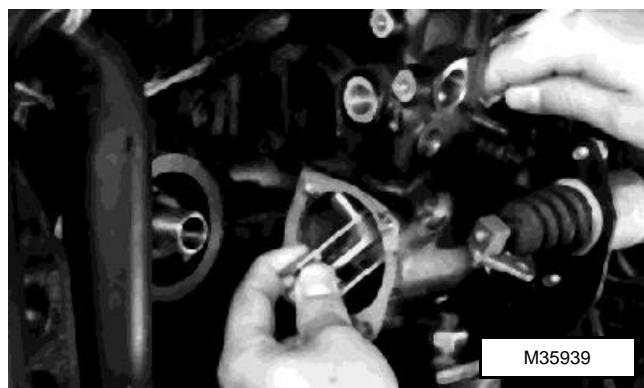


15. Remove governor shaft, bronze washer and spacer.



16. Turn governor weights until one weight is toward the engine. Remove governor linkage assembly.





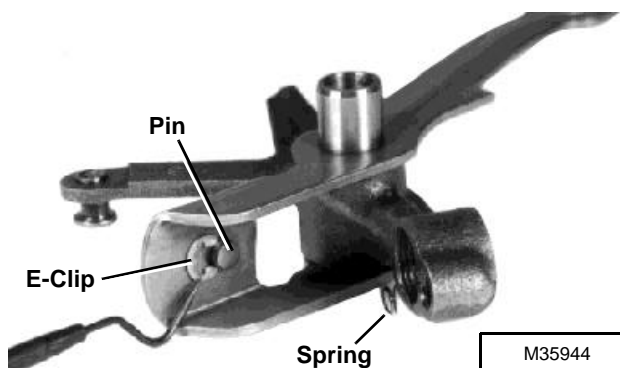
M35939

17. Remove spring pin.



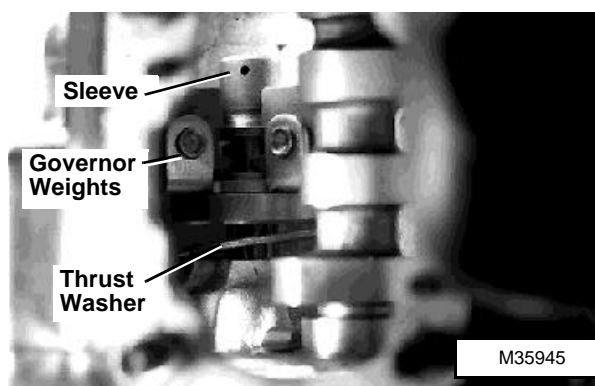
M35943

18. Remove e-clip, pin and spring.



M35944

19. Remove sleeve, governor weights and thrust washer.



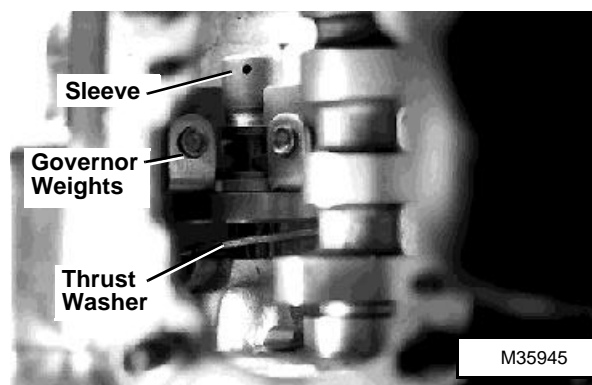
M35945

20. Inspect all parts for wear or damage. (See *Inspection* procedures.)

Installation

- Coat all internal parts with clean engine oil.

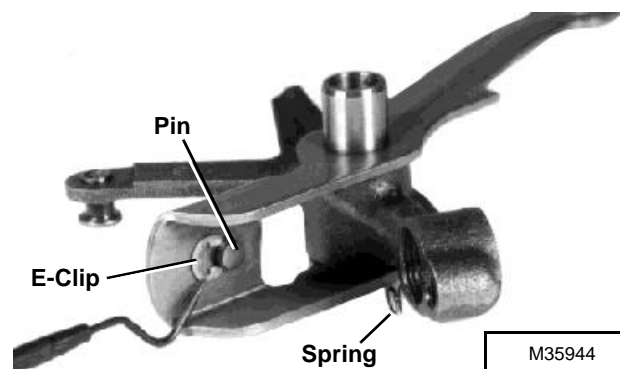
1. Align splines on oil pump rotor shaft with splines in thrust washer and governor weights. Install thrust washer, governor weights and sleeve on rotor shaft.



M35945

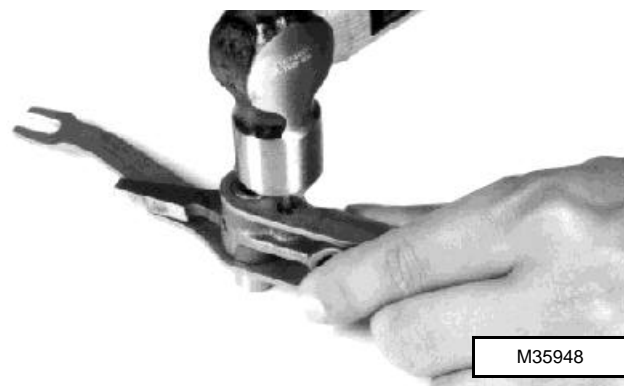
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2. Install spring, pin and e-clip.



M35944

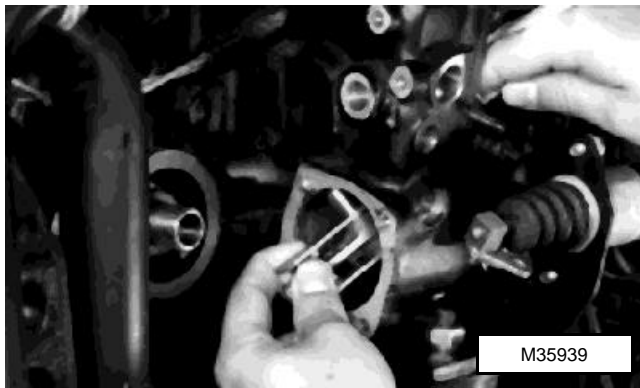
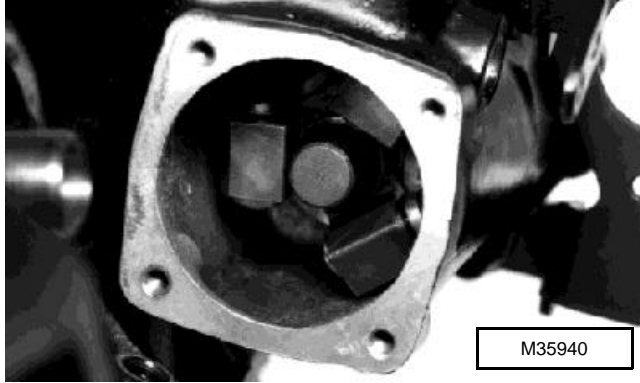
3. Install spring pin.



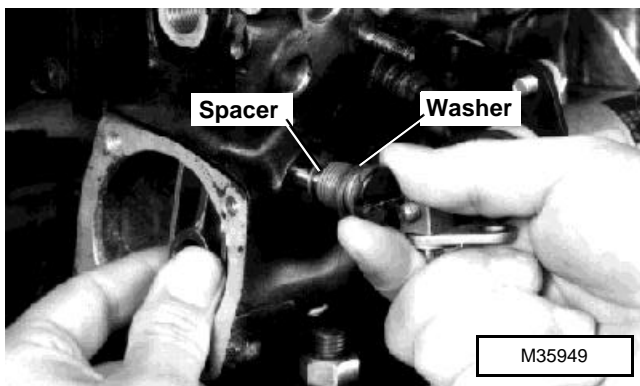
M35948

Fuel System

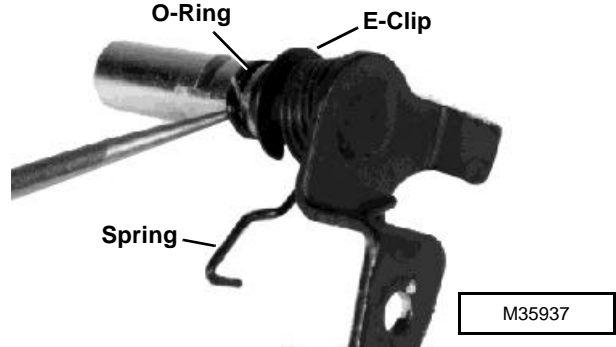
- Turn governor weights until one weight is toward the engine. Install governor linkage assembly.



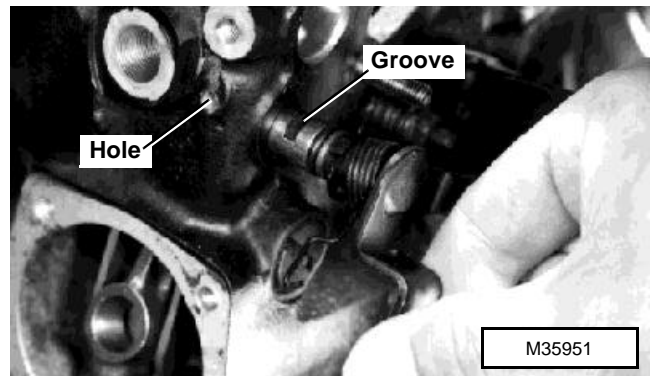
- Install spacer and new bronze washer on governor shaft.
- Insert governor shaft through governor linkage assembly. Tighten shaft to **49 N•m (36 lb-ft)**.



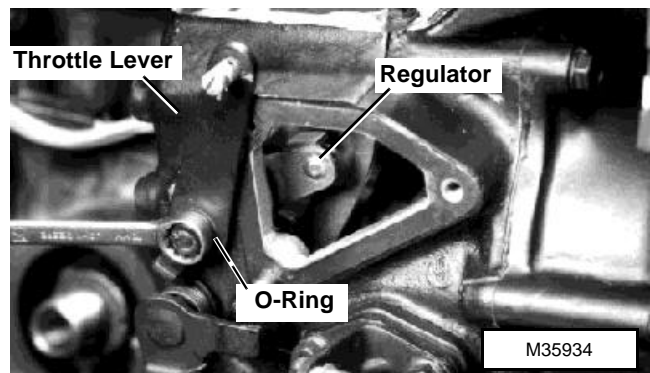
- Install spring, e-clip and new o-ring.



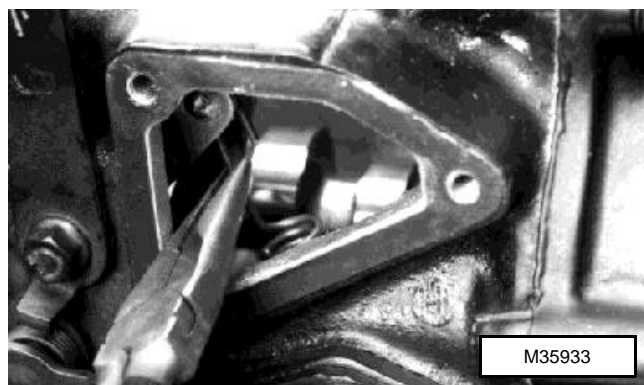
- Align groove in fuel shutoff lever with hole in timing gear housing and install lever. Make sure groove is visible through hole.
- Apply thread lock and sealer (low strength) on threads of set screw. Install and tighten set screw.



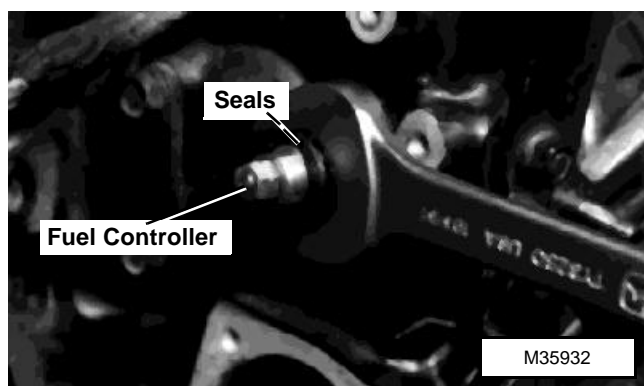
- Install new o-ring on regulator.
- Install throttle lever and nut.



12. Connect spring to throttle lever regulator then to governor linkage assembly.

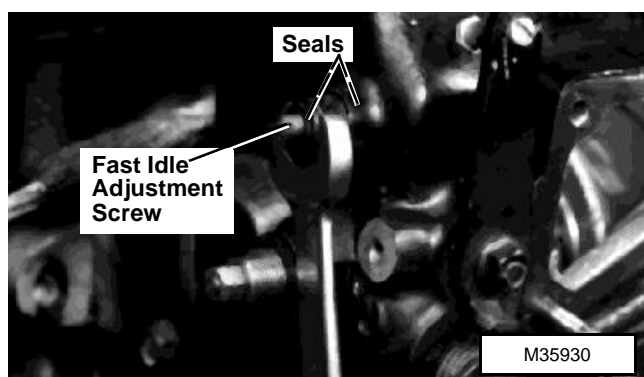


13. Install new seals and fuel controller. Tighten lock nut.



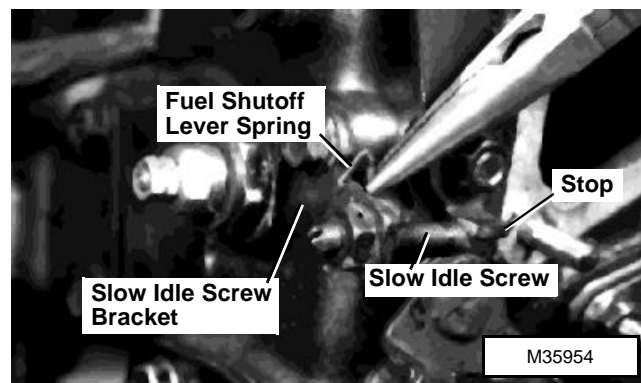
14. Install new seals and fast idle adjustment screw. Tighten lock nut.

NOTE: Do not install cap nuts or sealing wire until installation procedures have been completed and fast and slow idle adjustments have been made. Idle adjustments are made after engine has been installed in the machine.



15. Install slow idle screw bracket so the stop on the lever contacts the end of slow idle screw. Install and tighten cap screw.

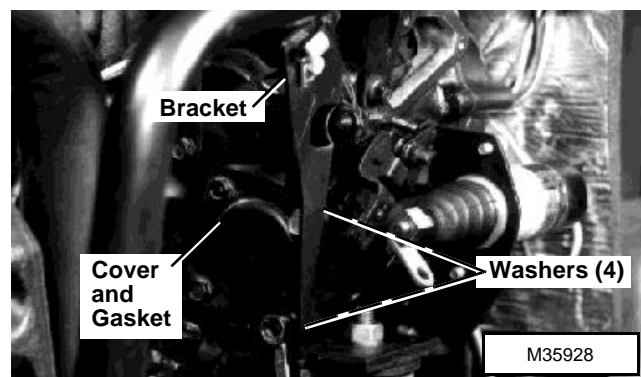
16. Install fuel shutoff lever spring on slow idle screw bracket.



1

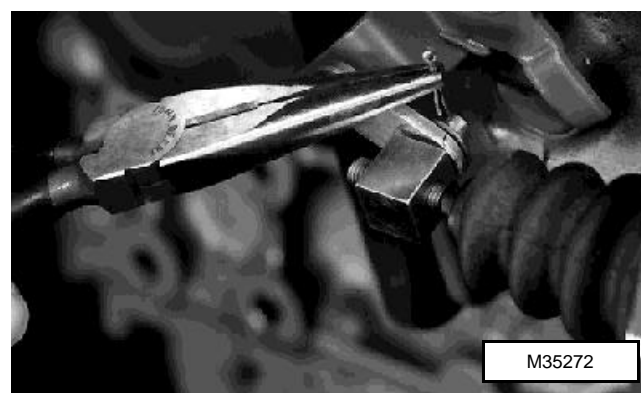
17. Install new gasket, cover and two cap screws.

18. Install four washers (two each hole location), bracket and two cap screws. Tighten all four cap screws to **9 N•m (78 lb-in.)**.



19. Install oil dipstick tube and oil filter.

20. Connect fuel shutoff solenoid linkage and install washer and cotter pin.



Fuel System

21. Install fuel injection pump. (See procedure in this group.)
22. Adjust fuel shutoff solenoid. (See *Checks, Tests and Adjustments* in this section.)
23. Check and adjust slow and fast idle settings. (See procedure in Machine Technical Manual.)

Inspection

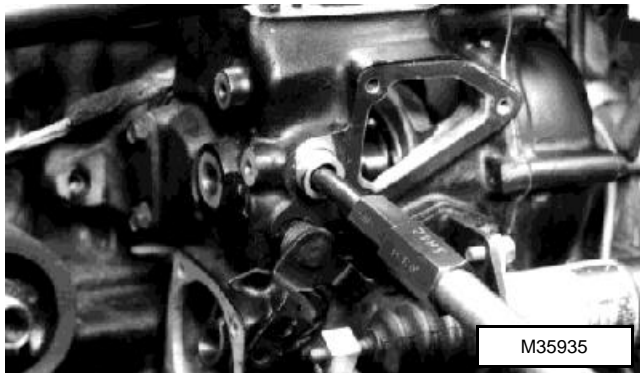
1 *NOTE: Throttle lever bushing is press fit in timing gear housing. Remove bushing only if replacement is necessary.*

1. Inspect throttle lever bushing for wear or damage. Replace if necessary.

To replace bushing:

Remove bushing using a blind hole puller set.

Install bushing with chamfered end toward gear housing using a driver set. Push in bushing until flush with surface of gear housing.



2. Measure governor shaft diameter. If O.D. is less than **7.90 mm (0.311 in.)**, replace governor shaft.



3. Measure governor shaft bore diameter in governor linkage.



Governor Shaft Bore I.D.

Wear Limit. 8.15 mm (0.321 in.)

Clearance. 0.18 mm (0.007 in.)

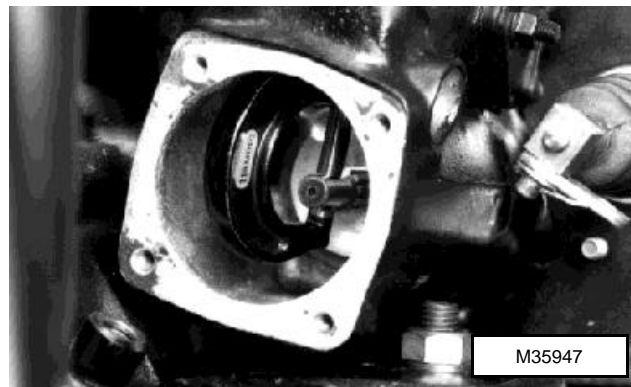
If shaft bore exceeds wear limit, replace governor linkage. ^{a a}

If bore clearance (bore I.D. minus shaft O.D.) exceeds specification, replace governor shaft, governor linkage or both.

4. Measure inside diameter of sleeve. If I.D. is more than **9.20 mm (0.362 in.)**, replace sleeve.



5. Measure oil pump rotor shaft diameter.



Rotor Shaft O.D.

Wear Limit. 8.90 mm (0.350 in.)

Clearance. 0.15 mm (0.006 in.)

If shaft diameter is less than wear limit, replace pump rotor shaft. Inspect splines on shaft for chipped or broken teeth. If necessary, replace oil pump rotor shaft. (See *Lubrication System* in this section.)

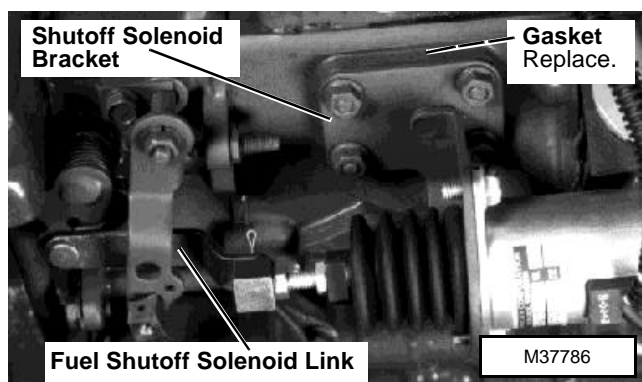
If clearance (sleeve I.D. minus shaft O.D.) exceeds specification, replace sleeve, oil pump rotor shaft or both.

FUEL CONTROL AND GOVERNOR LINKAGE - 3TN66 AND LATER 3TNA72

Removal

1. 375 SSL, 655 CUT, F915 FM, 455 LGT, 755/56 CUT:

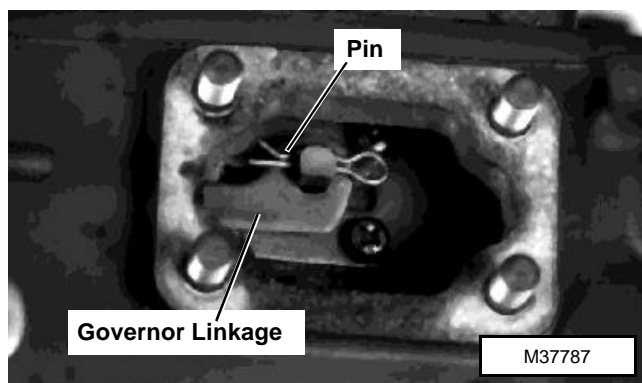
- Disconnect fuel shutoff solenoid link.
- Remove four nuts, shutoff solenoid bracket and gasket.



330 LGT, 15 EX, 430 LGT (Later), 670 CUT, F925/35 FM, 3009 OEM:

- Remove four nuts, cover and gasket.

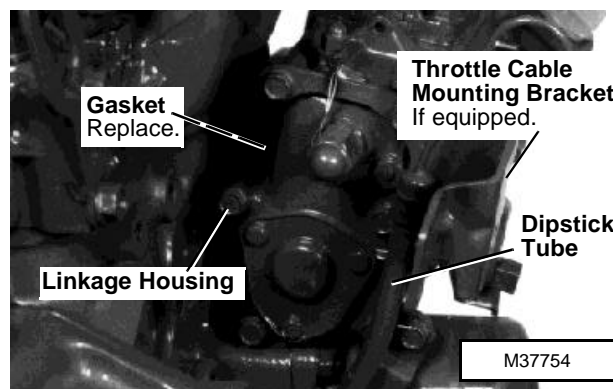
2. Remove pin and washer, if equipped, to disconnect governor linkage.



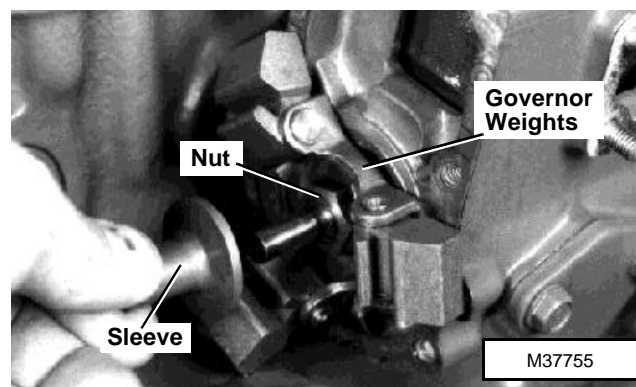
3. Remove dipstick tube.

4. 670 CUT, 15 EX, 375 SSL, 3009 OEM: Remove six cap screws, linkage housing and gasket.
430 LGT (Later), 330 LGT, 655 CUT, F915 FM, 455 LGT, 755/56 CUT, F925/35 FM:

- Remove three cap screws and throttle cable mounting bracket.
- Remove three cap screws, linkage housing and gasket.



5. Remove sleeve.
6. Remove nut and governor weights.



7. Disassemble and inspect all parts for wear or damage. (See *Disassembly* and *Inspection* procedures.)

Installation

Installation is done in the reverse order of removal.

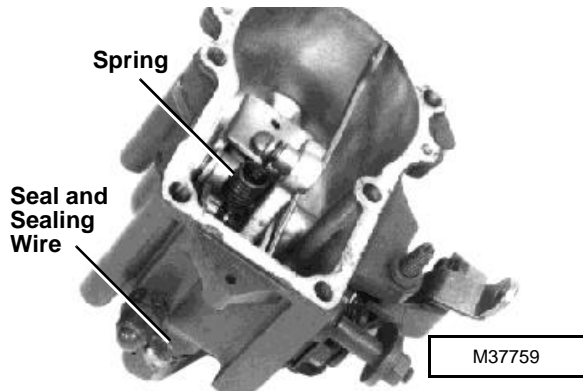
- Governor linkage may have two holes. Connect governor linkage to injection pump rack using hole closest to injection pump gear.
- Adjust fuel shutoff solenoid. (See *Checks, Tests and Adjustments* in this section.)
- Check and adjust slow and fast idle settings. (See procedure in Machine Technical Manual.)
- Check and adjust slow and fast idle settings. (See procedure in Machine Technical Manual.)

Fuel System

Disassembly

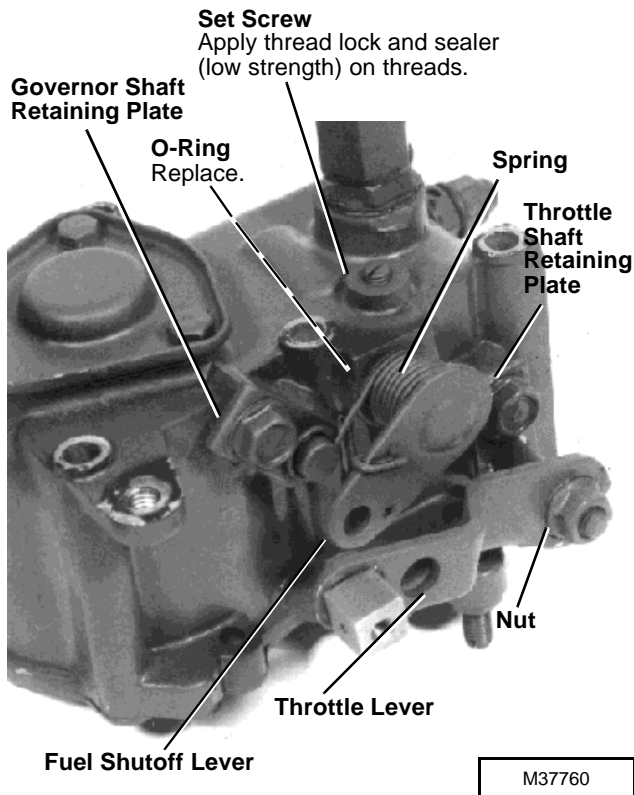
1. Remove spring.
2. Remove seal and sealing wire.

1



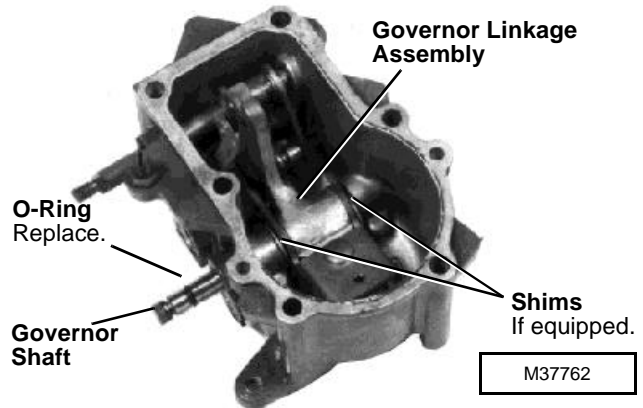
NOTE: Washer is on 670 CUT, 455 LGT and 3009 OEM only.

3. Remove nut, washer, if equipped, and throttle lever.
4. Remove cap screw and throttle shaft retaining plate.
5. Remove cap screw and governor shaft retaining plate.
6. Remove set screw, fuel shutoff lever, spring and O-ring.

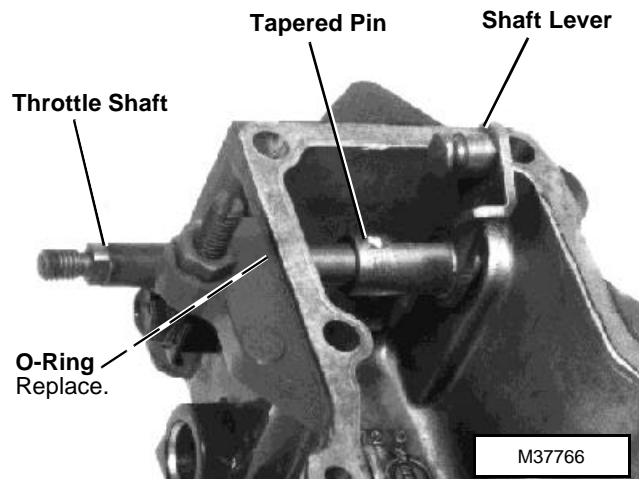


NOTE: Shims are on all engines except 670 CUT and 3009 OEM applications.

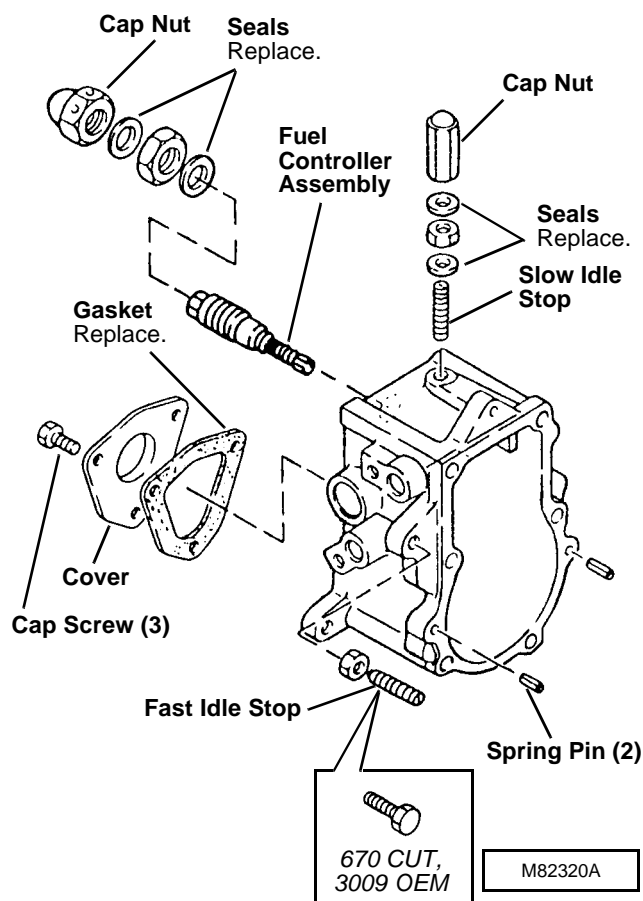
7. Remove governor shaft, governor linkage assembly, shims and O-ring.



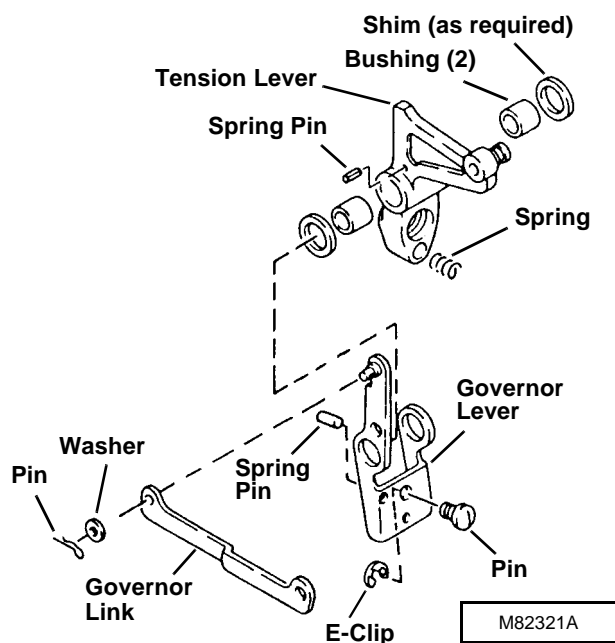
8. Rotate throttle shaft assembly as shown.
9. Remove tapered pin from tapered hole using a punch.
10. Remove throttle shaft, shaft lever and O-ring.



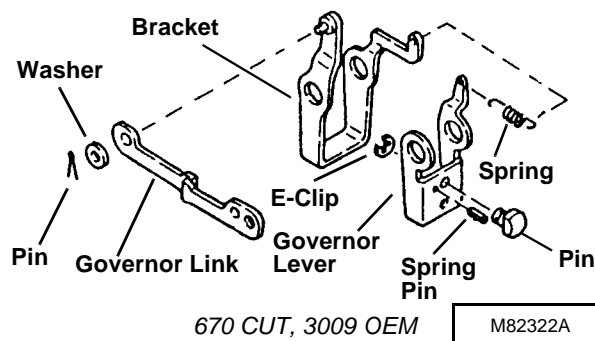
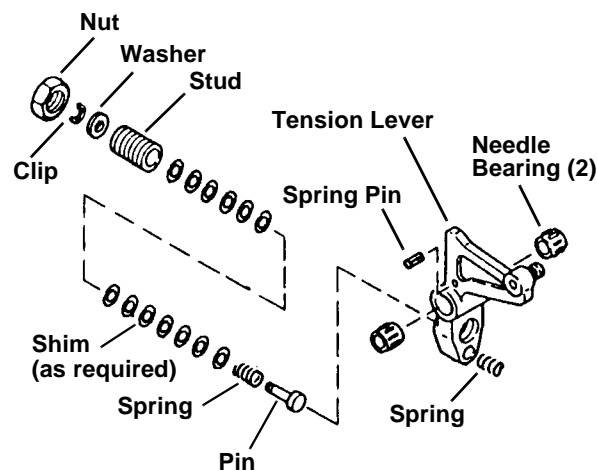
11. Remove cover, gasket, fuel controller assembly, fast idle stop and slow idle stop.



12. Disassemble governor linkage assembly.



All Except 670 CUT, 3009 OEM



13. Inspect all parts for wear or damage. Replace as necessary. (See *Inspection* procedures.)

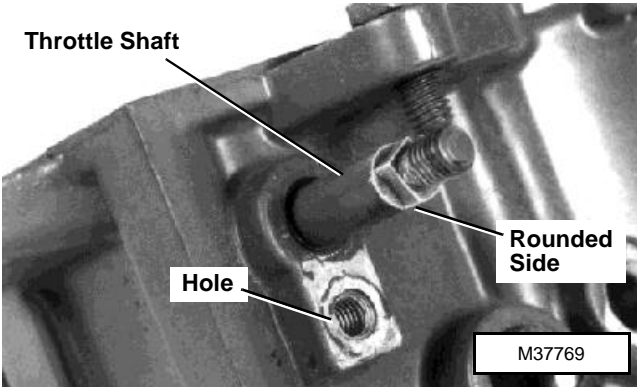
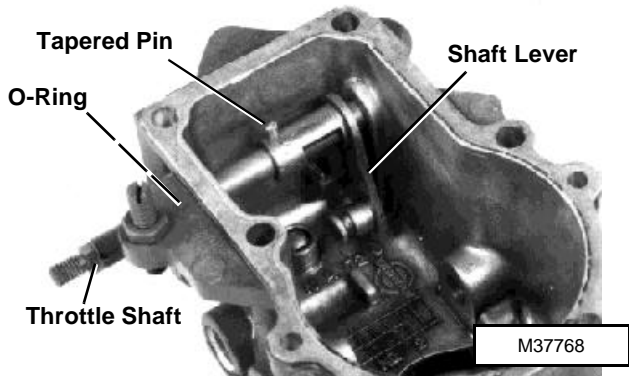
Assembly

Assembly is done in the reverse order of disassembly.

- Apply clean engine oil on all internal parts.
- When installing throttle shaft:
 - Install new O-ring, throttle shaft and shaft lever. Rotate shaft until rounded side of shaft is facing toward hole.
 - Position shaft lever as shown and install tapered pin in tapered hole.

Fuel System

1



- Seal and sealing wire are not installed until governor linkage housing installation procedures have been completed and fast and slow idle adjustments have been made. Idle adjustments are made after engine has been installed in the machine.

Inspection

1. Measure governor shaft diameter. If O.D. is less than **7.90 mm (0.311 in.)**, replace governor shaft.



2. Measure governor shaft bore diameter in governor linkage.

Governor Shaft Bore I.D.

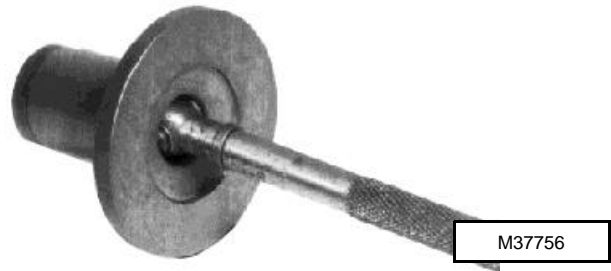
Wear Limit..... 8.15 mm (0.321 in.)

Clearance..... 0.18 mm (0.007 in.)

If shaft bore exceeds wear limit, replace governor linkage.

If bore clearance (bore I.D. minus shaft O.D.) exceeds specification, replace governor shaft, governor linkage or both.

3. Measure inside diameter of sleeve. If I.D. is more than **8.20 mm (0.323 in.)**, replace sleeve.



4. Measure injection pump camshaft diameter.



Injection Pump Camshaft O.D.

Wear Limit..... 7.90 mm (0.311 in.)

Clearance..... 0.15 mm (0.006 in.)

If camshaft diameter is less than wear limit, replace injection pump camshaft. (See procedure in this group.)

If clearance (sleeve I.D. minus camshaft O.D.) exceeds specification, replace sleeve, injection pump camshaft or both.

5. Inspect all parts for wear or damage. Replace as necessary.

FUEL INJECTION NOZZLES (PINTLE-TYPE)

Removal/Installation

IMPORTANT: Never steam clean or pour cold water on injection pump while the pump is running or warm. Doing so can damage the pump.

1. Clean the injection pump lines and area around the pump using a parts cleaning solvent or steam cleaner.

CAUTION

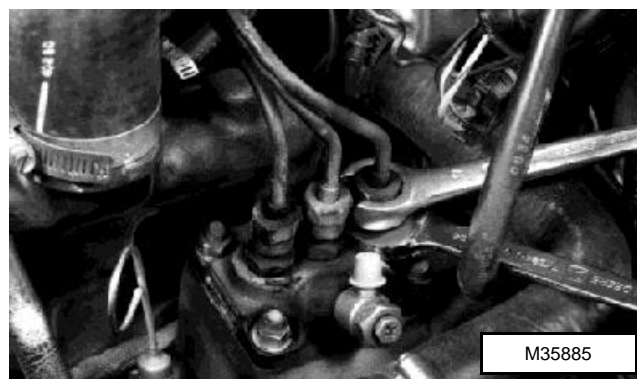
Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.

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

NOTE: Nozzles are matched to the cylinders. If removing more than one nozzle, tag nozzles, according to the cylinder from which it was removed.

IMPORTANT: When removing injection lines, **DO NOT** turn pump delivery valve fittings. Turning fittings may damage pump internally.

2. Loosen fuel injection line connectors slightly to release pressure in the fuel system. When loosening connectors, use another wrench to keep delivery valves from loosening. **1**

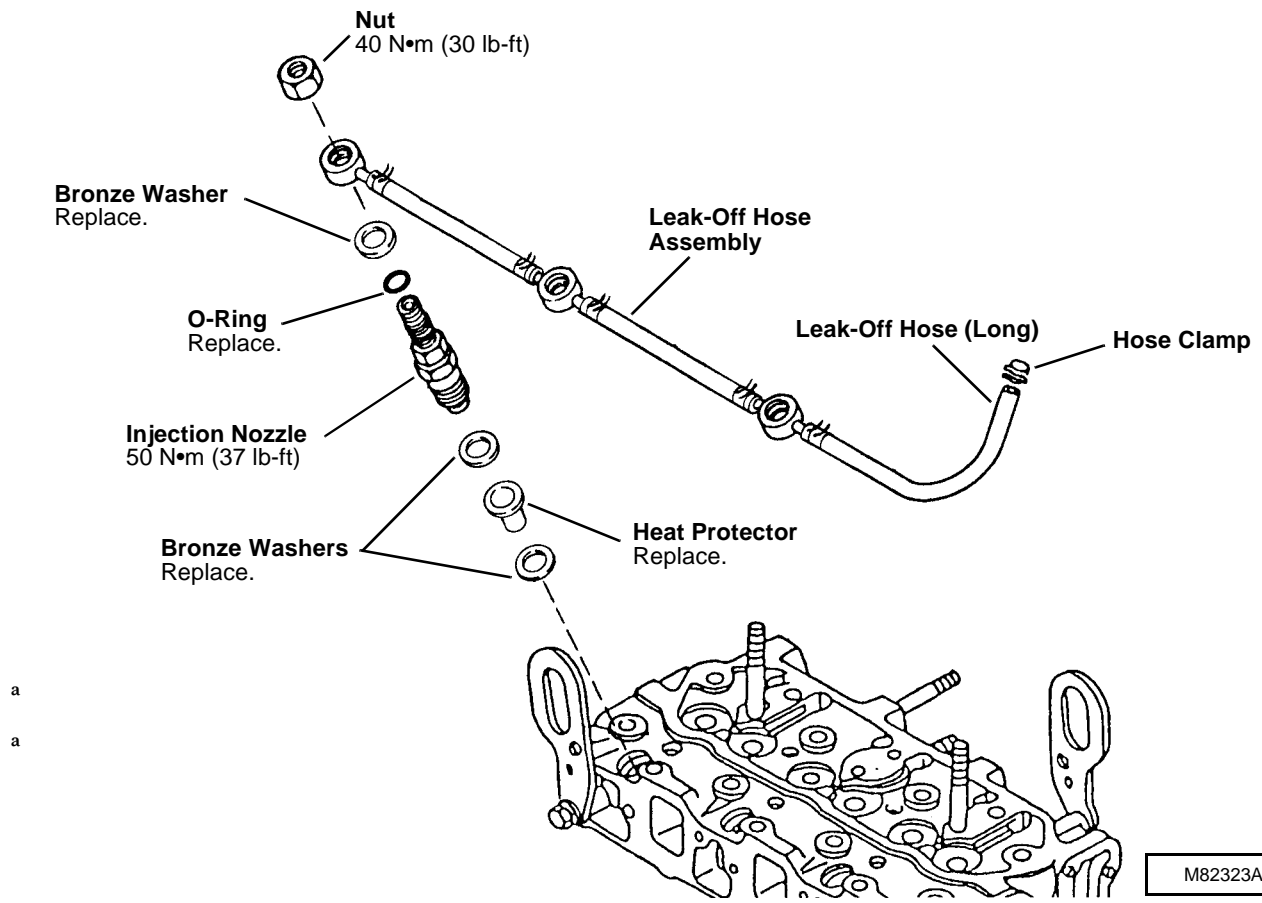


3. Loosen line clamp and remove fuel injection lines.
4. Disconnect long leak-off hose.
5. Remove nuts and leak-off hose assembly.
6. Remove bronze washers and o-rings.
7. Remove injection nozzle, washers and heat protector.
8. Test injection nozzles. (See *Checks, Tests and Adjustments* in this section.)

Installation is done in reverse order of removal.

Fuel System

1

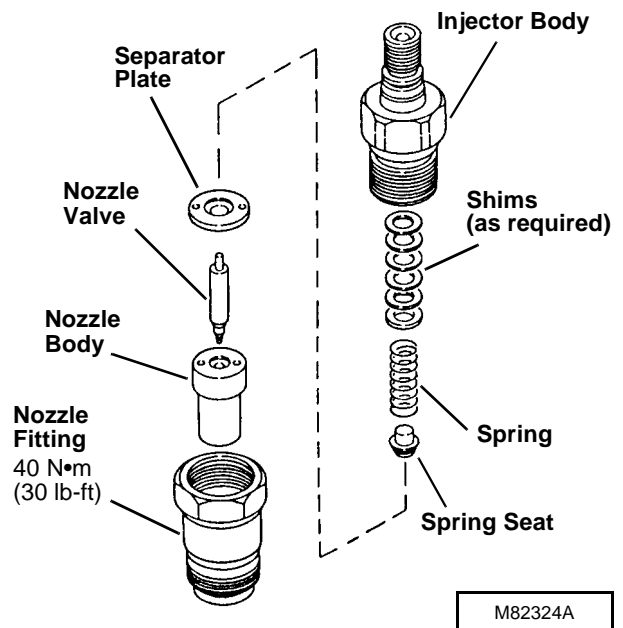


Disassembly/Assembly

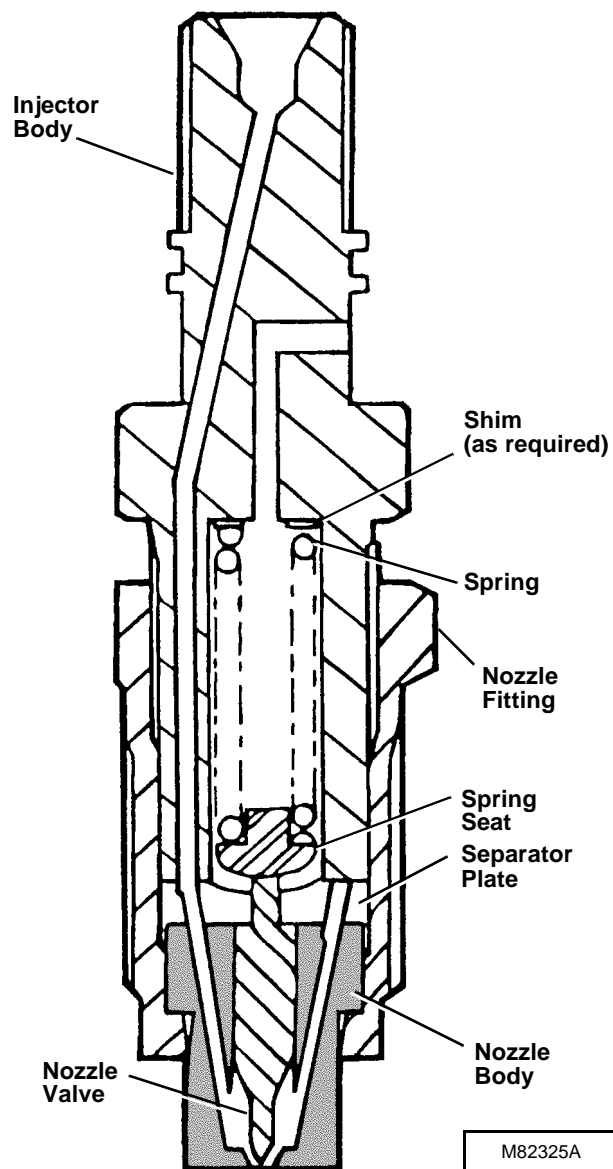
NOTE: If servicing more than one nozzle, keep parts for each nozzle separate from one another.

IMPORTANT: If injection nozzles are disassembled to be cleaned, the same number and thickness of shims must be installed.

- Clean and inspect nozzle assembly. (See *Cleaning/Inspection* procedures.)
- After assembly is complete, test injection nozzle. (See *Checks, Tests and Adjustments* in this section.)



CROSS SECTION



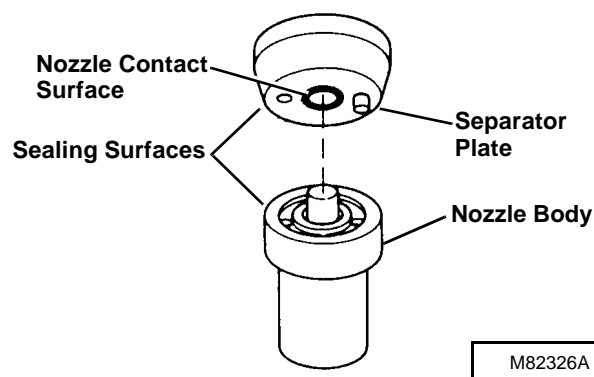
Cleaning/Inspection

NOTE: To clean nozzles properly, JDF13 Nozzle Cleaning Kit is recommended. The Cleaning Kit is available through the John Deere SERVICEGARD™ Catalog.

1. Remove anti-corrosive grease from new or reconditioned nozzles by washing them thoroughly in diesel fuel.

IMPORTANT: Never use a steel brush to clean nozzles as this will distort the spray hole.

2. Remove carbon from used nozzles, and clean by washing in diesel fuel. If parts are coated with hardened carbon or lacquer, it may be necessary to use a brass wire brush (supplied in Nozzle Cleaning Kit).
3. After removing carbon or lacquer from the exterior of nozzle, inspect sealing surfaces between separator plate and nozzle body for nicks or scratches. **1**
4. Inspect condition of separator plate and nozzle body. Contact area of separator plate (both parts) must not be scored or pitted. Use an inspection magnifier (No. 16487 or equivalent) to aid in making the inspection.
5. Check nozzle contact surface on separator plate for wear. If contact surface is more than **0.10 mm (0.0039 in.)**, replace nozzle assembly.



6. Inspect the piston (large) part of nozzle valve to see that it is not scratched or scored and that lower (tip) end of valve is not broken. If any of these conditions are present, replace the nozzle assembly.

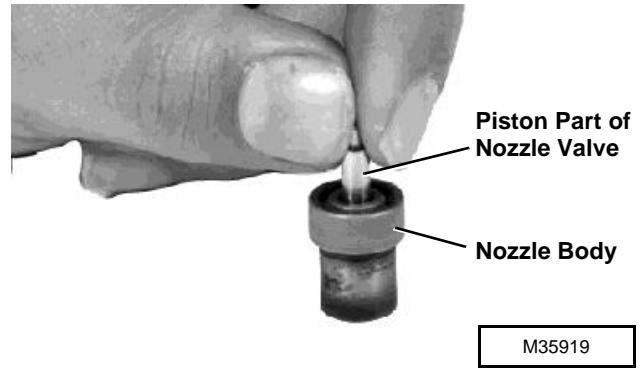
Fuel System

7. Further inspect the nozzle assembly by performing a slide test. Use the following procedure:

- Dip the nozzle valve in clean diesel fuel. Insert valve in nozzle body.
- Hold nozzle vertical, and pull valve out about 1/3 of its engaged length.
- Release valve. Valve should slide down to its seat by its own weight.

1

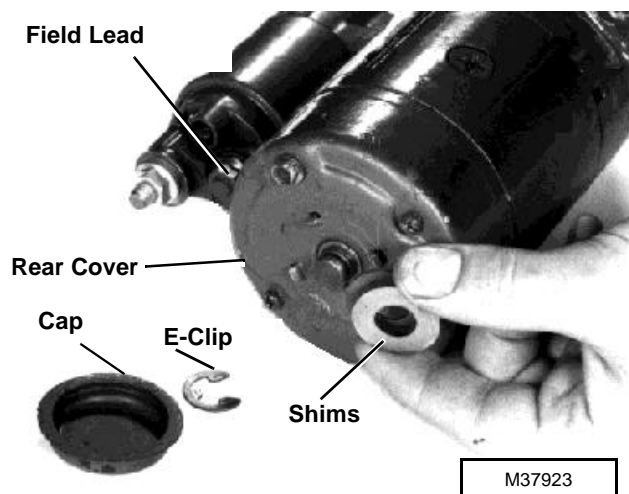
Replace nozzle assembly if the valve does not slide freely to its seat.



STARTER - HITACHI 0.8 kW

Disassembly/Inspection

1. Disconnect field lead.
2. Remove two cap screws and two screws from rear cover.
3. Pry off plastic cap.
4. Remove e-clip, shims and rear cover.

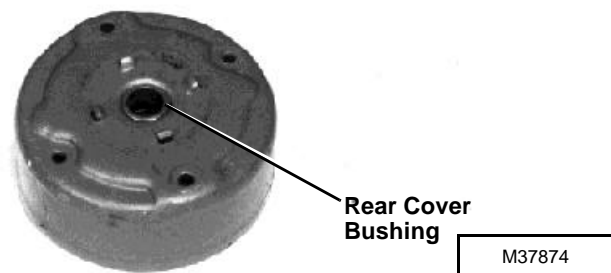


5. Inspect cover bushing for wear or damage. Replace if necessary.

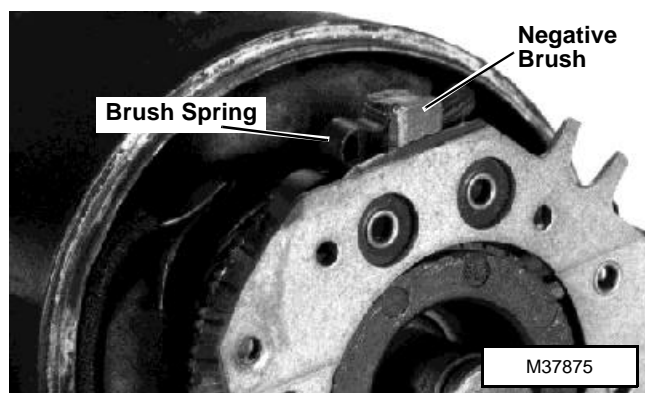
To replace bushing:

Remove bushing using a blind-hole puller set. Install new bushing until it bottoms in cover bore using a driver set.

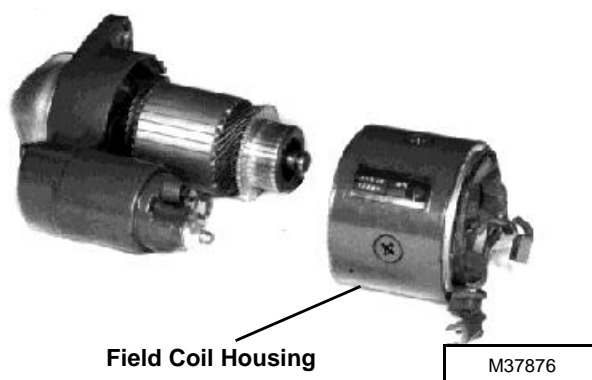
Ream out bushing to **12.50 - 12.53 mm (0.492 - 0.493 in.)**.



6. Remove field coil brushes from brush holder.
7. Pry brush springs away and pull negative brushes up enough to allow spring to hold brush in place.
8. Remove brush holder.



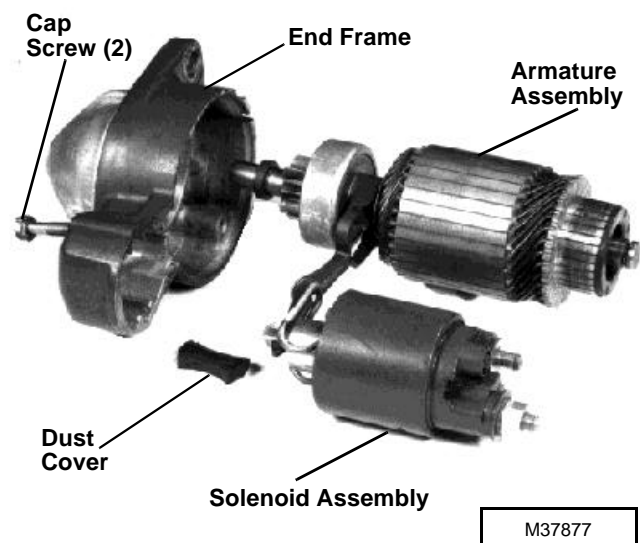
9. Remove field coil housing from armature/solenoid assembly.



10. Remove two cap screws and pivot bolt, if equipped.

11. Remove dust cover.

12. Remove solenoid and armature assemblies from end frame.

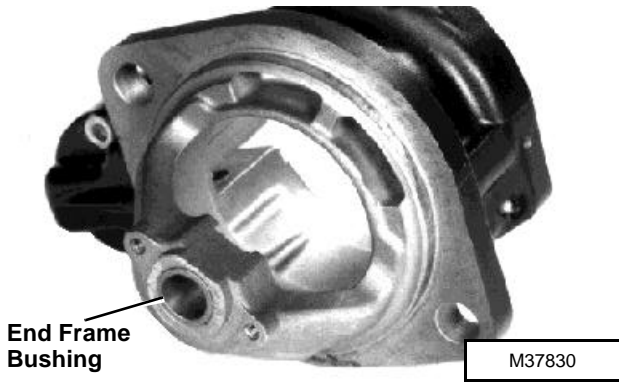


Starter

13. Inspect end frame bushing for wear or damage. Replace if necessary.

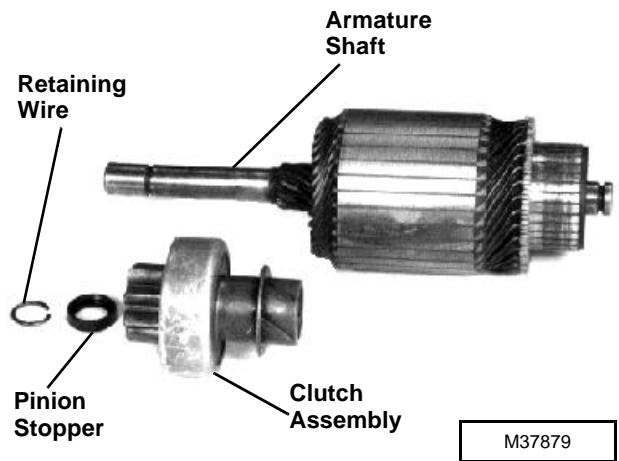
Replace bushing using a driver set. Install bushing flush with face of housing.

1



14. Slide pinion stopper away from retaining wire using a piece of pipe or deep socket. Remove retaining wire, pinion stopper, and clutch assembly from armature shaft.

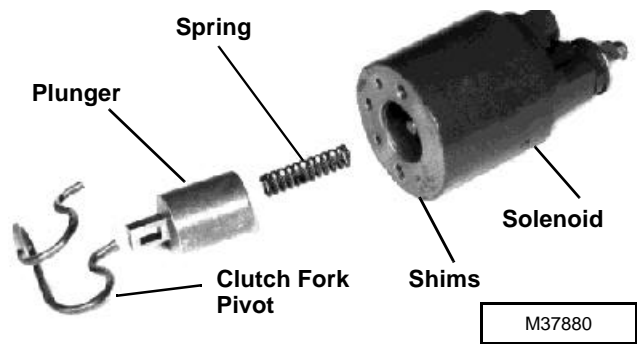
15. Inspect clutch assembly for wear or damage. Gear should rotate in one direction only. Replace if necessary.



16. Remove clutch fork pivot, plunger, spring and shim(s) from solenoid.

17. Inspect all parts for wear or damage. Replace as necessary.

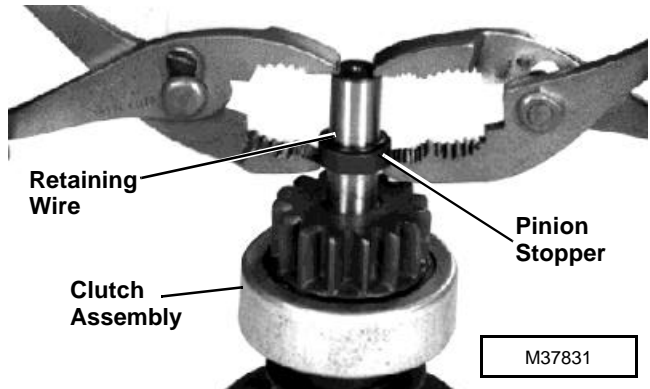
18. Inspect and test brushes, holder, field coil and armature. (See *Test* procedures.)



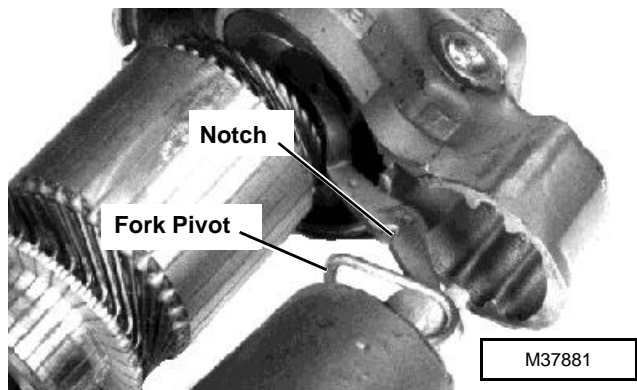
Assembly

Assembly is done in the reverse order of disassembly.

- After installing clutch assembly, pinion stopper and retaining wire on armature shaft, use two pliers to press pinion stopper over retaining wire.



- When installing solenoid and armature assemblies into end frame, make sure fork pivot seats in notch on clutch fork.



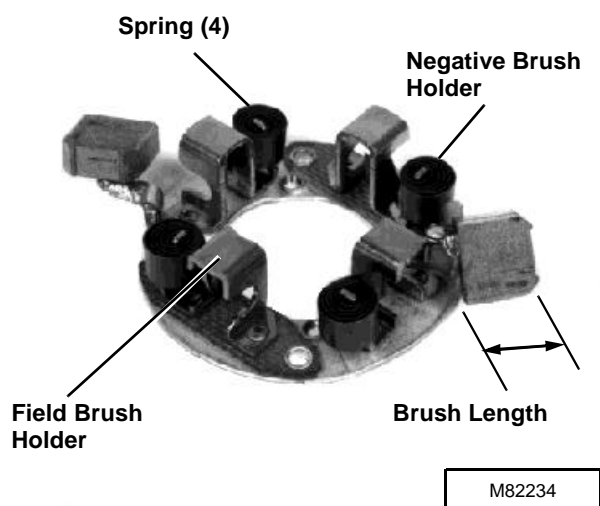
IMPORTANT: When installing rear cover, be sure field coil brush wires do not touch cover. Turn brush holder slightly to take up slack in brush wires. Press wires inward to clear rear cover.

Test

1. Measure holder and field coil brush lengths. Minimum brush length is **7.70 mm (0.303 in.)**. Replace brush holder or field coil if brush length is below minimum.

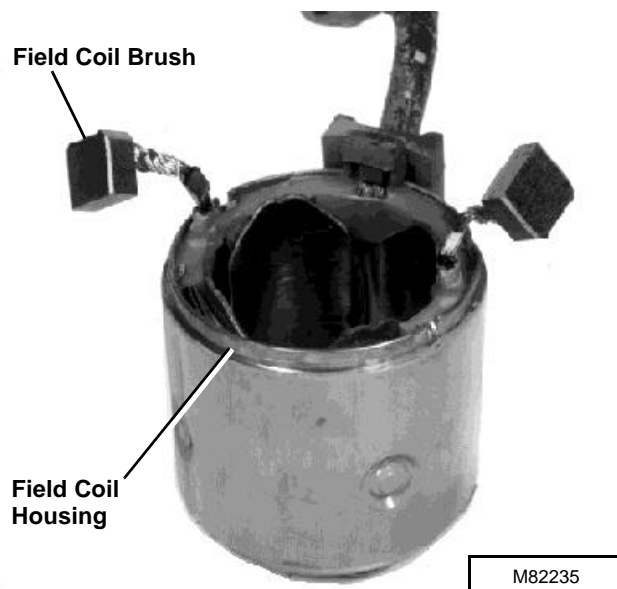
NOTE: Test brush holder using an ohmmeter or test light.

2. Test brush holder:
Touch one probe of tester to negative brush holder and other probe to field brush holder. If there is continuity, replace the brush holder.
3. Inspect springs for wear or damage. Replace if necessary.



NOTE: Test field coil using an ohmmeter or test light.

4. Test for grounded field winding:
Touch one probe of tester to field coil brush and other probe to field coil housing. Be sure the brush lead is not touching the frame. If there is continuity, the coil is grounded and the field coil housing assembly must be replaced.
5. Test for open field coil:
Touch one probe of tester to each field coil brush. If there is no continuity, the field coil is open and the field coil housing assembly must be replaced.



1

IMPORTANT: Do not clean armature with solvent. Solvent can damage insulation on windings. Use only mineral spirits and a brush.

6. Inspect armature. Look for signs of dragging against pole shoes.
7. Inspect commutator. Look for roughness, burned bars, or any material which might cause short circuits between bars. If necessary, clean and touch up with 400 sandpaper. NEVER use emery cloth. Clean all dust from armature when finished.

NOTE: Test armature windings using an ohmmeter or test light.

8. Test for grounded windings:
Touch probes on one commutator bar and armature shaft. Armature windings are connected in series, so only one commutator bar needs to be checked.

Starter

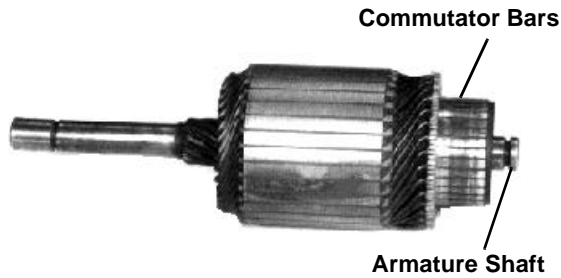
If test shows continuity, a winding is grounded and the armature must be replaced.

9. Test for open circuited windings:

Touch probes on two different commutator bars.

If test shows no continuity, there is an open circuit and the armature must be replaced.

1



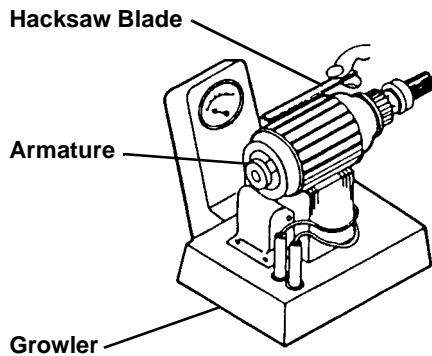
M82246

10. Test for short circuited windings using a growler. Put armature in a growler and hold a hacksaw blade above each slot while slowly rotating armature.

If coil is shorted, the blade will vibrate on the slot.

NOTE: A short circuit most often occurs because of copper dust or filings between two commutator segments.

11. If test indicates short circuited windings, clean the commutator of dust and filings. Check the armature again. If the test still indicates a short circuit, replace the armature.

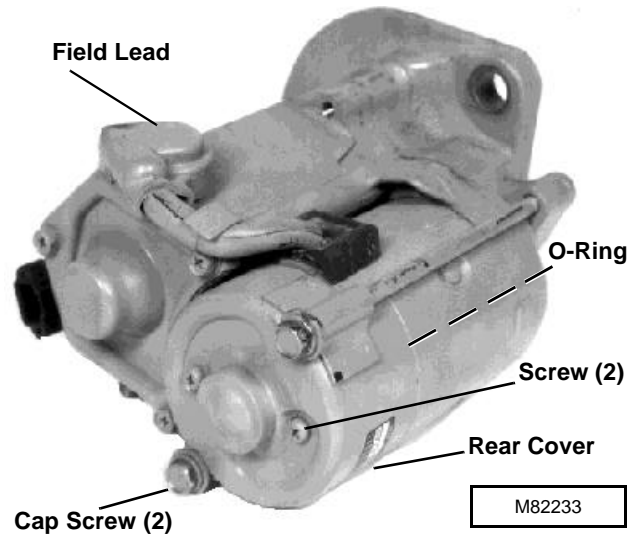


M82125A

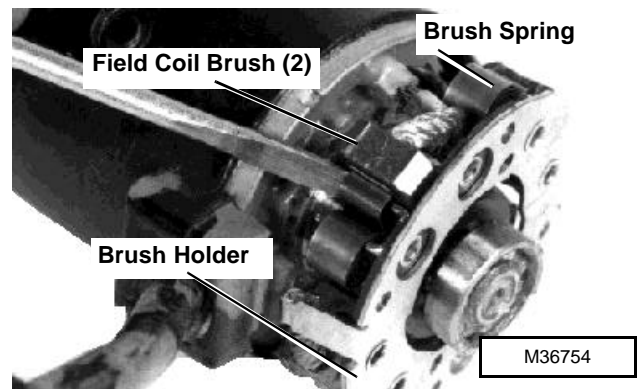
STARTER MOTOR - NIPPONDENSO 1.0 kW

Disassembly

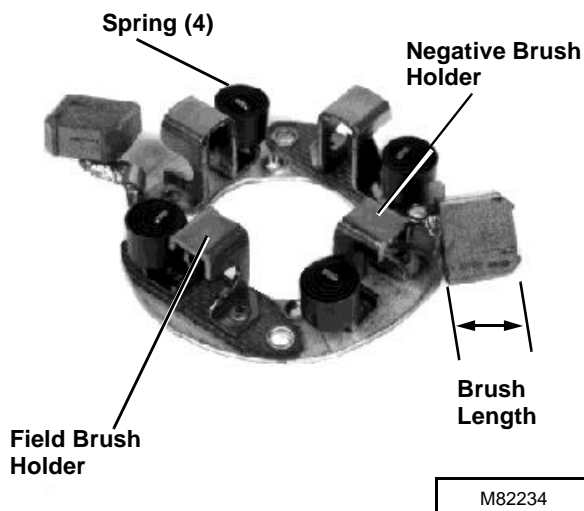
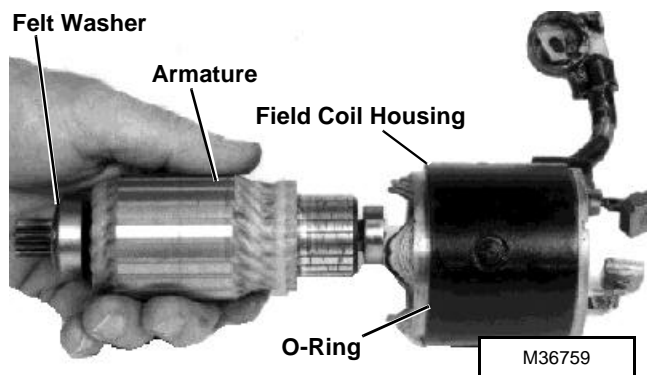
1. Disconnect field lead.
2. Remove two cap screws and two screws.
3. Remove rear cover and o-ring, if equipped.



4. Remove field coil brushes from brush holder.
5. Pry brush springs away and pull negative brushes up enough to allow spring to hold brush in place.
6. Remove brush holder.



7. Remove armature from field coil housing.
8. Remove felt washer and o-ring, if equipped.
9. Inspect and test brushes, holder, field coil and armature. (See *Inspection/Test* procedures.)



Assembly

Assembly is done in the reverse order of disassembly.

- Apply multipurpose grease to bearing cup inside rear cover and felt washer, if equipped.

IMPORTANT: When installing rear cover, be sure field coil brush wires do not touch cover. Turn brush holder slightly to take up slack in brush wires. Press wires inward to clear rear cover.

Inspection/Test/Replacement

1. Measure holder and field coil brush lengths. Minimum brush length is **8.5 mm (0.335 in.)**. Replace brush holder or field coil if brush length is below minimum.

NOTE: Test brush holder using an ohmmeter or test light.

2. Test brush holder:

Touch one probe of tester to negative brush holder and other probe to field brush holder. If there is continuity, replace the brush holder.

3. Inspect springs for wear or damage. Replace if necessary.

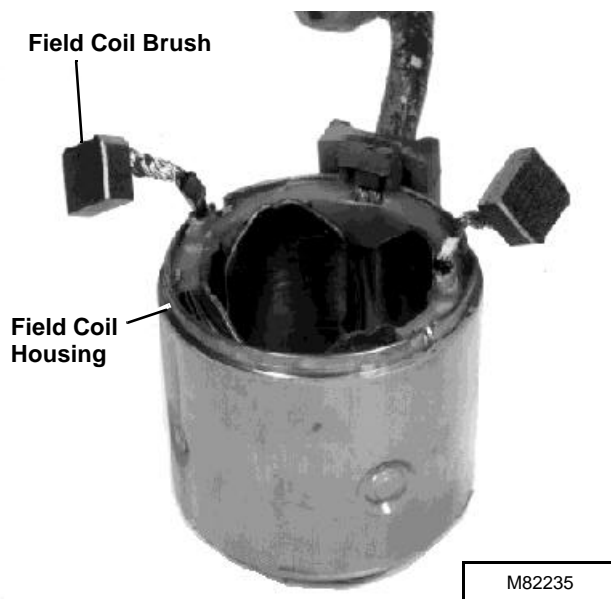
NOTE: Test field coil using an ohmmeter or test light.

4. Test for grounded field winding:

Touch one probe of tester to field coil brush and other probe to field coil housing. Be sure the brush lead is not touching the frame. If there is continuity, the coil is grounded and the field coil housing assembly must be replaced.

5. Test for open field coil:

Touch one probe of tester to each field coil brush. If there is no continuity, the field coil is open and the field coil housing assembly must be replaced.



Starter

IMPORTANT: Do not clean armature with solvent. Solvent can damage insulation on windings. Use only mineral spirits and a brush.

6. Inspect armature. Look for signs of dragging against pole shoes.
7. Inspect commutator. Look for roughness, burned bars, or any material which might cause short circuits between bars. If necessary, clean and touch up with 400 sandpaper. NEVER use emery cloth. Clean all dust from armature when finished.

1

NOTE: Test armature windings using an ohmmeter or test light.

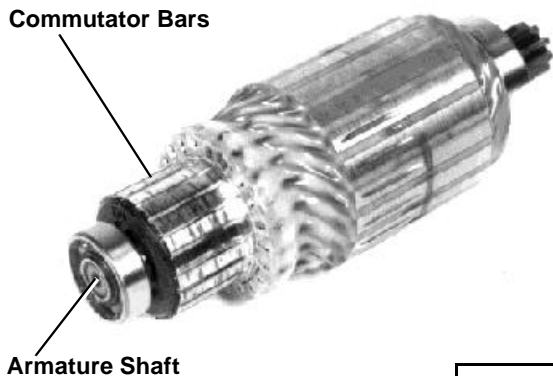
8. Test for grounded windings:

Touch probes on one commutator bar and armature shaft. Armature windings are connected in series, so only one commutator bar needs to be checked.

If test shows continuity, a winding is grounded and the armature must be replaced.

9. Test for open circuited windings:

Touch probes on two different commutator bars. If test shows no continuity, there is an open circuit and the armature must be replaced.

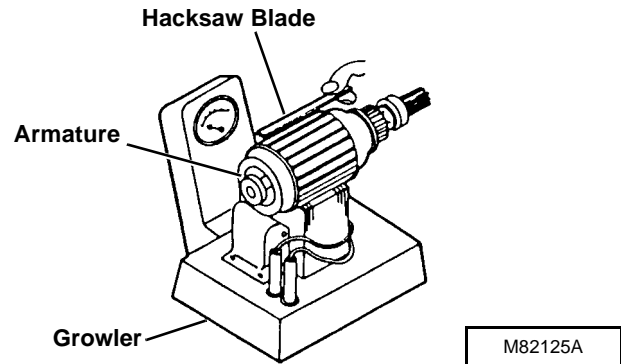


10. Test for short circuited windings using a growler. Put armature in a growler and hold a hacksaw blade above each slot while slowly rotating armature.

If coil is shorted, the blade will vibrate on the slot.

NOTE: A short circuit most often occurs because of copper dust or filings between two commutator segments.

11. If test indicates short circuited windings, clean the commutator of dust and filings. Check the armature again. If the test still indicates a short circuit, replace the armature.



12. Inspect armature cover and housing bearings for wear or damage. Replace if necessary.

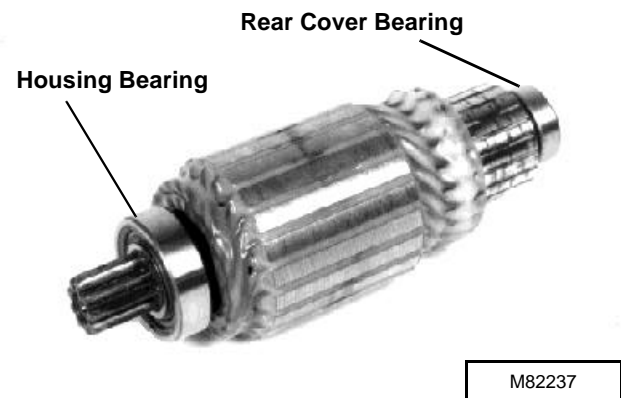
To replace bearings:

Bearings are press fit. Remove bearings using a knife-edge puller set.

IMPORTANT: Install both bearings with sealed side toward armature.

Install new housing bearing tight against shoulder of shaft using a piece of pipe.

Install new rear cover bearing tight against shoulder of shaft using a driver set.

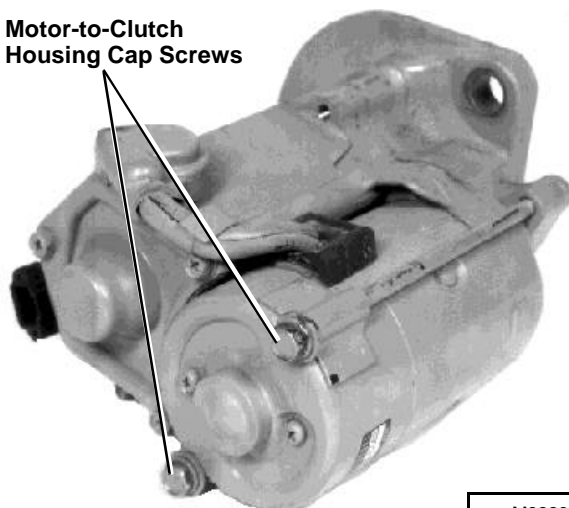


STARTER GEAR TRAIN AND OVERRUNNING CLUTCH - NIPPONDENSO 1.0 kW

Disassembly/Inspection

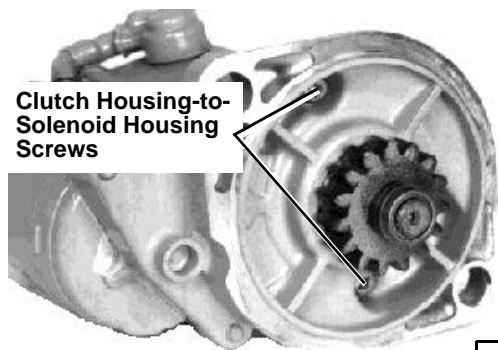
1. Remove two motor-to-clutch housing cap screws and two clutch housing-to-solenoid housing screws.

Motor-to-Clutch
Housing Cap Screws



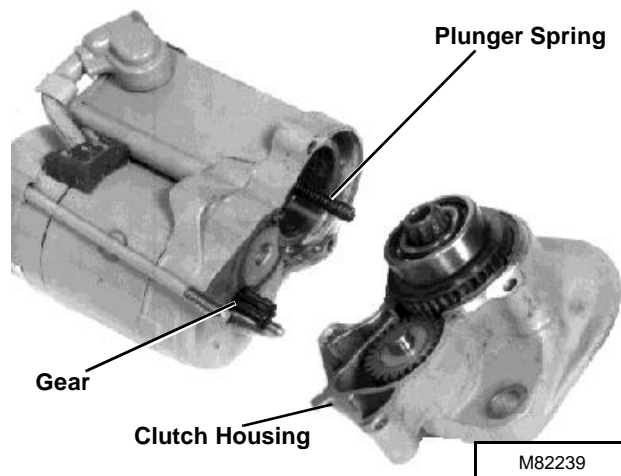
M82233

Clutch Housing-to-
Solenoid Housing
Screws



M82238

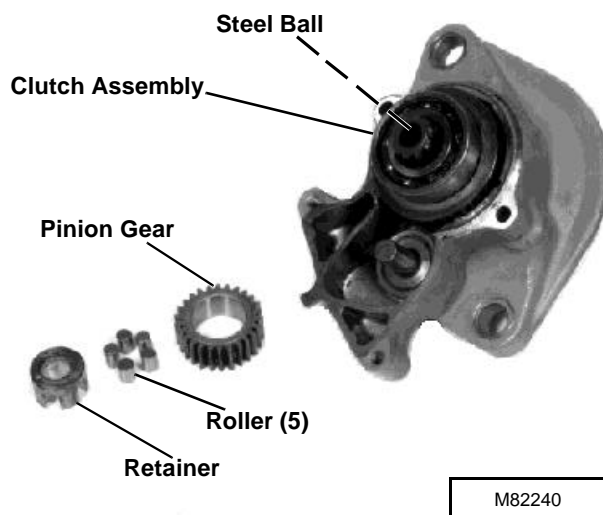
2. Separate clutch housing from solenoid/motor assembly.
3. Remove plunger spring and gear, if equipped.



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NOTE: Starter is equipped with either a 33 mm (1.299 in.), 44 mm (1.732 in.) or 44.5 mm (1.752 in.) drive gear on end of clutch shaft. Disassembly procedures are slightly different.

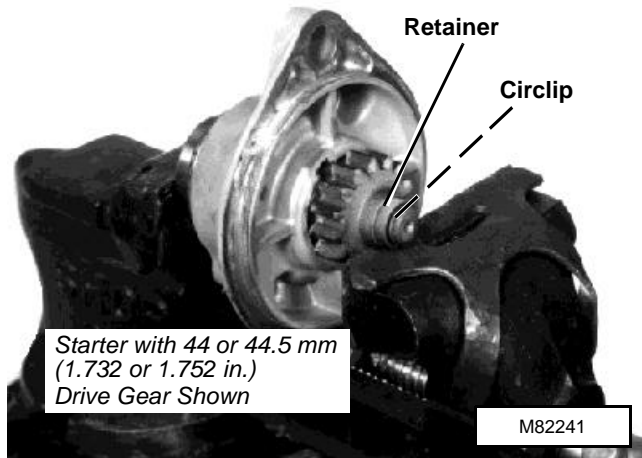
4. Starter with 33 mm (1.299 in.) drive gear:
Remove clutch assembly from housing.
5. Remove retainer, five rollers and pinion gear.
6. Remove steel ball.



Starter

- Put clutch (housing) assembly into a soft-jawed vice, as shown.
- Tighten vise slowly, until drive gear compresses.
- Remove retainer and circlip.

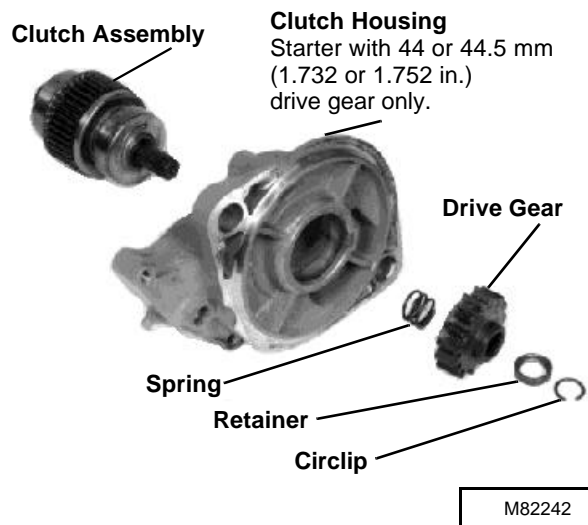
1



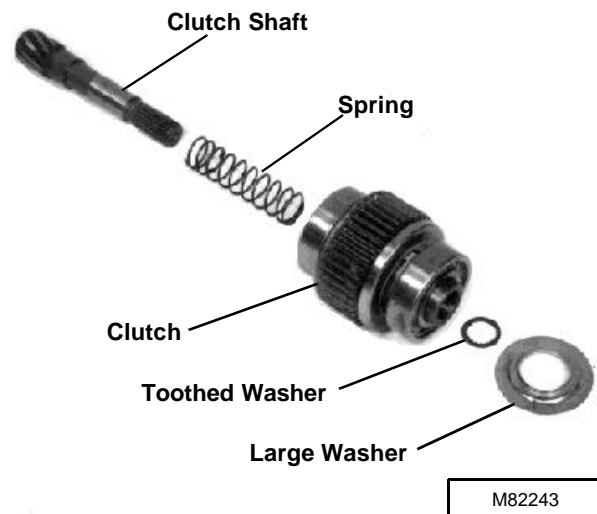
CAUTION

Shaft could be propelled from clutch unit with considerable force if spring is not allowed to extend fully while in vise.

- While holding clutch assembly, slowly open vise until all spring compression is relieved.
- Starter with 33 mm (1.299 in.) drive gear: Remove drive gear and spring from clutch assembly.
- Starter with 44 mm (1.732 in.) or 44.5 mm (1.752 in.) drive gear: Remove drive gear, spring and clutch assembly from housing.



- Remove washer, toothed washer, spring and clutch shaft.
- Inspect all parts for wear or damage. Replace as necessary.



Assembly

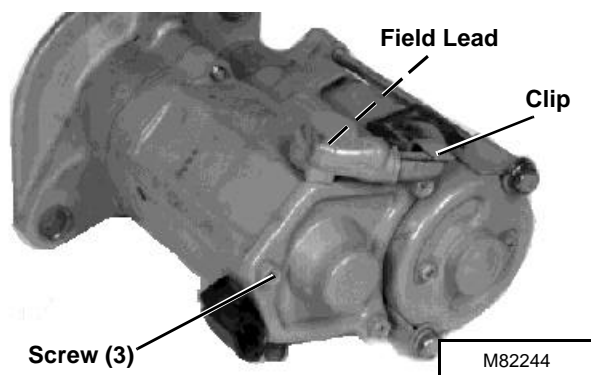
Assembly is done in the reverse order of disassembly.

- Apply multipurpose grease to bearings, clutch shaft, springs, pinion gears, retainer, rollers and steel ball.
- Install large washer with flat side toward clutch assembly.
- Install retainer with cupped side away from clutch assembly.

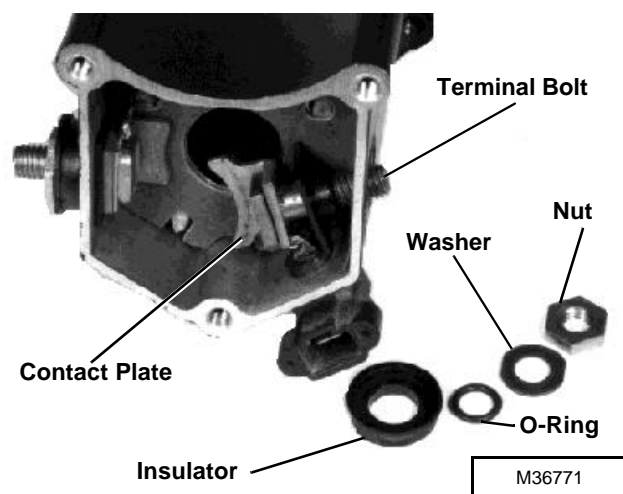
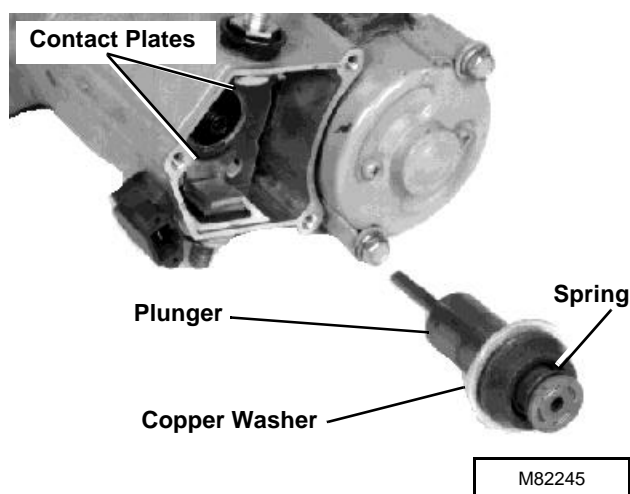
STARTER SOLENOID - NIPPONDENSO 1.0 kW

Disassembly/Inspection

1. Disconnect field lead.
2. Remove three screws and clip.
3. Remove cover and gasket.



4. Remove plunger.
5. Disassemble terminals. Remove parts from each terminal in order shown.
6. Inspect copper washer and contact plates for excessive burning or pitting. Clean burnt areas to improve electrical contact. Replace contacts or plunger if necessary. The solenoid is not serviceable. If defective, replace solenoid housing assembly.

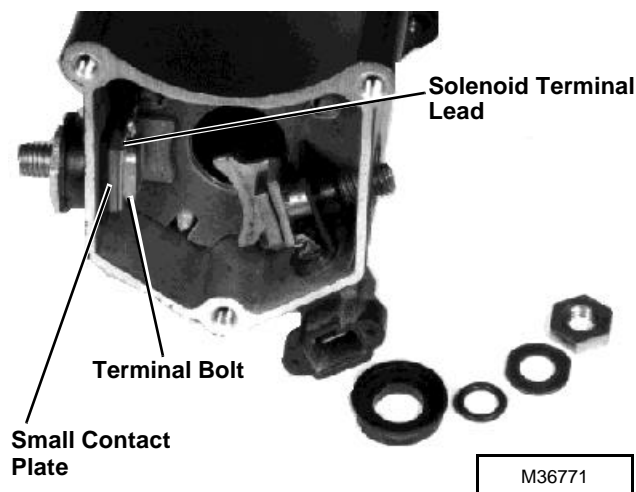


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Assembly

Assembly is done in the reverse order of disassembly.

NOTE: The assembly sequence of the left and right terminals is similar. Be sure solenoid terminal lead is installed between terminal bolt and contact plate. Also, be sure smaller contact plate is on the left side.



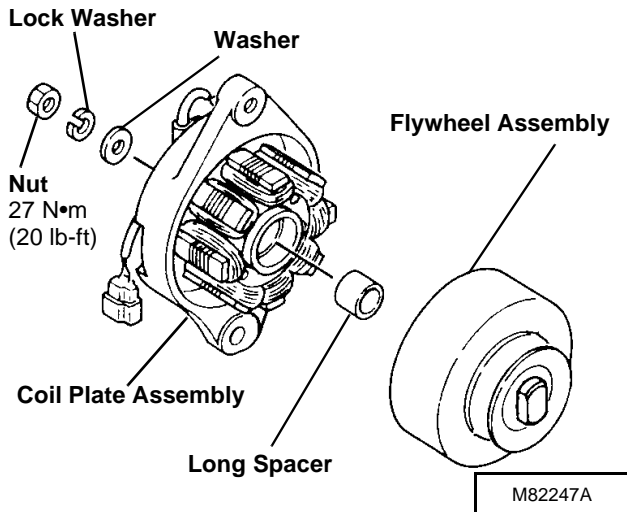
Alternator

ALTERNATOR - KOKOSAN 20A

Disassembly/Inspection

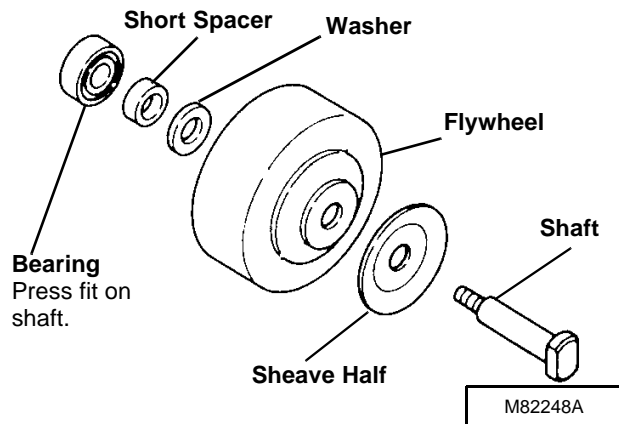
1. Remove nut and washers.
2. Tap on end of shaft with a soft-faced hammer to separate flywheel assembly from coil plate assembly.
3. Remove long spacer.

1



NOTE: Bearing and flywheel are press fit on shaft.

4. Remove shaft from bearing, short spacer, washer, flywheel and sheave half, using a press.
5. Inspect all parts for wear or damage. Replace as necessary.



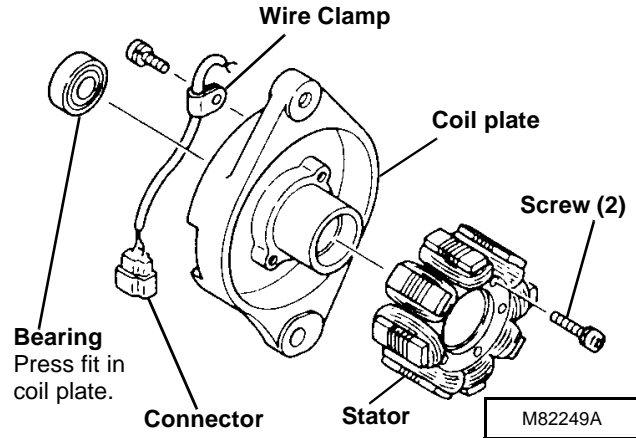
NOTE: Remove bearing only if replacement is necessary.

6. Inspect bearing in coil plate for wear or damage. Replace if necessary.

To replace bearing:

Remove bearing using a spark plug socket and a press. Install bearing into coil plate until it bottoms in bore using a 1 in. socket.

7. Remove wire clamp.
8. Remove connector from harness leads.
9. Remove two screws and stator.
10. Inspect all parts for wear or damage. Replace as necessary.



Assembly

Assembly is done in the reverse order of disassembly.

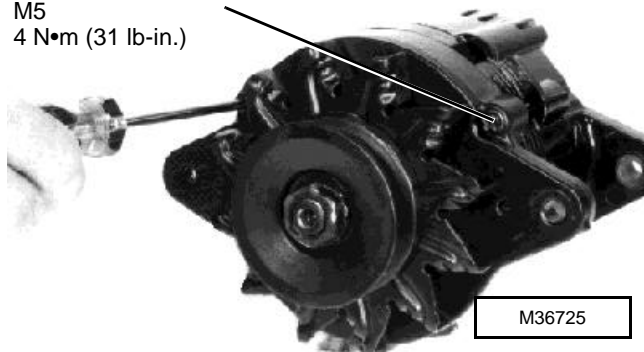
- With sheave half on shaft, press shaft into flywheel until sheave half bottoms on flywheel face.
- With washer and short spacer installed, press new bearing onto shaft until it bottoms on spacer.

VOLTAGE REGULATOR - NIPPONDENSO 35A

Replacement

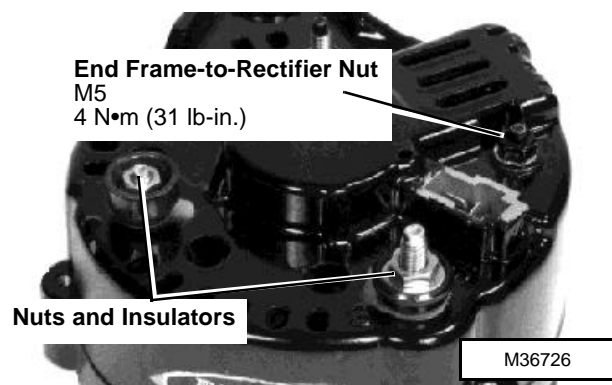
1. Remove three attaching screws.

Attaching Screw (3)
M5
4 N•m (31 lb-in.)



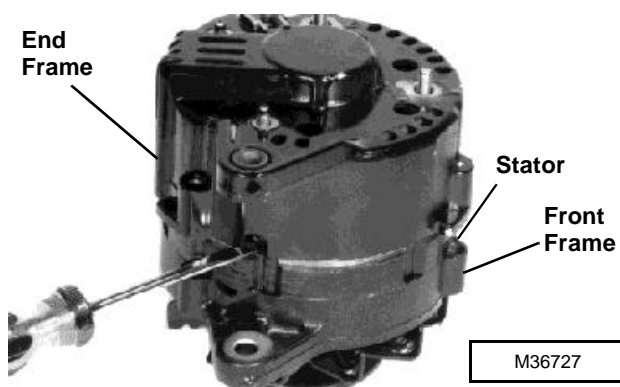
2. Remove end frame-to-rectifier nut.

- Remove nuts and insulators.



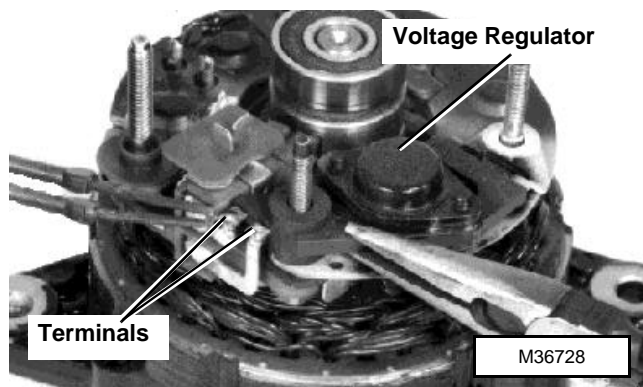
IMPORTANT: Do not pry against stator wires.

- Use a screwdriver to pry end frame from stator. Do not separate stator from front frame.



IMPORTANT: Do not heat connections longer than necessary to melt solder, as excess heat will damage rectifier assembly.

- Use a soldering gun with a least 120 watt capacity to disconnect terminals. Replace voltage regulator.



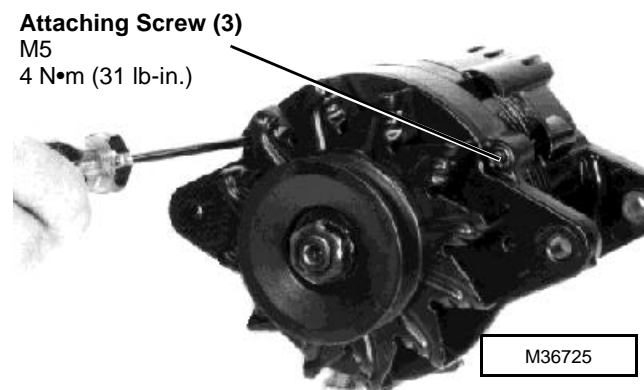
Installation is done in the reverse order of removal.

- If additional solder is needed, use ONLY 60-40 rosin-core solder.

ALTERNATOR - NIPPONDENSO 35A

Disassembly

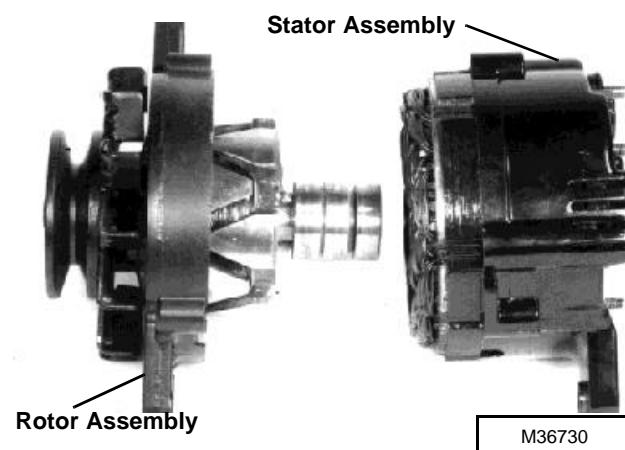
- Remove three attaching screws.



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IMPORTANT: Do not pry against stator wires.

- Use a screwdriver to separate rotor assembly from stator assembly.

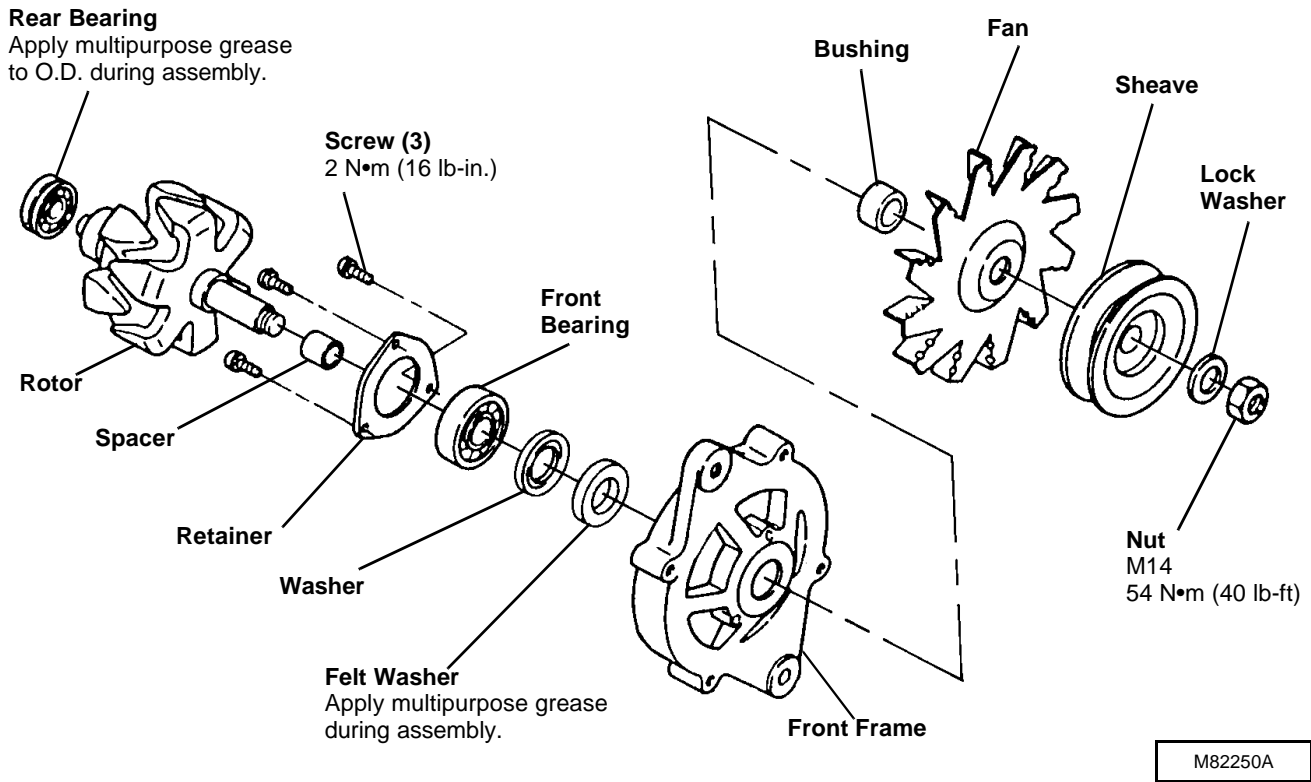


Rotor Assembly:

- Rear bearing is press fit. Replace only if necessary. Remove bearing using a puller set. Install bearing until flush with end of rotor shaft. Press only on inner race of bearing.
- Put rotor assembly in a soft-jawed vise. Remove nut, lock washer, sheave, fan and bushing.
 - Put front frame on open jaws of vice. Use a soft-faced hammer to remove rotor and spacer.
 - Remove three screws, retainer, front bearing, washer and felt washer.
 - Inspect all parts for wear or damage. Replace as necessary.

Alternator

1



7. Test rotor. (See *Inspection/Test* procedures.)

Stator Assembly:

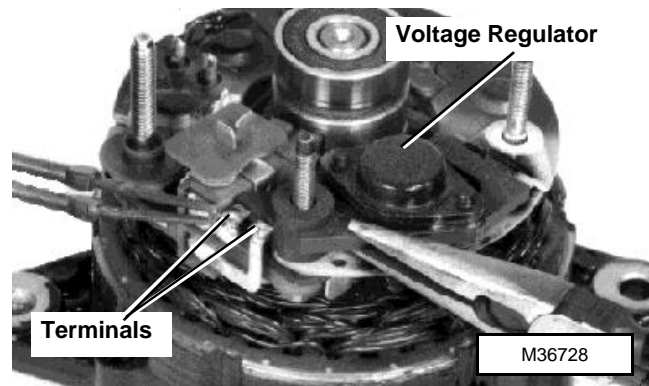
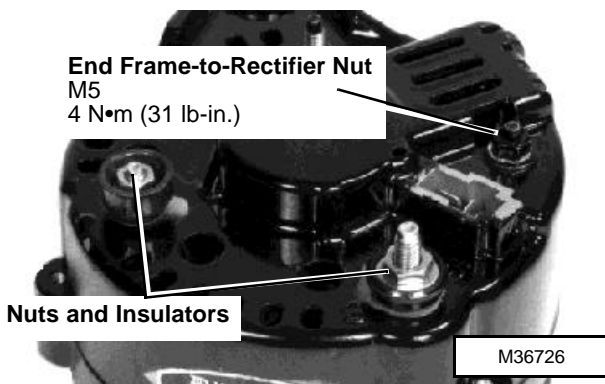
8. Remove end frame-to-rectifier nut.

9. Remove nuts and insulators.

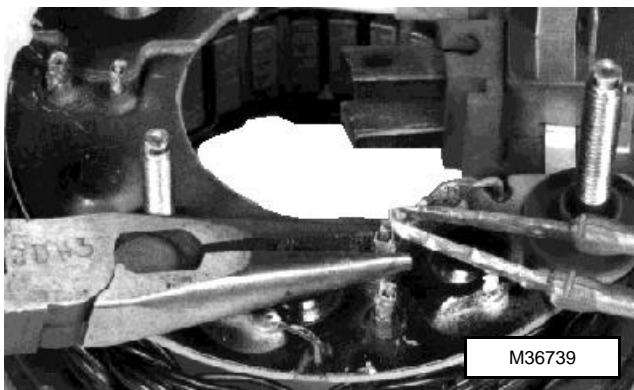
IMPORTANT: Do not pry against stator wires.

10. Use a screwdriver to pry end frame from stator.

11. Use a soldering gun with at least 120 watt capacity to disconnect terminals. Remove voltage regulator.



12. Melt solder inside the connecting pipes. While solder is hot, open the flattened pipe with a needle nose pliers. Pull stator wire from pipe.



13. Inspect and test brushes, stator and rectifier. (See *Inspection/Test* procedures.)

Assembly

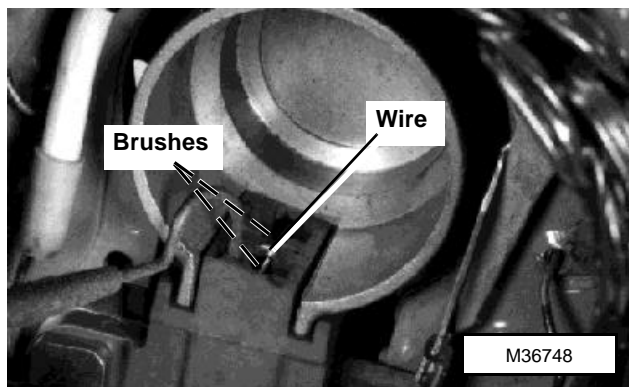
Assembly is done in the reverse order of disassembly.

NOTE: The three pair of lead wires on the stator are not evenly spaced. Rotate the rectifier until the terminal pipes align with the stator leads.

- Bend the stator lead wires, as necessary, to obtain an approximate distance of **33.50 mm (1.300 in.)** from stator to rectifier. Connect the six leads using a soldering gun.
- If additional solder is needed, use **ONLY 60-40 rosin-core solder.**

IMPORTANT: Be sure six stator lead wires do not contact end frame when installed.

- Before assembling stator assembly to rotor assembly, push brushes into brush holder and insert a wire through access hole in rear at end frame to lock brushes in place.

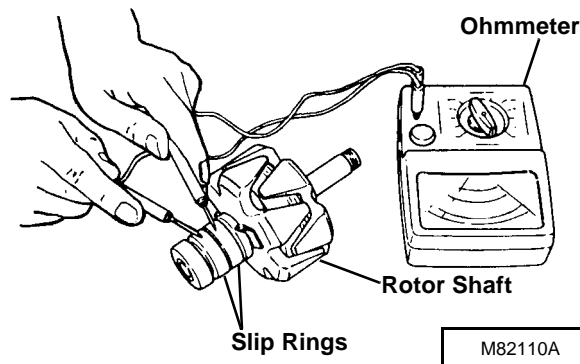


- Assemble rotor assembly to stator assembly and fasten with three attaching screws. Remove wire from access hole.

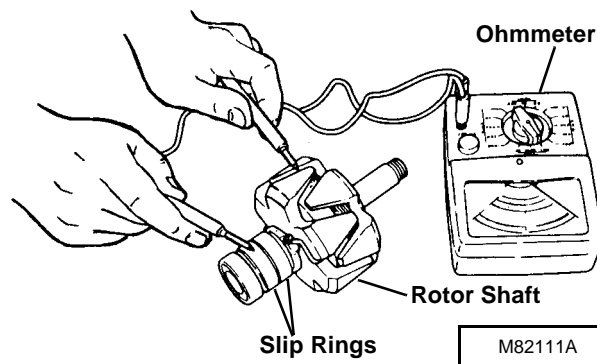
Inspection/Test

Rotor:

- Inspect the rotor slip rings for dirt build-up, rough spots, or out of roundness. If necessary, polish the surface of the slip rings using No. 00 sandpaper or 400-grit silicon carbide paper.
- Touch the probes of an ohmmeter to slip rings. Replace rotor if test indicates no continuity (no needle movement).



- Touch the probes of the ohmmeter to the shaft and one of the slip rings. Repeat for other slip ring. Replace rotor if test shows continuity (needle movement).



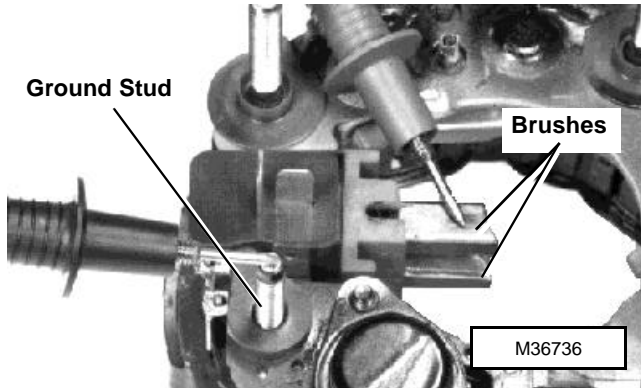
Brushes:

- Inspect brush holder and brushes for damage. Brushes must slide freely and the springs must hold the brushes firmly against the slip rings of the rotor.
- Measure brushes for wear. Minimum exposed length must be **5.50 mm (0.220 in.)** or to wear limit line on brushes. Replace brushes as necessary.

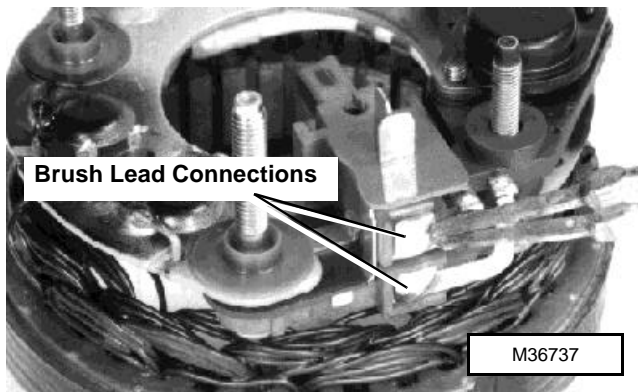
Alternator

- Use an ohmmeter or a test light to check for continuity. Check between the two brushes and between each brush and ground stud. There should be no continuity. Replace brush holder-rectifier assembly if there is continuity.

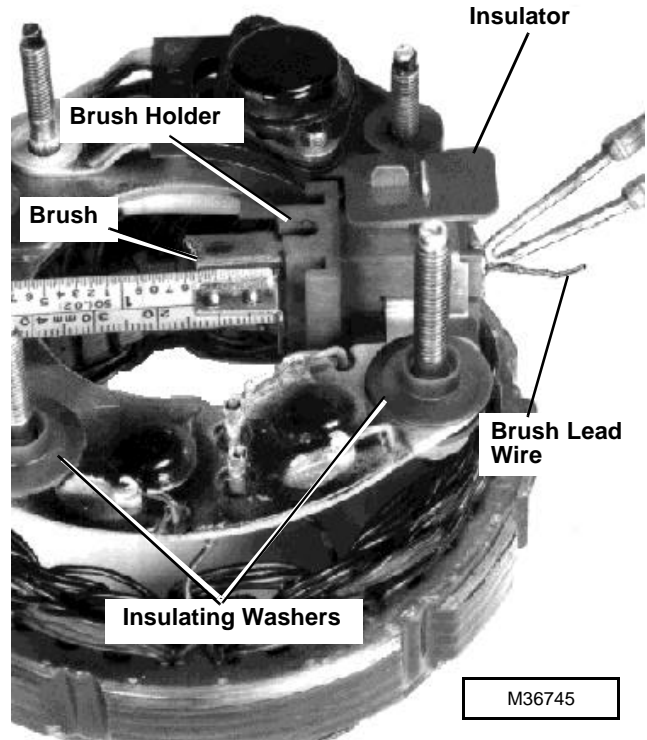
1



- To replace brushes:
 - Melt solder from brush lead connections and - remove brushes and springs.
 - Inspect springs for wear or damage. Replace as necessary.



- Push brush lead wire through spring. Insert spring and brush in brush holder with lead protruding through hole in brush holder. Make sure the longest side of brush is on side of brush holder with raised lip.
- Hold brushes in position so that exposed length is 13 mm (0.500 in.)
- Solder brush leads in this position. Cut off excess length of brush lead wire.
- Be sure insulating washers and insulator are in place.



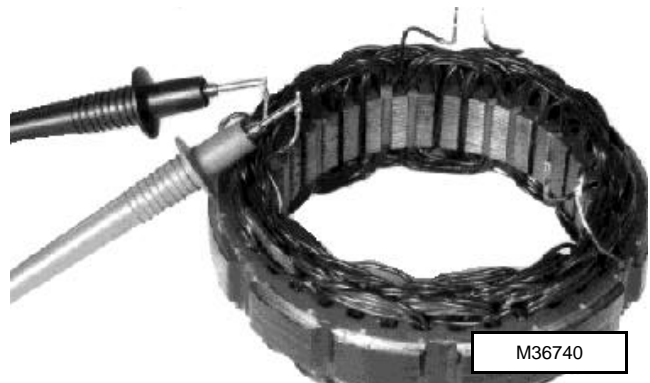
NOTE: If additional solder is needed, use ONLY 60-40 rosin-core solder.

Stator:

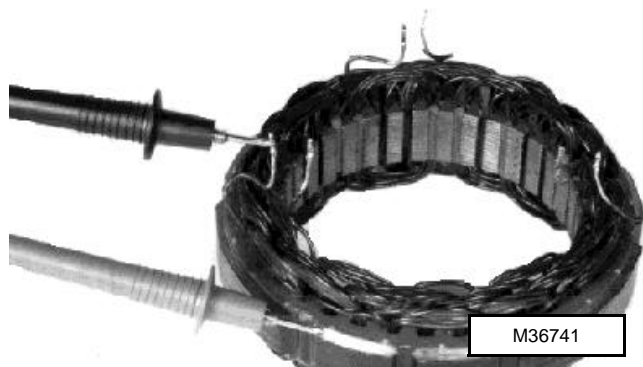
- Inspect stator for defective insulation, discoloration or a burned odor. If any of these defects are found, replace stator.

NOTE: Use an ohmmeter that is sensitive to resistance of 0 to 1 ohm.

- Touch probes of an ohmmeter to each pair of stator wires. Equal continuity readings should be observed between each pair of leads. If readings are not equal, replace stator.



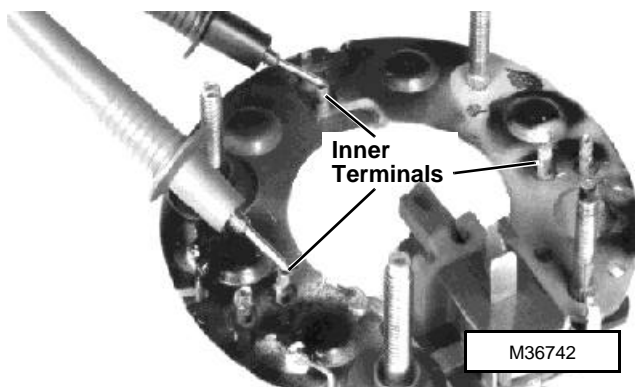
- Touch one probe of the ohmmeter to the bare metal surface of stator and the other probe to a bare stator lead wire. Repeat for each wire. Replace stator if test indicates continuity.



Rectifier:

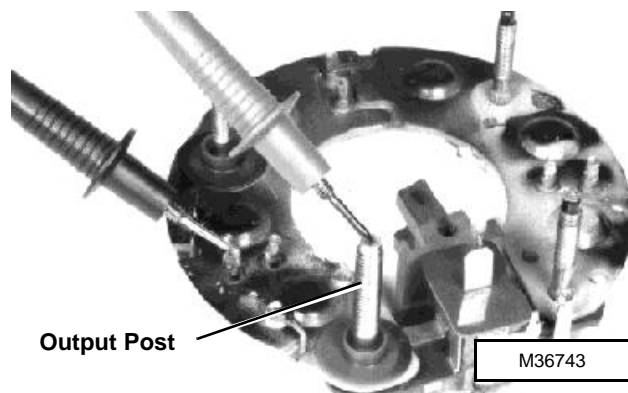
NOTE: The three inner terminals are connected by a printed circuit in the rectifier.

- Test the three inner terminals using an ohmmeter. Move probes so all terminals are cross checked. Replace the rectifier if test shows no continuity.



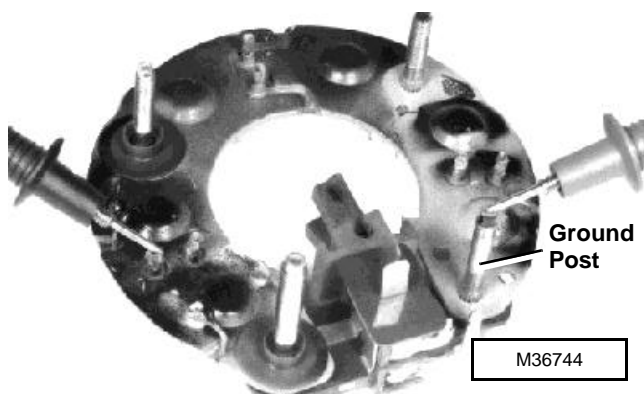
NOTE: Each of the three outer terminals on the rectifier is connected to two diodes permitting current flow in only one direction.

- Test the diodes by touching probes to output post and the three outer terminals.
- Switch the probes and check each terminal again. There should be continuity in only one direction between each terminal and the output post.



- Test the diodes by touching probes to ground post and the three outer terminals.
- Switch the probes and check each terminal again. There should be continuity in only one direction between each terminal and the ground post.

A shorted diode would have continuity in both directions. An open diode would have no continuity in either direction. Replace the rectifier assembly if any of the six diodes are defective.



1

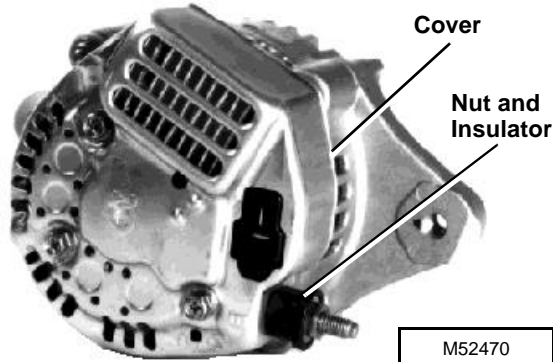
Alternator

VOLTAGE REGULATOR - NIPPONDENSO 40A

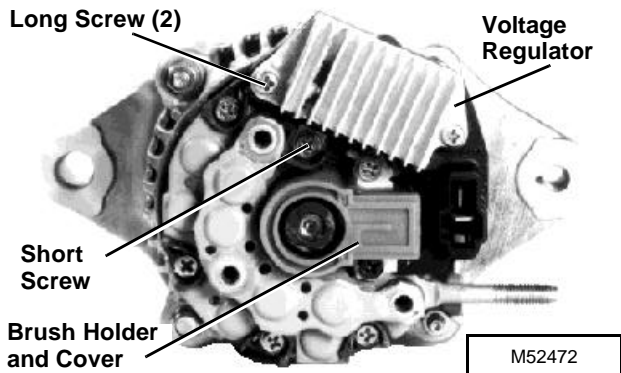
Replacement

1. Remove nut and insulator.
2. Remove three screws and cover.

1



3. Remove two screws, brush holder and cover.
4. Remove three screws. Replace voltage regulator.



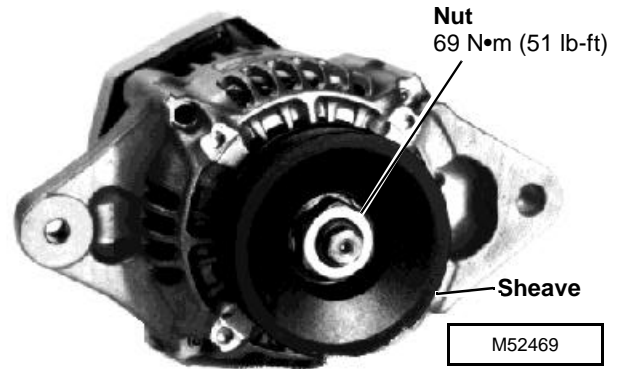
Installation is done in the reverse order of removal.

IMPORTANT: Make sure to install short screw at location shown. Longer screw will contact frame and cause damage to the charging system.

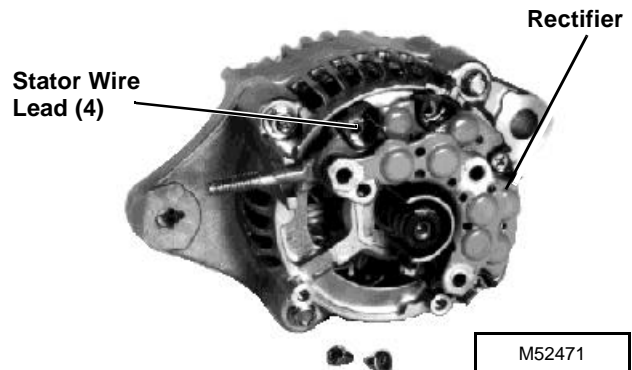
ALTERNATOR - NIPPONDENSO 40A

Disassembly

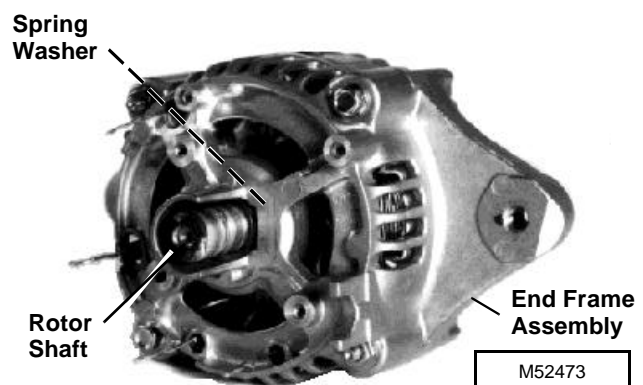
1. Remove voltage regulator. (See *VOLTAGE REGULATOR - REPLACEMENT* in this group.)
2. Remove nut.
3. Remove sheave using a puller set.



4. Remove four screws and straighten stator wire leads.
5. Remove rectifier.



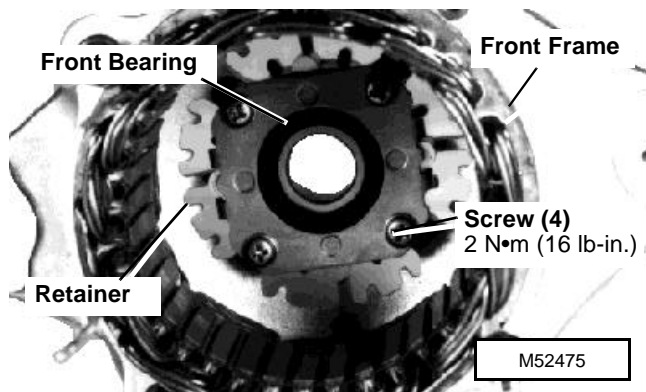
6. Remove two nuts, two screws and end frame assembly.
7. Press rotor shaft from end frame.
8. Remove spring washer.



9. Remove four screws and retainer.

NOTE: Front bearing is press fit in front frame. Remove bearing only if replacement is necessary.

10. Inspect bearing in front frame for wear or damage. Replace if necessary. Replace bearing using a driver set and a press.



11. Inspect and test brushes, stator and rectifier. (See *Inspection/Test* in this group.)

Assembly

Assembly is done in the reverse order of disassembly.

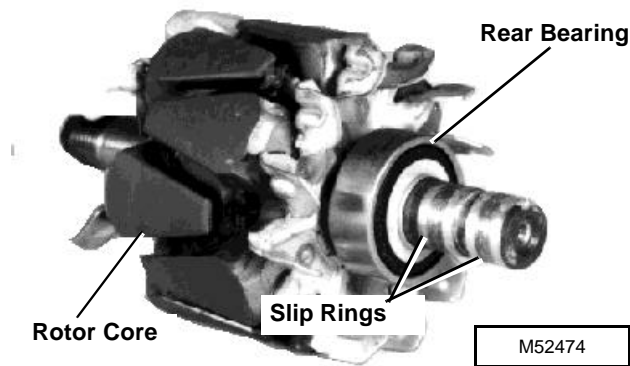
- After installing rectifier, form a loop in stator wire leads, insert screws through loop and secure rectifier and wire leads.

Inspection/Test

Rotor:

NOTE: Rear bearing and rotor assembly are not serviced separately. Damaged parts require that rotor assembly and bearing be replaced as a unit.

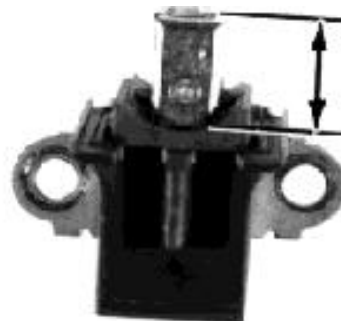
- Inspect bearing for wear or damage. Replace complete rotor if necessary.
- Inspect slip rings for dirt build-up, rough spots or out-of-roundness. If necessary, polish the surface of the slip rings using No. 00 sandpaper or 400-grit silicone carbide paper. Measure outer diameter of slip rings. Replace rotor if less than **14 mm (0.550 in.)**.
- Touch the probes of an ohmmeter to slip rings. Replace rotor if test indicates no continuity (no needle movement).
- Touch probes of ohmmeter to the rotor core and one of the slip rings. Repeat for other slip ring. Replace rotor if test shows continuity (needle movement).



1

Brushes:

- Inspect brush holder, brushes and springs for damage. Brushes must slide freely and springs must hold brushes firmly against the slip rings of the rotor.
- Measure length of brush protruding from holder. If length is less than wear limit, replace brushes.

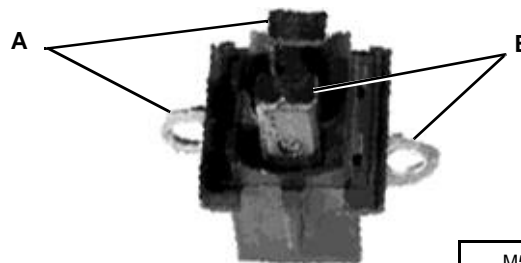


Brush Length Specifications

New..... **10.50 mm (0.410 in.)**

Wear Limit..... 4.50 mm (0.170 in.)

- Check continuity between brush and terminal “A”. Check continuity between brush and terminal “B”. There should be continuity only at these points.



Alternator

Stator:

- Inspect stator for defective insulation, discoloration or a burned odor. If any of these defects are found, replace stator.

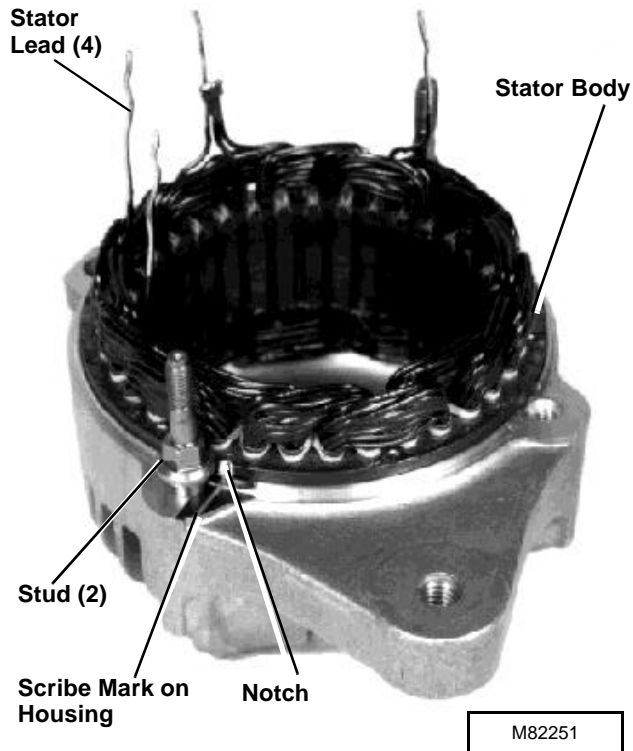
NOTE: Use an ohmmeter that is sensitive to resistance of 0 to 1 ohm.

- Check for continuity between each stator lead and stator body. Replace stator if test indicates continuity.

1

To replace stator:

- Scribe a mark on housing, at notch in stator, to aid in installation of a new stator.
- Remove two studs.
- Replace stator using a punch and hammer.

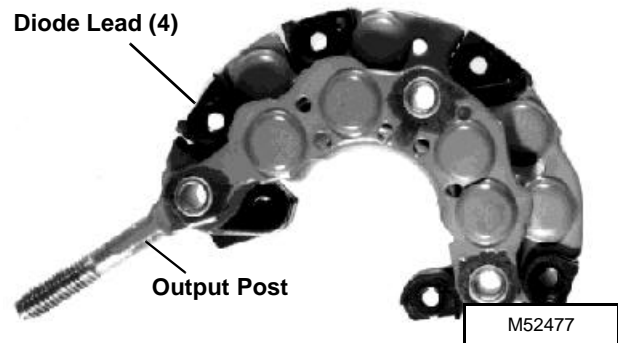


Rectifier:

NOTE: Set the ohmmeter to the K ohm range.

- Check continuity between output post and each diode lead. Reverse ohmmeter leads and recheck. There should be continuity in one direction, but not the other.

A shorted diode would have continuity in both directions. An open diode would have no continuity in either direction. Replace the rectifier if any of the four diodes are defective.



ENGINE AND FUEL SYSTEM TROUBLESHOOTING CHART

<p>PROBLEM OR SYMPTOM</p> <p>CHECK OR SOLUTION</p>	<p>Engine will not crank.</p>	<p>Engine cranks but will not start or starts hard.</p>	<p>Engine will not stay running, or stalls frequently.</p>	<p>Engine runs rough, misses, noisy, vibrates or low on power. Fuel in oil. Oil level high.</p>	<p>Engine surges, or has uneven or uncontrolled rpm.</p>	<p>Oil in the coolant or coolant in the oil.</p>	<p>Engine has low oil pressure.</p>	<p>Engine operating temperature is incorrect.</p>	<p>Lack of fuel at injection pump.</p>	<p>Exhaust smoke blue or uses too much oil.</p>	<p>Exhaust smoke white.</p>	<p>Exhaust smoke black or grey or uses too much fuel.</p>
<p>Fuel pump screen, fuel filter, or fuel line restricted. Fuel dirty, contains water or wrong grade.</p>		●	●	●	●			●		●	●	
<p>Air filter elements dirty or plugged. Replace.</p>		●	●	●	●		●		●		●	
<p>Fuel shut-off valve turned off, or restricted. Solenoid linkage misadjusted. See adjustment.</p>		●	●	●	●		●	●				
<p>Muffler or exhaust manifold leak.</p>			●	●								
<p>Defective glow plugs.</p>		●										
<p>Injection pump or governor malfunctioning. Injection pump timing incorrect.</p>		●		●	●					●	●	
<p>Defective cranking components or connectors.</p>	●			●								
<p>Low compression from worn rings, cylinder bore, piston, valves or warped head.</p>		●	●	●		●			●		●	
<p>Valve clearance incorrect.</p>	●	●	●	●			●				●	
<p>Burned or warped valves and valve seats. Defective valve spring.</p>		●	●	●	●				●		●	
<p>Starter cranking rpm too slow. Damaged starter. Excessive engine load.</p>	●	●						●				
<p>Fuel pump leaking or not operating. See Fuel Supply Pump Pressure Test.</p>		●	●	●	●			●		●		
<p>Engine oil viscosity or level incorrect.</p>	●	●					●	●	●			
<p>Injector pressure incorrect or leaking.</p>		●	●	●	●		●			●	●	
<p>Cylinder head gaskets leaking or damaged.</p>	●	●	●		●	●	●	●	●		●	
<p>Radiator.</p>				●		●	●					

Diagnosis

ENGINE SYSTEM DIAGNOSIS

Conditions:

- Engine mounted on level surface.
- Key switch off unless indicated otherwise.

Test Location	Normal	If Not Normal
1 1. Engine dipstick and exterior engine surface-engine oil check.	Oil level between “L” and “H” marks. Oil not burnt, or contaminated with metal particles, fuel, or coolant. No external leakage, filter clean.	Change oil and inspect for source of contamination. Check gaskets, seals, plugs, cylinder head, block, and intake manifold and breather. Change oil filter.
2. Coolant tank and radiator. - Cooling System Check.	Coolant level between marks on tank when engine is warm. Coolant in radiator full to top. Coolant not contaminated with oil, fuel or discolored brown. Radiator screen free of debris. Hoses not cracked or leaking, clamps and radiator cap tight. Fan belt tight, not glazed or cracked. Fan blades not damaged or warped.	Add proper coolant mix. Drain and flush system. Check for source of contamination. Clean or replace. Pressure test radiator and cap. Replace and adjust belt tension. Replace fan.
3. Fuel tank, pump, pump screen, lines, filter, filter shutoff valve. - Fuel System Check	Fuel level correct, not contaminated, correct grade of fuel, no water. Fuel pump screen and in-line filter free of debris. Fuel shutoff valve in “ON” position. Fuel hoses not cracked or leaking. Fuel hose clamps tight. Fuel tank does not have vacuum.	Drain and clean fuel tank. Add fresh fuel. Replace filters. Move to “ON” position. Replace. Replace or tighten. Replace fuel tank check valve.
4. Air filter and air intake. - Air Intake System Check	Air filter hose not cracked, clamps tight. Element not plugged. Air filter housing sealed, no dirt tracking inside filter element.	Replace and tighten clamps. Replace element or housing.
5. Fuel shutoff solenoid. (Key in RUN position.)	Fuel shutoff solenoid must pull in and stay in. Solenoid must bottom out. Shutoff shaft must still move slightly.	Check shutoff solenoid adjustment. Clean any dirt from under solenoid boot. If solenoid will not pull in and hold in, see Fuel Shutoff Solenoid Circuit Test Points in ELECTRICAL section of Machine TM.
6. Glow plug indicator light. (Key in RUN position.)	Indicator light should come on up to 15 seconds depending on air temperature.	See Glow Plug Circuit Test Points in ELECTRICAL section of Machine TM.

ENGINE SYSTEM DIAGNOSIS - Continued

Test Location	Normal	If Not Normal
7. Fuel filter, fuel pump. (Key switch in RUN position.)	Fuel level increases in filter. Fuel pump operating - listen for humming sound. Fuel present in return hose at fuel pump.	See Fuel Pump Circuit Test Points in ELECTRICAL section of Machine TM. Test fuel pump pressure. (See <i>Operational Tests</i> in this section.) Replace fuel filter.
8. Throttle lever and cable.	Linkage not binding and adjusted correctly.	Repair, replace or adjust cable.
9. Intake and exhaust valves.	Cold engine. Valve clearance within specification. Valves not sticking.	Check and adjust. (See <i>Checks, Tests and Adjustments</i> in this section.) Check valve guides and stems.
10. Fuel at injectors. (Key in START position - engine cranking.)	Crack fuel injection lines at injectors. Fuel shutoff solenoid pulled in. Engine must crank.	Check spray pattern and cranking pressure. (See <i>Checks, Tests and Adjustments</i> in this section.) Replace injectors. See Cranking Circuit Test Points in ELECTRICAL section of Machine TM.
11. Injector ports. (Key in START position.)	Cylinder compression within specification. Pressure difference between cylinders within specification.	Perform cylinder compression test. (See <i>Operational Tests</i> in this section.)
12. Flywheel and starter.	Minimum cranking rpm within specification.	See Starter Amp Draw Test in ELECTRICAL section of Machine TM.
13. Injection pump timing inspection. (Key OFF.)	Timing should be correct. Remove pump as the LAST possible solution.	Perform injection pump static timing adjustment. (See <i>Checks, Tests and Adjustments</i> in this section.) Have pump tested by a qualified Service Repair Shop.
14. Injection pump idle settings. (Engine running).	Engine runs smooth under load. Engine rpm to specification.	See Slow Idle and Fast Idle Adjustments in ENGINE section of Machine TM.
15. Oil pressure sender port.	Oil pressure in specification.	Test engine oil pressure. (See <i>Operational Tests</i> in this section.)
16. Thermostat. (Engine at operating temperature.)	Clean from corrosion, rust, or debris. Opening temperature within specification.	Replace thermostat. Perform thermostat opening test. (See <i>Checks, Tests and Adjustments</i> in this section.)
17. Muffler.	Not restricted.	Replace muffler.

Checks, Tests and Adjustments

VALVE CLEARANCE, CHECK AND ADJUSTMENT - EARLY 3TNA72 (430 LGT)

Reason:

To achieve correct engine operation.

Equipment:

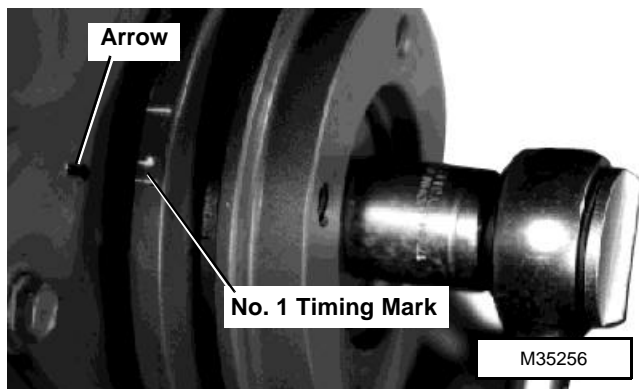
1

- Feeler Gauge

Procedure:

NOTE: "Top Dead Center (TDC)" is the piston at its highest point.

1. Remove rocker arm cover.
2. Turn crankshaft pulley clockwise until No.1 cylinder timing mark on pulley aligns with arrow on timing gear cover.

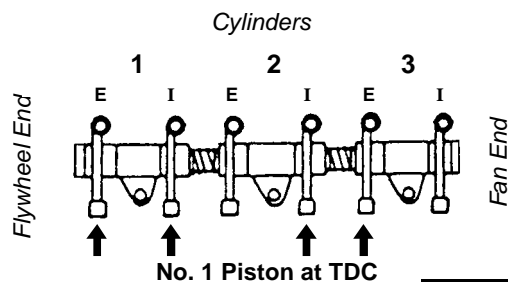


NOTE: No. 1 cylinder is the closest to the flywheel.

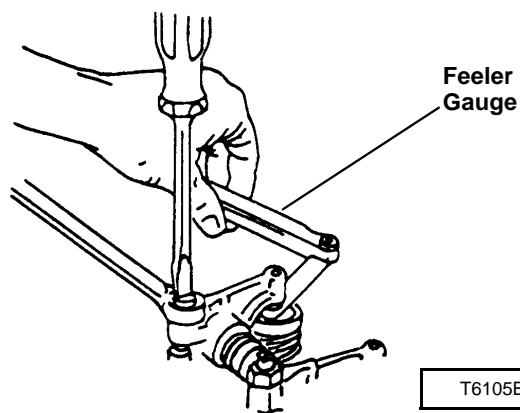
3. Try to move both No. 1 cylinder rocker arms or push rods.

If rocker arm push rods are not loose, rotate flywheel one revolution (360°). If both rocker arm push rods are loose the piston is at TDC on compression stroke.

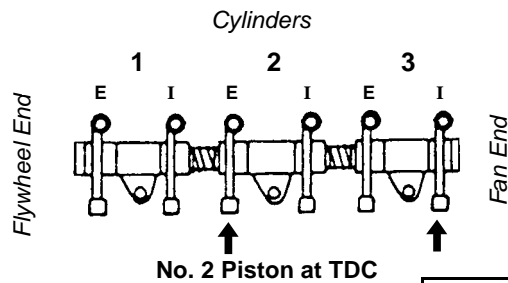
4. Measure and adjust valve clearance on the valves (arrows) with No. 1 piston at TDC.



To adjust valves, loosen nut and turn adjusting screw until clearance is **0.20 mm (0.008 in.)**. Hold screw while tightening nut.



5. Turn crankshaft pulley one revolution (360°). This puts the piston in No. 2 cylinder at TDC compression stroke.
6. Measure and adjust valve clearance on the valves (arrows) with No. 2 piston at TDC.



VALVE CLEARANCE, CHECK AND ADJUSTMENT - 3TN66 AND LATER 3TNA72

Reason:

To achieve correct engine operation.

Equipment:

- Feeler Gauge

Procedure:

NOTE: Location of the index mark will be different as a result of the various engine applications.

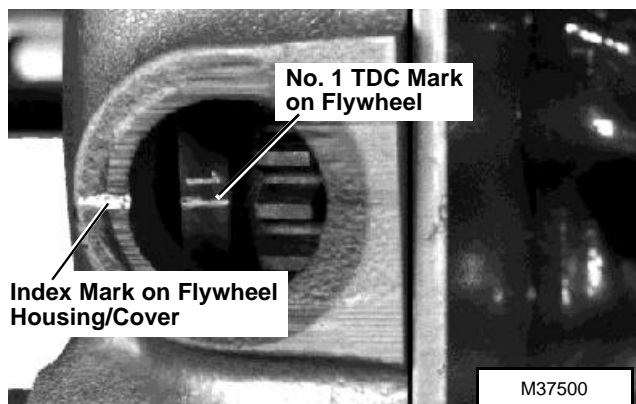
The index mark appears on the following:

- 15 EX, 3009 OEM: Flywheel housing.
- 330/332 LGT, F915 FM, 430 LGT (Later), F925/35 FM: Flywheel cover.
- 375 SSL, 670 CUT: Flywheel plate.
- 655 CUT, 455 LGT, 755/56 CUT: Flywheel guard and plate.

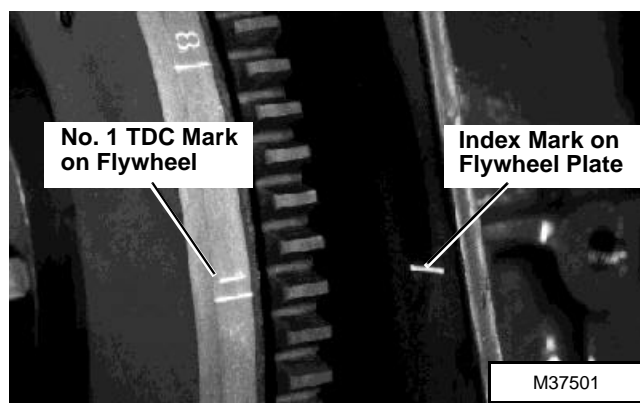
1. Remove rocker arm cover.
2. Remove plug from timing hole in flywheel housing/cover, if equipped.

NOTE: "Top Dead Center (TDC)" is the piston at its highest point.

3. Turn crankshaft pulley clockwise until No.1 cylinder TDC mark on flywheel aligns with index mark on flywheel housing/cover or plate.



330/332 LGT, F915 FM, 430 LGT (Later), F925/35 FM, 15 EX, 3009 OEM



375 SSL, 670 CUT

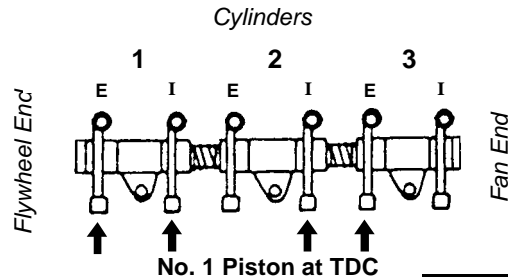
1

NOTE: No. 1 cylinder is the closest to the flywheel.

4. Try to move both No. 1 cylinder rocker arms or push rods.

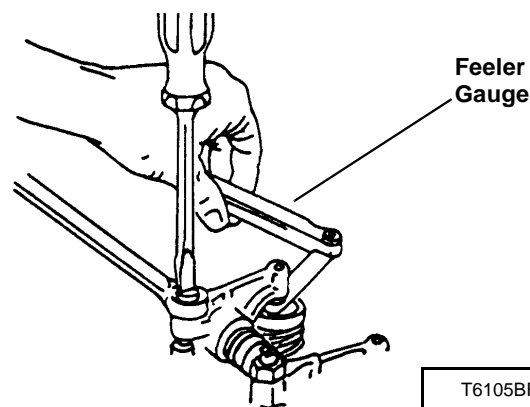
If rocker arm push rods are not loose, rotate flywheel one revolution (360°). If both rocker arm push rods are loose, the piston is at TDC on compression stroke.

5. Measure and adjust valve clearance on the valves (arrows) with No. 1 piston at TDC.



M82327A

To adjust valves, loosen nut and turn adjusting screw until clearance is **0.20 mm (0.008 in.)**. Hold screw while tightening nut.

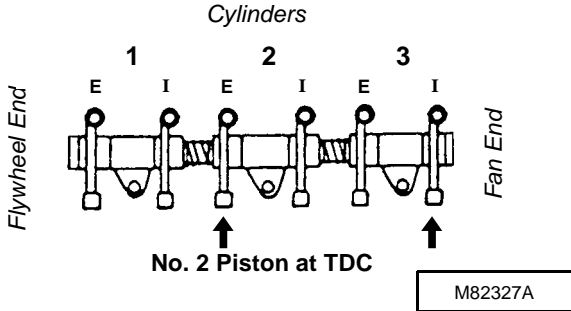


T6105BF

Checks, Tests and Adjustments

6. Turn crankshaft pulley one revolution (360°). This puts the piston in No. 2 cylinder at TDC compression stroke.
7. Measure and adjust valve clearance on the valves (arrows) with No. 2 piston at TDC.

1



CONNECTING ROD SIDE PLAY CHECK

Reason:

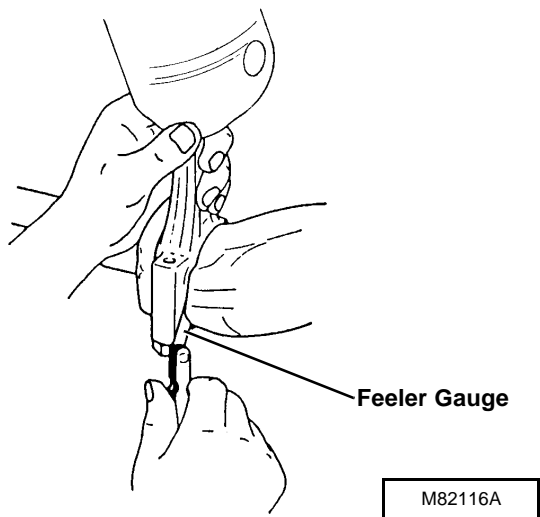
To determine proper side clearance between crankshaft and connecting rod.

Equipment:

- Feeler Gauge

Procedure:

1. Insert a feeler gauge, according to specifications, between connecting rod cap and crankshaft.



Specifications:

Standard Clearance 0.20 - 0.40 mm
 (0.0079 - 0.0157 in.)
Wear Limit 0.55 mm (0.0217 in.)

Results:

- If side play exceeds wear limit, replace connecting rod and connecting rod cap.

CONNECTING ROD BEARING CLEARANCE CHECK

Reason:

To measure oil clearance between connecting rod bearing and crankshaft journal.

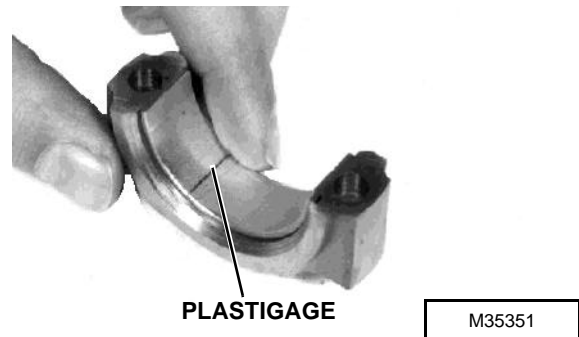
Equipment:

- PLASTIGAGE®

Procedure:

IMPORTANT: Connecting rod caps must be installed on the same connecting rod and in the same direction to prevent crankshaft and connecting rod damage.

1. Remove connecting rod cap.
2. Wipe oil from bearing insert and crankshaft journal.
3. Put a piece of PLASTIGAGE, or an equivalent, along the full length of the bearing insert approximately 6 mm (0.250 in.) off center.

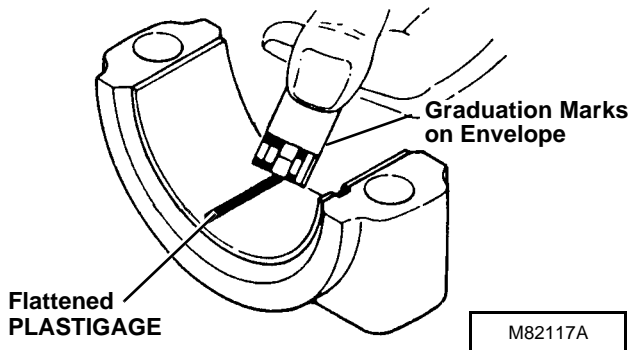


4. Turn crankshaft approximately 30° from bottom dead center.

5. Install connecting rod end cap and original cap screws. Tighten cap screws to **23 N•m (203 lb-in.)**.
6. Remove cap screws and connecting rod cap.

NOTE: The flattened PLASTIGAGE will be found on either the bearing insert or crankshaft journal.

7. Use the graduation marks on the envelope to compare the width of the flattened PLASTIGAGE at its widest point.
8. Determine bearing clearance. The number within the graduation marks indicates the bearing clearance in inches or millimeters depending on which side of the envelope is used.
9. Remove PLASTIGAGE.



Specifications:

Standard Clearance **0.020 - 0.072 mm**
 **(0.0008 - 0.0028 in.)**
Wear Limit..... **0.15 mm (0.0059 in.)**

Results:

- If clearance exceeds wear limit, replace bearing inserts.

®PLASTIGAGE is a registered trademark of the DANA Corporation.

CRANKSHAFT, END PLAY CHECK

Reason:

To determine proper side clearance between crankshaft and engine block.

Equipment:

- Dial Indicator

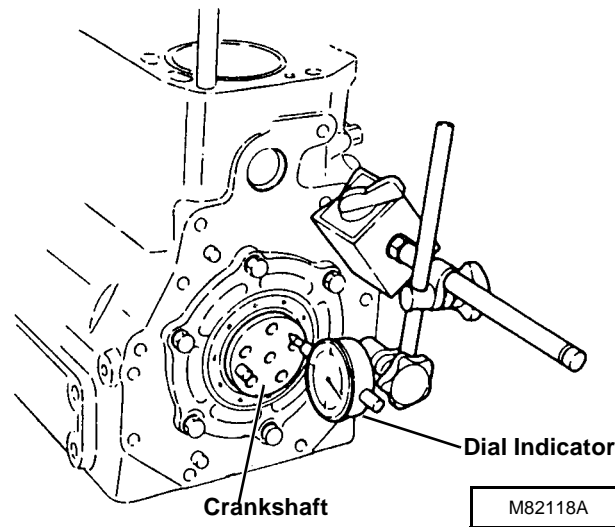
Procedure:

NOTE: Crankshaft end play can be measured at front end or rear end of crankshaft. Procedure is performed from the rear end. The flywheel is removed to show detail.

1. Fasten dial indicator to engine and position indicator tip on end of crankshaft.

IMPORTANT: Do not use excessive force when moving crankshaft to avoid damaging bearings.

2. Push crankshaft toward rear as far as possible.
3. Zero the dial indicator.
4. Using a bar, gently pry the crankshaft as far forward as possible.



Specifications:

Standard Clearance **0.090 - 0.271 mm**
 **(0.004 - 0.011 in.)**
Wear Limit..... **0.33 mm (0.0129 in.)**

Results:

- If end play exceeds wear limit, replace thrust bearings.

Checks, Tests and Adjustments

CRANKSHAFT MAIN BEARING, CLEARANCE CHECK

Reason:

To measure oil clearance between main bearing and crankshaft journal.

Equipment:

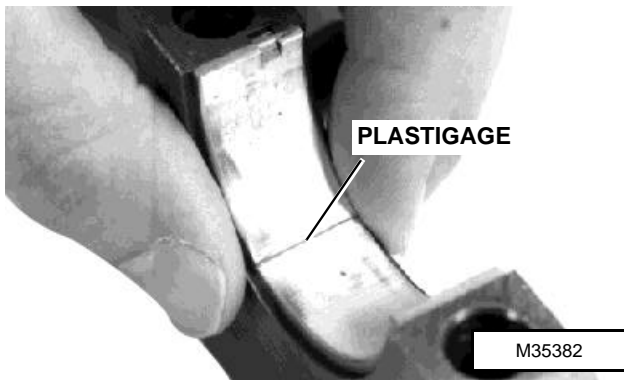
1

- PLASTIGAGE®

Procedure:

IMPORTANT: Main bearing caps must be installed on the same main bearing and in the same direction to prevent crankshaft and main bearing damage.

1. Remove main bearing cap.
2. Wipe oil from bearing insert and crankshaft journal.
3. Put a piece of PLASTIGAGE, or an equivalent, along the full length of the bearing insert approximately 6 mm (0.250 in.) off center.



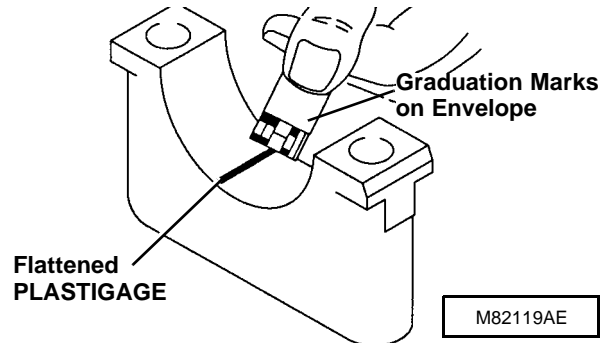
4. Install main bearing cap and cap screws. Tighten cap screws to:
3TN66..... 54 N•m (40 lb-ft)
3TNA72 (3009) 79 N•m (58 lb-ft)

5. Remove cap screws and main bearing cap.

NOTE: The flattened PLASTIGAGE will be found on either the bearing insert or crankshaft journal.

6. Use the graduation marks on the envelope to compare the width of the flattened PLASTIGAGE at its widest point.

7. Determine main bearing clearance. The number within the graduation marks indicates the bearing clearance in inches or millimeters depending on which side of the envelope is used.
8. Remove PLASTIGAGE.



Specifications:

Standard Clearance 0.020 - 0.072 mm
.....(0.0008 - 0.0028 in.)
Wear Limit..... 0.15 mm (0.0059 in.)

Results:

- If clearance exceeds wear limit, replace bearing inserts.

®PLASTIGAGE is a registered trademark of the DANA Corporation.

VALVE LIFT CHECK

Reason:

Can indicate excessive wear on cam lobes, followers, and/or push rods.

Equipment:

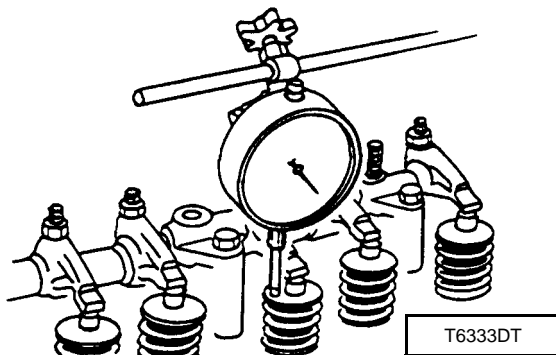
- Dial Indicator

Procedure:

1. Adjust valve clearance. (See procedure in this group.)
2. Remove rocker arm cover. (See *Cylinder Head, Valves and Manifolds* in this section.)
3. Fasten dial indicator to engine and position indicator tip on valve retainer. Valve must be fully closed and rocker arm must move freely.
4. Zero the dial indicator.
5. Manually turn crankshaft pulley clockwise (from fan end).

6. Observe dial indicator as valve is moved to the full open position. Valve lift (intake and exhaust) should be **7.5 mm (0.300 in.)**.

Repeat for each valve.



Results:

- If valve lift is less than specification, remove and inspect camshaft, followers and push rods. (See *Camshaft and Timing Gear Train* and/or *Cylinder Head, Valves and Manifolds* in this section.)

CAMSHAFT END PLAY CHECK

Reason:

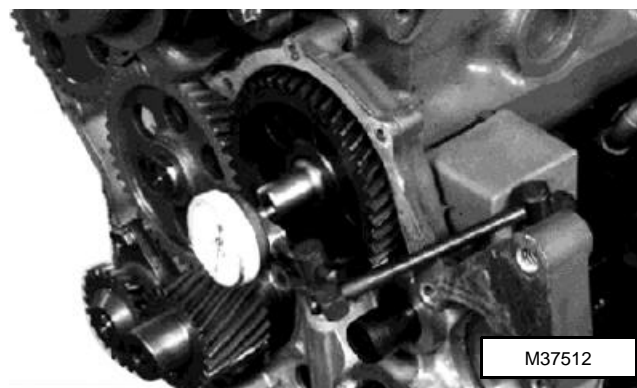
To determine proper side clearance between camshaft gear end journal and thrust plate.

Equipment:

- Dial Indicator

Procedure:

1. Remove timing gear cover. (See *Camshaft and Timing Gear Train* in this section.)
2. Fasten dial indicator to engine and position indicator tip on end of camshaft.
3. Push camshaft toward the rear as far as possible.
4. Zero the dial indicator.
5. Pull camshaft forward as far as possible.



Specifications:

Standard Clearance 0.05 - 0.20 mm
.....(0.0020 - 0.0079 in.)
Wear Limit. 0.40 mm (0.016 in.)

Results:

- If end play exceeds wear limit, remove camshaft and replace thrust plate. (See *Camshaft and Timing Gear Train* in this section.)

Checks, Tests and Adjustments

TIMING GEAR BACKLASH, CHECK - EARLY 3TNA72 (430 LGT)

Reason:

To check for wear between meshing gears, resulting in excessive noise and poor engine performance.

Equipment:

- 1 • Dial Indicator

Procedure:

1. Measure backlash between meshing gears.

Specifications:

Standard Backlash

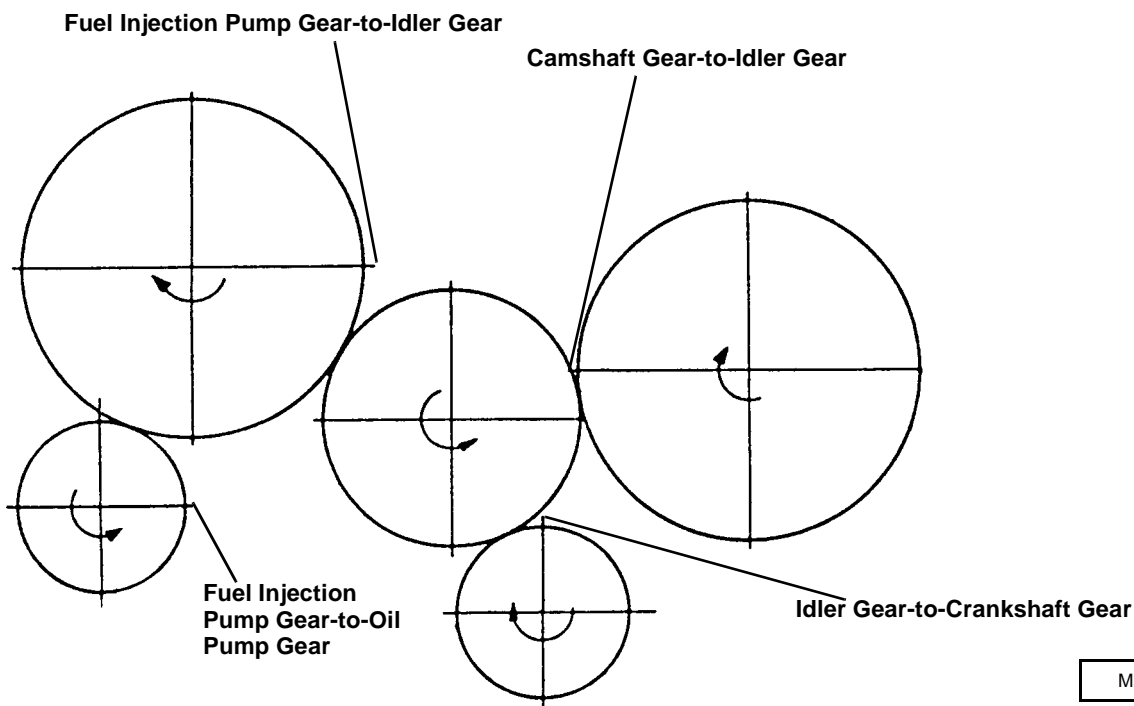
Fuel Injection Pump Gear-to-Oil Pump Gear
Pump Gear..... 0.11 - 0.19 mm
.....(0.0043 - 0.0075 in.)

All Except Fuel Injection Pump Gear-to-Oil Pump Gear
Pump Gear..... 0.04 - 0.12 mm
.....(0.0016 - 0.0047 in.)
Wear Limit..... 0.20 mm (0.0079 in.)

Results:

- If backlash exceeds wear limit, replace meshing gears as a set:

Idler Gear, Camshaft Gear, Crankshaft Gear, AND/OR Idler Gear, Fuel Injection Pump Gear, and Oil Pump Gear.



TIMING GEAR BACKLASH, CHECK - 3TN66 AND LATER 3TNA72

Reason:

To check for wear between meshing gears, resulting in excessive noise and poor engine performance.

Equipment:

- Dial Indicator

Procedure:

1. Measure backlash between meshing gears.

Specifications:

Standard Backlash

Crankshaft Gear-to-Oil

Pump Gear..... 0.11 - 0.19 mm
.....(0.0043 - 0.0075 in.)

All Except

Crankshaft Gear-to-Oil

Pump Gear..... 0.04 - 0.12 mm
.....(0.0016 - 0.0047 in.)

Wear Limit..... 0.20 mm (0.0079 in.)

Results:

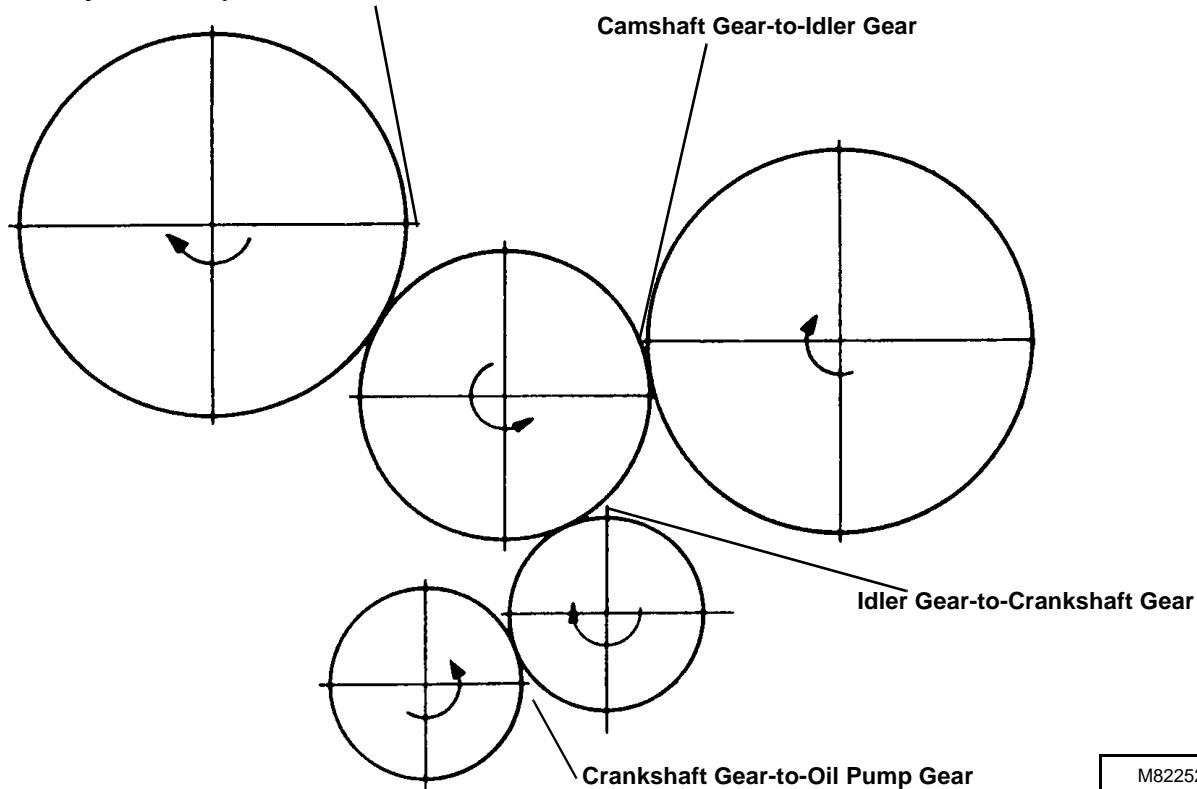
- If backlash exceeds wear limit, replace meshing gears as a set:

Idler Gear, Camshaft Gear, Crankshaft Gear, Oil Pump Gear AND/OR Idler Gear, Fuel Injection Pump Gear.

1

Fuel Injection Pump Gear-to-Idler Gear

Camshaft Gear-to-Idler Gear



M82252A

FUEL INJECTION NOZZLE TEST (PINTLE-TYPE)

CAUTION

Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.

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

Reason:

To determine opening pressure, leakage, chatter and spray pattern of the fuel injection nozzle.

Equipment:

- D01109AA Diesel Fuel Injection Nozzle Tester
- D01110AA Adapter Set
- 23622 Straight Adapter
- Container

Connections:

1. Connect fuel injection nozzle to D01109AA Diesel Fuel Injection Nozzle Tester using parts from D01110AA Adapter Set and 23622 Straight Adapter.

IMPORTANT: Use clean filtered diesel fuel when testing injection nozzles to get best test results.

Procedure 1:

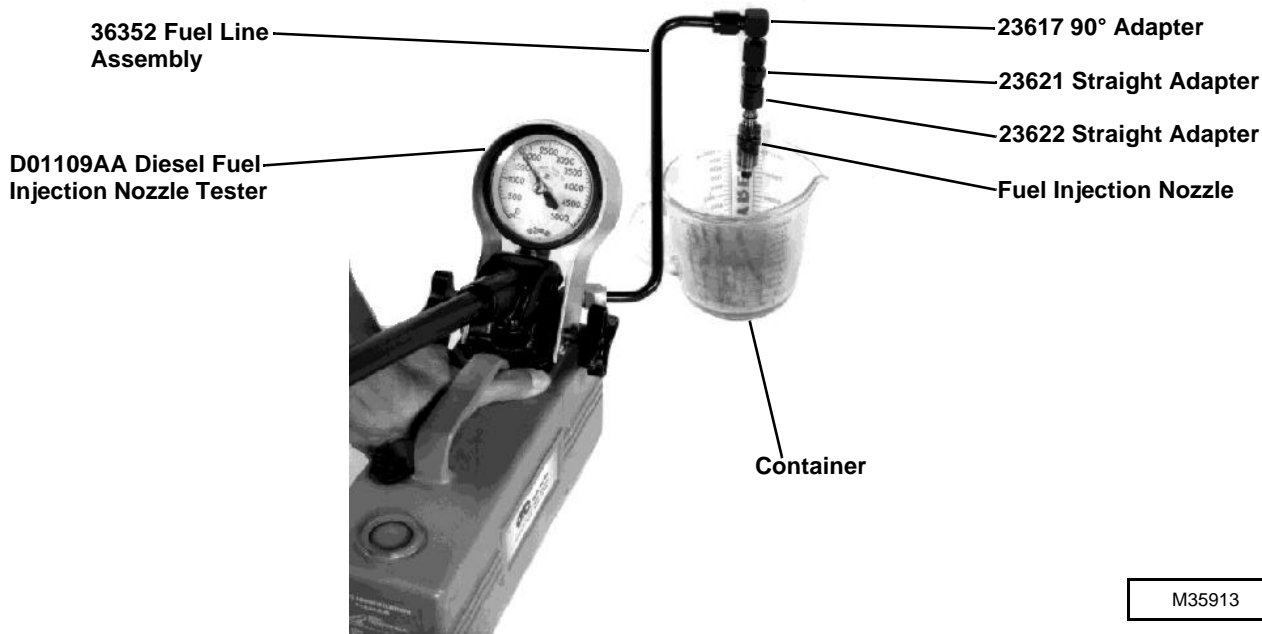
Test fuel injection nozzle **opening pressure** following the Nozzle Tester manufacturer's instructions.

Specifications:

**Opening Pressure 11722 ± 480 kPa
..... (1700 ± 70 psi)**

Results:

- If pressure reading does not meet specification, disassemble injection nozzle and inspect nozzle assembly for contamination or stuck valve. If necessary, add or remove shims to change opening pressure.



1

Procedure 2:

Test fuel injection nozzle **leakage** following the Nozzle Tester manufacturer's instructions.

1. Dry nozzle completely using a lint-free cloth.
2. Pressurize nozzle to **11032 kPa (1600 psi)**.
3. Watch for leakage from nozzle spray orifice. Leakage time should be a minimum of **10 seconds**.

Results:

- If leakage time does not meet specification, disassemble injection nozzle and inspect nozzle assembly for contamination. Inspect valve seating surface. Replace nozzle assembly if necessary.

Procedure 3:

Test fuel injection nozzle **chatter and spray pattern** following the Nozzle Tester manufacturer's instructions.

1. Pressurize nozzle to **11722 ± 480 kPa (1700 ± 70 psi)**.
2. Listen for “chatter” sound and watch spray pattern.

Specifications:

Slow Hand

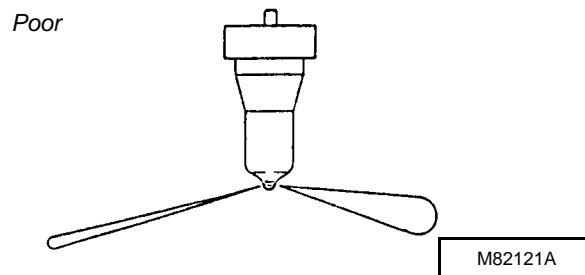
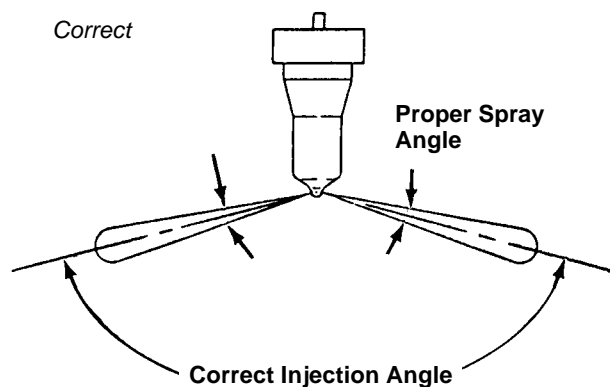
Lever Movement Chatter Sound

Slow Hand

Lever Movement Fine Stream
. Spray Pattern

Fast Hand

Lever Movement Fine Atomized
. Spray Pattern

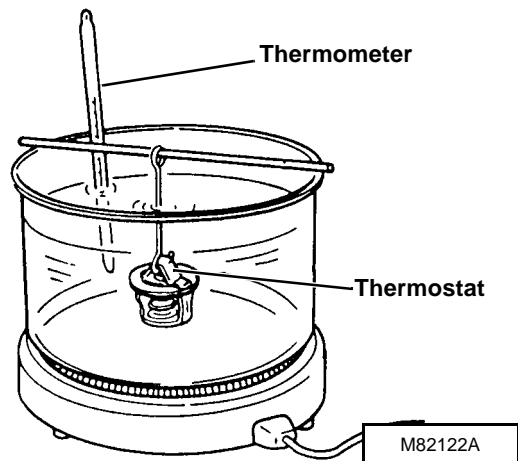


Checks, Tests and Adjustments

Results:

- If nozzle chatter or spray pattern does not meet specifications, disassemble injection nozzle and inspect nozzle assembly for contamination. Inspect valve seating surface. Replace nozzle assembly if necessary.
- If there is excessive difference in spray angle or injection angle, incomplete atomization or sluggish starting/stopping of injection, disassemble injection nozzle and inspect nozzle assembly for contamination. Replace nozzle assembly if necessary.

1



THERMOSTAT OPENING TEST

Reason:

To determine opening temperature of thermostat.

Equipment:

- Thermometer
- Glass Container
- Heating Unit

Procedure:

CAUTION

DO NOT allow thermostat or thermometer to rest against the side or bottom of glass container when heating water. Either may rupture if overheated.

1. Suspend thermostat and a thermometer in a container of water.
2. Heat and stir the water. Observe opening action of thermometer and compare temperatures with specifications.
3. Remove thermostat and observe its closing action as it cools.

Specifications:

Begin Opening 71° C (160° F)
Fully Open 85° C (184° F)
Minimum Lift Height8 mm (0.310 in.)

Results:

- If thermostat does not open according to specifications, replace.
- If closing action is not smooth and slow, replace thermostat.

COOLANT TEMPERATURE SENSOR TEST

Reason:

To determine operating temperature of sensor.

Equipment:

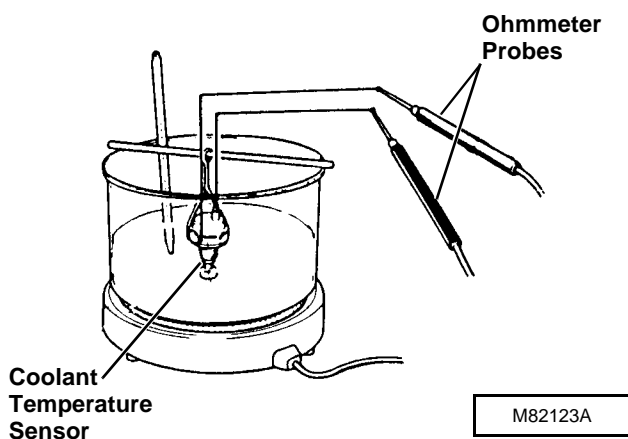
- Thermometer
- Glass Container
- Heating Unit
- Ohmmeter

Procedure:

CAUTION

DO NOT allow switch or thermometer to rest against the side or bottom of glass container when heating water. Either may rupture if overheated.

1. Connect lead wires from ohmmeter probes, to sensor terminal and body.
2. Suspend sensor and a thermometer in a container of water.
3. Heat and stir the water. Observe water temperature when continuity occurs. Water temperature should be **107 - 113° C (225 - 235°F)**.



Results:

- If continuity does not occur within temperature listed, replace sensor.

STARTER NO-LOAD AMP DRAW/RPM TEST

Reason:

To determine if starter is binding or has excessive amperage draw under no load.

Equipment:

- JT05712 Current Gun
- JT05719 Hand-Held Digital Tachometer
- Jumper Cables
- Jumper Wire

Procedure:

1. Mount starter in a vise.

NOTE: Check that battery is fully charged and of proper size to ensure accuracy of test.

2. Connect jumper cables to a 12 volt battery.
3. Connect positive (+) cable to solenoid battery terminal on starter.
4. Connect negative (-) cable to starter body.
5. Attach Current Gun to positive cable.

IMPORTANT: Complete this test in 20 seconds or less to prevent starter damage.

6. Use a jumper wire to briefly connect positive (+) starter terminal to solenoid terminal "S". Starter should engage and run.
7. Read and record starter amperage and rpm.

Specifications:

Maximum Starter Amperage

Hitachi 0.8 kW..... 60 Amps at 7000 rpm

Nippondenso 1.0 kW.. 90 Amps at 3000 rpm

Minimum Starter RPM

Hitachi 0.8 kW..... 7000

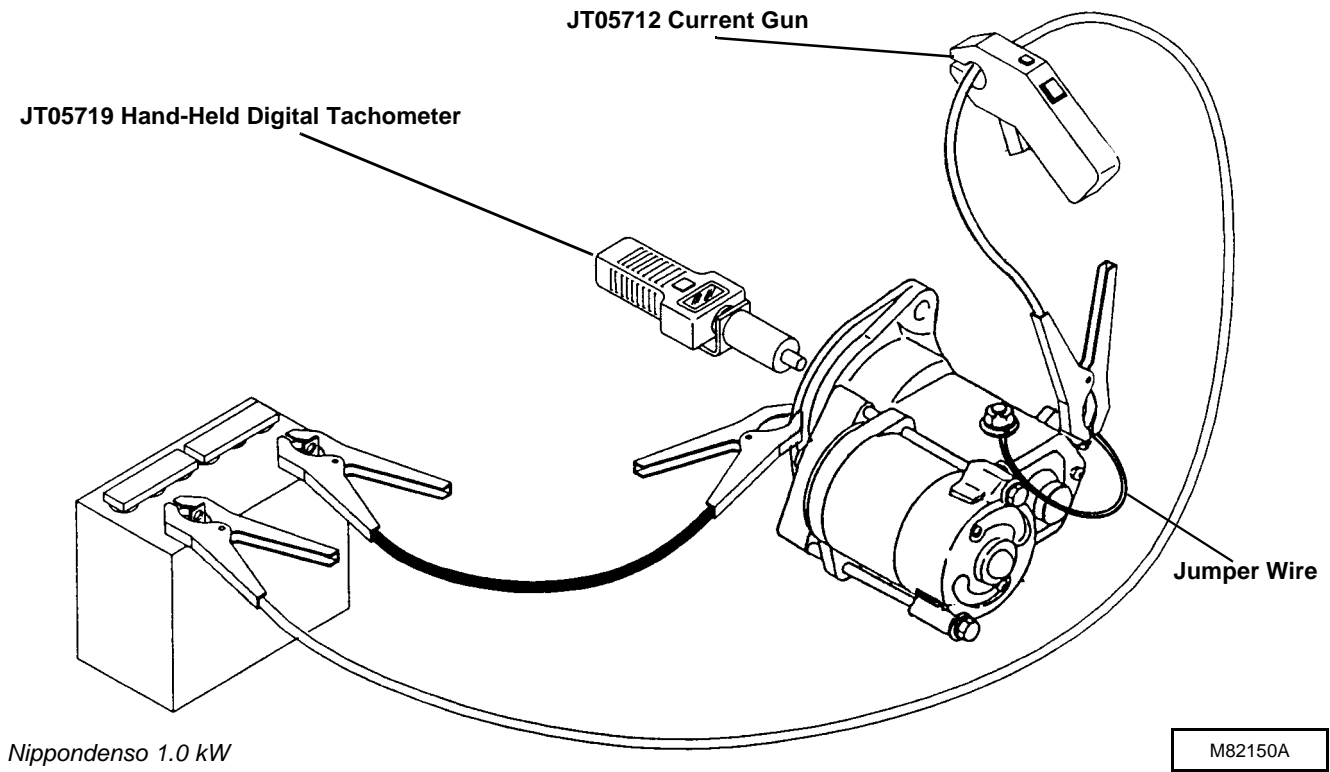
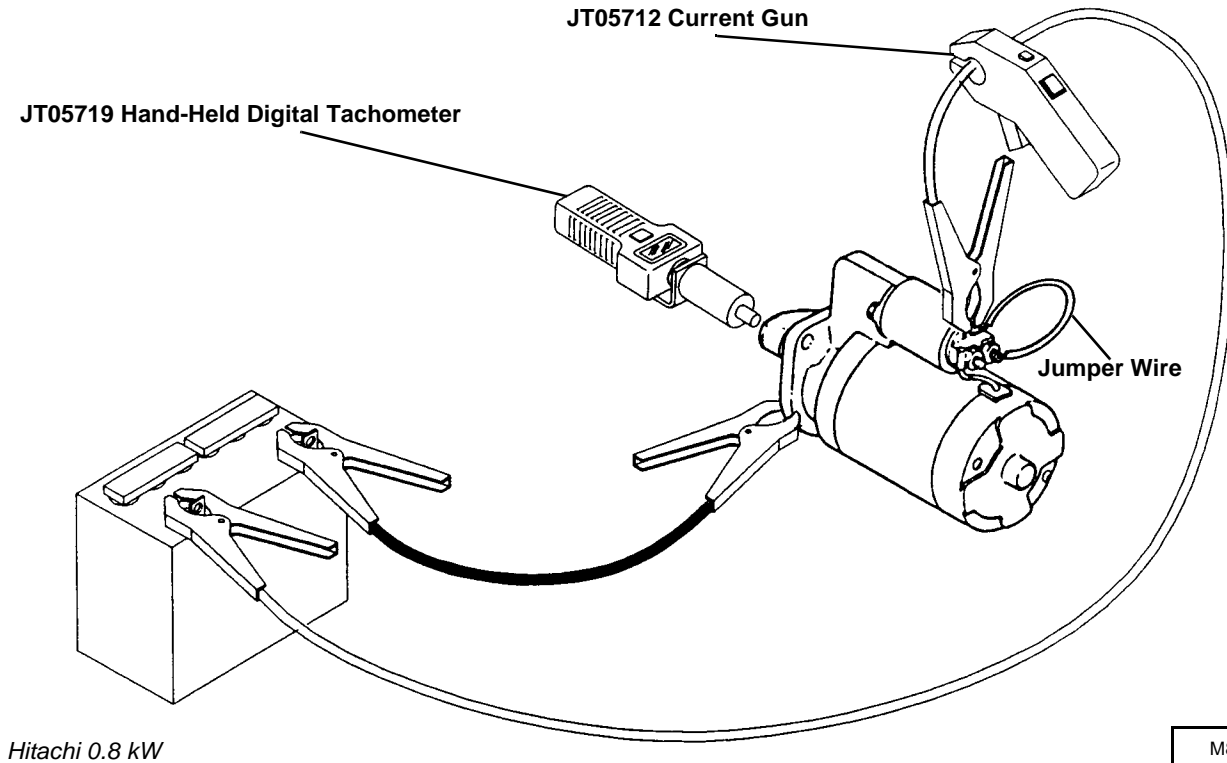
Nippondenso 1.0 kW..... 3000

Results:

- If solenoid "clicks" or chatters and motor does not turn, replace solenoid.
- If pinion gear engages and motor doesn't turn, repair or replace starter motor.
- If starter engages and runs but amperage is more than specifications, repair or replace starter.
- If rpm is less than specification, with battery fully charged, repair or replace starter.

Checks, Tests and Adjustments

1



INJECTION PUMP STATIC TIMING ADJUSTMENT - EARLY 3TNA72 (430 LGT)

Reason:

To make sure that injection pump timing is set to manufacturers specification.

Equipment:

- Timing Tool (No. 1 fuel injection line cut off at first bend)
- External fuel supply

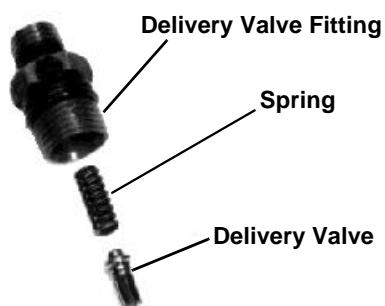
Procedure:

IMPORTANT: Injection pump timing should be correct. Once timing is set, it will not normally change during the life of the engine, unless it was altered.

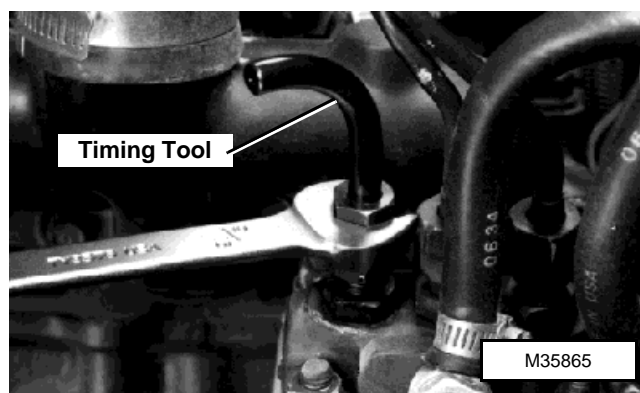
Check and adjust timing only as the last option. Check fuel, fuel supply system, injectors, air intake system and cylinder compression before continuing.

NOTE: The flywheel turns counterclockwise (as viewed from the flywheel end). The number one fuel injection line is toward the flywheel.

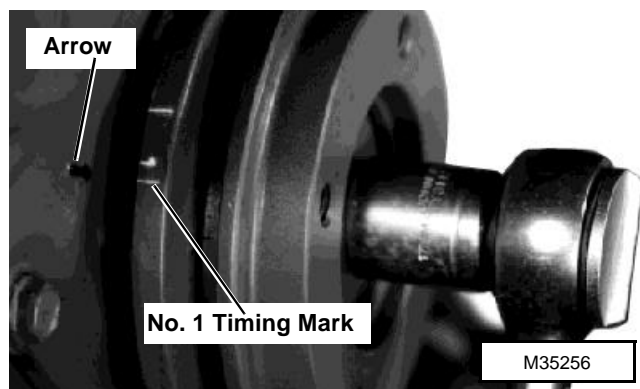
1. Remove the number one fuel injection line and delivery valve fitting.
2. Remove spring and delivery valve. Do not remove delivery valve seat.
3. Install delivery valve fitting and tighten to **42 N•m (31 lb-ft)**.



4. Install timing tool (number one fuel line cut off at first bend).



5. Remove glow plugs to aid in turning crankshaft pulley.
6. Turn crankshaft pulley in either direction until the No. 1 cylinder timing mark aligns with arrow on timing gear cover.



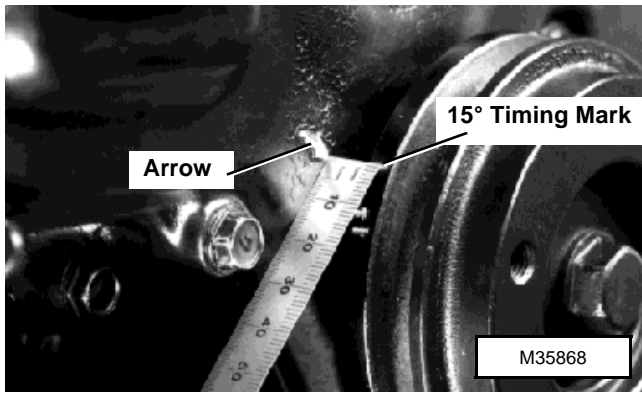
7. Put a container under timing tool to collect any fuel.
8. Turn key switch to ON position. DO NOT start engine. Push fuel shutoff solenoid plunger to "hold" position.
9. Turn flywheel clockwise (as viewed from the flywheel end) until fuel flows in a stream.
10. Slowly turn flywheel counterclockwise until fuel flow changes from a stream and then stops completely. This is the point of injection timing at which the pump is set.

NOTE: If the fuel flow does not stop, the number one piston is on the exhaust stroke instead of the compression stroke. Turn flywheel one revolution and repeat Steps 6 - 10.

11. Check timing mark on camshaft pulley. The 15° timing mark must line up with the arrow on timing gear cover.

Checks, Tests and Adjustments

1



Specifications:

Injection Pump Timing. 15° BTDC
. (Before Top Dead Center)

Engine Crankshaft

Position. No.1 Cylinder
. on TDC Compression Stroke

Distance On Outer Surface of Crankshaft
Pulley for Every 0.1 mm (0.004 in.) of
Shim Thickness 1° or 1 mm (3/64 in.)

Results:

- If timing is not according to specifications:
 - Remove injection pump and shims (See *Fuel System* in this section.)
 - Measure old shims to determine shim thickness.
 - Measure approximate distance between timing mark and arrow.

NOTE: Crankshaft pulley always turns clockwise when engine is running.

- If timing mark has not reached arrow, **RETARD** pump timing by increasing total shim thickness. If mark has passed arrow, **ADVANCE** timing by decreasing total shim thickness. Use new shims.

For every 0.1 mm (0.004 in.) of shim thickness, there is approximately a 1° or 1 mm (3/64 in.) change in crankshaft pulley timing.

Shim Pack:	Approximate Timing Change on Crankshaft Pulley
Shim Size	
0.2 mm (0.007 in.)	2° or 2 mm (5/64 in.)
0.3 mm (0.012 in.)	3° or 3 mm (1/8 in.)
0.5 mm (0.020 in.)	5° or 5 mm (13/64 in.)

- Install new shims with the **THICKEST** shim against the injection pump body and the **THINNEST** shim against the gear housing.
- If timing did not change, have pump tested by a diesel injection service shop.
- If timing is OK:
 - Remove timing tool.
 - Remove delivery valve fitting.
 - Install delivery valve and spring.
 - Install new o-ring and delivery valve fitting. Tighten to **42 N•m (31 lb-ft)**.
 - Install number one injection line.

INJECTION PUMP STATIC TIMING ADJUSTMENT - 3TN66 AND LATER 3TNA72

Reason:

To make sure that injection pump timing is set to manufacturers specification.

Equipment:

- Timing Tool (No. 1 fuel injection line cut off at first bend)
- External fuel supply

Procedure:

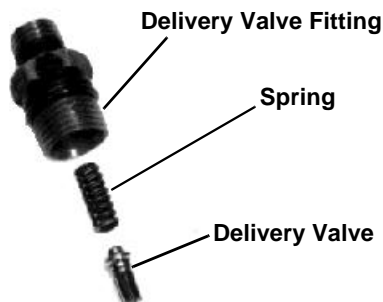
IMPORTANT: Injection pump timing should be correct. Once timing is set, it will not normally change during the life of the engine, unless it was altered.

Check and adjust timing only as the last option. Check fuel, fuel supply system, injectors, air intake system and cylinder compression before continuing.

NOTE: The flywheel turns counterclockwise (as viewed from the flywheel end). The number one fuel injection line is toward the flywheel.

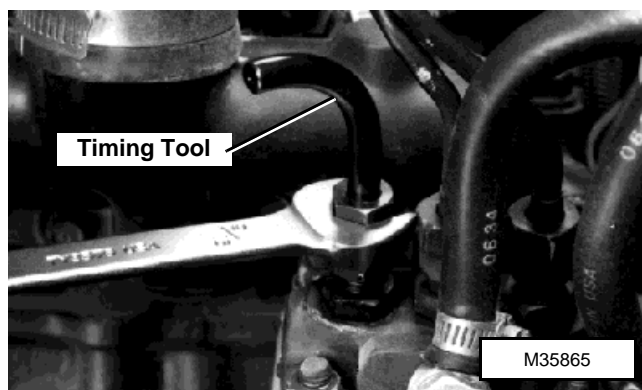
1. Remove the number one fuel injection line and delivery valve fitting.

2. Remove spring and delivery valve. Do not remove delivery valve seat.
3. Install delivery valve fitting and tighten to **42 N•m (31 lb-ft)**.

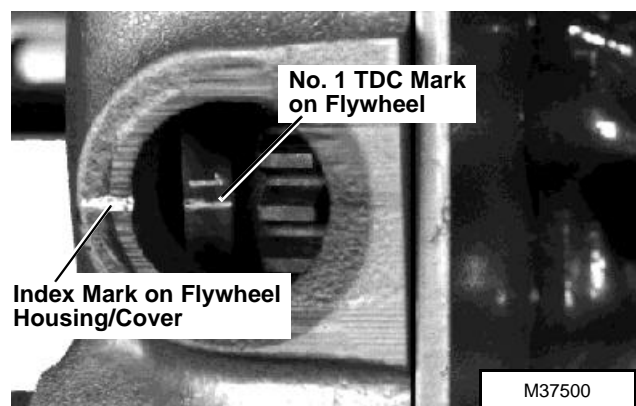


T6333HP

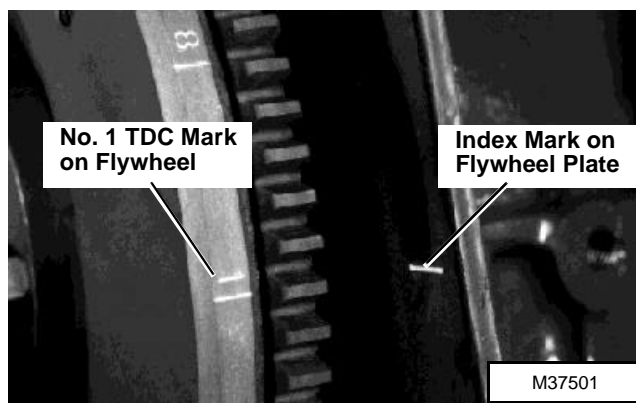
4. Install timing tool (number one fuel line cut off at first bend).



5. Remove glow plugs to aid turning crankshaft pulley.
6. Remove plug from flywheel housing/cover, if equipped.
7. Turn crankshaft pulley in either direction until the No. 1 cylinder top dead center (TDC) mark aligns with the index mark on the flywheel housing/cover or plate.



330/332 LGT, F915 FM, 430 LGT (Later),
F925/35 FM, 15 EX, 3009 OEM



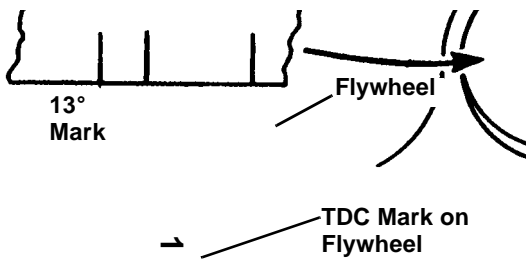
375 SSL, 670 CUT

8. Put a container under timing tool to collect any fuel.
9. Turn key switch to ON position. DO NOT start engine. Push fuel shutoff solenoid plunger to "hold" position.
10. Turn flywheel clockwise (as viewed from the flywheel end) until fuel flows in a stream.
11. Slowly turn flywheel counterclockwise until fuel flow changes from a stream and then stops completely. This is the point of injection timing at which the pump is set.

NOTE: If the fuel flow does not stop, the number one piston is on the exhaust stroke instead of the compression stroke. Turn flywheel one revolution and repeat Steps 7 - 11.

12. Check timing mark on flywheel. The index mark must line up with the 13° mark on flywheel.

Checks, Tests and Adjustments



1

Index Mark on Flywheel Housing/Cover or Plate

T6471CS

Specifications:

Injection Pump Timing **13° BTDC**
 **(Before Top Dead Center)**

Engine Crankshaft Position **No.1 Cylinder**
 **on TDC Compression Stroke**

Distance On Outer Surface Of Flywheel Per 1° Of Rotation **2.62 mm (0.100 in.)**

Results:

- If timing is not according to specifications:
 - Remove injection pump and shims. (See *Fuel System* in this section.)
 - Install new shim(s) with a total shim pack thickness of **0.5 mm (0.020 in.)**.
 - Install injection pump and recheck timing.
- If engine performance is poor, check air cleaners, fuel filter, fuel supply, injectors and cylinder compression before removing pump for service. Check all timing gears for wear. Retest performance.
- If performance did not change, have pump tested by a diesel injection service. When reinstalling injection pump, use same thickness of shim pack

removed. If shim pack thickness is unknown or new pump is installed, replace with **0.5 mm (0.020 in.)** shim pack thickness.

- If timing is OK:
 - Install rubber plug in flywheel housing/cover, if equipped.
 - Remove timing tool.
 - Remove delivery valve fitting.
 - Install delivery valve and spring.
 - Install new o-ring and delivery valve fitting. Tighten to **42 N•m (31 lb-ft)**.
 - Install number one injection line.

FAN/ALTERNATOR DRIVE BELT ADJUSTMENT

Reason:

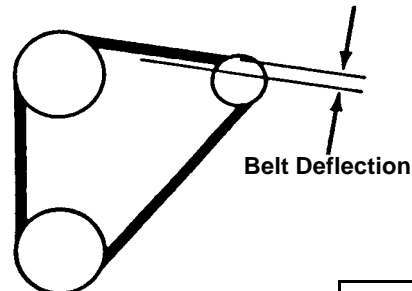
To keep proper tension on belt to drive water pump and alternator. To prevent shortened belt and bearing life.

Equipment:

- JDG529 or JDST28 Belt Tension Gauge
- Straight Edge

Procedure:

1. Check belt tension between fan and alternator using Belt Tension Gauge and a straight edge.



M54014

Specifications:

Applied Force **.98 N (22 lb-force)**
Deflection **10 - 15 mm (0.400 - 0.600 in.)**

Results:

- If deflection is not within specifications:
 - Loosen both alternator mounting cap screws/nuts.
 - Apply force to FRONT alternator housing only (near the belt) until tension is correct.
 - Tighten cap screws/nuts.

FUEL SHUTOFF SOLENOID ADJUSTMENT

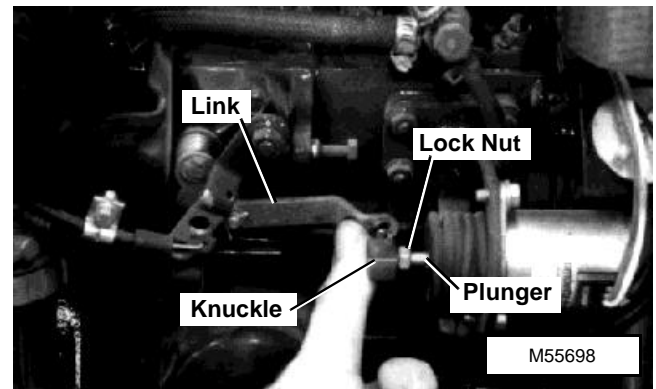
Reason:

To ensure that fuel shutoff solenoid retracts fully, moving the injection pump shutoff control lever far enough to allow full rack travel.

Procedure:

1. Loosen lock nut.
2. Disconnect link from solenoid.
3. Hold solenoid plunger bottomed in solenoid body.

4. Move link toward solenoid until it stops.
5. Turn plunger rod in or out of knuckle until knuckle and link holes line up. Turn out two additional turns. The additional turns insure that the solenoid bottoms out before the linkage.
6. Assemble and check for free movement when key switch is turned ON. Also check that linkage returns completely to the STOP position when key switch is turned OFF.



1

Operational Tests

RADIATOR, BUBBLE TEST

Reason:

To determine if compression pressure is leaking from cylinder.

Equipment:

- JDG472 Adapter

Procedure:

1. With coolant at proper level and radiator cap tight, run engine for 5 minutes to bring to operating temperature.
2. Remove cap from recovery tank.
3. Check for bubbles coming from overflow hose at bottom of tank.

If bubbles are present, isolate source of compression leak:

- Remove injection nozzles.
- Install JDG472 Adapter in injection port of cylinder to be tested.
- Move piston to bottom of stroke with intake and exhaust valves closed.
- Connect hose from compressed air source to adapter.
- Apply the specified maximum air pressure into cylinder:

3TN66.....2448 kPa (355 psi)

3TNA72

All Except

3009 OEM2448 kPa (355 psi)

3009 OEM2455 kPa (356 psi)

- Check for bubbles in recovery tank or air escaping from muffler, air cleaner or oil fill opening.
- Repeat for each cylinder.

Results:

- If bubbles are present, check for cracks in cylinder head and block. Check for damaged head gasket.

- If air escapes from muffler, check for worn exhaust valve.
- If air escapes from air cleaner, check for worn intake valve.
- If air escapes from engine oil fill, check for worn piston rings.

COOLING SYSTEM, PRESSURE TEST

Reason:

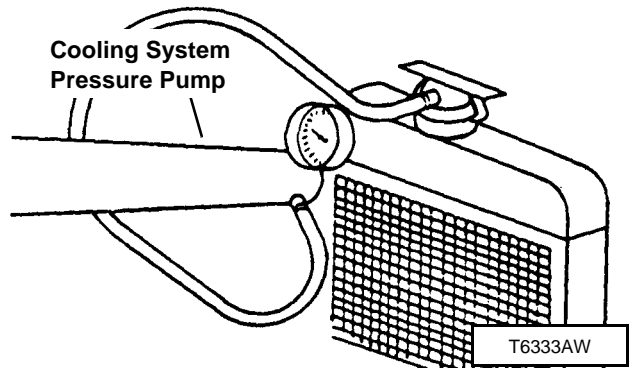
Inspect cooling system for leaks.

Equipment:

- D05104ST Cooling System Pressure Pump
- JDG692 Radiator Pressure Test Kit (Adapters)

Procedure:

1. Remove cap and attach pressure pump to radiator.
2. Apply pressure according to specifications.
3. Check for leaks throughout cooling system.



Specifications - 3TN66:

Maximum Pressure.....117 kPa (17 psi)

**Minimum Pressure
after 15 Seconds90 kPa (13 psi)**

Specifications - 3TNA72:

15 EX, 670 CUT, 3009 OEM

Maximum Pressure.....97 kPa (14 psi)

**Minimum Pressure
after 15 Seconds 88 kPa (12.8 psi)**

430 LGT, 455 LGT, 755/56 CUT, F925/35 FM

Maximum Pressure.....117 kPa (17 psi)

**Minimum Pressure
after 15 seconds.....90 kPa (13 psi)**

Results:

- Pressure should hold to specifications. If pressure decreases, check for leaks. Repair leaks or replace parts as necessary.
- If pressure test still indicates leakage after all external leaks have been stopped, a defective head gasket, cracked block, or cylinder head may be the cause. Perform *RADIATOR BUBBLE TEST*.

RADIATOR CAP, PRESSURE TEST

Reason:

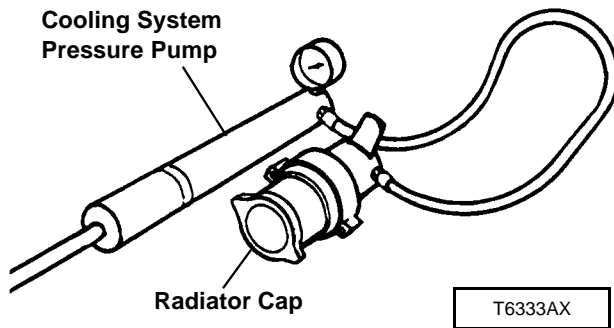
Test radiator cap for operating in correct pressure range.

Equipment:

- D05104ST Cooling System Pressure Pump
- JDG692 Radiator Pressure Test Kit (Adapters)

Procedure:

1. Install radiator cap on pressure pump.
2. Apply pressure. Pressure valve in cap should open according to specifications.



Specifications:

Valve Opening Pressure

3TN66.....	97 kPa (14 psi)
3TNA72	
15 EX, 3009 OEM.....	88 kPa (12.8 psi)
670 CUT.....	55 kPa (8 psi)
430 LGT, 455 LGT, 655 CUT, 755/56 CUT,	
F925/35 FM.....	97 kPa (14 psi)

Results:

- If cap leaks, retighten and test again. Replace cap if pressure is not within specification.

CYLINDER, COMPRESSION PRESSURE TEST

Reason:

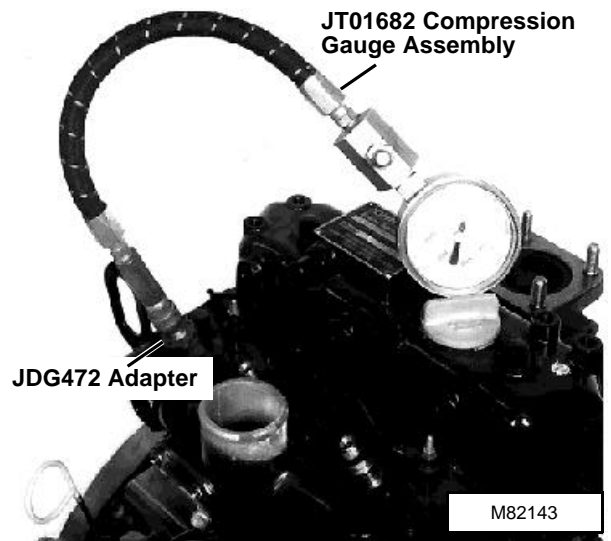
To determine the condition of the pistons, rings, cylinder walls and valves.

Equipment:

- JT01682 Compression Gauge Assembly
- JDG472 Adapter

Procedure:

1. Run engine for 5 minutes to bring to operating temperature. Shut off engine.
2. Remove injection nozzles. (See *Fuel System* in this section.)
3. Install Adapter and Compression Gauge Assembly in injector port.
4. Disconnect fuel shut-off solenoid connector.
5. Crank engine for three seconds with starter.
6. Record pressure reading for each cylinder.



1

Operational Tests

Specifications:

Compression Pressure

3TN66.....2448 kPa (355 psi)

3TNA72

All Except

3009 OEM2448 kPa (355 psi)

3009 OEM2455 kPa (356 psi)

Maximum Difference

Between Cylinders490 kPa (71 psi)

NOTE: Pressure listed is for 300 m (1000 ft) above sea level. For naturally aspirated engines, reduce specification an additional 4% for each 300 m (1000 ft) of altitude.

Results:

- If pressure reading is below specification, squirt approximately two teaspoons of clean engine oil into cylinders through injector ports and repeat test.
- If pressure increases significantly, check piston, rings and cylinder walls for wear or damage.
- If pressure does not increase significantly after retest, check for leaking valves, valve seats or cylinder head gasket.

ENGINE OIL PRESSURE TEST

Reason:

To determine if engine bearings or lubrication system components are worn.

Equipment:

- JT03017 Hose Assembly
- JT05577 Pressure Gauge (100 psi)
- JT03349 Connector
(All Except 430 LGT, 15 EX)
- JT03338 90° Elbow Connector (430 LGT)
- JT05487 Connector (15 EX)

Procedure:

1. Remove oil pressure sender.
2. Install Connector.

3. Connect Hose Assembly and Pressure Gauge.

IMPORTANT: Do not run if no pressure present.

4. Start engine. If pressure reading is below 69 kPa (10 psi), STOP ENGINE.
5. Run engine approximately five minutes to heat oil, then check oil pressure at fast and/or slow idle.

Specifications - 375 SSL:

Idle Speed

Fast 3625 ± 25 rpm

Slow 1450 ± 50 rpm

Engine Oil Pressure 294 - 392 kPa
.....(43 - 57 psi)

Specifications - 330/332 LGT:

Idle Speed

Fast 3350 ± 100 rpm

Slow 1450 ± 50 rpm

Engine Oil Pressure 294 - 440 kPa
.....(43 - 64 psi)

Specifications - 655 CUT, 430 LGT, 755/56 CUT, 670 CUT:

Fast Idle 3425 ± 25 rpm

Engine Oil Pressure 365 ± 69 kPa
..... (53 ± 10 psi)

Specifications - F915 FM, F925/35 FM:

Idle Speed

Fast 3635 ± 35 rpm

Slow 1450 ± 50 rpm

Engine Oil Pressure 294 - 440 kPa
.....(43 - 64 psi)

Specifications - 455 LGT:

Idle Speed

Fast 3350 ± 100 rpm

Slow 1650 ± 50 rpm

Engine Oil Pressure 294 - 440 kPa
.....(43 - 64 psi)

Specifications - 15 EX:

Idle Speed

Fast 2425 ± 25 rpm

Slow 800 ± 25 rpm

Engine Oil Pressure 117 - 345 kPa
..... (17 - 50 psi)

Specifications - 3009 OEM:

Slow Idle 1300 rpm

Engine Oil Pressure 147 kPa (21 psi)

Results:

- If oil pressure is not within specifications, inspect oil pressure regulating valve parts for wear or damage. Add or remove shims as necessary. (See *Lubrication System* in this section.)
- If oil pressure does not increase, see “Engine Has Low Oil Pressure” in *Diagnosis* group.

AIR INTAKE SYSTEM LEAKAGE TEST

Reason:

Check for leaks in air intake system.

Equipment:

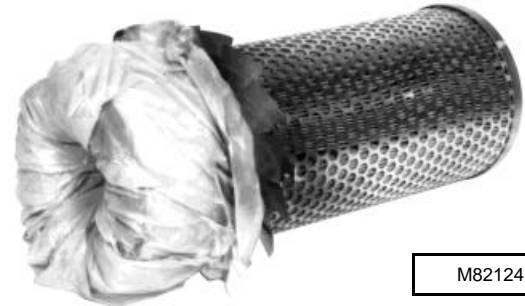
- Air Pressure Regulator

Procedure:

1. Remove air cleaner restriction indicator/switch, if equipped and install test fitting.
2. Connect air pressure regulator to manifold using hose and fitting from air cleaner.
3. Remove air cleaner cover and main filter element.
4. Put large plastic bag into and over end of main filter element. Install main filter element and cover.
5. Pressurize air intake system between **34 - 69 kPa (5 - 10 psi)**. If air intake system cannot be pressurized, turn engine slightly to close valves.

6. Spray soap solution over all connections from air cleaner to intake manifold or turbocharger, if equipped, and check for leaks.

IMPORTANT: When reinstalling starting aid nozzle, position arrow on nozzle pointing against intake air flow.



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Results:

- Find leaks and repair or replace parts as necessary.

FUEL SUPPLY PUMP PRESSURE TEST - 3TNA72 (670 CUT, 3009 OEM)

Reason:

To determine supply pump operating pressure.

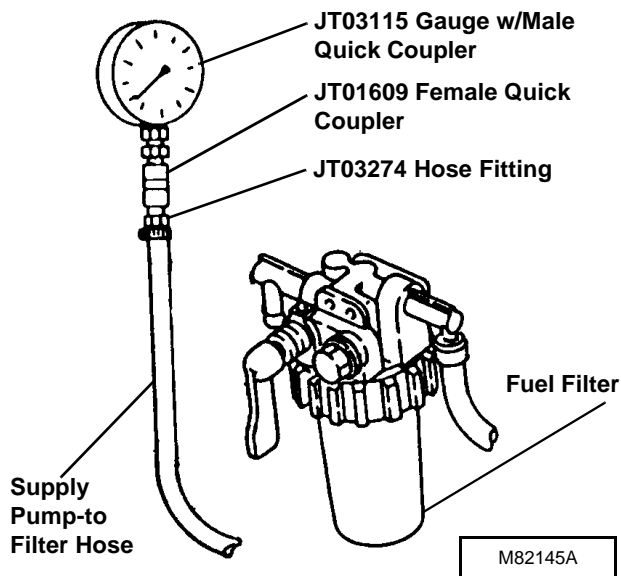
Equipment:

- JT03274 Hose Fitting
- JT01609 Female Quick Coupler
- JT03115 Gauge w/Male Quick Coupler (0 - 150 psi)

Procedure:

1. Disconnect supply pump-to-filter hose.
2. Install Hose Fitting, Coupler and Gauge.
3. Pull fuel shut-off cable out and crank engine using the starter. Do not run starter for more than 10 seconds at a time. Gauge should read more than **29 kPa (4.3 psi)**.

1



Results:

- If pressure is below specification, replace fuel supply pump.

FUEL DRAIN BACK TEST

Reason:

Determines if air is entering the fuel system at connections, allowing fuel to siphon back to tank.

Procedure:

1. Disconnect fuel supply line and 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 fuel supply pump, injection pump, filter(s) and water separator, if equipped.
3. Plug end of fuel return hose.
4. Pressurize fuel system at fuel supply line, to a maximum pressure of **103 kPa (15 psi)**.
5. Apply liquid soap and water solution to all joints and connections in the fuel system and inspect for leaks.

Results:

- Find leaks and repair or replace parts as necessary.

BLEED FUEL SYSTEM

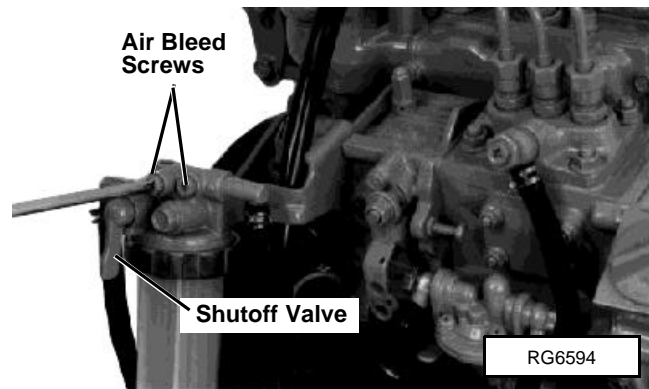
Reason:

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.

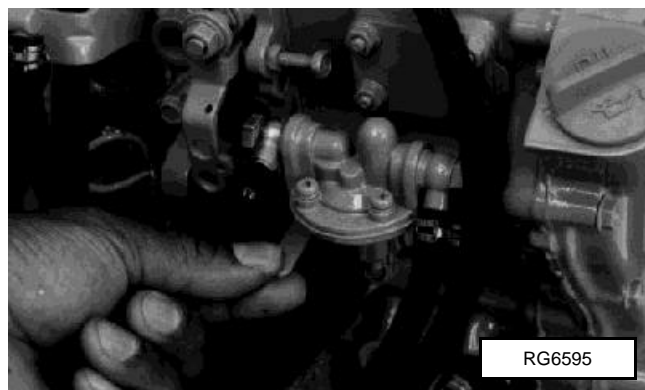
Procedure:

IMPORTANT: Modification or alteration of the injection pump, pump timing, or the injection nozzles in any way not approved by the manufacturer will terminate the warranty obligation.

1. Turn fuel filter shutoff valve to “OPEN” position.
2. Loosen both air bleed screws on fuel filter base.

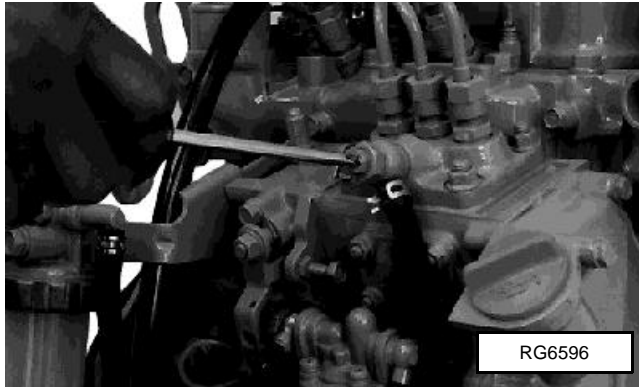


3. Turn ignition switch to “ON” position.
4. Operate hand primer lever of fuel supply pump, if equipped, until fuel flows free of air bubbles. Tighten bleed screws.



5. Loosen bleed screw on injection pump. Operate hand primer, if equipped, and tighten bleed screw when fuel flows free of air bubbles.

6. Start engine. If engine does not start after several attempts, proceed with steps 7 through 10.



7. Loosen all three injector line nuts using a 17 mm wrench. Be sure not to loosen bottom nut of injector.

8. Crank engine over with starter.
9. When fuel appears at injectors, tighten line nuts.
10. Start engine. If engine does not start, repeat bleed procedure.



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3TN75, 3TN78, 3TNC78 (3011) 3TN82, 3TNA82, AND 3TN84 (3014) ENGINES

- Specifications 2-1
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Section 2

ENGINE SPECIFICATIONS - 3TN75, 3TN78, 3TNC78 (3011)

Rocker Arm Cover	
Special Nut Torque	18 N•m (160 lb-in.)
Rocker Arm Assembly	
Mounting Cap Screw Torque	26 N•m (226 lb-in.)
Rocker Arm Shaft O.D.	
Standard	15.97 - 15.98 mm (0.6286 - 0.6293 in.)
Wear Limit	15.95 mm (0.6280 in.)
Rocker Arm and Shaft Support I.D.'s	
Clearance	0.13 mm (0.005 in.)
Standard	16.00 - 16.02 mm (0.630 - 0.631 in.)
Wear Limit	16.09 mm (0.633 in.)
Push Rod Length	
Standard	146.65 - 147.35 mm (5.774 - 5.801 in.)
Push Rod Bend	
Standard	0.03 mm (0.001 in.) or less
Wear Limit	0.30 mm (0.012 in.)
Cylinder Head and Valves	
Mounting Cap Screw Torque	
First	21 N•m (186 lb-in.)
Second	42 N•m (31 lb-ft)
Final	69 N•m (51 lb-ft)
Cylinder Head Distortion	
Standard	0.05 mm (0.002 in.) or less
Wear Limit	0.15 mm (0.006 in.)
Maximum Amount of Metal to be Removed	0.20 mm (0.008 in.)
Valve Seat Width	
Intake Valve	
Standard	1.36 - 1.53 mm (0.054 - 0.060 in.)
Wear Limit	1.98 mm (0.078 in.)
Exhaust Valve	
Standard	1.66 - 1.87 mm (0.065 - 0.074 in.)
Wear Limit	2.27 mm (0.089 in.)
Intake and Exhaust Valves	
Valve Faces	
Minimum Margin	0.51 mm (0.020 in.)
Exhaust Angle	45°
Intake Angle	30°
Valve Stem O.D.	
Distance A .....	.30 mm (1.181 in.)
Distance B .....	.50 mm (1.969 in.)
Intake and Exhaust Valves	
Standard	6.94 - 6.96 mm (0.2732 - 0.2740 in.)
Wear Limit	6.90 mm (0.2717 in.)
Valve Recession	
Standard	0.30 - 0.50 mm (0.012 - 0.020 in.)
Wear Limit	1.00 mm (0.039 in.)
Valve Guides	
Valve Guide I.D.	
Maximum Clearance	0.20 mm (0.008 in.)
Standard	7.00 - 7.02 mm (0.275 - 0.276 in.)
Wear Limit	7.08 mm (0.279 in.)

Specifications

Valve Guides, continued

Valve Guide Height 12 mm (0.472 in.)

Valve Springs

Spring Free Length

Standard 42 mm (1.654 in.)

Wear Limit 41.50 mm (1.630 in.)

Maximum Spring Inclination 1.10 mm (0.044 in.)

Exhaust Manifold

Mounting Cap Screw and Nut Torque 26 N•m (226 lb-in.)

Intake Manifold

Mounting Cap Screw Torque 26 N•m (226 lb-in.)

Valve Seat Angles

Valve Seat Surface

Exhaust Valve 45°

Intake Valve 30°

Lower Seat Surface 70°

Upper Seat Surface 15°

Piston-to-Cylinder Head Clearance

3TN75 0.59 - 0.77 mm (0.023 - 0.030 in.)

3TN78, 3TNC78 (3011) 0.63 - 0.77 mm (0.025 - 0.030 in.)

Piston and Connecting Rod Cap Screw Torque 39 N•m (29 lb-ft)

Connecting Rod Bearing I.D.

Clearance 0.16 mm (0.006 in.)

Standard 43 - 43.042 mm (1.693 - 1.695 in.)

Wear Limit 43.07 mm (1.696 in.)

Piston Ring Groove Clearance

First Compression Ring

Standard 0.070 - 0.105 mm (0.0028 - 0.0041 in.)

Wear Limit 0.25 mm (0.0098 in.)

Second Compression Ring

Standard 0.035 - 0.070 mm (0.0014 - 0.0028 in.)

Wear Limit 0.25 mm (0.0098 in.)

Oil Ring

Standard 0.030 - 0.060 mm (0.0012 - 0.0024 in.)

Wear Limit 0.20 mm (0.0079 in.)

Piston Ring End Gap

3TN75

Compression Rings and Oil Ring

Standard 0.20 - 0.40 mm (0.008 - 0.016 in.)

Wear Limit 1.50 mm (0.0591 in.)

3TN78, 3TNC78 (3011)

Standard

Compression Rings 0.25 - 0.40 mm (0.0010 - 0.016 in.)

Oil Ring 0.20 - 0.40 mm (0.008 - 0.016 in.)

Wear Limit 1.50 mm (0.0591 in.)

Piston Pin

Pin O.D.

Standard 22.991 - 23.00 mm (0.905 - 0.906 in.)

Wear Limit 22.90 mm (0.902 in.)

Bore I.D.

Clearance 0.045 mm (0.0018 in.)

Standard 23.00 - 23.009 mm (0.9055 - 0.9059 in.)

Wear Limit 23.02 mm (0.906 in.)

2

Piston Pin, continued

Bushing I.D.

Clearance	0.110 mm (0.0043 in.)
Standard	23.025 - 23.038 mm (0.9065 - 0.9070 in.)
Wear Limit	23.10 mm (0.909 in.)

Piston O.D.

3TN75

Distance A.	12.5 mm (0.492 in.)
Standard Piston Size	
Standard	74.91 - 74.94 mm (2.949 - 2.951 in.)
Wear Limit	74.81 mm (2.945 in.)

0.25 mm (0.10 in.) Oversize Piston

Standard	75.17 - 75.18 mm (2.959 - 2.960 in.)
Wear Limit	75.06 mm (2.955 in.)

0.50 mm (0.020 in.) Oversize Piston (F1145 FM Only)

Standard	75.42 - 75.43 mm (2.969 - 2.970 in.)
Wear Limit	75.31 mm (2.965 in.)

3TN78, 3TNC78 (3011)

Distance A.	.23 mm (0.905 in.)
Standard Size Piston	
Standard	77.895 - 77.925 mm (3.067 - 3.068 in.)
Wear Limit	77.81 mm (3.063 in.)

0.25 mm (0.010 in.) Oversize Piston

Standard	78.15 - 78.18 mm (3.076 - 3.077 in.)
Wear Limit	78.05 mm (3.053 in.)

0.50 mm (0.020 in.) Oversize Piston (3011 OEM Only)

Standard	78.40 - 78.42 mm (3.086 - 3.087 in.)
Wear Limit	78.30 mm (3.083 in.)

Cylinder Bore I.D.

3TN75

Standard Size Bore

Clearance	0.22 mm (0.009 in.)
Standard	75.00 - 75.03 mm (2.953 - 2.954 in.)
Wear Limit	75.20 mm (2.961 in.)

0.25 mm (0.010 in.) Oversize Bore

Standard	75.25 - 75.28 mm (2.963 - 2.964 in.)
Wear Limit	75.45 mm (2.970 in.)

0.50 mm (0.020 in.) Oversize Bore (F1145 FM Only)

Standard	75.50 - 75.53 mm (2.972 - 2.974 in.)
Wear Limit	75.70 mm (2.980 in.)

3TN78, 3TNC78 (3011)

Standard Size Bore

Clearance	0.22 mm (0.009 in.)
Standard	78.00 - 78.03 mm (3.071 - 3.072 in.)
Wear Limit	78.20 mm (3.079 in.)

0.25 mm (0.010 in.) Oversize Bore

Standard	78.25 - 78.28 mm (3.081 - 3.082 in.)
Wear Limit	78.45 mm (3.089 in.)

0.50 mm (0.020 in.) Oversize Bore (3011 OEM Only)

Standard	78.50 - 78.53 mm (3.091 - 3.092 in.)
Wear Limit	78.70 mm (3.099 in.)

Deglazing 30 - 40° cross-hatch pattern

Reboring 30 - 40° cross-hatch pattern

Specifications

Crankcase Extension Housing

Mounting Cap Screw Torque

Flywheel Housing/Plate-to-Extension	49 N•m (36 lb-ft)
Seal Case-to-Extension	26 N•m (226 lb-in.)
Extension-to-Block	27 N•m (20 lb-ft)
Extension-to-Timing Gear Cover	22 N•m (195 lb-in.)

Crankshaft Rear Oil Seal

Seal Case-to-Block Cap Screw Torque	26 N•m (226 lb-in.)
Seal Case-to-Extension Cap Screw Torque	21 N•m (180 lb-in.)

Crankshaft and Main Bearings

Main Bearing Cap Screw Torque	79 N•m (58 lb-ft)
Crankshaft Maximum Bend	0.02 mm (0.0007 in.)
Connecting Rod Journal O.D.	

Standard	42.952 - 42.962 mm (1.6910 - 1.6914 in.)
Wear Limit	42.91 mm (1.689 in.)

Main Bearing Journal O.D.

Standard	46.952 - 46.962 mm (1.8485 - 1.8489 in.)
Wear Limit	46.91 mm (1.847 in.)

Main Bearing I.D.

Clearance	0.15 mm (0.0059 in.)
Standard	47.00 - 47.045 mm (1.850 - 1.852 in.)
Wear Limit	47.10 mm (1.8541 in.)

Flywheel

Maximum Distortion	0.02 mm (0.0008 in.)
Mounting Cap Screw Torque	83 N•m (61 lb-ft)
3TN75 (F1145 FM) Pulley-to-Isolator Mount Plate Cap Screw Torque	49 N•m (36 lb-ft)

Flywheel Housing/Plate Mounting Cap Screw Torque	49 N•m (36 lb-ft)
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Camshaft

Mounting Cap Screw Torque	26 N•m (226 lb-in.)
---------------------------------	---------------------

Camshaft Side Gap

Standard	0.05 - 0.20 mm (0.0020 - 0.0079 in.)
Wear Limit	0.40 mm (0.016 in.)

Maximum Camshaft Bend	0.02 mm (0.001 in.)
-----------------------------	---------------------

Lobe Height

Standard	38.635 - 38.765 mm (1.521 - 1.526 in.)
Wear Limit	38.40 mm (1.512 in.)

Journal O.D.

Gear Housing and Flywheel Ends

Standard	44.92 - 44.95 mm (1.769 - 1.770 in.)
Wear Limit	44.80 mm (1.764 in.)

Intermediate

Standard	44.91 - 44.94 mm (1.768 - 1.769 in.)
Wear Limit	44.80 mm (1.764 in.)

Bushing I.D.

Clearance	0.20 mm (0.0078 in.)
Standard	44.990 - 45.055 mm (1.771 - 1.744 in.)
Wear Limit	45.10 mm (1.776 in.)

Bore I.D.

Clearance	0.20 mm (0.008 in.)
Standard	45.00 - 45.025 mm (1.772 - 1.773 in.)
Wear Limit	45.10 mm (1.776 in.)

Cam Followers	
Stem O.D.	
Standard	11.975 - 11.990 mm (0.471 - 0.472 in.)
Wear Limit	11.93 mm (0.470 in.)
Bore I.D.	
Clearance	0.10 mm (0.004 in.)
Standard	12.000 - 12.018 mm (0.472 - 0.473 in.)
Wear Limit	12.05 mm (0.474 in.)
Timing Gear Cover	
Fan Mounting Cap Screw Torque	11 N•m (226 lb-in.)
Cover Mounting Cap Screw Torque	26 N•m (226 lb-in.)
Crankcase Extension Housing-to-Cover Cap Screw Torque	22 N•m (195 lb-in.)
Crankshaft Pulley Cap Screw Torque	115 N•m (85 lb-ft)
Idler Gear	
Shaft O.D.	
Standard	45.950 - 45.975 mm (1.809 - 1.810 in.)
Wear Limit	45.93 mm (1.808 in.)
Bushing I.D.	
Clearance	0.15 mm (0.0059 in.)
Standard	46.00 - 46.025 mm (1.811 - 1.812 in.)
Wear Limit	46.03 mm (1.812 in.)
Timing Gear Cover Mounting Plate Cap Screw Torque	25 N•m (220 lb-in.)
Oil Pan and Strainer Mounting Cap Screw Torque	26 N•m (226 lb-in.)
Oil Pump	
Mounting Cap Screw Torque	25 N•m (18 lb-ft)
Rotor Shaft O.D.-to-Backing Plate I.D. Clearance	
Standard	0.015 - 0.048 mm (0.0006 - 0.0035 in.)
Wear Limit	0.20 mm (0.0078 in.)
Rotor Recess	
Standard	0.05 - 0.10 mm (0.0020 - 0.0039 in.)
Wear Limit	0.15 mm (0.0059 in.)
Outer Rotor-to-Pump Body Clearance	
Standard	0.09 - 0.16 mm (0.0035 - 0.0063 in.)
Wear Limit	0.25 mm (0.0098 in.)
Inner-to-Outer Rotor Clearance	
Standard	0.02 - 0.04 mm (0.0008 - 0.0016 in.)
Wear Limit	0.15 mm (0.0059 in.)
Oil Pressure Regulating Valve	
Spring	
Compressed Length	27.50 mm (1.080 in.) @ 20.5 N (4.6 lb-force)
Free Length	46 mm (1.810 in.)
Housing-to-Valve Body Retaining Nut Torque	30 N•m (22 lb-ft)
Housing-to-Engine Block Cap Screw Torque	27 N•m (20 lb-ft)
Thermostat and Housing - 3TN78	
Thermostat Cover Cap Screw Torque	20 N•m (180 lb-in.)
Plate-to-Housing Cap Screw Torque	9 N•m (78 lb-in.)
Housing Mounting Cap Screw Torque	26 N•m (226 lb-in.)
Thermostat - 3TN75, 3TNC78 (3011)	
Cover Cap Screw Torque	20 N•m (180 lb-in.) 70
Water Pump - 3TN78	
Fan Mounting Cap Screw Torque	11 N•m (96 lb-in.)
Mounting Cap Screw Torque	26 N•m (226 lb-in.)
Plate-to-Housing Screw Torque	15 N•m (134 lb-in.)
Plug-to-Housing Torque	15 N•m (130 lb-in.)

Specifications

Water Pump - 3TN78, continued

Bottom of Pulley Flange-to-Top of Housing	17 mm (0.670 in.)
Top of Impeller-to-Housing	2 mm (0.080 in.) below housing

Water Pump - 3TN75, 3TNC78 (3011)

Adapter-to-Plate Cap Screw Torque	9 N•m (78 lb-in.)
Fan Mounting Cap Screw Torque	11 N•m (96 lb-in.)
Mounting Cap Screw Torque	26 N•m (226 lb-in.)
Plate-to-Housing Cap Screw Torque	9 N•m (78 lb-in.)
Plug-to-Housing Torque	15 N•m (130 lb-in.)
Bottom of Pulley Flange-to-Top of Housing	17 mm (0.670 in.)
Top of Impeller-to-Housing	2 mm (0.080 in.) below housing

Fuel Supply Pump - 3TN75, 3TNC78 (3011)

External Lube Line Mounting Bolt Torque	15 N•m (130 lb-in.)
Mounting Nut Torque	11 N•m (96 lb-in.)

2

Fuel Injection Pump

Injection Pump Gear Nut Torque	90 N•m (66 lb-ft)
Mounting Nut Torque	26 N•m (19 lb-ft)
Lube Line-to-Block Bolt Torque	25 N•m (217 lb-in.)

Fuel Injection Nozzles

Mounting Nut Torque	5 N•m (39 lb-in.)
Retaining Nut Torque	43 N•m (31 lb-ft)
Separator Plate Nozzle Contact Surface Maximum Wear	0.10 mm (0.0039 in.)

Starter - 3TN78 (Hitachi 0.8 kW)

Minimum Brush Length	9 mm (0.354 in.)
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Starter Motor - 3TN75, 3TNC78 (3011) (Nippondenso 1.0 kW)

Minimum Brush Length	8.5 mm (0.335 in.)
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Alternator - 3TN78 (Hitachi 25A)

Attaching Screw Torque	4 N•m (31 lb-in.)
Rotor Assembly	
Retainer-to-Front Frame Screw Torque	2 N•m (16 lb-in.)
Sheave Nut Torque	49 N•m (36 lb-ft)
End Frame-to-Rectifier Nut Torque	4 N•m (31 lb-in.)
Stator-to-Rectifier Lead Wire Distance	33.50 mm (1.300 in.)
Minimum Brush Length	5.50 mm (0.220 in.)

Alternator - 3TN75 (Nippondenso 35A)

Attaching Screw Torque	4 N•m (31 lb-in.)
Rotor Assembly	
Retainer-to-Front Frame Screw Torque	2 N•m (16 lb-in.)
Pulley Nut Torque	54 N•m (40 lb-ft)
Stator-to-Rectifier Lead Wire Distance	33.50 mm (1.300 in.)
Minimum Brush Length	5.50 mm (0.220 in.)

Alternator - 3TN75, 3TNC78 (3011) (Nippondenso 40A)

Sheave Nut Torque	69 N•m (51 lb-ft)
Retainer-to-Front Frame Screw Torque	2 N•m (16 lb-in.)
Minimum Rotor Slip Ring O.D.	14 mm (0.550 in.)
Brush Length	
New	10.50 mm (0.410 in.)
Wear Limit	4.50 mm (0.170 in.)

Checks, Tests and Adjustments

Valve Clearance	0.20 mm (0.008 in.)
Connecting Rod Side Play	
Standard Clearance	0.20 - 0.40 mm (0.0079 - 0.0157 in.)
Wear Limit	0.55 mm (0.0217 in.)

Checks, Tests and Adjustments, continued

Connecting Rod Bearing Clearance	
Standard Clearance	0.038 - 0.090 mm (0.0015 - 0.0035 in.)
Wear Limit	0.16 mm (0.0063 in.)
Crankshaft End Play	
Standard Clearance	0.090 - 0.271 mm (0.004 - 0.011 in.)
Wear Limit	0.33 mm (0.0129 in.)
Crankshaft Main Bearing Clearance	
Main Bearing Cap Cap Screw Torque	79 N•m (58 lb-ft)
Standard Clearance	0.038 - 0.090 mm (0.0015 - 0.0035 in.)
Wear Limit	0.06 mm (0.0063 in.)
Valve Lift (Intake and Exhaust)	8.8 mm (0.350 in.)
Camshaft End Play	
Standard Clearance	0.05 - 0.20 mm (0.0020 - 0.0079 in.)
Wear Limit	0.40 mm (0.016 in.)
Timing Gear Backlash	
Standard Backlash	
All Except Crankshaft Gear-to-Oil Pump Gear	0.04 - 0.12 mm (0.0016 - 0.0047 in.)
Crankshaft Gear-to-Oil Pump Gear	0.11 - 0.19 mm (0.0043 - 0.0075 in.)
Wear Limit	0.20 mm (0.0079 in.)
Fuel Injection Nozzle	
Opening Pressure	19600 ± 480 kPa (2843 ± 70 psi)
Leakage at 17640 kPa (2558 psi)	Minimum of 5 Seconds
Chatter and Spray Pattern at 19600 ± 480 kPa (2843 ± 70 psi)	
Slow Hand Lever Movement	Chatter Sound
Slow Hand Lever Movement	Fine Stream Spray Pattern
Fast Hand Lever Movement	Fine Atomized Spray Pattern
Thermostat	
Begin Opening	71° C (160°F)
Fully Open	85° C (184° F)
Minimum Lift Height	8 mm (0.310 in.)
Coolant Temperature Switch Continuity	107 - 113° C (225 - 235° F)
Starter No-Load Amp Draw/RPM	
Maximum Starter Amperage	
Hitachi 2.0 kW	110 Amps at 4500 rpm
Nippondenso 1.0 kW	90 Amps at 3000 rpm
Minimum Starter RPM	
Hitachi 2.0 kW	4500
Nippondenso 1.0 kW	3000
Fuel Injection Pump Static Timing	
Injection Pump Timing	16° ± 1° BTDC (Before Top Dead Center)
Engine Crankshaft Position	No. 1 Cylinder on TDC Compression Stroke
Fan/Alternator Drive Belt Tension	
Applied Force	98 N (22 lb-force)
Deflection	10 - 15 mm (0.400 - 0.600 in.)
Operational Tests	
Radiator, Bubble Test	
Maximum Air Pressure Into Cylinder	
3TN75, 3TN78	2448 kPa (355 psi)
3TNC78 (3011)	2158 kPa (313 psi)
Cooling System	
3TN75	
Maximum Pressure	117 kPa (17 psi)
Minimum Pressure after 15 Seconds	90 kPa (13 psi)

Specifications

Operational Tests - Cooling System, continued

3TN78, 3TNC78 (3011)

Maximum Pressure 97 kPa (14 psi)

Minimum Pressure after 15 Seconds 88 kPa (12.8 psi)

Radiator Cap

Valve Opening Pressure

3TN75 90 kPa (13 psi)

3TN78, 3TNC78 (3011) 88 kPa (12.8 psi)

Cylinder, Compression Pressure

Compression Pressure

3TN75, 3TN78 2448 kPa (355 psi)

3TNC78 (3011) 2158 kPa (313 psi)

Maximum Difference Between Cylinders 490 kPa (71 psi)

Engine Oil Pressure

3TN75

F1145 FM

Slow Idle 1450 ± 50 rpm

Fast Idle 3425 rpm

Oil Pressure 294 - 440 kPa (43 - 64 psi)

855/56 CUT

Fast Idle 3425 ± 25 rpm

Oil Pressure 365 ± 69 kPa (53 ± 10 psi)

3TN78

Idle Speed

Slow 800 ± 25 rpm

Fast 2450 ± 25 rpm

Oil Pressure

Slow Idle 262 kPa (38 psi)

Fast Idle 345 ± 48 kPa (50 ± 7 psi)

3TNC78 (3011)

Low Idle Speed

Industrial 1300 rpm

Generator 1200 rpm

Oil Pressure 147 kPa (21 psi)

Air Intake System Holding Pressure 34 - 69 kPa (5 - 10 psi)

Minimum Fuel Supply Pump Pressure 29 kPa (4.3 psi)

Fuel System Holding Pressure (Maximum) 103 kPa (15 psi)

ENGINE SPECIFICATIONS - 3TN82, 3TNA82, 3TN84 (3014)

Rocker Arm Cover

Special Nut Torque 18 N•m (160 lb-in.)

Rocker Arm Assembly

Mounting Cap Screw Torque 26 N•m (226 lb-in.)

Rocker Arm Shaft O.D.

Standard 15.97 - 15.98 mm (0.6286 - 0.6293 in.)

Wear Limit 15.95 mm (0.6280 in.)

Rocker Arm and Shaft Support I.D.'s

Clearance 0.13 mm (0.005 in.)

Standard 16.00 - 16.02 mm (0.630 - 0.631 in.)

Wear Limit 16.09 mm (0.633 in.)

Push Rod Length

Standard 178.25 - 178.75 mm (7.018 - 7.037 in.)

Push Rod Bend

Standard 0.03 mm (0.001 in.) or less

Wear Limit 0.30 mm (0.012 in.)

2

Cylinder Head and Valves

Mounting Cap Screw Torque

First	24 N•m (212 lb-in.)
Second	48 N•m (36 lb-ft)
Final	78 N•m (58 lb-ft)

Cylinder Head Distortion

Standard	0.05 mm (0.002 in.) or less
Wear Limit	0.15 mm (0.006 in.)
Maximum Amount of Metal to be Removed	0.20 mm (0.008 in.)

Valve Seat Width

Intake Valve

Standard	1.07 - 1.24 mm (0.042 - 0.049 in.)
Wear Limit	1.74 mm (0.069 in.)

Exhaust Valve

Standard	1.24 - 1.45 mm (0.049 - 0.057 in.)
Wear Limit	1.94 mm (0.076 in.)

Intake and Exhaust Valves

Valve Faces

Minimum Margin	0.51 mm (0.020 in.)
Exhaust Angle	45°
Intake Angle	30°

Valve Stem O.D.

Distance A. . . . .	.30 mm (1.181 in.)
Distance B. . . . .	.60 mm (2.360 in.)

Intake and Exhaust Valves

Standard	7.96 - 7.98 mm (0.3134 - 0.3142 in.)
Wear Limit	7.90 mm (0.3110 in.)

Valve Recession

Standard	0.30 - 0.50 mm (0.012 - 0.020 in.)
Wear Limit	1.00 mm (0.039 in.)

Valve Guides

Valve Guide I.D.

Maximum Clearance	0.20 mm (0.008 in.)
Standard	8.01 - 8.03 (0.315 - 0.316 in.)
Wear Limit	8.10 mm (0.319 in.)

Valve Guide Height

.15 mm (0.591 in.)
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Valve Springs

Spring Free Length

Standard40 mm (1.575 in.)
Wear Limit	39.50 mm (1.550 in.)

Maximum Spring Inclination

.	1.10 mm (0.044 in.)
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Exhaust Manifold

Mounting Cap Screw and Nut Torque

.	26 N•m (226 lb-in.)
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Intake Manifold

Mounting Cap Screw Torque

.	26 N•m (226 lb-in.)
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Valve Seat Angles

Valve Seat Surface

Exhaust Valve	45°
Intake Valve	30°

Lower Seat Surface

.	70°
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Upper Seat Surface

.	15°
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Piston-to-Cylinder Head Clearance

.	0.64 - 0.82 mm (0.025 - 0.032 in.)
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Piston and Connecting Rod Cap Screw Torque

.	47 N•m (35 lb-ft)
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Specifications

Connecting Rod Bearing I.D.

Clearance	0.16 mm (0.006 in.)
Standard	48 - 48.042 mm (1.888 - 1.891 in.)
Wear Limit	48.07 mm (1.893 in.)

Piston Ring Groove Clearance

First Compression Ring

Standard	0.075 - 0.110 mm (0.0030 - 0.0043 in.)
Wear Limit	0.25 mm (0.0098 in.)

Second Compression Ring

Standard	0.45 - 0.080 mm (0.0018 - 0.0031 in.)
Wear Limit	0.25 mm (0.0098 in.)

Oil Ring

Standard	0.025 - 0.060 mm (0.0010 - 0.0024 in.)
Wear Limit	0.20 mm (0.0079 in.)

2 Piston Ring End Gap

3TN82, 3TNA82

Standard

First Compression Ring	0.25 - 0.40 mm (0.010 - 0.016 in.)
Oil Ring	0.20 - 0.40 mm (0.008 - 0.016 in.)
Second Compression Ring	0.20 - 0.35 mm (0.008 - 0.014 in.)

Wear Limit	1.50 mm (0.0591 in.)
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3TN84 (3014)

Standard

Compression Rings	0.20 - 0.40 mm (0.008 - 0.016 in.)
Oil Ring	0.25 - 0.45 mm (0.010 - 0.018 in.)

Wear Limit	1.50 mm (0.0591 in.)
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Piston Pin

Pin O.D.

Standard	25.987 - 26.00 mm (1.023 - 1.024 in.)
Wear Limit	25.90 mm (1.020 in.)

Bore I.D.

Clearance	0.045 mm (0.0018 in.)
Standard	26.00 - 26.009 mm (1.0236 - 1.0240 in.)
Wear Limit	26.02 mm (1.024 in.)

Bushing I.D.

Clearance	0.110 mm (0.0043 in.)
Standard	26.025 - 26.038 mm (1.0246 - 1.0251 in.)
Wear Limit	26.10 mm (1.028 in.)

Piston O.D.

3TN82, 3TNA82

Distance A.	24 mm (0.945 in.)
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Standard Size Piston

Standard	81.90 - 81.93 mm (3.224 - 3.225 in.)
Wear Limit	81.80 mm (3.221 in.)

0.25 mm (0.010 in.) Oversize Piston

Standard	82.15 - 82.17 mm (3.234 - 3.235 in.)
Wear Limit	82.05 mm (3.230 in.)

0.50 mm (0.020 in.) Oversize Piston (575 SSL Only)

Standard	82.40 - 82.42 mm (3.244 - 3.245 in.)
Wear Limit	82.30 mm (3.240 in.)

Piston O.D., continued

3TN84 (3014)

Distance A. . . . .	.24 mm (0.945 in.)
Standard Size Piston	
Standard	83.90 - 83.93 mm (3.303 - 3.304 in.)
Wear Limit	83.80 mm (3.299 in.)
0.25 mm (0.10 in.) Oversize Piston	
Standard	84.15 - 84.17 mm (3.313 - 3.314 in.)
Wear Limit	84.05 mm (3.309 in.)
0.50 mm (0.020 in.) Oversize Piston (3014 OEM Only)	
Standard	84.40 - 84.42 mm (3.323 - 3.324 in.)
Wear Limit	84.30 mm (3.319 in.)

Cylinder Bore I.D.

3TN82, 3TNA82

Standard Size Bore	
Clearance	0.35 mm (0.014 in.)
Standard	82.00 - 82.03 mm (3.228 - 3.230 in.)
Wear Limit	82.20 mm (3.236 in.)
0.25 mm (0.010 in.) Oversize Bore	
Standard	82.25 - 82.28 mm (3.238 - 3.239 in.)
Wear Limit	82.45 mm (3.246 in.)
0.50 mm (0.020 in.) Oversize Bore (575 SSL Only)	
Standard	82.50 - 82.53 mm (3.248 - 3.249 in.)
Wear Limit	82.70 mm (3.256 in.)

3TN84 (3014)

Standard Size Bore	
Clearance	0.35 mm (0.014 in.)
Standard	84.00 - 84.03 mm (3.307 - 3.308 in.)
Wear Limit	84.20 mm (3.315 in.)
0.25 mm (0.010 in.) Oversize Bore	
Standard	84.25 - 84.28 mm (3.317 - 3.318 in.)
Wear Limit	84.45 mm (3.325 in.)
0.50 mm (0.020 in.) Oversize Bore (3014 OEM Only)	
Standard	84.50 - 84.53 mm (3.327 - 3.328 in.)
Wear Limit	84.70 mm (3.335 in.)

Deglazing	30 - 40° cross-hatch pattern
Reboring	30 - 40° cross-hatch pattern

Crankcase Extension Housing

Mounting Cap Screw Torque

Flywheel Housing/Plate-to-Extension	49 N•m (36 lb-ft)
Seal Case-to-Extension	26 N•m (226 lb-in.)
Extension-to-Block	27 N•m (20 lb-ft)
Extension-to-Timing Gear Cover	22 N•m (195 lb-in.)

Crankshaft Rear Oil Seal

Seal Case-to-Block Cap Screw Torque	26 N•m (226 lb-in.)
Seal Case-to-Extension Cap Screw Torque	21 N•m (180 lb-in.)

Crankshaft and Main Bearings

Main Bearing Cap Screw Torque	98 N•m (72 lb-ft)
Crankshaft Maximum Bend	0.02 mm (0.0007 in.)
Connecting Rod Journal O.D.	
Standard	47.952 - 47.962 mm (1.8879 - 1.8883 in.)
Wear Limit	47.91 mm (1.886 in.)

Specifications

Crankshaft and Main Bearings, continued

Main Bearing Journal O.D.

Standard 46.952 - 46.962 mm (1.9666 - 1.9670 in.)

Wear Limit 49.90 mm (1.965 in.)

Main Bearing I.D.

Clearance 0.15 mm (0.0059 in.)

Standard 50.00 - 50.045 mm (1.969 - 1.970 in.)

Wear Limit 50.10 mm (1.972 in.)

Flywheel

Maximum Distortion 0.02 mm (0.0008 in.)

Mounting Cap Screw Torque 83 N•m (61 lb-ft)

Flywheel Housing/Plate Mounting Cap Screw Torque 49 N•m (36 lb-ft)

Camshaft

Mounting Cap Screw Torque 26 N•m (226 lb-in.)

Camshaft Side Gap

Standard 0.05 - 0.20 mm (0.0020 - 0.0079 in.)

Wear Limit 0.40 mm (0.016 in.)

Maximum Camshaft Bend 0.02 mm (0.001 in.)

Lobe Height

Standard 38.635 - 38.765 mm (1.521 - 1.526 in.)

Wear Limit 38.40 mm (1.512 in.)

Journal O.D.

Gear Housing and Flywheel Ends

Standard 44.92 - 44.95 mm (1.769 - 1.770 in.)

Wear Limit 44.80 mm (1.764 in.)

Intermediate

Standard 44.91 - 44.94 mm (1.768 - 1.769 in.)

Wear Limit 44.80 mm (1.764 in.)

Bushing I.D.

Clearance 0.20 mm (0.0078 in.)

Standard 44.990 - 45.055 mm (1.771 - 1.744 in.)

Wear Limit 45.10 mm (1.776 in.)

Bore I.D.

Clearance 0.20 mm (0.008 in.)

Standard 45.00 - 45.025 mm (1.772 - 1.773 in.)

Wear Limit 45.10 mm (1.776 in.)

Cam Followers

Stem O.D.

Standard 11.975 - 11.990 mm (0.471 - 0.472 in.)

Wear Limit 11.93 mm (0.470 in.)

Bore I.D.

Clearance 0.10 mm (0.004 in.)

Standard 12.000 - 12.018 mm (0.472 - 0.473 in.)

Wear Limit 12.05 mm (0.474 in.)

Timing Gear Cover

Cover Mounting Cap Screw Torque 26 N•m (226 lb-in.)

Crankcase Extension Housing-to-Cover Cap Screw Torque 22 N•m (195 lb-in.)

Crankshaft Pulley Cap Screw Torque 115 N•m (85 lb-ft)

Fan Mounting Cap Screw Torque 11 N•m (226 lb-in.)

Oil Pan-to-Cover Cap Screw Torque 22 N•m (195 lb-in.)

Idler Gear

Shaft O.D

Standard 45.950 - 45.975 mm (1.809 - 1.810 in.)

Wear Limit 45.93 mm (1.808 in.)

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Idler Gear, continued	
Bushing I.D.	
Clearance	0.15 mm (0.0059 in.)
Standard	46.00 - 46.025 mm (1.811 - 1.812 in.)
Wear Limit	46.03 mm (1.812 in.)
Timing Gear Cover Mounting Plate Cap Screw Torque	25 N•m (220 lb-in.)
Oil Pan and Strainer Mounting Cap Screw Torque	26 N•m (226 lb-in.)
Oil Pump	
Mounting Cap Screw Torque	25 N•m (18 lb-ft)
Rotor Shaft O.D.-to-Backing Plate I.D. Clearance	
Standard	0.015 - 0.048 mm (0.0006 - 0.0035 in.)
Wear Limit	0.20 mm (0.0078 in.)
Rotor Recess	
Standard	0.03 - 0.09 mm (0.0011 - 0.0035 in.)
Wear Limit	0.15 mm (0.0059 in.)
Outer Rotor-to-Pump Body Clearance	
Standard	0.10 - 0.17 mm (0.0039 - 0.0067 in.)
Wear Limit	0.25 mm (0.0098 in.)
Inner-to-Outer Rotor Clearance	
Standard	0.05 - 0.105 mm (0.0019 - 0.0041 in.)
Wear Limit	0.15 mm (0.0059 in.)
Oil Cooler - 3TN84 (955 CUT)	
Oil Cooler-to-Valve Body Retaining Nut Torque	30 N•m (22 lb-ft)
Oil Pressure Regulating Valve	
Spring	
Compressed Length	27.50 mm (1.080 in.) @ 20.5 N (4.6 lb-force)
Free Length	46 mm (1.810 in.)
Housing-to-Valve Body Retaining Nut Torque	30 N•m (22 lb-ft)
Housing-to-Engine Block Cap Screw Torque	27 N•m (20 lb-ft)
Thermostat and Housing - 3TN82 (30 EX), 3TN84 (955 CUT, 3014 OEM)	
Thermostat Cover Cap Screw Torque	20 N•m (180 lb-in.)
Plate-to-Housing Cap Screw Torque	9 N•m (78 lb-in.)
Housing Mounting Cap Screw Torque	26 N•m (226 lb-in.)
Thermostat - 3TN82 (575 SSL), 3TNA82, 3TN84 (870 CUT)	
Cover Cap Screw Torque	20 N•m (180 lb-in.)
Water Pump - 3TN82 (30 EX), 3TN84 (955 CUT, 3014 OEM)	
Fan Mounting Cap Screw	11 N•m (96 lb-in.)
Mounting Cap Screw Torque	26 N•m (226 lb-in.)
Plate-to-Housing Screw Torque	15 N•m (134 lb-in.)
Plug-to-Housing Torque	15 N•m (130 lb-in.)
3TN82 (30 EX)	
Top of Pulley Flange-to-Top of Housing	27 mm (1.060 in.)
Top of Impeller-to-Housing	1 mm (0.040 in.) below housing
3TN84 (955 CUT, 3014 OEM)	
Bottom of Pulley Flange-to-Top of Housing	17 mm (0.670 in.)
Top of Impeller-to-Housing	2 mm (0.080 in.) below housing
Water Pump - 3TN82 (575 SSL), 3TNA82, 3TN84 (870 CUT)	
Mounting Cap Screw Torque	26 N•m (226 lb-in.)
Fan Mounting Cap Screw Torque	11 N•m (96 lb-in.)
Plate-to-Housing Cap Screw Torque	9 N•m (78 lb-in.)
Adapter-to-Plate Cap Screw Torque	9 N•m (78 lb-in.)
Bottom of Pulley Flange-to-Top of Housing	17 mm (0.670 in.)
Impeller-to-Pump Housing	2 mm (0.080 in.) below housing

Specifications

Fuel Supply Pump - 3TNA82, 3TN84 (3014)

External Lube Line Mounting Bolt Torque	15 N•m (130 lb-in.)
Mounting Nut Torque	11 N•m (96 lb-in.)

Fuel Injection Pump

Injection Pump Gear Nut Torque	90 N•m (66 lb-ft)
Mounting Nut Torque	26 N•m (19 lb-ft)
Lube Line-to-Block Bolt Torque	25 N•m (217 lb-in.)

Fuel Injection Nozzles

Mounting Nut Torque	5 N•m (39 lb-in.)
Retaining Nut Torque	43 N•m (31 lb-ft)
Separator Plate Nozzle Contact Surface Maximum Wear	0.10 mm (0.0039 in.)

Starter Motor - 3TN82 (30 EX) (Hitachi 2.0 kW)

Minimum Brush Length	.9 mm (0.354 in.)
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2 Starter Motor - 3TNA82, 3TN84 (3014) (Nippondenso 1.0 and 1.2 kW)

Minimum Brush Length	8.5 mm (0.335 in.)
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Starter Motor - 3TN82 (575 SSL) (Nippondenso 1.4 kW)

Minimum Brush Length	8.5 mm (0.335 in.)
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Alternator -3TNA82, 3TN84 (870 CUT) (Kokosan 20A)

Flywheel Assembly-to-Coil Plate Assembly Nut Torque	27 N•m (20 lb-ft)
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Alternator - 3TN82 (30 EX) (Hitachi 25A)

Attaching Screw Torque	4 N•m (31 lb-in.)
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Rotor Assembly

Retainer-to-Front Frame Screw Torque	2 N•m (16 lb-in.)
Sheave Nut Torque	49 N•m (36 lb-ft)

End Frame-to-Rectifier Nut Torque	4 N•m (31 lb-in.)
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Stator-to-Rectifier Lead Wire Distance	33.50 mm (1.300 in.)
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Minimum Brush Length	5.50 mm (0.220 in.)
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Alternator - 3TN82 (575 SSL), 3TNA82, 3TN84 (870 CUT, 955 CUT) (Nippondenso 35A)

Attaching Screw Torque	4 N•m (31 lb-in.)
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Rotor Assembly

Retainer-to-Front Frame Screw Torque	2 N•m (16 lb-in.)
Pulley Nut Torque	54 N•m (40 lb-ft)

Stator-to-Rectifier Lead Wire Distance	33.50 mm (1.300 in.)
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Minimum Brush Length	5.50 mm (0.220 in.)
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Alternator - 3TN82 (575 SSL), 3TN84 (955 CUT, 3014 OEM) (Nippondenso 40A)

Sheave Nut Torque	69 N•m (51 lb-ft)
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Retainer-to-Front Frame Screw Torque	2 N•m (16 lb-in.)
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Minimum Rotor Slip Ring O.D.	14 mm (0.550 in.)
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Brush Length

New	10.50 mm (0.410 in.)
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Wear Limit	4.50 mm (0.170 in.)
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Checks, Tests and Adjustments

Valve Clearance	0.20 mm (0.008 in.)
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Connecting Rod Side Play

Standard Clearance	0.20 - 0.40 mm (0.0079 - 0.0157 in.)
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Wear Limit	0.55 mm (0.0217 in.)
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Connecting Rod Bearing Clearance

Standard Clearance	0.038 - 0.090 mm (0.0015 - 0.0035 in.)
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Wear Limit	0.16 mm (0.0063 in.)
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Crankshaft End Play

Standard Clearance	0.090 - 0.271 mm (0.004 - 0.011 in.)
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Wear Limit	0.33 mm (0.0129 in.)
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Checks, Tests and Adjustments, continued

Crankshaft Main Bearing Clearance

Main Bearing Cap Screw Torque	98 N•m (72 lb-ft)
Standard Clearance	0.038 - 0.090 mm (0.0015 - 0.0035 in.)
Wear Limit	0.06 mm (0.0063 in.)

Valve Lift (Intake and Exhaust) 8.8 mm (0.350 in.)

Camshaft End Play

Standard Clearance	0.05 - 0.20 mm (0.0020 - 0.0079 in.)
Wear Limit	0.40 mm (0.016 in.)

Timing Gear Backlash

Standard Backlash	0.04 - 0.12 mm (0.0016 - 0.0047 in.)
Wear Limit	0.20 mm (0.0079 in.)

Fuel Injection Nozzle

Opening Pressure	19600 ± 480 kPa (2843 ± 70 psi)
Leakage at 17640 kPa (2558 psi)	Minimum of 5 Seconds
Chatter and Spray Pattern at 19600 ± 480 kPa (2843 ± 70 psi)	
Slow Hand Lever Movement	Chatter Sound
Slow Hand Lever Movement	Fine Stream Spray Pattern
Fast Hand Lever Movement	Fine Atomized Spray Pattern

Thermostat

Begin Opening	71° C (160°F)
Fully Open	85° C (184° F)
Minimum Lift Height	.8 mm (0.310 in.)

Coolant Temperature Switch Continuity 107 - 113° C (225 - 235° F)

Starter No-Load Amp Draw/RPM

Maximum Starter Amperage

Hitachi 2.0 kW	110 Amps at 4500 rpm
Nippondenso 1.0 and 1.2 kW	90 Amps at 3000 rpm
Nippondenso 1.4 kW	90 Amps at 3500 rpm

Minimum Starter RPM

Hitachi 2.0 kW	4500
Nippondenso 1.0 and 1.2 kW	3000
Nippondenso 1.4 kW	3500

Fuel Injection Pump Static Timing Adjustment

Injection Pump Timing

3TN82 (575 SSL)	17 ± 1° BTDC (Before Top Dead Center)
3TN82 (30 EX), 3TNA82, 3TN84 (3014)	16 ± 1° BTDC

Engine Crankshaft Position No. 1 Cylinder on TDC Compression Stroke

Fan/Alternator Drive Belt Tension

Applied Force	98 N (22 lb-force)
Deflection	10 - 15 mm (0.400 - 0.600 in.)

Oil Cooler Leakage - 3TN84 (955 CUT)

Applied Air Pressure 206 - 483 kPa (30 - 70 psi)

Operational Tests

Radiator, Bubble Test

Maximum Air Pressure Into Cylinder

3TN82, 3TNA82, 3TN84 (870 CUT, 955 CUT)	2448 kPa (355 psi)
3TN84 (3014 OEM)	2158 kPa (313 psi)

Cooling System

3TN82, 3TNA82, 3TN84 (870 CUT, 3014 OEM)

Maximum Pressure	97 kPa (14 psi)
Minimum Pressure after 15 Seconds	88 kPa (12.8 psi)

Specifications

Operational Tests - Cooling System, continued

3TN84 (955 CUT)

Maximum Pressure	117 kPa (17 psi)
Minimum Pressure after 15 Seconds	90 kPa (13 psi)

Radiator Cap

Valve Opening Pressure

3TN82, 3TNA82, 3TN84 (870 CUT, 3014 OEM)	88 kPa (12.8 psi)
3TN84 (955 CUT)	90 kPa (13 psi)

Cylinder, Compression Pressure

Compression Pressure

3TN82, 3TNA82, 3TN84 (870 CUT, 955 CUT)	2448 kPa (355 psi)
3TN84 (3014 OEM)	2158 kPa (313 psi)

Maximum Difference Between Cylinders	490 kPa (71 psi)
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Engine Oil Pressure

3TN82 (30 EX)

Idle Speed

Slow	800 ± 25 rpm
Fast	2450 ± 25 rpm

Oil Pressure

Slow Idle	262 kPa (38 psi)
Fast Idle	345 ± 48 kPa (50 ± 7 psi)

3TN82 (575 SSL)

Idle Speed

Slow	1250 ± 25 rpm
Fast	2875 ± 25 rpm

Oil Pressure	294 - 392 kPa (43 - 57 psi)
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3TNA82, 3TN84 (870 CUT)

Fast Idle	2750 - 2800 rpm
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Oil Pressure	365 ± 69 kPa (53 ± 10 psi)
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3TN84 (955 CUT)

Fast Idle	3425 ± 25 rpm
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Oil Pressure	365 ± 69 kPa (53 ± 10 psi)
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3TN84 (3014 OEM)

Low Idle Speed

Industrial	1300 rpm
Generator	1200 rpm

Oil Pressure	147 kPa (21 psi)
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Air Intake System Holding Pressure	34 - 69 kPa (5 - 10 psi)
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Minimum Fuel Supply Pump Pressure	29 kPa (4.3 psi)
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Fuel System Holding Pressure (Maximum)	103 kPa (15 psi)
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2

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).

D-20018WI Valve Guide Knurler

Use to knurl inside diameter of valve guides on 3TN75, 3TN78 and 3TNC78 (3011) engine.

D-20019WI Valve Guide Knurler

Use to knurl inside diameter of valve guides on 3TN82, 3TNA82 and 3TN84 (3014) engines.

JDE118 Valve Guide Driver

Use to remove and install valve guides in cylinder head.

D-20020WI Valve Guide Reamer

Use to ream out new valve guides on 3TN75, 3TN78 and 3TNC78 (3011) engine.

D-20021WI Valve Guide Reamer

Use to ream out new valve guides on 3TN82, 3TNA82 and 3TN84 (3014) engines.

SERVICE PARTS KITS

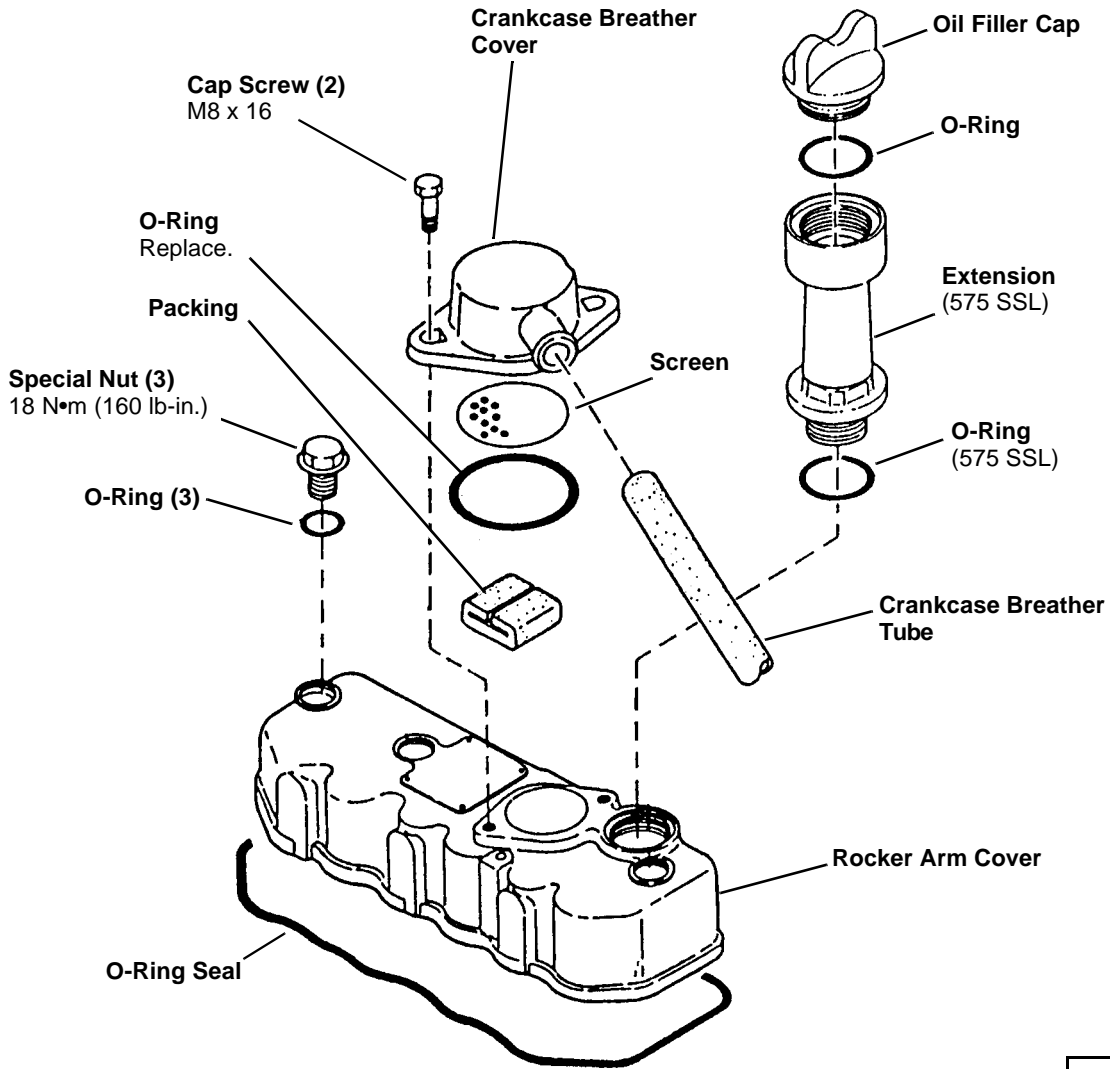
The following kits are available through your parts catalog:

- Cylinder Head Gasket Kits

Cylinder Head, Valves and Manifolds

ROCKER ARM COVER

- Wash packing in a safe solvent and blow dry with air pressure. If packing comes apart or is deteriorated, replace it.



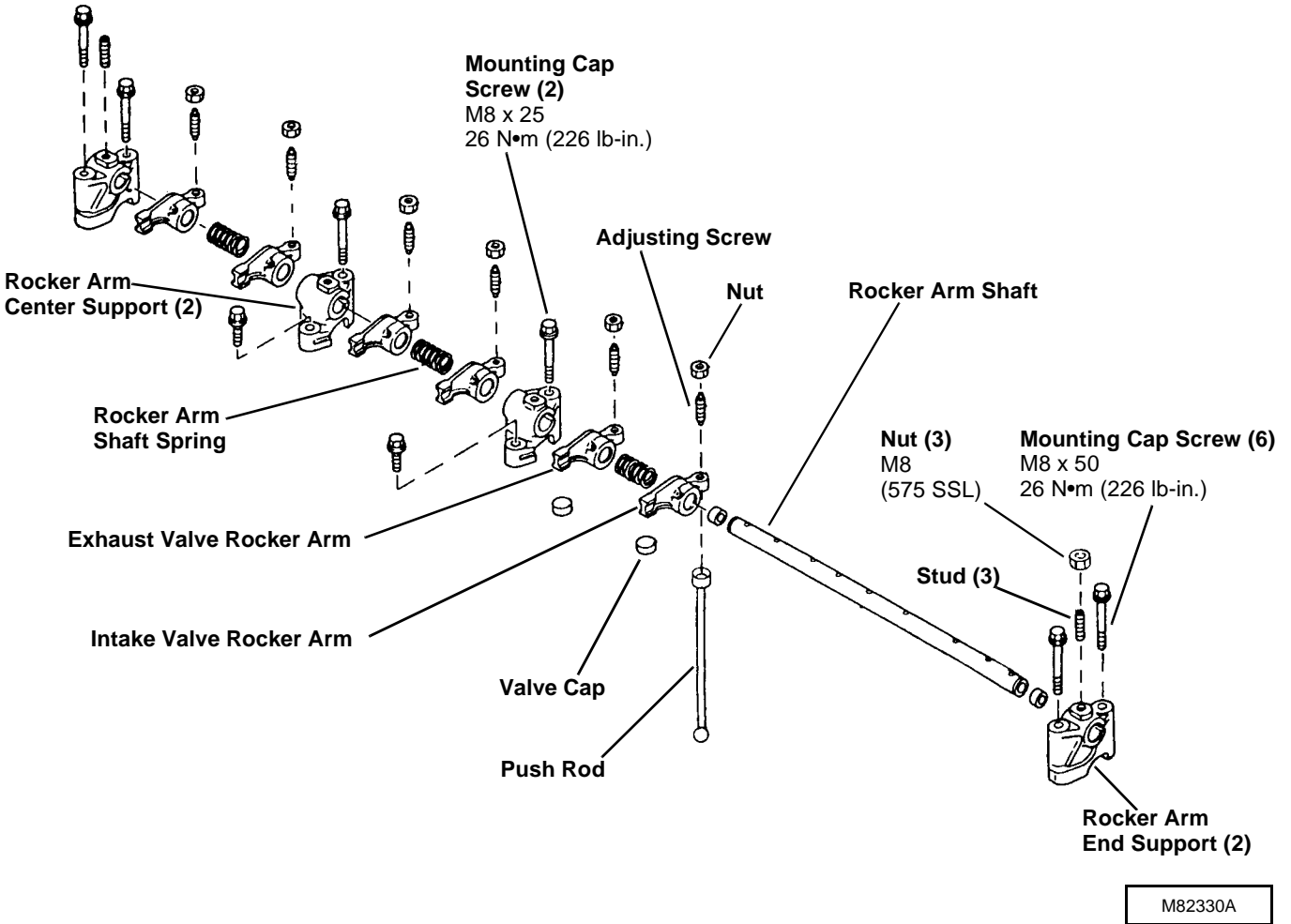
M82329A

ROCKER ARM ASSEMBLY

Removal/Installation and Disassembly/Assembly

1. Remove rocker arm cover. (See procedure in this group.)
 - Remove and install studs using two M8 nuts.

- Inspect all parts for wear or damage. (See *Inspection* procedures.)
- Lubricate all parts with clean oil during assembly.
- Adjust valve clearance. (See *Checks, Tests and Adjustments* in this section.)



Cylinder Head, Valves and Manifolds

Inspection

- Measure outer diameter of rocker arm shaft.



2

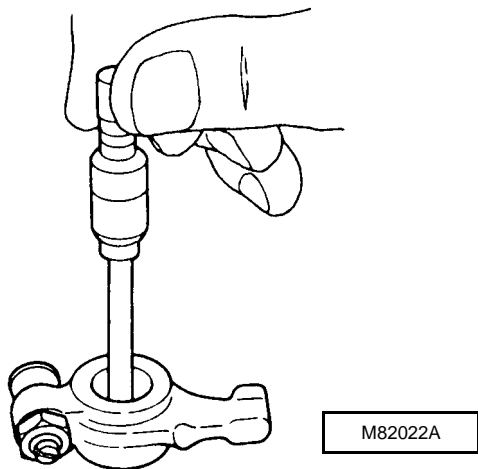
Rocker Arm Shaft O.D.:

Standard 15.97 - 15.98 mm
 (0.6286 - 0.6293 in.)

Wear Limit 15.95 mm (0.6280 in.)

Replace rocker arm shaft if less than wear limit.

- Measure inner diameters of rocker arms and supports.



Rocker Arm and Shaft Support I.D.'s:

Standard 16.00 - 16.02 mm
 (0.630 - 0.631 in.)

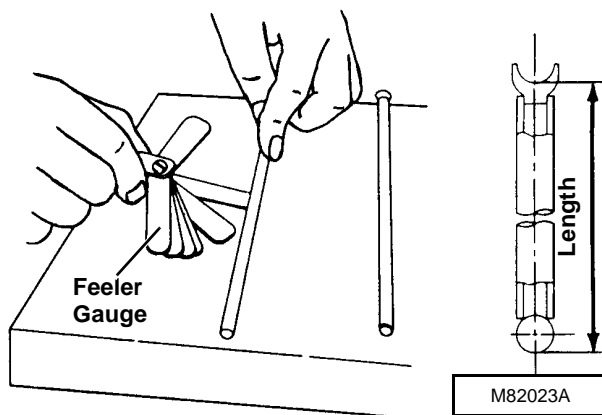
Wear Limit 16.09 mm (0.633 in.)

Clearance 0.13 mm (0.005 in.)

Replace rocker arms or supports if I.D. is more than wear limit.

If shaft and support/arm clearance (support/arm I.D. minus shaft O.D.) exceed wear limit, replace all parts.

- Measure length and bending of push rod.



Push Rod Length:

3TN75, 3TN78,
 3TNC78 (3011) 146.65 - 147.35 mm
 (5.774 - 5.801 in.)

3TN82, 3TNA82,
 3TN84 (3014) 178.25 - 178.75 mm
 (7.018 - 7.037 in.)

Push Rod Bend:

Standard 0.03 mm (0.001 in.) or less

Wear Limit 0.30 mm (0.012 in.)

Replace push rod if not within specifications.

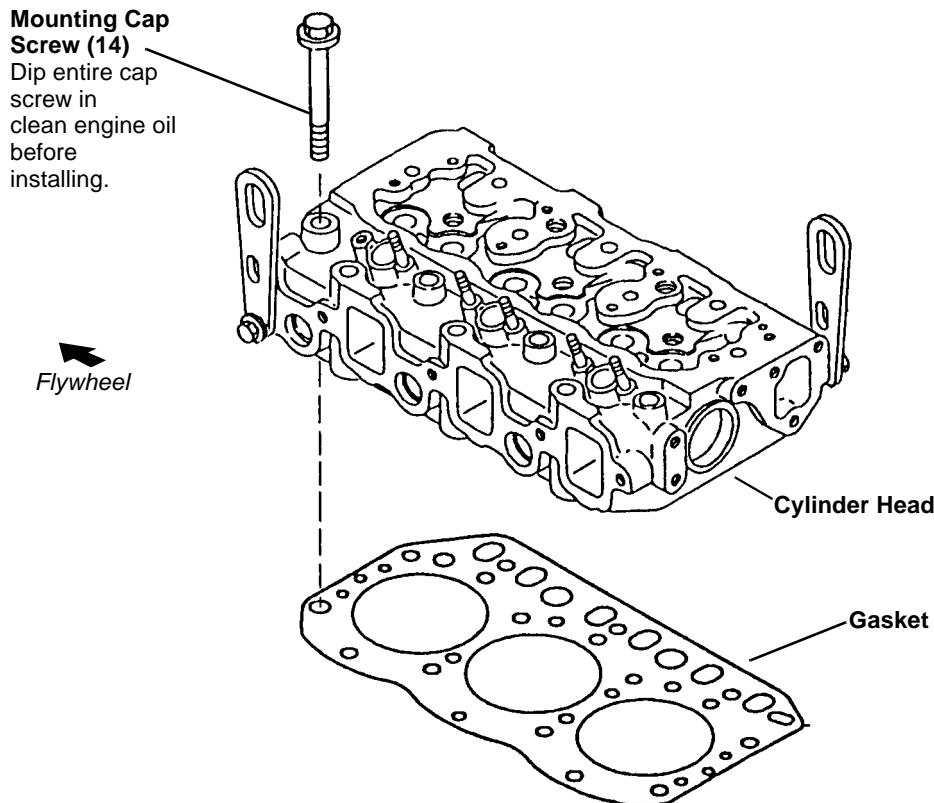
CYLINDER HEAD AND VALVES

Removal/Installation

1. Remove rocker arm assembly, push rods and valve caps. (See procedure in this group.)
2. Remove exhaust and intake manifolds. (See procedures in this group.)
3. Remove water pump. (See *Cooling System* in this section.)

4. Remove fuel injection nozzles. (See *Fuel System* in this section.)
5. Disassemble and inspect cylinder head and valves. (See *Disassembly/ Assembly and Inspection/Replacement* procedures.)

IMPORTANT: Oil passage in gasket must be located over oil passage in cylinder block.



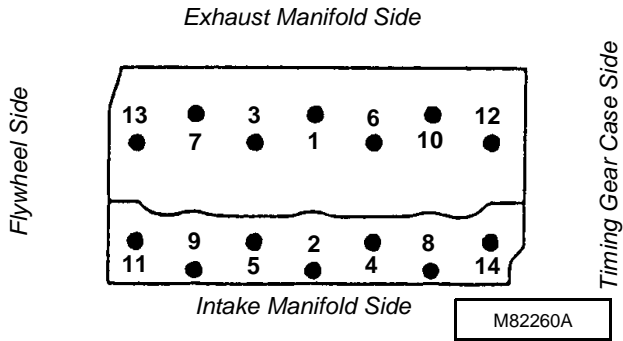
M82331A

Cylinder Head, Valves and Manifolds

6. Tighten mounting cap screws, in the sequence shown, in three stages of gradually-increasing torque.

IMPORTANT: Cylinder head mounting cap screws must be checked for proper torque after 50 hours of engine operation.

2



Torque Specifications - 3TN75, 3TN78, 3TNC78 (3011):

- First 21 N•m (186 lb-in.)
- Second 42 N•m (31 lb-ft)
- Final 69 N•m (51 lb-ft)

Torque Specifications - 3TN82, 3TNA82, 3TN84 (3014):

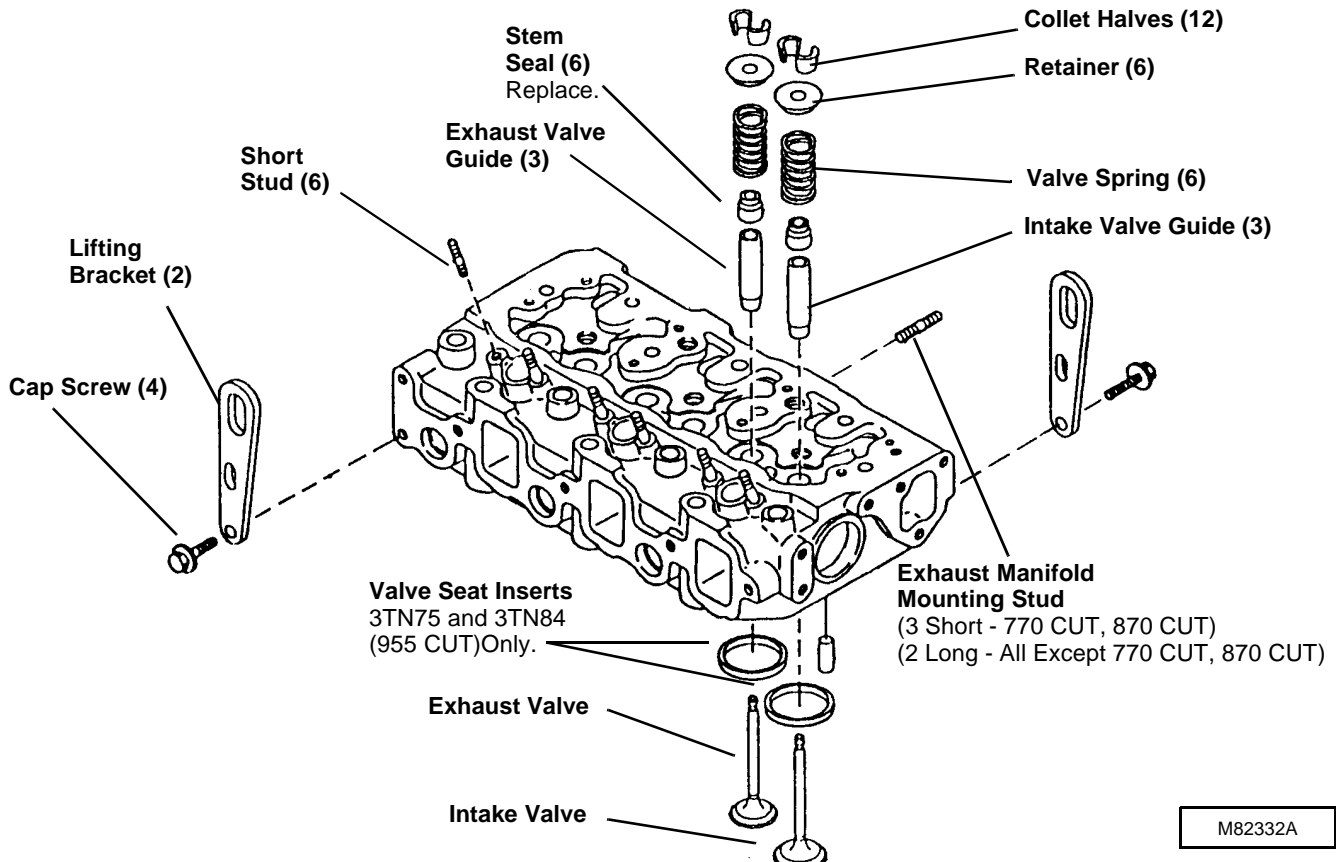
- First 24 N•m (212 lb-in.)
- Second 48 N•m (36 lb-ft)
- Final 78 N•m (58 lb-ft)

Disassembly/Assembly

- Compress valve springs using a valve spring compressor.
- Intake and exhaust valve guides are press fit. Remove guides only if replacement is necessary. (See *Inspection/Replacement* procedures.)
- On 3TN75, 3TN84 (955 CUT), intake and exhaust valve seat inserts are press fit. Remove inserts only if replacement is necessary.
- Inspect all parts for wear or damage. (See *Inspection/Replacement* procedures.)

IMPORTANT: Do not reuse stem seals if removed. Used seals will leak.

- Apply clean engine oil on intake and exhaust valve stems during assembly.
- Install springs with smaller pitch end or paint mark toward cylinder head.



*NOTE: If new valves are installed, measure valve recession. (See **Inspection/Replacement** procedures.)*

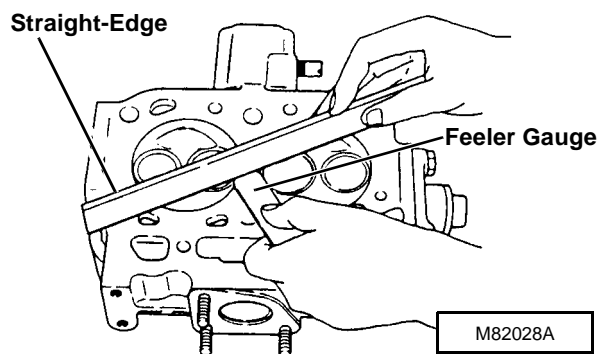
After each valve has been assembled, tap on top of valve stem with a plastic hammer to seat retainer.

Inspection/Replacement

Before inspection, thoroughly clean all components of carbon or dirt.

Cylinder Head:

- Measure cylinder head flatness. Place a straight-edge along each of the four sides and each diagonal. Measure clearance between straight edge and combustion surface with a feeler gauge.



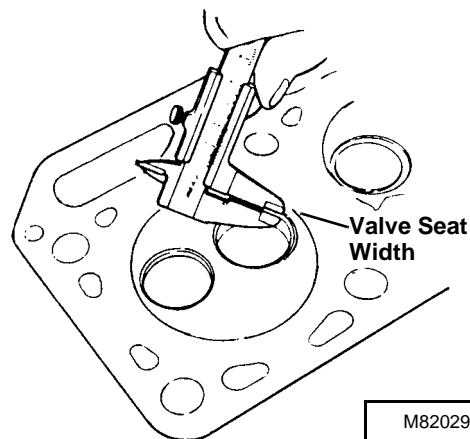
Cylinder Head Distortion:

Standard 0.05 mm (0.002 in.) or less
Wear Limit. 0.15 mm (0.006 in.)

If distortion exceeds the wear limit, resurface or replace cylinder head. Remove only enough metal to make cylinder head flat; but do not remove more than **0.20 mm (0.008 in.)**.

If cylinder head was resurfaced:

- Measure piston-to-cylinder head clearance. (See procedure in this group.)
- Measure valve recession. (See procedure in this group.)
- Measure valve seat width.



Valve Seat Width - 3TN75, 3TN78, 3TNC78 (3011):

Intake Valve

Standard 1.36 - 1.53 mm
 (0.054 - 0.060 in.)
Wear Limit. 1.98 mm (0.078 in.)

Exhaust Valve

Standard 1.66 - 1.87 mm
 (0.065 - 0.074 in.)
Wear Limit. 2.27 mm (0.089 in.)

Valve Seat Width - 3TN82, 3TNA82, 3TN84 (3014):

Intake Valve

Standard 1.07 - 1.24 mm
 (0.042 - 0.049 in.)
Wear Limit. 1.74 mm (0.069 in.)

Exhaust Valve

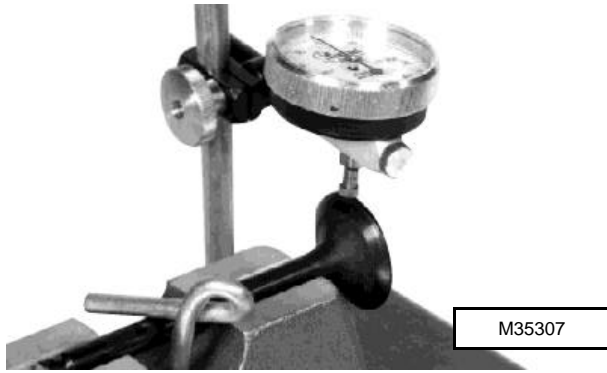
Standard 1.24 - 1.45 mm
 (0.049 - 0.057 in.)
Wear Limit. 1.94 mm (0.076 in.)

If necessary, grind valve seats to meet specifications. (See **GRIND VALVE SEATS** procedure.)

Intake and Exhaust Valves:

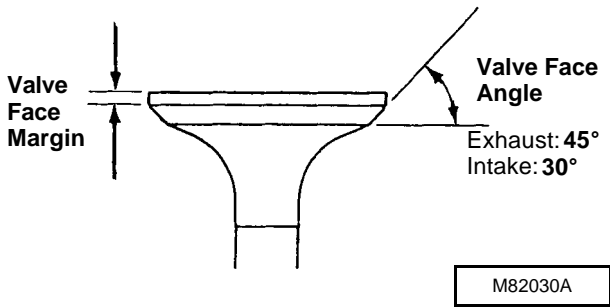
- Check valve for out-of-round, bent or warped condition using a valve inspection center. Replace valve if necessary.

Cylinder Head, Valves and Manifolds

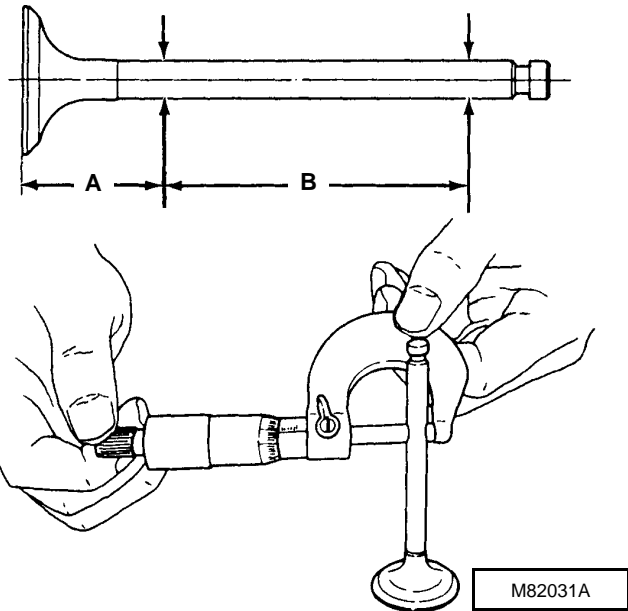


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- If valve faces are worn, burned or pitted, grind valves to proper face angle. If valve face margin is less than **0.51 mm (0.020 in.)** after grinding, replace valve.



- Measure valve stem diameter at two locations shown. Replace valve if measurement exceeds wear limit.



Valve Stem O.D. - 3TN75, 3TN78, 3TNC78 (3011):

Distance A30 mm (1.181 in.)
 Distance B50 mm (1.969 in.)

Intake and Exhaust Valves

Standard 6.94 - 6.96 mm
(0.2732 - 0.2740 in.)
 Wear Limit..... 6.90 mm (0.2717 in.)

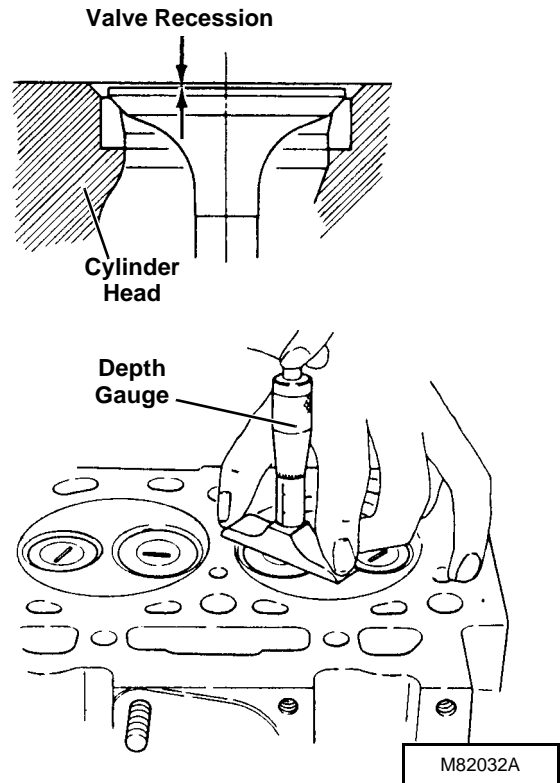
Valve Stem O.D. - 3TN82, 3TNA82, 3TN84 (3014):

Distance A30 mm (1.181 in.)
 Distance B60 mm (2.360 in.)

Intake and Exhaust Valves

Standard 7.96 - 7.98 mm
(0.3134 - 0.3142 in.)
 Wear Limit..... 7.90 mm (0.3110 in.)

- Measure valve recession using a depth gauge. Replace valve or cylinder head if measurement exceeds wear limit.



Valve Recession:

Standard 0.30 - 0.50 mm
 (0.012 - 0.020 in.)
Wear Limit 1.00 mm (0.039 in.)

Valve Guides:

- Clean valve guides using a valve guide brush.
- Measure valve guide inside diameter.

Valve Guide I.D. - 3TN75, 3TN78, 3TNC78 (3011):

Standard 7.00 - 7.02 mm
 (0.275 - 0.276 in.)
Wear Limit 7.08 mm (0.279 in.)

Valve Guide I.D. - 3TN82, 3TNA82, 3TN84 (3014):

Standard 8.01 - 8.03 mm
 (0.315 - 0.316 in.)
Wear Limit 8.10 mm (0.319 in.)

If diameter exceeds wear limit, knurl or replace guide.

If diameter is less than wear limit, determine guide-to-stem clearance (guide diameter minus stem diameter).

If clearance exceeds **0.15 mm (0.006 in.)** but is less than **0.20 mm (0.008 in.)**, knurl valve guides.

- Knurl valve guides using:
 - 3TN75, 3TN78, 3TNC78 (3011):
D-20018WI Valve Guide Knurler
 - 3TN82, 3TNA82, 3TN84 (3014):
D-20019WI Valve Guide Knurler

If clearance exceeds **0.20 mm (0.008 in.)**, replace valve guide.

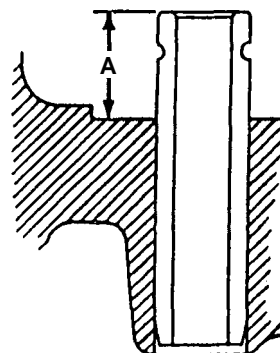
- Replace valve guides using JDE118 Valve Guide Driver.

Intake and exhaust valve guides are different. The exhaust valve guide has one groove and the intake valve guide has none. Install valve guides with tapered ends down. Push valve guides down until top of valve guides are a specified distance (A) from top of cylinder head.

Valve Guide Height "A":

3TN75, 3TN78,
 3TNC78 (3011) 12 mm (0.472 in.)
 3TN82, 3TNA82,
 3TN84 (3014) 15 mm (0.591 in.)

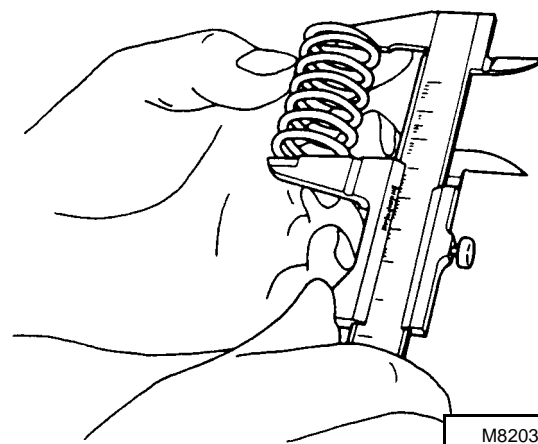
- Ream inside diameter of valve guides using:
 - 3TN75, 3TN78, 3TNC78 (3011):
D-20020WI Valve Guide Reamer
 - 3TN82, 3TNA82, 3TN84 (3014):
D-20021WI Valve Guide Reamer



M82193A

Valve Springs:

- Measure spring free length. Replace spring if measurement exceeds wear limit.



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Spring Free Length - 3TN75, 3TN78, 3TNC78 (3011):

Standard 42 mm (1.654 in.)
Wear Limit 41.50 mm (1.630 in.)

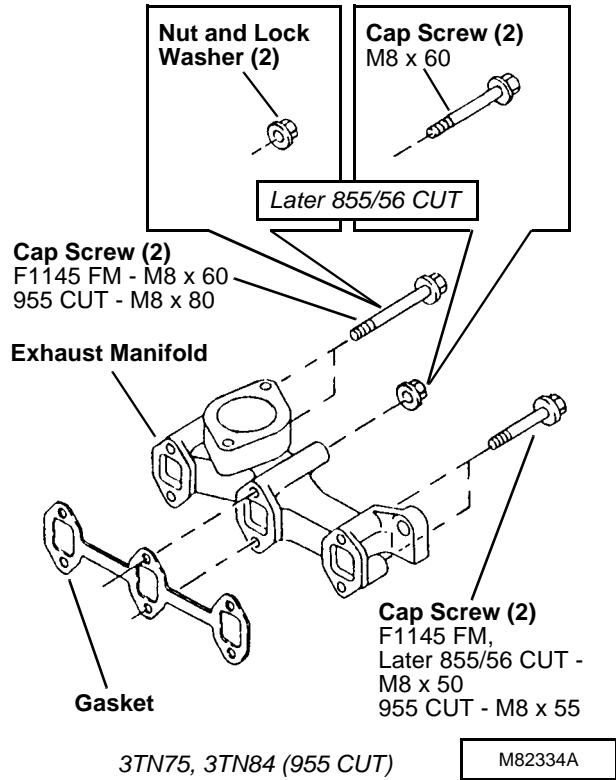
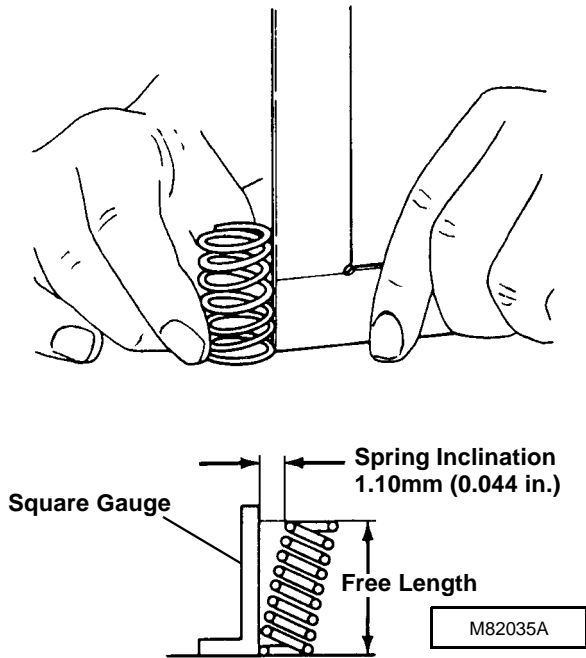
Spring Free Length - 3TN82, 3TNA82, 3TN84 (3014):

Standard 40 mm (1.575 in.)
Wear Limit 39.50 mm (1.550 in.)

Cylinder Head, Valves and Manifolds

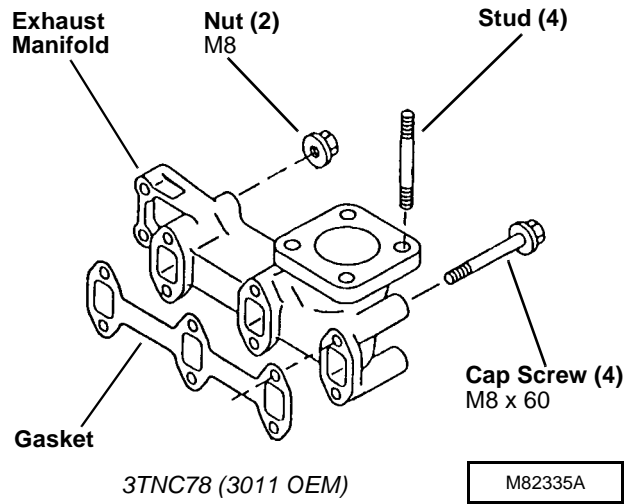
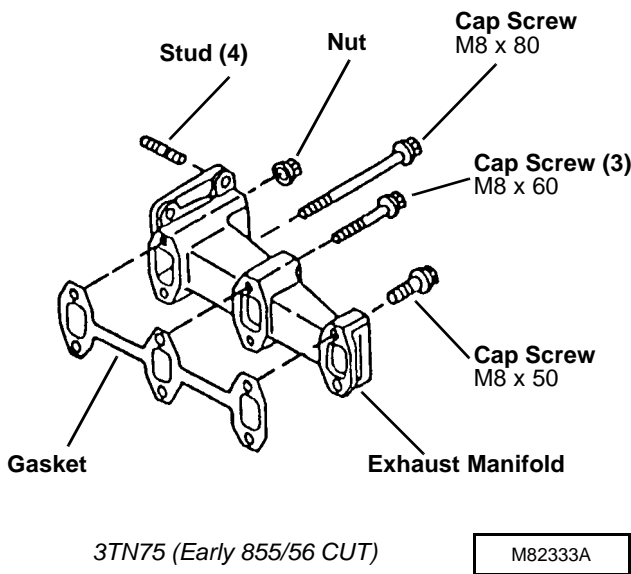
- Measure spring inclination. Replace spring if measurement exceeds specification.

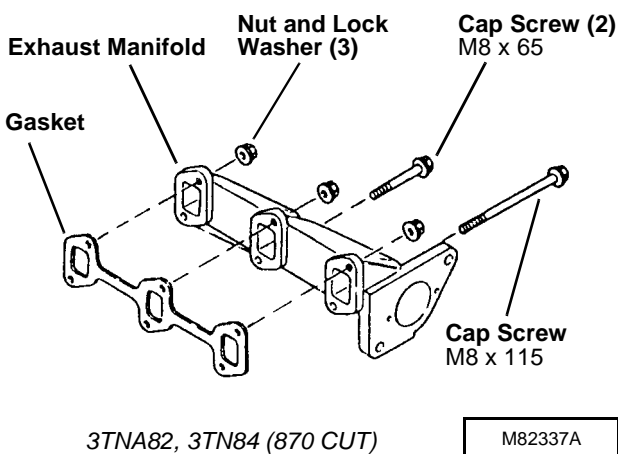
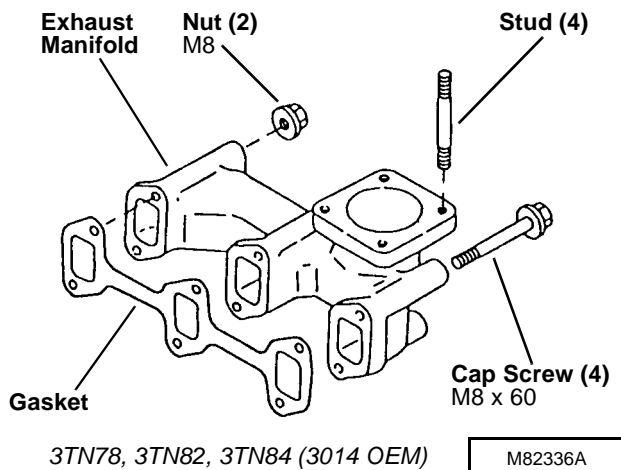
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EXHAUST MANIFOLD

1. Remove muffler and gasket, if equipped.
- Tighten all hardware to **26 N•m (226 lb-in.)**.





INTAKE MANIFOLD

NOTE: Air heater removal/installation is similar to procedures found in ACCESSORIES - SERIES 220 POWER UNIT ENGINES section.

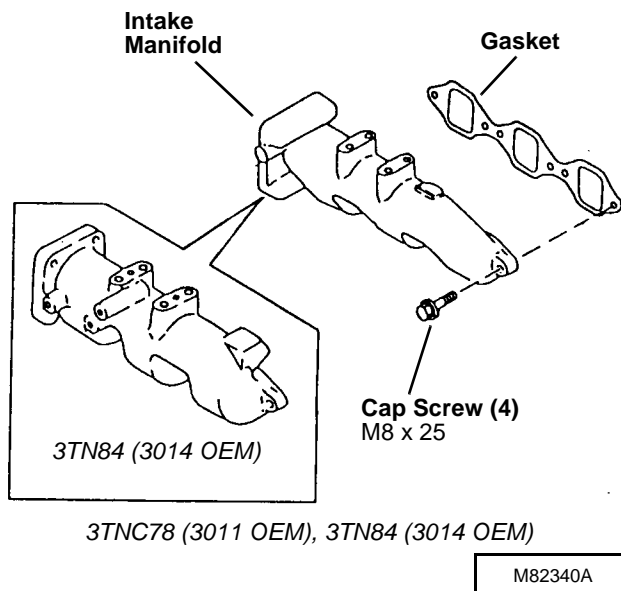
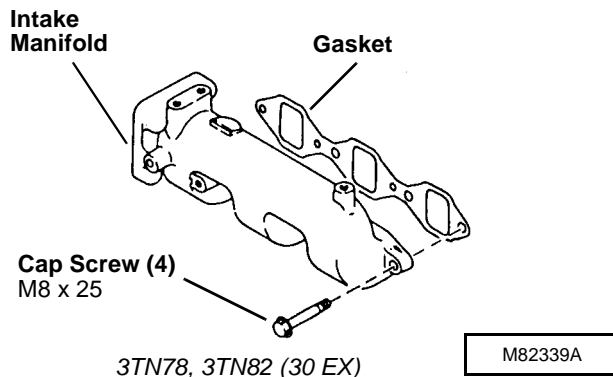
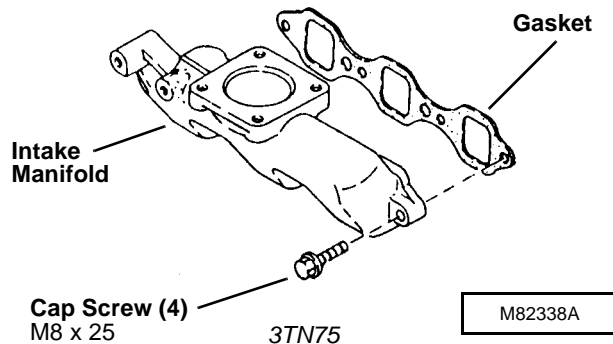
1. Remove intake air heater. (See procedure in *ACCESSORIES - SERIES 220 POWER UNIT ENGINES* section.)
2. Remove fuel filter assembly mounting cap screw(s), if equipped.
3. Remove fuel injection lines. (See *Fuel System* in this section.)

4. OEM Power Unit engines (3011 and 3014):

- Remove air cleaner and mount bracket.
- Remove instrument panel and bracket.
- Remove radiator support rod.

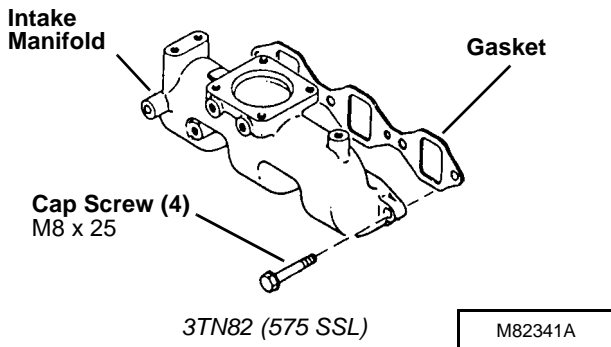
(See procedures in *ACCESSORIES - SERIES 220 POWER UNIT ENGINES* section.)

- Tighten all mounting cap screws to **26 N•m (226 lb-in.)**.

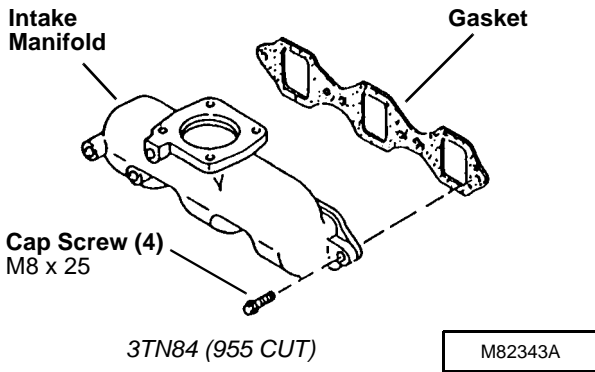
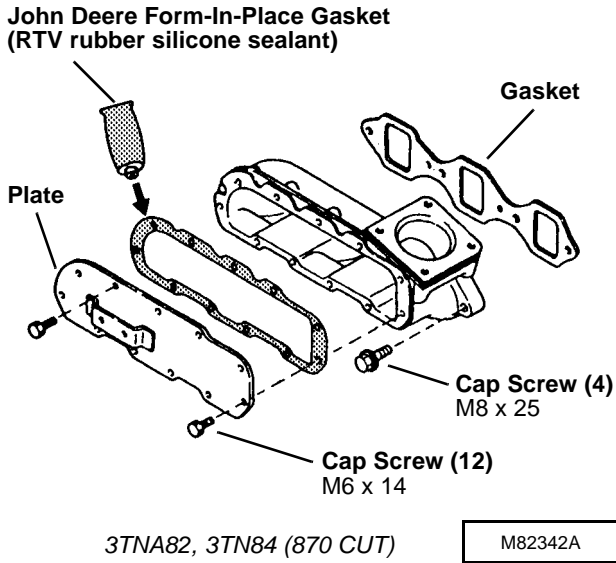


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Cylinder Head, Valves and Manifolds



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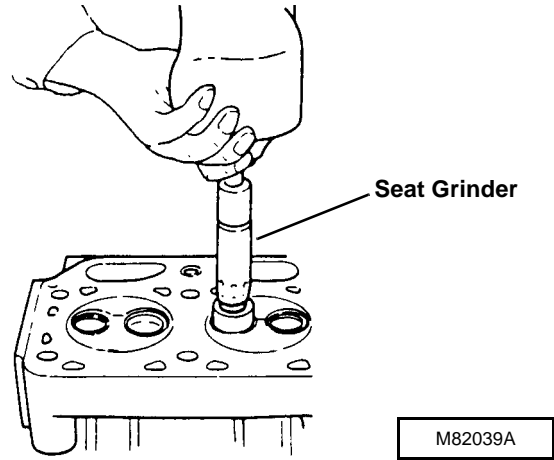


GRIND VALVE SEATS

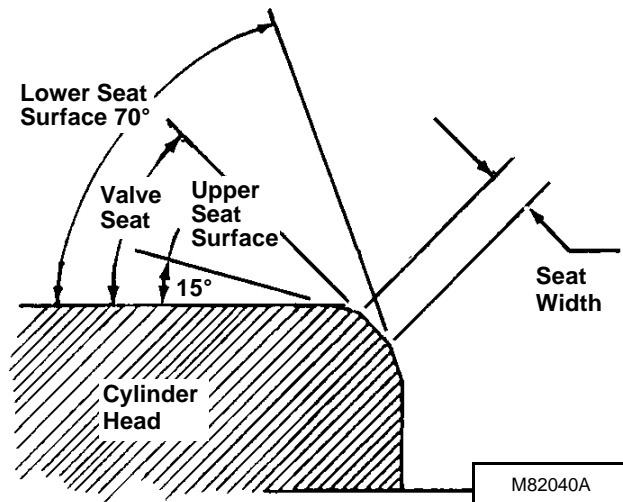
IMPORTANT: Valve seats should never be cut. Cutting a valve seat can damage its sealing surface, which may result in leaks or valve/seat failure. Valve seats should be ground and lapped.

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

1. Grind intake valve seat using a 30° seat grinder and exhaust valve seat using a 45° seat grinder. Follow tool manufacturers instructions.



2. Measure valve seat width after grinding.
3. If seat is too wide after grinding, grind lower seat surface using a 70° seat grinder until seat width is close to specifications.
4. Grind upper seat surface using a 15° seat grinder until seat width is narrowed to specifications.
5. If valve seats are ground, measure valve recession and check contact pattern between the seat and valve with bluing dye.
6. Lap valves. (See procedure in this group.)



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

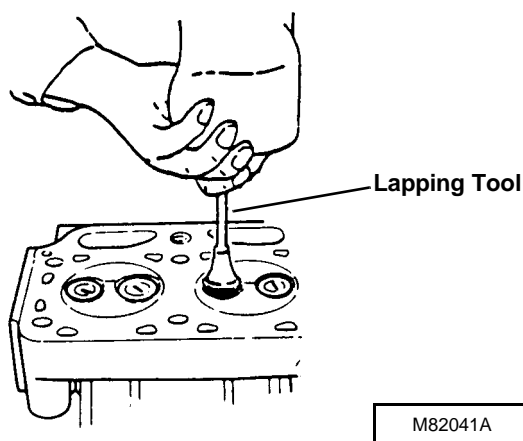
NOTE: Valve seat inserts are available for 3TN75 and 3TN84 (955 CUT) engines only.

LAP VALVES

NOTE: Use a rubber type lapping tool for valves without a lapping tool groove slit.

If seat does not make proper contact, lap the valve into the seat:

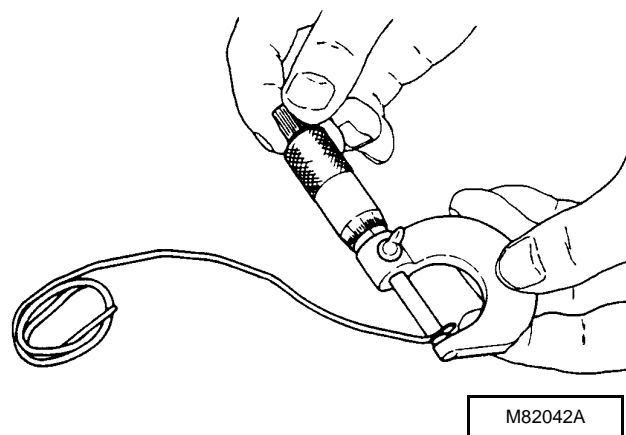
1. Apply small amount of fine lapping compound to face of valve.
2. Turn valve to lap valve to seat.
3. Lift valve from seat every 8 to 10 strokes. Lap until a uniform ring appears around the surface of the valve face.
4. Wash all parts in solvent to remove lapping compound. Dry parts.
5. Check position of lap mark on valve face. Lap mark must be on or near center of valve face.



MEASURE PISTON-TO-CYLINDER HEAD CLEARANCE

1. Place three 10 mm (0.400 in.) long pieces of 1.50 mm (0.060 in.) diameter soft wire in three positions on the flat part of the piston head.

2. Install cylinder head and old gasket. Install cylinder head cap screws and tighten in proper sequence to specified torque. (See *CYLINDER HEAD AND VALVES - Removal/Installation* in this group.)
3. Slowly turn crankshaft one complete revolution.
4. Remove cylinder head and gasket.
5. Measure thickness of flattened section of each piece of wire. Calculate average thickness of wires to obtain piston-to-cylinder head clearance specification.



Piston-to-Cylinder Head Clearance:

3TN75.....	0.59 - 0.77 mm
.....	(0.023 - 0.030 in.)
3TN78, 3TNC78 (3011)	0.63 - 0.77 mm
.....	(0.025 - 0.030 in.)
3TN82, 3TNA82,	
3TN84 (3014).....	0.64 - 0.82 mm
.....	(0.025 - 0.032 in.)

If clearance is less than specifications, replace cylinder head.

Pistons, Rods and Cylinder Block

SERVICE PARTS KITS

The following kits are available through your parts catalog:

- Cylinder Block Gasket Kit
- Cylinder Head Gasket Kit
- Oversized Pistons and Rings
- Undersized Connecting Rod Bearing Inserts

PISTON AND CONNECTING ROD

Removal

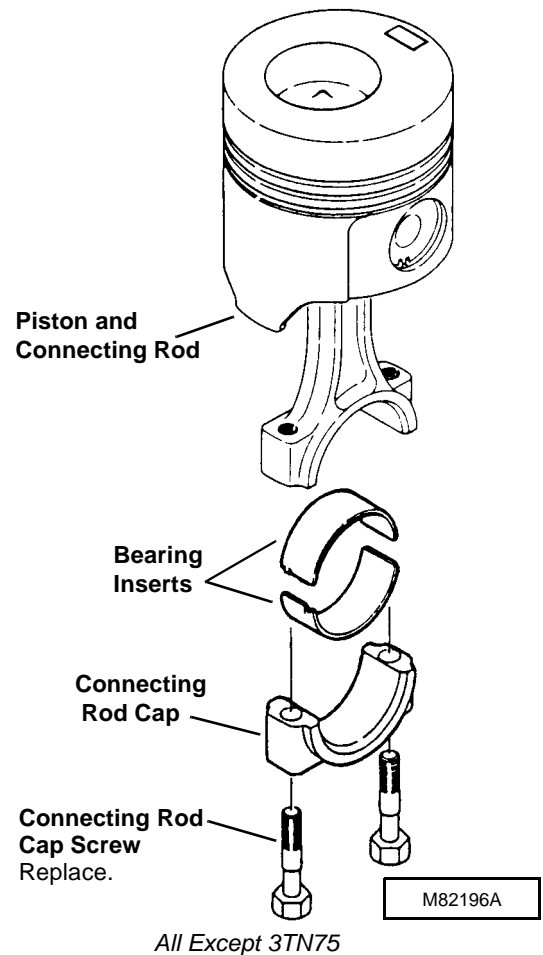
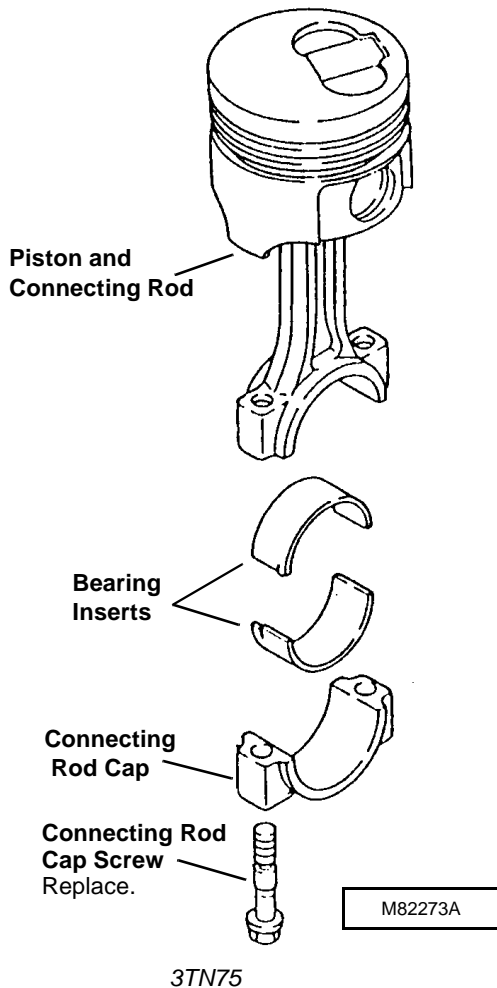
1. Remove oil pan and strainer tube. (See *Lubrication System* in this section.)
2. Remove cylinder head. (See *Cylinder Head, Valves and Manifolds* in this section.)
3. Check cylinder bore for ridges. These ridges can cause damage to piston if ridge is not removed.
4. If necessary, remove ridge from top of cylinder bore using a ridge reamer.
5. Measure connecting rod side play. (See *Checks, Tests and Adjustments* in this section.)
6. Measure connecting rod bearing clearance. (See *Checks, Tests and Adjustments* in this section.)

IMPORTANT: Keep connecting rods and caps together. Rods and caps are a matched set. Note alignment marks on each part.

7. Remove two cap screws, connecting rod cap and bearing inserts.

IMPORTANT: Pistons and cylinders are matched. Pistons must be installed in the cylinders from which they are removed.

8. Note connecting rod alignment mark in relation to the cylinders. Starting at flywheel end with cylinder number one, then two, etc.
9. Push piston and connecting rod out of cylinder bore using a wooden dowel.
10. Disassemble and inspect all parts for wear or damage. (See *Disassembly and Inspection/Replacement* procedures.)



Pistons, Rods and Cylinder Block

Installation

- Apply clean engine oil on all parts during installation.
- Never reuse connecting rod cap screws, replace with new.

IMPORTANT: Pistons must be installed in cylinders from which they were removed and in the same direction. Be careful not to damage crankshaft rod journal while installing piston.

1. If new piston rings were installed, deglaze cylinder bore. (See procedure in this group.)
2. 3TN75: Install piston and connecting rod into the cylinder from which it was removed, with piston recess on top of piston toward fuel injection pump.

All Except 3TN75: Install piston and connecting rod into the cylinder from which it was removed, with alignment mark on connecting rod and/or with piston size mark on top of piston toward fuel injection pump.

IMPORTANT: Do not touch bearing insert surfaces. Oil and acid from your finger will corrode the bearing surface.

3. Install bearing inserts on connecting rod and rod cap, aligning tangs with grooves.

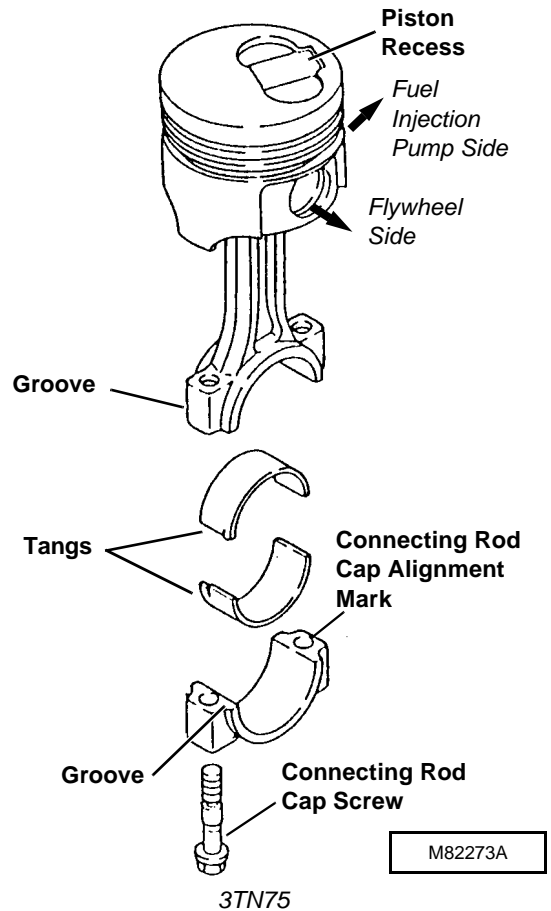
IMPORTANT: Connecting rod caps must be installed on the same connecting rods they were removed from.

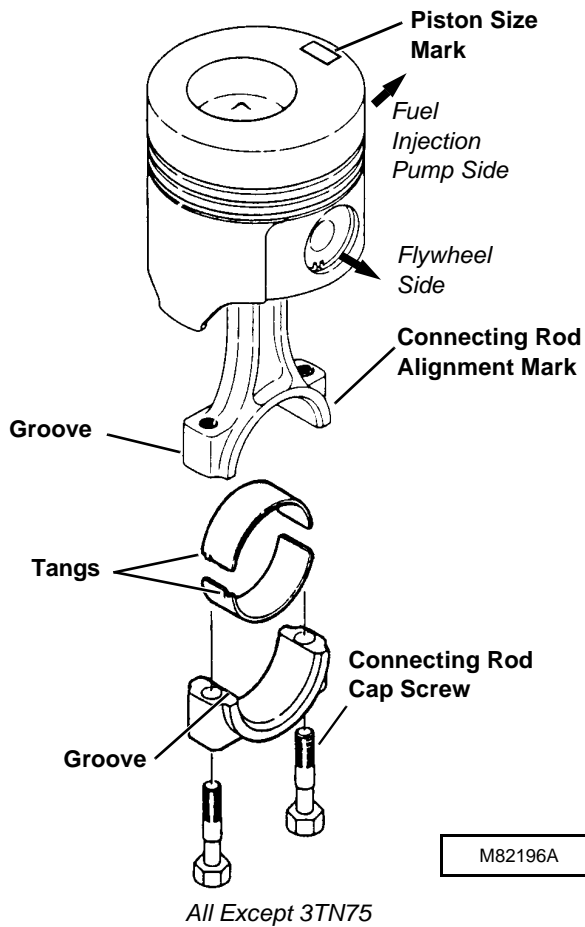
4. Match the connecting rods to caps using alignment marks. Install caps.
5. Dip entire connecting rod cap screws in clean engine oil. Install new cap screws and tighten to specifications.

Connecting Rod Cap Screw Torque Specifications:

3TN75, 3TN78,
3TNC78 (3011) 39 N•m (29 lb-ft)
3TN82, 3TNA82,
3TN84 (3014) 47 N•m (35 lb-ft)

6. If a new piston and connecting rod were installed, stamp a number corresponding to the cylinder number on the connecting rod cap and connecting rod.





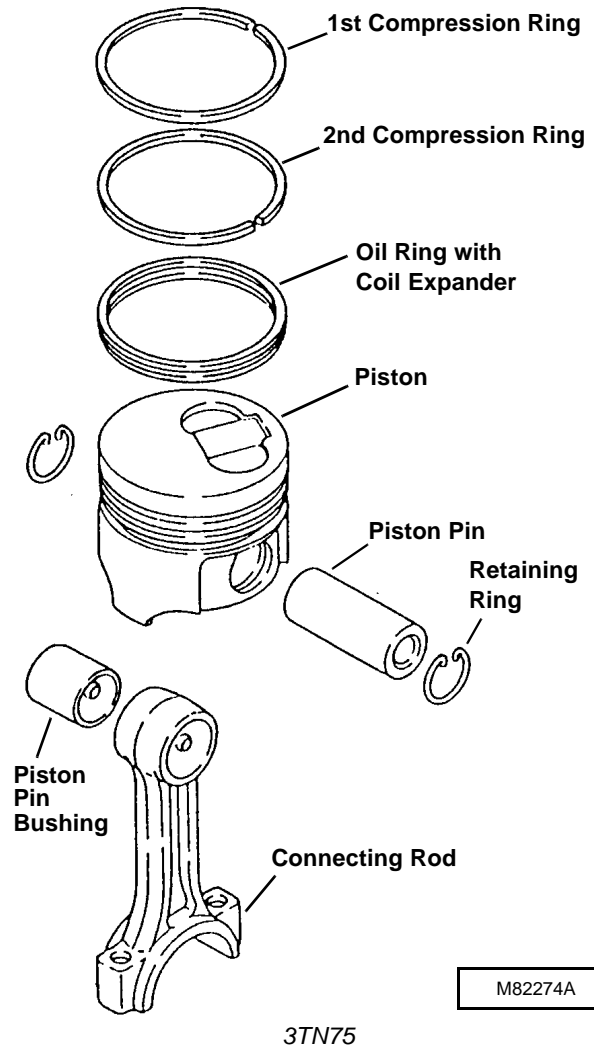
7. Install cylinder head. (See *Cylinder Head, Valves and Manifolds* in this section.)
8. Install oil pan and strainer tube. (See *Lubrication System* in this section.)

Disassembly

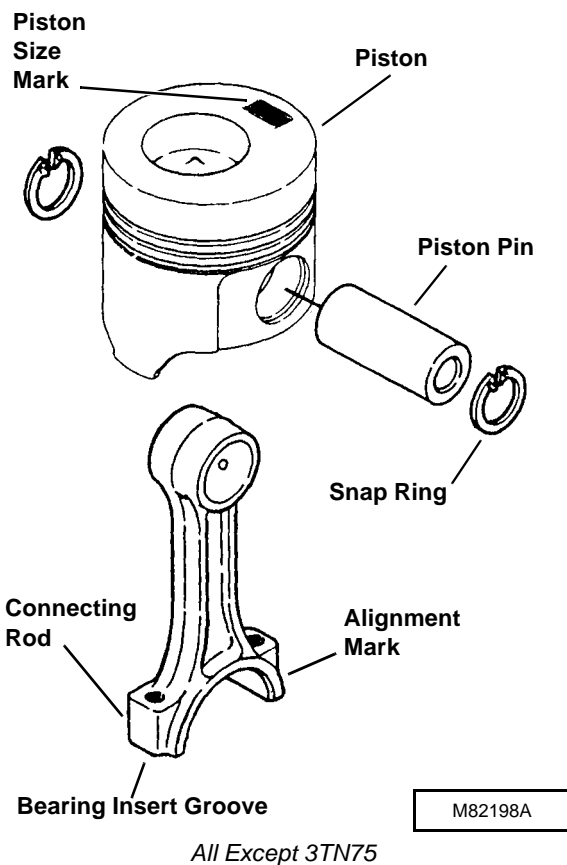
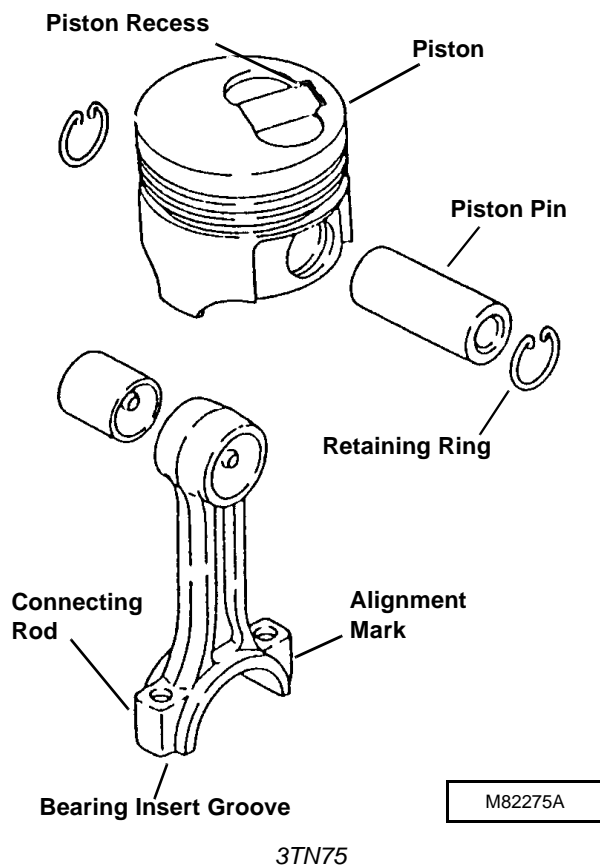
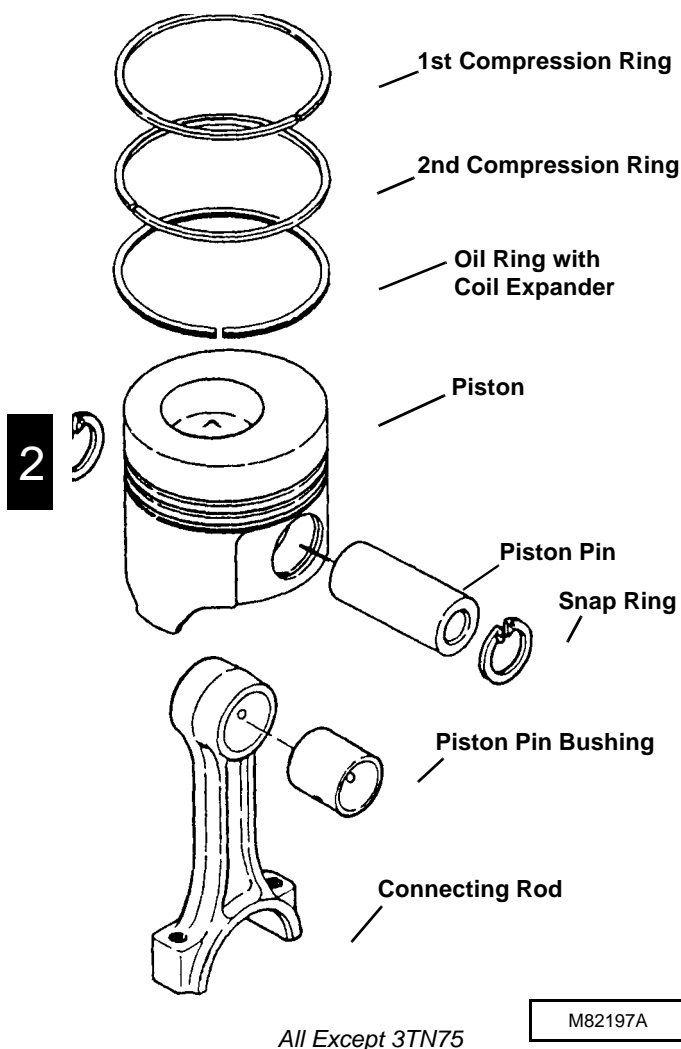
IMPORTANT: Pistons must be installed on the same connecting rod they were removed from.

- Put a mark on each piston and connecting rod to aid in assembly.

- Piston pin bushing is press fit in connecting rod. Remove bushing only if replacement is necessary. (See *Inspection/Replacement* procedures.)
- Inspect all parts for wear or damage. Replace as necessary. (See *Inspection/Replacement* procedures.)



Pistons, Rods and Cylinder Block



Assembly

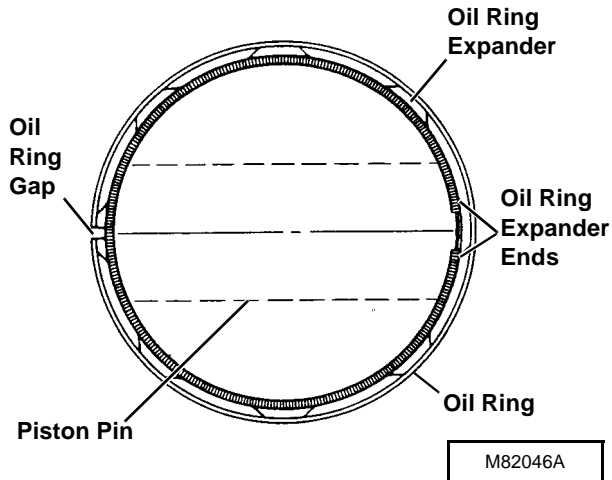
- Apply clean engine oil to all parts during assembly.

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

1. 3TN75: Assemble piston to connecting rod with recess mark on same side as connecting rod "punched" alignment mark. If a new connecting rod is used, assemble piston to connecting rod with piston recess opposite connecting rod bearing insert groove.

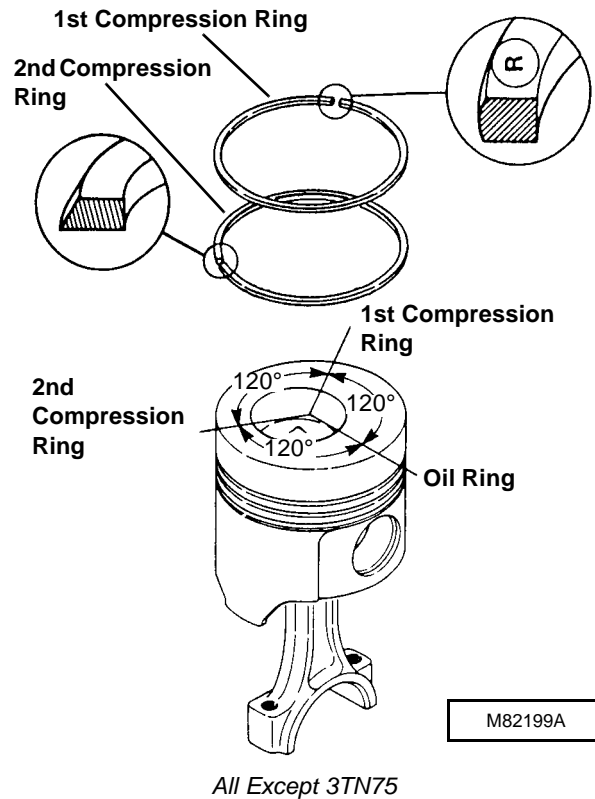
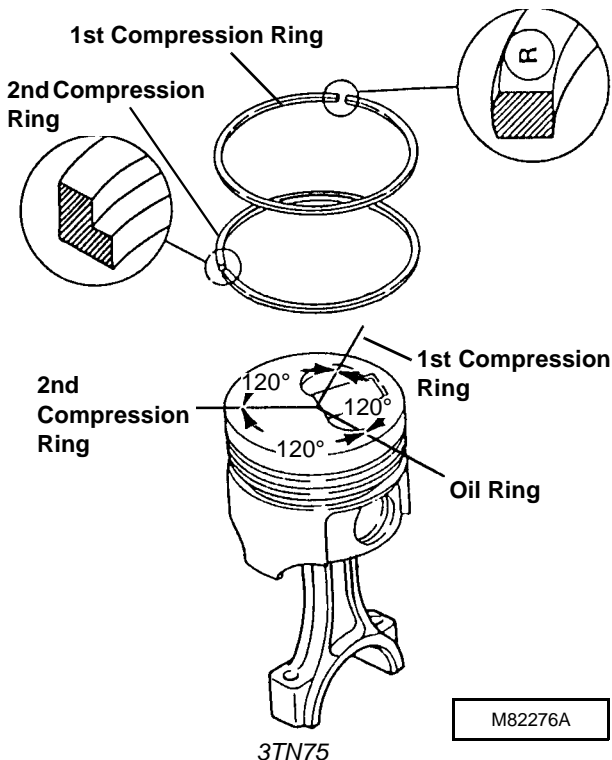
All except 3TN75: Assemble piston to connecting rod with piston size mark on same side as connecting rod "punched" alignment mark. If a new connecting rod is used, assemble piston to connecting rod with piston size mark opposite connecting rod bearing insert groove.

2. Install piston pin and retaining/snap rings.
3. Install oil ring expander in bottom ring groove of piston with ends above either end of piston pin.
4. Install oil ring over expander with ring gap opposite (180°) of expander ends.



5. 3TN75: Install second compression ring, with chamfer toward top of piston, in middle groove. Turn ring until gap is 120° ring gap.

All Except 3TN75: Install second compression ring, with small diameter of taper toward top of piston, in middle groove. Turn ring until gap is 120° away from oil ring gap.



6. Install first compression ring (chrome plated), with manufacturer's mark "R", "T" or "RN" (near ring gap) toward top of piston, in top groove. Turn ring until gap is 120° away from second ring gap.

Inspection/Replacement

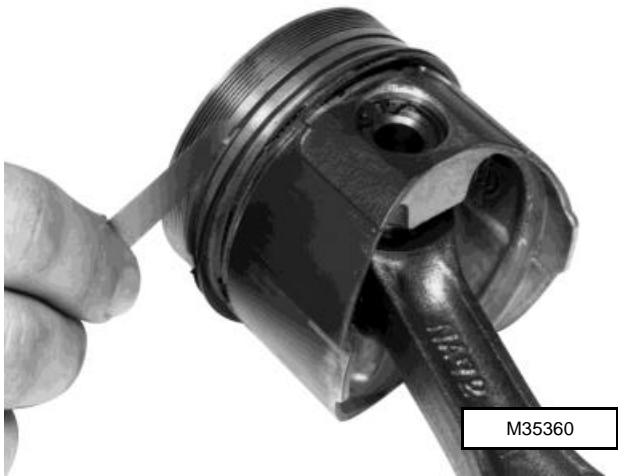
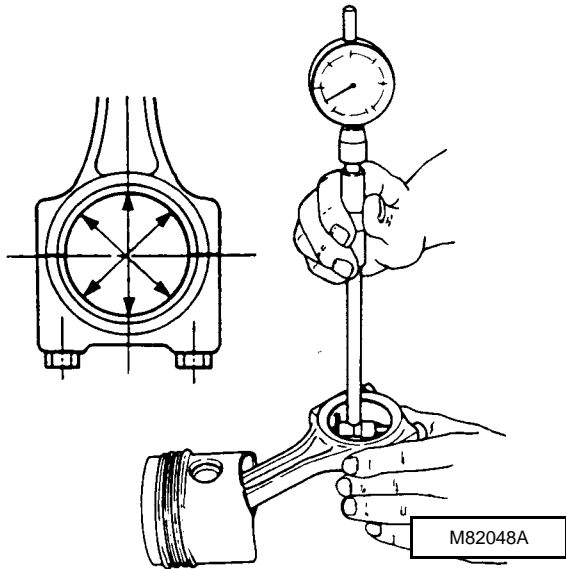
1. Inspect all parts for wear or damage. Replace as necessary.
2. Measure crankshaft connecting rod journal diameter. (See *Crankshaft, Main Bearings and Flywheel* in this section.)
3. Install connecting rod cap and bearing inserts on connecting rod. Install old connecting rod cap screws and tighten to specifications.

Connecting Rod Cap Screw Torque Specifications:

3TN75, 3TN78,
 3TNC78 (3011) 39 N•m (29 lb-ft)
 3TN82, 3TNA82,
 3TN84 (3014) 47 N•m (35 lb-ft)

4. Measure connecting rod bearing diameter.

2



Connecting Rod Bearing I.D. - 3TN75, 3TN78, 3TNC78 (3011):

- Standard 43 - 43.042 mm
.....(1.693 - 1.695 in.)
- Wear Limit..... 43.07 mm (1.696 in.)
- Clearance..... 0.16 mm (0.006 in.)

Connecting Rod Bearing I.D. - 3TN82, 3TNA82, 3TN84 (3014):

- Standard 48 - 48.042 mm
.....(1.888 - 1.891 in.)
- Wear Limit..... 48.07 mm (1.893 in.)
- Clearance..... 0.16 mm (0.006 in.)

If bearing diameter exceeds wear limit, replace bearing inserts.

If bearing clearance (bearing I.D. minus crankshaft journal O.D.) exceeds specification, grind crankshaft connecting rod journals and install undersized bearing inserts, or replace bearing inserts and crankshaft.

5. With rings installed on piston, measure piston ring groove clearance. Measure several places around each piston.

Piston Ring Groove Clearance - 3TN75, 3TN78, 3TNC78 (3011):

First Compression Ring

- Standard 0.070 - 0.105 mm
.....(0.0028 - 0.0041 in.)
- Wear Limit..... 0.25 mm (0.0098 in.)

Second Compression Ring

- Standard 0.035 - 0.070 mm
.....(0.0014 - 0.0028 in.)
- Wear Limit..... 0.25 mm (0.0098 in.)

Oil Ring

- Standard 0.030 - 0.060 mm
.....(0.0012 - 0.0024 in.)
- Wear Limit..... 0.20 mm (0.0079 in.)

Piston Ring Groove Clearance - 3TN82, 3TNA82, 3TN84 (3014):

First Compression Ring

- Standard 0.075 - 0.110 mm
.....(0.0030 - 0.0043 in.)
- Wear Limit..... 0.25 mm (0.0098 in.)

Second Compression Ring

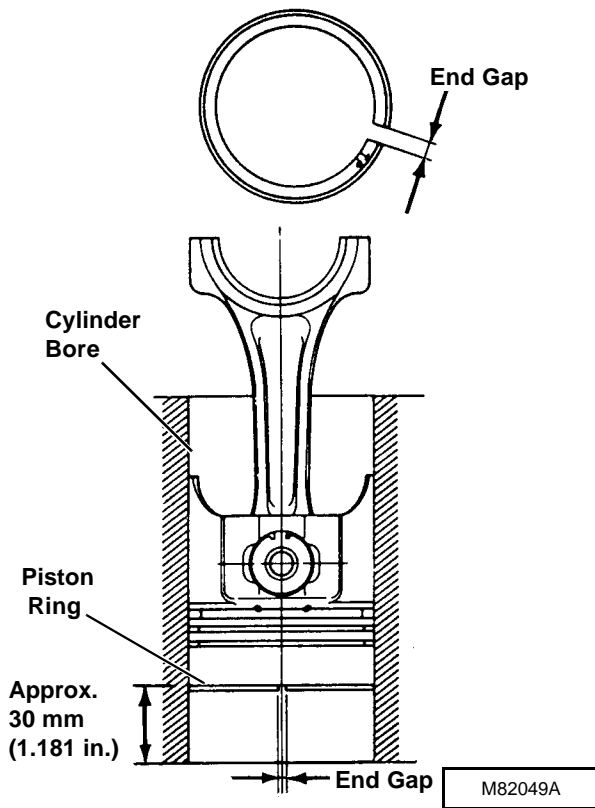
- Standard 0.45 - 0.080 mm
.....(0.0018 - 0.0031 in.)
- Wear Limit..... 0.25 mm (0.0098 in.)

Oil Ring

Standard 0.025 - 0.060 mm
 (0.0010 - 0.0024 in.)
Wear Limit..... 0.20 mm (0.0079 in.)

If clearance exceeds wear limit, replace rings or piston.

6. Measure piston ring end gap. Push ring into cylinder bore, using a piston, until ring is approximately **30 mm (1.181 in.)** from bottom of cylinder bore.



Piston Ring End Gap - 3TN75:

Compression Rings and Oil Ring

Standard 0.20 - 0.40 mm
 (0.008 - 0.016 in.)
Wear Limit..... 1.50 mm (0.0591 in.)

Piston Ring End Gap - 3TN78, 3TNC78 (3011):

Standard

Compression Rings..... 0.25 - 0.40 mm
 (0.010 - 0.016 in.)
Oil Ring 0.20 - 0.40 mm
 (0.008 - 0.016 in.)
Wear Limit..... 1.50 mm (0.0591 in.)

Piston Ring End Gap - 3TN82, 3TNA82:

Standard

First Compression Ring . . . 0.25 - 0.40 mm
 (0.010 - 0.016 in.)
Second Compression Ring . . 0.20 - 0.35 mm
 (0.008 - 0.014 in.)
Oil Ring 0.20 - 0.40 mm
 (0.008 - 0.016 in.)
Wear Limit:..... 1.50 mm (0.0591 in.)

Piston Ring End Gap - 3TN84 (3014):

Standard

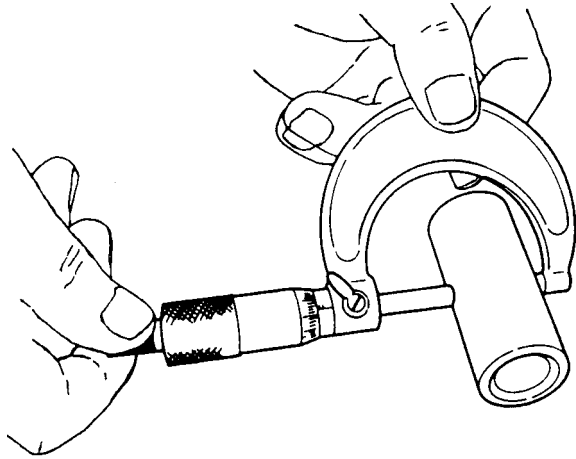
Compression Rings..... 0.20 - 0.40 mm
 (0.008 - 0.016 in.)
Oil Ring 0.25 - 0.45 mm
 (0.010 - 0.018 in.)
Wear Limit:..... 1.50 mm (0.0591 in.)

If end gap exceeds wear limit, replace rings.

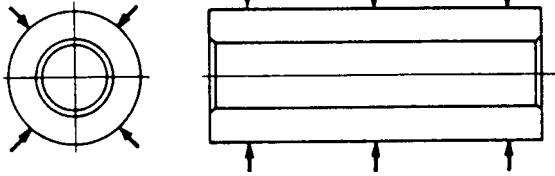
7. Measure piston pin diameter. Measure diameter at six places.

Pistons, Rods and Cylinder Block

2



Measuring Positions



M82050A

Piston Pin O.D. - 3TN75, 3TN78, 3TNC78 (3011):

Standard 22.991 - 23.00 mm
 (0.905 - 0.906 in.)
Wear Limit..... 22.90 mm (0.902 in.)

Piston Pin O.D. - 3TN82, 3TNA82, 3TN84 (3014):

Standard 25.987 - 26.00 mm
 (1.023 - 1.024 in.)
Wear Limit..... 25.90 mm (1.020 in.)

If pin diameter is less than wear limit, replace pin.

8. Measure piston pin bore diameter in piston.



M37683

Piston Pin Bore I.D. - 3TN75, 3TN78, 3TNC78 (3011):

Standard 23.00 - 23.009 mm
 (0.9055 - 0.9059 in.)
Wear Limit..... 23.02 mm (0.906 in.)
Clearance..... 0.045 mm (0.0018 in.)

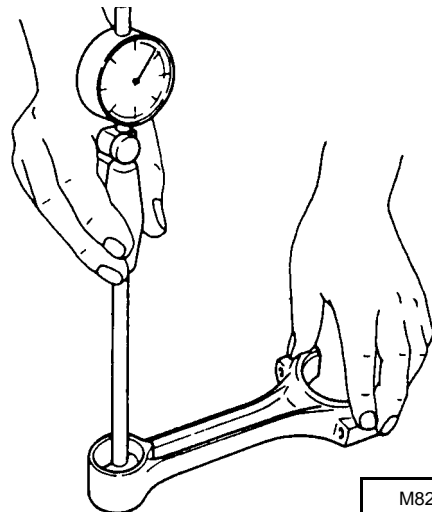
Piston Pin Bore I.D. - 3TN82, 3TNA82, 3TN84 (3014):

Standard 26.00 - 26.009 mm
 (1.0236 - 1.0240 in.)
Wear Limit..... 26.02 mm (1.024 in.)
Clearance..... 0.045 mm (0.0018 in.)

If piston pin bore exceeds wear limit, replace piston.

If bore clearance (bore I.D. minus pin O.D.) exceeds specification, replace piston, piston pin or both.

9. Measure piston pin bushing diameter in connecting rod.



M82051A

Piston Pin Bushing I.D. - 3TN75, 3TN78, 3TNC78 (3011):

Standard	..... 23.025 - 23.038 mm
	..... (0.9065 - 0.9070 in.)
Wear Limit	..... 23.10 mm (0.909 in.)
Clearance	..... 0.110 mm (0.0043 in.)

Piston Pin Bushing I.D. - 3TN82, 3TNA82, 3TN84 (3014):

Standard	..... 26.025 - 26.038 mm
	..... (1.0246 - 1.0251 in.)
Wear Limit	..... 26.10 mm (1.028 in.)
Clearance	..... 0.110 mm (0.0043 in.)

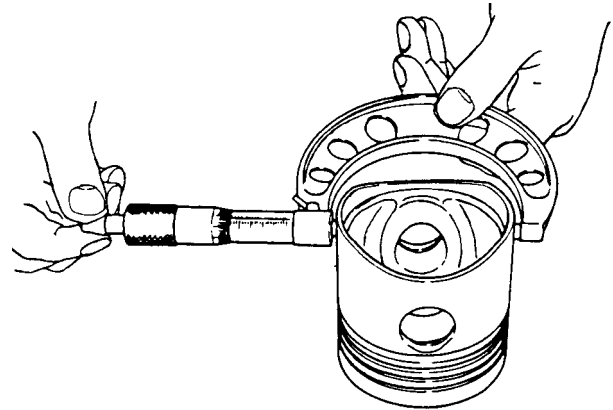
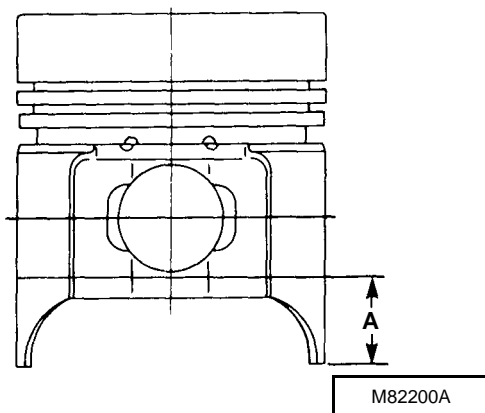
If bushing diameter exceeds wear limit, replace bushing.

If bushing clearance (bushing I.D. minus pin O.D.) exceeds specification, replace bushing, piston pin or both.

Piston pin bushing is press fit. Replace bushing using a driver set. When installing bushing, make sure to align oil hole in bushing with hole in connecting rod.

10. Measure piston diameter perpendicular to piston pin bore at distance A.

NOTE: If engine has had a previous major overhaul, oversize pistons and rings may have been installed. Pistons and rings are available in 0.25 mm (0.010 in.) oversize for all engines and 0.50 mm (0.020 in.) oversize for 3TN75 (F1145 FM), 3TN82 (575 SSL), 3TNC78 (3011 OEM) and 3TN84 (3014 OEM).



Piston O.D. - 3TN75:

Distance A 12.5 mm (0.492 in.)

Standard Size Piston

Standard	..... 74.91 - 74.94 mm
	..... (2.949 - 2.951 in.)
Wear Limit	..... 74.81 mm (2.945 in.)

0.25 mm (0.010 in.) Oversize Piston

Standard	..... 75.17 - 75.18 mm
	..... (2.959 - 2.960 in.)
Wear Limit	..... 75.06 mm (2.955 in.)

0.50 mm (0.020 in.) Oversize Piston (F1145 FM Only)

Standard	..... 75.42 - 75.43 mm
	..... (2.969 - 2.970 in.)
Wear Limit	..... 75.31 mm (2.965 in.)

Piston O.D. - 3TN78, 3TNC78 (3011):

Distance A 23 mm (0.905 in.)

Standard Size Piston

Standard	..... 77.895 - 77.925 mm
	..... (3.067 - 3.068 in.)
Wear Limit	..... 77.81 mm (3.063 in.)

0.25 mm (0.010 in.) Oversize Piston

Standard	..... 78.15 - 78.18 mm
	..... (3.076 - 3.077 in.)
Wear Limit	..... 78.05 mm (3.073 in.)

Pistons, Rods and Cylinder Block

0.50 mm (0.020 in.) Oversize Piston (3011 OEM Only)

Standard 78.40 - 78.42 mm
..... (3.086 - 3.087 in.)
Wear Limit..... 78.30 mm (3.083 in.)

Piston O.D. - 3TN82, 3TNA82:

Distance A 24 mm (0.945 in.)

Standard Size Piston

Standard 81.90 - 81.93 mm
..... (3.224 - 3.226 in.)
Wear Limit..... 81.80 mm (3.221 in.)

2

0.25 mm (0.010 in.) Oversize Piston

Standard 82.15 - 82.17 mm
..... (3.234 - 3.235 in.)
Wear Limit..... 82.05 mm (3.230 in.)

0.50 mm (0.020 in.) Oversize Piston (575 SSL Only)

Standard 82.40 - 82.42 mm
..... (3.244 - 3.245 in.)
Wear Limit..... 82.30 mm (3.240 in.)

Piston O.D. - 3TN84 (3014):

Distance A 24 mm (0.945 in.)

Standard Size Piston

Standard 83.90 - 83.93 mm
..... (3.303 - 3.304 in.)
Wear Limit..... 83.80 mm (3.299 in.)

0.25 mm (0.010 in.) Oversize Piston

Standard 84.15 - 84.17 mm
..... (3.313 - 3.314 in.)
Wear Limit..... 84.05 mm (3.309 in.)

0.50 mm (0.020 in.) Oversize Piston (3014 OEM Only)

Standard 84.40 - 84.42 mm
..... (3.323 - 3.324 in.)
Wear Limit..... 84.30 mm (3.319 in.)

If piston diameter is less than wear limit, install a new piston.

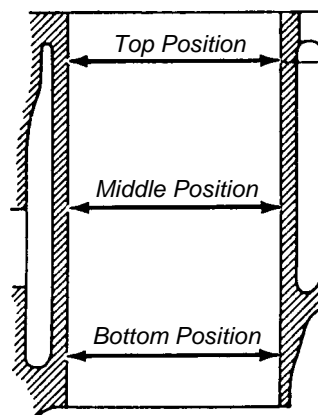
11. Measure cylinder bore diameter. (See procedure in this group.)

CYLINDER BORE

Inspection

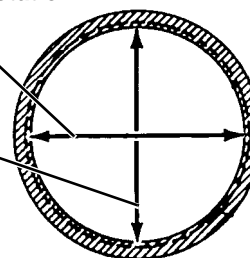
Measure cylinder bore diameter at three positions; top, middle and bottom. At these three positions, measure in both directions; along crankshaft center line and direction of crankshaft rotation.

NOTE: If engine has had a previous major overhaul, oversize pistons and rings may have been installed.



Direction of Crankshaft Rotation

Direction of Crankshaft Centerline



M82053A

Cylinder Bore I.D. - 3TN75:

Standard Size Bore

Standard 75.00 - 75.03 mm
..... (2.953 - 2.954 in.)
Wear Limit 75.20 mm (2.961 in.)
Clearance..... 0.22 mm (0.009 in.)

0.25 mm (0.010 in.) Oversize Bore

Standard 75.25 - 75.28 mm
..... (2.963 - 2.964 in.)
Wear Limit..... 75.45 mm (2.970 in.)
Clearance..... 0.22 mm (0.009 in.)

0.50 mm (0.020 in.) Oversize Bore (F1145 FM Only)

Standard 75.50 - 75.53 mm
..... (2.972 - 2.974 in.)
Wear Limit..... 75.70 mm (2.980 in.)
Clearance..... 0.22 mm (0.009 in.)

Cylinder Bore I.D. - 3TN78, 3TNC78 (3011):

Standard Size Bore

Standard 78.00 - 78.03 mm
..... (3.071 - 3.072 in.)
Wear Limit 78.20 mm (3.079 in.)
Clearance..... 0.22 mm (0.009 in.)

0.25 mm (0.010 in.) Oversize Bore

Standard 78.25 - 78.28 mm
..... (3.081 - 3.082 in.)
Wear Limit..... 78.45 mm (3.089 in.)

0.50 mm (0.020 in.) Oversize Bore (3011 OEM Only)

Standard 78.50 - 78.53 mm
..... (3.091 - 3.092 in.)
Wear Limit..... 78.70 mm (3.099 in.)

Cylinder Bore I.D. - 3TN82, 3TNA82:

Standard Size Bore

Standard 82.00 - 82.03 mm
..... (3.228 - 3.230 in.)
Wear Limit 82.20 mm (3.236 in.)
Clearance..... 0.35 mm (0.014 in.)

0.25 mm (0.010 in.) Oversize Bore

Standard 82.25 - 82.28 mm
..... (3.238 - 3.239 in.)
Wear Limit..... 82.45 mm (3.246 in.)

0.50 mm (0.020 in.) Oversize Bore (575 SSL Only)

Standard 82.50 - 82.53 mm
..... (3.248 - 3.249 in.)
Wear Limit..... 82.70 mm (3.256 in.)

Cylinder Bore I.D. - 3TN84 (3014):

Standard Size Bore

Standard 84.00 - 84.03 mm
..... (3.307 - 3.308 in.)
Wear Limit 84.20 mm (3.315 in.)
Clearance..... 0.35 mm (0.014 in.)

0.25 mm (0.010 in.) Oversize Bore

Standard 84.25 - 84.28 mm
..... (3.317 - 3.318 in.)
Wear Limit..... 84.45 mm (3.325 in.)

0.50 mm (0.020 in.) Oversize Bore (3014 OEM Only)

Standard 84.50 - 84.53 mm
..... (3.327 - 3.328 in.)
Wear Limit..... 84.70 mm (3.335 in.)

If cylinder bore exceeds wear limit, replace cylinder block or have cylinder rebored. (See *Reboring* procedure.)

If cylinder is rebored, oversize pistons and rings must be installed. Pistons and rings are available in 0.25 mm (0.010 in.) oversize for all engines and 0.50 mm (0.020 in.) oversize for 3TN75 (F1145 FM), 3TN82 (575 SSL), 3TNC78 (3011 OEM), and 3TN84 (3014 OEM).

If clearance (cylinder bore I.D. minus piston O.D.) exceeds specification, replace cylinder block, piston or both; or rebore cylinder and install oversize piston and rings.

Pistons, Rods and Cylinder Block

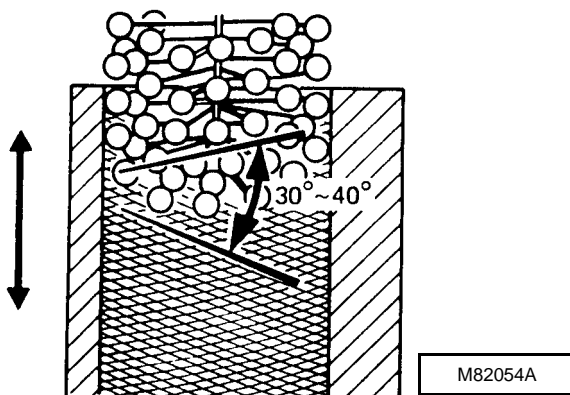
Deglazing

IMPORTANT: If cylinder bores are to be deglazed with crankshaft installed in engine, put clean shop towels over crankshaft to protect journal and bearing surfaces from any abrasives.

1. Deglaze cylinder bores using a flex-hone with 180 grit stones.
2. Use flex-hone as instructed by manufacturer to obtain a **30 - 40° cross-hatch pattern** as shown.

2 **IMPORTANT:** Do not use gasoline, kerosene or commercial solvents to clean cylinder bores. Solvents will not remove all abrasives from cylinder walls.

3. Remove excess abrasive residue from cylinder walls using a clean dry rag. Clean cylinder walls using clean white rags and warm soapy water. Continue to clean cylinder until white rags show no discoloration.



Reboring

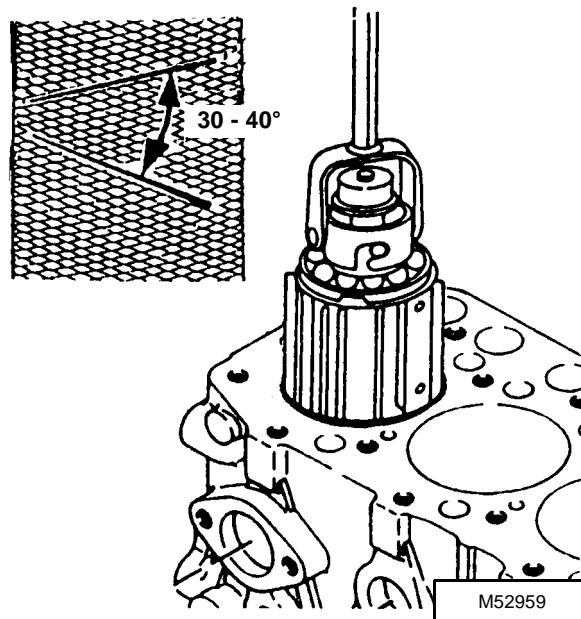
NOTE: The cylinder block can be rebored to use oversize pistons and rings. Pistons and rings are available in 0.25 mm (0.010 in.) oversize for all engines and 0.50 mm (0.020 in.) oversize for 3TN75 (F1145 FM), 3TN82 (575 SSL), 3TNC78 (3011 OEM) and 3TN84 (3014 OEM). (See this group for cylinder bore I. D. specifications.)

1. Align center of bore to drill press center.

IMPORTANT: Check stone for wear or damage. Use a rigid hone with 300 grit stones.

2. Adjust hone so lower end is even with lower end of cylinder bore.

3. Adjust rigid hone stones until they contact narrowest point of cylinder.
4. Coat cylinder with honing oil. Hone should turn by hand. Adjust if too tight.
5. Run drill press at about 250 RPM. Move hone up and down in order to obtain a **30 - 40° crosshatch pattern**.



NOTE: Measure bore when cylinder is cool.

6. Stop press and check cylinder diameter.

NOTE: Finish should not be smooth. It should have a 30 - 40° crosshatch pattern.

7. Remove rigid hone when cylinder is within 0.03 mm (0.001 in.) of desired size.
8. Use a flex hone with 180 grit stones for honing to final size.
9. Check bore for size, taper and out-of-round. (See *Inspection* procedures.)

IMPORTANT: Do not use solvents to clean cylinder bore. Solvents will not remove all metal particles and abrasives produced during honing.

10. Clean cylinder thoroughly using warm soapy water until clean white rags show no discoloration.
11. Dry cylinder and apply engine oil.

OTHER MATERIALS

Number	Name	Use
LOCTITE® PRODUCTS U.S./ Canadian/ LOCTITE No.		
TY15130/ NA/ #395	John Deere Form-In-Place Gasket	Seals crankcase extension housing, rear oil seal case and flywheel housing to engine block.

SERVICE PARTS KITS

The following kits are available through your parts catalog:

- Cylinder Block Gasket Kit
- Undersized Main Bearing Inserts

Crankshaft, Main Bearings and Flywheel

CRANKCASE EXTENSION HOUSING - 3TN75, 3TNC78 (3011 OEM), 3TN82 (575 SSL), 3TN84 (955 CUT, 3014 OEM)

1. Remove flywheel. (See procedure in this group.)
2. Remove oil pan and oil strainer. (See *Lubrication System* in this section.)
3. Remove seal case-to-extension cap screws and flywheel plate/housing-to-extension cap screws.

2



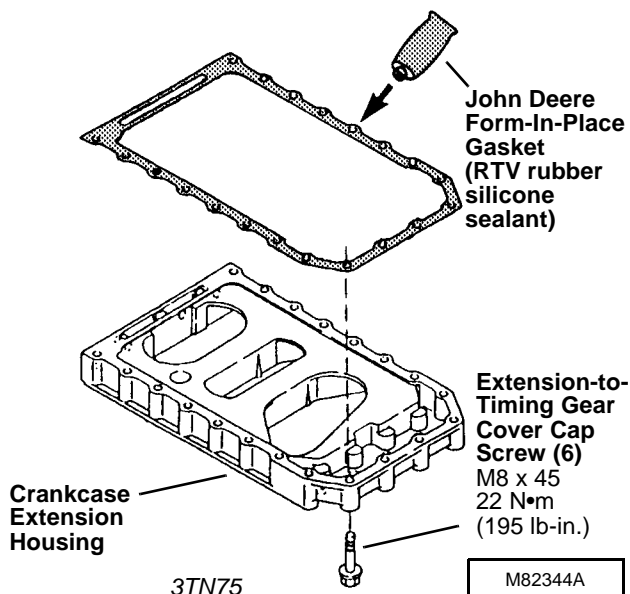
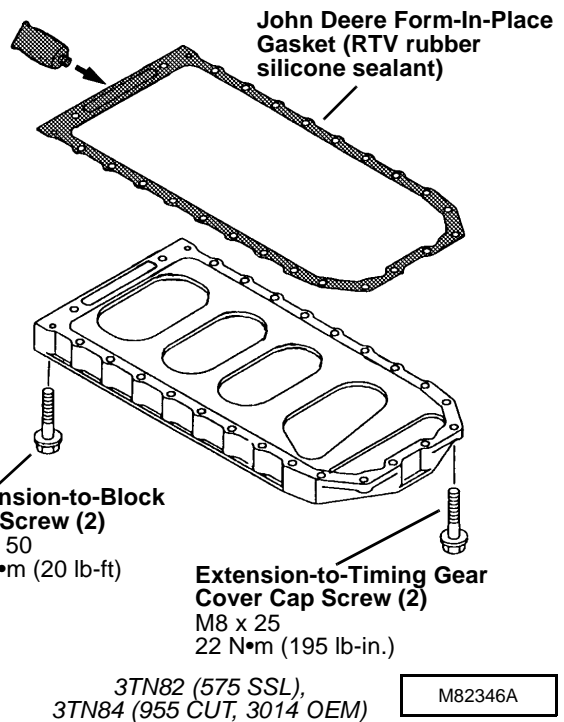
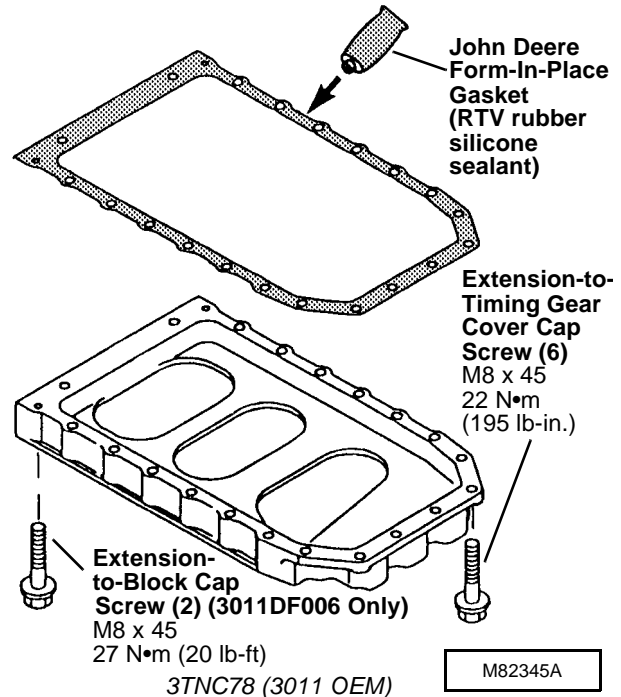
**Seal Case - to-
Extension Cap
Screw (3)**
M8 x 35
26 N•m (226 lb-in.)

**Flywheel Plate/Housing-to-
Extension Cap Screw (4)**
M10 x 25 (Flywheel Plate)
M10 x 30 (Flywheel Housing)
49 N•m (36 lb-ft)

M82056

4. Remove remaining cap screws and extension housing.

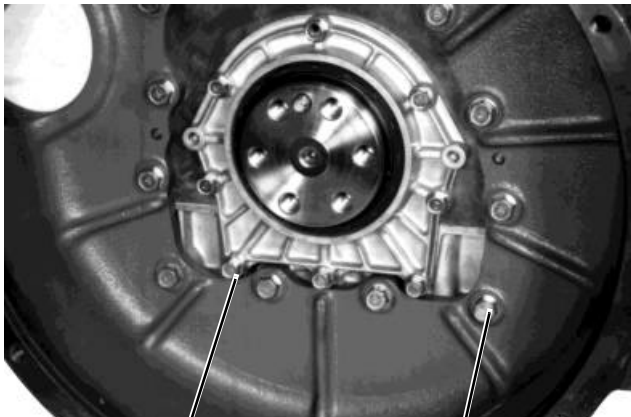
Installation is done in the reverse order of removal.



CRANKCASE EXTENSION HOUSING - 3TN78 (25 EX), 3TN82 (30 EX), 3TNA82 (770 CUT), 3TN84 (870 CUT)

1. Remove flywheel. (See procedure in this group.)
2. Remove oil pan/plate. (See *Lubrication System* in this section.)

- Remove seal case-to-extension cap screws and flywheel plate/housing-to-extension cap screws.



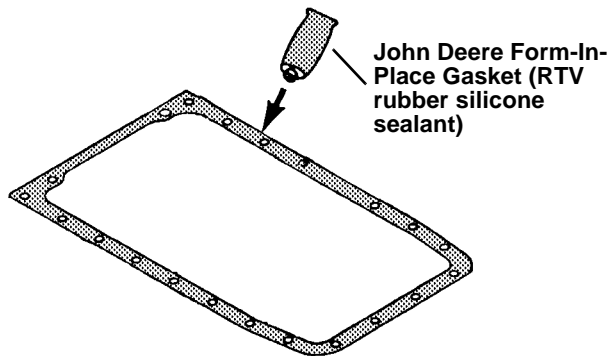
Seal Case - to-Extension Cap Screw (3)
M8 x 30
26 N•m (226 lb-in.)

Flywheel Plate/Housing-to-Extension Cap Screw
Plate: (4) M10 x 20
Housing: (2) M10 x 25
49 N•m (36 lb-ft)

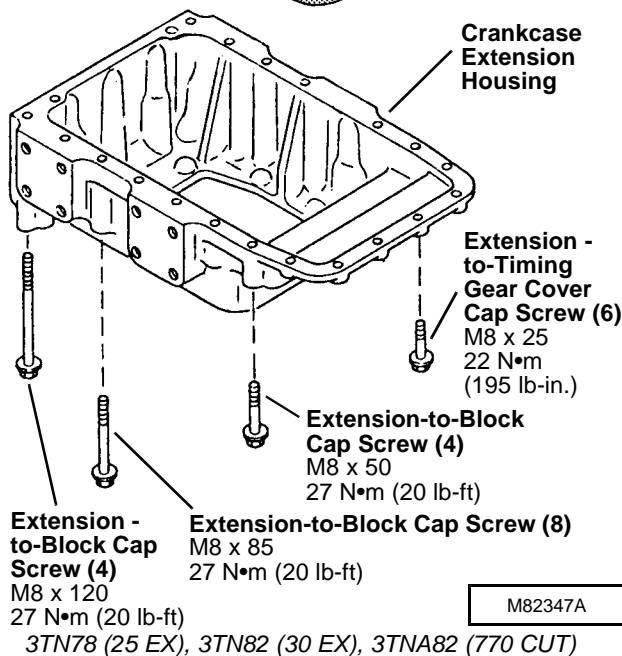
M82056

- Remove remaining cap screws and extension housing.

Installation is done in the reverse order of removal.



John Deere Form-In-Place Gasket (RTV rubber silicone sealant)



Crankcase Extension Housing

Extension - to-Timing Gear Cover Cap Screw (6)
M8 x 25
22 N•m (195 lb-in.)

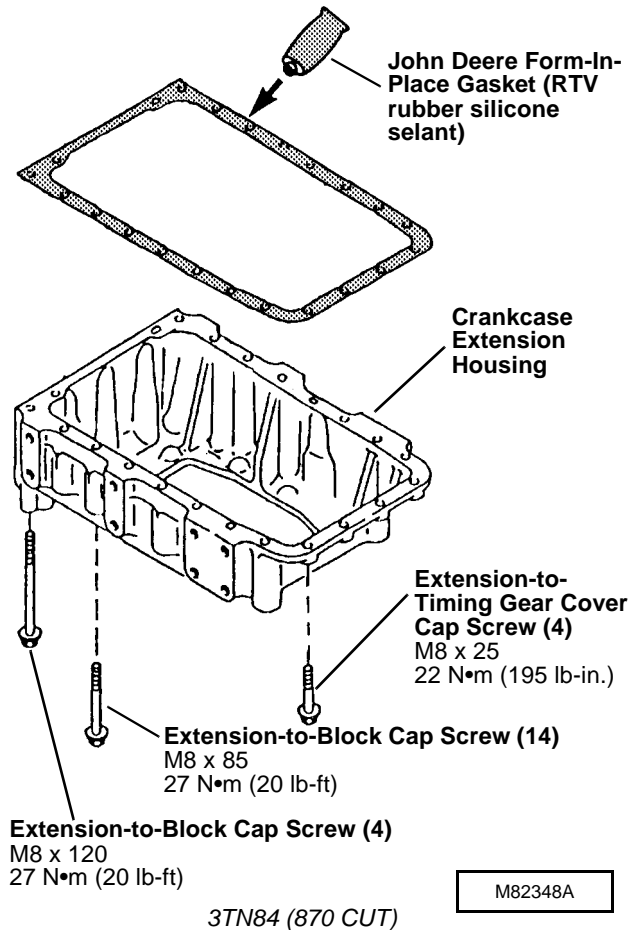
Extension-to-Block Cap Screw (4)
M8 x 50
27 N•m (20 lb-ft)

Extension - to-Block Cap Screw (4)
M8 x 120
27 N•m (20 lb-ft)

Extension-to-Block Cap Screw (8)
M8 x 85
27 N•m (20 lb-ft)

M82347A

3TN78 (25 EX), 3TN82 (30 EX), 3TNA82 (770 CUT)



John Deere Form-In-Place Gasket (RTV rubber silicone sealant)

Crankcase Extension Housing

Extension-to-Timing Gear Cover Cap Screw (4)
M8 x 25
22 N•m (195 lb-in.)

Extension-to-Block Cap Screw (14)
M8 x 85
27 N•m (20 lb-ft)

Extension-to-Block Cap Screw (4)
M8 x 120
27 N•m (20 lb-ft)

M82348A

3TN84 (870 CUT)

CRANKSHAFT REAR OIL SEAL

Replacement

- Remove flywheel. (See procedure in this group.)
 - Replace oil seal using a driver set. Install seal, with lip toward cylinder block. Install seal flush with surface of oil seal case.

NOTE: If crankshaft is grooved at oil seal contact point, seal can be installed 3 mm (0.120 in.) farther into oil seal case.

On 3TN78, 3TN82 (30 EX), 3TNA82, 3TN84 (870 CUT): All nine seal case cap screws are M8 x 30 long.

CRANKSHAFT AND MAIN BEARINGS

Removal

1. Check crankshaft end play. (See *Checks, Tests and Adjustments* in this section.)
 2. Remove rear oil seal. (See procedure in this group.)
 3. Remove flywheel housing. (See procedure in this group.)
 4. Remove crankcase extension housing. (See procedure in this group.)
- NOTE: On 3TNA82 and 3TN84 (870 CUT), crankshaft can be removed without removing timing gear cover mounting plate.*
5. Remove timing gear cover mounting plate. (See *Camshaft and Timing Gear Train* in this section.)
 6. Check crankshaft bearing clearance. (See *Checks, Tests and Adjustments* in this section.)

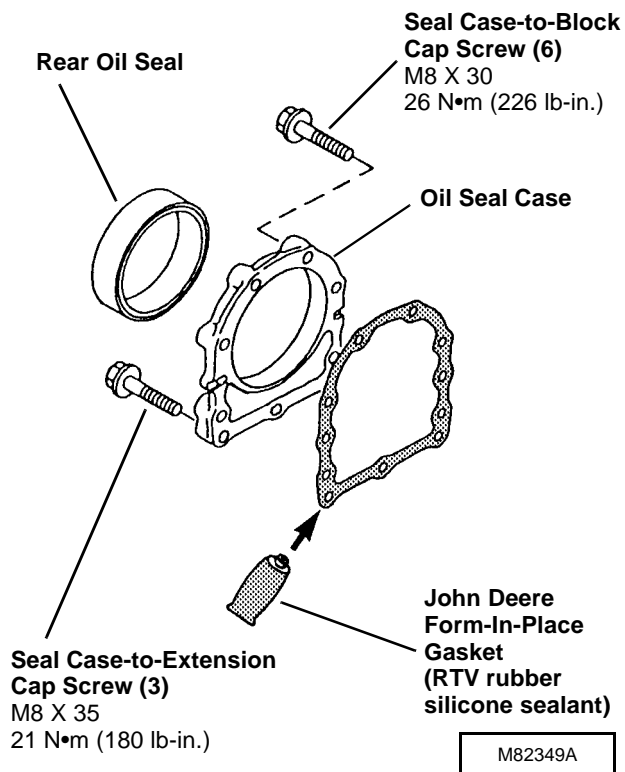
IMPORTANT: Connecting rod end caps must be installed on the same connecting rods from which they were removed. Note alignment marks on caps and rods.

7. Remove connecting rod cap screws and end caps.
8. Push pistons and connecting rods away from crankshaft.

IMPORTANT: Main bearing caps must be installed on the same main bearings from which they were removed.

9. Remove main bearing cap screws, caps and cap thrust bearings.
10. Remove crankshaft.
11. Remove block thrust bearings and main bearing inserts.
12. Inspect all parts for wear or damage. (See *Inspection/Replacement* procedures.)

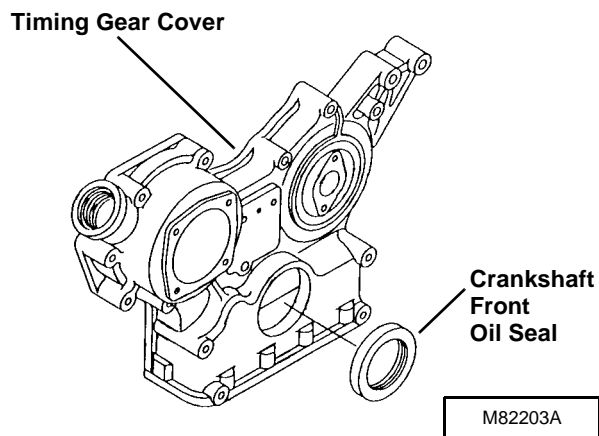
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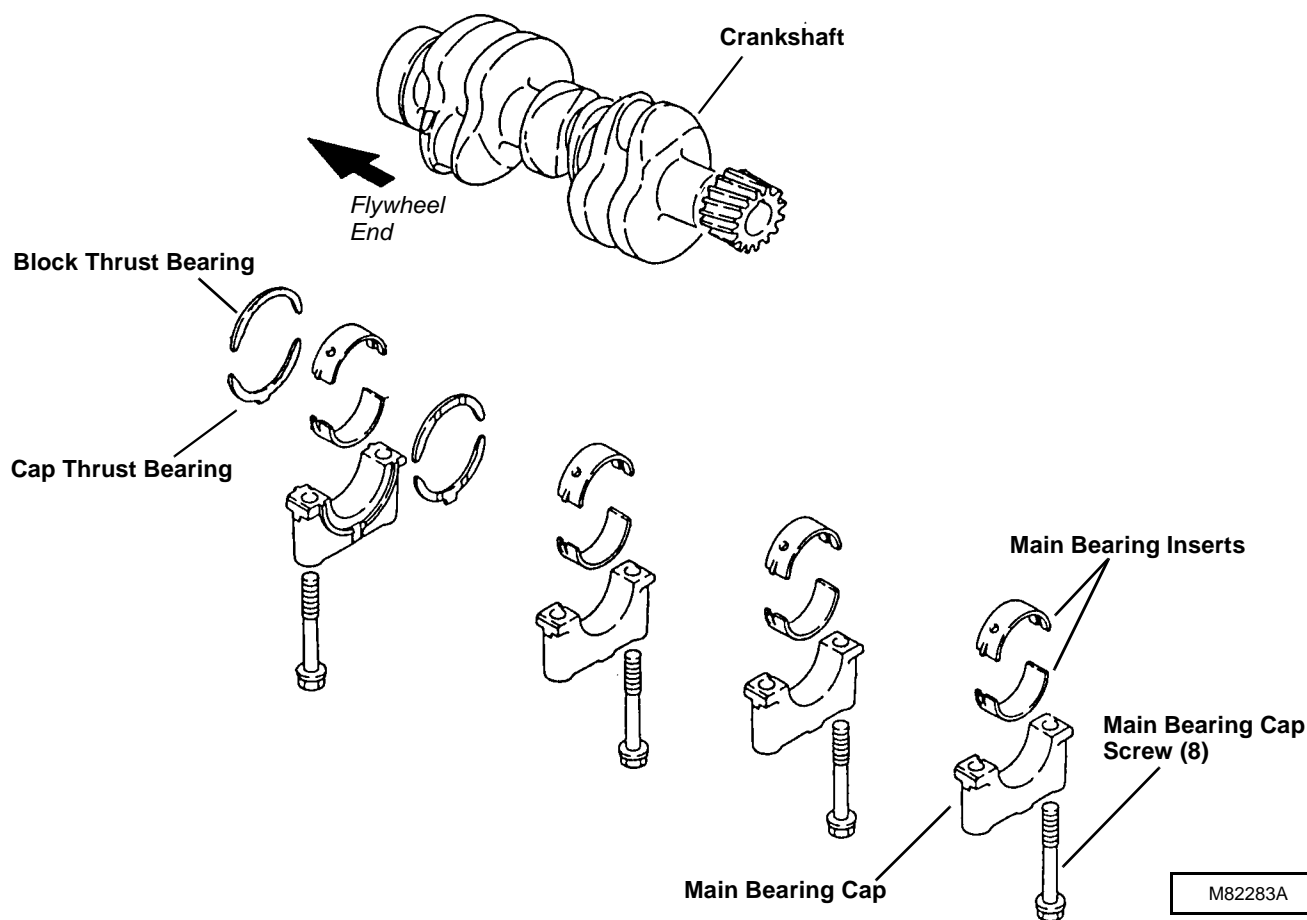


CRANKSHAFT FRONT OIL SEAL

Replacement

- Remove timing gear cover. (See *Camshaft and Timing Gear Train* in this section.)
- Replace oil seal using a driver set. Install seal with lip toward inside of gear housing cover. Install seal flush with surface of cover.





Installation

- Apply clean engine oil on all parts during installation.

IMPORTANT: Do not touch bearing insert surfaces. Oil and acid from your finger will corrode the bearing surface.

1. Install grooved bearing inserts in crankshaft bearing bores, aligning tangs with slots in bores.
2. Install block thrust bearings with oil grooves facing away from engine block.
3. Install crankshaft.
4. Install smooth bearing inserts in main bearing caps, aligning tangs with slots in caps.

NOTE: Main bearing caps have “raised arrows” that are stamped with numbers. Both correspond to their location on the engine block. The number “1” main bearing bore is at flywheel end. Install bearing caps beginning with number 1, then 2, etc. The main bearing cap at gear train end does not have a number. Also install bearing caps with the “arrow” toward the flywheel end.

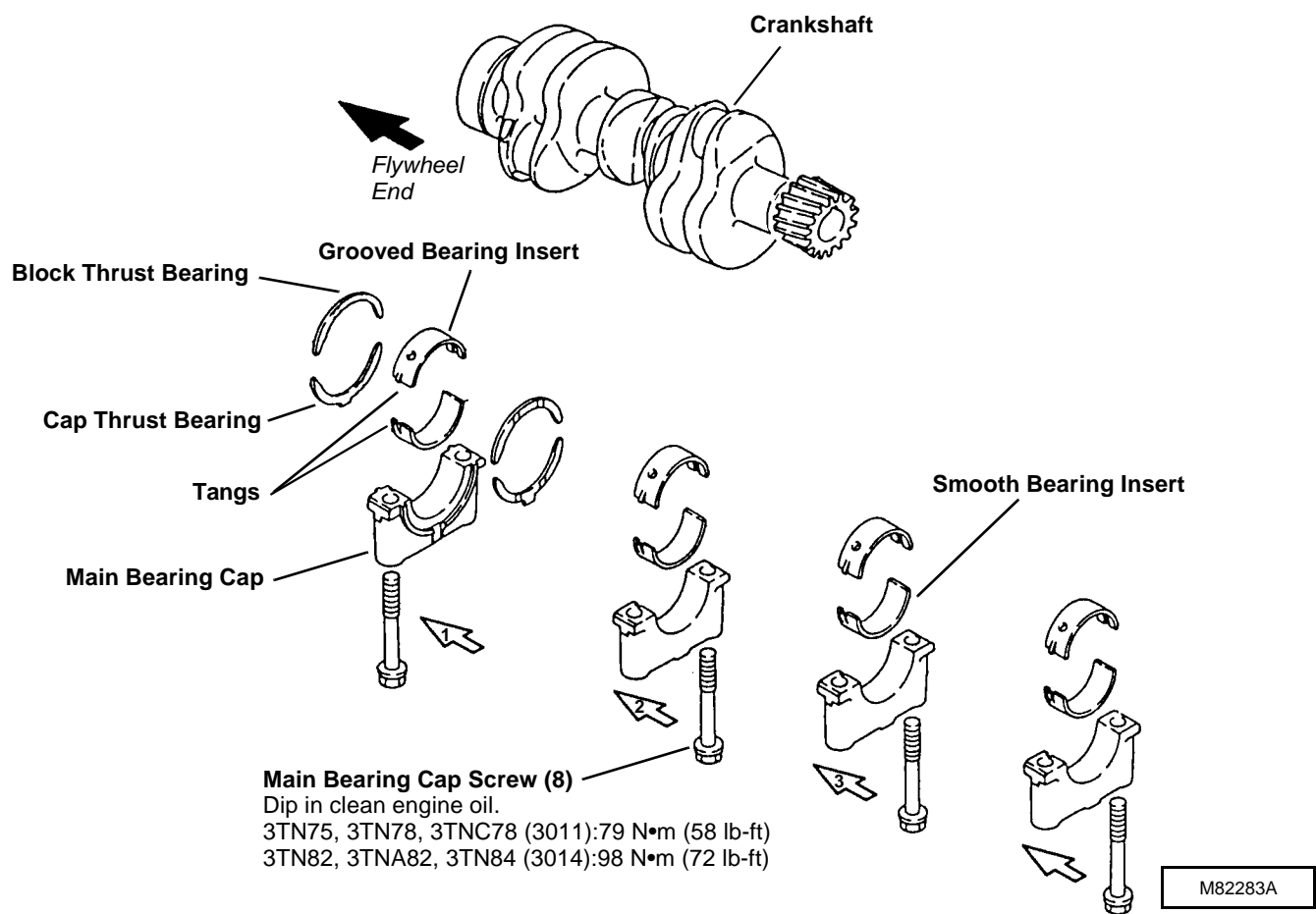
5. Install cap thrust bearings, with oil grooves facing away from cap, in the number “1” main bearing cap.
6. Install main bearing caps in their original locations with arrows pointing toward flywheel side of engine.

IMPORTANT: DO NOT use high speed power tools or air wrenches to tighten main bearing cap screws.

7. Dip entire main bearing cap screws in clean engine oil. Install cap screws and tighten. **DO NOT** tighten to specifications.
8. Using a soft-faced hammer, tap the front end of the crankshaft then the rear end of the crankshaft to align the thrust bearings.
9. Tighten main bearing cap screws to specifications. When tightening, start at center main bearing cap and work your way out, alternating to the ends. Turn crankshaft by hand. If it does not turn easily, disassemble the parts and find the cause.

Crankshaft, Main Bearings and Flywheel

2



IMPORTANT: Connecting rod caps must be installed on the same connecting rods they were removed from.

Never reuse connecting rod cap screws, replace with new.

- 10. Match the connecting rod caps to the rods using alignment marks. Install caps.
- 11. Dip entire connecting rod cap screws in clean engine oil. Install new cap screws and tighten to specifications.

NOTE: On 3TNA82 and 3TN84 (870 CUT), crankshaft can be installed without removing timing gear cover mounting plate.

- 12. Install timing gear cover mounting plate. (See *Camshaft and Timing Gear Train* in this section.)
- 13. Install crankcase extension housing. (See procedure in this group.)
- 14. Install flywheel housing. (See procedure in this group.)
- 15. Install rear oil seal. (See procedure in this group.)

Connecting Rod Cap Screw Torque Specifications:

- 3TN75, 3TN78,
3TNC78 (3011) 39 N•m (29 lb-ft)
- 3TN82, 3TNA82,
3TN84 (3014) 47 N•m (35 lb-ft)

Inspection/Replacement

1. Inspect crankshaft gear for chipped or broken teeth. Replace if necessary.

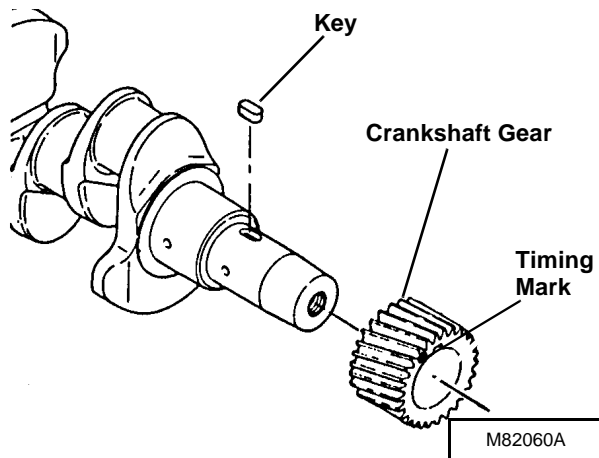
To replace gear:

Remove gear from crankshaft using a knife-edge puller and a press.

CAUTION

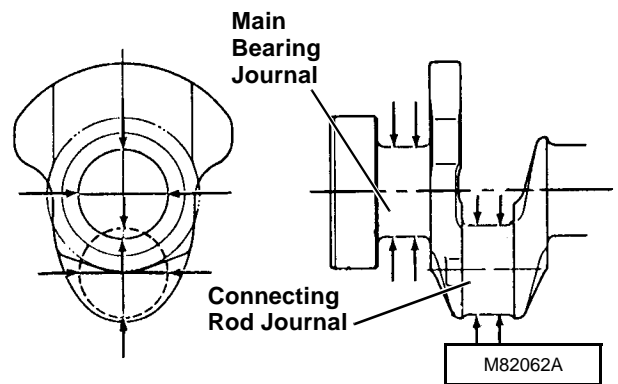
DO NOT heat oil over 182° C (360° F). Oil fumes or oil can ignite above 193° C (380° F). Use a thermometer. Do not allow a flame or heating element to come in direct contact with the oil. Heat the oil in a well-ventilated area. Plan a safe handling procedure to avoid burns.

Heat gear to approximately 150°C (300°F). Install gear with timing mark "A" toward press table. Align slot in gear with key in shaft. Press crankshaft into gear until gear is tight against crankshaft shoulder.



2. Inspect crankshaft for bend using v-blocks and a dial indicator. Turn crankshaft slowly and read variation on indicator. If variation is greater than **0.02 mm (0.0007 in.)**, replace crankshaft.
3. Measure crankshaft connecting rod journal and main bearing journal diameters. Measure several places around each journal.

NOTE: If engine has had a previous major overhaul, journals may have been ground and undersized bearing inserts installed.

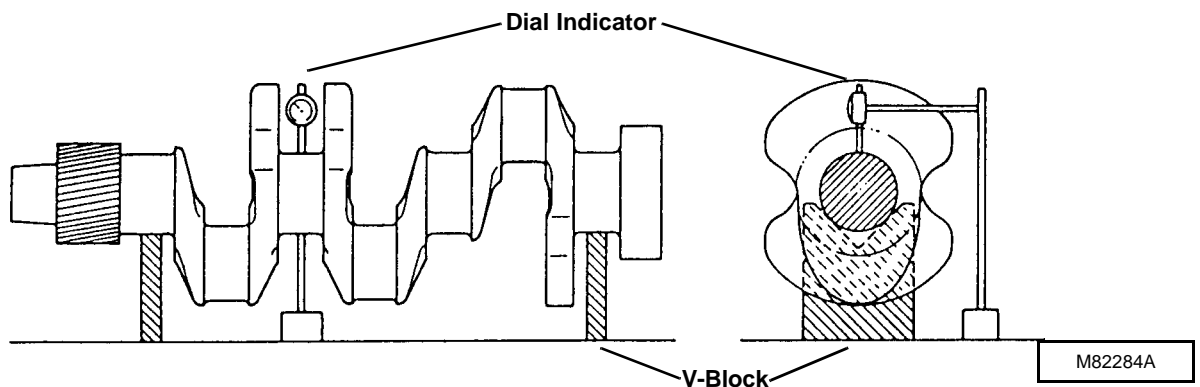


Connecting Rod Journal O.D. - 3TN75, 3TN78, 3TNC78 (3011):

Standard 42.952 - 42.962 mm
 (1.6910 - 1.6914 in.)
 Wear Limit..... 42.91 mm (1.689 in.)

Connecting Rod Journal O.D. - 3TN82, 3TNA82, 3TN84 (3014):

Standard 47.952 - 47.962 mm
 (1.8879 - 1.8883 in.)
 Wear Limit..... 47.91 mm (1.886 in.)



Crankshaft, Main Bearings and Flywheel

Main Bearing Journal O.D. - 3TN75, 3TN78, 3TNC78 (3011):

Standard 46.952 - 46.962 mm
..... (1.8485 - 1.8489 in.)
Wear Limit..... 46.91 mm (1.847 in.)

Main Bearing Journal O.D. - 3TN82, 3TNA82, 3TN84 (3014):

Standard 46.952 - 46.962 mm
..... (1.9666 - 1.9670 in.)
Wear Limit..... 49.90 mm (1.965 in.)

2 If journal diameter is less than wear limit, replace crankshaft or have journals ground undersize by a qualified machine shop.

If journals are ground, undersize bearing inserts must be installed. Bearing inserts are available in 0.25 mm (0.010 in.) undersize.

4. Install bearing inserts and main bearing cap on main bearing. Tighten main bearing cap screws to specifications.

Main Bearing Cap Screw Torque Specifications:

3TN75, 3TN78,
3TNC78 (3011) 79 N•m (58 lb-ft)

3TN82, 3TNA82,
3TN84 (3014) 98 N•m (72 lb-ft)

5. Measure main bearing diameter.

Main Bearing I.D. - 3TN75, 3TN78, 3TNC78 (3011):

Standard 47.00 - 47.045 mm
..... (1.850 - 1.852 in.)
Wear Limit..... 47.10 mm (1.8541 in.)
Clearance..... 0.15 mm (0.0059 in.)

Main Bearing I.D. - 3TN82, 3TNA82, 3TN84 (3014):

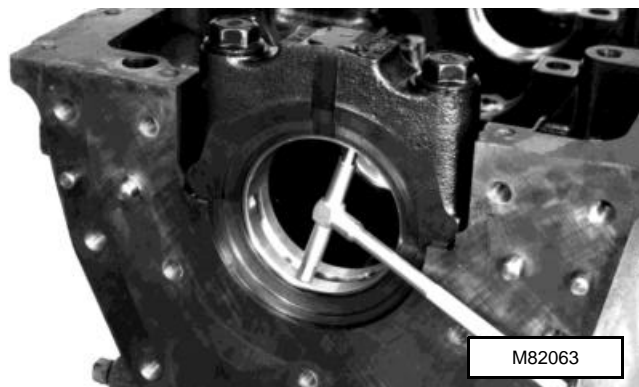
Standard 50.00 - 50.045 mm
..... (1.969 - 1.970 in.)
Wear Limit..... 50.10 mm (1.972 in.)
Clearance..... 0.15 mm (0.0059 in.)

If bearing diameter exceeds wear limit, replace bearing inserts.

If bearing clearance (bearing I.D. minus crankshaft main bearing journal O.D.) exceeds specification, replace bearing inserts and crankshaft or have crankshaft journals ground undersize by a qualified machine shop and install undersized bearing inserts.

Bearing inserts are available in 0.25 mm (0.010 in.) undersize.

6. Clean and inspect oil passages in main bearing journals, connecting rod journals and main bearing bores in cylinder block.
7. Inspect crankshaft for cracks or damage. Replace if necessary.

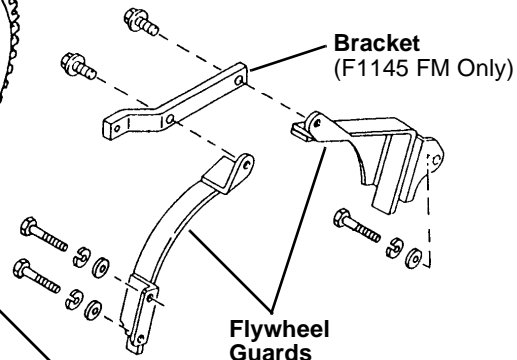
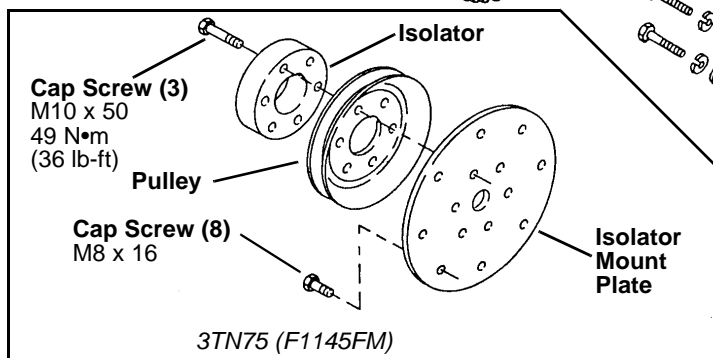
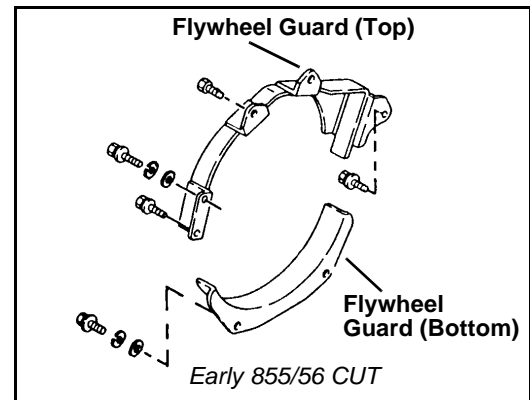
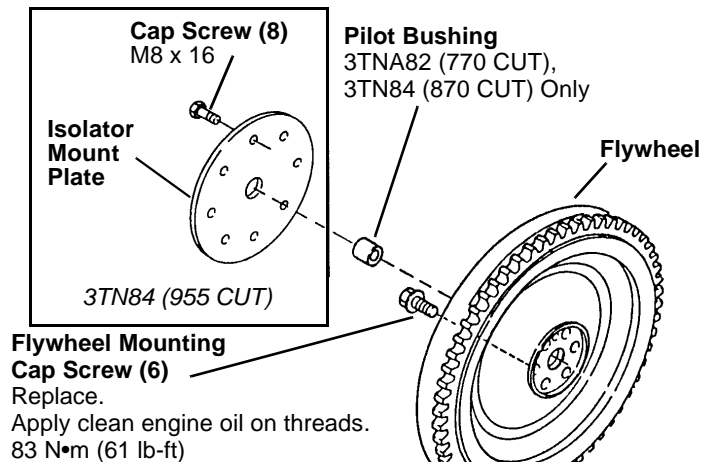
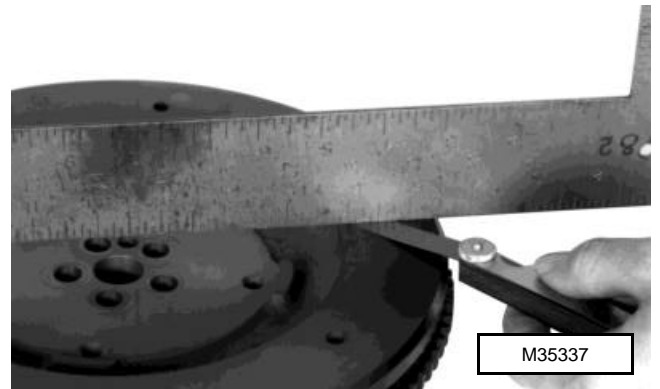


FLYWHEEL

IMPORTANT: Never reuse flywheel mounting cap screws. Always install new.

- 3TN75 (F1145FM): Remove cooling fan, isolator, pulley, isolator mount plate and flywheel guards.
 - 3TN75 (855/56 CUT): Remove flywheel guards.
 - 3TN84 (955 CUT): Remove isolator mount plate and flywheel guards.
 - 3TN78, 3TN82: Remove center flex coupler. (See procedure in Machine Technical Manual.)
- Remove mounting cap screws and flywheel.

- Inspect pilot bushing, if equipped, for wear or damage. Replace if necessary using a driver set. Install bushing flush with flywheel surface.
- Measure flywheel flatness. Place a straight edge across flywheel surface opposite of ring gear. Measure clearance between straight edge and flywheel surface with a feeler gauge. If clearance exceeds **0.02 mm (0.0008 in.)**, replace flywheel.



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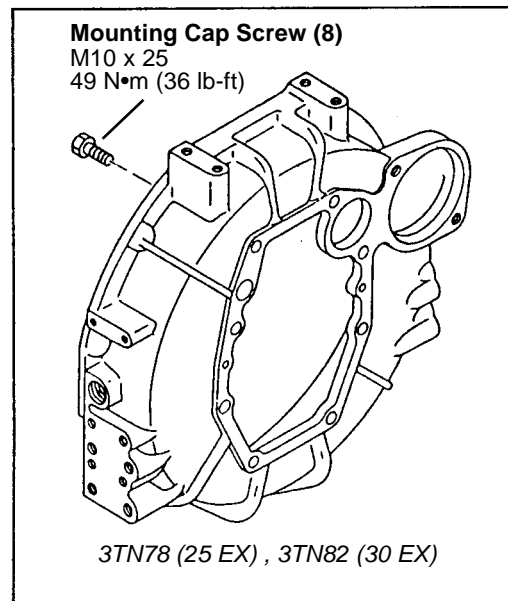
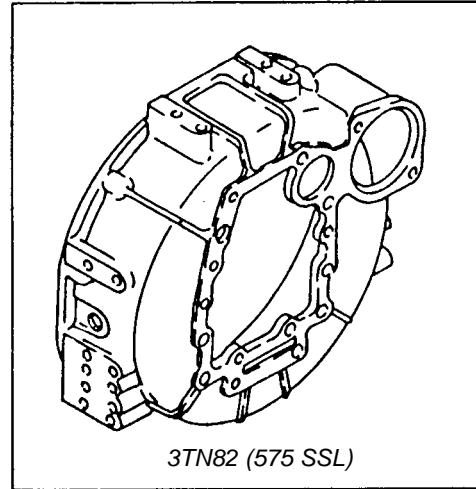
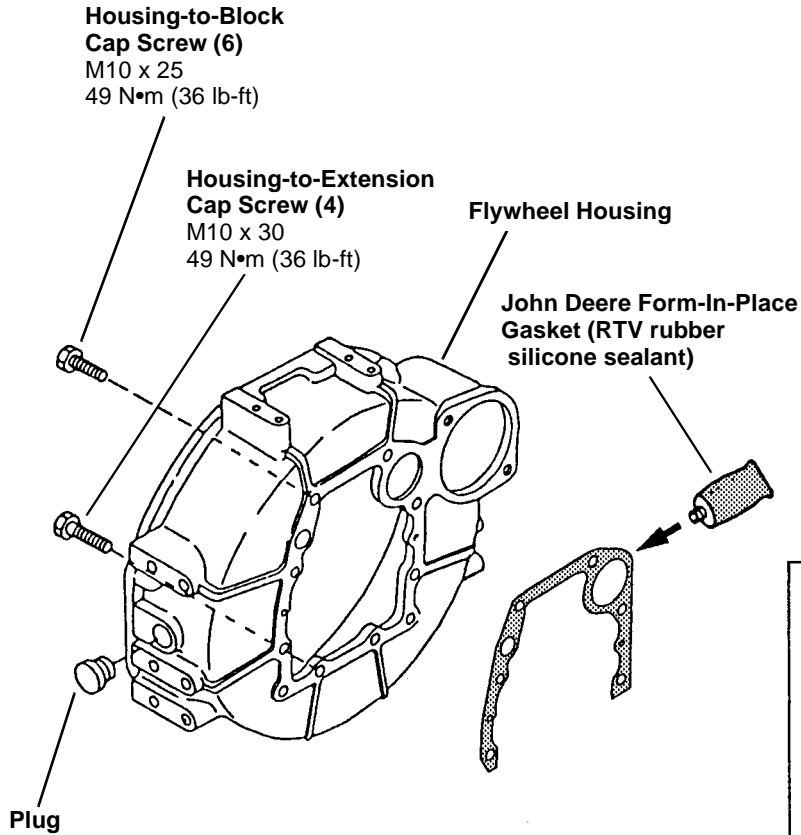
Crankshaft, Main Bearings and Flywheel

FLYWHEEL HOUSING - 3TN78, 3TNC78 (3011), 3TN82, 3TN84 (3014)

1. Remove flywheel. (See procedure in this group.)
2. Remove starter.

NOTE: 3TNC78 (3011DF001 OEM) and 3TN84 (3014DF001 OEM) engines are equipped with a flywheel plate in place of a housing. (See procedure in this group.)

2



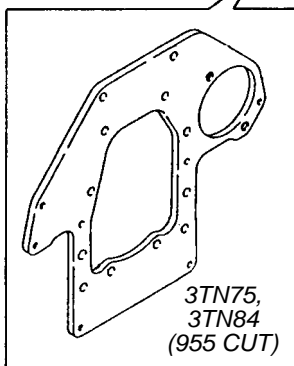
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FLYWHEEL PLATE - 3TN75, 3TNC78 (3011), 3TNA82, 3TN84 (3014)

1. Remove flywheel. (See procedure in this group.)
2. Remove starter.

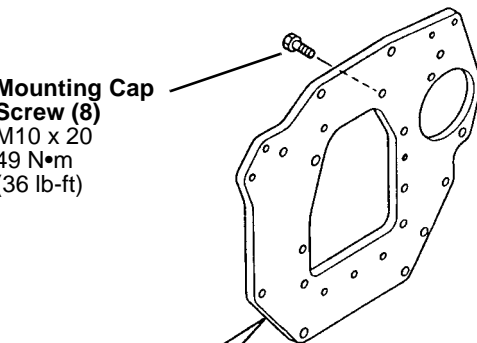
Plate-to-Block Cap Screw (6)
M10 x 20
49 N•m (36 lb-ft)

Plate-to-Extension Cap Screw (4)
M10 x 25
49 N•m
(36 lb-ft)



3TN75, 3TNC78 (3011), 3TN84 (955 CUT, 3014 OEM)

Mounting Cap Screw (8)
M10 x 20
49 N•m
(36 lb-ft)



3TNA82, 3TN84 (870 CUT)

2

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).

D15001NU Magnetic Follower Holder Kit

Hold cam followers when removing and installing camshaft.

OTHER MATERIALS

Number

Name

Use

LOCTITE® PRODUCTS

U.S./

2

Canadian/

LOCTITE No.

TY15130/

John Deere Form-In-Place
Gasket

Seals camshaft plug, timing gear cover and
plate to engine block.

NA/

#395

TY9370/

Thread Lock and Sealer
(Medium Strength)

Apply to threads of crankshaft pulley
cap screw.

TY9477/

#242

SERVICE PARTS KITS

The following kits are available through your parts catalog:

- Cylinder Head Gasket Kit
- Cylinder Block Gasket Kit

® LOCTITE is a registered trademark of the Loctite Corp.

CAMSHAFT

Removal

1. Remove rocker arm assembly and push rods. (See *Cylinder Head, Valves and Manifolds* in this section.)
2. Remove timing gear cover. (See procedure in this group.)
3. Check camshaft end play. (See *Checks, Tests and Adjustments* in this section.)
4. Check backlash of timing gears. (See *Checks, Tests and Adjustments* in this section.)

NOTE: If a magnetic follower holder kit is not available, turn engine until oil pan is upward, to hold cam followers away from camshaft.

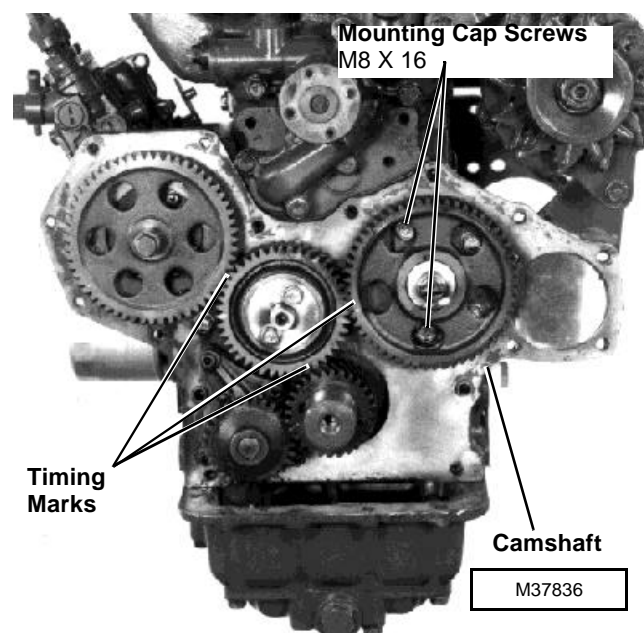
5. Hold cam followers away from camshaft using a magnetic follower holder kit such as D15001NU.

NOTE: Due to the odd number of teeth on the idler gear, timing marks will only align periodically.

6. Rotate crankshaft and align timing marks.

IMPORTANT: DO NOT allow camshaft lobes to hit bearing surfaces while removing camshaft. Machined surfaces can be damaged.

7. Remove two cap screws and camshaft.
8. Inspect all parts for wear or damage. (See *Inspection/Replacement* procedures.)



Installation

- Apply clean engine oil on all parts during installation.

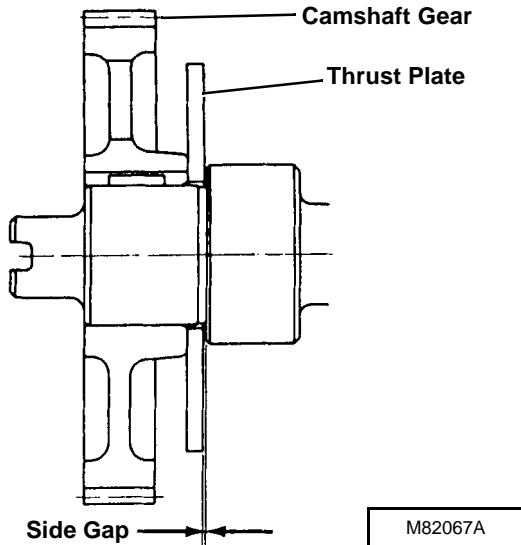
IMPORTANT: DO NOT allow camshaft lobes to hit bearing surfaces while installing camshaft. Machined surfaces can be damaged.

1. Rotate crankshaft to align timing marks.
2. Install camshaft.
3. Install and tighten mounting cap screws to **26 N•m (226 lb-in.)**.
4. Install timing gear cover. (See procedure in this group.)
5. Install push rods and rocker arm assembly. (See *Cylinder Head, Valves and Manifolds* in this section.)

Camshaft and Timing Gear Train

Inspection/Replacement

1. Check camshaft side gap using a feeler gauge.



2

Camshaft Side Gap:

Standard 0.05 - 0.20 mm
..... (0.0020 - 0.0079 in.)

Wear Limit..... 0.40 mm (0.016 in.)

If side gap is at wear limit, remove gear and replace thrust plate.

2. Inspect gear for chipped or broken teeth. Replace if necessary.

To remove/replace gear:

Remove gear from camshaft using a knife-edge puller and a press.

CAUTION

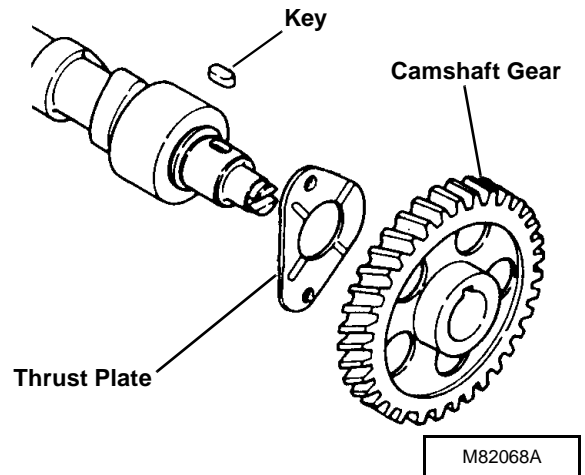
DO NOT heat oil over 182° C (360° F). Oil fumes or oil can ignite above 193° C (380° F). Use a thermometer. Do not allow a flame or heating element to come in direct contact with the oil. Heat the oil in a well-ventilated area. Plan a safe handling procedure to avoid burns.

Heat gear to approximately 150°C (300°F).

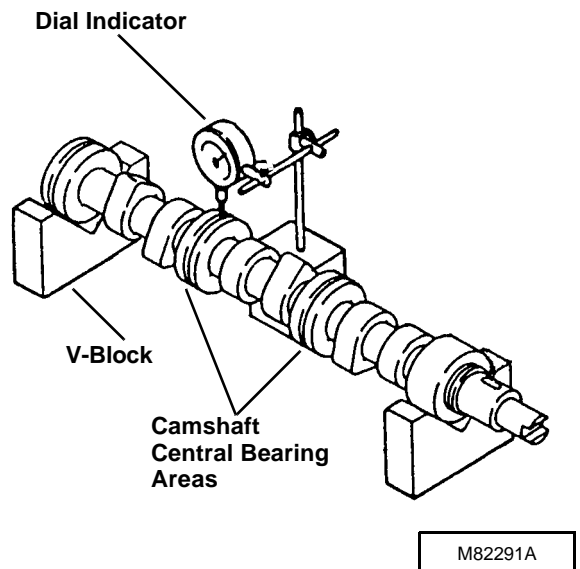
IMPORTANT: Be sure thrust plate is not between camshaft gear and camshaft shoulder while installing gear.

Install thrust plate if removed. Install gear with timing mark "C" side toward press table. Align slot in gear with key in shaft. Press camshaft into gear until gear is tight against camshaft shoulder.

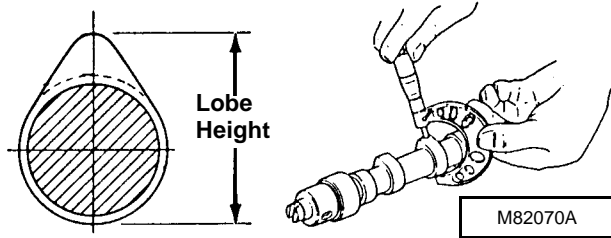
Thrust plate must spin freely on camshaft.



3. Inspect camshaft for bend using v-blocks and a dial indicator. Turn camshaft slowly and read variation on indicator. If variation is greater than 0.02 mm (0.001 in.), replace camshaft.



4. Measure camshaft lobe height.

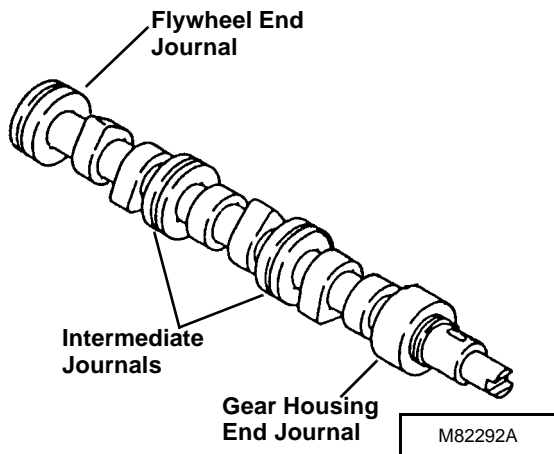


Lobe Height:

- Standard** 38.635 - 38.765 mm
.....(1.521 - 1.526 in.)
- Wear Limit**..... 38.40 mm (1.512 in.)

If lobe height is less than wear limit, replace camshaft.

5. Measure camshaft end and intermediate journal diameters.



Camshaft Journal O.D.:

Gear Housing and Flywheel Ends

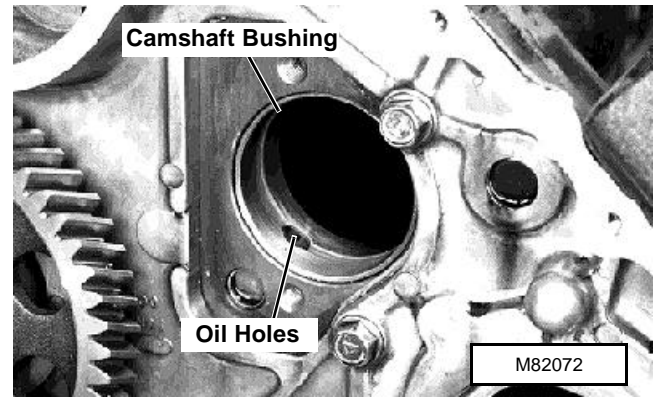
- Standard** 44.92 - 44.95 mm
.....(1.769 - 1.770 in.)
- Wear Limit**..... 44.80 mm (1.764 in.)

Intermediate

- Standard** 44.91 - 44.94 mm
.....(1.768 - 1.769 in.)
- Wear Limit**..... 44.80 mm (1.764 in.)

If journal diameters are less than wear limit, replace camshaft.

6. Measure camshaft bushing diameter at gear housing end.



2

Camshaft Bushing I.D.:

- Standard** 44.990 - 45.055 mm
.....(1.771 - 1.774 in.)
- Wear Limit**..... 45.10 mm (1.776 in.)
- Clearance**..... 0.20 mm (0.0078 in.)

If bushing diameter exceeds wear limit, replace bushing.

If bushing clearance (bushing I.D. minus camshaft journal O.D.) exceeds specification, replace bushing, camshaft or both.

To replace bushing:

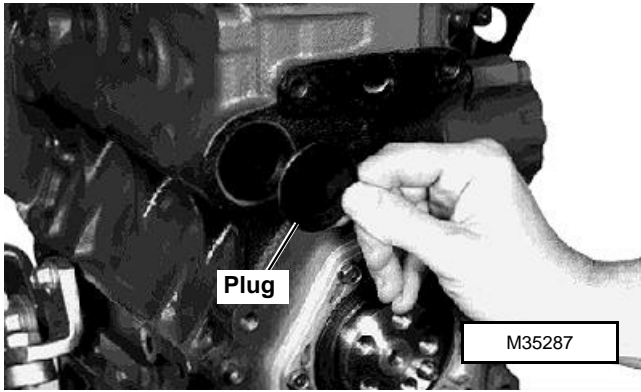
Remove bushing using a chisel. Be careful not to push bushing inside of engine. Align oil holes in new bushing and cylinder block. Install bushing using a driver set.

NOTE: Flywheel housing/plate must be removed to measure camshaft intermediate and flywheel end bearing diameters.

7. Measure intermediate and flywheel end camshaft bore diameters using the following procedures:

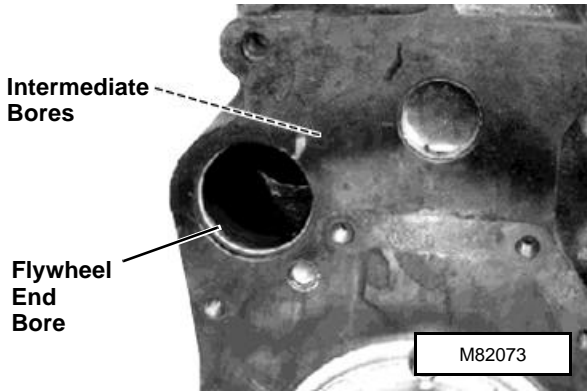
- Remove flywheel housing/plate. (See *Crankshaft, Main Bearings and Flywheel* in this section.)
- Remove plug using a long wooden dowel. Insert wooden dowel through gear housing side.

Camshaft and Timing Gear Train



2

- Measure intermediate and flywheel end camshaft bore diameters.



Camshaft Bore I.D.:

Standard 45.00 - 45.025 mm
 (1.772 - 1.773 in.)

Wear Limit 45.10 mm (1.776 in.)

Clearance 0.20 mm (0.008 in.)

If bore diameter exceeds wear limit, replace cylinder block.

If bore clearance (bore I.D. minus camshaft journal O.D.) exceeds specification, replace camshaft, cylinder block or both.

- Apply John Deere Form-In Place Gasket, or an equivalent, on outer edge of plug. Install plug until it bottoms in bore.
- Install flywheel housing.

CAM FOLLOWERS

Removal/Installation

1. Remove camshaft. (See procedure in this group.)
2. Remove oil pan and strainer. (See *Lubrication System* in this section.)

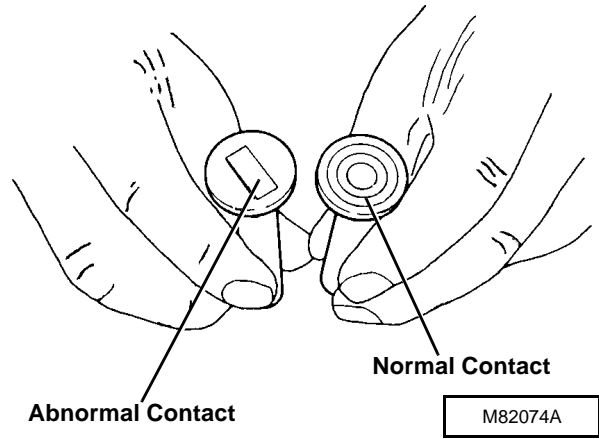
IMPORTANT: Cam followers must be installed in the same bores from which they were removed.

3. Put a mark on each cam follower and cylinder block bore to aid in installation.
4. Remove cam followers.
5. Inspect all parts for wear or damage. (See *Inspection* procedures.)
6. Apply clean engine oil on all parts during installation.

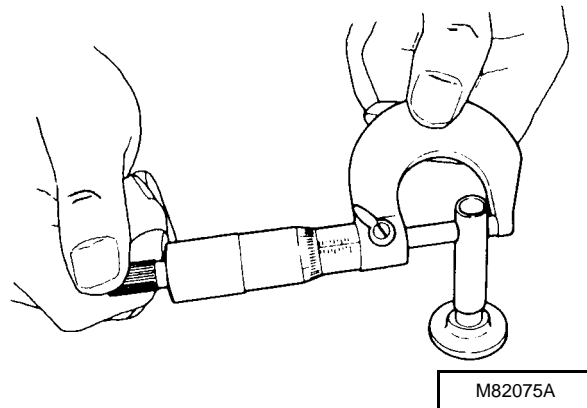
Installation is done in the reverse order of removal.

Inspection

- Inspect cam follower contact surface for abnormal wear. Replace if necessary.



- Measure cam follower stem diameter.



Cam Follower Stem O.D.:

Standard 11.975 - 11.990 mm
(0.471 - 0.472 in.)

Wear Limit..... 11.93 mm (0.470 in.)

If stem diameter is less than wear limit, replace cam follower.

- Measure cam follower bore diameter in cylinder block.

Cam Follower Bore I.D.:

Standard 12.000 - 12.018 mm
(0.472 - 0.473 in.)

Wear Limit..... 12.05 mm (0.474 in.)

Clearance..... 0.10 mm (0.004 in.)

If cam follower bore diameter exceeds wear limit, replace cylinder block.

If bore clearance (bore I.D. minus follower stem O.D.) exceeds specification, replace cam follower, cylinder block or both.

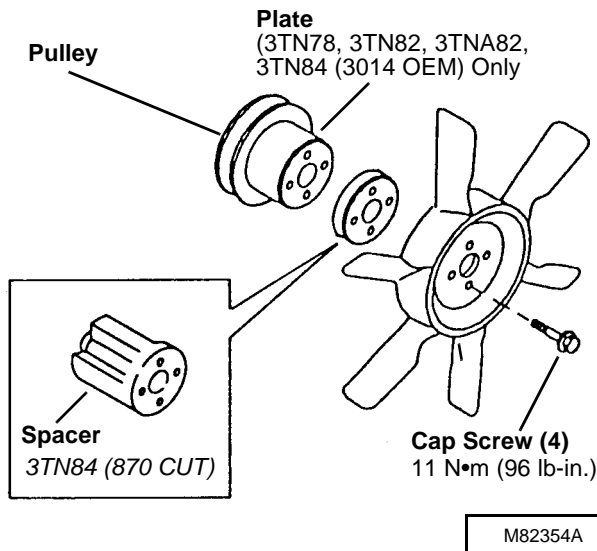
TIMING GEAR COVER

Removal/Installation

1. Remove alternator and belt.

NOTE: 3TN75 (F1145 FM) fan is mounted on flywheel end of engine. Alternator belt pulley does not have to be removed to access timing gear cover.

2. Remove fan, spacer/plate, if equipped, and pulley.



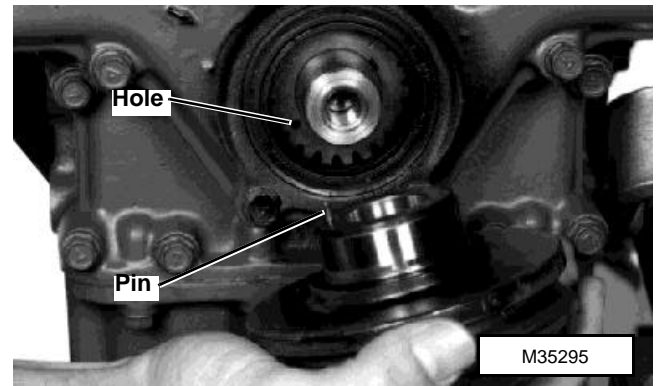
3. Remove crankshaft pulley cap screw and washer.
4. Remove crankshaft pulley using a two-jaw puller kit.
5. Remove key, if equipped.
6. Remove tachometer, if equipped.
7. 3TNA82 (770 CUT), 3TN84 (870 CUT): Remove hydraulic pump and steering pump, if equipped. (See procedure in Machine Technical Manual).

NOTE: It is not necessary to remove auxiliary drive cover and gasket, if equipped, end cover and o-ring or fuel injection pump gear cover to remove timing gear cover.

8. Remove mounting cap screws and timing gear cover.

Installation is done in the reverse order of removal.

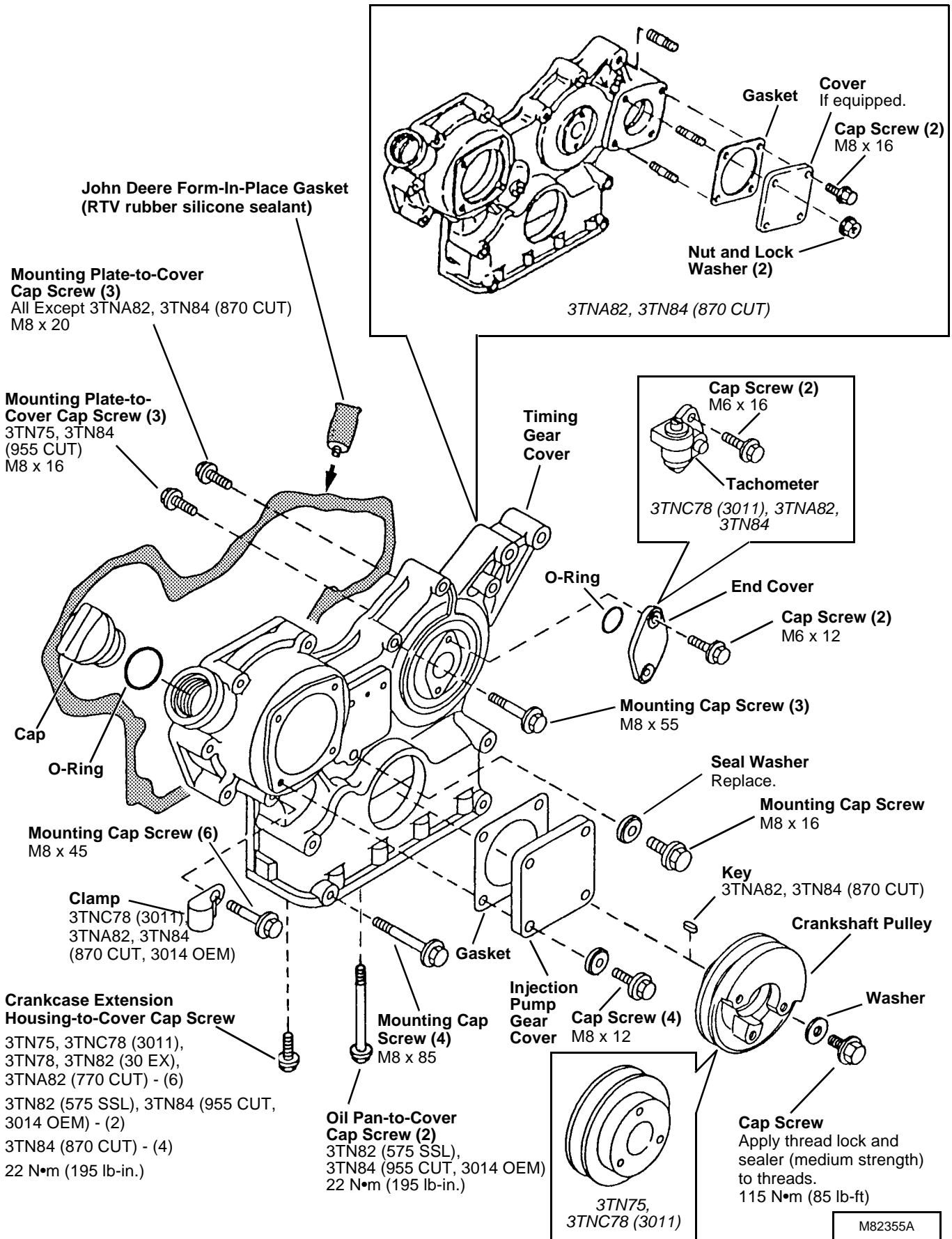
- Replace seal washer.
- Tighten all mounting cap screws to **26 N•m (226 lb-in.)**
- All except 3TNA82 (770 CUT), 3TN84 (870 CUT): Align pin in crankshaft pulley with hole in crankshaft gear. Install crankshaft pulley.



- 3TNA82 (770 CUT), 3TN84 (870 CUT): Install key and crankshaft pulley.
- Adjust fan/alternator drive belt tension. (See *Checks, Tests and Adjustments* in this section.)

Camshaft and Timing Gear Train

2



IDLER GEAR

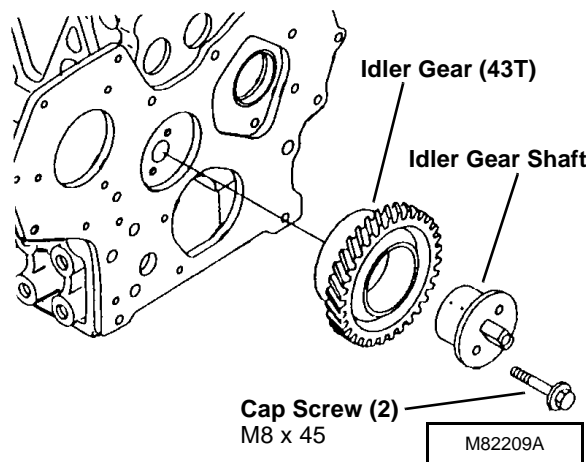
Removal/Installation

1. Remove timing gear cover. (See procedure in this group.)
2. Check backlash of timing gears. (See *Checks, Tests and Adjustments* in this section.)

NOTE: Due to the odd number of teeth on the idler gear, timing marks will only align periodically. When all timing marks on gears align, the piston closest to the water pump is at TDC on compression stroke. Number one cylinder is closest to the flywheel.

3. Rotate crankshaft and align timing marks.
4. Remove two cap screws, shaft and gear.
5. Inspect all parts for wear or damage. (See *Inspection/Replacement* procedures.)

Installation is done in the reverse order of removal.



Inspection/Replacement

- Inspect gear for chipped or broken teeth. Replace if necessary.
- Measure idler gear shaft diameter.

Idler Gear Shaft O.D.:

Standard 45.950 - 45.975 mm
 (1.809 - 1.810 in.)

Wear Limit 45.93 mm (1.808 in.)

If shaft diameter is less than wear limit, replace idler gear shaft.

- Measure idler gear bushing diameter.

Idler Gear Bushing I.D.:

Standard 46.00 - 46.025 mm
 (1.811 - 1.812 in.)

Wear Limit 46.03 mm (1.812 in.)

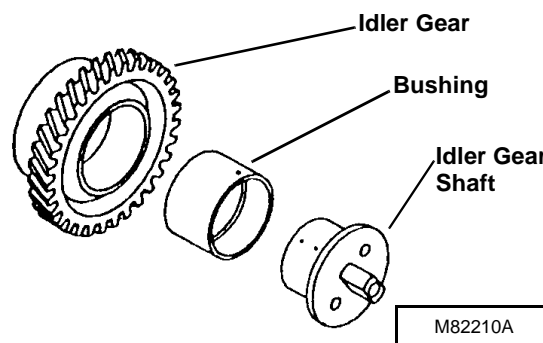
Clearance 0.15 mm (0.0059 in.)

If bushing diameter exceeds wear limit, replace bushing.

To replace bushing:

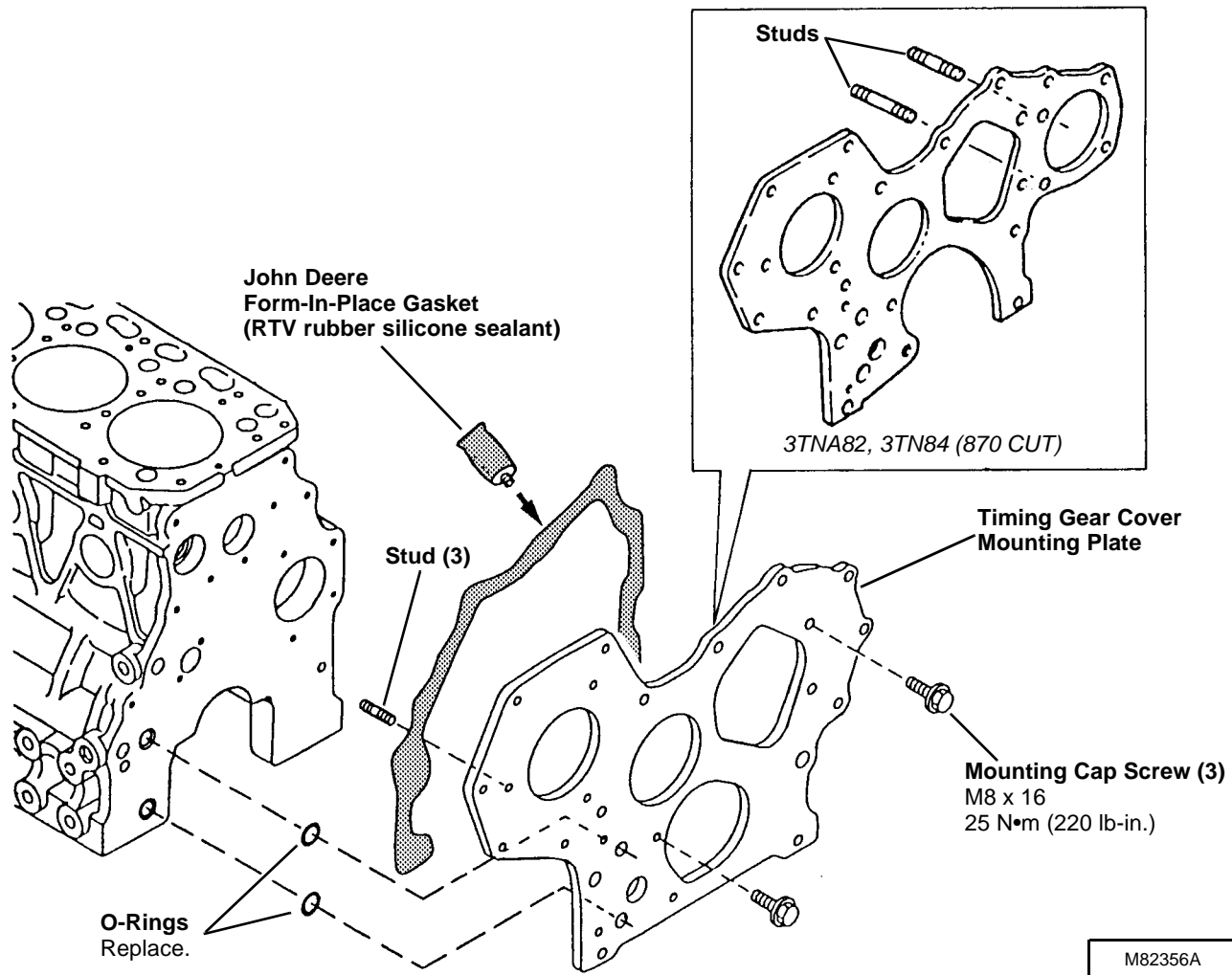
Replace bushing using a driver set. Align oil holes in bushing and idler gear. Install bushing flush with surface of idler gear.

If bushing clearance (bushing I.D. minus shaft O.D.) exceeds specification, replace bushing, shaft or both.



2

2



TIMING GEAR COVER MOUNTING PLATE

Removal/Installation

1. Remove camshaft. (See procedure in this group.)
 2. Remove idler gear. (See procedure in this group.)
 3. Remove fuel injection pump. (See *Fuel System* in this section.)
 4. Remove oil pump. (See *Lubrication System* in this section.)
 5. 3TNA82, 3TN84 (870 CUT): Remove hydraulic pump drive assembly. (See procedure in *Machine Technical Manual*.)
 6. Remove mounting cap screws and plate.
 7. Replace o-rings.
- Installation is done in the reverse order of removal.

OTHER MATERIALS

Number	Name	Use
LOCTITE® PRODUCTS U.S./ Canadian/ Loctite No.		
TY15130/ NA/ #395	John Deere Form-In-Place Gasket	Seals oil pan/plate to crankcase extension housing.

®LOCTITE is a registered trademark of the Loctite Corp.

Lubrication System

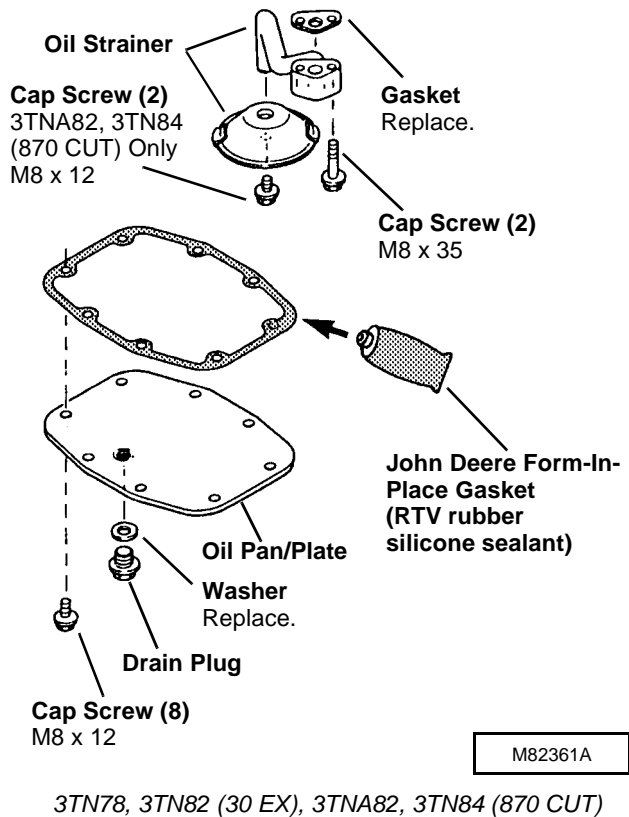
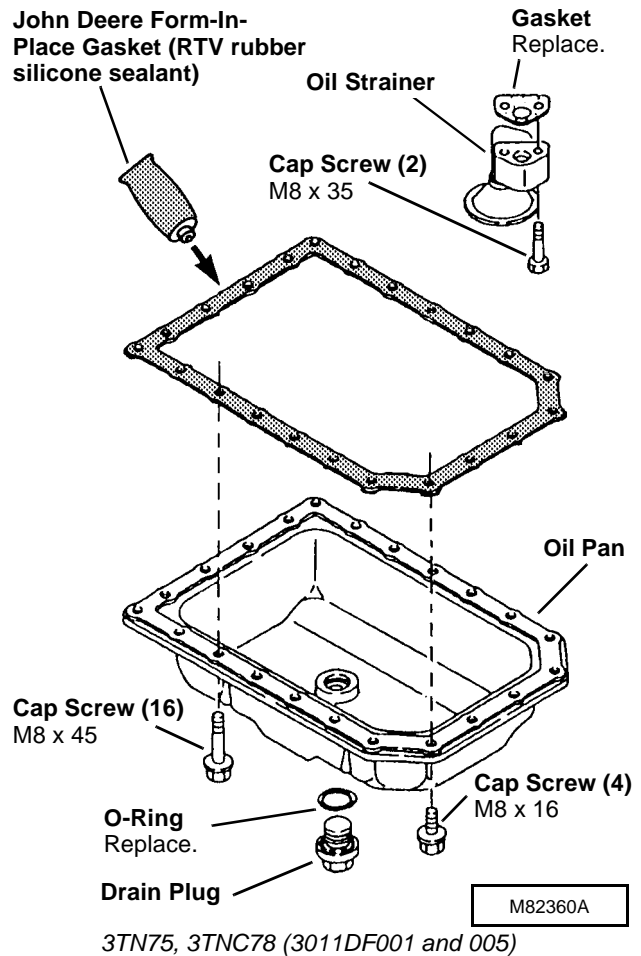
OIL PAN AND STRAINER

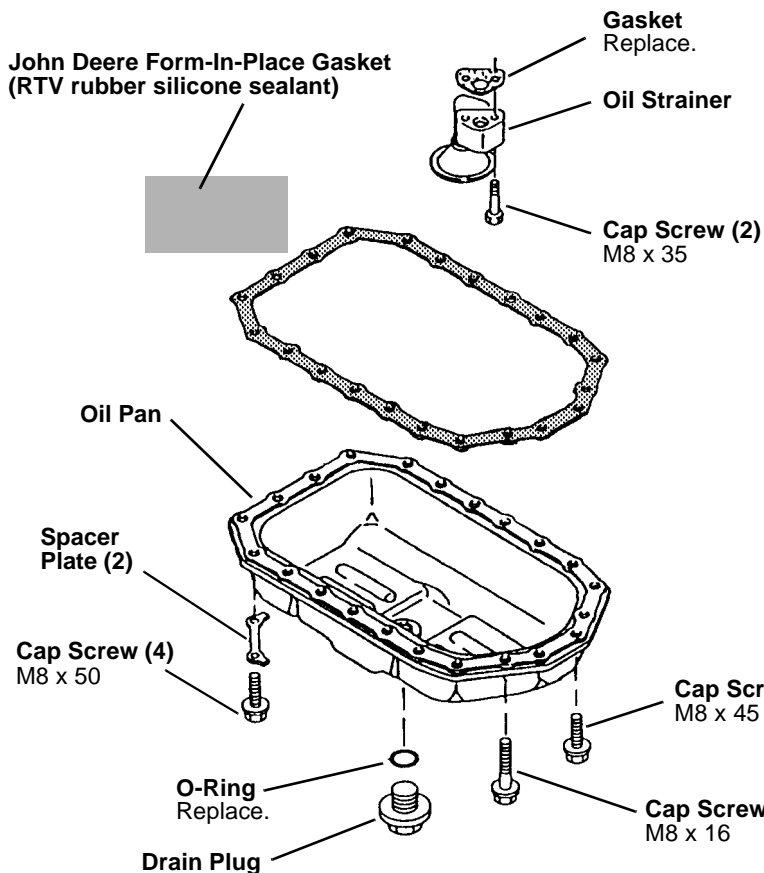
Removal/Installation

2

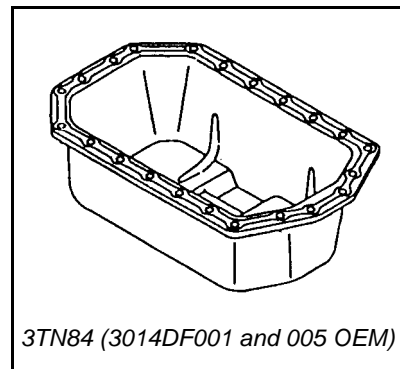
- Approximate crankcase oil capacity is:

3TN75	3.9L (4.1 qt)
3TN78, 3TN82 (30 EX), 3TNA82	4.0L (4.2 qt)
3TNC78 (3011) DF001 and 005	4.2L (4.4 qt)
DF006	6.2L (6.5 qt)
3TN82 (575 SSL)	6.0L (6.3 qt)
3TN84 (870 CUT)	4.8L (5.1 qt)
(955 CUT)	4.3L (4.5 qt)
(3014 OEM) DF001 and 005	5.2L (5.4 qt)
DF006	7.4L (7.7 qt)
- Tighten all cap screws to **26 N•m (226 lb-in.)**.
- Fill engine with proper engine oil. (See *SPECIFICATIONS AND GENERAL INFORMATION* section.)

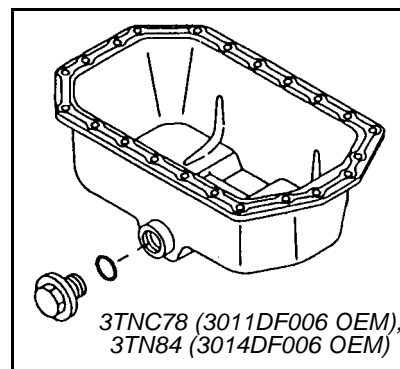




3TNC78 (3011DF006 OEM), 3TN82 (575 SSL), 3TN84 (955 CUT, 3014 OEM)



3TN84 (3014DF001 and 005 OEM)



3TNC78 (3011DF006 OEM),
3TN84 (3014DF006 OEM)

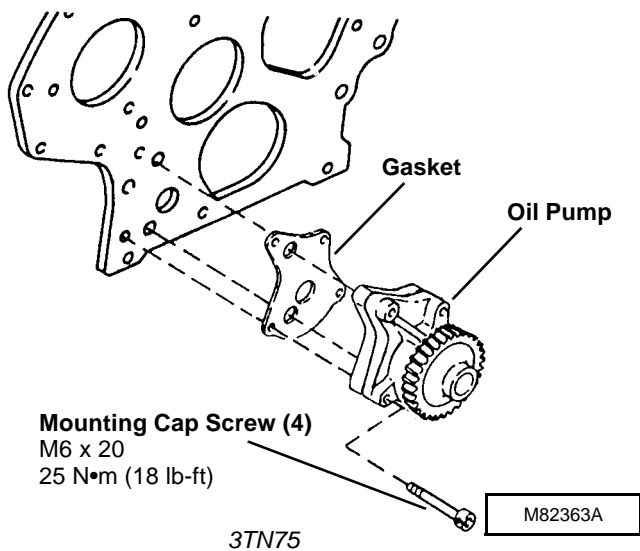
M82362A

OIL PUMP

Removal/Installation

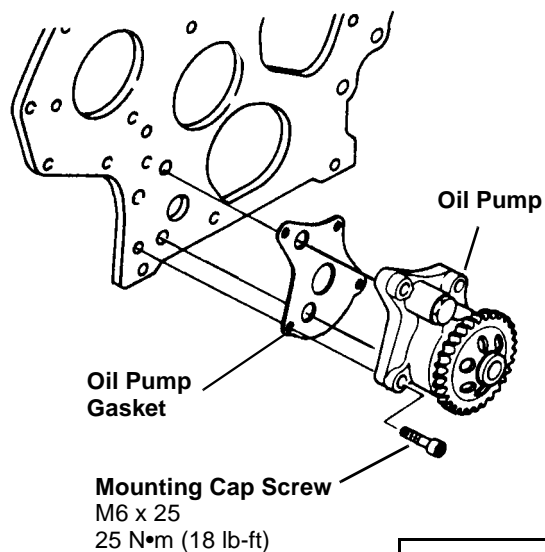
1. Remove timing gear cover. (See *Camshaft and Timing Gear Train* in this section.)
2. Check oil pump gear backlash. Replace entire oil pump assembly if backlash is more than **0.25 mm (0.010 in.)**.

3. Remove mounting cap screws, oil pump and gasket.
4. Inspect all parts for wear or damage. (See *Disassembly/Assembly* procedures).



M82363A

3TN75



M82215A

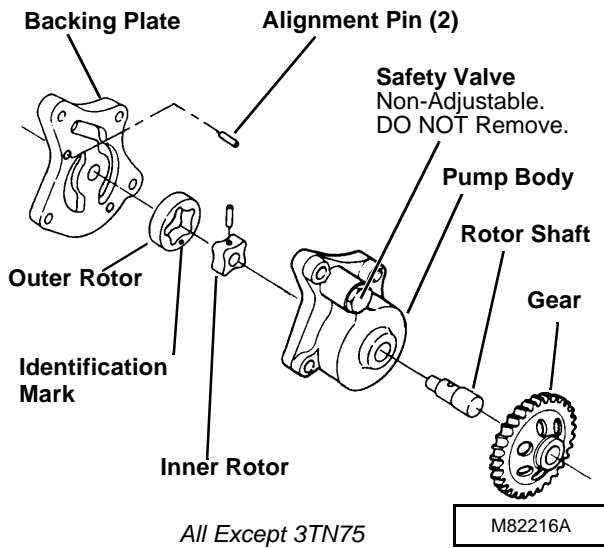
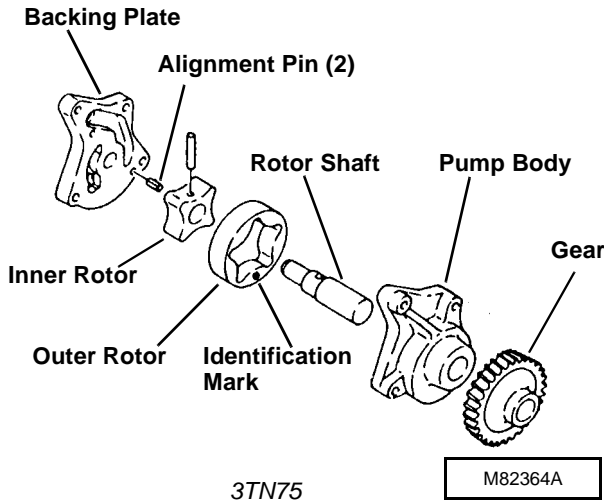
All Except 3TN75

Lubrication System

Disassembly/Assembly

- Gear is press fit on rotor shaft. Remove gear using a knife edge puller and a press.
- Inspect parts for wear or damage. (See *Inspection* procedures.)
- Coat all parts with clean engine oil.
- Install outer rotor with identification mark facing toward rotor shaft assembly.

2



Inspection

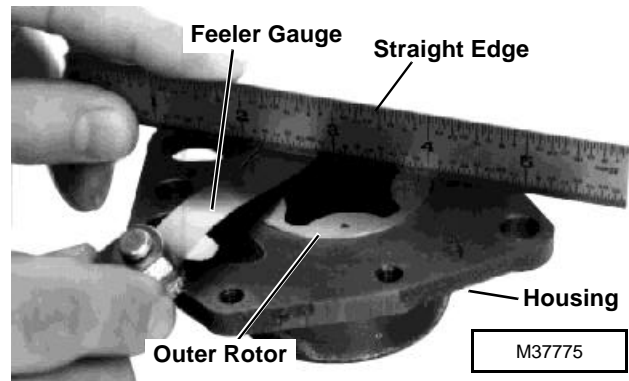
- Check rotor shaft outer diameter and the shaft hole diameter in backing plate. If clearance is more than wear limit, replace entire assembly.

Rotor Shaft and Plate Clearance:

Standard 0.015 - 0.048 mm
(0.0006 - 0.0035 in.)

Wear Limit..... 0.20 mm (0.0078 in.)

- Check rotor recess. If rotors are below face of pump housing more than wear limit, replace rotor assembly.



Rotor Recess - 3TN75, 3TN78, 3TNC78 (3011):

Standard 0.05 - 0.10 mm
(0.0020 - 0.0039 in.)

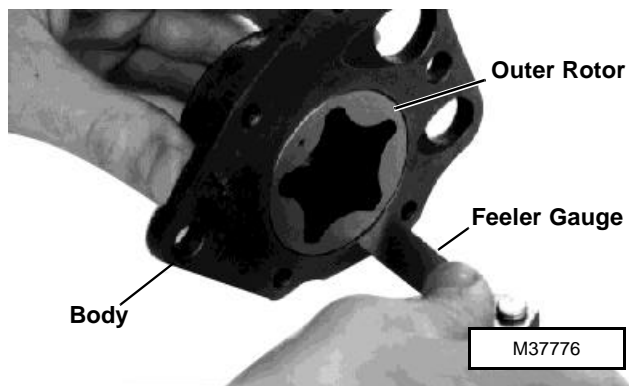
Wear Limit..... 0.15 mm (0.0059 in.)

Rotor Recess - 3TN82, 3TNA82, 3TN84 (3014):

Standard 0.03 - 0.09 mm
(0.0011 - 0.0035 in.)

Wear Limit..... 0.15 mm (0.0059 in.)

- Check outer rotor-to-pump body clearance. If clearance is more than wear limit, replace entire assembly.



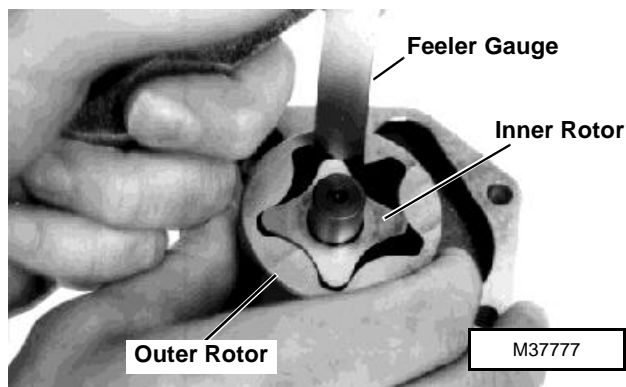
Outer Rotor-to-Pump Body Clearance - 3TN75, 3TN78, 3TNC78 (3011):

Standard 0.09 - 0.16 mm
(0.0035 - 0.0063 in.)
 Wear Limit..... 0.25 mm (0.0098 in.)

Outer Rotor-to-Pump Body Clearance - 3TN82, 3TNA82, 3TN84 (3014):

Standard 0.10 - 0.17 mm
(0.0039 - 0.0067 in.)
 Wear Limit..... 0.25 mm (0.0098 in.)

- Check inner-to-outer rotor clearance. If clearance is more than wear limit, replace rotor assembly.



Inner-to-Outer Rotor Clearance - 3TN75, 3TN78, 3TNC78 (3011):

Standard 0.02 - 0.04 mm
(0.0008 - 0.0016 in.)
 Wear Limit..... 0.15 mm (0.0059 in.)

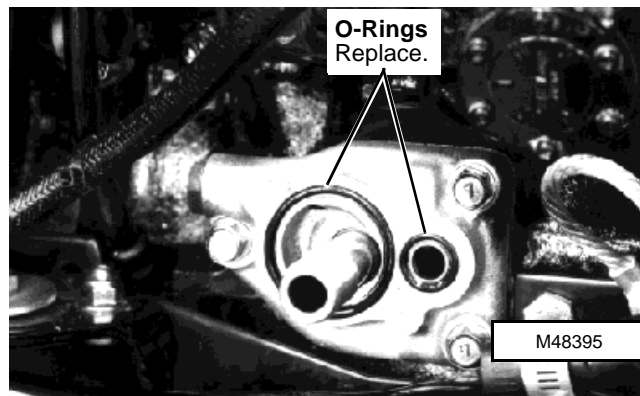
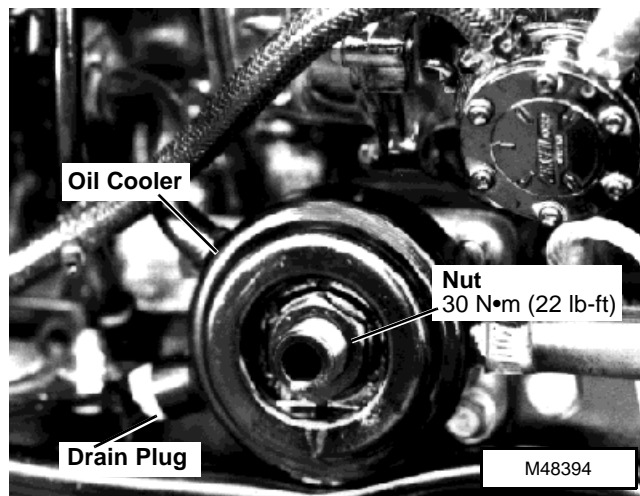
Inner-to-Outer Rotor Clearance - 3TN82, 3TNA82, 3TN84 (3014):

Standard 0.05 - 0.105 mm
(0.0019 - 0.0041 in.)
 Wear Limit..... 0.15 mm (0.0059 in.)

OIL COOLER - 3TN84 (955 CUT)

1. Remove drain plug to drain engine cooling system.
2. Remove oil filter.

3. Disconnect coolant hoses.
4. Remove nut, oil cooler and o-rings.



5. Pressure test oil cooler. (See *Checks, Tests and Adjustments* in this section.)

Installation is done in reverse order of removal.

OIL PRESSURE REGULATING VALVE - 3TN84 (955 CUT)

Removal/Installation

1. Remove oil cooler. (See procedure in this group.)
2. Remove mounting cap screws, pressure control valve housing and gasket.

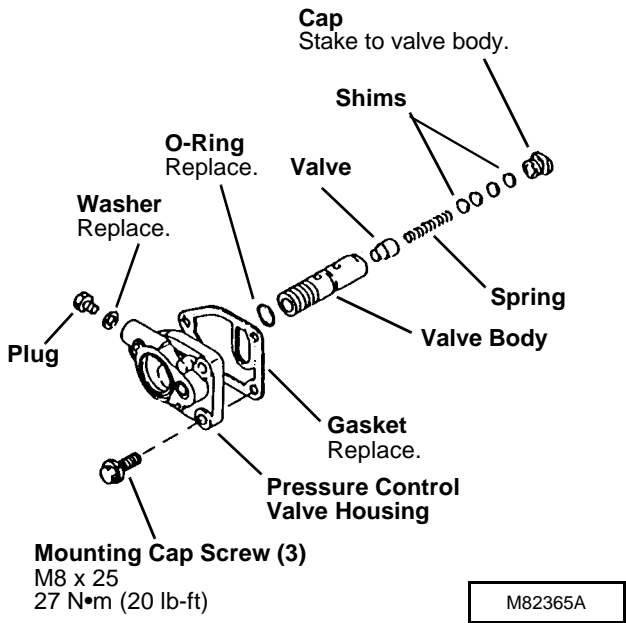
NOTE: Valve components are not serviced individually. Replace complete regulating valve if any components are defective.

Lubrication System

3. Inspect all parts for wear or damage. Replace complete regulating valve if necessary.

Installation is done in the reverse order of removal.

2



OIL PRESSURE REGULATING VALVE - ALL EXCEPT 3TN84 (955 CUT)

Removal/Installation

1. Remove oil filter.
2. Remove three cap screws, valve assembly and gasket.

NOTE: If adjusting engine oil pressure, retaining nut need not be removed.

3. If adjusting pressure only, remove cap and add shims. Each 1 mm (0.039 in.) of shim thickness increases oil pressure 15.6 kPa (2.3 psi).

NOTE: Valve components are not serviced individually. Replace complete regulating valve if any components are defective.

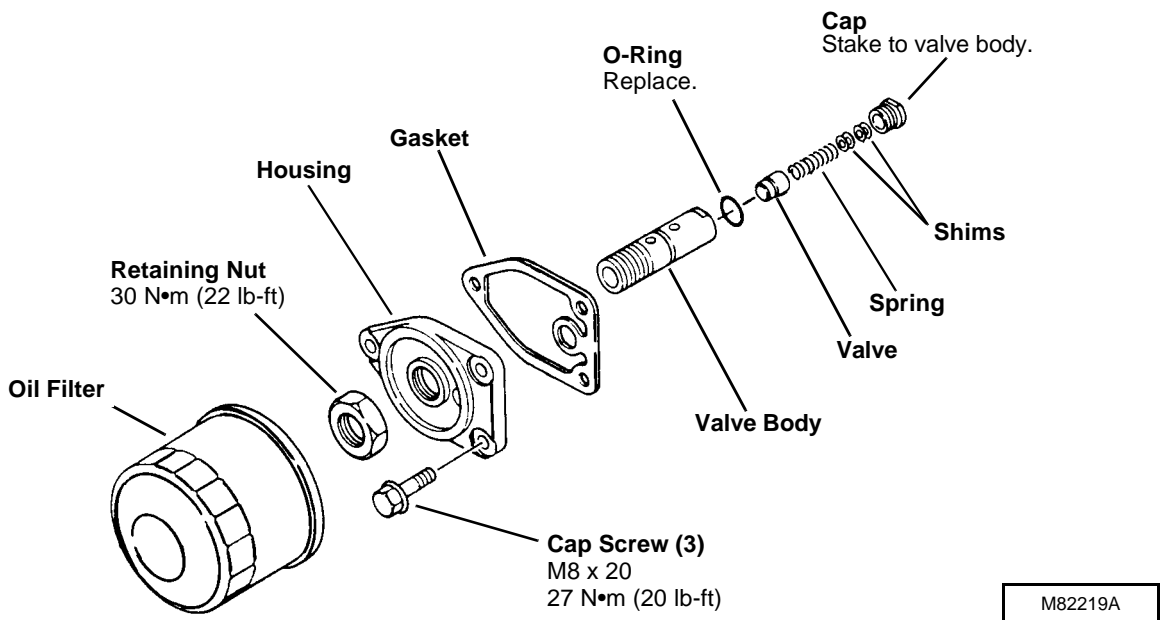
4. Inspect all parts for wear or damage. Replace complete valve if necessary.
5. Check spring free and compressed length.

Spring Specifications:

Free Length 46 mm (1.810 in.)

Compressed Length . . . 27.50 mm (1.080 in.)
 @ 20.5 N (4.6 lb-force)

Installation is done in the reverse order of removal.



OTHER MATERIALS

Number	Name	Use
LOCTITE® PRODUCTS U.S./ Canadian/ LOCTITE No.	John Deere Pipe Sealant with TEFLON®	3TN78, 3TN82 (30 EX), 3TN84 (955 CUT, 3014 OEM): Apply to threads of plug and nipple in thermostat housing and pipe plug in water pump housing.
TY9375/ TY9480/ #592		

®LOCTITE is a registered trademark of the Loctite Corp.
 ®TEFLON is a registered trademark of the Du Pont Company.

Cooling System

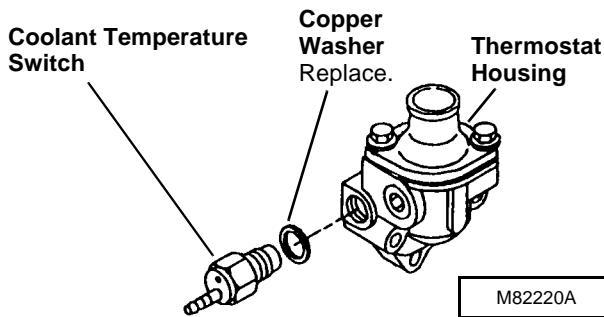
COOLANT TEMPERATURE SWITCH

Replacement

NOTE: Some engines may also be equipped with a coolant temperature sender. Sender is located opposite of switch in thermostat housing. Replacement procedures are the same.

1. Disconnect wiring lead, if equipped.
2. Open engine drain valve to drain coolant.
3. Remove switch and washer.
4. Test switch. (See *Checks, Tests and Adjustments* in this section.)

Installation is done in reverse order of removal.

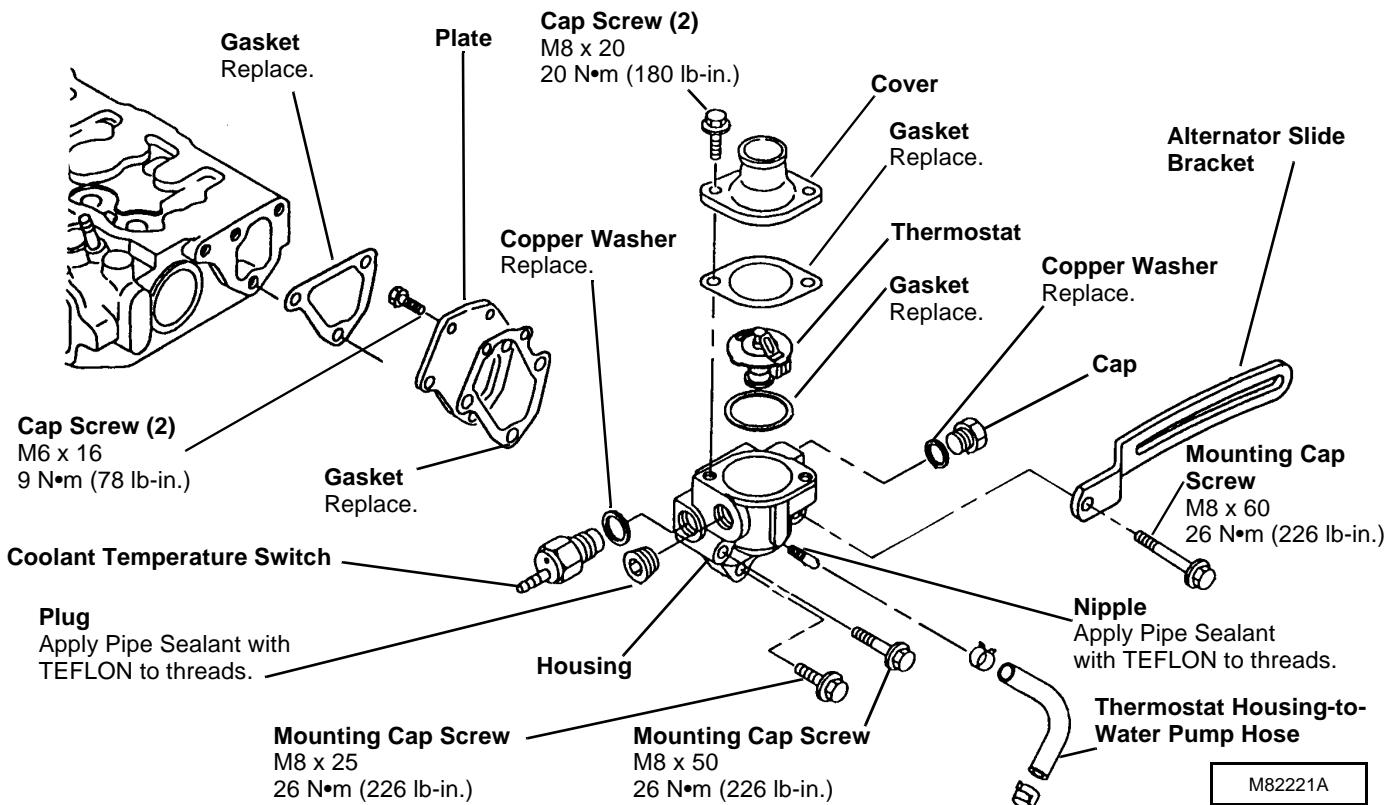


THERMOSTAT AND HOUSING - 3TN78, 3TN82 (30 EX), 3TN84 (955 CUT, 3014 OEM)

1. Drain engine coolant.
2. Remove upper radiator hose, if equipped.
3. Disconnect coolant temperature switch/sender wiring lead(s).
4. Loosen alternator-to-bracket mounting cap screw.
5. Loosen clamps and remove thermostat housing-to-water pump hose.
6. Remove mounting cap screws, housing and gasket.
7. Inspect all parts for wear or damage. Replace as necessary.
8. Test thermostat. (See *Checks, Tests and Adjustments* in this section.)

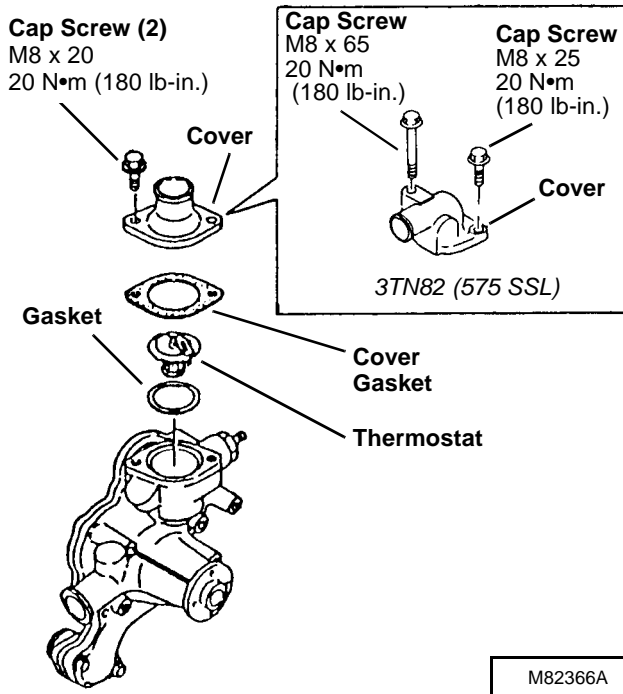
Installation is done in reverse order of removal.

Adjust fan/alternator drive belt tension. (See *Checks, Tests and Adjustments* in this section.)



THERMOSTAT - 3TN75, 3TNC78 (3011), 3TN82 (575 SSL), 3TNA82, 3TN84 (870 CUT)

- Replace gaskets.
- Test thermostat. (See *Checks, Tests and Adjustments* in this section.)

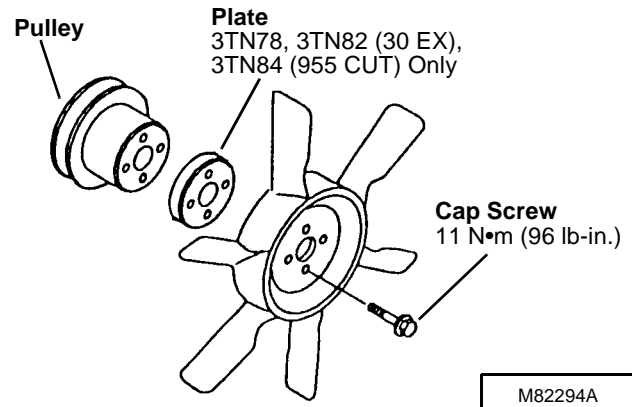


WATER PUMP - 3TN78, 3TN82 (30 EX), 3TN84 (955 CUT, 3014 OEM)

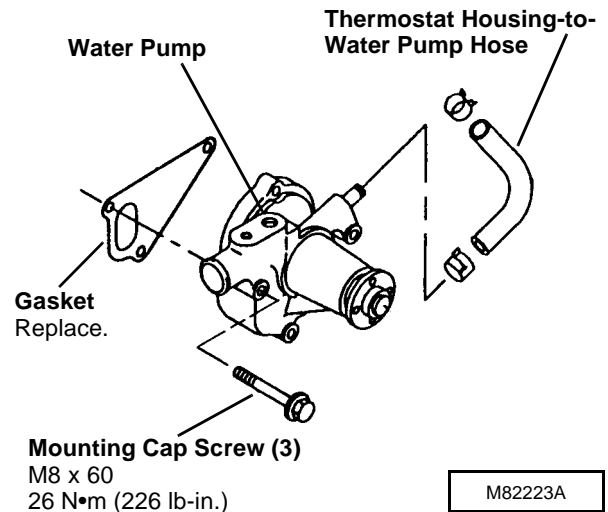
Removal/Installation

1. Drain engine coolant.
2. Remove fan/alternator belt.
3. 3TN78, 3TN82 (30 EX), 3TN84 (955 CUT): Remove fan, plate, if equipped, and pulley.

3TN84 (3014 OEM): Remove cooling fan. (See procedure in *ACCESSORIES - SERIES 220 POWER UNIT ENGINES* section.)



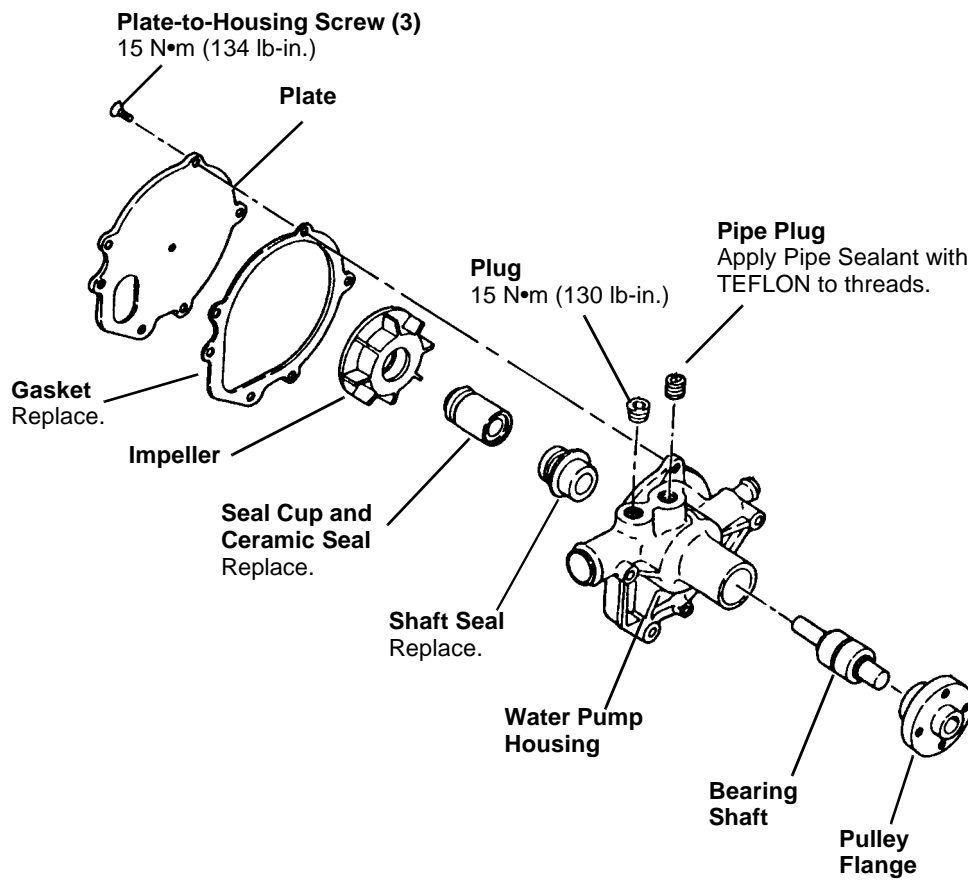
4. Remove lower radiator hose, if equipped.
 5. Loosen clamps and remove thermostat housing-to-water pump hose.
 6. Remove three mounting cap screws, pump and gasket.
 7. Inspect all parts for wear or damage. (See *Disassembly/Assembly* procedures.)
- Installation is done in the reverse order of removal.



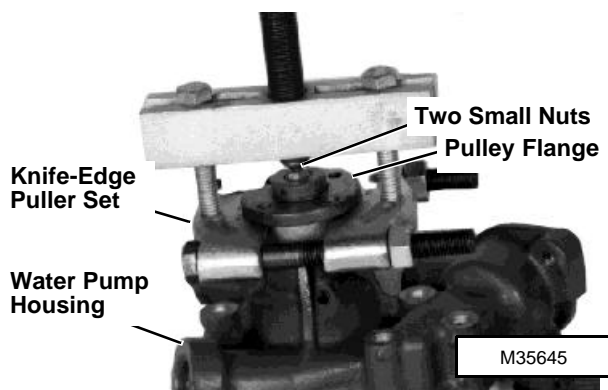
Cooling System

Disassembly

1. Apply heat to three plate-to-housing screws.
Remove screws, plate and gasket



2. Apply extreme heat to pulley flange. Remove flange using a knife-edge puller set and two small nuts.



3. Place water pump assembly on a press table. Install supports under water pump housing, staying clear of impeller. Press bearing shaft assembly through water pump housing using a piece of pipe or a deep socket.

IMPORTANT: Impeller bore is tapered. When pressing bearing shaft from impeller, allow enough clearance between cap screw and impeller bore to prevent cap screw from binding.

4. Remove impeller from bearing shaft using a knife-edge puller, a 3/8 in. cap screw and a press.
5. Remove shaft seal, ceramic seal and seal cup.
6. Inspect all parts for wear or damage. Replace as necessary.

Assembly

1. Install bearing shaft into pump housing, long end down, using a piece of pipe or deep socket and a press. Press shaft into pump housing until bearing surface is flush with pump housing surface.
2. Install new shaft seal over impeller side of bearing shaft, rubber seal side away from pump housing. Push shaft seal into pump housing, until it stops, using a 25 mm or 1 in. socket and a press.

IMPORTANT: Support pump housing on bearing shaft only. DO NOT support on housing or damage to housing will occur.

3. Place water pump housing on a press table. Support housing on bearing shaft using a driver disk. Install pulley flange onto shaft with straight hub facing away from housing.

3TN82 (30 EX): Press pulley flange onto bearing shaft until **top** of flange is **27 mm (1.060 in.)** from top of housing.

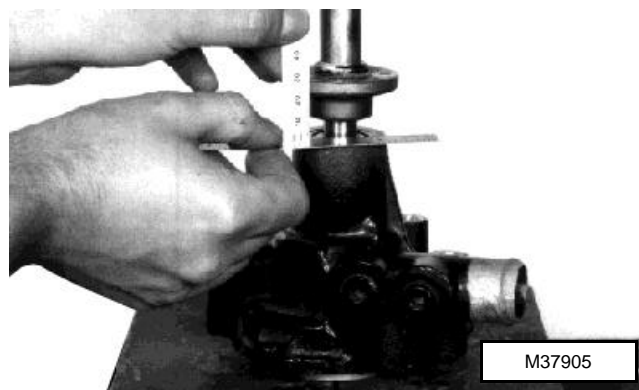
3TN78, 3TN84 (955 CUT, 3014 OEM): Press pulley flange onto bearing shaft until **bottom** of flange is **17 mm (0.670 in.)** from top of housing.

IMPORTANT: DO NOT touch lapped sealing surface of ceramic seal with bare hands. It must be clean and dry.

4. Install seal cup and ceramic seal in impeller.
5. Install a knife-edge puller around bearing shaft, between pulley flange and pump housing. Place pump housing, with knife-edge puller down, on a press table. Install impeller with ceramic seal toward shaft seal.

3TN82 (30 EX): Press impeller on bearing shaft until top of impeller is **1 mm (0.040 in.)** below housing.

3TN78, 3TN84 (955 CUT, 3014 OEM): Press impeller on bearing shaft until top of impeller is **2 mm (0.080 in.)** below housing.



6. Install new gasket, plate, three screws, two cap screws and nuts. Tighten to specifications.

Cooling System

WATER PUMP - 3TN75, 3TNC78 (3011), 3TN82 (575 SSL), 3TNA82, 3TN84 (870 CUT)

Removal/Installation

1. Open engine drain valve to drain coolant.
2. Remove fan/alternator drive belt.

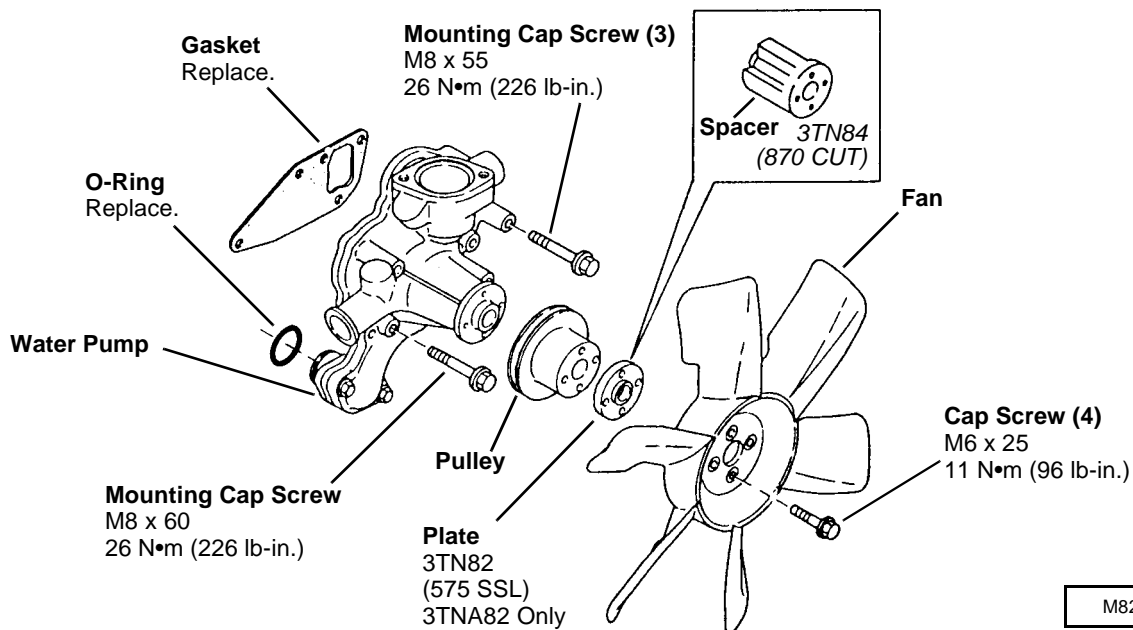
NOTE: 3TN75 (F1145 FM): Fan is mounted on flywheel end of engine.

3. Remove four cap screws, fan, spacer/plate, if equipped, and pulley.
4. Remove four mounting cap screws, pump and gasket.
5. Inspect all parts for wear or damage. (See *Disassembly/Assembly* procedures.)

Installation is done in the reverse order of removal.

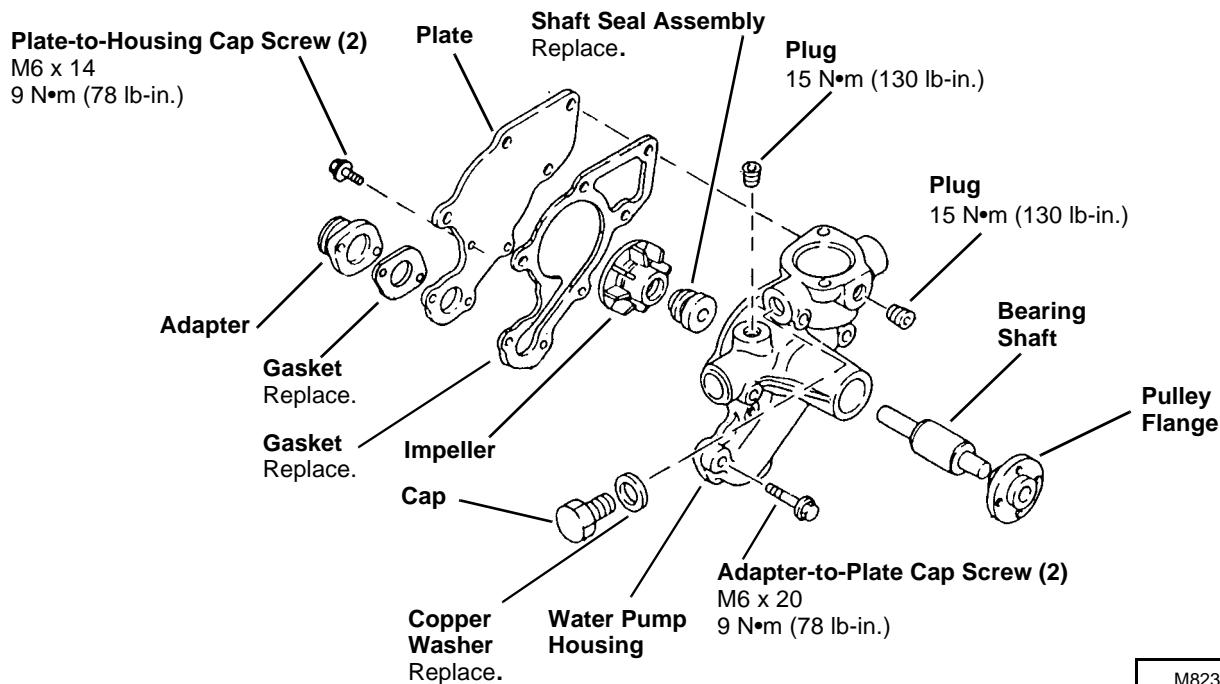
- Adjust fan/alternator drive belt tension. (See *Checks, Tests and Adjustments* in this section.)

2



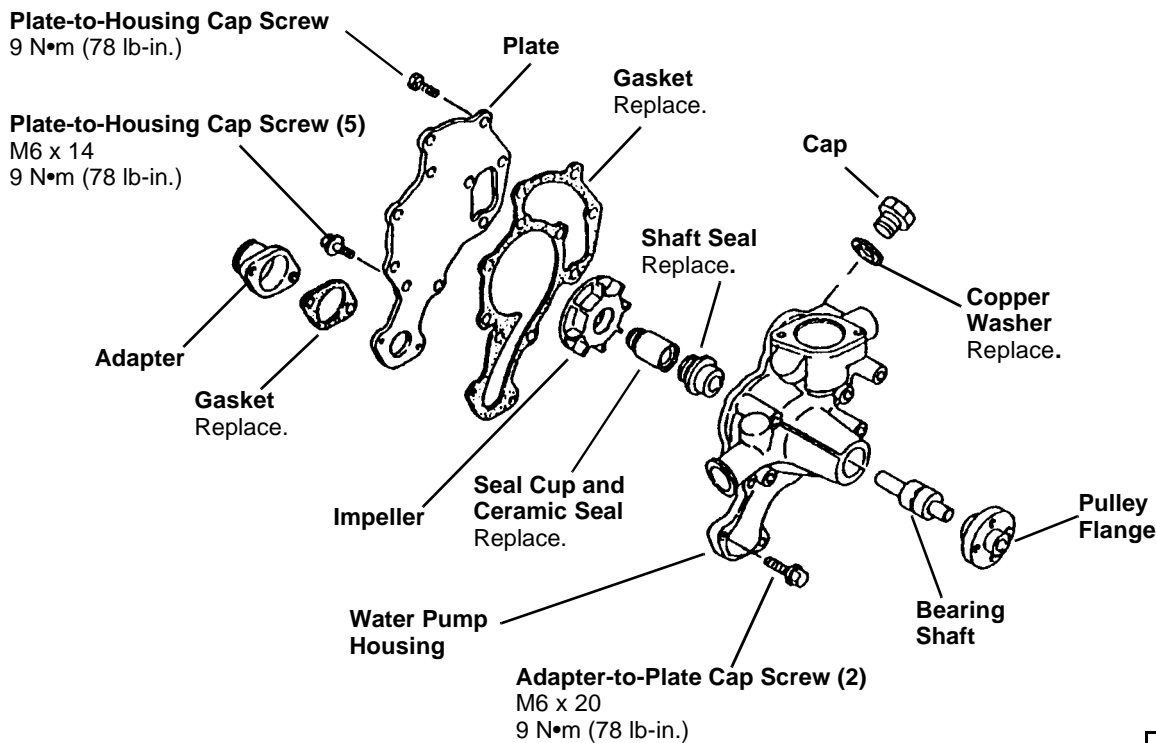
Disassembly

1. Remove thermostat. (See procedure in this group.)
2. Remove coolant temperature switch. (See procedure in this group.)
3. Remove two cap screws, adapter and gasket.
4. Apply heat to plate-to-housing cap screws. Remove cap screws, plate and gasket.



3TN75, 3TNC78 (3011)

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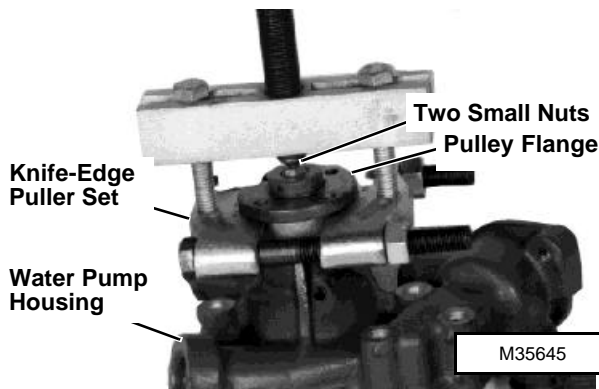


3TN82 (575 SSL), 3TNA82, 3TN84 (870 CUT)

M82226A

Cooling System

5. Apply extreme heat to pulley flange. Remove flange using a knife-edge puller set and two small nuts.



2

6. Place water pump assembly on a press table. Install supports under water pump housing, staying clear of impeller. Press bearing shaft assembly through water pump housing using a piece of pipe or a deep socket.

IMPORTANT: Impeller bore is tapered. When pressing bearing shaft from impeller, allow enough clearance between cap screw and impeller bore to prevent cap screw from binding.

7. Remove impeller from bearing shaft using a knife-edge puller, a 3/8 in. cap screw and a press.
8. Remove shaft seal (shaft seal assembly), ceramic seal and seal cup.
9. Inspect all parts for wear or damage. Replace as necessary.

Assembly

1. Install bearing shaft into pump housing, long end down, using a piece of pipe or deep socket and a press. Press shaft into pump housing until bearing surface is flush with pump housing surface.
2. Install new shaft seal over impeller side of bearing shaft, rubber seal side away from pump housing. Push shaft seal into pump housing, until it stops, using a 25 mm or 1 in. socket and a press.

IMPORTANT: Support pump housing on bearing shaft only. DO NOT support on housing or damage to housing will occur.

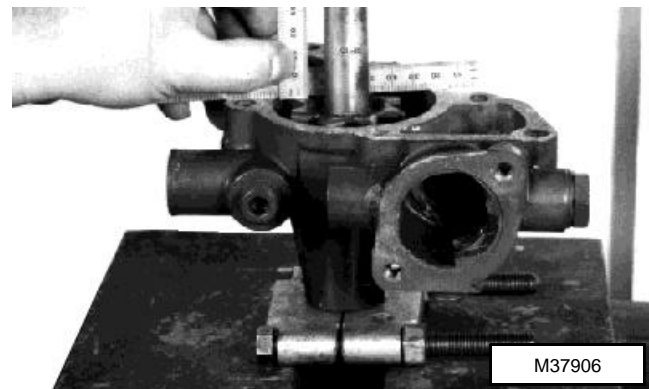
3. Place water pump housing on a press table. Support housing on bearing shaft using a driver disk. Install pulley flange onto shaft with straight hub facing away from housing.

Press pulley flange onto bearing shaft until **bottom** of flange is **17 mm (0.670 in.)** from top of housing.

IMPORTANT: DO NOT touch lapped sealing surface of ceramic seal with bare hands. It must be clean and dry.

4. Install seal cup and ceramic seal (shaft seal assembly) in impeller.
5. Install a knife-edge puller around bearing shaft, between pulley flange and pump housing. Place pump housing, with knife-edge puller down, on a press table. Install impeller with ceramic seal toward shaft seal.

Press impeller on bearing shaft until top of impeller is **2 mm (0.080 in.)** below housing.



6. Install new gasket, plate and cap screws. Tighten to specifications.
7. Install new gasket, adapter and cap screws. Tighten to specifications.
8. Install coolant temperature switch. (See procedure in this group.)
9. Install thermostat. (See procedure in this group.)

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).

JDF13 Nozzle Cleaning Kit

Use to clean fuel injection nozzles.

SERVICE PARTS KITS

The following kits are available through your parts catalog:

- Cylinder Block Gasket Kit
- Fuel Injection Nozzle Shim Pack

Fuel System

FUEL SUPPLY PUMP - IF EQUIPPED

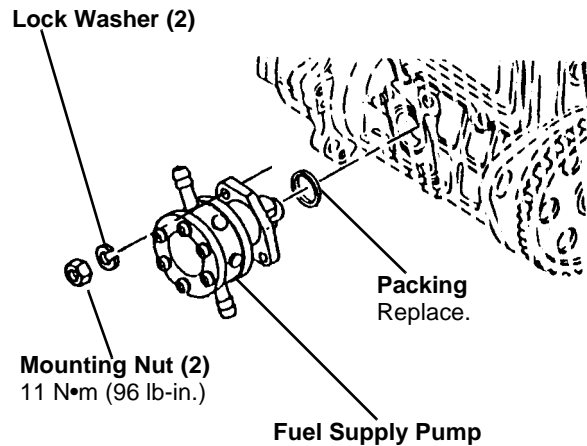
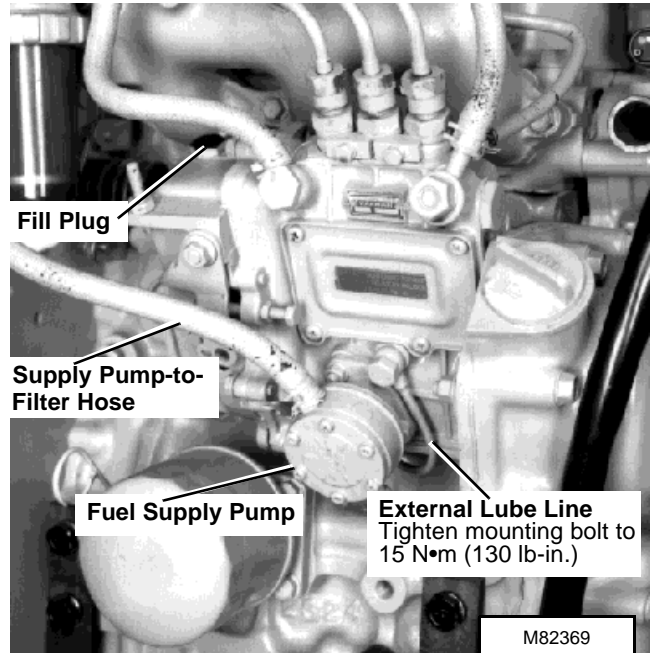
Replacement

NOTE: 3TN78 and 3TN82 engines are not equipped with a fuel supply pump.

Oil will leak out of fuel injection pump housing when supply pump is removed.

IMPORTANT: If oil has been drained out of fuel injection pump housing, add oil as necessary. Fuel injection pump can become damaged if operated dry or without proper amount of oil.

2 After fuel supply pump is installed, disconnect external lube line to fuel injection pump housing. Remove fill plug and add clean engine oil to housing. Add until oil begins to drip out of lube line hole. (For proper oil specification see *SPECIFICATIONS AND GENERAL INFORMATION* section.)



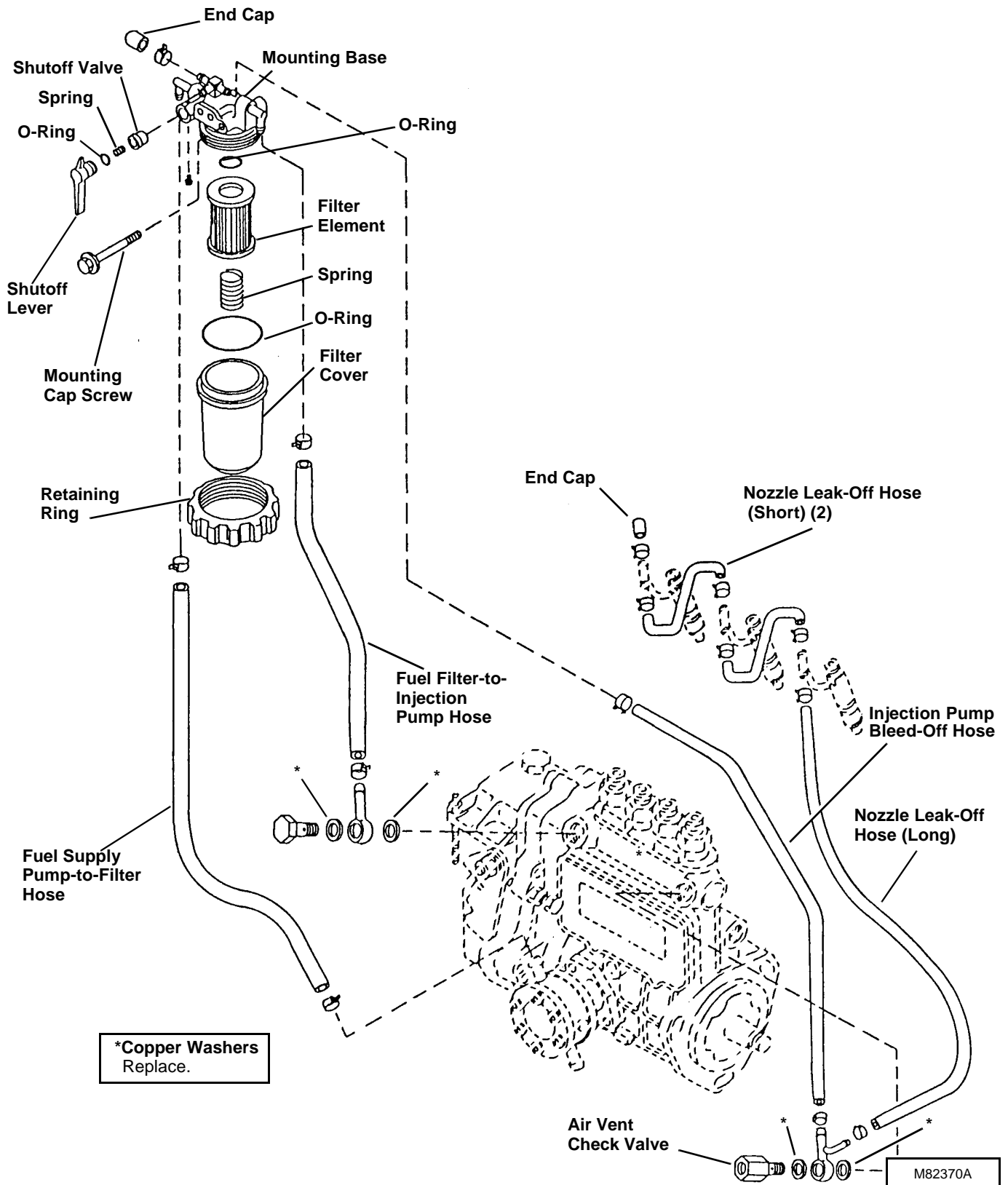
M82228A

FUEL FILTER ASSEMBLY - IF EQUIPPED

NOTE: Fuel filter assemblies will be slightly different for each engine model depending

on engine application. 3TN84 (3014 OEM) shown.

IMPORTANT: Replace all copper washers. Damaged or used washers may leak.



FUEL INJECTION PUMP

Removal

CAUTION

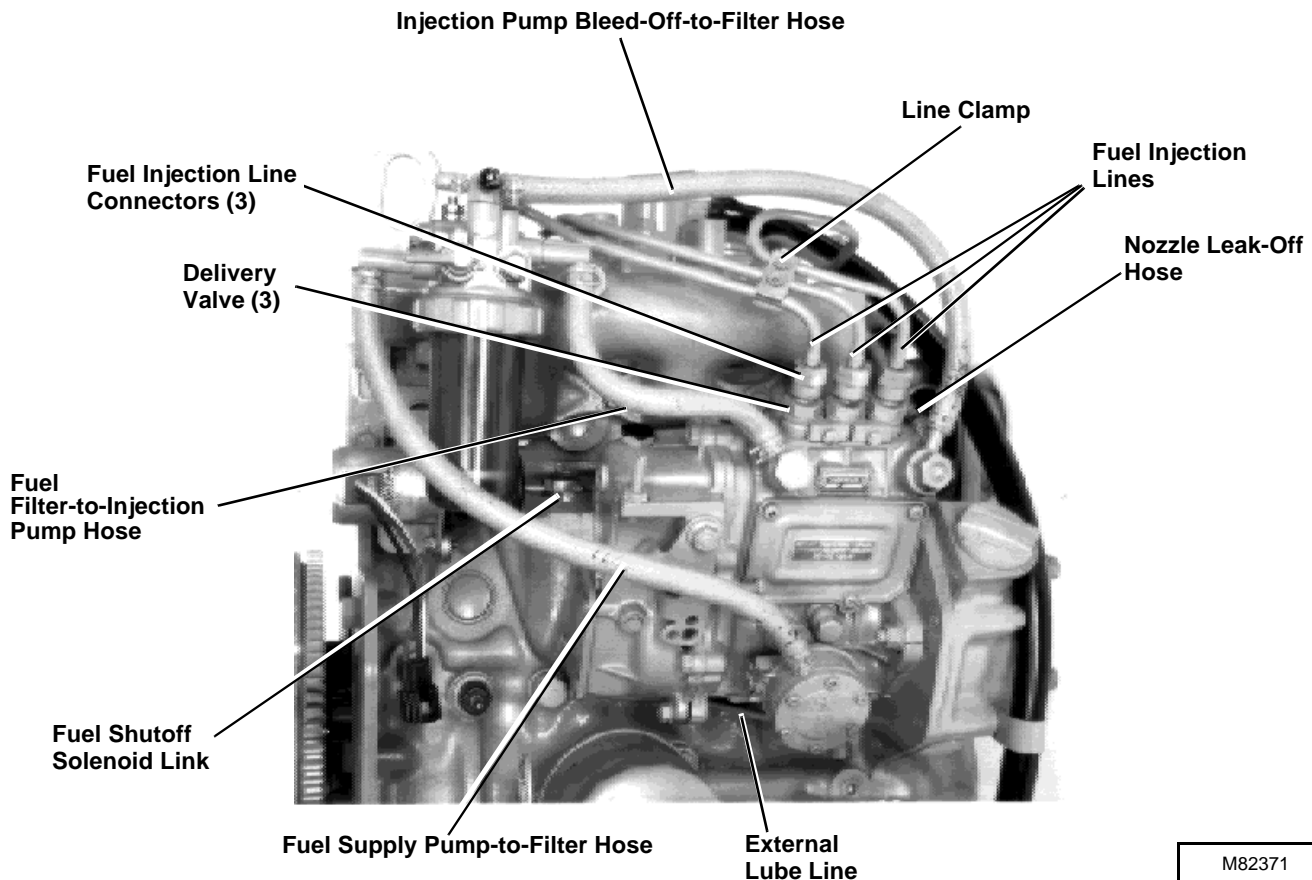
Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.

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

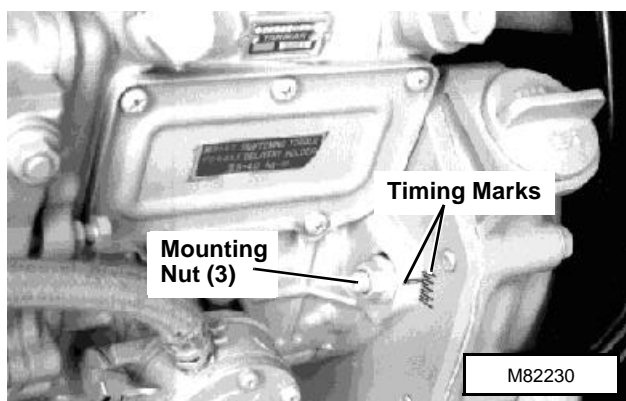
2

IMPORTANT: Never steam clean or pour cold water on injection pump while the pump is running or warm. Doing so can damage the pump.

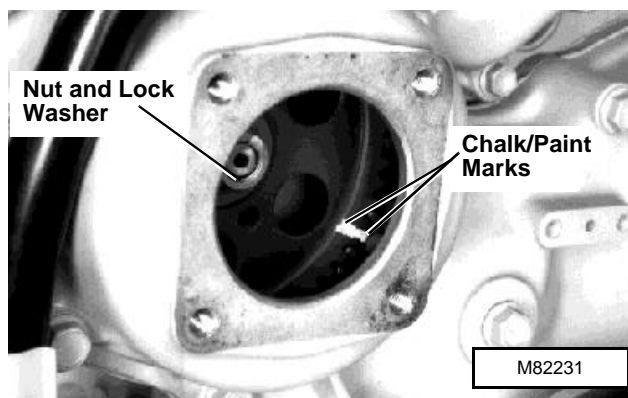
1. Clean the injection pump lines and area around the pump using a parts cleaning solvent or steam cleaner.
2. Loosen fuel injection line connectors slightly to release pressure in the fuel system. When loosening connectors, use another wrench to keep delivery valves from loosening.
3. Loosen line clamp(s) and remove fuel injection lines.
4. Disconnect hoses to/from fuel filter, if equipped.
5. Remove external lube line.
6. Disconnect fuel shutoff solenoid link.
7. Note position of timing marks on injection pump and gear cover mounting plate.
8. Remove three mounting nuts.



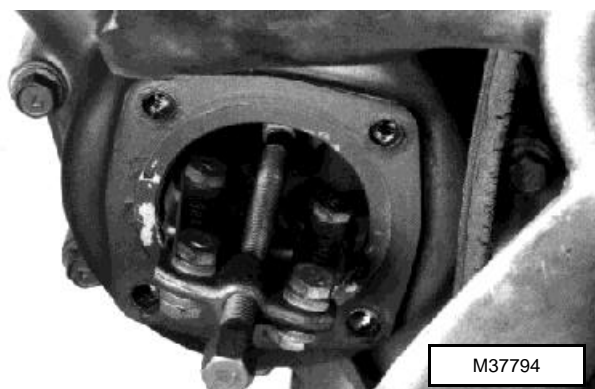
M82371



9. Remove fan guard, if equipped.
10. Remove four cap screws, washers, cover and gasket.
11. Use chalk or paint to mark injection pump gear to idler gear.
12. Remove nut and lock washer.



13. Pull gear from injection pump shaft using a two jaw puller.



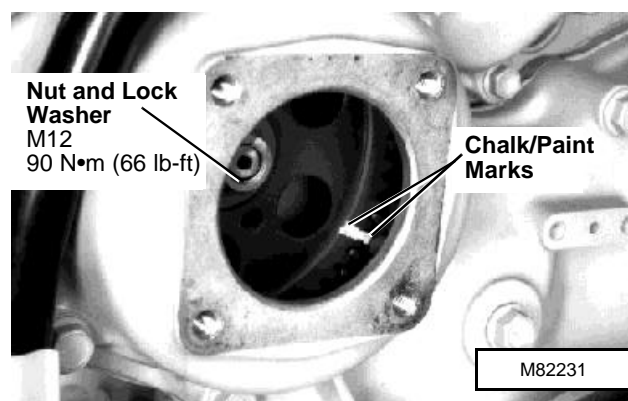
14. Remove injection pump and o-ring.

DO NOT attempt to service the injection pump or governor. If unit is in need of repair, it must be serviced by a qualified fuel injection repair shop. If replacement is necessary, replace entire unit.

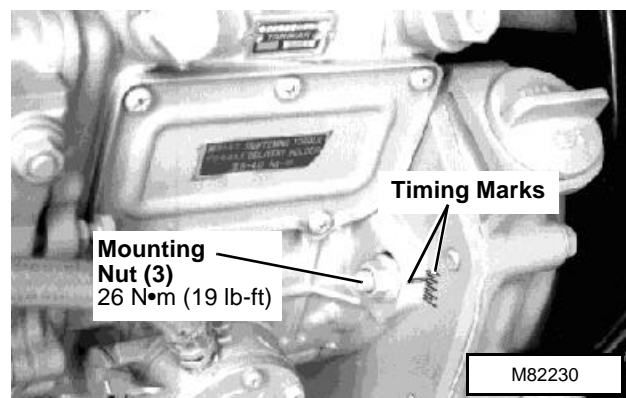
Installation

1. Install new o-ring on injection pump.
2. Put injection pump onto back of gear cover mounting plate. Align key on shaft with keyway in gear. Be sure to align marks on gears made during removal.
3. Install lock washer and nut. Tighten to specification.

2



4. Install new gasket, cover, four washers and cap screws.
5. Install fan guard, if equipped.
6. Install three mounting nuts. Do not tighten.
7. Align marks on mounting plate and injection pump, to same place as when removed, and tighten mounting nuts to specifications.



8. Connect fuel shutoff solenoid link.
9. Connect hoses to/from fuel filter.

Fuel System

10. Install fuel injection lines and tighten line clamp cap screws.

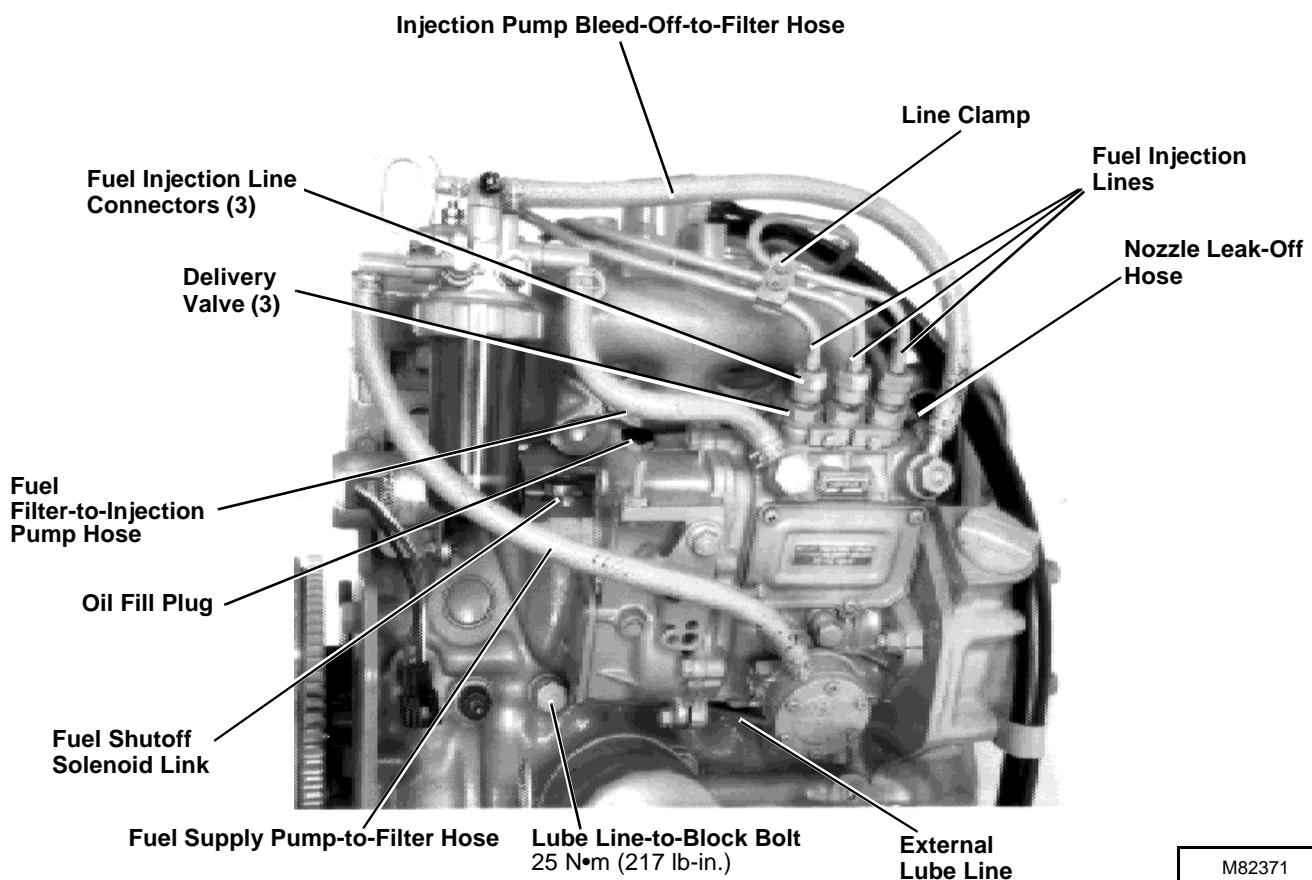
IMPORTANT: If oil has been drained out of fuel injection pump housing, add oil as necessary. Fuel injection pump can become damaged if operated dry or without proper amount of oil.

11. Remove fill plug and add clean engine oil to housing. Add until oil begins to drip out of external lube line inlet. (For proper oil specification see *SPECIFICATIONS AND GENERAL INFORMATION* section.)

12. Install external lube line. When installing line, put one copper washer between mounting bolt head and lube line and the other between lube line and housing.

If new injection pump is being installed, check and adjust injection pump static timing. (See *Checks, Tests and Adjustments* in this section.)

2



FUEL INJECTION NOZZLES (HOLE-TYPE)

Removal/Installation

IMPORTANT: Never steam clean or pour cold water on injection pump while the pump is running or warm. Doing so can damage the pump.

1. Clean the injection pump lines and area around the pump using a parts cleaning solvent or steam cleaner.

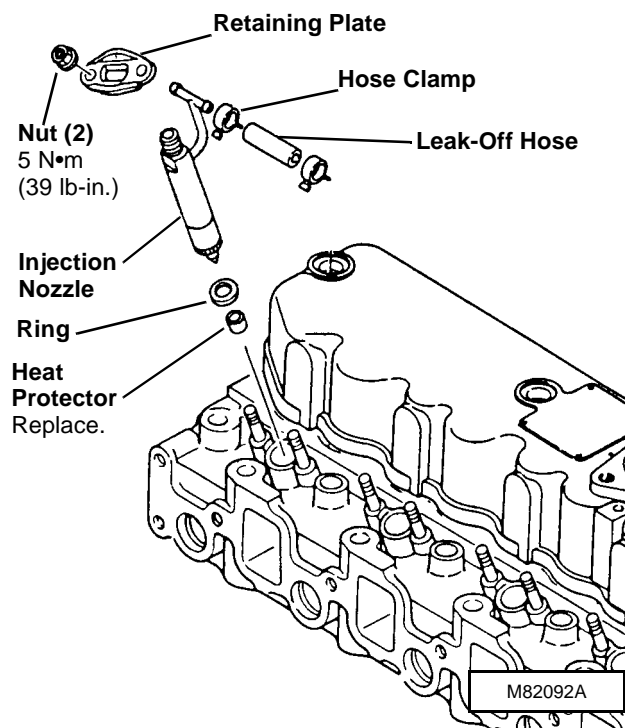
CAUTION

Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.

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

NOTE: Nozzles are matched to the cylinders. If removing more than one nozzle, tag nozzles, according to the cylinder from which it was removed.

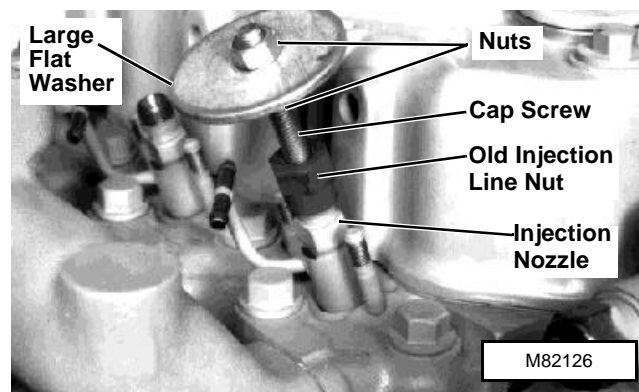
2. Loosen fuel injection line connectors-to-nozzles slightly to release pressure in the fuel system.
3. Loosen line clamp(s) and remove fuel injection lines.
4. Remove clamps and leak-off hoses.
5. Remove nuts and retaining plates.
6. Remove injection nozzle, ring and teflon heat protector. If ring and protector stay in cylinder head, thread a cap screw into protector and pull from cylinder head.



2

If nozzles are stuck in cylinder head:

- Grind the head of a cap screw so it fits inside a nut from an old injection line.
- Use two nuts to attach a large flat washer to the cap screw.
- Install assembly onto nozzle and use a puller and slide hammer to pull nozzle from cylinder head.



7. Test injection nozzles. (See *Checks, Tests and Adjustments* in this section.)

Installation is done in reverse order of removal.

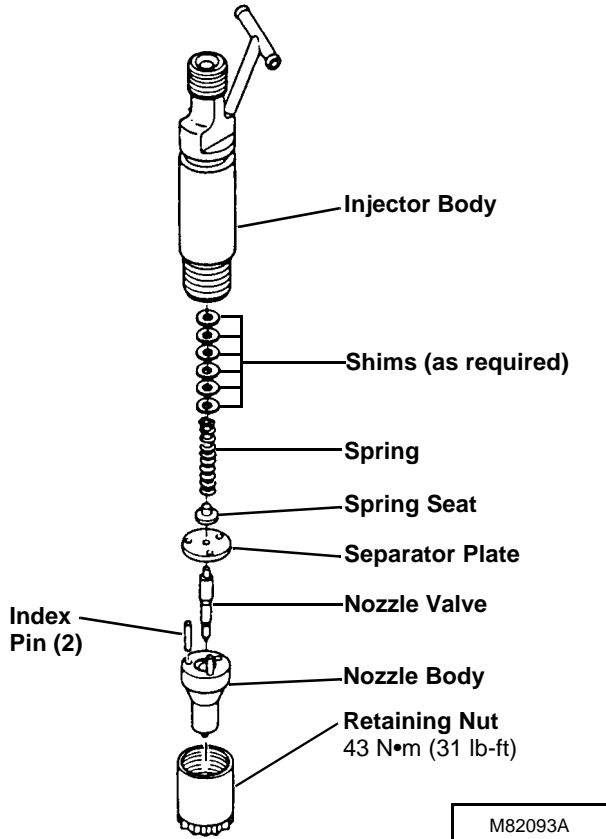
Fuel System

Disassembly/Assembly

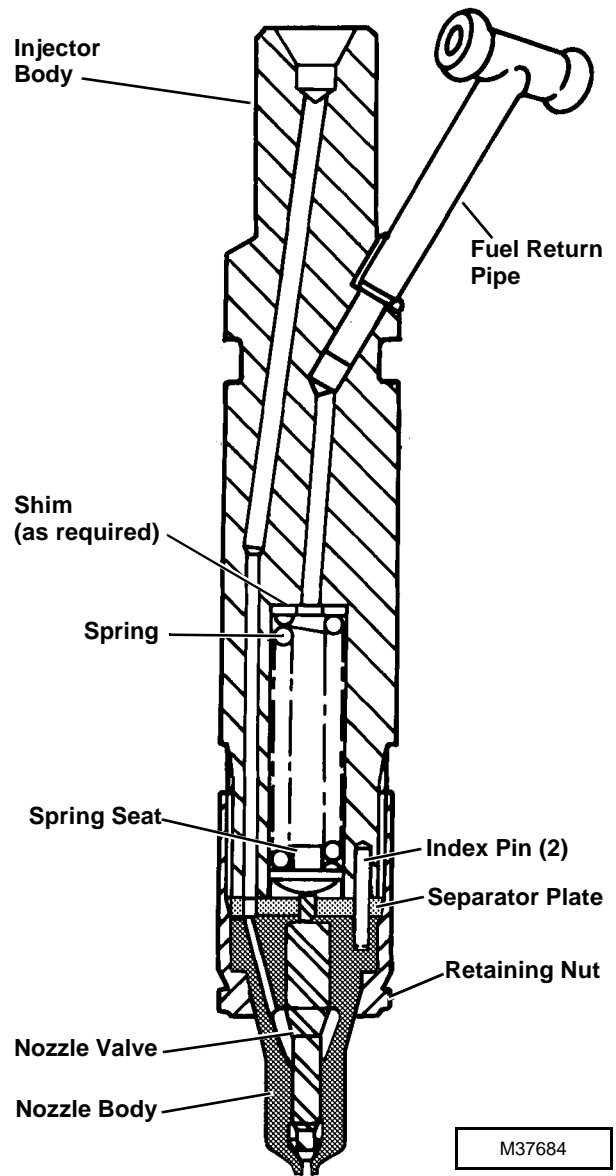
NOTE: If servicing more than one nozzle, keep parts for each nozzle separate from one another.

- Clean and inspect nozzle assembly. (See *Cleaning/Inspection* procedures.)
- After assembly is complete, test injection nozzle. (See *Checks, Tests and Adjustments* in this section.)

2



Cross Section



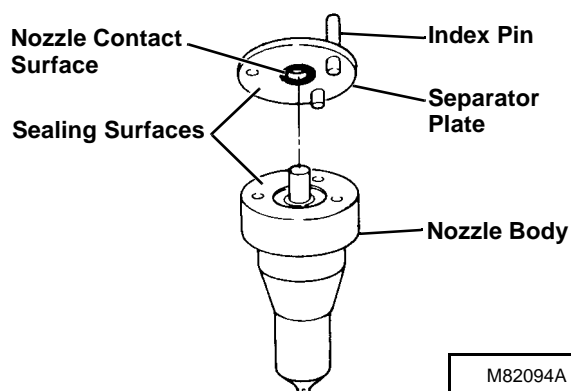
Cleaning/Inspection

NOTE: To clean nozzles properly, JDF13 Nozzle Cleaning Kit is recommended. The Cleaning Kit is available through the John Deere SERVICEGARD™ Catalog.

1. Remove anti-corrosive grease from new or reconditioned nozzles by washing them thoroughly in diesel fuel.

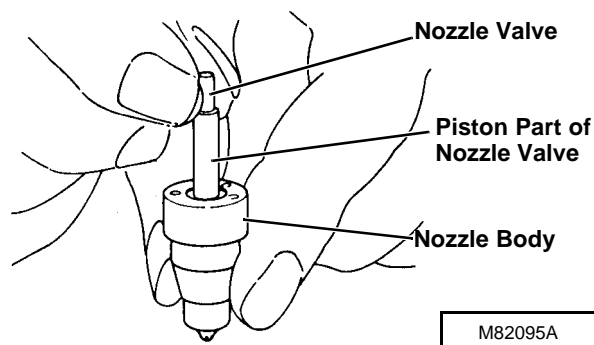
IMPORTANT: Never use a steel brush to clean nozzles as this will distort the spray hole.

2. Remove carbon from used nozzles, and clean by washing in diesel fuel. If parts are coated with hardened carbon or lacquer, it may be necessary to use a brass wire brush (supplied in Nozzle Cleaning Kit).
3. After removing carbon or lacquer from the exterior of nozzle, inspect sealing surfaces between separator plate and nozzle body for nicks or scratches.
4. Inspect condition of separator plate and nozzle body. Contact area of separator plate (both parts) must not be scored or pitted. Use an inspection magnifier (No. 16487 or equivalent) to aid in making the inspection.
5. Check nozzle contact surface on separator plate for wear. If contact surface is more than **0.10 mm (0.0039 in.)**, replace nozzle assembly.



6. Inspect the piston (large) part of nozzle valve to see that it is not scratched or scored and that lower (tip) end of valve is not broken. If any of these conditions are present, replace the nozzle assembly.
7. Further inspect the nozzle assembly by performing a slide test. Use the following procedure:
 - Dip the nozzle valve in clean diesel fuel. Insert valve in nozzle body.
 - Hold nozzle vertical, and pull valve out about 1/3 of its engaged length.
 - Release valve. Valve should slide down to its seat by its own weight.

Replace nozzle assembly if the valve does not slide freely to its seat.



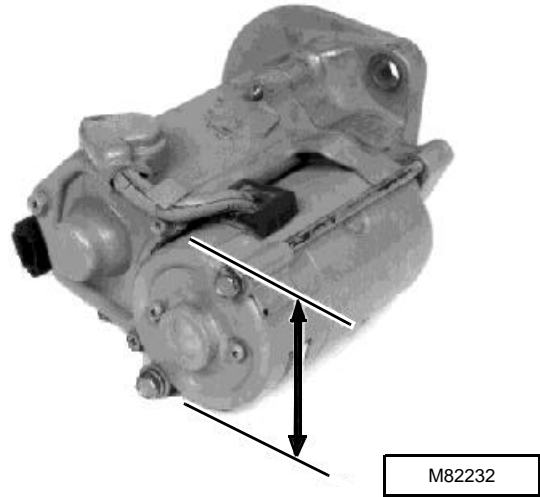
2

Starter

STARTER IDENTIFICATION CHART

The various starters covered in this group are identified by manufacturer and output rating.

To help identify the starters, measure the outside diameter of the motor.



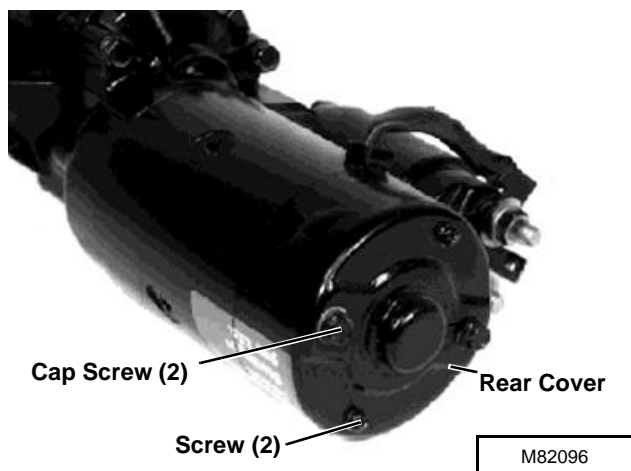
2

Manufacturer	Rated Output	Motor Outside Diameter
Hitachi	2.0 kW	80 mm (3.150 in.)
Nippondenso	1.0 kW	68 mm (2.680 in.)
Nippondenso	1.2 kW	72 mm (2.835 in.)
Nippondenso	1.4 kW	76 mm (3.000 in.)

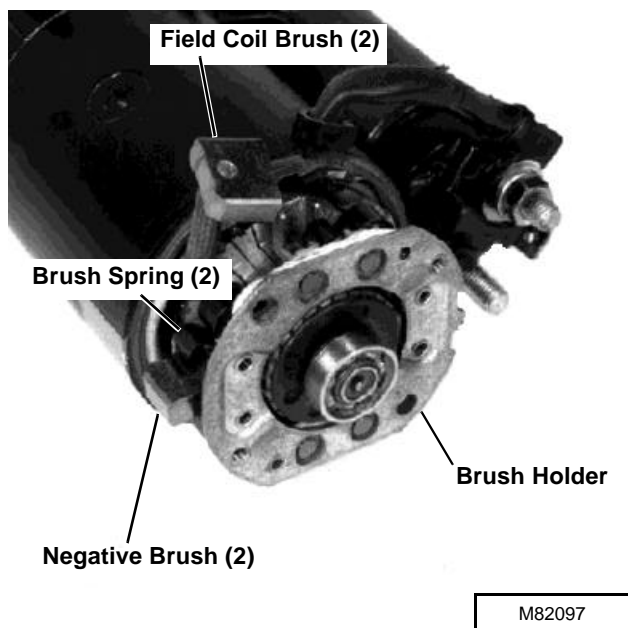
STARTER MOTOR - HITACHI 2.0 kW

Disassembly

1. Remove two cap screws and two screws.
2. Remove rear cover.

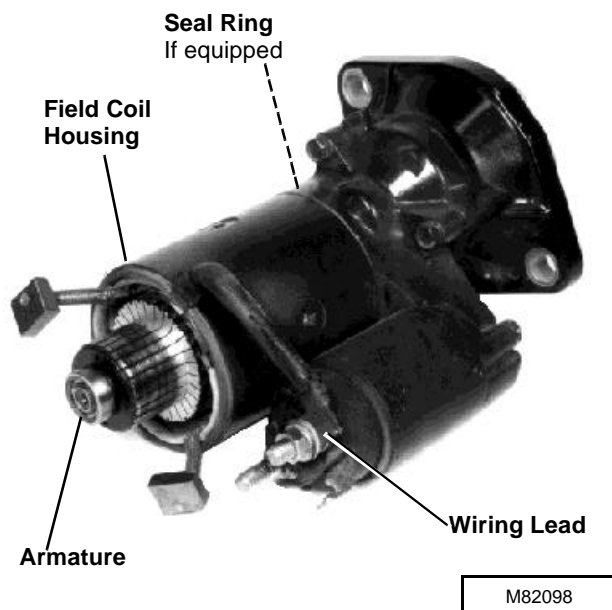


3. Remove field coil brushes from brush holder.
4. Pry brush springs away and pull negative brushes up enough to allow spring to hold brush in place.
5. Remove brush holder.



6. Disconnect wiring lead.
7. Remove field coil housing, armature and seal ring, if equipped.

8. Inspect and test brushes, holder, field coil and armature. (See *Inspection/Test* procedures.)



2

Assembly

Assembly is done in the reverse order of disassembly.

- Apply multipurpose grease to bearing cup inside rear cover.

IMPORTANT: When installing rear cover, be sure field coil brush wires do not touch cover. Turn brush holder slightly to take up slack in brush wires. Press wires inward to clear rear cover.

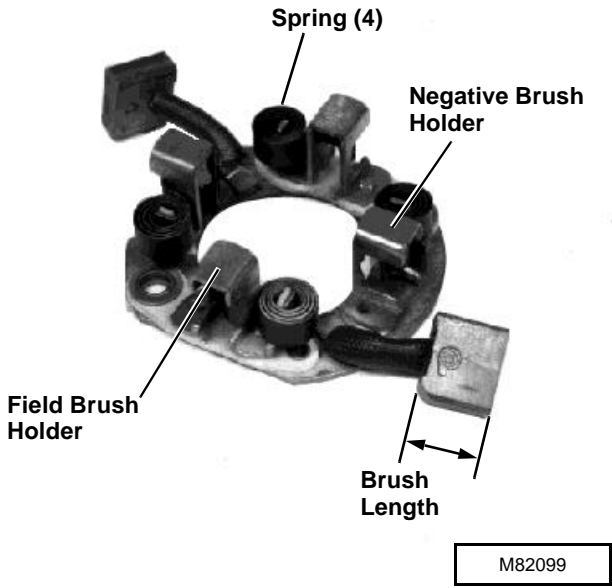
Inspection/Test/Replacement

1. Measure holder and field coil brush lengths. Minimum brush length is **9 mm (0.354 in.)**. Replace brush holder or field coil if brush length is below minimum.

NOTE: Test brush holder using an ohmmeter or test light.

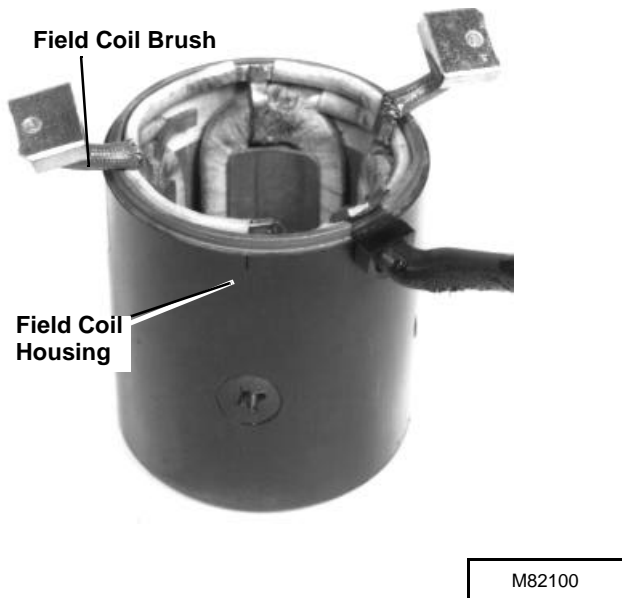
2. Test brush holder:
Touch one probe of tester to negative brush holder and other probe to field brush holder. If there is continuity, replace the brush holder.
3. Inspect springs for wear or damage. Replace if necessary.

2



NOTE: Test field coil using an ohmmeter or test light.

4. Test for grounded field winding:
Touch one probe of tester to field coil brush and other probe to field coil housing. Be sure the brush lead is not touching the frame. If there is continuity, the coil is grounded and the field coil housing assembly must be replaced.
5. Test for open field coil:
Touch one probe of tester to each field coil brush. If there is no continuity, the field coil is open and the field coil housing assembly must be replaced.



IMPORTANT: Do not clean armature with solvent. Solvent can damage insulation on windings. Use only mineral spirits and a brush.

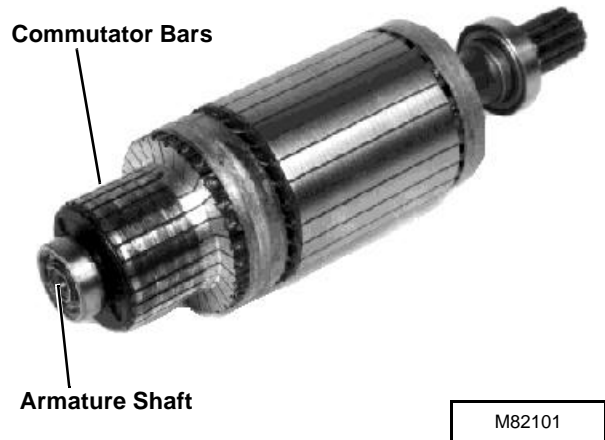
6. Inspect armature. Look for signs of dragging against pole shoes.
7. Inspect commutator. Look for roughness, burned bars, or any material which might cause short circuits between bars. If necessary, clean and touch up with 400 sandpaper. NEVER use emery cloth. Clean all dust from armature when finished.

NOTE: Test armature windings using an ohmmeter or test light.

8. Test for grounded windings:
Touch probes on one commutator bar and armature shaft. Armature windings are connected in series, so only one commutator bar needs to be checked.

If test shows continuity, a winding is grounded and the armature must be replaced.

9. Test for open circuited windings:
Touch probes on two different commutator bars. If test shows no continuity, there is an open circuit and the armature must be replaced.

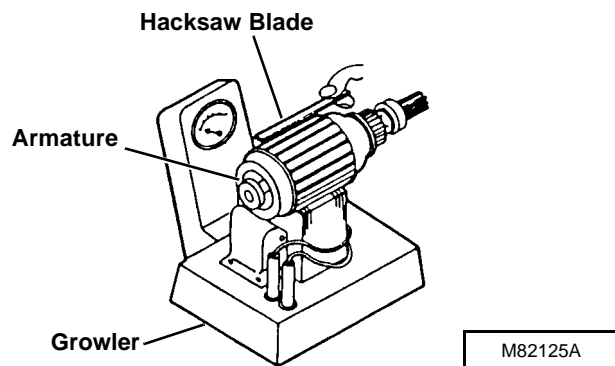


10. Test for short circuited windings using a growler.
Put armature in a growler and hold a hacksaw blade above each slot while slowly rotating armature.

If coil is shorted, the blade will vibrate on the slot.

NOTE: A short circuit most often occurs because of copper dust or filings between two commutator segments.

- If test indicates short circuited windings, clean the commutator of dust and filings. Check the armature again. If the test still indicates a short circuit, replace the armature.



- Inspect armature cover and housing bearings for wear or damage. Replace if necessary.

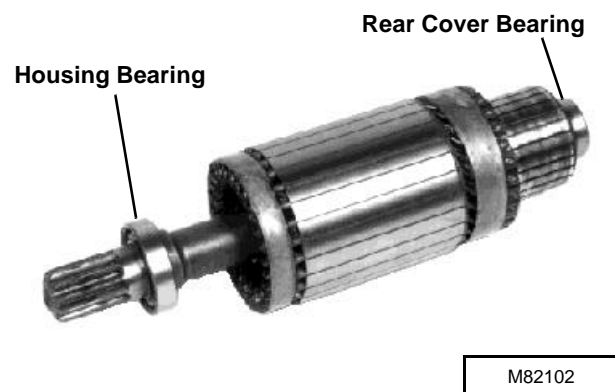
To replace bearings:

Bearings are press fit. Remove bearings using a knife-edge puller set.

IMPORTANT: Install both bearings with sealed side toward armature.

Install new housing bearing tight against shoulder of shaft using a piece of pipe.

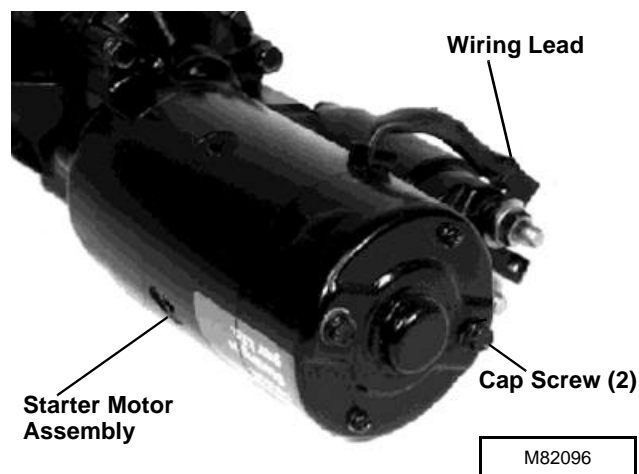
Install new rear cover bearing tight against shoulder of shaft using a driver set.



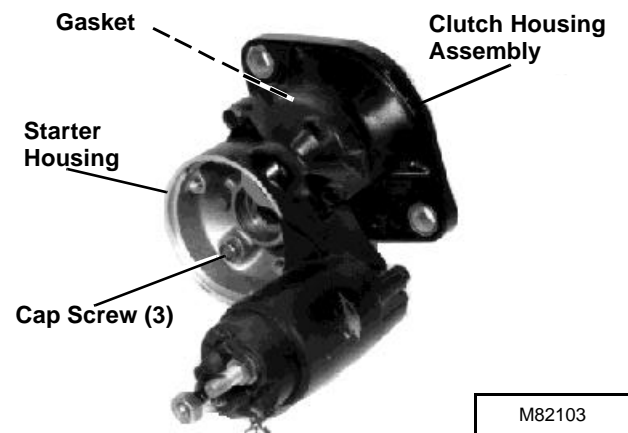
STARTER OVERRUNNING CLUTCH - HITACHI 2.0 kW

Disassembly

- Disconnect wiring lead.
- Remove two cap screws.
- Remove starter motor assembly.



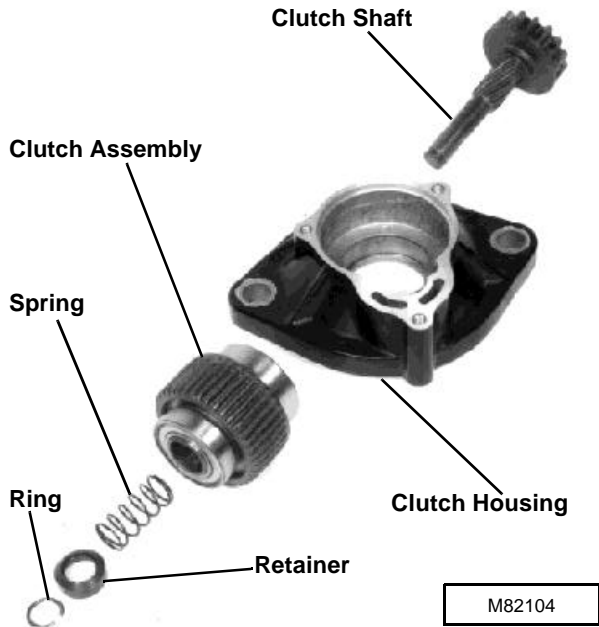
- Remove three cap screws.
- Separate clutch housing assembly from starter housing. Remove gasket.



Starter

6. Remove ring, retainer, spring, clutch assembly and clutch shaft from clutch housing.
7. Inspect all parts for wear or damage. Replace as necessary.

2



Assembly

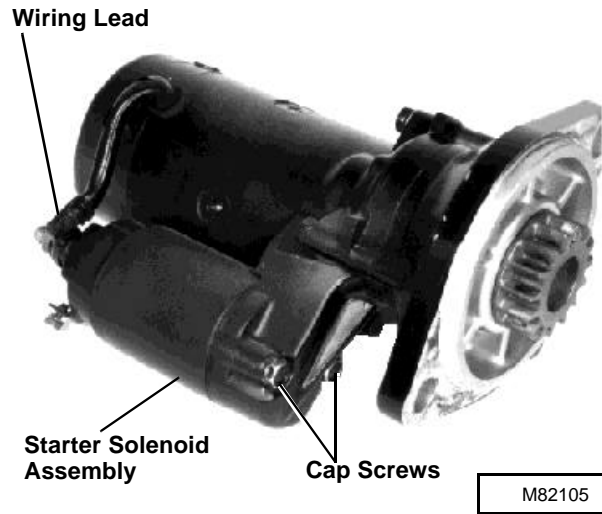
Assembly is done in the reverse order of disassembly.

- Apply multipurpose grease to all internal components during assembly.
- Install retainer with large cupped side toward clutch assembly.

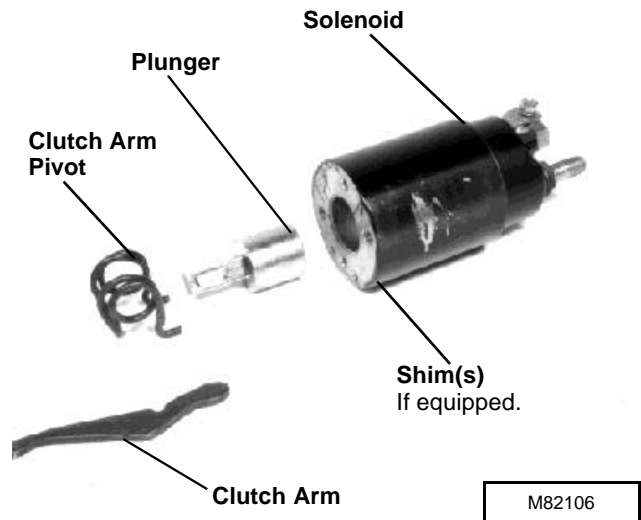
STARTER SOLENOID - HITACHI 2.0 kW

Disassembly

1. Disconnect wiring lead.
2. Remove cap screws.
3. Remove starter solenoid assembly.



4. Remove clutch arm, clutch arm pivot, plunger and shim(s), if equipped, from solenoid.
5. Inspect all parts for wear or damage. Replace as necessary.



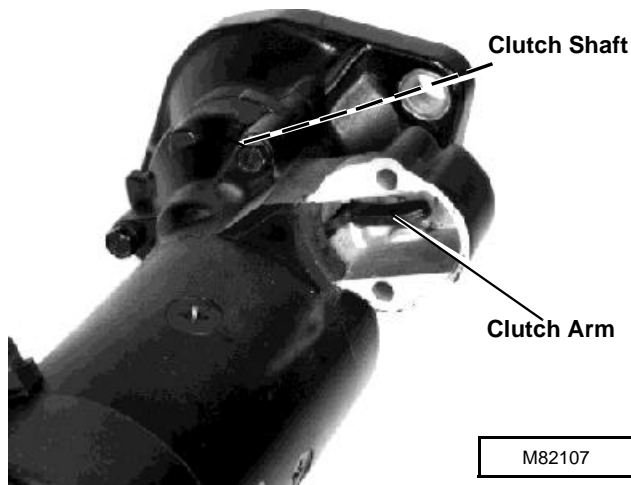
Assembly

Assembly is done in the reverse order of disassembly.

- Apply multipurpose grease to all internal components during assembly.

IMPORTANT: Make sure long end of clutch arm is installed all the way into starter housing. Clutch arm must be install on end of clutch shaft or starter will not operate.

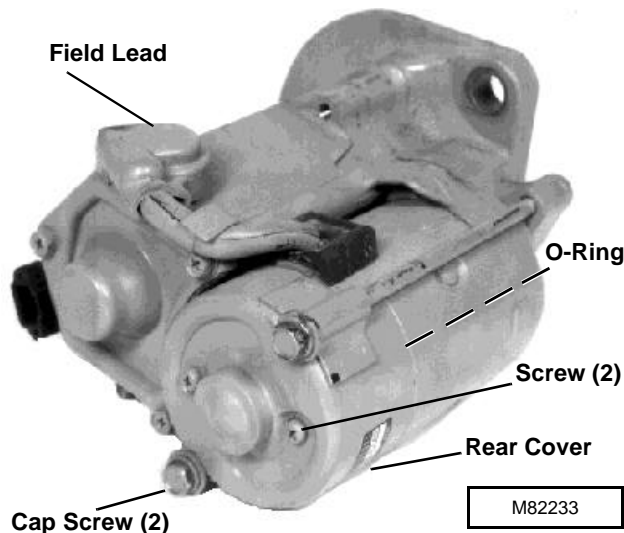
- Pull clutch shaft away from housing and insert clutch arm in starter housing. Push arm in until it stops.



STARTER MOTOR - NIPPONDENSO 1.0 kW AND 1.2 kW

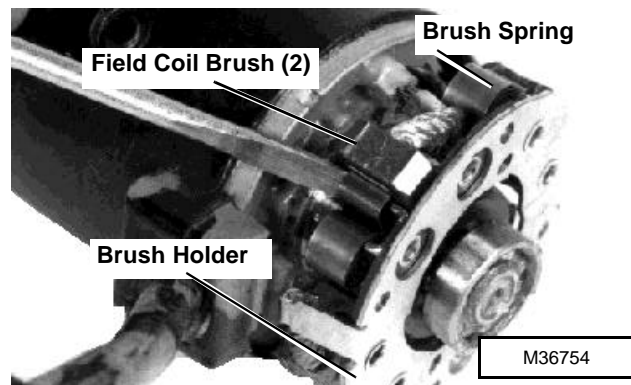
Disassembly

1. Disconnect field lead.
2. Remove two cap screws and two screws.
3. Remove rear cover and o-ring, if equipped.



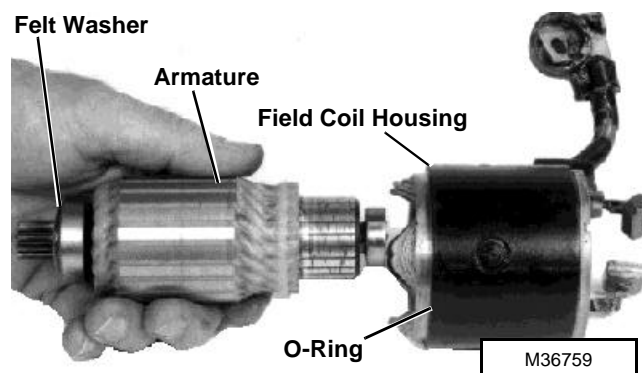
4. Remove field coil brushes from brush holder.

5. Pry brush springs away and pull negative brushes up enough to allow spring to hold brush in place.
6. Remove brush holder.



2

7. Remove armature from field coil housing.
8. Remove felt washer and o-ring, if equipped.
9. Inspect and test brushes, holder, field coil and armature. (See *Inspection/Test* procedures.)



Assembly

Assembly is done in the reverse order of disassembly.

- Apply multipurpose grease to bearing cup inside rear cover and felt washer, if equipped.

IMPORTANT: When installing rear cover, be sure field coil brush wires do not touch cover. Turn brush holder slightly to take up slack in brush wires. Press wires inward to clear rear cover.

Inspection/Test/Replacement

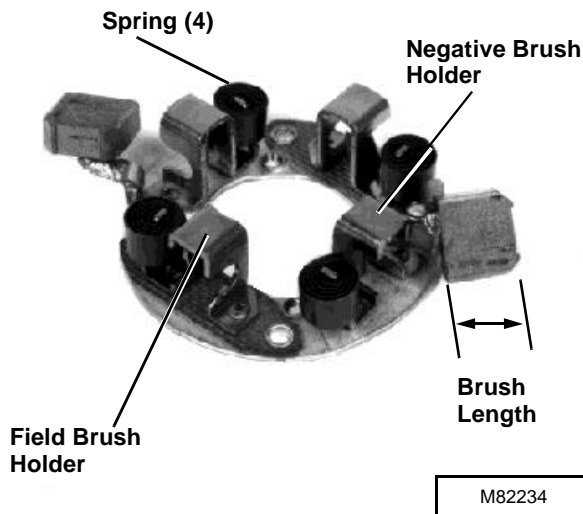
1. Measure holder and field coil brush lengths. Minimum brush length is **8.5 mm (0.335 in.)**. Replace brush holder or field coil if brush length is below minimum.

NOTE: Test brush holder using an ohmmeter or test light.

2. Test brush holder:

Touch one probe of tester to negative brush holder and other probe to field brush holder. If there is continuity, replace the brush holder.

- 2 3. Inspect springs for wear or damage. Replace if necessary.



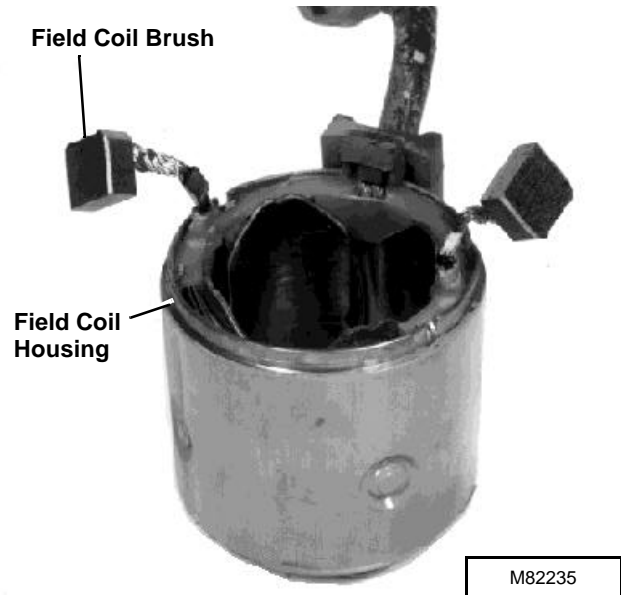
NOTE: Test field coil using an ohmmeter or test light.

4. Test for grounded field winding:

Touch one probe of tester to field coil brush and other probe to field coil housing. Be sure the brush lead is not touching the frame. If there is continuity, the coil is grounded and the field coil housing assembly must be replaced.

5. Test for open field coil:

Touch one probe of tester to each field coil brush. If there is no continuity, the field coil is open and the field coil housing assembly must be replaced.



IMPORTANT: Do not clean armature with solvent. Solvent can damage insulation on windings. Use only mineral spirits and a brush.

6. Inspect armature. Look for signs of dragging against pole shoes.
7. Inspect commutator. Look for roughness, burned bars, or any material which might cause short circuits between bars. If necessary, clean and touch up with 400 sandpaper. NEVER use emery cloth. Clean all dust from armature when finished.

NOTE: Test armature windings using an ohmmeter or test light.

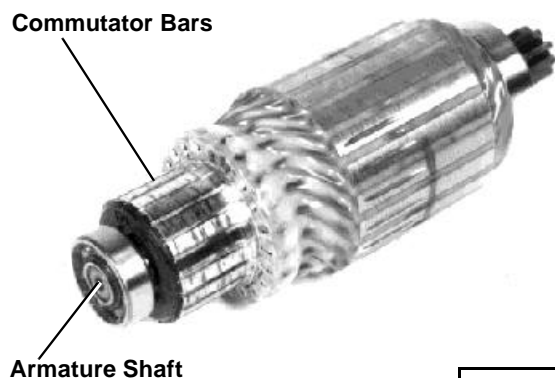
8. Test for grounded windings:

Touch probes on one commutator bar and armature shaft. Armature windings are connected in series, so only one commutator bar needs to be checked.

If test shows continuity, a winding is grounded and the armature must be replaced.

9. Test for open circuited windings:

Touch probes on two different commutator bars. If test shows no continuity, there is an open circuit and the armature must be replaced.



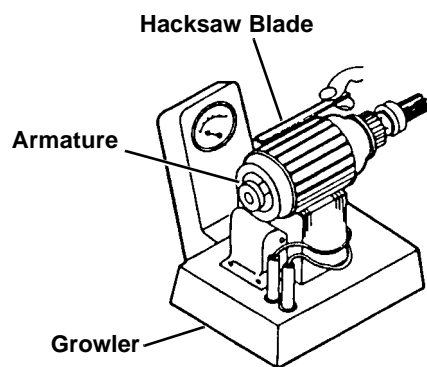
M82236

10. Test for short circuited windings using a growler. Put armature in a growler and hold a hacksaw blade above each slot while slowly rotating armature.

If coil is shorted, the blade will vibrate on the slot.

NOTE: A short circuit most often occurs because of copper dust or filings between two commutator segments.

11. If test indicates short circuited windings, clean the commutator of dust and filings. Check the armature again. If the test still indicates a short circuit, replace the armature.



M82125A

12. Inspect armature cover and housing bearings for wear or damage. Replace if necessary.

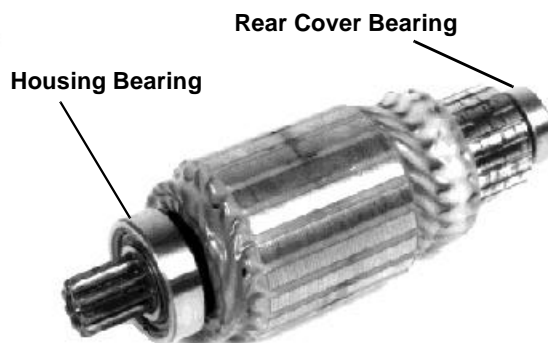
To replace bearings:

Bearings are press fit. Remove bearings using a knife-edge puller set.

IMPORTANT: Install both bearings with sealed side toward armature.

Install new housing bearing tight against shoulder of shaft using a piece of pipe.

Install new rear cover bearing tight against shoulder of shaft using a driver set.



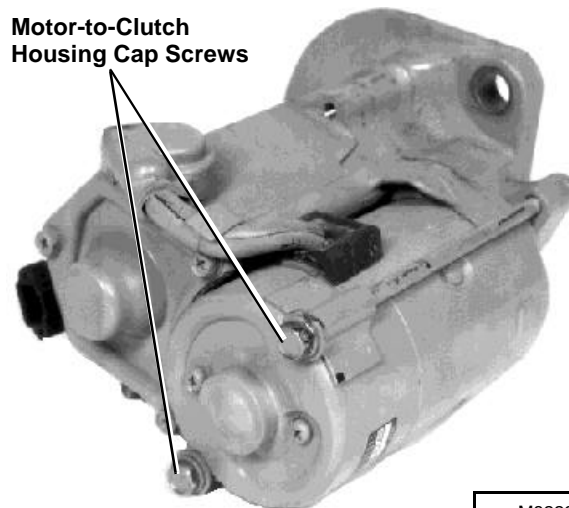
M82237

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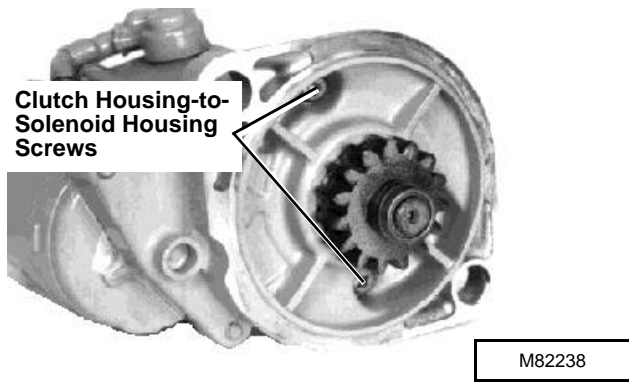
STARTER GEAR TRAIN AND OVERRUNNING CLUTCH - NIPPONDENSO 1.0 kW AND 1.2 kW

Disassembly/Inspection

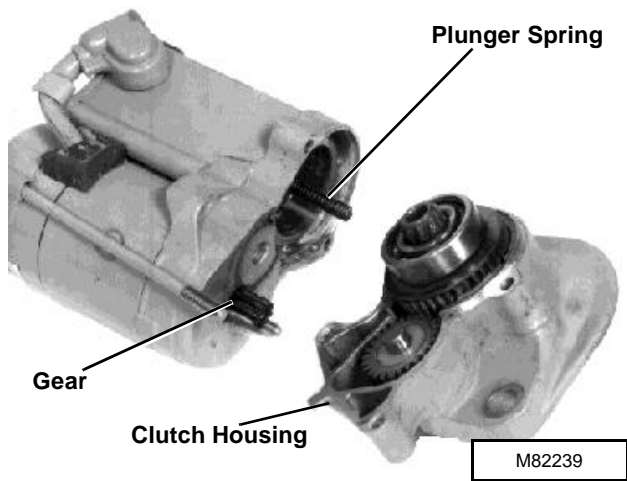
1. Remove two motor-to-clutch housing cap screws and two clutch housing-to-solenoid housing screws.



M82233

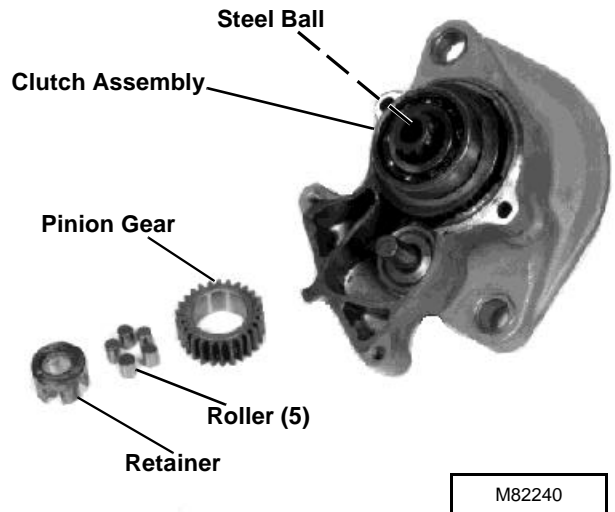


2. Separate clutch housing from solenoid/motor assembly.
3. Remove plunger spring and gear, if equipped.

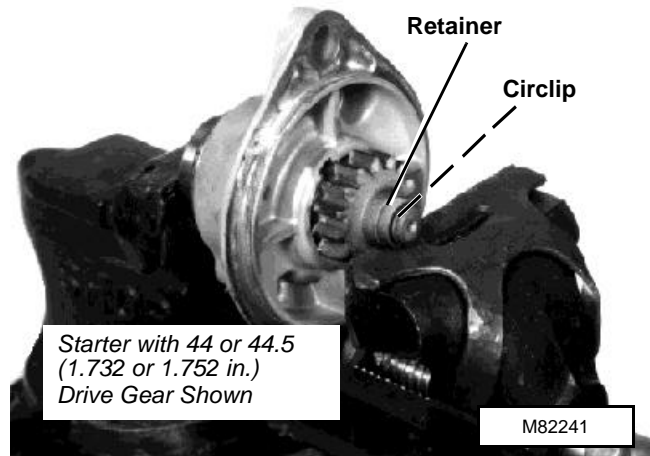


NOTE: Starter is equipped with either a 33 mm (1.299 in.), 44 mm (1.732 in.) or 44.5 mm (1.752 in.) drive gear on end of clutch shaft. Disassembly procedures are slightly different.

4. Starter with 33 mm (1.299 in.) drive gear: Remove clutch assembly from housing.
5. Remove retainer, five rollers and pinion gear.
6. Remove steel ball.



7. Put clutch (housing) assembly into a soft-jawed vice, as shown.
8. Tighten vise slowly, until drive gear compresses.
9. Remove retainer and circlip.



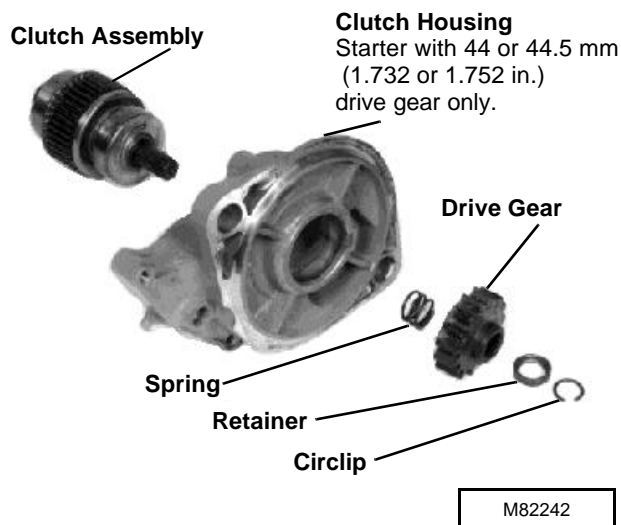
CAUTION

Shaft could be propelled from clutch unit with considerable force if spring is not allowed to extend fully while in vise.

10. While holding clutch assembly, slowly open vise until all spring compression is relieved.

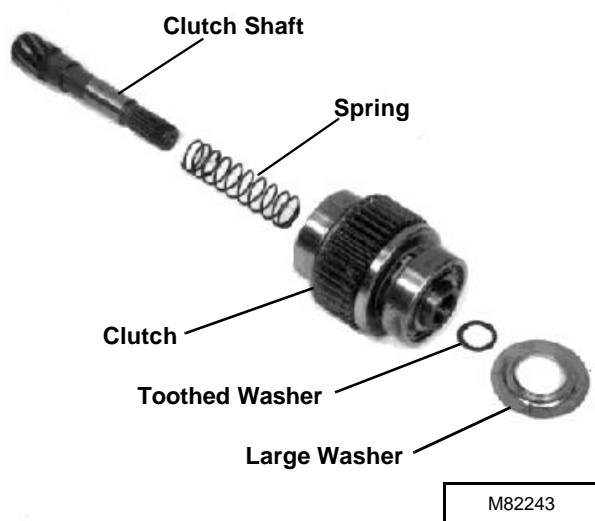
11. Starter with 33 mm (1.299 in.) drive gear:
Remove drive gear and spring from clutch assembly.

Starter with 44 mm (1.732 in.) or 44.5 mm (1.752 in.) drive gear: Remove drive gear, spring and clutch assembly from housing.



12. Remove washer, toothed washer, spring and clutch shaft.

13. Inspect all parts for wear or damage. Replace as necessary.



Assembly

Assembly is done in the reverse order of disassembly.

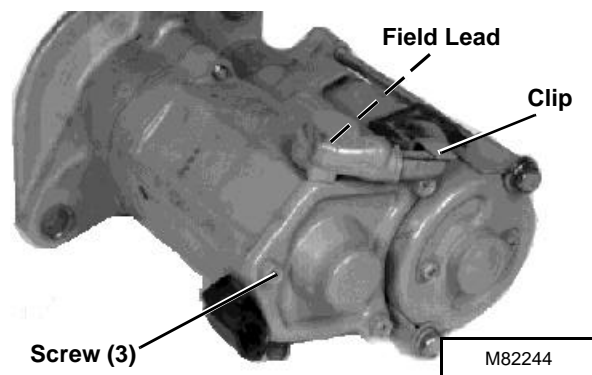
- Apply multipurpose grease to bearings, clutch shaft, springs, pinion gears, retainer, rollers and steel ball.
- Install large washer with flat side toward clutch assembly.
- Install retainer with cupped side away from clutch assembly.

STARTER SOLENOID - NIPPONDENSO 1.0 kW AND 1.2 kW

2

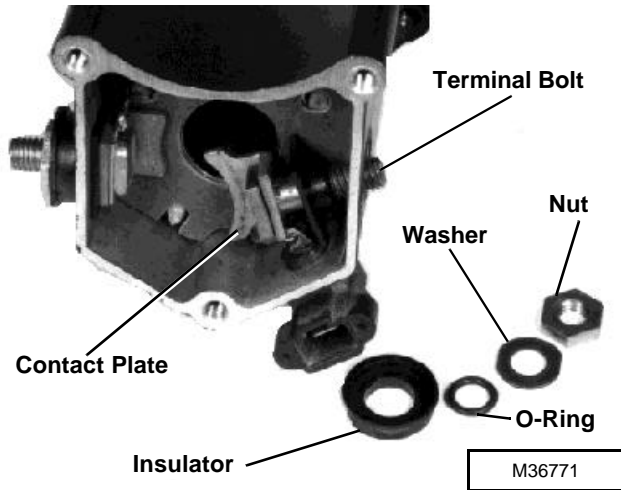
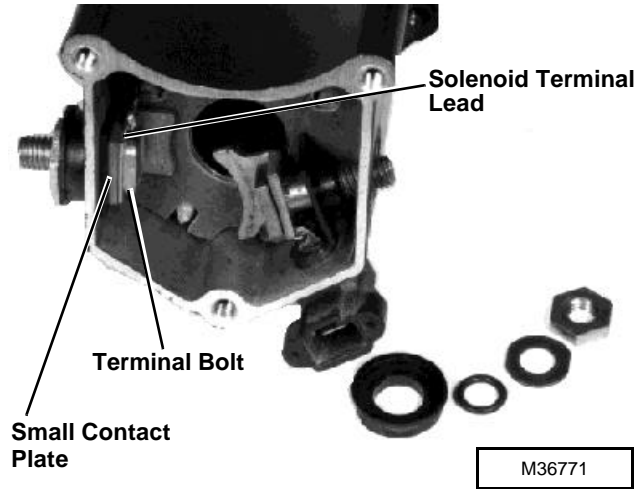
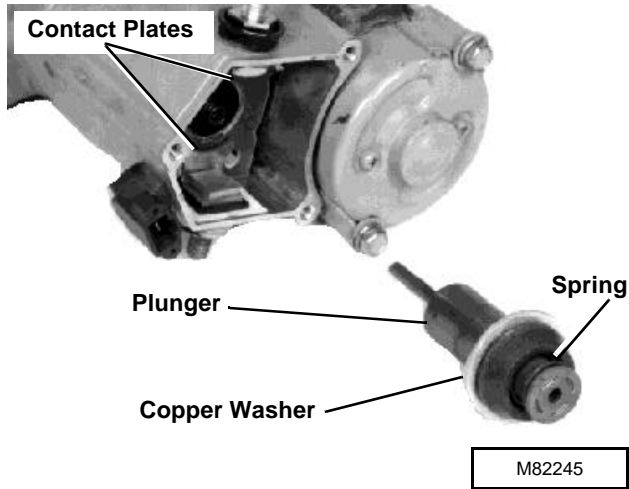
Disassembly/Inspection

1. Disconnect field lead.
2. Remove three screws and clip.
3. Remove cover and gasket.



4. Remove plunger.
5. Disassemble terminals. Remove parts from each terminal in order shown.
6. Inspect copper washer and contact plates for excessive burning or pitting. Clean burnt areas to improve electrical contact. Replace contacts or plunger if necessary. The solenoid is not serviceable. If defective, replace solenoid housing assembly.

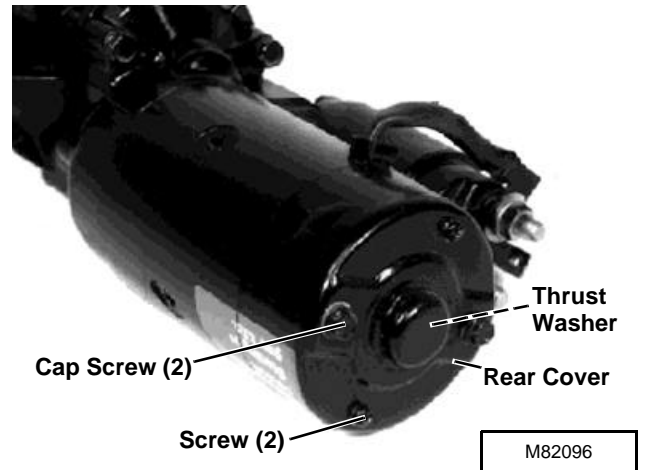
2



STARTER MOTOR - NIPPONDENSO 1.4 kW

Disassembly

1. Remove two cap screws and two screws.
2. Remove rear cover and thrust washer, if equipped.

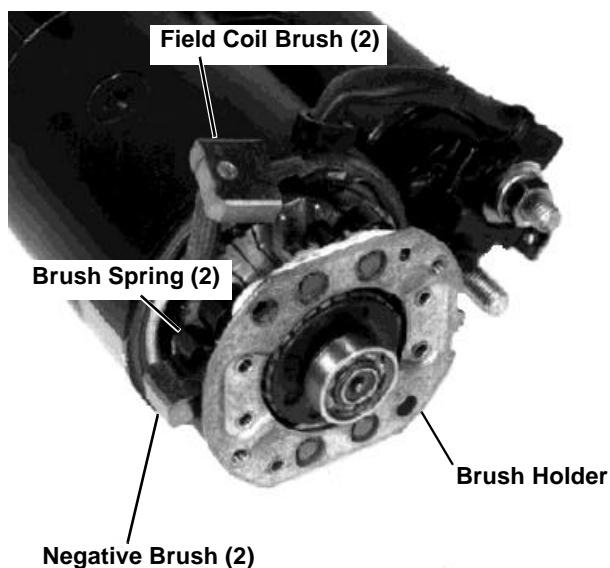


Assembly

Assembly is done in the reverse order of disassembly.

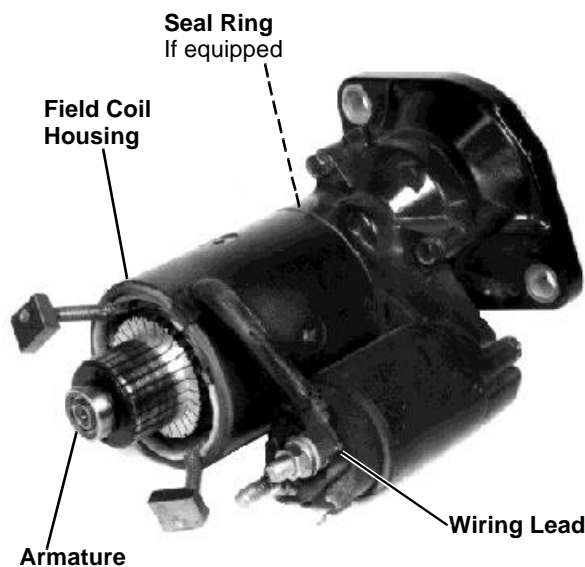
NOTE: The assembly sequence of the left and right terminals is similar. Be sure solenoid terminal lead is installed between terminal bolt and contact plate. Also, be sure smaller contact plate is on the left side.

3. Remove field coil brushes from brush holder.
4. Pry brush springs away and pull negative brushes up enough to allow spring to hold brush in place.
5. Remove brush holder.



M82097

6. Disconnect wiring lead and relay leads, if equipped.
7. Remove field coil housing, armature and o-ring, if equipped.
8. Inspect and test brushes, holder, field coil and armature. (See *Inspection/Test* procedures.)



M82098

Assembly

Assembly is done in the reverse order of disassembly.

- Apply multipurpose grease to bearing cup inside rear cover.

IMPORTANT: When installing rear cover, be sure field coil brush wires do not touch cover. Turn brush holder slightly to take up slack in brush wires. Press wires inward to clear rear cover.

Inspection/Test/Replacement

2

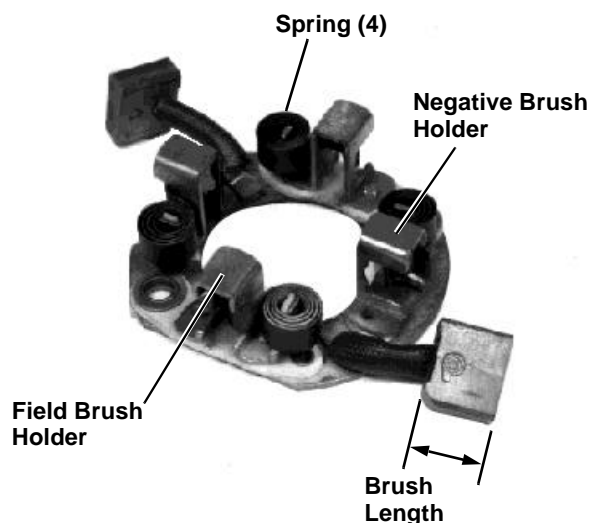
1. Measure holder and field coil brush lengths. Minimum brush length is **8.5 mm (0.335 in.)**. Replace brush holder or field coil if brush length is below minimum.

NOTE: Test brush holder using an ohmmeter or test light.

2. Test brush holder:

Touch one probe of tester to negative brush holder and other probe to field brush holder. If there is continuity, replace the brush holder.

3. Inspect springs for wear or damage. Replace if necessary.



M82099

NOTE: Test field coil using an ohmmeter or test light.

4. Test for grounded field winding:

Starter

Touch one probe of tester to field coil brush and other probe to field coil housing. Be sure the brush lead is not touching the frame. If there is continuity, the coil is grounded and the field coil housing assembly must be replaced.

5. Test for open field coil:

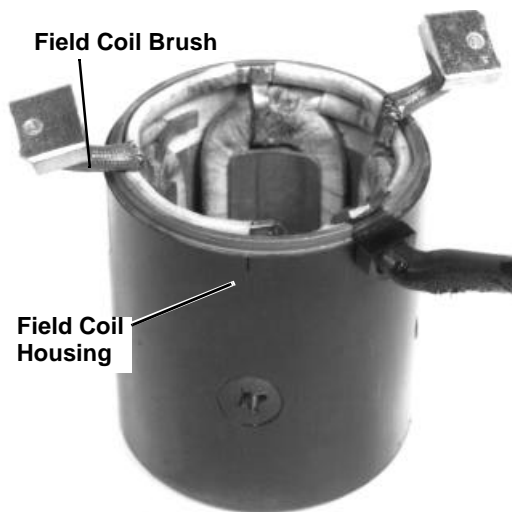
Touch one probe of tester to each field coil brush. If there is no continuity, the field coil is open and the field coil housing assembly must be replaced.

IMPORTANT: Do not clean armature with solvent. Solvent can damage insulation on windings. Use only mineral spirits and a brush.

2

6. Inspect armature. Look for signs of dragging against pole shoes.

7. Inspect commutator. Look for roughness, burned bars, or any material which might cause short circuits between bars. If necessary, clean and touch up with 400 sandpaper. NEVER use emery cloth. Clean all dust from armature when finished.



M82100

NOTE: Test armature windings using an ohmmeter or test light.

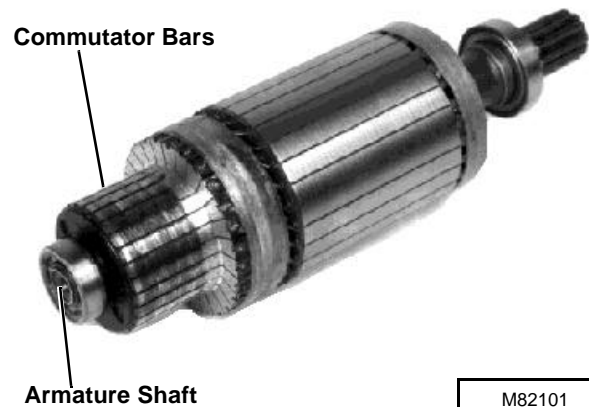
8. Test for grounded windings:

Touch probes on one commutator bar and armature shaft. Armature windings are connected in series, so only one commutator bar needs to be checked.

If test shows continuity, a winding is grounded and the armature must be replaced.

9. Test for open circuited windings:

Touch probes on two different commutator bars. If test shows no continuity, there is an open circuit and the armature must be replaced.



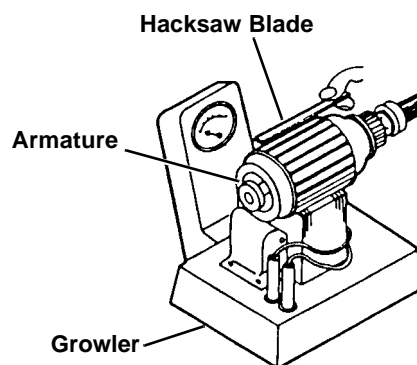
M82101

10. Test for short circuited windings using a growler. Put armature in a growler and hold a hacksaw blade above each slot while slowly rotating armature.

If coil is shorted, the blade will vibrate on the slot.

NOTE: A short circuit most often occurs because of copper dust or filings between two commutator segments.

11. If test indicates short circuited windings, clean the commutator of dust and filings. Check the armature again. If the test still indicates a short circuit, replace the armature.



M82125A

12. Inspect armature cover and housing bearings for wear or damage. Replace if necessary.

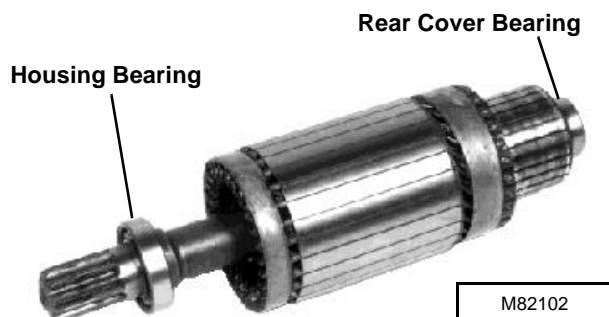
To replace bearings:

Bearings are press fit. Remove bearings using a knife-edge puller set.

IMPORTANT: Install both bearings with sealed side toward armature.

Install new housing bearing tight against shoulder of shaft using a piece of pipe.

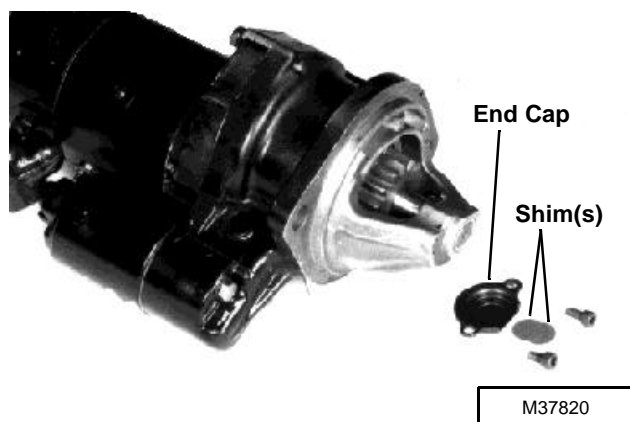
Install new rear cover bearing tight against shoulder of shaft using a driver set.



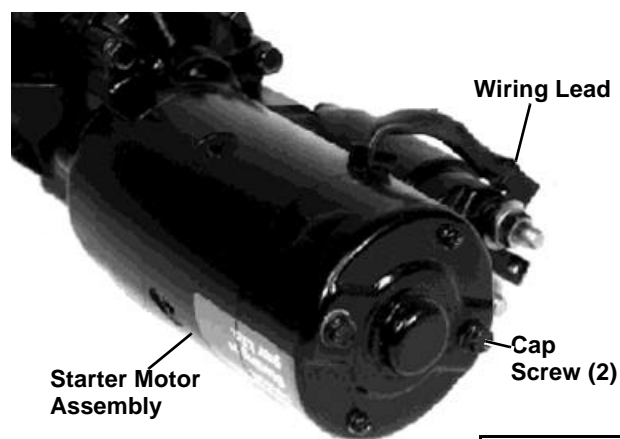
STARTER GEAR TRAIN AND SOLENOID - NIPPONDENSO 1.4 kW

Disassembly/Inspection

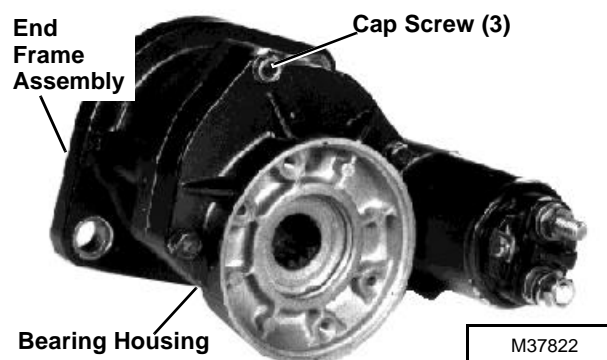
1. Remove two socket head screws, end cap and shim(s).



2. Disconnect wiring lead and relay leads, if equipped.
3. Remove two cap screws.
4. Remove starter motor assembly from bearing housing.



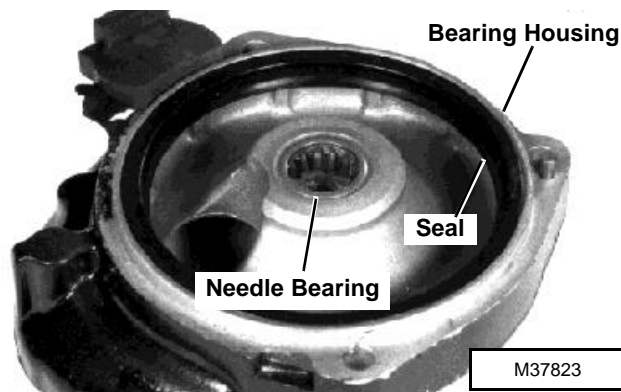
5. Remove three cap screws.
6. Separate end frame assembly from bearing housing.



7. Inspect seal and needle bearing for wear or damage. Replace as necessary.

To replace needle bearing:

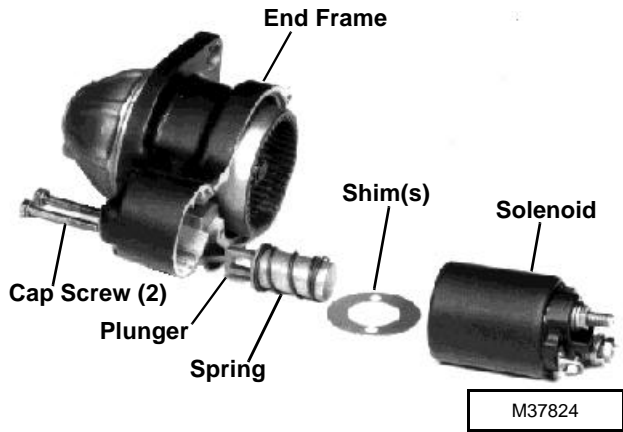
Remove bearing using a blind-hole puller set. Install new bearing flush with housing surface using a driver set.



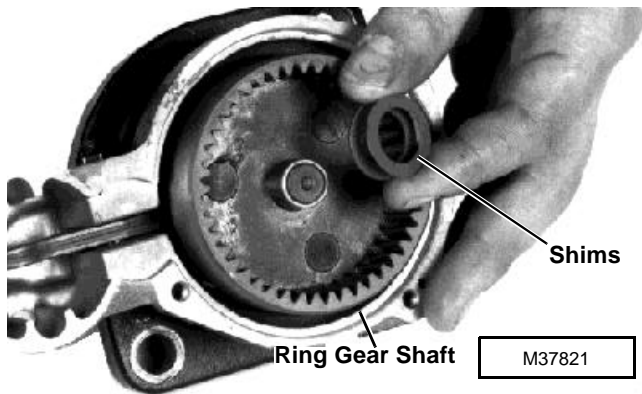
Starter

8. Remove two cap screws, plunger, spring, shims and solenoid.

2

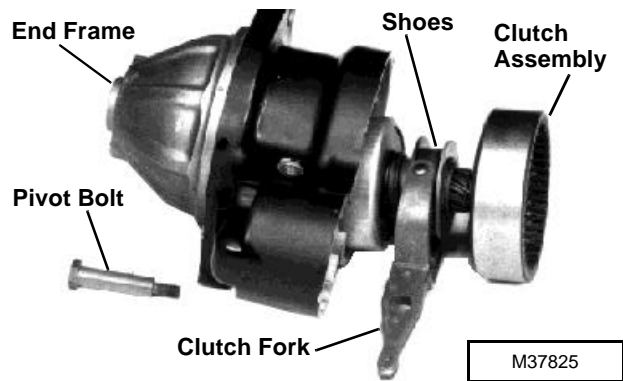


9. Remove shims from ring gear shaft.



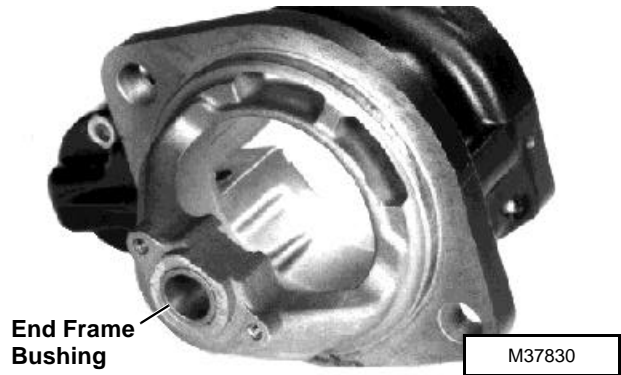
10. Remove pivot bolt, clutch fork and clutch assembly.

11. Inspect shoes on fork for wear or damage. Replace fork if necessary.



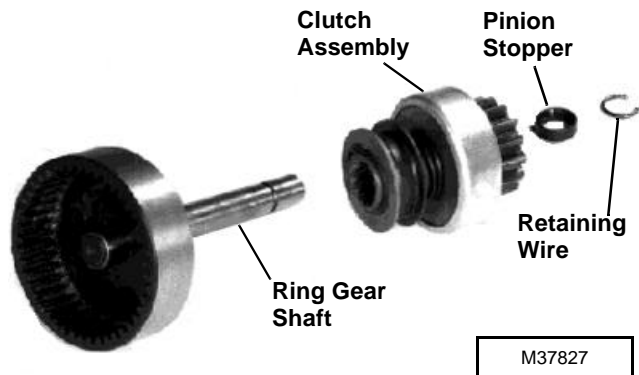
12. Inspect end frame bushing for wear or damage. Replace if necessary.

Replace bushing using a driver set. Install bushing flush with face of housing.



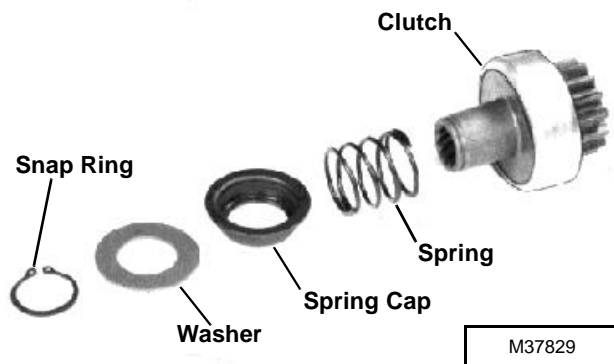
13. Slide pinion stopper away from retaining wire using a piece of pipe or deep socket. Remove retaining wire, pinion stopper, and clutch assembly from ring gear shaft.

14. Inspect all parts for wear or damage. Replace as necessary.



15. Remove snap ring, washer, spring cap, and spring from clutch.

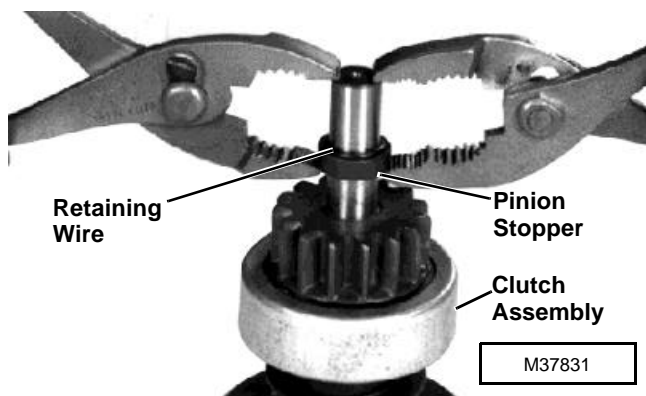
16. Inspect all parts for wear or damage. Replace as necessary.



Assembly

Assembly is done in the reverse order of disassembly.

- After installing clutch assembly, pinion stopper and retaining wire on ring gear shaft, use two pliers to press pinion stopper over retaining wire.

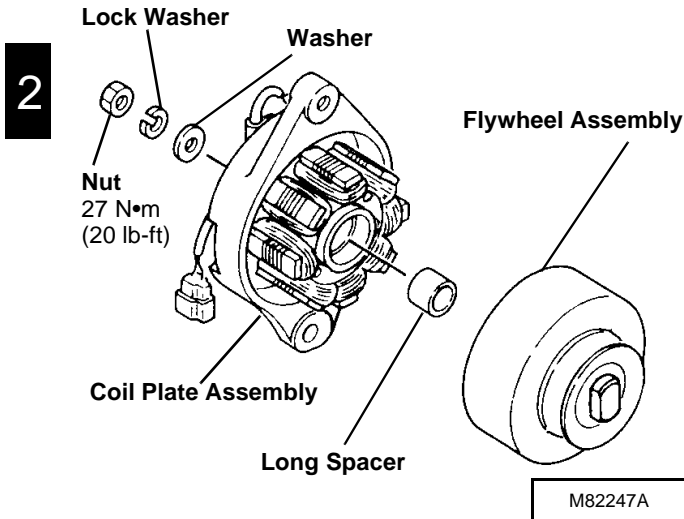


Alternator

ALTERNATOR - KOKOSAN 20A

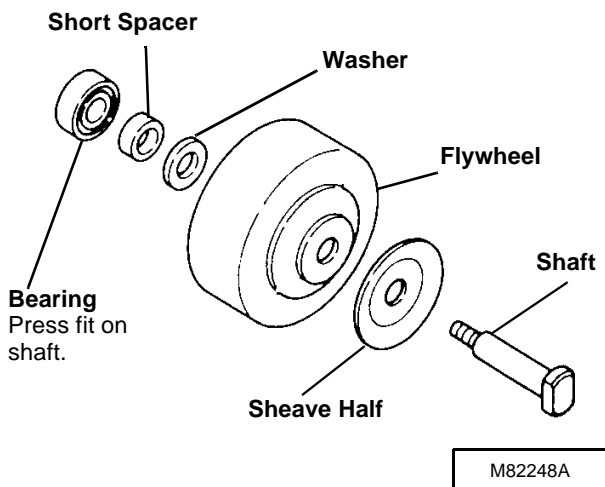
Disassembly/Inspection

1. Remove nut and washers.
2. Tap on end of shaft with a soft-faced hammer to separate flywheel assembly from coil plate assembly.
3. Remove long spacer.



NOTE: Bearing and flywheel are press fit on shaft.

4. Remove shaft from bearing, short spacer, washer, flywheel and sheave half, using a press.
5. Inspect all parts for wear or damage. Replace as necessary.



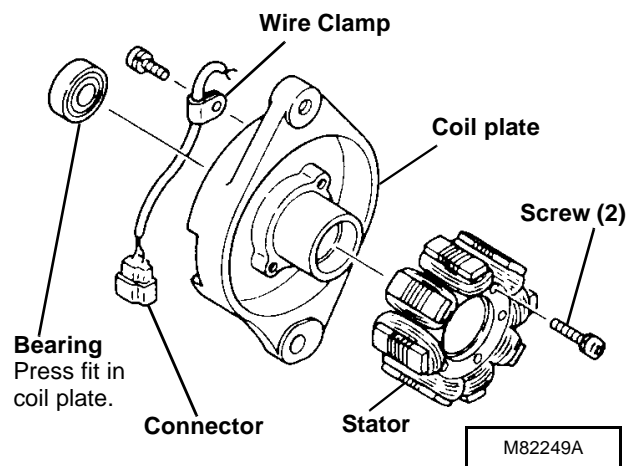
NOTE: Remove bearing only if replacement is necessary.

6. Inspect bearing in coil plate for wear or damage. Replace if necessary.

To replace bearing:

Remove bearing using a spark plug socket and a press. Install bearing into coil plate until it bottoms in bore using a 1 in. socket.

7. Remove wire clamp.
8. Remove connector from harness leads.
9. Remove two screws and stator.
10. Inspect all parts for wear or damage. Replace as necessary.

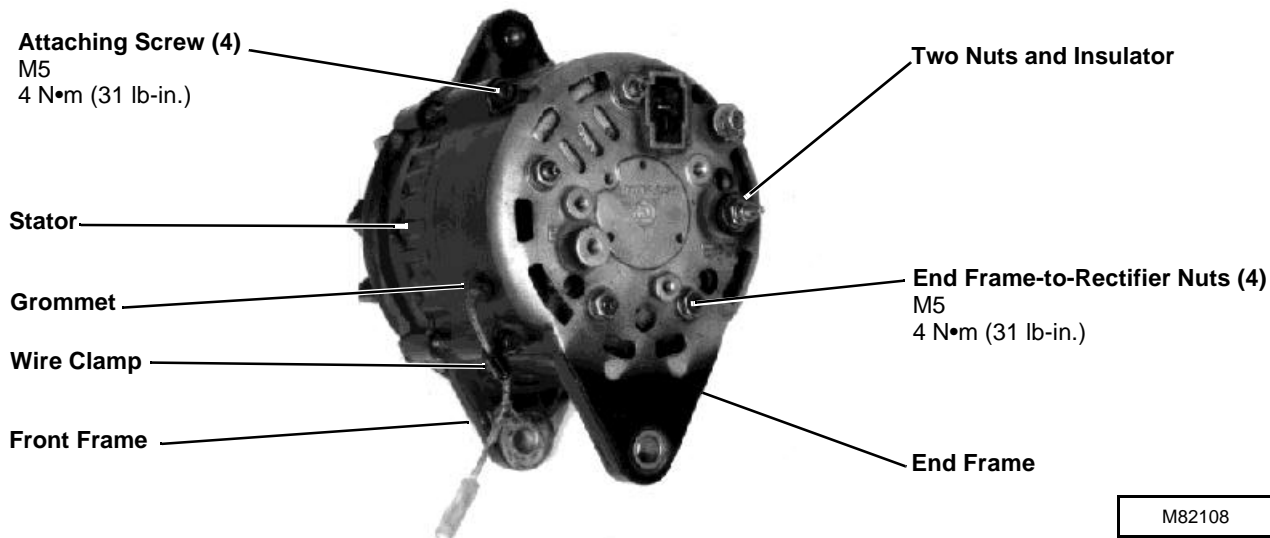


Assembly

Assembly is done in the reverse order of disassembly.

- With sheave half on shaft, press shaft into flywheel until sheave half bottoms on flywheel face.
- With washer and short spacer installed, press new bearing onto shaft until it bottoms on spacer.

VOLTAGE REGULATOR - HITACHI 25A



2

Replacement

1. Remove three screws and cover.
2. Remove four attaching screws, wire clamp and grommet.
3. Remove four end frame-to-rectifier nuts.
4. Remove two nuts and insulator.

IMPORTANT: Do not pry against stator wires.

5. Use a screwdriver to pry end frame from stator. Do not separate stator from front frame.
6. Remove two screws and insulator.

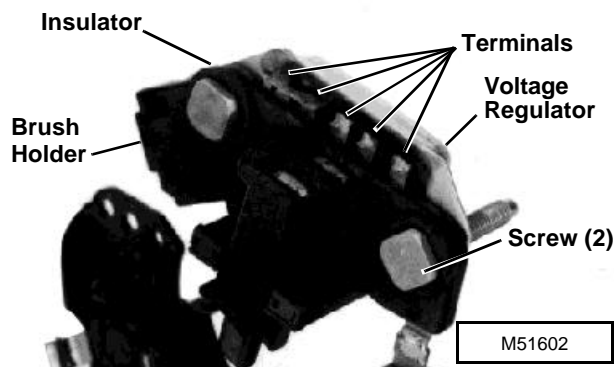
7. Use a soldering gun with at least 120 watt capacity to disconnect five terminals. Replace voltage regulator.

- If additional solder is needed, use ONLY 60-40 rosin-core solder.

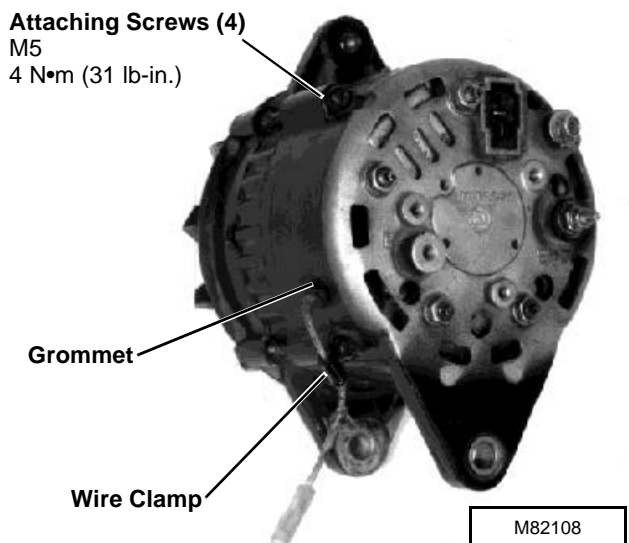
ALTERNATOR - HITACHI 25A

Disassembly

1. Remove three screws and cover.
2. Remove four attaching screws, wire clamp and grommet.



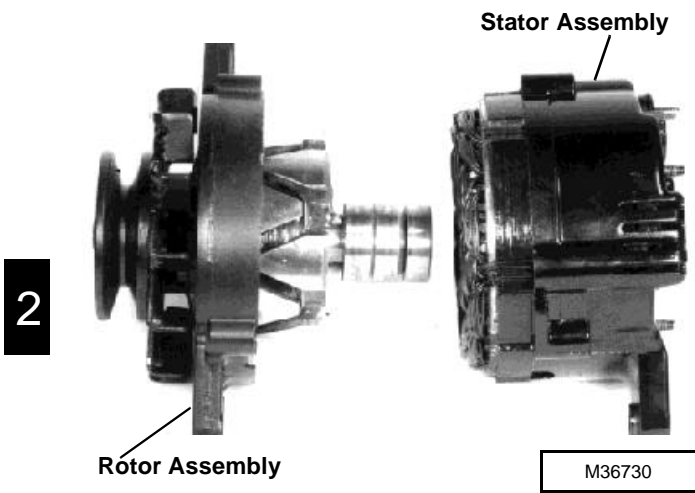
IMPORTANT: Do not heat connections longer than necessary to melt solder, as excess heat will damage rectifier assembly.



Alternator

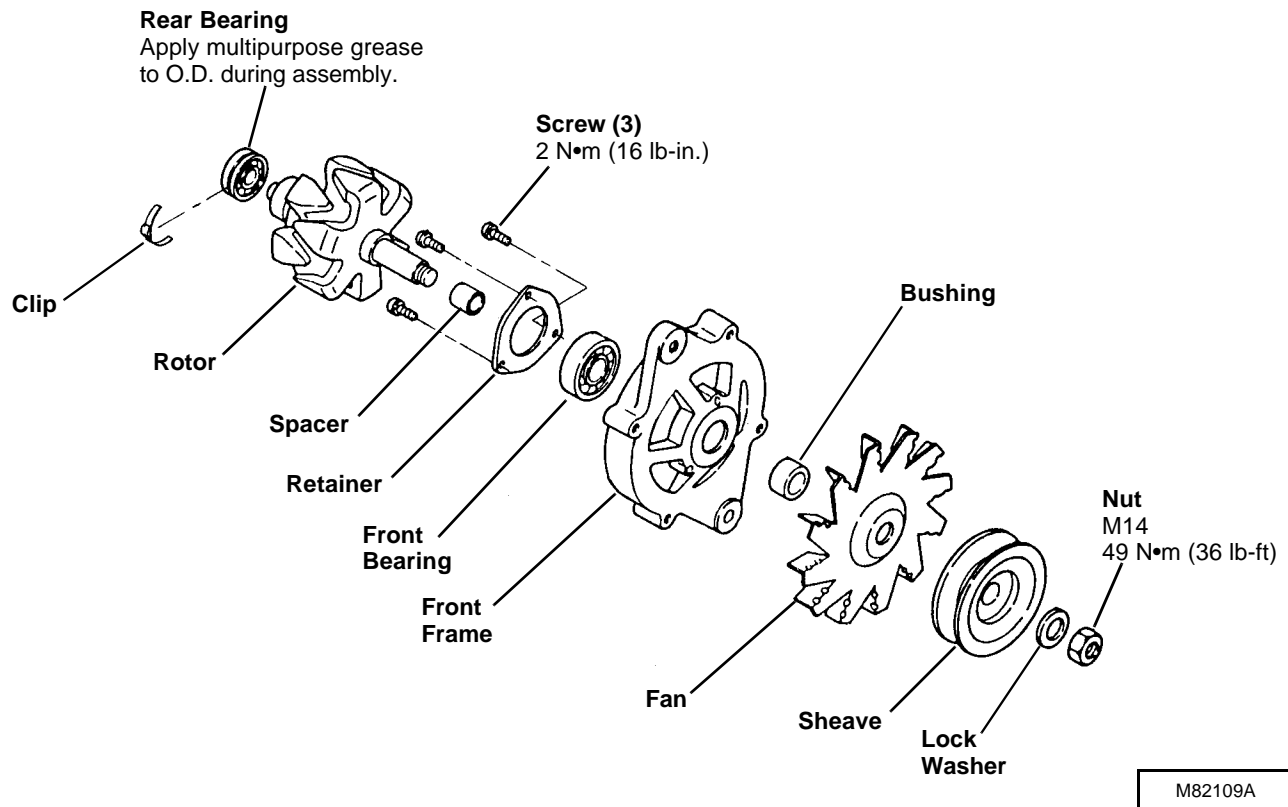
IMPORTANT: Do not pry against stator wires.

3. Use a screwdriver to separate rotor assembly from stator assembly.



Rotor Assembly:

- Rear bearing is press fit. Replace only if necessary. Remove bearing using a puller set. Install bearing until flush with end of rotor shaft. Press only on inner race of bearing.
4. Put rotor assembly in a soft-jawed vise. Remove nut, lock washer, sheave, fan and bushing.
 5. Put front frame on open jaws of vice. Use a soft-faced hammer to remove rotor and spacer.
 6. Remove three screws, retainer and front bearing.
 7. Inspect all parts for wear or damage. Replace as necessary.
 8. Test rotor. (See *Inspection/Test* procedures.)



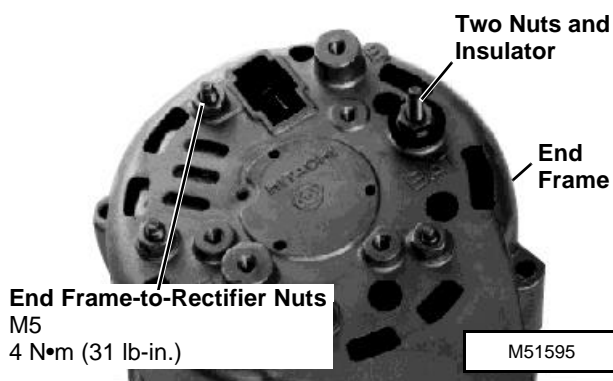
Stator Assembly:

9. Remove four end frame-to-rectifier nuts.

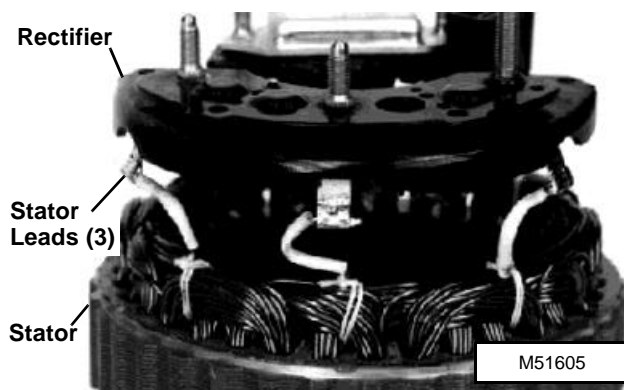
10. Remove two nuts and insulator.

IMPORTANT: Do not pry against stator wires.

11. Use a screwdriver to pry end frame from stator



12. Use a soldering gun with at least 120 watt capacity to disconnect three stator leads. Remove rectifier.



13. Inspect and test brushes, stator and rectifier. (See *Inspection/Test* procedures.)

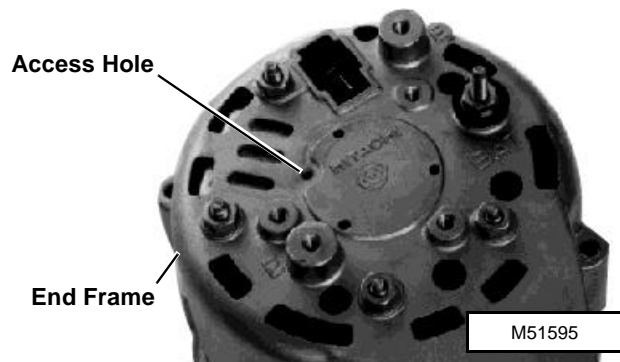
Assembly

Assembly is done in the reverse order of disassembly.

- Bend the stator lead wires, as necessary, to obtain an approximate distance of **33.50 mm (1.300 in.)** from stator to rectifier. Connect the three leads using a soldering gun.
- If additional solder is needed, use **ONLY 60-40 rosin-core solder.**

IMPORTANT: Be sure stator lead wires do not contact end frame when installed.

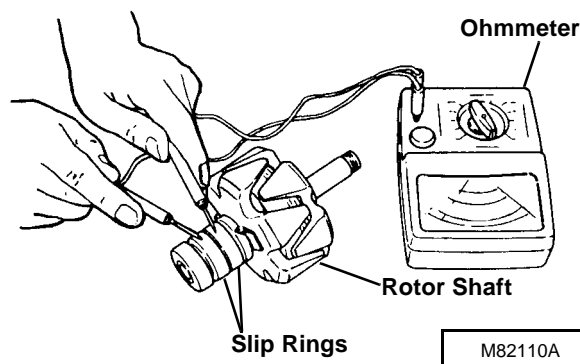
- Before assembling stator assembly to rotor assembly, push brushes into brush holder and insert a wire through access hole to lock brushes in place.
- Assemble rotor assembly to stator assembly and fasten with four attaching screws. Remove wire from access hole.



Inspection/Test

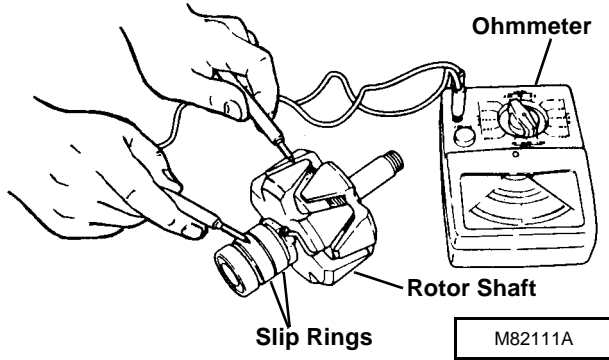
Rotor:

- Inspect the rotor slip rings for dirt build-up, rough spots, or out of roundness. If necessary, polish the surface of the slip rings using No. 00 sandpaper or 400-grit silicon carbide paper.
- Touch the probes of an ohmmeter to slip rings. Replace rotor if test indicates no continuity (no needle movement).



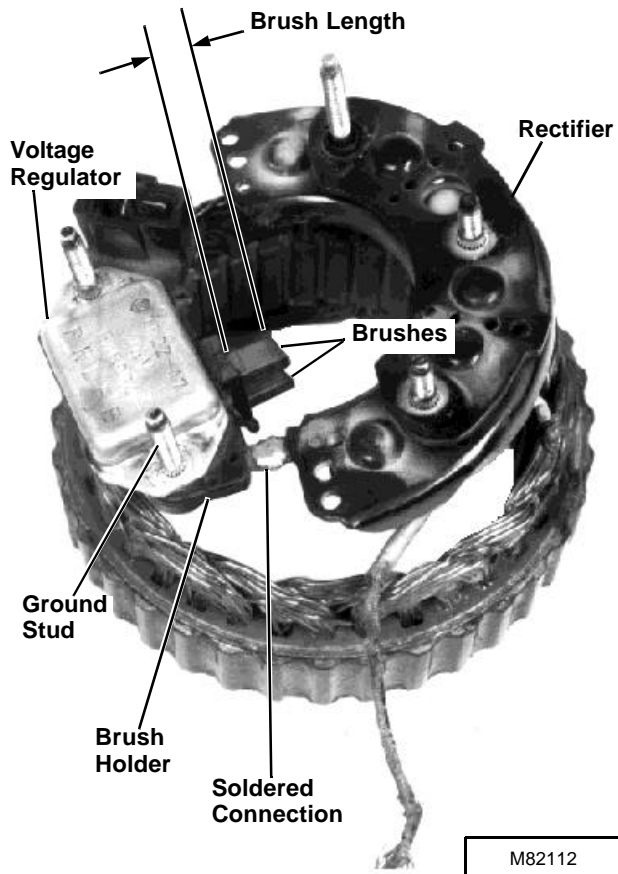
- Touch the probes of the ohmmeter to the shaft and one of the slip rings. Repeat for other slip ring. Replace rotor if test shows continuity (needle movement).

Alternator



2 Brushes:

- Inspect brush holder and brushes for damage. Brushes must slide freely and the springs must hold the brushes firmly against the slip rings of the rotor.
- Measure brushes for wear. Minimum exposed length must be **5.50 mm (0.220 in.)** or to wear limit line on brushes. Replace brushes as necessary.



- Use an ohmmeter or a test light to check for continuity. Check between the two brushes and between each brush and ground stud. There should be no continuity. Replace brush holder-rectifier assembly if there is continuity.
- To replace brushes, melt solder from connection. Remove voltage regulator if necessary. (See *VOLTAGE REGULATOR REPLACEMENT* in this group.)

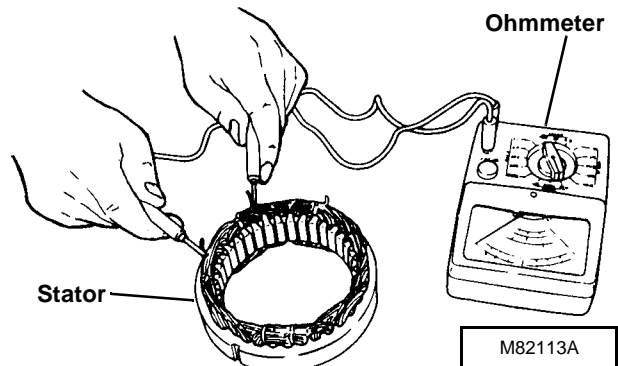
NOTE: If additional solder is needed, use ONLY 60-40 rosin-core solder.

Stator:

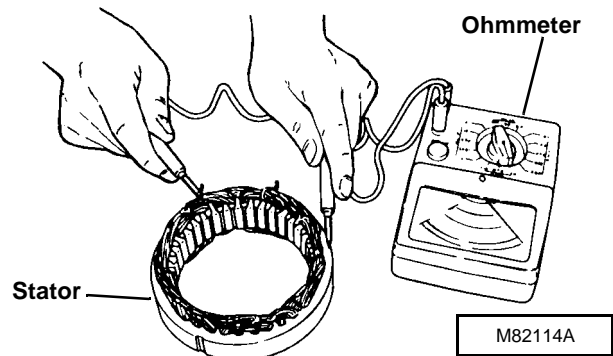
- Inspect stator for defective insulation, discoloration or a burned odor. If any of these defects are found, replace stator.

NOTE: Use an ohmmeter that is sensitive to resistance of 0 to 1 ohm.

- Touch probes of an ohmmeter to lead wires of stator in three possible combinations. Continuity should read approximately **0.26 ohms**. If readings are not equal, replace stator.



- Touch one probe of the ohmmeter to the bare metal surface of stator and the other probe to a bare stator lead wire. Repeat for each wire. Replace stator if test indicates continuity.



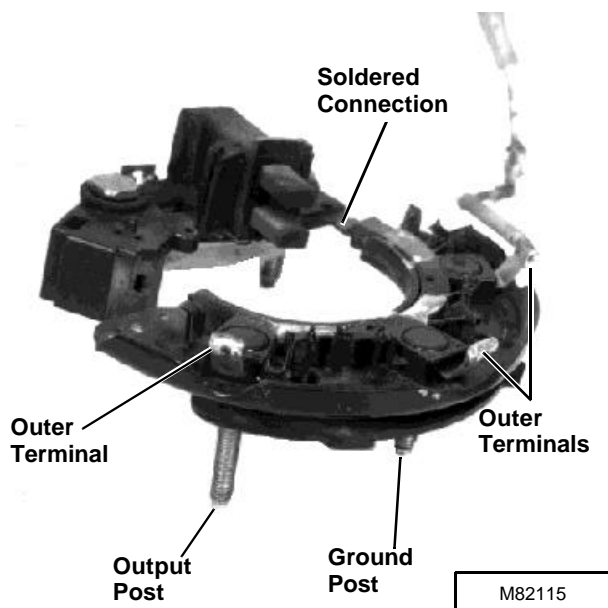
Rectifier:

- Test the diodes by touching probes to ground post and the three outer terminals.
- Switch the probes and check each terminal again. There should be continuity in only one combination of each terminals and the ground post.
- Test the diodes by touching probes to output post and the three outer terminals.
- Switch the probes and check each terminal again. There should be continuity in only one combination of each terminal and the output post.

A shorted diode would have continuity in both directions. An open diode would have no continuity in either direction. Replace the rectifier assembly if any of the three diodes are defective.

- To replace rectifier, melt solder from connection.

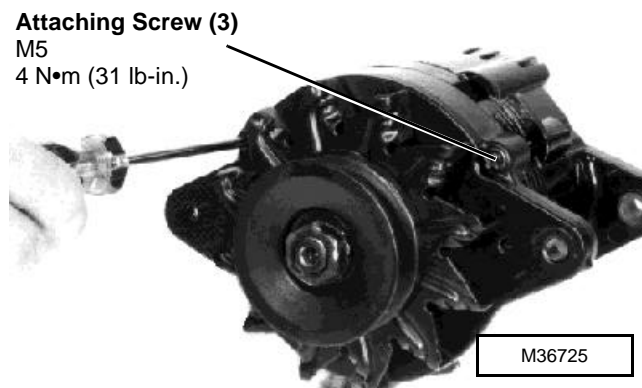
NOTE: If additional solder is needed, use ONLY 60-40 rosin-core solder.



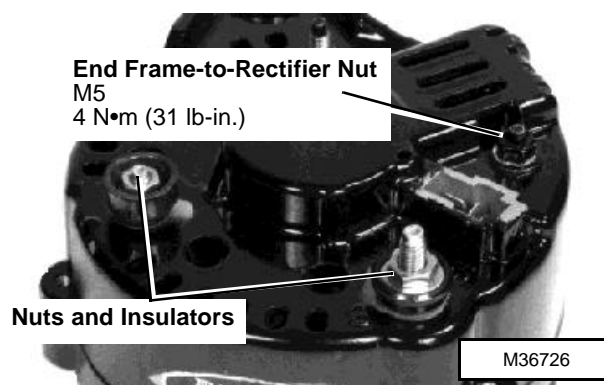
VOLTAGE REGULATOR - NIPPONDENSO 35A

Replacement

1. Remove three attaching screws.

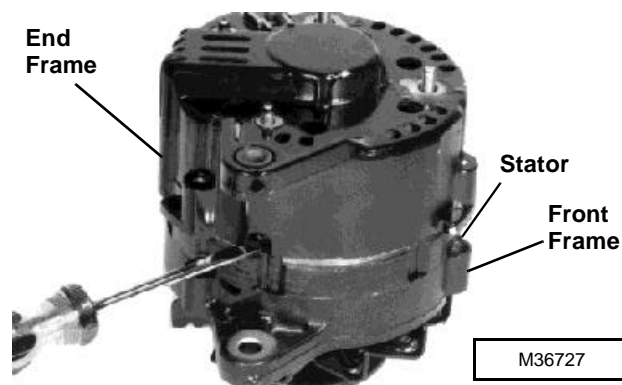


2. Remove end frame-to-rectifier nut.
3. Remove nuts and insulators.



IMPORTANT: Do not pry against stator wires.

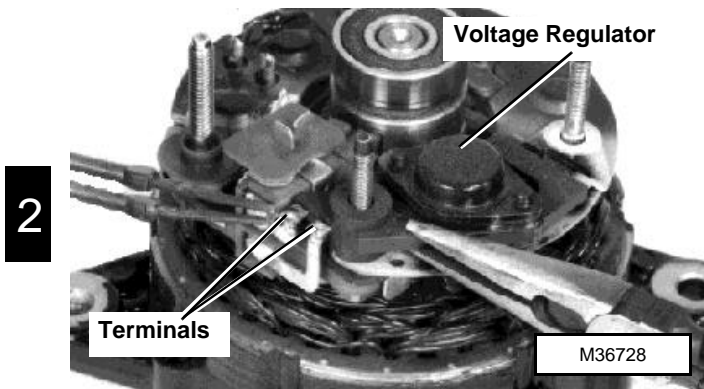
4. Use a screwdriver to pry end frame from stator. Do not separate stator from front frame.



Alternator

IMPORTANT: Do not heat connections longer than necessary to melt solder, as excess heat will damage rectifier assembly.

5. Use a soldering gun with a least 120 watt capacity to disconnect terminals. Replace voltage regulator.



Installation is done in the reverse order of removal.

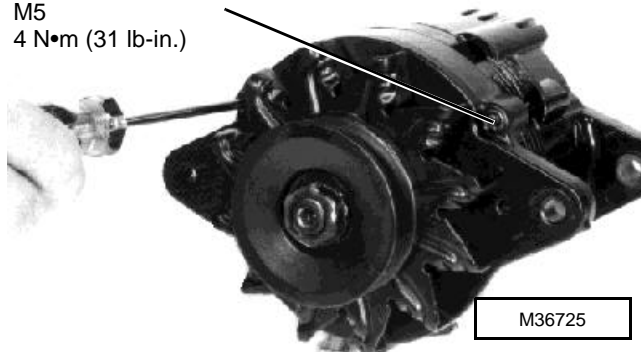
- If additional solder is needed, use ONLY 60-40 rosin-core solder.

ALTERNATOR - NIPPONDENSO 35A

Disassembly

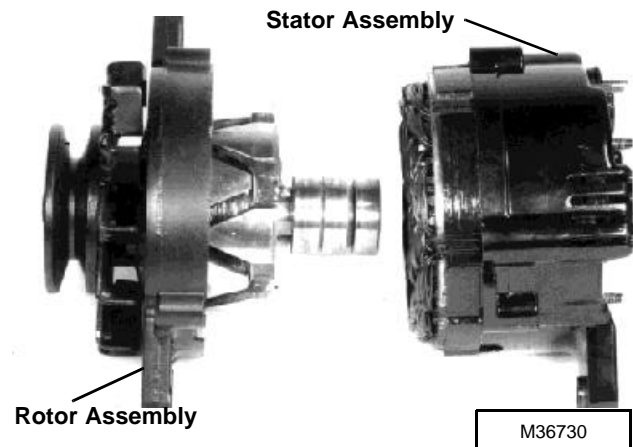
1. Remove three attaching screws.

Attaching Screw (3)
M5
4 N•m (31 lb-in.)



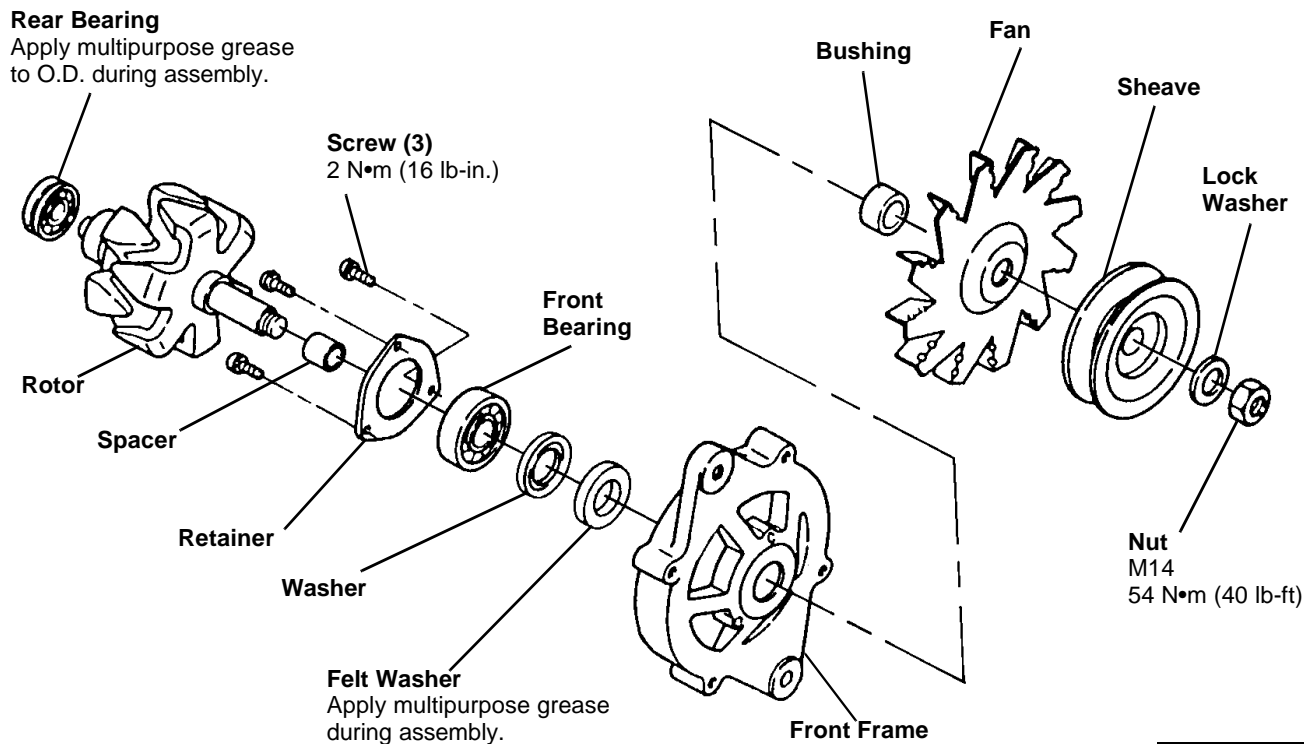
IMPORTANT: Do not pry against stator wires.

2. Use a screwdriver to separate rotor assembly from stator assembly.



Rotor Assembly:

- Rear bearing is press fit. Replace only if necessary. Remove bearing using a puller set. Install bearing until flush with end of rotor shaft. Press only on inner race of bearing.
3. Put rotor assembly in a soft-jawed vise. Remove nut, lock washer, sheave, fan and bushing.
 4. Put front frame on open jaws of vice. Use a soft-faced hammer to remove rotor and spacer.
 5. Remove three screws, retainer, front bearing, washer and felt washer.
 6. Inspect all parts for wear or damage. Replace as necessary.



2

M82250A

7. Test rotor. (See *Inspection/Test* procedures.)

Stator Assembly:

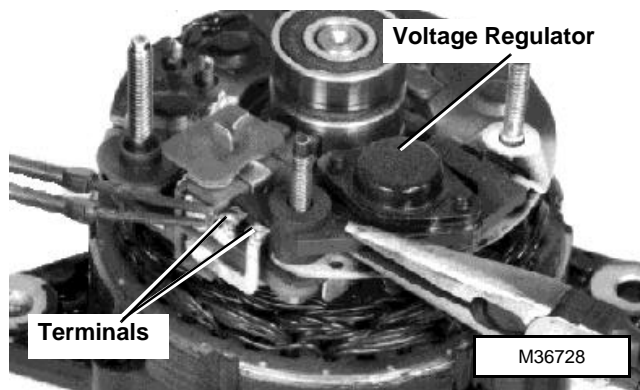
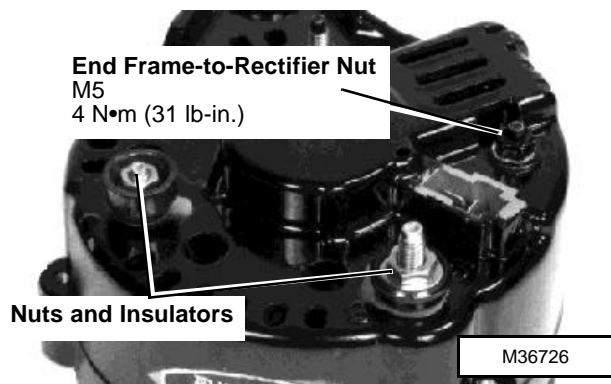
8. Remove end frame-to-rectifier nut.

9. Remove nuts and insulators.

IMPORTANT: Do not pry against stator wires.

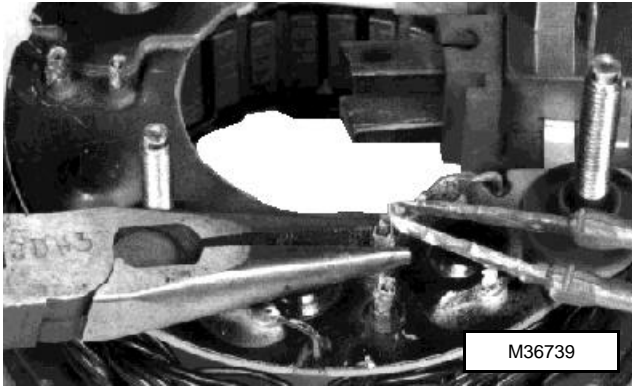
10. Use a screwdriver to pry end frame from stator.

11. Use a soldering gun with at least 120 watt capacity to disconnect terminals. Remove voltage regulator.



12. Melt solder inside the connecting pipes. While solder is hot, open the flattened pipe with a needle nose pliers. Pull stator wire from pipe.

Alternator



2

13. Inspect and test brushes, stator and rectifier. (See *Inspection/Test* procedures.)

Assembly

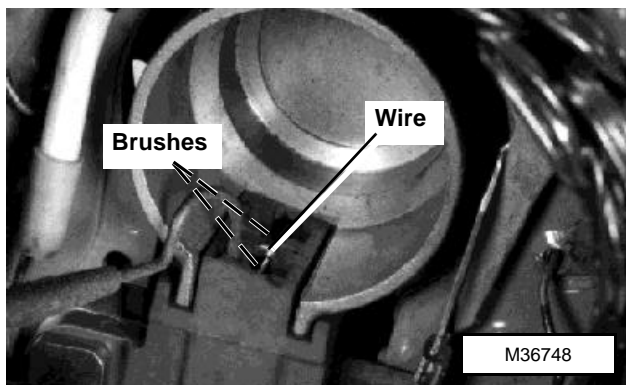
Assembly is done in the reverse order of disassembly.

NOTE: The three pair of lead wires on the stator are not evenly spaced. Rotate the rectifier until the terminal pipes align with the stator leads.

- Bend the stator lead wires, as necessary, to obtain an approximate distance of **33.50 mm (1.300 in.)** from stator to rectifier. Connect the six leads using a soldering gun.
- If additional solder is needed, use **ONLY 60-40 rosin-core solder**.

IMPORTANT: Be sure six stator lead wires do not contact end frame when installed.

- Before assembling stator assembly to rotor assembly, push brushes into brush holder and insert a wire through access hole in rear at end frame to lock brushes in place.

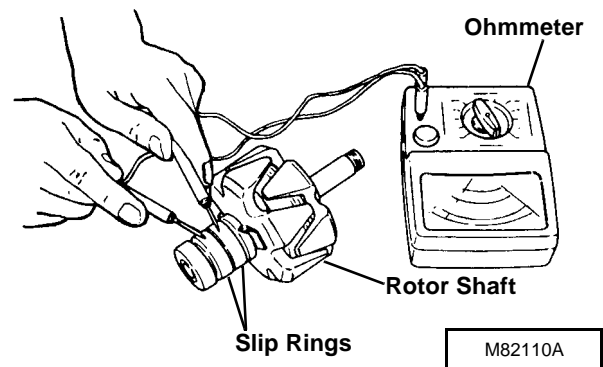


- Assemble rotor assembly to stator assembly and fasten with three attaching screws. Remove wire from access hole.

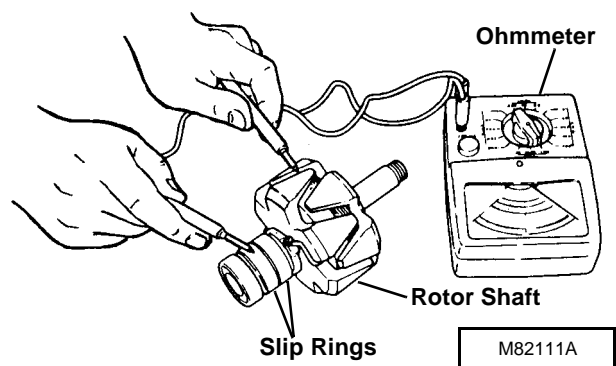
Inspection/Test

Rotor:

- Inspect the rotor slip rings for dirt build-up, rough spots, or out of roundness. If necessary, polish the surface of the slip rings using No. 00 sandpaper or 400-grit silicon carbide paper.
- Touch the probes of an ohmmeter to slip rings. Replace rotor if test indicates no continuity (no needle movement).



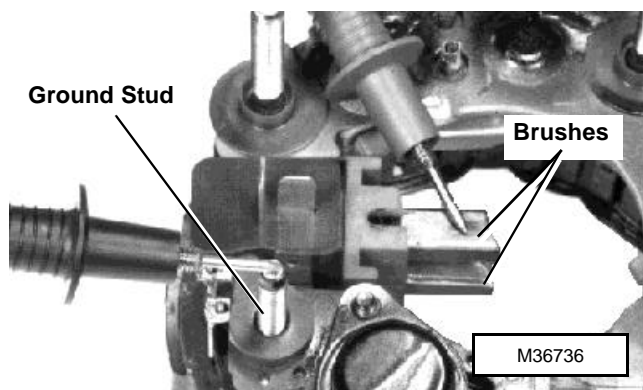
- Touch the probes of the ohmmeter to the shaft and one of the slip rings. Repeat for other slip ring. Replace rotor if test shows continuity (needle movement).



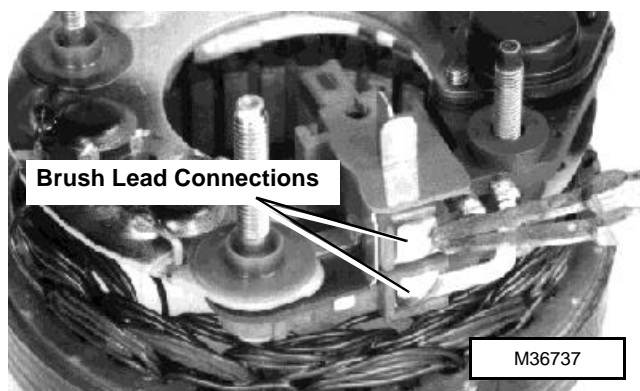
Brushes:

- Inspect brush holder and brushes for damage. Brushes must slide freely and the springs must hold the brushes firmly against the slip rings of the rotor.

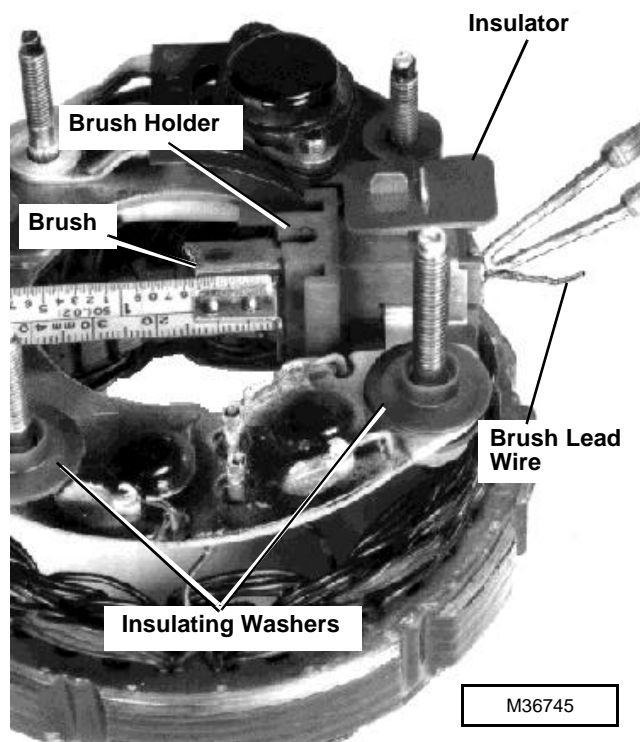
- Measure brushes for wear. Minimum exposed length must be **5.50 mm (0.220 in.)** or to wear limit line on brushes. Replace brushes as necessary.
- Use an ohmmeter or a test light to check for continuity. Check between the two brushes and between each brush and ground stud. There should be no continuity. Replace brush holder-rectifier assembly if there is continuity.



- To replace brushes:
 - Melt solder from brush lead connections and - remove brushes and springs.
 - Inspect springs for wear or damage. Replace as necessary.



- Push brush lead wire through spring. Insert spring and brush in brush holder with lead protruding through hole in brush holder. Make sure the longest side of brush is on side of brush holder with raised lip.
- Hold brushes in position so that exposed length is 13 mm (0.500 in.)
- Solder brush leads in this position. Cut off excess length of brush lead wire.
- Be sure insulating washers and insulator are in place.



2

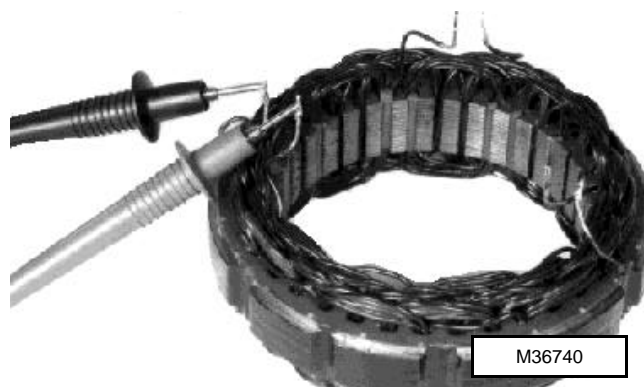
NOTE: If additional solder is needed, use ONLY 60-40 rosin-core solder.

Stator:

- Inspect stator for defective insulation, discoloration or a burned odor. If any of these defects are found, replace stator.

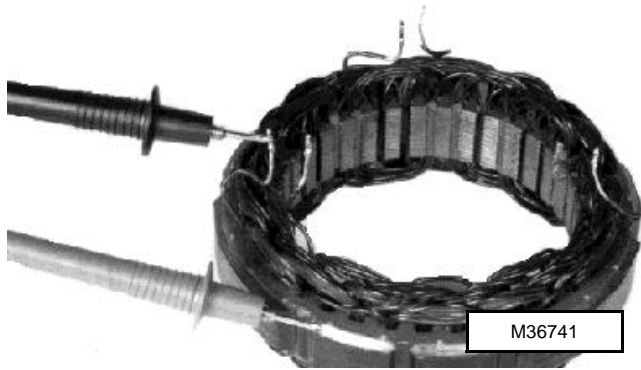
NOTE: Use an ohmmeter that is sensitive to resistance of 0 to 1 ohm.

- Touch probes of an ohmmeter to each pair of stator wires. Equal continuity readings should be observed between each pair of leads. If readings are not equal, replace stator.



Alternator

- Touch one probe of the ohmmeter to the bare metal surface of stator and the other probe to a bare stator lead wire. Repeat for each wire. Replace stator if test indicates continuity.

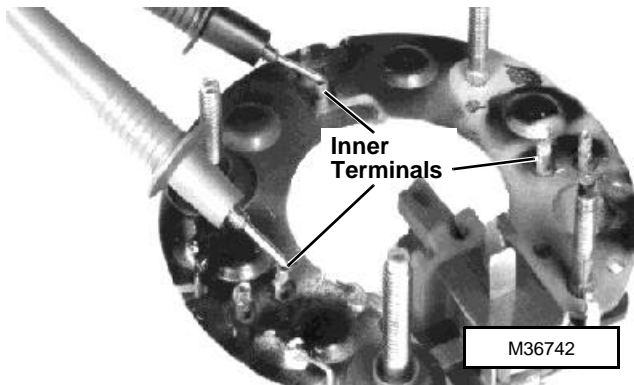


2

Rectifier:

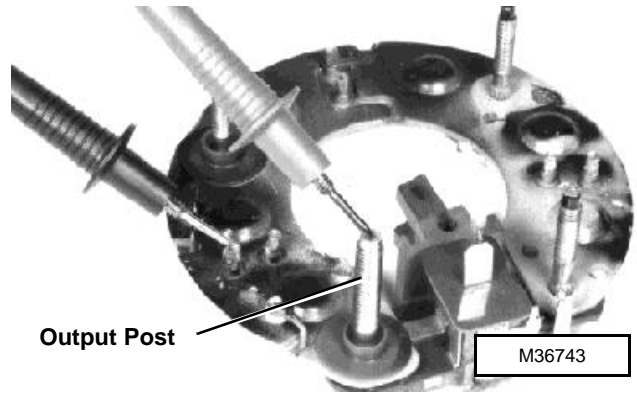
NOTE: The three inner terminals are connected by a printed circuit in the rectifier.

- Test the three inner terminals using an ohmmeter. Move probes so all terminals are cross checked. Replace the rectifier if test shows no continuity.



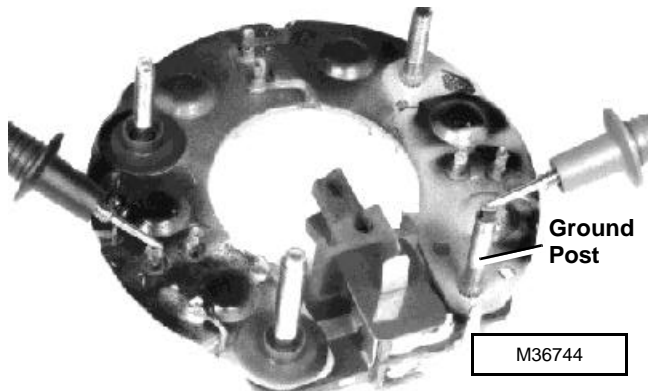
NOTE: Each of the three outer terminals on the rectifier is connected to two diodes permitting current flow in only one direction.

- Test the diodes by touching probes to output post and the three outer terminals.
- Switch the probes and check each terminal again. There should be continuity in only one direction between each terminal and the output post.



- Test the diodes by touching probes to ground post and the three outer terminals.
- Switch the probes and check each terminal again. There should be continuity in only one direction between each terminal and the ground post.

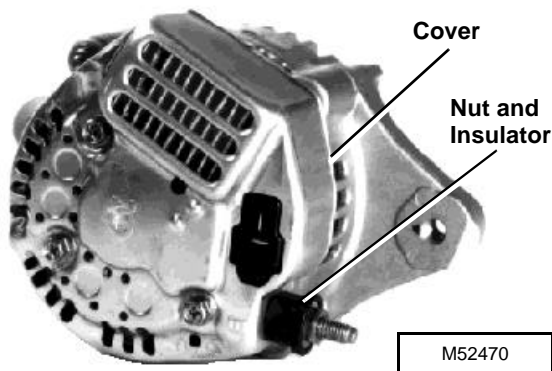
A shorted diode would have continuity in both directions. An open diode would have no continuity in either direction. Replace the rectifier assembly if any of the six diodes are defective.



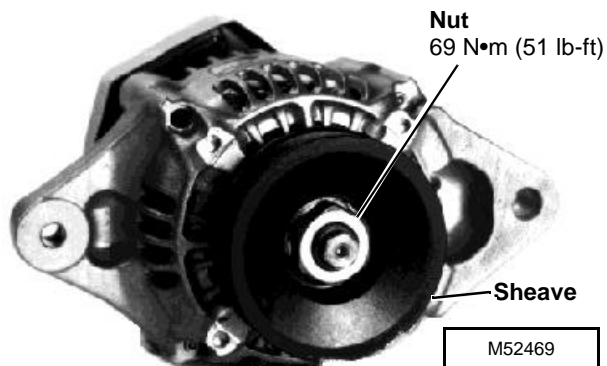
VOLTAGE REGULATOR - NIPPONDENSO 40A

Replacement

1. Remove nut and insulator.
2. Remove three screws and cover.

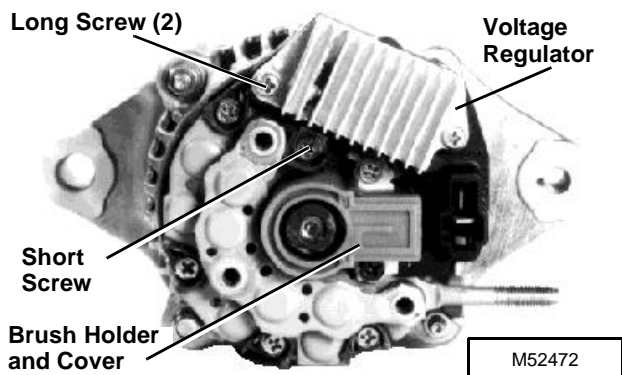


3. Remove two screws, brush holder and cover.
4. Remove three screws. Replace voltage regulator.



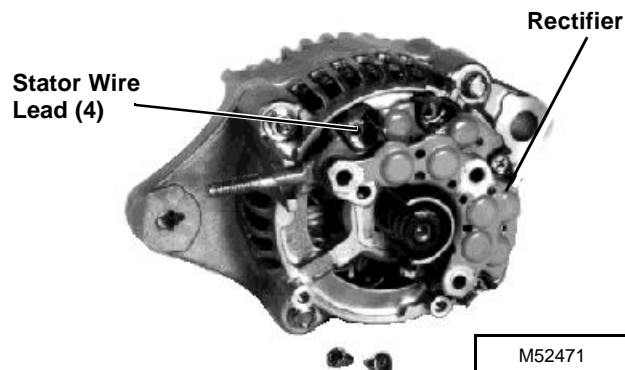
4. Remove four screws and straighten stator wire leads.
5. Remove rectifier.

2



Installation is done in the reverse order of removal.

IMPORTANT: Make sure to install short screw at location shown. Longer screw will contact frame and cause damage to the charging system.

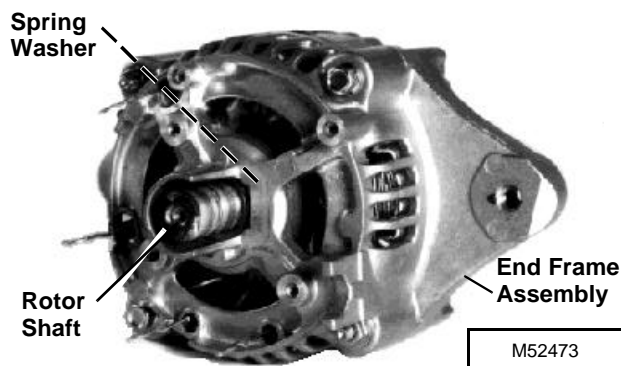


6. Remove two nuts, two screws and end frame assembly.
7. Press rotor shaft from end frame.
8. Remove spring washer.

ALTERNATOR - NIPPONDENSO 40A

Disassembly

1. Remove voltage regulator. (See *VOLTAGE REGULATOR - REPLACEMENT* in this group.)
2. Remove nut.
3. Remove sheave using a puller set.

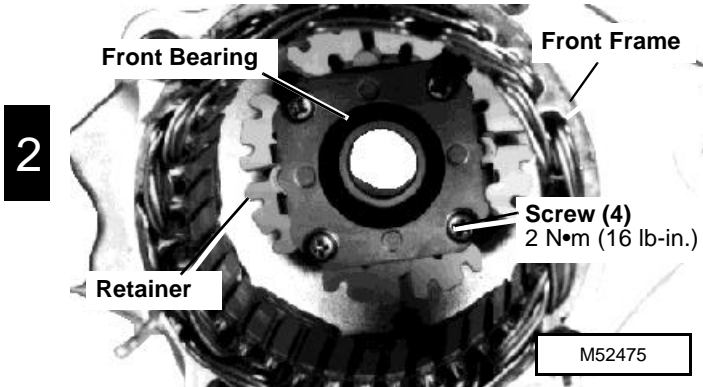


Alternator

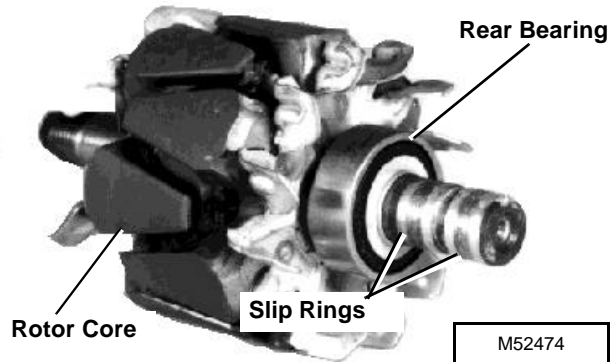
9. Remove four screws and retainer.

NOTE: Front bearing is press fit in front frame. Remove bearing only if replacement is necessary.

10. Inspect bearing in front frame for wear or damage. Replace if necessary. Replace bearing using a driver set and a press.



- Touch the probes of an ohmmeter to slip rings. Replace rotor if test indicates no continuity (no needle movement).
- Touch probes of ohmmeter to the rotor core and one of the slip rings. Repeat for other slip ring. Replace rotor if test shows continuity (needle movement).



11. Inspect and test brushes, stator and rectifier. (See *Inspection/Test* in this group.)

Assembly

Assembly is done in the reverse order of disassembly.

- After installing rectifier, form a loop in stator wire leads, insert screws through loop and secure rectifier and wire leads.

Inspection/Test

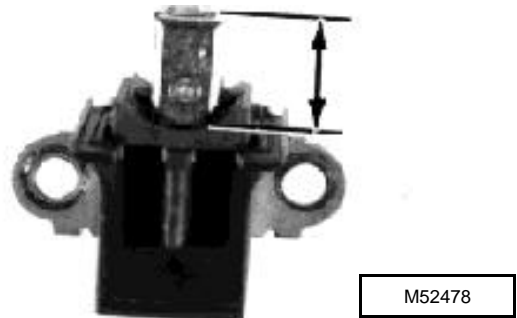
Rotor:

NOTE: Rear bearing and rotor assembly are not serviced separately. Damaged parts require that rotor assembly and bearing be replaced as a unit.

- Inspect bearing for wear or damage. Replace complete rotor if necessary.
- Inspect slip rings for dirt build-up, rough spots or out-of-roundness. If necessary, polish the surface of the slip rings using No. 00 sandpaper or 400-grit silicone carbide paper. Measure outer diameter of slip rings. Replace rotor if less than **14 mm (0.550 in.)**.

Brushes:

- Inspect brush holder, brushes and springs for damage. Brushes must slide freely and springs must hold brushes firmly against the slip rings of the rotor.
- Measure length of brush protruding from holder. If length is less than wear limit, replace brushes.

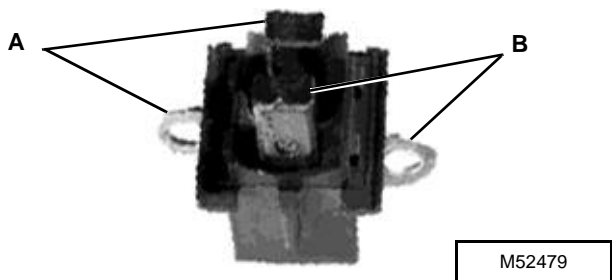


Brush Length Specifications

New..... 10.50 mm (0.410 in.)

Wear Limit..... 4.50 mm (0.170 in.)

- Check continuity between brush and terminal "A". Check continuity between brush and terminal "B". There should be continuity only at these points.



Rectifier:

NOTE: Set the ohmmeter to the K ohm range.

- Check continuity between output post and each diode lead. Reverse ohmmeter leads and recheck. There should be continuity in one direction, but not the other.

A shorted diode would have continuity in both directions. An open diode would have no continuity in either direction. Replace the rectifier if any of the four diodes are defective.

Stator:

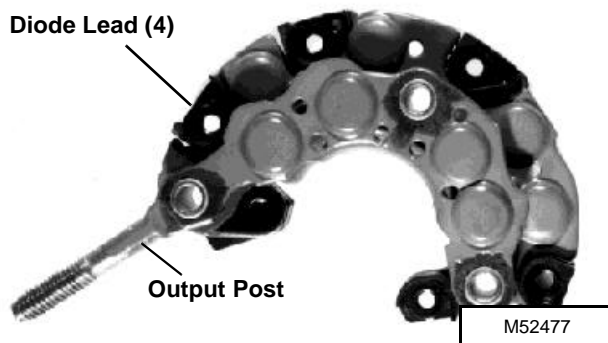
- Inspect stator for defective insulation, discoloration or a burned odor. If any of these defects are found, replace stator.

NOTE: Use an ohmmeter that is sensitive to resistance of 0 to 1 ohm.

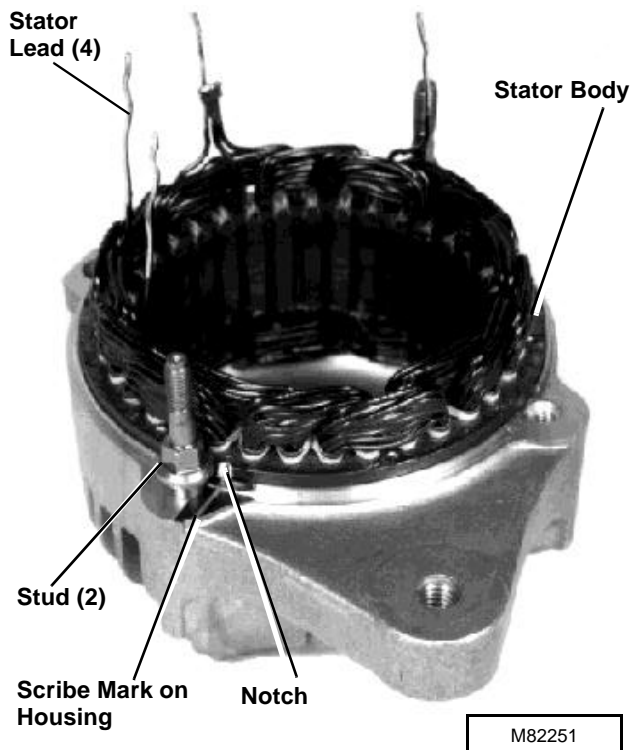
- Check for continuity between each stator lead and stator body. Replace stator if test indicates continuity.

To replace stator:

- Scribe a mark on housing, at notch in stator, to aid in installation of a new stator.
- Remove two studs.
- Replace stator using a punch and hammer.



2



Diagnosis

ENGINE AND FUEL SYSTEM TROUBLESHOOTING CHART

2

CHECK OR SOLUTION	PROBLEM OR SYMPTOM											
	Engine will not crank.	Engine cranks but will not start or starts hard.	Engine will not stay running, or stalls frequently.	Engine runs rough, misses, noisy, vibrates or low on power. Fuel in oil. Oil level high.	Engine surges, or has uneven or uncontrolled rpm.	Oil in the coolant or coolant in the oil.	Engine has low oil pressure.	Engine operating temperature is incorrect.	Lack of fuel at injection pump.	Exhaust smoke blue or uses too much oil.	Exhaust smoke white.	Exhaust smoke black or grey or uses too much fuel.
Fuel pump screen, fuel filter, or fuel line restricted. Fuel dirty, contains water or wrong grade.		●	●	●	●			●		●	●	
Air filter elements dirty or plugged. Replace.		●	●	●	●		●		●		●	
Fuel shut-off valve turned off, or restricted. Solenoid linkage misadjusted. See adjustment.		●	●	●	●		●	●				
Muffler or exhaust manifold leak.			●	●								
Defective manifold heater.		●										
Injection pump or governor malfunctioning. Injection pump timing incorrect.		●		●	●					●	●	
Defective cranking components or connectors.	●			●								
Low compression from worn rings, cylinder bore, piston, valves or warped head.		●	●	●		●			●		●	
Valve clearance incorrect.	●	●	●	●			●				●	
Burned or warped valves and valve seats. Defective valve spring.		●	●	●	●				●		●	
Starter cranking rpm too slow. Damaged starter. Excessive engine load.	●	●						●				
Fuel pump leaking or not operating. See Fuel Supply Pump Pressure Test.		●	●	●	●			●		●		
Engine oil viscosity or level incorrect.	●	●					●	●	●			
Injector pressure incorrect or leaking.		●	●	●	●		●			●	●	
Cylinder head gaskets leaking or damaged.	●	●	●		●	●	●	●	●		●	
Radiator/oil cooler leak.				●		●	●					

ENGINE SYSTEM DIAGNOSIS

Conditions:

- Engine mounted on level surface.
- Key switch off unless indicated otherwise.

Test Location	Normal	If Not Normal
1. Engine dipstick and exterior engine surface-engine oil check.	Oil level between "L" and "H" marks. Oil not burnt, or contaminated with metal particles, fuel, or coolant. No external leakage, filter clean.	Change oil and inspect for source of contamination. Check gaskets, seals, plugs, cylinder head, block, and intake manifold and breather. Change oil filter.
2. Coolant tank and radiator. - Cooling System Check.	Coolant level between marks on tank when engine is warm. Coolant in radiator full to top. Coolant not contaminated with oil, fuel or discolored brown. Radiator screen free of debris. Hoses not cracked or leaking, clamps and radiator cap tight. Fan belt tight, not glazed or cracked. Fan blades not damaged or warped.	Add proper coolant mix. Drain and flush system. Check for source of contamination. Clean or replace. Pressure test radiator and cap. Replace and adjust belt tension. Replace fan.
3. Fuel tank, pump, pump screen, lines, filter, filter shutoff valve. - Fuel System Check	Fuel level correct, not contaminated, correct grade of fuel, no water. Fuel pump screen and in-line filter free of debris. Fuel shutoff valve in "ON" position. Fuel hoses not cracked or leaking. Fuel hose clamps tight. Fuel tank does not have vacuum.	Drain and clean fuel tank. Add fresh fuel. Replace filters. Move to "ON" position. Replace. Replace or tighten. Replace fuel tank check valve.
4. Air filter and air intake. - Air Intake System Check	Air filter hose not cracked, clamps tight. Element not plugged. Air filter housing sealed, no dirt tracking inside filter element.	Replace and tighten clamps. Replace element or housing.
5. Fuel shutoff solenoid. (Key in RUN position.)	Fuel shutoff solenoid must pull in and stay in. Solenoid must bottom out. Shutoff shaft must still move slightly.	Check shutoff solenoid adjustment. Clean any dirt from under solenoid boot. If solenoid will not pull in and hold in, see Fuel Shutoff Solenoid Circuit Test Points in ELECTRICAL section of Machine TM.
6. Air heater indicator light. (Key in RUN position.)	Indicator light should come on up to 15 seconds depending on air temperature.	See Air Heater Circuit Test Points in ELECTRICAL section of Machine TM.

Diagnosis

ENGINE SYSTEM DIAGNOSIS - Continued

Test Location	Normal	If Not Normal
7. Fuel filter, fuel pump. (Key switch in RUN position.)	Fuel level increases in filter. Fuel pump operating - listen for humming sound. Fuel present in return hose at fuel pump.	See Fuel Pump Circuit Test Points in ELECTRICAL section of Machine TM. Test fuel pump pressure. (See <i>Operational Tests</i> in this section.) Replace fuel filter.
8. Throttle lever and cable.	Linkage not binding and adjusted correctly.	Repair, replace or adjust cable.
9. Intake and exhaust valves.	Cold engine. Valve clearance within specification. Valves not sticking.	Check and adjust. (See <i>Checks, Tests and Adjustments</i> in this section.) Check valve guides and stems.
10. Fuel at injectors. (Key in START position - engine cranking.)	Crack fuel injection lines at injectors. Fuel shutoff solenoid pulled in. Engine must crank.	Check spray pattern and cranking pressure. (See <i>Checks, Tests and Adjustments</i> in this section.) Replace injectors. See Cranking Circuit Test Points in ELECTRICAL section of Machine TM.
11. Injector ports. (Key in START position.)	Cylinder compression within specification. Pressure difference between cylinders within specification.	Perform cylinder compression test. (See <i>Operational Tests</i> in this section.)
12. Flywheel and starter.	Minimum cranking rpm within specification.	See Starter Amp Draw Test in ELECTRICAL section of Machine TM.
13. Injection pump timing inspection. (Key OFF.)	Timing should be correct. Remove pump as the LAST possible solution.	Perform injection pump static timing adjustment. (See <i>Checks, Tests and Adjustments</i> in this section.) Have pump tested by a qualified Service Repair Shop.
14. Injection pump idle settings. (Engine running).	Engine runs smooth under load. Engine rpm to specification.	See Slow Idle and Fast Idle Adjustments in ENGINE section of Machine TM.
15. Oil pressure sender port.	Oil pressure in specification.	Test engine oil pressure. (See <i>Operational Tests</i> in this section.)
16. Thermostat. (Engine at operating temperature.)	Clean from corrosion, rust, or debris. Opening temperature within specification.	Replace thermostat. Perform thermostat opening test. (See <i>Checks, Tests and Adjustments</i> in this section.)
17. Muffler.	Not restricted.	Replace muffler.

VALVE CLEARANCE, CHECK AND ADJUSTMENT

Reason:

To achieve correct engine operation.

Equipment:

- Feeler Gauge

Procedure:

NOTE: Location of the index mark will be different as a result of the various engine applications.

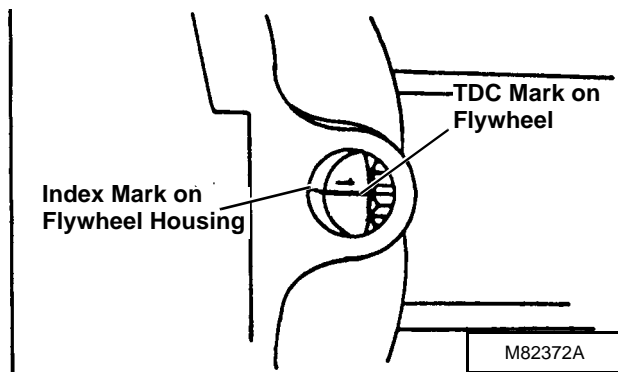
The index mark appears on the following:

- 3TN75 (F1145 FM): Edge of flywheel guard and plate.
- 3TN75 (855/56 CUT), 3TNC78 (3011DF001 OEM), 3TN84 (870 CUT, 955 CUT, 3014DF001 OEM): Flywheel plate.
- 3TN78, 3TNC78 (3011DF001, 005, 006 OEM), 3TN82, 3TN84 (3014DF001, 005, 006 OEM): Flywheel housing.

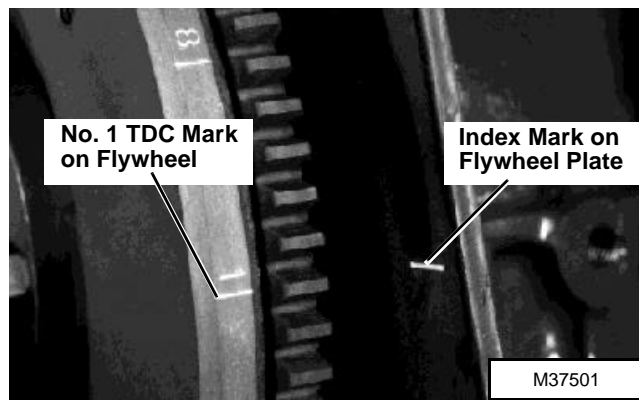
1. Remove rocker arm cover.
2. Remove plug from timing hole in flywheel housing, if equipped.

NOTE: "Top Dead Center (TDC)" is the piston at its highest point.

3. Turn crankshaft pulley clockwise until No.1 cylinder TDC mark on flywheel aligns with index mark on flywheel housing or plate.



3TN78, 3TNC78 (3011), 3TN82, 3TN84 (3014 OEM)



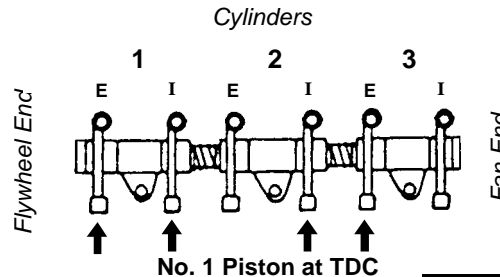
3TN75, 3TNC78 (3011DF001 OEM), 3TNA82, 3TN84 (870 CUT, 955 CUT, 3014DF001 OEM)

NOTE: No. 1 cylinder is the closest to the flywheel.

4. Try to move both No. 1 cylinder rocker arms or push rods.

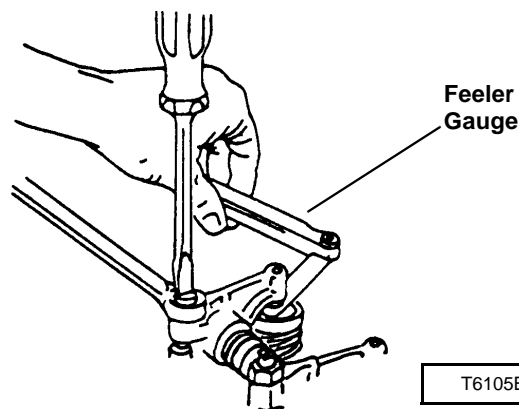
If rocker arm push rods are not loose, rotate flywheel one revolution (360°). If both rocker arm push rods are loose the piston is at TDC on compression stroke.

5. Measure and adjust valve clearance on the valves (arrows) with No. 2 piston at TDC.



M82327A

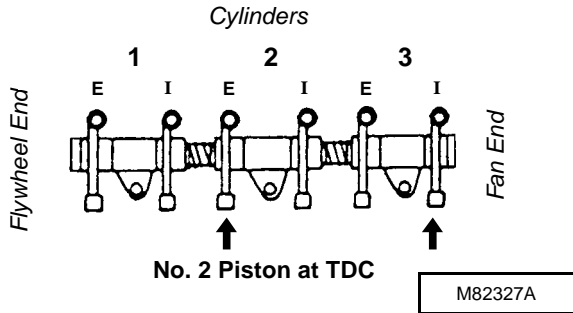
To adjust valves, loosen nut and turn adjusting screw until clearance is **0.20 mm (0.008 in.)**. Hold screw while tightening nut.



T6105BF

Checks, Tests and Adjustments

- Turn crankshaft pulley one revolution (360°). This puts the piston in No. 2 cylinder at TDC compression stroke.
- Measure and adjust valve clearance on the valves (arrows) with No. 2 piston at TDC.



2

CONNECTING ROD SIDE PLAY CHECK

Reason:

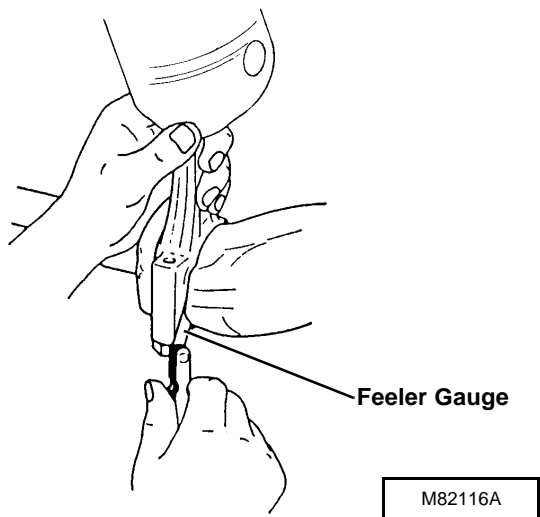
To determine proper side clearance between crankshaft and connecting rod.

Equipment:

- Feeler Gauge

Procedure:

- Insert a feeler gauge, according to specifications, between connecting rod cap and crankshaft.



Specifications:

Standard Clearance 0.20 - 0.40 mm
.....(0.0079 - 0.0157 in.)
Wear Limit. 0.55 mm (0.0217 in.)

Results:

- If side play exceeds wear limit, replace connecting rod and connecting rod cap.

CONNECTING ROD BEARING CLEARANCE CHECK

Reason:

To measure oil clearance between connecting rod bearing and crankshaft journal.

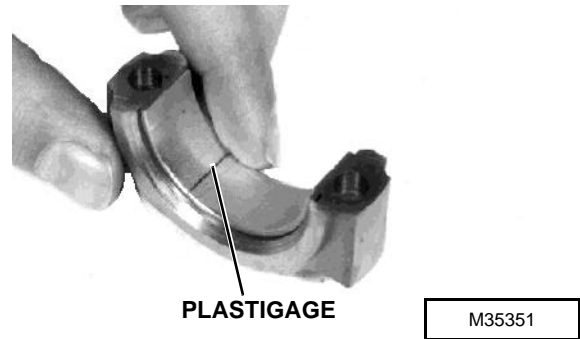
Equipment:

- PLASTIGAGE®

Procedure:

IMPORTANT: Connecting rod caps must be installed on the same connecting rod and in the same direction to prevent crankshaft and connecting rod damage.

- Remove connecting rod cap.
- Wipe oil from bearing insert and crankshaft journal.
- Put a piece of PLASTIGAGE, or an equivalent, along the full length of the bearing insert approximately 6 mm (0.250 in.) off center.



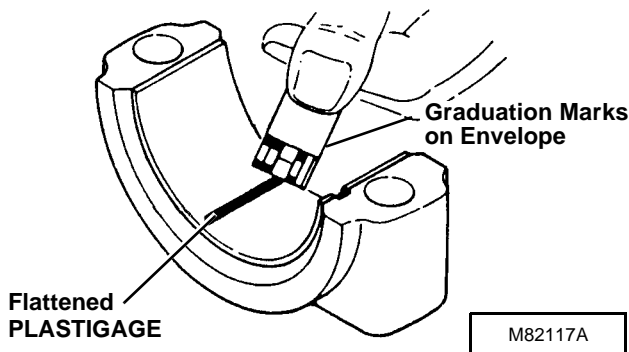
- Turn crankshaft approximately 30° from bottom dead center.

5. Install connecting rod end cap and original cap screws. Tighten cap screws to:
3TN75, 3TN78,
3TNC78 (3011) 39 N•m (29 lb-ft)
3TN82, 3TNA82,
3TN84 (3014) 47 N•m (35 lb-ft)

6. Remove cap screws and connecting rod cap.

NOTE: The flattened PLASTIGAGE will be found on either the bearing insert or crankshaft journal.

7. Use the graduation marks on the envelope to compare the width of the flattened PLASTIGAGE at its widest point.
8. Determine bearing clearance. The number within the graduation marks indicates the bearing clearance in inches or millimeters depending on which side of the envelope is used.
9. Remove PLASTIGAGE.



Specifications:

Standard Clearance 0.038 - 0.090 mm
. (0.0015 - 0.0035 in.)
Wear Limit. 0.16 mm (0.0063 in.)

Results:

- If clearance exceeds wear limit, replace bearing inserts.

®PLASTIGAGE is a registered trademark of the DANA Corporation.

CRANKSHAFT, END PLAY CHECK

Reason:

To determine proper side clearance between crankshaft and engine block.

Equipment:

- Dial Indicator

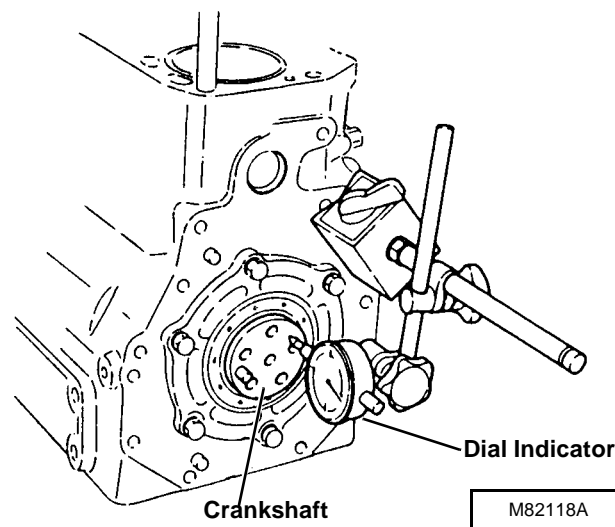
Procedure:

NOTE: Crankshaft end play can be measured at front end or rear end of crankshaft. Procedure is performed from the rear end. The flywheel is removed to show detail.

1. Fasten dial indicator to engine and position indicator tip on end of crankshaft.

IMPORTANT: Do not use excessive force when moving crankshaft to avoid damaging bearings.

2. Push crankshaft toward rear as far as possible.
3. Zero the dial indicator.
4. Using a bar, gently pry the crankshaft as far forward as possible.



Specifications:

Standard Clearance 0.090 - 0.271 mm
. (0.004 - 0.011 in.)
Wear Limit. 0.33 mm (0.0129 in.)

Results:

- If end play exceeds wear limit, replace thrust bearings.

Checks, Tests and Adjustments

CRANKSHAFT MAIN BEARING, CLEARANCE CHECK

Reason:

To measure oil clearance between main bearing and crankshaft journal.

Equipment:

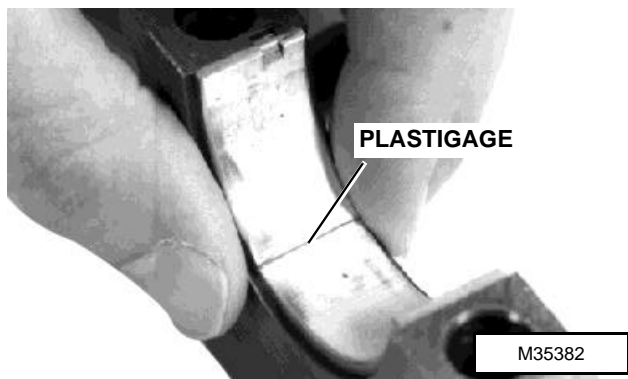
- PLASTIGAGE®

Procedure:

IMPORTANT: Main bearing caps must be installed on the same main bearing and in the same direction to prevent crankshaft and main bearing damage.

2

1. Remove main bearing cap.
2. Wipe oil from bearing insert and crankshaft journal.
3. Put a piece of PLASTIGAGE, or an equivalent, along the full length of the bearing insert approximately 6 mm (0.250 in.) off center.

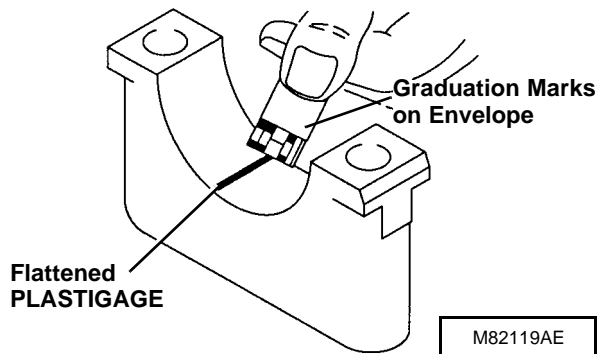


4. Install main bearing cap and cap screws. Tighten cap screws to:
3TN75, 3TN78,
3TNC78 (3011) 79 N•m (58 lb-ft)
3TN82, 3TNA82,
3TN84 (3014) 98 N•m (72 lb-ft)
5. Remove cap screws and main bearing cap.

NOTE: The flattened PLASTIGAGE will be found on either the bearing insert or crankshaft journal.

6. Use the graduation marks on the envelope to compare the width of the flattened PLASTIGAGE at its widest point.

7. Determine main bearing clearance. The number within the graduation marks indicates the bearing clearance in inches or millimeters depending on which side of the envelope is used.
8. Remove PLASTIGAGE.



Specifications:

Standard Clearance 0.038 - 0.090 mm
..... (0.0015 - 0.0035 in.)
Wear Limit 0.06 mm (0.0063 in.)

Results:

- If clearance exceeds wear limit, replace bearing inserts.

®PLASTIGAGE is a registered trademark of the DANA Corporation.

VALVE LIFT CHECK

Reason:

Can indicate excessive wear on cam lobes, followers, and/or push rods.

Equipment:

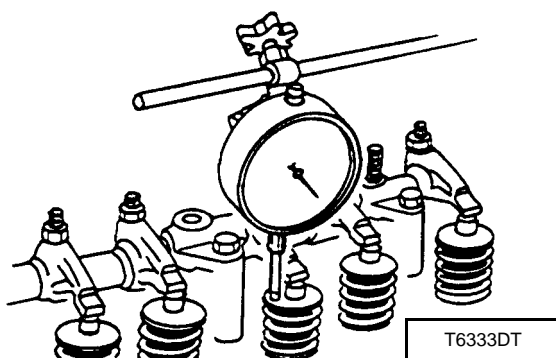
- Dial Indicator

Procedure:

1. Adjust valve clearance. (See procedure in this group.)
2. Remove rocker arm cover. (See *Cylinder Head, Valves and Manifolds* in this section.)
3. Fasten dial indicator to engine and position indicator tip on valve retainer. Valve must be fully closed and rocker arm must move freely.

4. Zero the dial indicator.
5. Manually turn crankshaft pulley clockwise (from fan end).
6. Observe dial indicator as valve is moved to the full open position. Valve lift (intake and exhaust) should be **8.8 mm (0.350 in.)**.

Repeat for each valve.



Results:

- If valve lift is less than specification, remove and inspect camshaft, followers and push rods. (See *Camshaft and Timing Gear Train* and/or *Cylinder Head, Valves and Manifolds* in this section.)

CAMSHAFT END PLAY CHECK

Reason:

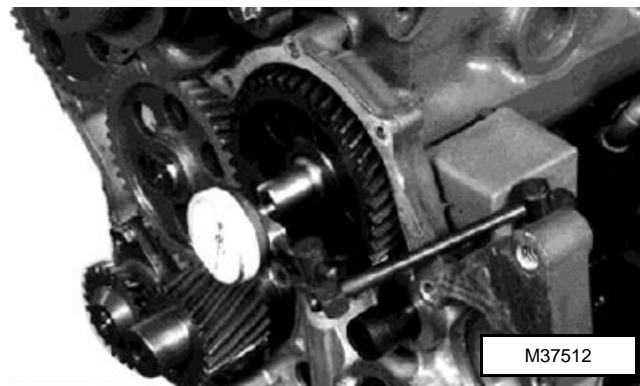
To determine proper side clearance between camshaft gear end journal and thrust plate.

Equipment:

- Dial Indicator

Procedure:

1. Remove timing gear cover. (See *Camshaft and Timing Gear Train* in this section.)
2. Fasten dial indicator to engine and position indicator tip on end of camshaft.
3. Push camshaft toward the rear as far as possible.
4. Zero the dial indicator.
5. Pull camshaft forward as far as possible.



Specifications:

Standard Clearance 0.05 - 0.20 mm
 (0.0020 - 0.0079 in.)
Wear Limit 0.40 mm (0.016 in.)

Results:

- If end play exceeds wear limit, remove camshaft and replace thrust plate. (See *Camshaft and Timing Gear Train* in this section.)

TIMING GEAR BACKLASH, CHECK

Reason:

To check for wear between meshing gears, resulting in excessive noise and poor engine performance.

Equipment:

- Dial Indicator

Procedure:

1. Measure backlash between meshing gears.

Specifications - 3TN75, 3TN78, 3TNC78 (3011):

Standard Backlash

Crankshaft Gear-to-Oil

Pump Gear 0.11 - 0.19 mm
 (0.0043 - 0.0075 in.)

All Except Crankshaft Gear-to-Oil

Pump Gear 0.04 - 0.12 mm
 (0.0016 - 0.0047 in.)

Wear Limit 0.20 mm (0.0079 in.)

Checks, Tests and Adjustments

Specifications - 3TN82, 3TNA82,
3TN84 (3014):

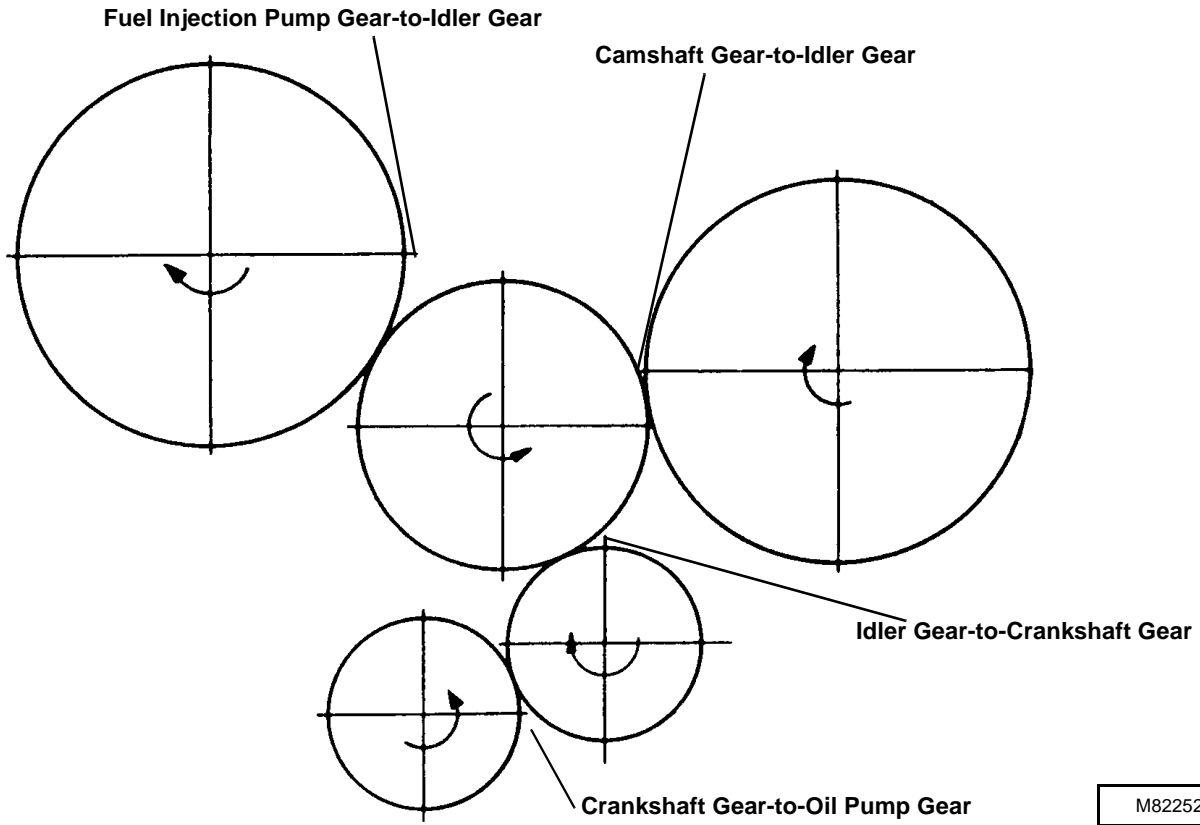
Standard Backlash 0.04 - 0.12 mm
..... (0.0016 - 0.0047 in.)
Wear Limit..... 0.20 mm (0.0079 in.)

Results:

- If backlash exceeds wear limit, replace meshing gears as a set:

Idler Gear, Camshaft Gear, Crankshaft Gear, Oil Pump Gear AND/OR Idler Gear, Fuel Injection Pump Gear.

2



M82252A

FUEL INJECTION NOZZLE TEST (HOLE-TYPE)

CAUTION

Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.

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

Reason:

To determine opening pressure, leakage, chatter and spray pattern of the fuel injection nozzle.

Equipment:

- D01109AA Diesel Fuel Injection Nozzle Tester
- D01110AA Adapter Set
- 23622 Straight Adapter
- Container

Connections:

1. Connect fuel injection nozzle to D01109AA Diesel Fuel Injection Nozzle Tester using parts from D01110AA Adapter Set and 23622 Straight Adapter.

IMPORTANT: Use clean filtered diesel fuel when testing injection nozzles to get best test results.

Procedure 1:

Test fuel injection nozzle opening pressure following the Nozzle Tester manufacturer's instructions.

Specifications:

Opening Pressure 19600 ± 480 kPa
. (2843 \pm 70 psi)

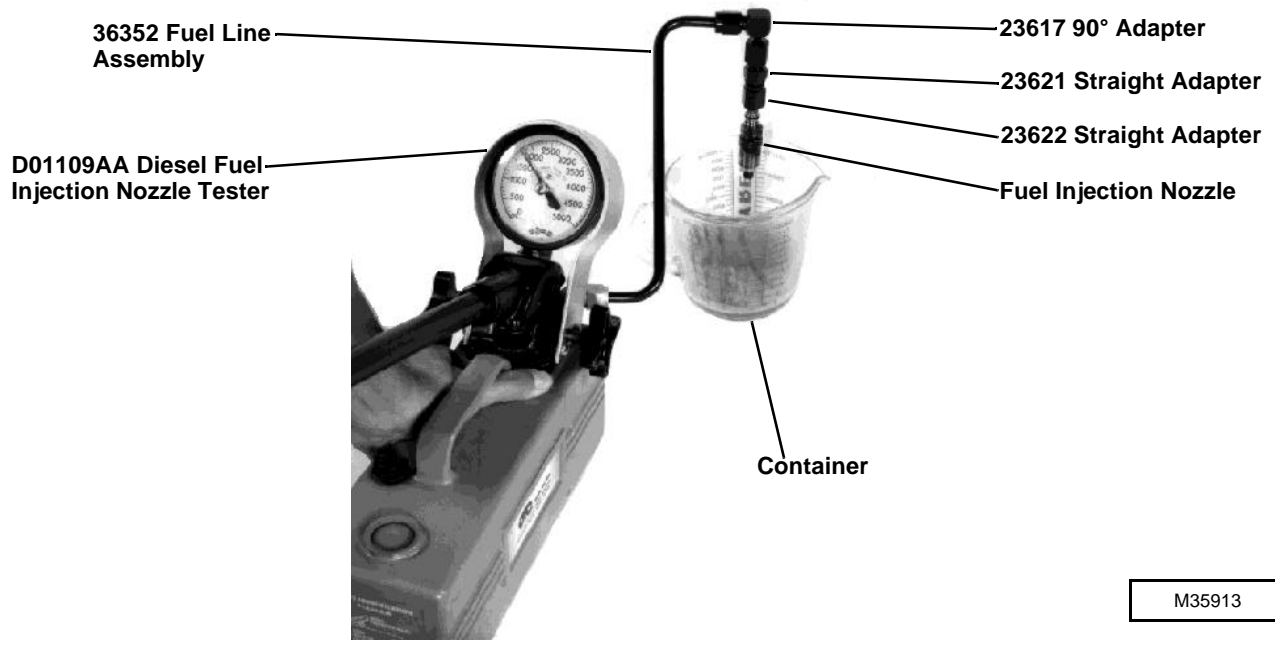
Results:

- If pressure reading does not meet specification, disassemble injection nozzle and inspect nozzle assembly for contamination or stuck valve. If necessary, add or remove shims to change opening pressure.

2

Checks, Tests and Adjustments

2



Procedure 2:

Test fuel injection nozzle **leakage** following the Nozzle Tester manufacturer's instructions.

1. Dry nozzle completely using a lint-free cloth.
2. Pressurize nozzle to **17640 kPa (2558 psi)**.
3. Watch for leakage from nozzle spray orifice. Leakage time should be a minimum of **5 seconds**.

Results:

- If leakage time does not meet specification, disassemble injection nozzle and inspect nozzle assembly for contamination. Inspect valve seating surface. Replace nozzle assembly if necessary.

Procedure 3:

Test fuel injection nozzle **chatter and spray pattern** following the Nozzle Tester manufacturer's instructions.

1. Pressurize nozzle to **19600 ± 480 kPa (2843 ± 70 psi)**.
2. Listen for “chatter” sound and watch spray pattern.

Specifications:

Slow Hand

Lever Movement Chatter Sound

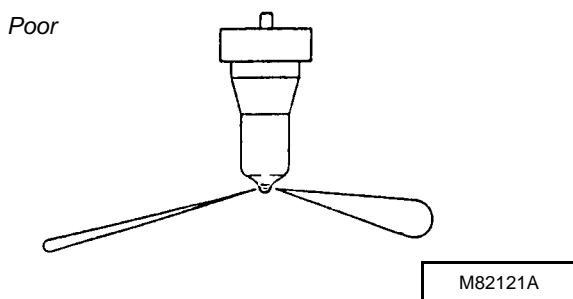
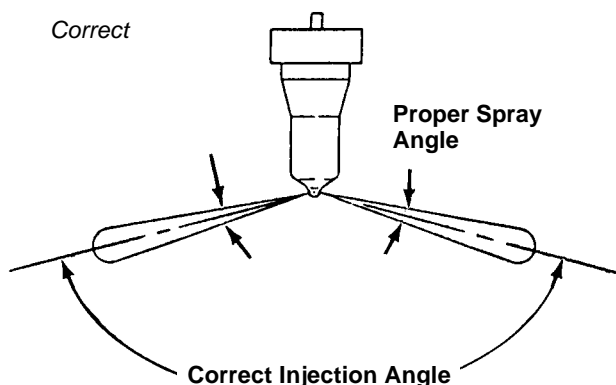
Slow Hand

Lever Movement Fine Stream
 Spray Pattern

Fast Hand

Lever Movement Fine Atomized
 Spray Pattern

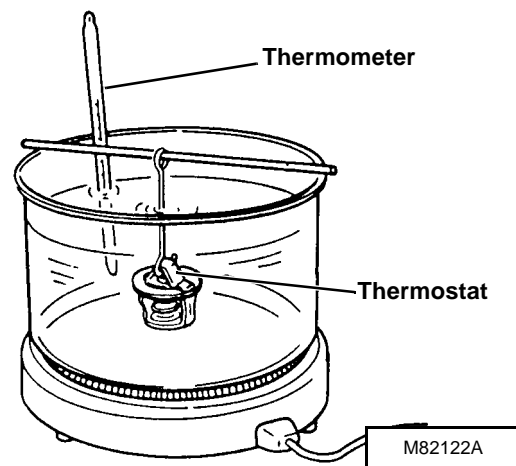
Procedure:



CAUTION

DO NOT allow thermostat or thermometer to rest against the side or bottom of glass container when heating water. Either may rupture if overheated.

1. Suspend thermostat and a thermometer in a container of water.
2. Heat and stir the water. Observe opening action of thermometer and compare temperatures with specifications.
3. Remove thermostat and observe its closing action as it cools.



Results:

- If nozzle chatter or spray pattern does not meet specifications, disassemble injection nozzle and inspect nozzle assembly for contamination. Inspect valve seating surface. Replace nozzle assembly if necessary.
- If there is excessive difference in spray angle or injection angle, incomplete atomization or sluggish starting/stopping of injection, disassemble injection nozzle and inspect nozzle assembly for contamination. Replace nozzle assembly if necessary.

Specifications:

Begin Opening 71° C (160° F)
Fully Open 85° C (184° F)
Minimum Lift Height 8 mm (0.310 in.)

THERMOSTAT OPENING TEST

Reason:

To determine opening temperature of thermostat.

Equipment:

- Thermometer
- Glass Container
- Heating Unit

Results:

- If thermostat does not open according to specifications, replace.
- If closing action is not smooth and slow, replace thermostat.

Checks, Tests and Adjustments

COOLANT TEMPERATURE SWITCH TEST

Reason:

To determine operating temperature of sender.

Equipment:

- Thermometer
- Glass Container
- Heating Unit
- Ohmmeter

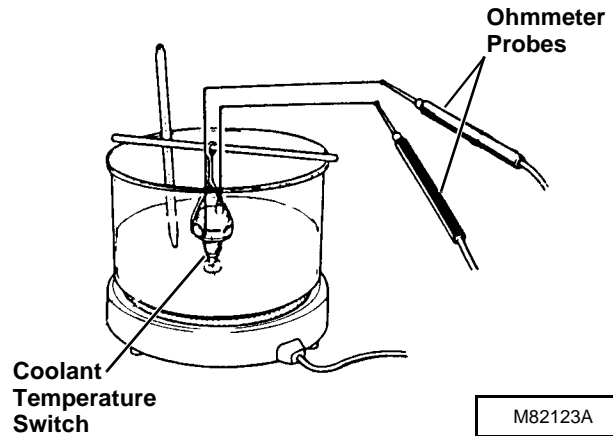
2 Procedure:

CAUTION

DO NOT allow switch or thermometer to rest against the side or bottom of glass container when heating water. Either may rupture if overheated.

1. Connect lead wires from ohmmeter probes, to sender terminal and body.

2. Suspend sender and a thermometer in a container of water.
3. Heat and stir the water. Observe water temperature when continuity occurs. Water temperature should be **107 - 113° C (225 - 235°F)**.



Results:

- If continuity does not occur within temperature listed, replace sender.

STARTER NO-LOAD AMP DRAW/RPM TEST

Reason:

To determine if starter is binding or has excessive amperage draw under no load.

Equipment:

- JT05712 Current Gun
- JT05719 Hand-Held Digital Tachometer
- Jumper Cables
- Jumper Wire

Procedure:

1. Mount starter in a vise.

NOTE: Check that battery is fully charged and of proper size to ensure accuracy of test.

2. Connect jumper cables to a 12 volt battery.
3. Connect positive (+) cable to solenoid battery terminal on starter.
4. Connect negative (-) cable to starter body.
5. Attach Current Gun to positive cable.

IMPORTANT: Complete this test in 20 seconds or less to prevent starter damage.

6. Use a jumper wire to briefly connect positive (+) starter terminal to solenoid terminal "S". Starter should engage and run.
7. Read and record starter amperage and rpm.

Specifications:

Maximum Starter Amperage

Hitachi 2.0 kW. 110 Amps at 4500 rpm

Nippondenso 1.0 kW

and 1.2 kW. 90 Amps at 3000 rpm

Nippondenso 1.4 kW. . 90 Amps at 3500 rpm

Minimum Starter RPM

Hitachi 2.0 kW. 4500

Nippondenso 1.0 kW

and 1.2 kW. 3000

Nippondenso 1.4 kW. 3500

2

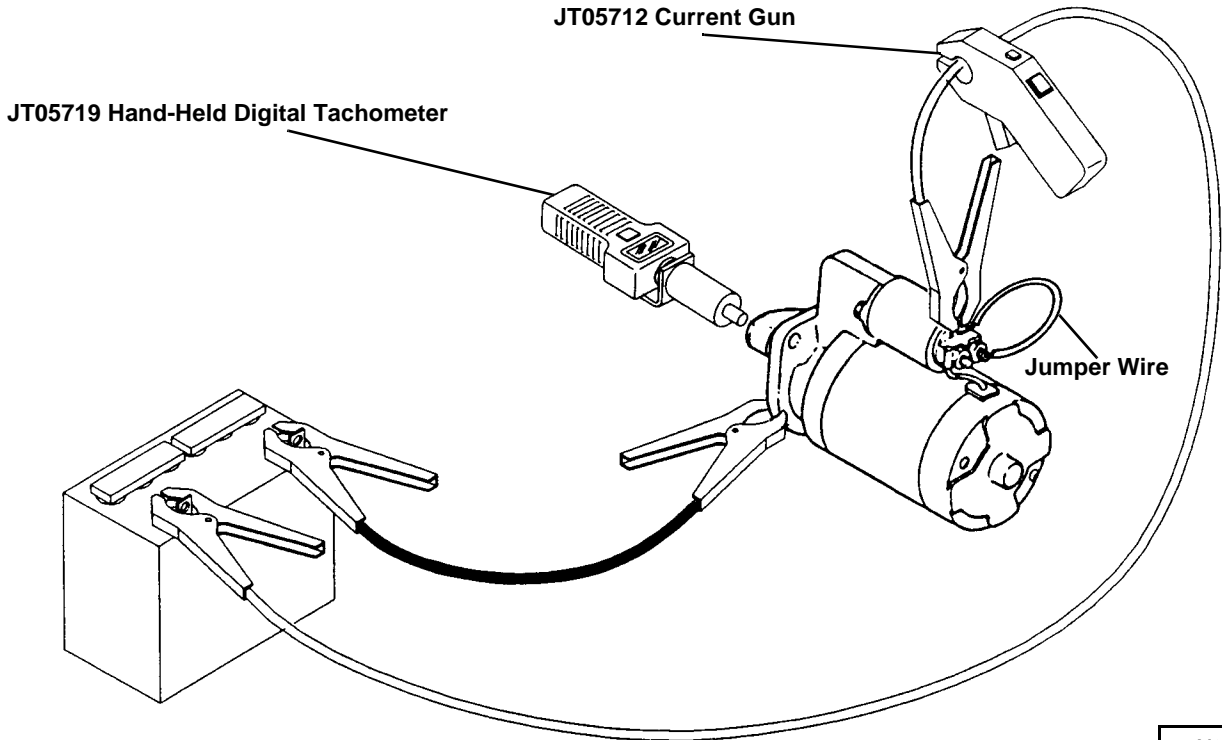
Results:

- If solenoid "clicks" or chatters and motor does not turn, replace solenoid.
- If pinion gear engages and motor doesn't turn, repair or replace starter motor.
- If starter engages and runs but amperage is more than specifications, repair or replace starter.

If rpm is less than specification, with battery fully charged, repair or replace starter.

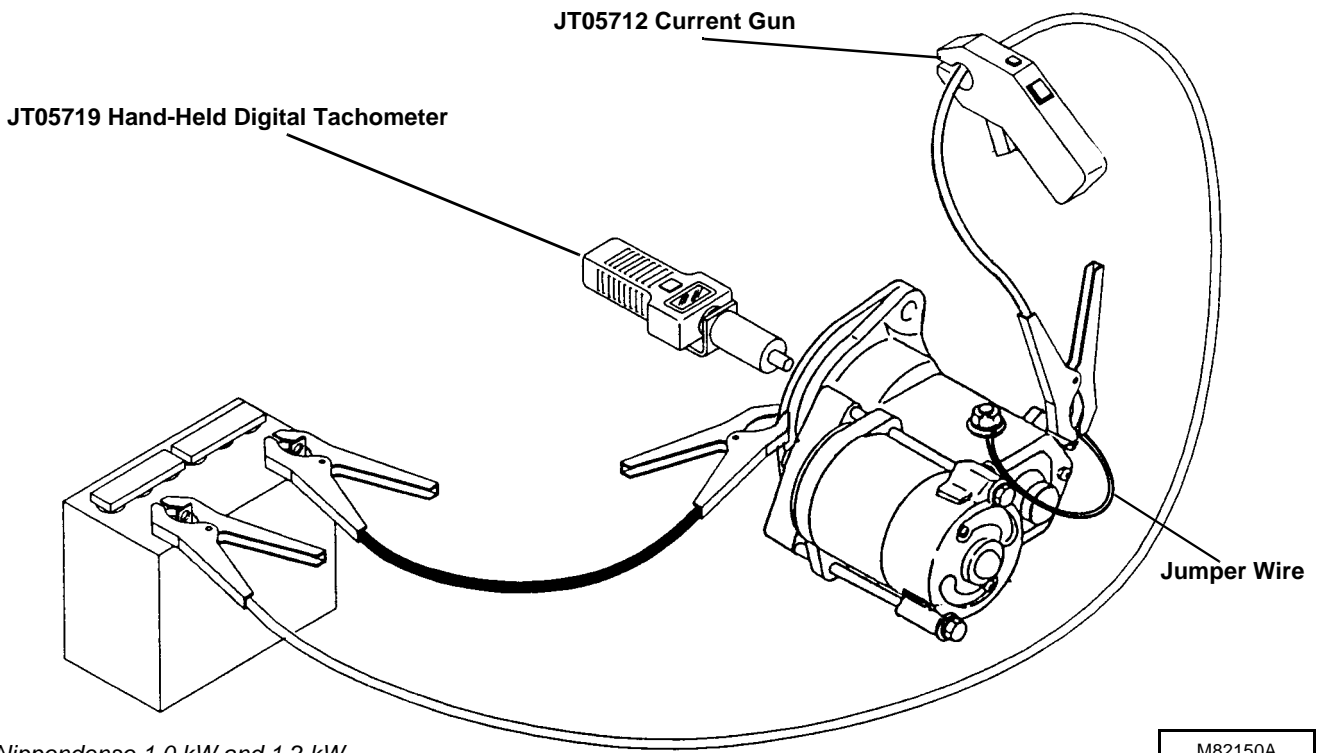
Checks, Tests and Adjustments

2



All Except Nippondenso 1.0 kW and 1.2 kW

M82149A



Nippondenso 1.0 kW and 1.2 kW

M82150A

INJECTION PUMP STATIC TIMING ADJUSTMENT

Reason:

To make sure that injection pump timing is set to manufacturers specification.

Equipment:

- Timing Tool (No. 1 fuel injection line cut off at first bend)
- External fuel supply

Procedure:

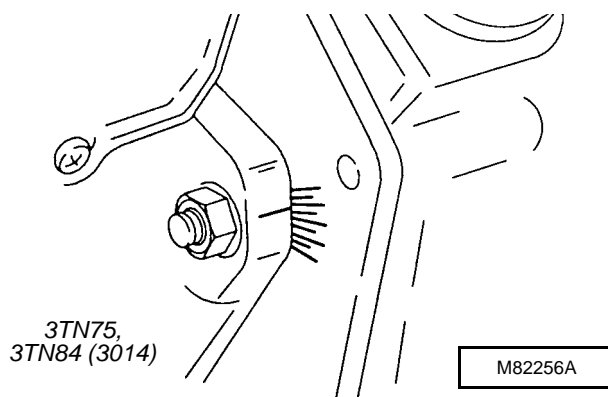
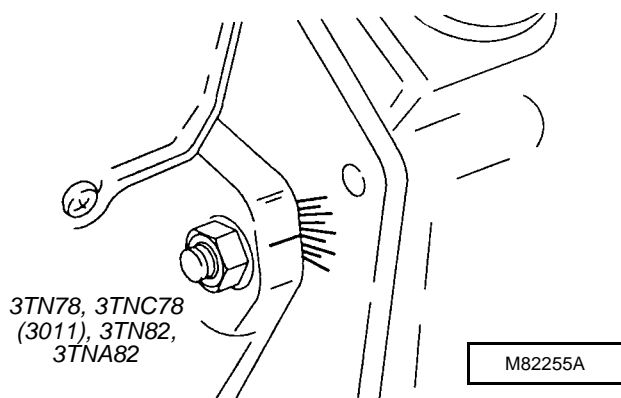
IMPORTANT: Injection pump timing should be correct. Once timing is set, it will not normally change during the life of the engine, unless it was altered.

Check and adjust timing only as the last option. Check fuel, fuel supply system, injectors, air intake system and cylinder compression before continuing.

NOTE: If injection pump has been removed from engine without disturbing engine crankshaft and pump shaft, perform Step 1 only. Otherwise, perform the entire timing procedure.

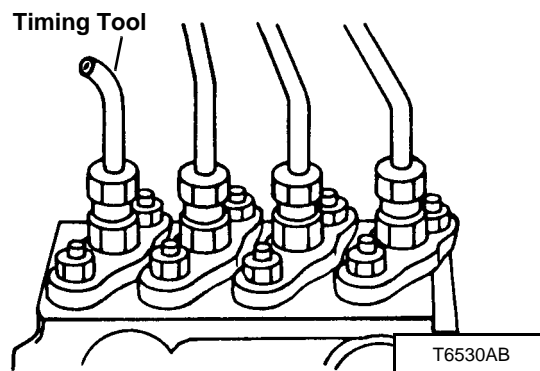
1. 3TN78, 3TNC78 (3011), 3TN82, 3TNA82: Align arrow or line on injection pump flange with the sixth mark (line) on timing gear mounting plate.

3TN75, 3TN84 (3014): Align arrow or line on injection pump flange between third and fourth marks (lines) on timing gear mounting plate.

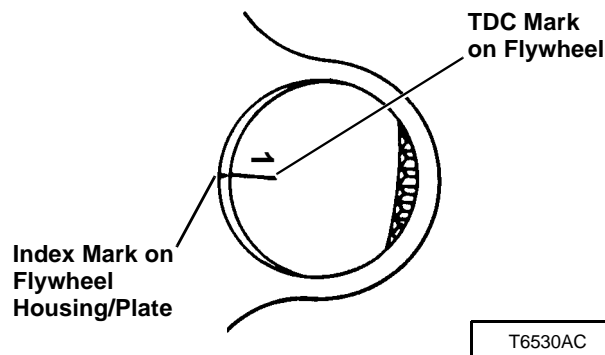


NOTE: Normal rotation, as viewed from the flywheel end, is counterclockwise. The number one fuel injection line is toward the flywheel.

2. Remove the number one fuel injection line.
3. Install timing tool (number one fuel line cut off at first bend).



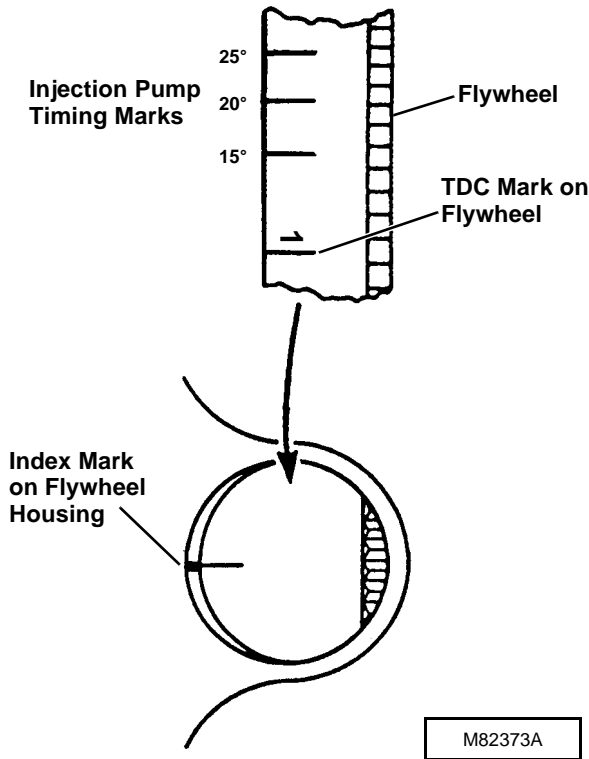
4. Remove rubber plug from flywheel housing, if equipped.
5. Turn crankshaft pulley in either direction until the No. 1 cylinder top dead center (TDC) mark aligns with the index mark on the flywheel housing/plate.



Checks, Tests and Adjustments

6. Prime pump to fill it with fuel. 1 L (1.06 qt) of fuel is more than adequate.
7. Hold throttle lever in run position.
8. Turn flywheel clockwise (as viewed from the flywheel end) until tip of Timing Tool has become **MOIST** with solid fuel.
9. Check timing mark on flywheel. The index mark must line up with the injection pump timing mark on flywheel. See specifications.

2



Specifications:

Injection Pump Timing Mark

- 3TN75 (F1145 FM, 855/56 CUT)..... $16^{\circ} \pm 1^{\circ}$ BTDC
..... (Before Top Dead Center)
- 3TN78 (25 EX)..... $16^{\circ} \pm 1^{\circ}$ BTDC
- 3TNC78 (3011 OEM) $16^{\circ} \pm 1^{\circ}$ BTDC
- 3TN82
(575 SSL) $17^{\circ} \pm 1^{\circ}$ BTDC
(30 EX)..... $16^{\circ} \pm 1^{\circ}$ BTDC
- 3TNA82 (770 CUT)..... $16^{\circ} \pm 1^{\circ}$ BTDC
- 3TN84 (870 CUT, 955 CUT, 3014 OEM) $16^{\circ} \pm 1^{\circ}$ BTDC

Engine Crankshaft

Position..... No.1 Cylinder
.....on TDC Compression Stroke

Results:

- If timing is not according to specifications, loosen pump mounting bolts and turn pump towards engine block to retard timing or away from block to advance timing. Recheck timing.
- If timing did not change, remove pump and have tested by a diesel injection service shop.
- If timing is OK:
 - Install rubber plug in flywheel housing, if equipped.
 - Remove timing tool.
 - Install number one injection line.

FAN/ALTERNATOR DRIVE BELT ADJUSTMENT

Reason:

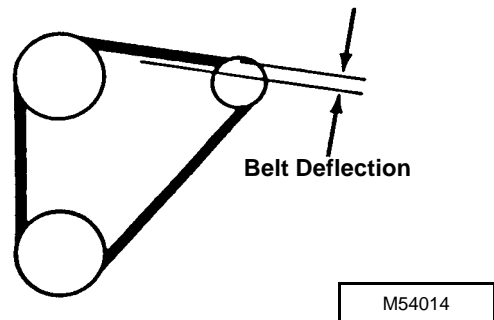
To keep proper tension on belt to drive water pump and alternator. To prevent shortened belt and bearing life.

Equipment:

- JDG529 or JDST28 Belt Tension Gauge
- Straight Edge

Procedure:

1. Check belt tension between fan and alternator using Belt Tension Gauge and a straight edge.



Specifications:

Applied Force98 N (22 lb-force)

Deflection10 - 15 mm (0.400 - 0.600 in.)

Results:

- If deflection is not within specifications:
 - Loosen both alternator mounting cap screws/nuts.
 - Apply force to FRONT alternator housing only (near the belt) until tension is correct.
 - Tighten cap screws/nuts.

ENGINE OIL COOLER LEAKAGE TEST - 3TN84 (955 CUT)

Reason:

Inspect oil cooler for leaks.

Procedure:

1. Plug one end of coolant inlet or outlet passage.
2. Apply regulated air pressure of **206 - 483 kPa (30 - 70 psi)** to other end.
3. Dip oil cooler into water and check for leaks.

Optional test:

If a leak did not appear, use a hot water bath to possibly open crack(s).

Results:

- Repair leak(s) or replace oil cooler if necessary.

FUEL SHUTOFF SOLENOID ADJUSTMENT

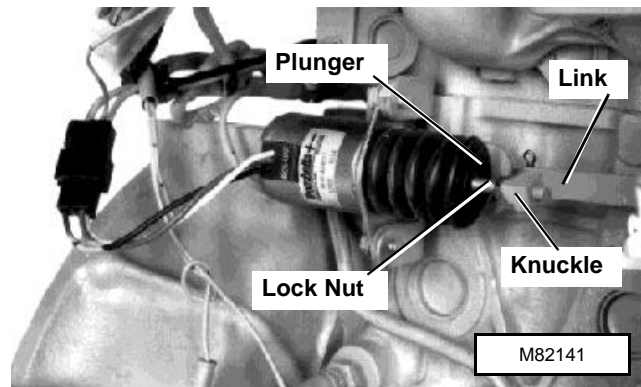
Reason:

To ensure that fuel shutoff solenoid retracts fully, moving the injection pump shutoff control lever far enough to allow full rack travel.

Procedure:

1. Loosen lock nut.
2. Disconnect link from solenoid.
3. Hold solenoid plunger bottomed in solenoid body.
4. Move link toward solenoid until it stops
5. Turn plunger rod in or out of knuckle until knuckle and link holes line up. Turn out two additional turns. The additional turns insure that the solenoid bottoms out before the linkage.
6. Assemble and check for free movement when key switch is turned ON. Also check that linkage returns completely to the STOP position when key switch is turned OFF.

2



Operational Tests

RADIATOR, BUBBLE TEST

Reason:

To determine if compression pressure is leaking from cylinder.

Equipment:

- JDG560 Adapter

Procedure:

1. With coolant at proper level and radiator cap tight, run engine for 5 minutes to bring to operating temperature.
2. Remove cap from recovery tank.
3. Check for bubbles coming from overflow hose at bottom of tank.

If bubbles are present, isolate source of compression leak:

- Remove injection nozzles.
- Install JDG560 Adapter in injection port of cylinder to be tested.
- Move piston to bottom of stroke with intake and exhaust valves closed.
- Connect hose from compressed air source to adapter.
- Apply the specified maximum air pressure into cylinder:

**3TN75, 3TN78, 3TN82, 3TNA82, 3TN84
(870 CUT, 955 CUT) 2448 kPa (355 psi)**

**3TNC78 (3011 OEM),
3TN84 (3014 OEM) 2158 kPa (313 psi)**

- Check for bubbles in recovery tank or air escaping from muffler, air cleaner or oil fill opening.
- Repeat for each cylinder.

Results:

- If bubbles are present, check for cracks in cylinder head and block. Check for damaged head gasket.
- If air escapes from muffler, check for worn exhaust valve.

- If air escapes from air cleaner, check for worn intake valve.
- If air escapes from engine oil fill, check for worn piston rings.

COOLING SYSTEM, PRESSURE TEST

Reason:

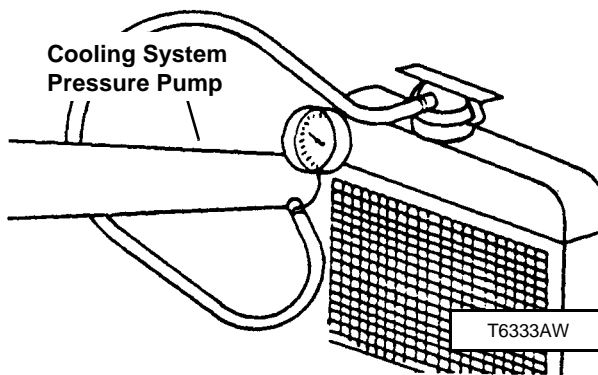
Inspect cooling system for leaks.

Equipment:

- D05104ST Cooling System Pressure Pump
- JDG692 Radiator Pressure Test Kit (Adapters)

Procedure:

1. Remove cap and attach pressure pump to radiator.
2. Apply pressure according to specifications.
3. Check for leaks throughout cooling system.



Specifications - 3TN75, 3TN84 (955 CUT):

Maximum Pressure 117 kPa (17 psi)
Minimum Pressure
after 15 Seconds 90 kPa (13 psi)

Specifications - 3TN78, 3TNC78 (3011), 3TN82, 3TNA82, 3TN84 (870 CUT, 3014 OEM):

Maximum Pressure 97 kPa (14 psi)
Minimum Pressure
after 15 Seconds 88 kPa (12.8 psi)

Results:

- Pressure should hold to specifications. If pressure decreases, check for leaks. Repair leaks or replace parts as necessary.
- If pressure test still indicates leakage after all external leaks have been stopped, a defective head gasket, cracked block, or cylinder head may be the cause. Perform *RADIATOR BUBBLE TEST*.

RADIATOR CAP, PRESSURE TEST

Reason:

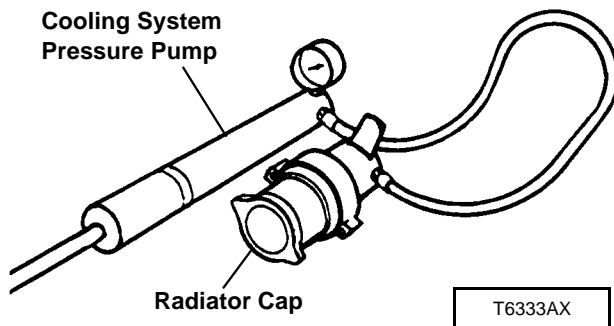
Test radiator cap for operating in correct pressure range.

Equipment:

- D05104ST Cooling System Pressure Pump
- JDG692 Radiator Pressure Test Kit (Adapters)

Procedure:

1. Install radiator cap on pressure pump.
2. Apply pressure. Pressure valve in cap should open according to specifications.



Specifications:

Valve Opening Pressure

- 3TN75,
 3TN84 (955 CUT) 90 kPa (13 psi)
 3TN78, 3TNC78 (3011),
 3TN82, 3TNA82, 3TN84
 (870 CUT, 3014 OEM) 88 kPa (12.8 psi)

Results:

- If cap leaks, retighten and test again. Replace cap if pressure is not within specification.

CYLINDER, COMPRESSION PRESSURE TEST

Reason:

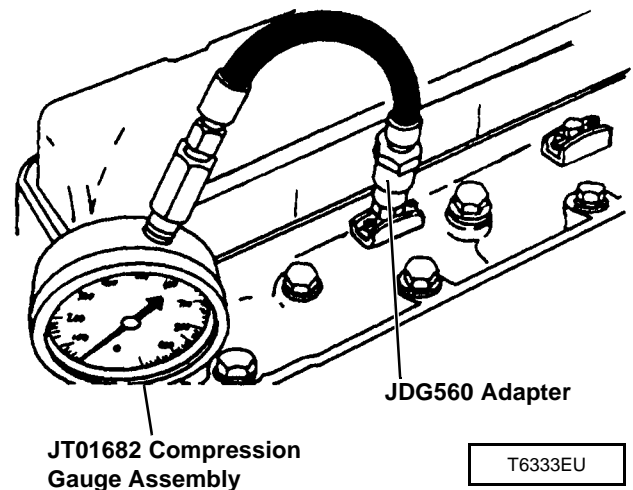
To determine the condition of the pistons, rings, cylinder walls and valves.

Equipment:

- JT01682 Compression Gauge Assembly
- JDG560 Adapter

Procedure:

1. Run engine for 5 minutes to bring to operating temperature. Shut off engine.
2. Remove injection nozzles. (See *Fuel System* in this section.)
3. Remove heat protector from end of injector and install on Adapter.
4. Install Adapter and Compression Gauge Assembly in injector port. Install retaining plate and tighten nuts to 4.5 N•m (39 lb-in.)
5. Hold fuel shut-off knob in shut-off position.
6. Crank engine for three seconds with starter.
7. Record pressure reading for each cylinder.



Operational Tests

Specifications:

Compression Pressure

3TN75, 3TN78, 3TN82,
3TNA82, 3TN84
(870 CUT, 955 CUT) 2448 kPa (355 psi)
3TNC78 (3011 OEM),
3TN84 (3014 OEM) 2158 kPa (313 psi)

**Maximum Difference Between
Cylinders 490 kPa (71 psi)**

NOTE: Pressure listed is for 300 m (1000 ft) above sea level. For naturally aspirated engines, reduce specification an additional 4% for each 300 m (1000 ft) of altitude.

2

Results:

- If pressure reading is below specification, squirt approximately two teaspoons of clean engine oil into cylinders through injector ports and repeat test.
- If pressure increases significantly, check piston, rings and cylinder walls for wear or damage.
- If pressure does not increase significantly after retest, check for leaking valves, valve seats or cylinder head gasket.

ENGINE OIL PRESSURE TEST

Reason:

To determine if engine bearings or lubrication system components are worn.

Equipment:

- JT03017 Hose Assembly
- JT05577 Pressure Gauge (100 psi)
- JT05487 Connector (4TN78T)
- JT03349 Connector (All Except 4TN78T)

Procedure:

1. Remove oil pressure sender.
2. Install Connector.
3. Connect Hose Assembly and Pressure Gauge.

IMPORTANT: Do not run if no pressure present.

4. Start engine. If pressure reading is below 69 kPa (10 psi), STOP ENGINE.

5. Run engine approximately five minutes to heat oil, then check oil pressure at fast and/or slow idle.

Specifications - 3TN75:

F1145 FM
Slow Idle 1450 ± 50 rpm
Fast Idle 3425 rpm
Oil Pressure 294 - 440 kPa
. (43 - 64 psi)

855/56 CUT
Fast Idle 3425 ± 25 rpm
Oil Pressure 365 ± 69 kPa
. (53 ± 10 psi)

Specifications - 3TN78, 3TN82 (30 EX):

Idle Speed
Slow 800 ± 25 rpm
Fast 2450 ± 25 rpm

Oil Pressure
Slow Idle 262 kPa (38 psi)
Fast Idle 345 ± 48 kPa
. (50 ± 7 psi)

Specifications - 3TNC78 (3011), 3TN84 (3014):

Low Idle Speed
Industrial 1300 rpm
Generator 1200 rpm
Oil Pressure 147 kPa (21 psi)

Specifications - 3TN82 (575 SSL):

Idle Speed
Slow 1250 ± 25 rpm
Fast 2875 ± 25 rpm
Oil Pressure 294 - 392 kPa
. (43 - 57 psi)

Specifications - 3TNA82, 3TN84 (870 CUT):

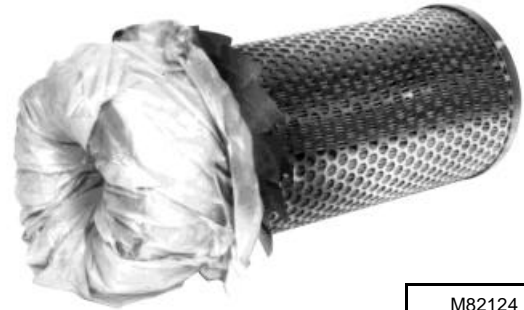
Fast Idle 2750 - 2800 rpm
Oil Pressure 365 ± 69 kPa
. (53 ± 10 psi)

Specifications - 3TN84 (955 CUT):

Fast Idle 3425 ± 25 rpm
Oil Pressure 365 ± 69 kPa
. (53 ± 10 psi)

Results:

- If oil pressure is not within specifications, inspect oil pressure regulating valve parts for wear or damage. Add or remove shims as necessary. (See *Lubrication System* in this section.)
- If oil pressure does not increase, see “Engine Has Low Oil Pressure” in *Diagnosis* group.



M82124

AIR INTAKE SYSTEM LEAKAGE TEST

Reason:

Check for leaks in air intake system.

Equipment:

- Air Pressure Regulator

Procedure:

1. Remove air cleaner restriction indicator/switch and install test fitting.
2. Connect air pressure regulator to manifold using hose and fitting from air cleaner.
3. Remove air cleaner cover and main filter element.
4. Put large plastic bag into and over end of main filter element. Install main filter element and cover.
5. Pressurize air intake system between **34 - 69 kPa (5 - 10 psi)**. If air intake system cannot be pressurized, turn engine slightly to close valves.
6. Spray soap solution over all connections from air cleaner to intake manifold or turbocharger, if equipped, and check for leaks.

IMPORTANT: When reinstalling starting aid nozzle, position arrow on nozzle pointing against intake air flow.

Results:

- Find leaks and repair or replace parts as necessary.

FUEL SUPPLY PUMP PRESSURE TEST - IF EQUIPPED

NOTE: 3TN78 and 3TN82 engines are not equipped with a fuel supply pump.

Reason:

To determine supply pump operating pressure.

Equipment:

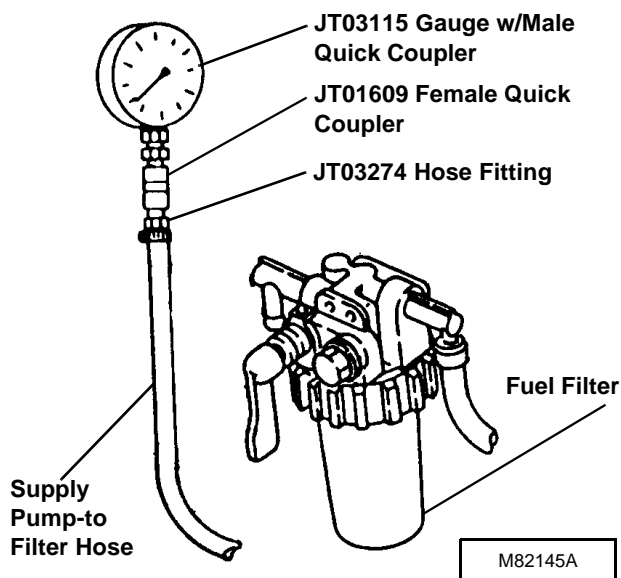
- JT03274 Hose Fitting
- JT01609 Female Quick Coupler
- JT03115 Gauge w/Male Quick Coupler (0 - 150 psi)

Operational Tests

Procedure:

1. Disconnect supply pump-to-filter hose.
2. Install Hose Fitting, Coupler and Gauge.
3. Pull fuel shut-off cable out and crank engine using the starter. Do not run starter for more than 10 seconds at a time. Gauge should read more than **29 kPa (4.3 psi)**.

2



Results:

- If pressure is below specification, repair or replace fuel supply pump.

FUEL DRAIN BACK TEST

Reason:

Determines if air is entering the fuel system at connections, allowing fuel to siphon back to tank.

Procedure:

1. Disconnect fuel supply line and 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 fuel supply pump, injection pump, filter(s) and water separator, if equipped.
3. Plug end of fuel return hose.
4. Pressurize fuel system at fuel supply line, to a maximum pressure of **103 kPa (15 psi)**.
5. Apply liquid soap and water solution to all joints and connections in the fuel system and inspect for leaks.

Results:

- Find leaks and repair or replace parts as necessary.

BLEED FUEL SYSTEM

IMPORTANT: Modification or alteration of the injection pump, pump timing, or the injection nozzles in any way not approved by the manufacturer will terminate the warranty obligation.

All engines are equipped with an automatic air venting system which makes the fuel system self-bleeding.

- Assure that all fuel line connections are securely tightened.
- Add fuel to fuel tank.
- Crank engine to allow fuel system to bleed itself.

4TN78T, 4TN82 AND 4TN84(T) (4019) ENGINES

Specifications	3-1
Cylinder Head, Valves and Manifolds	3-17
Pistons, Rods and Cylinder Block	3-30
Crankshaft, Main Bearings and Flywheel	3-41
Camshaft and Timing Gear Train	3-53
Lubrication System	3-62
Cooling System	3-69
Fuel System	3-77
Starter	3-86
Alternator	3-105
Diagnosis	3-119
Checks, Tests and Adjustments	3-122
Operational Tests	3-139

Section 3

ENGINE SPECIFICATIONS - 4TN78T

Rocker Arm Cover

Special Nut Torque 18 N•m (160 lb-in.)

Rocker Arm Assembly

Mounting Cap Screw Torque 26 N•m (226 lb-in.)

Rocker Arm Shaft O.D.

Standard 15.97 - 15.98 mm (0.6286 - 0.6293 in.)

Wear Limit 15.95 mm (0.6280 in.)

Rocker Arm and Shaft Support I.D.'s

Clearance 0.13 mm (0.005 in.)

Standard 16.00 - 16.02 mm (0.630 - 0.631 in.)

Wear Limit 16.09 mm (0.633 in.)

Push Rod Length

Standard 146.65 - 147.35 mm (5.774 - 5.801 in.)

Push Rod Bend

Standard 0.03 mm (0.001 in.) or less

Wear Limit 0.30 mm (0.012 in.)

Cylinder Head and Valves

Mounting Cap Screw Torque

First 22 N•m (16 lb-ft)

Second 43 N•m (32 lb-ft)

Final 69 N•m (51 lb-ft)

Cylinder Head Distortion

Standard 0.05 mm (0.002 in.) or less

Wear Limit 0.15 mm (0.006 in.)

Maximum Amount of Metal to be Removed 0.20 mm (0.008 in.)

Valve Seat Width

Intake Valve

Standard 1.36 - 1.53 mm (0.054 - 0.060 in.)

Wear Limit 1.98 mm (0.078 in.)

Exhaust Valve

Standard 1.66 - 1.87 mm (0.065 - 0.074 in.)

Wear Limit 2.27 mm (0.089 in.)

Intake and Exhaust Valves

Valve Faces

Minimum Margin 0.51 mm (0.020 in.)

Exhaust Angle 45°

Intake Angle 30°

Valve Stem O.D.

Distance A 30 mm (1.181 in.)

Distance B 50 mm (1.969 in.)

Intake and Exhaust Valves

Standard 6.94 - 6.96 mm (0.2732 - 0.2740 in.)

Wear Limit 6.90 mm (0.2717 in.)

Valve Recession

Standard 0.30 - 0.50 mm (0.012 - 0.020 in.)

Wear Limit 1.00 mm (0.039 in.)

Specifications

Valve Guides

Valve Guide I.D.

Maximum Clearance	0.20 mm (0.008 in.)
Standard	7.00 - 7.02 mm (0.275 - 0.276 in.)
Wear Limit	7.08 mm (0.279 in.)

Valve Guide Height	12 mm (0.472 in.)
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Valve Springs

Spring Free Length

Standard	40 mm (1.575 in.)
Wear Limit	39.50 mm (1.550 in.)

Maximum Spring Inclination	1.10 mm (0.044 in.)
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Exhaust Manifold

Mounting Cap Screw and Nut Torque	26 N•m (226 lb-in.)
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Intake Manifold

Mounting Cap Screw Torque	26 N•m (226 lb-in.)
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Valve Seat Angles

Valve Seat Surface

Exhaust Valve	45°
Intake Valve	30°

Lower Seat Surface	70°
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Upper Seat Surface	15°
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Piston-to-Cylinder Head Clearance	0.59 - 0.77 mm (0.023 - 0.030 in.)
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Piston and Connecting Rod Cap Screw Torque	39 N•m (29 lb-ft)
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Connecting Rod Bearing I.D.

Clearance	0.16 mm (0.006 in.)
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Standard	43 - 43.042 mm (1.693 - 1.695 in.)
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Wear Limit	43.07 mm (1.696 in.)
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Piston Ring Groove Clearance

First Compression Ring

Standard	0.070 - 0.105 mm (0.0028 - 0.0041 in.)
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Wear Limit	0.25 mm (0.0098 in.)
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Second Compression Ring

Standard	0.035 - 0.070 mm (0.0014 - 0.0028 in.)
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Wear Limit	0.25 mm (0.0098 in.)
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Oil Ring

Standard	0.030 - 0.060 mm (0.0012 - 0.0024 in.)
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Wear Limit	0.20 mm (0.0078 in.)
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Piston Ring End Gap

Compression Rings and Oil Ring

Standard	0.20 - 0.40 mm (0.008 - 0.016 in.)
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Wear Limit	1.50 mm (0.0591 in.)
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Piston Pin

Pin O.D.

Standard	22.991 - 23.00 mm (0.905 - 0.906 in.)
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Wear Limit	22.90 mm (0.902 in.)
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Bore I.D.

Clearance	0.018 mm (0.0007 in.)
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Standard	23.00 - 23.009 mm (0.9055 - 0.9059 in.)
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Wear Limit	23.02 mm (0.906 in.)
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Piston Pin, continued

Bushing I.D.

Clearance	0.110 mm (0.0043 in.)
Standard	23.025 - 23.038 mm (0.9065 - 0.9070 in.)
Wear Limit	23.10 mm (0.909 in.)

Piston O.D.

Distance A.23 mm (0.905 in.)
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Standard Size Piston

Standard	77.895 - 77.925 mm (3.067 - 3.068 in.)
Wear Limit	77.81 mm (3.063 in.)

0.25 mm (0.010 in.) Oversize Piston

Standard	78.15 - 78.18 mm (3.076 - 3.077 in.)
Wear Limit	78.05 mm (3.073 in.)

Cylinder Bore I.D.

Standard Size Bore

Clearance	0.22 mm (0.009 in.)
Standard	78.00 - 78.03 mm (3.071 - 3.072 in.)
Wear Limit	78.20 mm (3.079 in.)

0.25 mm (0.010 in.) Oversize Bore

Standard	78.25 - 78.28 mm (3.081 - 3.082 in.)
Wear Limit	78.45 mm (3.089 in.)

Deglazing 30 - 40° cross-hatch pattern

Reboring 30 - 40° cross-hatch pattern

Crankcase Extension Housing

Mounting Cap Screw Torque

Flywheel Housing/Plate-to-Extension	49 N•m (36 lb-ft)
Seal Case-to-Extension	26 N•m (226 lb-in.)
Extension-to-Block	27 N•m (20 lb-ft)
Extension-to-Timing Gear Cover	22 N•m (195 lb-in.)

Crankshaft Rear Oil Seal

Seal Case-to-Block Cap Screw Torque 26 N•m (226 lb-in.)

Seal Case-to-Extension Cap Screw Torque 21 N•m (180 lb-in.)

Crankshaft and Main Bearings

Main Bearing Cap Screw Torque 79 N•m (58 lb-ft)

Crankshaft Maximum Bend 0.02 mm (0.0007 in.)

Connecting Rod Journal O.D.

Standard	42.952 - 42.962 mm (1.6910 - 1.6914 in.)
Wear Limit	42.91 mm (1.689 in.)

Main Bearing Journal O.D.

Standard	46.952 - 46.962 mm (1.8485 - 1.8489 in.)
Wear Limit	46.91 mm (1.847 in.)

Main Bearing I.D.

Clearance	0.16 mm (0.006 in.)
Standard	47.00 - 47.045 mm (1.850 - 1.852 in.)
Wear Limit	47.10 mm (1.8541 in.)

Flywheel

Maximum Distortion..... 0.02 mm (0.0008 in.)

Mounting Cap Screw Torque 83 N•m (61 lb-ft)

Flywheel Housing Mounting Cap Screw Torque 49 N•m (36 lb-ft)

Specifications

Camshaft

Mounting Cap Screw Torque 26 N•m (226 lb-in.)

Camshaft Side Gap

Standard 0.05 - 0.20 mm (0.0020 - 0.0079 in.)

Wear Limit 0.40 mm (0.016 in.)

Maximum Camshaft Bend 0.02 mm (0.001 in.)

Lobe Height

Standard 38.635 - 38.765 mm (1.521 - 1.526 in.)

Wear Limit 38.40 mm (1.512 in.)

Journal O.D.

Gear Housing and Flywheel Ends

Standard 44.92 - 44.95 mm (1.769 - 1.770 in.)

Wear Limit 44.80 mm (1.764 in.)

Intermediate

Standard 44.91 - 44.94 mm (1.768 - 1.769 in.)

Wear Limit 44.80 mm (1.764 in.)

Bushing I.D.

Clearance 0.20 mm (0.0079 in.)

Standard 44.990 - 45.055 mm (1.771 - 1.744 in.)

Wear Limit 45.10 mm (1.776 in.)

Bore I.D.

Clearance 0.18 mm (0.007 in.)

Standard 45.00 - 45.025 mm (1.772 - 1.773 in.)

Wear Limit 45.10 mm (1.776 in.)

Cam Followers

Stem O.D.

Standard 11.975 - 11.990 mm (0.471 - 0.472 in.)

Wear Limit 11.93 mm (0.470 in.)

Bore I.D.

Clearance 0.10 mm (0.004 in.)

Standard 12.000 - 12.018 mm (0.472 - 0.473 in.)

Wear Limit 12.05 mm (0.474 in.)

Timing Gear Cover

Fan Mounting Cap Screw Torque 11 N•m (96 lb-in.)

Cover Mounting Cap Screw Torque 26 N•m (226 lb-in.)

Crankcase Extension Housing-to-Cover Cap Screw Torque 22 N•m (195 lb-in.)

Crankshaft Pulley Cap Screw Torque 115 N•m (85 lb-ft)

Idler Gear

Shaft O.D

Standard 45.950 - 45.975 mm (1.809 - 1.810 in.)

Wear Limit 45.93 mm (1.808 in.)

Bushing I.D.

Clearance 0.15 mm (0.0059 in.)

Standard 46.00 - 46.025 mm (1.811 - 1.812 in.)

Wear Limit 46.08 mm (1.814 in.)

Timing Gear Cover Mounting Plate Cap Screw Torque 25 N•m (220 lb-in.)

Oil Pan and Strainer Mounting Cap Screw Torque 26 N•m (226 lb-in.)

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Oil Pump

Mounting Cap Screw Torque	25 N•m (18 lb-ft)
Rotor Shaft O.D.-to-Backing Plate I.D. Clearance	
Standard	0.015 - 0.048 mm (0.0006 - 0.0035 in.)
Wear Limit	0.20 mm (0.0078 in.)
Rotor Recess	
Standard	0.05 - 0.10 mm (0.0020 - 0.0039 in.)
Wear Limit	0.15 mm (0.0059 in.)
Outer Rotor-to-Pump Body Clearance	
Standard	0.09 - 0.16 mm (0.0035 - 0.0063 in.)
Wear Limit	0.25 mm (0.0098 in.)
Inner-to-Outer Rotor Clearance	
Standard	0.02 - 0.04 mm (0.0008 - 0.0016 in.)
Wear Limit	0.15 mm (0.0059 in.)

Oil Cooler

Oil Cooler-to-Mounting Block Mounting Bolt Torque	30 N•m (22 lb-ft)
Mounting Block-to-Engine Block Cap Screw Torque	27 N•m (20 lb-ft)

Piston Cooling Nozzle Mounting Bolt Torque	15 N•m (130 lb-in.)
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Thermostat and Housing

Thermostat Cover Cap Screw Torque	20 N•m (180 lb-in.)
Plate-to-Housing Cap Screw Torque	9 N•m (78 lb-in.)
Housing Mounting Cap Screw Torque	26 N•m (226 lb-in.)

Water Pump

Mounting Cap Screw Torque	26 N•m (226 lb-in.)
Plate-to-Housing Screw Torque	15 N•m (134 lb-in.)
Plug-to-Housing Torque	15 N•m (130 lb-in.)
Bottom of Pulley Flange-to-Top of Housing	17 mm (0.670 in.)
Top of Impeller-to-Housing	2 mm (0.080 in.) below housing

Fuel Injection Pump

Injection Pump Gear Nut Torque	90 N•m (66 lb-ft)
Mounting Nut Torque	26 N•m (19 lb-ft)
Lube Line-to-Block Bolt Torque	25 N•m (217 lb-in.)

Fuel Injection Nozzles

Mounting Nut Torque	5 N•m (39 lb-in.)
Retaining Nut Torque	43 N•m (31 lb-ft)
Separator Plate Nozzle Contact Surface Maximum Wear	0.10 mm (0.0039 in.)

Starter - Hitachi 0.8 kW

Cover Bushing (Reamed Out)	12.50 - 12.53 mm (0.492 - 0.493 in.)
Minimum Brush Length	7.70 mm (0.303 in.)

Alternator - Hitachi 25A

Attaching Screw Torque	4 N•m (31 lb-in.)
Rotor Assembly	
Retainer-to-Front Frame Screw Torque	2 N•m (16 lb-in.)
Sheave Nut Torque	49 N•m (36 lb-ft)
End Frame-to-Rectifier Nut Torque	4 N•m (31 lb-in.)
Stator-to-Rectifier Lead Wire Distance	33.50 mm (1.300 in.)
Minimum Brush Length	5.50 mm (0.220 in.)

Specifications

Checks, Tests and Adjustments

Valve Clearance	0.20 mm (0.008 in.)
Connecting Rod Side Play	
Standard Clearance	0.20 - 0.40 mm (0.0079 - 0.0157 in.)
Wear Limit	0.55 mm (0.0217 in.)
Connecting Rod Bearing Clearance	
Standard Clearance	0.038 - 0.090 mm (0.0015 - 0.0035 in.)
Wear Limit	0.16 mm (0.0063 in.)
Crankshaft End Play	
Standard Clearance	0.090 - 0.271 mm (0.004 - 0.011 in.)
Wear Limit	0.33 mm (0.0129 in.)
Crankshaft Main Bearing Clearance	
Main Bearing Cap Cap Screw Torque	79 N•m (58 lb-ft)
Standard Clearance	0.038 - 0.090 mm (0.0015 - 0.0035 in.)
Wear Limit	0.06 mm (0.0063 in.)
Valve Lift (Intake and Exhaust)	8.8 mm (0.350 in.)
Camshaft End Play	
Standard Clearance	0.05 - 0.20 mm (0.0020 - 0.0079 in.)
Wear Limit	0.40 mm (0.016 in.)
Timing Gear Backlash	
Standard Backlash	
All Except Crankshaft Gear-to-Oil Pump Gear	0.04 - 0.12 mm (0.0016 - 0.0047 in.)
Crankshaft Gear-to-Oil Pump Gear	0.11 - 0.19 mm (0.0043 - 0.0075 in.)
Wear Limit	0.20 mm (0.0079 in.)
Fuel Injection Nozzle	
Opening Pressure	19600 ± 480 kPa (2843 ± 70 psi)
Leakage at 17640 kPa (2558 psi)	Minimum of 5 Seconds
Chatter and Spray Pattern at 19600 ± 480 kPa (2843 ± 70 psi)	
Slow Hand Lever Movement	Chatter Sound
Slow Hand Lever Movement	Fine Stream Spray Pattern
Fast Hand Lever Movement	Fine Atomized Spray Pattern
Thermostat	
Begin Opening	71° C (160° F)
Fully Open	85° C (184° F)
Minimum Lift Height	8 mm (0.310 in.)
Coolant Temperature Switch Continuity	107 - 133° C (225 - 235° F)
Starter No-Load Amp Draw/RPM	
Maximum Starter Amperage	
Hitachi 0.8 kW	60 Amps at 7000 rpm
Minimum Starter RPM	
Hitachi 0.8 kW	7000
Fuel Injection Pump Static Timing	
Injection Pump Timing	14° BTDC (Before Top Dead Center)
Engine Crankshaft Position	No. 1 Cylinder on TDC Compression Stroke
Distance on Outer Surface of Flywheel Per 1° of Rotation	2.88 mm (0.110 in.)
Timing Lines on Pump Mounting Plate	2.5° Apart

Checks, Tests and Adjustments, continued

Fan/Alternator Drive Belt Tension

Applied Force	98 N (22 lb-force)
Deflection	10 - 15 mm (0.400 - 0.600 in.)

Oil Cooler Leakage

Applied Air Pressure	206 - 483 kPa (30 - 70 psi)
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Operational Tests

Radiator, Bubble Test

Maximum Air Pressure Into Cylinder	2448 kPa (355 psi)
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Cooling System

Maximum Pressure	97 kPa (14 psi)
Minimum Pressure after 15 Seconds	88 kPa (12.8 psi)

Radiator Cap

Valve Opening Pressure	88 kPa (12.8 psi)
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Cylinder, Compression Pressure

Minimum Compression Pressure	2448 kPa (355 psi)
Maximum Difference Between Cylinders	490 kPa (71 psi)

Engine Oil Pressure

Idle Speed

Fast	2750 ± 25 rpm
Slow	800 ± 25 rpm

Oil Pressure

Fast Idle	345 ± 48kPa (50 ± 7 psi)
Slow Idle	214 kPa (31 psi)

Air Intake System Holding Pressure	34 - 69 kPa (5 - 10 psi)
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Minimum Fuel Supply Pump Pressure	29 kPa (4.3 psi)
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Fuel System Holding Pressure (Maximum)	103 kPa (15 psi)
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ENGINE SPECIFICATIONS - 4TN82, 4TN84(T) (4019)

Rocker Arm Cover

Special Nut Torque	18 N•m (160 lb-in.)
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Rocker Arm Assembly

Mounting Cap Screw Torque	26 N•m (226 lb-in.)
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Rocker Arm Shaft O.D.

Standard	15.97 - 15.95 mm (0.6286 - 0.6293 in.)
Wear Limit	15.96 mm (0.6280 in.)

Rocker Arm and Shaft Support I.D.'s

Clearance	0.13 mm (0.005 in.)
Standard	16.00 - 16.02 mm (0.630 - 0.631 in.)
Wear Limit	16.09 mm (0.633 in.)

Push Rod Length

Standard	178.25 - 178.75 mm (7.018 - 7.037 in.)
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Push Rod Bend

Standard	0.03 mm (0.001 in.) or less
Wear Limit	0.30 mm (0.012 in.)

Specifications

Cylinder Head and Valves

Mounting Cap Screw Torque

First	24 N•m (18 lb-ft)
Second	49 N•m (36 lb-ft)
Final	78 N•m (58 lb-ft)

Cylinder Head Distortion

Standard	0.05 mm (0.002 in.) or less
Wear Limit	0.15 mm (0.006 in.)
Maximum Amount of Metal to be Removed	0.20 mm (0.008 in.)

Valve Seat Width

Intake Valve

Standard	1.07 - 1.24 mm (0.042 - 0.049 in.)
Wear Limit	1.74 mm (0.069 in.)

Exhaust Valve

Standard	1.24 - 1.45 mm (0.049 - 0.057 in.)
Wear Limit	1.94 mm (0.076 in.)

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Intake and Exhaust Valves

Valve Faces

Minimum Margin	0.51 mm (0.020 in.)
Exhaust Angle	45°
Intake Angle	30°

Valve Stem O.D.

Distance A. . . . .	.30 mm (1.181 in.)
Distance B. . . . .	.60 mm (2.360 in.)

Intake Valve

Standard	7.96 - 7.98 mm (0.3134 - 0.3142 in.)
Wear Limit	7.90 mm (0.3110 in.)

Exhaust Valve

Standard	7.96 - 7.97 mm (0.3134 - 0.3138 in.)
Wear Limit	7.90 mm (0.3110 in.)

Valve Recession

Standard	0.30 - 0.50 mm (0.012 - 0.020 in.)
Wear Limit	1.00 mm (0.039 in.)

Valve Guides

Valve Guide I.D.

Maximum Clearance	0.20 mm (0.008 in.)
Standard	8.01 - 8.03 (0.315 - 0.316 in.)
Wear Limit	8.10 mm (0.319 in.)

Valve Guide Height

.	15 mm (0.591 in.)
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Valve Springs

Spring Free Length

Standard40 mm (1.575 in.)
Wear Limit	39.50 mm (1.550 in.)

Maximum Spring Inclination

.	1.10 mm (0.044 in.)
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Exhaust Manifold

Mounting Cap Screw and Nut Torque	26 N•m (226 lb-in.)
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Intake Manifold

Mounting Cap Screw Torque	26 N•m (226 lb-in.)
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Valve Seat Angles	
Valve Seat Surface	
Exhaust Valve	45°
Intake Valve	30°
Lower Seat Surface	70°
Upper Seat Surface	15°
Piston-to-Cylinder Head Clearance	0.64 - 0.82 mm (0.025 - 0.032 in.)
Piston and Connecting Rod Cap Screw Torque	47 N•m (35 lb-ft)
Connecting Rod Bearing I.D.	
Clearance	0.16 mm (0.006 in.)
Standard	48 - 48.042 mm (1.888 - 1.891 in.)
Wear Limit	48.07 mm (1.893 in.)
Piston Ring Groove Clearance	
First Compression Ring	
Standard	0.075 - 0.110 mm (0.0030 - 0.0043 in.)
Wear Limit	0.25 mm (0.0098 in.)
Second Compression Ring	
Standard	0.45 - 0.080 mm (0.0018 - 0.0031 in.)
Wear Limit	0.25 mm (0.0098 in.)
Oil Ring	
Standard	0.025 - 0.060 mm (0.0010 - 0.0024 in.)
Wear Limit	0.20 mm (0.0079 in.)
Piston Ring End Gap	
4TN82	
Standard	
First Compression Ring	0.25 - 0.40 mm (0.010 - 0.016 in.)
Oil Ring	0.20 - 0.40 mm (0.008 - 0.016 in.)
Second Compression Ring	0.20 - 0.35 mm (0.008 - 0.014 in.)
Wear Limit	1.50 mm (0.0591 in.)
4TN84 (4019D)	
Standard	
Compression Rings	0.20 - 0.40 mm (0.008 - 0.016 in.)
Oil Ring	0.25 - 0.45 mm (0.010 - 0.018 in.)
Wear Limit	1.50 mm (0.0591 in.)
4TN84T (4019T)	
Standard	
First Compression Ring and Oil Ring	0.25 - 0.45 mm (0.010 - 0.018 in.)
Second Compression Ring	0.20 - 0.40 mm (0.008 - 0.016 in.)
Wear Limit	1.50 mm (0.0591 in.)
Piston Pin	
Pin O.D.	
Standard	25.987 - 26.00 mm (1.023 - 1.024 in.)
Wear Limit	25.90 mm (1.020 in.)
Bore I.D.	
Clearance	0.022 mm (0.0009 in.)
Standard	26.00 - 26.009 mm (1.0236 - 1.0240 in.)
Wear Limit	26.02 mm (1.024 in.)

Specifications

Piston Pin, continued

Bushing I.D.

Clearance	0.110 mm (0.0043 in.)
Standard	26.025 - 26.038 mm (1.0246 - 1.0251 in.)
Wear Limit	26.10 mm (1.028 in.)

Piston O.D.

4TN82

Distance A.	.24 mm (0.945 in.)
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Standard Size Piston

Standard	81.90 - 81.93 mm (3.224 - 3.225 in.)
Wear Limit	81.80 mm (3.220 in.)

0.25 mm (0.010 in.) Oversize Piston

Standard	82.15 - 82.18 mm (3.234 - 3.235 in.)
Wear Limit	82.05 mm (3.230 in.)

0.50 mm (0.020 in.) Oversize Piston

Standard	82.40 - 82.42 mm (3.244 - 3.245 in.)
Wear limit	82.30 mm (3.240 in.)

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4TN84(T) (4019)

Distance A.	.24 mm (0.945 in.)
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Standard Size Piston

Standard	83.90 - 83.93 mm (3.303 - 3.304 in.)
Wear Limit	83.80 mm (3.299 in.)

0.25 mm (0.10 in.) Oversize Piston

Standard	84.15 - 84.18 mm (3.313 - 3.314 in.)
Wear Limit	84.05 mm (3.309 in.)

0.50 mm (0.020 in.) Oversize Piston

Standard	84.40 - 84.42 mm (3.323 - 3.324 in.)
Wear Limit	84.30 mm (3.319 in.)

Cylinder Bore I.D.

4TN82

Standard Size Bore

Clearance	0.35 mm (0.014 in.)
Standard	82.00 - 82.03 mm (3.228 - 3.230 in.)
Wear Limit	82.20 mm (3.236 in.)

0.25 mm (0.010 in.) Oversize Bore

Standard	82.25 - 82.28 mm (3.238 - 3.239 in.)
Wear Limit	82.45 mm (3.246 in.)

0.50 mm (0.020 in.) Oversize Bore

Standard	82.50 - 82.53 mm (3.248 - 3.249 in.)
Wear Limit	82.70 mm (3.256 in.)

4TN84(T) (4019)

Standard Size Bore

Clearance	0.35 mm (0.014 in.)
Standard	84.00 - 84.03 mm (3.307 - 3.308 in.)
Wear Limit	84.20 mm (3.315 in.)

0.25 mm (0.010 in.) Oversize Bore

Standard	84.25 - 84.28 mm (3.317 - 3.318 in.)
Wear Limit	84.45 mm (3.325 in.)

4TN84(T) (4019), continued

0.50 mm (0.020 in.) Oversize Bore

Standard 84.50 - 84.53 mm (3.327 - 3.328 in.)

Wear Limit 84.70 mm (3.335 in.)

Deglazing 30 - 40° cross-hatch pattern

Reboring 30 - 40° cross-hatch pattern

Balancer Assembly - 4TN82RJK, 4TN84RJK

Mounting Cap Screw Torque 27 N•m (20 lb-ft)

Drive Gear Nut Torque 106 N•m (78 lb-ft)

Retaining Plate Cap Screw Torque 27 N•m (20 lb-ft)

Crankcase Extension Housing

Mounting Cap Screw Torque

Flywheel Housing/Plate-to-Extension 49 N•m (36 lb-ft)

Seal Case-to-Extension 26 N•m (226 lb-in.)

Extension-to-Block 27 N•m (20 lb-ft)

Extension-to-Timing Gear Cover 22 N•m (195 lb-in.)

Crankshaft Rear Oil Seal

Seal Case-to-Block Cap Screw Torque 26 N•m (226 lb-in.)

Seal Case-to-Extension Cap Screw Torque 21 N•m (180 lb-in.)

Crankshaft and Main Bearings

Main Bearing Cap Screw Torque 98 N•m (72 lb-ft)

Crankshaft Maximum Bend 0.02 mm (0.0007 in.)

Connecting Rod Journal O.D.

Standard 47.952 - 47.962 mm (1.8879 - 1.8883 in.)

Wear Limit 47.91 mm (1.886 in.)

Main Bearing Journal O.D.

Standard 46.952 - 46.962 mm (1.9666 - 1.9670 in.)

Wear Limit 49.90 mm (1.965 in.)

Main Bearing I.D.

Clearance 0.16 mm (0.006 in.)

Standard 50.00 - 50.045 mm (1.969 - 1.970 in.)

Wear Limit 50.10 mm (1.972 in.)

Flywheel

Maximum Distortion 0.02 mm (0.0008 in.)

Mounting Cap Screw Torque 83 N•m (61 lb-ft)

Flywheel Housing Mounting Cap Screw Torque 49 N•m (36 lb-ft)

Flywheel Plate Mounting Cap Screw Torque 49 N•m (36 lb-ft)

Camshaft

Mounting Cap Screw Torque 26 N•m (226 lb-in.)

Camshaft Side Gap

Standard 0.05 - 0.20 mm (0.0020 - 0.0079 in.)

Wear Limit 0.40 mm (0.016 in.)

Maximum Camshaft Bend 0.02 mm (0.001 in.)

Lobe Height

Standard 38.635 - 38.765 mm (1.521 - 1.526 in.)

Wear Limit 38.40 mm (1.512 in.)

Specifications

Camshaft, continued

Journal O.D.

Gear Housing and Flywheel Ends

Standard 44.92 - 44.95 mm (1.769 - 1.770 in.)

Wear Limit 44.80 mm (1.764 in.)

Intermediate

Standard 44.91 - 44.94 mm (1.768 - 1.769 in.)

Wear Limit 44.80 mm (1.764 in.)

Bushing I.D.

Clearance 0.20 mm (0.0079 in.)

Standard 44.990 - 45.055 mm (1.771 - 1.744 in.)

Wear Limit 45.10 mm (1.776 in.)

Bore I.D.

Clearance 0.18 mm (0.007 in.)

Standard 45.00 - 45.025 mm (1.772 - 1.773 in.)

Wear Limit 45.10 mm (1.776 in.)

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Cam Followers

Stem O.D.

Standard 11.975 - 11.990 mm (0.471 - 0.472 in.)

Wear Limit 11.93 mm (0.470 in.)

Bore I.D.

Clearance 0.10 mm (0.004 in.)

Standard 12.000 - 12.018 mm (0.472 - 0.473 in.)

Wear Limit 12.05 mm (0.474 in.)

Timing Gear Cover

Fan Mounting Cap Screw Torque 11 N•m (96 lb-in.)

Cover Mounting Cap Screw Torque 26 N•m (226 lb-in.)

Crankcase Extension Housing-to-Cover Cap Screw Torque 22 N•m (195 lb-in.)

Crankshaft Pulley Cap Screw Torque 115 N•m (85 lb-ft)

Idler Gear

Shaft O.D

Standard 45.950 - 45.975 mm (1.809 - 1.810 in.)

Wear Limit 45.93 mm (1.808 in.)

Bushing I.D.

Clearance 0.15 mm (0.0059 in.)

Standard 46.00 - 46.025 mm (1.811 - 1.812 in.)

Wear Limit 46.08 mm (1.814 in.)

Timing Gear Cover Mounting Plate Cap Screw Torque 25 N•m (220 lb-in.)

Oil Pan and Strainer Mounting Cap Screw Torque 26 N•m (226 lb-in.)

Oil Pump

Mounting Cap Screw Torque 25 N•m (18 lb-ft)

Rotor Shaft O.D.-to-Backing Plate I.D. Clearance

Standard 0.015 - 0.048 mm (0.0006 - 0.0035 in.)

Wear Limit 0.20 mm (0.0078 in.)

Rotor Recess

Standard 0.03 - 0.09 mm (0.0011 - 0.0035 in.)

Wear Limit 0.15 mm (0.0059 in.)

Oil Pump, continued

Outer Rotor-to-Pump Body Clearance

Standard 0.10 - 0.17 mm (0.0039 - 0.0067 in.)

Wear Limit 0.25 mm (0.0098 in.)

Inner-to-Outer Rotor Clearance

Standard 0.05 - 0.105 mm (0.0019 - 0.0041 in.)

Wear Limit 0.15 mm (0.0059 in.)

Oil Cooler - 4TN84T (4019TF001 and 005)

Oil Cooler-to-Mounting Block Mounting Bolt Torque 30 N•m (22 lb-ft)

Mounting Block-to-Engine Block Cap Screw Torque 27 N•m (20 lb-ft)

Oil Pressure Regulating Valve - All Except 4TN84T (4019TF001 and 005)

Spring

Compressed Length 27.50 mm (1.080 in.) @ 20.5 N (4.6 lb-force)

Free Length 46 mm (1.810 in.)

Housing-to-Valve Body Retaining Nut Torque 30 N•m (22 lb-ft)

Housing-to-Engine Block Cap Screw Torque 27 N•m (20 lb-ft)

Piston Cooling Nozzles - 4TN84T (4019TF001 and 005)

Mounting Bolt Torque 15 N•m (130 lb-in.)

Thermostat and Housing - 4TN82RJE, 4TN82ESP and 4TN84(T) (4019)

Thermostat Cover Cap Screw Torque 20 N•m (180 lb-in.)

Plate-to-Housing Cap Screw Torque 9 N•m (78 lb-in.)

Housing Mounting Cap Screw Torque 26 N•m (226 lb-in.)

Thermostat - 4TN82RJK and 4TN84RJK

Cover Cap Screw Torque 20 N•m (180 lb-in.)

Water Pump - 4TN82RJE, 4TN82ESP and 4TN84(T) (4019)

Mounting Cap Screw Torque 26 N•m (226 lb-in.)

Plate-to-Housing Screw Torque 15 N•m (134 lb-in.)

Plug-to-Housing Torque 15 N•m (130 lb-in.)

4TN82RJE and 4TN82ESP

Top of Pulley Flange-to-Top of Housing 27 mm (1.060 in.)

Top of Impeller-to-Housing 1 mm (0.040 in.) below housing

4TN84(T) (4019)

Bottom of Pulley Flange-to-Top of Housing 17 mm (0.670 in.)

Top of Impeller-to-Housing 2 mm (0.080 in.) below housing

Water Pump - 4TN82RJK and 4TN84RJK

Mounting Cap Screw Torque 26 N•m (226 lb-in.)

Fan Mounting Cap Screw Torque 11 N•m (96 lb-in.)

Plate-to-Housing Cap Screw Torque 9 N•m (78 lb-in.)

Adapter-to-Plate Cap Screw Torque 9 N•m (78 lb-in.)

4TN82RJK

Top of Pulley Flange-to-Top of Housing 27 mm (1.060 in.)

Impeller-to-Pump Housing 1 mm (0.040 in.) below housing

4TN84RJK

Bottom of Pulley Flange-to-Top of Housing 17 mm (0.670 in.)

Impeller-to-Pump Housing 2 mm (0.080 in.) below housing

Fuel Supply Pump - All Except 4TN82RJE and 4TN82ESP

External Lube Line Mounting Bolt Torque 15 N•m (130 lb-in.)

Mounting Nut Torque 11 N•m (96 lb-in.)

Specifications

Fuel Injection Pump

Injection Pump Gear Nut Torque	90 N•m (66 lb-ft)
Mounting Nut Torque	26 N•m (19 lb-ft)
Lube Line-to-Block Bolt Torque	25 N•m (217 lb-in.)

Fuel Injection Nozzles

Mounting Nut Torque	5 N•m (39 lb-in.)
Retaining Nut Torque	43 N•m (31 lb-ft)
Separator Plate Nozzle Contact Surface Maximum Wear	0.10 mm (0.0039 in.)

Starter Motor - 4TN82RJE (Hitachi 2.0 kW)

Minimum Brush Length	.9 mm (0.354 in.)
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Starter Motor - 4TN82RJK, 4TN84RJK (Nippondenso 1.0 kW)

Minimum Brush Length	8.5 mm (0.335 in.)
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Starter Motor - 4TN82ESP, 4TN84(T) (4019) (Nippondenso 1.4 kW)

Minimum Brush Length	8.5 mm (0.335 in.)
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Alternator - 4TN82RJK, 4TN84RJK (Kokosan 20A)

Flywheel Assembly-to-Coil Plate Assembly Nut Torque	27 N•m (20 lb-ft)
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Alternator - 4TN82, 4TN84RJK (Nippondenso 35A)

Attaching Screw Torque	4 N•m (31 lb-in.)
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Rotor Assembly

Retainer-to-Front Frame Screw Torque	2 N•m (16 lb-in.)
Pulley Nut Torque	54 N•m (40 lb-ft)
Stator-to-Rectifier Lead Wire Distance	33.50 mm (1.300 in.)
Minimum Brush Length	5.50 mm (0.220 in.)

Alternator - 4TN82ESP/RJE, 4TN84(T) (4019) (Nippondenso 40A)

Sheave Nut Torque	69 N•m (51 lb-ft)
Retainer-to-Front Frame Screw Torque	2 N•m (16 lb-in.)
Minimum Rotor Slip Ring O.D.	14 mm (0.550 in.)
Brush Length	
New	10.50 mm (0.410 in.)
Wear Limit	4.50 mm (0.170 in.)

Checks, Tests and Adjustments

Valve Clearance	0.20 mm (0.008 in.)
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Connecting Rod Side Play

Standard Clearance	0.20 - 0.40 mm (0.0079 - 0.0157 in.)
Wear Limit	0.55 mm (0.0217 in.)

Connecting Rod Bearing Clearance

Standard Clearance	0.038 - 0.090 mm (0.0015 - 0.0035 in.)
Wear Limit	0.16 mm (0.0063 in.)

Crankshaft End Play

Standard Clearance	0.090 - 0.271 mm (0.004 - 0.011 in.)
Wear Limit	0.33 mm (0.0129 in.)

Crankshaft Main Bearing Clearance

Main Bearing Cap Cap Screw Torque	98 N•m (72 lb-ft)
Standard Clearance	0.038 - 0.090 mm (0.0015 - 0.0035 in.)
Wear Limit	0.06 mm (0.0063 in.)

Valve Lift (Intake and Exhaust)	8.8 mm (0.350 in.)
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Checks, Tests and Adjustments, continued

Camshaft End Play

Standard Clearance	0.05 - 0.20 mm (0.0020 - 0.0079 in.)
Wear Limit	0.40 mm (0.016 in.)

Timing Gear Backlash

Standard Backlash	0.04 - 0.12 mm (0.0016 - 0.0047 in.)
Wear Limit	0.20 mm (0.0079 in.)

Fuel Injection Nozzle

Opening Pressure	19600 ± 480 kPa (2843 ± 70 psi)
Leakage at 17640 kPa (2558 psi)	Minimum of 5 Seconds
Chatter and Spray Pattern at 19600 ± 480 kPa (2843 ± 70 psi)	
Slow Hand Lever Movement	Chatter Sound
Slow Hand Lever Movement	Fine Stream Spray Pattern
Fast Hand Lever Movement	Fine Atomized Spray Pattern

Thermostat

Begin Opening	71° C (160°F)
Fully Open	85° C (184° F)
Minimum Lift Height	8 mm (0.310 in.)

Coolant Temperature Switch Continuity 107 - 133° C (225 - 235° F)

Starter No-Load Amp Draw/RPM

Maximum Starter Amperage

Hitachi 2.0 kW	110 Amps at 4500 rpm
Nippondenso 1.0 kW	90 Amps at 3000 rpm
Nippondenso 1.4 kW	90 Amps at 3500 rpm

Minimum Starter RPM

Hitachi 2.0 kW	4500
Nippondenso 1.0 kW	3000
Nippondenso 1.4 kW	3500

Fuel Injection Pump Static Timing Adjustment

Injection Pump Timing Mark

4TN82 (970 CUT, 675 SSL, 3325/65 GM)	15° ± 1° BTDC (Before Top Dead Center)
4TN84	
(1070 CUT)	15° ± 1° BTDC
(4019D OEM)	16° ± 1° BTDC
4TN84T (4019T OEM)	
4019TF001 and 005	15° ± 1° BTDC
4019TF006	12° ± 1° BTDC

Engine Crankshaft Position No. 1 Cylinder on TDC Compression Stroke

Fan/Alternator Drive Belt Tension

Applied Force	98 N (22 lb-force)
Deflection	10 - 15 mm (0.400 - 0.600 in.)

Oil Cooler Leakage - 4TN84T (4019TF001 and 005)

Applied Air Pressure 206 - 483 kPa (30 - 70 psi)

Operational Tests

Radiator, Bubble Test

Maximum Air Pressure Into Cylinder

4TN82RJK, 4TN84RJK, 4TN82RJE, 4TN82ESP	2448 kPa (355 psi)
4TN84(T) (4019)	2158 kPa (313 psi)

Specifications

Cooling System

4TN82RJK, 4TN84RJK, 4TN84(T) (4019)

Maximum Pressure 97 kPa (14 psi)

Minimum Pressure after 15 Seconds 88 kPa (12.8 psi)

4TN82RJE, 4TN82ESP

Maximum Pressure 69 kPa (10 psi)

Minimum Pressure after 15 Seconds 55 kPa (8 psi)

Radiator Cap

Valve Opening Pressure

4TN82RJK, 4TN84RJK, 4TN84(T) (4019) 88 kPa (12.8 psi)

4TN82RJE, 4TN82ESP 55 kPa (8 psi)

Cylinder, Compression Pressure

Minimum Compression Pressure

4TN82RJK, 4TN84RJK,

4TN82RJE, 4TN82ESP 2448 kPa (355 psi)

4TN84(T) (4019) 2158 kPa (313 psi)

Maximum Difference Between Cylinders 490 kPa (71 psi)

Engine Oil Pressure

4TN82RJE

Idle Speed

Fast 2800 rpm

Slow 1000 ± 50 rpm

Oil Pressure 294 - 440 kPa (43 - 64 psi)

4TN82ESP

Idle Speed

Fast 2875 ± 25 rpm

Slow 900 ± 25 rpm

Oil Pressure 294 - 392 kPa (43 - 57 psi)

4TN82RJK, 4TN84RJK

Fast Idle Speed

4TN82RJK 2750 - 2800 rpm

4TN84RJK 2850 - 2900 rpm

Oil Pressure 365 ± 69 kPa (53 ± 10 psi)

4TN84(T) (4019)

Low Idle Speed

Generator 1200 rpm

Industrial 1300 rpm

Oil Pressure 147 kPa (21 psi)

Air Intake System Holding Pressure 34 - 69 kPa (5 - 10 psi)

Minimum Fuel Supply Pump Pressure 29 kPa (4.3 psi)

Fuel System Holding Pressure (Maximum) 103 kPa (15 psi)

3

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).

D-20018WI Valve Guide Knurler

Use to knurl inside diameter of valve guides on 4TN78T engine.

D-20019WI Valve Guide Knurler

Use to knurl inside diameter of valve guides on 4TN82 and 4TN84(T)(4019) engines.

JDE118 Valve Guide Driver

Use to remove and install valve guides in cylinder head.

D-20020WI Valve Guide Reamer

Use to ream out new valve guides on 4TN78T engine.

D-20021WI Valve Guide Reamer

Use to ream out new valve guides on 4TN82 and 4TN84(T)(4019) engines.

SERVICE PARTS KITS

The following kits are available through your parts catalog:

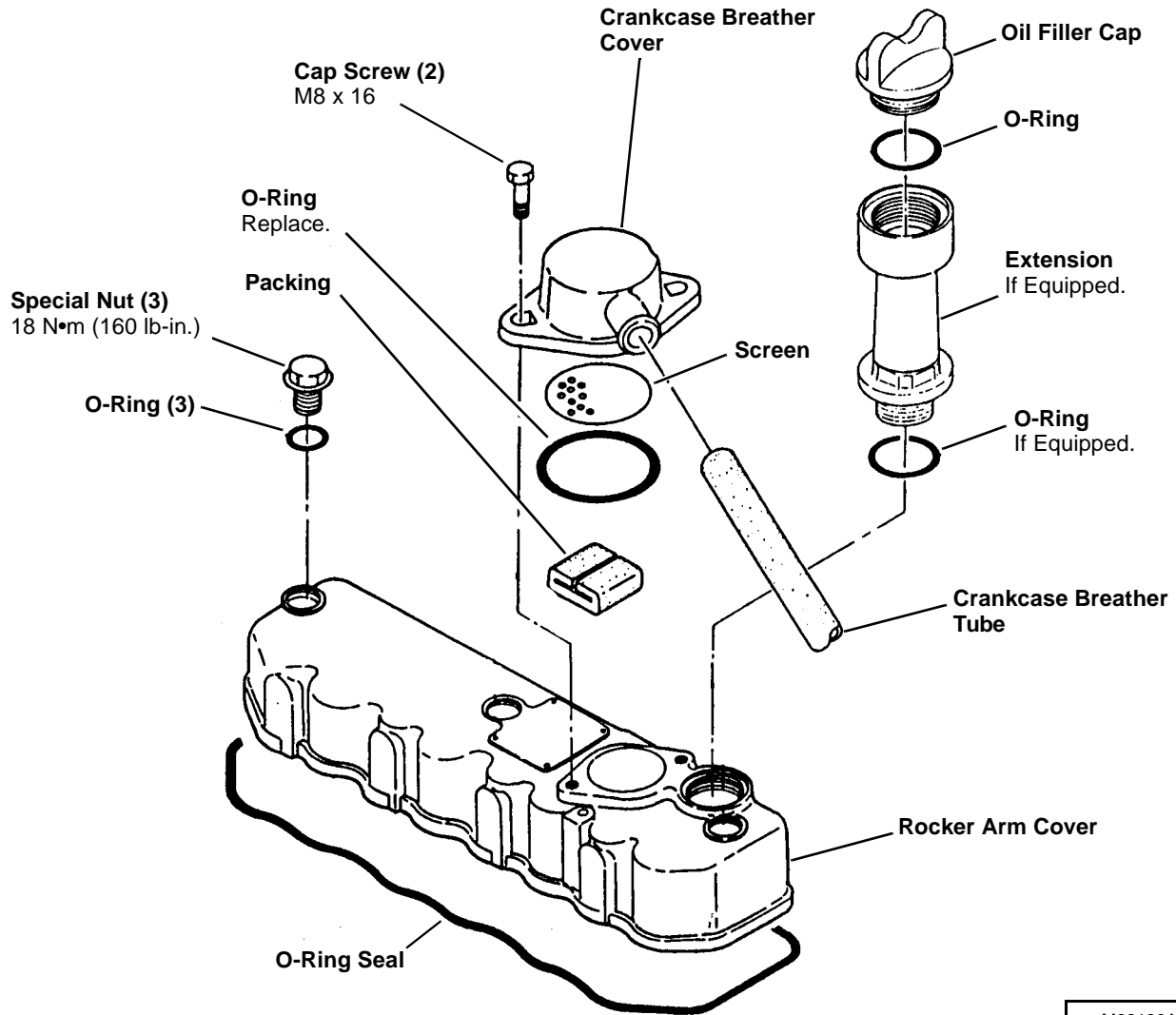
- Cylinder Head Gasket Kits

Cylinder Head, Valves and Manifolds

ROCKER ARM COVER

- Wash packing in a safe solvent and blow dry with air pressure. If packing comes apart or is deteriorated, replace it.

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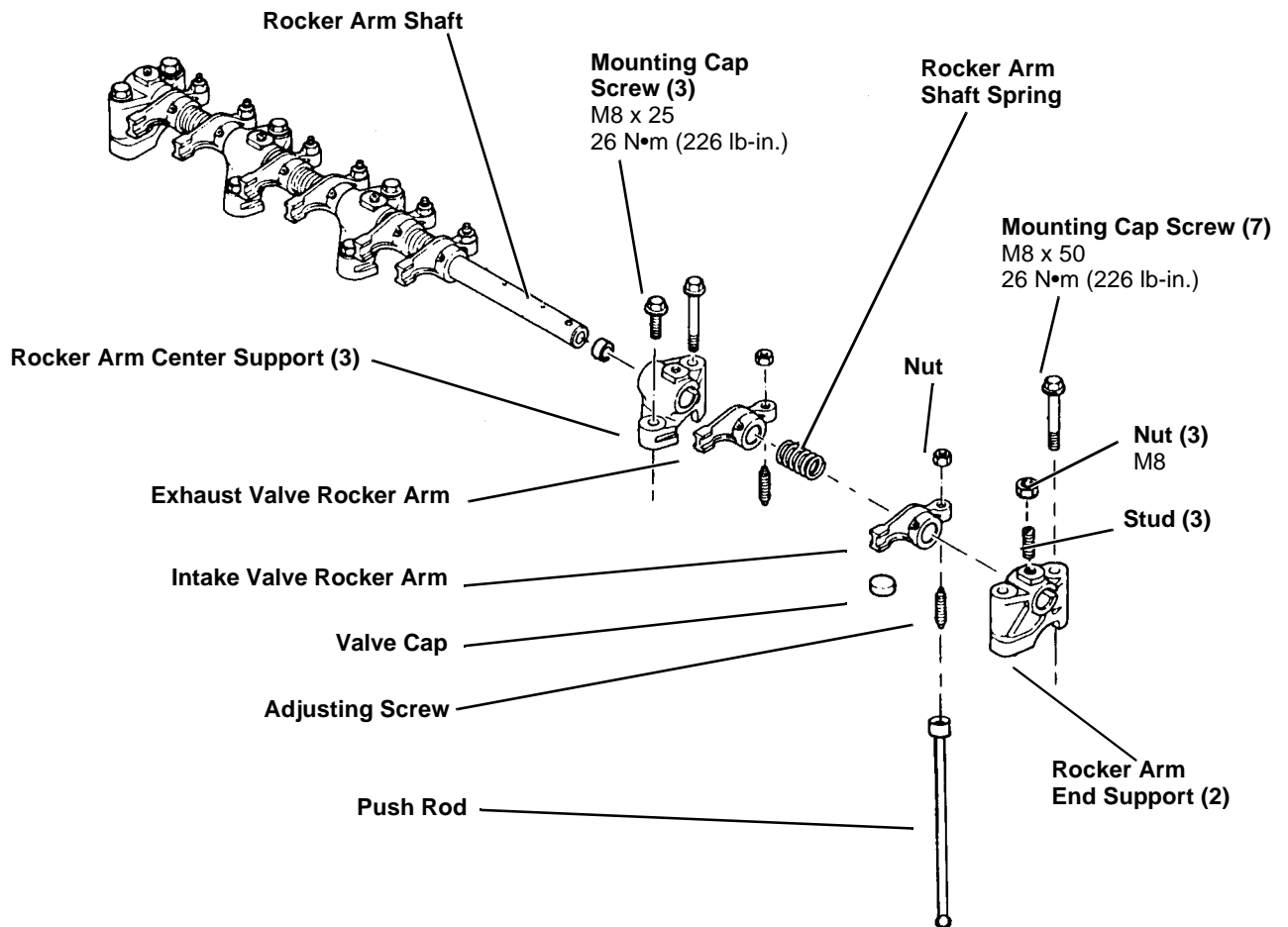
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ROCKER ARM ASSEMBLY

Removal/Installation and Disassembly/Assembly

1. Remove rocker arm cover. (See procedure in this group.)
 - Remove and install studs using two M8 nuts.

- Inspect all parts for wear or damage. (See *Inspection* procedures.)
- Lubricate all parts with clean oil during assembly.
- Adjust valve clearance. (See *Checks, Tests and Adjustments* in this section.)



M82190A

Cylinder Head, Valves and Manifolds

Inspection

- Measure outer diameter of rocker arm shaft.



Rocker Arm and Shaft Support I.D.'s:

Standard	16.00 - 16.02 mm .....(0.630 - 0.631 in.)
Wear Limit	16.09 mm (0.633 in.)
Clearance	0.13 mm (0.005 in.)

Replace rocker arms or supports if I.D. is more than wear limit.

If shaft and support/arm clearance (support/arm I.D. minus shaft O.D.) exceed wear limit, replace all parts.

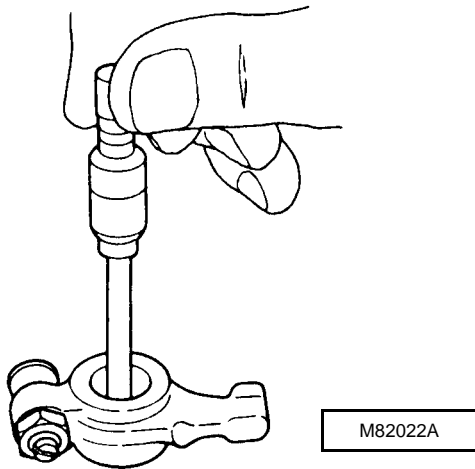
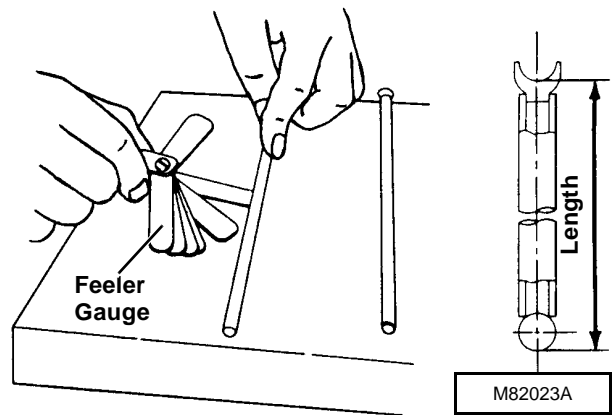
- Measure length and bending of push rod.

Rocker Arm Shaft O.D.:

3	Standard	15.97 - 15.95 mm .....(0.6286 - 0.6293 in.)
	Wear Limit	15.95 mm (0.6280 in.)

Replace rocker arm shaft if less than wear limit.

- Measure inner diameters of rocker arms and supports.



Push Rod Length:

4TN78T	146.65 - 147.35 mm .....(5.774 - 5.801 in.)
4TN82,	
4TN84(T)(4019)	178.25 - 178.75 mm .....(7.018 - 7.037 in.)

Push Rod Bend:

Standard	0.03 mm (0.001 in.) or less
Wear Limit	0.30 mm (0.012 in.)

Replace push rod if not within specifications.

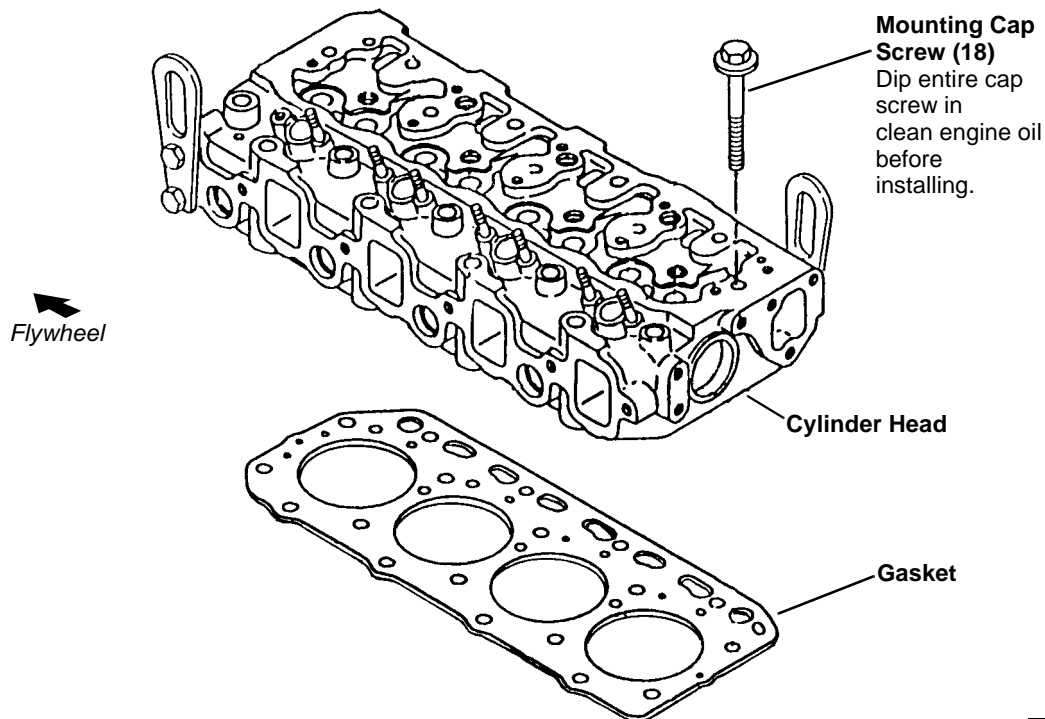
CYLINDER HEAD AND VALVES

Removal/Installation

1. Remove rocker arm assembly, push rods and valve caps. (See procedure in this group.)
2. Remove exhaust and intake manifolds. (See procedures in this group.)
3. Remove water pump. (See *Cooling System* in this section.)

4. Remove fuel injection nozzles. (See *Fuel System* in this section.)
5. Disassemble and inspect cylinder head and valves. (See *Disassembly/ Assembly and Inspection/Replacement* procedures.)

IMPORTANT: Oil passage in gasket must be located over oil passage in cylinder block.

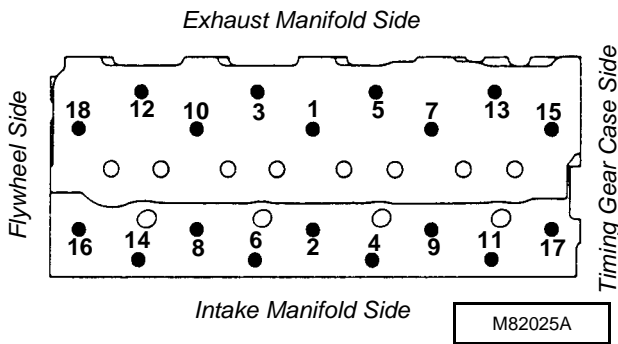


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Cylinder Head, Valves and Manifolds

6. Tighten mounting cap screws, in the sequence shown, in three stages of gradually-increasing torque.

IMPORTANT: Cylinder head mounting cap screws must be checked for proper torque after 50 hours of engine operation.



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Torque Specifications - 4TN78T:

- First 22 N•m (16 lb-ft)
- Second 43 N•m (32 lb-ft)
- Final 69 N•m (51 lb-ft)

Torque Specifications - 4TN82, 4TN84(T)(4019):

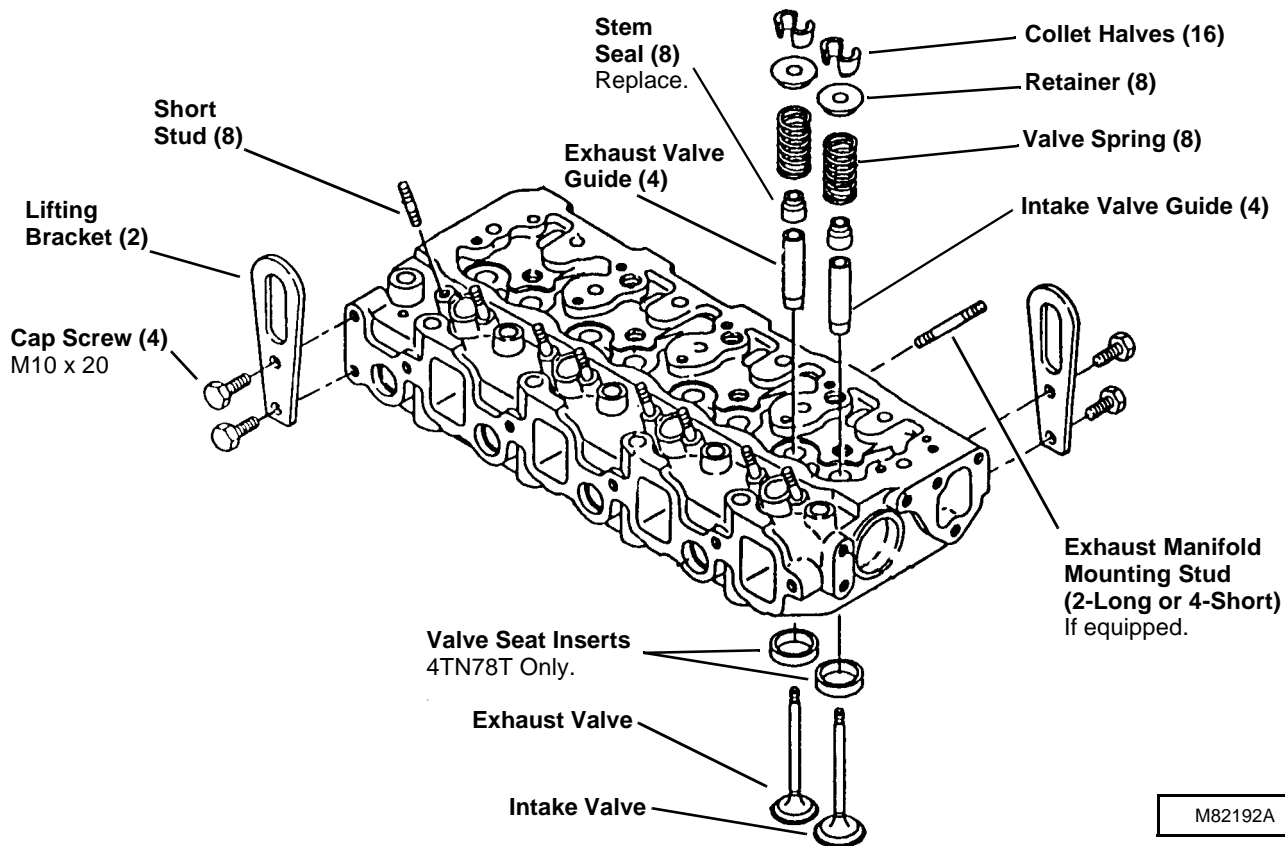
- First 24 N•m (18 lb-ft)
- Second 49 N•m (36 lb-ft)
- Final 78 N•m (58 lb-ft)

Disassembly/Assembly

- Compress valve springs using a valve spring compressor.
- Intake and exhaust valve guides are press fit. Remove guides only if replacement is necessary. (See *Inspection/Replacement* procedures.)
- On 4TN78T, intake and exhaust valve seat inserts are press fit. Remove inserts only if replacement is necessary.
- Inspect all parts for wear or damage. (See *Inspection/Replacement* procedures.)

IMPORTANT: Do not reuse stem seals if removed. Used seals will leak.

- Apply clean engine oil on intake and exhaust valve stems during assembly.
- Install springs with smaller pitch end or paint mark toward cylinder head.



NOTE: If new valves are installed, measure valve recession. (See *Inspection/Replacement* procedures.)

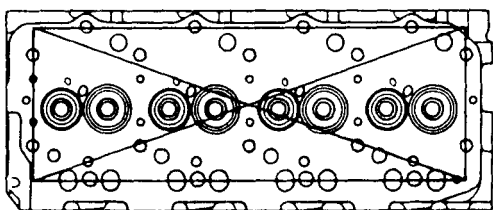
After each valve has been assembled, tap on top of valve stem with a plastic hammer to seat retainer.

Inspection/Replacement

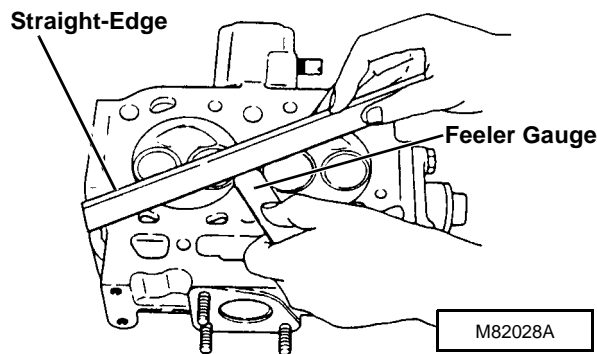
Before inspection, thoroughly clean all components of carbon or dirt.

Cylinder Head:

- Measure cylinder head flatness. Place a straight-edge along each of the four sides and each diagonal. Measure clearance between straight edge and combustion surface with a feeler gauge.



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Cylinder Head Distortion:

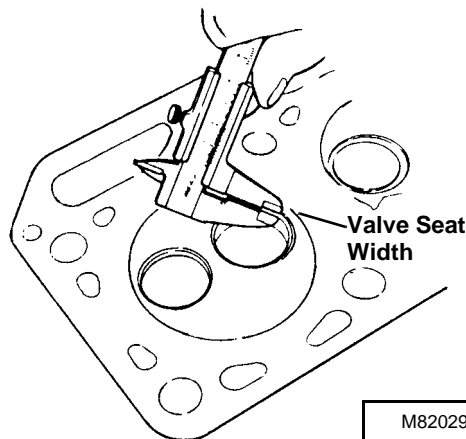
Standard 0.05 mm (0.002 in.) or less
Wear Limit. 0.15 mm (0.006 in.)

If distortion exceeds the wear limit, resurface or replace cylinder head. Remove only enough metal to make cylinder head flat; but do not remove more than **0.20 mm (0.008 in.)**.

If cylinder head was resurfaced:

- Measure piston-to-cylinder head clearance. (See procedure in this group.)

- Measure valve recession. (See procedure in this group.)
- Measure valve seat width.



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Valve Seat Width - 4TN78T:

Intake Valve

Standard 1.36 - 1.53 mm
 (0.054 - 0.060 in.)
Wear Limit. 1.98 mm (0.078 in.)

Exhaust Valve

Standard 1.66 - 1.87 mm
 (0.065 - 0.074 in.)
Wear Limit. 2.27 mm (0.089 in.)

Valve Seat Width - 4TN82, 4TN84(T)(4019):

Intake Valve

Standard 1.07 - 1.24 mm
 (0.042 - 0.049 in.)
Wear Limit. 1.74 mm (0.069 in.)

Exhaust Valve

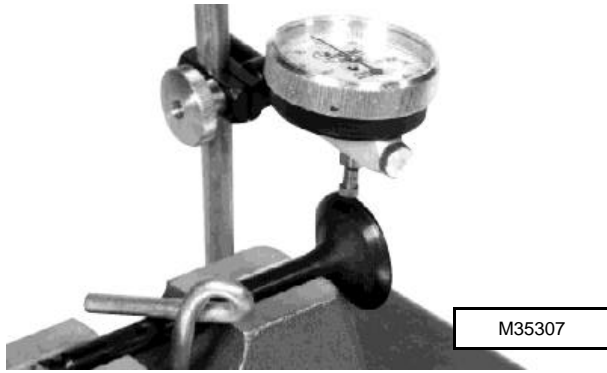
Standard 1.24 - 1.45 mm
 (0.049 - 0.057 in.)
Wear Limit. 1.94 mm (0.076 in.)

If necessary, grind valve seats to meet specifications. (See *GRIND VALVE SEATS* procedure.)

Intake and Exhaust Valves:

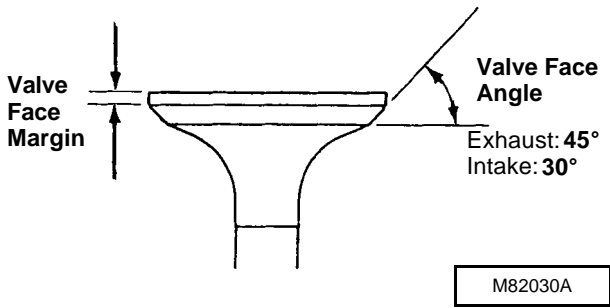
- Check valve for out-of-round, bent or warped condition using a valve inspection center. Replace valve if necessary.

Cylinder Head, Valves and Manifolds

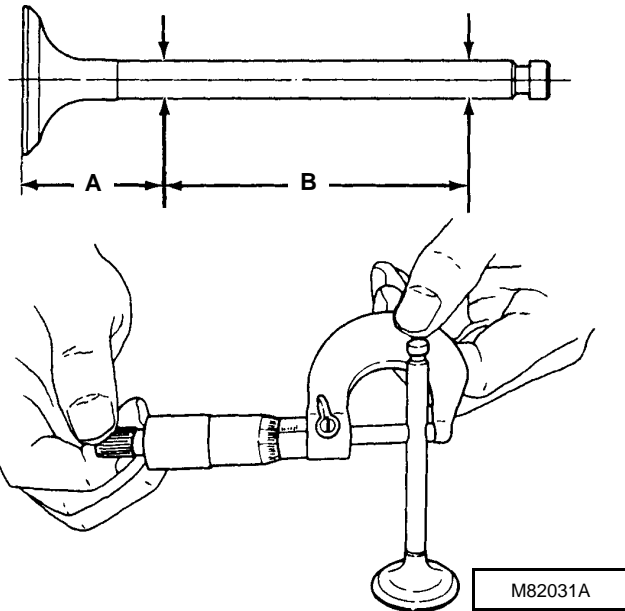


- If valve faces are worn, burned or pitted, grind valves to proper face angle. If valve face margin is less than **0.51 mm (0.020 in.)** after grinding, replace valve.

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- Measure valve stem diameter at two locations shown. Replace valve if measurement exceeds wear limit.



Valve Stem O.D. - 4TN78T:

Distance A30 mm (1.181 in.)

Distance B50 mm (1.969 in.)

Intake and Exhaust Valves

Standard 6.94 - 6.96 mm
..... (0.2732 - 0.2740 in.)

Wear Limit..... 6.90 mm (0.2717 in.)

Valve Stem O.D. - 4TN82, 4TN84(T)(4019):

Distance A30 mm (1.181 in.)

Distance B60 mm (2.360 in.)

Intake Valve

Standard 7.96 - 7.98 mm
..... (0.3134 - 0.3142 in.)

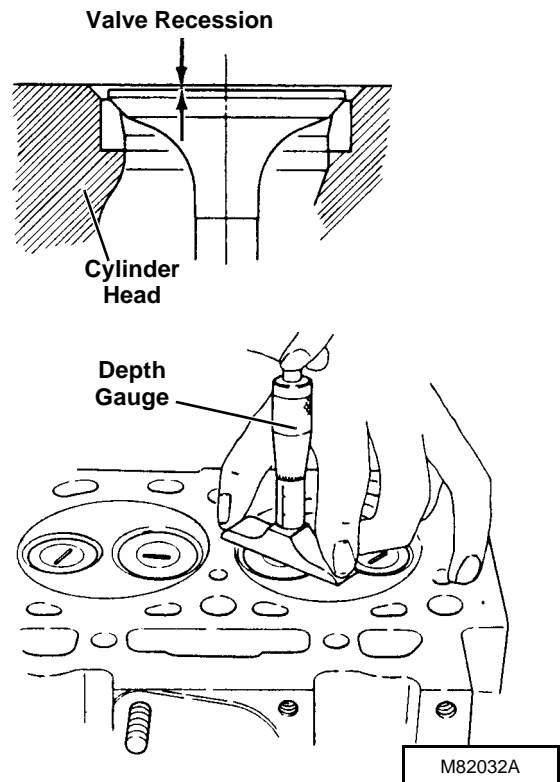
Wear Limit..... 7.90 mm (0.3110 in.)

Exhaust Valve

Standard 7.96 - 7.97 mm
..... (0.3134 - 0.3138 in.)

Wear Limit..... 7.90 mm (0.3110 in.)

- Measure valve recession using a depth gauge. Replace valve or cylinder head if measurement exceeds wear limit.



Valve Recession:

Standard 0.30 - 0.50 mm
 (0.012 - 0.020 in.)
Wear Limit 1.00 mm (0.039 in.)

Valve Guides:

Clean valve guides using a valve guide brush.

Measure valve guide inside diameter.

Valve Guide I.D. - 4TN78T:

Standard 7.00 - 7.02 mm
 (0.275 - 0.276 in.)
Wear Limit 7.08 mm (0.279 in.)
Maximum Clearance ... 0.20 mm (0.008 in.)

Valve Guide I.D. - 4TN82, 4TN84(T)(4019):

Standard 8.01 - 8.03 mm
 (0.315 - 0.316 in.)
Wear Limit 8.10 mm (0.319 in.)

If diameter exceeds wear limit, knurl or replace guide.

If diameter is less than wear limit, determine guide-to-stem clearance (guide diameter minus stem diameter).

If clearance exceeds **0.15 mm (0.006 in.)** but is less than **0.20 mm (0.008 in.)**, knurl valve guides.

- Knurl valve guides using:
 - 4TN78T: D-20018WI Valve Guide Knurler
 - 4TN82, 4TN84(T)(4019): D-20019WI Valve Guide Knurler

If clearance exceeds **0.20 mm (0.008 in.)**, replace valve guide.

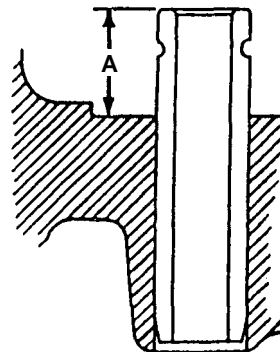
- Replace valve guides using JDE118 Valve Guide Driver.

Intake and exhaust valve guides are different. The exhaust valve guide has one groove and the intake valve guide has none. Install valve guides with tapered ends down. Push valve guides down until top of valve guides are a specified distance (A) from top of cylinder head.

Valve Guide Height "A":

4TN78T 12 mm (0.472 in.)
4TN82, 4TN84(T)(4019) ... 15 mm (0.591 in.)

- Ream inside diameter of valve guides using:
 - 4TN78T: D-20020WI Valve Guide Reamer
 - 4TN82, 4TN84(T)(4019): D-20021WI Valve Guide Reamer

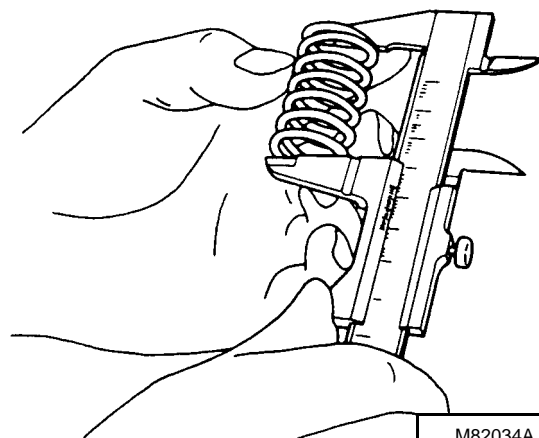


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Valve Springs:

- Measure spring free length. Replace spring if measurement exceeds wear limit.



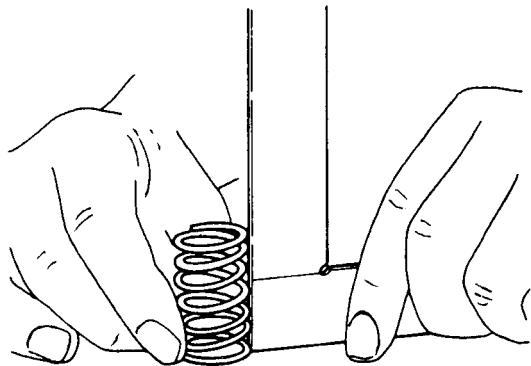
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Spring Free Length:

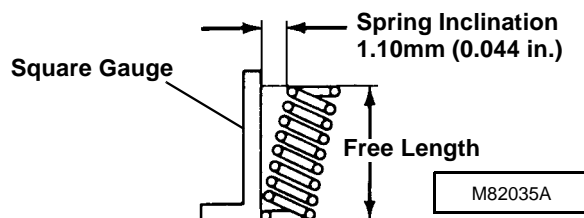
Standard 40 mm (1.575 in.)
Wear Limit 39.50 mm (1.550 in.)

Cylinder Head, Valves and Manifolds

- Measure spring inclination. Replace spring if measurement exceeds specification.



3



EXHAUST MANIFOLD

1. Remove muffler and gasket, if equipped.

NOTE: Turbocharger removal/installation procedures are similar to unit used on Series 220 Engines. Follow procedures used in ACCESSORIES - SERIES 220 POWER UNIT ENGINES section. Service procedures are also similar.

2. Remove turbocharger, if equipped. (See procedure in ACCESSORIES - SERIES 220 POWER UNIT ENGINES section).

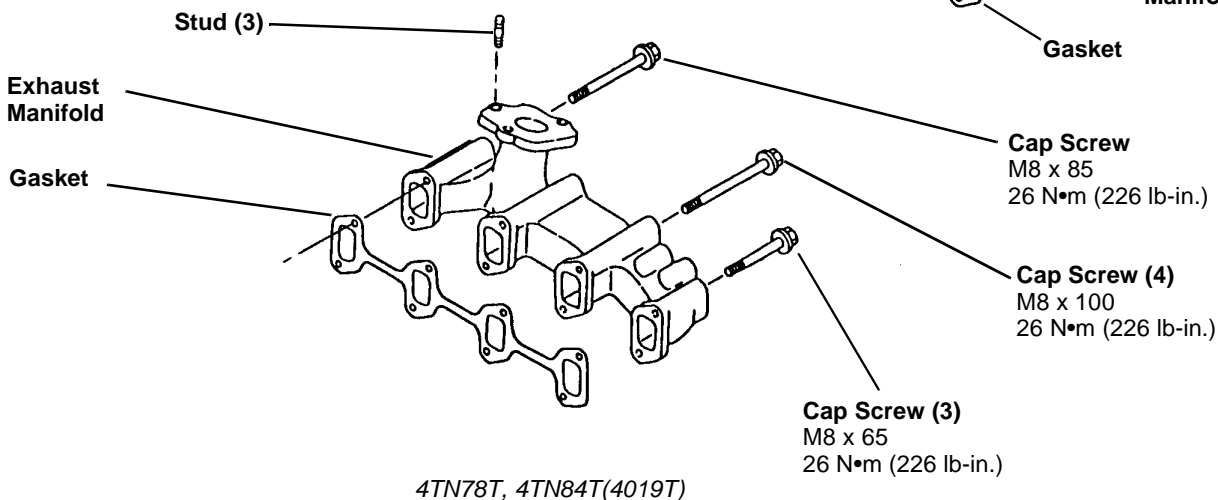
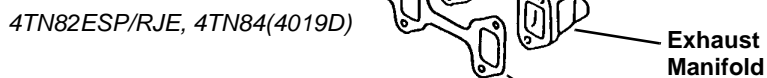
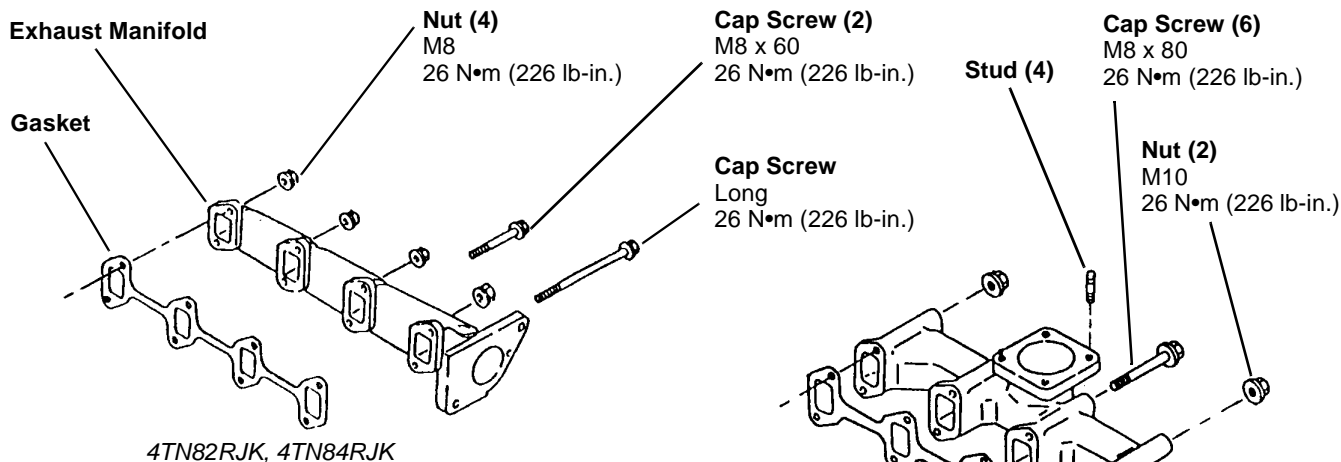
INTAKE MANIFOLD

NOTE: Air heater removal/installation is similar to procedures found in ACCESSORIES - SERIES 220 POWER UNIT ENGINES section.

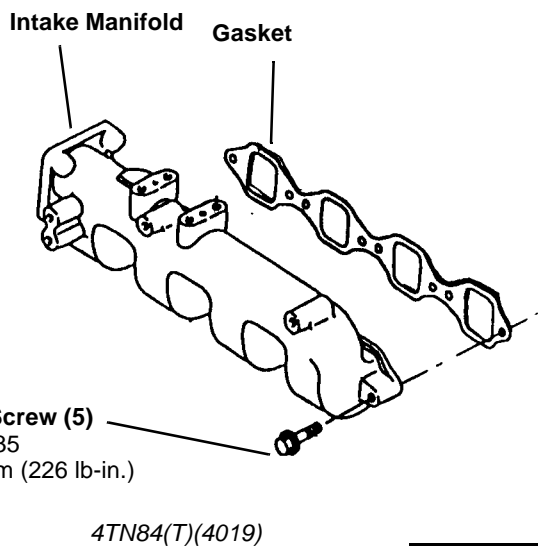
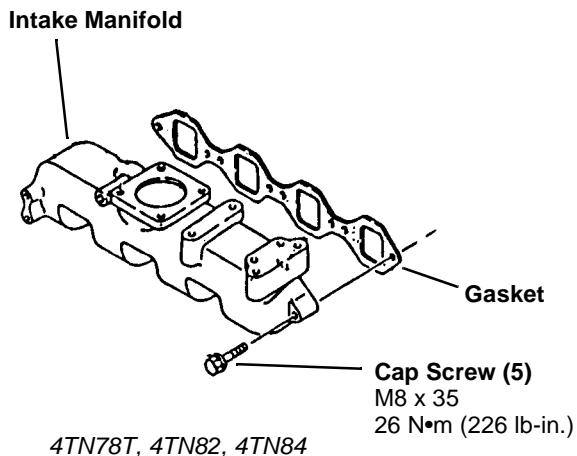
1. Remove intake air heater. (See procedure in ACCESSORIES - SERIES 220 POWER UNIT ENGINES section.)
2. Remove fuel filter assembly mounting cap screw(s), if equipped.
3. Remove fuel injection lines. (See *Fuel System* in this section.)
4. OEM Power Unit engine (4019):
 - Remove air cleaner and mount bracket.
 - Remove instrument panel and bracket.
 - Remove radiator support rod.

(See procedures in ACCESSORIES - SERIES 220 POWER UNIT ENGINES section.)

Cylinder Head, Valves and Manifolds



M82195A



M82194A

3

Cylinder Head, Valves and Manifolds

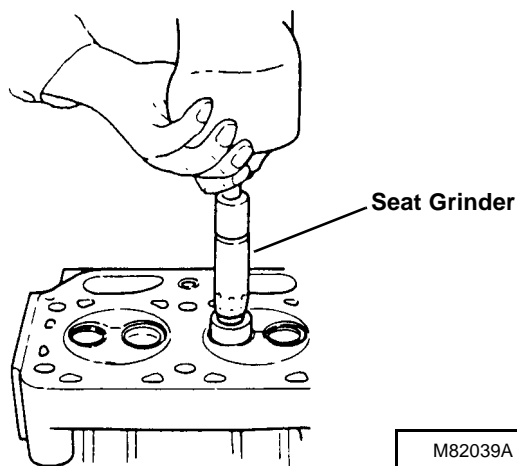
GRIND VALVE SEATS

IMPORTANT: Valve seats should never be cut.

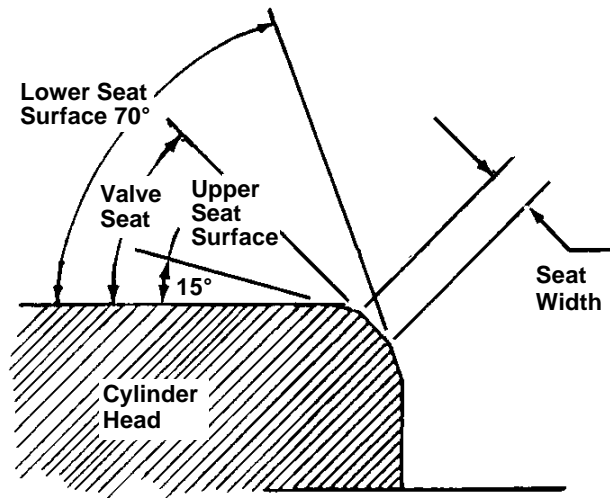
Cutting a valve seat can damage its sealing surface, which may result in leaks or valve/seat failure. Valve seats should be ground and lapped.

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

1. Grind intake valve seat using a 30° seat grinder and exhaust valve seat using a 45° seat grinder. Follow tool manufacturers instructions.



2. Measure valve seat width after grinding.
3. If seat is too wide after grinding, grind lower seat surface using a 70° seat grinder until seat width is close to specifications.
4. Grind upper seat surface using a 15° seat grinder until seat width is narrowed to specifications.
5. If valve seats are ground, measure valve recession and check contact pattern between the seat and valve with bluing dye.
6. Lap valves. (See procedure in this group.)



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

NOTE: Valve seat inserts are available for 4TN78T engine only.

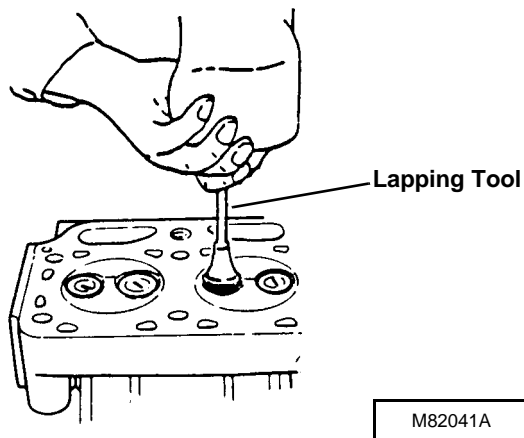
LAP VALVES

NOTE: Use a rubber type lapping tool for valves without a lapping tool groove slit.

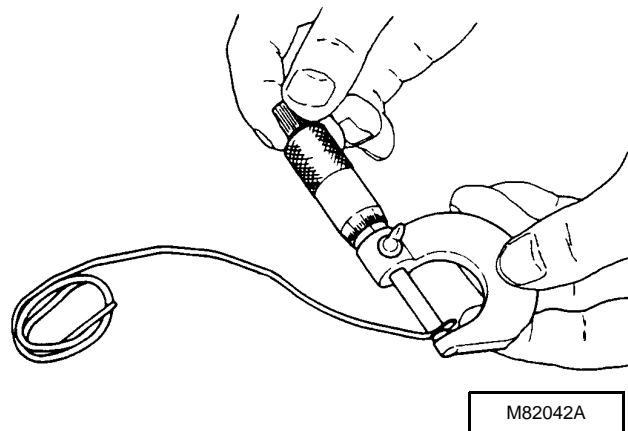
If seat does not make proper contact, lap the valve into the seat:

1. Apply small amount of fine lapping compound to face of valve.
2. Turn valve to lap valve to seat.
3. Lift valve from seat every 8 to 10 strokes. Lap until a uniform ring appears around the surface of the valve face.
4. Wash all parts in solvent to remove lapping compound. Dry parts.

5. Check position of lap mark on valve face. Lap mark must be on or near center of valve face.



3. Slowly turn crankshaft one complete revolution.
4. Remove cylinder head and gasket.
5. Measure thickness of flattened section of each piece of wire. Calculate average thickness of wires to obtain piston-to-cylinder head clearance specification.



MEASURE PISTON-TO-CYLINDER HEAD CLEARANCE

1. Place three 10 mm (0.400 in.) long pieces of 1.50 mm (0.060 in.) diameter soft wire in three positions on the flat part of the piston head.
2. Install cylinder head and old gasket. Install cylinder head cap screws and tighten in proper sequence to specified torque. (See *CYLINDER HEAD AND VALVES - Removal/Installation* in this group.)

Piston-to-Cylinder Head Clearance:

4TN78T.....	0.59 - 0.77 mm
.....	(0.023 - 0.030 in.)
4TN82, 4TN84(T)(4019)	0.64 - 0.82 mm
.....	(0.025 - 0.032 in.)

If clearance is less than specifications, replace cylinder head.

Pistons, Rods and Cylinder Block

SERVICE PARTS KITS

The following kits are available through your parts catalog:

- Cylinder Block Gasket Kit
- Cylinder Head Gasket Kit
- Oversized Pistons and Rings
- Undersized Connecting Rod Bearing Inserts

PISTON AND CONNECTING ROD

Removal

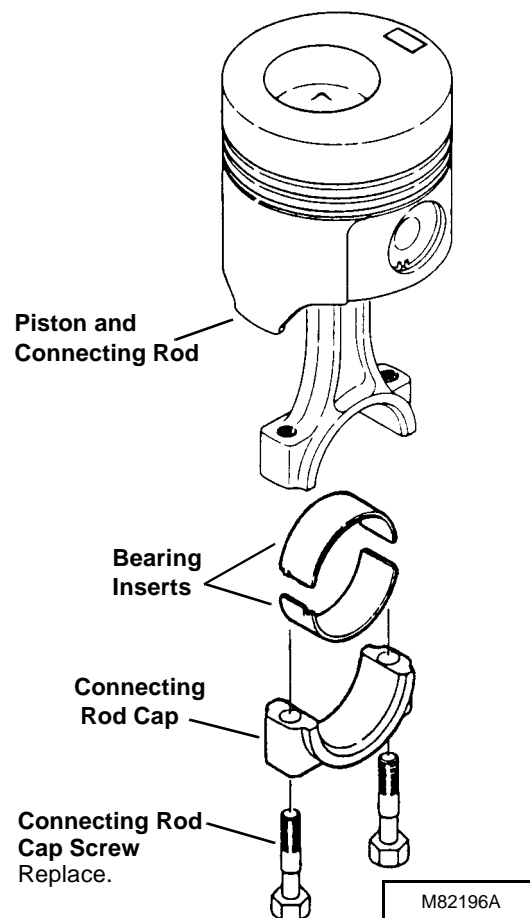
1. Remove oil pan and strainer tube. (See *Lubrication System* in this section.)
2. Remove cylinder head. (See *Cylinder Head, Valves and Manifolds* in this section.)
3. Check cylinder bore for ridges. These ridges can cause damage to piston if ridge is not removed.
4. If necessary, remove ridge from top of cylinder bore using a ridge reamer.
5. Measure connecting rod side play. (See *Checks, Tests and Adjustments* in this section.)
6. Measure connecting rod bearing clearance. (See *Checks, Tests and Adjustments* in this section.)

IMPORTANT: Keep connecting rods and caps together. Rods and caps are a matched set. Note alignment marks on each part.

7. Remove two cap screws, connecting rod cap and bearing inserts.

IMPORTANT: Pistons and cylinders are matched. Pistons must be installed in the cylinders from which they are removed.

8. Note connecting rod alignment mark in relation to the cylinders. Starting at flywheel end with cylinder number one, then two, etc.
9. Push piston and connecting rod out of cylinder bore using a wooden dowel.
10. Disassemble and inspect all parts for wear or damage. (See *Disassembly and Inspection/Replacement* procedures.)



3

Installation

- Apply clean engine oil on all parts during installation.
- Never reuse connecting rod cap screws, replace with new.

IMPORTANT: Pistons must be installed in cylinders from which they were removed and in the same direction. Be careful not to damage crankshaft rod journal while installing piston.

1. If new piston rings were installed, deglaze cylinder bore. (See procedure in this group.)
2. Install piston and connecting rod into the cylinder from which it was removed, with piston size mark on top of piston toward fuel injection pump.

Pistons, Rods and Cylinder Block

IMPORTANT: Do not touch bearing insert surfaces. Oil and acid from your finger will corrode the bearing surface.

3. Install bearing inserts on connecting rod and rod cap, aligning tangs with grooves.

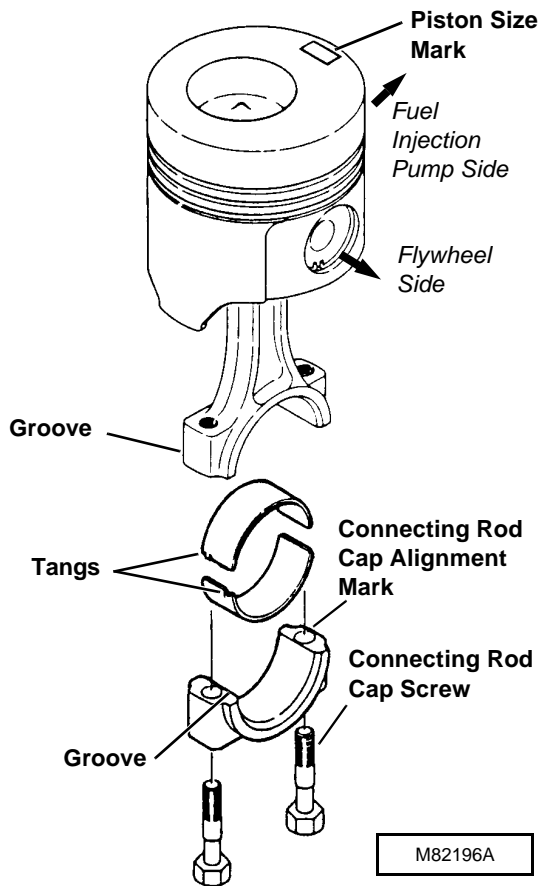
IMPORTANT: Connecting rod caps must be installed on the same connecting rods they were removed from.

4. Match the connecting rods to caps using alignment marks. Install caps.
5. Dip entire connecting rod cap screws in clean engine oil. Install new cap screws and tighten to specifications.

3 Connecting Rod Cap Screw Torque Specifications:

- 4TN78T 39 N•m (29 lb-ft)
- 4TN82, 4TN84(T)(4019) ... 47 N•m (35 lb-ft)

6. If a new piston and connecting rod were installed, stamp a number corresponding to the cylinder number on the connecting rod cap and connecting rod

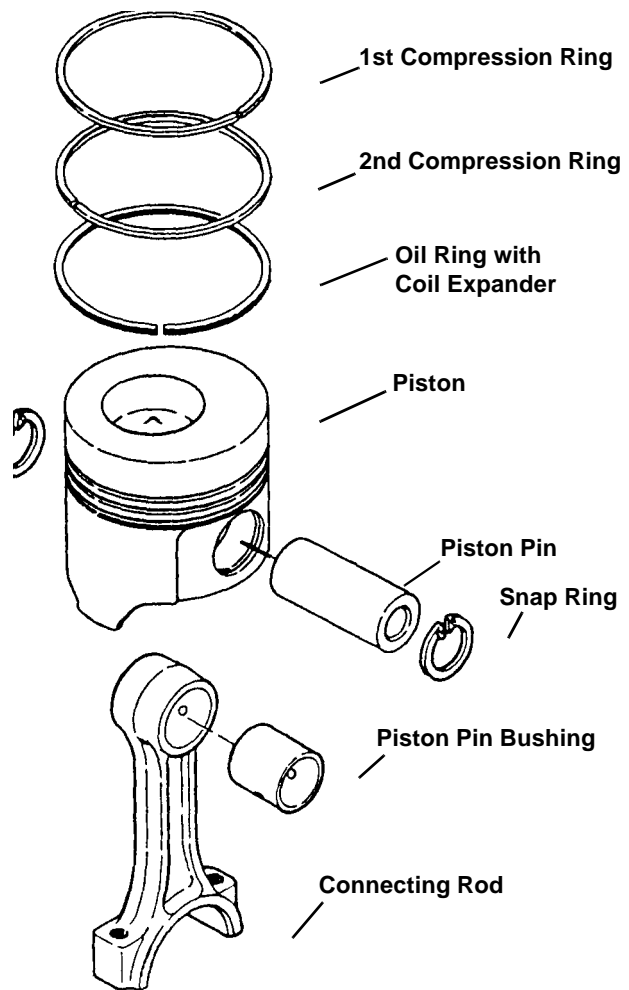


7. Install cylinder head. (See *Cylinder Head, Valves and Manifolds* in this section.)
8. Install oil pan and strainer tube. (See *Lubrication System* in this section.)

Disassembly

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

- Put a mark on each piston and connecting rod to aid in assembly.
- Piston pin bushing is press fit in connecting rod. Remove bushing only if replacement is necessary. (See *Inspection/Replacement* procedures.)
- Inspect all parts for wear or damage. Replace as necessary. (See *Inspection/Replacement* procedures.)

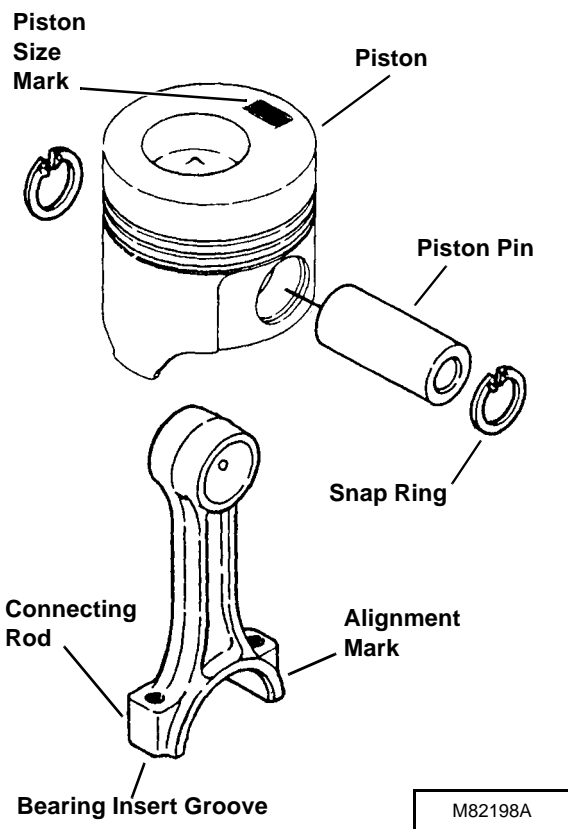


Assembly

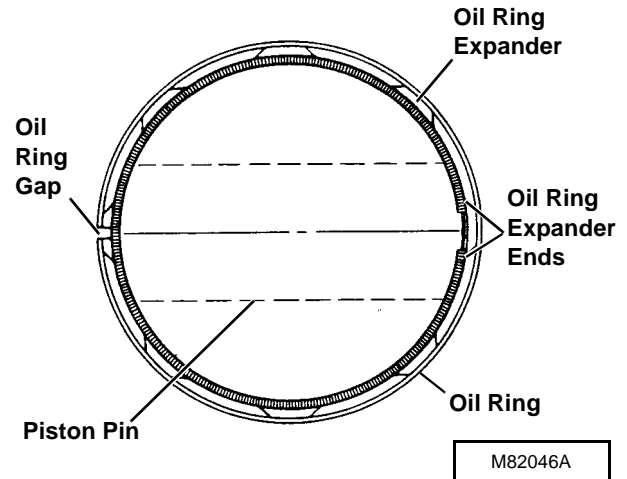
- Apply clean engine oil to all parts during assembly.

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

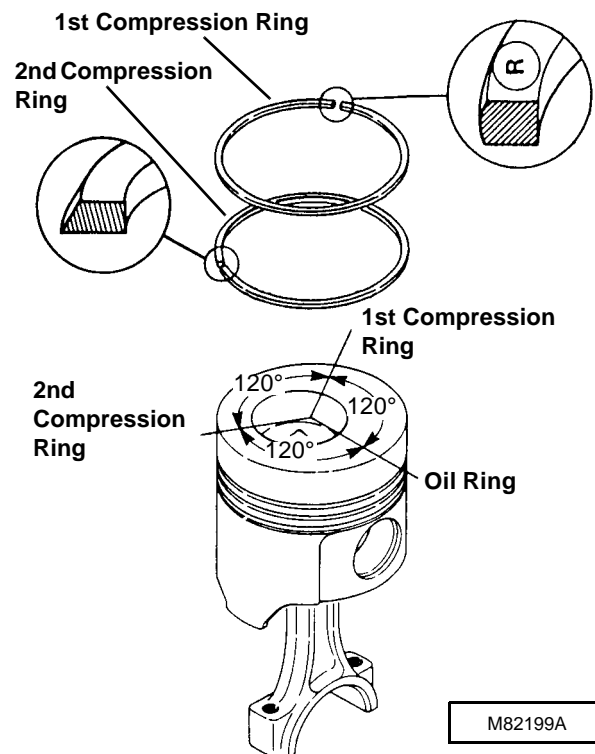
1. Assemble piston to connecting rod with piston size mark on same side as connecting rod "punched" alignment mark. If a new connecting rod is used, assemble piston to connecting rod with piston size mark opposite connecting rod bearing insert groove.
2. Install piston pin and snap rings.



3. Install oil ring expander in bottom ring groove of piston with ends above either end of piston pin.
4. Install oil ring over expander with ring gap opposite (180°) of expander ends.



5. Install second compression ring, with small diameter of taper toward top of piston, in middle groove. Turn ring until gap is 120° away from oil ring gap.
6. Install first compression ring (chrome plated), with manufacturer's mark "R", "T" or "RN" (near ring gap) toward top of piston, in top groove. Turn ring until gap is 120° away from second ring gap.



3

Pistons, Rods and Cylinder Block

Inspection/Replacement

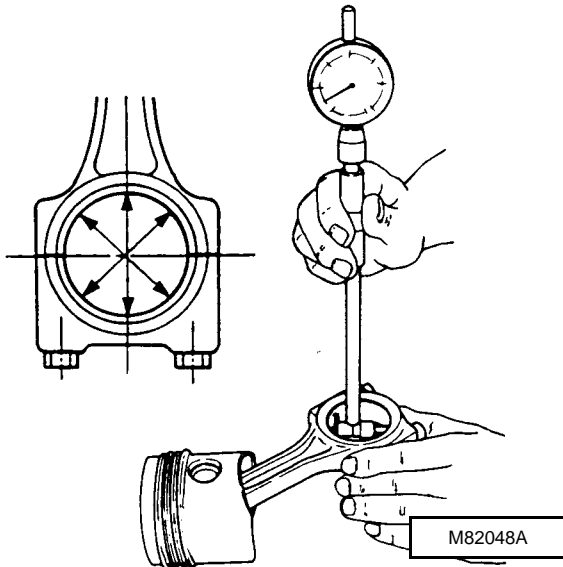
1. Inspect all parts for wear or damage. Replace as necessary.
2. Measure crankshaft connecting rod journal diameter. (See *Crankshaft, Main Bearings and Flywheel* in this section.)
3. Install connecting rod cap and bearing inserts on connecting rod. Install old connecting rod cap screws and tighten to specifications.

Connecting Rod Cap Screw Torque Specifications:

4TN78T 39 N•m (29 lb-ft)
4TN82, 4TN84(T) (4019) .. 47 N•m (35 lb-ft)

3

4. Measure connecting rod bearing diameter.



Connecting Rod Bearing I.D. - 4TN78T:

Standard 43 - 43.042 mm
..... (1.693 - 1.695 in.)
Wear Limit..... 43.07 mm (1.696 in.)
Clearance..... 0.16 mm (0.006 in.)

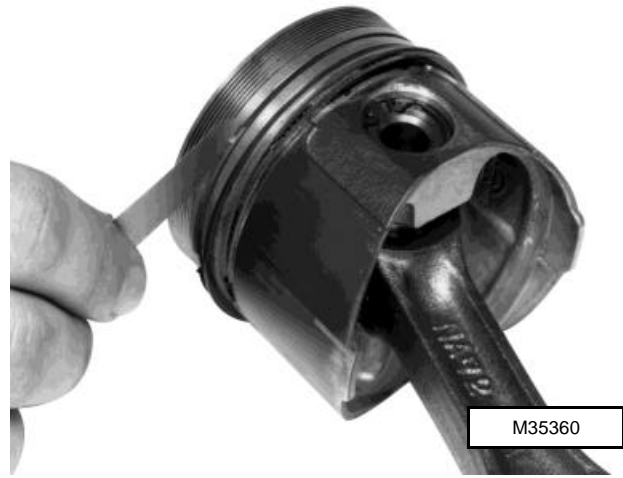
Connecting Rod Bearing I.D. - 4TN82, 4TN84(T)(4019):

Standard 48 - 48.042 mm
..... (1.888 - 1.891 in.)
Wear Limit..... 48.07 mm (1.893 in.)
Clearance..... 0.16 mm (0.006 in.)

If bearing diameter exceeds wear limit, replace bearing inserts.

If bearing clearance (bearing I.D. minus crankshaft journal O.D.) exceeds specification, grind crankshaft connecting rod journals and install undersized bearing inserts, or replace bearing inserts and crankshaft.

5. With rings installed on piston, measure piston ring groove clearance. Measure several places around each piston.



Piston Ring Groove Clearance - 4TN78T:

First Compression Ring

Standard 0.070 - 0.105 mm
..... (0.0028 - 0.0041 in.)
Wear Limit..... 0.25 mm (0.0098 in.)

Second Compression Ring

Standard 0.035 - 0.070 mm
..... (0.0014 - 0.0028 in.)
Wear Limit..... 0.25 mm (0.0098 in.)

Oil Ring

Standard 0.030 - 0.060 mm
..... (0.0012 - 0.0024 in.)
Wear Limit..... 0.20 mm (0.0078 in.)

Piston Ring Groove Clearance - 4TN82, 4TN84(T)(4019):

First Compression Ring

Standard 0.075 - 0.110 mm
 (0.0030 - 0.0043 in.)
 Wear Limit..... 0.25 mm (0.0098 in.)

Second Compression Ring

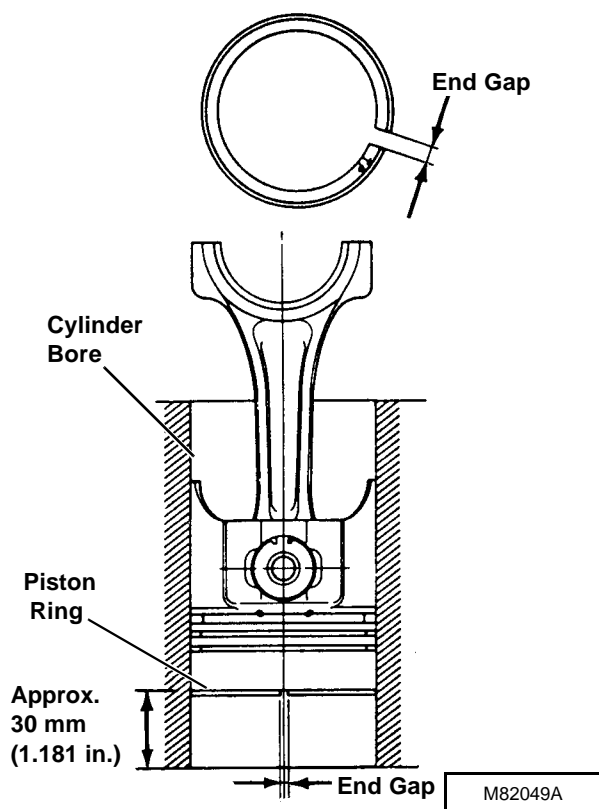
Standard 0.45 - 0.080 mm
 (0.0018 - 0.0031 in.)
 Wear Limit..... 0.25 mm (0.0098 in.)

Oil Ring

Standard 0.025 - 0.060 mm
 (0.0010 - 0.0024 in.)
 Wear Limit..... 0.20 mm (0.0079 in.)

If clearance exceeds wear limit, replace rings or piston.

6. Measure piston ring end gap. Push ring into cylinder bore, using a piston, until ring is approximately **30 mm (1.181 in.)** from bottom of cylinder bore.



Piston Ring End Gap - 4TN78T:

Compression Rings and Oil Ring

Standard 0.20 - 0.40 mm
 (0.008 - 0.016 in.)
 Wear Limit..... 1.50 mm (0.0591 in.)

Piston Ring End Gap - 4TN82:

Standard

First Compression Ring 0.25 - 0.40 mm
 (0.010 - 0.016 in.)
 Second Compression Ring .. 0.20 - 0.35 mm
 (0.008 - 0.014 in.)
 Oil Ring 0.20 - 0.40 mm
 (0.008 - 0.016 in.)
 Wear Limit: 1.50 mm (0.0591 in.)

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Piston Ring End Gap - 4TN84 (4019D):

Standard

Compression Rings..... 0.20 - 0.40 mm
 (0.008 - 0.016 in.)
 Oil Ring 0.25 - 0.45 mm
 (0.010 - 0.018 in.)
 Wear Limit: 1.50 mm (0.0591 in.)

Piston Ring End Gap - 4TN84T (4019T):

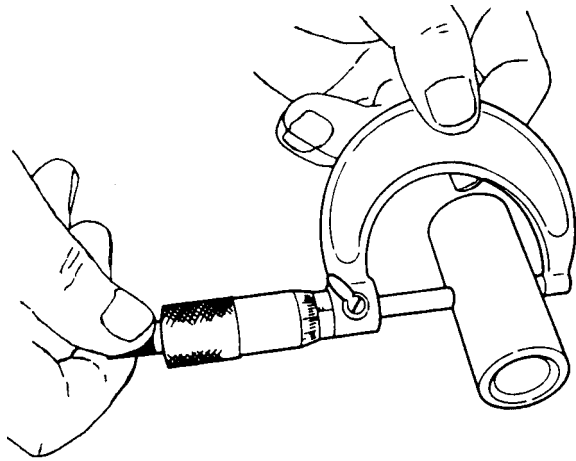
Standard

First Compression Ring
 and Oil Ring 0.25 - 0.45 mm
 (0.010 - 0.018 in.)
 Second Compression Ring .. 0.20 - 0.40 mm
 (0.008 - 0.016 in.)
 Wear Limit..... 1.50 mm (0.0591 in.)

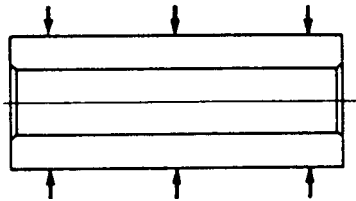
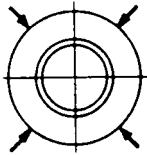
If end gap exceeds wear limit, replace rings.

7. Measure piston pin diameter. Measure diameter at six places.

Pistons, Rods and Cylinder Block



Measuring Positions



M82050A

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Piston Pin O.D. - 4TN78T:

Standard 22.991 - 23.00 mm
 (0.905 - 0.906 in.)
 Wear Limit..... 22.90 mm (0.902 in.)

Piston Pin O.D. - 4TN82, 4TN84(T)(4019):

Standard 25.987 - 26.00 mm
 (1.023 - 1.024 in.)
 Wear Limit..... 25.90 mm (1.020 in.)

If pin diameter is less than wear limit, replace pin.

8. Measure piston pin bore diameter in piston.



M37683

Piston Pin Bore I.D. - 4TN78T:

Standard 23.00 - 23.009 mm
 (0.9055 - 0.9059 in.)
 Wear Limit..... 23.02 mm (0.906 in.)
 Clearance..... 0.018 mm (0.0007 in.)

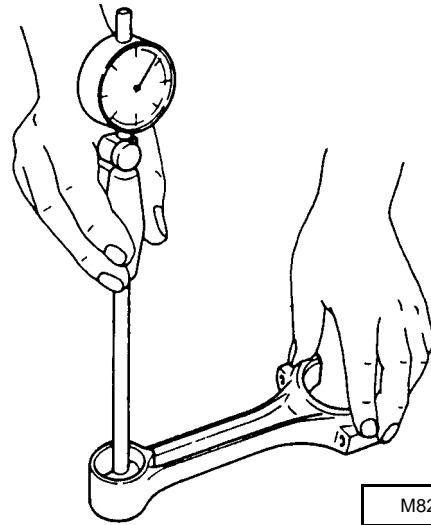
Piston Pin Bore I.D. - 4TN82, 4TN84(T)(4019):

Standard 26.00 - 26.009 mm
 (1.0236 - 1.0240 in.)
 Wear Limit..... 26.02 mm (1.024 in.)
 Clearance..... 0.022 mm (0.0009 in.)

If piston pin bore exceeds wear limit, replace piston.

If bore clearance (bore I.D. minus pin O.D.) exceeds specification, replace piston, piston pin or both.

9. Measure piston pin bushing diameter in connecting rod.



M82051A

Piston Pin Bushing I.D. - 4TN78T:

Standard 23.025 - 23.038 mm
 (0.9065 - 0.9070 in.)
 Wear Limit..... 23.10 mm (0.909 in.)
 Clearance..... 0.110 mm (0.0043 in.)

Piston Pin Bushing I.D. - 4TN82,4TN84(T)(4019):

Standard 26.025 - 26.038 mm
 (1.0246 - 1.0251 in.)
 Wear Limit..... 26.10 mm (1.028 in.)
 Clearance..... 0.110 mm (0.0043 in.)

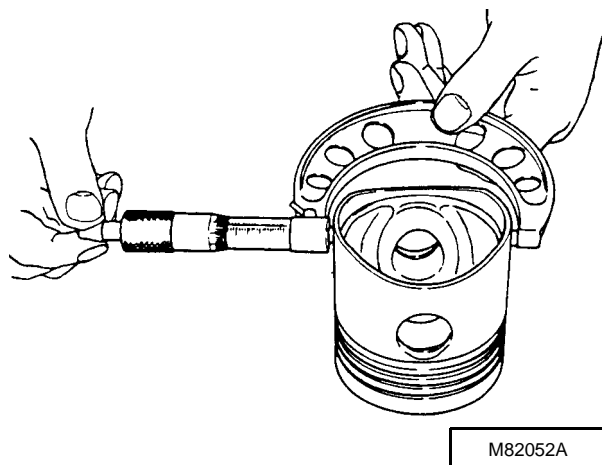
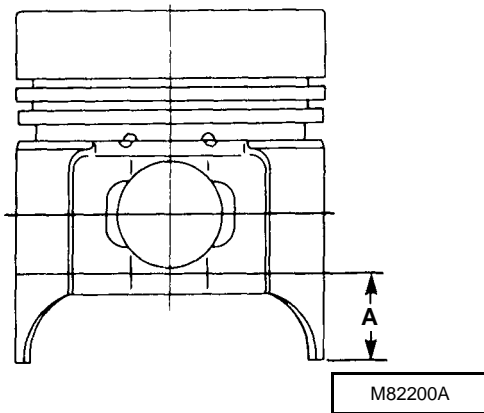
If bushing diameter exceeds wear limit, replace bushing.

If bushing clearance (bushing I.D. minus pin O.D.) exceeds specification, replace bushing, piston pin or both.

Piston pin bushing is press fit. Replace bushing using a driver set. When installing bushing, make sure to align oil hole in bushing with hole in connecting rod.

10. Measure piston diameter perpendicular to piston pin bore at distance A.

NOTE: If engine has had a previous major overhaul, oversize pistons and rings may have been installed. Pistons and rings are available in 0.25 mm (0.010 in.) oversize for all engines and 0.50 mm (0.020 in.) oversize for 4TN82 and 4TN84(T)(4019).



Piston O.D. - 4TN78T:

Distance A 23 mm (0.905 in.)

Standard Size Piston

Standard 77.895 - 77.925 mm
..... (3.067 - 3.068 in.)

Wear Limit..... 77.81 mm (3.063 in.)

0.25 mm (0.010 in.) Oversize Piston

Standard 78.15 - 78.18 mm
..... (3.076 - 3.077 in.)

Wear Limit..... 78.05 mm (3.073 in.)

Piston O.D. - 4TN82:

Distance A 24 mm (0.945 in.)

Standard Size Piston

Standard 81.90 - 81.93 mm
..... (3.224 - 3.225 in.)

Wear Limit..... 81.80 mm (3.220 in.)

0.25 mm (0.010 in.) Oversize Piston

Standard 82.15 - 82.18 mm
..... (3.234 - 3.235 in.)

Wear Limit..... 82.05 mm (3.230 in.)

0.50 mm (0.020 in.) Oversize Piston

Standard 82.40 - 82.42 mm
..... (3.244 - 3.245 in.)

Wear Limit..... 82.30 mm (3.240 in.)

Piston O.D. - 4TN84(T)(4019)

Distance A 24 mm (0.945 in.)

Standard Size Piston

Standard 83.90 - 83.93 mm
..... (3.303 - 3.304 in.)

Wear Limit..... 83.80 mm (3.299 in.)

0.25 mm (0.010 in.) Oversize Piston

Standard 84.15 - 84.18 mm
..... (3.313 - 3.314 in.)

Wear Limit..... 84.05 mm (3.309 in.)

3

Pistons, Rods and Cylinder Block

0.50 mm (0.020 in.) Oversize Piston

Standard 84.40 - 84.42 mm
..... (3.323 - 3.324 in.)
Wear Limit..... 84.30 mm (3.319 in.)

If piston diameter is less than wear limit, install a new piston.

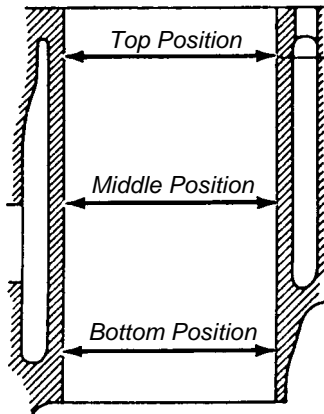
11. Measure cylinder bore diameter. (See procedure in this group.)

CYLINDER BORE

Inspection

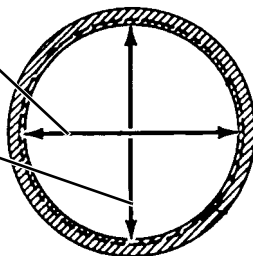
3 Measure cylinder bore diameter at three positions; top, middle and bottom. At these three positions, measure in both directions; along crankshaft center line and direction of crankshaft rotation.

NOTE: If engine has had a previous major overhaul, oversize pistons and rings may have been installed.



Direction of Crankshaft Rotation

Direction of Crankshaft Centerline



M82053A

Cylinder Bore I.D. - 4TN78T:

Standard Size Bore

Standard 78.00 - 78.03 mm
..... (3.071 - 3.072 in.)
Wear Limit 78.20 mm (3.079 in.)
Clearance..... 0.22 mm (0.009 in.)

0.25 mm (0.010 in.) Oversize Bore

Standard 78.25 - 78.28 mm
..... (3.081 - 3.082 in.)
Wear Limit..... 78.45 mm (3.089 in.)

Cylinder Bore I.D. - 4TN82:

Standard Size Bore

Standard 82.00 - 82.03 mm
..... (3.228 - 3.230 in.)
Wear Limit 82.20 mm (3.236 in.)
Clearance..... 0.35 mm (0.014 in.)

0.25 mm (0.010 in.) Oversize Bore

Standard 82.25 - 82.28 mm
..... (3.238 - 3.239 in.)
Wear Limit..... 82.45 mm (3.246 in.)

0.50 mm (0.020 in.) Oversize Bore

Standard 82.50 - 82.53 mm
..... (3.248 - 3.249 in.)
Wear Limit..... 82.70 mm (3.256 in.)

Cylinder Bore I.D. - 4TN84(T)(4019):

Standard Size Bore

Standard 84.00 - 84.03 mm
..... (3.307 - 3.308 in.)
Wear Limit 84.20 mm (3.315 in.)
Clearance..... 0.35 mm (0.014 in.)

0.25 mm (0.010 in.) Oversize Bore

Standard 84.25 - 84.28 mm
..... (3.317 - 3.318 in.)
Wear Limit..... 84.45 mm (3.325 in.)

0.50 mm (0.020 in.) Oversize Bore

Standard 84.50 - 84.53 mm

..... (3.327 - 3.328 in.)

Wear Limit..... 84.70 mm (3.335 in.)

If cylinder bore exceeds wear limit, replace cylinder block or have cylinder rebored. (See *Reboring* procedure.)

If cylinder is rebored, oversize pistons and rings must be installed. Pistons and rings are available in 0.25 mm (0.010 in.) oversize for all engines and 0.50 mm (0.020 in.) oversize for 4TN82 and 4TN84(T)(4019).

If clearance (cylinder bore I.D. minus piston O.D.) exceeds specification, replace cylinder block, piston or both; or rebores cylinder and install oversize piston and rings.

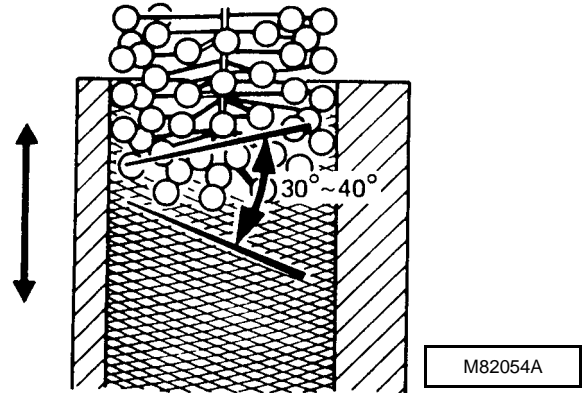
Deglazing

IMPORTANT: If cylinder bores are to be deglazed with crankshaft installed in engine, put clean shop towels over crankshaft to protect journal and bearing surfaces from any abrasives.

1. Deglaze cylinder bores using a flex-hone with 180 grit stones.
2. Use flex-hone as instructed by manufacturer to obtain a **30 - 40° cross-hatch pattern** as shown.

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

3. Remove excess abrasive residue from cylinder walls using a clean dry rag. Clean cylinder walls using clean white rags and warm soapy water. Continue to clean cylinder until white rags show no discoloration.



Reboring

NOTE: The cylinder block can be rebored to use oversize pistons and rings. Pistons and rings are available in 0.25 mm (0.010 in.) oversize for all engines and 0.50 mm (0.020 in.) oversize for 4TN82 and 4TN84(T)(4019). (See this group for cylinder bore I. D. specifications.)

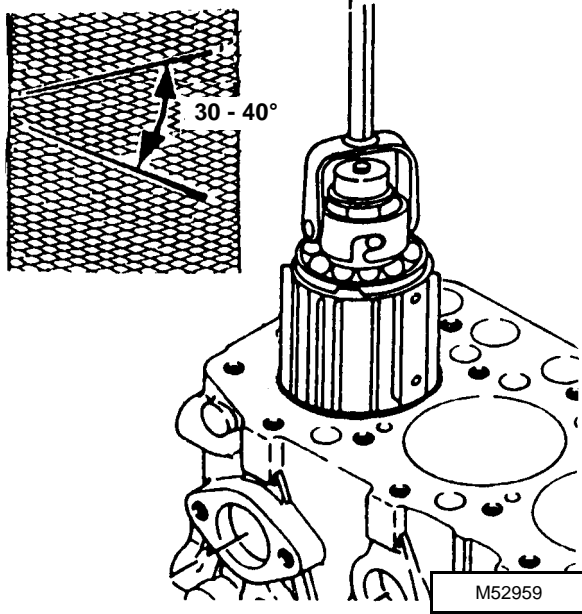
3

1. Align center of bore to drill press center.

IMPORTANT: Check stone for wear or damage. Use a rigid hone with 300 grit stones.

2. Adjust hone so lower end is even with lower end of cylinder bore.
3. Adjust rigid hone stones until they contact narrowest point of cylinder.
4. Coat cylinder with honing oil. Hone should turn by hand. Adjust if too tight.
5. Run drill press at about 250 RPM. Move hone up and down in order to obtain a **30 - 40° crosshatch pattern**.

Pistons, Rods and Cylinder Block



3

NOTE: Measure bore when cylinder is cool.

6. Stop press and check cylinder diameter.

NOTE: Finish should not be smooth. It should have a 30 - 40° crosshatch pattern.

7. Remove rigid hone when cylinder is within 0.03 mm (0.001 in.) of desired size.

8. Use a flex hone with 180 grit stones for honing to final size.

9. Check bore for size, taper and out-of-round. (See *Inspection* procedures.)

IMPORTANT: Do not use solvents to clean cylinder bore. Solvents will not remove all metal particles and abrasives produced during honing.

10. Clean cylinder thoroughly using warm soapy water until clean white rags show no discoloration.

11. Dry cylinder and apply engine oil.

OTHER MATERIALS

Number	Name	Use
LOCTITE® PRODUCTS U.S./ Canadian/ LOCTITE No.		
TY15130/ NA/ #395	John Deere Form-In-Place Gasket	Seals crankcase extension housing, rear oil seal case and flywheel housing to engine block.

SERVICE PARTS KITS

The following kits are available through your parts catalog:

- Cylinder Block Gasket Kit
- Undersized Main Bearing Inserts

Crankshaft, Main Bearings and Flywheel

BALANCER ASSEMBLY - 4TN82RJK, 4TN84RJK

Removal/Installation

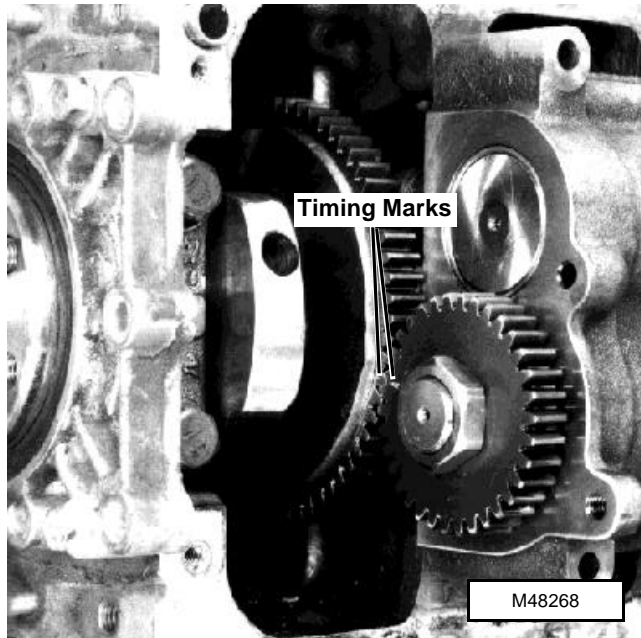
1. Remove oil pan. (See *Lubrication System* in this section.)

NOTE: Crankcase extension is removed to show detail.

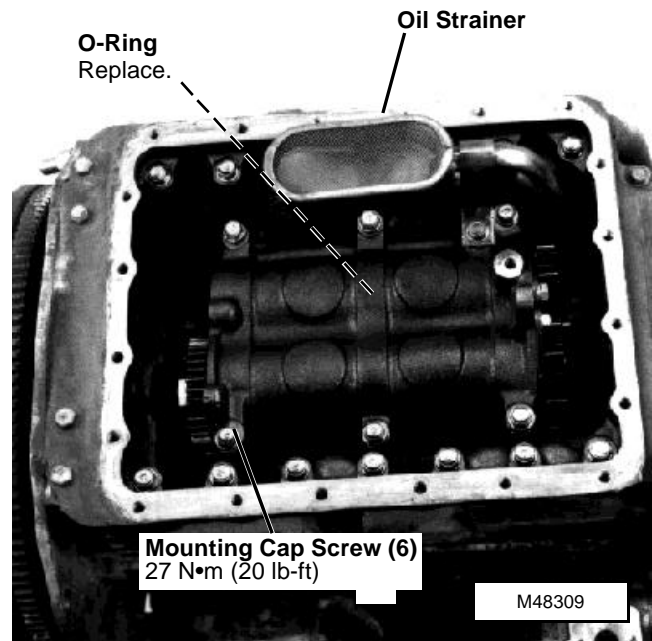
2. Align balancer-to-crankshaft timing marks.

IMPORTANT: Rotate crankshaft to find timing marks or scribe a mark across balancer gear and crankshaft gear teeth before removing balancer assembly.

3



3. Remove oil strainer. (See *Lubrication System* in this section.)
4. Remove six mounting cap screws.
5. Remove balancer assembly and o-ring.
6. Disassemble and inspect balancer assembly. (See *Disassembly/Inspection* procedures.)



Installation is done in the reverse order of removal.

- Align balancer-to-crankshaft timing marks when installing balancer assembly.

Disassembly/Assembly

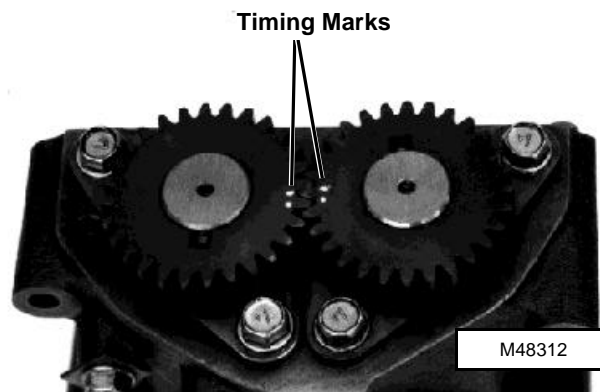
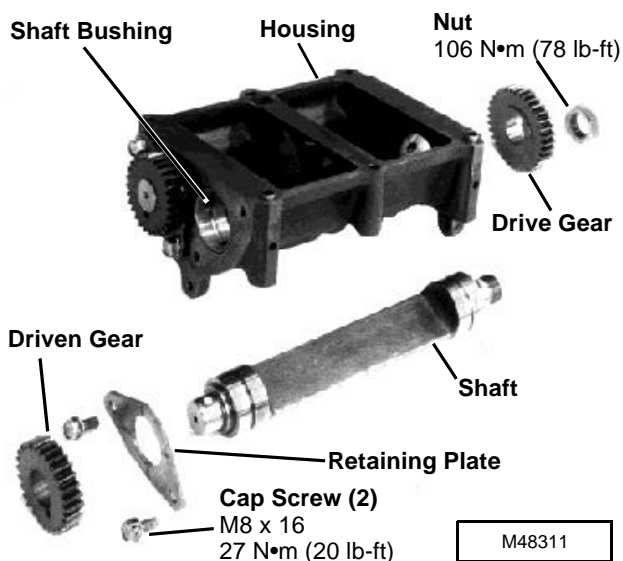
1. Remove nut, drive gear, cap screws and shaft assemblies.

NOTE: Driven gears are press fit on balancer shafts.

2. Remove driven gear using a knife-edge puller and a press.
3. Remove retaining plate.
4. Inspect all parts for wear or damage. Replace as necessary.

NOTE: Shaft bushings cannot be replaced separately. Replace balancer housing if necessary.

If drive gear is damaged, check balancer gear on crankshaft for damage. Replace if necessary. (See *CRANKSHAFT - Inspection/Replacement* procedure in this group.)



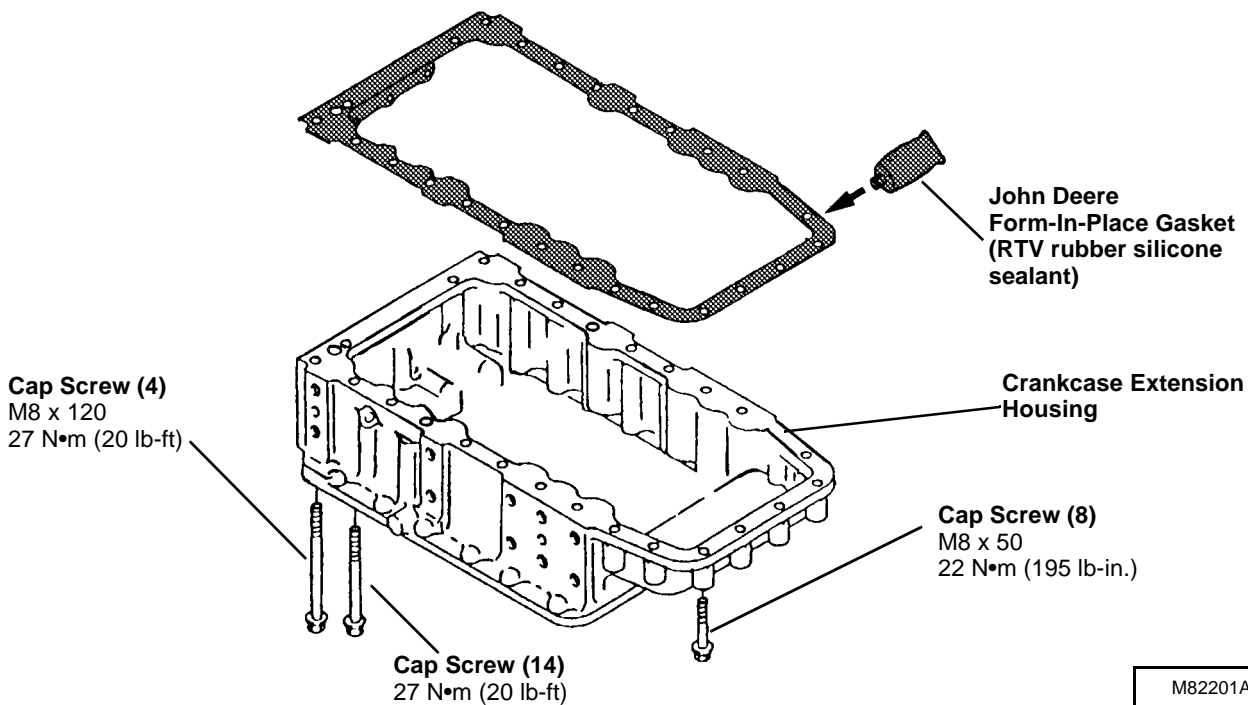
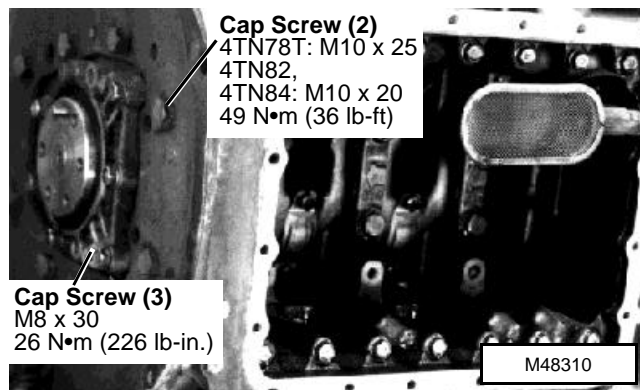
CRANKCASE EXTENSION HOUSING - 4TN78T, 4TN82RJK, 4TN84RJK

1. Remove flywheel. (See procedure in this group.)
2. Remove oil pan/plate. (See *Lubrication System* in this section.)

3

Assembly is done in the reverse order of disassembly.

- Install retaining plate on shaft with grooves toward driven gear.
- Press driven gear on balancer shaft until flush with beveled edge. Install gear with timing marks facing away from retainer plate.
- Apply clean engine oil on all parts during assembly.
- Align driven gear timing marks when installing balancer shaft assemblies.



Crankshaft, Main Bearings and Flywheel

CRANKCASE EXTENSION HOUSING - 4TN82RJE, 4TN82ESP, 4TN84(T)(4019)

1. Remove flywheel. (See procedure in this group.)
2. Remove oil pan and oil strainer. (See *Lubrication System* in this section.)

3

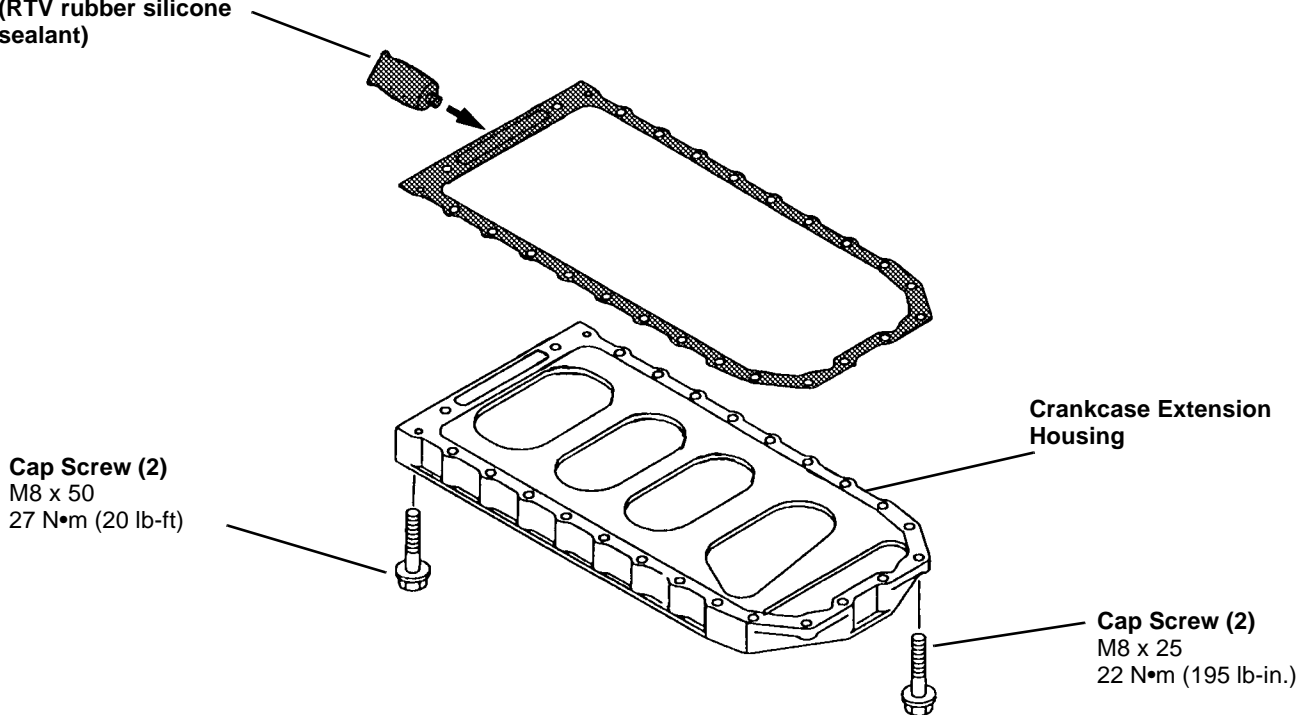


Cap Screw (3)
M8 x 35
26 N•m (226 lb-in.)

Cap Screw (4)
M10 x 30
49 N•m (36 lb-ft)

M82056

**John Deere
Form-In-Place Gasket
(RTV rubber silicone
sealant)**



Cap Screw (2)
M8 x 50
27 N•m (20 lb-ft)

**Crankcase Extension
Housing**

Cap Screw (2)
M8 x 25
22 N•m (195 lb-in.)

M82202A

CRANKSHAFT REAR OIL SEAL

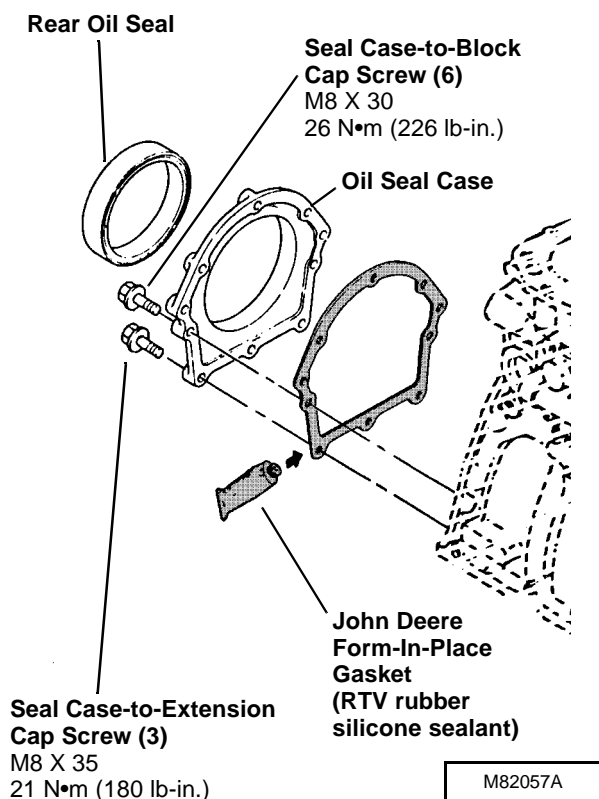
Replacement

1. Remove flywheel. (See procedure in this group.)

- Replace oil seal using a driver set. Install seal, with lip toward cylinder block. Install seal flush with surface of oil seal case.

NOTE: If crankshaft is grooved at oil seal contact point, seal can be installed 3 mm (0.120 in.) farther into oil seal case.

On 4TN78T, 4TN82RJK, 4TN84RJK: All nine seal case cap screws are M8 x 30 long.

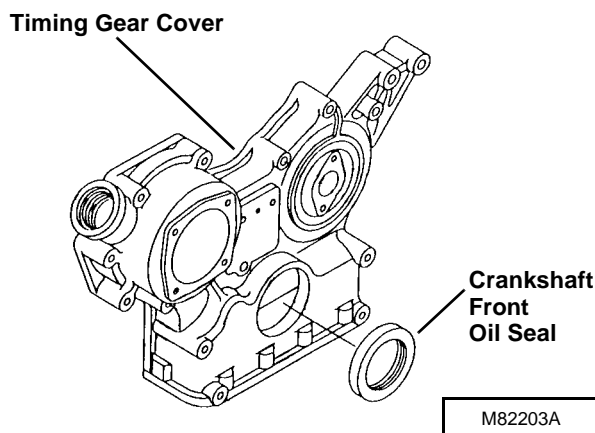


CRANKSHAFT FRONT OIL SEAL

Replacement

- Remove timing gear cover. (See *Camshaft and Timing Gear Train* in this section.)

- Replace oil seal using a driver set. Install seal with lip toward inside of gear housing cover. Install seal flush with surface of cover.



3

CRANKSHAFT AND MAIN BEARINGS

Removal

1. Check crankshaft end play. (See *Checks, Tests and Adjustments* in this section.)
2. Remove rear oil seal. (See procedure in this group.)
3. Remove flywheel housing. (See procedure in this group.)
4. Remove crankcase extension housing. (See procedure in this group.)
5. Remove balancer assembly, if equipped. (See procedure in this group.)

NOTE: On 4TN82 (970 CUT) and 4TN84 (1070 CUT), crankshaft can be removed without removing timing gear cover mounting plate.

6. Remove timing gear cover mounting plate. (See *Camshaft and Timing Gear Train* in this section.)
7. Check crankshaft bearing clearance. (See *Checks, Tests and Adjustments* in this section.)

IMPORTANT: Connecting rod end caps must be installed on the same connecting rods from which they were removed. Note alignment marks on caps and rods.

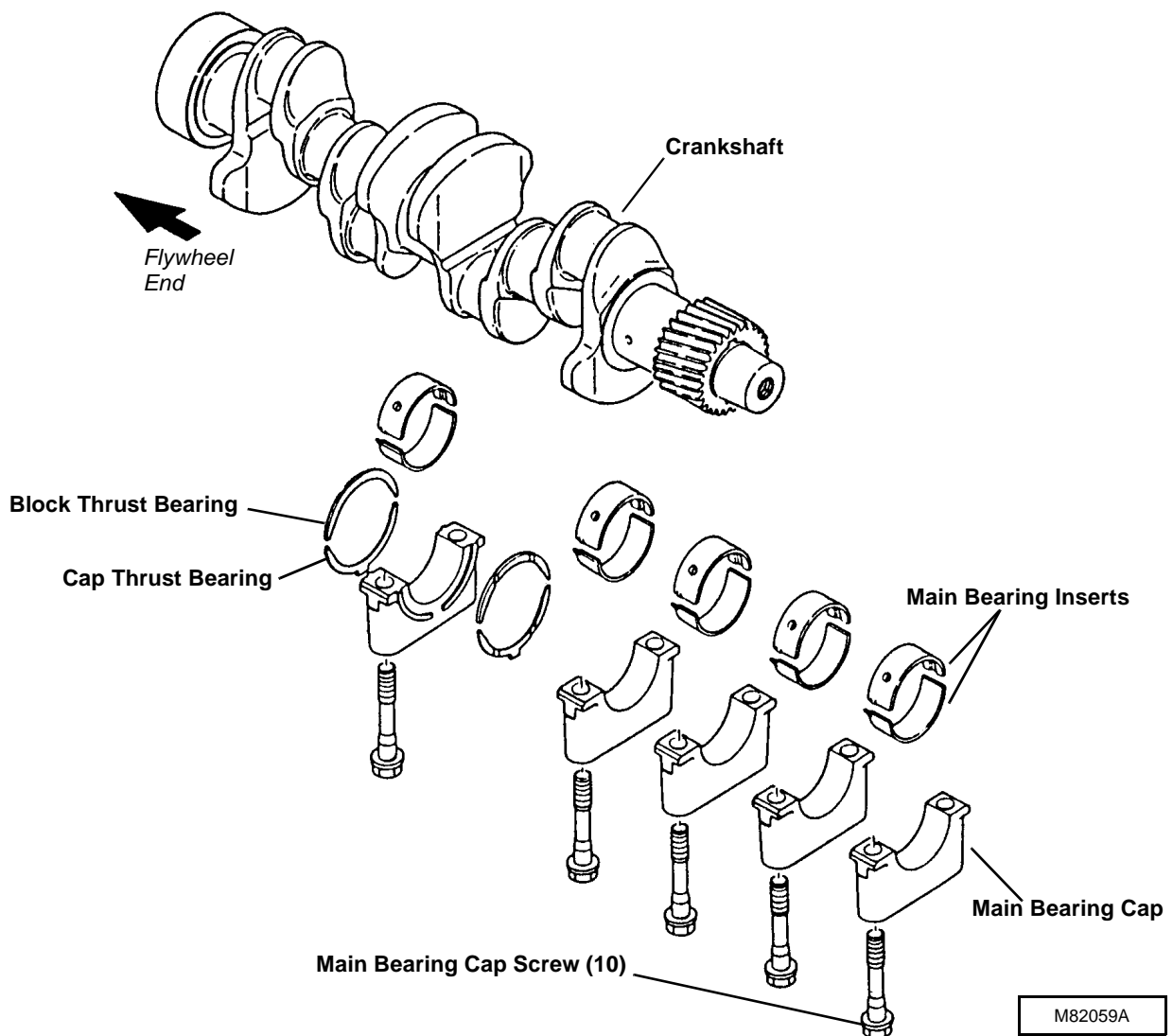
Crankshaft, Main Bearings and Flywheel

8. Remove connecting rod cap screws and end caps.
9. Push pistons and connecting rods away from crankshaft.

IMPORTANT: Main bearing caps must be installed on the same main bearings from which they were removed.

10. Remove main bearing cap screws, caps and cap thrust bearings.
11. Remove crankshaft.
12. Remove block thrust bearings and main bearing inserts.
13. Inspect all parts for wear or damage. (See *Inspection/Replacement* procedures.)

3



Installation

- Apply clean engine oil on all parts during installation.

IMPORTANT: Do not touch bearing insert surfaces. Oil and acid from your finger will corrode the bearing surface.

1. Install grooved bearing inserts in crankshaft bearing bores, aligning tangs with slots in bores.
2. Install block thrust bearings with oil grooves facing away from engine block.
3. Install crankshaft.
4. Install smooth bearing inserts in main bearing caps, aligning tangs with slots in caps.

NOTE: Main bearing caps have “raised arrows” that are stamped with numbers. Both correspond to their location on the engine block. The number “1” main bearing bore is at flywheel end. Install bearing caps beginning with number 1, then 2, etc. The main bearing cap at gear train end does not have a number. Also install bearing caps with the “arrow” toward the flywheel end.

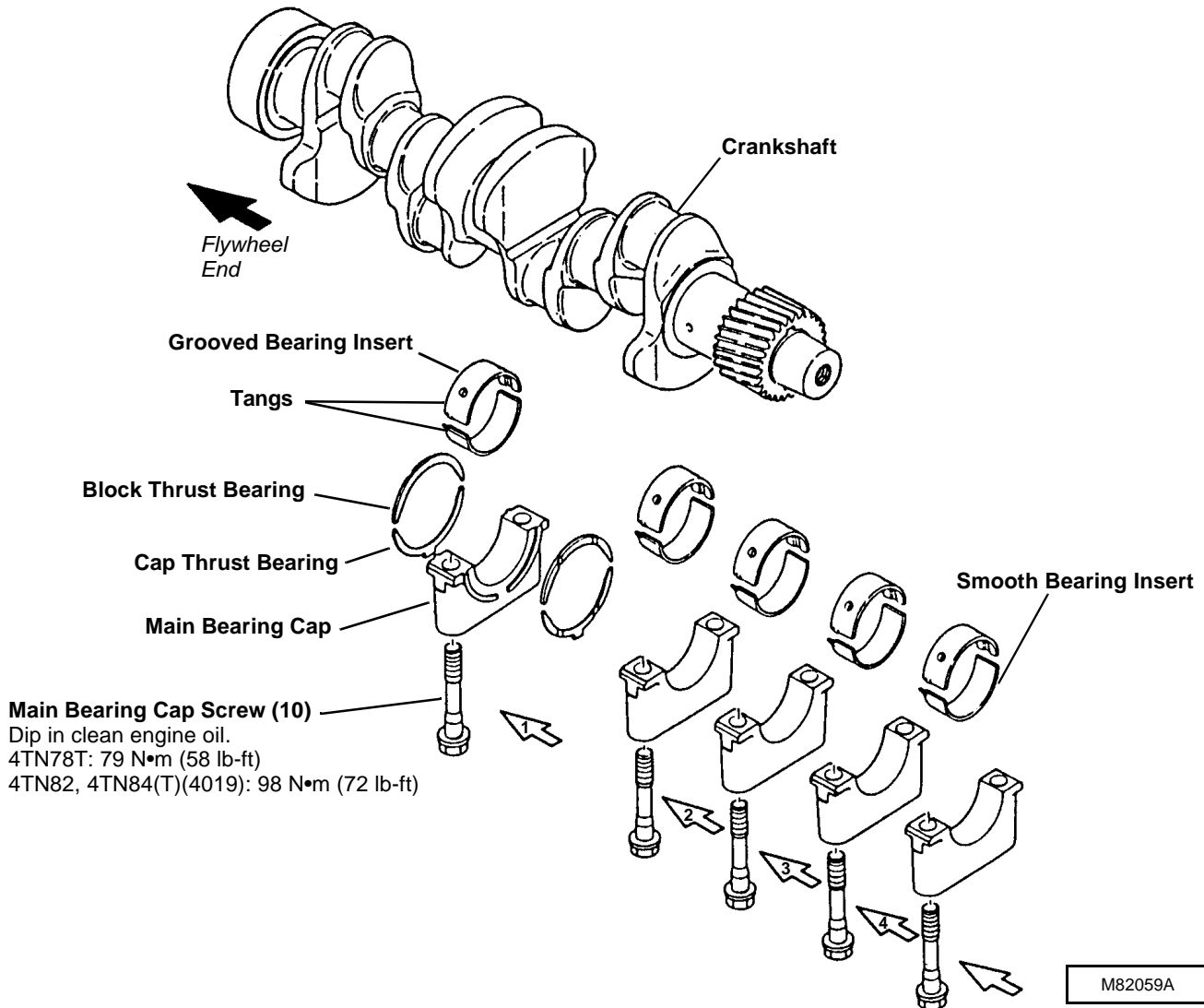
5. Install cap thrust bearings, with oil grooves facing away from cap, in the number “1” main bearing cap.
6. Install main bearing caps in their original locations with arrows pointing toward flywheel side of engine.

IMPORTANT: DO NOT use high speed power tools or air wrenches to tighten main bearing cap screws.

7. Dip entire main bearing cap screws in clean engine oil. Install cap screws and tighten. **DO NOT** tighten to specifications.
8. Using a soft-faced hammer, tap the front end of the crankshaft then the rear end of the crankshaft to align the thrust bearings.
9. Tighten main bearing cap screws to specifications. When tightening, start at center main bearing cap and work your way out, alternating to the ends. Turn crankshaft by hand. If it does not turn easily, disassemble the parts and find the cause.

Crankshaft, Main Bearings and Flywheel

3



IMPORTANT: Connecting rod caps must be installed on the same connecting rods they were removed from.

Never reuse connecting rod cap screws, replace with new.

- 10. Match the connecting rod caps to the rods using alignment marks. Install caps.
- 11. Dip entire connecting rod cap screws in clean engine oil. Install new cap screws and tighten to specifications.

Connecting Rod Cap Screw Torque Specifications:

- 4TN78T 39 N•m (29 lb-ft)
- 4TN82, 4TN84(T)(4019) ... 47 N•m (35 lb-ft)

NOTE: On 4TN82 (970 CUT) and 4TN84 (1070 CUT), crankshaft can be installed without removing timing gear cover mounting plate.

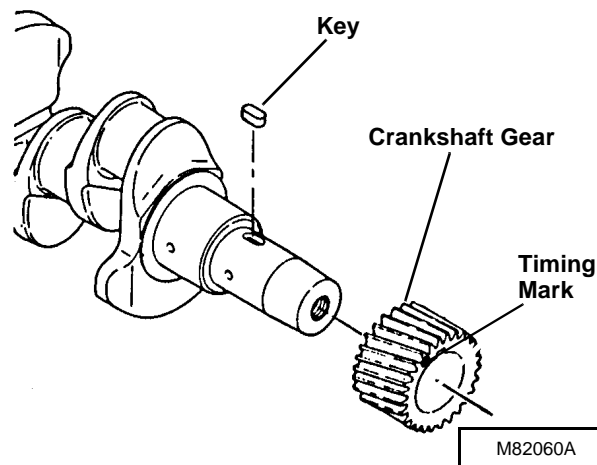
- 12. Install timing gear cover mounting plate. (See *Camshaft and Timing Gear Train* in this section.)
- 13. Install balancer, if equipped. (See procedure in this group.)
- 14. Install crankcase extension housing. (See procedure in this group.)
- 15. Install flywheel housing. (See procedure in this group.)
- 16. Install rear oil seal. (See procedure in this group.)

Inspection/Replacement

1. Inspect crankshaft gear for chipped or broken teeth. Replace if necessary.

To replace gear:

Remove gear from crankshaft using a knife-edge puller and a press.



CAUTION

DO NOT heat oil over 182° C (360° F). Oil fumes or oil can ignite above 193° C (380° F). Use a thermometer. Do not allow a flame or heating element to come in direct contact with the oil. Heat the oil in a well-ventilated area. Plan a safe handling procedure to avoid burns.

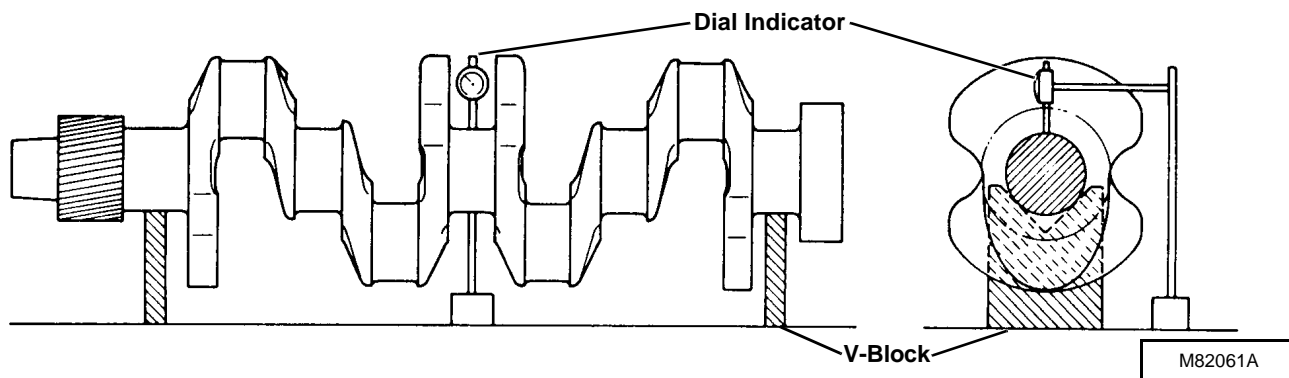
Heat gear to approximately 150°C (300°F). Install gear with timing mark "A" toward press table. Align slot in gear with key in shaft. Press crankshaft into gear until gear is tight against crankshaft shoulder.

2. If equipped, inspect balancer gear on crankshaft for chipped or broken teeth. Replace if necessary.

To replace gear:

- Scribe a mark across crankshaft at location of timing mark on gear, to aid in assembly.
- Remove gear using a knife-edge puller and a press.
- Heat gear to approximately 150°C (300°F). Install new gear with timing mark facing away from press table. Align timing mark on gear with mark on crankshaft made during disassembly. Press gear onto crankshaft until gear is tight against crankshaft shoulder.

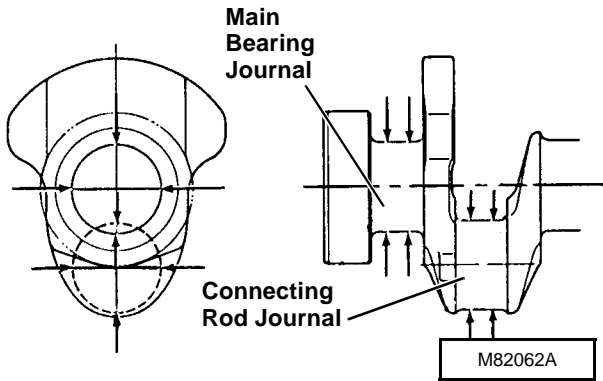
3. Inspect crankshaft for bend using v-blocks and a dial indicator. Turn crankshaft slowly and read variation on indicator. If variation is greater than **0.02 mm (0.0007 in.)**, replace crankshaft.



Crankshaft, Main Bearings and Flywheel

4. Measure crankshaft connecting rod journal and main bearing journal diameters. Measure several places around each journal.

NOTE: If engine has had a previous major overhaul, journals may have been ground and undersized bearing inserts installed.



3

Connecting Rod Journal O.D. - 4TN78T:

Standard 42.952 - 42.962 mm
 (1.6910 - 1.6914 in.)
 Wear Limit..... 42.91 mm (1.689 in.)

Connecting Rod Journal O.D. - 4TN82, 4TN84(T)(4019):

Standard 47.952 - 47.962 mm
 (1.8879 - 1.8883 in.)
 Wear Limit..... 47.91 mm (1.886 in.)

Main Bearing Journal O.D. - 4TN78T:

Standard 46.952 - 46.962 mm
 (1.8485 - 1.8489 in.)
 Wear Limit..... 46.91 mm (1.847 in.)

Main Bearing Journal O.D. - 4TN82, 4TN84(T)(4019):

Standard 46.952 - 46.962 mm
 (1.9666 - 1.9670 in.)
 Wear Limit..... 49.90 mm (1.965 in.)

If journal diameter is less than wear limit, replace crankshaft or have journals ground undersize by a qualified machine shop.

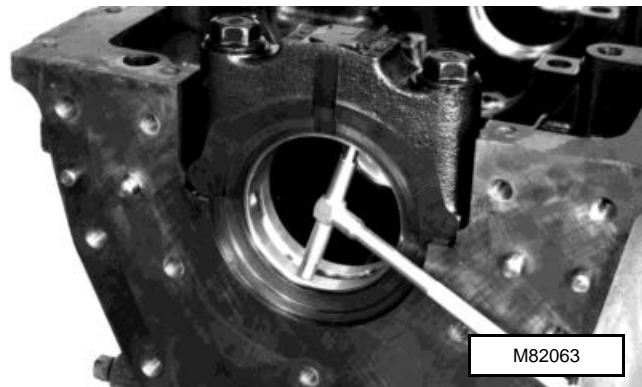
If journals are ground, undersize bearing inserts must be installed. Bearing inserts are available in 0.25 mm (0.010 in.) undersize.

5. Install bearing inserts and main bearing cap on main bearing. Tighten main bearing cap screws to specifications.

Main Bearing Cap Screw Torque Specifications:

4TN78T 79 N•m (58 lb-ft)
 4TN82,
 4TN84(T)(4019)..... 98 N•m (72 lb-ft)

6. Measure main bearing diameter.



Main Bearing I.D. - 4TN78T:

Standard 47.00 - 47.045 mm
 (1.850 - 1.852 in.)
 Wear Limit..... 47.10 mm (1.8541 in.)
 Clearance..... 0.16 mm (0.006 in.)

Main Bearing I.D. - 4TN82, 4TN84(T)(4019):

Standard 50.00 - 50.045 mm
 (1.969 - 1.970 in.)
 Wear Limit..... 50.10 mm (1.972 in.)
 Clearance..... 0.16 mm (0.006 in.)

If bearing diameter exceeds wear limit, replace bearing inserts.

If bearing clearance (bearing I.D. minus crankshaft main bearing journal O.D.) exceeds specification, replace bearing inserts and crankshaft or have crankshaft journals ground undersize by a qualified machine shop and install undersized bearing inserts.

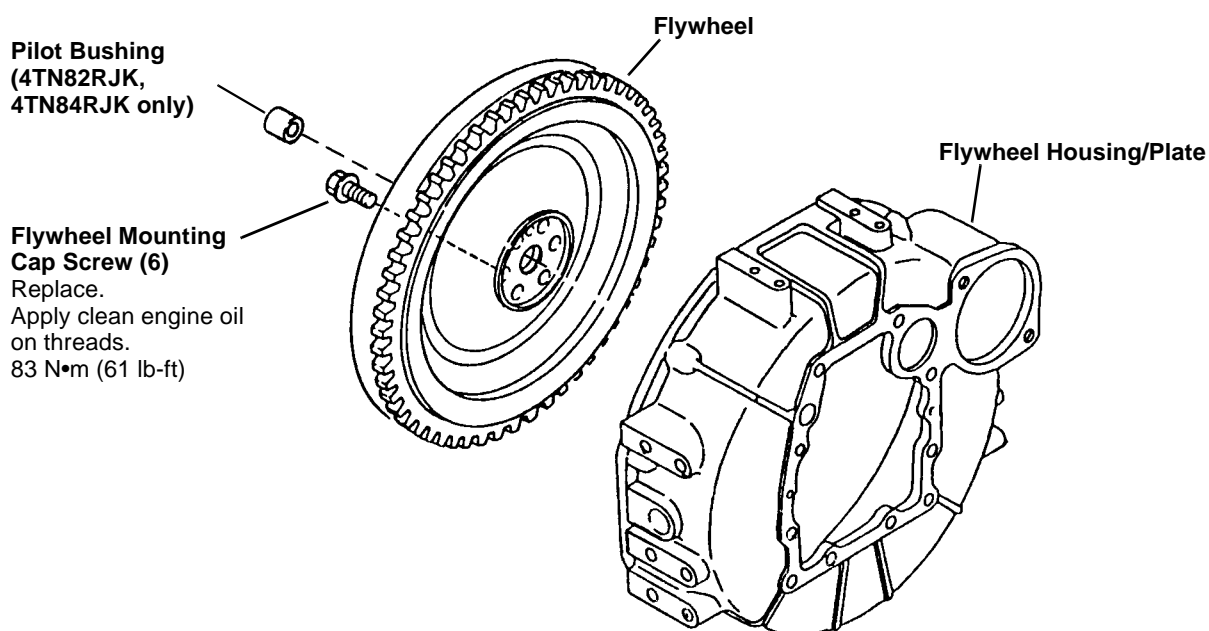
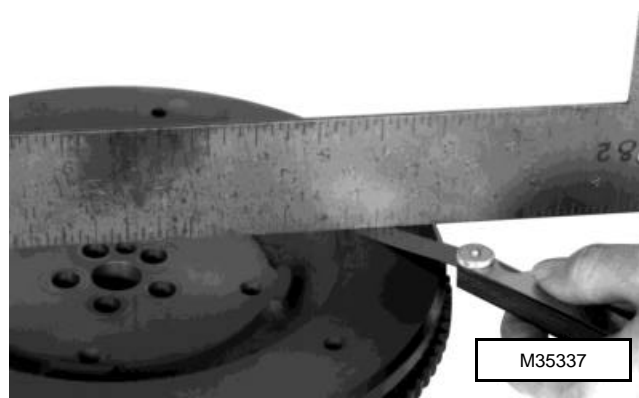
Bearing inserts are available in 0.25 mm (0.010 in.) undersize.

7. Clean and inspect oil passages in main bearing journals, connecting rod journals and main bearing bores in cylinder block.
8. Inspect crankshaft for cracks or damage. Replace if necessary.

FLYWHEEL

IMPORTANT: Never reuse flywheel mounting cap screws. Always install new.

- Inspect pilot bushing, if equipped, for wear or damage. Replace if necessary using a driver set. Install bushing flush with flywheel surface.
- Measure flywheel flatness. Place a straight edge across flywheel surface opposite of ring gear. Measure clearance between straight edge and flywheel surface with a feeler gauge. If clearance exceeds **0.02 mm (0.0008 in.)**, replace flywheel.



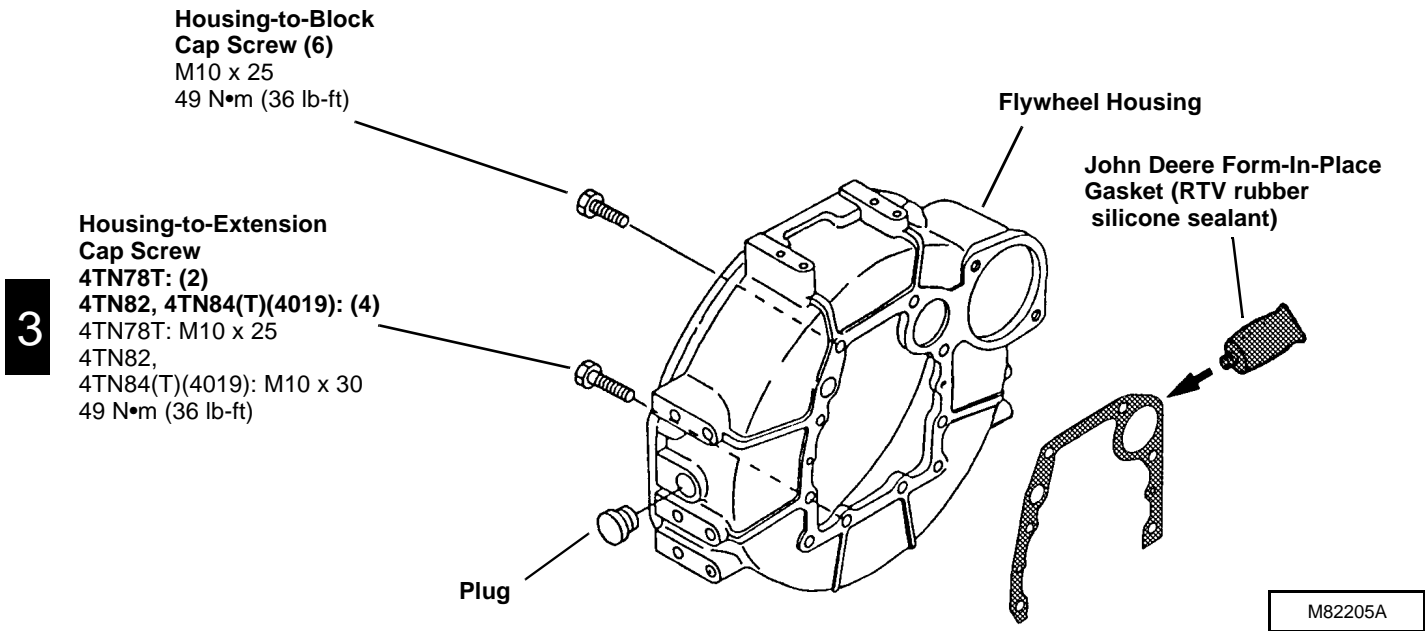
M82204A

Crankshaft, Main Bearings and Flywheel

FLYWHEEL HOUSING - 4TN78T, 4TN82RJE, 4TN82ESP, 4TN84(T) (4019 DF/TF005 and 006)

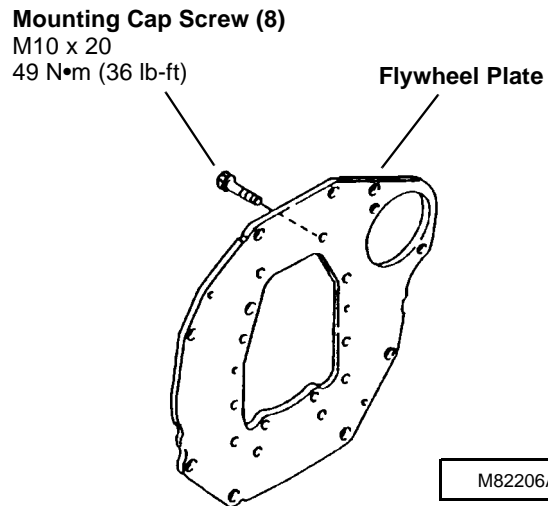
NOTE: 4TN84(T)(4019 DF/TF001) engines are equipped with a flywheel plate in place of a housing. (See procedure in this group.)

1. Remove flywheel. (See procedure in this group.)
2. Remove starter.



FLYWHEEL PLATE - 4TN82RJK, 4TN84RJK, 4TN84(T)(4019 DF/TF001)

1. Remove flywheel. (See procedure in this group.)
2. Remove starter.



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).

D15001NU Magnetic Follower Holder Kit

Hold cam followers when removing and installing camshaft.

OTHER MATERIALS

Number	Name	Use
LOCTITE® PRODUCTS		
U.S./		
Canadian/		
LOCTITE No.		
TY15130/ NA/ #395	John Deere Form-In-Place Gasket	Seals camshaft plug, timing gear cover and plate to engine block.
TY9370/ TY9477/ #242	Thread Lock and Sealer (Medium Strength)	Apply to threads of crankshaft pulley cap screw.

3

SERVICE PARTS KITS

The following kits are available through your parts catalog:

- Cylinder Head Gasket Kit
- Cylinder Block Gasket Kit

® LOCTITE is a registered trademark of the Loctite Corp.

Camshaft and Timing Gear Train

CAMSHAFT

Removal

1. Remove rocker arm assembly and push rods. (See *Cylinder Head, Valves and Manifolds* in this section.)
2. Remove timing gear cover. (See procedure in this group.)
3. Check camshaft end play. (See *Checks, Tests and Adjustments* in this section.)
4. Check backlash of timing gears. (See *Checks, Tests and Adjustments* in this section.)

NOTE: If a magnetic follower holder kit is not available, turn engine until oil pan is upward, to hold cam followers away from camshaft.

3

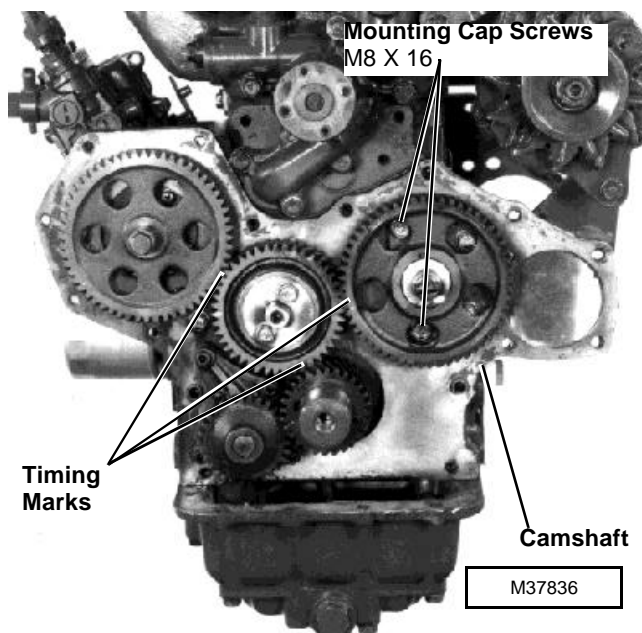
5. Hold cam followers away from camshaft using a magnetic follower holder kit such as D15001NU.

NOTE: Due to the odd number of teeth on the idler gear, timing marks will only align periodically.

6. Rotate crankshaft and align timing marks.

IMPORTANT: DO NOT allow camshaft lobes to hit bearing surfaces while removing camshaft. Machined surfaces can be damaged.

7. Remove two cap screws and camshaft.
8. Inspect all parts for wear or damage. (See *Inspection/Replacement* procedures.)



Installation

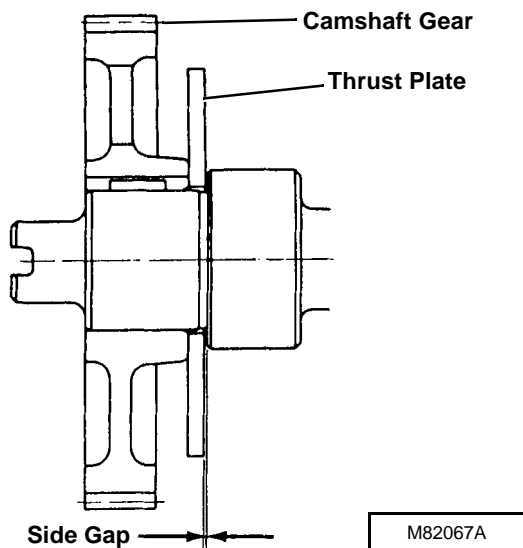
- Apply clean engine oil on all parts during installation.

IMPORTANT: DO NOT allow camshaft lobes to hit bearing surfaces while installing camshaft. Machined surfaces can be damaged.

1. Rotate crankshaft to align timing marks.
2. Install camshaft.
3. Install and tighten mounting cap screws to **26 N•m (226 lb-in.)**.
4. Install timing gear cover. (See procedure in this group.)
5. Install push rods and rocker arm assembly. (See *Cylinder Head, Valves and Manifolds* in this section.)

Inspection/Replacement

1. Check camshaft side gap using a feeler gauge.



Camshaft Side Gap:

Standard 0.05 - 0.20 mm
 (0.0020 - 0.0079 in.)

Wear Limit..... 0.40 mm (0.016 in.)

If side gap is at wear limit, remove gear and replace thrust plate.

2. Inspect gear for chipped or broken teeth. Replace if necessary.

To remove/replace gear:

Remove gear from camshaft using a knife-edge puller and a press.

CAUTION

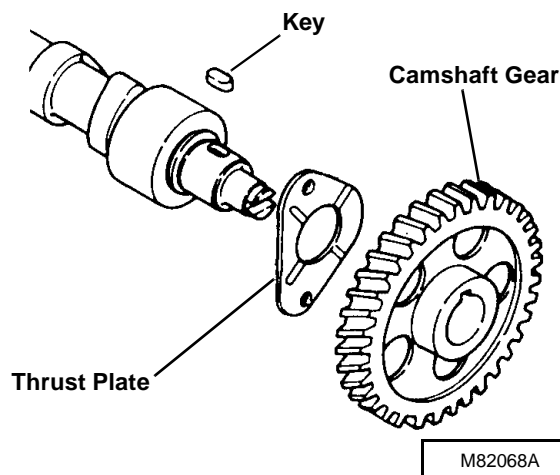
DO NOT heat oil over 182° C (360° F). Oil fumes or oil can ignite above 193° C (380° F). Use a thermometer. Do not allow a flame or heating element to come in direct contact with the oil. Heat the oil in a well-ventilated area. Plan a safe handling procedure to avoid burns.

Heat gear to approximately 150°C (300°F).

IMPORTANT: Be sure thrust plate is not between camshaft gear and camshaft shoulder while installing gear.

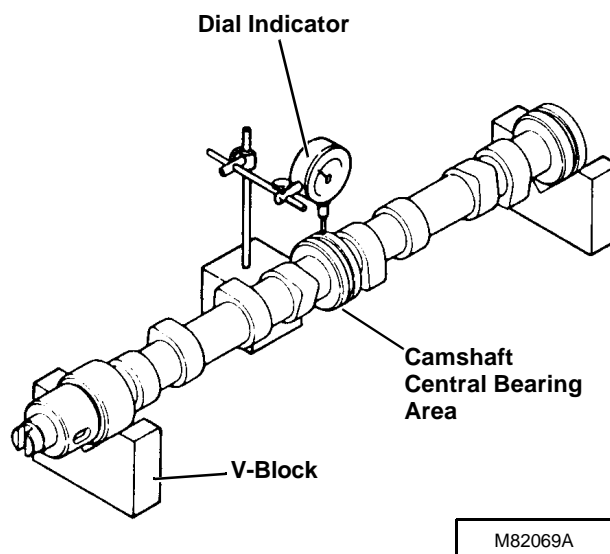
Install thrust plate if removed. Install gear with timing mark "C" side toward press table. Align slot in gear with key in shaft. Press camshaft into gear until gear is tight against camshaft shoulder.

Thrust plate must spin freely on camshaft.



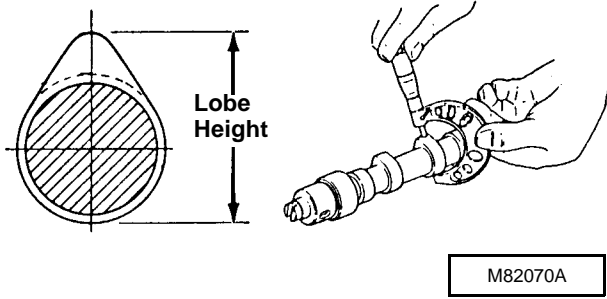
3

3. Inspect camshaft for bend using v-blocks and a dial indicator. Turn camshaft slowly and read variation on indicator. If variation is greater than 0.02 mm (0.001 in.), replace camshaft.



4. Measure camshaft lobe height.

Camshaft and Timing Gear Train



Lobe Height:

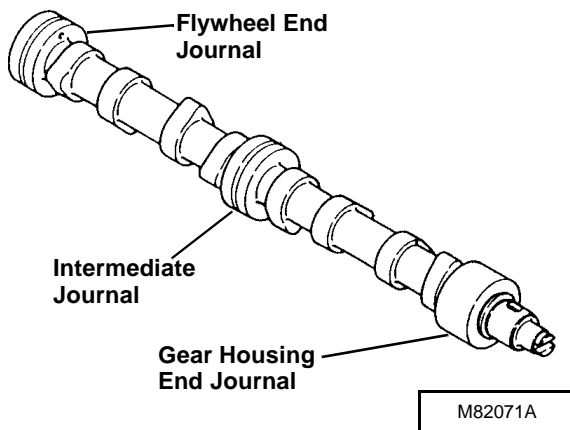
Standard 38.635 - 38.765 mm
 (1.521 - 1.526 in.)

Wear Limit..... 38.40 mm (1.512 in.)

3

If lobe height is less than wear limit, replace camshaft.

5. Measure camshaft end and intermediate journal diameters.



Camshaft Journal O.D.:

Gear Housing and Flywheel Ends

Standard 44.92 - 44.95 mm
 (1.769 - 1.770 in.)

Wear Limit..... 44.80 mm (1.764 in.)

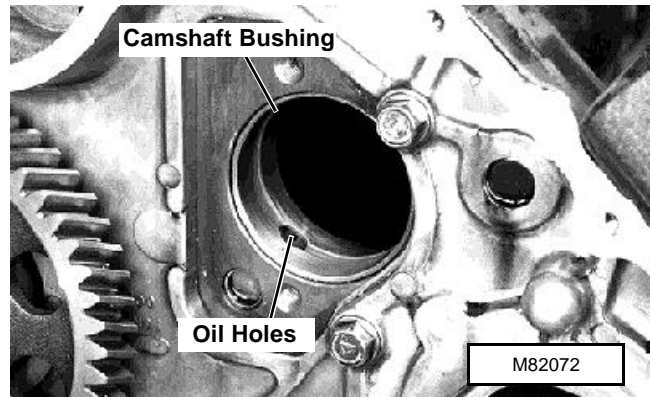
Intermediate

Standard 44.91 - 44.94 mm
 (1.768 - 1.769 in.)

Wear Limit..... 44.80 mm (1.764 in.)

If journal diameters are less than wear limit, replace camshaft.

6. Measure camshaft bushing diameter at gear housing end.



Camshaft Bushing I.D.:

Standard..... 44.990 - 45.055 mm
 (1.771 - 1.774 in.)

Wear Limit..... 45.10 mm (1.776 in.)

Clearance..... 0.20 mm (0.0079 in.)

If bushing diameter exceeds wear limit, replace bushing.

If bushing clearance (bushing I.D. minus camshaft journal O.D.) exceeds specification, replace bushing, camshaft or both.

To replace bushing:

Remove bushing using a chisel. Be careful not to push bushing inside of engine. Align oil holes in new bushing and cylinder block. Install bushing using a driver set.

NOTE: Flywheel housing must be removed to measure camshaft intermediate and flywheel end bearing diameters.

7. Measure intermediate and flywheel end camshaft bore diameters using the following procedures:

- Remove flywheel housing. (See *Crankshaft, Main Bearings and Flywheel* in this section.)
- Remove plug using a long wooden dowel. Insert wooden dowel through gear housing side.

CAM FOLLOWERS

Removal/Installation

1. Remove camshaft. (See procedure in this group.)
2. Remove oil pan and strainer. (See *Lubrication System* in this section.)

IMPORTANT: Cam followers must be installed in the same bores from which they were removed.

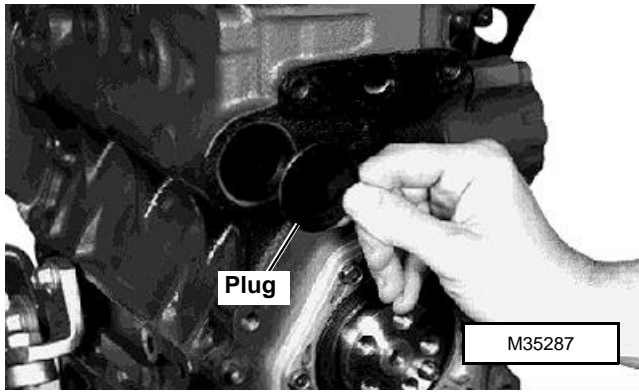
3. Put a mark on each cam follower and cylinder block bore to aid in installation.
4. Remove cam followers.
5. Inspect all parts for wear or damage. (See *Inspection* procedures.)
6. Apply clean engine oil on all parts during installation.

3

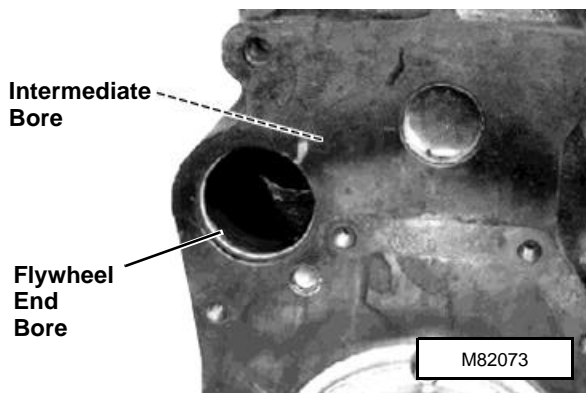
Installation is done in the reverse order of removal.

Inspection

- Inspect cam follower contact surface for abnormal wear. Replace if necessary.



- Measure intermediate and flywheel end camshaft bore diameters.



Camshaft Bore I.D.:

Standard 45.00 - 45.025 mm
 (1.772 - 1.773 in.)

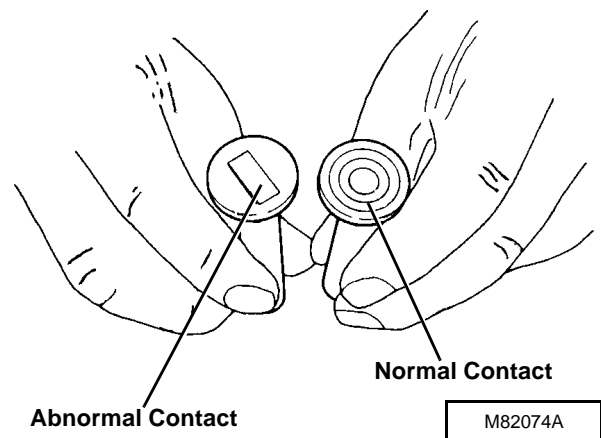
Wear Limit..... 45.10 mm (1.776 in.)

Clearance..... 0.18 mm (0.007 in.)

If bore diameter exceeds wear limit, replace cylinder block.

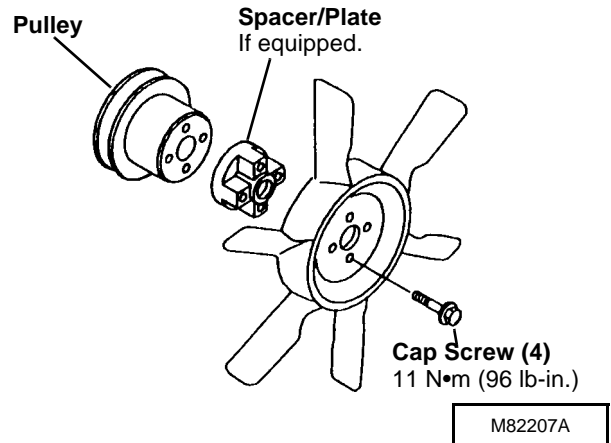
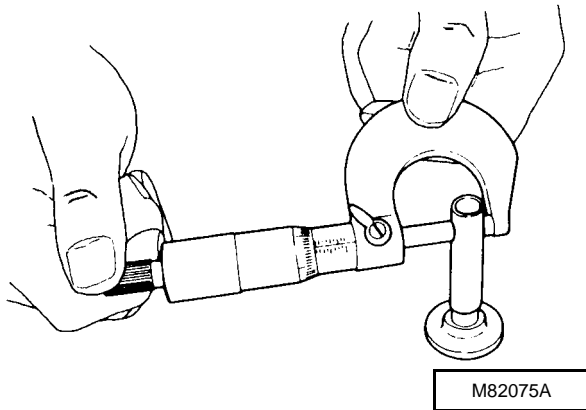
If bore clearance (bore I.D. minus camshaft journal O.D.) exceeds specification, replace camshaft, cylinder block or both.

- Apply John Deere Form-In Place Gasket, or an equivalent, on outer edge of plug. Install plug until it bottoms in bore.
- Install flywheel housing.



Camshaft and Timing Gear Train

- Measure cam follower stem diameter.



3 Cam Follower Stem O.D.:

Standard	11.975 - 11.990 mm .....(0.471 - 0.472 in.)
Wear Limit	11.93 mm (0.470 in.)

If stem diameter is less than wear limit, replace cam follower.

- Measure cam follower bore diameter in cylinder block.

Cam Follower Bore I.D.:

Standard	12.000 - 12.018 mm .....(0.472 - 0.473 in.)
Wear Limit	12.05 mm (0.474 in.)
Clearance	0.10 mm (0.004 in.)

If cam follower bore diameter exceeds wear limit, replace cylinder block.

If bore clearance (bore I.D. minus follower stem O.D.) exceeds specification, replace cam follower, cylinder block or both.

3. Remove crankshaft pulley cap screw and washer.
 4. Remove crankshaft pulley using a two-jaw puller kit.
 5. Remove tachometer, if equipped.
 6. 4TN82RJK (970 CUT), 4TN84RJK (1070 CUT): Remove hydraulic pump and steering pump, if equipped. (See procedure in Machine Technical Manual).
- NOTE: It is not necessary to remove auxiliary drive cover and gasket, if equipped, end cover and o-ring or fuel injection pump gear cover to remove timing gear cover.*
7. Remove 18 mounting cap screws and timing gear cover.

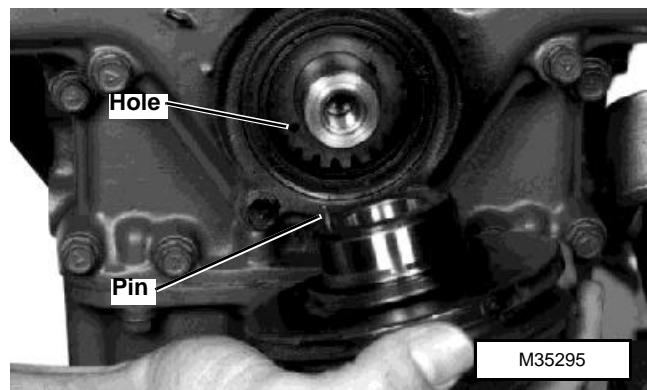
Installation is done in the reverse order of removal.

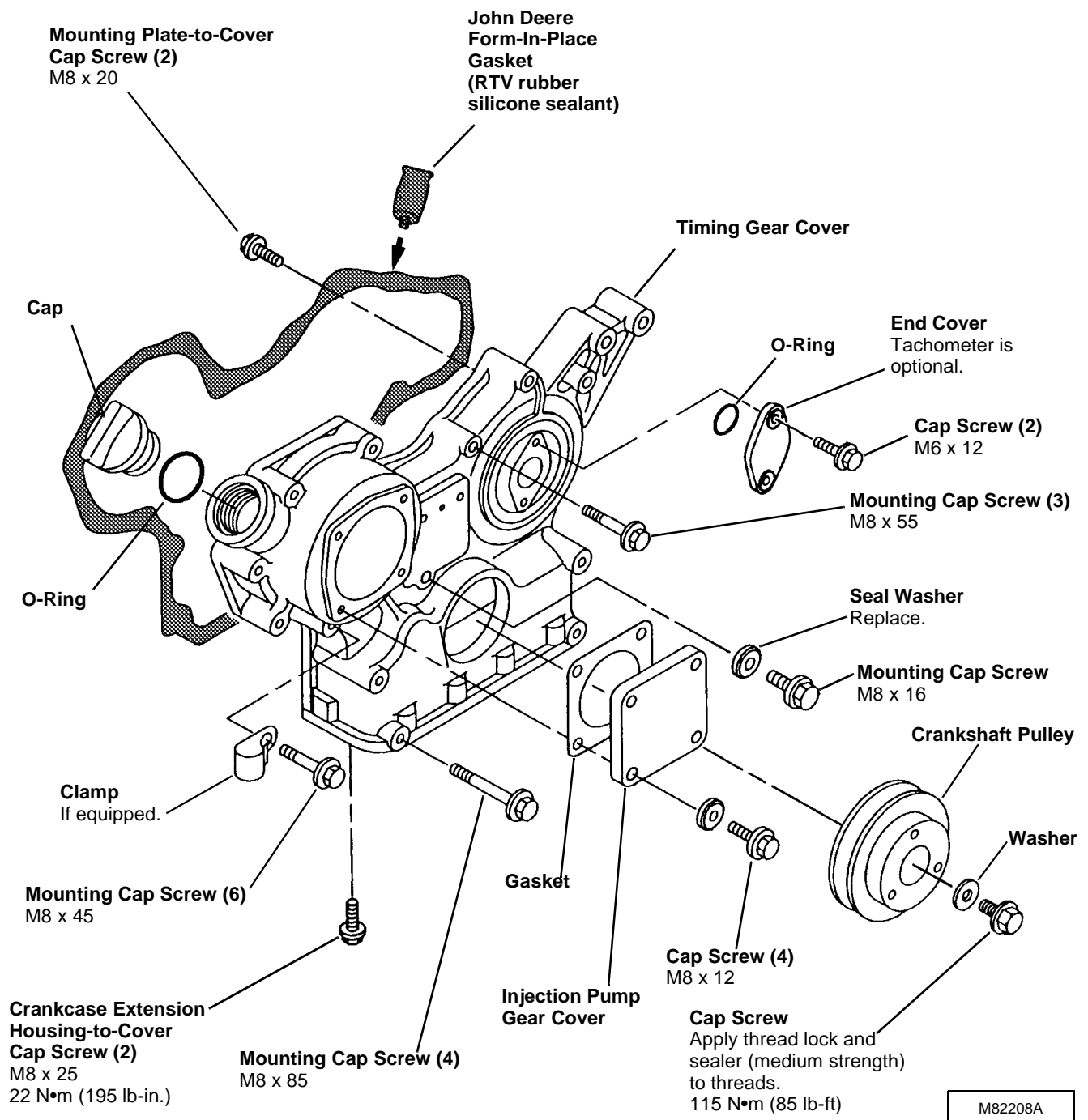
- Replace seal washer.
- Tighten all mounting cap screws to **26 N•m (226 lb-in.)**
- Align pin in crankshaft pulley with hole in crankshaft gear. Install crankshaft pulley.
- Adjust fan/alternator drive belt tension. (See *Checks, Tests and Adjustments* in this section.)

TIMING GEAR COVER

Removal/Installation

1. Remove alternator and belt.
2. Remove fan, spacer/plate, if equipped, and pulley.





3

IDLER GEAR

Removal/Installation

1. Remove timing gear cover. (See procedure in this group.)
2. Check backlash of timing gears. (See *Checks, Tests and Adjustments* in this section.)

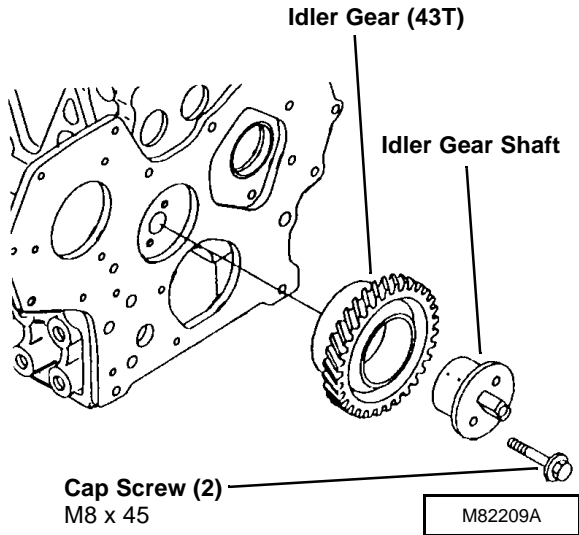
NOTE: Due to the odd number of teeth on the idler gear, timing marks will only align periodically. When all timing marks on gears align, the piston closest to the water pump is at TDC on compression stroke. Number one cylinder is closest to the flywheel.

3. Rotate crankshaft and align timing marks.
4. Remove two cap screws, shaft and gear.

Camshaft and Timing Gear Train

5. Inspect all parts for wear or damage. (See *Inspection/Replacement* procedures.)

Installation is done in the reverse order of removal.



3

Inspection/Replacement

- Inspect gear for chipped or broken teeth. Replace if necessary.
- Measure idler gear shaft diameter.

Idler Gear Shaft O.D.:

Standard 45.950 - 45.975 mm
 (1.809 - 1.810 in.)

Wear Limit 45.93 mm (1.808 in.)

If shaft diameter is less than wear limit, replace idler gear shaft.

- Measure idler gear bushing diameter.

Idler Gear Bushing I.D.:

Standard 46.00 - 46.025 mm
 (1.811 - 1.812 in.)

Wear Limit 46.08 mm (1.814 in.)

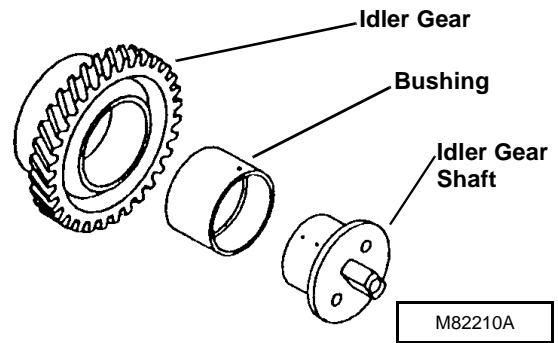
Clearance 0.15 mm (0.0059 in.)

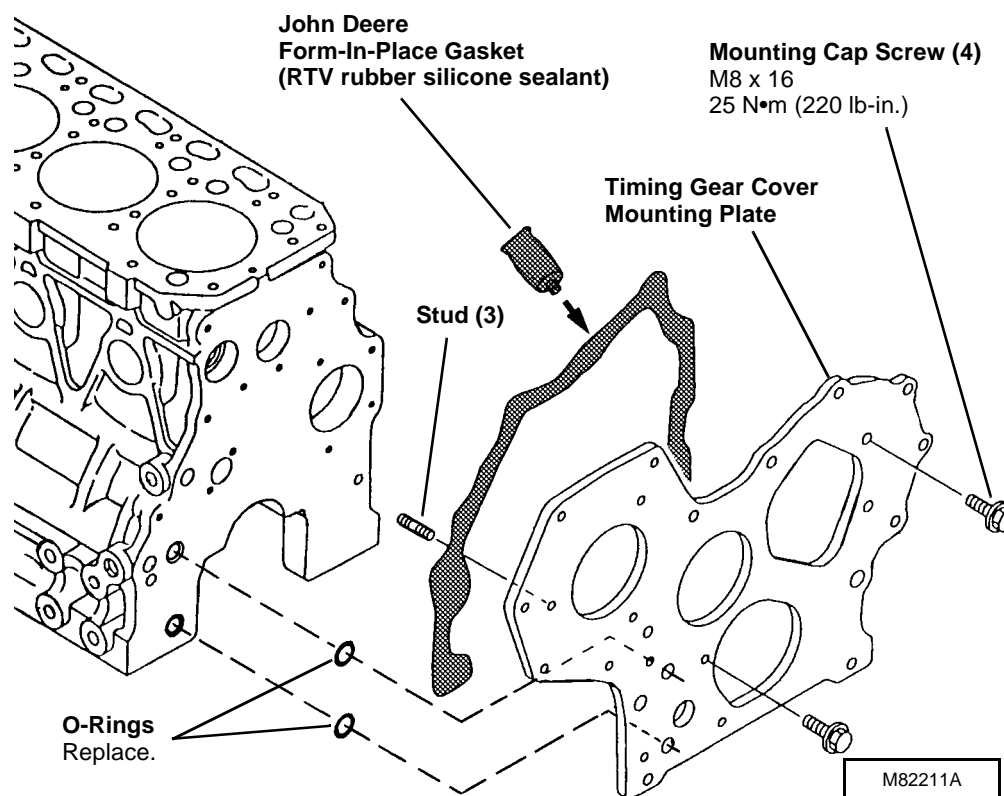
If bushing diameter exceeds wear limit, replace bushing.

To replace bushing:

Replace bushing using a driver set. Align oil holes in bushing and idler gear. Install bushing flush with surface of idler gear.

If bushing clearance (bushing I.D. minus shaft O.D.) exceeds specification, replace bushing, shaft or both.





3

TIMING GEAR COVER MOUNTING PLATE

Removal/Installation

1. Remove camshaft. (See procedure in this group.)
2. Remove idler gear. (See procedure in this group.)
3. Remove fuel injection pump. (See *Fuel System* in this section.)
4. Remove oil pump. (See *Lubrication System* in this section.)
5. Remove mounting cap screws and plate.
6. Replace o-rings.

Installation is done in the reverse order of removal.

Lubrication System

OTHER MATERIALS

Number	Name	Use
LOCTITE® PRODUCTS U.S./ Canadian/ Loctite No.		
TY15130/ NA/ #395	John Deere Form-In-Place Gasket	Seals oil pan to crankcase extension housing.
TY9375/ TY9480/ filter	John Deere Pipe Sealant with TEFLON® #592	4TN78T and 4TN84T (4019TF001 and 005): Apply to threads of plug in oil mounting block.

3

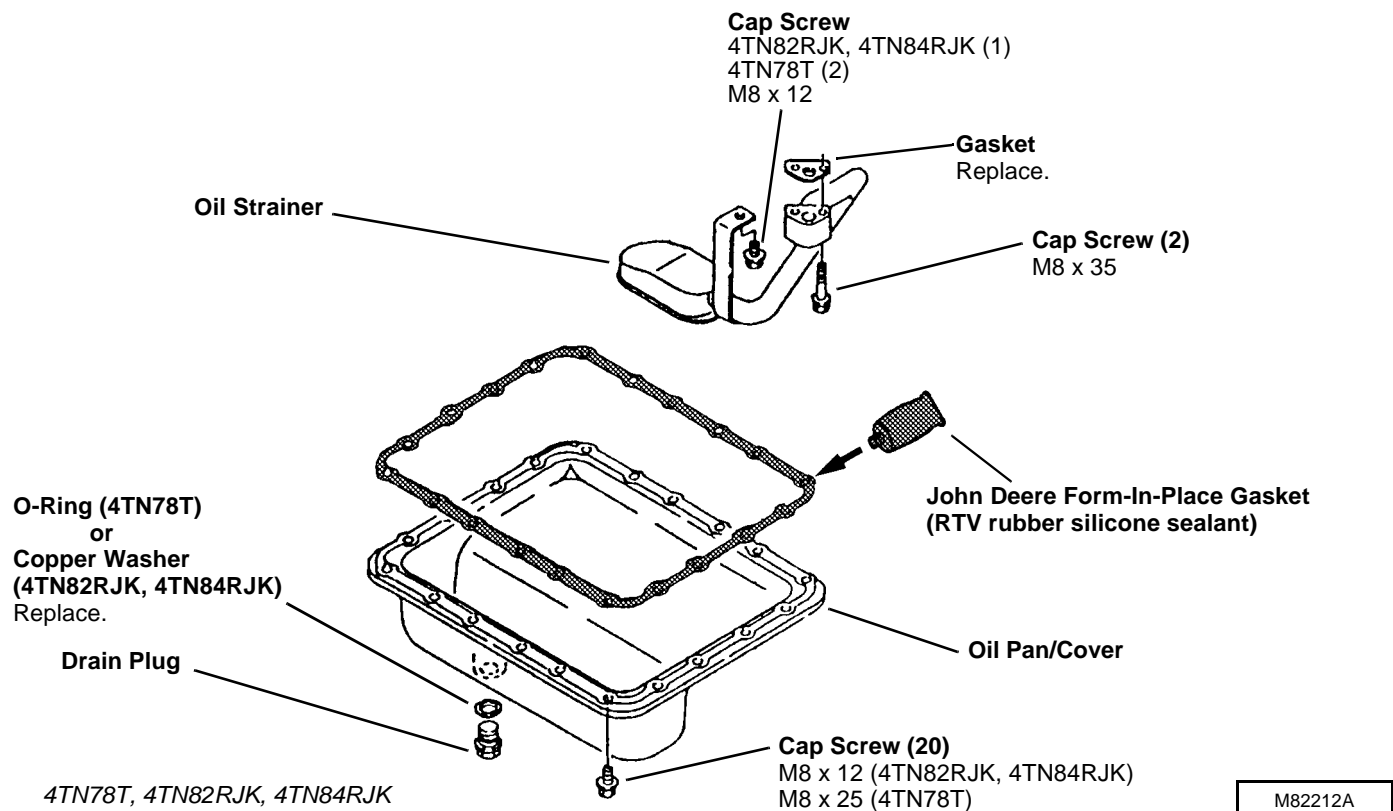
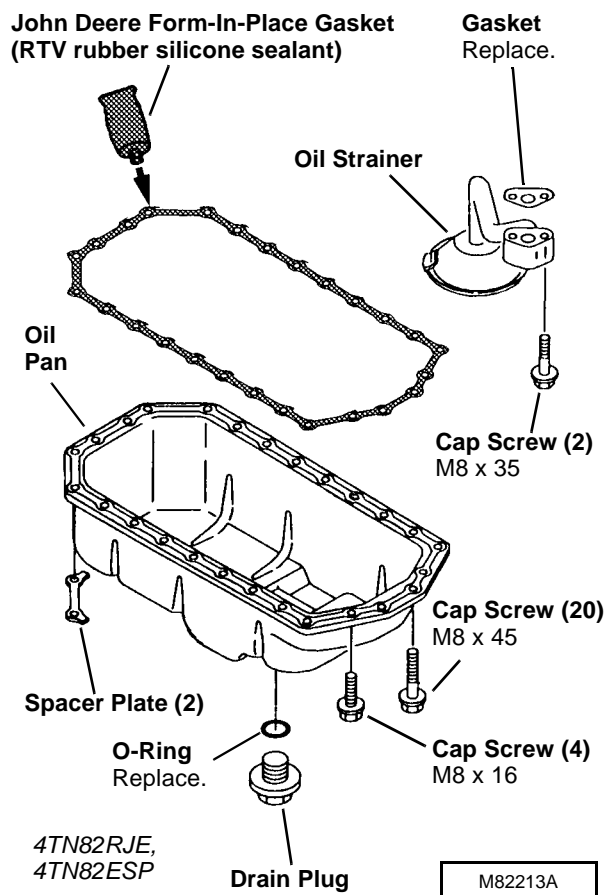
®LOCTITE is a registered trademark of the Loctite Corp.

®TEFLON is a registered trademark of the Du Pont Company.

OIL PAN AND STRAINER

Removal/Installation

- Approximate crankcase oil capacity is:
 - 4TN78T..... 7.5L (8 qt)
 - 4TN82RJK 5.3L (5.6 qt)
 - 4TN82RJE/ESP 5.7L (6 qt)
 - 4TN84RJK 5.3L (5.6 qt)
 - 4TN84(T)(4019)
 - 4019D/TF001 and 005 6.8L (7.1 qt)
 - 4019D/TF006..... 9.5L (9.9 qt)
- Tighten all cap screws to **26 N•m (226 lb-in.)**.
- Fill engine with proper engine oil. (See *SPECIFICATIONS AND GENERAL INFORMATION* section.)



Lubrication System

John Deere Form-In-Place Gasket
(RTV rubber silicone sealant)

Oil Strainer

Gasket

Cap Screw (2)
M8 x 35

Spacer Plate (2)

Oil Pan
(4019D/TF001, 005)

4019D/TF006

Cap Screw (18)
M8 x 45

Cap Screw (4)
M8 x 50

O-Ring
Replace.

Drain Plug

Cap Screw (4)
M8 x 16

4TN84(T)(4019)

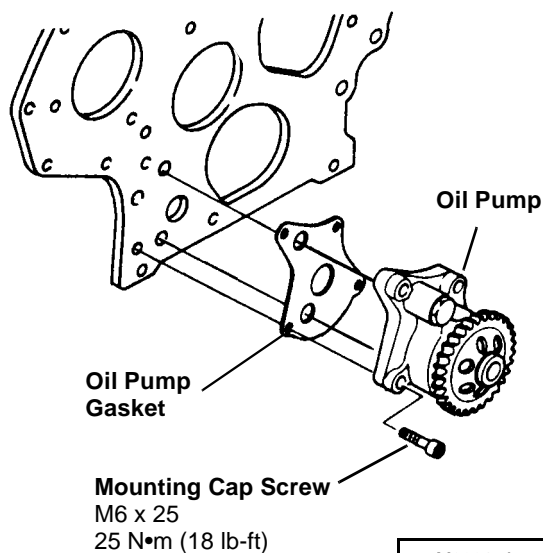
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3

OIL PUMP

Removal/Installation

1. Remove timing gear cover. (See *Camshaft and Timing Gear Train* in this section.)
2. Check oil pump gear backlash. Replace entire oil pump assembly if backlash is more than **0.25 mm (0.010 in.)**.
3. Remove four mounting cap screws, oil pump and gasket.
4. Inspect all parts for wear or damage. (See *Disassembly/Assembly* procedures).



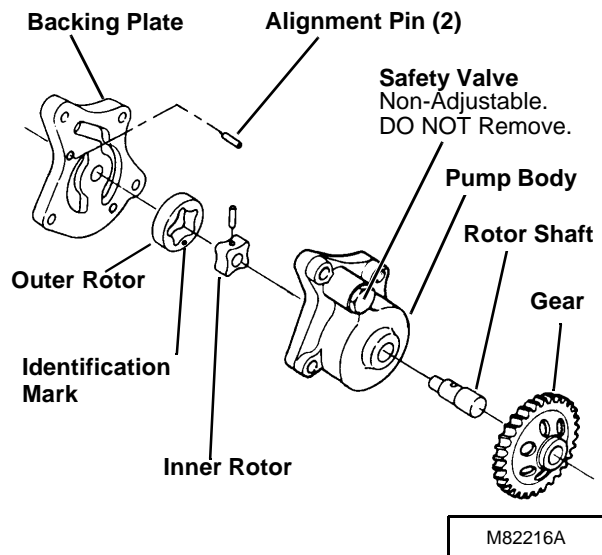
Disassembly/Assembly

- Gear is press fit on rotor shaft. Remove gear using a knife edge puller and a press.

NOTE: Safety valve is on 4TN78T and 4TN84T (4019TF001 and 005) only.

- Inspect parts for wear or damage. (See *Inspection* procedures.)
- Coat all parts with clean engine oil.

- Install outer rotor with identification mark facing toward rotor shaft assembly.



Inspection

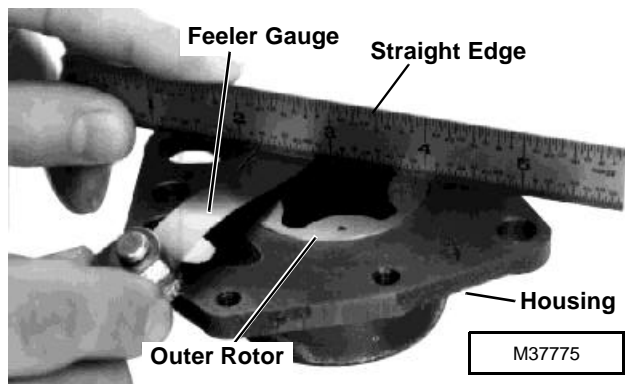
- Check rotor shaft outer diameter and the shaft hole diameter in backing plate. If clearance is more than wear limit, replace entire assembly

Rotor Shaft and Plate Clearance:

Standard 0.015 - 0.048 mm
 (0.0006 - 0.0035 in.)

Wear Limit..... 0.20 mm (0.0078 in.)

- Check rotor recess. If rotors are below face of pump housing more than wear limit, replace rotor assembly.



Rotor Recess - 4TN78T:

Standard 0.05 - 0.10 mm
 (0.0020 - 0.0039 in.)

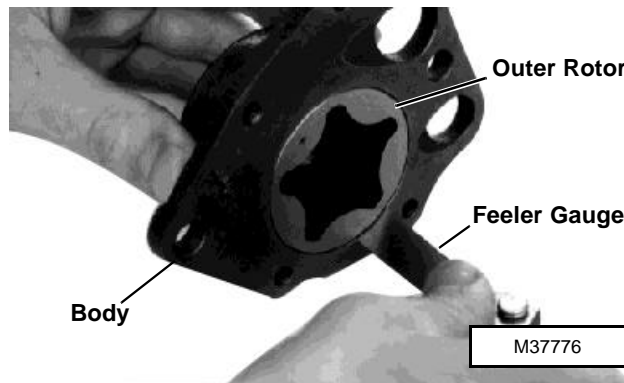
Wear Limit..... 0.15 mm (0.0059 in.)

Rotor Recess - 4TN82, 4TN84(T)(4019):

Standard 0.03 - 0.09 mm
 (0.0011 - 0.0035 in.)

Wear Limit..... 0.15 mm (0.0059 in.)

- Check outer rotor-to-pump body clearance. If clearance is more than wear limit, replace entire assembly



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Outer Rotor-to-Pump Body Clearance - 4TN78T:

Standard 0.09 - 0.16 mm
 (0.0035 - 0.0063 in.)

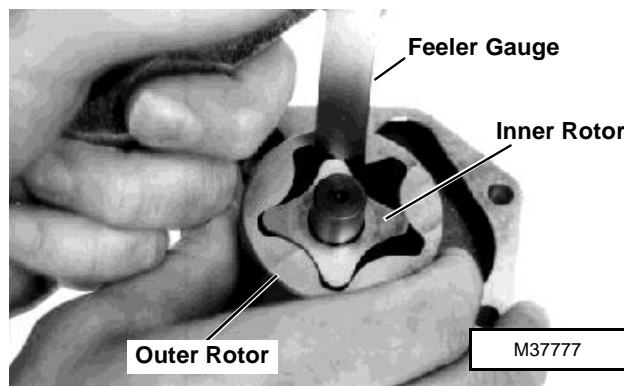
Wear Limit..... 0.25 mm (0.0098 in.)

Outer Rotor-to-Pump Body Clearance - 4TN82, 4TN84(T)(4019):

Standard 0.10 - 0.17 mm
 (0.0039 - 0.0067 in.)

Wear Limit..... 0.25 mm (0.0098 in.)

- Check inner-to-outer rotor clearance. If clearance is more than wear limit, replace rotor assembly.



Lubrication System

Inner-to-Outer Rotor Clearance - 4TN78T:

Standard 0.02 - 0.04 mm

.....(0.0008 - 0.0016 in.)

Wear Limit..... 0.15 mm (0.0059 in.)

Inner-to-Outer Rotor Clearance - 4TN82, 4TN84(T)(4019):

Standard 0.05 - 0.105 mm

.....(0.0019 - 0.0041 in.)

Wear Limit..... 0.15 mm (0.0059 in.)

OIL COOLER - 4TN78T AND 4TN84T (4019TF001 and 005)

3 NOTE: 4TN84T(4019TF001 and 005):
Approximate cooling system capacity is
4.7L (4.9 qt).

1. 4TN84T(4019TF001 and 005): Drain cooling system.
2. Remove oil filter.

3. Disconnect coolant hoses.
4. Remove mounting bolt, oil cooler and o-rings.
5. Remove three cap screws, oil filter mounting block and gasket.

NOTE: See OIL PRESSURE REGULATING VALVE if service is necessary.

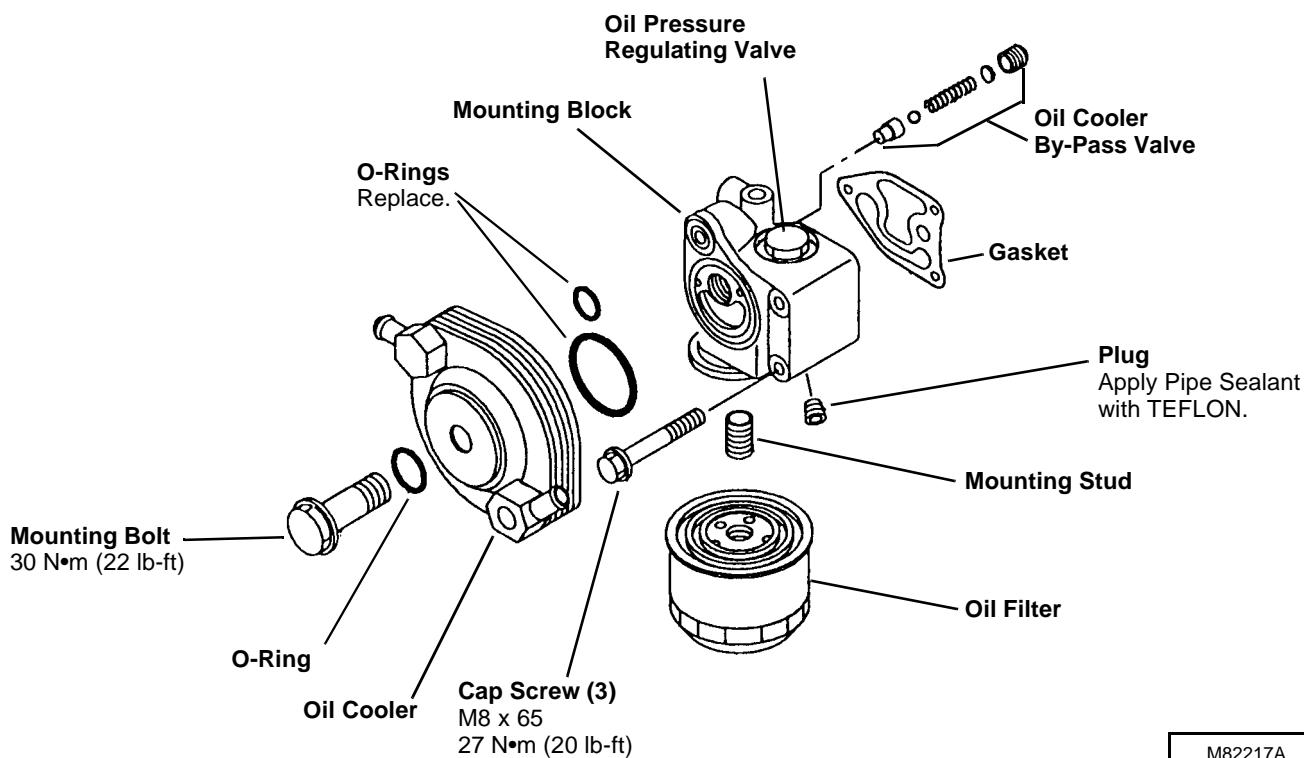
6. Inspect all parts for wear or damage. Replace as necessary.

NOTE: Oil cooler bypass valve components are not serviced separately. Bypass valve and mounting block are replaced as an assembly. Remove parts only to inspect for wear or damage.

7. Pressure test oil cooler. (See Checks, Tests and Adjustments in this section.)

Installation is done in reverse order of removal.

- Close drain valve and fill radiator with proper coolant to top of filler neck. (See SPECIFICATIONS AND GENERAL INFORMATION section.)

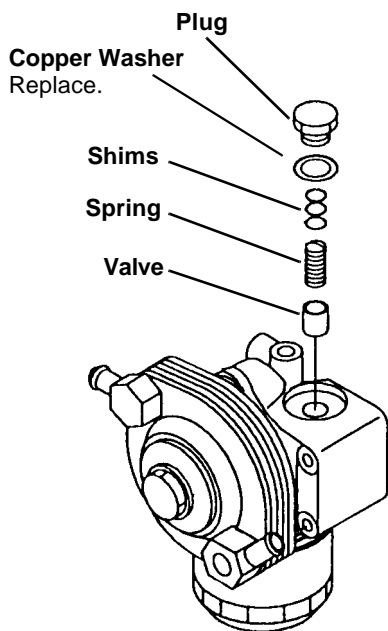


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OIL PRESSURE REGULATING VALVE - 4TN78T AND 4TN84T (4019TF001 and 005)

Removal/Installation

- Inspect all parts for wear or damage. Replace as necessary.



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OIL PRESSURE REGULATING VALVE - 4TN82, 4TN84 (4019DF) AND 4TN84T (4019TF006)

Removal/Installation

1. Remove oil filter.
2. Remove three cap screws, valve assembly and gasket.

NOTE: If adjusting engine oil pressure, retaining nut need not be removed.

3. If adjusting pressure only, remove cap and add shims. Each 1 mm (0.039 in.) of shim thickness increases oil pressure 15.6 kPa (2.3 psi).

NOTE: Valve components are not serviced individually. Replace complete regulating valve if any components are defective.

3

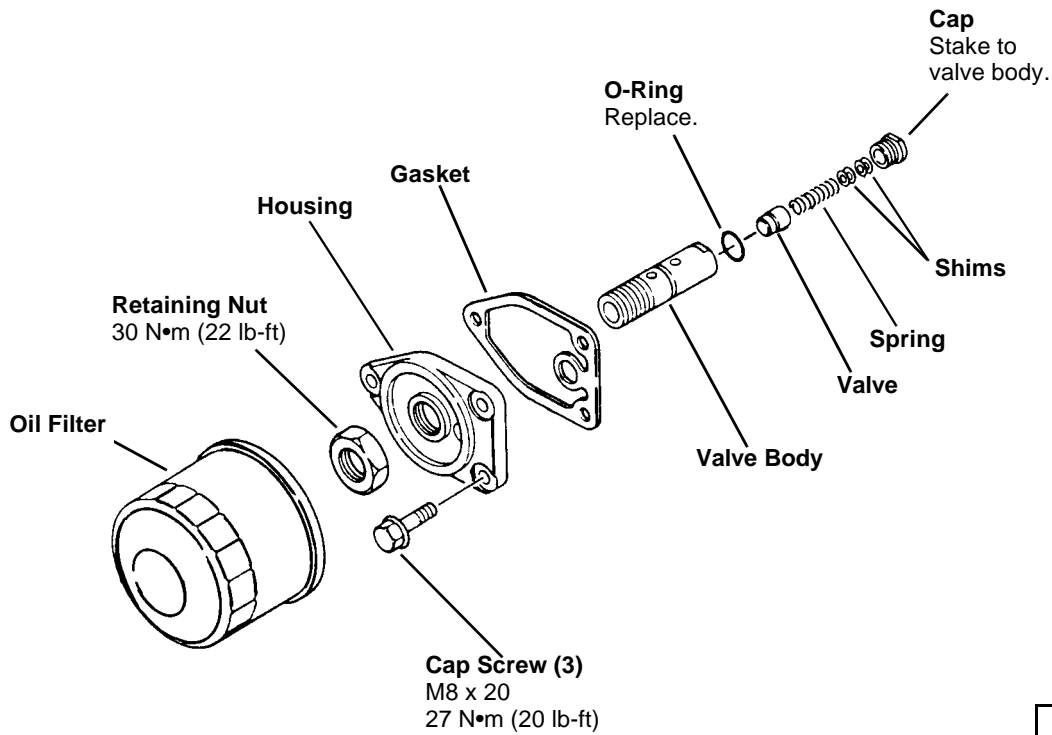
4. Inspect all parts for wear or damage. Replace complete valve if necessary.
5. Check spring free and compressed length.

Spring Specifications:

Free Length 46 mm (1.810 in.)

**Compressed Length . . . 27.50 mm (1.080 in.)
 @ 20.5 N (4.6 lb-force)**

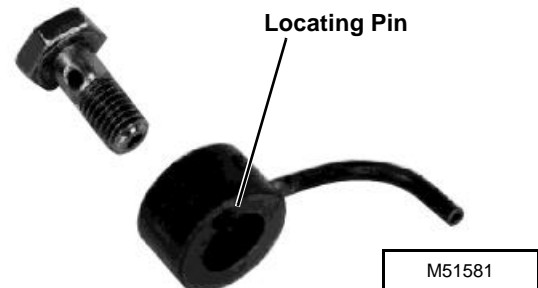
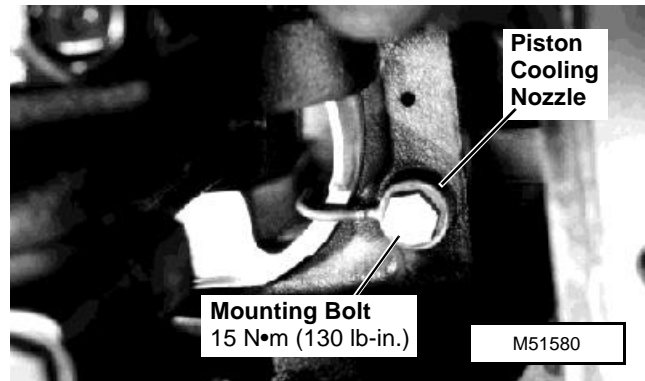
Installation is done in the reverse order of removal.



PISTON COOLING NOZZLES - 4TN78T AND 4TN84T (4019TF001 and 005)

Replacement

1. Remove oil pan and strainer. (See procedure in this group.)
 - Install nozzle with locating pin in locating hole of cylinder block.



OTHER MATERIALS

Number	Name	Use
LOCTITE® PRODUCTS U.S./ Canadian/ LOCTITE No.	John Deere Pipe Sealant with TEFLON®	4TN78T, 4TN82RJE, 4TN82ESP and 4TN84(T)(4019): Apply to threads of plug and nipple in thermostat housing and pipe plug in water pump housing.

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Cooling System

COOLANT TEMPERATURE SWITCH

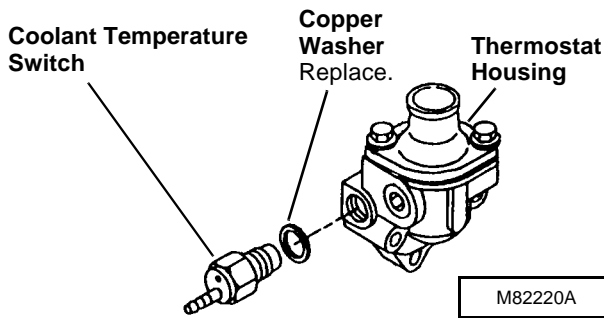
Replacement

NOTE: Some engines may also be equipped with a coolant temperature sender. Sender is located opposite of switch in thermostat housing. Replacement procedures are the same.

1. Disconnect wiring lead, if equipped.
2. Open engine drain valve to drain coolant.
3. Remove switch and washer.
4. Test switch. (See *Checks, Tests and Adjustments* in this section.)

Installation is done in reverse order of removal.

3

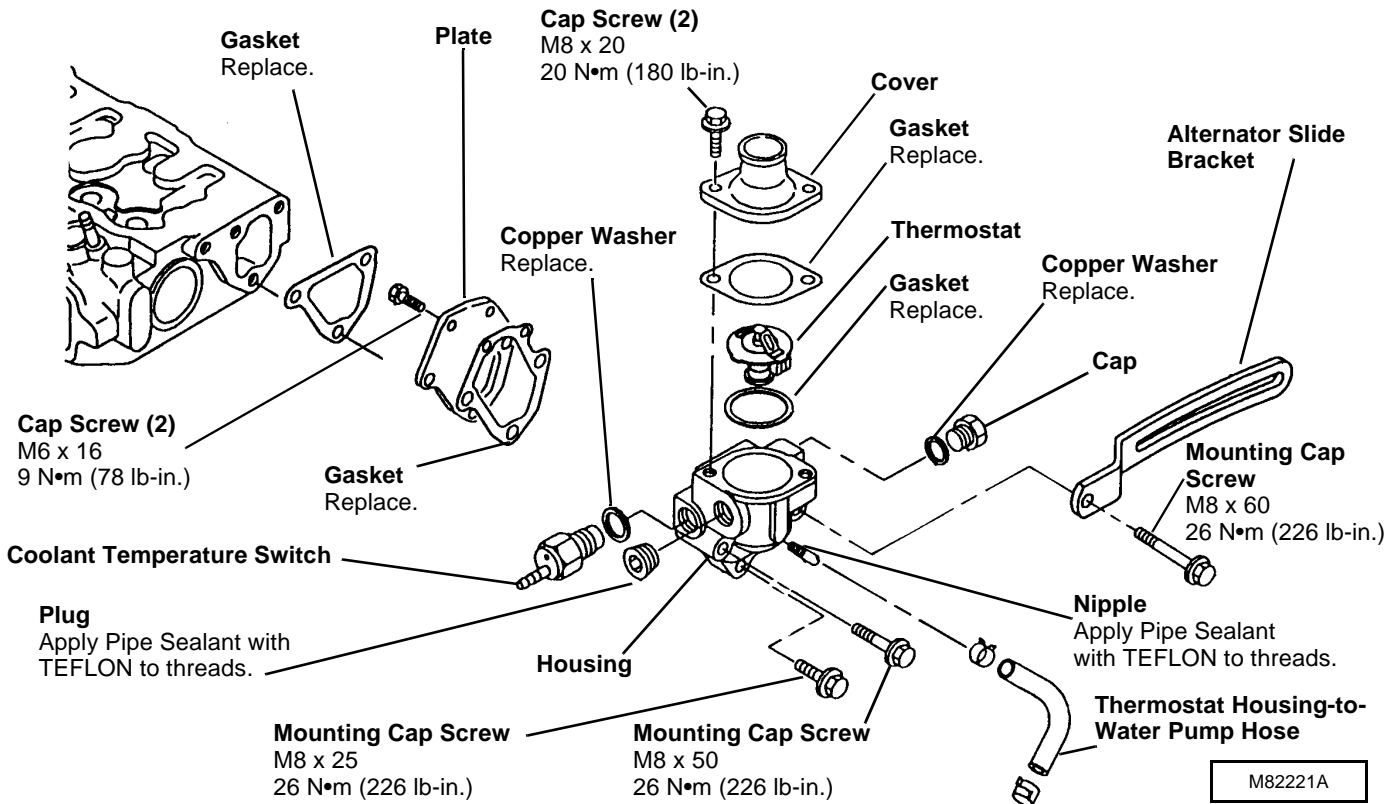


THERMOSTAT AND HOUSING - 4TN78T, 4TN82RJE, 4TN82ESP AND 4TN84(T) (4019)

1. Drain engine coolant.
2. Remove upper radiator hose, if equipped.
3. Disconnect coolant temperature switch/sender wiring lead(s).
4. Loosen alternator-to-bracket mounting cap screw.
5. Loosen clamps and remove thermostat housing-to-water pump hose.
6. Remove mounting cap screws, housing and gasket.
7. Inspect all parts for wear or damage. Replace as necessary.
8. Test thermostat. (See *Checks, Tests and Adjustments* in this section.)

Installation is done in reverse order of removal.

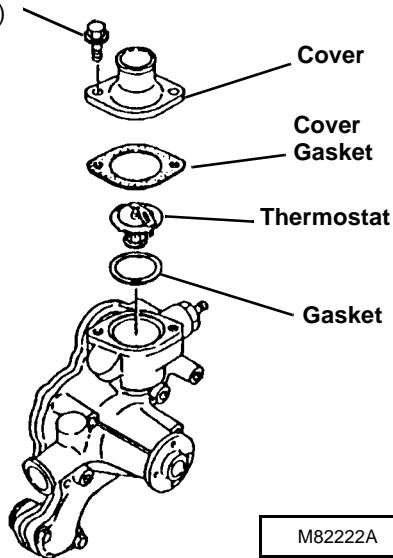
- Adjust fan/alternator drive belt tension. (See *Checks, Tests and Adjustments* in this section.)



THERMOSTAT - 4TN82RJK AND 4TN84RJK

- Replace gaskets.
- Test thermostat. (See *Checks, Tests and Adjustments* in this section.)

Cap Screw (2)
M8 x 20
20 N•m (180 lb-in.)

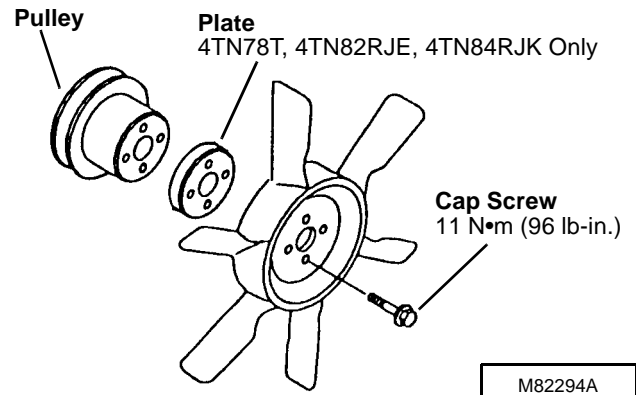


WATER PUMP - 4TN78T, 4TN82RJE, 4TN82ESP AND 4TN84(T) (4019)

Removal/Installation

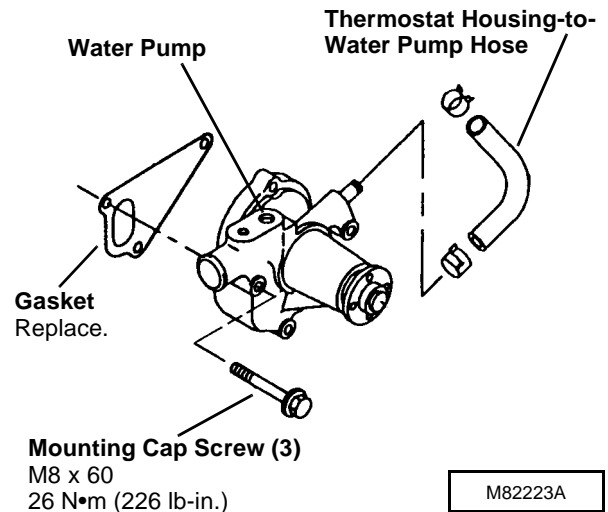
1. Drain engine coolant.
2. Remove fan/alternator belt.
3. 4TN78T, 4TN82RJE, 4TN82ESP, 4TN84RJK: Remove fan, plate, if equipped, and pulley.

4TN84(T) (4019): Remove cooling fan. (See procedure in *ACCESSORIES - SERIES 220 POWER UNIT ENGINES* section.)



4. Remove lower radiator hose, if equipped.
5. Loosen clamps and remove thermostat housing-to-water pump hose.
6. Remove three mounting cap screws, pump and gasket.
7. Inspect all parts for wear or damage. (See *Disassembly/Assembly* procedures.)

Installation is done in the reverse order of removal.

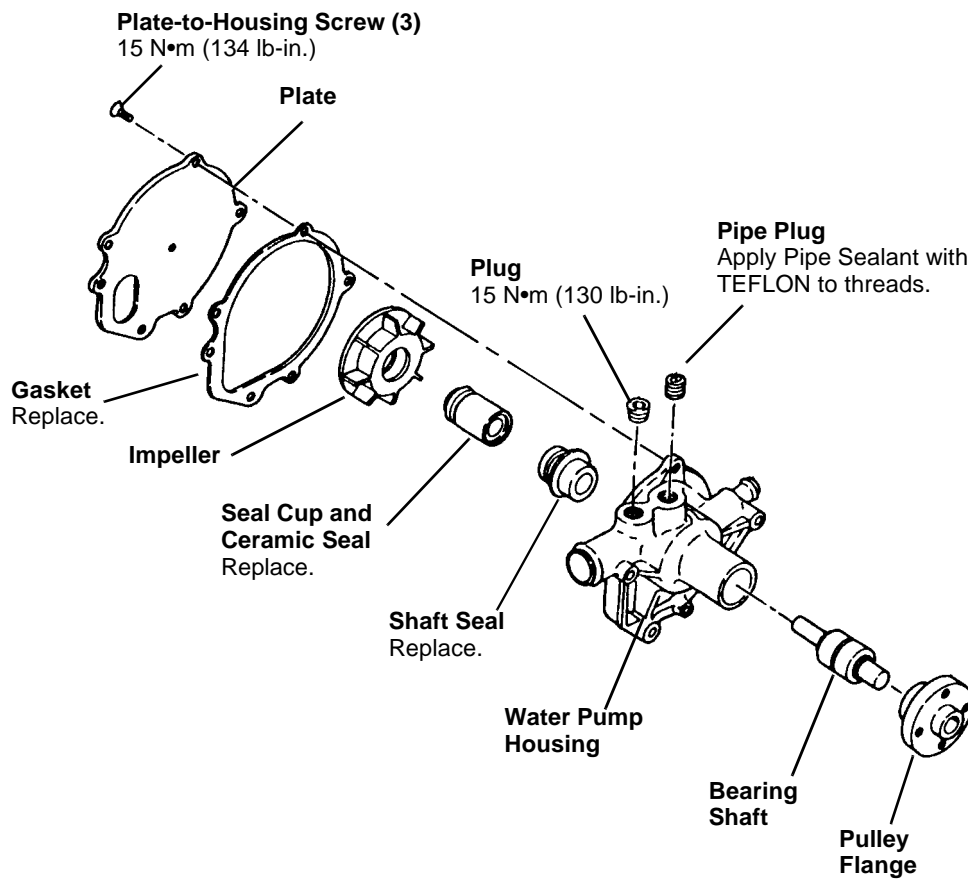


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Cooling System

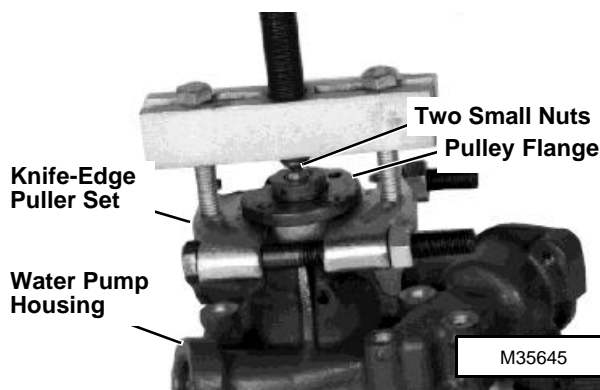
Disassembly

1. Apply heat to three plate-to-housing screws.
Remove screws, plate and gasket



3

2. Apply extreme heat to pulley flange. Remove flange using a knife-edge puller set and two small nuts.



3. Place water pump assembly on a press table. Install supports under water pump housing, staying clear of impeller. Press bearing shaft assembly through water pump housing using a piece of pipe or a deep socket.

IMPORTANT: Impeller bore is tapered. When pressing bearing shaft from impeller, allow enough clearance between cap screw and impeller bore to prevent cap screw from binding.

4. Remove impeller from bearing shaft using a knife-edge puller, a 3/8 in. cap screw and a press.
5. Remove shaft seal, ceramic seal and seal cup.
6. Inspect all parts for wear or damage. Replace as necessary.

Assembly

1. Install bearing shaft into pump housing, long end down, using a piece of pipe or deep socket and a press. Press shaft into pump housing until bearing surface is flush with pump housing surface.
2. Install new shaft seal over impeller side of bearing shaft, rubber seal side away from pump housing. Push shaft seal into pump housing, until it stops, using a 25 mm or 1 in. socket and a press.

IMPORTANT: Support pump housing on bearing shaft only. DO NOT support on housing or damage to housing will occur.

3. Place water pump housing on a press table. Support housing on bearing shaft using a driver disk. Install pulley flange onto shaft with straight hub facing away from housing.

4TN82RJE and 4TN82ESP: Press pulley flange onto bearing shaft until **top** of flange is **27 mm (1.060 in.)** from top of housing.

4TN78T and 4TN84(T)(4019): Press pulley flange onto bearing shaft until **bottom** of flange is **17 mm (0.670 in.)** from top of housing.

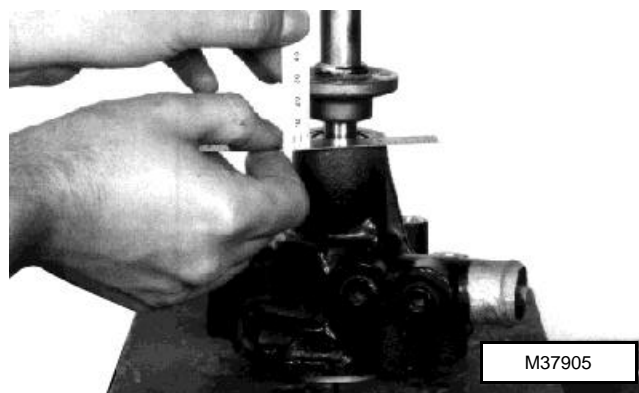
IMPORTANT: DO NOT touch lapped sealing surface of ceramic seal with bare hands. It must be clean and dry.

4. Install seal cup and ceramic seal in impeller.

5. Install a knife-edge puller around bearing shaft, between pulley flange and pump housing. Place pump housing, with knife-edge puller down, on a press table. Install impeller with ceramic seal toward shaft seal.

4TN82RJE and 4TN82ESP: Press impeller on bearing shaft until top of impeller is **1 mm (0.040 in.)** below housing.

4TN78T and 4TN84(T)(4019): Press impeller on bearing shaft until top of impeller is **2 mm (0.080 in.)** below housing.



6. Install new gasket, plate, three screws, two cap screws and nuts. Tighten to specifications.

Cooling System

WATER PUMP - 4TN82RJK AND 4TN84RJK

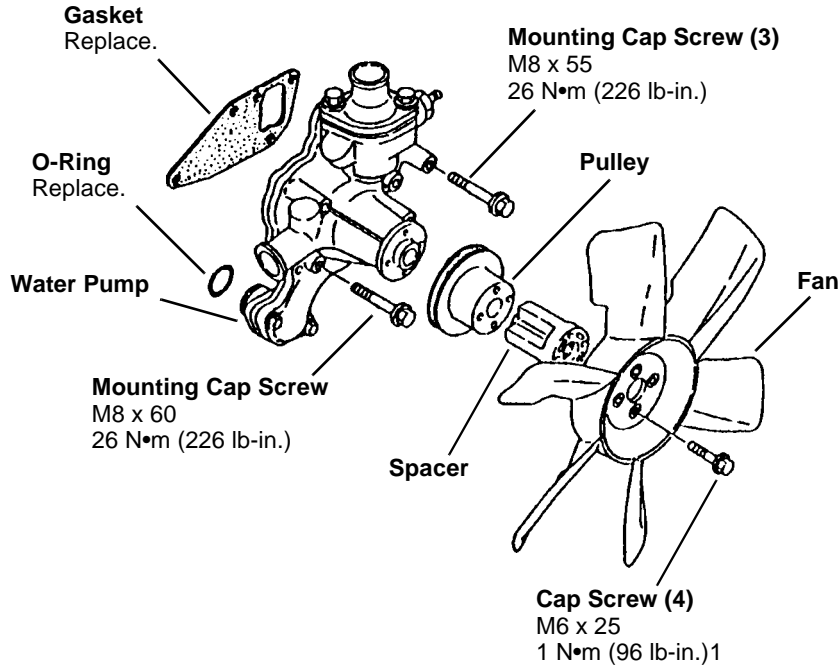
Removal/Installation

1. Open engine drain valve to drain coolant.
2. Remove fan/alternator drive belt.

3. Remove four cap screws, fan, spacer and pulley.
4. Remove four mounting cap screws, pump and gasket.
5. Inspect all parts for wear or damage. (See *Disassembly/Assembly* procedures.)

Installation is done in the reverse order of removal.

- Adjust fan/alternator drive belt tension. (See *Checks, Tests and Adjustments* in this section.)

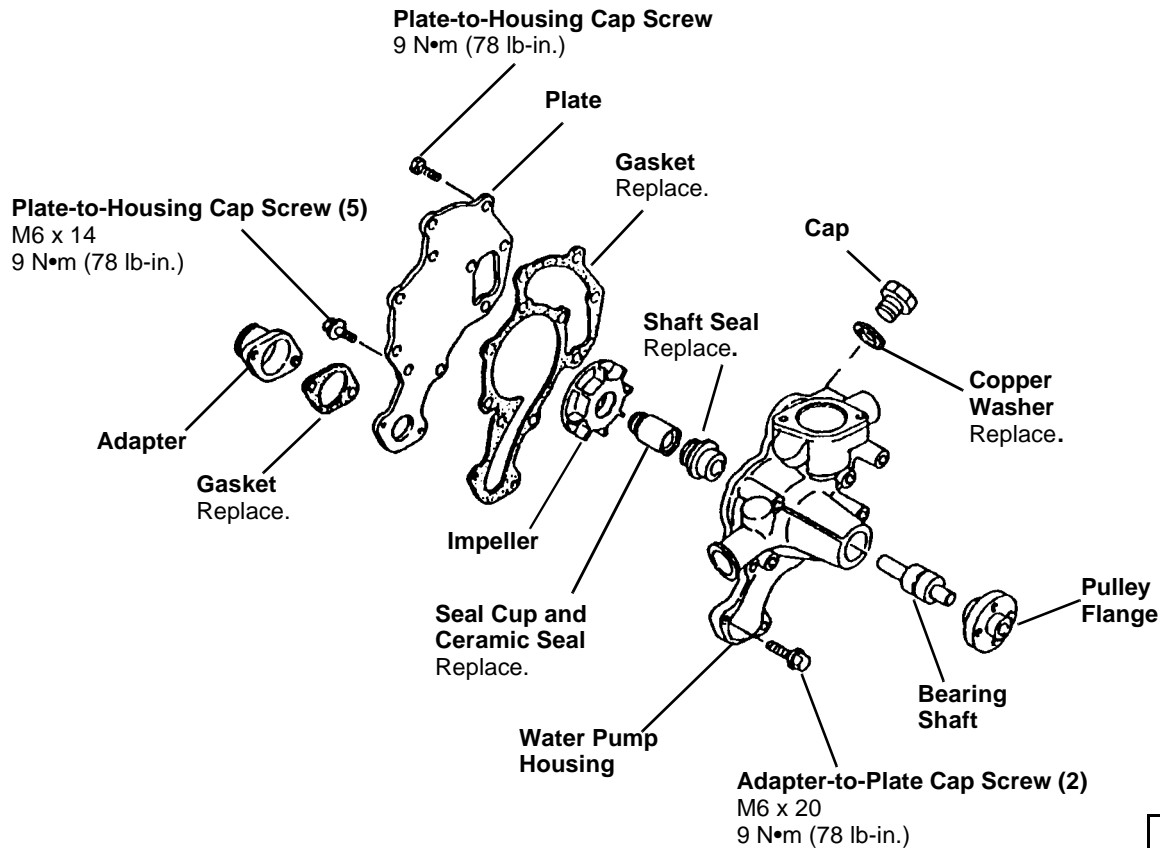


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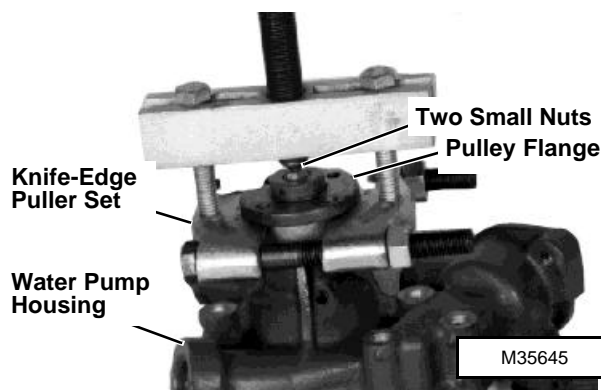
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Disassembly

1. Remove thermostat. (See procedure in this group.)
2. Remove coolant temperature switch. (See procedure in this group.)
3. Remove two cap screws, adapter and gasket.
4. Apply heat to six plate-to-housing cap screws. Remove cap screws, plate and gasket.



5. Apply extreme heat to pulley flange. Remove flange using a knife-edge puller set and two small nuts.
6. Place water pump assembly on a press table. Install supports under water pump housing, staying clear of impeller. Press bearing shaft assembly through water pump housing using a piece of pipe or a deep socket.



IMPORTANT: Impeller bore is tapered. When pressing bearing shaft from impeller, allow enough clearance between cap screw and impeller bore to prevent cap screw from binding.

Cooling System

7. Remove impeller from bearing shaft using a knife-edge puller, a 3/8 in. cap screw and a press.
8. Remove shaft seal, ceramic seal and seal cup.
9. Inspect all parts for wear or damage. Replace as necessary.

Assembly

1. Install bearing shaft into pump housing, long end down, using a piece of pipe or deep socket and a press. Press shaft into pump housing until bearing surface is flush with pump housing surface.
2. Install new shaft seal over impeller side of bearing shaft, rubber seal side away from pump housing. Push shaft seal into pump housing, until it stops, using a 25 mm or 1 in. socket and a press.

3

IMPORTANT: Support pump housing on bearing shaft only. DO NOT support on housing or damage to housing will occur.

3. Place water pump housing on a press table. Support housing on bearing shaft using a driver disk. Install pulley flange onto shaft with straight hub facing away from housing.

4TN82RJK: Press pulley flange onto bearing shaft until **top** of flange is **27 mm (1.060 in.)** from top of housing.

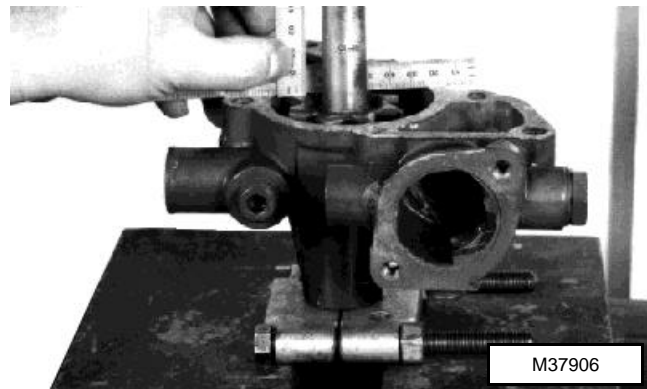
4TN84RJK: Press pulley flange onto bearing shaft until **bottom** of flange is **17 mm (0.670 in.)** from top of housing.

IMPORTANT: DO NOT touch lapped sealing surface of ceramic seal with bare hands. It must be clean and dry.

4. Install seal cup and ceramic seal in impeller.
5. Install a knife-edge puller around bearing shaft, between pulley flange and pump housing. Place pump housing, with knife-edge puller down, on a press table. Install impeller with ceramic seal toward shaft seal.

4TN82RJK: Press impeller on bearing shaft until top of impeller is **1 mm (0.040 in.)** below housing.

4TN84RJK: Press impeller on bearing shaft until top of impeller is **2 mm (0.080 in.)** below housing.



6. Install new gasket, plate and six cap screws. Tighten to specifications.
7. Install new gasket, adapter and cap screws. Tighten to specifications.
8. Install coolant temperature switch. (See procedure in this group.)
9. Install thermostat. (See procedure in this group.)

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).

JDF13 Nozzle Cleaning Kit

Use to clean fuel injection nozzles.

SERVICE PARTS KITS

The following kits are available through your parts catalog:

- Cylinder Block Gasket Kit
- Fuel Injection Nozzle Shim Pack

Fuel System

FUEL SUPPLY PUMP - IF EQUIPPED

Replacement

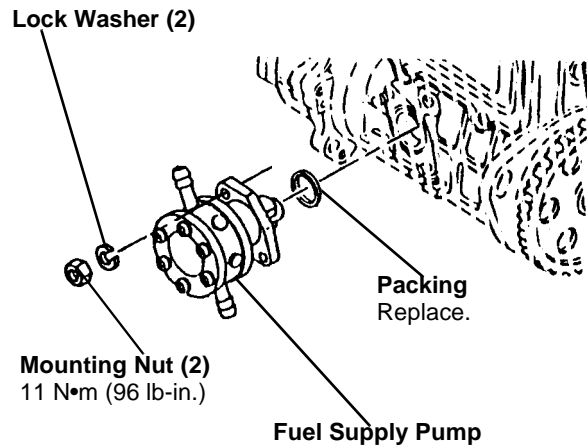
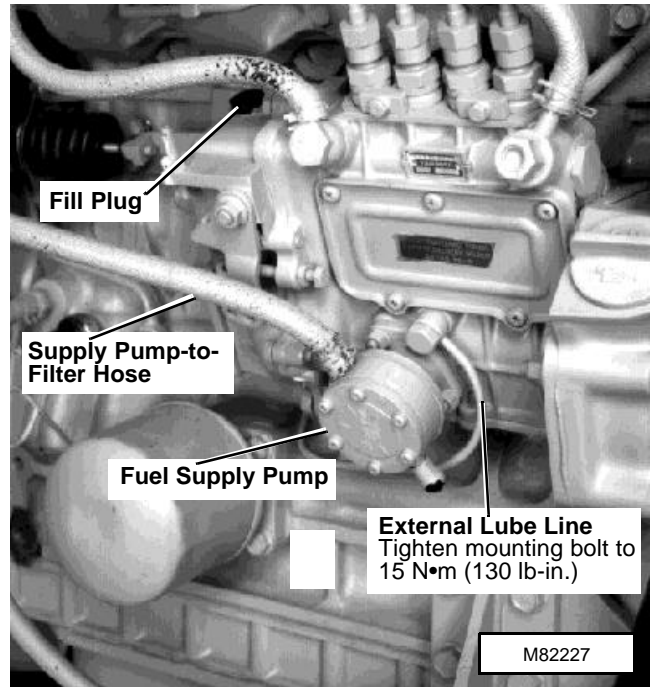
NOTE: 4TN78T, 4TN82RJE and 4TN82ESP engines are not equipped with a fuel supply pump.

Oil will leak out of fuel injection pump housing when supply pump is removed.

IMPORTANT: If oil has been drained out of fuel injection pump housing, add oil as necessary. Fuel injection pump can become damaged if operated dry or without proper amount of oil.

After fuel supply pump is installed, disconnect external lube line to fuel injection pump housing. Remove fill plug and add clean engine oil to housing. Add until oil begins to drip out of lube line hole (For proper oil specification see *SPECIFICATIONS AND GENERAL INFORMATION* section.)

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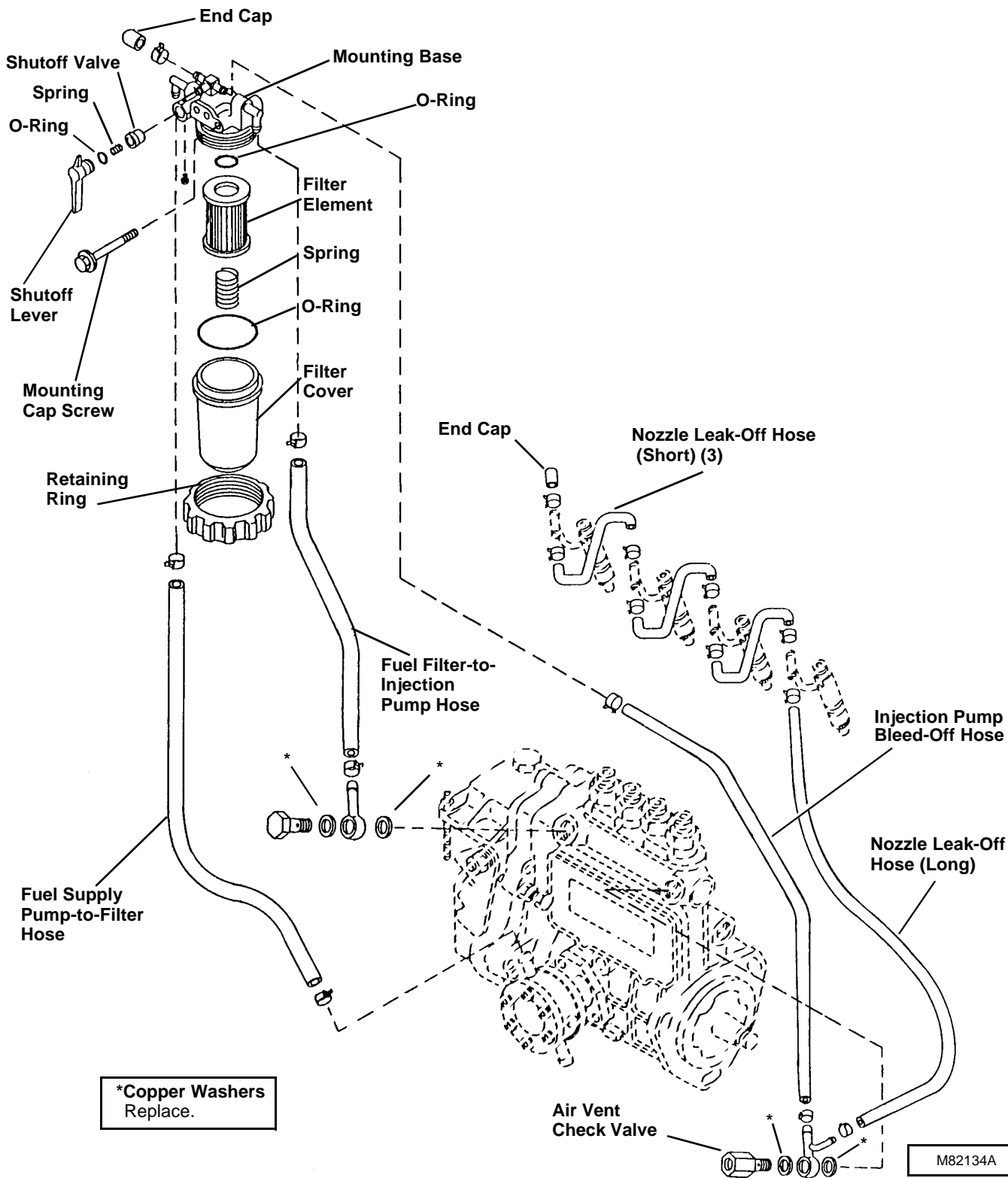
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FUEL FILTER ASSEMBLY - IF EQUIPPED

IMPORTANT: Replace all copper washers. Damaged or used washers may leak.

NOTE: Fuel filter assemblies will be slightly different for each engine model depending on engine application. 4TN84(T) (4019 OEM) shown.

3



FUEL INJECTION PUMP

Removal

CAUTION

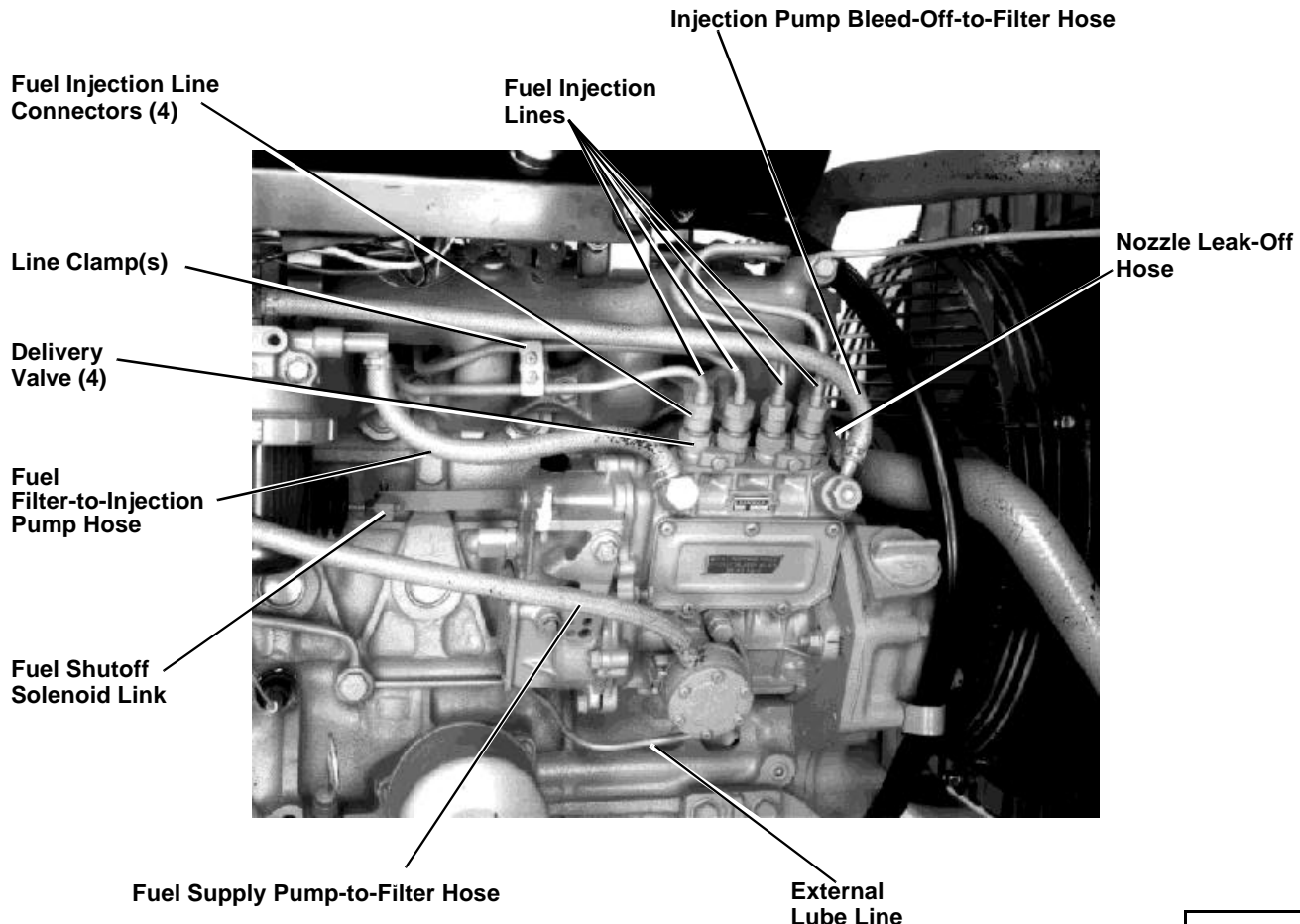
Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.

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

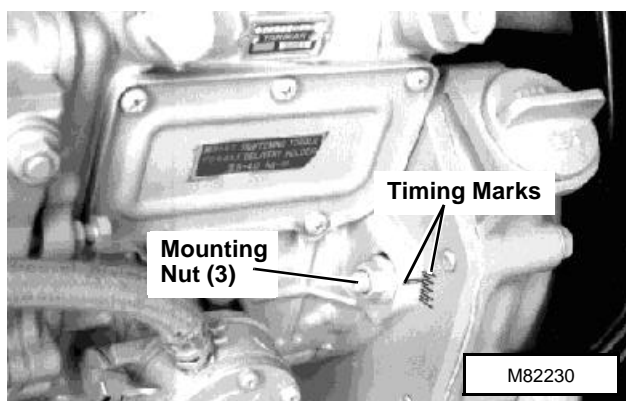
3

IMPORTANT: Never steam clean or pour cold water on injection pump while the pump is running or warm. Doing so can damage the pump.

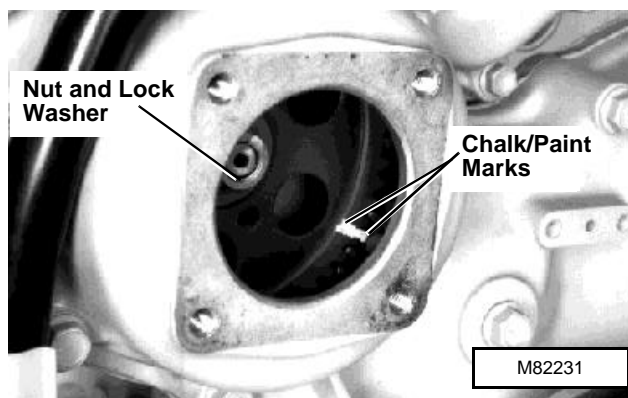
1. Clean the injection pump lines and area around the pump using a parts cleaning solvent or steam cleaner.
2. Loosen fuel injection line connectors slightly to release pressure in the fuel system. When loosening connectors, use another wrench to keep delivery valves from loosening.
3. Loosen line clamp(s) and remove fuel injection lines.
4. Disconnect hoses to/from fuel filter, if equipped.
5. Remove external lube line.
6. Disconnect fuel shutoff solenoid link.
7. Note position of timing marks on injection pump and gear cover mounting plate.
8. Remove three mounting nuts.



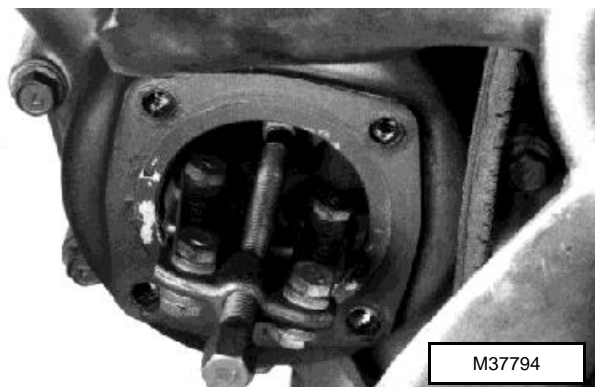
M82229



9. Remove fan guard, if equipped.
10. Remove four cap screws, washers, cover and gasket.
11. Use chalk or paint to mark injection pump gear to idler gear.
12. Remove nut and lock washer.



13. Pull gear from injection pump shaft using a two jaw puller.

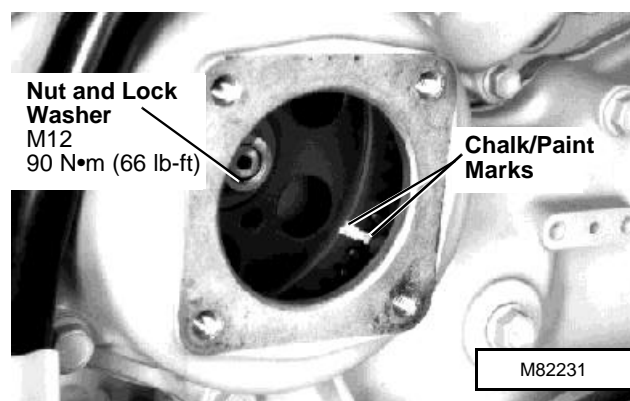


14. Remove injection pump and o-ring.

DO NOT attempt to service the injection pump or governor. If unit is in need of repair, it must be serviced by a qualified fuel injection repair shop. If replacement is necessary, replace entire unit.

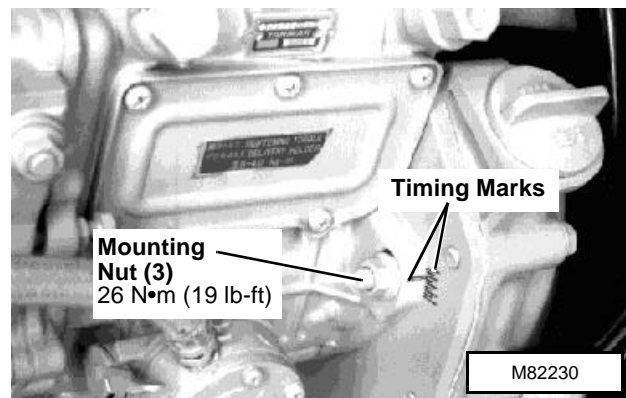
Installation

1. Install new o-ring on injection pump.
2. Put injection pump onto back of gear cover mounting plate. Align key on shaft with keyway in gear. Be sure to align marks on gears made during removal.
3. Install lock washer and nut. Tighten to specification.



3

4. Install new gasket, cover, four washers and cap screws.
5. Install fan guard, if equipped.
6. Install three mounting nuts. Do not tighten.
7. Align marks on mounting plate and injection pump, to same place as when removed, and tighten mounting nuts to specifications.



8. Connect fuel shutoff solenoid link.
9. Connect hoses to/from fuel filter.

Fuel System

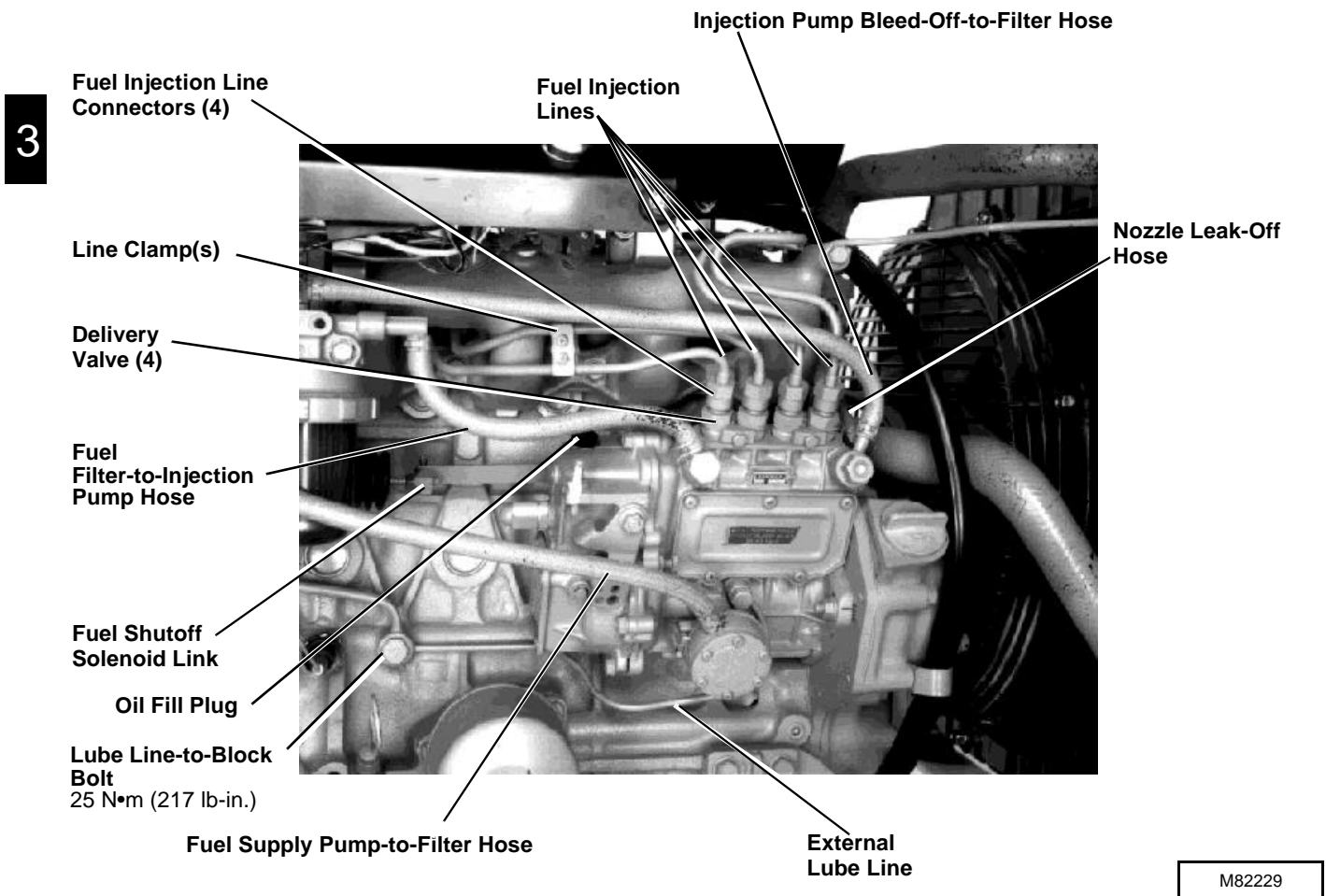
10. Install fuel injection lines and tighten line clamp cap screws.

IMPORTANT: If oil has been drained out of fuel injection pump housing, add oil as necessary. Fuel injection pump can become damaged if operated dry or without proper amount of oil.

11. Remove fill plug and add clean engine oil to housing. Add until oil begins to drip out of external lube line inlet. (For proper oil specification see *SPECIFICATIONS AND GENERAL INFORMATION* section.)

12. Install external lube line. When installing line, put one copper washer between mounting bolt head and lube line and the other between lube line and housing.

If new injection pump is being installed, check and adjust injection pump static timing. (See *Checks, Tests and Adjustments* in this section.)



FUEL INJECTION NOZZLES (HOLE-TYPE)

Removal/Installation

IMPORTANT: Never steam clean or pour cold water on injection pump while the pump is running or warm. Doing so can damage the pump.

1. Clean the injection pump lines and area around the pump using a parts cleaning solvent or steam cleaner.

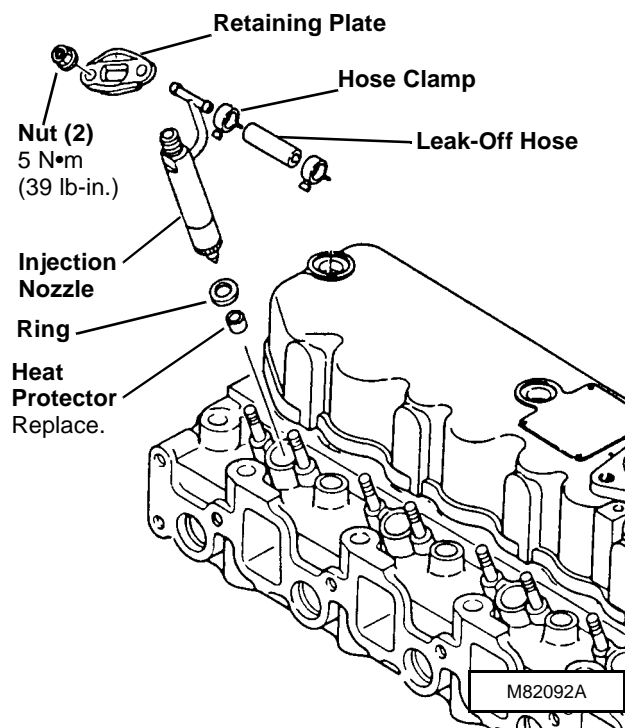
CAUTION

Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.

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

NOTE: Nozzles are matched to the cylinders. If removing more than one nozzle, tag nozzles, according to the cylinder from which it was removed.

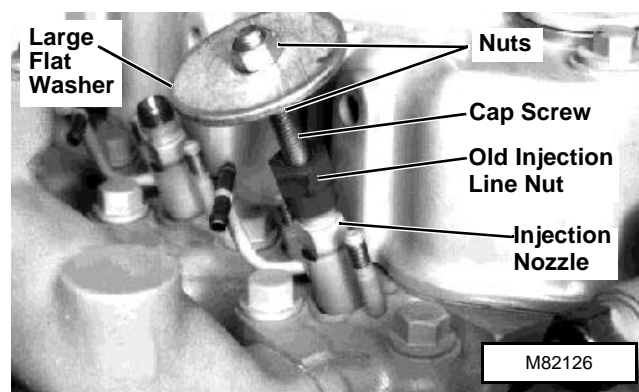
2. Loosen fuel injection line connectors-to-nozzles slightly to release pressure in the fuel system.
3. Loosen line clamp(s) and remove fuel injection lines.
4. Remove clamps and leak-off hoses.
5. Remove nuts and retaining plates.
6. Remove injection nozzle, ring and teflon heat protector. If ring and protector stay in cylinder head, thread a cap screw into protector and pull from cylinder head.



3

If nozzles are stuck in cylinder head:

- Grind the head of a cap screw so it fits inside a nut from an old injection line.
- Use two nuts to attach a large flat washer to the cap screw.
- Install assembly onto nozzle and use a puller and slide hammer to pull nozzle from cylinder head.



7. Test injection nozzles. (See *Checks, Tests and Adjustments* in this section.)

Installation is done in reverse order of removal.

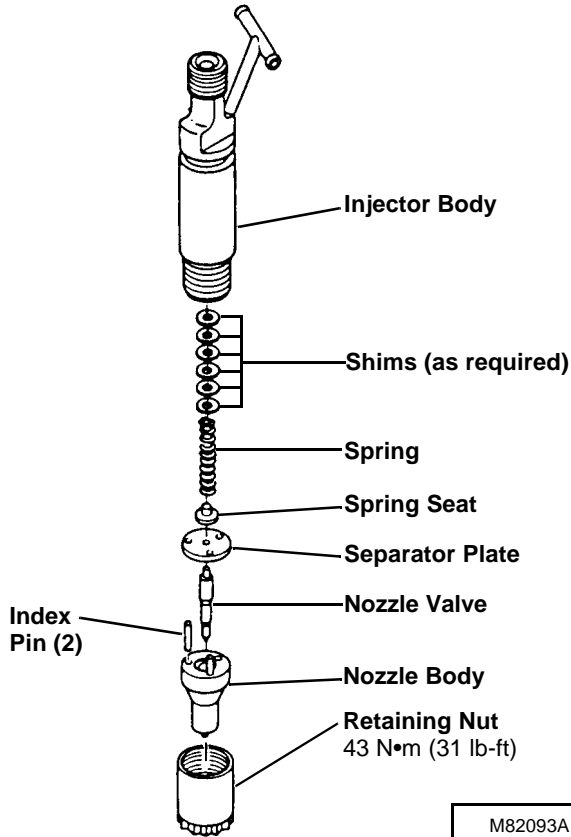
Fuel System

Disassembly/Assembly

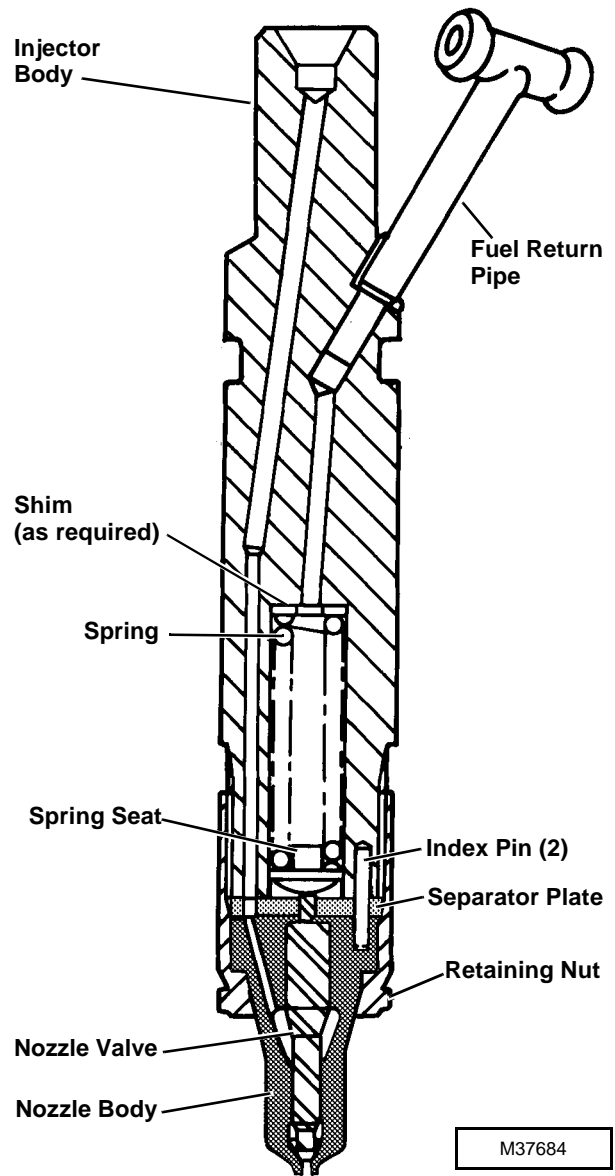
NOTE: If servicing more than one nozzle, keep parts for each nozzle separate from one another.

- Clean and inspect nozzle assembly. (See *Cleaning/Inspection* procedures.)
- After assembly is complete, test injection nozzle. (See *Checks, Tests and Adjustments* in this section.)

3



Cross Section



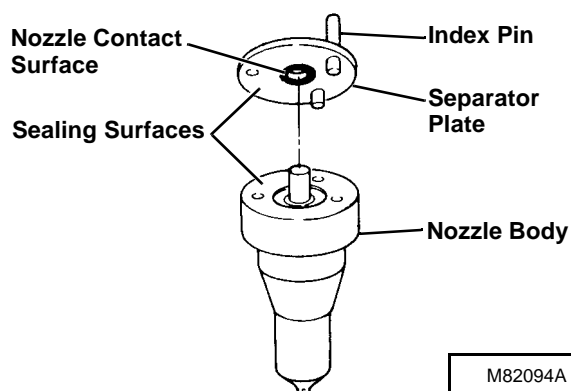
Cleaning/Inspection

NOTE: To clean nozzles properly, JDF13 Nozzle Cleaning Kit is recommended. The Cleaning Kit is available through the John Deere SERVICEGARD™ Catalog.

1. Remove anti-corrosive grease from new or reconditioned nozzles by washing them thoroughly in diesel fuel.

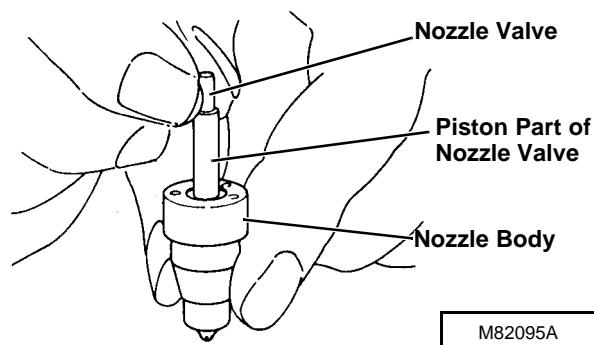
IMPORTANT: Never use a steel brush to clean nozzles as this will distort the spray hole.

2. Remove carbon from used nozzles, and clean by washing in diesel fuel. If parts are coated with hardened carbon or lacquer, it may be necessary to use a brass wire brush (supplied in Nozzle Cleaning Kit).
3. After removing carbon or lacquer from the exterior of nozzle, inspect sealing surfaces between separator plate and nozzle body for nicks or scratches.
4. Inspect condition of separator plate and nozzle body. Contact area of separator plate (both parts) must not be scored or pitted. Use an inspection magnifier (No. 16487 or equivalent) to aid in making the inspection.
5. Check nozzle contact surface on separator plate for wear. If contact surface is more than **0.10 mm (0.0039 in.)**, replace nozzle assembly.



6. Inspect the piston (large) part of nozzle valve to see that it is not scratched or scored and that lower (tip) end of valve is not broken. If any of these conditions are present, replace the nozzle assembly.
7. Further inspect the nozzle assembly by performing a slide test. Use the following procedure:
 - Dip the nozzle valve in clean diesel fuel. Insert valve in nozzle body.
 - Hold nozzle vertical, and pull valve out about 1/3 of its engaged length.
 - Release valve. Valve should slide down to its seat by its own weight.

Replace nozzle assembly if the valve does not slide freely to its seat.



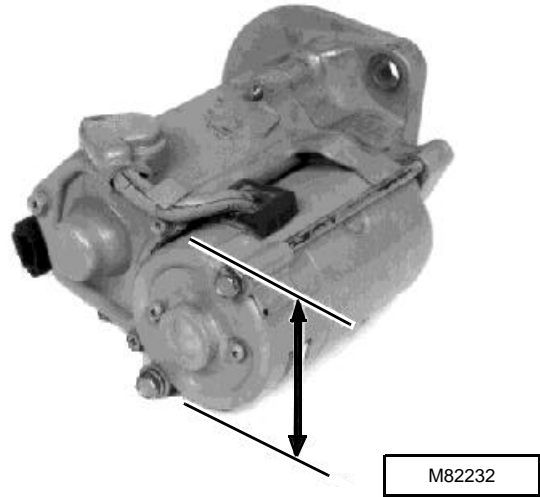
3

Starter

STARTER IDENTIFICATION CHART

The various starters covered in this group are identified by manufacturer and output rating.

To help identify the starters, measure the outside diameter of the motor.



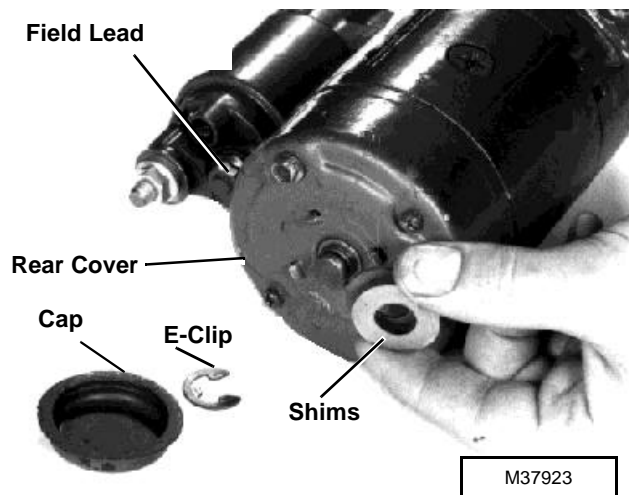
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Manufacturer	Rated Output	Motor Outside Diameter
Hitachi	0.8 kW	N/A
Hitachi	2.0 kW	80 mm (3.150 in.)
Nippondenso	1.0 kW	68 mm (2.680 in.)
Nippondenso	1.4 kW	76 mm (3.000 in.)

STARTER - HITACHI 0.8 kW

Disassembly/Inspection

1. Disconnect field lead.
2. Remove two cap screws and two screws from rear cover.
3. Pry off plastic cap.
4. Remove e-clip, shims and rear cover.

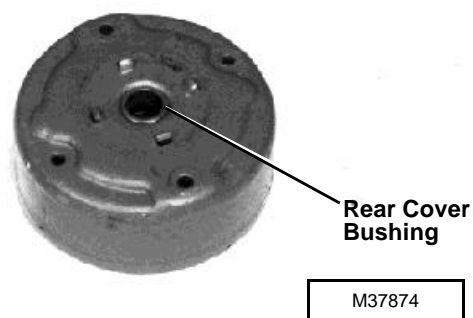


5. Inspect cover bushing for wear or damage. Replace if necessary.

To replace bushing:

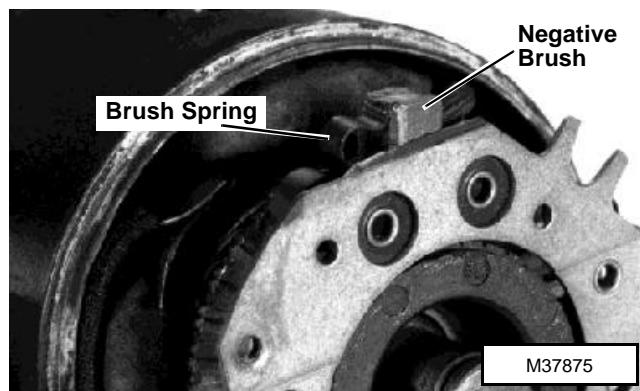
Remove bushing using a blind-hole puller set. Install new bushing until it bottoms in cover bore using a driver set.

Ream out bushing to **12.50 - 12.53 mm (0.492 - 0.493 in.)**.

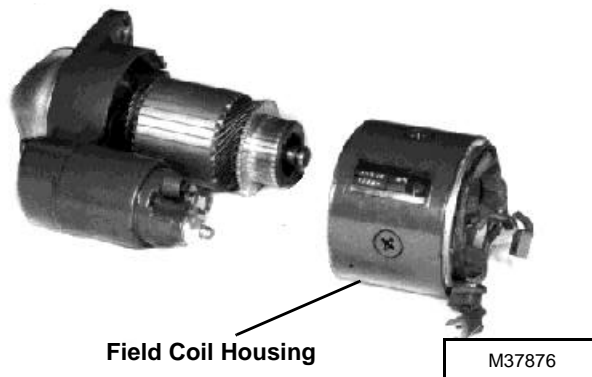


6. Remove field coil brushes from brush holder.
7. Pry brush springs away and pull negative brushes up enough to allow spring to hold brush in place.

8. Remove brush holder.

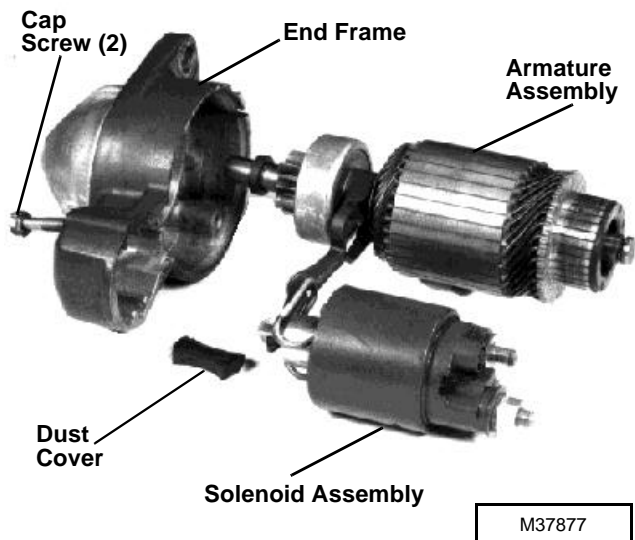


9. Remove field coil housing from armature/solenoid assembly.



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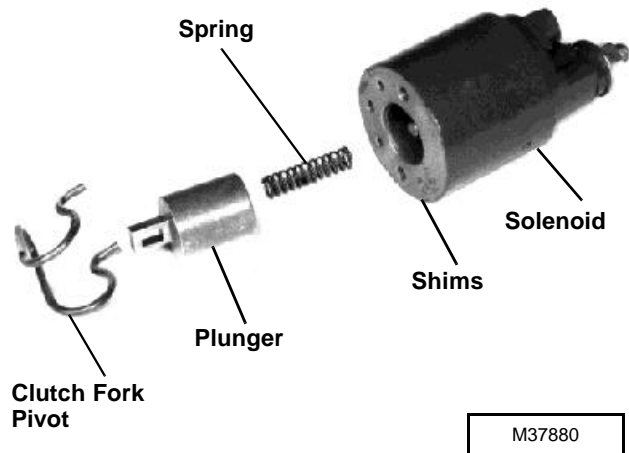
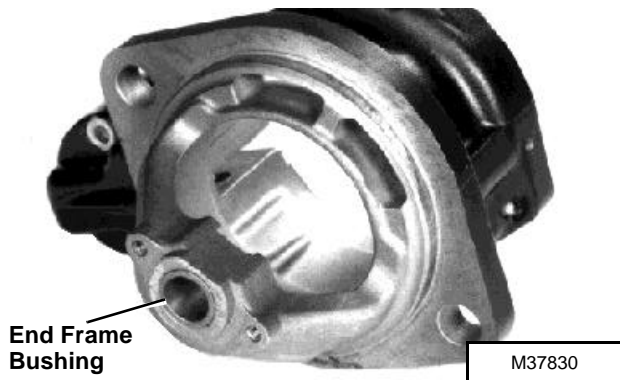
10. Remove two cap screws and pivot bolt, if equipped.
11. Remove dust cover.
12. Remove solenoid and armature assemblies from end frame.



Starter

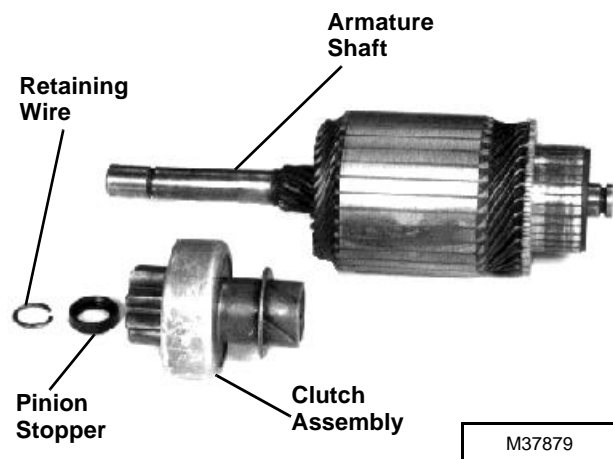
13. Inspect end frame bushing for wear or damage.
Replace if necessary.

Replace bushing using a driver set. Install bushing flush with face of housing.



3 14. Slide pinion stopper away from retaining wire using a piece of pipe or deep socket. Remove retaining wire, pinion stopper, and clutch assembly from armature shaft.

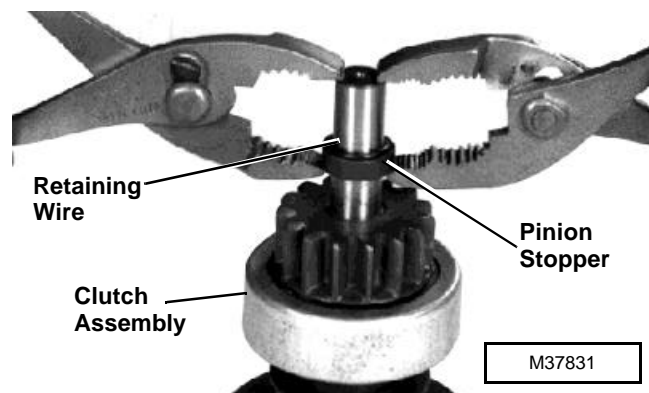
15. Inspect clutch assembly for wear or damage. Gear should rotate in one direction only. Replace if necessary.



Assembly

Assembly is done in the reverse order of disassembly.

- After installing clutch assembly, pinion stopper and retaining wire on armature shaft, use two pliers to press pinion stopper over retaining wire.

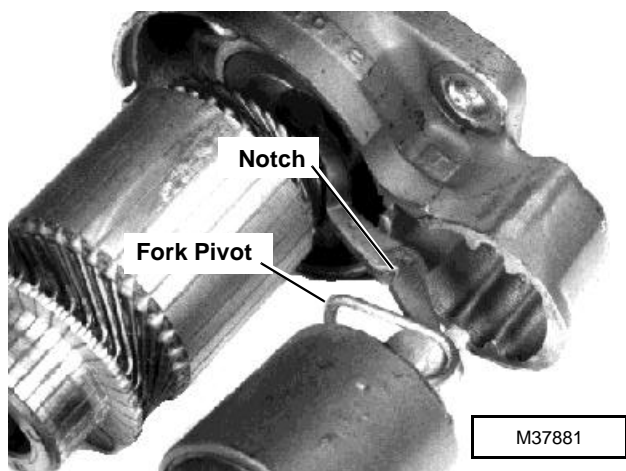


16. Remove clutch fork pivot, plunger, spring and shim(s) from solenoid.

17. Inspect all parts for wear or damage. Replace as necessary.

18. Inspect and test brushes, holder, field coil and armature. (See *Test* procedures.)

- When installing solenoid and armature assemblies into end frame, make sure fork pivot seats in notch on clutch fork.



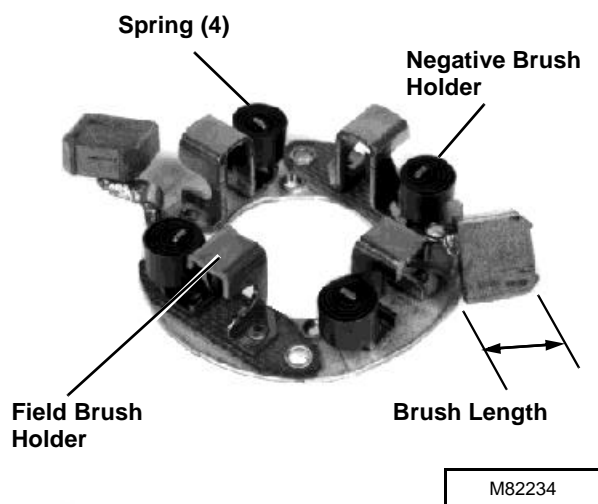
IMPORTANT: When installing rear cover, be sure field coil brush wires do not touch cover. Turn brush holder slightly to take up slack in brush wires. Press wires inward to clear rear cover.

Test

1. Measure holder and field coil brush lengths. Minimum brush length is **7.70 mm (0.303 in.)**. Replace brush holder or field coil if brush length is below minimum.

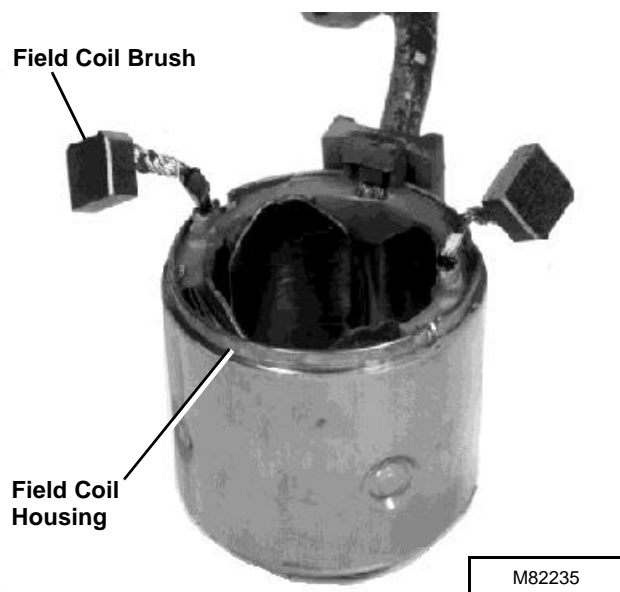
NOTE: Test brush holder using an ohmmeter or test light.

2. Test brush holder:
Touch one probe of tester to negative brush holder and other probe to field brush holder. If there is continuity, replace the brush holder.
3. Inspect springs for wear or damage. Replace if necessary.



NOTE: Test field coil using an ohmmeter or test light.

4. Test for grounded field winding:
Touch one probe of tester to field coil brush and other probe to field coil housing. Be sure the brush lead is not touching the frame. If there is continuity, the coil is grounded and the field coil housing assembly must be replaced.
5. Test for open field coil:
Touch one probe of tester to each field coil brush. If there is no continuity, the field coil is open and the field coil housing assembly must be replaced.



3

IMPORTANT: Do not clean armature with solvent. Solvent can damage insulation on windings. Use only mineral spirits and a brush.

6. Inspect armature. Look for signs of dragging against pole shoes.
7. Inspect commutator. Look for roughness, burned bars, or any material which might cause short circuits between bars. If necessary, clean and touch up with 400 sandpaper. NEVER use emery cloth. Clean all dust from armature when finished.

NOTE: Test armature windings using an ohmmeter or test light.

8. Test for grounded windings:
Touch probes on one commutator bar and armature shaft. Armature windings are connected in series, so only one commutator bar needs to be checked.

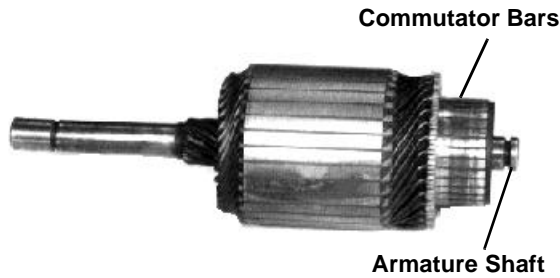
Starter

If test shows continuity, a winding is grounded and the armature must be replaced.

9. Test for open circuited windings:

Touch probes on two different commutator bars.

If test shows no continuity, there is an open circuit and the armature must be replaced.



M82246

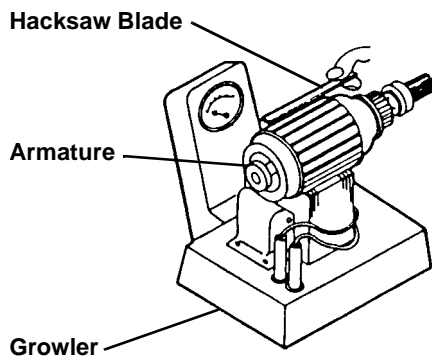
3

10. Test for short circuited windings using a growler. Put armature in a growler and hold a hacksaw blade above each slot while slowly rotating armature.

If coil is shorted, the blade will vibrate on the slot.

NOTE: A short circuit most often occurs because of copper dust or filings between two commutator segments.

11. If test indicates short circuited windings, clean the commutator of dust and filings. Check the armature again. If the test still indicates a short circuit, replace the armature.

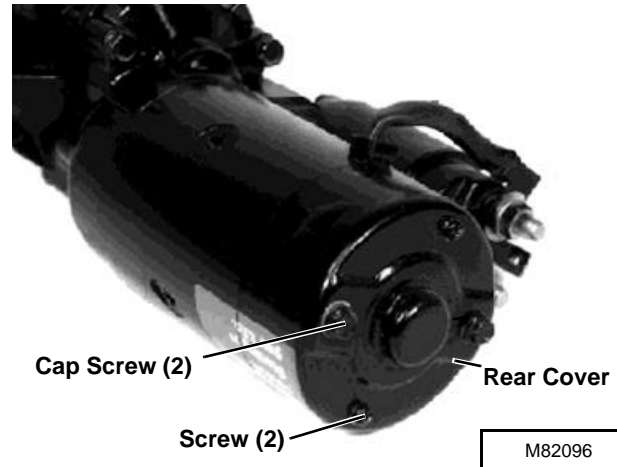


M82125A

STARTER MOTOR - HITACHI 2.0 kW

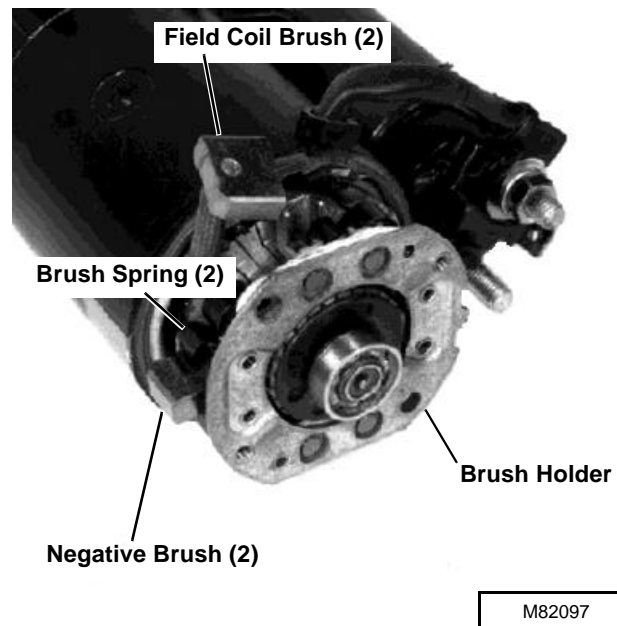
Disassembly

1. Remove two cap screws and two screws.
2. Remove rear cover.



M82096

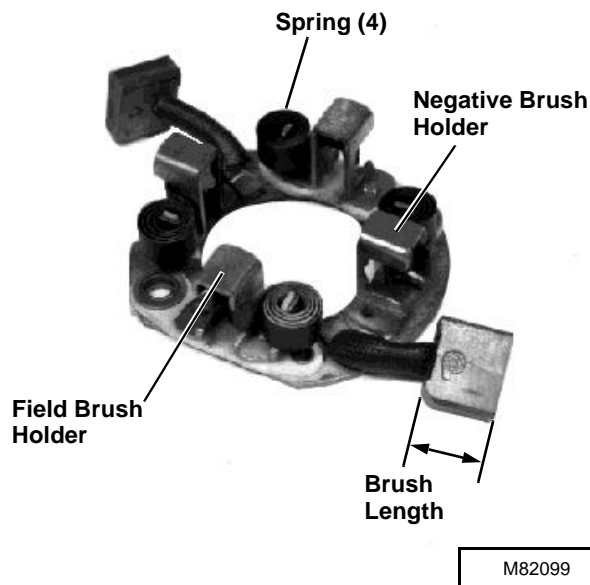
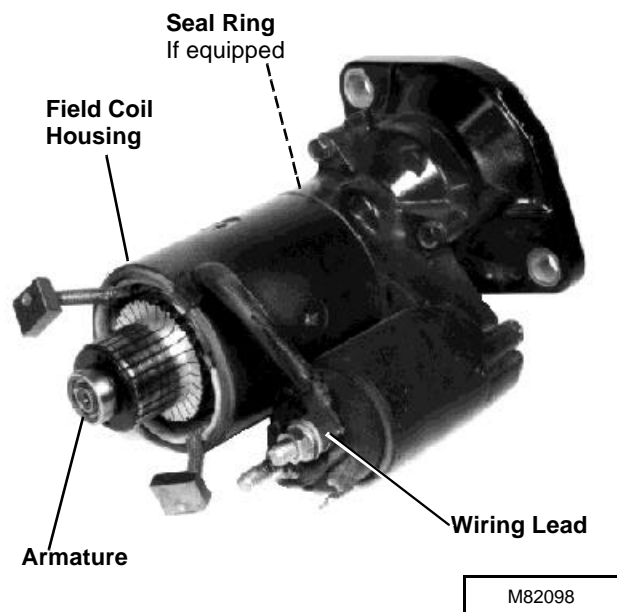
3. Remove field coil brushes from brush holder.
4. Pry brush springs away and pull negative brushes up enough to allow spring to hold brush in place.
5. Remove brush holder.



M82097

6. Disconnect wiring lead.
7. Remove field coil housing, armature and seal ring, if equipped.

8. Inspect and test brushes, holder, field coil and armature. (See *Inspection/Test* procedures.)



3

NOTE: Test field coil using an ohmmeter or test light.

Assembly

Assembly is done in the reverse order of disassembly.

- Apply multipurpose grease to bearing cup inside rear cover.

IMPORTANT: When installing rear cover, be sure field coil brush wires do not touch cover. Turn brush holder slightly to take up slack in brush wires. Press wires inward to clear rear cover.

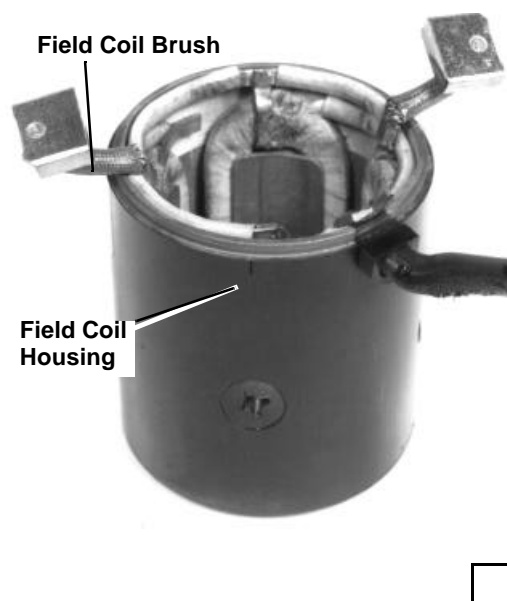
Inspection/Test/Replacement

1. Measure holder and field coil brush lengths. Minimum brush length is **9 mm (0.354 in.)**. Replace brush holder or field coil if brush length is below minimum.

NOTE: Test brush holder using an ohmmeter or test light.

2. Test brush holder:
Touch one probe of tester to negative brush holder and other probe to field brush holder. If there is continuity, replace the brush holder.
3. Inspect springs for wear or damage. Replace if necessary.

4. Test for grounded field winding:
Touch one probe of tester to field coil brush and other probe to field coil housing. Be sure the brush lead is not touching the frame. If there is continuity, the coil is grounded and the field coil housing assembly must be replaced.
5. Test for open field coil:
Touch one probe of tester to each field coil brush. If there is no continuity, the field coil is open and the field coil housing assembly must be replaced.



Starter

IMPORTANT: Do not clean armature with solvent. Solvent can damage insulation on windings. Use only mineral spirits and a brush.

6. Inspect armature. Look for signs of dragging against pole shoes.
7. Inspect commutator. Look for roughness, burned bars, or any material which might cause short circuits between bars. If necessary, clean and touch up with 400 sandpaper. NEVER use emery cloth. Clean all dust from armature when finished.

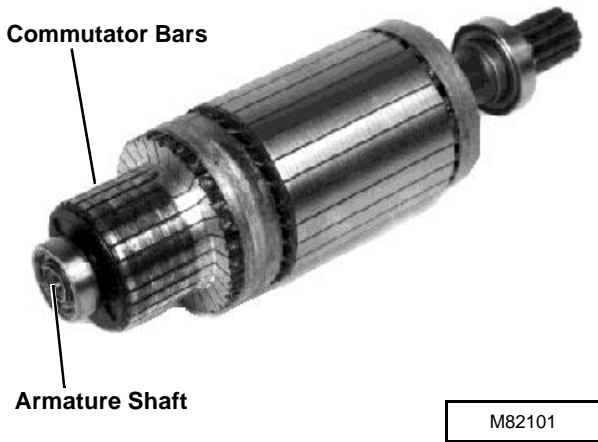
NOTE: Test armature windings using an ohmmeter or test light.

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8. Test for grounded windings:
Touch probes on one commutator bar and armature shaft. Armature windings are connected in series, so only one commutator bar needs to be checked.

If test shows continuity, a winding is grounded and the armature must be replaced.

9. Test for open circuited windings:
Touch probes on two different commutator bars. If test shows no continuity, there is an open circuit and the armature must be replaced.

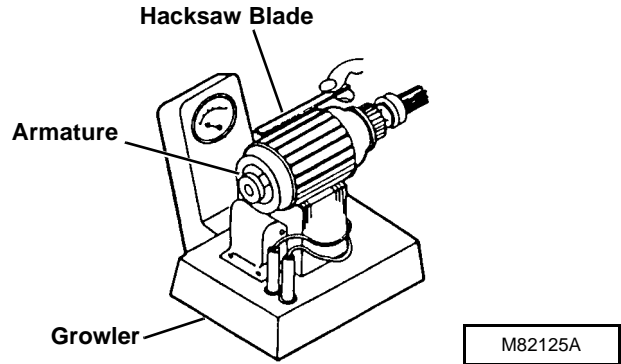


10. Test for short circuited windings using a growler.
Put armature in a growler and hold a hacksaw blade above each slot while slowly rotating armature.

If coil is shorted, the blade will vibrate on the slot.

NOTE: A short circuit most often occurs because of copper dust or filings between two commutator segments.

11. If test indicates short circuited windings, clean the commutator of dust and filings. Check the armature again. If the test still indicates a short circuit, replace the armature.



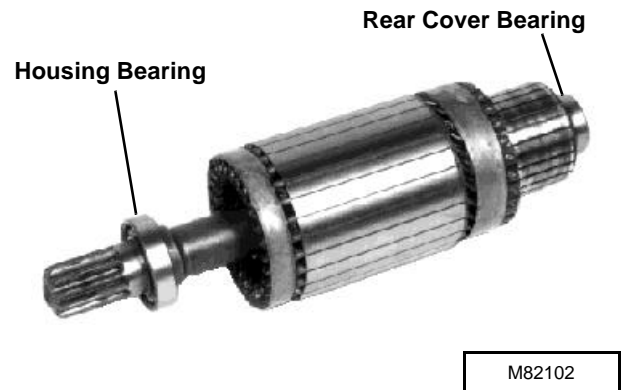
12. Inspect armature cover and housing bearings for wear or damage. Replace if necessary.

To replace bearings:
Bearings are press fit. Remove bearings using a knife-edge puller set.

IMPORTANT: Install both bearings with sealed side toward armature.

Install new housing bearing tight against shoulder of shaft using a piece of pipe.

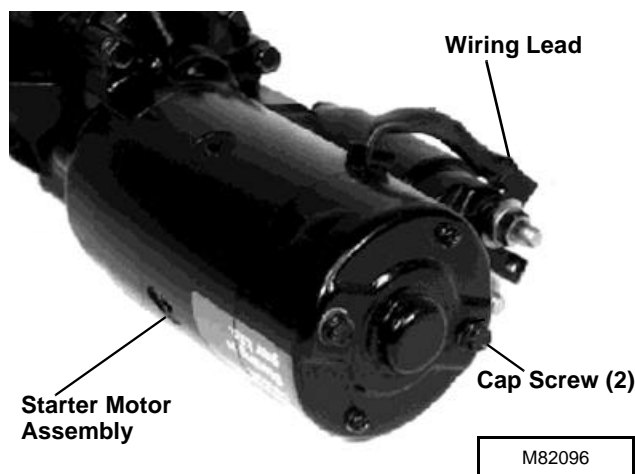
Install new rear cover bearing tight against shoulder of shaft using a driver set.



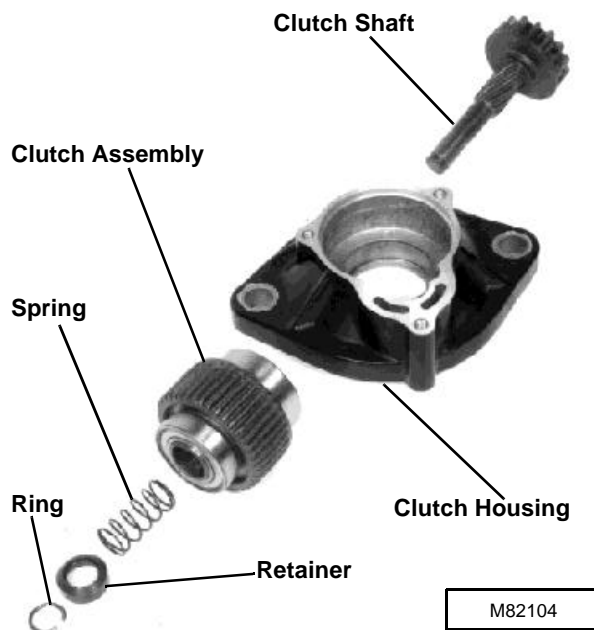
STARTER OVERRUNNING CLUTCH - HITACHI 2.0 kW

Disassembly

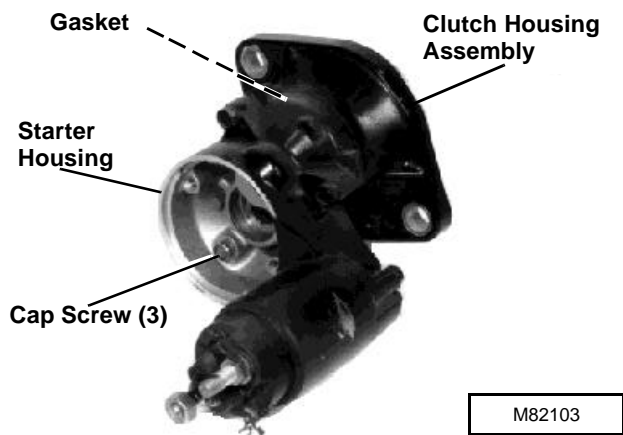
1. Disconnect wiring lead.
2. Remove two cap screws.
3. Remove starter motor assembly.



6. Remove ring, retainer, spring, clutch assembly and clutch shaft from clutch housing.
7. Inspect all parts for wear or damage. Replace as necessary.



4. Remove three cap screws.
5. Separate clutch housing assembly from starter housing. Remove gasket.



Assembly

Assembly is done in the reverse order of disassembly.

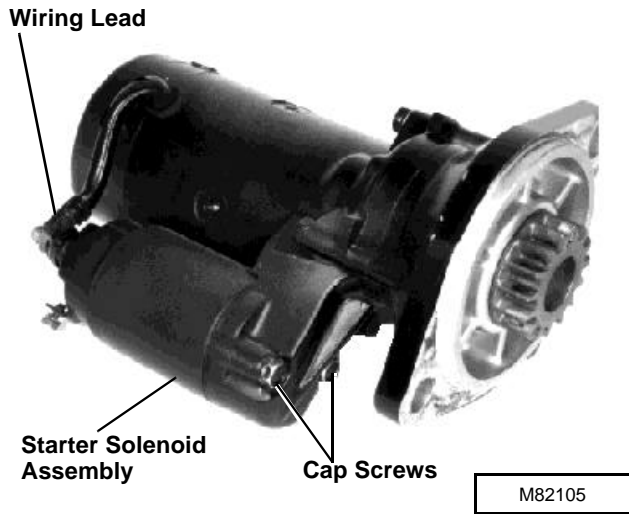
- Apply multipurpose grease to all internal components during assembly.
- Install retainer with large cupped side toward clutch assembly.

STARTER SOLENOID - HITACHI 2.0 kW

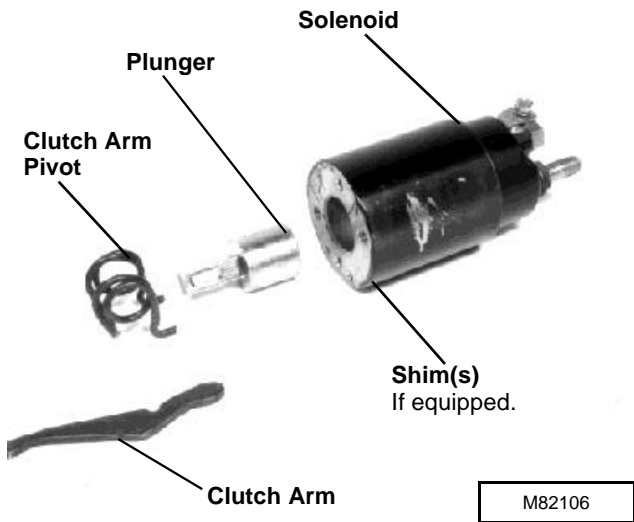
Disassembly

1. Disconnect wiring lead.
2. Remove cap screws.
3. Remove starter solenoid assembly.

Starter



- 3**
4. Remove clutch arm, clutch arm pivot, plunger and shim(s), if equipped, from solenoid.
 5. Inspect all parts for wear or damage. Replace as necessary.



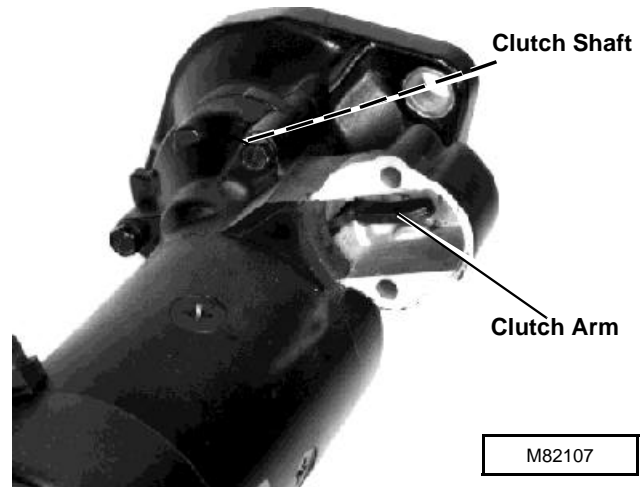
Assembly

Assembly is done in the reverse order of disassembly.

- Apply multipurpose grease to all internal components during assembly.

IMPORTANT: Make sure long end of clutch arm is installed all the way into starter housing. Clutch arm must be install on end of clutch shaft or starter will not operate.

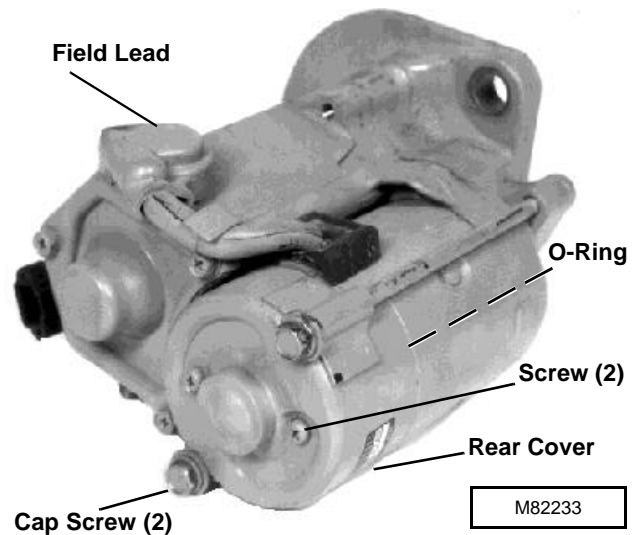
- Pull clutch shaft away from housing and insert clutch arm in starter housing. Push arm in until it stops.



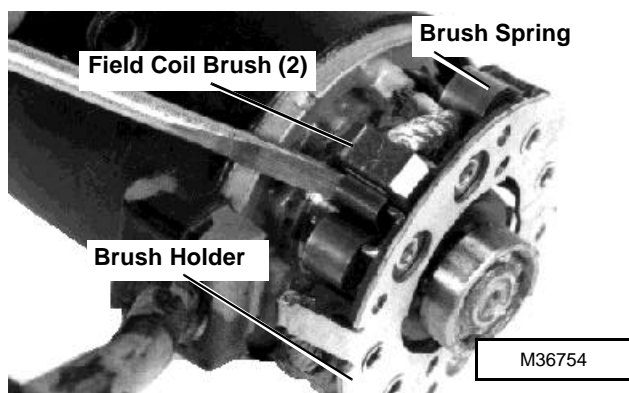
STARTER MOTOR - NIPPONDENSO 1.0 kW

Disassembly

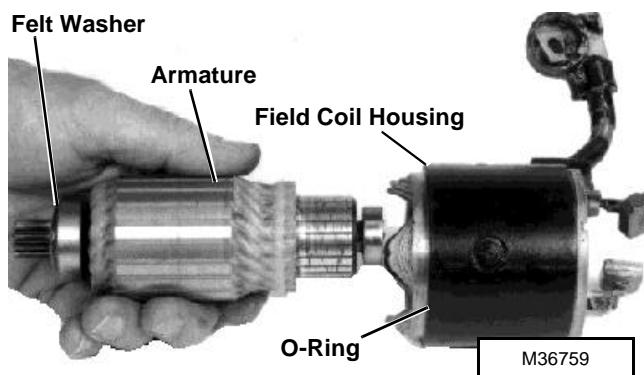
1. Disconnect field lead.
2. Remove two cap screws and two screws.
3. Remove rear cover and o-ring, if equipped.



4. Remove field coil brushes from brush holder.
5. Pry brush springs away and pull negative brushes up enough to allow spring to hold brush in place.
6. Remove brush holder.



7. Remove armature from field coil housing.
8. Remove felt washer and o-ring, if equipped.
9. Inspect and test brushes, holder, field coil and armature. (See *Inspection/Test* procedures.)



Assembly

Assembly is done in the reverse order of disassembly.

- Apply multipurpose grease to bearing cup inside rear cover and felt washer, if equipped.

IMPORTANT: When installing rear cover, be sure field coil brush wires do not touch cover. Turn brush holder slightly to take up slack in brush wires. Press wires inward to clear rear cover.

Inspection/Test/Replacement

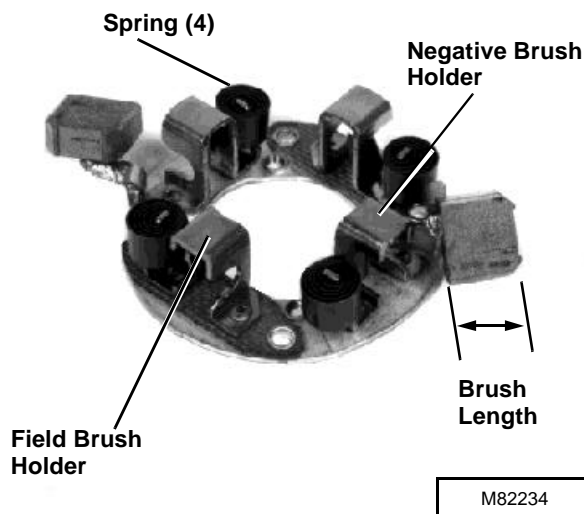
1. Measure holder and field coil brush lengths. Minimum brush length is **8.5 mm (0.335 in.)**. Replace brush holder or field coil if brush length is below minimum.

NOTE: Test brush holder using an ohmmeter or test light.

2. Test brush holder:

Touch one probe of tester to negative brush holder and other probe to field brush holder. If there is continuity, replace the brush holder.

3. Inspect springs for wear or damage. Replace if necessary.



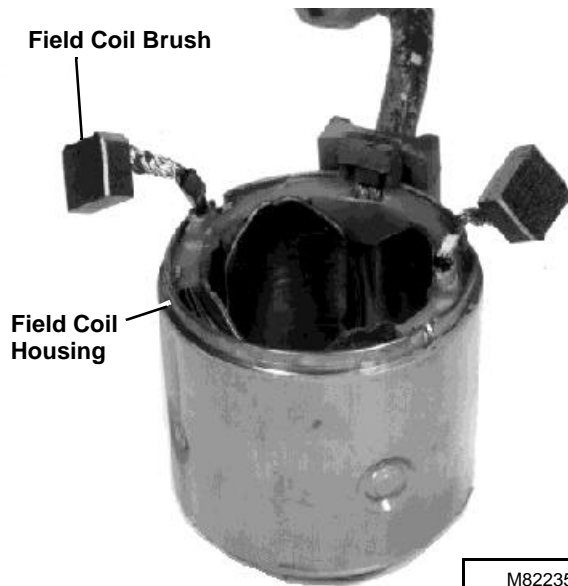
NOTE: Test field coil using an ohmmeter or test light.

4. Test for grounded field winding:

Touch one probe of tester to field coil brush and other probe to field coil housing. Be sure the brush lead is not touching the frame. If there is continuity, the coil is grounded and the field coil housing assembly must be replaced.

5. Test for open field coil:

Touch one probe of tester to each field coil brush. If there is no continuity, the field coil is open and the field coil housing assembly must be replaced.



3

IMPORTANT: Do not clean armature with solvent. Solvent can damage insulation on windings. Use only mineral spirits and a brush.

6. Inspect armature. Look for signs of dragging against pole shoes.
7. Inspect commutator. Look for roughness, burned bars, or any material which might cause short circuits between bars. If necessary, clean and touch up with 400 sandpaper. NEVER use emery cloth. Clean all dust from armature when finished.

NOTE: Test armature windings using an ohmmeter or test light.

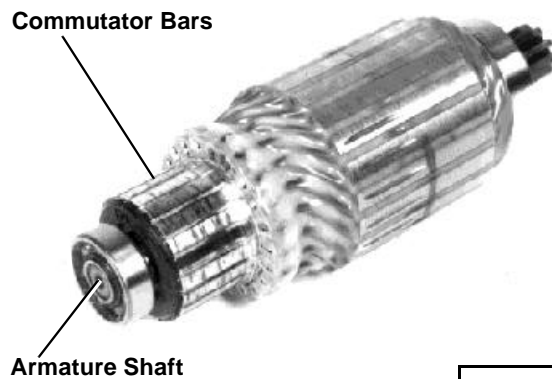
8. Test for grounded windings:

Touch probes on one commutator bar and armature shaft. Armature windings are connected in series, so only one commutator bar needs to be checked.

If test shows continuity, a winding is grounded and the armature must be replaced.

9. Test for open circuited windings:

Touch probes on two different commutator bars. If test shows no continuity, there is an open circuit and the armature must be replaced.

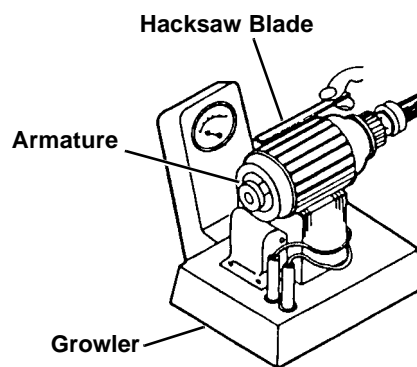


10. Test for short circuited windings using a growler. Put armature in a growler and hold a hacksaw blade above each slot while slowly rotating armature.

If coil is shorted, the blade will vibrate on the slot.

NOTE: A short circuit most often occurs because of copper dust or filings between two commutator segments.

11. If test indicates short circuited windings, clean the commutator of dust and filings. Check the armature again. If the test still indicates a short circuit, replace the armature.



12. Inspect armature cover and housing bearings for wear or damage. Replace if necessary.

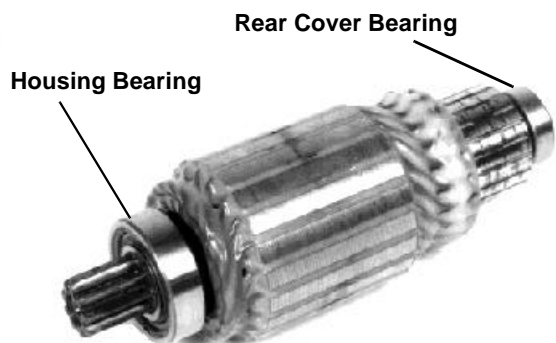
To replace bearings:

Bearings are press fit. Remove bearings using a knife-edge puller set.

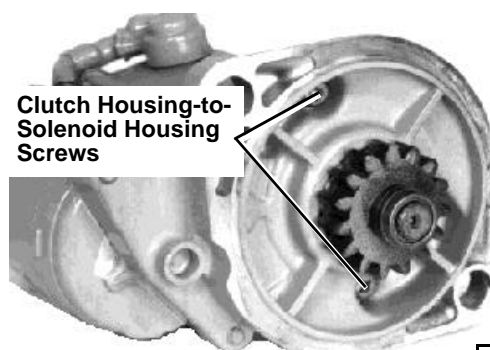
IMPORTANT: Install both bearings with sealed side toward armature.

Install new housing bearing tight against shoulder of shaft using a piece of pipe.

Install new rear cover bearing tight against shoulder of shaft using a driver set.



M82237



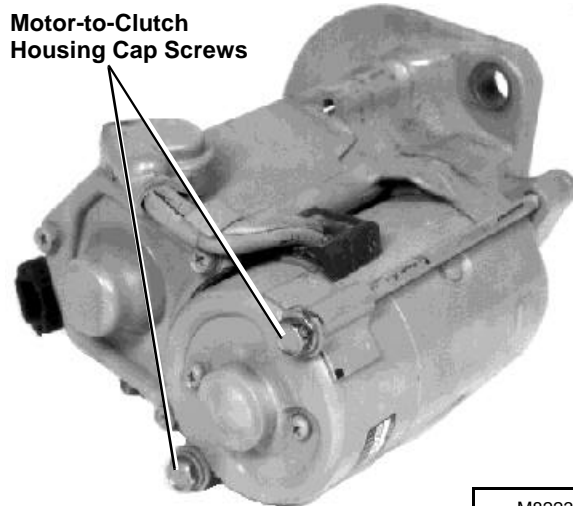
M82238

2. Separate clutch housing from solenoid/motor assembly.
3. Remove plunger spring and gear, if equipped.

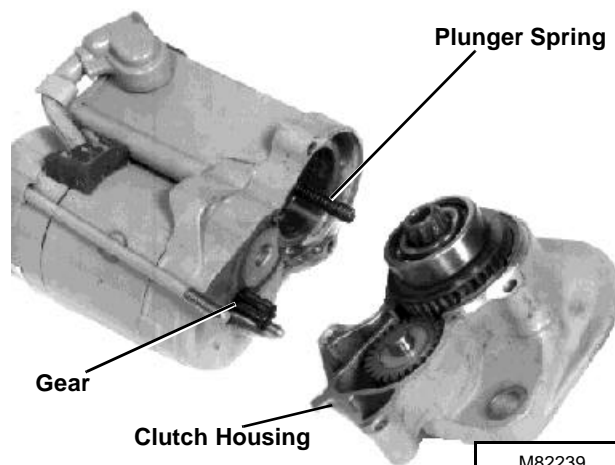
STARTER GEAR TRAIN AND OVERRUNNING CLUTCH - NIPPONDENSO 1.0 kW

Disassembly/Inspection

1. Remove two motor-to-clutch housing cap screws and two clutch housing-to-solenoid housing screws.



M82233



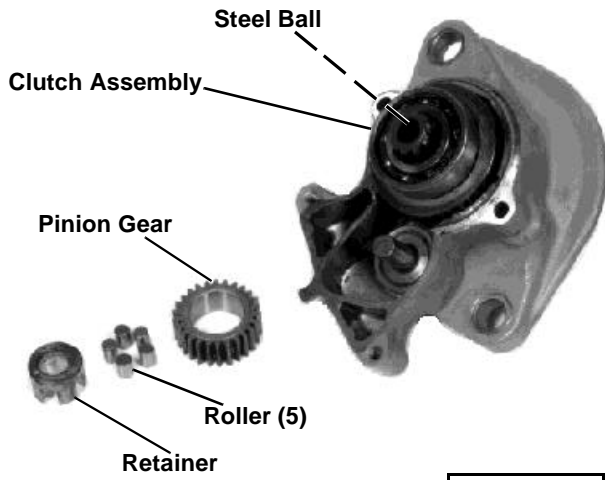
M82239

3

NOTE: Starter is equipped with either a 33 mm (1.299 in.), 44 mm (1.732 in.) or 44.5 mm (1.752 in.) drive gear on end of clutch shaft. Disassembly procedures are slightly different.

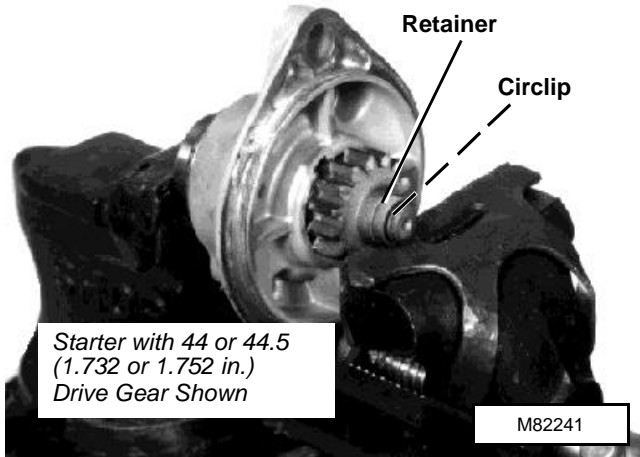
4. Starter with 33 mm (1.299 in.) drive gear: Remove clutch assembly from housing.
5. Remove retainer, five rollers and pinion gear.
6. Remove steel ball.

Starter



M82240

- 3**
7. Put clutch (housing) assembly into a soft-jawed vice, as shown.
 8. Tighten vise slowly, until drive gear compresses.
 9. Remove retainer and circlip.



M82241

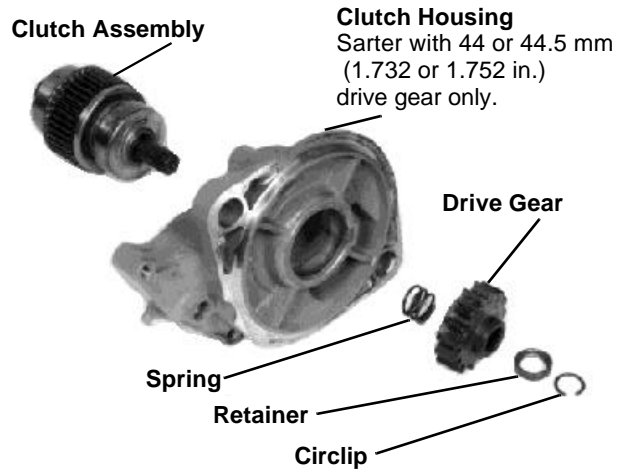
CAUTION

Shaft could be propelled from clutch unit with considerable force if spring is not allowed to extend fully while in vise.

10. While holding clutch assembly, slowly open vise until all spring compression is relieved.

11. Starter with 33 mm (1.299 in.) drive gear: Remove drive gear and spring from clutch assembly.

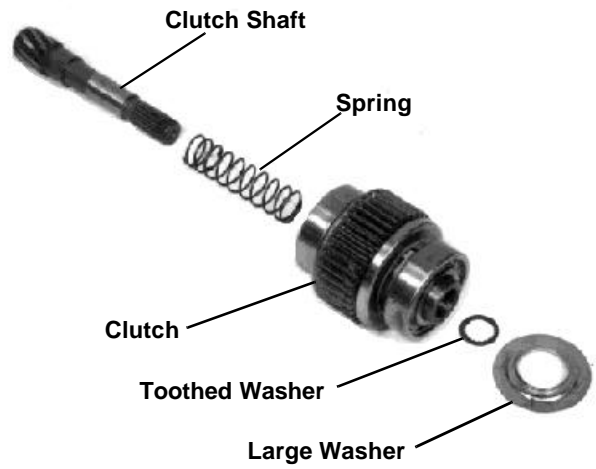
Starter with 44 mm (1.732 in.) or 44.5 mm (1.752 in.) drive gear: Remove drive gear, spring and clutch assembly from housing.



M82242

12. Remove washer, toothed washer, spring and clutch shaft.

13. Inspect all parts for wear or damage. Replace as necessary.



M82243

Assembly

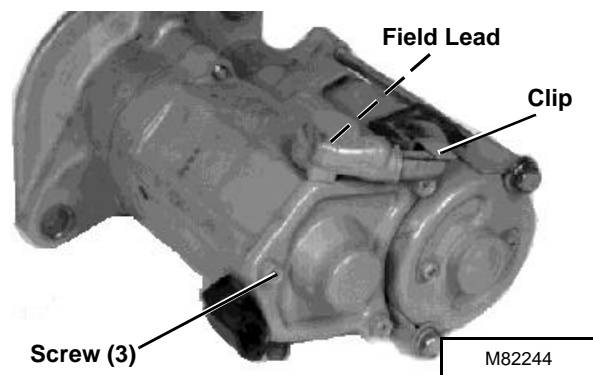
Assembly is done in the reverse order of disassembly.

- Apply multipurpose grease to bearings, clutch shaft, springs, pinion gears, retainer, rollers and steel ball.
- Install large washer with flat side toward clutch assembly.
- Install retainer with cupped side away from clutch assembly.

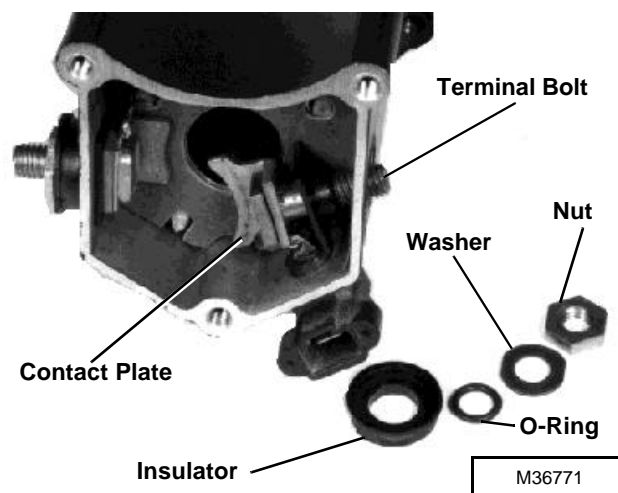
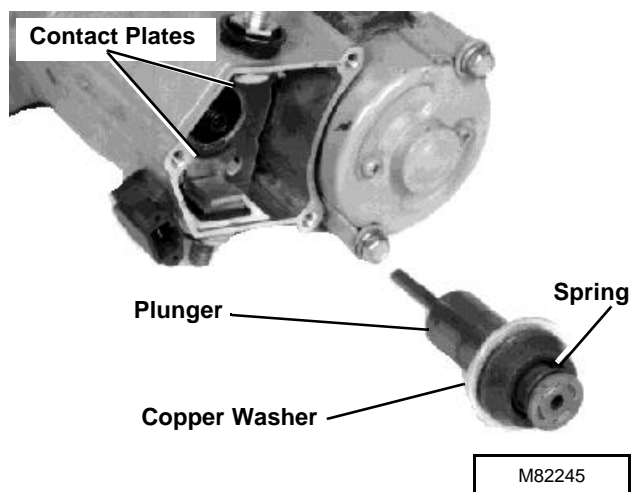
STARTER SOLENOID - NIPPONDENSO 1.0 kW

Disassembly/Inspection

1. Disconnect field lead.
2. Remove three screws and clip.
3. Remove cover and gasket.



4. Remove plunger.
5. Disassemble terminals. Remove parts from each terminal in order shown.
6. Inspect copper washer and contact plates for excessive burning or pitting. Clean burnt areas to improve electrical contact. Replace contacts or plunger if necessary. The solenoid is not serviceable. If defective, replace solenoid housing assembly.



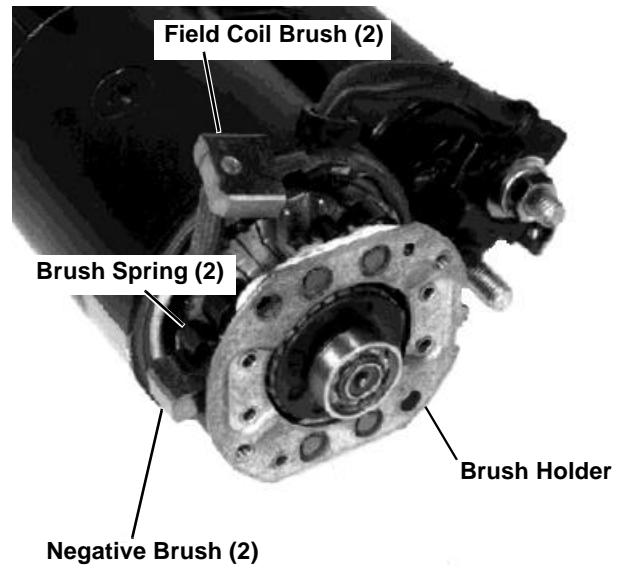
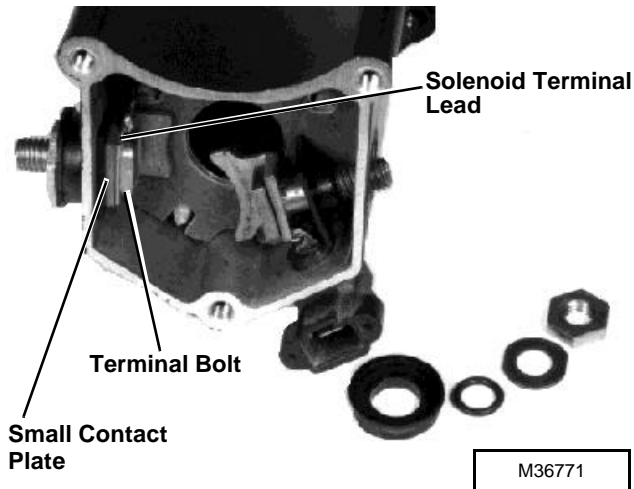
3

Assembly

Assembly is done in the reverse order of disassembly.

NOTE: The assembly sequence of the left and right terminals is similar. Be sure solenoid terminal lead is installed between terminal bolt and contact plate. Also, be sure smaller contact plate is on the left side.

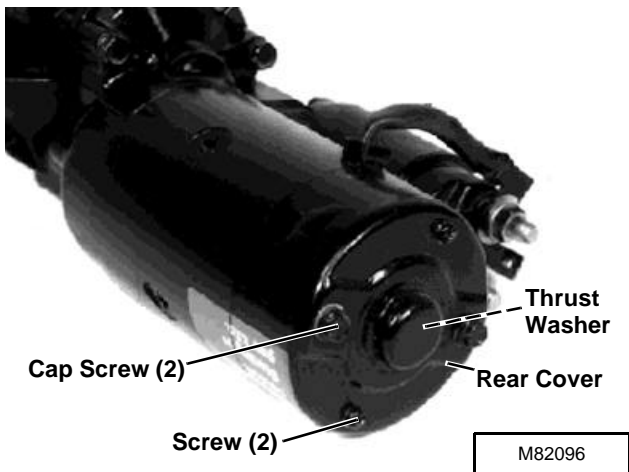
Starter



3 STARTER MOTOR - NIPPONDENSO 1.4 kW

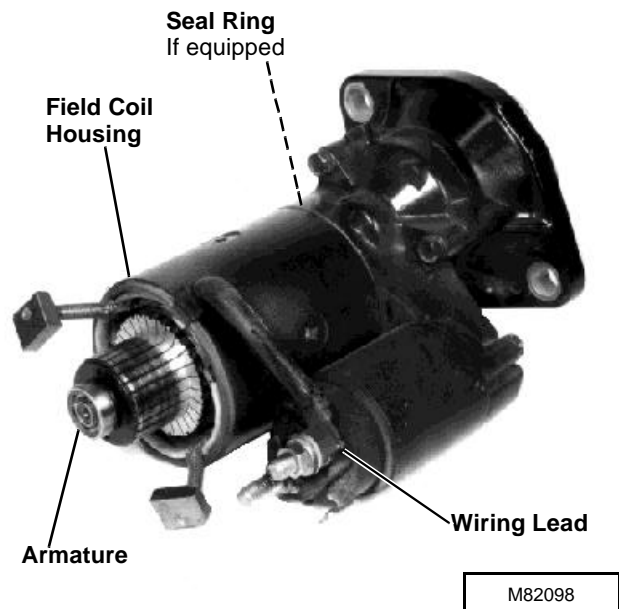
Disassembly

1. Remove two cap screws and two screws.
2. Remove rear cover and thrust washer, if equipped.



3. Remove field coil brushes from brush holder.
4. Pry brush springs away and pull negative brushes up enough to allow spring to hold brush in place.
5. Remove brush holder.

6. Disconnect wiring lead and relay leads, if equipped.
7. Remove field coil housing, armature and o-ring, if equipped.
8. Inspect and test brushes, holder, field coil and armature. (See *Inspection/Test* procedures.)



Assembly

Assembly is done in the reverse order of disassembly.

- Apply multipurpose grease to bearing cup inside rear cover.

IMPORTANT: When installing rear cover, be sure field coil brush wires do not touch cover. Turn brush holder slightly to take up slack in brush wires. Press wires inward to clear rear cover.

Inspection/Test/Replacement

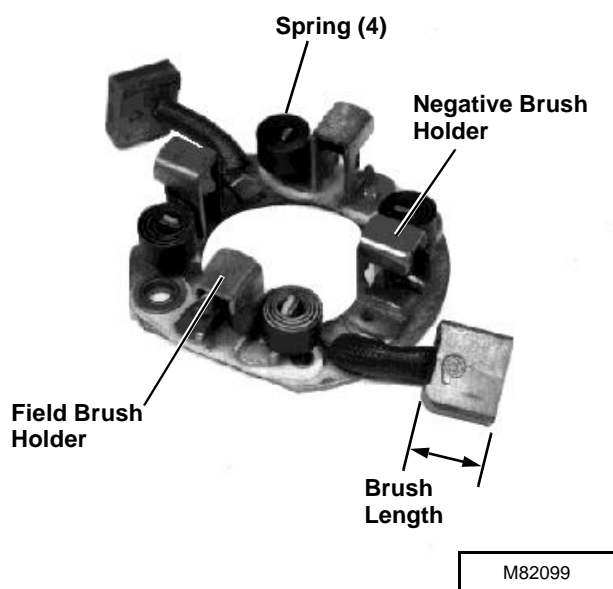
1. Measure holder and field coil brush lengths. Minimum brush length is **8.5 mm (0.335 in.)**. Replace brush holder or field coil if brush length is below minimum.

NOTE: Test brush holder using an ohmmeter or test light.

2. Test brush holder:

Touch one probe of tester to negative brush holder and other probe to field brush holder. If there is continuity, replace the brush holder.

3. Inspect springs for wear or damage. Replace if necessary.



NOTE: Test field coil using an ohmmeter or test light.

4. Test for grounded field winding:

Touch one probe of tester to field coil brush and other probe to field coil housing. Be sure the brush lead is not touching the frame. If there is continuity, the coil is grounded and the field coil housing assembly must be replaced.

5. Test for open field coil:

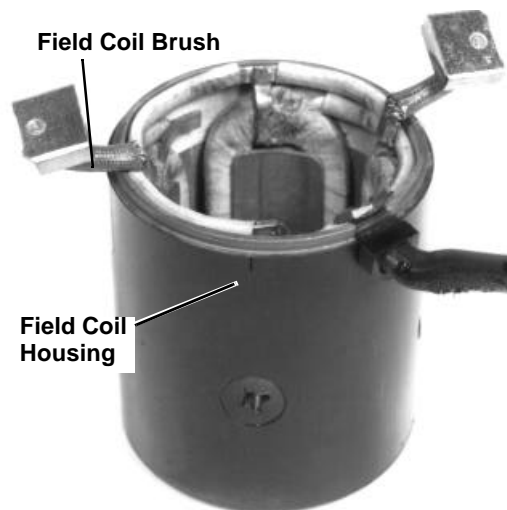
Touch one probe of tester to each field coil brush. If there is no continuity, the field coil is open and the field coil housing assembly must be replaced.

IMPORTANT: Do not clean armature with solvent. Solvent can damage insulation on windings. Use only mineral spirits and a brush.

6. Inspect armature. Look for signs of dragging against pole shoes.

7. Inspect commutator. Look for roughness, burned bars, or any material which might cause short circuits between bars. If necessary, clean and touch up with 400 sandpaper. NEVER use emery cloth. Clean all dust from armature when finished.

3



NOTE: Test armature windings using an ohmmeter or test light.

8. Test for grounded windings:

Touch probes on one commutator bar and armature shaft. Armature windings are connected in series, so only one commutator bar needs to be checked.

If test shows continuity, a winding is grounded and the armature must be replaced.

Starter

9. Test for open circuited windings:

Touch probes on two different commutator bars. If test shows no continuity, there is an open circuit and the armature must be replaced.



3

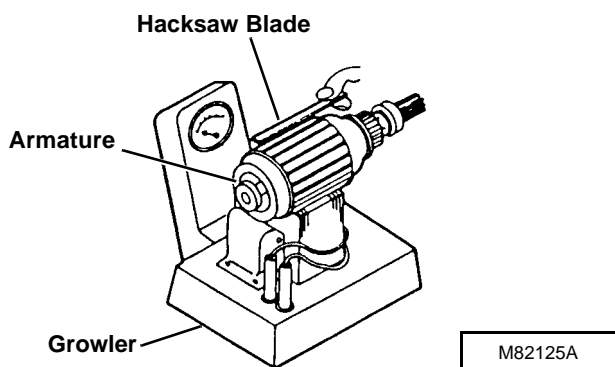
10. Test for short circuited windings using a growler.

Put armature in a growler and hold a hacksaw blade above each slot while slowly rotating armature.

If coil is shorted, the blade will vibrate on the slot.

NOTE: A short circuit most often occurs because of copper dust or filings between two commutator segments.

11. If test indicates short circuited windings, clean the commutator of dust and filings. Check the armature again. If the test still indicates a short circuit, replace the armature.



12. Inspect armature cover and housing bearings for wear or damage. Replace if necessary.

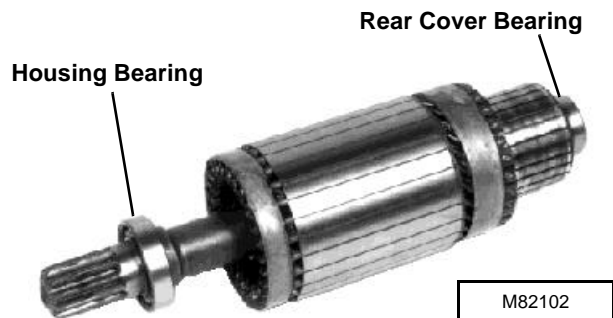
To replace bearings:

Bearings are press fit. Remove bearings using a knife-edge puller set.

IMPORTANT: Install both bearings with sealed side toward armature.

Install new housing bearing tight against shoulder of shaft using a piece of pipe.

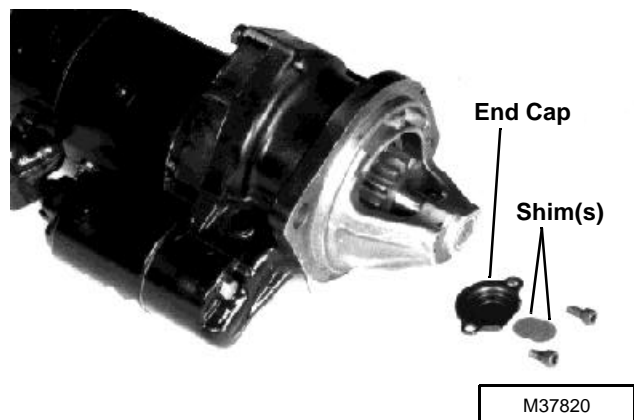
Install new rear cover bearing tight against shoulder of shaft using a driver set.



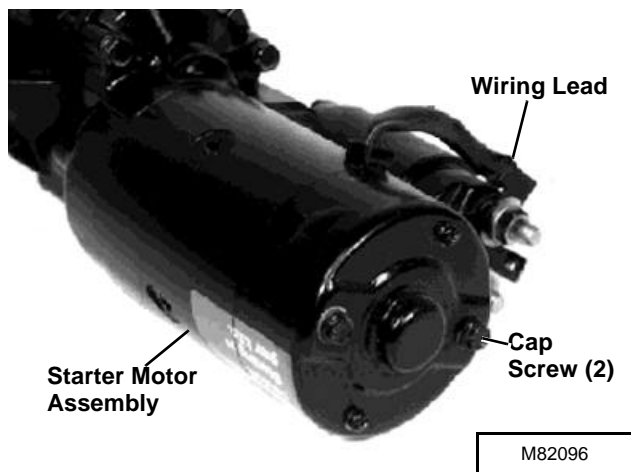
STARTER GEAR TRAIN AND SOLENOID - NIPPONDENSO 1.4 kW

Disassembly/Inspection

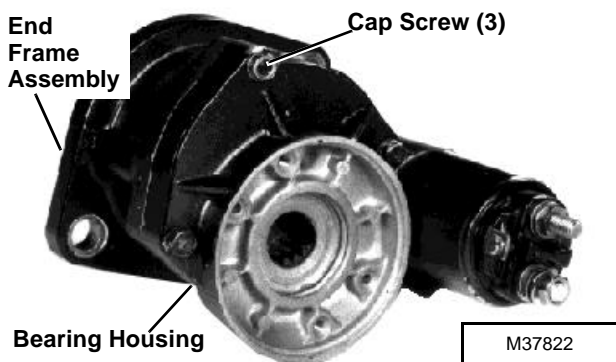
1. Remove two socket head screws, end cap and shim(s).



2. Disconnect wiring lead and relay leads, if equipped.
3. Remove two cap screws.
4. Remove starter motor assembly from bearing housing.



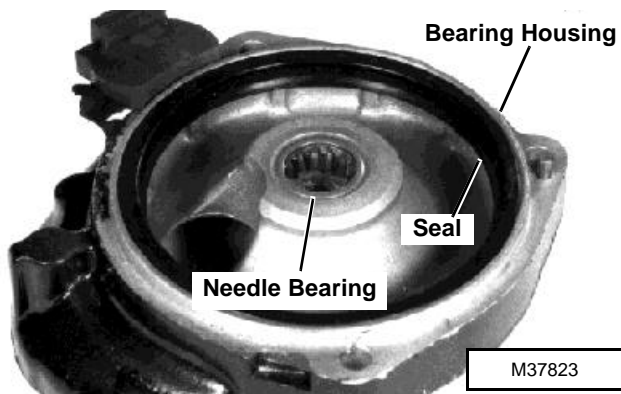
5. Remove three cap screws.
6. Separate end frame assembly from bearing housing.



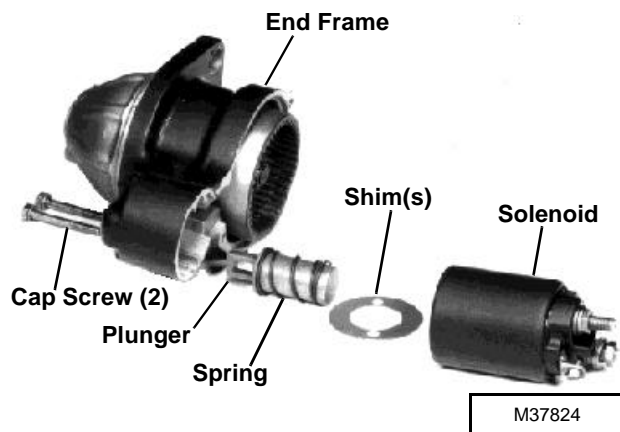
7. Inspect seal and needle bearing for wear or damage. Replace as necessary.

To replace needle bearing:

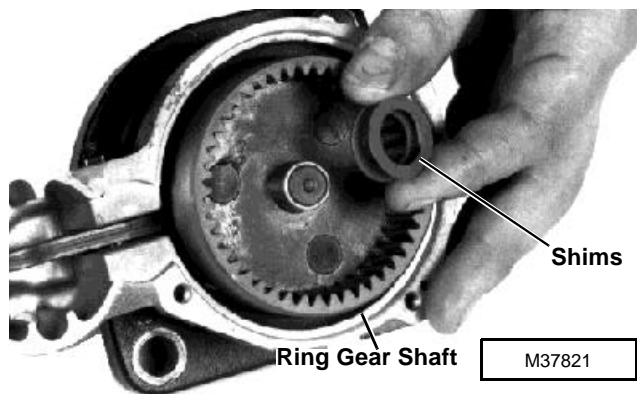
Remove bearing using a blind-hole puller set. Install new bearing flush with housing surface using a driver set.



8. Remove two cap screws, plunger, spring, shims and solenoid.

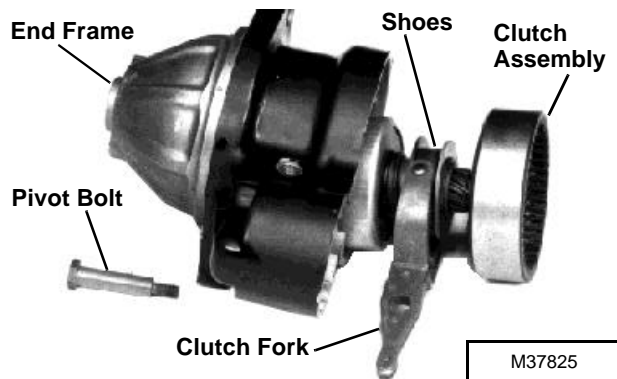


9. Remove shims from ring gear shaft.



10. Remove pivot bolt, clutch fork and clutch assembly.

11. Inspect shoes on fork for wear or damage. Replace fork if necessary.

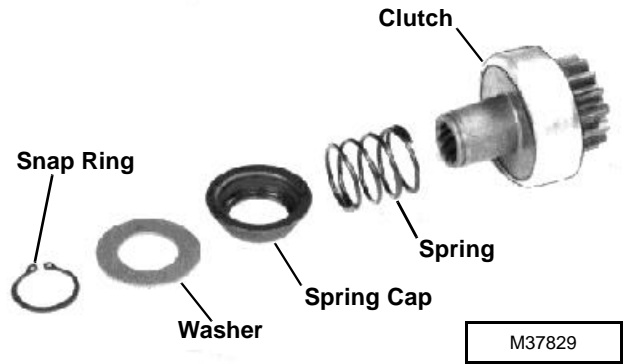
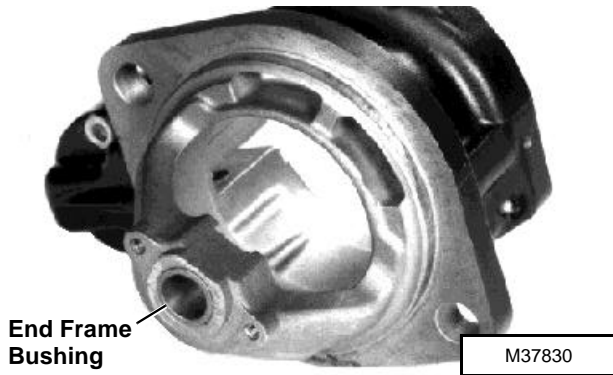


12. Inspect end frame bushing for wear or damage. Replace if necessary.

3

Starter

Replace bushing using a driver set. Install bushing flush with face of housing.



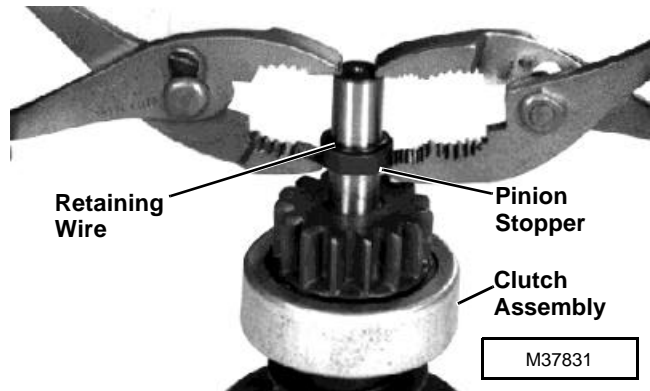
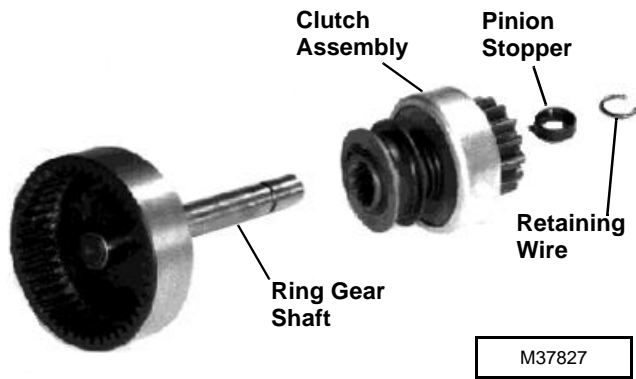
3 13. Slide pinion stopper away from retaining wire using a piece of pipe or deep socket. Remove retaining wire, pinion stopper, and clutch assembly from ring gear shaft.

14. Inspect all parts for wear or damage. Replace as necessary.

Assembly

Assembly is done in the reverse order of disassembly.

- After installing clutch assembly, pinion stopper and retaining wire on ring gear shaft, use two pliers to press wire on ring gear shaft, use two pliers to press pinion stopper over retaining wire.



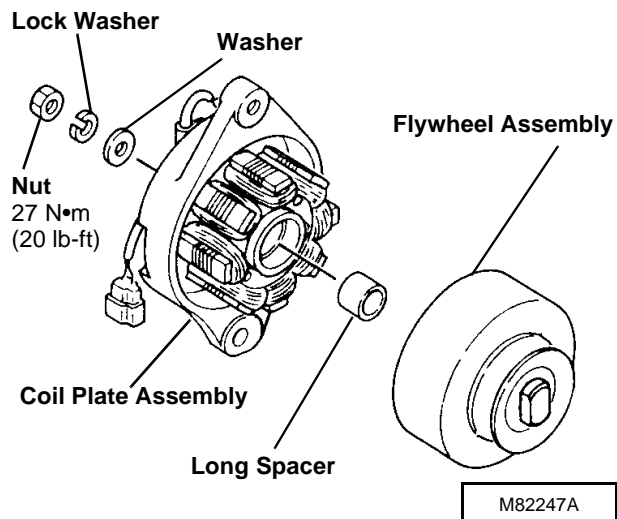
15. Remove snap ring, washer, spring cap, and spring from clutch.

16. Inspect all parts for wear or damage. Replace as necessary.

ALTERNATOR - KOKOSAN 20A

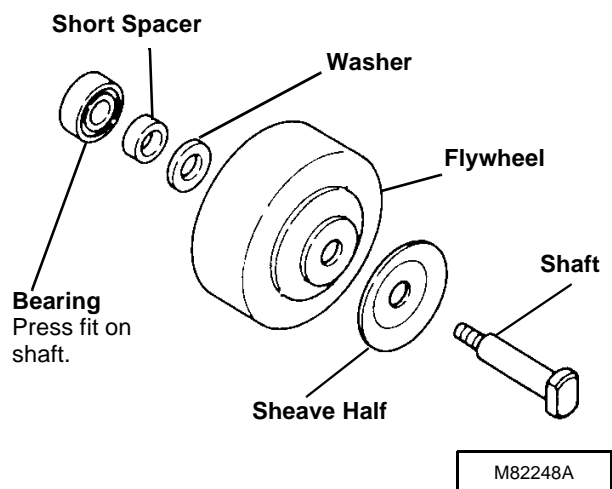
Disassembly/Inspection

1. Remove nut and washers.
2. Tap on end of shaft with a soft-faced hammer to separate flywheel assembly from coil plate assembly.
3. Remove long spacer.



NOTE: Bearing and flywheel are press fit on shaft.

4. Remove shaft from bearing, short spacer, washer, flywheel and sheave half, using a press.
5. Inspect all parts for wear or damage. Replace as necessary.



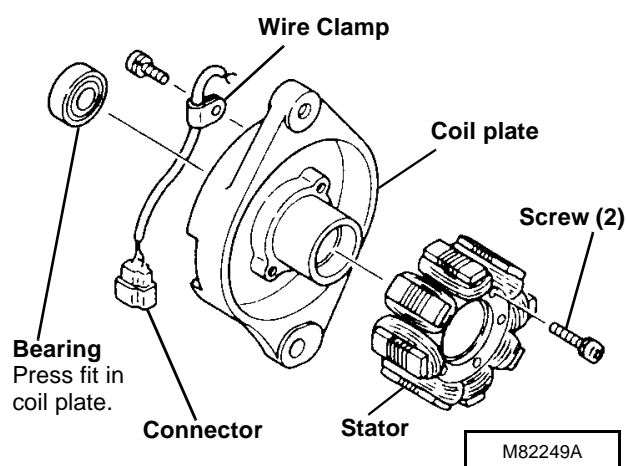
NOTE: Remove bearing only if replacement is necessary.

6. Inspect bearing in coil plate for wear or damage. Replace if necessary.

To replace bearing:

Remove bearing using a spark plug socket and a press. Install bearing into coil plate until it bottoms in bore using a 1 in. socket.

7. Remove wire clamp.
8. Remove connector from harness leads.
9. Remove two screws and stator.
10. Inspect all parts for wear or damage. Replace as necessary.



3

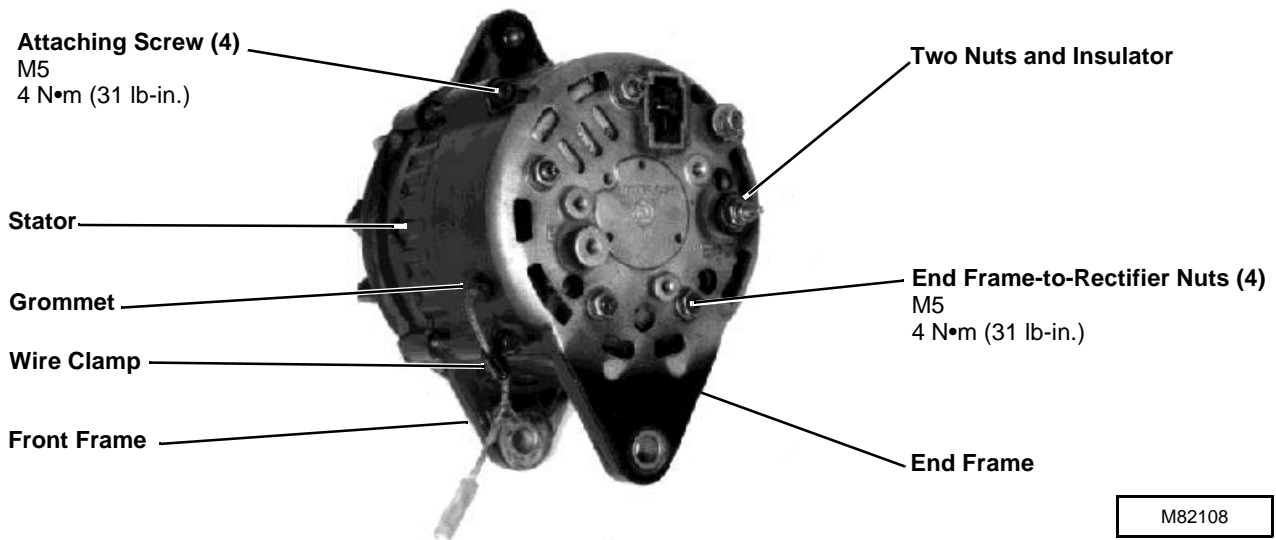
Assembly

Assembly is done in the reverse order of disassembly.

- With sheave half on shaft, press shaft into flywheel until sheave half bottoms on flywheel face.
- With washer and short spacer installed, press new bearing onto shaft until it bottoms on spacer.

Alternator

VOLTAGE REGULATOR - HITACHI 25A



3

Replacement

11. Remove three screws and cover.
12. Remove four attaching screws, wire clamp and grommet.
13. Remove four end frame-to-rectifier nuts.
14. Remove two nuts and insulator.

IMPORTANT: Do not pry against stator wires.

15. Use a screwdriver to pry end frame from stator.
Do not separate stator from front frame.
16. Remove two screws and insulator.

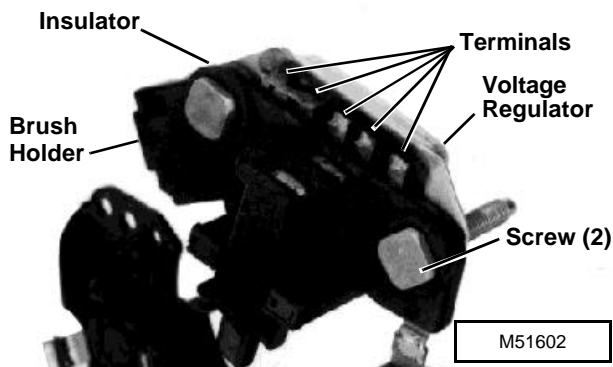
17. Use a soldering gun with at least 120 watt capacity to disconnect five terminals. Replace voltage regulator.

- If additional solder is needed, use ONLY 60-40 rosin-core solder.

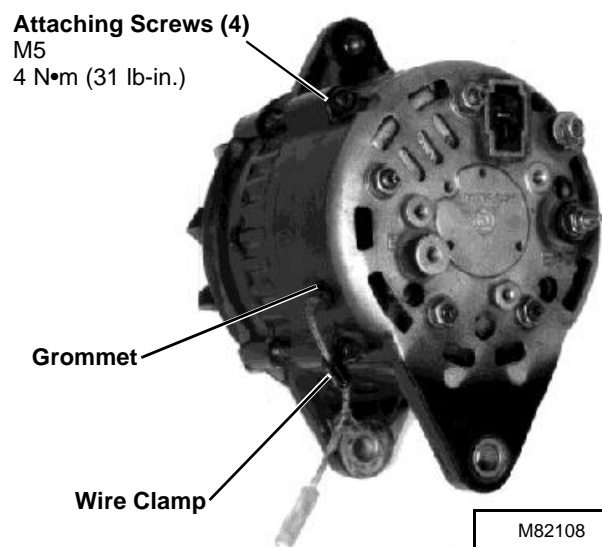
ALTERNATOR - HITACHI 25A

Disassembly

1. Remove three screws and cover.
2. Remove four attaching screws, wire clamp and grommet.

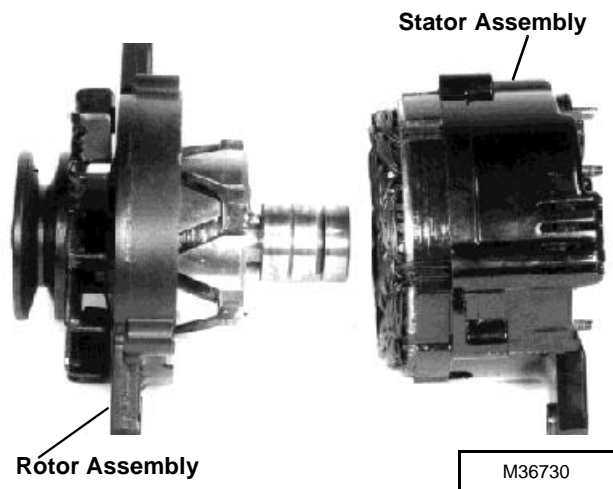


IMPORTANT: Do not heat connections longer than necessary to melt solder, as excess heat will damage rectifier assembly.



IMPORTANT: Do not pry against stator wires.

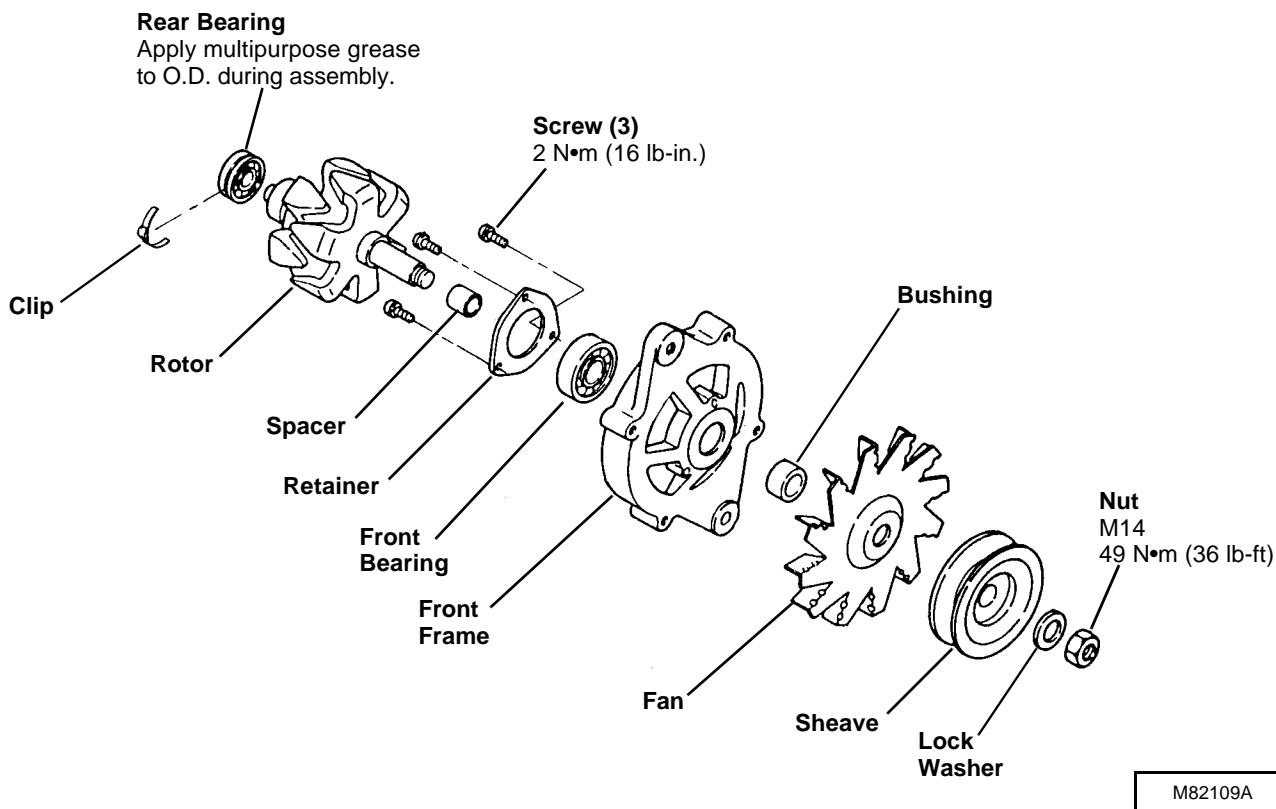
- Use a screwdriver to separate rotor assembly from stator assembly.



Rotor Assembly:

- Rear bearing is press fit. Replace only if necessary. Remove bearing using a puller set. Install bearing until flush with end of rotor shaft. Press only on inner race of bearing.
- Put rotor assembly in a soft-jawed vise. Remove nut, lock washer, sheave, fan and bushing.
 - Put front frame on open jaws of vice. Use a soft-faced hammer to remove rotor and spacer.
 - Remove three screws, retainer and front bearing.
 - Inspect all parts for wear or damage. Replace as necessary.
 - Test rotor. (See *Inspection/Test* procedures.)

3



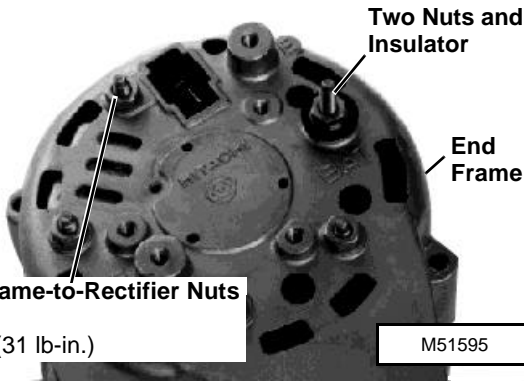
Alternator

Stator Assembly:

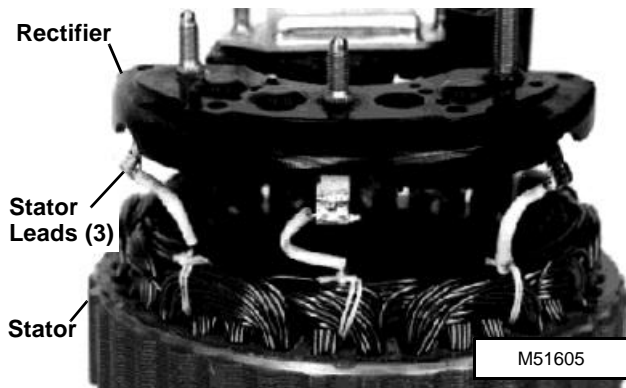
9. Remove four end frame-to-rectifier nuts.
10. Remove two nuts and insulator.

IMPORTANT: Do not pry against stator wires.

11. Use a screwdriver to pry end frame from stator



12. Use a soldering gun with at least 120 watt capacity to disconnect three stator leads. Remove rectifier.



13. Inspect and test brushes, stator and rectifier. (See *Inspection/Test* procedures.)

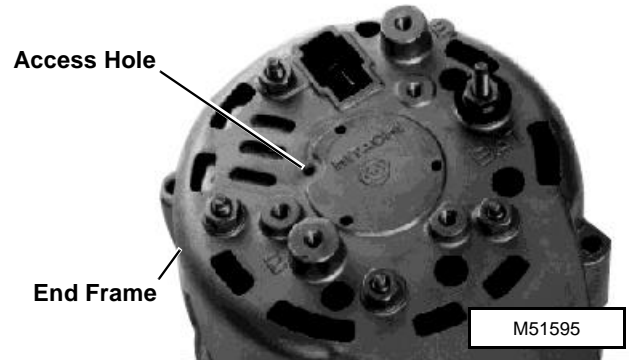
Assembly

Assembly is done in the reverse order of disassembly.

- Bend the stator lead wires, as necessary, to obtain an approximate distance of **33.50 mm (1.300 in.)** from stator to rectifier. Connect the three leads using a soldering gun.
- If additional solder is needed, use **ONLY 60-40 rosin-core solder.**

IMPORTANT: Be sure stator lead wires do not contact end frame when installed.

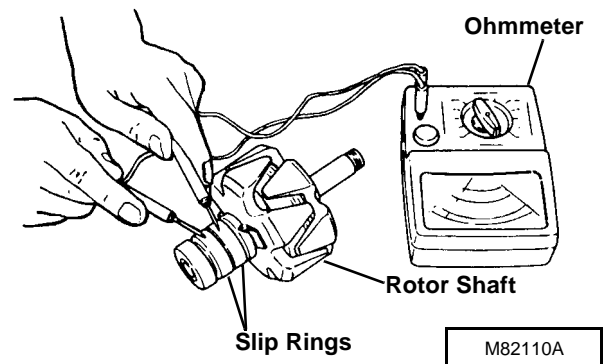
- Before assembling stator assembly to rotor assembly, push brushes into brush holder and insert a wire through access hole to lock brushes in place.
- Assemble rotor assembly to stator assembly and fasten with four attaching screws. Remove wire from access hole.



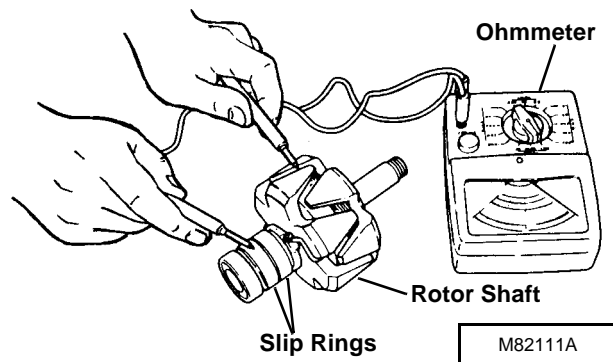
Inspection/Test

Rotor:

- Inspect the rotor slip rings for dirt build-up, rough spots, or out of roundness. If necessary, polish the surface of the slip rings using No. 00 sandpaper or 400-grit silicon carbide paper.
- Touch the probes of an ohmmeter to slip rings. Replace rotor if test indicates no continuity (no needle movement).

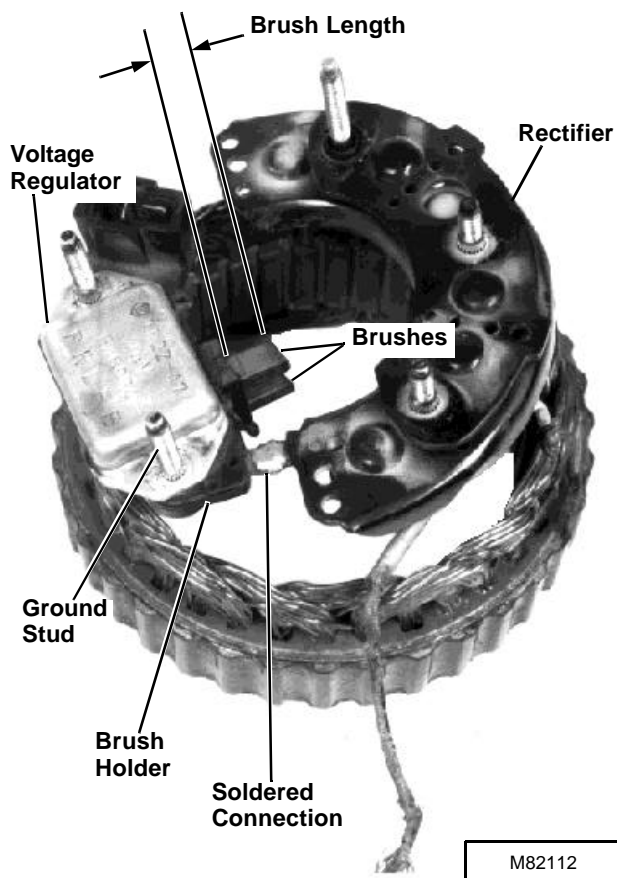


- Touch the probes of the ohmmeter to the shaft and one of the slip rings. Repeat for other slip ring. Replace rotor if test shows continuity (needle movement).



Brushes:

- Inspect brush holder and brushes for damage. Brushes must slide freely and the springs must hold the brushes firmly against the slip rings of the rotor.
- Measure brushes for wear. Minimum exposed length must be **5.50 mm (0.220 in.)** or to wear limit line on brushes. Replace brushes as necessary.



- Use an ohmmeter or a test light to check for continuity. Check between the two brushes and between each brush and ground stud. There should be no continuity. Replace brush holder-rectifier assembly if there is continuity.
- To replace brushes, melt solder from connection. Remove voltage regulator if necessary. (See *VOLTAGE REGULATOR REPLACEMENT* in this group.)

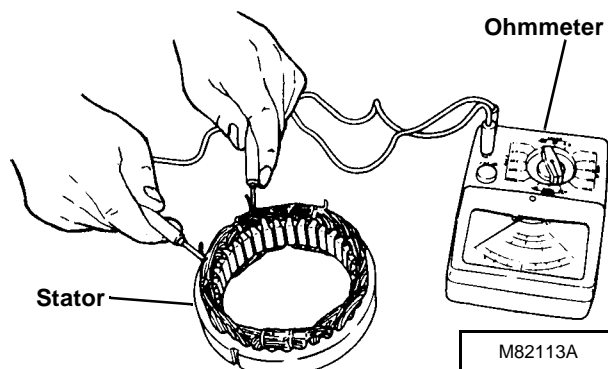
NOTE: If additional solder is needed, use ONLY 60-40 rosin-core solder.

Stator:

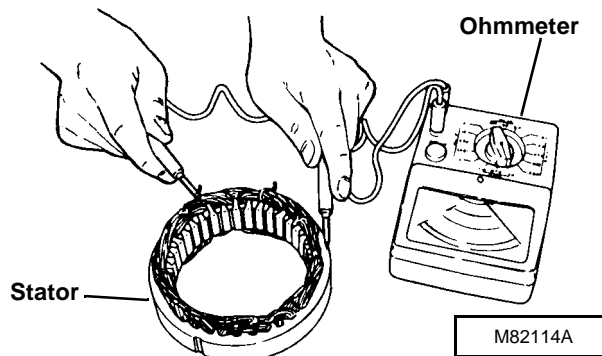
- Inspect stator for defective insulation, discoloration or a burned odor. If any of these defects are found, replace stator.

NOTE: Use an ohmmeter that is sensitive to resistance of 0 to 1 ohm.

- Touch probes of an ohmmeter to lead wires of stator in three possible combinations. Continuity should read approximately **0.26 ohms**. If readings are not equal, replace stator.



- Touch one probe of the ohmmeter to the bare metal surface of stator and the other probe to a bare stator lead wire. Repeat for each wire. Replace stator if test indicates continuity.



Alternator

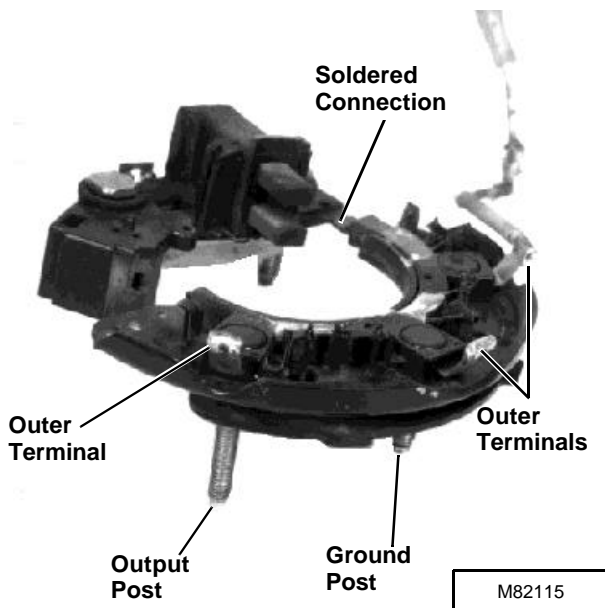
Rectifier:

- Test the diodes by touching probes to ground post and the three outer terminals.
- Switch the probes and check each terminal again. There should be continuity in only one combination of each terminals and the ground post.
- Test the diodes by touching probes to output post and the three outer terminals.
- Switch the probes and check each terminal again. There should be continuity in only one combination of each terminal and the output post.

3 A shorted diode would have continuity in both directions. An open diode would have no continuity in either direction. Replace the rectifier assembly if any of the three diodes are defective.

- To replace rectifier, melt solder from connection.

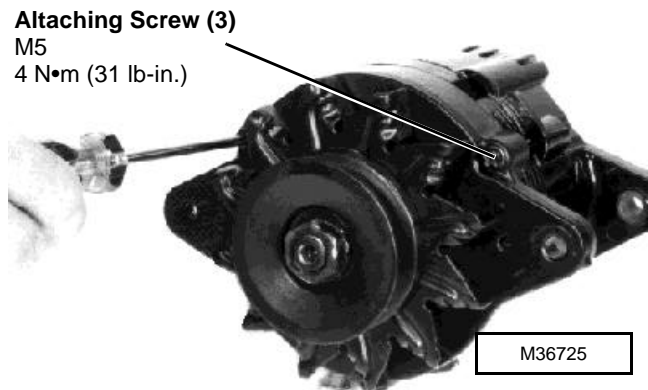
NOTE: If additional solder is needed, use ONLY 60-40 rosin-core solder.



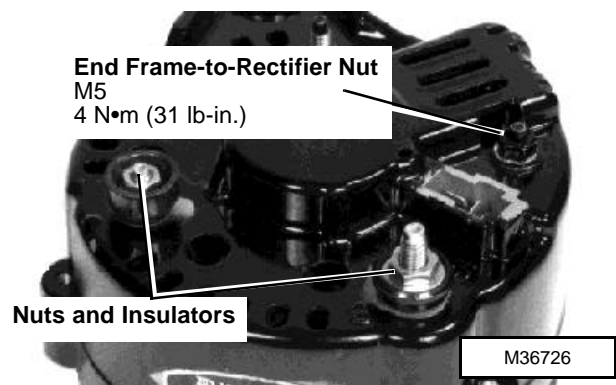
VOLTAGE REGULATOR - NIPPONDENSO 35A

Replacement

1. Remove three attaching screws.

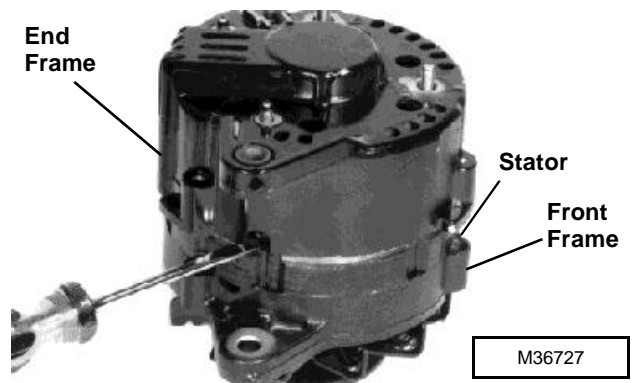


2. Remove end frame-to-rectifier nut.
3. Remove nuts and insulators.



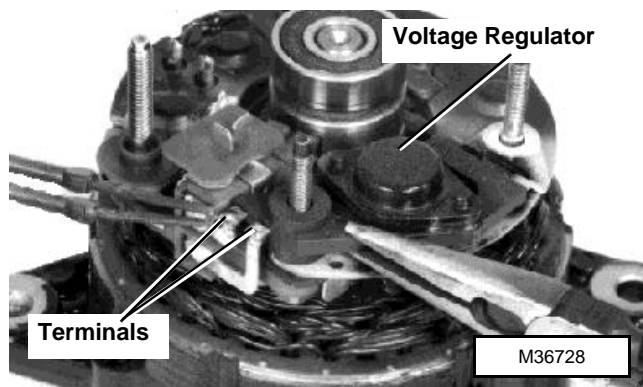
IMPORTANT: Do not pry against stator wires.

4. Use a screwdriver to pry end frame from stator. Do not separate stator from front frame.



IMPORTANT: Do not heat connections longer than necessary to melt solder, as excess heat will damage rectifier assembly.

5. Use a soldering gun with a least 120 watt capacity to disconnect terminals. Replace voltage regulator.



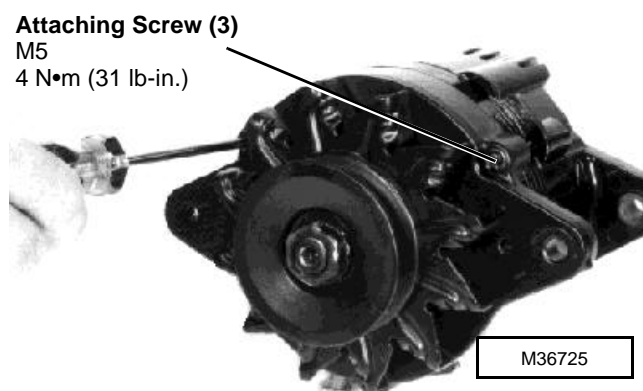
Installation is done in the reverse order of removal.

- If additional solder is needed, use ONLY 60-40 rosin-core solder.

ALTERNATOR - NIPPONDENSO 35A

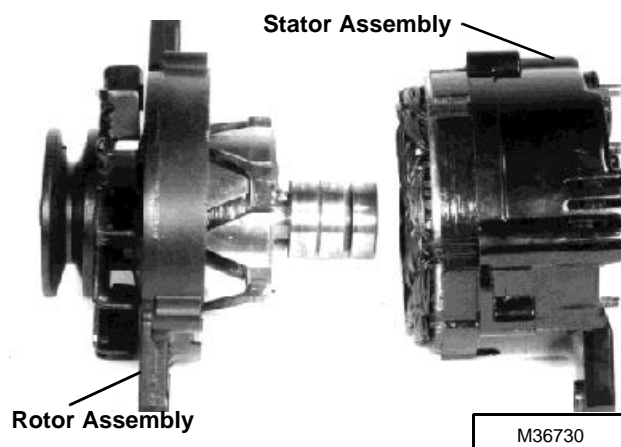
Disassembly

1. Remove three attaching screws.



IMPORTANT: Do not pry against stator wires.

2. Use a screwdriver to separate rotor assembly from stator assembly.

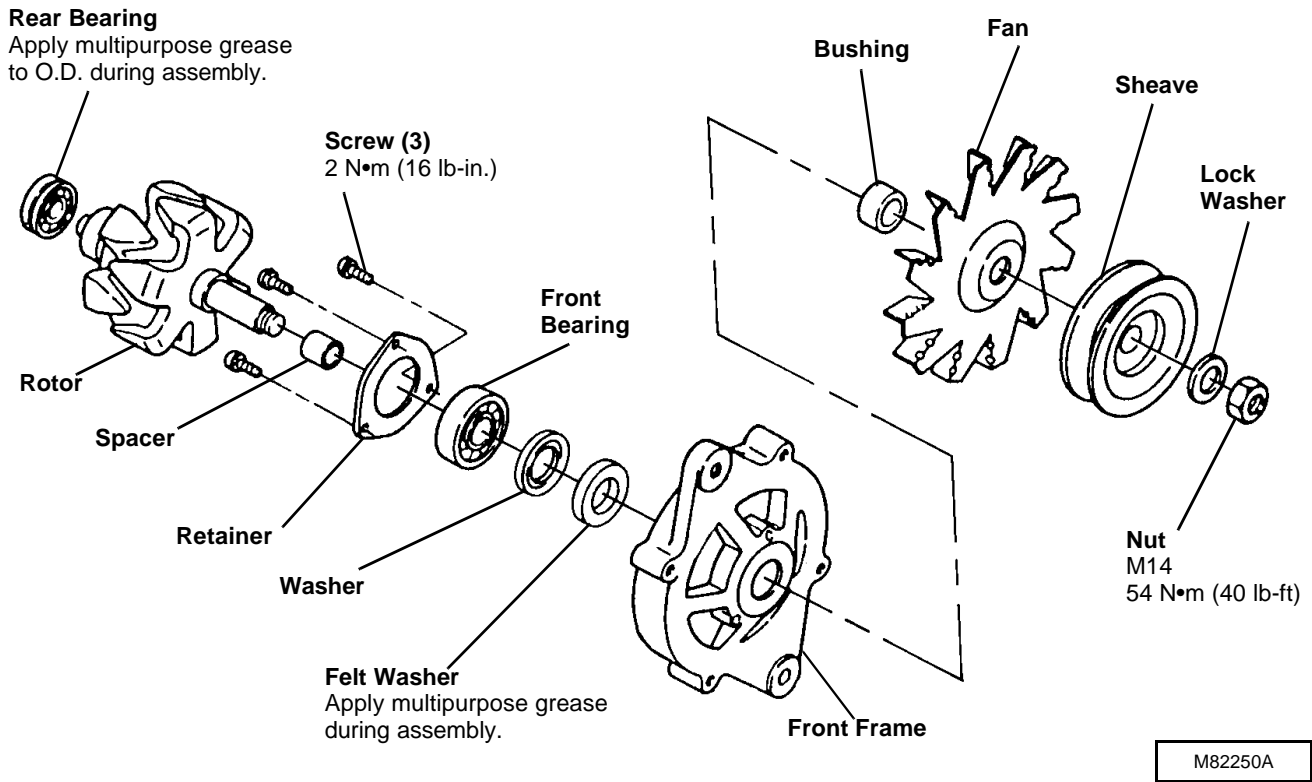


Rotor Assembly:

- Rear bearing is press fit. Replace only if necessary. Remove bearing using a puller set. Install bearing until flush with end of rotor shaft. Press only on inner race of bearing.
3. Put rotor assembly in a soft-jawed vise. Remove nut, lock washer, sheave, fan and bushing.
 4. Put front frame on open jaws of vice. Use a soft-faced hammer to remove rotor and spacer.
 5. Remove three screws, retainer, front bearing, washer and felt washer.
 6. Inspect all parts for wear or damage. Replace as necessary.

Alternator

3



7. Test rotor. (See *Inspection/Test* procedures.)

Stator Assembly:

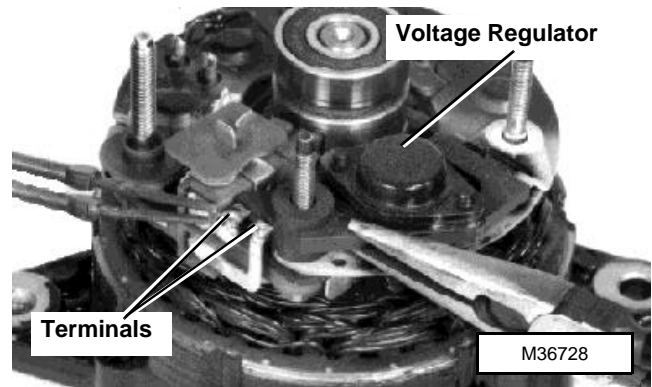
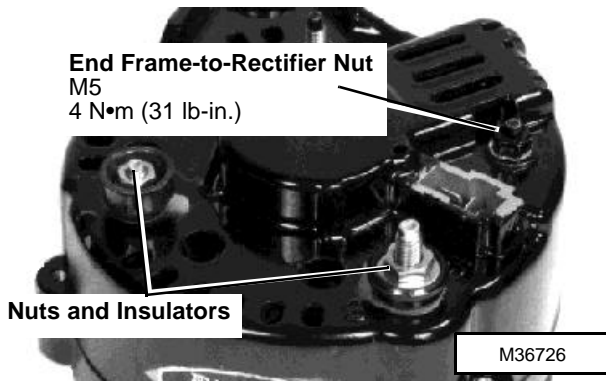
8. Remove end frame-to-rectifier nut.

9. Remove nuts and insulators.

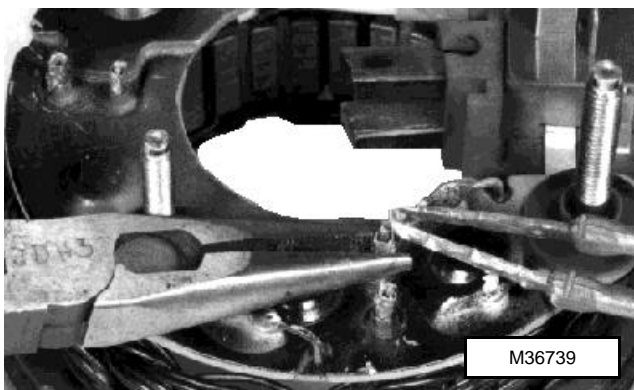
IMPORTANT: Do not pry against stator wires.

10. Use a screwdriver to pry end frame from stator.

11. Use a soldering gun with at least 120 watt capacity to disconnect terminals. Remove voltage regulator.



12. Melt solder inside the connecting pipes. While solder is hot, open the flattened pipe with a needle nose pliers. Pull stator wire from pipe.



13. Inspect and test brushes, stator and rectifier. (See *Inspection/Test* procedures.)

Assembly

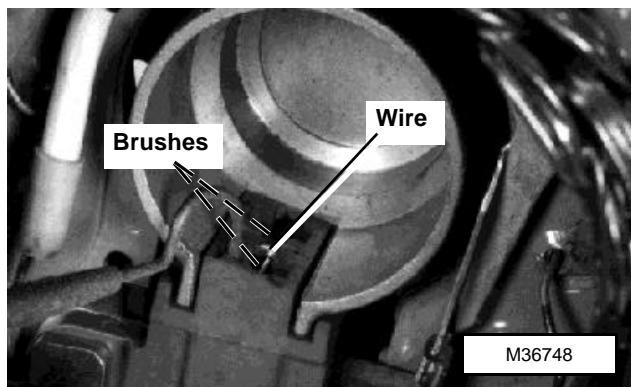
Assembly is done in the reverse order of disassembly.

NOTE: The three pair of lead wires on the stator are not evenly spaced. Rotate the rectifier until the terminal pipes align with the stator leads.

- Bend the stator lead wires, as necessary, to obtain an approximate distance of **33.50 mm (1.300 in.)** from stator to rectifier. Connect the six leads using a soldering gun.
- If additional solder is needed, use **ONLY** 60-40 rosin-core solder.

IMPORTANT: Be sure six stator lead wires do not contact end frame when installed.

- Before assembling stator assembly to rotor assembly, push brushes into brush holder and insert a wire through access hole in rear at end frame to lock brushes in place.

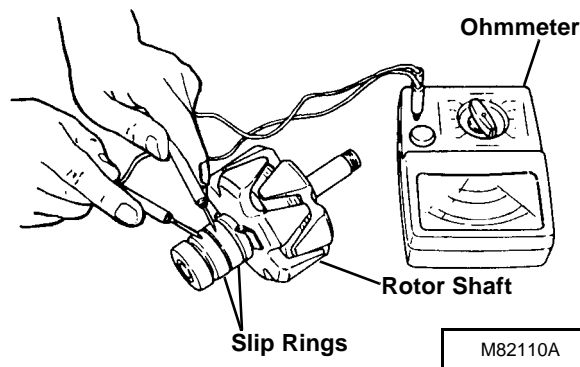


- Assemble rotor assembly to stator assembly and fasten with three attaching screws. Remove wire from access hole.

Inspection/Test

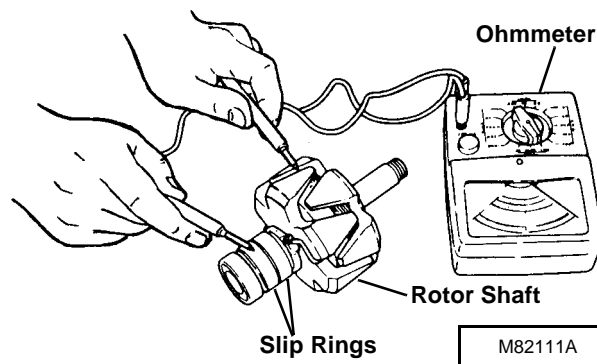
Rotor:

- Inspect the rotor slip rings for dirt build-up, rough spots, or out of roundness. If necessary, polish the surface of the slip rings using No. 00 sandpaper or 400-grit silicon carbide paper.
- Touch the probes of an ohmmeter to slip rings. Replace rotor if test indicates no continuity (no needle movement).



3

- Touch the probes of the ohmmeter to the shaft and one of the slip rings. Repeat for other slip ring. Replace rotor if test shows continuity (needle movement).

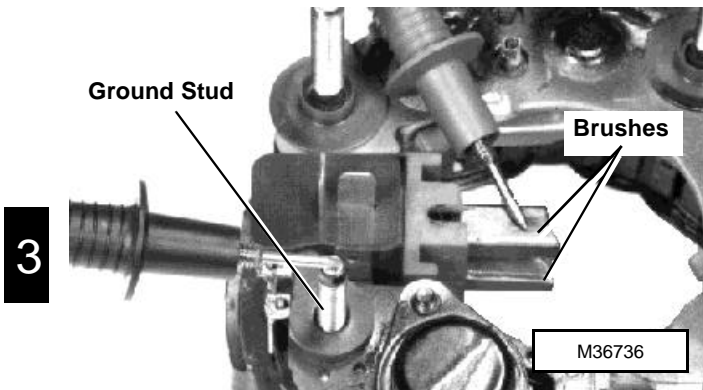


Brushes:

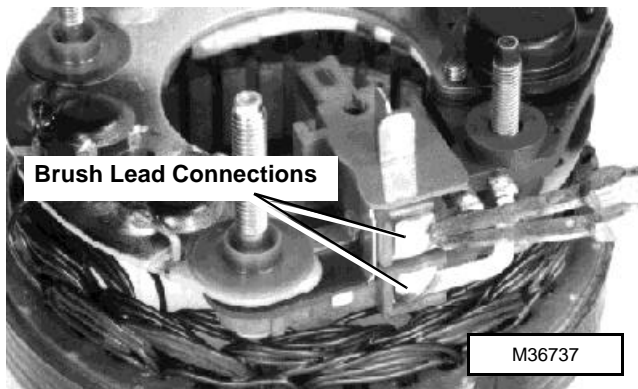
- Inspect brush holder and brushes for damage. Brushes must slide freely and the springs must hold the brushes firmly against the slip rings of the rotor.

Alternator

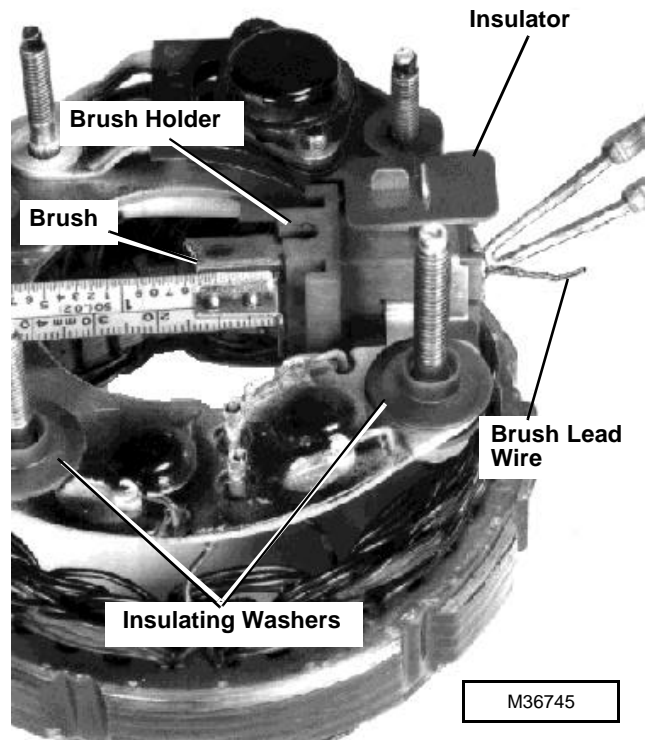
- Measure brushes for wear. Minimum exposed length must be **5.50 mm (0.220 in.)** or to wear limit line on brushes. Replace brushes as necessary.
- Use an ohmmeter or a test light to check for continuity. Check between the two brushes and between each brush and ground stud. There should be no continuity. Replace brush holder-rectifier assembly if there is continuity.



- To replace brushes:
 - Melt solder from brush lead connections and - remove brushes and springs.
 - Inspect springs for wear or damage. Replace as necessary.



- Push brush lead wire through spring. Insert spring and brush in brush holder with lead protruding through hole in brush holder. Make sure the longest side of brush is on side of brush holder with raised lip.
- Hold brushes in position so that exposed length is 13 mm (0.500 in.)
- Solder brush leads in this position. Cut off excess length of brush lead wire.
- Be sure insulating washers and insulator are in place.



NOTE: If additional solder is needed, use ONLY 60-40 rosin-core solder.

Stator:

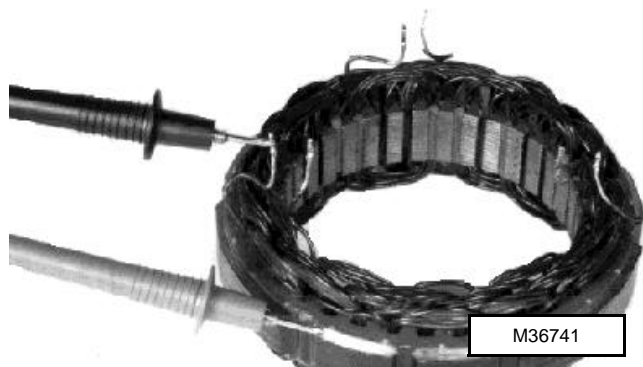
- Inspect stator for defective insulation, discoloration or a burned odor. If any of these defects are found, replace stator.

NOTE: Use an ohmmeter that is sensitive to resistance of 0 to 1 ohm.

- Touch probes of an ohmmeter to each pair of stator wires. Equal continuity readings should be observed between each pair of leads. If readings are not equal, replace stator.



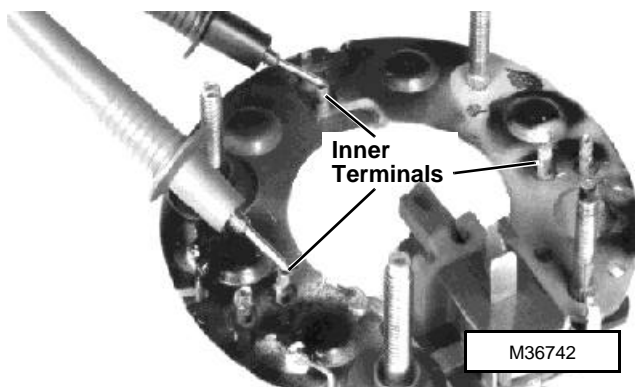
- Touch one probe of the ohmmeter to the bare metal surface of stator and the other probe to a bare stator lead wire. Repeat for each wire. Replace stator if test indicates continuity.



Rectifier:

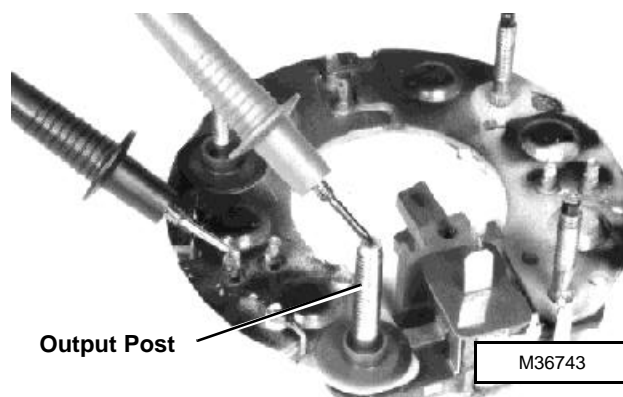
NOTE: The three inner terminals are connected by a printed circuit in the rectifier.

- Test the three inner terminals using an ohmmeter. Move probes so all terminals are cross checked. Replace the rectifier if test shows no continuity.



NOTE: Each of the three outer terminals on the rectifier is connected to two diodes permitting current flow in only one direction.

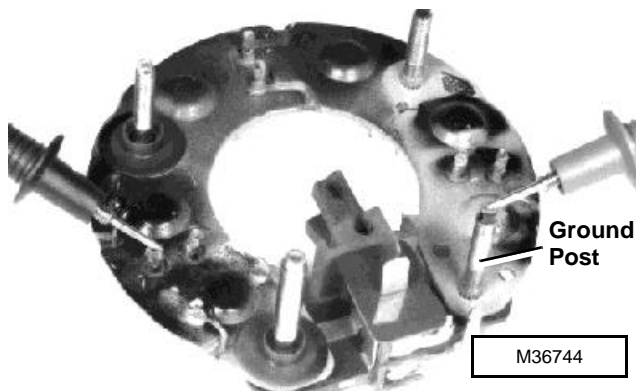
- Test the diodes by touching probes to output post and the three outer terminals.
- Switch the probes and check each terminal again. There should be continuity in only one direction between each terminal and the output post.



- Test the diodes by touching probes to ground post and the three outer terminals.
- Switch the probes and check each terminal again. There should be continuity in only one direction between each terminal and the ground post.

3

A shorted diode would have continuity in both directions. An open diode would have no continuity in either direction. Replace the rectifier assembly if any of the six diodes are defective.

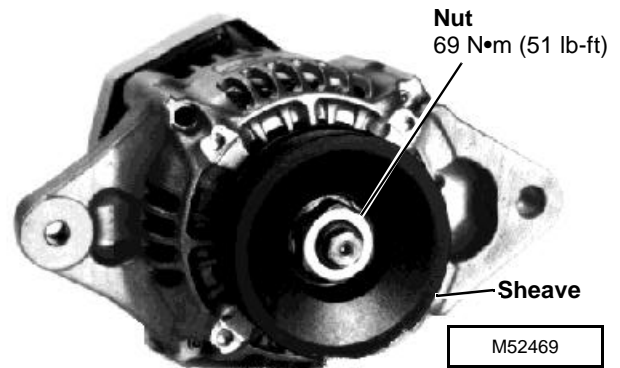
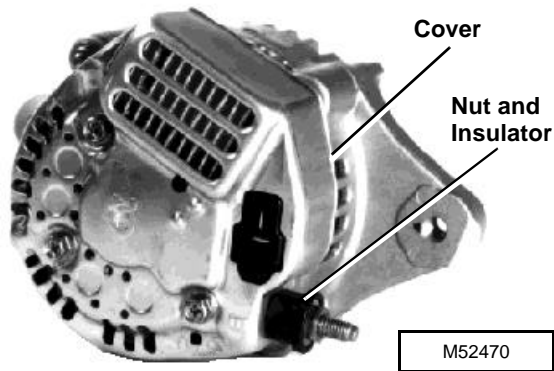


VOLTAGE REGULATOR - NIPPONDENSO 40A

Replacement

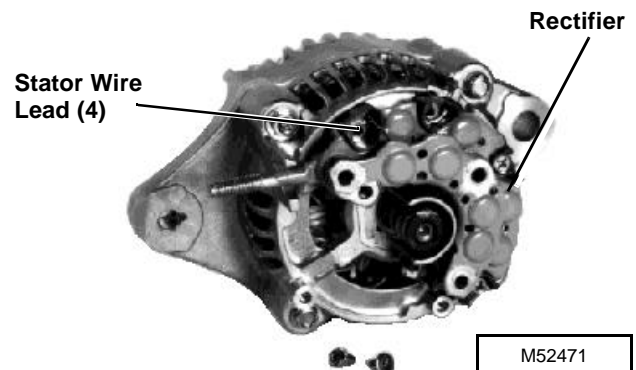
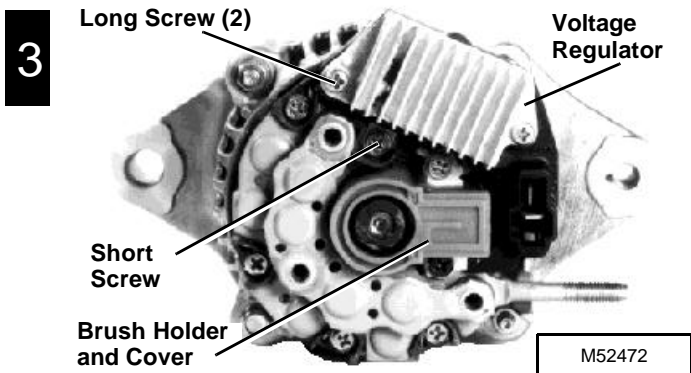
1. Remove nut and insulator.
2. Remove three screws and cover.

Alternator



3. Remove two screws, brush holder and cover.
4. Remove three screws. Replace voltage regulator.

4. Remove four screws and straighten stator wire leads.
5. Remove rectifier.



Installation is done in the reverse order of removal.

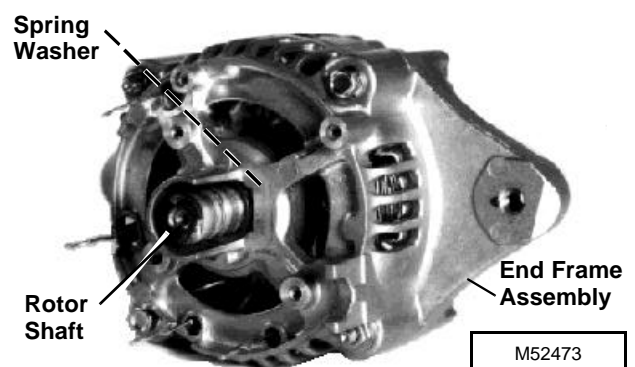
IMPORTANT: Make sure to install short screw at location shown. Longer screw will contact frame and cause damage to the charging system.

6. Remove two nuts, two screws and end frame assembly.
7. Press rotor shaft from end frame.
8. Remove spring washer.

ALTERNATOR - NIPPONDENSO 40A

Disassembly

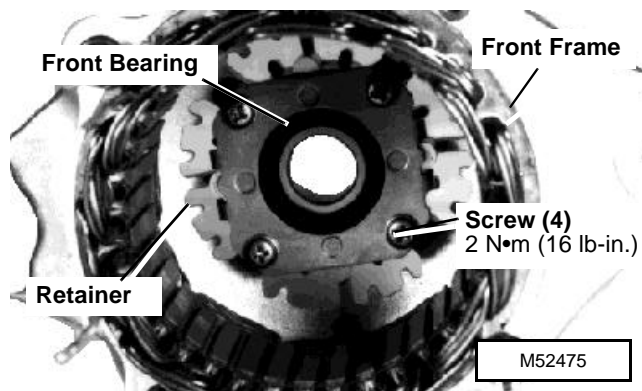
1. Remove voltage regulator. (See *VOLTAGE REGULATOR - REPLACEMENT* in this group.)
2. Remove nut.
3. Remove sheave using a puller set.



9. Remove four screws and retainer.

NOTE: Front bearing is press fit in front frame. Remove bearing only if replacement is necessary.

10. Inspect bearing in front frame for wear or damage. Replace if necessary. Replace bearing using a driver set and a press.



11. Inspect and test brushes, stator and rectifier. (See *Inspection/Test* in this group.)

Assembly

Assembly is done in the reverse order of disassembly.

- After installing rectifier, form a loop in stator wire leads, insert screws through loop and secure rectifier and wire leads.

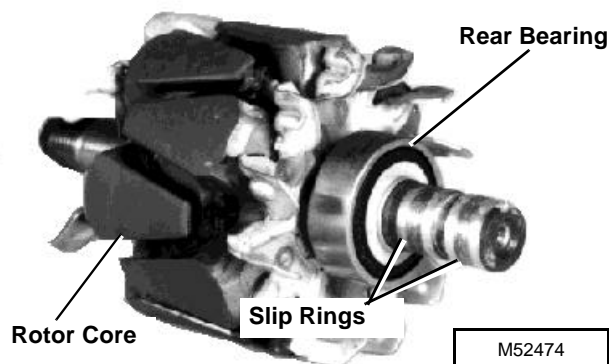
Inspection/Test

Rotor:

NOTE: Rear bearing and rotor assembly are not serviced separately. Damaged parts require that rotor assembly and bearing be replaced as a unit.

- Inspect bearing for wear or damage. Replace complete rotor if necessary.
- Inspect slip rings for dirt build-up, rough spots or out-of-roundness. If necessary, polish the surface of the slip rings using No. 00 sandpaper or 400-grit silicone carbide paper. Measure outer diameter of slip rings. Replace rotor if less than **14 mm (0.550 in.)**.

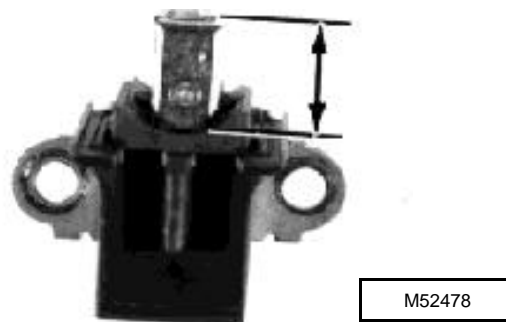
- Touch the probes of an ohmmeter to slip rings. Replace rotor if test indicates no continuity (no needle movement).
- Touch probes of ohmmeter to the rotor core and one of the slip rings. Repeat for other slip ring. Replace rotor if test shows continuity (needle movement).



3

Brushes:

- Inspect brush holder, brushes and springs for damage. Brushes must slide freely and springs must hold brushes firmly against the slip rings of the rotor.
- Measure length of brush protruding from holder. If length is less than wear limit, replace brushes.



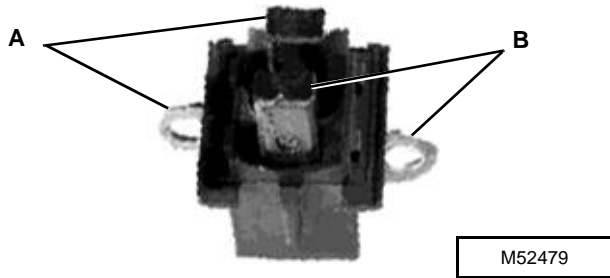
Brush Length Specifications

New..... **10.50 mm (0.410 in.)**

Wear Limit..... **4.50 mm (0.170 in.)**

- Check continuity between brush and terminal “A”. Check continuity between brush and terminal “B”. There should be continuity only at these points.

Alternator



Rectifier:

NOTE: Set the ohmmeter to the K ohm range.

- Check continuity between output post and each diode lead. Reverse ohmmeter leads and recheck. There should be continuity in one direction, but not the other.

A shorted diode would have continuity in both directions. An open diode would have no continuity in either direction. Replace the rectifier if any of the four diodes are defective.

Stator:

- Inspect stator for defective insulation, discoloration or a burned odor. If any of these defects are found, replace stator.

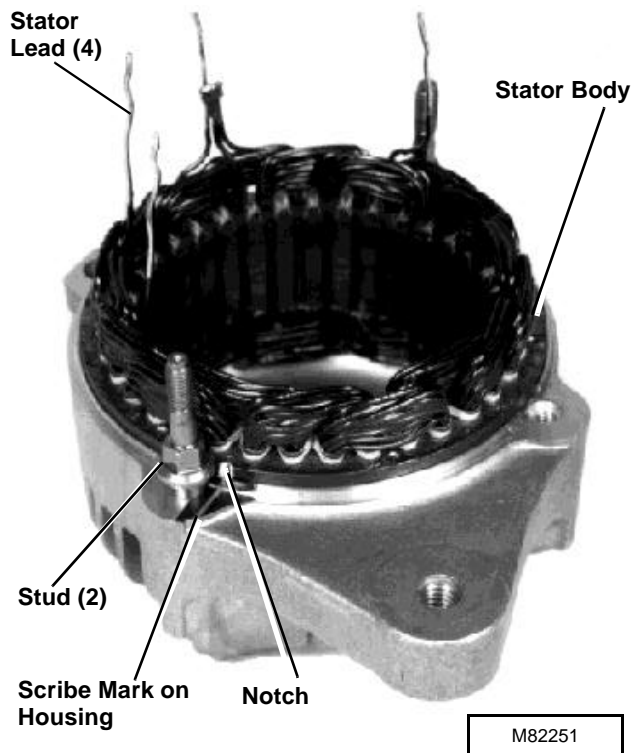
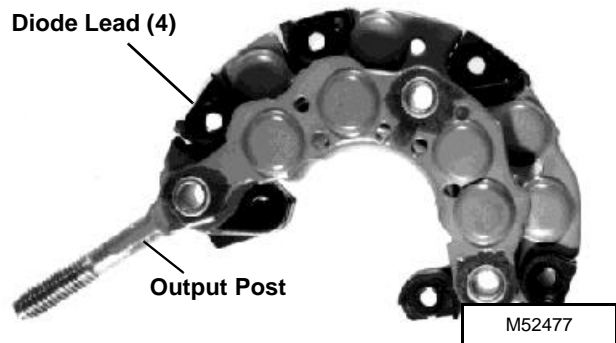
NOTE: Use an ohmmeter that is sensitive to resistance of 0 to 1 ohm.

3

- Check for continuity between each stator lead and stator body. Replace stator if test indicates continuity.

To replace stator:

- Scribe a mark on housing, at notch in stator, to aid in installation of a new stator.
- Remove two studs.
- Replace stator using a punch and hammer.



ENGINE AND FUEL SYSTEM TROUBLESHOOTING CHART

<p>PROBLEM OR SYMPTOM</p> <p>CHECK OR SOLUTION</p>	Engine will not crank.	Engine cranks but will not start or starts hard.	Engine will not stay running, or stalls frequently.	Engine runs rough, misses, noisy, vibrates or low on power. Fuel in oil. Oil level high.	Engine surges, or has uneven or uncontrolled rpm.	Oil in the coolant or coolant in the oil.	Engine has low oil pressure.	Engine operating temperature is incorrect.	Lack of fuel at injection pump.	Exhaust smoke blue or uses too much oil.	Exhaust smoke white.	Exhaust smoke black or grey or uses too much fuel.
Fuel pump screen, fuel filter, or fuel line restricted. Fuel dirty, contains water or wrong grade.		●	●	●	●				●		●	●
Air filter elements dirty or plugged. Replace.		●	●	●	●			●		●		●
Fuel shut-off valve turned off, or restricted. Solenoid linkage misadjusted. See adjustment.		●	●	●	●			●	●			
Muffler or exhaust manifold leak.			●	●								
Defective manifold heater.		●										
Injection pump or governor malfunctioning. Injection pump timing incorrect.		●		●	●						●	●
Defective cranking components or connectors.	●			●								
Low compression from worn rings, cylinder bore, piston, valves or warped head.		●	●	●		●				●		●
Valve clearance incorrect.	●	●	●	●				●				●
Burned or warped valves and valve seats. Defective valve spring.		●	●	●	●					●		●
Starter cranking rpm too slow. Damaged starter. Excessive engine load.	●	●							●			
Fuel pump leaking or not operating. See Fuel Supply Pump Pressure Test.		●	●	●	●				●		●	
Engine oil viscosity or level incorrect.	●	●					●	●		●		
Injector pressure incorrect or leaking.		●	●	●	●			●			●	●
Cylinder head gaskets leaking or damaged.	●	●	●		●	●	●	●		●		●
Radiator/oil cooler leak.				●		●		●				
Turbocharger				●								●

Diagnosis

ENGINE SYSTEM DIAGNOSIS

Conditions:

- Engine mounted on level surface.
- Key switch off unless indicated otherwise.

Test Location	Normal	If Not Normal
1. Engine dipstick and exterior engine surface-engine oil check.	Oil level between “L” and “H” marks. Oil not burnt, or contaminated with metal particles, fuel, or coolant. No external leakage, filter clean.	Change oil and inspect for source of contamination. Check gaskets, seals, plugs, cylinder head, block, and intake manifold and breather. Change oil filter.
2. Coolant tank and radiator. - Cooling System Check.	Coolant level between marks on tank when engine is warm. Coolant in radiator full to top. Coolant not contaminated with oil, fuel or discolored brown. Radiator screen free of debris. Hoses not cracked or leaking, clamps and radiator cap tight. Fan belt tight, not glazed or cracked. Fan blades not damaged or warped.	Add proper coolant mix. Drain and flush system. Check for source of contamination. Clean or replace. Pressure test radiator and cap. Replace and adjust belt tension. Replace fan.
3. Fuel tank, pump, pump screen, lines, filter, filter shutoff valve. - Fuel System Check	Fuel level correct, not contaminated, correct grade of fuel, no water. Fuel pump screen and in-line filter free of debris. Fuel shutoff valve in “ON” position. Fuel hoses not cracked or leaking. Fuel hose clamps tight. Fuel tank does not have vacuum.	Drain and clean fuel tank. Add fresh fuel. Replace filters. Move to “ON” position. Replace. Replace or tighten. Replace fuel tank check valve.
4. Air filter and air intake. - Air Intake System Check	Air filter hose not cracked, clamps tight. Element not plugged. Air filter housing sealed, no dirt tracking inside filter element.	Replace and tighten clamps. Replace element or housing.
5. Fuel shutoff solenoid. (Key in RUN position.)	Fuel shutoff solenoid must pull in and stay in. Solenoid must bottom out. Shutoff shaft must still move slightly.	Check shutoff solenoid adjustment. Clean any dirt from under solenoid boot. If solenoid will not pull in and hold in, see Fuel Shutoff Solenoid Circuit Test Points in ELECTRICAL section of Machine TM.
6. Air heater indicator light. (Key in RUN position.)	Indicator light should come on up to 15 seconds depending on air temperature.	See Air Heater Circuit Test Points in ELECTRICAL section of Machine TM.

3

ENGINE SYSTEM DIAGNOSIS - Continued

Test Location	Normal	If Not Normal
7. Fuel filter, fuel pump. (Key switch in RUN position.)	Fuel level increases in filter. Fuel pump operating - listen for humming sound. Fuel present in return hose at fuel pump.	See Fuel Pump Circuit Test Points in ELECTRICAL section of Machine TM. Test fuel pump pressure. (See <i>Operational Tests</i> in this section.) Replace fuel filter.
8. Throttle lever and cable.	Linkage not binding and adjusted correctly.	Repair, replace or adjust cable.
9. Intake and exhaust valves.	Cold engine. Valve clearance within specification. Valves not sticking.	Check and adjust. (See <i>Checks, Tests and Adjustments</i> in this section.) Check valve guides and stems.
10. Fuel at injectors. (Key in START position - engine cranking.)	Crack fuel injection lines at injectors. Fuel shutoff solenoid pulled in. Engine must crank.	Check spray pattern and cranking pressure. (See <i>Checks, Tests and Adjustments</i> in this section.) Replace injectors. See Cranking Circuit Test Points in ELECTRICAL section of Machine TM.
11. Injector ports. (Key in START position.)	Cylinder compression within specification. Pressure difference between cylinders within specification.	Perform cylinder compression test. (See <i>Operational Tests</i> in this section.)
12. Flywheel and starter.	Minimum cranking rpm within specification.	See Starter Amp Draw Test in ELECTRICAL section of Machine TM.
13. Injection pump timing inspection. (Key OFF.)	Timing should be correct. Remove pump as the LAST possible solution.	Perform injection pump static timing adjustment. (See <i>Checks, Tests and Adjustments</i> in this section.) Have pump tested by a qualified Service Repair Shop.
14. Injection pump idle settings. (Engine running).	Engine runs smooth under load. Engine rpm to specification.	See Slow Idle and Fast Idle Adjustments in ENGINE section of Machine TM.
15. Oil pressure sender port.	Oil pressure in specification.	Test engine oil pressure. (See <i>Operational Tests</i> in this section.)
16. Thermostat. (Engine at operating temperature.)	Clean from corrosion, rust, or debris. Opening temperature within specification.	Replace thermostat. Perform thermostat opening test. (See <i>Checks, Tests and Adjustments</i> in this section.)
17. Muffler.	Not restricted.	Replace muffler.

Checks, Tests and Adjustments

VALVE CLEARANCE, CHECK AND ADJUSTMENT

Reason:

To achieve correct engine operation.

Equipment:

- Feeler Gauge

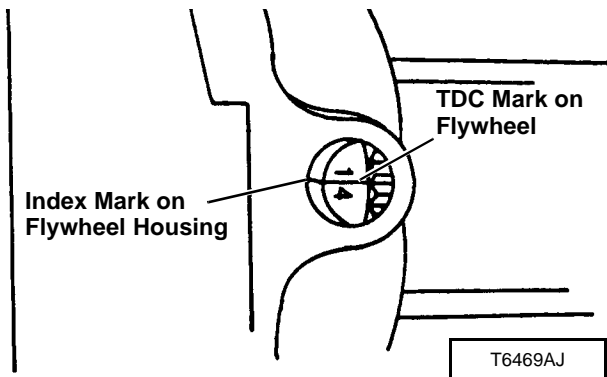
Procedure:

1. Remove rocker arm cover.
2. Remove plug from timing hole on flywheel housing.

NOTE: "Top Dead Center (TDC)" is the piston at its highest point.

3

3. Turn crankshaft pulley clockwise until No.1 cylinder TDC mark on flywheel aligns with index mark on flywheel housing.

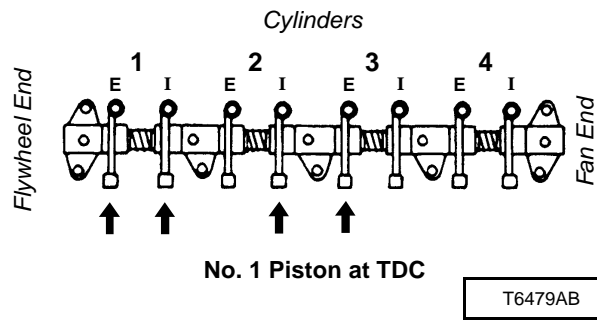


NOTE: No. 1 cylinder is the closest to the flywheel.

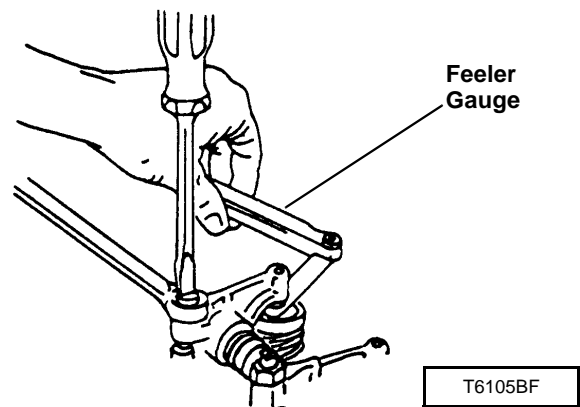
4. Try to move both No. 1 cylinder rocker arms or push rods.

If rocker arm push rods are not loose, rotate flywheel one revolution (360°). If both rocker arm push rods are loose the piston is at TDC on compression stroke.

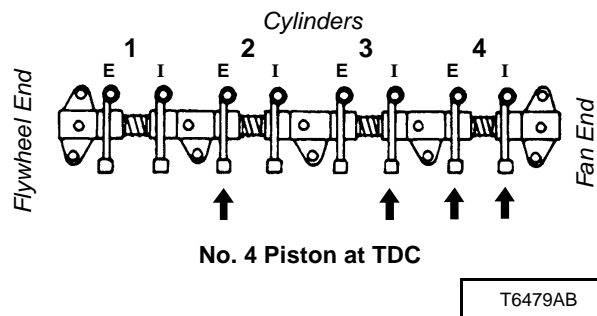
5. Measure and adjust valve clearance on the valves (arrows) with No. 1 piston at TDC.



To adjust valves, loosen nut and turn adjusting screw until clearance is **0.20 mm (0.008 in.)**. Hold screw while tightening nut.



6. Turn crankshaft pulley one revolution (360°). This puts the piston in No. 4 cylinder at TDC compression stroke.
7. Measure and adjust valve clearance on the valves (arrows) with No. 4 piston at TDC.



CONNECTING ROD SIDE PLAY CHECK

Reason:

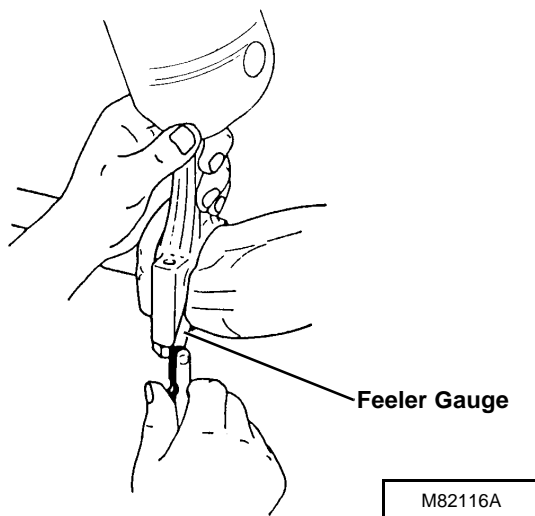
To determine proper side clearance between crankshaft and connecting rod.

Equipment:

- Feeler Gauge

Procedure:

1. Insert a feeler gauge, according to specifications, between connecting rod cap and crankshaft.



Specifications:

Standard Clearance 0.20 - 0.40 mm
 (0.0079 - 0.0157 in.)

Wear Limit..... 0.55 mm (0.0217 in.)

Results:

- If side play exceeds wear limit, replace connecting rod and connecting rod cap.

CONNECTING ROD BEARING CLEARANCE CHECK

Reason:

To measure oil clearance between connecting rod bearing and crankshaft journal.

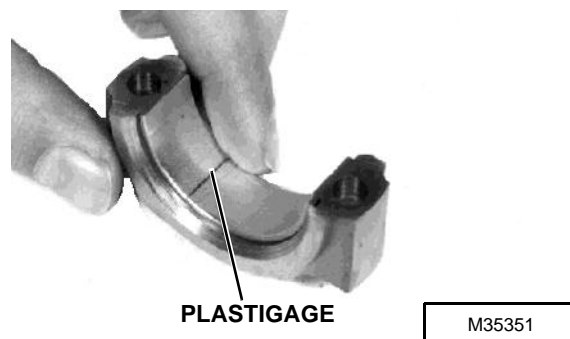
Equipment:

- PLASTIGAGE®

Procedure:

IMPORTANT: Connecting rod caps must be installed on the same connecting rod and in the same direction to prevent crankshaft and connecting rod damage.

1. Remove connecting rod cap.
2. Wipe oil from bearing insert and crankshaft journal.
3. Put a piece of PLASTIGAGE, or an equivalent, along the full length of the bearing insert approximately 6 mm (0.250 in.) off center.



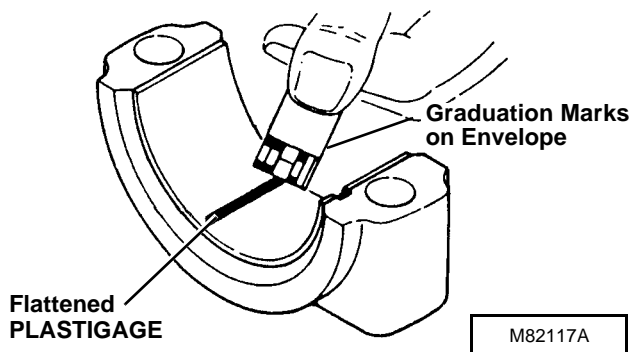
4. Turn crankshaft approximately 30° from bottom dead center.
5. Install connecting rod end cap and original cap screws. Tighten cap screws to:
4TN78T 39 N•m (29 lb-ft)
4TN82, 4TN84(T)(4019) ... 47 N•m (35 lb-ft)
6. Remove cap screws and connecting rod cap.

NOTE: The flattened PLASTIGAGE will be found on either the bearing insert or crankshaft journal.

7. Use the graduation marks on the envelope to compare the width of the flattened PLASTIGAGE at its widest point.
8. Determine bearing clearance. The number within the graduation marks indicates the bearing clearance in inches or millimeters depending on which side of the envelope is used.

Checks, Tests and Adjustments

9. Remove PLASTIGAGE.



Specifications:

Standard Clearance 0.038 - 0.090 mm
.....(0.0015 - 0.0035 in.)

Wear Limit..... 0.16 mm (0.0063 in.)

3

Results:

- If clearance exceeds wear limit, replace bearing inserts.

®PLASTIGAGE is a registered trademark of the DANA Corporation.

CRANKSHAFT, END PLAY CHECK

Reason:

To determine proper side clearance between crankshaft and engine block.

Equipment:

- Dial Indicator

Procedure:

NOTE: Crankshaft end play can be measured at front end or rear end of crankshaft. Procedure is performed from the rear end. The flywheel is removed to show detail.

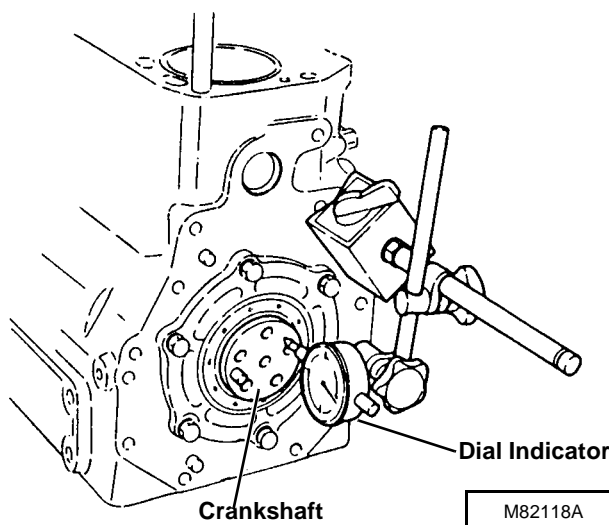
1. Fasten dial indicator to engine and position indicator tip on end of crankshaft.

IMPORTANT: Do not use excessive force when moving crankshaft to avoid damaging bearings.

2. Push crankshaft toward rear as far as possible.

3. Zero the dial indicator.

4. Using a bar, gently pry the crankshaft as far forward as possible.



Specifications:

Standard Clearance 0.090 - 0.271 mm
.....(0.004 - 0.011 in.)

Wear Limit..... 0.33 mm (0.0129 in.)

Results:

- If end play exceeds wear limit, replace thrust bearings.

CRANKSHAFT MAIN BEARING, CLEARANCE CHECK

Reason:

To measure oil clearance between main bearing and crankshaft journal.

Equipment:

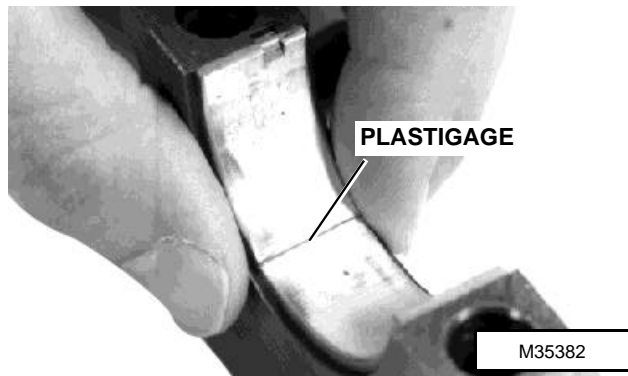
- PLASTIGAGE®

Procedure:

IMPORTANT: Main bearing caps must be installed on the same main bearing and in the same direction to prevent crankshaft and main bearing damage.

1. Remove main bearing cap.
2. Wipe oil from bearing insert and crankshaft journal.

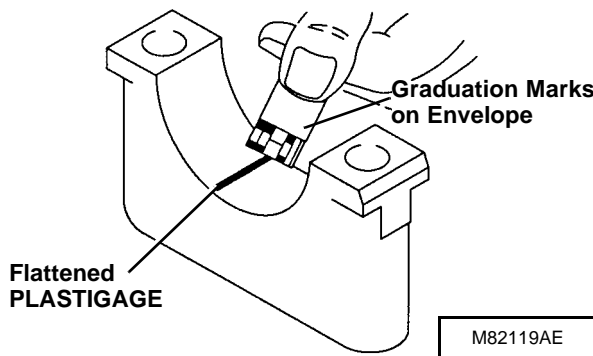
- Put a piece of PLASTIGAGE, or an equivalent, along the full length of the bearing insert approximately 6 mm (0.250 in.) off center.



- Install main bearing cap and cap screws. Tighten cap screws to:
 - 4TN78T 79 N•m (58 lb-ft)**
 - 4TN82, 4TN84(T)(4019) . . . 98 N•m (72 lb-ft)**
- Remove cap screws and main bearing cap.

NOTE: The flattened PLASTIGAGE will be found on either the bearing insert or crankshaft journal.

- Use the graduation marks on the envelope to compare the width of the flattened PLASTIGAGE at its widest point.
- Determine main bearing clearance. The number within the graduation marks indicates the bearing clearance in inches or millimeters depending on which side of the envelope is used.
- Remove PLASTIGAGE.



Specifications:

Standard Clearance 0.038 - 0.090 mm
. (0.0015 - 0.0035 in.)
Wear Limit. 0.06 mm (0.0063 in.)

Results:

- If clearance exceeds wear limit, replace bearing inserts.

®PLASTIGAGE is a registered trademark of the DANA Corporation.

VALVE LIFT CHECK

Reason:

Can indicate excessive wear on cam lobes, followers, and/or push rods.

3

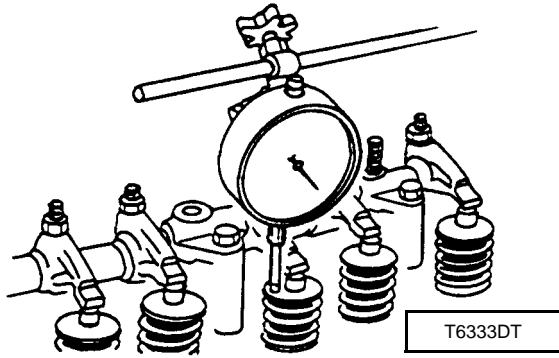
Equipment:

- Dial Indicator

Procedure:

- Adjust valve clearance. (See procedure in this group.)
- Remove rocker arm cover. (See *Cylinder Head, Valves and Manifolds* in this section.)
- Fasten dial indicator to engine and position indicator tip on valve retainer. Valve must be fully closed and rocker arm must move freely.
- Zero the dial indicator.
- Manually turn crankshaft pulley clockwise (from fan end).
- Observe dial indicator as valve is moved to the full open position. Valve lift (intake and exhaust) should be **8.8 mm (0.350 in.)**.

Repeat for each valve.



Results:

- If valve lift is less than specification, remove and inspect camshaft, followers and push rods. (See *Camshaft and Timing Gear Train* and/or *Cylinder Head, Valves and Manifolds* in this section.)

3

CAMSHAFT END PLAY CHECK

Reason:

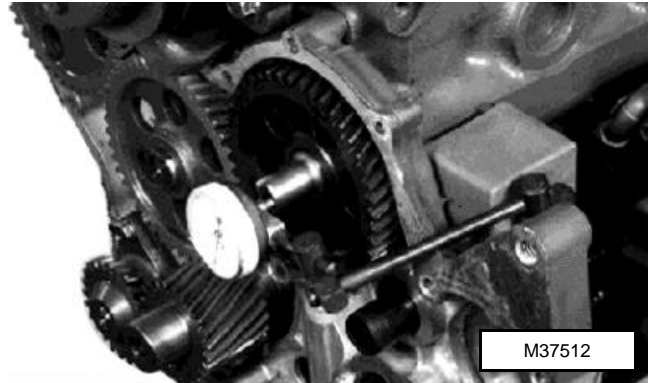
To determine proper side clearance between camshaft gear end journal and thrust plate.

Equipment:

- Dial Indicator

Procedure:

1. Remove timing gear cover. (See *Camshaft and Timing Gear Train* in this section.)
2. Fasten dial indicator to engine and position indicator tip on end of camshaft.
3. Push camshaft toward the rear as far as possible.
4. Zero the dial indicator.
5. Pull camshaft forward as far as possible.



Specifications:

Standard Clearance 0.05 - 0.20 mm
..... (0.0020 - 0.0079 in.)
Wear Limit 0.40 mm (0.016 in.)

Results:

- If end play exceeds wear limit, remove camshaft and replace thrust plate. (See *Camshaft and Timing Gear Train* in this section.)

TIMING GEAR BACKLASH, CHECK

Reason:

To check for wear between meshing gears, resulting in excessive noise and poor engine performance.

Equipment:

- Dial Indicator

Procedure:

1. Measure backlash between meshing gears.

Specifications - 4TN78T:

Standard Backlash

Crankshaft Gear-to-Oil

Pump Gear..... 0.11 - 0.19 mm
.....(0.0043 - 0.0075 in.)

All Except Crankshaft Gear-to-Oil

Pump Gear..... 0.04 - 0.12 mm
.....(0.0016 - 0.0047 in.)

Wear Limit..... 0.20 mm (0.0079 in.)

Specifications - 4TN82, 4TN84(T)(4019):

Standard Backlash 0.04 - 0.12 mm
.....(0.0016 - 0.0047 in.)

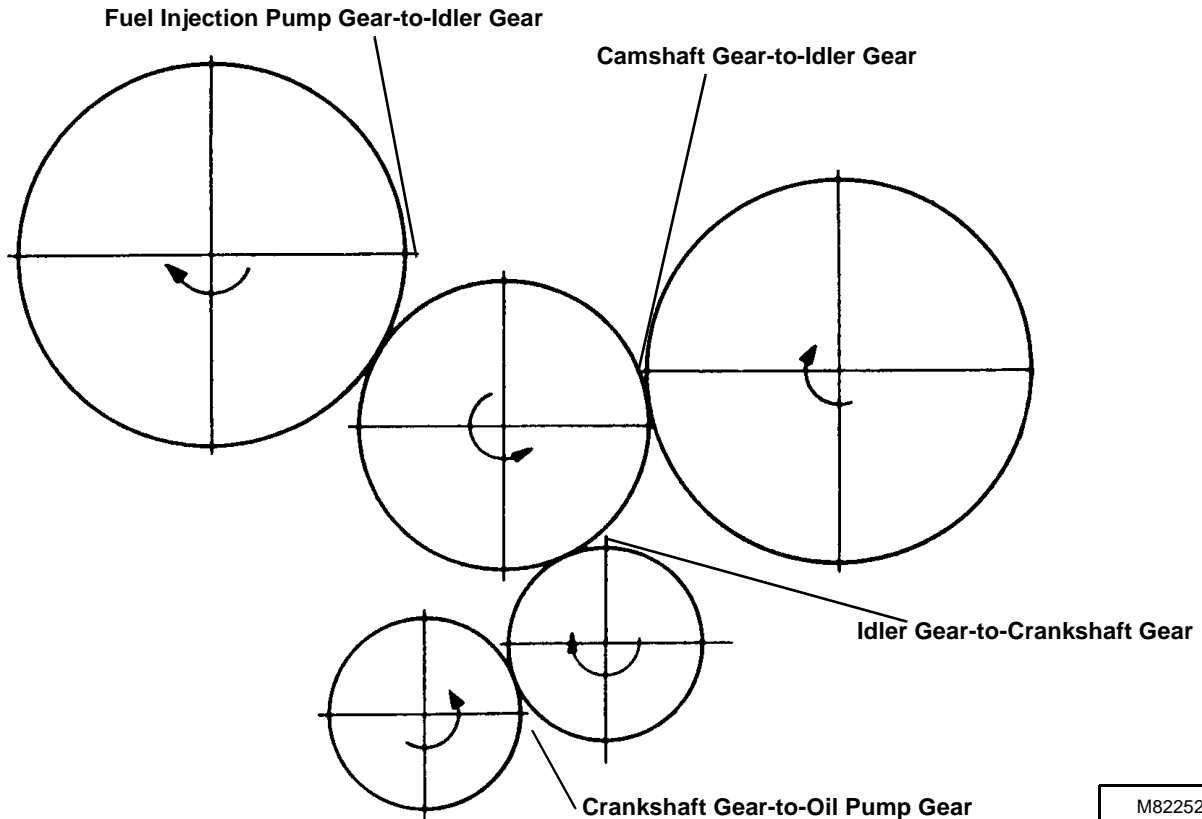
Wear Limit..... 0.20 mm (0.0079 in.)

Results:

- If backlash exceeds wear limit, replace meshing gears as a set:

Idler Gear, Camshaft Gear, Crankshaft Gear, Oil Pump Gear AND/OR Idler Gear, Fuel Injection Pump Gear.

3



M82252A

FUEL INJECTION NOZZLE TEST (HOLE-TYPE)

CAUTION

Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.

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

3

Reason:

To determine opening pressure, leakage, chatter and spray pattern of the fuel injection nozzle.

Equipment:

- D01109AA Diesel Fuel Injection Nozzle Tester
- D01110AA Adapter Set
- 23622 Straight Adapter
- Container

Connections:

1. Connect fuel injection nozzle to D01109AA Diesel Fuel Injection Nozzle Tester using parts from D01110AA Adapter Set and 23622 Straight Adapter.

IMPORTANT: Use clean filtered diesel fuel when testing injection nozzles to get best test results.

Procedure 1:

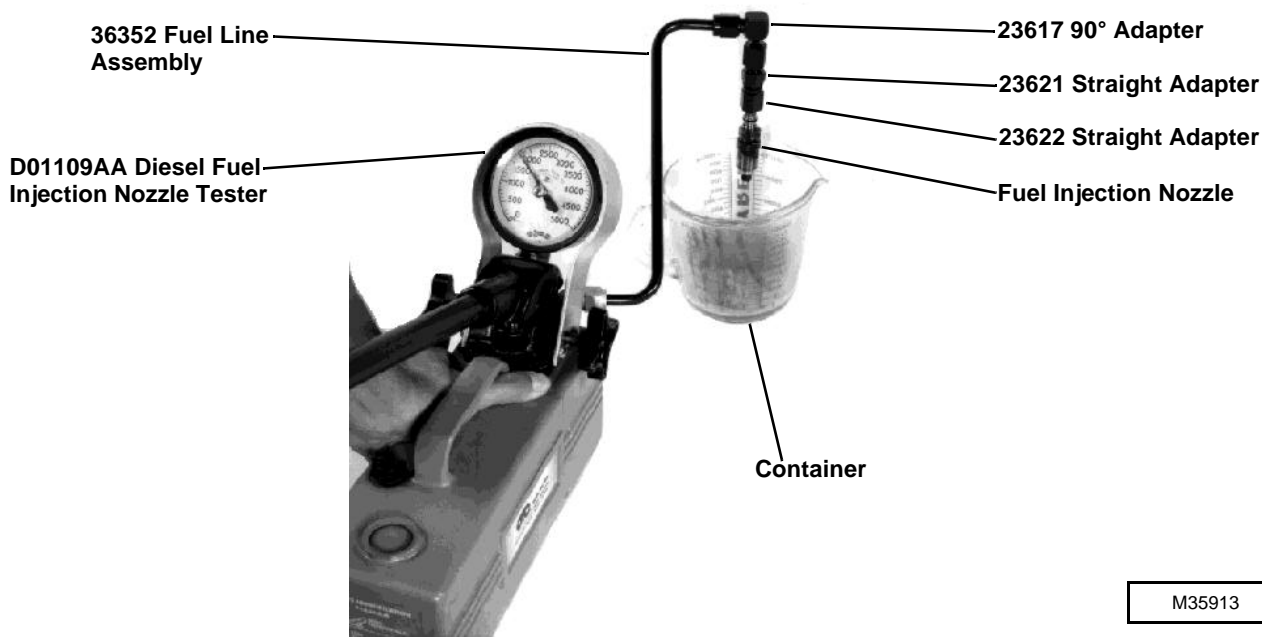
Test fuel injection nozzle opening pressure following the Nozzle Tester manufacturer's instructions.

Specifications:

Opening Pressure 19600 ± 480 kPa
..... (2843 ± 70 psi)

Results:

- If pressure reading does not meet specification, disassemble injection nozzle and inspect nozzle assembly for contamination or stuck valve. If necessary, add or remove shims to change opening pressure.



M35913

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Procedure 2:

Test fuel injection nozzle **leakage** following the Nozzle Tester manufacturer's instructions.

1. Dry nozzle completely using a lint-free cloth.
2. Pressurize nozzle to **17640 kPa (2558 psi)**.
3. Watch for leakage from nozzle spray orifice. Leakage time should be a minimum of **5 seconds**.

Results:

- If leakage time does not meet specification, disassemble injection nozzle and inspect nozzle assembly for contamination. Inspect valve seating surface. Replace nozzle assembly if necessary.

Procedure 3:

Test fuel injection nozzle **chatter and spray pattern** following the Nozzle Tester manufacturer's instructions.

1. Pressurize nozzle to **19600 ± 480 kPa (2843 ± 70 psi)**.
2. Listen for “chatter” sound and watch spray pattern.

Specifications:

Slow Hand

Lever Movement Chatter Sound

Slow Hand

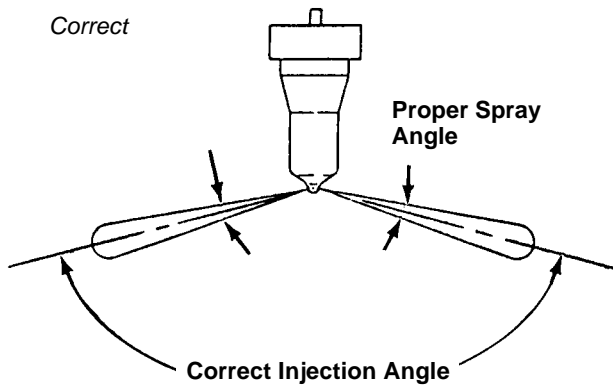
Lever Movement Fine Stream
. Spray Pattern

Fast Hand

Lever Movement Fine Atomized
. Spray Pattern

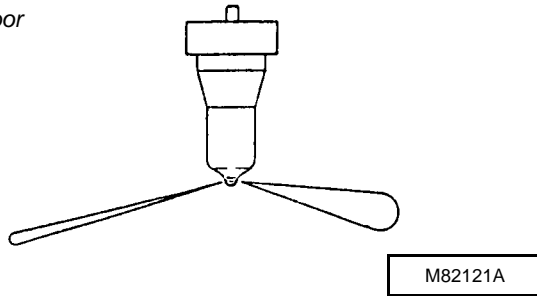
Checks, Tests and Adjustments

Procedure:



3

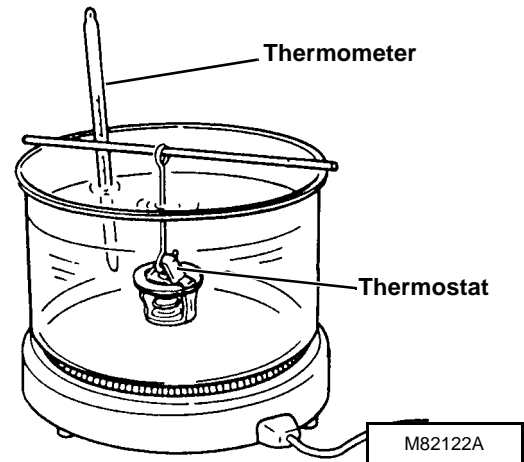
Poor



CAUTION

DO NOT allow thermostat or thermometer to rest against the side or bottom of glass container when heating water. Either may rupture if overheated.

1. Suspend thermostat and a thermometer in a container of water.
2. Heat and stir the water. Observe opening action of thermometer and compare temperatures with specifications.
3. Remove thermostat and observe its closing action as it cools.



Results:

- If nozzle chatter or spray pattern does not meet specifications, disassemble injection nozzle and inspect nozzle assembly for contamination. Inspect valve seating surface. Replace nozzle assembly if necessary.
- If there is excessive difference in spray angle or injection angle, incomplete atomization or sluggish starting/stopping of injection, disassemble injection nozzle and inspect nozzle assembly for contamination. Replace nozzle assembly if necessary.

Specifications:

Begin Opening 71° C (160° F)
Fully Open 85° C (184° F)
Minimum Lift Height 8 mm (0.310 in.)

THERMOSTAT OPENING TEST

Reason:

To determine opening temperature of thermostat.

Equipment:

- Thermometer
- Glass Container
- Heating Unit

Results:

- If thermostat does not open according to specifications, replace.
- If closing action is not smooth and slow, replace thermostat.

COOLANT TEMPERATURE SWITCH TEST

Reason:

To determine operating temperature of sender.

Equipment:

- Thermometer
- Glass Container
- Heating Unit
- Ohmmeter

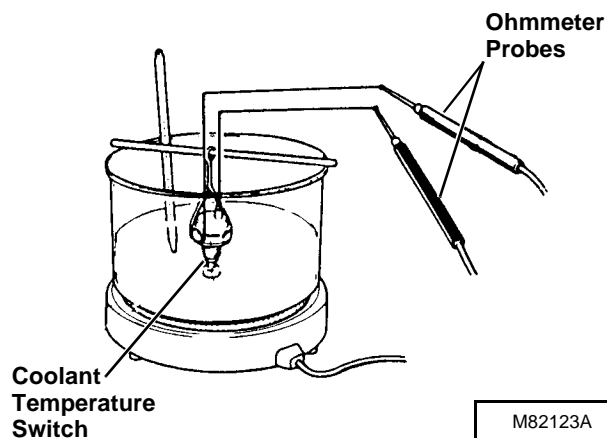
Procedure:

CAUTION

DO NOT allow switch or thermometer to rest against the side or bottom of glass container when heating water. Either may rupture if overheated.

1. Connect lead wires from ohmmeter probes, to sender terminal and body.

2. Suspend sender and a thermometer in a container of water.
3. Heat and stir the water. Observe water temperature when continuity occurs. Water temperature should be **107 - 113° C (225 - 235°F)**.



3

Results:

- If continuity does not occur within temperature listed, replace sender.

Checks, Tests and Adjustments

STARTER NO-LOAD AMP DRAW/RPM TEST

Reason:

To determine if starter is binding or has excessive amperage draw under no load.

Equipment:

- JT05712 Current Gun
- JT05719 Hand-Held Digital Tachometer
- Jumper Cables
- Jumper Wire

Procedure:

1. Mount starter in a vise.

3 *NOTE: Check that battery is fully charged and of proper size to ensure accuracy of test.*

2. Connect jumper cables to a 12 volt battery.
3. Connect positive (+) cable to solenoid battery terminal on starter.
4. Connect negative (-) cable to starter body.
5. Attach Current Gun to positive cable.

IMPORTANT: Complete this test in 20 seconds or less to prevent starter damage.

6. Use a jumper wire to briefly connect positive (+) starter terminal to solenoid terminal "S". Starter should engage and run.
7. Read and record starter amperage and rpm.

Specifications:

Maximum Starter Amperage

Hitachi 0.8 kW. 60 Amps at 7000 rpm

Hitachi 2.0 kW. 110 Amps at 4500 rpm

Nippondenso 1.0 kW. . 90 Amps at 3000 rpm

Nippondenso 1.4 kW. . 90 Amps at 3500 rpm

Minimum Starter RPM

Hitachi 0.8 kW. 7000

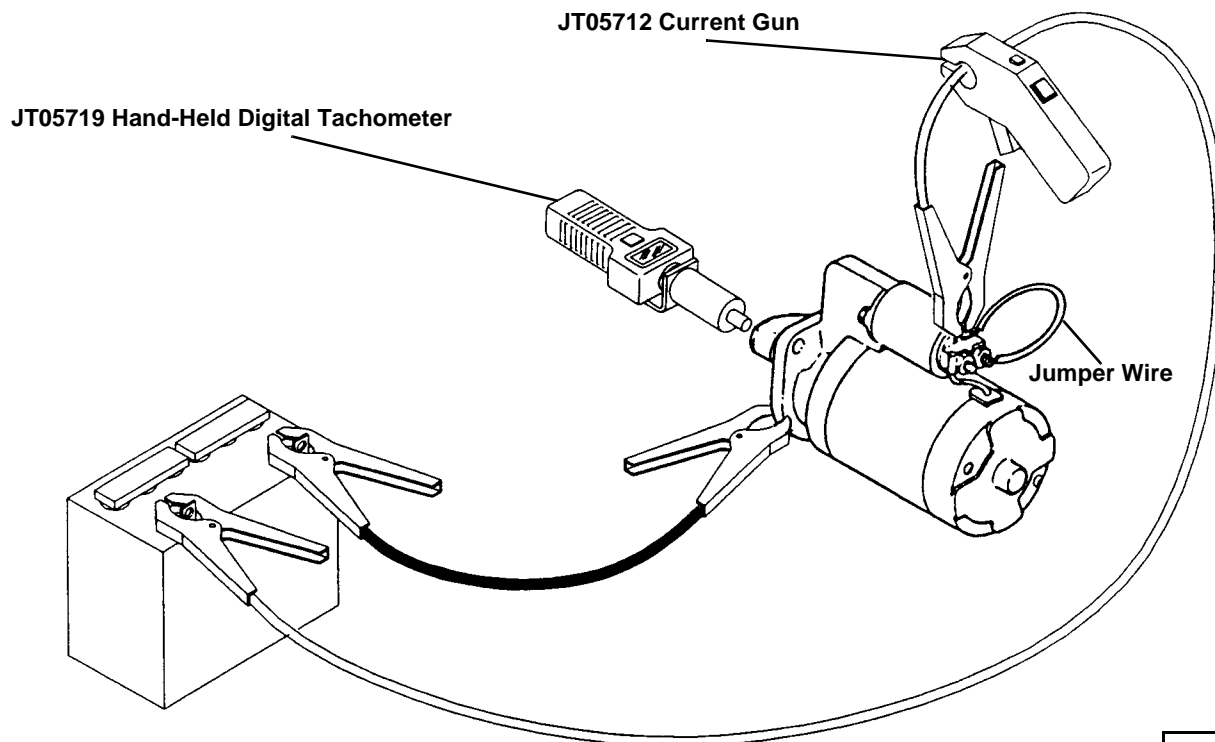
Hitachi 2.0 kW. 4500

Nippondenso 1.0 kW. 3000

Nippondenso 1.4 kW. 3500

Results:

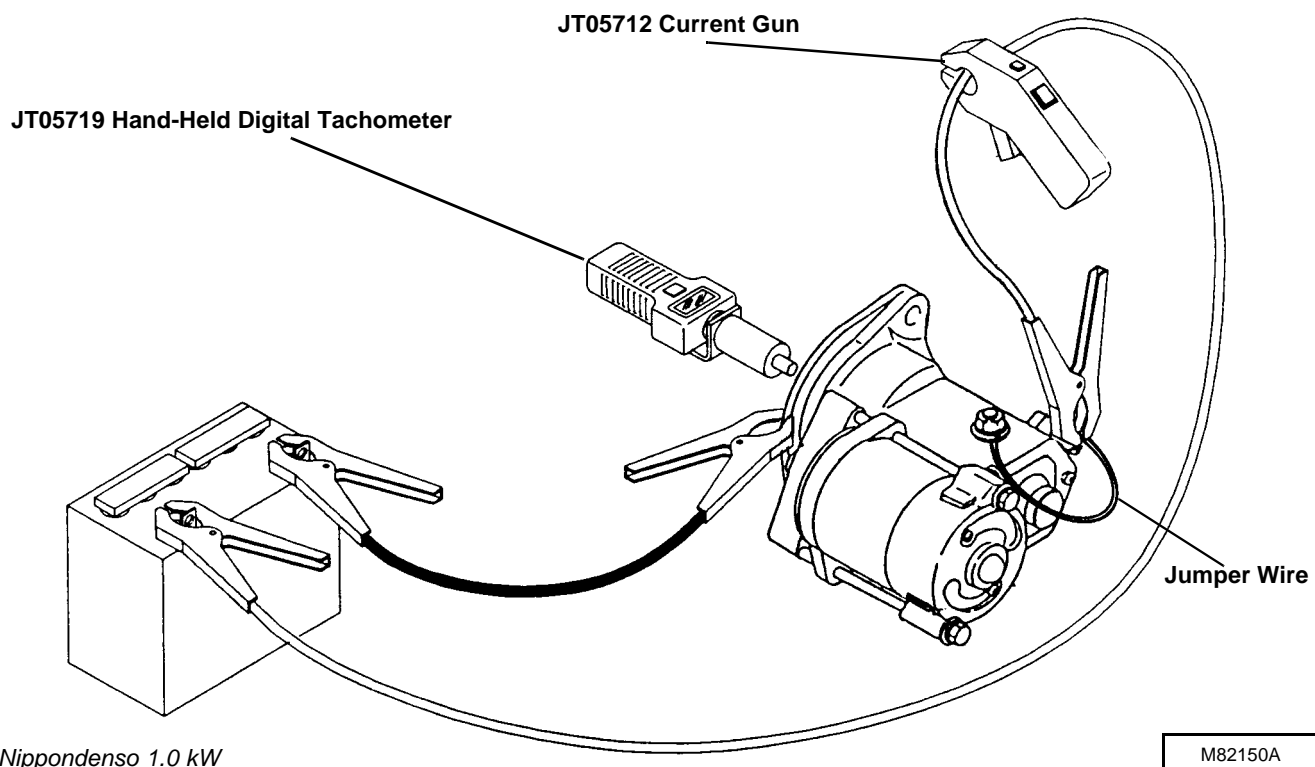
- If solenoid "clicks" or chatters and motor does not turn, replace solenoid.
- If pinion gear engages and motor doesn't turn, repair or replace starter motor.
- If starter engages and runs but amperage is more than specifications, repair or replace starter.
- If rpm is less than specification, with battery fully charged, repair or replace starter.



All Except Nippondenso 1.0 kW

M82149A

3



Nippondenso 1.0 kW

M82150A

Checks, Tests and Adjustments

INJECTION PUMP STATIC TIMING ADJUSTMENT - 4TN78T

Reason:

To make sure that injection pump timing is set to manufacturers specification.

Equipment:

- Timing Tool (No. 1 fuel injection line cut off at first bend)
- External fuel supply

Procedure:

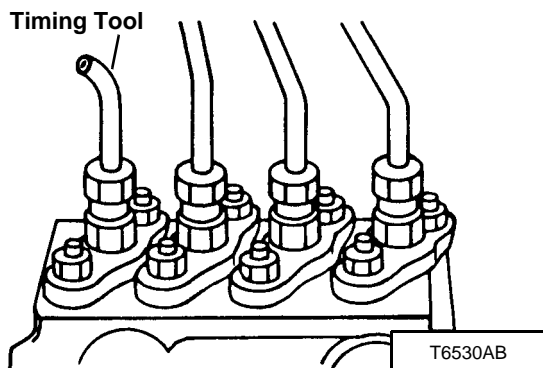
IMPORTANT: Injection pump timing should be correct. Once timing is set, it will not normally change during the life of the engine, unless it was altered.

3

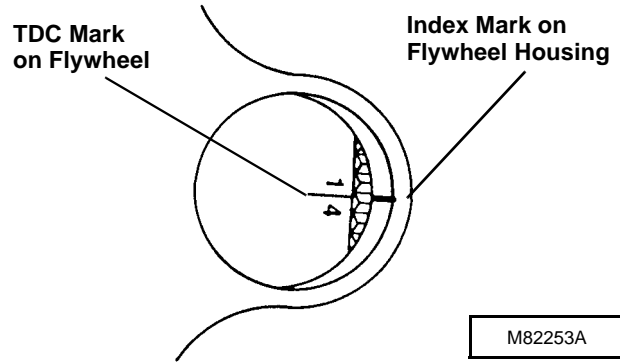
Check and adjust timing only as the last option. Check fuel, fuel supply system, injectors, air intake system and cylinder compression before continuing.

NOTE: Normal rotation, as viewed from the flywheel end, is counterclockwise. The number one fuel injection line is toward the flywheel.

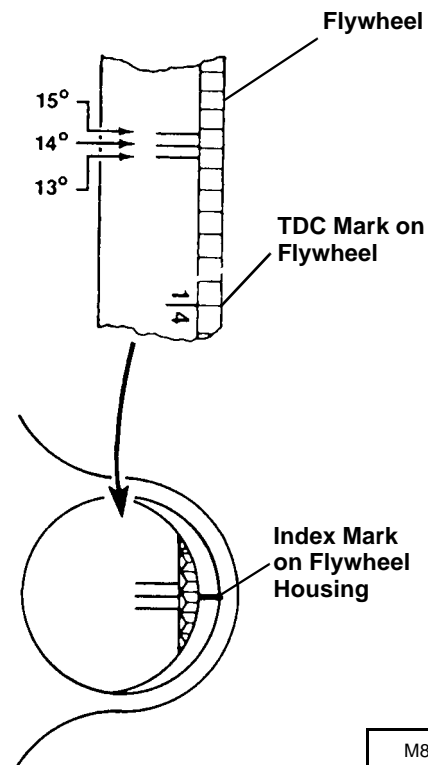
1. Remove the number one fuel injection line.
2. Install timing tool (number one fuel line cut off at first bend).



3. Remove rubber plug from flywheel housing.
4. Turn crankshaft pulley in either direction until the No. 1 cylinder top dead center (TDC) mark aligns with the index mark on the flywheel housing.



5. Prime pump to fill it with fuel. 1 L (1.06 qt) of fuel is more than adequate.
6. Hold throttle lever in run position.
7. Turn flywheel clockwise (as viewed from the flywheel end) until tip of Timing Tool has become **MOIST** with solid fuel.
8. Check timing mark on flywheel. The index mark must line up with the 14° mark on flywheel.



Specifications:

Injection Pump Timing.14° BTDC
..... (Before Top Dead Center)

Engine Crankshaft
Position. No.1 Cylinder
.....on TDC Compression Stroke

Distance On Outer Surface Of Flywheel
Per 1° Of Rotation. 2.88 mm (0.110 in.)

Timing Lines On Pump
Mounting Plate2.5° Apart

Results:

- If timing is not according to specifications, loosen pump mounting bolts and turn pump towards engine block to retard timing or away from block to advance timing. Recheck timing.
- If timing did not change, remove pump and have tested by a diesel injection service shop.
- If timing is OK:
 - Install rubber plug in flywheel housing.
 - Remove timing tool.
 - Install number one injection line.

INJECTION PUMP STATIC TIMING ADJUSTMENT - 4TN82 AND 4TN84(T)(4019)

Reason:

To make sure that injection pump timing is set to manufacturers specification.

Equipment:

- Timing Tool (No. 1 fuel injection line cut off at first bend)
- External fuel supply

Procedure:

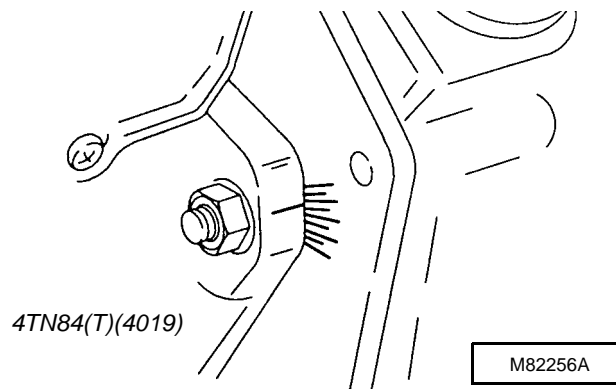
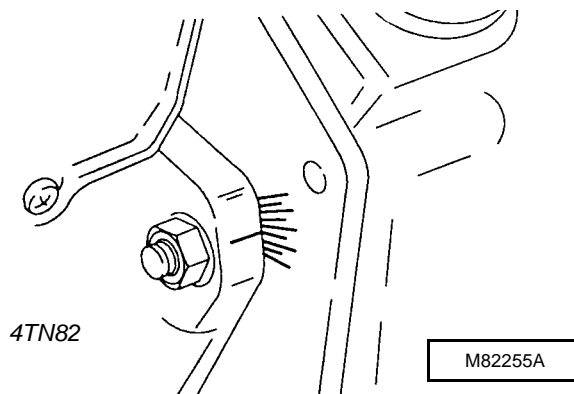
IMPORTANT: Injection pump timing should be correct. Once timing is set, it will not normally change during the life of the engine, unless it was altered.

Check and adjust timing only as the last option. Check fuel, fuel supply system, injectors, air intake system and cylinder compression before continuing.

NOTE: If injection pump has been removed from engine without disturbing engine crankshaft and pump shaft, perform Step 1 only. Otherwise, perform the entire timing procedure.

1. 4TN82: Align arrow or line on injection pump flange with the sixth mark (line) on timing gear mounting plate. **3**

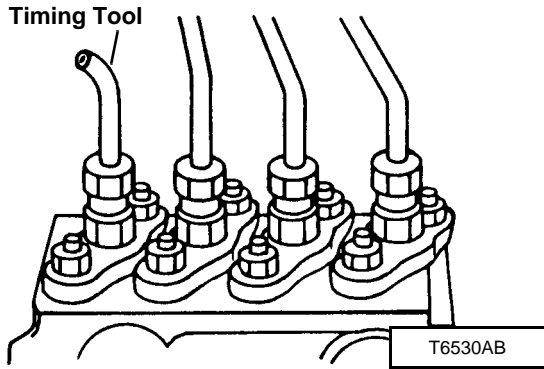
4TN84(T)(4019): Align arrow or line on injection pump flange between third and fourth marks (lines) on timing gear mounting plate.



Checks, Tests and Adjustments

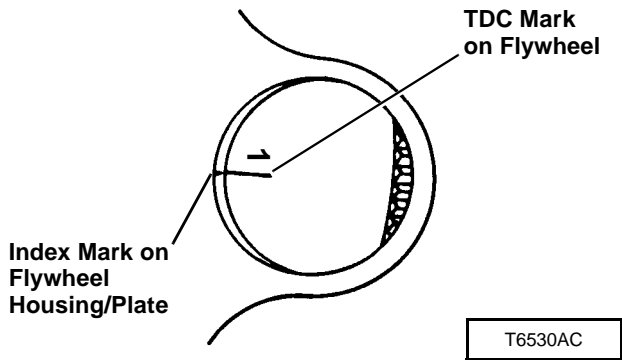
NOTE: Normal rotation, as viewed from the flywheel end, is counterclockwise. The number one fuel injection line is toward the flywheel.

2. Remove the number one fuel injection line.
3. Install timing tool (number one fuel line cut off at first bend).

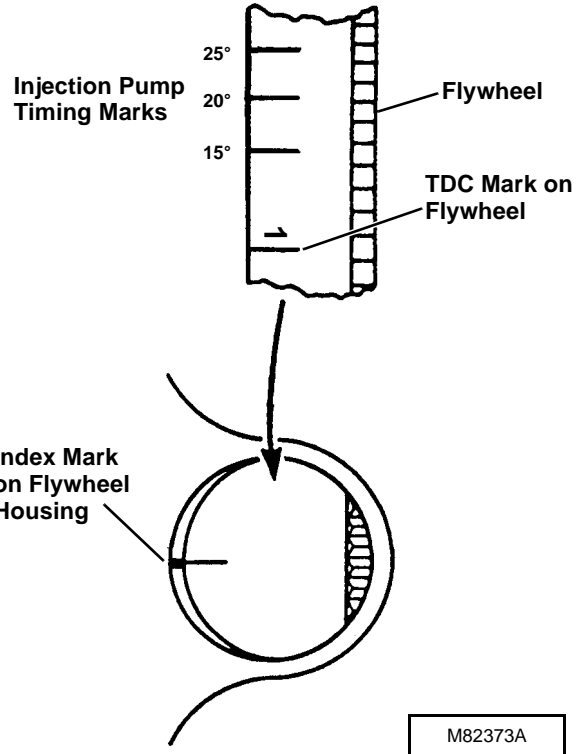


3

4. Remove rubber plug from flywheel housing, if equipped.
5. Turn crankshaft pulley in either direction until the No. 1 cylinder top dead center (TDC) mark aligns with the index mark on the flywheel housing/plate.



6. Prime pump to fill it with fuel. 1 L (1.06 qt) of fuel is more than adequate.
7. Hold throttle lever in run position.
8. Turn flywheel clockwise (as viewed from the flywheel end) until tip of Timing Tool has become **MOIST** with solid fuel.
9. Check timing mark on flywheel. The index mark must line up with injection pump timing mark on flywheel. See specifications.



Specifications:

Injection Pump Timing Mark

4TN82 (970 CUT, 675 SSL, 3325/65 GM) $15^\circ \pm 1^\circ$ BTDC
 (Before Top Dead Center)

4TN84

(1070 CUT) $15^\circ \pm 1^\circ$ BTDC
 (4019D OEM) $16^\circ \pm 1^\circ$ BTDC

4TN84T (4019T OEM)

4019TF001 and 005 $15^\circ \pm 1^\circ$ BTDC
 4019TF006 $12^\circ \pm 1^\circ$ BTDC

Engine Crankshaft

Position No. 1 Cylinder
 on TDC Compression Stroke

Results:

- If timing is not according to specifications, loosen pump mounting bolts and turn pump towards engine block to retard timing or away from block to advance timing. Recheck timing.
- If timing did not change, remove pump and have tested by a diesel injection service shop.
- If timing is OK:
 - Install rubber plug in flywheel housing, if equipped.
 - Remove timing tool.
 - Install number one injection line.

FAN/ALTERNATOR DRIVE BELT ADJUSTMENT

Reason:

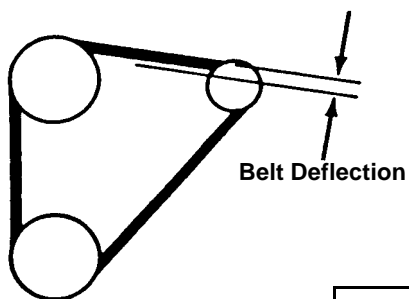
To keep proper tension on belt to drive water pump and alternator. To prevent shortened belt and bearing life.

Equipment:

- JDG529 or JDST28 Belt Tension Gauge
- Straight Edge

Procedure:

1. Check belt tension between fan and alternator using Belt Tension Gauge and a straight edge.



Specifications:

Applied Force98 N (22 lb-force)

Deflection10 - 15 mm (0.400 - 0.600 in.)

Results:

- If deflection is not within specifications:
 - Loosen both alternator mounting cap screws/nuts.
 - Apply force to FRONT alternator housing only (near the belt) until tension is correct.
 - Tighten cap screws/nuts.

ENGINE OIL COOLER LEAKAGE TEST - 4TN78T AND 4TN84T (4019TF001 and 005)

3

Reason:

Inspect oil cooler for leaks.

Procedure:

1. Plug one end of coolant inlet or outlet passage.
2. Apply regulated air pressure of **206 - 483 kPa (30 - 70 psi)** to other end.
3. Dip oil cooler into water and check for leaks.

Optional test:

If a leak did not appear, use a hot water bath to possibly open crack(s).

Results:

- Repair leak(s) or replace oil cooler if necessary.

Checks, Tests and Adjustments

FUEL SHUTOFF SOLENOID ADJUSTMENT

Reason:

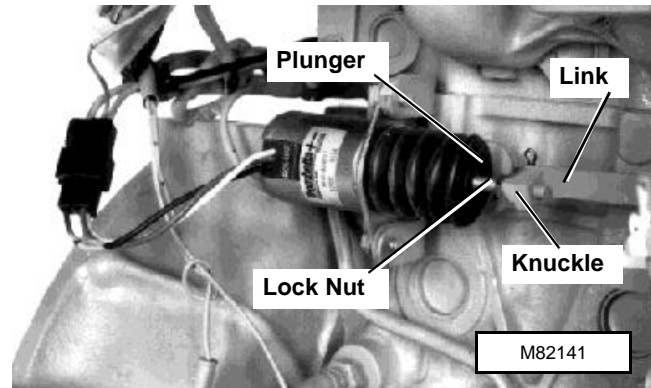
To ensure that fuel shutoff solenoid retracts fully, moving the injection pump shutoff control lever far enough to allow full rack travel.

Procedure:

1. Loosen lock nut.
2. Disconnect link from solenoid.
3. Hold solenoid plunger bottomed in solenoid body.
4. Move link toward solenoid until it stops

3

5. Turn plunger rod in or out of knuckle until knuckle and link holes line up. Turn out two additional turns. The additional turns insure that the solenoid bottoms out before the linkage.
6. Assemble and check for free movement when key switch is turned ON. Also check that linkage returns completely to the STOP position when key switch is turned OFF.



RADIATOR, BUBBLE TEST

Reason:

To determine if compression pressure is leaking from cylinder.

Equipment:

- JDG560 Adapter

Procedure:

1. With coolant at proper level and radiator cap tight, run engine for 5 minutes to bring to operating temperature.
2. Remove cap from recovery tank.
3. Check for bubbles coming from overflow hose at bottom of tank.

If bubbles are present, isolate source of compression leak:

- Remove injection nozzles.
- Install JDG560 Adapter in injection port of cylinder to be tested.
- Move piston to bottom of stroke with intake and exhaust valves closed.
- Connect hose from compressed air source to adapter.
- Apply the specified maximum air pressure into cylinder:

**4TN78T, 4TN82RJK,
4TN84RJK, 4TN82RJE,
4TN82ESP 2448 kPa (355 psi)
4TN84(T)(4019) 2158 kPa (313 psi)**

- Check for bubbles in recovery tank or air escaping from muffler, air cleaner or oil fill opening.
- Repeat for each cylinder.

Results:

- If bubbles are present, check for cracks in cylinder head and block. Check for damaged head gasket.
- If air escapes from muffler, check for worn exhaust valve.

- If air escapes from air cleaner, check for worn intake valve.
- If air escapes from engine oil fill, check for worn piston rings.

COOLING SYSTEM, PRESSURE TEST

Reason:

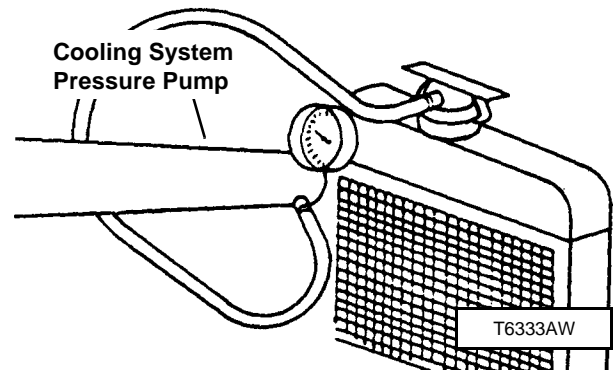
Inspect cooling system for leaks.

Equipment:

- D05104ST Cooling System Pressure Pump
- JDG692 Radiator Pressure Test Kit (Adapters)

Procedure:

1. Remove cap and attach pressure pump to radiator.
2. Apply pressure according to specifications.
3. Check for leaks throughout cooling system.



**Specifications - 4TN78T, 4TN82RJK,
4TN84RJK, 4TN84(T)(4019):**

**Maximum Pressure 97 kPa (14 psi)
Minimum Pressure
after 15 Seconds 88 kPa (12.8 psi)**

Specifications - 4TN82RJE, 4TN82ESP:

**Maximum Pressure 69 kPa (10 psi)
Minimum Pressure
after 15 Seconds 55 kPa (8 psi)**

3

Operational Tests

Results:

- Pressure should hold to specifications. If pressure decreases, check for leaks. Repair leaks or replace parts as necessary.
- If pressure test still indicates leakage after all external leaks have been stopped, a defective head gasket, cracked block, or cylinder head may be the cause. Perform *RADIATOR BUBBLE TEST*.

RADIATOR CAP, PRESSURE TEST

Reason:

Test radiator cap for operating in correct pressure range.

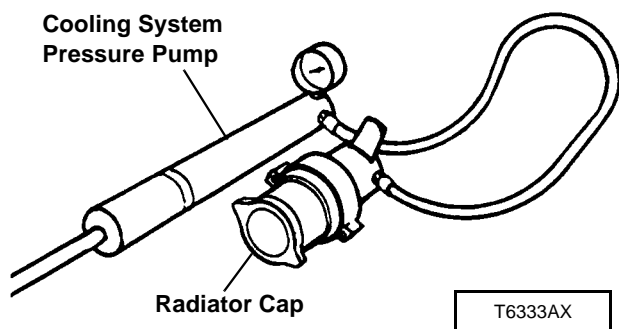
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Equipment:

- D05104ST Cooling System Pressure Pump
- JDG692 Radiator Pressure Test Kit (Adapters)

Procedure:

1. Install radiator cap on pressure pump.
2. Apply pressure. Pressure valve in cap should open according to specifications.



Specifications:

Valve Opening Pressure

4TN78T, 4TN82RJK, 4TN84RJK,
4TN84(T)(4019) 88 kPa (12.8 psi)
4TN82RJE, 4TN82ESP 55 kPa (8 psi)

Results:

- If cap leaks, retighten and test again. Replace cap if pressure is not within specification.

CYLINDER, COMPRESSION PRESSURE TEST

Reason:

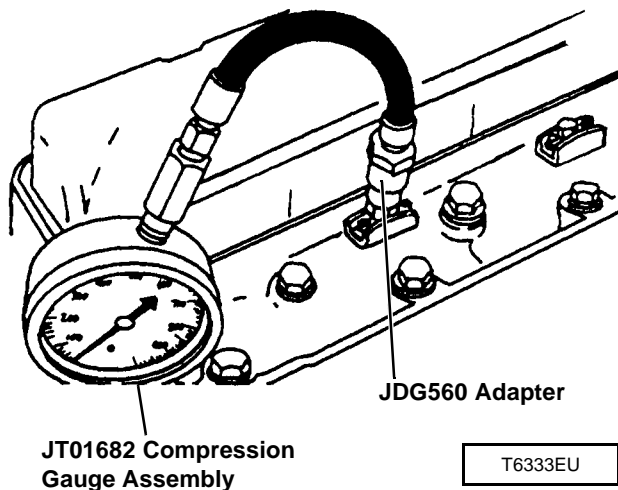
To determine the condition of the pistons, rings, cylinder walls and valves.

Equipment:

- JT01682 Compression Gauge Assembly
- JDG560 Adapter

Procedure:

1. Run engine for 5 minutes to bring to operating temperature. Shut off engine.
2. Remove injection nozzles. (See *Fuel System* in this section.)
3. Remove heat protector from end of injector and install on Adapter.
4. Install Adapter and Compression Gauge Assembly in injector port. Install retaining plate and tighten nuts to 4.5 N•m (39 lb-in.)
5. Hold fuel shut-off knob in shut-off position.
6. Crank engine for three seconds with starter.
7. Record pressure reading for each cylinder.



Specifications:

Minimum Compression Pressure

- 4TN78T, 4TN82RJK,
4TN84RJK, 4TN82RJE,
4TN82ESP 2448 kPa (355 psi)
- 4TN84(T)(4019)..... 2158 kPa (313 psi)

Maximum Difference Between

Cylinders 490 kPa (71 psi)

NOTE: Pressure listed is for 300 m (1000 ft) above sea level. For naturally aspirated engines, reduce specification an additional 4% for each 300 m (1000 ft) of altitude. For turbo charged engines, reduce specification an additional 3.6% (4TN78T) or 3% (4TN84T)(4019T) for each additional 300 m (1000 ft) of altitude.

Results:

- If pressure reading is below specification, squirt approximately two teaspoons of clean engine oil into cylinders through injector ports and repeat test.
- If pressure increases significantly, check piston, rings and cylinder walls for wear or damage.
- If pressure does not increase significantly after retest, check for leaking valves, valve seats or cylinder head gasket.

ENGINE OIL PRESSURE TEST

Reason:

To determine if engine bearings or lubrication system components are worn.

Equipment:

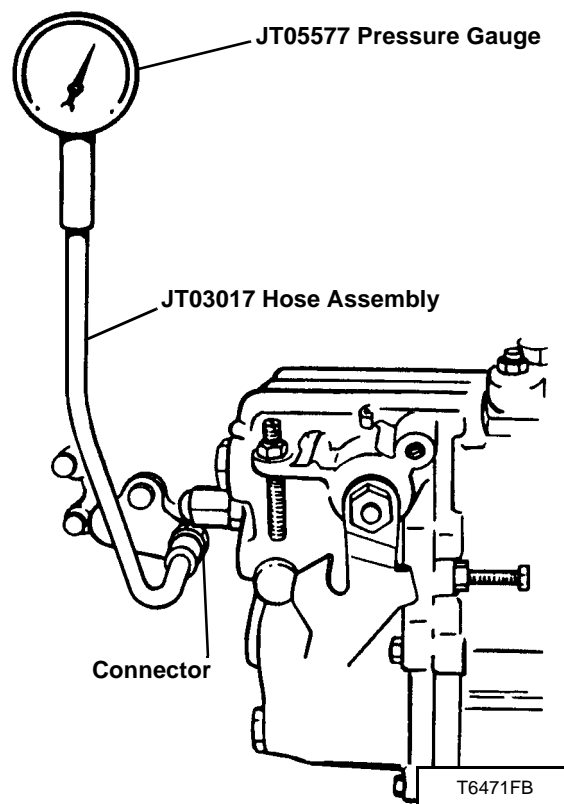
- JT03017 Hose Assembly
- JT05577 Pressure Gauge (100 psi)
- JT05487 Connector (4TN78T)
- JT03349 Connector (All Except 4TN78T)

Procedure:

1. Remove oil pressure sender.
2. Install Connector.
3. Connect Hose Assembly and Pressure Gauge.

IMPORTANT: Do not run if no pressure present.

4. Start engine. If pressure reading is below 69 kPa (10 psi), STOP ENGINE.
5. Run engine approximately five minutes to heat oil, then check oil pressure at fast and/or slow idle.



3

Specifications - 4TN78T:

Idle Speed

- Fast 2750 ± 25 rpm
- Slow 800 ± 25 rpm

Engine Oil Pressure

- Fast Idle 345 ± 48 kPa (50 ± 7 psi)
- Slow Idle 214 kPa (31 psi)

Specifications - 4TN82RJE:

Idle Speed

- Fast 2800 rpm
- Slow 1000 ± 50 rpm

Engine Oil Pressure 294 - 440 kPa
 (43 - 64 psi)

Operational Tests

Specifications - 4TN82ESP:

Idle Speed

Fast 2875 ± 25 rpm

Slow 900 ± 25 rpm

Engine Oil Pressure 294 - 392 kPa

..... (43 - 57 psi)

Specifications - 4TN82RJK, 4TN84RJK:

Fast Idle Speed

4TN82RJK.....2750 - 2800 rpm

4TN84RJK.....2850 - 2900 rpm

Engine Oil Pressure 365 ± 69 kPa

..... (53 ± 10 psi)

3 Specifications - 4TN84(T)(4019):

Low Idle Speed

Industrial 1300 rpm

Generator..... 1200 rpm

Engine Oil Pressure 147 kPa (21 psi)

Results:

- If oil pressure is not within specifications, inspect oil pressure regulating valve parts for wear or damage. Add or remove shims as necessary. (See *Lubrication System* in this section.)
- If oil pressure does not increase, see “Engine Has Low Oil Pressure” in *Diagnosis* group.

AIR INTAKE SYSTEM LEAKAGE TEST

Reason:

Check for leaks in air intake system.

Equipment:

- Air Pressure Regulator

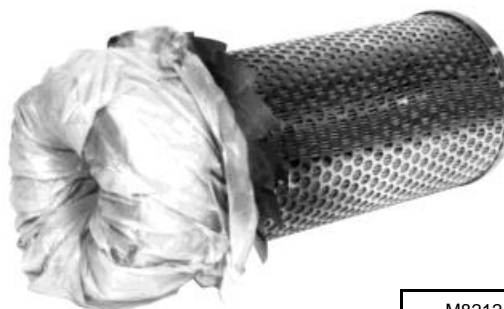
Procedure:

1. Remove air cleaner restriction indicator/switch and install test fitting.
2. Connect air pressure regulator to manifold using hose and fitting from air cleaner.
3. Remove air cleaner cover and main filter element.
4. Put large plastic bag into and over end of main

filter element. Install main filter element and cover.

5. Pressurize air intake system between **34 - 69 kPa (5 - 10 psi)**. If air intake system cannot be pressurized, turn engine slightly to close valves.
6. Spray soap solution over all connections from air cleaner to intake manifold or turbocharger, if equipped, and check for leaks.

IMPORTANT: When reinstalling starting aid nozzle, position arrow on nozzle pointing against intake air flow.



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Results:

- Find leaks and repair or replace parts as necessary.

FUEL SUPPLY PUMP PRESSURE TEST - IF EQUIPPED

NOTE: 4TN78T, 4TN82RJE and 4TN82ESP engines are not equipped with a fuel supply pump.

Reason:

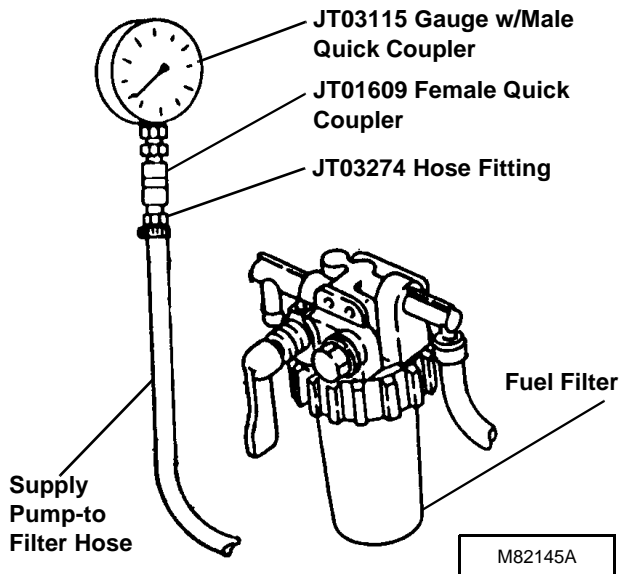
To determine supply pump operating pressure.

Equipment:

- JT03274 Hose Fitting
- JT01609 Female Quick Coupler
- JT03115 Gauge w/Male Quick Coupler (0 - 150 psi)

Procedure:

1. Disconnect supply pump-to-filter hose.
2. Install Hose Fitting, Coupler and Gauge.
3. Pull fuel shut-off cable out and crank engine using the starter. Do not run starter for more than 10 seconds at a time. Gauge should read more than **29 kPa (4.3 psi)**.



Results:

- If pressure is below specification, repair or replace fuel supply pump.

FUEL DRAIN BACK TEST

Reason:

Determines if air is entering the fuel system at connections, allowing fuel to siphon back to tank.

Procedure:

1. Disconnect fuel supply line and 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 fuel supply pump, injection pump, filter(s) and water separator, if equipped.
3. Plug end of fuel return hose.
4. Pressurize fuel system at fuel supply line, to a maximum pressure of **103 kPa (15 psi)**.
5. Apply liquid soap and water solution to all joints and connections in the fuel system and inspect for leaks.

Results:

- Find leaks and repair or replace parts as necessary.

BLEED FUEL SYSTEM

IMPORTANT: Modification or alteration of the injection pump, pump timing, or the injection nozzles in any way not approved by the manufacturer will terminate the warranty obligation.

All engines are equipped with an automatic air venting system which makes the fuel system self-bleeding.

- Assure that all fuel line connections are securely tightened.
- Add fuel to fuel tank.
- Crank engine to allow fuel system to bleed itself.

4TN100 ENGINE

Specifications	4-1
Cylinder Head, Valves and Manifolds	4-8
Pistons, Rods and Cylinder Block	4-21
Crankshaft, Main Bearings and Flywheel	4-30
Camshaft and Timing Gear Train	4-40
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Starter (Nippondenso 1.4 kW)	4-70
Alternator (Hitachi 25A)	4-75
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Section 4

ENGINE SPECIFICATIONS - 4TN100

Rocker Arm Cover Mounting Cap Screw Torque	26 N•m (226 lb-in.)
Rocker Arm Assembly	
Mounting Cap Screw and Nut Torque	26 N•m (226 lb-in.)
Push Rod Bend	
Standard	0.05 mm (0.002 in.) or Less
Wear Limit	0.30 mm (0.012 in.)
Push Rod Length	
Standard	178.25 - 178.75 mm (7.018 - 7.037 in.)
Rocker Arm and Shaft Support I.D.'s	
Clearance	0.06 mm (0.002 in.)
Standard	18.50 - 18.52 mm (0.728 - 0.729 in.)
Wear Limit	18.60 mm (0.732 in.)
Rocker Arm Shaft O.D.	
Standard	18.46 - 18.48 mm (0.727 - 0.728 in.)
Wear Limit	18.35 mm (0.722 in.)
Cylinder Head and Valves	
Cylinder Head Distortion	
Maximum Amount of Metal to be Removed	0.20 mm (0.008 in.)
Standard	0.05 mm (0.002 in.) or Less
Wear Limit	0.20 mm (0.008 in.)
Mounting Cap Screw Torque	
First	49 N•m (36 lb-ft)
Second	98 N•m (72 lb-ft)
Final	157 N•m (116 lb-ft)
Valve Seat Width (Exhaust Valve)	
Standard	2.02 - 2.33 mm (0.079 - 0.089 in.)
Wear Limit	2.73 mm (0.108 in.)
Valve Seat Width (Intake Valve)	
Standard	1.38 - 1.62 mm (0.054 - 0.064 in.)
Wear Limit	2.12 mm (0.084 in.)
Intake and Exhaust Valves	
Valve Face	
Exhaust Angle	45°
Intake Angle	30°
Minimum Margin	0.51 mm (0.020 in.)
Valve Recession	
Standard	0.20 - 0.40 mm (0.008 - 0.016 in.)
Wear Limit	1.80 mm (0.071 in.)
Valve Stem O.D. (Exhaust Valve)	
Standard	8.94 - 8.96 mm (0.3520 - 0.3528 in.)
Wear Limit	8.90 mm (0.3504 in.)
Valve Stem O.D. (Intake Valve)	
Standard	8.96 - 8.98 mm (0.3528 - 0.3535 in.)
Wear Limit	8.90 mm (0.3504 in.)
Valve Guides	
Valve Guide Height	11.50 mm (0.453 in.)
Valve Guide I.D.	

Specifications

Maximum Clearance	0.20 mm (0.008 in.)
Standard	9.00 - 9.02 mm (0.354 - 0.355 in.)
Wear Limit	9.10 mm (0.358 in.)
Valve Springs	
Maximum Spring Tension	41.50 mm (1.634 in.) at 12.6 N (5.7 lb force)
Spring Free Length	
Standard	43 mm (1.693 in.)
Wear Limit	42.50 mm (1.673 in.)
Maximum Spring Inclination	1.20 mm (0.047 in.)
Exhaust Manifold	
Mounting Cap Screw Torque	26 N•m (226 lb-in.)
Intake Manifold	
Mounting Cap Screw Torque	26 N•m (226 lb-in.)
Valve Seat Angles	
Lower Seat Surface	70°
Upper Seat Surface	15°
Valve Seat Surface	
Exhaust Valve	45°
Intake Valve	30°
Piston-to-Cylinder Head Clearance	0.71 - 0.89 mm (0.028 - 0.035 in.)
4 Piston and Connecting Rod Cap Screw Torque	98 N•m (69 lb-ft)
Connecting Rod Bearing I.D.	
Clearance	0.09 mm (0.004 in.)
Standard	60 - 60.042 mm (2.3622 - 2.3639 in.)
Wear Limit	60.10 mm (2.3661 in.)
Piston Ring Groove Clearance	
First Compression Ring	
Standard	0.090 - 0.125 mm (0.0035 - 0.0049 in.)
Wear Limit	0.20 mm (0.0079 in.)
Oil Ring	
Standard	0.030 - 0.065 mm (0.0012 - 0.0026 in.)
Wear Limit	0.15 mm (0.0059 in.)
Second Compression Ring	
Standard	0.035 - 0.070 mm (0.0014 - 0.0028 in.)
Wear Limit	0.15 mm (0.0059 in.)
Piston Ring End Gap	
Compression Rings	
Standard	0.25 - 0.40 mm (0.0098 - 0.0157 in.)
Wear Limit	1.50 mm (0.0591 in.)
Oil Ring	
Standard	0.30 - 0.50 mm (0.0118 - 0.0197 in.)
Wear Limit	1.50 mm (0.0591 in.)
Piston Pin	
Bore I.D.	
Clearance	0.022 mm (0.0009 in.)
Standard	34.00 - 34.011 mm (1.3386 - 1.3390 in.)
Wear Limit	34.02 mm (1.3393 in.)
Bushing I.D.	
Clearance	0.061 mm (0.0024 in.)

Standard	34.03 - 34.05 mm (1.3398 - 1.3406 in.)
Wear Limit	34.10 mm (1.3425 in.)
Pin O.D.	
Standard	33.989 - 34.00 mm (1.3381 - 1.3386 in.)
Wear Limit	33.90 mm (1.3346 in.)
Piston O.D.	
0.25 mm (0.010 in.) Oversize Piston	
Standard	100.15 - 100.18 mm (3.943 - 3.944 in.)
Wear Limit	100.05 mm (3.939 in.)
Standard Size Piston	
Standard	99.895 - 99.925 mm (3.9329 - 3.9341 in.)
Wear Limit	99.79 mm (3.9287 in.)
Cylinder Bore I.D.	
0.25 mm (0.010 in.) Oversize Bore	
Standard	100.25 - 100.28 mm (3.947 - 3.948 in.)
Wear Limit	100.45 mm (3.955 in.)
Deglazing	30 - 40° Cross-Hatch Pattern
Reboring	30 - 40° Cross-Hatch Pattern
Standard Size Bore	
Clearance	0.41 mm (0.016 in.)
Standard	100.00 - 100.03 mm (3.9370 - 3.9382 in.)
Wear Limit	100.15 mm (3.9429 in.)
Crankcase Extension Housing	
Mounting Cap Screw Torque	
Extension-to-Block (M12)	88 N•m (65 lb-ft)
Extension-to-Block (M8)	26 N•m (226 lb-in.)
Extension-to-Gear Housing	21 N•m (180 lb-in.)
Flywheel Housing-to-Extension	49 N•m (36 lb-ft)
Seal Case-to-Extension	21 N•m (180 lb-in.)
Crankshaft Rear Oil Seal	
Seal Case-to-Block Cap Screw Torque	26 N•m (226 lb-in.)
Seal Case-to-Extension Cap Screw Torque	21 N•m (180 lb-in.)
Crankshaft Front Oil Seal Depth	3.18 mm (0.125 in.) Below Surface of Cover
Crankshaft and Main Bearings	
Connecting Rod Journal O.D.	
Standard	59.952 -59.964 mm (2.3603 - 2.3608 in.)
Wear Limit	59.90 mm (2.3583 in.)
Crankshaft Maximum Bend	0.02 mm (0.0007 in.)
Crankshaft and Main Bearings - Continued	
Main Bearing Cap Screw Torque	
Initial	136 N•m (100 lb-ft)
Final	196 N•m (145 lb-ft)
Main Bearing I.D.	
Clearance	0.09 mm (0.004 in.)
Standard	60.00 - 60.042 mm (2.3622 - 2.3639 in.)
Wear Limit	60.10 mm (2.3661 in.)
Main Bearing Journal O.D.	
Standard	69.952 - 69.964 mm (2.7540 - 2.7545 in.)
Wear Limit	69.90 mm (2.7520 in.)

Specifications

Flywheel

Maximum Distortion	0.02 mm (0.0008 in.)
Mounting Cap Screw Torque	196 N•m (145 lb-ft)

Flywheel Housing Mounting Cap Screw Torque 49 N•m (36 lb-ft)

Camshaft

Bore I.D.

Standard	57.00 - 57.03 mm (2.2441 - 2.2453 in.)
Clearance	0.12 mm (0.005 in.)
Wear Limit	57.10 mm (2.2480 in.)

Bushing Depth 1.6 mm (0.062 in.)

Bushing I.D.

Clearance	0.14 mm (0.006 in.)
Standard	56.98 - 57.05 mm (2.2433 - 2.2461 in.)
Wear Limit	57.10 mm (2.2480 in.)

Camshaft Side Gap

Standard	0.05 - 0.20 mm (0.0020 - 0.0079 in.)
Wear Limit	0.29 mm (0.0114 in.)

End Journal O.D.

Standard	56.91 - 56.94 mm (2.2406 - 2.2417 in.)
Wear Limit	56.80 mm (2.2362 in.)

Intermediate Journal O.D.

Standard	56.89 - 56.92 mm (2.2398 - 2.2409 in.)
Wear Limit	56.80 mm (2.2362 in.)

Lobe Height

Standard	48.435 - 48.565 mm (1.9069 - 1.9120 in.)
Wear Limit	48.20 mm (1.897 in.)

Maximum Camshaft Bend 0.05 mm (0.0020 in.)

Mounting Cap Screw Torque 26 N•m (226 lb-in.)

Cam Followers

Bore I.D.

Clearance	0.052 mm (0.0020 in.)
Standard	14.249 - 14.270 mm (0.5610 - 0.5618 in.)
Wear Limit	14.30 mm (0.5630 in.)

Cam Followers - Continued

Stem O.D.

Standard	14.218 - 14.233 mm (0.5598 - 0.5604 in.)
Wear Limit	14.17 mm (0.5579 in.)

Timing Gear Cover

Cover Mounting Cap Screw Torque 26 N•m (226 lb-in.)

Fan Mounting Cap Screw Torque 65 N•m (47 lb-ft)

Fan Spacer-to-Water Pump Socket-Head Cap Screw Torque 11 N•m (96 lb-in.)

Crankshaft Pulley Cap Screw Torque 115 N•m (85 lb-ft)

Idler Gear

Bushing I.D.

Clearance	0.075 mm (0.0030 in.)
Standard	46.00 - 46.025 mm (1.8110 - 1.8120 in.)
Wear Limit	46.09 mm (1.8146 in.)

Shaft O.D.

Standard	45.95 - 45.975 mm (1.8091 - 1.8100 in.)
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Wear Limit	45.9 mm (1.8071 in.)
Timing Gear Housing	
Mounting Cap Screw Torque	
Extension-to-Gear Housing	21 N•m (180 lb-in.)
Gear Housing-to-Block	25 N•m (220 lb-in.)
Oil Strainer Mounting Cap Screw Torque	26 N•m (226 lb-in.)
Oil Pan Mounting Cap Screw Torque	
Oil Pan-to-Block	26 N•m (226 lb-in.)
Oil Pan-to-Extension	21 N•m (180 lb-in.)
Oil Pump	
Inner-to-Outer Rotor Maximum Clearance	0.25 mm (0.010 in.)
Maximum Gear Backlash	0.25 mm (0.010 in.)
Maximum Outer Rotor Recess	0.25 mm (0.010 in.)
Mounting Cap Screw Torque	25 N•m (18 lb-ft)
Outer Rotor-to-Pump Housing Maximum Clearance	0.25 mm (0.010 in.)
Rotor Shaft Assembly-to-Housing Cap Screw Torque	6 N•m (53 lb-in.)
Rotor Shaft O.D.-to-Housing I.D. Maximum Clearance	0.20 mm (0.008 in.)
Oil Cooler	
Adapter-to-Housing Cap Screw Torque	24 N•m (18 lb-ft)
Mounting Cap Screw Torque	24 N•m (18 lb-ft)
Oil Cooler-to-Housing Nut Torque	49 N•m (36 lb-ft)
Oil Cooler By-Pass Valve Spring	
Compressed Length	37 mm (1.450 in.) @ 3.75 N (0.840 lb force)
Free Length	63 mm (2.480 in.)
Oil Pressure Regulating Valve Spring	
Compressed Length	50 mm (1.970 in.) @ 5.40 N (1.200 lb force)
Free Length	51 mm (2.010 in.)
Piston Cooling Nozzle Mounting Bolt Torque	15 N•m (130 lb-in.)
Thermostat Cover Cap Screw Torque	20 N•m (180 lb-in.)
Water Pump	
Adapter Fitting-to-Housing Torque	23 N•m (199 lb-in.)
Adapter-to-Plate Screw Torque	10 N•m (91 lb-in.)
Bottom of Pulley Flange-to-Top of Housing	11 mm (0.433 in.)
Fan Mounting Cap Screw Torque	65 N•m (47 lb-ft)
Fan Spacer-to-Pump Socket-Head Cap Screw Torque	11 N•m (96 lb-in.)
Impeller-to-Pump Housing Clearance	0.30 - 1.10 mm (0.012 - 0.043 in.)
Mounting Cap Screw Torque	26 N•m (226 lb-in.)
Plate-to-Housing Screw Torque	15 N•m (134 lb-in.)
Plug-to-Housing Torque	15 N•m (130 lb-in.)
Fuel Supply Pump	
Mounting Nut Torque	11 N•m (96 lb-in.)
External Lube Line Inlet Mounting Bolt Torque	15 N•m (130 lb-in.)
Fuel Injection Pump	
External Lube Line Inlet Mounting Bolt Torque	15 N•m (130 lb-in.)
Lube Line-to-Block Bolt Torque	25 N•m (217 lb-in.)
Mounting Cap Screw Torque	27 N•m (20 lb-ft)
Fuel Injection Nozzles	
Mounting Nut Torque	5 N•m (39 lb-in.)
Retaining Nut Torque	43 N•m (31 lb-ft)

Specifications

Separator Plate Nozzle Contact Surface Maximum Wear	0.10 mm (0.0039 in.)
Starter Minimum Brush Length	8.5 mm (0.335 in.)
Alternator	
Minimum Brush Length	5.50 mm (0.220 in.)
Rotor Assembly	
Pulley Nut Torque	49 N•m (36 lb-ft)
Retainer-to-Front Frame Screw Torque	2 N•m (16 lb-in.)
Rotor-to-Stator Assembly Attaching Screw Torque	4 N•m (31 lb-in.)
Stator Assembly	
End Frame-to-Rectifier Nut Torque	4 N•m (31 lb-in.)
Stator-to-Rectifier Lead Wire Distance	33.50 mm (1.300 in.)
Checks, Tests and Adjustments	
Camshaft End Play	
Standard Clearance	0.05 - 0.20 mm (0.0020 - 0.0079 in.)
Wear Limit	0.29 mm (0.0114 in.)
Connecting Rod Bearing Clearance	
Standard Clearance	0.036 - 0.090 mm (0.0014 - 0.0035 in.)
Wear Limit	0.15 mm (0.0059 in.)
Connecting Rod Side Play	
Standard Clearance	0.20 - 0.40 mm (0.0079 - 0.0157 in.)
Wear Limit	0.45 mm (0.0177 in.)
Coolant Temperature Sender Continuity	107 - 133° C (225 - 235° F)
Thermostat	
Begin Opening	71° C (160° F)
Fully Open	85° C (184° F)
Minimum Lift Height	.8 mm (0.310 in.)
Checks, Tests and Adjustments - Continued	
Crankshaft End Play	
Standard Clearance	0.132 - 0.223 mm (0.0052 - 0.0088 in.)
Wear Limit	0.29 mm (0.0114 in.)
Crankshaft Main Bearing Clearance	
Main Bearing Cap Cap Screw Torque	196 N•m (145 lb-ft)
Standard Clearance	0.036 - 0.093 mm (0.0014 - 0.0037 in.)
Wear Limit	0.09 mm (0.0040 in.)
Fan/Alternator Drive Belt	
Applied Force	98 N (22 lb-force)
Deflection	10 - 15 mm (0.400 - 0.600 in.)
Fuel Injection Nozzle	
Chatter and Spray Pattern at 20100 ± 490 kPa (2915 ± 71 psi) Pressure	
Slow Hand Lever Movement	Chatter Sound
Slow Hand Lever Movement	Fine Stream Spray Pattern
Fast Hand Lever Movement	Fine Atomized Spray Pattern
Leakage	Minimum 5 Seconds at 18100 kPa (2625 psi)
Opening Pressure	19615 kPa (2850 psi)
Injection Pump Static Timing	
Distance on Outer Surface of Flywheel per 1° of Rotation	3.5 mm (0.130 in.)
Engine Crankshaft Position	No. 1 Cylinder on TDC Compression Stroke
Injection Pump Timing	16° BTDC (Before Top Dead Center)
Timing Lines on Pump Mounting Plate	2° Apart

Starter, No-Load Amp Draw/RPM	
Maximum Starter Amperage	90 amps at 3500 rpm
Minimum Starter RPM	3500
Timing Gear Backlash	
Standard Backlash.	0.08 - 0.16 mm (0.0031 - 0.0063 in.)
Wear Limit	0.25 mm (0.0098 in.)
Valve Clearance	0.30 mm (0.012 in.)
Valve Lift Intake and Exhaust	6.5 mm (0.256 in.)
Operational Tests	
Air Intake System Holding Pressure.	34 - 69 kPa (5 - 10 psi)
Cooling System	
Maximum Pressure	97 kPa (14 psi)
Minimum Pressure After 15 Seconds	88 kPa (12.8 psi)
Cylinder Compression Pressure	
Compression Pressure.	2942 kPa (427 psi)
Maximum Difference Between Cylinders	588 kPa (85 psi)
Engine Oil Pressure	
Fast Idle.	2375 ± 50 rpm
Oil Pressure Fast Idle	343 - 441 kPa (50 - 64 psi)
Oil Pressure Slow Idle (Minimum).	98 kPa (14 psi)
Slow Idle.	900 ± 50 rpm
Fuel Supply Pump Pressure (Minimum)	216 kPa (31 psi)
Fuel System Holding Pressure (Maximum)	103 kPa (15 psi)
Radiator Cap	
Valve Opening Pressure	88 kPa (12.8 psi)

Cylinder Head, Valves and Manifolds

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).

JT07092 Valve Guide Knurler (9 mm)

Use to knurl inside diameter of valve guides.

JDE118 Valve Guide Driver

Use to remove and install valve guides in cylinder head.

JT07091 Valve Guide Reamer (9 mm)

Use to ream out new valve guides.

OTHER MATERIALS

Number

Name

Use

LOCTITE® PRODUCTS

U.S./

Canadian/

LOCTITE No.

4

TY9375/

TY9480/

#592

John Deere Pipe Sealant
with TEFLON®

Apply to threads of fitting on top of
cylinder head.

SERVICE PARTS KITS

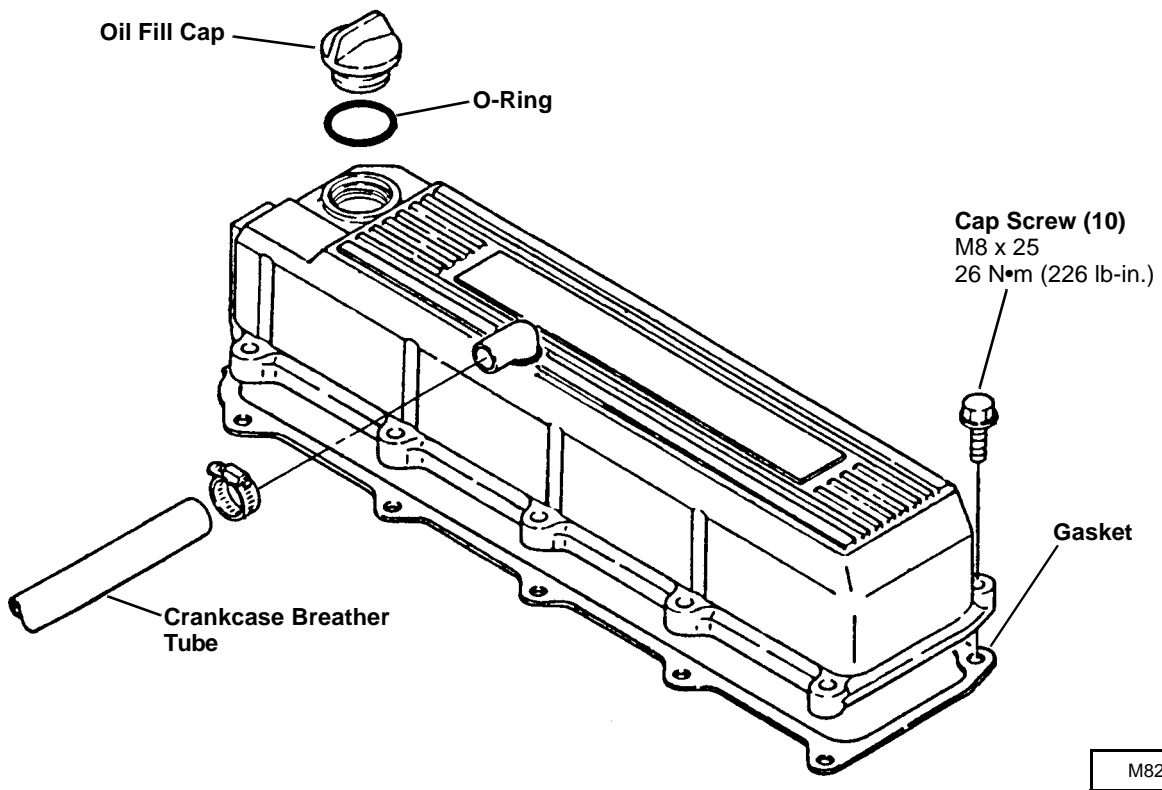
The following kits are available through your parts catalog:

- Cylinder Head Gasket Kit

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®TEFLON is a registered trademark of the Du Pont Company.

ROCKER ARM COVER



Cylinder Head, Valves and Manifolds

ROCKER ARM ASSEMBLY

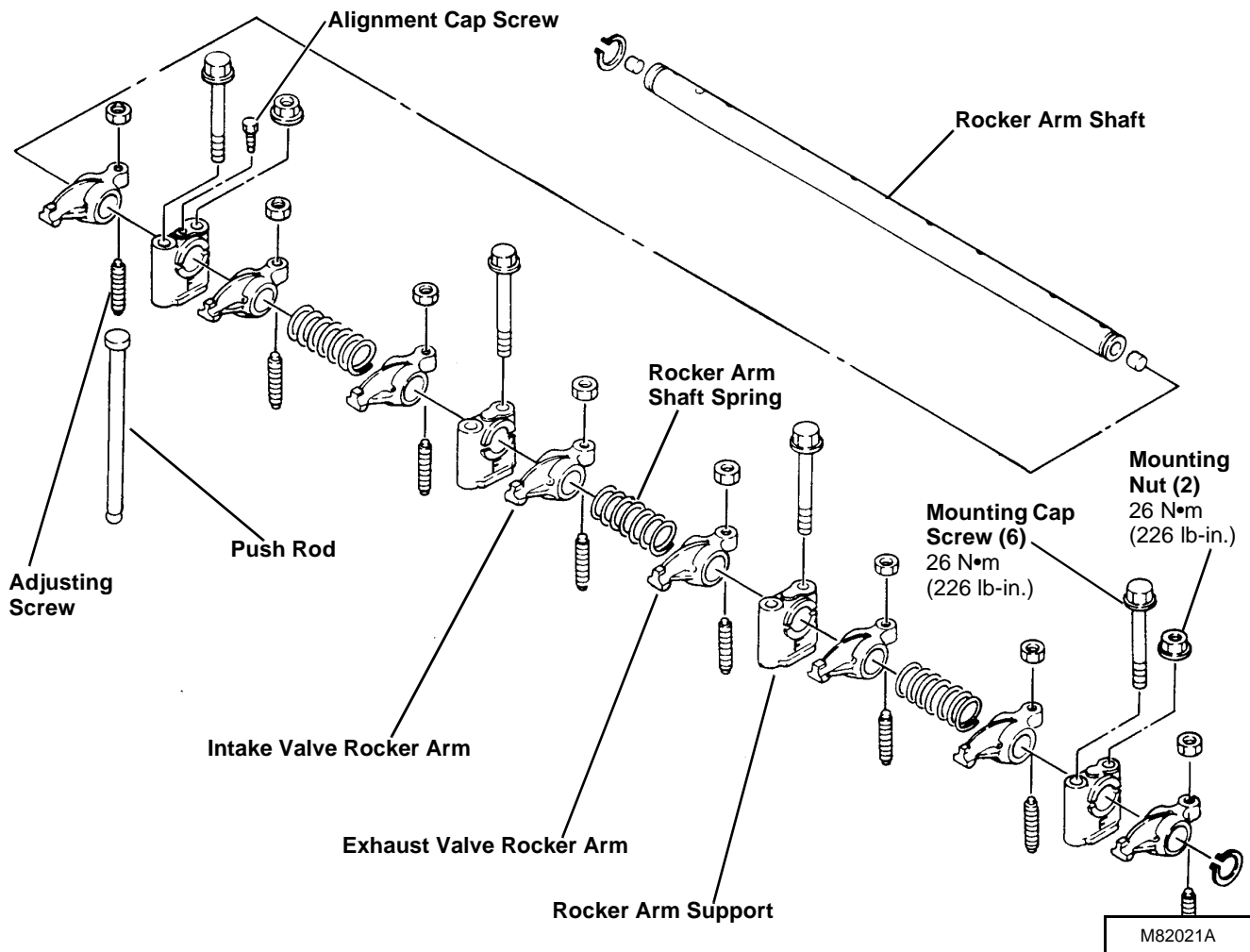
Removal/Installation and Disassembly/Assembly

1. Remove rocker arm cover. (See procedure in this group.)
 - Inspect all parts for wear or damage. (See Inspection procedures.)
 - Lubricate all parts with clean oil during assembly.

IMPORTANT: Install rocker arm support, with alignment cap screw on rocker arm shaft, with raised letter "F" facing toward other supports. Install remaining rocker arm supports on rocker arm shaft with raised letter "F" facing away from support with alignment cap screw.

- Adjust valve clearance. (See *Checks, Tests and Adjustments* in this section.)

4



Inspection

- Measure outer diameter of rocker arm shaft.



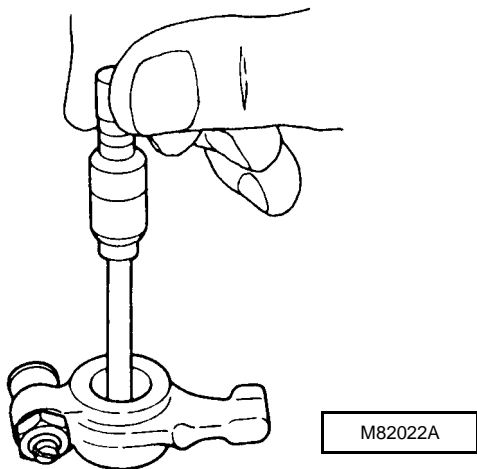
Rocker Arm Shaft O.D.:

Standard 18.46 - 18.48 mm
 (0.727 - 0.728 in.)

Wear Limit 18.35 mm (0.722 in.)

Replace rocker arm shaft if less than wear limit.

- Measure inner diameters of rocker arms and supports.



Rocker Arm and Shaft Support I.D.'s:

Standard 18.50 - 18.52 mm
 (0.728 - 0.729 in.)

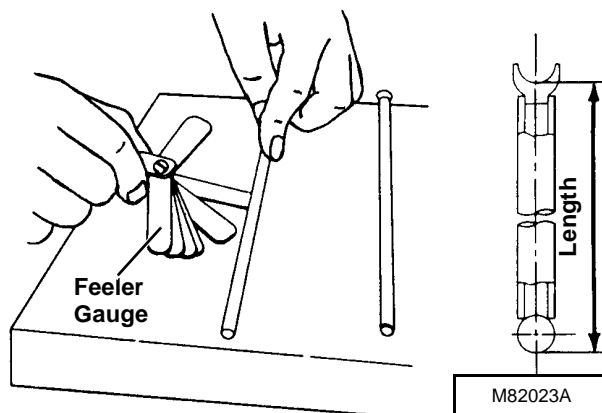
Wear Limit 18.60 mm (0.732 in.)

Clearance 0.06 mm (0.002 in.)

Replace rocker arms or supports if I.D. is more than wear limit.

If shaft and support/arm clearance (support/arm I.D. minus shaft O.D.) exceed wear limit, replace all parts.

- Measure length and bending of push rod.



Push Rod Length:

Standard 178.25 - 178.75 mm
 (7.018 - 7.037 in.)

Push Rod Bend:

Standard 0.05 mm (0.002 in.) or less

Wear Limit 0.30 mm (0.012 in.)

Replace push rod if not within specifications.

Cylinder Head, Valves and Manifolds

CYLINDER HEAD AND VALVES

Removal/Installation

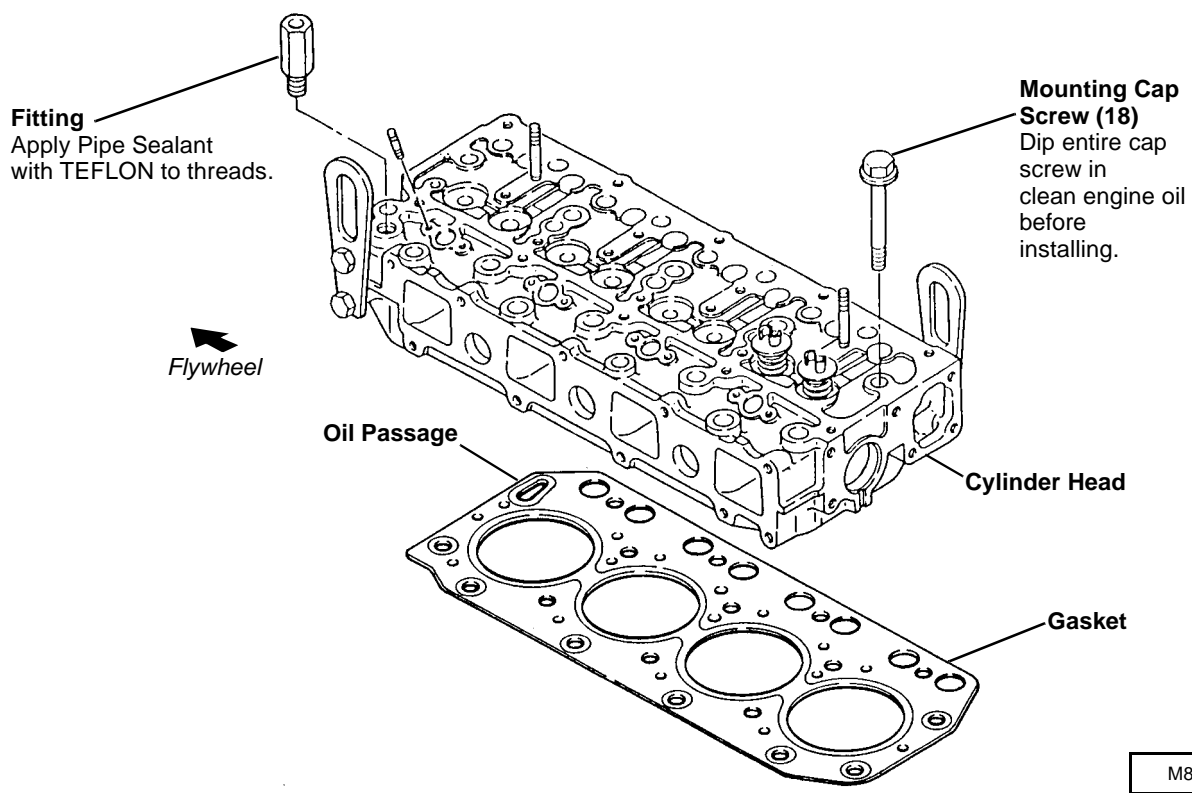
1. Remove rocker arm assembly and push rods. (See procedures in this group.)
2. Remove exhaust and intake manifolds. (See procedures in this group.)
3. Remove water pump. (See *Cooling System* in this section.)
4. Remove fuel injection nozzles. (See *Fuel System* in this section.)

NOTE: Fitting must be removed to remove mounting cap screw.

5. Disassemble and inspect cylinder head and valves. (See *Disassembly/ Assembly and Inspection/Replacement* procedures.)

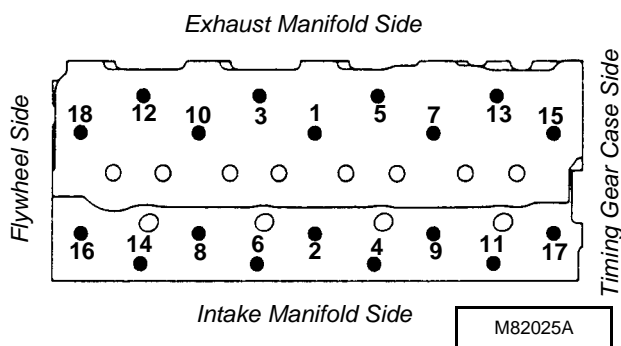
IMPORTANT: Oil passage in gasket must be located over oil passage in cylinder block. Install gasket as shown.

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6. Tighten mounting cap screws, in the sequence shown, in three stages of gradually-increasing torque.

IMPORTANT: Cylinder head mounting cap screws must be checked for proper torque after 50 hours of engine operation.



Torque Specifications:

- First 49 N•m (36 lb-ft)
- Second 98 N•m (72 lb-ft)
- Final 157 N•m (116 lb-ft)

Disassembly/Assembly

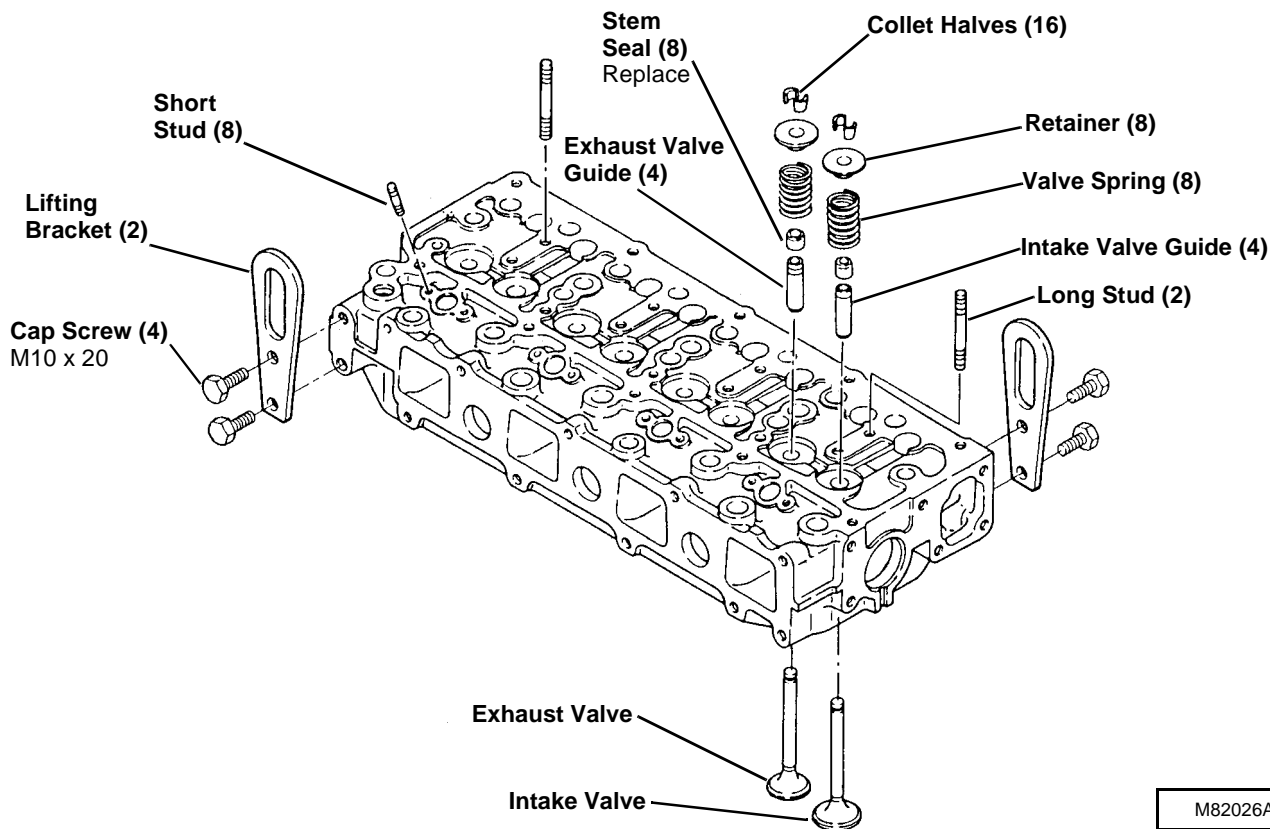
- Compress valve springs using a valve spring compressor.
- Intake and exhaust valve guides are press fit. Remove guides only if replacement is necessary. (See *Inspection/Replacement* procedures.)
- Inspect all parts for wear or damage. (See *Inspection/Replacement* procedures.)

IMPORTANT: Do not reuse stem seals if removed. Used seals will leak.

- Apply clean engine oil on intake and exhaust valve stems during assembly.

*NOTE: If new valves are installed, measure valve recession. (See **Inspection/Replacement** procedures.)*

After each valve has been assembled, tap on top of valve stem with a plastic hammer to seat retainer.



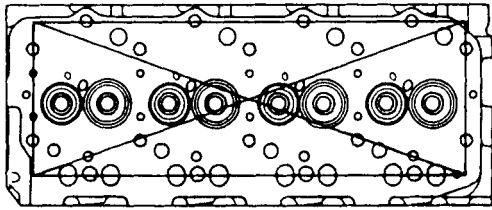
Cylinder Head, Valves and Manifolds

Inspection/Replacement

Before inspection, thoroughly clean all components of carbon or dirt.

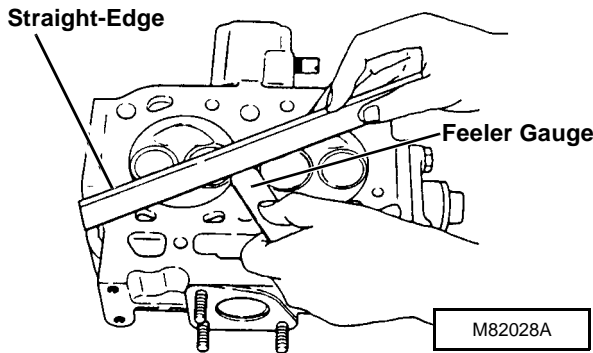
Cylinder Head:

- Measure cylinder head flatness. Place a straight-edge along each of the four sides and each diagonal. Measure clearance between straight edge and combustion surface with a feeler gauge.



M82027A

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M82028A

Cylinder Head Distortion:

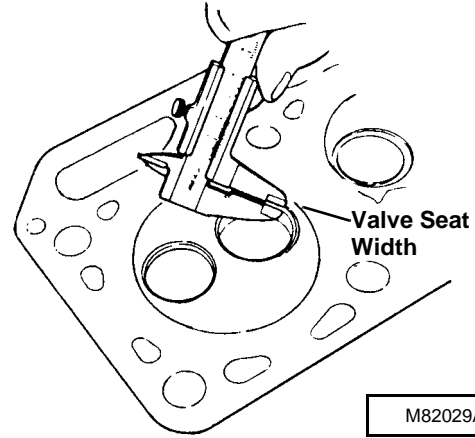
Standard 0.05 mm (0.002 in.) or less

Wear Limit 0.20 mm (0.008 in.)

If distortion exceeds the wear limit, resurface or replace cylinder head. Remove only enough metal to make cylinder head flat; but do not remove more than **0.20 mm (0.008 in.)**.

If cylinder head was resurfaced:

- Measure piston-to-cylinder head clearance. (See procedure in this group.)
- Measure valve recession. (See procedure in this group.)
- Measure valve seat width.



M82029A

Valve Seat Width:

Intake Valve:

Standard 1.38 - 1.62 mm

..... (0.054 - 0.064 in.)

Wear Limit 2.12 mm (0.084 in.)

Exhaust Valve:

Standard 2.02 - 2.23 mm

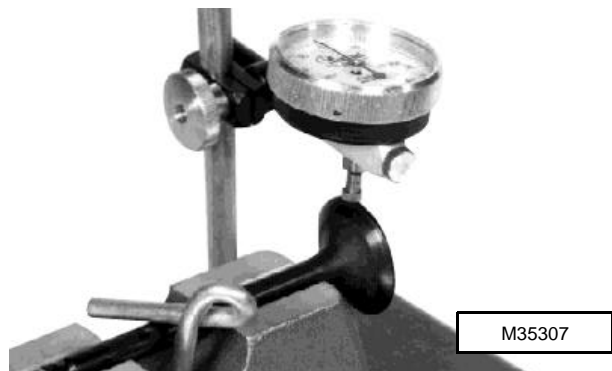
..... (0.079 - 0.089 in.)

Wear Limit 2.73 mm (0.108 in.)

If necessary, grind valve seats to meet specifications. (See *GRIND VALVE SEATS* procedure.)

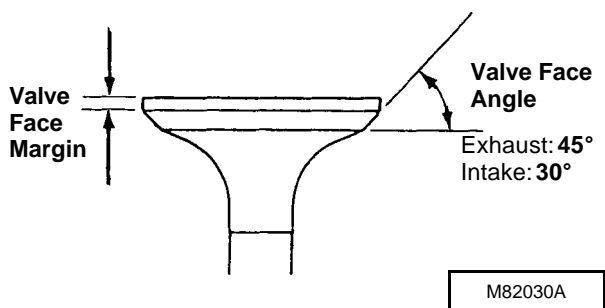
Intake and Exhaust Valves:

- Check valve for out-of-round, bent or warped condition using a valve inspection center. Replace valve if necessary.

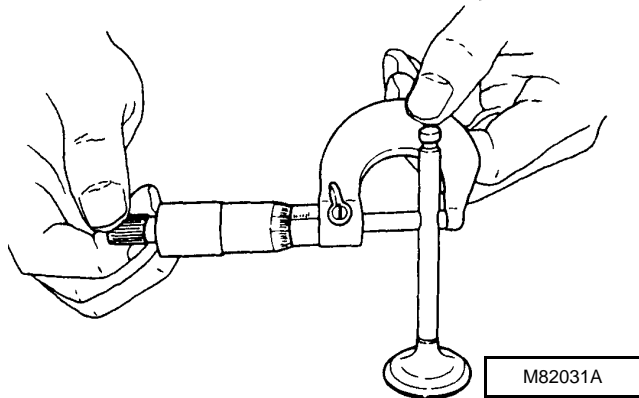
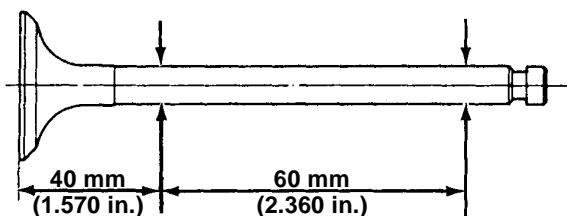


M35307

- If valve faces are worn, burned or pitted, grind valves to proper face angle. If valve face margin is less than **0.51mm (0.020 in.)** after grinding, replace valve.



- Measure valve stem diameter at two locations shown. Replace valve if measurement exceeds wear limit.



Valve Stem O.D.:

Intake Valve:

Standard 8.96 - 8.98 mm
..... (0.3528 - 0.3535 in.)

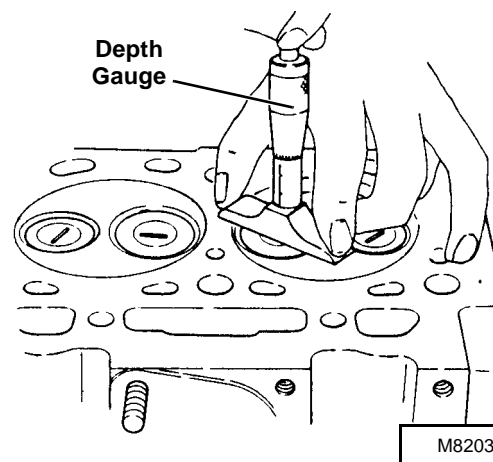
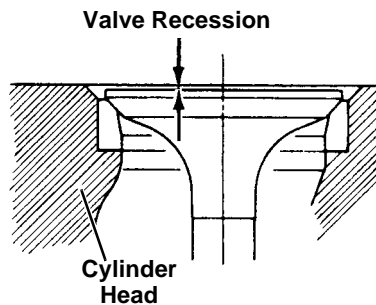
Wear Limit: 8.90 mm (0.3504 in.)

Exhaust Valve:

Standard 8.94 - 8.96 mm
..... (0.3520 - 0.3528 in.)

Wear Limit. 8.90 mm (0.3504 in.)

- Measure valve recession using a depth gauge. Replace valve or cylinder head if measurement exceeds wear limit.



Valve Recession:

Standard 0.20 - 0.40 mm
..... (0.008 - 0.016 in.)

Wear Limit. 1.80 mm (0.071 in.)

Valve Guides:

- Clean valve guides using a valve guide brush.
- Measure valve guide inside diameter.

Valve Guide I.D.:

Standard 9.00 - 9.02 mm
..... (0.354 - 0.355 in.)

Wear Limit. 9.10 mm (0.358 in.)

If diameter exceeds wear limit, knurl or replace guide.

If diameter is less than wear limit, determine guide-to-stem clearance (guide diameter minus stem diameter).

If clearance exceeds **0.15 mm (0.006 in.)** but is less than **0.20 mm (0.008 in.)**, knurl valve guide using JT07092 Knurler.

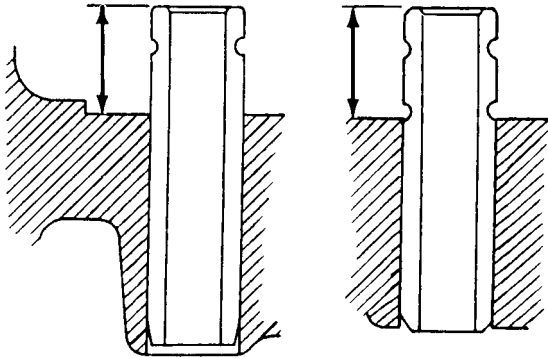
If clearance exceeds **0.20 mm (0.008 in.)**, replace valve guide.

- Replace valve guides using JDE118 Valve Guide Driver.

Cylinder Head, Valves and Manifolds

Intake and exhaust valve guides are different. The exhaust valve guide has two grooves and the intake valve guide has one. Install valve guides with grooves upward. Push valve guides down until top of valve guides are **11.50 mm (0.453 in.)** from top of cylinder head.

Ream inside diameter of valve guides using JT07091 Valve Guide Reamer.



Intake Valve Guide

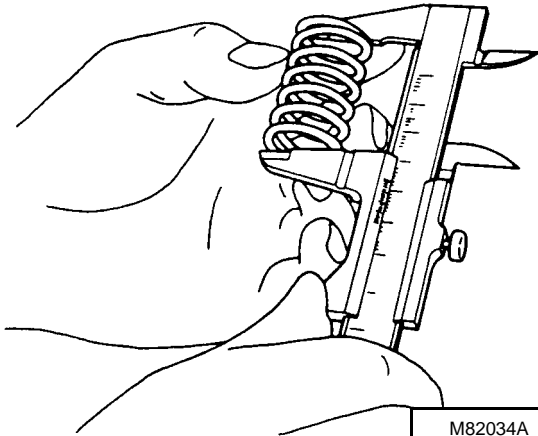
Exhaust Valve Guide

M82033A

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Valve Springs:

- Measure spring free length. Replace spring if measurement exceeds wear limit.



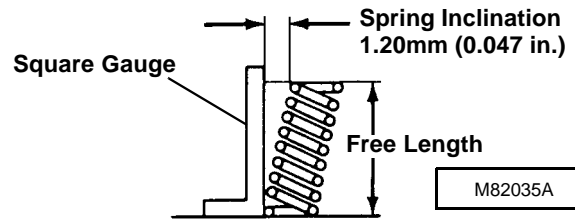
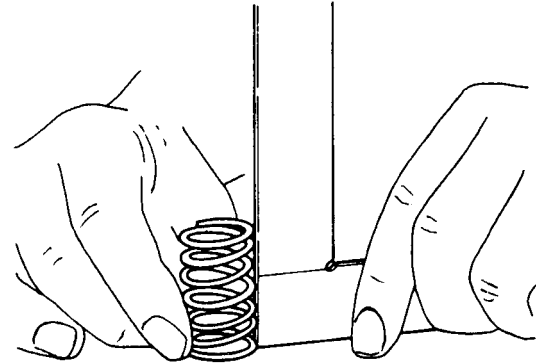
M82034A

Spring Free Length:

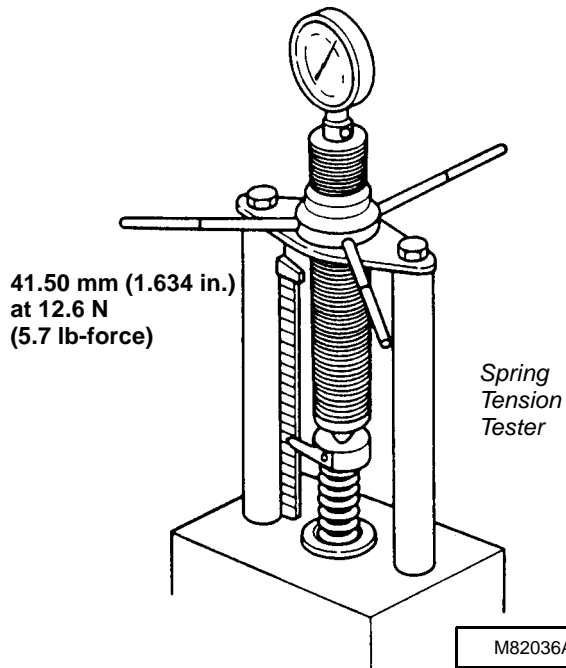
Standard43 mm (1.693 in.)

Wear Limit..... 42.50 mm (1.673 in.)

- Measure spring inclination. Replace spring if measurement exceeds specification.



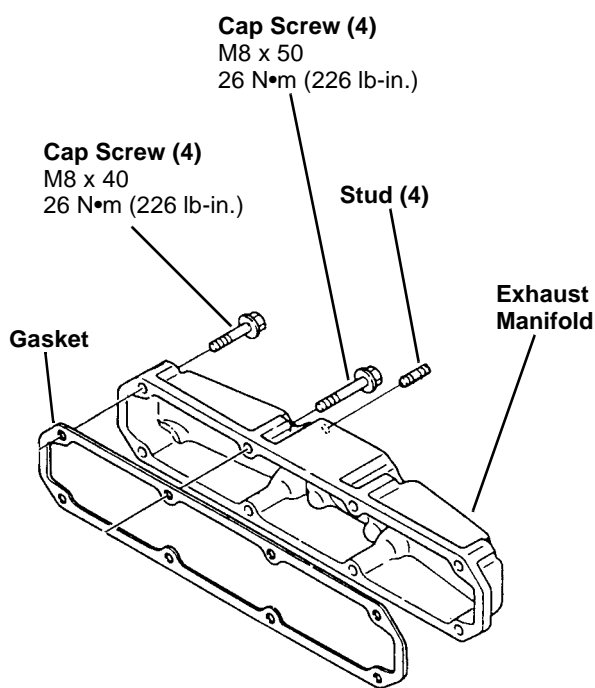
- Measure spring tension. Replace spring if measurement exceeds specification.



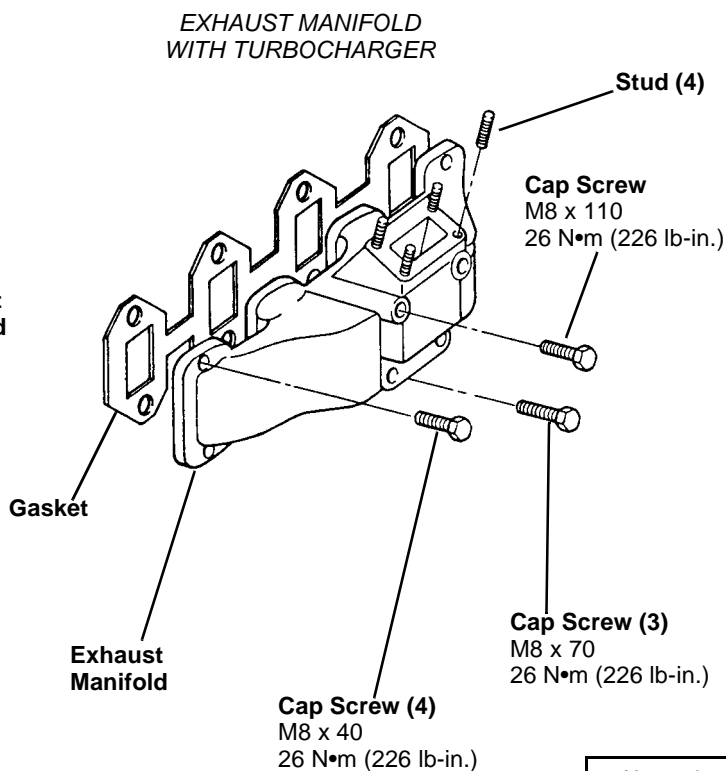
EXHAUST MANIFOLD

NOTE: Turbocharger removal/installation procedures are similar to unit used on Series 220 Engines. Follow procedures used in ACCESSORIES - SERIES 220 POWER UNIT ENGINES section. Service procedures are also similar.

1. Remove turbocharger, if equipped. (See procedure in ACCESSORIES - SERIES 220 POWER UNIT ENGINES section).



EXHAUST MANIFOLD
WITHOUT TURBOCHARGER



M82037A

Cylinder Head, Valves and Manifolds

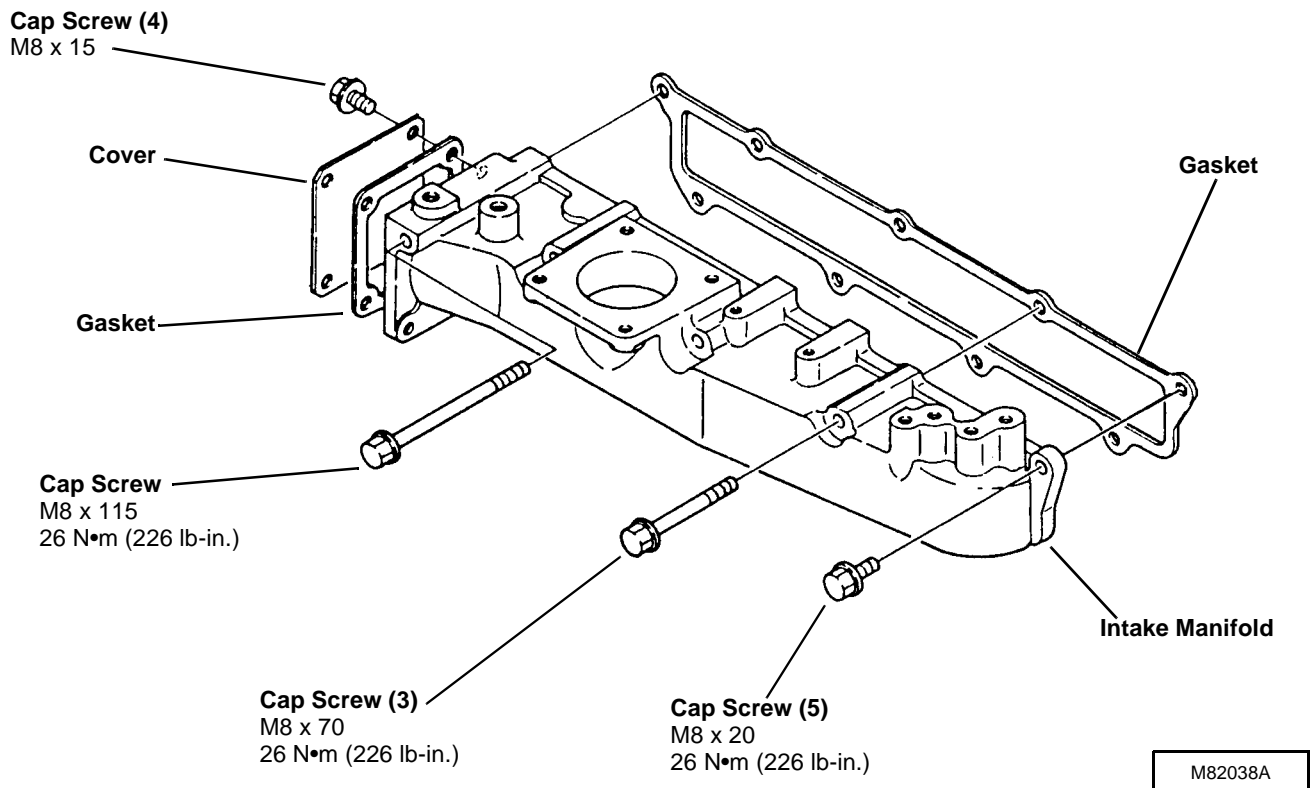
INTAKE MANIFOLD

NOTE: Air heater removal/installation is similar to procedures found in ACCESSORIES - SERIES 220 POWER UNIT ENGINES section.

1. Remove intake air heater. (See procedure in *ACCESSORIES - SERIES 220 POWER UNIT ENGINES* section.)
2. Remove two fuel filter assembly mounting cap screws.
3. Remove dipstick tube.

NOTE: Before placing intake manifold on engine, install one M8 x 70 cap screw in manifold at position shown.

4



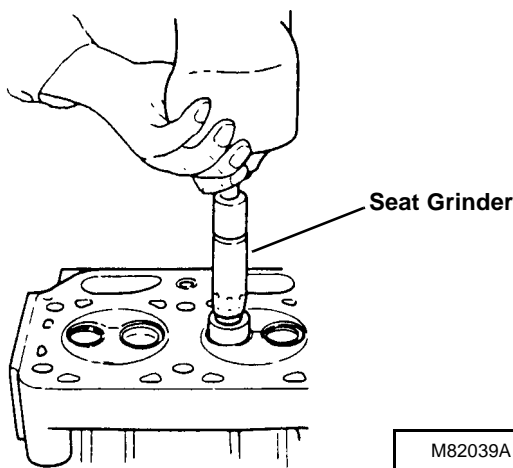
GRIND VALVE SEATS

IMPORTANT: Valve seats should never be cut.

Cutting a valve seat can damage its sealing surface, which may result in leaks or valve/seat failure. Valve seats should be ground and lapped.

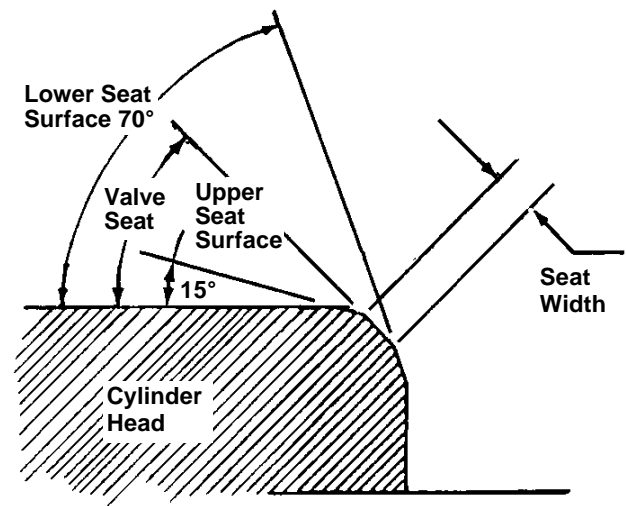
NOTE: LIGHTLY grind valve seats for a few seconds only to avoid excessive valve seat width.

1. Grind intake valve seat using a 30° seat grinder and exhaust valve seat using a 45° seat grinder. Follow tool manufacturers instructions.



2. Measure valve seat width after grinding.
3. If seat is too wide after grinding, grind lower seat surface using a 70° seat grinder until seat width is close to specifications.
4. Grind upper seat surface using a 15° seat grinder until seat width is narrowed to specifications.
5. If valve seats are ground, measure valve recession and check contact pattern between the seat and valve with bluing dye.

6. Lap valves. (See procedure in this group.)



If valve recession exceeds maximum specifications or seats cannot be reconditioned, replace valves and cylinder head.

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LAP VALVES

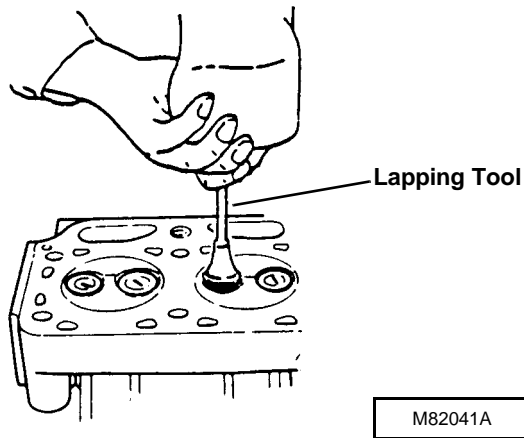
NOTE: Use a rubber type lapping tool for valves without a lapping tool groove slit.

If seat does not make proper contact, lap the valve into the seat:

1. Apply small amount of fine lapping compound to face of valve.
2. Turn valve to lap valve to seat.
3. Lift valve from seat every 8 to 10 strokes. Lap until a uniform ring appears around the surface of the valve face.
4. Wash all parts in solvent to remove lapping compound. Dry parts.

Cylinder Head, Valves and Manifolds

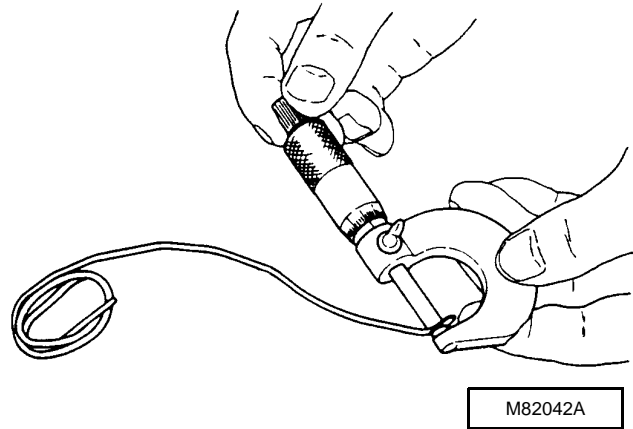
5. Check position of lap mark on valve face. Lap mark must be on or near center of valve face.



MEASURE PISTON-TO-CYLINDER HEAD CLEARANCE

- 4 1. Place three 10 mm (0.400 in.) long pieces of 1.50 mm (0.060 in.) diameter soft wire in three positions on the flat part of the piston head.
2. Install cylinder head and old gasket. Install cylinder head cap screws and tighten in proper sequence to specified torque. (See *CYLINDER HEAD AND VALVES - Removal/Installation* in this group.)

3. Slowly turn crankshaft one complete revolution.
4. Remove cylinder head and gasket.
5. Measure thickness of flattened section of each piece of wire. Calculate average thickness of wires to obtain piston-to-cylinder head clearance specification.



If clearance is less than **0.71 - 0.89 mm (0.028 - 0.035 in.)**, replace cylinder head.

SERVICE PARTS KITS

The following kits are available through your parts catalog:

- Cylinder Block Gasket Kit
- Cylinder Head Gasket Kit
- Connecting Rod Cap Screws
- Oversized Pistons and Rings
- Undersized Connecting Rod Bearing Inserts

PISTON AND CONNECTING ROD

Removal

1. Remove oil pan and strainer tube. (See *Lubrication System* in this section.)
2. Remove cylinder head. (See *Cylinder Head, Valves and Manifolds* in this section.)
3. Check cylinder bore for ridges. These ridges can cause damage to piston if ridge is not removed.
4. If necessary, remove ridge from top of cylinder bore using a ridge reamer.
5. Measure connecting rod side play. (See *Checks, Tests and Adjustments* in this section.)
6. Measure connecting rod bearing clearance. (See *Checks, Tests and Adjustments* in this section.)

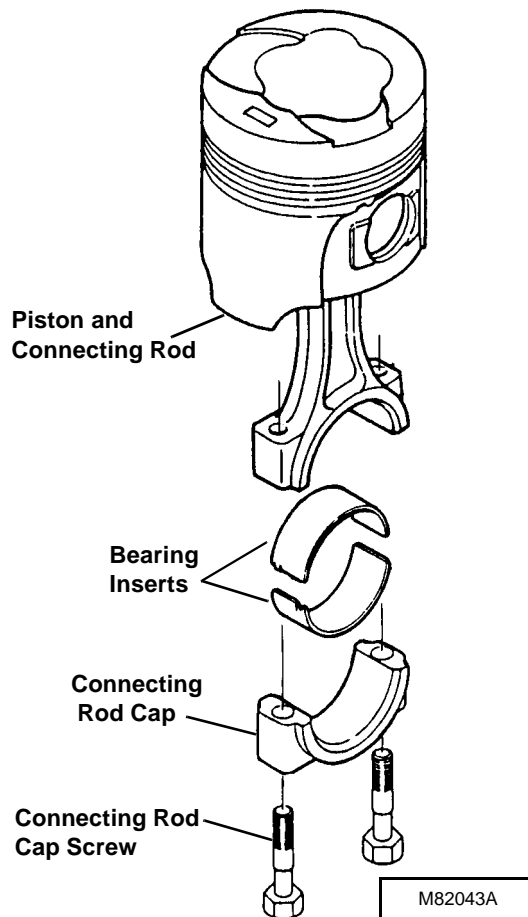
IMPORTANT: Keep connecting rods and caps together. Rods and caps are a matched set. Note alignment marks on each part.

4

7. Remove two cap screws, connecting rod cap and bearing inserts.

IMPORTANT: Pistons and cylinders are matched. Pistons must be installed in the cylinders from which they are removed.

8. Note connecting rod alignment mark in relation to the cylinders. Starting at flywheel end with cylinder number one, then two, etc.
9. Push piston and connecting rod out of cylinder bore using a wooden dowl.
10. Disassemble and inspect all parts for wear or damage. (See *Disassembly and Inspection/Replacement* procedures.)



Installation

- Apply clean engine oil on all parts during installation.
- Never reuse connecting rod cap screws, Replace with new.

IMPORTANT: Pistons must be installed in cylinders from which they were removed and in the same direction. Be careful not to damage crankshaft rod journal while installing piston.

1. If new piston rings were installed, deglaze cylinder bore. (See procedure in this group.)
2. Install piston and connecting rod into the cylinder from which it was removed, with piston size mark on top of piston toward camshaft.

IMPORTANT: Do not touch bearing insert surfaces. Oil and acid from your finger will corrode the bearing surface.

3. Install bearing inserts on connecting rod and rod cap, aligning tangs with grooves.

IMPORTANT: Connecting rod caps must be installed on the same connecting rods they were removed from.

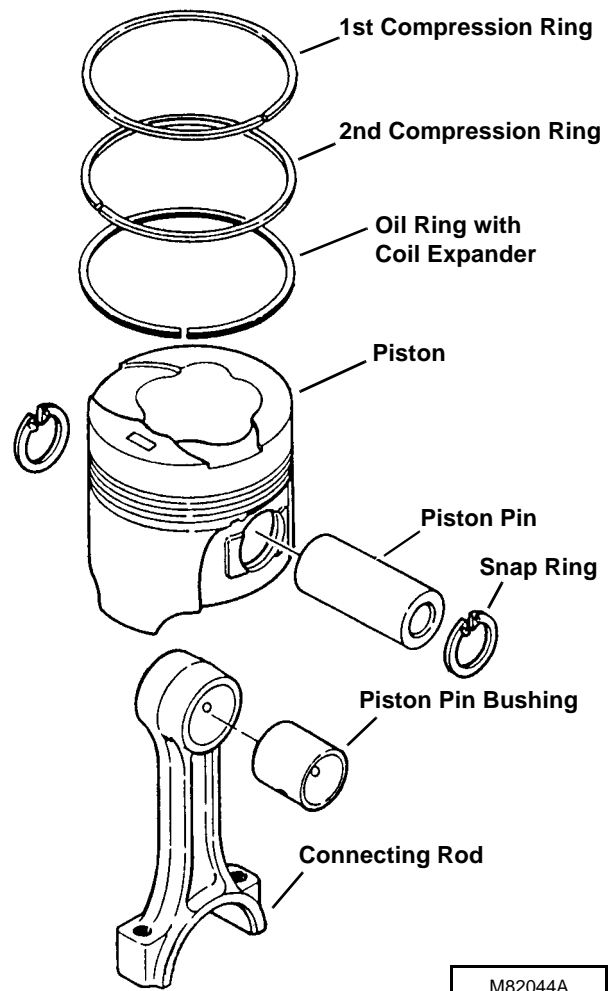
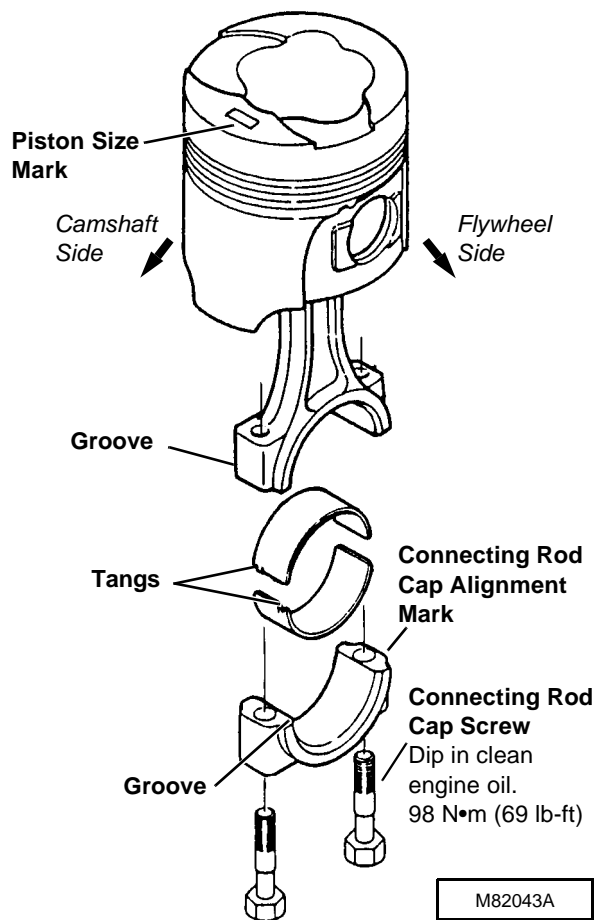
4. Match the connecting rods to caps using alignment marks. Install caps.
5. Dip entire connecting rod cap screws in clean engine oil. Install new cap screws and tighten to specifications.
6. If a new piston and connecting rod were installed, stamp a number corresponding to the cylinder number on the connecting rod cap and connecting rod.

7. Install cylinder head. (See *Cylinder Head, Valves and Manifolds* in this section.)
8. Install oil pan and strainer tube. (See *Lubrication System* in this section.)

Disassembly

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

- Put a mark on each piston and connecting rod to aid in assembly.
- Piston pin bushing is press fit in connecting rod. Remove bushing only if replacement is necessary. (See *Inspection/Replacement* procedures.)
- Inspect all parts for wear or damage. Replace as necessary. (See *Inspection/Replacement* procedures.)



Pistons, Rods and Cylinder Block

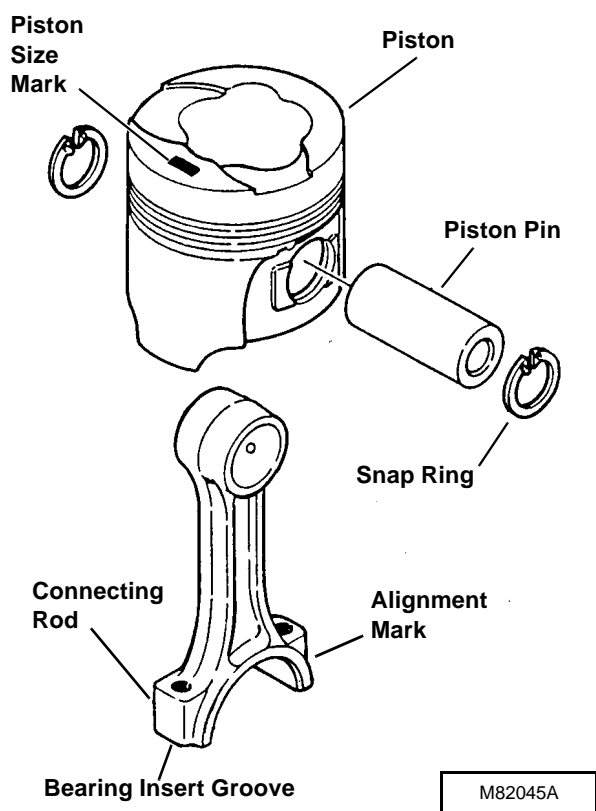
Assembly

- Apply clean engine oil to all parts during assembly.

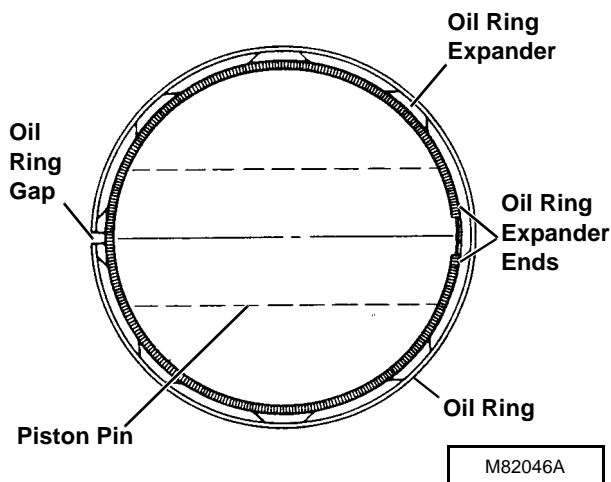
IMPORTANT: Pistons must be installed on the same connecting rod they were removed from.

1. Assemble piston to connecting rod with piston size mark opposite connecting rod "punched" alignment mark. If a new connecting rod is used, assemble piston to connecting rod with piston size mark on same side as connecting rod bearing insert groove.
2. Install piston pin and snap rings.

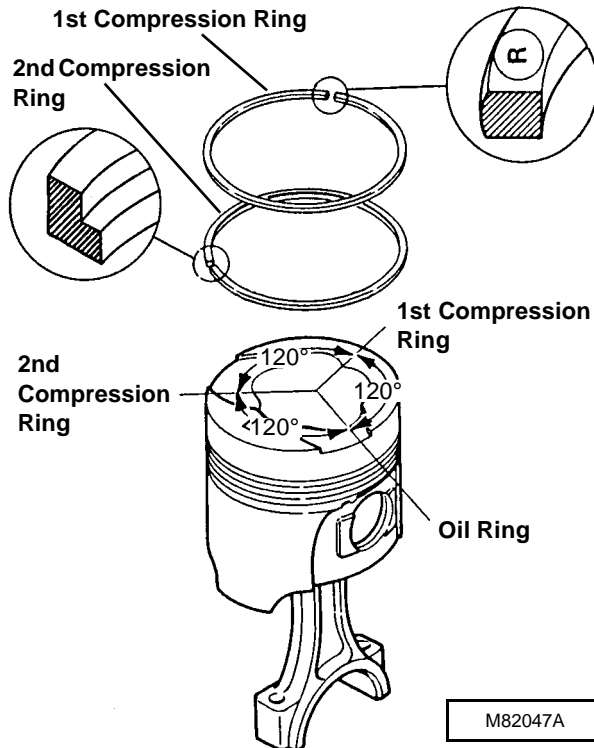
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3. Install oil ring expander in bottom ring groove of piston with ends above either end of piston pin.
4. Install oil ring over expander with ring gap opposite (180°) of expander ends.

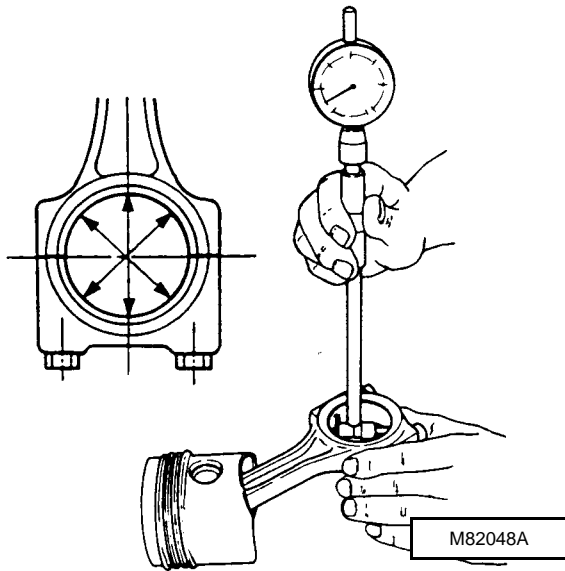


5. Install second compression ring, with chamfer toward top of piston, in middle groove. Turn ring until gap is 120° away from oil ring gap.
6. Install first compression ring, with manufacturer's mark "R" (near ring gap) toward top of piston, in top groove. Turn ring until gap is 120° away from second ring gap.



Inspection/Replacement

1. Inspect all parts for wear or damage. Replace as necessary.
2. Measure crankshaft connecting rod journal diameter. (See *Crankshaft, Main Bearings and Flywheel* in this section.)
3. Install connecting rod cap and bearing inserts on connecting rod. Install old connecting rod cap screws and tighten to **93 N•m (69 lb-ft)**.
4. Measure connecting rod bearing diameter.



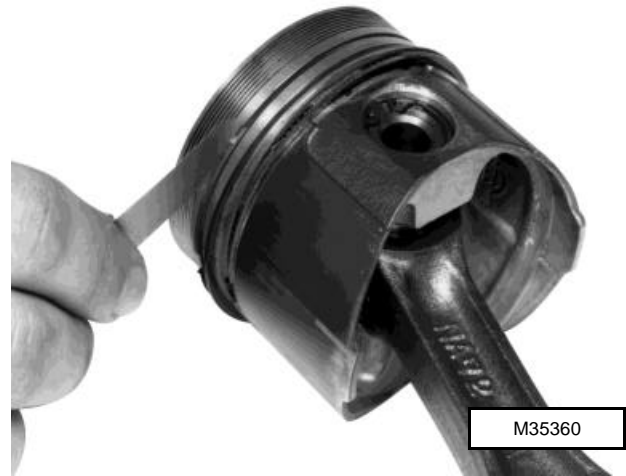
Connecting Rod Bearing I.D.:

Standard 60 - 60.042 mm
 (2.3622 - 2.3639 in.)
Wear Limit..... 60.10 mm (2.3661 in.)
Clearance..... 0.09 mm (0.004 in.)

If bearing diameter exceeds wear limit, replace bearing inserts.

If bearing clearance (bearing I.D. minus crankshaft journal O.D.) exceeds specification, grind crankshaft connecting rod journals and install undersized bearing inserts, or replace bearing inserts and crankshaft.

5. With rings installed on piston, measure piston ring groove clearance. Measure several places around each piston.



Piston Ring Groove Clearance:

First Compression Ring:

Standard 0.090 - 0.125 mm
 (0.0035 - 0.0049 in.)
Wear Limit..... 0.20 mm (0.0079 in.)

Second Compression Ring:

Standard 0.035 - 0.070 mm
 (0.0014 - 0.0028 in.)
Wear Limit..... 0.15 mm (0.0059 in.)

Oil Ring:

Standard 0.030 - 0.065 mm
 (0.0012 - 0.0026 in.)
Wear Limit..... 0.15 mm (0.0059 in.)

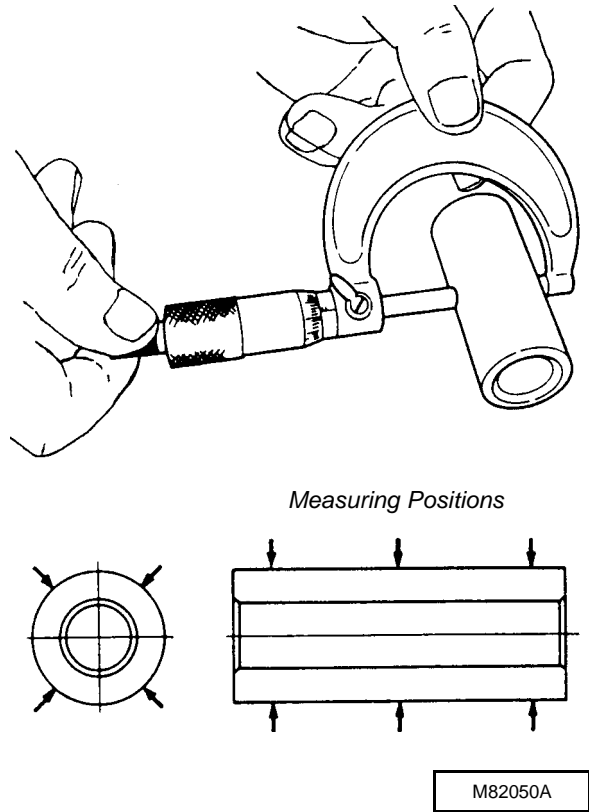
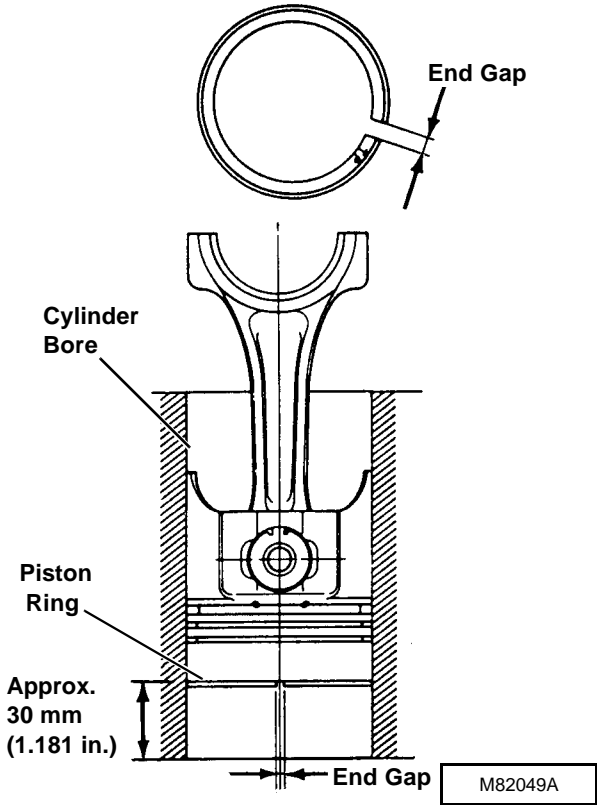
If clearance exceeds wear limit, replace rings or piston.

6. Measure piston ring end gap. Push ring into cylinder bore, using a piston, until ring is approximately **30 mm (1.181 in.)** from bottom of cylinder bore.

4

Pistons, Rods and Cylinder Block

4



Piston Ring End Gap:

Compression Rings:

- Standard 0.25 - 0.40 mm
.....(0.0098 - 0.0157 in.)
- Wear Limit..... 1.50 mm (0.0591 in.)

Oil Ring:

- Standard 0.30 - 0.50 mm
.....(0.0118 - 0.0197 in.)
- Wear Limit..... 1.50 mm (0.0591 in.)

If end gap exceeds wear limit, replace rings.

7. Measure piston pin diameter. Measure diameter at six places.

Piston Pin O.D.:

- Standard 33.989 - 34.00 mm
.....(1.3381 - 1.3386 in.)
- Wear Limit..... 33.90 mm (1.3346 in.)

If pin diameter is less than wear limit, replace pin.

8. Measure piston pin bore diameter in piston.



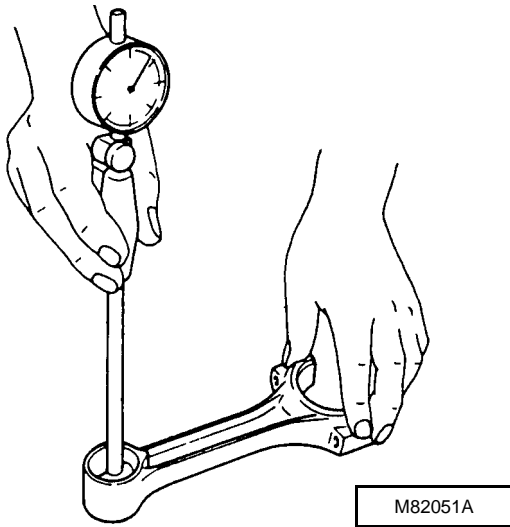
Piston Pin Bore I.D.:

- Standard** 34.00 - 34.011 mm
..... (1.3386 - 1.3390 in.)
Wear Limit..... 34.02 mm (1.3393 in.)
Clearance..... 0.022 mm (0.0009 in.)

If piston pin bore exceeds wear limit, replace piston.

If bore clearance (bore I.D. minus pin O.D.) exceeds specification, replace piston, piston pin or both.

9. Measure piston pin bushing diameter in connecting rod.



Piston Pin Bushing I.D.:

- Standard** 34.03 - 34.05 mm
..... (1.3398 - 1.3406 in.)
Wear Limit..... 34.10 mm (1.3425 in.)
Clearance..... 0.061 mm (0.0024 in.)

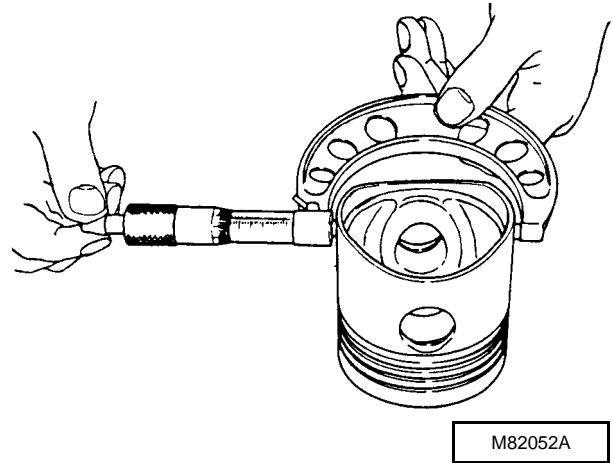
If bushing diameter exceeds wear limit, replace bushing.

If bushing clearance (bushing I.D. minus pin O.D.) exceeds specification, replace bushing, piston pin or both.

Piston pin bushing is press fit. Replace bushing using a driver set. When installing bushing, make sure to align oil hole in bushing with hole in connecting rod.

10. Measure piston diameter perpendicular to piston pin bore **25.50 mm (1.004 in.)** from bottom of piston.

NOTE: If engine has had a previous major overhaul, oversize pistons and rings may have been installed. Pistons and rings are available in 0.25 mm (0.010 in.) oversize.



4

Piston O.D.:

Standard Size Piston:

- Standard** 99.895 - 99.925 mm
..... (3.9329 - 3.9341 in.)
Wear Limit..... 99.79 mm (3.9287 in.)

0.25 mm (0.010 in.) Oversize Piston:

- Standard** 100.15 - 100.18 mm
..... (3.943 - 3.944 in.)
Wear Limit..... 100.05 mm (3.939 in.)

If piston diameter is less than wear limit, install a new piston.

11. Measure cylinder bore diameter. (See procedure in this group.)

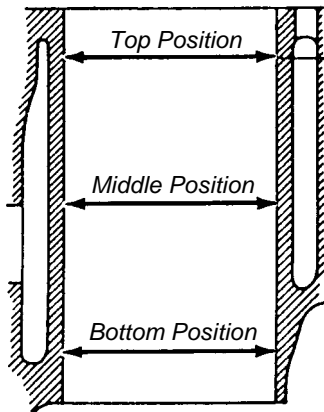
Pistons, Rods and Cylinder Block

CYLINDER BORE

Inspection

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

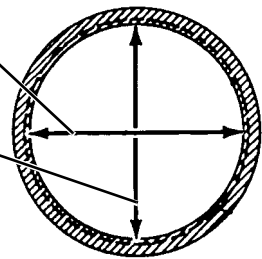
NOTE: If engine has had a previous major overhaul, oversize pistons and rings may have been installed.



4

Direction of Crankshaft Rotation

Direction of Crankshaft Centerline



M82053A

Cylinder Bore I.D.:

Standard Size Bore:

- Standard 100.00 - 100.03 mm
..... (3.9370 - 3.9382 in.)
- Wear Limit 100.15 mm (3.9429 in.)
- Clearance 0.41 mm (0.016 in.)

0.25 mm (0.010 in.) Oversize Bore:

- Standard 100.25 - 100.28 mm
..... (3.947 - 3.948 in.)
- Wear Limit 100.45 mm (3.955 in.)

If cylinder bore exceeds wear limit, replace cylinder block or have cylinder rebored. (See *Reboring* procedure.)

If cylinder is rebored, oversize pistons and rings must be installed. Pistons and rings are available in 0.25 mm (0.010 in.) oversize.

If clearance (cylinder bore I.D. minus piston O.D.) exceeds specification, replace cylinder block, piston or both; or rebore cylinder and install oversize piston and rings.

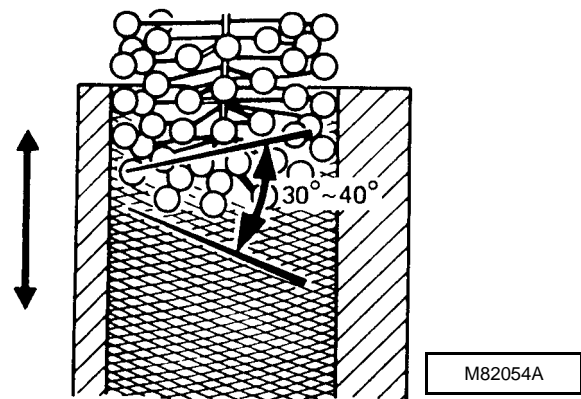
Deglazing

IMPORTANT: If cylinder bores are to be deglazed with crankshaft installed in engine, put clean shop towels over crankshaft to protect journal and bearing surfaces from any abrasives.

1. Deglaze cylinder bores using a flex-hone with 180 grit stones.
2. Use flex-hone as instructed by manufacturer to obtain a **30 - 40° cross-hatch pattern** as shown.

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

3. Remove excess abrasive residue from cylinder walls using a clean dry rag. Clean cylinder walls using clean white rags and warm soapy water. Continue to clean cylinder until white rags show no discoloration.



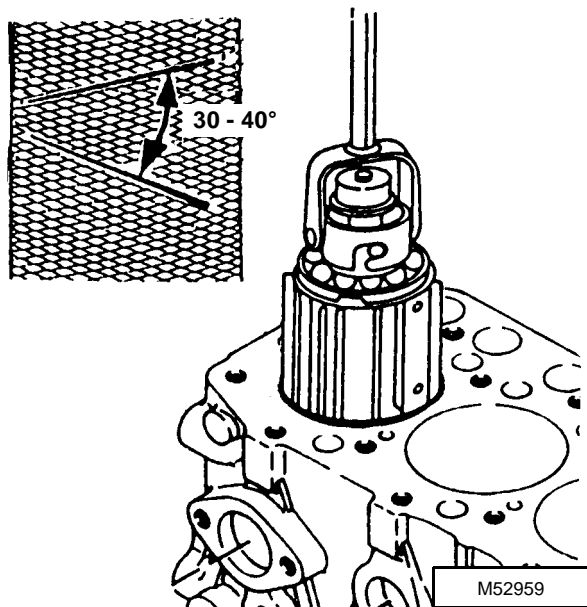
Reboring

NOTE: The cylinder block can be rebored to use 0.25 mm (0.010 in.) oversize pistons and rings. (See this group for cylinder bore I. D. specifications.)

1. Align center of bore to drill press center.

IMPORTANT: Check stone for wear or damage. Use a rigid hone with 300 grit stones.

2. Adjust hone so lower end is even with lower end of cylinder bore.
3. Adjust rigid hone stones until they contact narrowest point of cylinder.
4. Coat cylinder with honing oil. Hone should turn by hand. Adjust if too tight.
5. Run drill press at about 250 RPM. Move hone up and down in order to obtain a **30 - 40° crosshatch pattern.**



NOTE: Measure bore when cylinder is cool.

6. Stop press and check cylinder diameter.

NOTE: Finish should not be smooth. It should have a 30 - 40° crosshatch pattern.

7. Remove rigid hone when cylinder is within 0.03 mm (0.001 in.) of desired size.
8. Use a flex hone with 180 grit stones for honing to final size.
9. Check bore for size, taper and out-of-round. (See *Inspection* procedures.)

IMPORTANT: Do not use solvents to clean cylinder bore. Solvents will not remove all metal particles and abrasives produced during honing.

10. Clean cylinder thoroughly using warm soapy water until clean white rags show no discoloration.

11. Dry cylinder and apply engine oil.

Crankshaft, Main Bearings and Flywheel

OTHER MATERIALS

Number	Name	Use
LOCTITE® PRODUCTS U.S./ Canadian/ LOCTITE No.		
TY15130/ NA/ #395	John Deere Form-In-Place Gasket	Seals crankcase extension housing and rear oil seal case to engine block.

SERVICE PARTS KITS

The following kits are available through your parts catalog:

- Cylinder Block Gasket Kit
- Undersized Main Bearing Inserts
- Flywheel Mounting Cap Screws

CRANKCASE EXTENSION HOUSING

1. Remove flywheel. (See procedure in this group.)
2. Remove oil pan and oil strainer. (See *Lubrication System* in this section.)
3. Remove oil dipstick and tube, if equipped.

NOTE: 4TN100LFB shown. 4TN100RJF is not equipped with an oil dipstick tube.

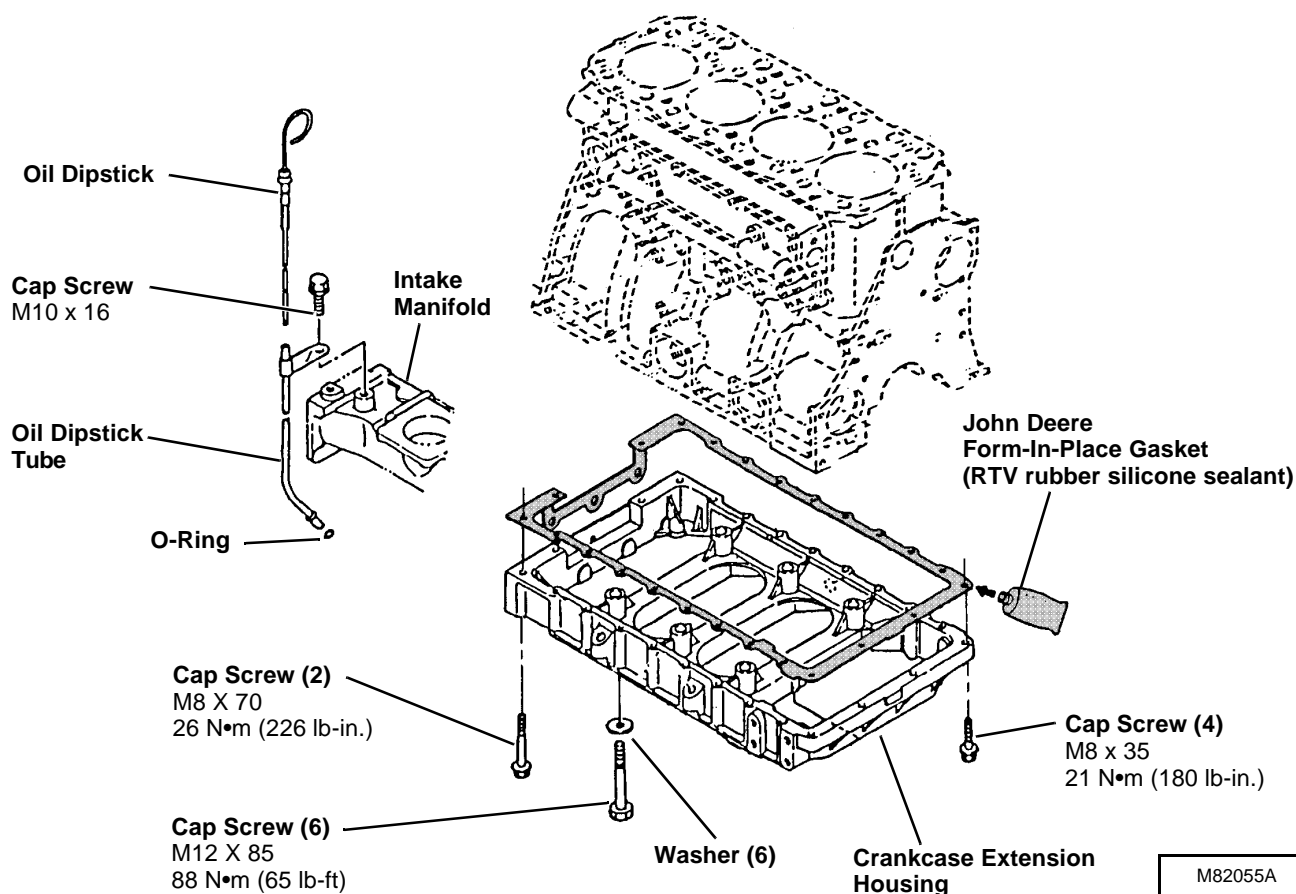


Cap Screw (3)
M8 x 25
21 N•m (180 lb-in.)

Cap Screw (4)
M10 x 30
49 N•m (36 lb-ft)

M82056

4



M82055A

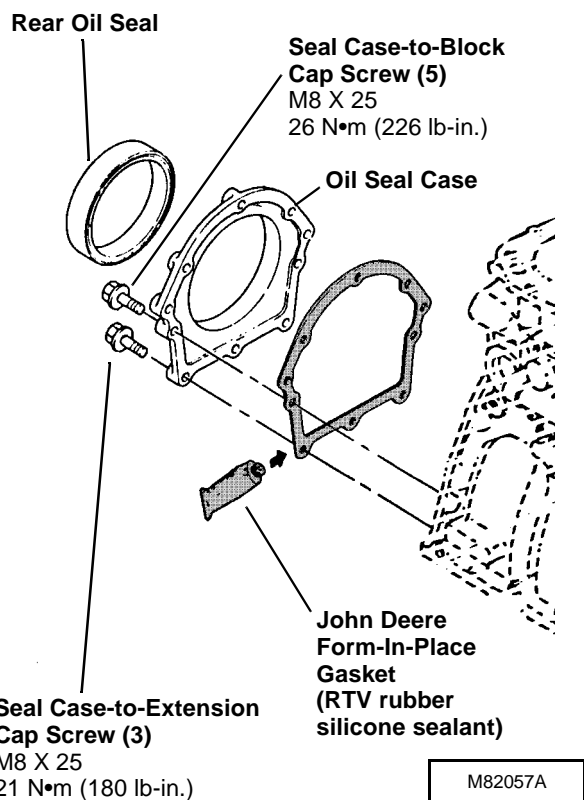
Crankshaft, Main Bearings and Flywheel

CRANKSHAFT REAR OIL SEAL

Replacement

1. Remove flywheel. (See procedure in this group.)

- Replace oil seal using a driver set. Install seal, with lip toward cylinder block. Install seal flush with surface of oil seal case.



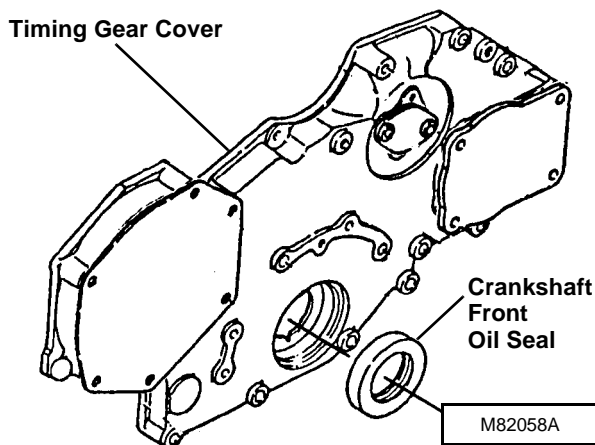
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CRANKSHAFT FRONT OIL SEAL

Replacement

- Remove timing gear cover. (See *Camshaft and Timing Gear Train* in this section.)

- Replace oil seal using a driver set. Install seal with lip toward inside of gear housing cover. Install seal **3.18 mm (0.125 in.)** below surface of cover.



CRANKSHAFT AND MAIN BEARINGS

Removal

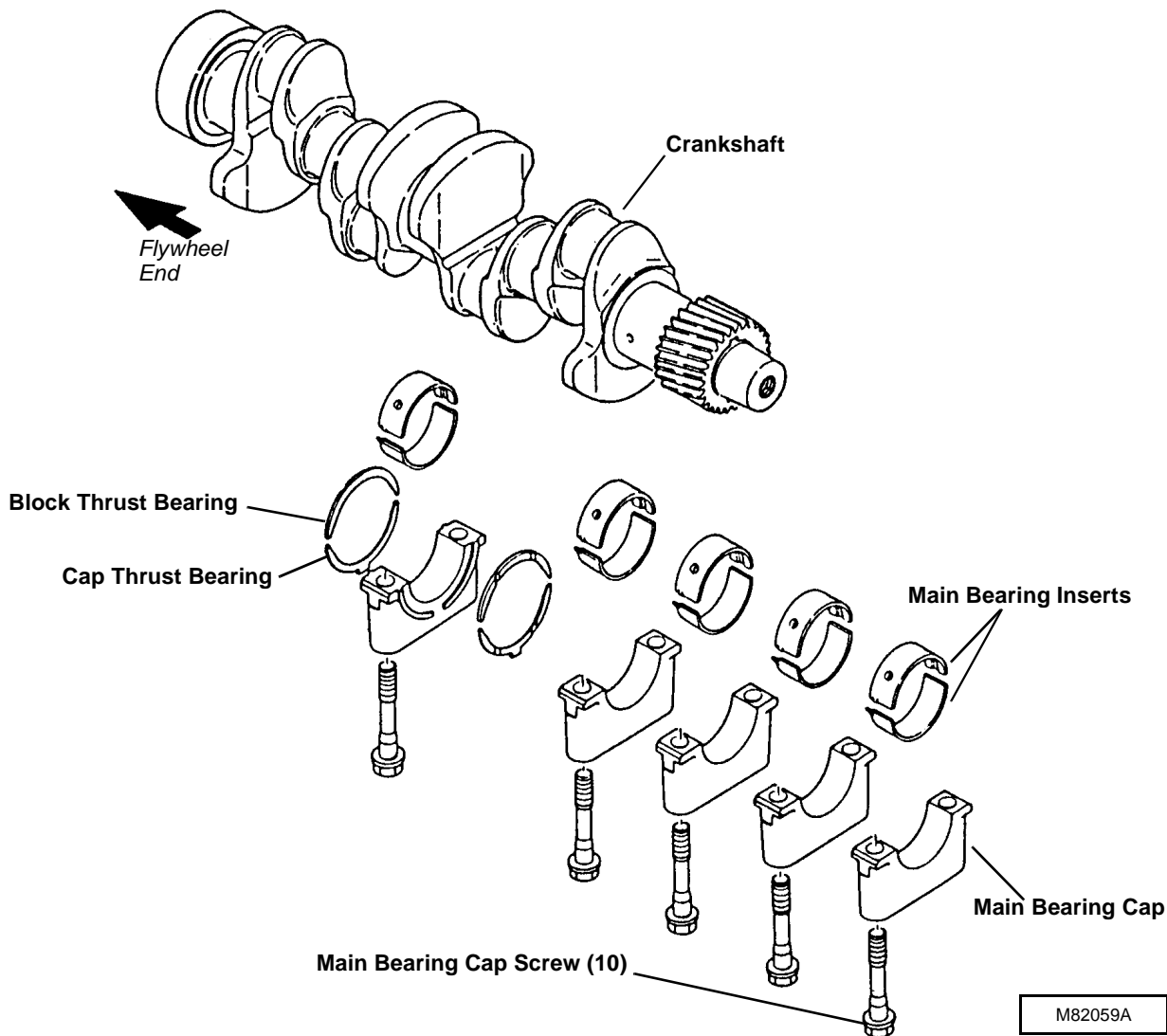
1. Check crankshaft end play. (See *Checks, Tests and Adjustments* in this section.)
2. Remove rear oil seal. (See procedure in this group.)
3. Remove flywheel housing. (See procedure in this group.)
4. Remove crankcase extension housing. (See procedure in this group.)
5. Remove timing gear housing. (See *Camshaft and Timing Gear Train* in this section.)
6. Check crankshaft bearing clearance. (See *Checks, Tests and Adjustments* in this section.)

IMPORTANT: Connecting rod end caps must be installed on the same connecting rods from which they were removed. Note alignment marks on caps and rods.

Crankshaft, Main Bearings and Flywheel

7. Remove connecting rod cap screws and end caps.
8. Push pistons and connecting rods away from crankshaft.
9. Remove main bearing cap screws, caps and cap thrust bearings.
10. Remove crankshaft.
11. Remove block thrust bearings and main bearing inserts.
12. Inspect all parts for wear or damage. (See *Inspection/Replacement* procedures.)

IMPORTANT: Main bearing caps must be installed on the same main bearings from which they were removed.



Crankshaft, Main Bearings and Flywheel

Installation

- Apply clean engine oil on all parts during installation.

IMPORTANT: Do not touch bearing insert surfaces. Oil and acid from your finger will corrode the bearing surface.

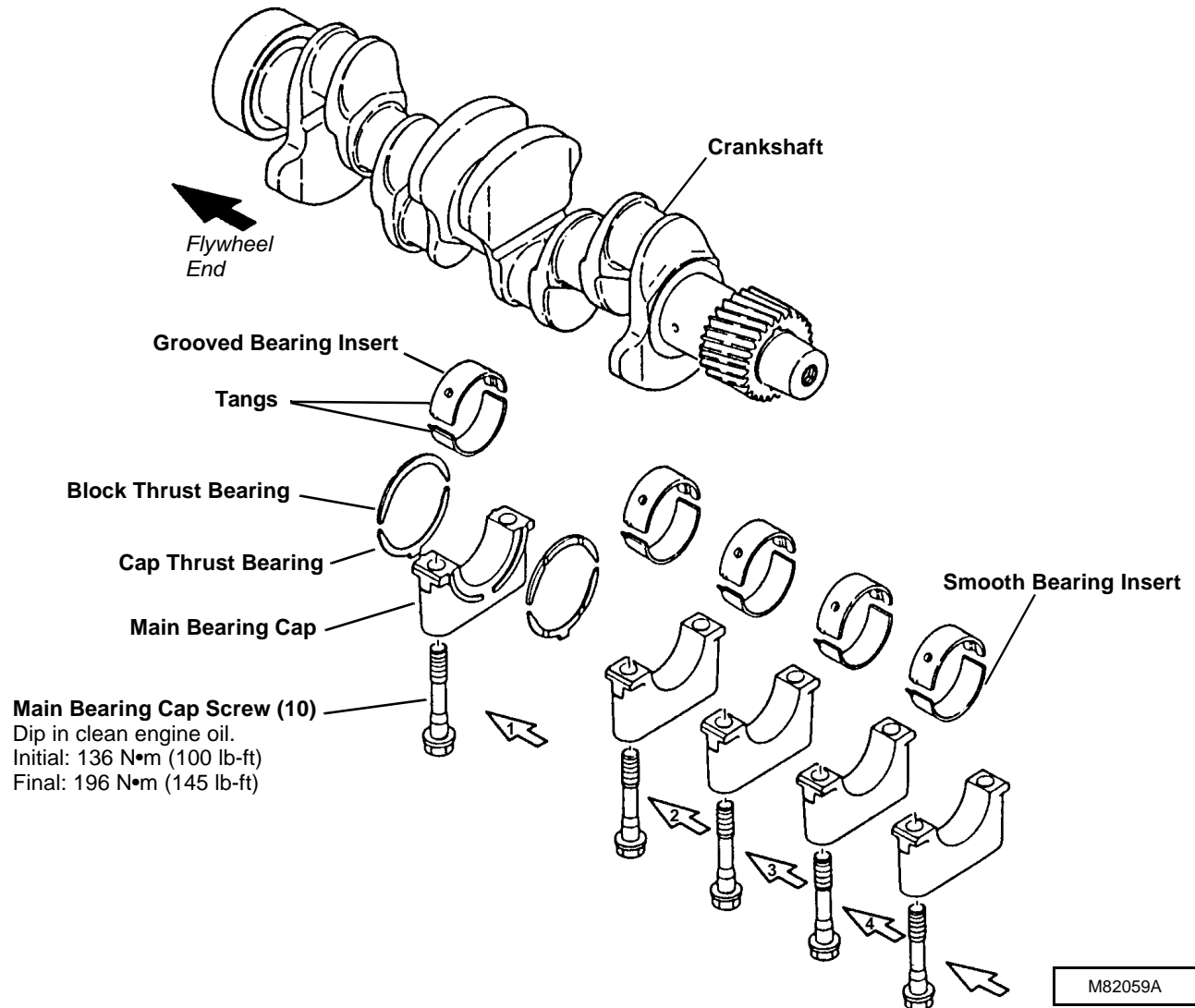
1. Install grooved bearing inserts in crankshaft bearing bores, aligning tangs with slots in bores.
2. Install block thrust bearings with oil grooves facing away from engine block.
3. Install crankshaft.
4. Install smooth bearing inserts in main bearing caps, aligning tangs with slots in caps.

NOTE: Main bearing caps have “raised arrows” that are stamped with numbers. Both correspond to their location on the engine block. The number “1” main bearing bore is at flywheel end. Install bearing caps beginning with number 1, then 2, etc. The main bearing cap at gear train end does not have a number. Also install bearing caps with the “arrow” toward the flywheel end.

5. Install cap thrust bearings, with oil grooves facing away from cap, in the number “1” main bearing cap.
6. Install main bearing caps in their original locations with arrows pointing toward flywheel side of engine.

IMPORTANT: DO NOT use high speed power tools or air wrenches to tighten main bearing cap screws.

7. Dip entire main bearing cap screws in clean engine oil. Install cap screws and tighten. **DO NOT** tighten to specifications.
8. Using a soft-faced hammer, tap the front end of the crankshaft then the rear end of the crankshaft to align the thrust bearings.
9. Tighten main bearing cap screws to specifications. When tightening, start at center main bearing cap and work your way out, alternating to the ends. Turn crankshaft by hand. If it does not turn easily, disassemble the parts and find the cause.



IMPORTANT: Connecting rod caps must be installed on the same connecting rods they were removed from.

Never reuse connecting rod cap screws, replace with new.

10. Match the connecting rod caps to the rods using alignment marks. Install caps.
11. Dip entire connecting rod cap screws in clean engine oil. Install new cap screws and tighten to **98 N•m (69 lb-ft)**.

12. Install timing gear housing. (See *Camshaft and Timing Gear Train* in this section.)
13. Install crankcase extension housing. (See procedure in this group.)
14. Install flywheel housing. (See procedure in this group.)
15. Install rear oil seal. (See procedure in this group.)

Crankshaft, Main Bearings and Flywheel

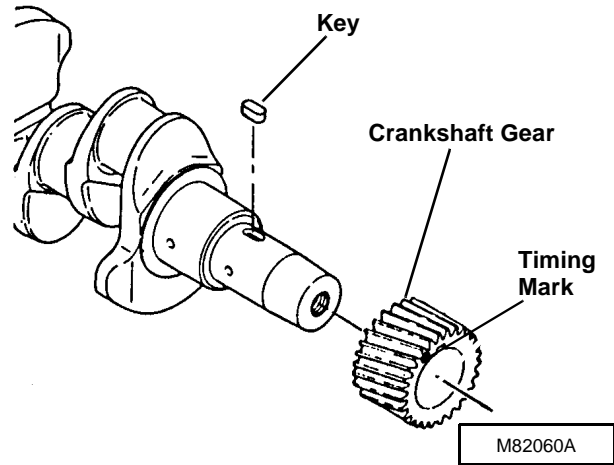
Inspection/Replacement

1. Inspect gear for chipped or broken teeth. Replace if necessary.

To replace gear:

Remove gear from crankshaft using a knife-edge puller and a press.

Heat gear to approximately 150° C (300° F). Install gear with timing mark "A" toward press table. Align slot in gear with key in shaft. Press crankshaft into gear until gear is tight against crankshaft shoulder.

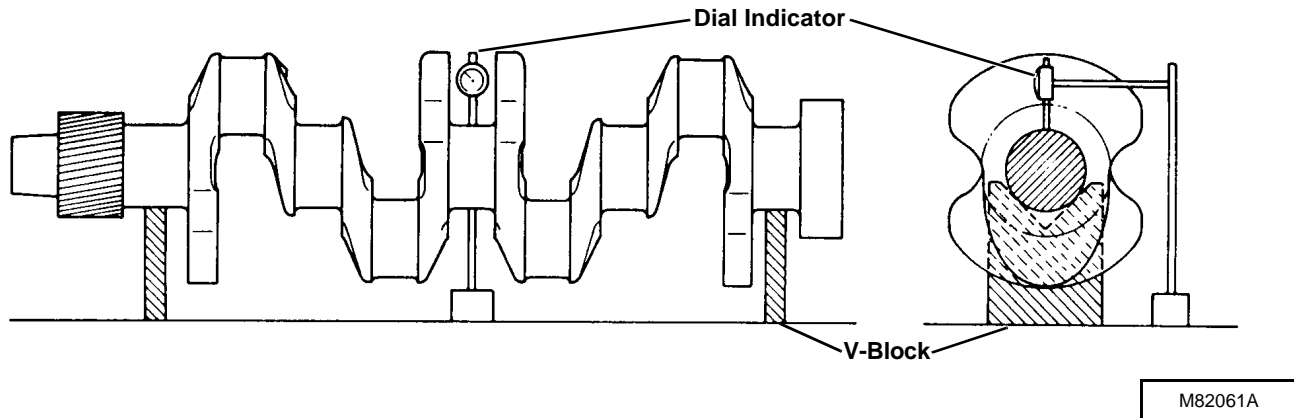


CAUTION

DO NOT heat oil over 182° C (360° F). Oil fumes or oil can ignite above 193° C (380° F). Use a thermometer. Do not allow a flame or heating element to come in direct contact with the oil. Heat the oil in a well-ventilated area. Plan a safe handling procedure to avoid burns.

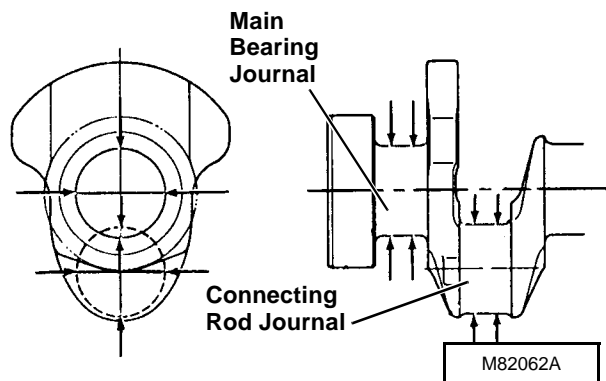
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2. Inspect crankshaft for bend using v-blocks and a dial indicator. Turn crankshaft slowly and read variation on indicator. If variation is greater than **0.02 mm (0.0007 in.)**, replace crankshaft.



3. Measure crankshaft connecting rod journal and main bearing journal diameters. Measure several places around each journal.

NOTE: If engine has had a previous major overhaul, journals may have been ground and undersized bearing inserts installed.



Connecting Rod Journal O.D.:

Standard 59.952 - 59.964 mm
 (2.3603 - 2.3608 in.)
Wear Limit..... 59.90 mm (2.3583 in.)

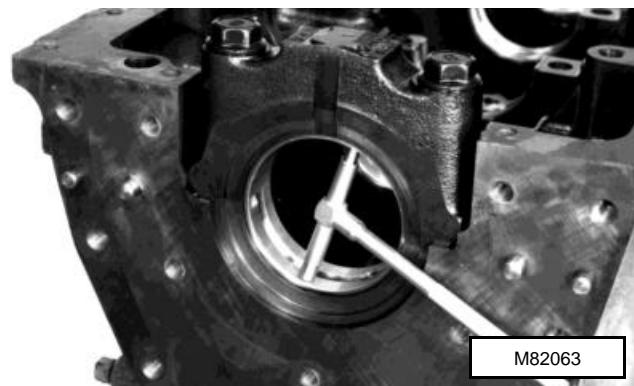
Main Bearing Journal O.D.:

Standard 69.952 - 69.964 mm
 (2.7540 - 2.7545 in.)
Wear Limit..... 69.90 mm (2.7520 in.)

If journal diameter is less than wear limit, replace crankshaft or have journals ground undersize by a qualified machine shop.

If journals are ground, undersize bearing inserts must be installed. Bearing inserts are available in 0.25 mm (0.010 in.) undersize.

4. Install bearing inserts and main bearing cap on main bearing. Tighten main bearing cap screws to **196 N•m (145 lb-ft)**.
5. Measure main bearing diameter.



Main Bearing I.D.:

Standard 60.00 - 60.042 mm
 (2.3622 - 2.3639 in.)
Wear Limit..... 60.10 mm (2.3661 in.)
Clearance..... 0.09 mm (0.004 in.)

4

If bearing diameter exceeds wear limit, replace bearing inserts.

If bearing clearance (bearing I.D. minus crankshaft main bearing journal O.D.) exceeds specification, replace bearing inserts and crankshaft or have crankshaft journals ground undersize by a qualified machine shop and install undersized bearing inserts.

Bearing inserts are available in 0.25 mm (0.010 in.) undersize.

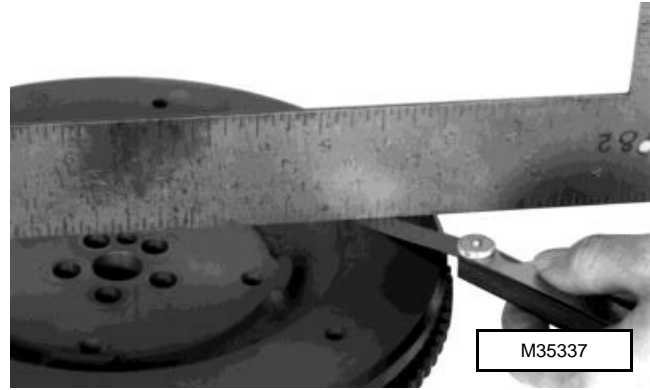
6. Clean and inspect oil passages in main bearing journals, connecting rod journals and main bearing bores in cylinder block.
7. Inspect crankshaft for cracks or damage. Replace if necessary.

Crankshaft, Main Bearings and Flywheel

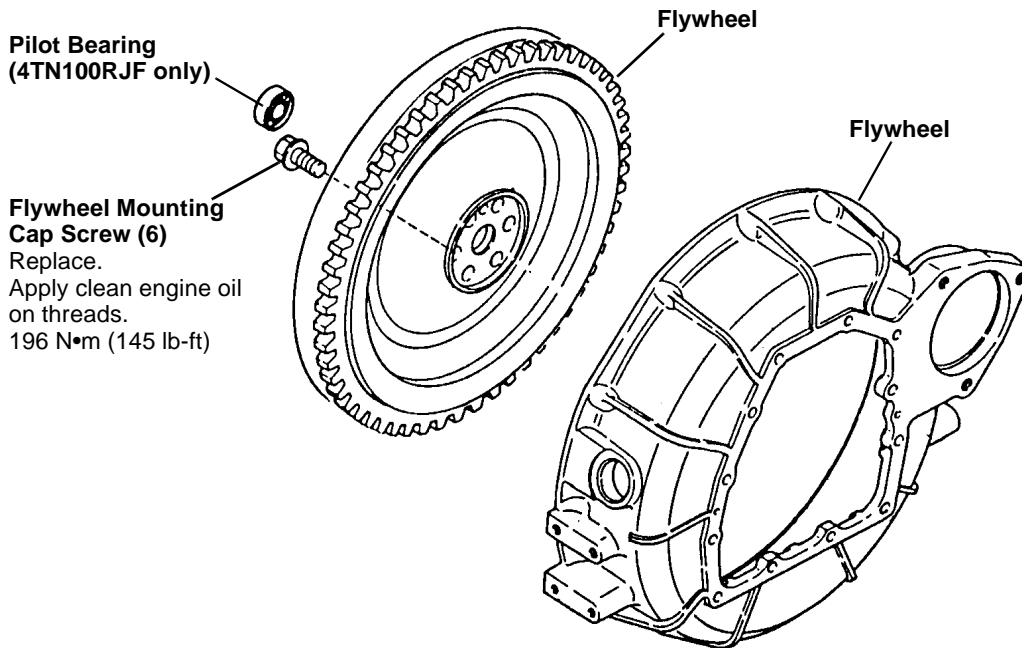
FLYWHEEL

IMPORTANT: Never reuse flywheel mounting cap screws. Always install new.

- Inspect pilot bearing, if equipped, for wear or damage. Replace if necessary using a driver set. Install bearing flush with flywheel surface.
- Measure flywheel flatness. Place a straight edge across flywheel surface opposite of ring gear. Measure clearance between straight edge and flywheel surface with a feeler gauge. If clearance exceeds **0.02 mm (0.0008 in.)**, replace flywheel.



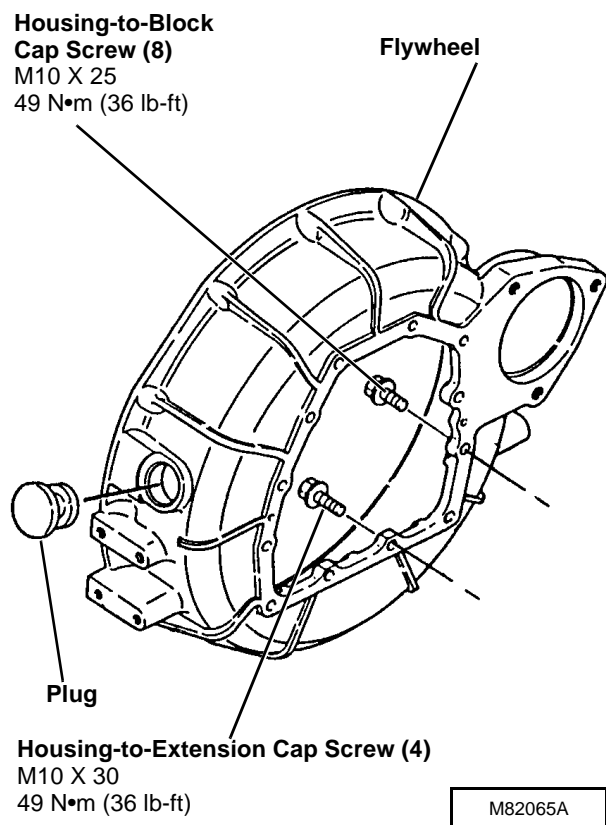
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M82064A

FLYWHEEL HOUSING

1. Remove flywheel. (See procedure in this group.)
2. Remove starter.



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).

D15001NU Magnetic Follower Holder Kit

Hold cam followers when removing and installing camshaft.

OTHER MATERIALS

Number

Name

Use

LOCTITE® PRODUCTS

U.S./

Canadian/

LOCTITE No.

TY15130/

NA/

#395

John Deere Form-In-Place
Gasket

Seals camshaft plug, timing gear cover and
housing to engine block.

TY9370/

4

TY9477/

#242

Thread Lock and Sealer
(Medium Strength)

Apply to threads of crankshaft pulley
cap screw.

SERVICE PARTS KITS

The following kits are available through your parts catalog:

- Cylinder Head Gasket Kit
- Cylinder Block Gasket Kit

® LOCTITE is a registered trademark of the Loctite Corp.

CAMSHAFT

Removal

1. Remove rocker arm assembly and push rods. (See *Cylinder Head, Valves and Manifolds* in this section.)
2. Remove timing gear cover. (See procedure in this group.)
3. Check camshaft end play. (See *Checks, Tests and Adjustments* in this section.)
4. Check backlash of timing gears. (See *Checks, Tests and Adjustments* in this section.)

NOTE: If a magnetic follower holder kit is not available, turn engine until oil pan is upward, to hold cam followers away from camshaft.

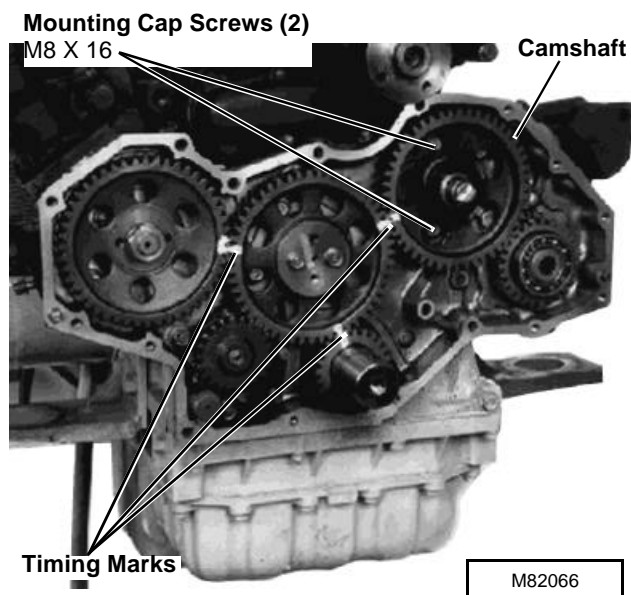
5. Hold cam followers away from camshaft using a magnetic follower holder kit such as D15001NU.

NOTE: Due to the odd number of teeth on the idler gear, timing marks will only align periodically.

6. Rotate crankshaft and align timing marks.

IMPORTANT: DO NOT allow camshaft lobes to hit bearing surfaces while removing camshaft. Machined surfaces can be damaged.

7. Remove two cap screws and camshaft.
8. Inspect all parts for wear or damage. (See *Inspection/Replacement* procedures.)



Installation

- Apply clean engine oil on all parts during installation.

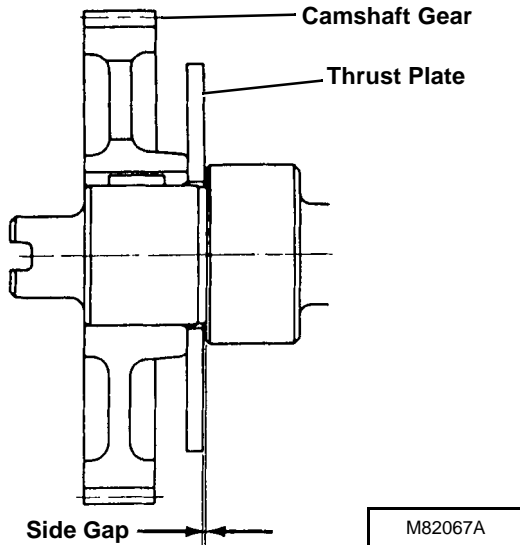
IMPORTANT: DO NOT allow camshaft lobes to hit bearing surfaces while installing camshaft. Machined surfaces can be damaged.

1. Rotate crankshaft to align timing marks.
2. Install camshaft.
3. Install and tighten mounting cap screws to **26 N•m (226 lb-in.)**.
4. Install timing gear cover. (See procedure in this group.)
5. Install push rods and rocker arm assembly. (See *Cylinder Head, Valves and Manifolds* in this section.)

Camshaft and Timing Gear Train

Inspection/Replacement

1. Check camshaft side gap using a feeler gauge.



4 Camshaft Side Gap:

Standard 0.05 - 0.20 mm
 (0.0020 - 0.0079 in.)

Wear Limit..... 0.29 mm (0.0114 in.)

If side gap is at wear limit, remove gear and replace thrust plate.

2. Inspect gear for chipped or broken teeth. Replace if necessary.

To remove/replace gear:

Remove gear from camshaft using a knife-edge puller and a press.

CAUTION

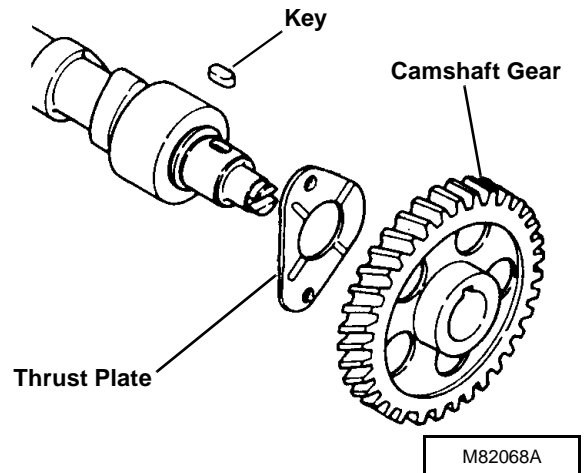
DO NOT heat oil over 182° C (360° F). Oil fumes or oil can ignite above 193° C (380° F). Use a thermometer. Do not allow a flame or heating element to come in direct contact with the oil. Heat the oil in a well-ventilated area. Plan a safe handling procedure to avoid burns.

Heat gear to approximately 150°C (300°F).

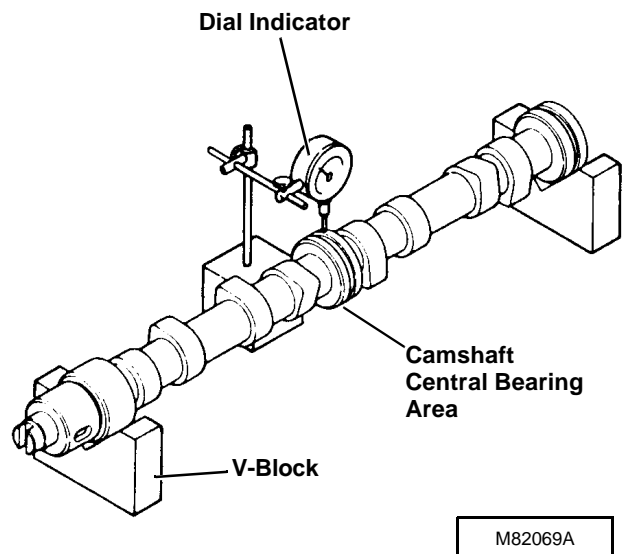
IMPORTANT: Be sure thrust plate is not between camshaft gear and camshaft shoulder while installing gear.

Install thrust plate if removed. Install gear with timing mark "C" side toward press table. Align slot in gear with key in shaft. Press camshaft into gear until gear is tight against camshaft shoulder.

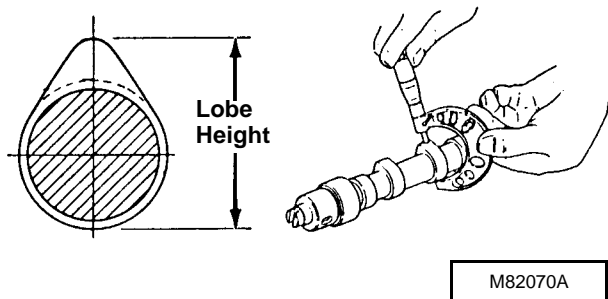
Thrust plate must spin freely on camshaft.



3. Inspect camshaft for bend using v-blocks and a dial indicator. Turn camshaft slowly and read variation on indicator. If variation is greater than 0.05 mm (0.0020 in.), replace camshaft.



4. Measure camshaft lobe height.



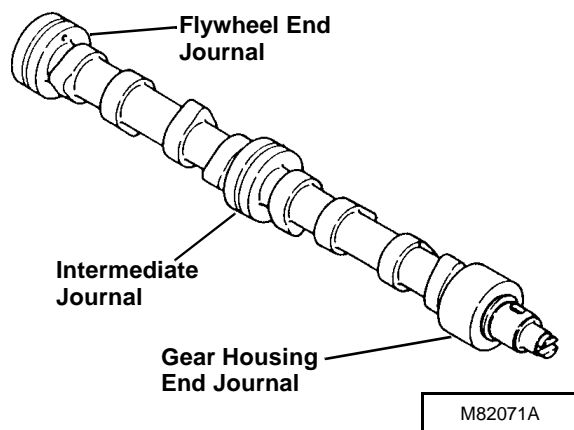
Lobe Height:

Standard 48.435 - 48.565 mm
 (1.9069 - 1.9120 in.)

Wear Limit..... 48.20 mm (1.897 in.)

If lobe height is less than wear limit, replace camshaft.

5. Measure camshaft end and intermediate journal diameters.



Camshaft Journal O.D.:

Gear Housing and Flywheel Ends:

Standard 56.91 - 56.94 mm
 (2.2406 - 2.2417 in.)

Wear Limit..... 56.80 mm (2.2362 in.)

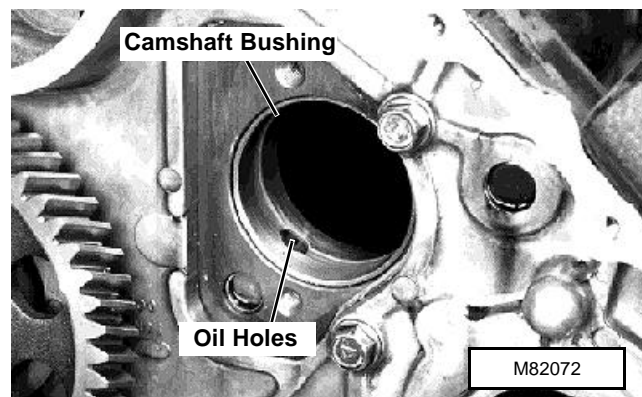
Intermediate:

Standard 56.89 - 56.92 mm
 (2.2398 - 2.2409 in.)

Wear Limit..... 56.80 mm (2.2362 in.)

If journal diameters are less than wear limit, replace camshaft.

6. Measure camshaft bushing diameter at gear housing end.



Camshaft Bushing I.D.:

Standard 56.98 - 57.05 mm
 (2.2433 - 2.2461 in.)

Wear Limit..... 57.10 mm (2.2480 in.)

Clearance..... 0.14 mm (0.006 in.)

If bushing diameter exceeds wear limit, replace bushing.

To replace bushing:

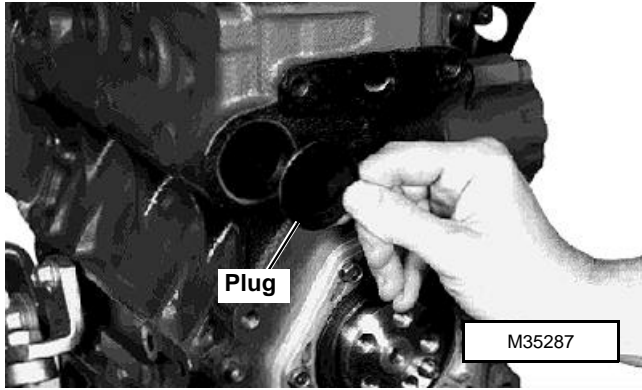
Remove bushing using a chisel. Be careful not to push bushing inside of engine. Align oil holes in new bushing and cylinder block. Install bushing **1.6 mm (0.062 in.)** below surface of cylinder block using a driver set.

If bushing clearance (bushing I.D. minus camshaft journal O.D.) exceeds specification, replace bushing, camshaft or both.

NOTE: Flywheel housing must be removed to measure camshaft intermediate and flywheel end bearing diameters.

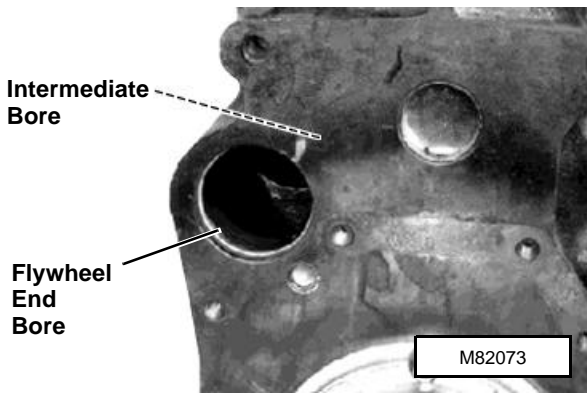
7. Measure intermediate and flywheel end camshaft bore diameters using the following procedures:

- Remove flywheel housing. (See *Crankshaft, Main Bearings and Flywheel* in this section.)
- Remove plug using a long wooden dowel. Insert wooden dowel through gear housing side.



- Measure intermediate and flywheel end camshaft bore diameters.

4



Camshaft Bore I.D.:

Standard 57.00 - 57.03 mm
 (2.2441 - 2.2453 in.)

Wear Limit..... 57.10 mm (2.2480 in.)

Clearance..... 0.12 mm (0.005 in.)

If bore diameter exceeds wear limit, replace cylinder block.

If bore clearance (bore I.D. minus camshaft journal O.D.) exceeds specification, replace camshaft, cylinder block or both.

- Apply John Deere Form-In Place Gasket, or an equivalent, on outer edge of plug. Install plug until it bottoms in bore.
- Install flywheel housing.

CAM FOLLOWERS

Removal/Installation

1. Remove camshaft. (See procedure in this group.)
2. Remove oil pan and strainer. (See *Lubrication System* in this section.)

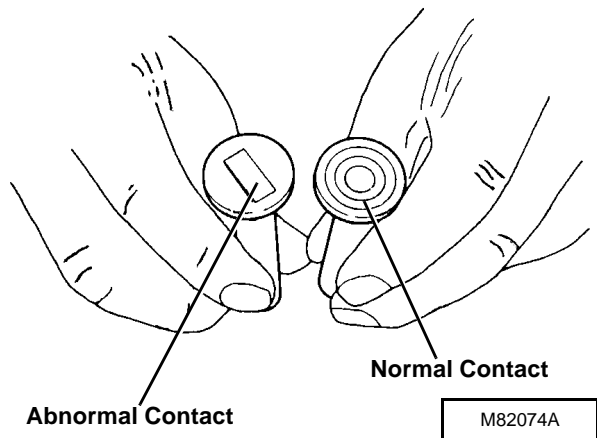
IMPORTANT: Cam followers must be installed in the same bores from which they were removed.

3. Put a mark on each cam follower and cylinder block bore to aid in installation.
4. Remove cam followers.
5. Inspect all parts for wear or damage. (See *Inspection* procedures.)
6. Apply clean engine oil on all parts during installation.

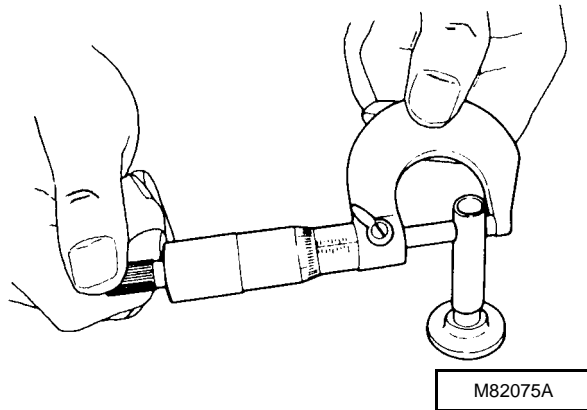
Installation is done in the reverse order of removal.

Inspection

- Inspect cam follower contact surface for abnormal wear. Replace if necessary.



- Measure cam follower stem diameter.



Cam Follower Stem O.D.:

Standard 14.218 - 14.233 mm
 (0.5598 - 0.5604 in.)

Wear Limit..... 14.17 mm (0.5579 in.)

If stem diameter is less than wear limit, replace cam follower.

- Measure cam follower bore diameter in cylinder block.

Cam Follower Bore I.D.:

Standard 14.249 - 14.270 mm
 (0.5610 - 0.5618 in.)

Wear Limit..... 14.30 mm (0.5630 in.)

Clearance..... 0.052 mm (0.0020 in.)

If cam follower bore diameter exceeds wear limit, replace cylinder block.

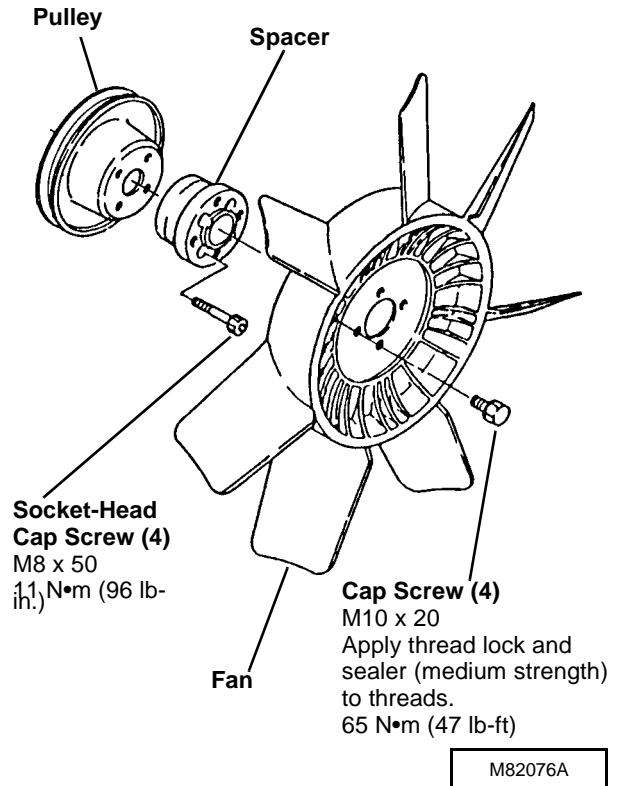
If bore clearance (bore I.D. minus follower stem O.D.) exceeds specification, replace cam follower, cylinder block or both.

TIMING GEAR COVER

Removal/Installation

1. Remove alternator and belt.
2. Remove fan, spacer and pulley.

3. Remove cap screw and washer.
4. Remove crankshaft pulley using a two-jaw puller kit.
5. Remove key.



4

NOTE: It is not necessary to remove auxiliary drive cover and gasket, end cover and o-ring or fuel injection pump gear cover to remove timing gear cover.

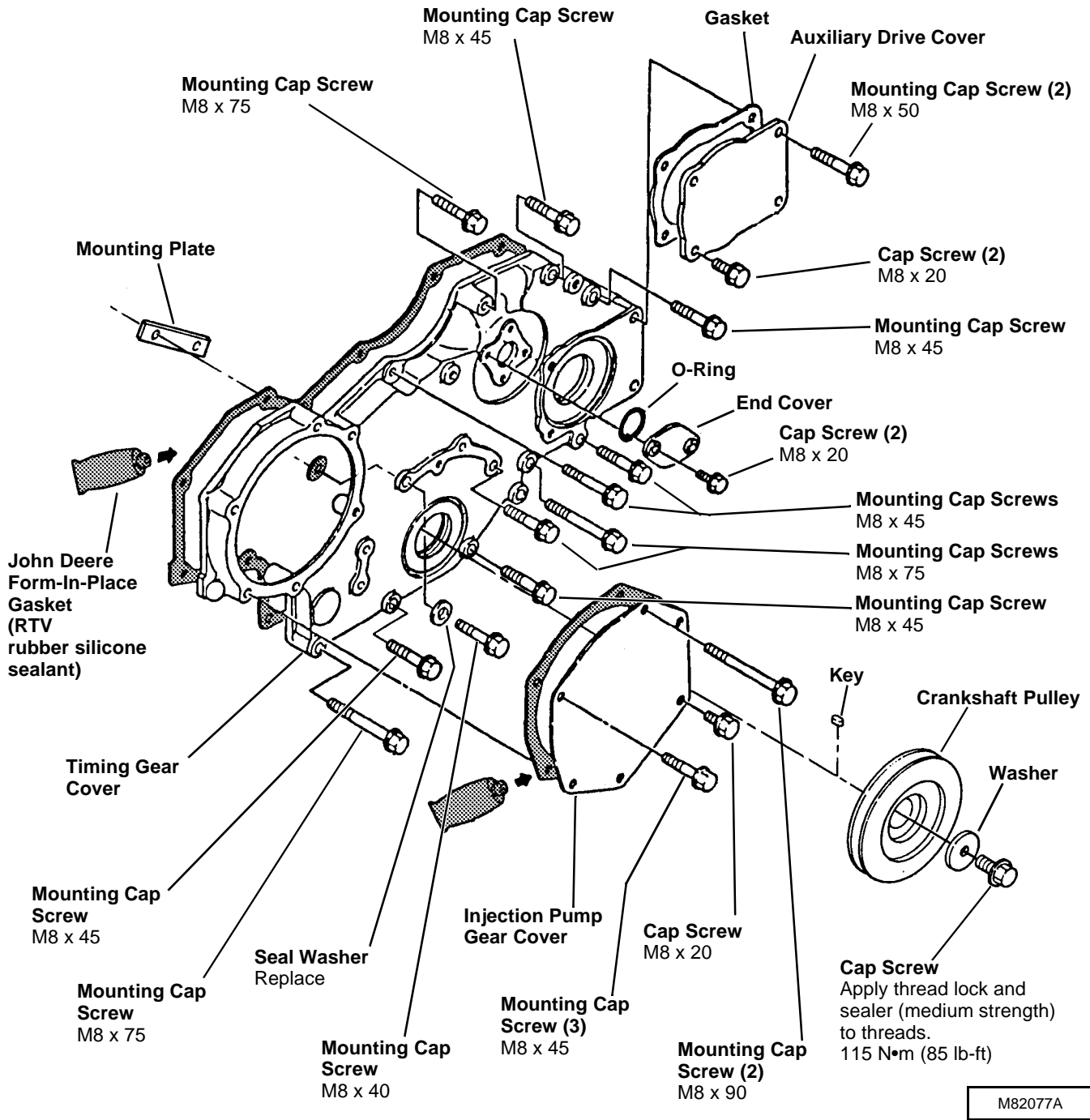
6. Remove 18 mounting cap screws and timing gear cover.

Installation is done in the reverse order of removal.

- Replace seal washer.
- Tighten all mounting cap screws to **26 N•m (226 lb-in.)**.
- Adjust fan/alternator drive belt tension. (See *Checks, Tests and Adjustments* in this section.)

Camshaft and Timing Gear Train

4



IDLER GEAR

Removal/Installation

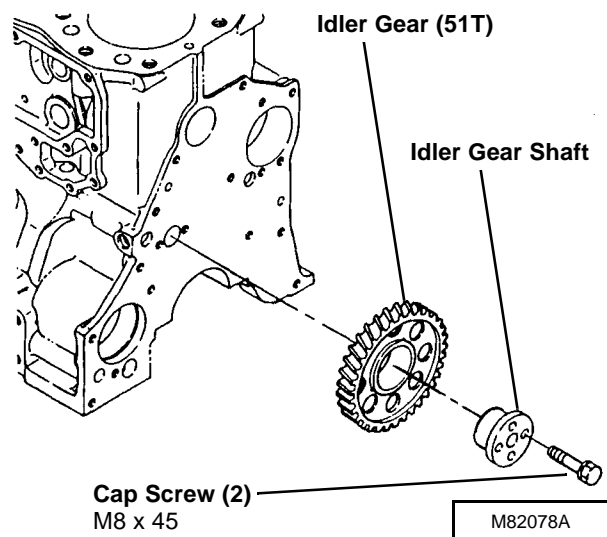
1. Remove timing gear cover. (See procedure in this group.)
2. Check backlash of timing gears. (See *Checks, Tests and Adjustments* in this section.)

NOTE: Due to the odd number of teeth on the idler gear, timing marks will only align periodically. When all timing marks on gears are aligned, the piston closest to the water pump is at TDC on compression stroke. Number one cylinder is closest to the flywheel.

3. Rotate crankshaft and align timing marks.
4. Remove two cap screws, shaft and gear.

5. Inspect all parts for wear or damage. (See *Inspection/Replacement* procedures.)

Installation is done in the reverse order of removal.

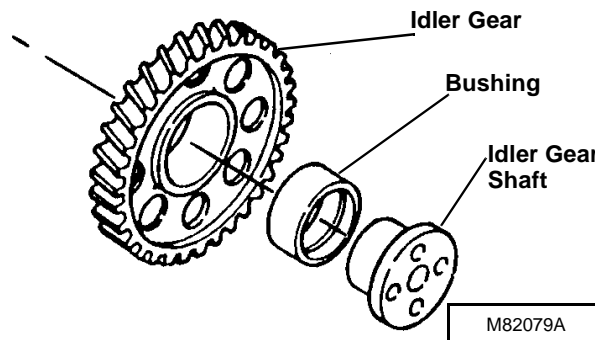


If bushing diameter exceeds wear limit, replace bushing.

To replace bushing:

Replace bushing using a driver set. Align oil holes in bushing and idler gear. Install bushing flush with surface of idler gear.

If bushing clearance (bushing I.D. minus shaft O.D.) exceeds specification, replace bushing, shaft or both.



Inspection/Replacement

- Inspect gear for chipped or broken teeth. Replace if necessary.
- Measure idler gear shaft diameter.

Idler Gear Shaft O.D.:

Standard 45.95 - 45.975 mm
..... (1.8091 - 1.8100 in.)

Wear Limit..... 45.9 mm (1.8071 in.)

If shaft diameter is less than wear limit, replace idler gear shaft.

- Measure idler gear bushing diameter.

Idler Gear Bushing I.D.:

Standard 46.00 - 46.025 mm
..... (1.8110 - 1.8120 in.)

Wear Limit..... 46.09 mm (1.8146 in.)

Clearance..... 0.075 mm (0.0030 in.)

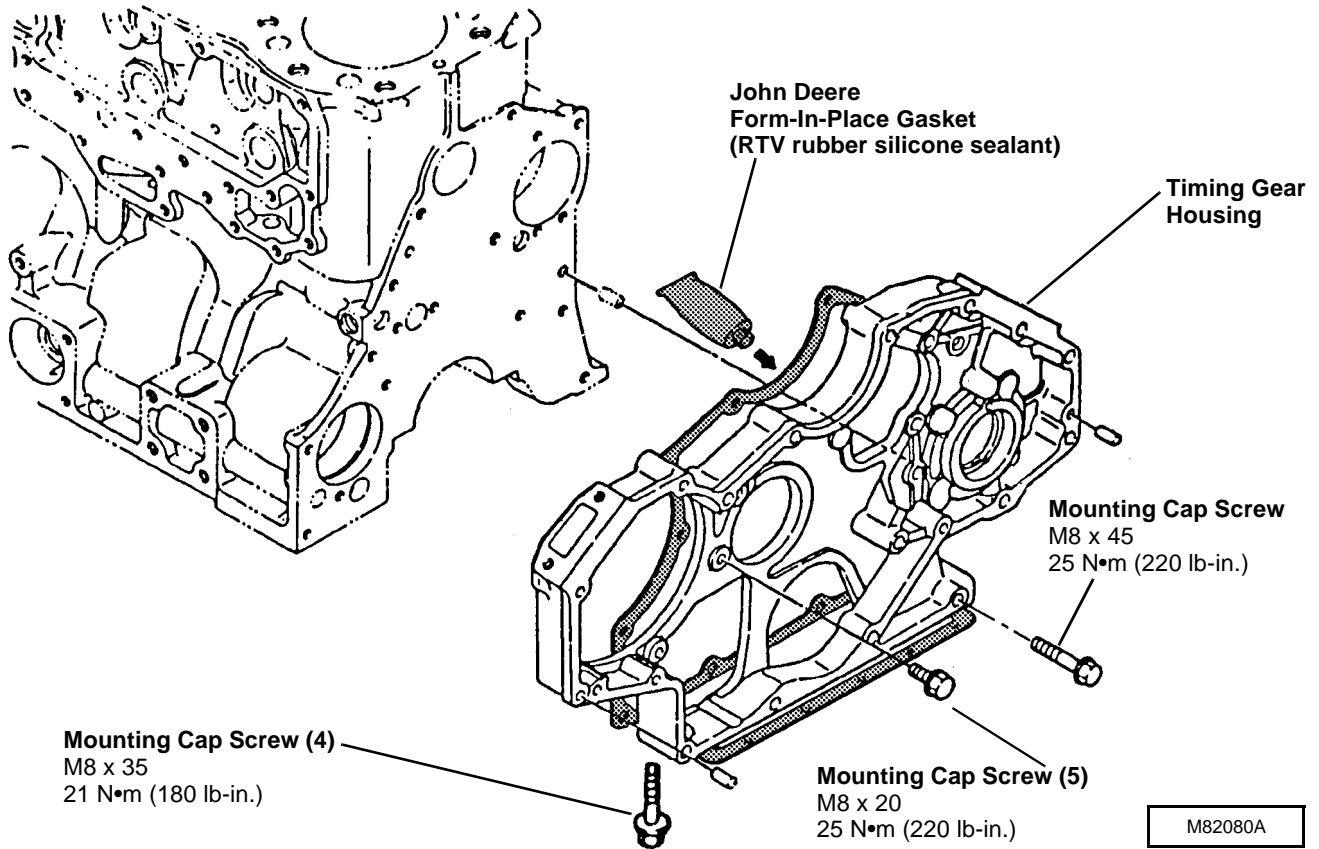
TIMING GEAR HOUSING

Removal/Installation

1. Remove camshaft. (See procedure in this group.)
2. Remove idler gear. (See procedure in this group.)
3. Remove fuel injection pump. (See *Fuel System* in this section.)
4. Remove mounting cap screws and housing.

Installation is done in the reverse order of removal.

Camshaft and Timing Gear Train



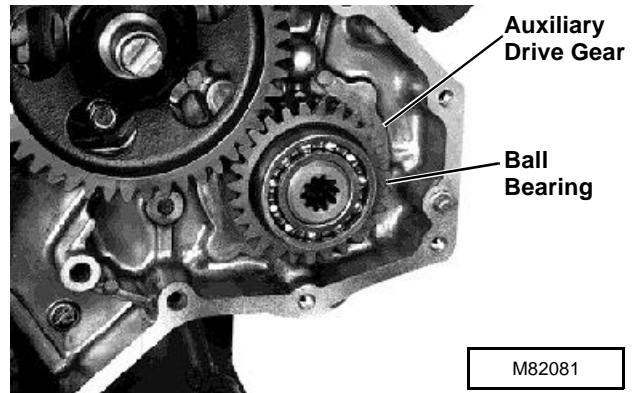
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AUXILIARY DRIVE GEAR - IF EQUIPPED

Remove timing gear cover. (See procedure in this group.)

NOTE: Bearings are slip fit in timing gear housing and cover and press fit on drive gear ends.

Inspect all parts for wear or damage. Replace as necessary.



OTHER MATERIALS

Number	Name	Use
LOCTITE® PRODUCTS U.S./ Canadian/ LOCTITE No.		
TY15130/ NA/ #395	John Deere Form-In-Place Gasket	Seals oil pan to crankcase extension housing.
TY9375/ TY9480/ #592	John Deere Pipe Sealant with TEFLON®	Apply to threads of plug in oil cooler.

®LOCTITE is a registered trademark of the Loctite Corp.

®TEFLON is a registered trademark of the Du Pont Company.

Lubrication System

OIL PAN AND STRAINER

Removal/Installation

- Approximate crankcase oil capacity is 12.7L (13.4 qt.).

- Replace all O-rings and copper washers, if equipped.
- Fill engine with proper engine oil. (See *SPECIFICATIONS AND GENERAL INFORMATION* section.)

4

Cap Screw (4)
M8 x 30
21 N•m (180 lb-in.)

John Deere Form-In-Place Gasket (RTV rubber silicone sealant)

Oil Pan

Cap Screw (4)
M8 x 30
21 N•m (180 lb-in.)

Cap Screw (18)
M8 x 85
26 N•m (226 lb-in.)

Drain Plug Assembly (4TN100LFB)

Copper Washer (2)
Replace

Drain Plug (4TN100RJF)

O-Ring (4TN100RJF)
Replace

O-Ring
Replace

Oil Strainer Tube

Cap Screw with Lock Washer (2)
M8 x 16
26 N•m (226 lb-in.)

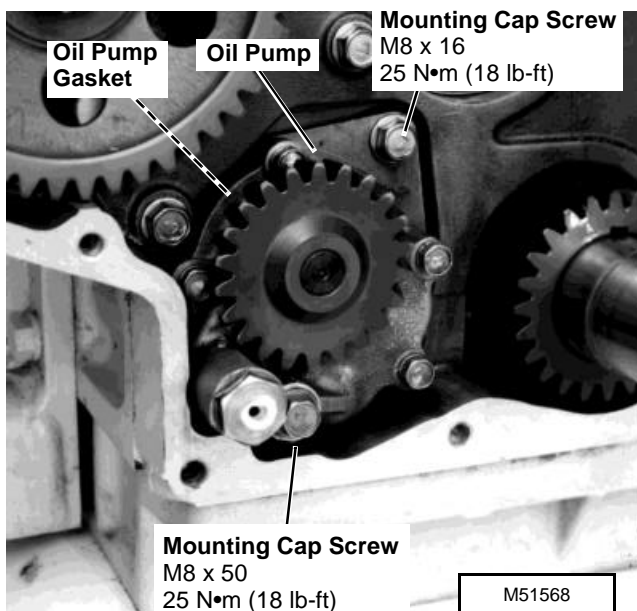
Cap Screw (2)
M8 x 16
26 N•m (226 lb-in.)

M82082A

OIL PUMP

Removal/Installation

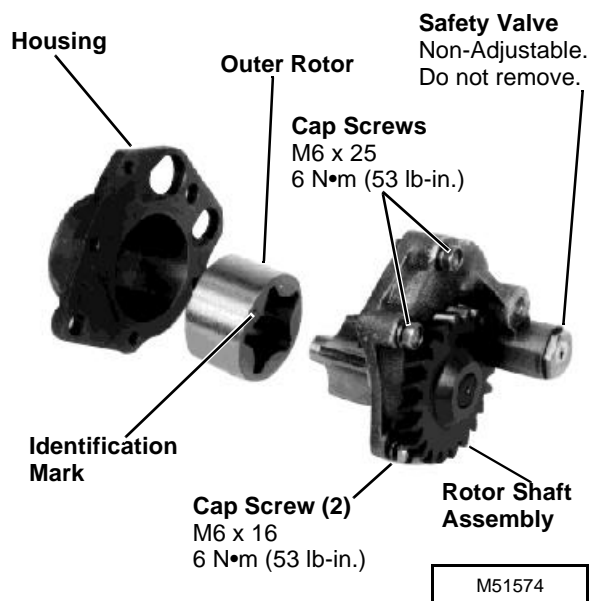
1. Remove timing gear cover. (See *Camshaft and Timing Gear Train* in this section.)
2. Check oil pump gear backlash. Replace entire oil pump assembly if backlash is more than **0.25 mm (0.010 in.)**.
3. Remove idler shaft and gear. (See *Camshaft and Timing Gear Train* in this section.)
4. Remove two mounting cap screws, oil pump and gasket.
5. Inspect all parts for wear or damage. (See *Disassembly/Assembly* procedures).



Disassembly/Assembly

- Do not remove gear to remove cap screws. Do not disassemble rotor shaft assembly other than shown. If any parts are worn or damaged, replace as an assembly.
- Inspect parts for wear or damage. (See *Inspection* procedures.)

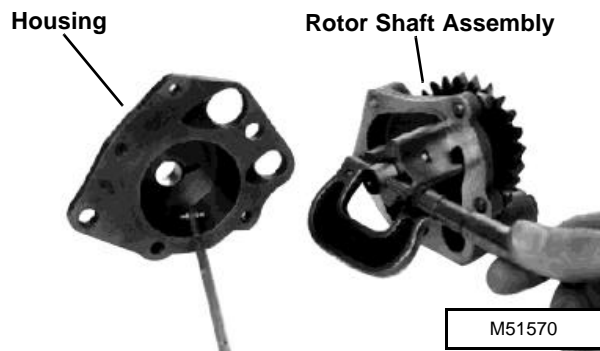
- Coat all parts with clean engine oil.
- Install outer rotor with identification mark facing toward rotor shaft assembly.



4

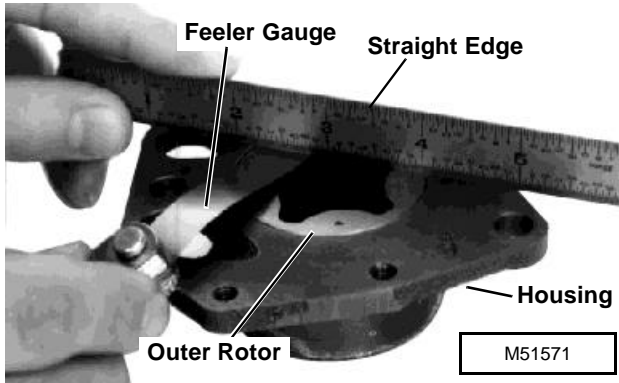
Inspection

- Check rotor shaft outer diameter and the shaft hole diameter in housing. If clearance is more than **0.20 mm (0.008 in.)**, replace entire assembly.



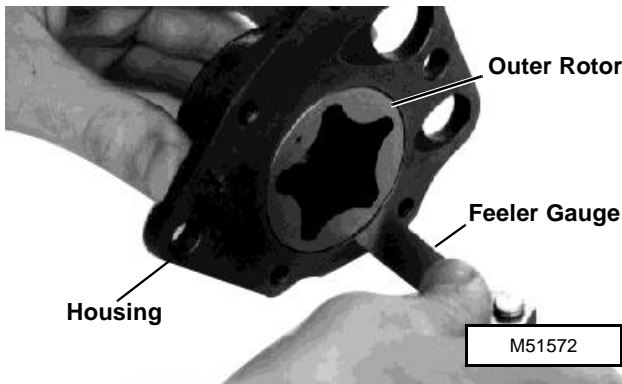
Lubrication System

- Check outer rotor recess. If outer rotor is below face of pump housing more than **0.25 mm (0.010 in.)**, replace entire assembly.

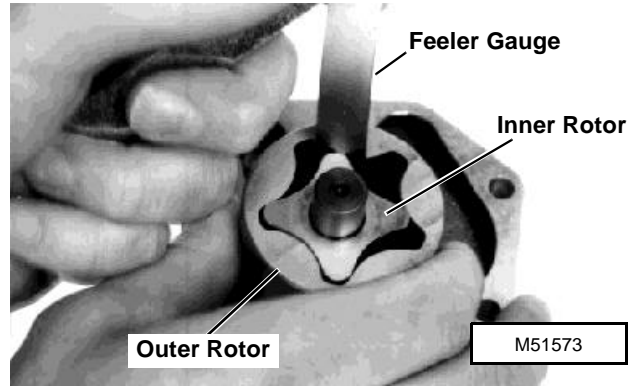


- Check outer rotor-to-pump housing clearance. If clearance is more than **0.25 mm (0.010 in.)**, replace entire assembly.

4



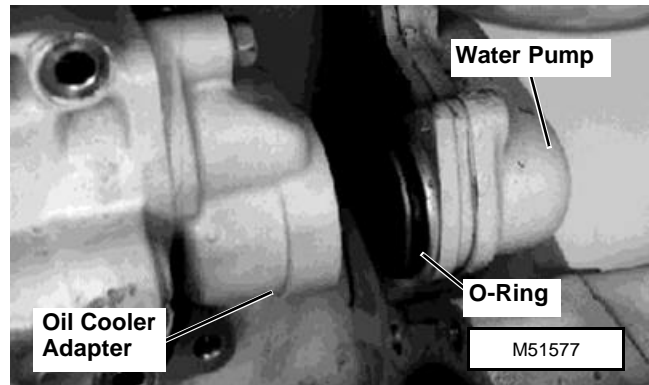
- Check inner-to-outer rotor clearance. If clearance is more than **0.25 mm (0.010 in.)**, replace entire assembly.

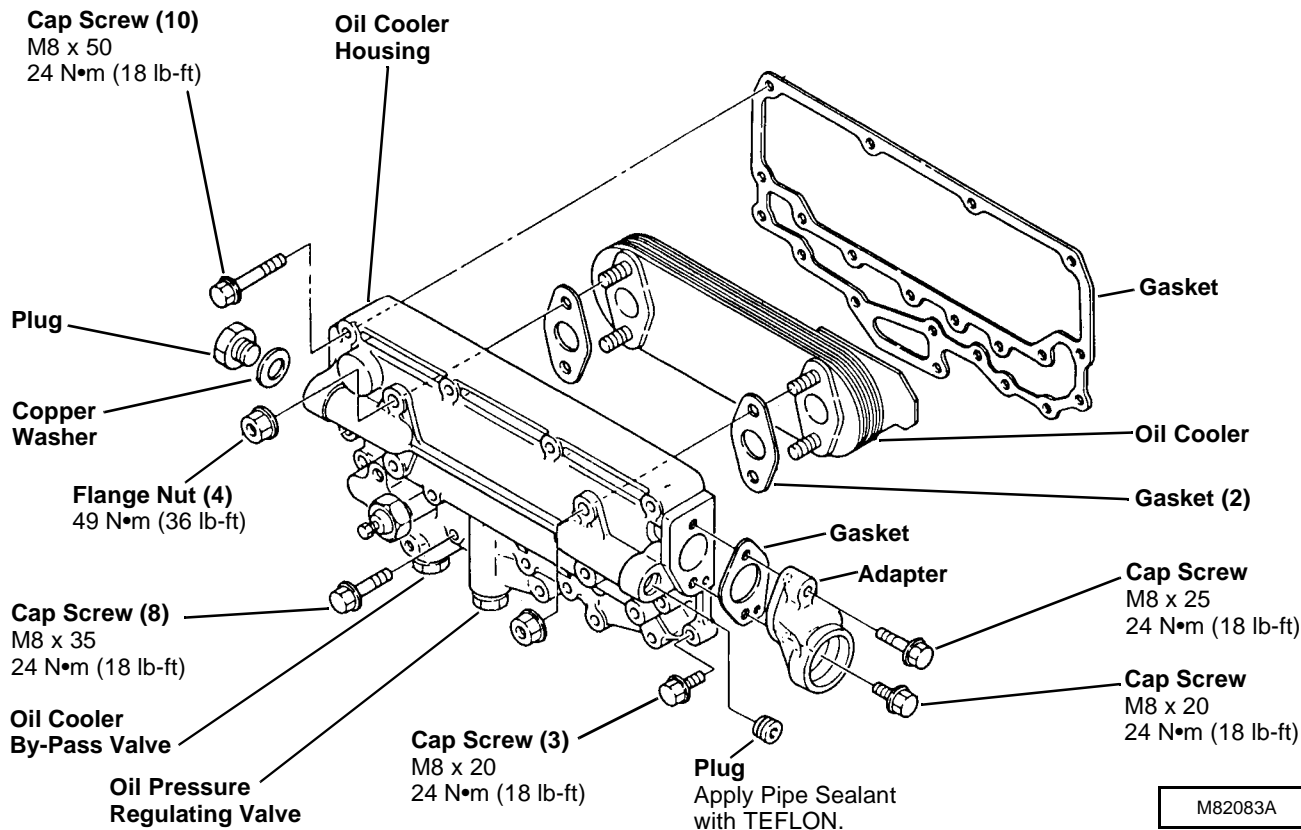


OIL COOLER

1. Remove fuel injection pump. (See *Fuel System* in this section.)
 - Replace O-ring, copper washer and gaskets. Damaged or used parts will leak.
 - Pressure test oil cooler. (See *Checks, Tests and Adjustments* section.)

NOTE: Oil cooler adapter is slip fit on water pump with an O-ring seal.





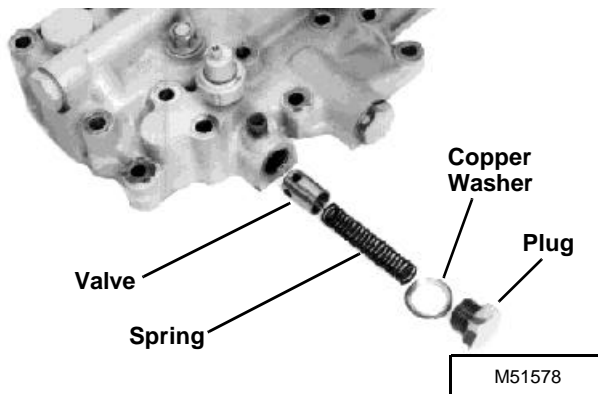
4

NOTE: See **OIL COOLER BY-PASS VALVE** and **OIL PRESSURE REGULATING VALVE** if service is necessary.

OIL COOLER BY-PASS VALVE

NOTE: Oil cooler is removed to show detail.

- Inspect parts for wear or damage. Check spring free and compressed lengths. Replace parts as necessary.
- Replace copper washer. A used washer may leak.



Spring Specifications:

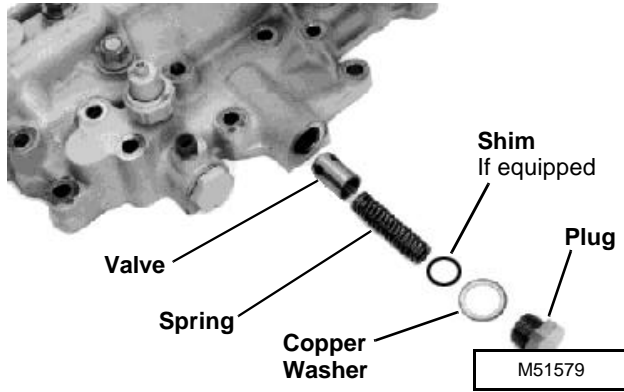
Free Length63 mm (2.480 in.)
 Compressed Length37 mm (1.450 in.)
 @ 3.75N (0.840 lb force)

Lubrication System

OIL PRESSURE REGULATING VALVE

NOTE: Oil cooler is removed to show detail.

- Inspect parts for wear or damage. Check spring free and compressed lengths. Replace parts as necessary.



4

- Replace copper washer. A used washer may leak.

NOTE: Valve assembly may or may not be equipped with shims.

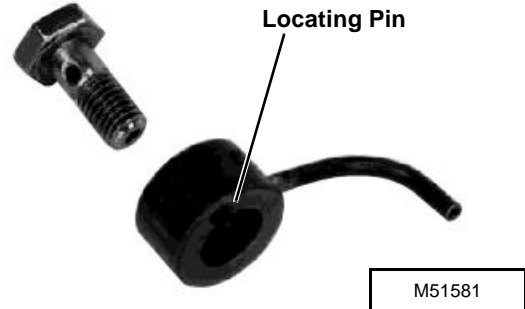
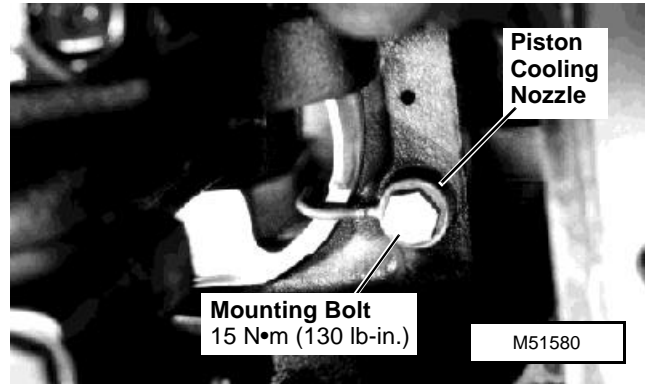
Spring Specifications:

Free Length 51 mm (2.010 in.).
Compressed Length 50 mm (1.970 in.)
. @ 5.40N (1.200 lb force)

PISTON COOLING NOZZLES

Replacement

1. Remove oil pan and strainer. (See procedure in this group.)
 - Install nozzle with locating pin in locating hole of cylinder block.



OTHER MATERIALS

Number	Name	Use
LOCTITE® PRODUCTS		
U.S./		
Canadian/		
LOCTITE No.		
TY9375/ TY9480/ #592	John Deere Pipe Sealant with TEFLON®	Apply to threads of coolant temperature sender, heater hose fitting and adapter fitting.
TY9370/ TY9477/ #242	Thread Lock and Sealer (Medium Strength)	Apply to threads of fan-to-spacer cap screws.

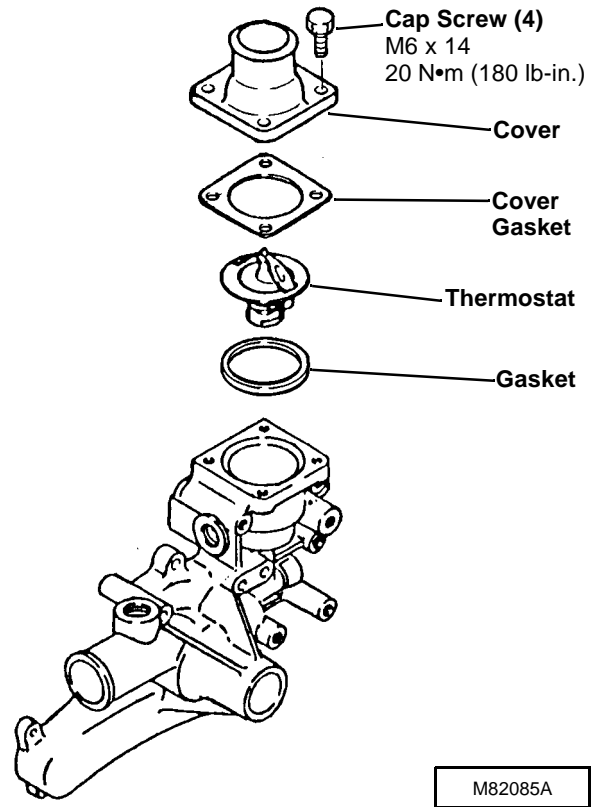
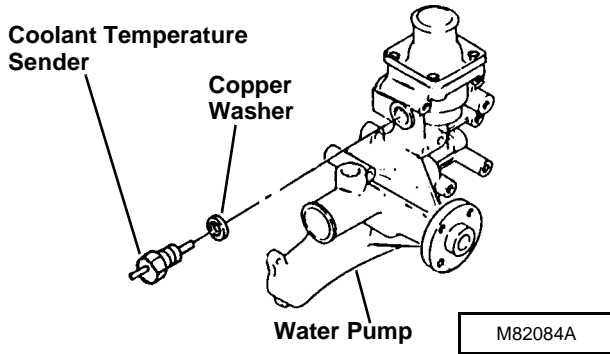
® *TEFLON* is a registered trademark of the Du Pont Company.

® *LOCTITE* is a registered trademark of the Loctite Corp.

Cooling System

COOLANT TEMPERATURE SENDER

- Replace copper washer.
- Test sender. (See *Checks, Tests and Adjustments* in this section.)
- Apply Pipe Sealant with TEFLON, or equivalent to threads of sender.



4 THERMOSTAT

- Replace gaskets.
- Test thermostat. (See *Checks, Tests and Adjustments* in this section.)

WATER PUMP

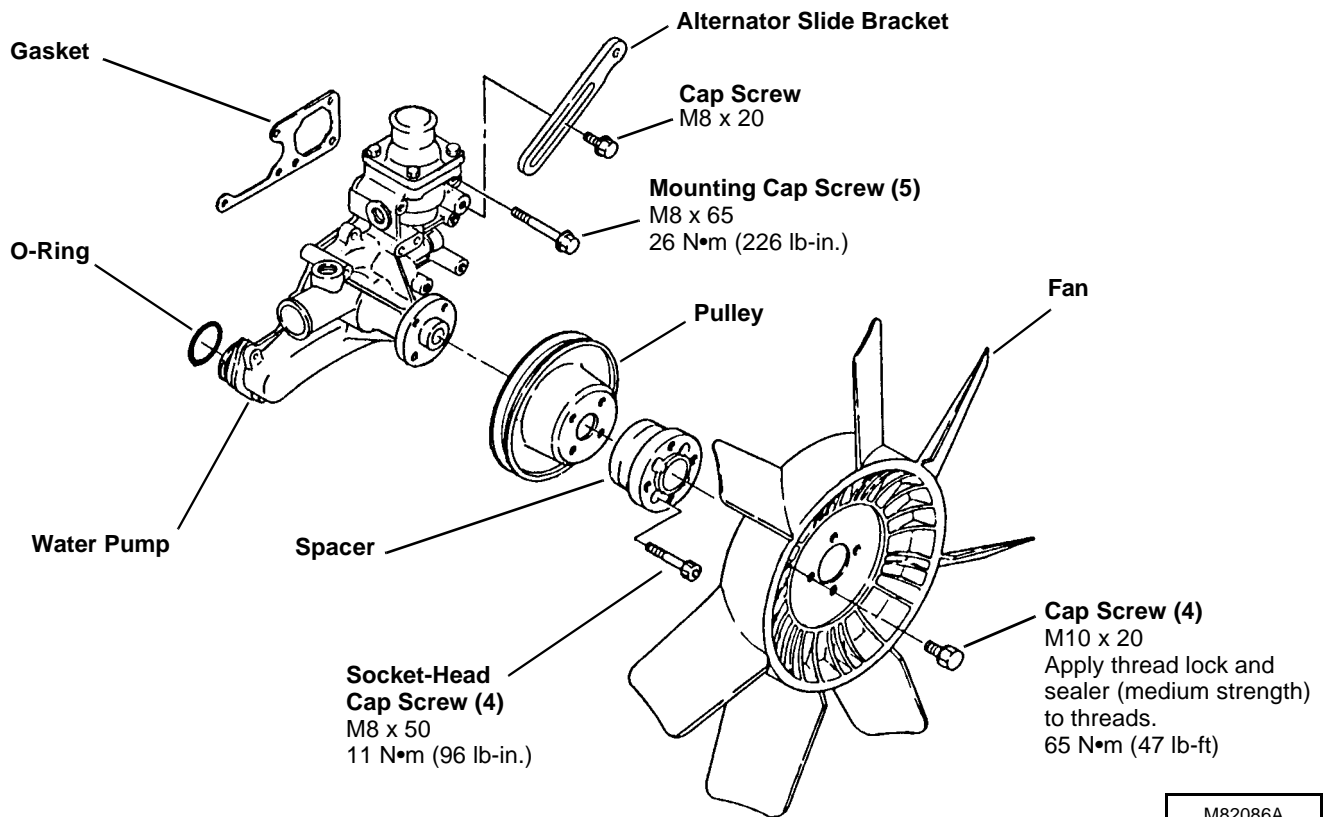
Removal/Installation

1. Open engine drain valve to drain coolant.
2. Remove fan/alternator drive belt.
3. Remove alternator slide bracket-to-water pump cap screw.
4. Remove four cap screws and fan.

5. Remove four socket head cap screws, spacer and pulley.
6. Remove five mounting cap screws, pump and gasket.
7. Inspect all parts for wear or damage. (See *Disassembly/Assembly* procedures.)

Installation is done in the reverse order of removal.

- Replace gasket and o-ring.
- Adjust fan/alternator drive belt tension. (See *Checks, Tests and Adjustments* in this section.)



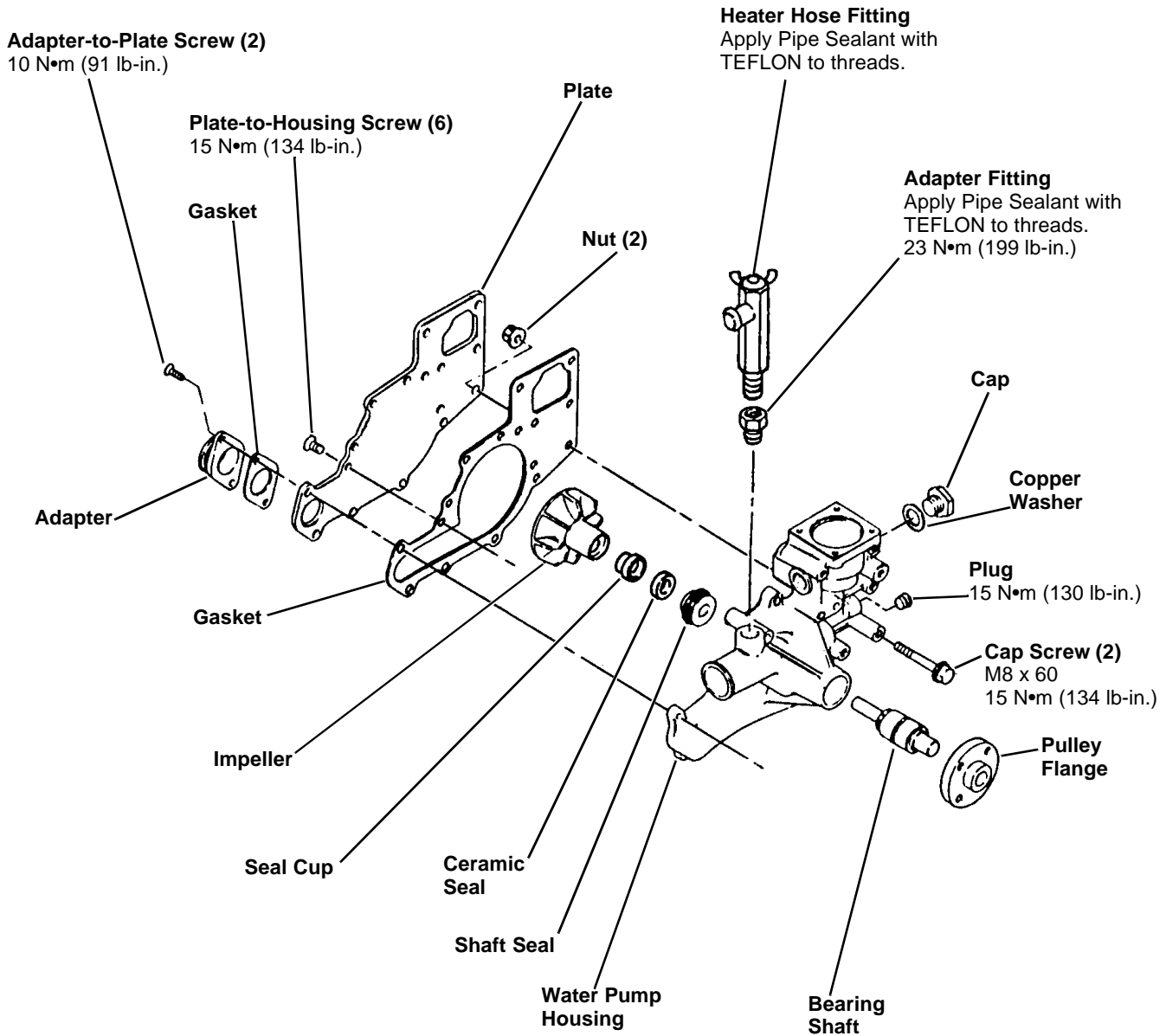
M82086A

Cooling System

Disassembly

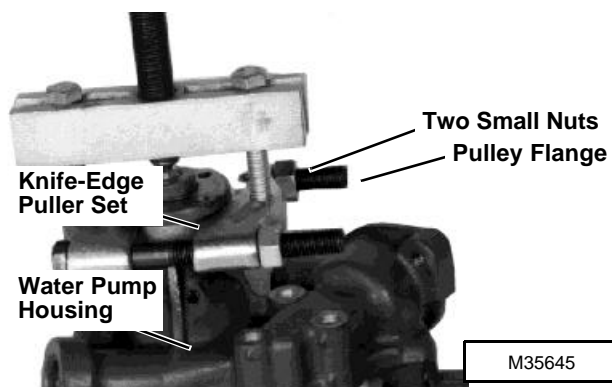
1. Remove thermostat. (See procedure in this group.)
2. Remove coolant temperature sender. (See procedure in this group.)
3. Remove two screws, adapter and gasket.
4. Remove two M8 cap screws and nuts.
5. Apply heat to six plate-to-housing screws. Remove screws, plate and gasket.

4



M82087A

- Apply extreme heat to pulley flange. Remove flange using a knife-edge puller set and two small nuts.



- Place water pump assembly on a press table. Install supports under water pump housing, staying clear of impeller. Press bearing shaft assembly through water pump housing using a piece of pipe or a deep socket.

IMPORTANT: Impeller bore is tapered. When pressing bearing shaft from impeller, allow enough clearance between cap screw and impeller bore to prevent cap screw from binding.

- Remove impeller from bearing shaft using a knife-edge puller, a 3/8 in. cap screw and a press.
- Remove shaft seal, ceramic seal and seal cup.
- Inspect all parts for wear or damage. Replace as necessary.

Assembly

NOTE: Replace shaft seal, ceramic seal, seal cup, gaskets and copper washer.

- Install bearing shaft into pump housing, long end down, using a piece of pipe or deep socket and a press. Press shaft into pump housing until bearing surface is flush with pump housing surface.
- Install new shaft seal over impeller side of bearing shaft, rubber seal side away from pump housing. Push shaft seal into pump housing, until it stops, using a 25 mm or 1 in. socket and a press.

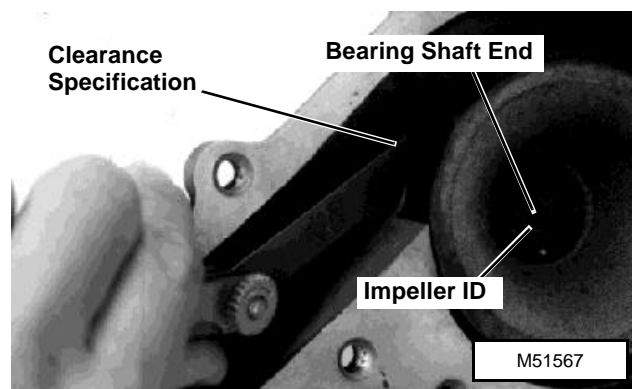
IMPORTANT: Support pump housing on bearing shaft only. DO NOT support on housing or damage to housing will occur.

- Place water pump housing on a press table. Support housing on bearing shaft using a driver disk. Install pulley flange onto shaft with straight hub facing away from housing. Press pulley flange onto bearing shaft until bottom of flange is **11 mm (0.433 in.)** from top of housing.

IMPORTANT: DO NOT touch lapped sealing surface of ceramic seal with bare hands. It must be clean and dry.

- Install seal cup and ceramic seal in impeller.
- Install a knife-edge puller around bearing shaft, between pulley flange and pump housing. Place pump housing, with knife-edge puller down, on a press table. Install impeller with ceramic seal toward shaft seal. Press impeller on bearing shaft until shaft end is flush with impeller ID surface OR clearance between impeller and pump housing is **0.30 - 1.10 mm (0.012 - 0.043 in.)**.

4



- Install new gasket, plate, six screws, two cap screws and nuts.
- Install new gasket, adapter and screws.
- Install coolant temperature sender. (See procedure in this group.)
- Install thermostat. (See procedure in this group.)

Fuel System

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).

JDF13 Nozzle Cleaning Kit

Use to clean fuel injection nozzles.

SERVICE PARTS KITS

The following kits are available through your parts catalog:

- Cylinder Block Gasket Kit
- Fuel Injection Nozzle Shim Pack

FUEL SUPPLY PUMP

NOTE: Oil will leak out of fuel injection pump housing when shaft or pump body is removed.

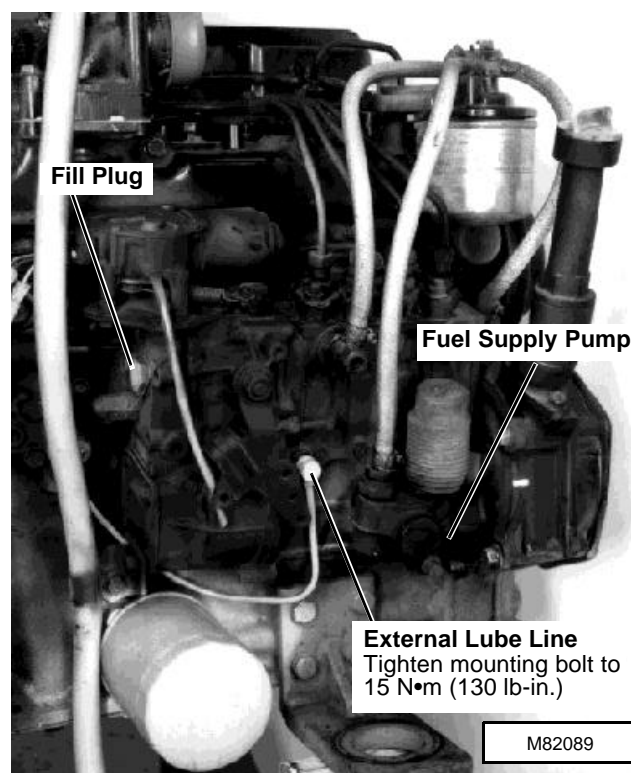
- Inspect all parts for wear or damage. Replace as necessary.

Replace all o-rings and copper washers. Damaged or used parts will leak.

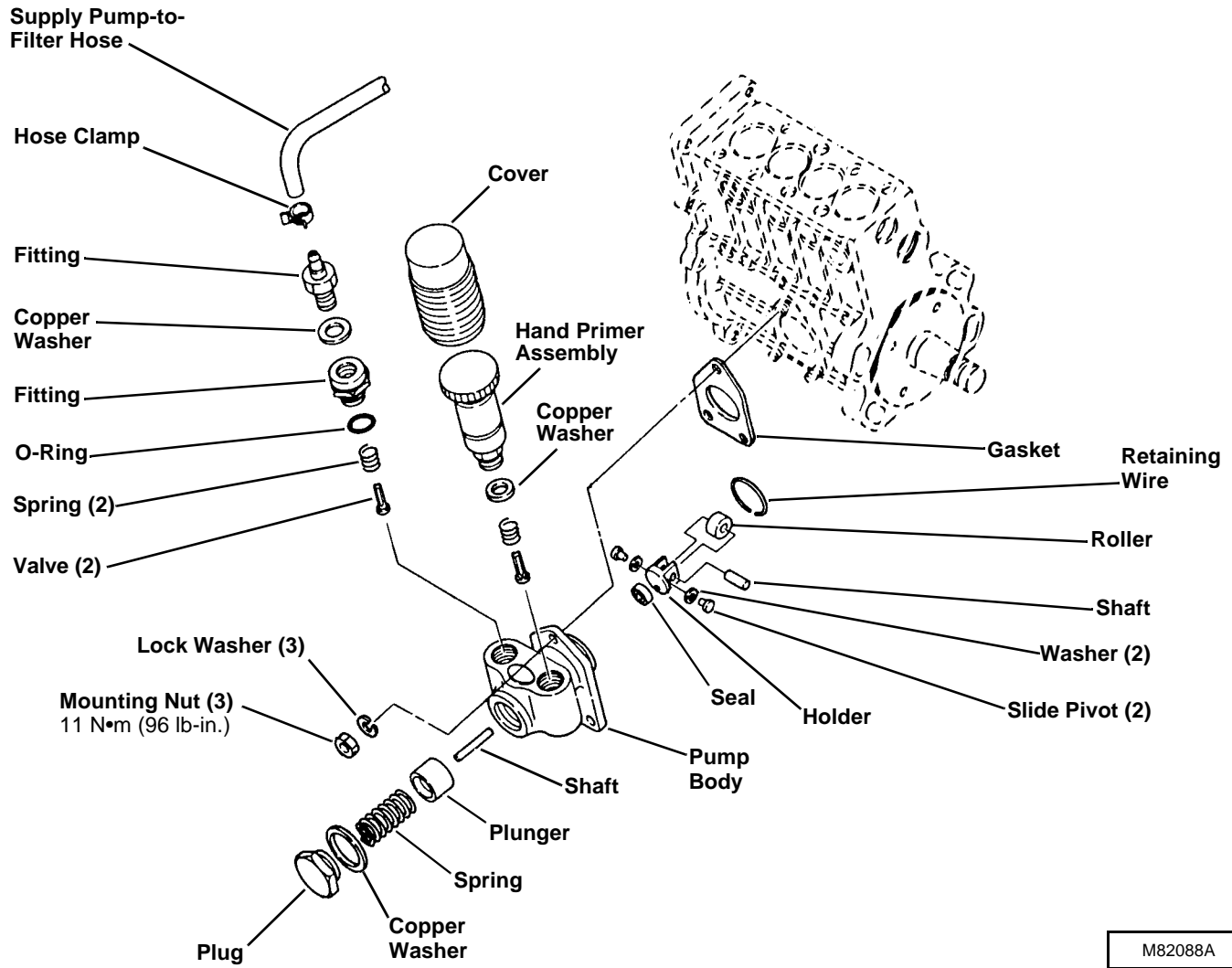
- Replace seal if necessary. Remove seal using a blind-hole puller set. Install seal, lips toward holder, flush with pump body.
- Install holder into pump body with small hole in holder toward bottom of pump body.

IMPORTANT: If oil has been drained out of fuel injection pump housing, add oil as necessary. Fuel injection pump can become damaged if operated dry or without proper amount of oil.

After fuel supply pump is installed, disconnect external lube line to fuel injection pump housing. Remove fill plug and add clean engine oil to housing. Add until oil begins to drip out of lube line hole (For proper oil specification see *SPECIFICATIONS AND GENERAL INFORMATION* section.)



Fuel System

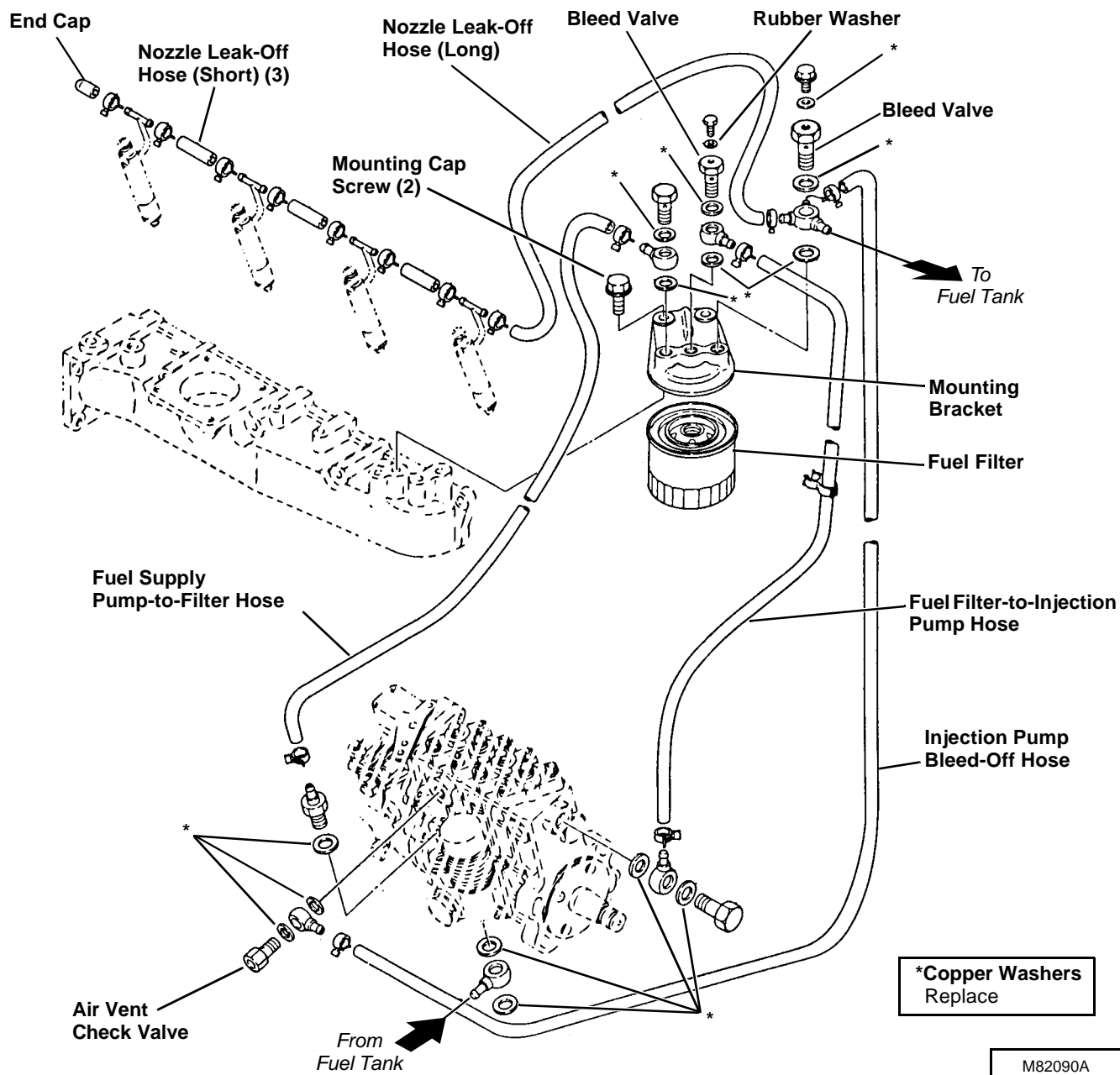


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M82088A

FUEL FILTER ASSEMBLY

IMPORTANT: Replace all copper washers.
Damaged or used washers may leak.



4

FUEL INJECTION PUMP

Removal

CAUTION

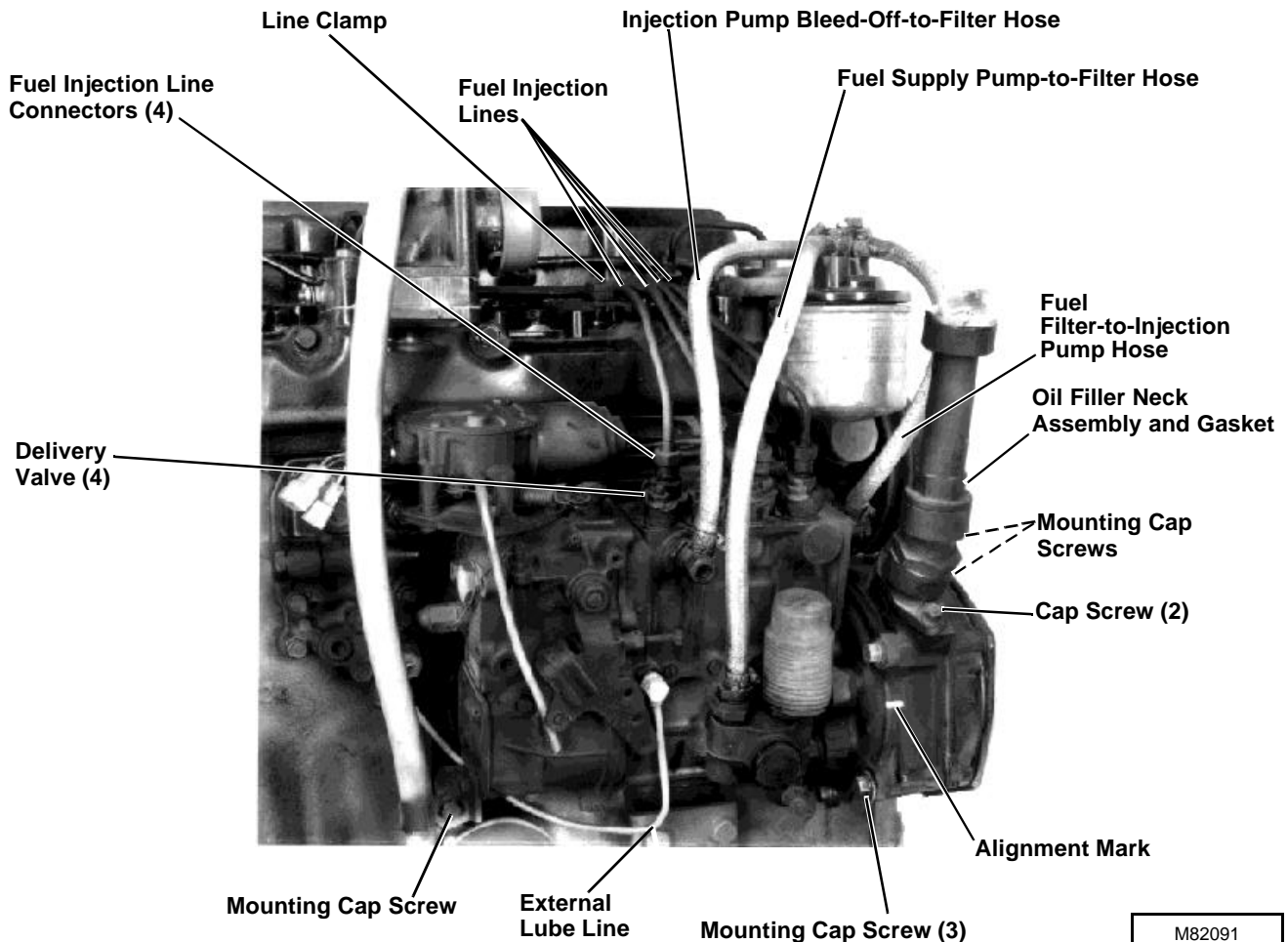
Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.

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

4

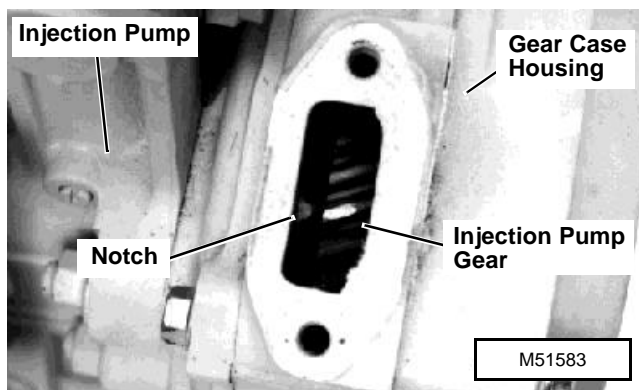
IMPORTANT: Never steam clean or pour cold water on injection pump while the pump is running or warm. Doing so can damage the pump.

1. Clean the injection pump lines and area around the pump using a parts cleaning solvent or steam cleaner.
2. Loosen fuel injection line connectors slightly to release pressure in the fuel system. When loosening connectors, use another wrench to keep delivery valves from loosening.
3. Loosen line clamp and remove fuel injection lines.
4. Disconnect hoses to/from fuel filter.
5. Remove external lube line.
6. Scribe an alignment mark across injection pump and gear case housing.



M82091

7. Remove two cap screws, oil filler neck assembly and gasket.
8. Use chalk or paint to mark injection pump gear to notch on gear case housing.

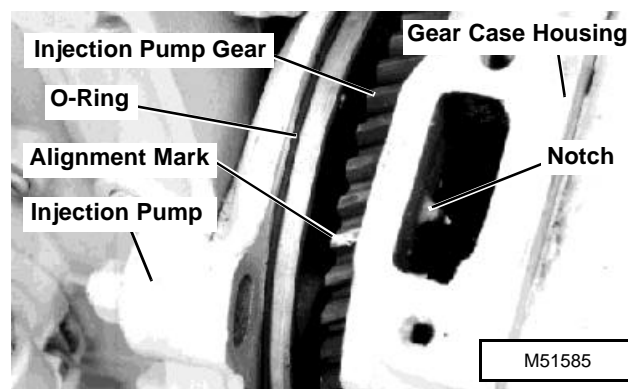


9. Remove six mounting cap screws, injection pump and o-ring.

DO NOT attempt to service the injection pump or governor. If unit is in need of repair, it must be serviced by a qualified fuel injection repair shop. If replacement is necessary, replace entire unit.

Installation

1. Install new o-ring on injection pump.
2. Put injection pump onto gear case housing. Align mark, made on injection pump gear during removal, with notch on housing.
3. Install six mounting cap screws. Do not tighten.
4. Align marks on housing and injection pump, made during removal, and tighten mounting cap screws.



5. Install new gasket, oil filler neck assembly and two cap screws.
6. Connect hoses to/from fuel filter.
7. Install fuel injection lines and tighten line clamp cap screws.

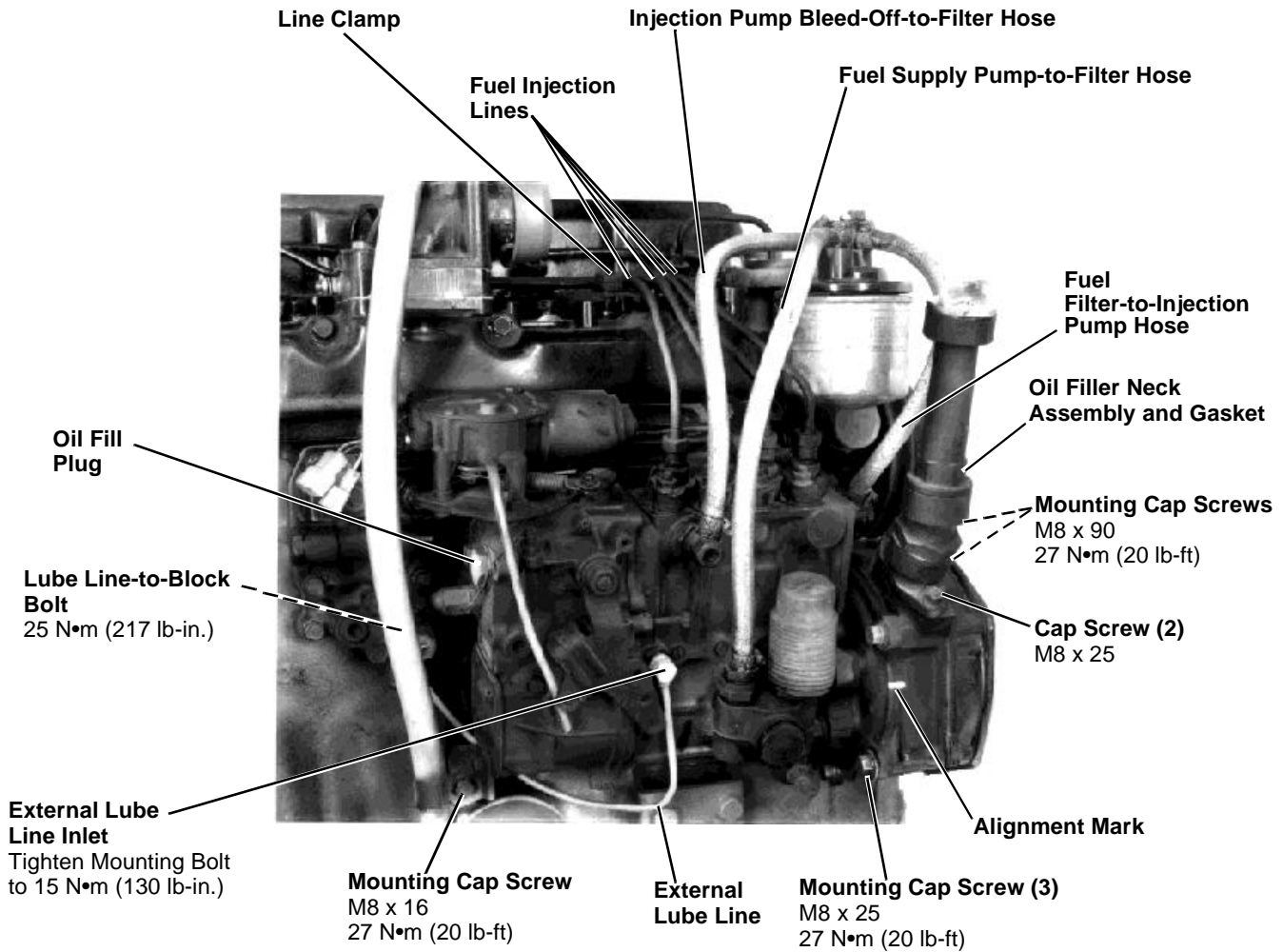
IMPORTANT: If oil has been drained out of fuel injection pump housing, add oil as necessary. Fuel injection pump can become damaged if operated dry or without proper amount of oil.

4

8. Remove fill plug and add clean engine oil to housing. Add until oil begins to drip out of external lube line inlet. (For proper oil specification see *SPECIFICATIONS AND GENERAL INFORMATION* section.)
9. Install external lube line. When installing line, put one copper washer between mounting bolt head and lube line and the other between lube line and housing.

If new injection pump is being installed, check and adjust injection pump static timing. (See *Checks, Tests and Adjustments* in this section.)

4



M82091

FUEL INJECTION NOZZLES (HOLE-TYPE)

Removal/Installation

IMPORTANT: Never steam clean or pour cold water on injection pump while the pump is running or warm. Doing so can damage the pump.

1. Clean the injection pump lines and area around the pump using a parts cleaning solvent or steam cleaner.

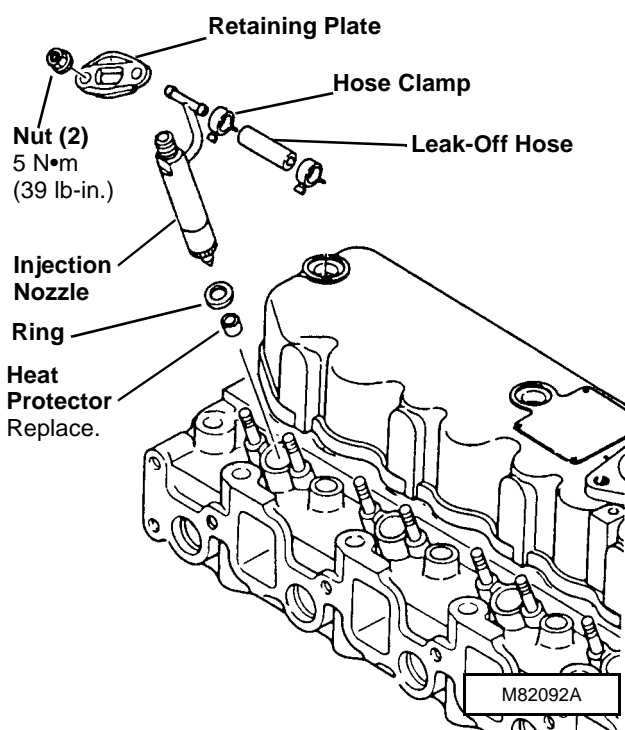
CAUTION

Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.

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

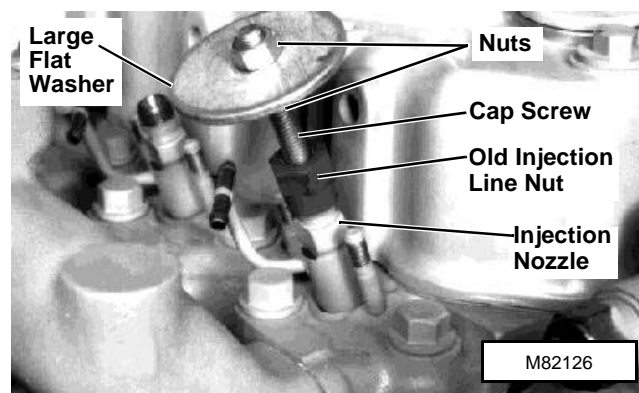
NOTE: Nozzles are matched to the cylinders. If removing more than one nozzle, tag nozzles, according to the cylinder from which it was removed.

2. Loosen fuel injection line connectors-to-nozzles slightly to release pressure in the fuel system.
3. Loosen line clamp and remove fuel injection lines.
4. Remove clamps and leak-off hoses.
5. Remove nuts and retaining plates.
6. Remove injection nozzle, ring and teflon heat protector. If ring and protector stay in cylinder head, thread a cap screw into protector and pull from cylinder head.



If nozzles are stuck in cylinder head:

- Grind the head of a cap screw so it fits inside a nut from an old injection line.
- Use two nuts to attach a large flat washer to the cap screw.
- Install assembly onto nozzle and use a puller and slide hammer to pull nozzle from cylinder head.



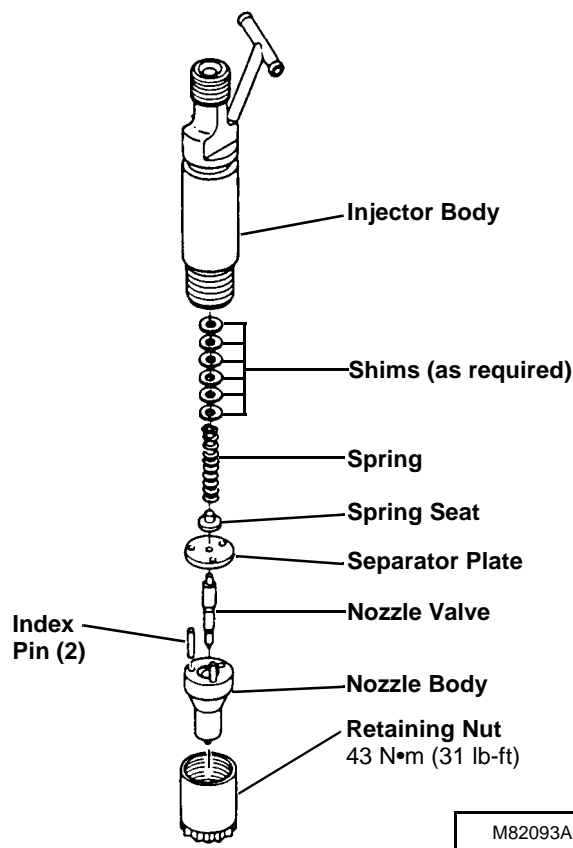
7. Test injection nozzles. (See *Checks, Tests and Adjustments* in this section.)

Disassembly/Assembly

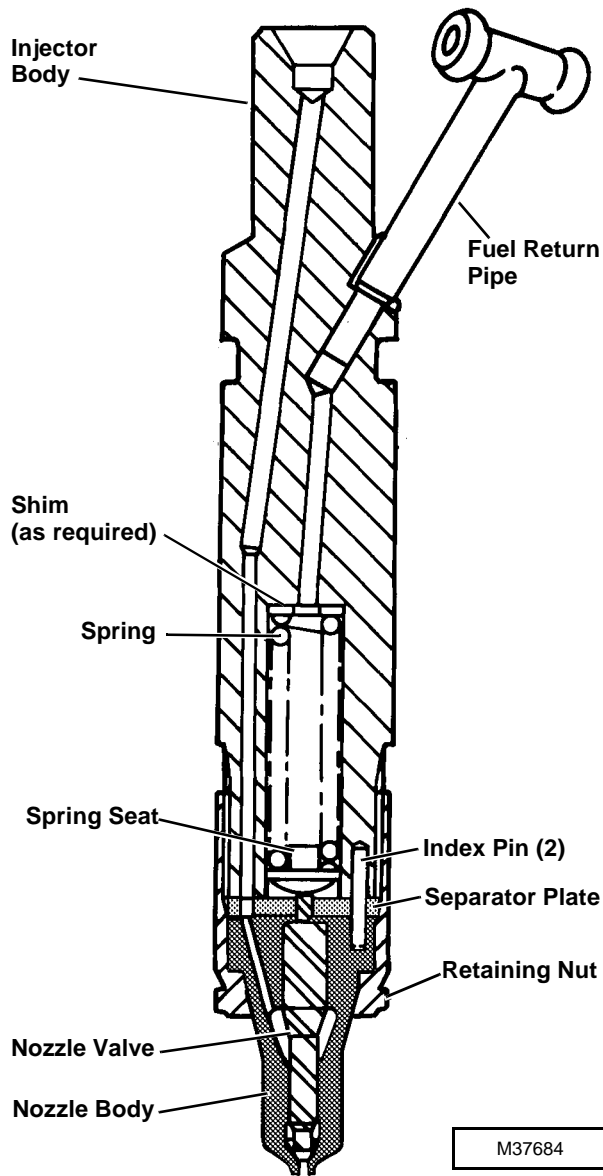
NOTE: If servicing more than one nozzle, keep parts for each nozzle separate from one another.

- Clean and inspect nozzle assembly. (See *Cleaning/Inspection* procedures.)
- After assembly is complete, test injection nozzle. (See *Checks, Tests and Adjustments* in this section.)

4



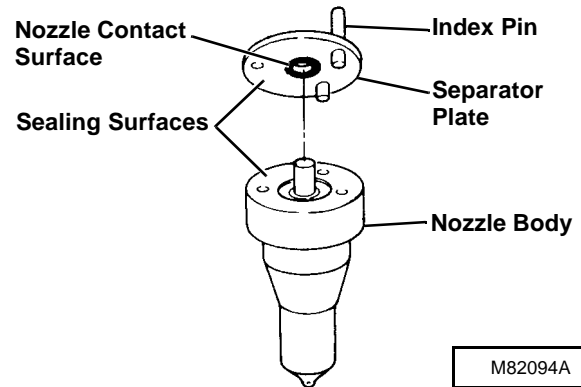
Cross Section



1. Remove anti-corrosive grease from new or reconditioned nozzles by washing them thoroughly in diesel fuel.

IMPORTANT: Never use a steel brush to clean nozzles as this will distort the spray hole.

2. Remove carbon from used nozzles, and clean by washing in diesel fuel. If parts are coated with hardened carbon or lacquer, it may be necessary to use a brass wire brush (supplied in Nozzle Cleaning Kit).
3. After removing carbon or lacquer from the exterior of nozzle, inspect sealing surfaces between separator plate and nozzle body for nicks or scratches.
4. Inspect condition of separator plate and nozzle body. Contact area of separator plate (both parts) must not be scored or pitted. Use an inspection magnifier (No. 16487 or equivalent) to aid in making the inspection.
5. Check nozzle contact surface on separator plate for wear. If contact surface is more than **0.10 mm (0.0039 in.)**, replace nozzle assembly.



Cleaning/Inspection

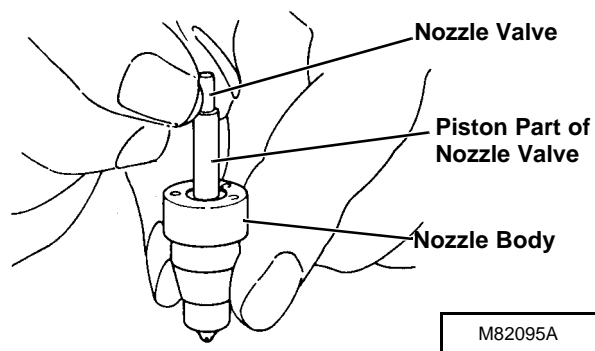
NOTE: To clean nozzles properly, JDF13 Nozzle Cleaning Kit is recommended. The Cleaning Kit is available through the John Deere SERVICEGARD™ Catalog.

6. Inspect the piston (large) part of nozzle valve to see that it is not scratched or scored and that lower (tip) end of valve is not broken. If any of these conditions are present, replace the nozzle assembly.

7. Further inspect the nozzle assembly by performing a slide test. Use the following procedure:

- Dip the nozzle valve in clean diesel fuel. Insert valve in nozzle body.
- Hold nozzle vertical, and pull valve out about 1/3 of its engaged length.
- Release valve. Valve should slide down to its seat by its own weight.

Replace nozzle assembly if the valve does not slide freely to its seat.

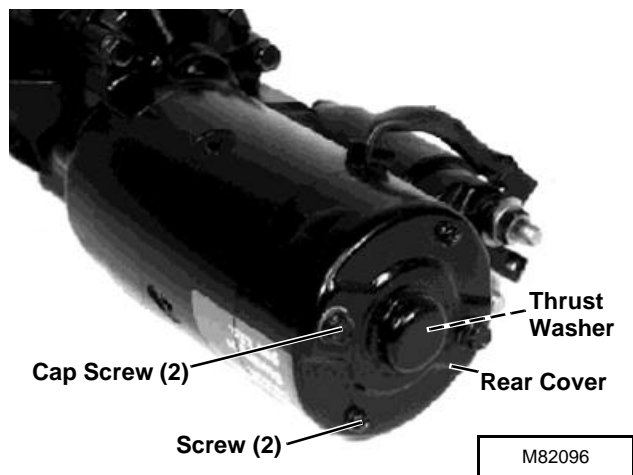


Starter (Nippondenso 1.4 kW)

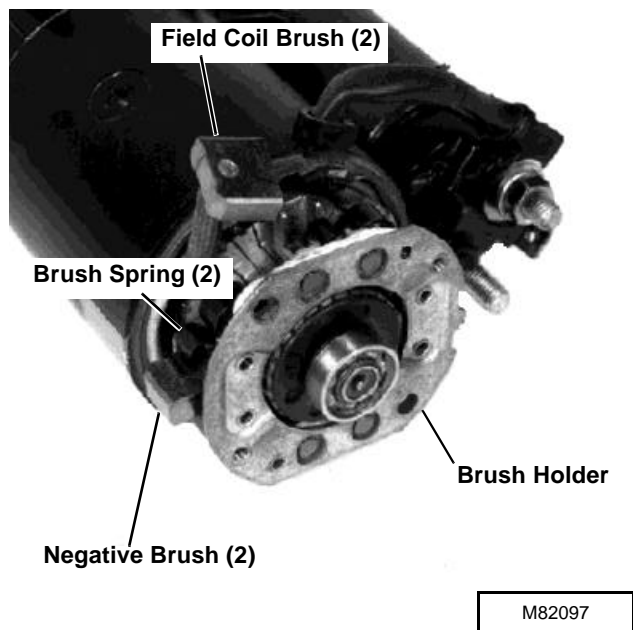
STARTER MOTOR

Disassembly

1. Remove two cap screws and two screws.
2. Remove rear cover and thrust washer, if equipped.

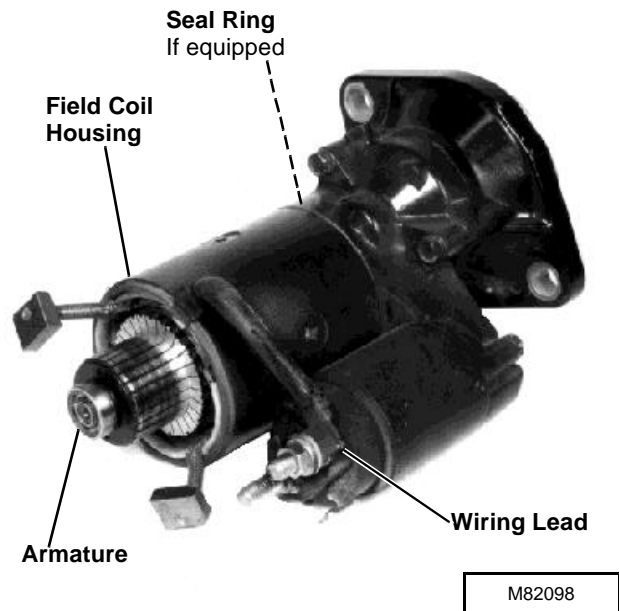


3. Remove field coil brushes from brush holder.
4. Pry brush springs away and pull negative brushes up enough to allow spring to hold brush in place.
5. Remove brush holder.



6. Disconnect wiring lead and relay leads, if equipped.
7. Remove field coil housing, armature and o-ring, if equipped.

8. Inspect and test brushes, holder, field coil and armature. (See *Inspection/Test* procedures.)



Assembly

Assembly is done in the reverse order of disassembly.

- Apply multipurpose grease to bearing cup inside rear cover.

IMPORTANT: When installing rear cover, be sure field coil brush wires do not touch cover. Turn brush holder slightly to take up slack in brush wires. Press wires inward to clear rear cover.

Inspection/Test/Replacement

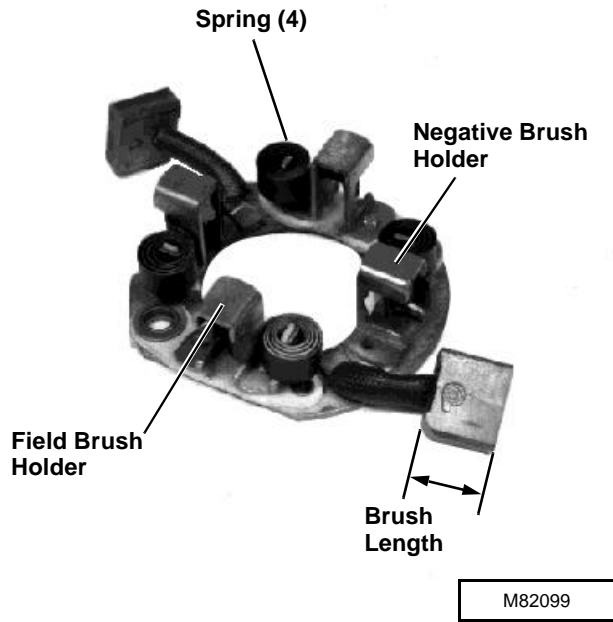
1. Measure holder and field coil brush lengths. Minimum brush length is **8.5 mm (0.335 in.)**. Replace brush holder or field coil if brush length is below minimum.

NOTE: Test brush holder using an ohmmeter or test light.

2. Test brush holder:

Touch one probe of tester to negative brush holder and other probe to field brush holder. If there is continuity, replace the brush holder.

3. Inspect springs for wear or damage. Replace if necessary.



NOTE: Test field coil using an ohmmeter or test light.

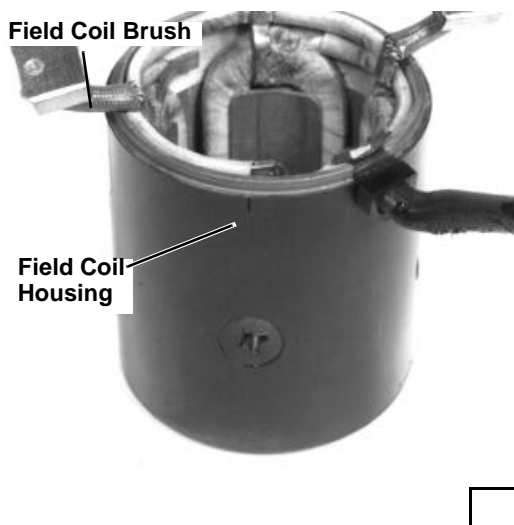
4. Inspect springs for wear or damage. Replace if necessary.

5. Test for grounded field winding:

Touch one probe of tester to field coil brush and other probe to field coil housing. Be sure the brush lead is not touching the frame. If there is continuity, the coil is grounded and the field coil housing assembly must be replaced.

6. Test for open field coil:

Touch one probe of tester to each field coil brush. If there is no continuity, the field coil is open and the field coil housing assembly must be replaced.



IMPORTANT: Do not clean armature with solvent. Solvent can damage insulation on windings. Use only mineral spirits and a brush.

7. Inspect armature. Look for signs of dragging against pole shoes.

8. Inspect commutator. Look for roughness, burned bars, or any material which might cause short circuits between bars. If necessary, clean and touch up with 400 sandpaper. NEVER use emery cloth. Clean all dust from armature when finished.

NOTE: Test armature windings using an ohmmeter or test light.

9. Test for grounded windings:

Touch probes on one commutator bar and armature shaft. Armature windings are connected in series, so only one commutator bar needs to be checked.

If test shows continuity, a winding is grounded and the armature must be replaced.

10. Test for open circuited windings:

Touch probes on two different commutator bars. If test shows no continuity, there is an open circuit and the armature must be replaced.

4



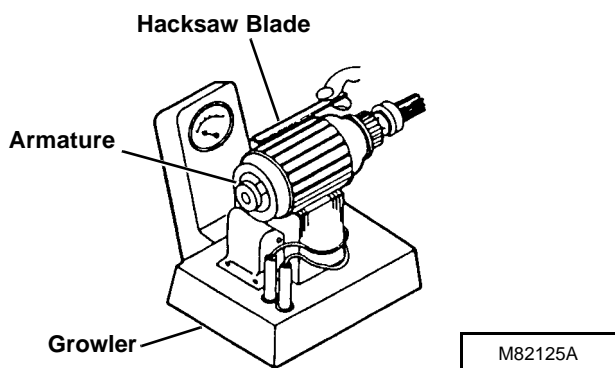
Starter (Nippondenso 1.4 kW)

11. Test for short circuited windings using a growler.
Put armature in a growler and hold a hacksaw blade above each slot while slowly rotating armature.

If coil is shorted, the blade will vibrate on the slot.

NOTE: A short circuit most often occurs because of copper dust or filings between two commutator segments.

12. If test indicates short circuited windings, clean the commutator of dust and filings. Check the armature again. If the test still indicates a short circuit, replace the armature.



13. Inspect armature cover and housing bearings for wear or damage. Replace if necessary.

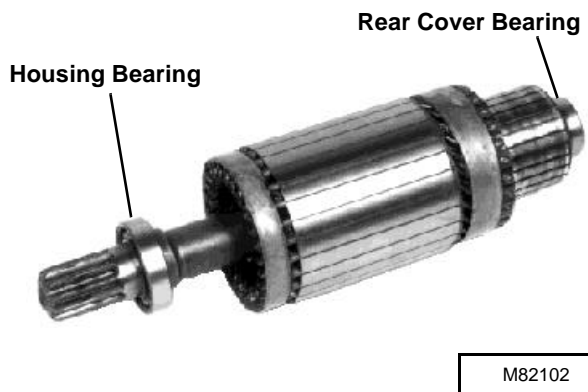
To replace bearings:

Bearings are press fit. Remove bearings using a knife-edge puller set.

IMPORTANT: Install both bearings with sealed side toward armature.

Install new housing bearing tight against shoulder of shaft using a piece of pipe.

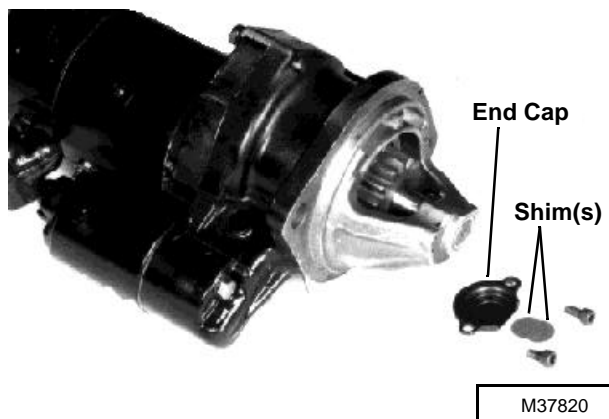
Install new rear cover bearing tight against shoulder of shaft using a driver set.



STARTER GEAR TRAIN AND SOLENOID

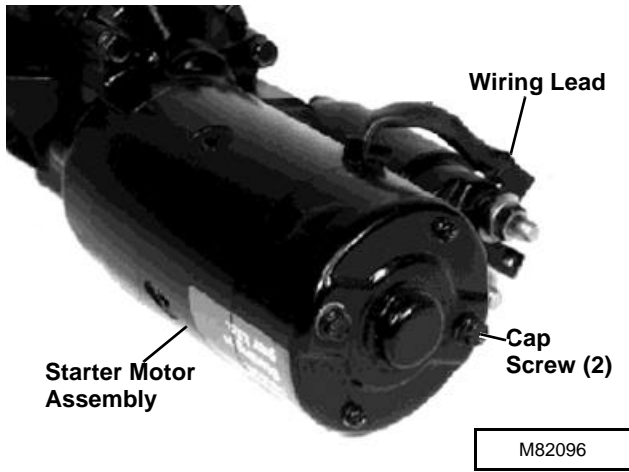
Disassembly/Inspection

1. Remove two socket head screws, end cap and shim(s).

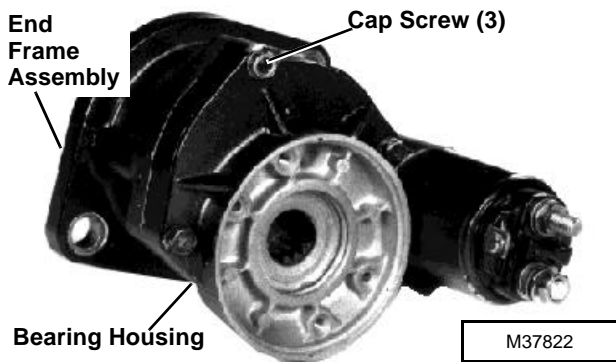


2. Disconnect wiring lead and relay leads, if equipped.
3. Remove two cap screws.
4. Remove starter motor assembly from bearing housing.

Starter (Nippondenso 1.4 kW)



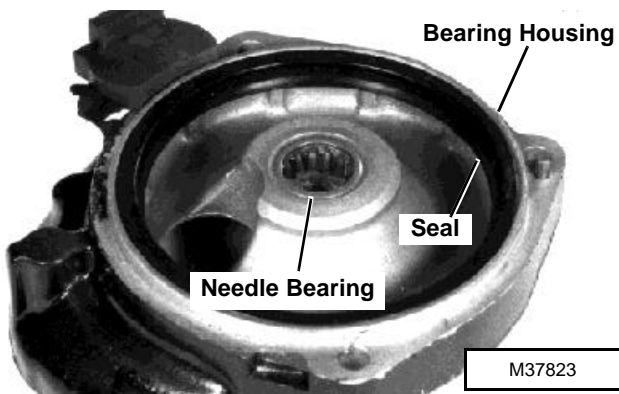
5. Remove three cap screws.
6. Separate end frame assembly from bearing housing.



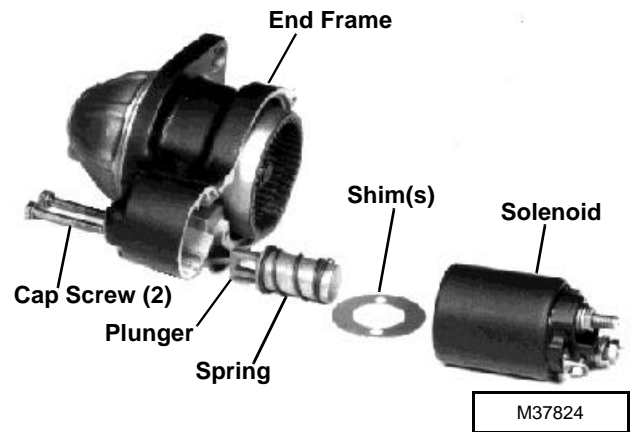
7. Inspect seal and needle bearing for wear or damage. Replace as necessary.

To replace needle bearing:

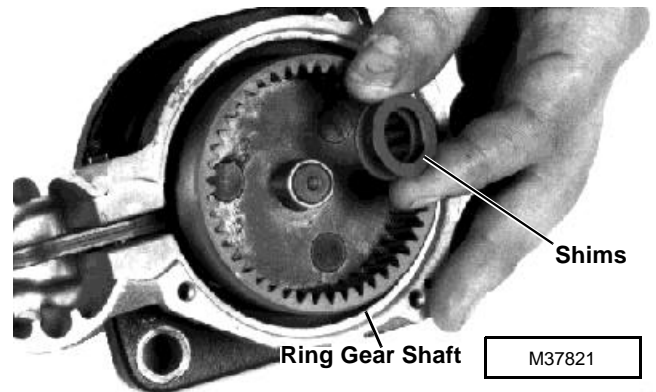
Remove bearing using a blind-hole puller set. Install new bearing flush with housing surface using a driver set.



8. Remove two cap screws, plunger, spring, shims and solenoid.



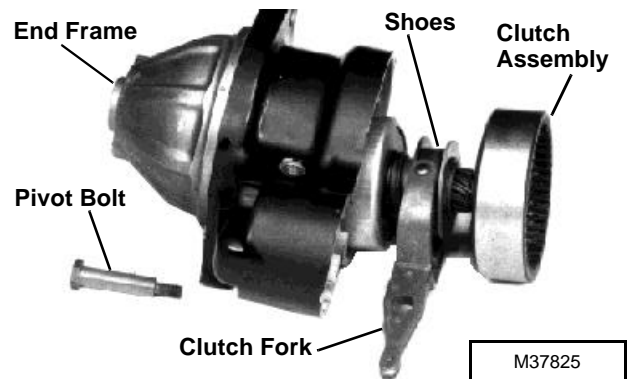
9. Remove shims from ring gear shaft.



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10. Remove pivot bolt, clutch fork and clutch assembly.

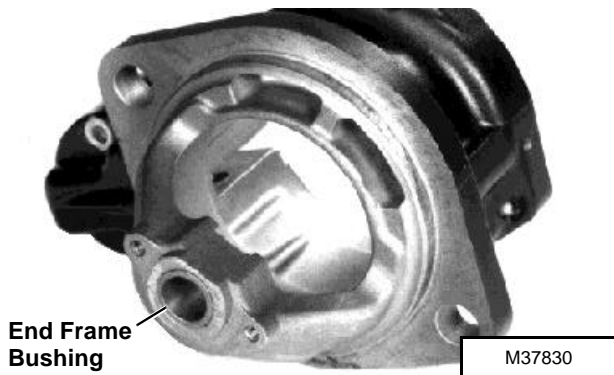
11. Inspect shoes on fork for wear or damage. Replace fork if necessary.



12. Inspect end frame bushing for wear or damage. Replace if necessary.

Starter (Nippondenso 1.4 kW)

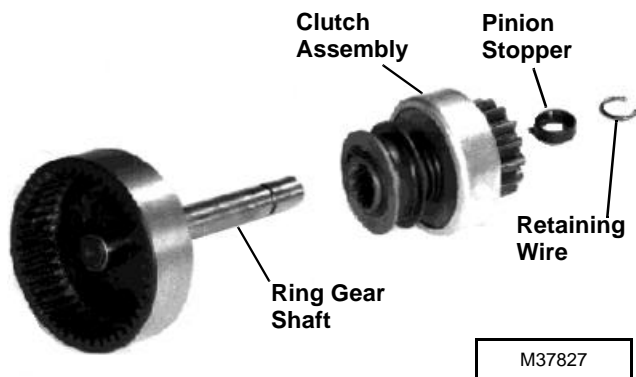
Replace bushing using a driver set. Install bushing flush with face of housing.



13. Slide pinion stopper away from retaining wire using a piece of pipe or deep socket. Remove retaining wire, pinion stopper, and clutch assembly from ring gear shaft.

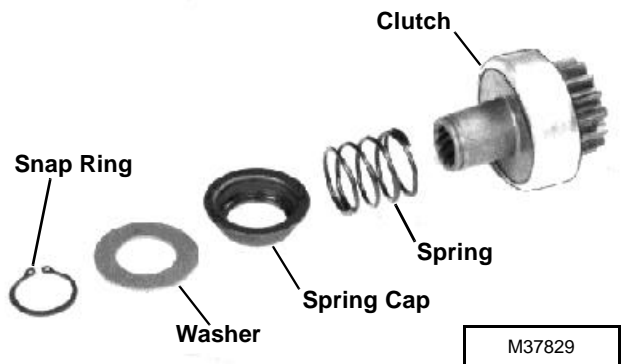
14. Inspect all parts for wear or damage. Replace as necessary.

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15. Remove snap ring, washer, spring cap, and spring from clutch.

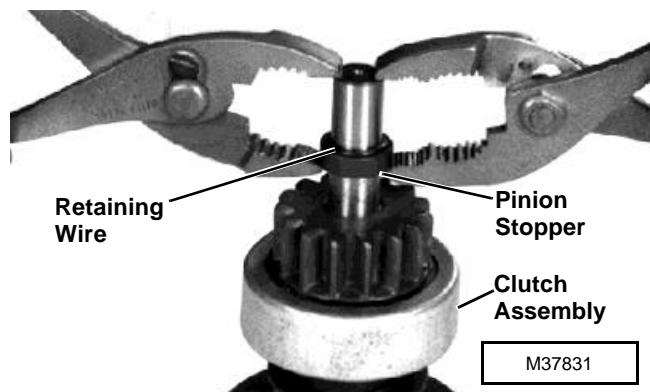
16. Inspect all parts for wear or damage. Replace as necessary.



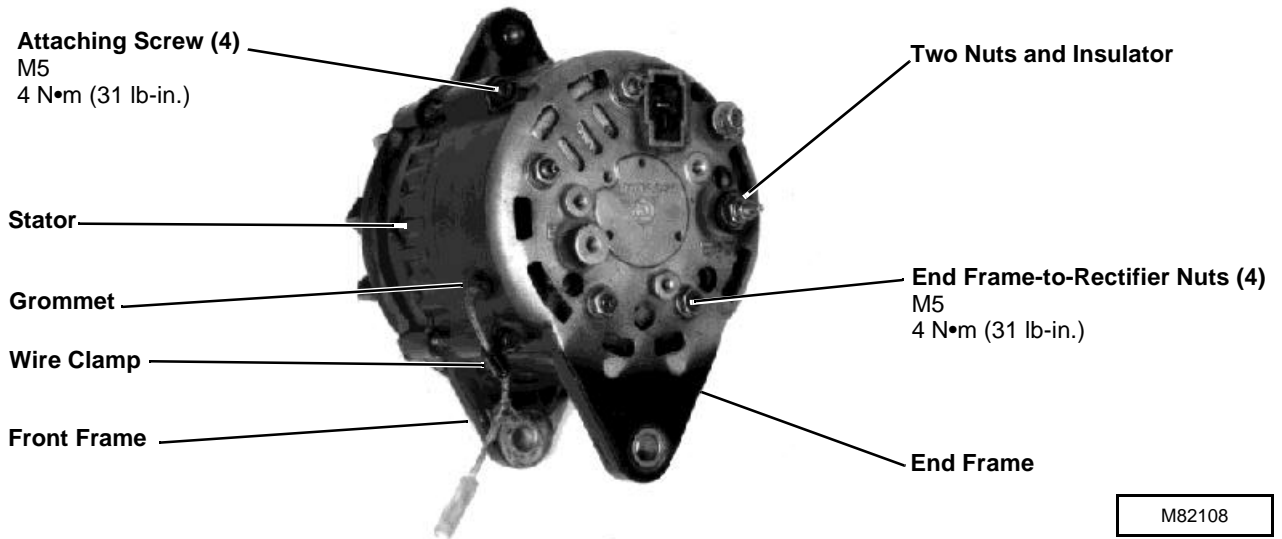
Assembly

Assembly is done in the reverse order of disassembly.

- After installing clutch assembly, pinion stopper and retaining wire on ring gear shaft, use two pliers to press pinion stopper over retaining wire.



VOLTAGE REGULATOR

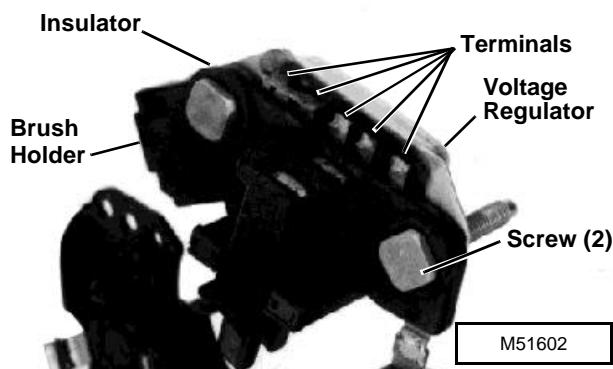


Replacement

1. Remove three screws and cover.
2. Remove four attaching screws, wire clamp and grommet.
3. Remove four end frame-to-rectifier nuts.
4. Remove two nuts and insulator.

IMPORTANT: Do not pry against stator wires.

5. Use a screwdriver to pry end frame from stator. Do not separate stator from front frame.
6. Remove two screws and insulator.



IMPORTANT: Do not heat connections longer than necessary to melt solder, as excess heat will damage rectifier assembly.

7. Use a soldering gun with at least 120 watt capacity to disconnect five terminals. Replace voltage regulator.

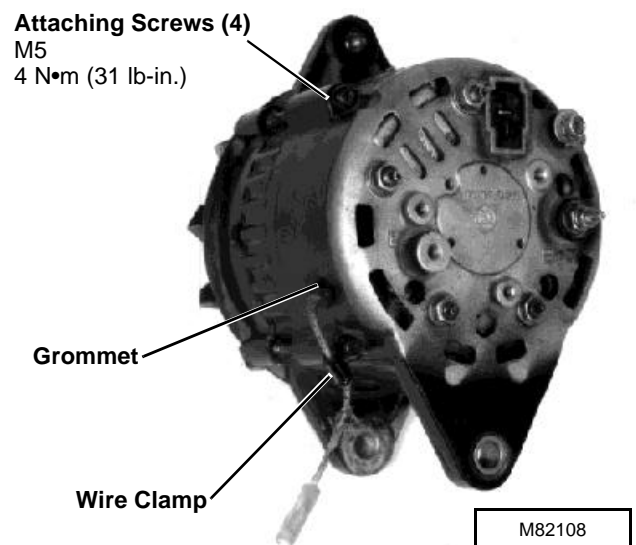
- If additional solder is needed, use ONLY 60-40 rosin-core solder.

4

ALTERNATOR

Disassembly

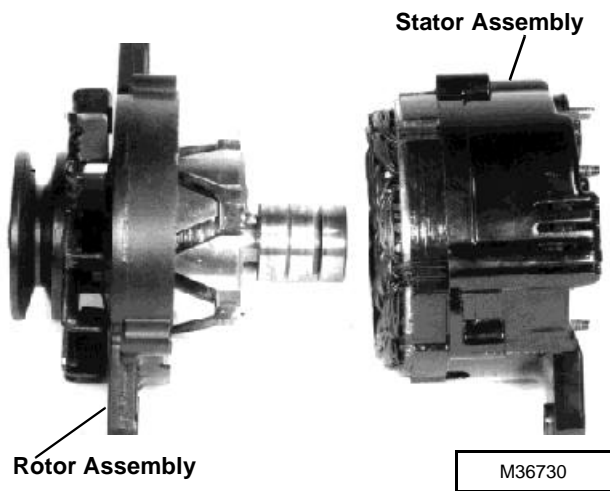
1. Remove three screws and cover.
2. Remove four attaching screws, wire clamp and grommet.



Alternator (Hitachi 25A)

IMPORTANT: Do not pry against stator wires.

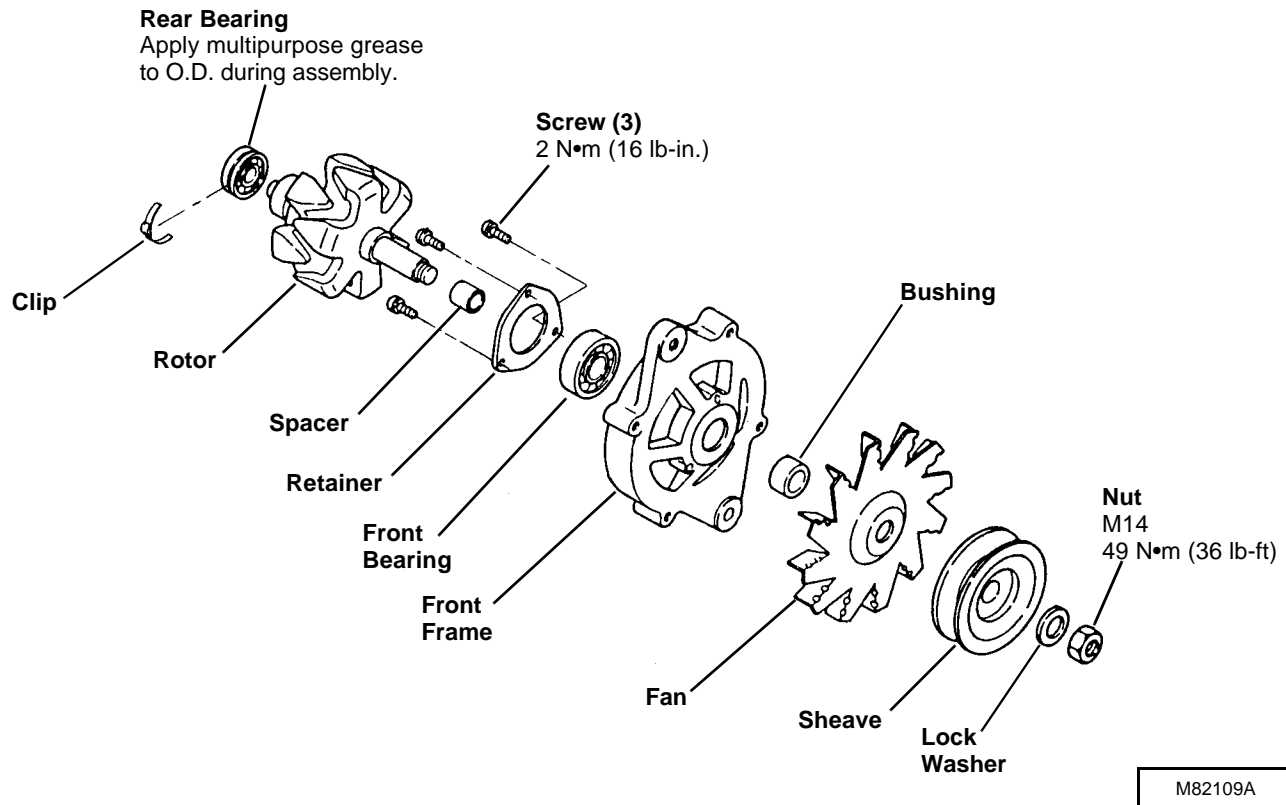
3. Use a screwdriver to separate rotor assembly from stator assembly.



Rotor Assembly:

- Rear bearing is press fit. Replace only if necessary. Remove bearing using a puller set. Install bearing until flush with end of rotor shaft. Press only on inner race of bearing.
4. Put rotor assembly in a soft-jawed vise. Remove nut, lock washer, sheave, fan and bushing.
 5. Put front frame on open jaws of vice. Use a soft-faced hammer to remove rotor and spacer.
 6. Remove three screws, retainer and front bearing.
 7. Inspect all parts for wear or damage. Replace as necessary.
 8. Test rotor. (See *Inspection/Test* procedures.)

4



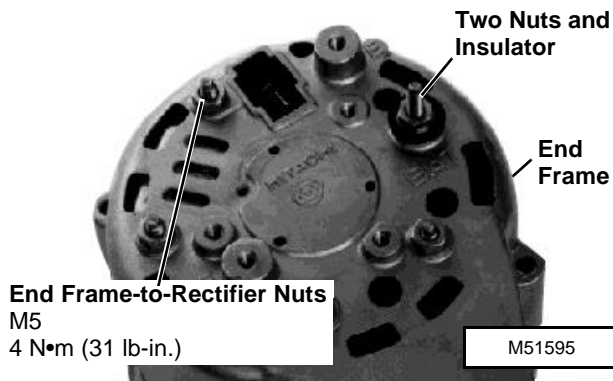
Stator Assembly:

9. Remove four end frame-to-rectifier nuts.

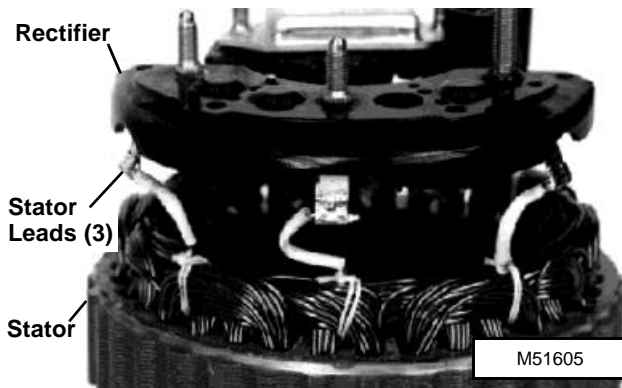
10. Remove two nuts and insulator.

IMPORTANT: Do not pry against stator wires.

11. Use a screwdriver to pry end frame from stator



12. Use a soldering gun with at least 120 watt capacity to disconnect three stator leads. Remove rectifier.



13. Inspect and test brushes, stator and rectifier. (See *Inspection/Test* procedures.)

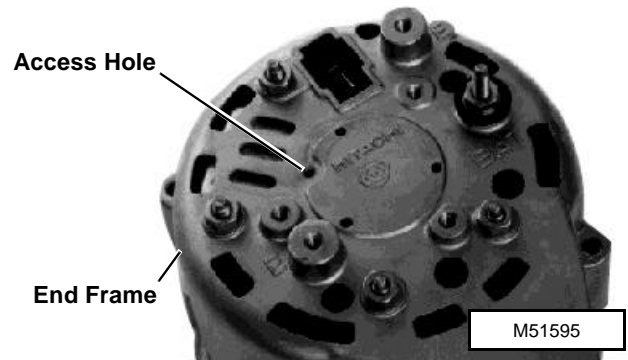
Assembly

Assembly is done in the reverse order of disassembly.

- Bend the stator lead wires, as necessary, to obtain an approximate distance of **33.50 mm (1.300 in.)** from stator to rectifier. Connect the three leads using a soldering gun.
- If additional solder is needed, use **ONLY 60-40 rosin-core solder.**

IMPORTANT: Be sure stator lead wires do not contact end frame when installed.

- Before assembling stator assembly to rotor assembly, push brushes into brush holder and insert a wire through access hole to lock brushes in place.
- Assemble rotor assembly to stator assembly and fasten with four attaching screws. Remove wire from access hole.

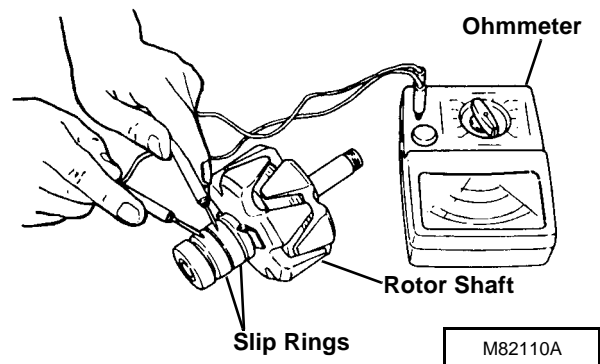


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Inspection/Test

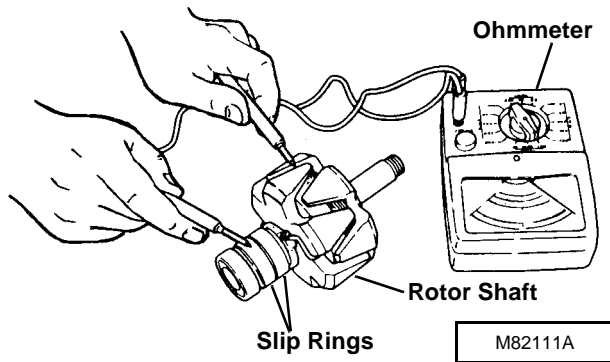
Rotor:

- Inspect the rotor slip rings for dirt build-up, rough spots, or out of roundness. If necessary, polish the surface of the slip rings using No. 00 sandpaper or 400-grit silicon carbide paper.
- Touch the probes of an ohmmeter to slip rings. Replace rotor if test indicates no continuity (no needle movement).



- Touch the probes of the ohmmeter to the shaft and one of the slip rings. Repeat for other slip ring. Replace rotor if test shows continuity (needle movement).

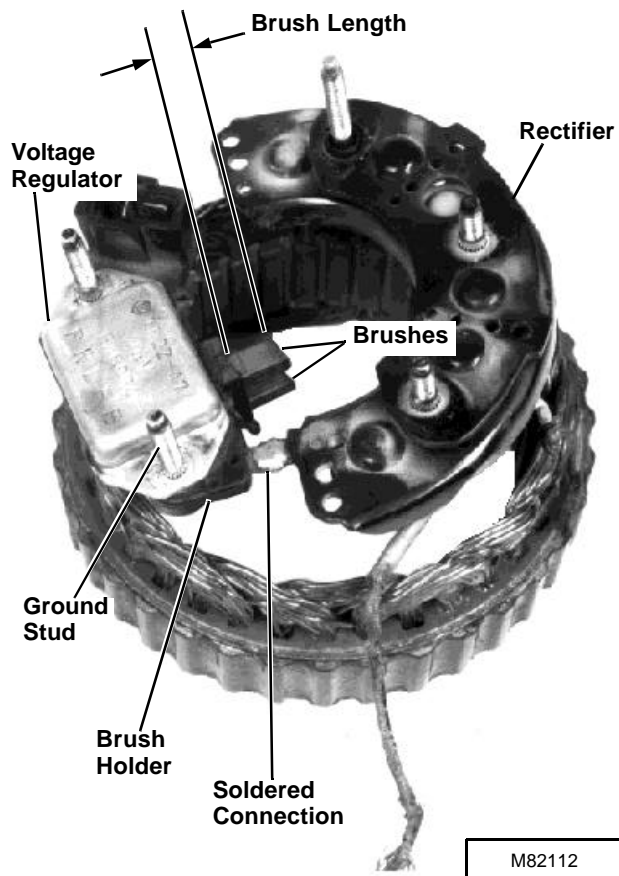
Alternator (Hitachi 25A)



Brushes:

- Inspect brush holder and brushes for damage. Brushes must slide freely and the springs must hold the brushes firmly against the slip rings of the rotor.
- Measure brushes for wear. Minimum exposed length must be **5.50 mm (0.220 in.)** or to wear limit line on brushes. Replace brushes as necessary.

4



- Use an ohmmeter or a test light to check for continuity. Check between the two brushes and between each brush and ground stud. There should be no continuity. Replace brush holder-rectifier assembly if there is continuity.
- To replace brushes, melt solder from connection. Remove voltage regulator if necessary. (See *VOLTAGE REGULATOR REPLACEMENT* in this group.)

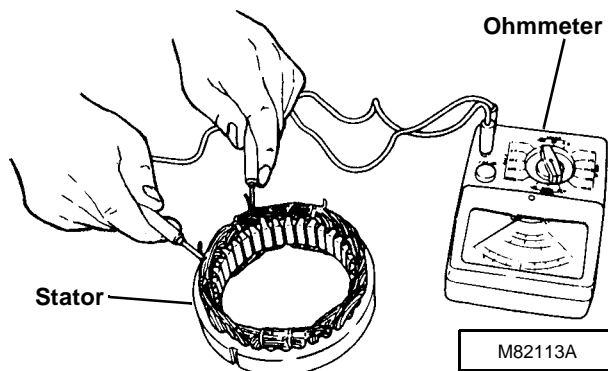
NOTE: If additional solder is needed, use ONLY 60-40 rosin-core solder.

Stator:

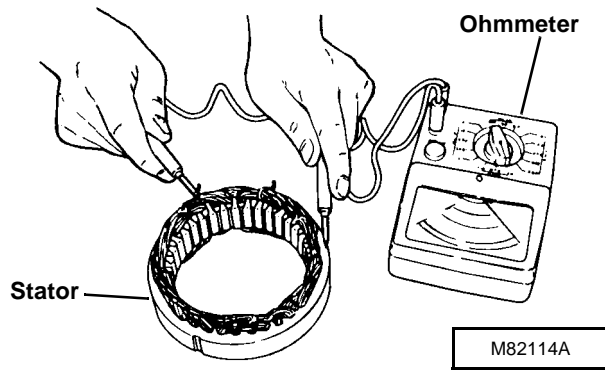
- Inspect stator for defective insulation, discoloration or a burned odor. If any of these defects are found, replace stator.

NOTE: Use an ohmmeter that is sensitive to resistance of 0 to 1 ohm.

- Touch probes of an ohmmeter to lead wires of stator in three possible combinations. Continuity should read approximately **0.26 ohms**. If readings are not equal, replace stator.



- Touch one probe of the ohmmeter to the bare metal surface of stator and the other probe to a bare stator lead wire. Repeat for each wire. Replace stator if test indicates continuity.



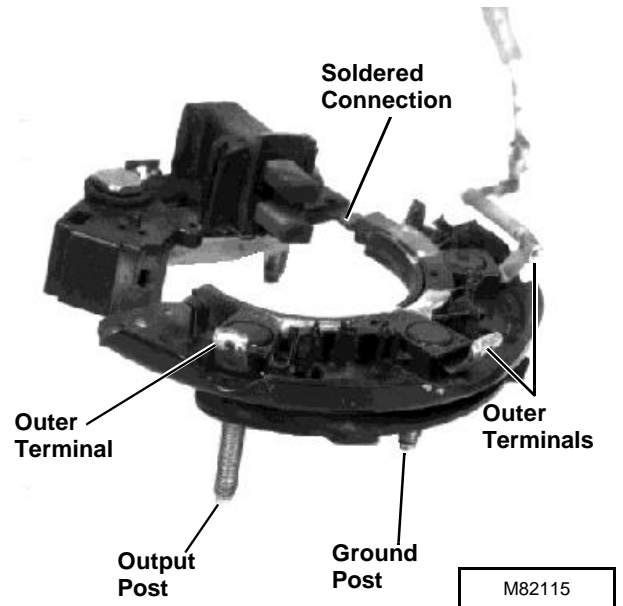
A shorted diode would have continuity in both directions. An open diode would have no continuity in either direction. Replace the rectifier assembly if any of the six diodes are defective.

- To replace rectifier, melt solder from connection.

NOTE: If additional solder is needed, use ONLY 60-40 rosin-core solder.

Rectifier:

- Test the diodes by touching probes to ground post and the three outer terminals.
- Switch the probes and check each terminal again. There should be continuity in only one combination of each terminals and the ground post.
- Test the diodes by touching probes to output post and the three outer terminals.
- Switch the probes and check each terminal again. There should be continuity in only one combination of each terminal and the output post.



ENGINE AND FUEL SYSTEM TROUBLESHOOTING CHART

CHECK OR SOLUTION	PROBLEM OR SYMPTOM											
	Engine will not crank.	Engine cranks but will not start or starts hard.	Engine will not stay running, or stalls frequently.	Engine runs rough, misses, noisy, vibrates or low on power. Fuel in oil. Oil level high.	Engine surges, or has uneven or uncontrolled rpm.	Oil in the coolant or coolant in the oil.	Engine has low oil pressure.	Engine operating temperature is incorrect.	Lack of fuel at injection pump.	Exhaust smoke blue or uses too much oil.	Exhaust smoke white.	Exhaust smoke black or grey or uses too much fuel.
Fuel pump screen, fuel filter, or fuel line restricted. Fuel dirty, contains water or wrong grade.		●	●	●	●			●		●	●	
Air filter elements dirty or plugged. Replace.		●	●	●	●		●		●		●	
Fuel shut-off valve turned off, or restricted. Solenoid linkage misadjusted. See adjustment.		●	●	●	●		●	●				
Muffler or exhaust manifold leak.			●	●								
Defective manifold heater.		●										
Injection pump or governor malfunctioning. Injection pump timing incorrect.		●		●	●					●	●	
Defective cranking components or connectors.	●			●								
Low compression from worn rings, cylinder bore, piston, valves or warped head.		●	●	●		●			●		●	
Valve clearance incorrect.	●	●	●	●			●				●	
Burned or warped valves and valve seats. Defective valve spring.		●	●	●	●				●		●	
Starter cranking rpm too slow. Damaged starter. Excessive engine load.	●	●						●				
Fuel pump leaking or not operating. See Fuel Supply Pump Pressure Test.		●	●	●	●			●		●		
Engine oil viscosity or level incorrect.	●	●					●	●	●			
Injector pressure incorrect or leaking.		●	●	●	●		●			●	●	
Cylinder head gaskets leaking or damaged.	●	●	●		●	●	●	●	●		●	
Radiator/oil cooler leak.				●		●	●					
Turbocharger				●							●	

4

ENGINE SYSTEM DIAGNOSIS

Conditions:

- Engine mounted on level surface.
- Key switch off unless indicated otherwise.

Test Location	Normal	If Not Normal
1. Engine dipstick and exterior engine surface-engine oil check.	Oil level between “L” and “H” marks. Oil not burnt, or contaminated with metal particles, fuel, or coolant. No external leakage, filter clean.	Change oil and inspect for source of contamination. Check gaskets, seals, plugs, cylinder head, block, and intake manifold and breather. Change oil filter.
2. Coolant tank and radiator. - Cooling System Check.	Coolant level between marks on tank when engine is warm. Coolant in radiator full to top. Coolant not contaminated with oil, fuel or discolored brown. Radiator screen free of debris. Hoses not cracked or leaking, clamps and radiator cap tight. Fan belt tight, not glazed or cracked. Fan blades not damaged or warped.	Add proper coolant mix. Drain and flush system. Check for source of contamination. Clean or replace. Pressure test radiator and cap. Replace and adjust belt tension. Replace fan.
3. Fuel tank, pump, pump screen, lines, filter, filter shutoff valve. - Fuel System Check	Fuel level correct, not contaminated, correct grade of fuel, no water. Fuel pump screen and in-line filter free of debris. Fuel shutoff valve in “ON” position. Fuel hoses not cracked or leaking. Fuel hose clamps tight. Fuel tank does not have vacuum.	Drain and clean fuel tank. Add fresh fuel. Replace filters. Move to “ON” position. Replace. Replace or tighten. Replace fuel tank check valve.
4. Air filter and air intake. - Air Intake System Check	Air filter hose not cracked, clamps tight. Element not plugged. Air filter housing sealed, no dirt tracking inside filter element.	Replace and tighten clamps. Replace element or housing.
5. Fuel shutoff solenoid. (Key in RUN position.)	Fuel shutoff solenoid must pull in and stay in. Solenoid must bottom out. Shutoff shaft must still move slightly.	Check shutoff solenoid adjustment. Clean any dirt from under solenoid boot. If solenoid will not pull in and hold in, see Fuel Shutoff Solenoid Circuit Test Points in ELECTRICAL section of Machine TM.
6. Air heater indicator light. (Key in RUN position.)	Indicator light should come on up to 15 seconds depending on air temperature.	See Air Heater Circuit Test Points in ELECTRICAL section of Machine TM.

Diagnosis

ENGINE SYSTEM DIAGNOSIS - Continued

Test Location	Normal	If Not Normal
7. Fuel filter, fuel pump. (Key switch in RUN position.)	Fuel level increases in filter. Fuel pump operating - listen for humming sound. Fuel present in return hose at fuel pump.	See Fuel Pump Circuit Test Points in ELECTRICAL section of Machine TM. Test fuel pump pressure. (See <i>Operational Tests</i> in this section.) Replace fuel filter.
8. Throttle lever and cable.	Linkage not binding and adjusted correctly.	Repair, replace or adjust cable.
9. Intake and exhaust valves.	Cold engine valve clearance of 0.30 mm (0.012 in.). Valves not sticking.	Check and adjust. (See <i>Checks, Tests and Adjustments</i> in this section.) Check valve guides and stems.
10. Fuel at injectors. (Key in START position - engine cranking.)	Crack fuel injection lines at injectors. Fuel shutoff solenoid pulled in. Engine must crank.	Check spray pattern and cracking pressure. (See <i>Checks, Tests and Adjustments</i> in this section.) Replace injectors. See Cranking Circuit Test Points in ELECTRICAL section of Machine TM.
4 11. Injector ports. (Key in START position.)	Minimum compression of 2942 kPa (427 psi) with a 588 kPa (85 psi) maximum difference between cylinders.	Perform cylinder compression test. (See <i>Operational Tests</i> in this section.)
12. Flywheel and starter.	Minimum cranking rpm - 300 rpm.	See Starter Amp Draw Test in ELECTRICAL section of Machine TM.
13. Injection pump timing inspection. (Key OFF.)	Timing should be correct. Remove pump as the LAST possible solution.	Perform injection pump static timing adjustment. (See <i>Checks, Tests and Adjustments</i> in this section.) Have pump tested by a qualified Service Repair Shop.
14. Injection pump idle settings. (Engine running).	Slow idle at 900 ± 50 rpm. Fast idle at 2375 ± 50 rpm.	See Slow Idle and Fast Idle Adjustments in ENGINE section of Machine TM.
15. Oil pressure sender port.	Minimum oil pressure at 900 rpm is 98 kPa (14 psi).	Test engine oil pressure. (See <i>Operational Tests</i> in this section.)
16. Thermostat. (Engine at operating temperature.)	Clean from corrosion, rust, or debris. Opening temperature 71°C (160°F) or 85°C (184°F).	Replace thermostat.
17. Muffler.	Not restricted.	Replace muffler.

VALVE CLEARANCE CHECK AND ADJUSTMENT

Reason:

To achieve correct engine operation.

Equipment:

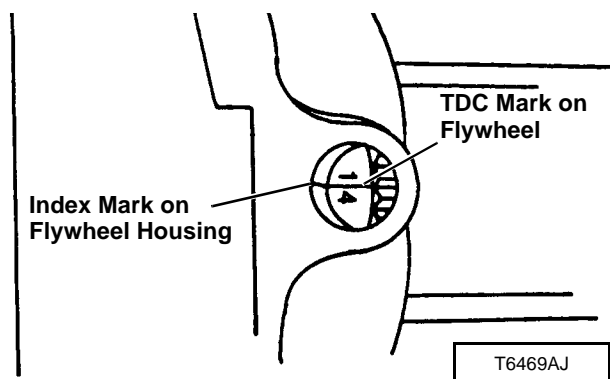
- Feeler Gauge

Procedure:

1. Remove rocker arm cover.
2. Remove plug from timing hole on flywheel housing.

NOTE: "Top Dead Center (TDC)" is the piston at its highest point.

3. Turn crankshaft pulley clockwise until No.1 cylinder TDC mark on flywheel aligns with index mark on flywheel housing.

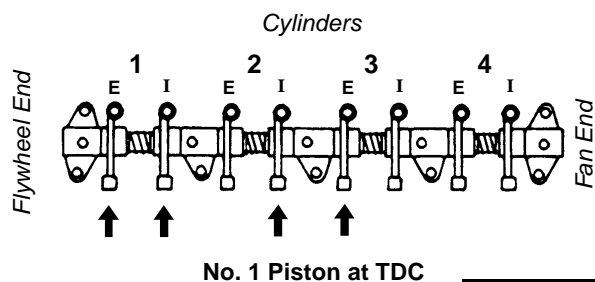


NOTE: No. 1 cylinder is the closest to the flywheel.

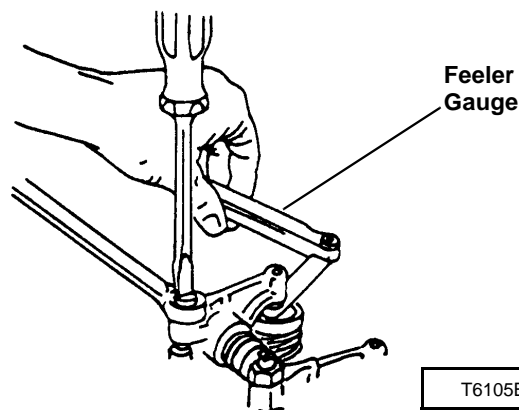
4. Try to move both No. 1 cylinder rocker arms or push rods.

If rocker arm push rods are not loose, rotate flywheel one revolution (360°). If both rocker arm push rods are loose the piston is at TDC on compression stroke.

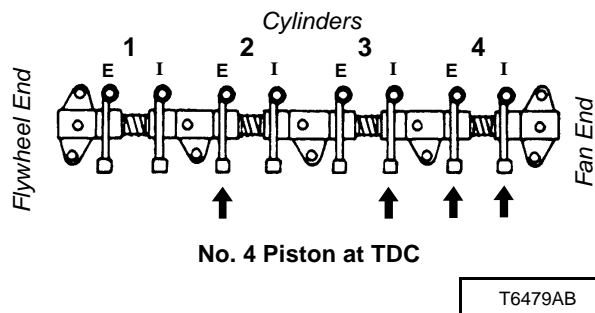
5. Measure and adjust valve clearance on the valves (arrows) with No. 1 piston at TDC.



To adjust valves, loosen nut and turn adjusting screw until clearance is **0.30 mm (0.012 in.)**. Hold screw while tightening nut.



6. Turn crankshaft pulley one revolution (360°). This puts the piston in No. 4 cylinder at TDC compression stroke.
7. Measure and adjust valve clearance on the valves (arrows) with No. 4 piston at TDC.



Checks, Tests and Adjustments

CONNECTING ROD SIDE PLAY CHECK

Reason:

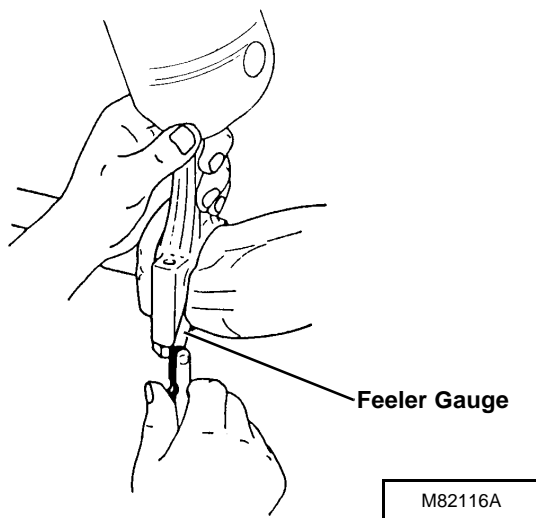
To determine proper side clearance between crankshaft and connecting rod.

Equipment:

- Feeler Gauge

Procedure:

1. Insert a feeler gauge, according to specifications, between connecting rod cap and crankshaft.



Specifications:

Standard Clearance 0.20 - 0.40 mm
..... (0.0079 - 0.0157 in.)

Wear Limit. 0.45 mm (0.0177 in.)

Results:

- If side play exceeds wear limit, replace connecting rod and connecting rod cap.

CONNECTING ROD BEARING CLEARANCE CHECK

Reason:

To measure oil clearance between connecting rod bearing and crankshaft journal.

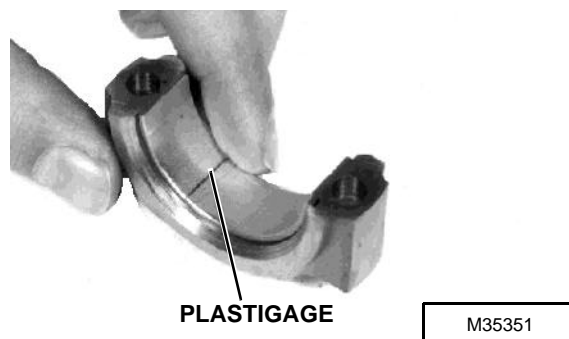
Equipment:

- PLASTIGAGE®

Procedure:

IMPORTANT: Connecting rod caps must be installed on the same connecting rod and in the same direction to prevent crankshaft and connecting rod damage.

1. Remove connecting rod cap.
2. Wipe oil from bearing insert and crankshaft journal.
3. Put a piece of PLASTIGAGE, or an equivalent, along the full length of the bearing insert approximately 6 mm (0.250 in.) off center.

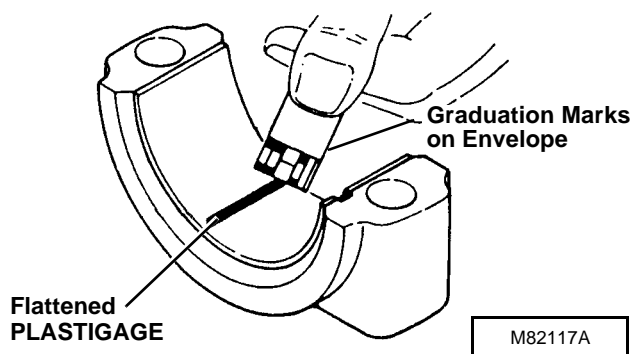


4. Turn crankshaft approximately 30° from bottom dead center.
5. Install connecting rod end cap and original cap screws. Tighten cap screws to **118 N•m (87 lb-ft)**.
6. Remove cap screws and connecting rod cap.

NOTE: The flattened PLASTIGAGE will be found on either the bearing insert or crankshaft journal.

7. Use the graduation marks on the envelope to compare the width of the flattened PLASTIGAGE at its widest point.
8. Determine bearing clearance. The number within the graduation marks indicates the bearing clearance in inches or millimeters depending on which side of the envelope is used.

9. Remove PLASTIGAGE.



Specifications:

Standard Clearance **0.036 - 0.090 mm**
 **(0.0014 - 0.0035 in.)**
Wear Limit **0.15 mm (0.0059 in.)**

Results:

- If clearance exceeds wear limit, replace bearing inserts.

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CRANKSHAFT END PLAY CHECK

Reason:

To determine proper side clearance between crankshaft and engine block.

Equipment:

- Dial Indicator

Procedure:

NOTE: Crankshaft end play can be measured at front end or rear end of crankshaft. Procedure is performed from the rear end. The flywheel is removed to show detail.

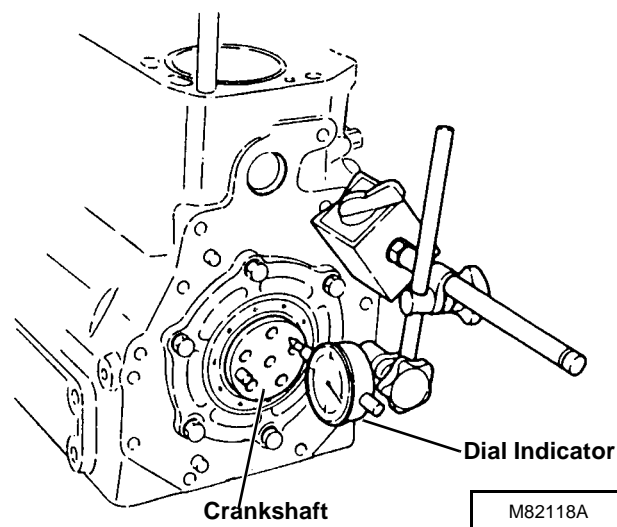
1. Fasten dial indicator to engine and position indicator tip on end of crankshaft.

IMPORTANT: Do not use excessive force when moving crankshaft to avoid damaging bearings.

2. Push crankshaft toward rear as far as possible.

3. Zero the dial indicator.

4. Using a bar, gently pry the crankshaft as far forward as possible.



Specifications:

Standard Clearance **0.132 - 0.223 mm**
 **(0.0052 - 0.0088 in.)**
Wear Limit **0.29 mm (0.0114 in.)**

Results:

- If end play exceeds wear limit, replace thrust bearings.

CRANKSHAFT MAIN BEARING CLEARANCE CHECK

Reason:

To measure oil clearance between main bearing and crankshaft journal.

Equipment:

- PLASTIGAGE®

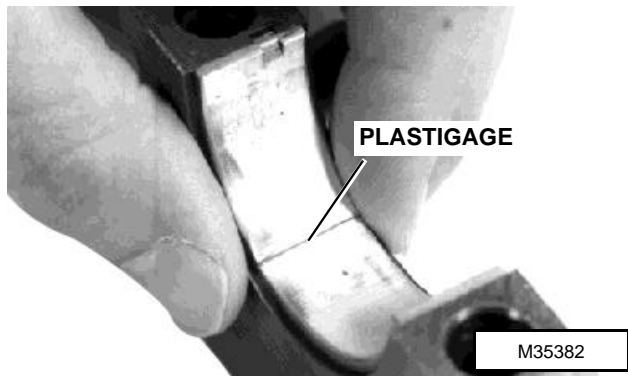
Procedure:

IMPORTANT: Main bearing caps must be installed on the same main bearing and in the same direction to prevent crankshaft and main bearing damage.

1. Remove main bearing cap.
2. Wipe oil from bearing insert and crankshaft journal.

Checks, Tests and Adjustments

- Put a piece of PLASTIGAGE, or an equivalent, along the full length of the bearing insert approximately 6 mm (0.250 in.) off center.

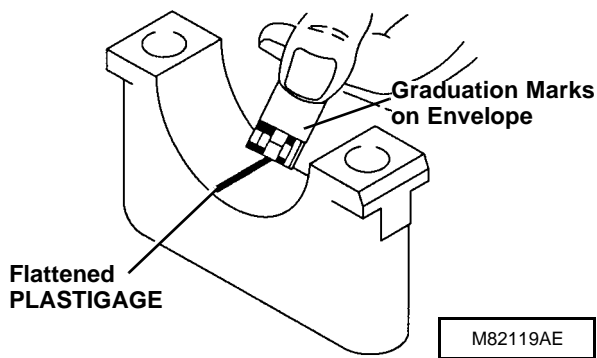


- Install main bearing cap and cap screws. Tighten cap screws to **196 N•m (145 lb-ft)**.
- Remove cap screws and main bearing cap.

4

NOTE: The flattened PLASTIGAGE will be found on either the bearing insert or crankshaft journal.

- Use the graduation marks on the envelope to compare the width of the flattened PLASTIGAGE at its widest point.
- Determine main bearing clearance. The number within the graduation marks indicates the bearing clearance in inches or millimeters depending on which side of the envelope is used.
- Remove PLASTIGAGE.



Specifications:

Standard Clearance **0.036 - 0.093 mm**
.....(0.0014 - 0.0037 in.)
Wear Limit..... **0.09 mm (0.0040 in.)**

Results:

- If clearance exceeds wear limit, replace bearing inserts.

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VALVE LIFT CHECK

Reason:

Can indicate excessive wear on cam lobes, followers, and/or push rods.

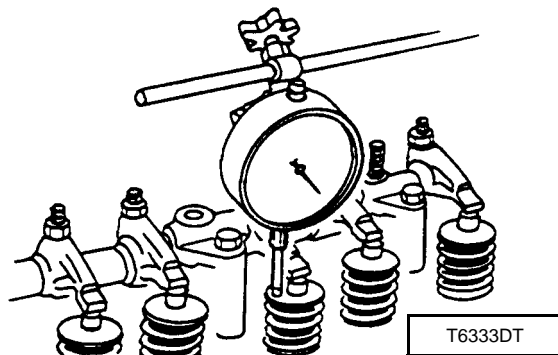
Equipment:

- Dial Indicator

Procedure:

- Adjust valve clearance. (See procedure in this group.)
- Remove rocker arm cover. (See *Cylinder Head, Valves and Manifolds* in this section.)
- Fasten dial indicator to engine and position indicator tip on valve retainer. Valve must be fully closed and rocker arm must move freely.
- Zero the dial indicator.
- Manually turn crankshaft pulley clockwise (from fan end).
- Observe dial indicator as valve is moved to the full open position. Valve lift (intake and exhaust) should be **6.5 mm (0.256 in.)**.

Repeat for each valve.



Results:

- If valve lift is less than specification, remove and inspect camshaft, followers and push rods. (See *Camshaft and Timing Gear Train* and/or *Cylinder Head, Valves and Manifolds* in this section.)

CAMSHAFT END PLAY CHECK

Reason:

To determine proper side clearance between camshaft gear end journal and thrust plate.

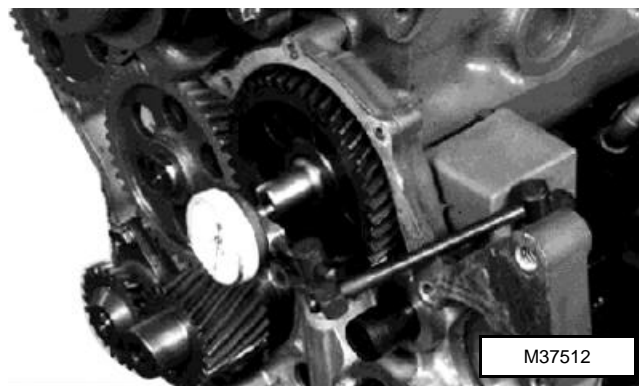
Equipment:

- Dial Indicator

Procedure:

1. Remove timing gear cover. (See *Camshaft and Timing Gear Train* in this section.)
2. Fasten dial indicator to engine and position indicator tip on end of camshaft.
3. Push camshaft toward the rear as far as possible.

4. Zero the dial indicator.
5. Pull camshaft forward as far as possible.

**Specifications:**

Standard Clearance 0.05 - 0.20 mm
..... (0.0020 - 0.0079 in.)
Wear Limit 0.29 mm (0.0114 in.)

Results:

- If end play exceeds wear limit, remove camshaft and replace thrust plate. (See *Camshaft and Timing Gear Train* in this section.)

Checks, Tests and Adjustments

TIMING GEAR BACKLASH CHECK

Reason:

To check for wear between meshing gears, resulting in excessive noise and poor engine performance.

Equipment:

- Dial Indicator

Procedure:

1. Measure backlash between meshing gears.

Specifications:

Standard Backlash 0.08 - 0.16 mm

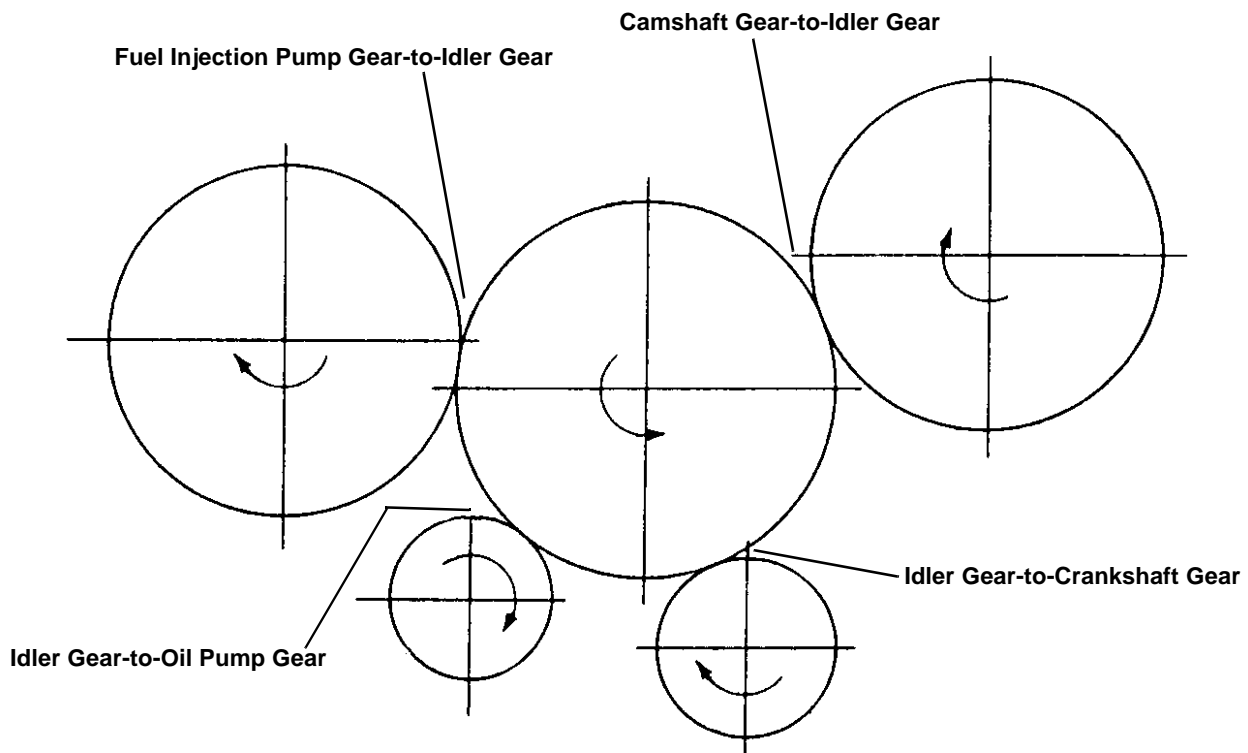
. (0.0031 - 0.0063 in.)

Wear Limit. 0.25 mm (0.0098 in.)

Results:

- If backlash exceeds wear limit, replace meshing gears as a set:

Idler Gear, Camshaft Gear, Crankshaft Gear AND/OR Idler Gear, Fuel Injection Pump Gear, Oil Pump Gear.



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FUEL INJECTION NOZZLE TEST (HOLE-TYPE)

CAUTION

Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.

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

Reason:

To determine opening pressure, leakage, chatter and spray pattern of the fuel injection nozzle.

Equipment:

- D01109AA Diesel Fuel Injection Nozzle Tester
- D01110AA Adapter Set
- 23622 Straight Adapter
- Container

Connections:

1. Connect fuel injection nozzle to D01109AA Diesel Fuel Injection Nozzle Tester using parts from D01110AA Adapter Set and 23622 Straight Adapter.

IMPORTANT: Use clean filtered diesel fuel when testing injection nozzles to get best test results.

Procedure 1:

Test fuel injection nozzle opening pressure following the Nozzle Tester manufacturer's instructions.

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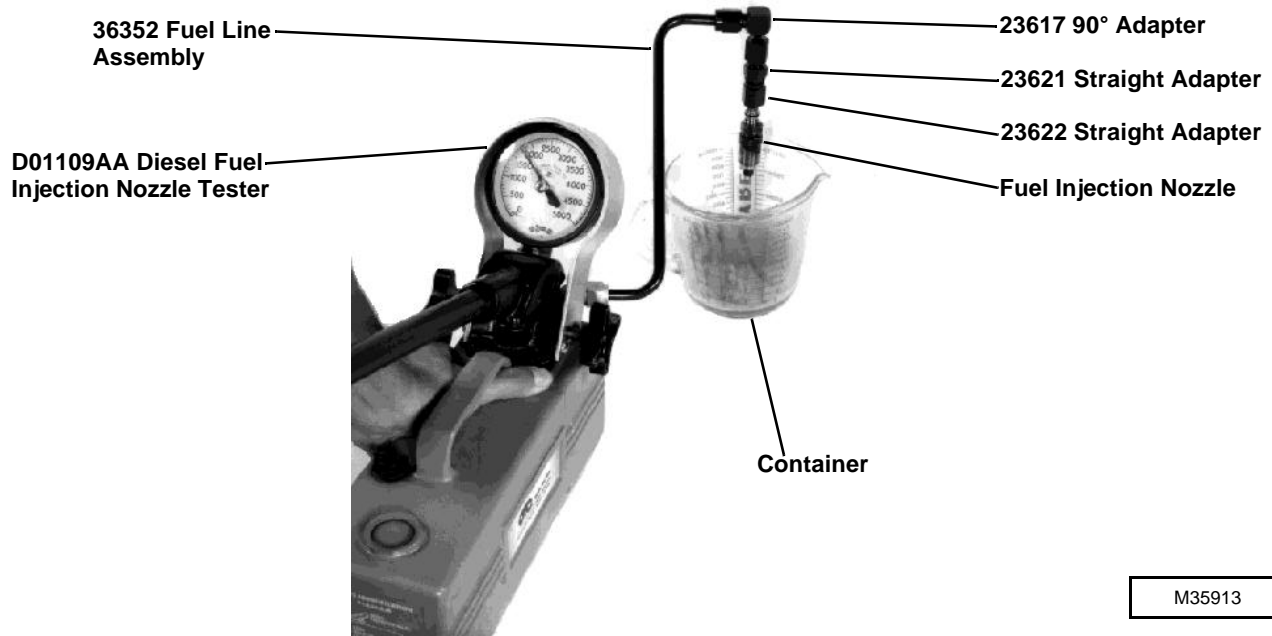
Specifications:

Opening Pressure19615 kPa (2850 psi)

Results:

- If pressure reading does not meet specification, disassemble injection nozzle and inspect nozzle assembly for contamination or stuck valve. If necessary, add or remove shims to change opening pressure.

Checks, Tests and Adjustments



Procedure 2:

4 Test fuel injection nozzle **leakage** following the Nozzle Tester manufacturer's instructions.

1. Dry nozzle completely using a lint-free cloth.
2. Pressurize nozzle to **18100 kPa (2625 psi)**.
3. Watch for leakage from nozzle spray orifice. Leakage time should be a minimum of **5 seconds**.

Results:

- If leakage time does not meet specification, disassemble injection nozzle and inspect nozzle assembly for contamination. Inspect valve seating surface. Replace nozzle assembly if necessary.

Procedure 3:

Test fuel injection nozzle **chatter and spray pattern** following the Nozzle Tester manufacturer's instructions.

1. Pressurize nozzle to **20100 ± 490 kPa (2915 ± 71 psi)**.
2. Listen for “chatter” sound and watch spray pattern.

Specifications:

Slow Hand

Lever Movement Chatter Sound

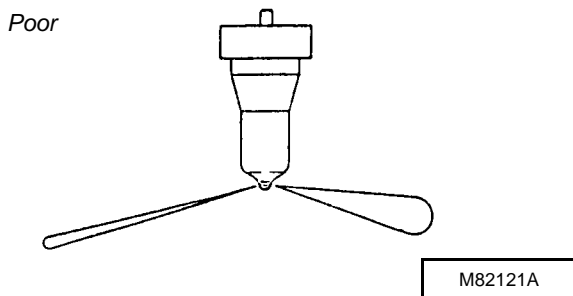
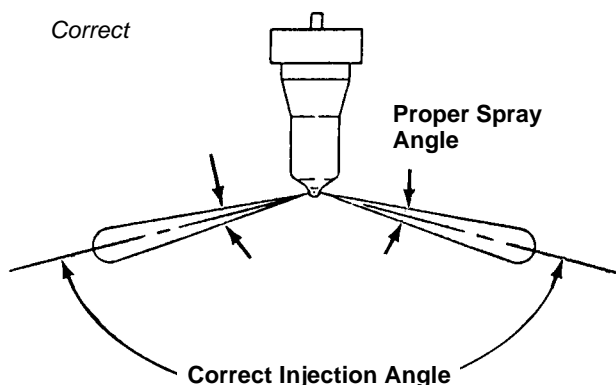
Slow Hand

Lever Movement Fine Stream
 Spray Pattern

Fast Hand

Lever Movement Fine Atomized
 Spray Pattern

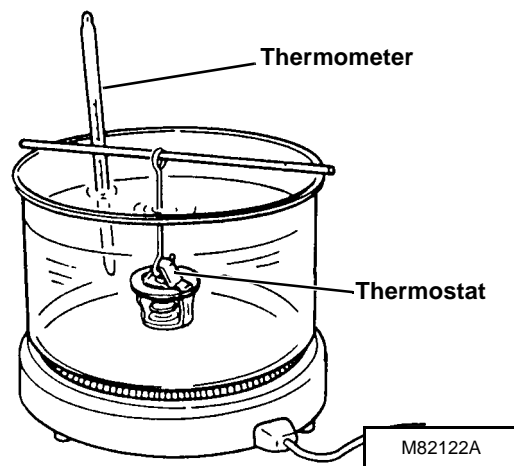
Procedure:



CAUTION

DO NOT allow thermostat or thermometer to rest against the side or bottom of glass container when heating water. Either may rupture if overheated.

1. Suspend thermostat and a thermometer in a container of water.
2. Heat and stir the water. Observe opening action of thermometer and compare temperatures with specifications.
3. Remove thermostat and observe its closing action as it cools.



4

Results:

- If nozzle chatter or spray pattern does not meet specifications, disassemble injection nozzle and inspect nozzle assembly for contamination. Inspect valve seating surface. Replace nozzle assembly if necessary.
- If there is excessive difference in spray angle or injection angle, incomplete atomization or sluggish starting/stopping of injection, disassemble injection nozzle and inspect nozzle assembly for contamination. Replace nozzle assembly if necessary.

THERMOSTAT OPENING TEST

Reason:

To determine opening temperature of thermostat.

Equipment:

- Thermometer
- Glass Container
- Heating Unit

Specifications:

Begin Opening 71° C (160° F)
Fully Open 85° C (184° F)
Minimum Lift Height 8 mm (0.310 in.)

Results:

- If thermostat does not open according to specifications, replace.
- If closing action is not smooth and slow, replace thermostat.

Checks, Tests and Adjustments

COOLANT TEMPERATURE SENDER TEST

Reason:

To determine operating temperature of sender.

Equipment:

- Thermometer
- Glass Container
- Heating Unit
- Ohmmeter

Procedure:

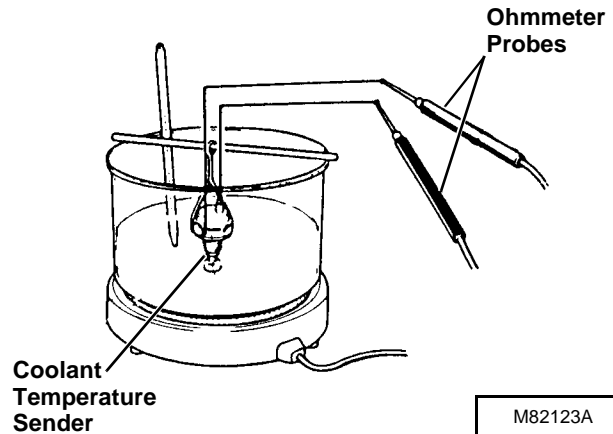
CAUTION

DO NOT allow sender or thermometer to rest against the side or bottom of glass container when heating water. Either may rupture if overheated.

4

1. Connect lead wires from ohmmeter probes, to sender terminal and body.

2. Suspend sender and a thermometer in a container of water.
3. Heat and stir the water. Observe water temperature when continuity occurs. Water temperature should be **107-113° C (225-235° F)**.



Results:

- If continuity does not occur within temperature listed, replace sender.

STARTER NO-LOAD AMP DRAW/RPM TEST

Reason:

To determine if starter is binding or has excessive amperage draw under no load.

Equipment:

- JT05712 Current Gun
- JT05719 Photo Tachometer
- Jumper Cables
- Jumper Wire

Procedure:

1. Mount starter in a vise.

NOTE: Check that battery is fully charged and of proper size to ensure accuracy of test.

2. Connect jumper cables to a 12 volt battery.
3. Connect positive (+) cable to solenoid battery terminal on starter.
4. Connect negative (-) cable to starter body.

5. Attach Current Gun to positive cable.

IMPORTANT: Complete this test in 20 seconds or less to prevent starter damage.

6. Use a jumper wire to briefly connect positive (+) starter terminal to solenoid terminal "S". Starter should engage and run.
7. Read and record starter amperage and rpm.

Specifications:

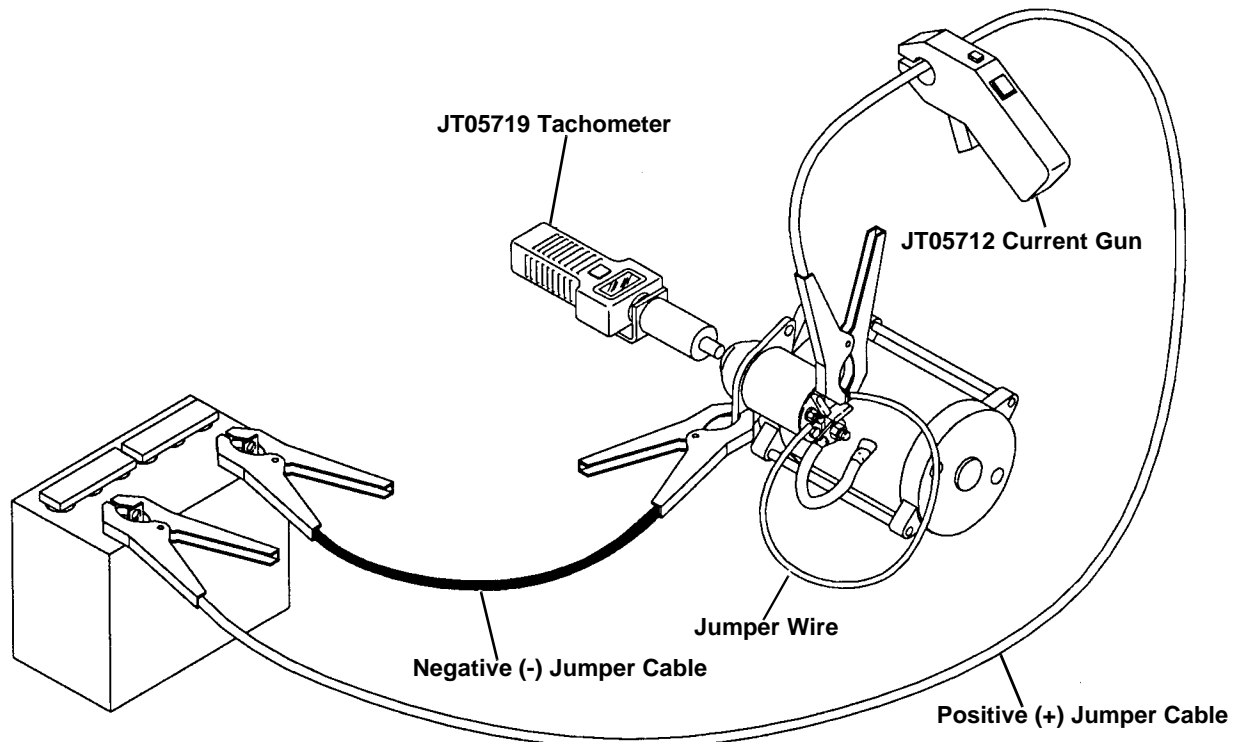
Maximum Starter

Amperage90 amps at 3500 rpm

Minimum Starter RPM 3500

Results:

- If solenoid "clicks" or chatters and motor does not turn, replace solenoid.
- If pinion gear engages and motor doesn't turn, repair or replace starter motor.
- If starter engages and runs but amperage is more than specifications, repair or replace starter.
- If rpm is less than specification, with battery fully charged, repair or replace starter.



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Checks, Tests and Adjustments

INJECTION PUMP STATIC TIMING ADJUSTMENT

Reason:

To make sure that injection pump timing is set to manufacturers specification.

Equipment:

- Timing Tool (No. 1 fuel injection line cut off at first bend)
- External fuel supply

Procedure:

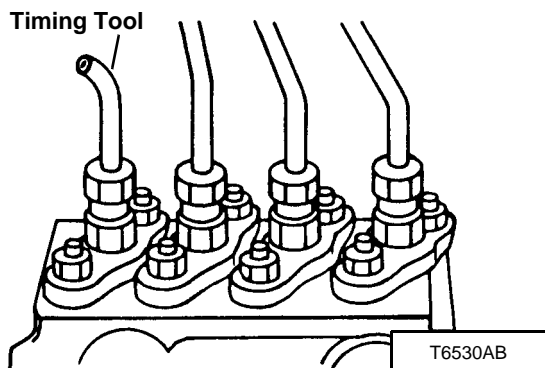
IMPORTANT: Injection pump timing should be correct. Once timing is set, it will not normally change during the life of the engine, unless it was altered.

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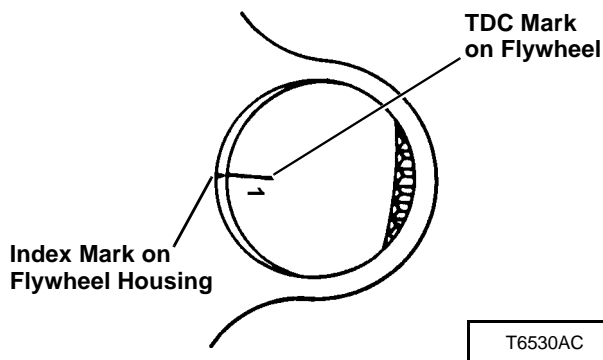
Check and adjust timing only as the last option. Check fuel, fuel supply system, injectors, air intake system and cylinder compression before continuing.

NOTE: Normal rotation, as viewed from the flywheel end, is counterclockwise. The number one fuel injection line is toward the flywheel.

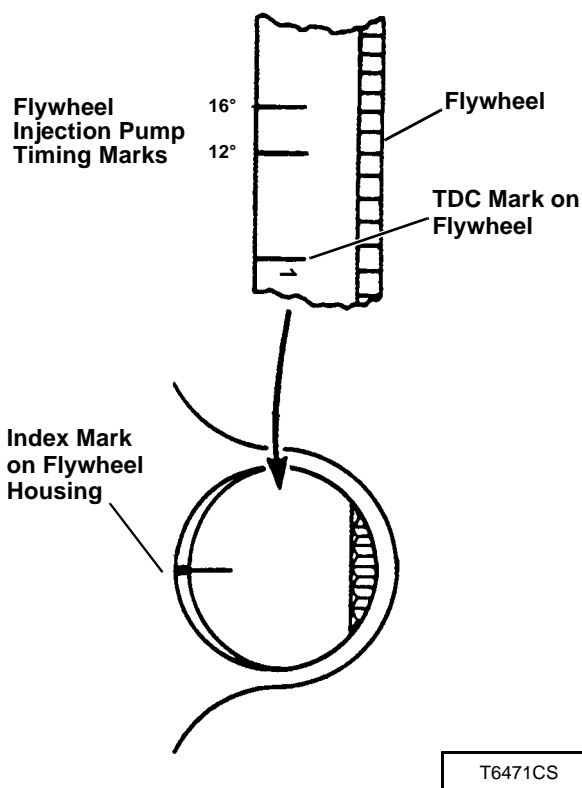
1. Remove the number one fuel injection line.
2. Install timing tool (number one fuel line cut off at first bend).



3. Remove rubber plug from flywheel housing.
4. Turn crankshaft pulley in either direction until the No. 1 cylinder top dead center (TDC) mark aligns with the index mark on the flywheel housing.



5. Operate hand operated primer pump to fill injection pump with fuel.
6. Hold throttle lever in RUN position.
7. Turn flywheel clockwise (as viewed from flywheel end) until tip of Timing Tool has become **MOIST** with solid fuel. This is the point of injection timing at which the pump is set.
8. Check timing mark on flywheel. The index mark must line up with the 16° mark on flywheel.



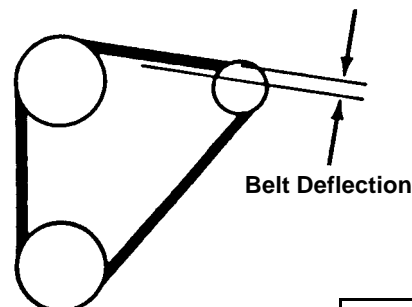
Specifications:

Injection Pump Timing 16° BTDC
 (Before Top Dead Center)

**Engine Crankshaft
Position** No.1 Cylinder
 on TDC Compression Stroke

**Distance On Outer Surface Of Flywheel
Per 1° Of Rotation** 3.5 mm (0.130 in.)

**Timing Lines On Pump
Mounting Plate** 2° Apart



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Results:

- If timing is not according to specifications, loosen pump mounting bolts and turn pump towards engine block to retard timing or away from block to advance timing. Recheck timing.
- If timing did not change, remove pump and have tested by a diesel injection service shop.
- If timing is OK:
 - Install rubber plug in flywheel housing.
 - Remove timing tool.
 - Install number one injection line.

FAN/ALTERNATOR DRIVE BELT ADJUSTMENT

Reason:

To keep proper tension on belt to drive water pump and alternator. To prevent shortened belt and bearing life.

Equipment:

- JDG529 or JDST28 Belt Tension Gauge
- Straight Edge

Procedure:

1. Check belt tension between fan and alternator using Belt Tension Gauge and a straight edge.

Specifications:

Applied Force 98 N (22 lb-force)
Deflection 10 - 15 mm (0.400 - 0.600 in.)

Results:

- If deflection is not within specifications:
 - Loosen both alternator mounting cap screws.
 - Apply force to FRONT alternator housing only (near the belt) until tension is correct.
 - Tighten cap screws.

4

ENGINE OIL COOLER LEAKAGE TEST

Reason:

Inspect oil cooler for leaks.

Procedure:

1. Plug one end of coolant inlet or outlet passage.
2. Apply regulated air pressure of 206 - 483 kPa (30 - 70 psi) to other end.
3. Dip oil cooler into water and check for leaks.
4. Optional test: If a leak did not appear, use a hot water bath to possibly open crack(s).

Results:

- Repair leak(s) or replace oil cooler if necessary.

Operational Tests

RADIATOR BUBBLE TEST

Reason:

To determine if compression pressure is leaking from cylinder.

Equipment:

- JDG560 Adapter

Procedure:

1. With coolant at proper level and radiator cap tight, run engine for 5 minutes to bring to operating temperature.
2. Remove cap from recovery tank.
3. Check for bubbles coming from overflow hose at bottom of tank.

If bubbles are present, isolate source of compression leak:

4

- Remove injection nozzles.
- Install JDG560 Adapter in injection port of cylinder to be tested.
- Move piston to bottom of stroke with intake and exhaust valves closed.
- Connect hose from compressed air source (**2942 kPa (427 psi) maximum**) to adapter.
- Check for bubbles in recovery tank or air escaping from muffler, air cleaner or oil fill opening.
- Repeat for each cylinder.

Results:

- If bubbles are present, check for cracks in cylinder head and block. Check for damaged head gasket.
- If air escapes from muffler, check for worn exhaust valve.
- If air escapes from air cleaner, check for worn intake valve.
- If air escapes from engine oil fill, check for worn piston rings.

COOLING SYSTEM PRESSURE TEST

Reason:

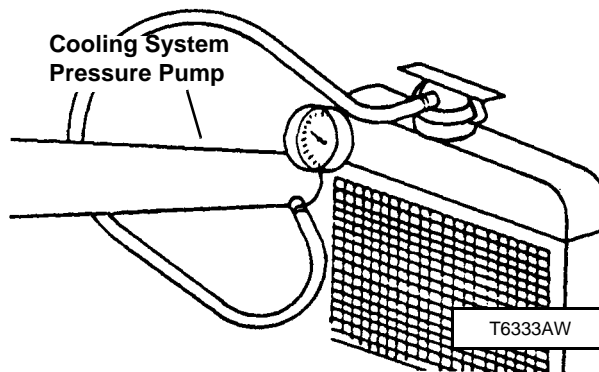
Inspect cooling system for leaks.

Equipment:

- D05104ST Cooling System Pressure Pump

Procedure:

1. Remove cap and attach pressure pump to radiator.
2. Apply **97 kPa (14 psi)** maximum pressure.
3. Check for leaks throughout cooling system.



Specifications:

**Minimum pressure
after 15 seconds 88 kPa (12.8 psi)**

Results:

- Pressure should hold to specifications. If pressure decreases, check for leaks. Repair leaks or replace parts as necessary.
- If pressure test still indicates leakage after all external leaks have been stopped, a defective head gasket, cracked block, or cylinder head may be the cause. Perform *RADIATOR BUBBLE TEST*.

RADIATOR CAP PRESSURE TEST

Reason:

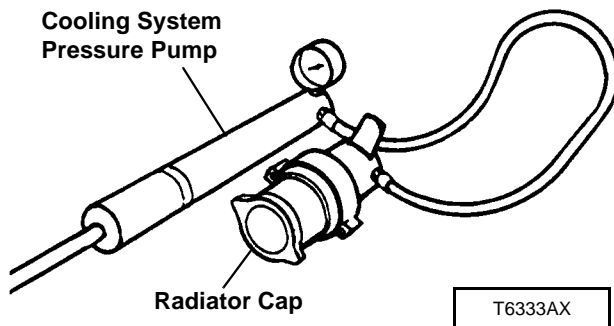
Test radiator cap for operating in correct pressure range.

Equipment:

- D05104ST Cooling System Pressure Pump

Procedure:

1. Install radiator cap on pressure pump.
2. Apply pressure. Pressure valve in cap should open at **88 kPa (12.8 psi)**.



Results:

- If cap leaks, retighten and test again. Replace cap if pressure is not within specification.

CYLINDER COMPRESSION PRESSURE TEST

Reason:

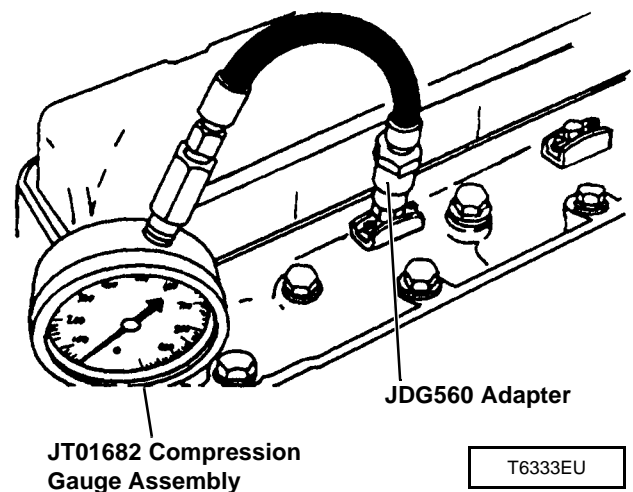
To determine the condition of the pistons, rings, cylinder walls and valves.

Equipment:

- JT01682 Compression Gauge Assembly
- JDG560 Adapter

Procedure:

1. Run engine for 5 minutes to bring to operating temperature. Shut off engine.
2. Remove injection nozzles. (See *Fuel System* in this section.)
3. Remove heat protector from end of injector and install on Adapter.
4. Install Adapter and Compression Gauge Assembly in injector port. Install retaining plate and tighten nuts to 4.5 N•m (39 lb-in.).
5. Hold fuel shut-off knob in shut-off position.
6. Crank engine for five seconds with starter.
7. Record pressure reading for each cylinder.



4

Specifications:

Compression Pressure . . . 2942 kPa (427 psi)

Maximum Difference Between

Cylinders 588 kPa (85 psi)

NOTE: Pressure listed is for 300 m (1000 ft) above sea level. Reduce specification an additional 3.6% for each additional 300 m (1000 ft) of altitude.

Results:

- If pressure reading is below specification, squirt approximately two teaspoons of clean engine oil into cylinders through injector ports and repeat test.

Operational Tests

- If pressure increases significantly, check piston, rings and cylinder walls for wear or damage.
- If pressure does not increase significantly after retest, check for leaking valves, valve seats or cylinder head gasket.

ENGINE OIL PRESSURE TEST

Reason:

To determine if engine bearings or lubrication system components are worn.

Equipment:

- JT05487 Connector
- JT03017 Hose Assembly
- JT05577 Pressure Gauge (100 psi)

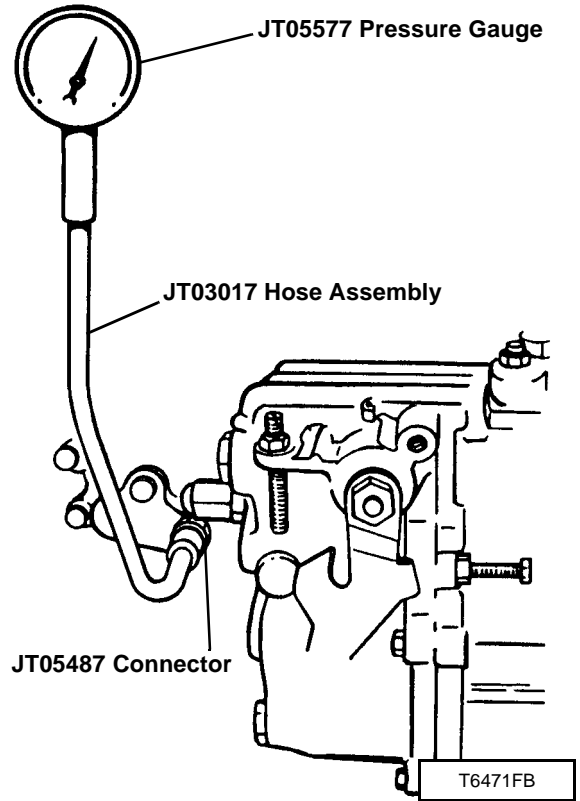
Procedure:

4

1. Remove oil pressure sender.
2. Install connector.
3. Connect Hose Assembly and Pressure Gauge.

IMPORTANT: Do not run if no pressure present.

4. Start engine. If pressure reading is below 69 kPa (10 psi), STOP ENGINE.
5. Run engine approximately five minutes to heat oil, then check oil pressure at fast and slow idle.



Specifications:

Fast Idle2375 ±50 rpm
Slow Idle.....900 ±50 rpm

Engine Oil Pressure:

Fast Idle343 - 441 kPa (50 - 64 psi)
Slow Idle (Minimum)98 kPa (14 psi)

Results:

- If oil pressure is not within specifications, inspect oil pressure regulating valve parts for wear or damage. Add or remove shims as necessary. (See *Lubrication System* in this section.)
- If oil pressure does not increase, see “Engine Has Low Oil Pressure” in *Diagnosis* group.

AIR INTAKE SYSTEM LEAKAGE TEST

Reason:

Check for leaks in air intake system.

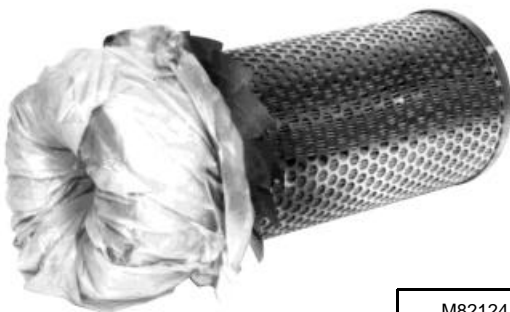
Equipment:

- Air Pressure Regulator

Procedure:

1. Remove air cleaner restriction indicator/switch and install test fitting.
2. Connect air pressure regulator to manifold using hose and fitting from air cleaner.
3. Remove air cleaner cover and main filter element.
4. Put large plastic bag into and over end of main filter element. Install main filter element and cover.
5. Pressurize air intake system between **34 - 69 kPa (5 - 10 psi)**. If air intake system cannot be pressurized, turn engine slightly to close valves.
6. Spray soap solution over all connections from air cleaner to intake manifold or turbocharger, if equipped, and check for leaks.

IMPORTANT: When reinstalling starting aid nozzle, position arrow on nozzle pointing against intake air flow.



Results:

- Find leaks and repair or replace parts as necessary.

FUEL SUPPLY PUMP PRESSURE TEST

Reason:

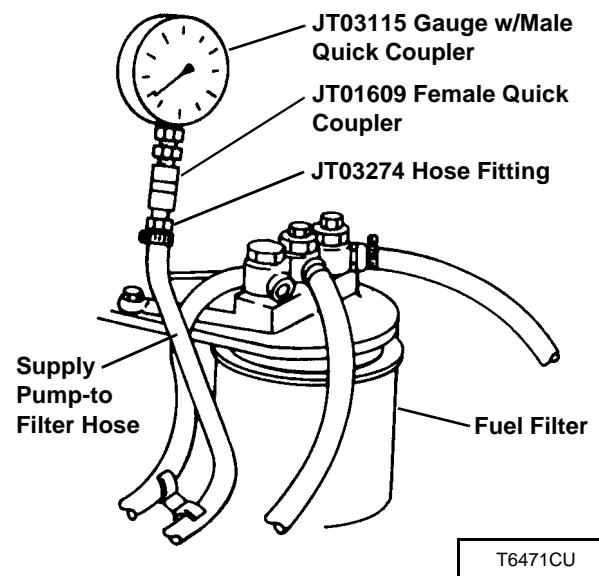
To determine supply pump operating pressure.

Equipment:

- JT03274 Hose Fitting
- JT01609 Female Quick Coupler
- JT03115 Gauge w/Male Quick Coupler (0 - 150 psi)

Procedure:

1. Disconnect supply pump-to-filter hose.
2. Install Hose Fitting, Coupler and Gauge.
3. Pull fuel shut-off cable out and crank engine using the starter. Do not run starter for more than 10 seconds at a time. Gauge should read more than **216 kPa (31 psi)**.



Results:

- If pressure is below specification, repair or replace fuel supply pump.

Operational Tests

FUEL DRAIN BACK TEST

Reason:

Determines if air is entering the fuel system at connections, allowing fuel to siphon back to tank.

Procedure:

1. Disconnect fuel supply line and 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 fuel supply pump, injection pump, filter(s) and water separator, if equipped.
3. Plug end of fuel return hose.
4. Pressurize fuel system at fuel supply line, to a maximum pressure of **103 kPa (15 psi)**.
5. Apply liquid soap and water solution to all joints and connections in the fuel system and inspect for leaks.

Results:

- Find leaks and repair or replace parts as necessary.

ACCESSORIES SERIES 220 POWER UNIT ENGINES

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Section 10

0

ENGINE ACCESSORIES SPECIFICATIONS

Turbocharger

Rotor Shaft Axial Play

Without Waste Gate (RHB3)

Standard 0.022 - 0.053 mm (0.0008 - 0.0021 in.)

Wear Limit 0.07 mm (0.0028 in.)

With Waste Gate (RHB5)

Standard 0.03 - 0.06 mm (0.0012 - 0.0024 in.)

Wear Limit 0.09 mm (0.0035 in.)

Rotor Shaft Radial Play

Without Waste Gate (RHB3)

Standard 0.061 - 0.093 mm (0.0024 - 0.0037 in.)

Wear Limit 0.12 mm (0.0047 in.)

With Waste Gate (RHB5)

Standard 0.08 - 0.13 mm (0.0031 - 0.0051 in.)

Wear Limit 0.17 mm (0.0067 in.)

Thrust Bearing-to-Center Housing Screw Torque 1 N•m (9 lb-in.)

Seal Plate-to-Center Housing Screw Torque 1 N•m (9 lb-in.)

Compressor Wheel Lock Nut Torque

RHB3 1 N•m (9 lb-in.)

RHB5 2 N•m (17 lb-in.)

Center Housing-to-Turbine Housing Cap Screw Torque

RHB3 12 N•m (108 lb-in.)

RHB5 28 N•m (247 lb-in.)

Center Housing-to-Compressor Housing Cap Screw Torque. 4 N•m (39 lb-in.)

Turbine Wheel/Shaft Deflection

RHB3

Standard 0.002 mm (0.00008)

Wear Limit 0.005 mm (0.00019)

RHB5

Standard 0.010 mm (0.00039)

Wear Limit 0.011 mm (0.00043)

Turbine Shaft O.D.

RHB3

Standard 6.257 - 6.263 mm (0.2463 - 0.2466 in.)

Wear Limit 6.250 mm (0.2461 in.)

RHB5

Standard 7.99 - 8.00 mm (0.3146 - 0.3150 in.)

Wear Limit 7.980 mm (0.3142 in.)

Shaft Seal Ring Groove Width

RHB3

Standard 1.038 - 1.062 mm (0.0409 - 0.0418 in.)

Wear Limit 1.070 mm (0.0421 in.)

RHB5

Standard 1.250 - 1.280 mm (0.0492 - 0.0504 in.)

Wear Limit 1.290 mm (0.0508 in.)

Oil Thrower Seal Ring Groove Widths

Small End

RHB3

Standard 0.82 - 0.83 mm (0.0323 - 0.0327 in.)

Wear Limit 0.84 mm (0.0331 in.)

10

Specifications

Oil Thrower Seal Ring Groove Widths, Small End - continued

RHB5

Standard 1.02 - 1.03 mm (0.0402 - 0.0406 in.)

Wear Limit 1.11 mm (0.0437 in.)

Large End

RHB3

Standard 1.02 - 1.03 mm (0.0402 - 0.0406 in.)

Wear Limit 1.04 mm (0.0409 in.)

RHB5

Standard 1.22 - 1.23 mm (0.0480 - 0.0484 in.)

Wear Limit 1.31 mm (0.0516 in.)

Seal Plate I.D.s

Side Without Slot

RHB3

Standard 7.968 - 8.00 mm (0.3137 - 0.3150 in.)

Wear Limit 8.015 mm (0.3156 in.)

RHB5

Standard 10.00 - 10.02 mm (0.3937 - 0.3945 in.)

Wear Limit 10.05 mm (0.3957 in.)

Side With Slot

RHB3

Standard 9.987 - 10.025 mm (0.3932 - 0.3947 in.)

Wear Limit 10.04 mm (0.3953 in.)

RHB5

Standard 12.40 - 12.42 mm (0.4882 - 0.4890 in.)

Wear Limit 12.45 mm (0.4902 in.)

Thrust Bushing Shoulder Length

RHB3

Standard 3.632 - 3.642 mm (0.1430 - 0.1434 in.)

Wear Limit 3.650 mm (0.1437 in.)

RHB5

Standard 4.04 - 4.05 mm (0.1591 - 0.1594 in.)

Wear Limit 4.07 mm (0.1602 in.)

Thrust Bearing Thickness

RHB3

Standard 3.59 - 3.61 mm (0.1413 - 0.1421 in.)

Wear Limit 3.58 mm (0.1409 in.)

RHB5

Standard 3.99 - 4.01 mm (0.1571 - 0.1579 in.)

Wear Limit 3.98 mm (0.1567 in.)

Journal Bearing I. D.

RHB3

Standard 6.275 - 6.285 mm (0.2470 - 0.2474 in.)

Wear Limit 6.290 mm (0.2476 in.)

RHB5

Standard 8.01 - 8.03 mm (0.3154 - 0.3161 in.)

Wear Limit 8.04 mm (0.3165 in.)

Journal Bearing O.D.

RHB3

Standard 9.940 - 9.946 mm (0.3913 - 0.3916 in.)

Wear Limit 9.930 mm (0.3909 in.)

0

Journal Bearing O. D. - continued

RHB5

Standard 12.32 - 12.33 mm (0.4850 - 0.4854 in.)

Wear Limit 12.31 mm (0.4846 in.)

Seal Ring Surface I.D.

RHB3

Standard 11.00 - 11.018 mm (0.4331 - 0.4338 in.)

Wear Limit 11.03 mm (0.4343 in.)

RHB5

Standard 15.00 - 15.02 mm (0.5906 - 0.5913 in.)

Wear Limit 15.05 mm (0.5925 in.)

Journal Bearing Surface I.D.

RHB3

Standard 9.995 - 10.005 mm (0.3935 - 0.3939 in.)

Wear Limit 10.01 mm (0.3941 in.)

RHB5

Standard 12.40 - 12.41 mm (0.4882 - 0.4886 in.)

Wear Limit 12.42 mm (0.4890 in.)

Fan/Alternator Belt

Applied Force 98 N (22 lb-force)

Belt Deflection 10 - 15 mm (0.400 - 0.600 in.)

Glow Plug Resistance 1.35 - 1.65 ohms

Coolant Temperature Sender Continuity 110° C (230° F)

Operational Tests and Adjustments

Radiator Bubble Test

Maximum Air Pressure Into Cylinder

3009 (3TNA72). 2455 kPa (356 psi)

3011 (3TNC78), 3014 (3TN84), 4019 (4TN84). 2158 kPa (313 psi)

Cooling System

Maximum Pressure 97 kPa (14 psi)

Minimum Pressure after 10 Seconds 88 kPa (12.8 psi)

Radiator Cap

Valve Opening Pressure 88 kPa (12.8 psi)

Cylinder Compression Pressure - 3009

Compression Pressure. 2455 kPa (356 psi)

Maximum Difference Between Cylinders 490 kPa (71 psi)

Cylinder Compression Pressure - 3011, 3014, 4019

Compression Pressure. 2158 kPa (313 psi)

Maximum Difference Between Cylinders 490 kPa (71 psi)

Engine Oil Pressure

Low Idle Speed

Industrial Application

All 1300 rpm

Generator Application

3009 (3TNA72). 1300 rpm

3011 (3TNC78), 3014 (3TN84), 4019 (4TN84). 1200 rpm

Engine Oil Pressure 147 kPa (21 psi)

Air Intake System Holding Pressure. 34 - 69 kPa (5 - 10 psi)

Fuel Supply Pump Pressure (minimum). 29 kPa (4.3 psi)

Fuel System Holding Pressure (maximum) 103 kPa (15 psi)

Specifications

Slow Idle Speed

Industrial Application

All 1300 rpm

Generator Application

3009 (3TNA72) 1300 rpm

3011 (3TNC78), 3014 (3TN84), 4019 (4TN84) 1200 rpm

Fast Idle Speed - 3009

Industrial Application 3300 rpm

Generator Application 3800 rpm

Fast Idle Speed - 3011, 3014 and 4019

Industrial Application 3300 rpm

Generator Application 1900 rpm

Fuel Shutoff Solenoid

Maximum Pull-in Amperage 50 Amps for 1/2 second

Maximum Hold-In Amperage 1 amp continuous

Starter

Amp Draw/RPM

3009 (3TNA72) 200 Amps at 300 rpm

3011 (3TNC78) and 3014 (3TN84) 230 Amps at 300 rpm

4019 (4TN84) 350 Amps at 1100 rpm

No-Load Amp Draw RPM

3009 (3TNA72) 60 Amps at 7000 rpm

3011 (3TNC78) and 3014 (3TN84) 90 Amps at 3000 rpm

4019 (4TN84) 90 Amps at 3500 rpm

Regulated Amperage

Fast Idle Speed

Industrial Application

All 3300 rpm

Generator Application

3009 (3TNA72) 3800 rpm

3011 (3TNC78), 3014 (3TN84), 4019 (4TN84) 1900 rpm

Minimum Regulated Amperage 35 amps

Unregulated Amperage

Fast Idle Speed

Industrial Application

All 3300 rpm

Generator Application

3009 (3TNA72) 3800 rpm

3011 (3TNC78), 3014 (3TN84), 4019 (4TN84) 1900 rpm

Minimum Regulated Amperage 35 amps

Regulated Voltage

Fast Idle Speed

Industrial Application

All 3300 rpm

Generator Application

3009 (3TNA72) 3800 rpm

3011 (3TNC78), 3014 (3TN84), 4019 (4TN84) 1900 rpm

Regulated Voltage 12.2 - 14.7 VDC

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).

*DFRG1 Extended Indicator Tip (RHB3)

Attach to a dial indicator gauge to check radial play of turbocharger rotor shaft.

*DFRG2 Extended Indicator Tip (RHB5)

Attach to a dial indicator gauge to check radial play of turbocharger rotor shaft.

OTHER MATERIALS

Number	Name	Use
LOCTITE® PRODUCTS		
U.S./		
Canadian/		
LOCTITE No.		
TY9370/ TY9477/ #242	Thread Lock and Sealer (Medium Strength)	Apply to threads of turbocharger thrust bearing and seal plate mounting screws.
TY15130/ NA/ #395	John Deere Form-In-Place Gasket	Seals turbocharger seal plate and compressor housing to center housing.

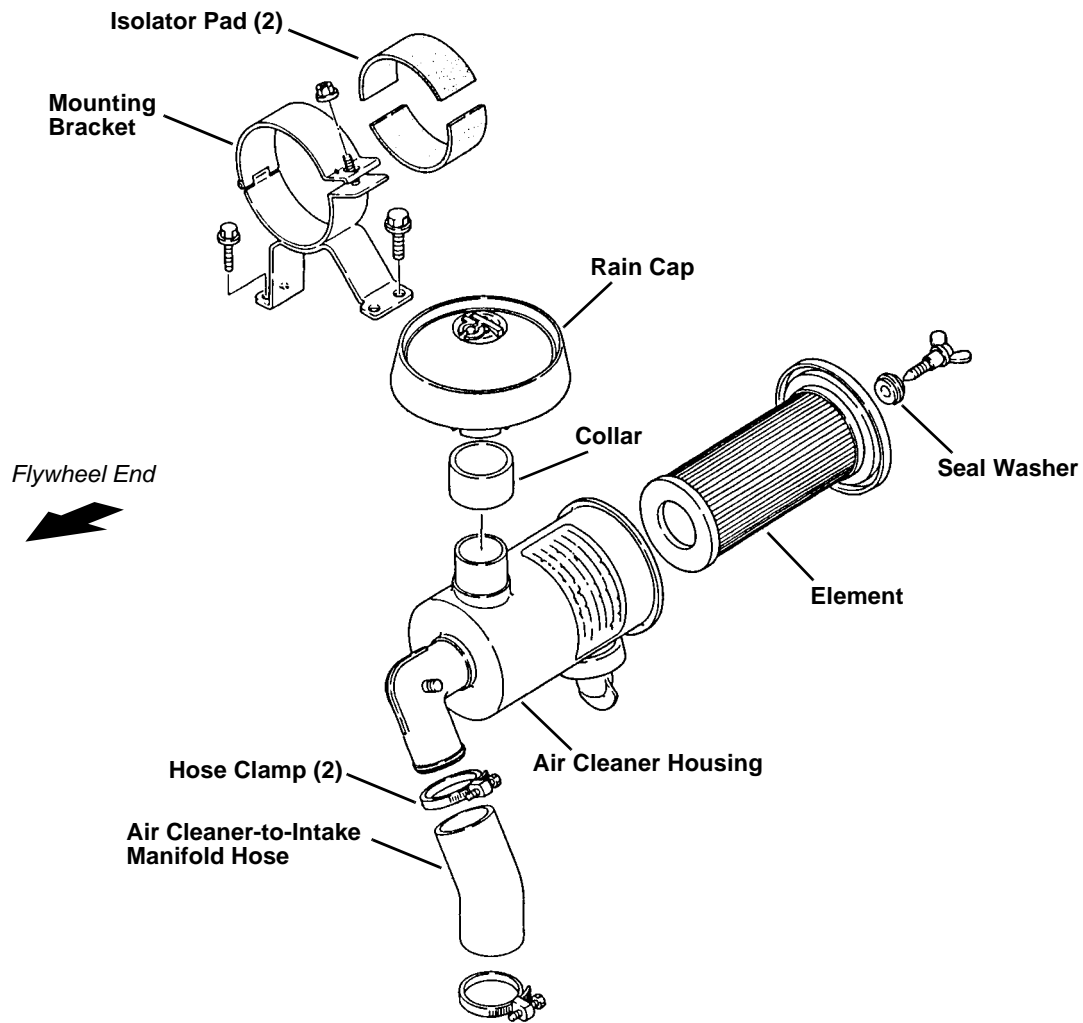
* *Fabricated tool, dealer made. (See Dealer Fabricated Tools in this section for instruction to make tools.)*

® *LOCTITE is a registered trademark of the Loctite Corp.*

Intake and Exhaust Systems

AIR CLEANER - 3009 (3TNA72)

Inspection

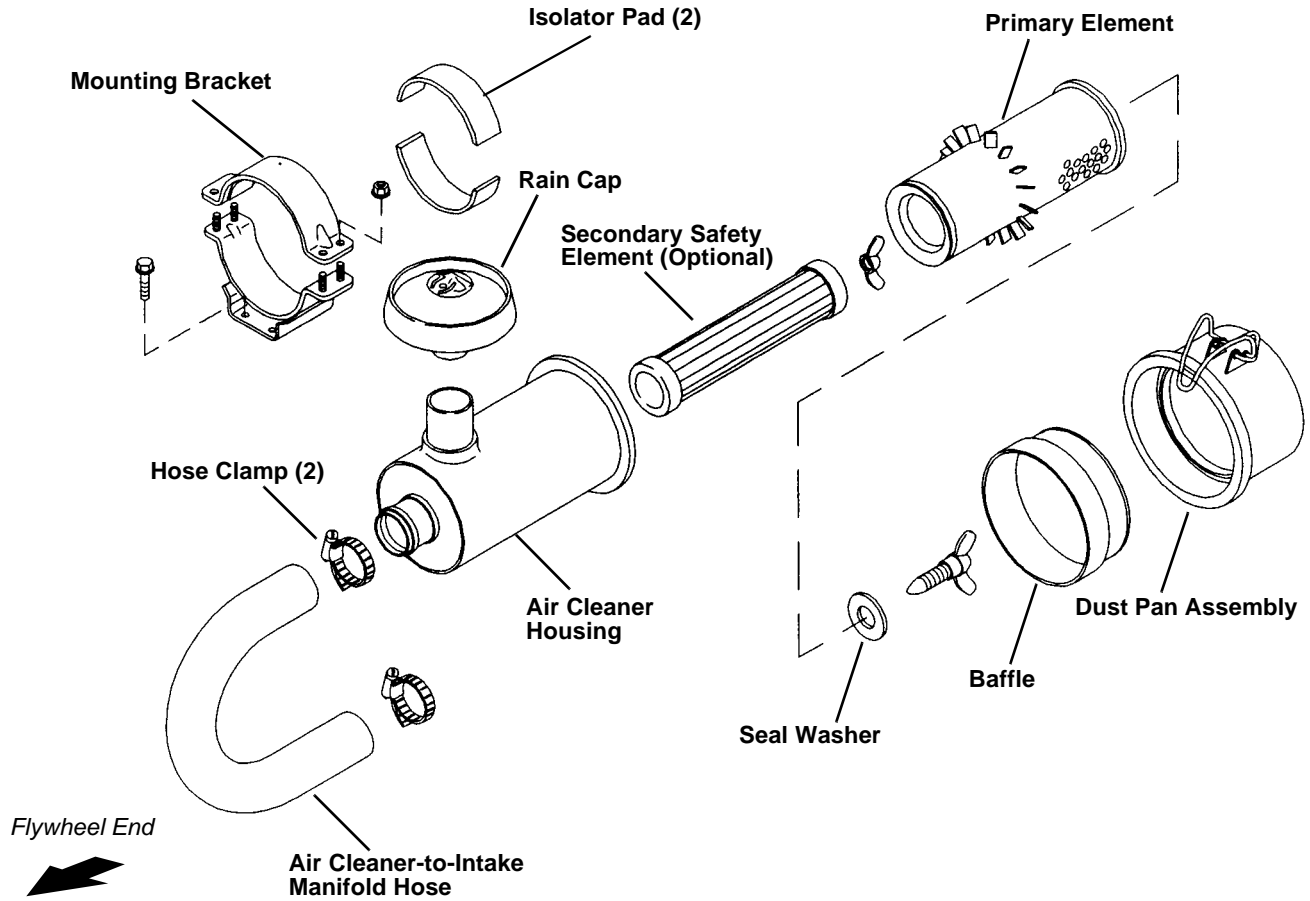


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AIR CLEANER - 3011(3TNC78), 3014 (3TN84) AND 4019D (4TN84)

Inspection



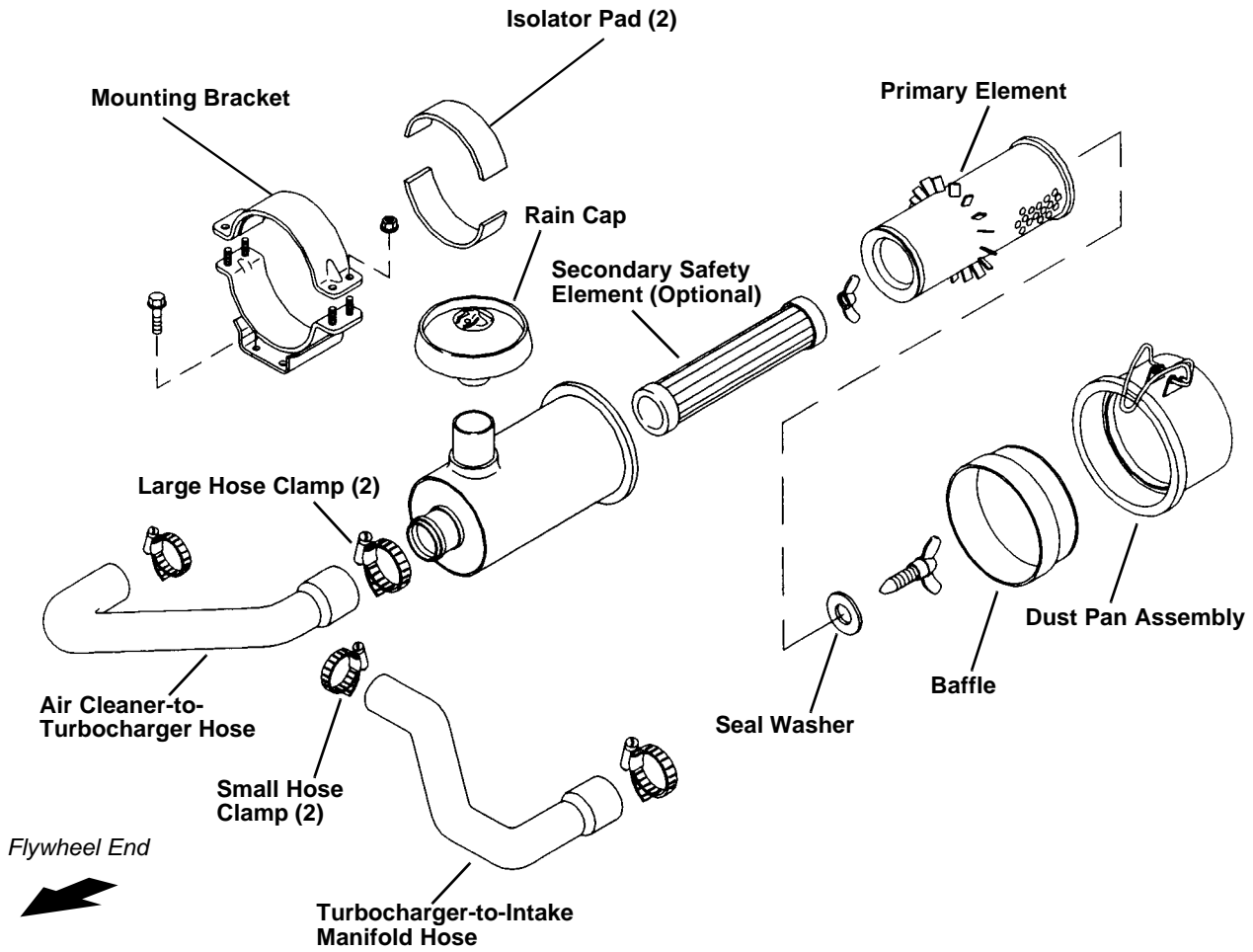
M82183AE

Intake and Exhaust Systems

AIR CLEANER - 4019T (4TN84T)

Inspection

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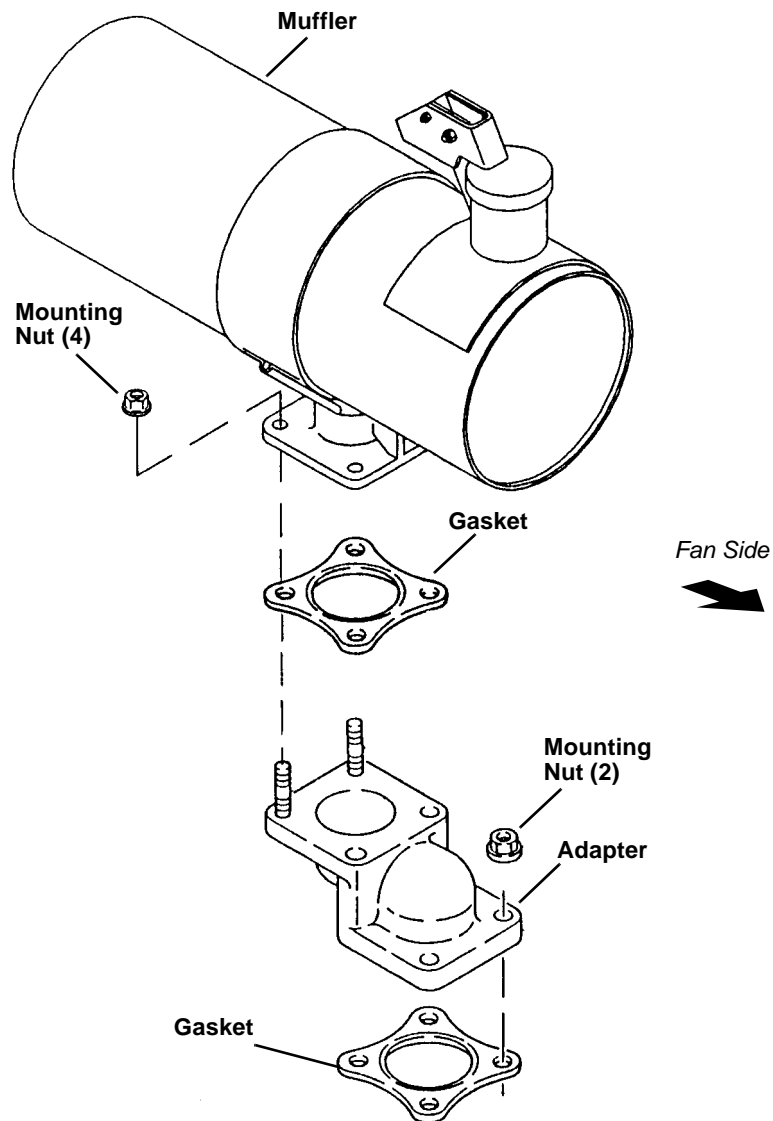
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MUFFLER - 3009 (3TNA72)

Removal/Installation

CAUTION

Muffler may be hot. Allow muffler to cool before removing. A hot muffler can cause serious burns.



M82188AE

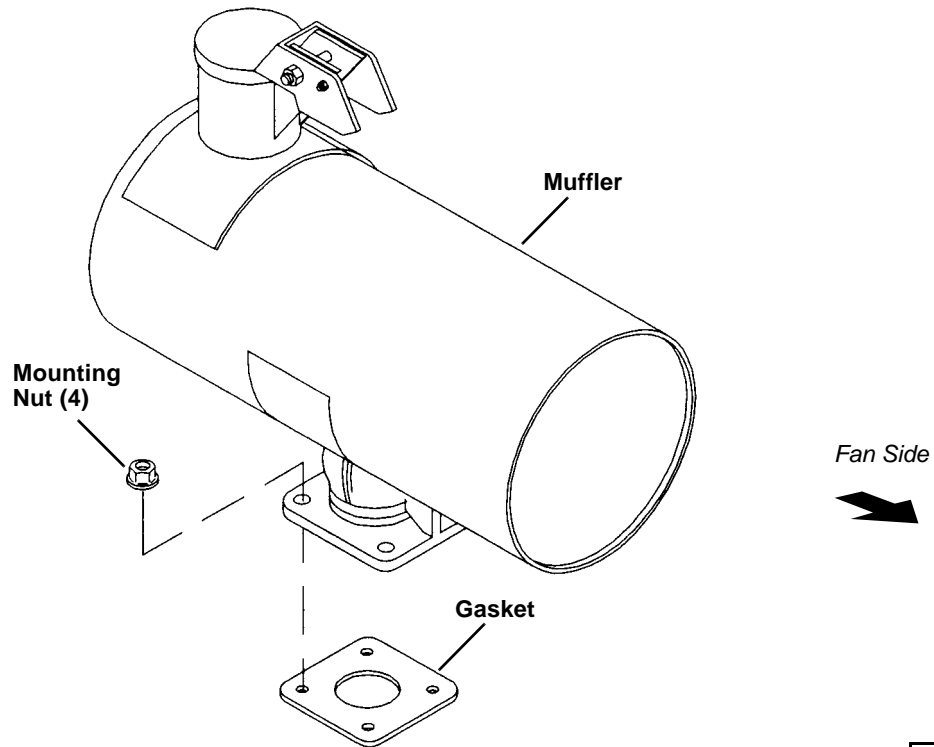
Intake and Exhaust Systems

MUFFLER - 3011 (3TNC78), 3014 (3TN84) AND 4019D (4TN84)

Removal/Installation

CAUTION

Muffler may be hot. Allow muffler to cool before removing. A hot muffler can cause serious burns.



M82127AE

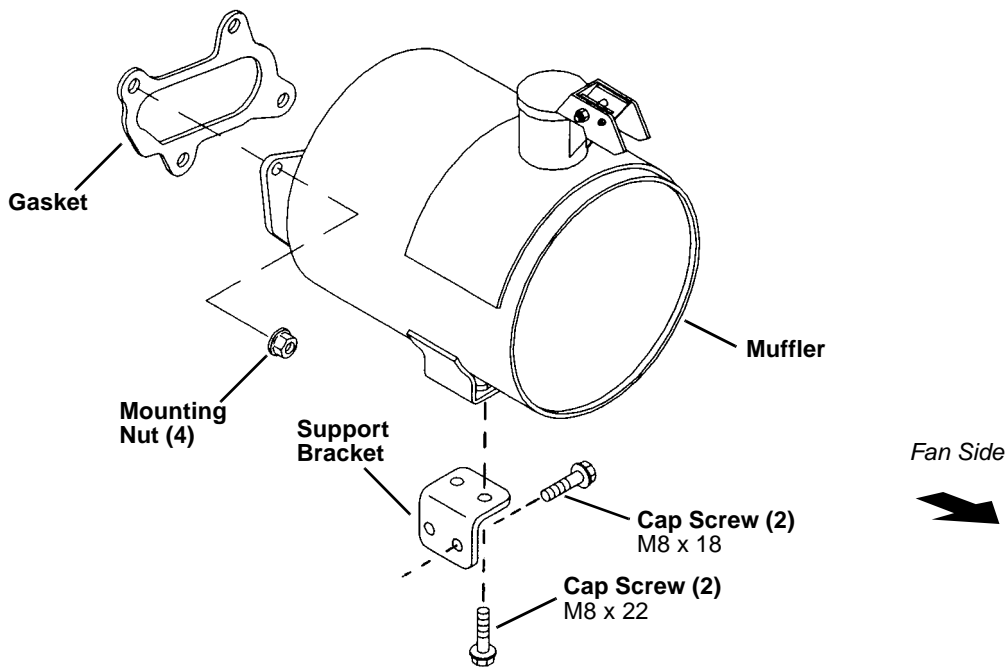
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MUFFLER - 4019T (4TN84T)

Removal/Installation

CAUTION

Muffler may be hot. Allow muffler to cool before removing. A hot muffler can cause serious burns.



M82128AE

EXTENDING TURBOCHARGER LIFE

Turbochargers are designed to last the life of the engine, but, because they operate at such high speeds (100,000 rpm or more); a moment's carelessness can cause them to fail in seconds.

The major causes of turbocharger failures are attributed to:

- Lack of lube oil (quick starts and hot shutdowns)
- Oil contamination
- Ingestion of foreign objects
- Restricted oil drainage
- Low oil level
- Operation on excessive side slopes
- Abnormally high exhaust temperatures

Lack of Lube Oil

Oil not only lubricates the turbo's spinning shaft and bearings, it also carries away heat. When oil flow stops or is reduced, heat is immediately transferred from the hot turbine wheel to the bearings, which are also heating up because of the increased friction due to the lack of oil. This combination causes the turbo shaft temperature to increase rapidly.

If oil flow does not increase and the process continues, bearings will fail. Once the bearings fail (which can happen in seconds) seals, shaft, turbine and compressor wheels can also be damaged.

The principle causes of turbo bearing lubrication problems are low oil pressure, a bent, plugged or undersized oil lube supply line, plugged or restricted oil galleries in the turbo, or improper machine start-up and shutdown procedures.

Oil levels and pressure should always be closely monitored. All worn hoses and lines should be replaced. The turbo oil supply line should be checked frequently to make sure it is not kinked or bent. It should always be replaced with a line of equal size, length and strength.

The easiest way to damage a turbo is through improper start-up and shutdown procedures. Always idle the engine for at least 30 seconds (no load) after start-up and before shutdown. Warming the engine up before applying a load allows oil pressure to build up and lines to fill with oil.

Idling the engine before shutdown allows the engine and turbo to cool. "Hot" shutdowns can cause the turbo to fail. After high-speed operation the turbo will continue to rotate long after the engine has been shut off and oil pressure has dropped to zero. This will cause heat to build up and create possible bearing damage. It can also cause carbon and varnish deposits to form.

Oil Contamination

A second cause of turbo failure is contaminated oil. It can be caused by a worn or damaged oil filter or not changing the lube oil at recommended intervals. Expecting the oil filter to remove dirt, sand, metal chips, ect. from the oil before they reach the engine or turbocharger can be a costly mistake. Contaminated oil may completely bypass the engine oil filter if; the oil filter or oil cooler is clogged, the filter is improperly installed, or the oil is thick during cold weather.

Four good ways of avoiding oil contamination are:

- Always inspect the engine thoroughly during a 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.

Injection of Foreign Objects

The third cause of turbo damage is the injection of foreign objects. Foreign objects or particles can be injected and cause damage to the turbo on both compressor and turbine sides. This is easy to avoid.

On the compressor side, foreign objects usually take the form of dust, sand, or shreds of air cleaner element that enter through improperly installed air cleaner elements. Leaky air inlet piping (loose clamps or torn rubber joints) or torn pleats in dry-type air cleaner elements also create problems.

The result is erosion of compressor blades that can cause the delicately balanced wheel to wobble.

IMPORTANT: Whenever an internal engine failure (valve, valve seat, piston) occurs, a thorough inspection of the turbocharger MUST BE performed before returning engine to service.

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.
- High crankcase pressure, due to restricted crankcase breather or excessive engine blowby.

Periodically check both the turbocharger oil drain tube and engine breather tube for damage or restriction. Correction of these conditions lead to longer turbo life.

Abnormally High Exhaust Temperatures

A fifth cause of turbocharger damage is abnormally high exhaust temperatures. Elevated exhaust temperatures cause choking of oil which can lead to bearing failure. Extreme over-temperature operation can cause wheel burst.

There are two basic causes of over-temperature:

- Restricted air flow.
- 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.

10

Intake and Exhaust Systems

TURBOCHARGER - YANMAR (RHB3 and RHB5)

Removal

NOTE: Model number RHB5 is equipped with a waste gate system. Removal/installation procedures are the same for both. Model RHB3 turbocharger is shown.

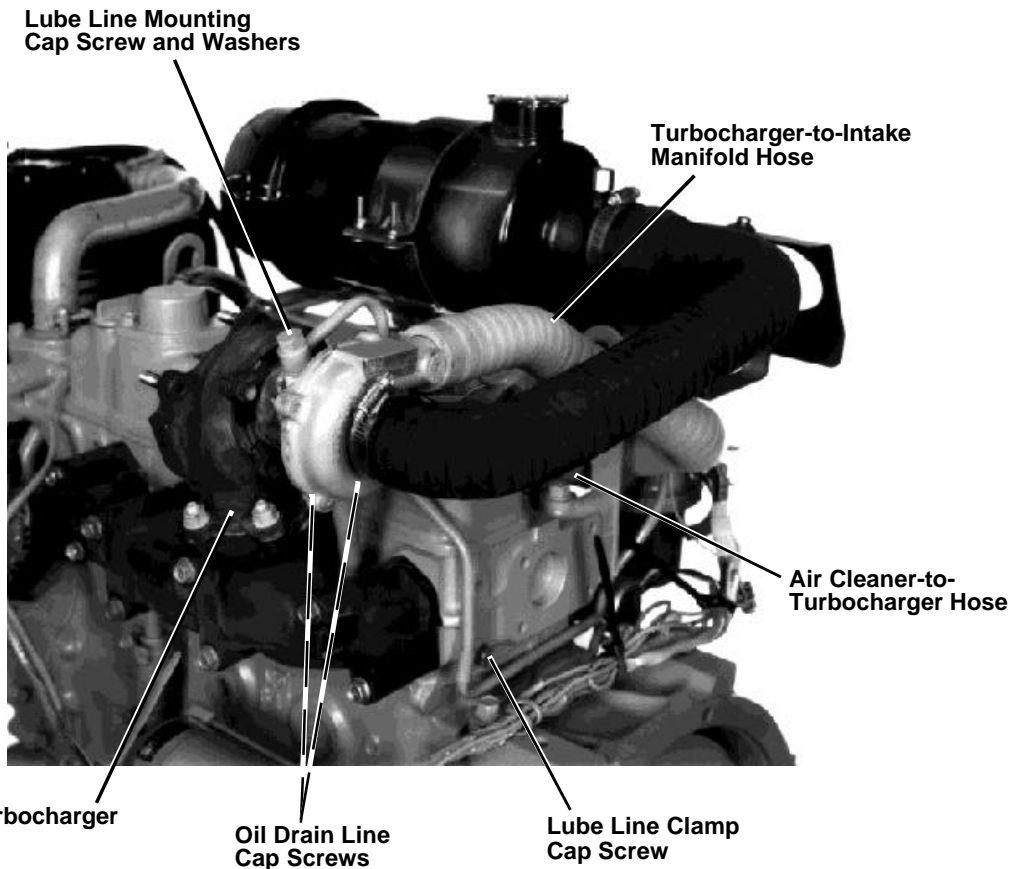
1. Remove muffler. (See procedure in this group.)

CAUTION

Turbocharger may be hot. Allow turbocharger to cool before removing. A hot turbocharger can cause serious burns.

IMPORTANT: When cleaning turbocharger, do not spray directly into compressor or turbine housings. If inspection is required, do not clean exterior of turbocharger prior to removal. Cleaning can remove evidence of a potential failure mode.

2. Remove air cleaner-to-turbocharger hose and clamps.
3. Remove turbocharger-to-intake manifold hose and clamps.
4. Remove lube line clamp cap screw.
5. Remove lube line mounting cap screw and two copper washers.
6. Remove two oil drain line cap screws. Disconnect line and remove o-ring.
7. Remove three nuts, turbocharger and gasket.



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8. Diagnose the cause of failure, if necessary. (See *TURBOCHARGER FAILURE ANALYSIS*.)
9. Inspect turbocharger. (See *TURBOCHARGER SEVEN-STEP INSPECTION*.)
10. Check rotor shaft axial and radial play. (See *Rotor Shaft Axial and Radial Play Check* procedures.)
11. Disassemble and inspect all parts for wear or damage, if necessary. (See *Disassembly* procedures.)

Installation

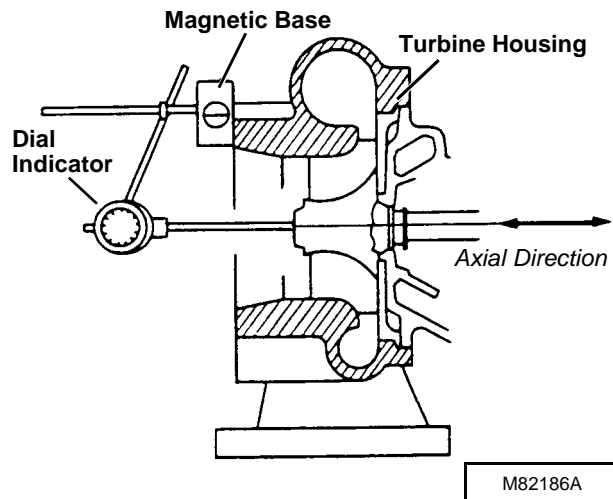
1. Prelube turbocharger: Fill oil inlet or drain port with clean oil and turn rotating assembly (by hand) to properly lubricate bearings.
2. Install new gasket, turbocharger and three nuts.
3. Install new o-ring and connect oil drain line. Install and tighten two mounting cap screws.
4. Install two new copper washers and lube line mounting cap screw.
5. Install lube line clamp cap screw.
6. Install turbocharger-to-intake manifold hose and clamps.
7. Install air cleaner-to-turbocharger hose and clamps.
8. Install muffler. (See procedure in this group.)

IMPORTANT: A new or repaired turbocharger does not have an adequate oil supply for immediate start-up of engine. Perform the following steps to prevent damage to turbocharger bearings.

9. Push the throttle lever to the "STOP" position or disconnect fuel shutoff solenoid connector, if equipped.
10. Crank engine over with starter until oil pressure gauge needle registers within the "GREEN" zone of pressure gauge. DO NOT crank engine longer than 30 seconds at a time to avoid damaging the starter.

Rotor Shaft Axial Play Check

1. Fasten dial indicator to turbine housing and position indicator tip on end of rotor shaft at turbine housing end.
2. Move rotor shaft in axial direction. Record measurement.



Axial Play Specifications: Without Waste Gate (RHB3)

Standard 0.022 - 0.053 mm
 (0.0008 - 0.0021 in.)
 Wear Limit..... 0.07 mm (0.0028 in.)

With Waste Gate (RHB5)

Standard 0.03 - 0.06 mm
 (0.0012 - 0.0024 in.)
 Wear Limit..... 0.09 mm (0.0035 in.)

If axial play is not within specifications, disassemble and inspect all components for wear or damage. (See *Disassembly* procedures.)

Rotor Shaft Radial Play Check

1. Attach DFRG1 or DFRG2 Extended Indicator Tip to Dial Indicator gauge.
2. Fasten dial indicator to bottom of turbocharger mounting flange. Insert extended indicator tip through oil drain opening and position tip on rotor shaft.
3. Hold both turbine and compressor wheels and move rotor shaft in radial direction. Record measurement.

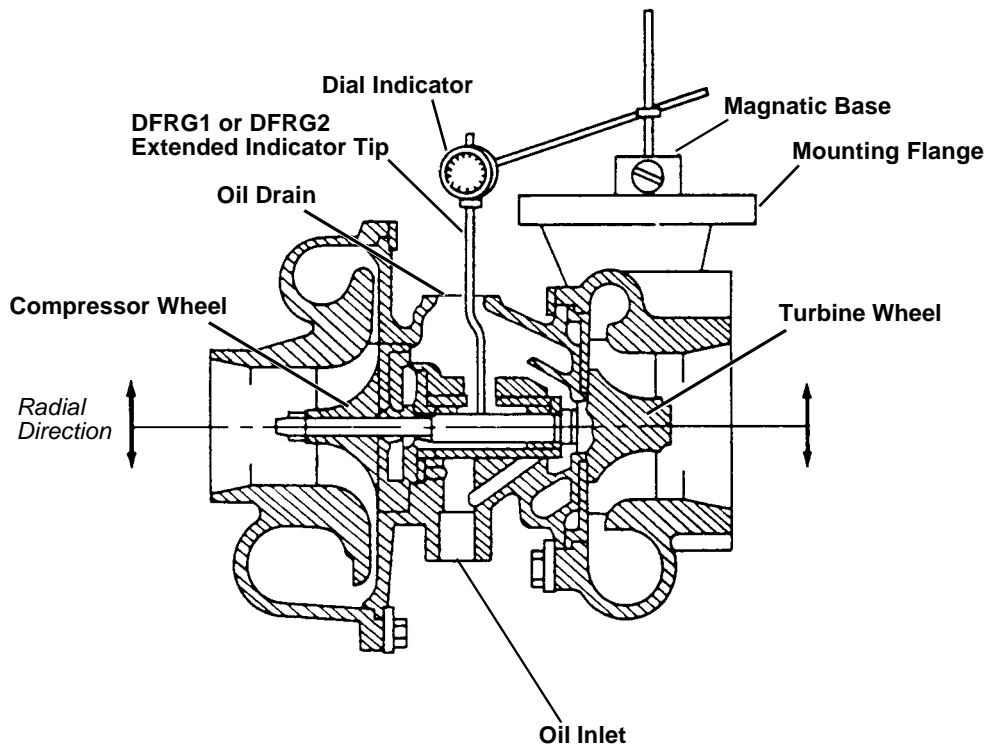
Radial Play Specifications: Without Waste Gate (RHB3)

Standard 0.061 - 0.093 mm
..... (0.0024 - 0.0037 in.)
Wear Limit..... 0.12 mm (0.0047 in.)

With Waste Gate (RHB5)

Standard 0.08 - 0.13 mm
..... (0.0031 - 0.0051 in.)
Wear Limit..... 0.17 mm (0.0067 in.)

If radial play is not within specifications, disassemble and inspect all components for wear or damage. (See *Disassembly* procedures.)

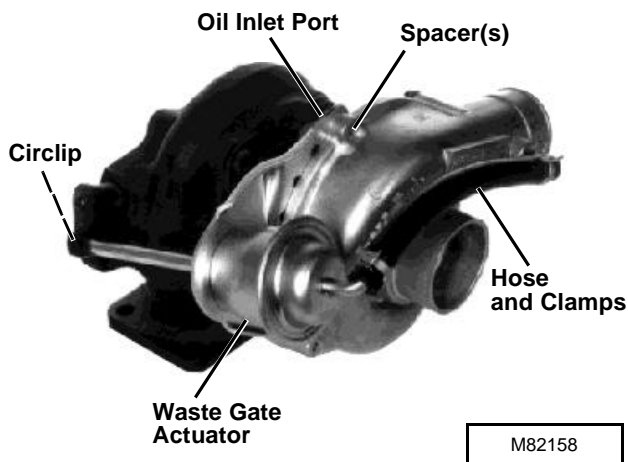


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Disassembly

NOTE: Model number RHB5 is equipped with a waste gate system. Service procedures are the same for both unless noted otherwise. Model RHB5 turbocharger is illustrated throughout service procedures.

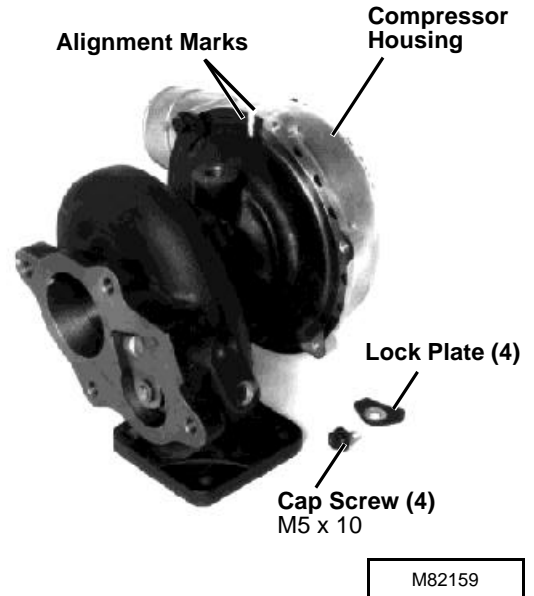
1. Remove circlip and disconnect rod.
2. Remove clamps and hose.
3. Remove two cap screws, waste gate actuator and spacer(s), if equipped.



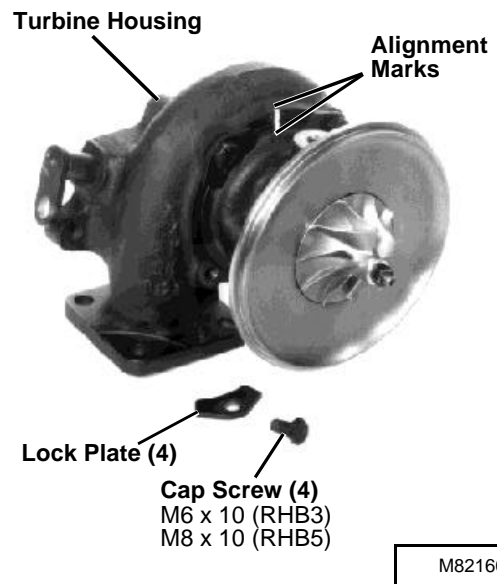
4. Scribe alignment marks across compressor housing and center housing to aid in assembly.
5. Remove four cap screws and lock plates.

IMPORTANT: Be careful when removing compressor housing. Damage to compressor wheel blades can occur.

6. Tap on compressor housing with a plastic hammer to remove from center housing.



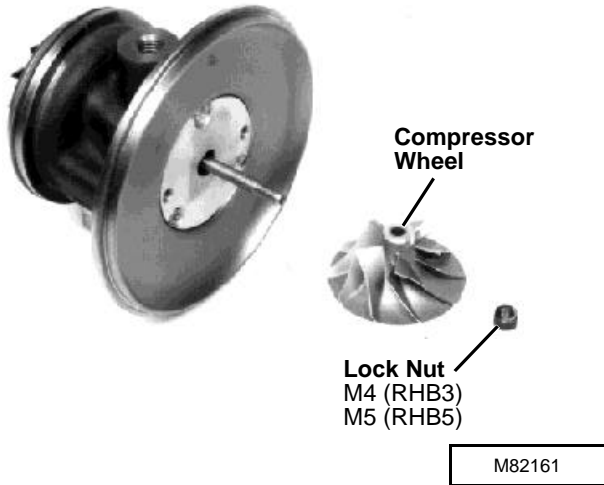
7. Scribe alignment marks across turbine housing and center housing to aid in assembly.
8. Remove four cap screws, lock plates and turbine housing.



Intake and Exhaust Systems

NOTE: Lock nut has left-hand threads.

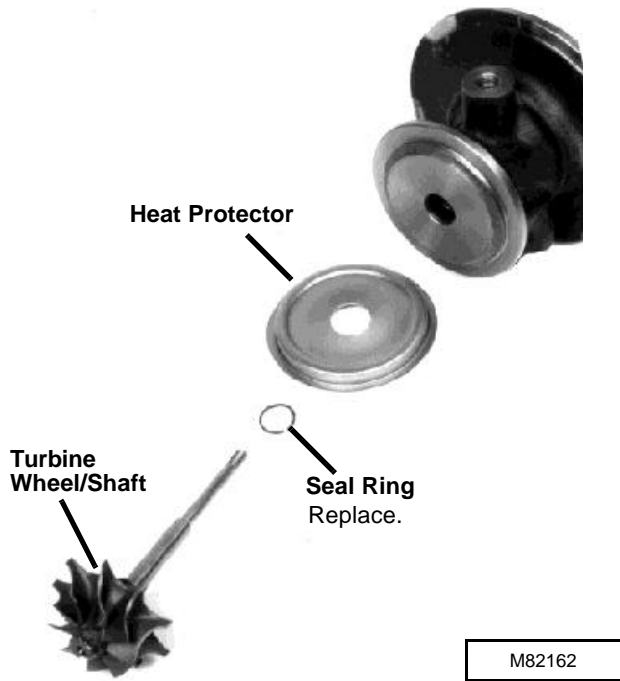
9. Remove lock nut and compressor wheel.



10. Remove turbine wheel/shaft and heat protector.

11. Remove seal ring.

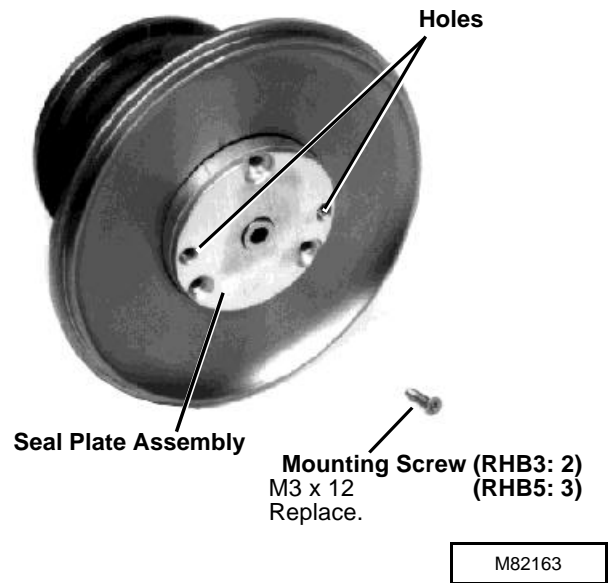
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12. Model RHB3: Tap two holes in seal plate using a 5 mm, 0.80 thread tap.

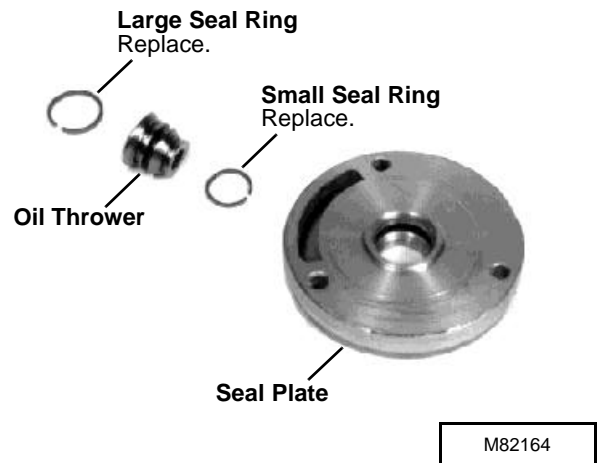
13. Remove seal plate mounting screws.

14. Insert two existing M5 cap screws (compressor housing-to-center housing cap screws) into threaded holes and pull out seal plate.



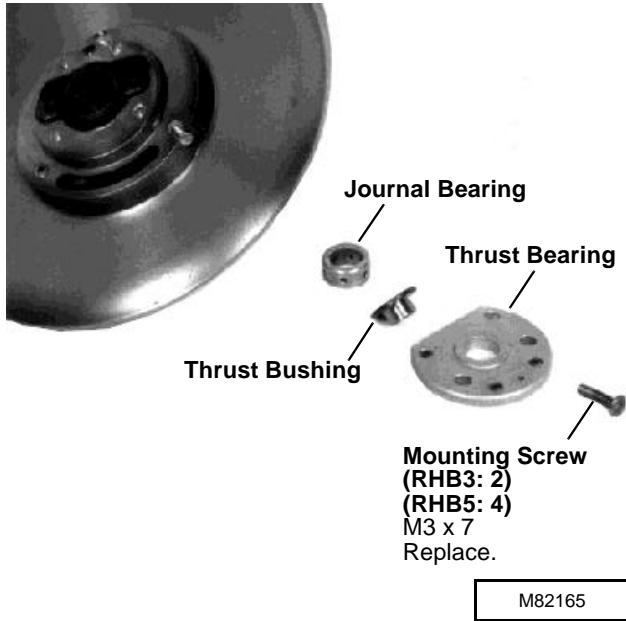
15. Remove oil thrower assembly from seal plate.

16. Remove seal rings.



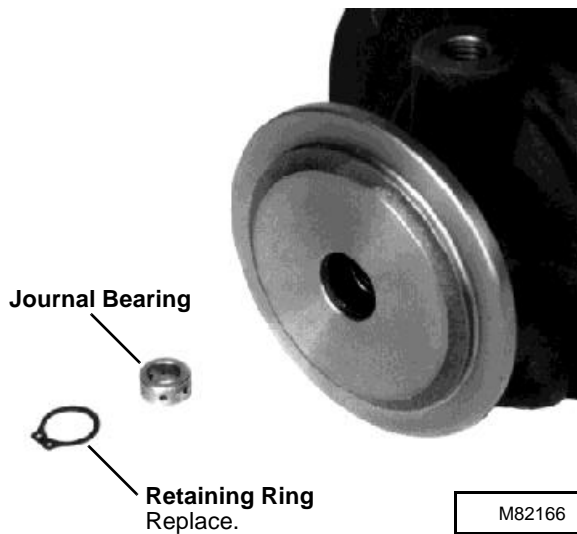
17. Remove thrust bearing mounting screws.

18. Remove thrust bearing, thrust bushing and journal bearing.



19. Remove retaining ring and journal bearing from turbine side.

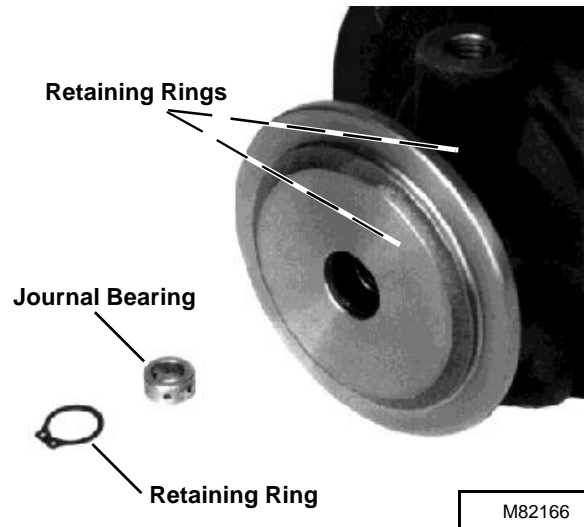
NOTE: There are two retaining rings inside center housing. Remove only if replacement is necessary.



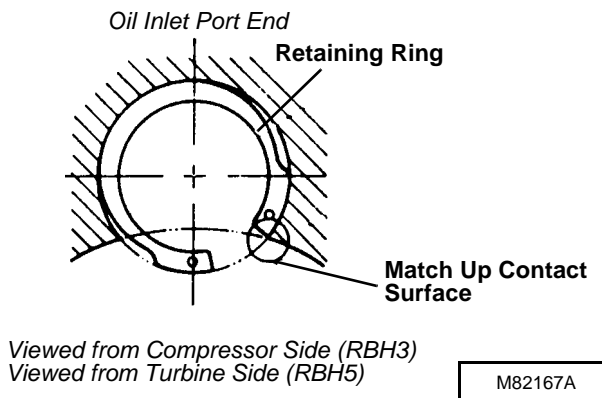
20. Inspect all parts for wear or damage. Replace as necessary. (See *Inspection* procedures.)

Assembly

1. If removed, install two new retaining rings into center housing with “open end” of rings facing toward oil outlet port.
2. Coat journal bearing with clean engine oil and install in center housing.

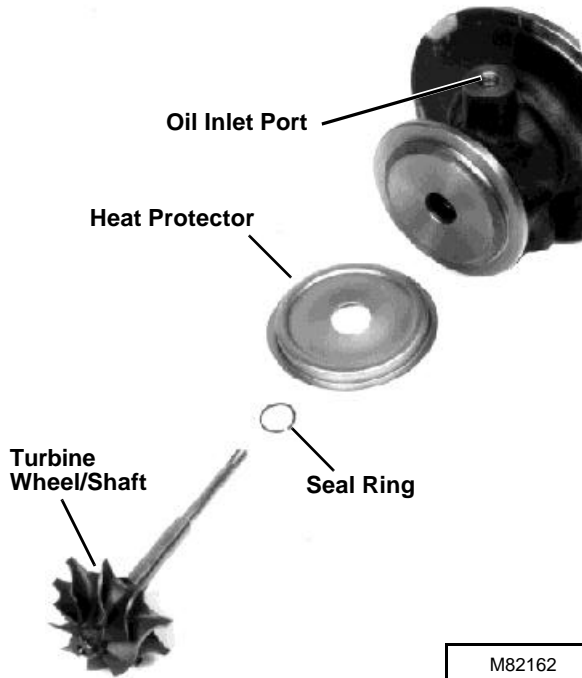


3. Install turbine side retaining ring with beveled edge toward journal bearing and with “open end” in direction shown.



4. Install new seal ring on turbine shaft.
5. Install heat protector and turbine wheel/shaft with “open end” of seal ring facing toward oil inlet port. Turbine wheel/shaft should “snap” into place.

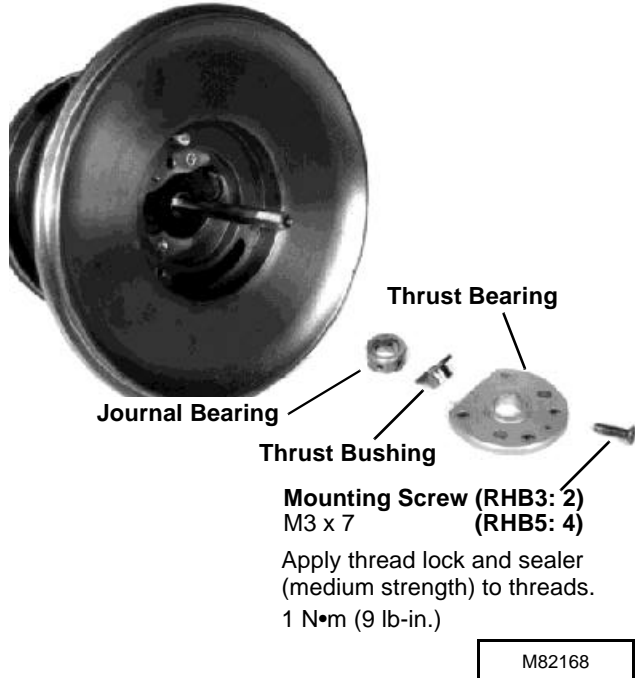
Intake and Exhaust Systems



6. Coat journal bearing and thrust bushing with clean engine oil and install in center housing.

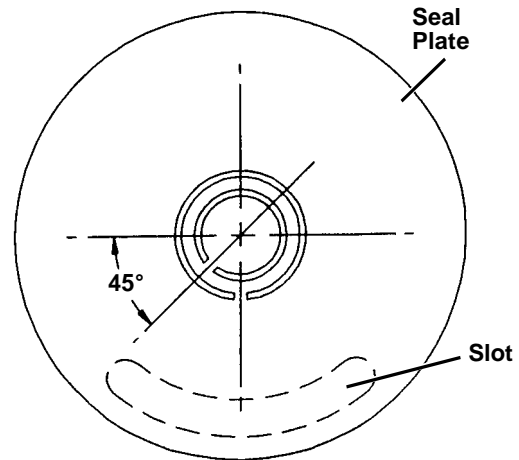
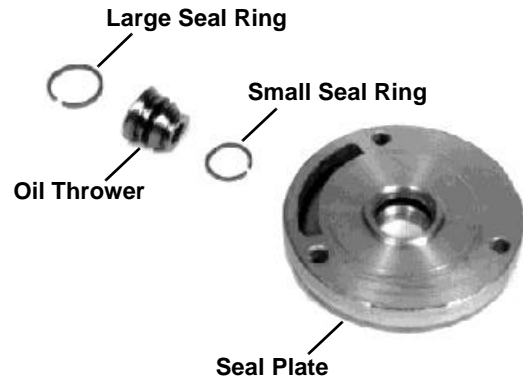
7. Install thrust bearing and mounting screws.

0



8. Install new seal rings on oil thrower.

9. Position seal rings on oil thrower as shown and insert thrower into seal plate. Oil thrower should “snap” into place.



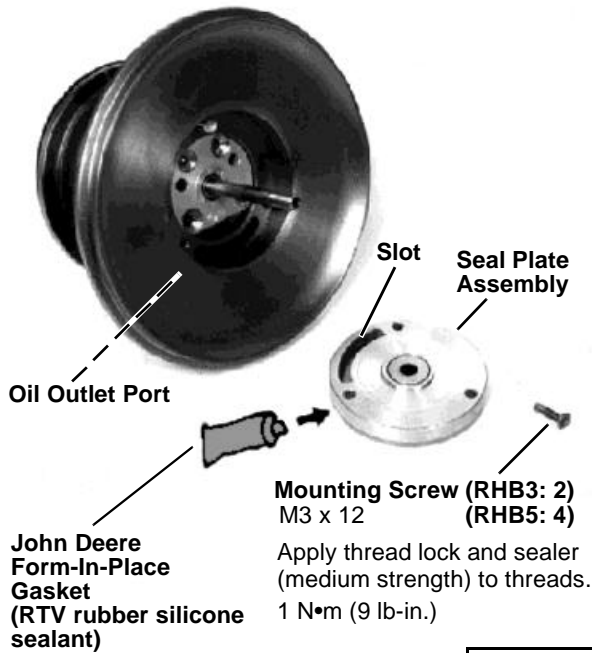
Viewed from Seal Plate Side Without Slot

M82169A

10. Clean mating surfaces of center housing and seal plate assembly using Clean and Cure Primer.

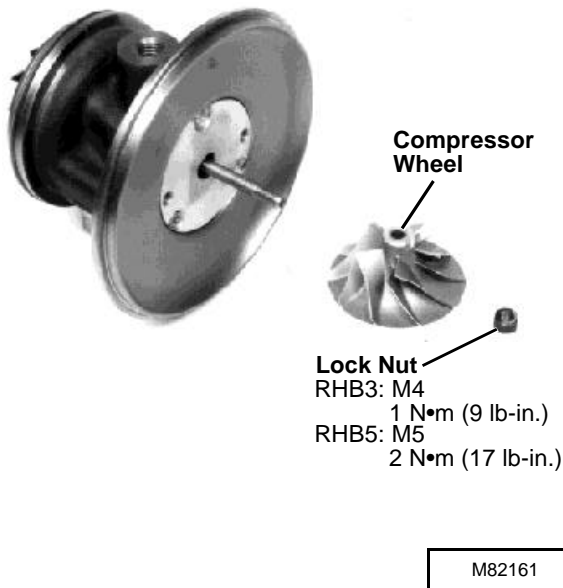
11. Install seal plate assembly with slot toward oil outlet port.

12. Install mounting screws.



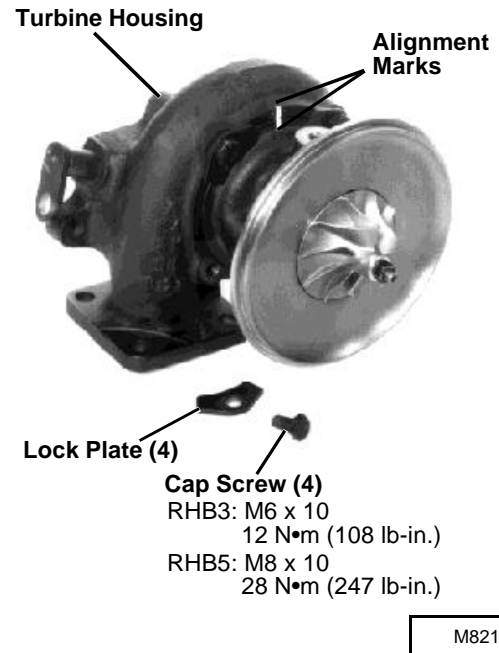
NOTE: Lock nut has left-hand threads.

13. Install compressor wheel and lock nut.



14. Install turbine housing.

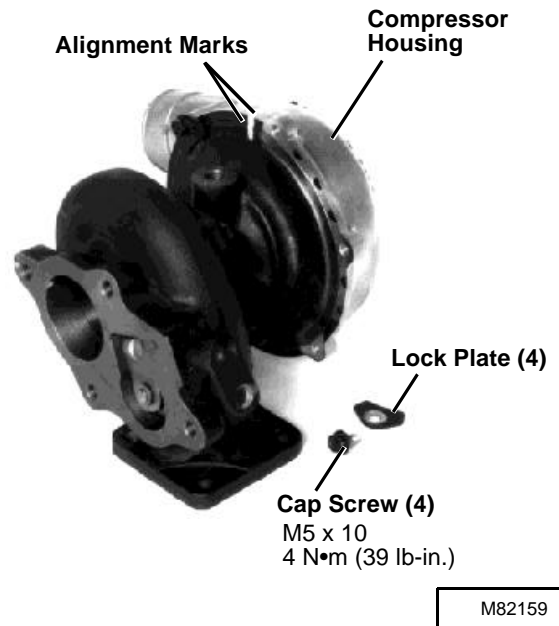
15. Align marks made during disassembly and install lock plates and cap screws.



16. Clean mating surfaces of center housing and compressor housing using Clean and Cure Primer. Apply a coat of John Deere Form-In-Place Gasket (RTV rubber silicone sealant) on compressor housing.

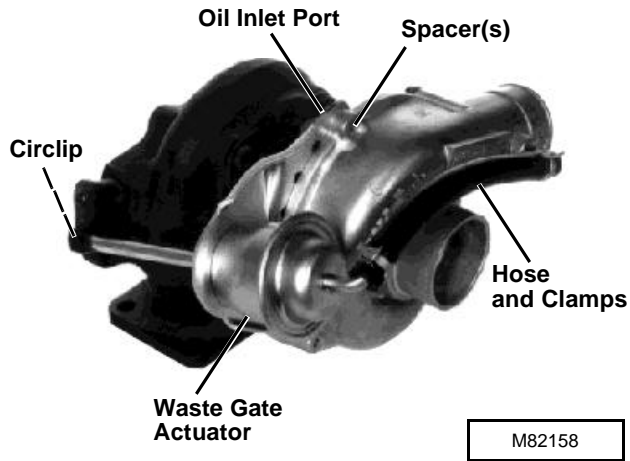
17. Install compressor housing.

18. Align marks made during disassembly and install lock plates and cap screws.



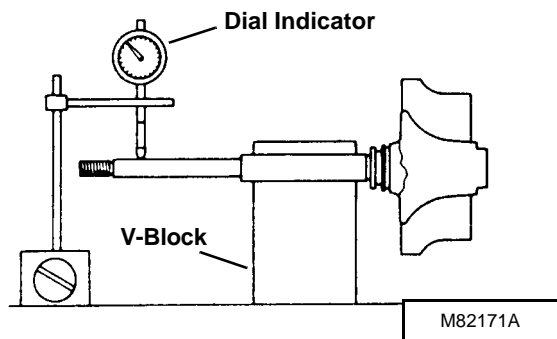
Intake and Exhaust Systems

19. Install spacer(s), if equipped, waste gate actuator and two cap screws. Tighten cap screws to **4 N•m (39 lb-in.)**.
20. Install hose and clamps.
21. Connect rod and install circlip.
22. Prelube turbocharger: Fill oil inlet or drain port with clean oil and turn rotating assembly (by hand) to properly lubricate bearings.



0 Inspection

1. Inspect all parts for wear or damage. Replace as necessary.
2. Inspect turbine wheel/shaft for bend using v-block and a dial indicator. Turn wheel/shaft slowly and read variation on indicator.



Turbine Wheel/Shaft Deflection:

RHB3

Standard **0.002 mm (0.00008)**

Wear Limit **0.005 mm (0.00019)**

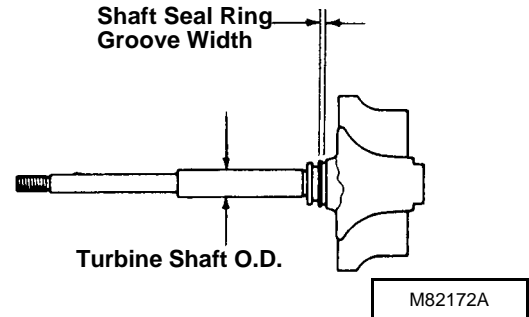
RHB5

Standard **0.010 mm (0.00039)**

Wear Limit **0.011 mm (0.00043)**

If variation is more than wear limit, replace wheel/shaft.

3. Measure turbine shaft diameter and seal ring groove width.



Turbine Shaft O.D.:

RHB3

Standard **6.257 - 6.263 mm**
..... **(0.2463 - 0.2466 in.)**

Wear Limit **6.250 mm (0.2461 in.)**

RHB5

Standard **7.99 - 8.00 mm**
..... **(0.3146 - 0.3150 in.)**

Wear Limit **7.980 mm (0.3142 in.)**

Shaft Seal Ring Groove Width:

RHB3

Standard **1.038 - 1.062 mm**
..... **(0.0409 - 0.0418 in.)**

Wear Limit **1.070 mm (0.0421 in.)**

RHB5

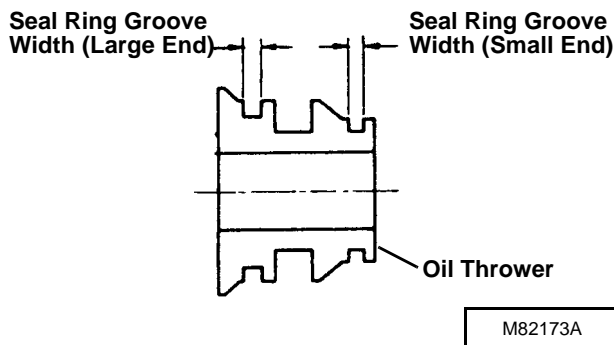
Standard **1.250 - 1.280 mm**
..... **(0.0492 - 0.0504 in.)**

Wear Limit **1.290 mm (0.0508 in.)**

If turbine shaft diameter is less than wear limit, replace turbine wheel/shaft and journal bearings.

If ring groove width is greater than wear limit, replace turbine wheel/shaft.

4. Measure seal ring groove widths in oil thrower.



Oil Thrower Seal Ring Groove Widths:

Small End

RHB3

Standard 0.82 - 0.83 mm
 (0.0323 - 0.0327 in.)
 Wear Limit..... 0.84 mm (0.0331 in.)

RHB5

Standard 1.02 - 1.03 mm
 (0.0402 - 0.0406 in.)
 Wear Limit..... 1.11 mm (0.0437 in.)

Large End

RHB3

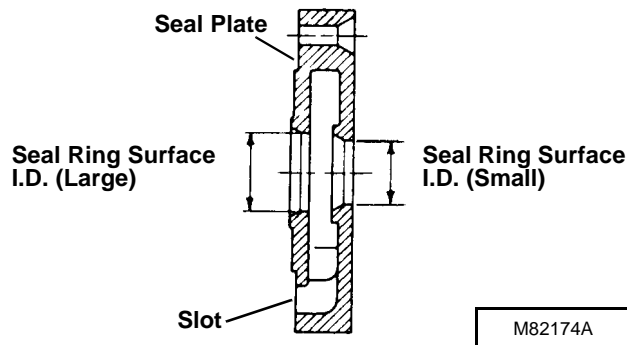
Standard 1.02 - 1.03 mm
 (0.0402 - 0.0406 in.)
 Wear Limit..... 1.04 mm (0.0409 in.)

RHB5

Standard 1.22 - 1.23 mm
 (0.0480 - 0.0484 in.)
 Wear Limit..... 1.31 mm (0.0516 in.)

If either ring groove width is greater than wear limit, replace oil thrower.

5. Measure inside diameters (seal ring surfaces) of seal plate.



Seal Plate I.D.s:

Side Without Slot

RHB3

Standard 7.968 - 8.00 mm
 (0.3137 - 0.3150 in.)
 Wear Limit..... 8.015 mm (0.3156 in.)

RHB5

Standard 10.00 - 10.02 mm
 (0.3937 - 0.3945 in.)
 Wear Limit..... 10.05 mm (0.3957 in.)

Side With Slot

RHB3

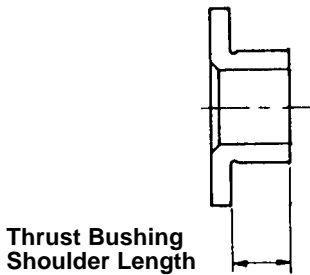
Standard 9.987 - 10.025 mm
 (0.3932 - 0.3947 in.)
 Wear Limit..... 10.04 mm (0.3953 in.)

RHB5

Standard 12.40 - 12.42 mm
 (0.4882 - 0.4890 in.)
 Wear Limit..... 12.45 mm (0.4902 in.)

If either inside diameter is less than wear limit, replace seal plate.

6. Measure length of thrust bushing shoulder.



M82175A

Thrust Bushing Shoulder Length:
RHB3

Standard 3.632 - 3.642 mm
 (0.1430 - 0.1434 in.)
 Wear Limit..... 3.650 mm (0.1437 in.)

RHB5

Standard 4.04 - 4.05 mm
 (0.1591 - 0.1594 in.)
 Wear Limit..... 4.07 mm (0.1602 in.)

0 If shoulder length is more than wear limit, replace thrust bushing.

7. Measure thrust bearing thickness.

Thrust Bearing Thickness:
RHB3

Standard 3.59 - 3.61 mm
 (0.1413 - 0.1421 in.)
 Wear Limit..... 3.58 mm (0.1409 in.)

RHB5

Standard 3.99 - 4.01 mm
 (0.1571 - 0.1579 in.)
 Wear Limit..... 3.98 mm (0.1567 in.)

If bearing thickness is less than wear limit, replace thrust bearing.

8. Measure outside and inside diameters of journal bearings.

Journal Bearing I.D.:

RHB3

Standard 6.275 - 6.285 mm
 (0.2470 - 0.2474 in.)
 Wear Limit..... 6.290 mm (0.2476 in.)

RHB5

Standard 8.01 - 8.03 mm
 (0.3154 - 0.3161 in.)
 Wear Limit..... 8.04 mm (0.3165 in.)

Journal Bearing O.D.:

RHB3

Standard 9.940 - 9.946 mm
 (0.3913 - 0.3916 in.)
 Wear Limit..... 9.930 mm (0.3909 in.)

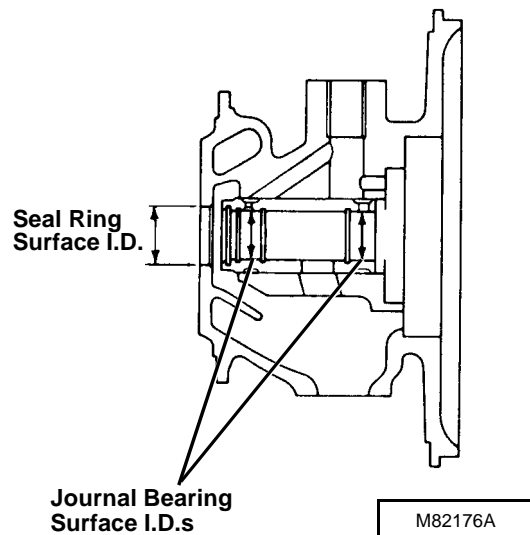
RHB5

Standard 12.32 - 12.33 mm
 (0.4850 - 0.4854 in.)
 Wear Limit..... 12.31 mm (0.4846 in.)

If inside diameter is more than wear limit, replace both journal bearings and turbine wheel/shaft.

If outside diameter is less than wear limit, replace both journal bearings, turbine wheel/shaft and center housing.

9. Inspect center housing for cracks or damage. Measure inside diameters (seal ring surface and journal bearing surfaces) of center housing.



Seal Ring Surface I.D.:

RHB3

Standard 11.00 - 11.018 mm
.....(0.4331 - 0.4338 in.)
Wear Limit..... 11.03 mm (0.4343 in.)

RHB5

Standard 15.00 - 15.02 mm
.....(0.5906 - 0.5913 in.)
Wear Limit..... 15.05 mm (0.5925 in.)

Journal Bearing Surface I.D.:

RHB3

Standard 9.995 - 10.005 mm
.....(0.3935 - 0.3939 in.)
Wear Limit..... 10.01 mm (0.3941 in.)

RHB5

Standard 12.40 - 12.41 mm
.....(0.4882 - 0.4886 in.)
Wear Limit..... 12.42 mm (0.4890 in.)

If seal ring surface diameter is more than wear limit, replace center housing.

If journal bearing surface diameters are more than wear limit, replace center housing, journal bearings and turbine wheel/shaft.

Intake and Exhaust Systems

TURBOCHARGER FAILURE ANALYSIS

Problem	Possible Cause	Suggested Remedy
Compressor Housing Inlet Defects		
Foreign Object Damage	Objects left in intake system.	Disassemble and inspect intake system for foreign objects. Inspect engine for internal damage.
	Leaking and/or defective intake system.	Inspect air intake system connections and air cleaner. Repair or replace as necessary. Inspect air intake related engine components.
Compressor Wheel Rub	Failure of journal bearings and/or thrust bushing and bearing.	Determine if engine and/or operator contributed to lack of lubrication, contaminated lubrication, excessive temperature, or debris generating engine failure in progress.
	Manufacturing defects.	Correct as required. (See <i>Disassembly</i> and <i>Inspection</i> procedures in this group.)
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 seal ring on oil thrower or defective seal around seal plate.	Repair as necessary. (See <i>Disassembly</i> and <i>Inspection</i> in 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 turbine shaft seal ring.	Repair as necessary. (See <i>Disassembly</i> and <i>Inspection</i> in this group.)
Internal Walls Deteriorated	Excessive operating temperature.	Check for restricted air intake.
		Check engine for overfueling.
		Check injection pump timing.

Problem	Possible Cause	Suggested Remedy
Turbine Housing Outlet Defects		
Turbine Wheel Rub	Failure of journal bearings and/or thrust bushing and bearing.	Determine if engine and/or operator contributed to lack of lubrication, contaminated lubrication, excessive temperature, or debris generating engine failure in progress.
	Manufacturing defect. Leaking air intake system.	Correct as required. (See <i>Disassembly</i> and <i>Inspection</i> procedures in this group.)
Foreign Object Damage	Internal engine failure. Objects left in intake system.	Inspect and repair engine as required. Disassemble and inspect air intake system. (See <i>AIR CLEANER</i> in this group.)
	Leaking air intake system.	Correct as required.
Oil and/or Excessive Carbon	Internal engine failure.	Verified by oil in turbine housing. Correct as required.
	Turbine shaft seal ring failure.	Inspect for excessive heat from overfueling and/or restricted air intake.
	Prolonged periods of low RPM engine idling.	Verify with operator to run engine under load or a higher RPM. (See Operator's manual).
	Restricted oil drain line.	Inspect and clean oil drain line as required.
Engine Center Housing and Joint Defects		
Leaks from Casting	Defective casting.	Replace turbocharger.
Leaks from Joints	Loose attaching screws.	Tighten to specifications. (See <i>Assembly</i> procedures in this group.)
	Defective heat shield or deteriorated sealant.	Inspect and repair as required. (See <i>Disassembly</i> and <i>Assembly</i> procedures in this group.)
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 & loads immediately after start-up.	Idle engine for a few minutes to allow oil to reach bearings before applying heavy loads.

Intake and Exhaust Systems

TURBOCHARGER SEVEN-STEP INSPECTION

The following inspection procedure is recommended for systematic failure analysis of a suspected failed turbocharger. This procedure will help to identify when a turbocharger has failed, and why it has failed, so the primary cause of the failure can be corrected.

Proper diagnosis of a non-failed turbocharger is important for two reasons. First, identification of a non-failed turbocharger will lead to further investigation and repair of the cause of a performance complaint.

Second, proper diagnosis eliminates the unnecessary expense incurred when a non-failed turbocharger is replaced.

The seven recommended inspection steps, which are explained in detail on the following pages, are:

- Compressor Housing Inlet and Compressor Wheel
- Compressor Housing Outlet
- Turbine Housing Inlet
- Turbine Housing Outlet and Turbine Wheel
- External Center Housing and Joints
- Internal Center Housing
- Turbo Bench Test

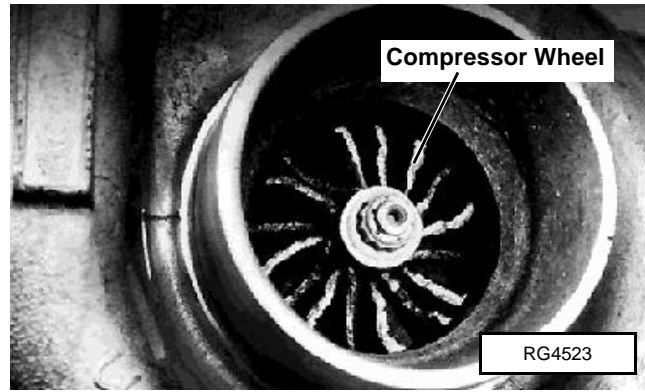
NOTE: To enhance the turbocharger inspection, an inspection sheet (Form No. DS-2280 available from Distribution Service Center) can be used that lists the inspection steps in the proper order and shows potential failure modes for each step. Check off each step as you complete the inspection and record any details or problems obtained during inspection. Retain this with the work order for future reference.

Compressor Housing Inlet and Compressor Wheel

1. Check compressor inlet and wheel for foreign object damage.

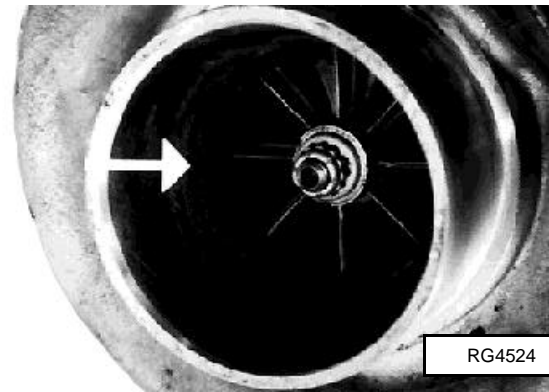
NOTE: Foreign object damage may be extensive or minor. In either case, the source of the foreign object must be found and corrected to eliminate further damages.

2. Mark findings on your checklist and continue the inspection.



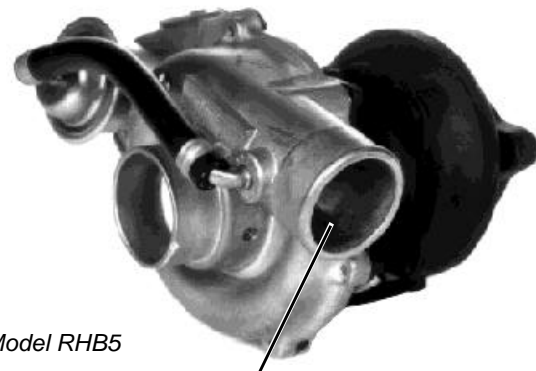
NOTE: You will need a good light source for this check.

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.



Compressor Housing Outlet

1. Check compressor housing outlet. 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.



Model RHB5

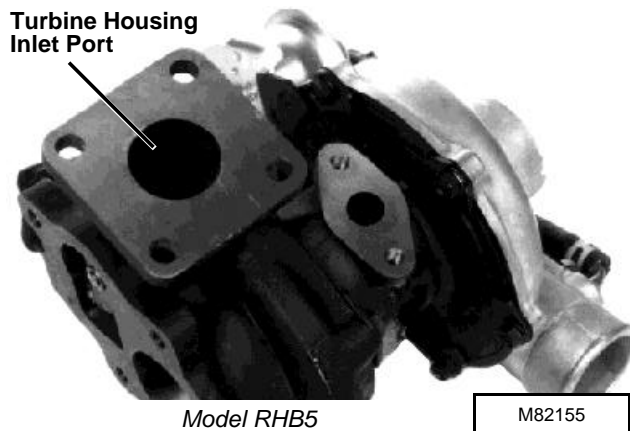
Compressor Housing Outlet

M82154

Turbine Housing Inlet

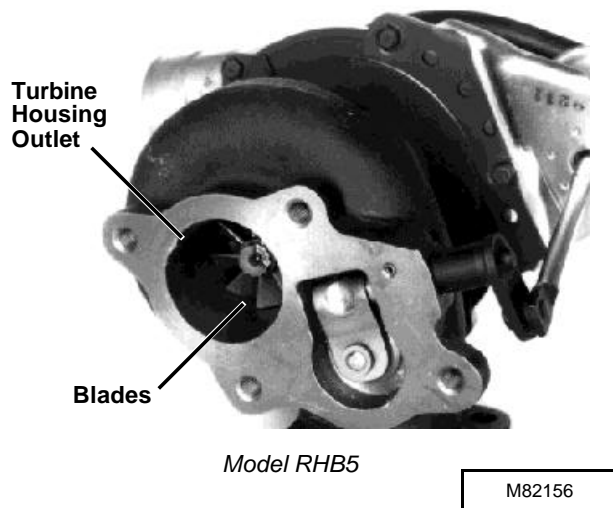
1. Check the turbine housing inlet port for oil in housing, excessive carbon deposit or erosion of walls.

NOTE: If the inlet is wet with oil or has excessive carbon deposits, an engine problem is likely. Wall erosion (cracking or missing pieces), indicate excessive exhaust temperature.

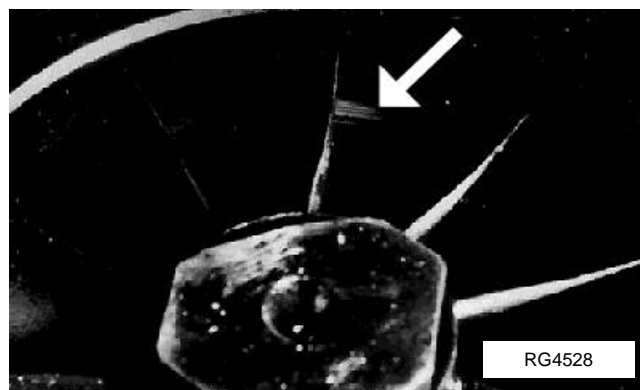


Turbine Housing Outlet and Turbine Wheel

1. Use a flashlight to look up inside the turbine housing outlet and check blades for foreign object damage.



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.



External Center Housing and Joints

1. Visually check the outside of the center housing, all connections to the compressor housing, and turbine housing for oil.

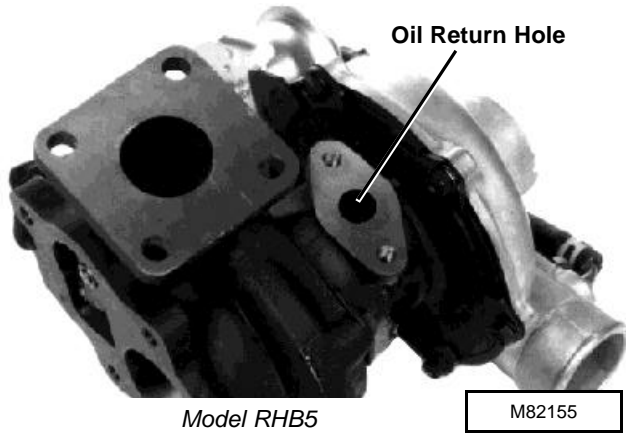
NOTE: If oil is present, make sure it is not coming from a leak at the oil supply or return line.



Internal Center Housing

1. Using a flashlight, look through the oil return hole to check the condition of the shaft and/or bearings. There should not be excess carbon deposits on the shaft or in the housing.

Intake and Exhaust Systems

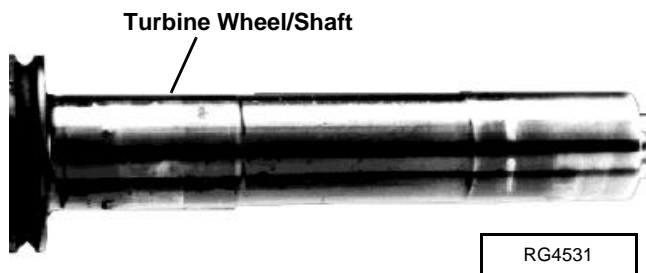


2. Excessive "blueing" or "coking" of oil along the complete length of the shaft indicates a possible lack of lubrication caused by an engine failure, or improper operation, such as hot shutdowns.



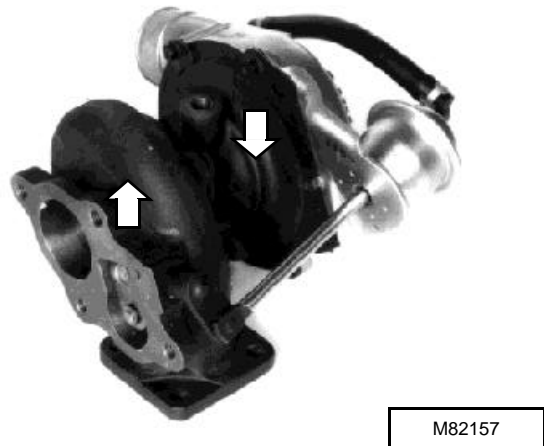
3. Pull up on the compressor end of the shaft and press down on the turbine end while rotating shaft. Neither the compressor wheel nor the turbine wheel should contact the housing at any point.

NOTE: There will be some "play" because the bearings inside the center housing are free floating.

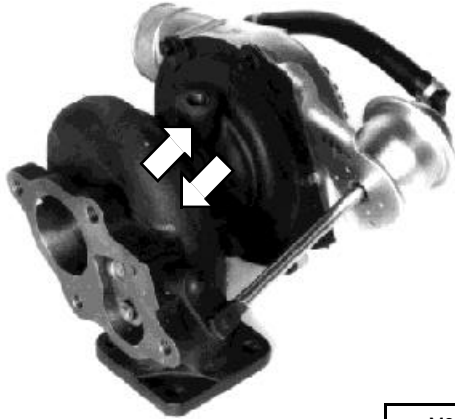


Turbo Bench Test

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.



4. 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.



M82157

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.) 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 to check rotor shaft axial and radial play. (See procedures in this group.) These procedures are not required if a failure mode has already been identified.

Cooling System

RADIATOR

Removal/Inspection

c CAUTION

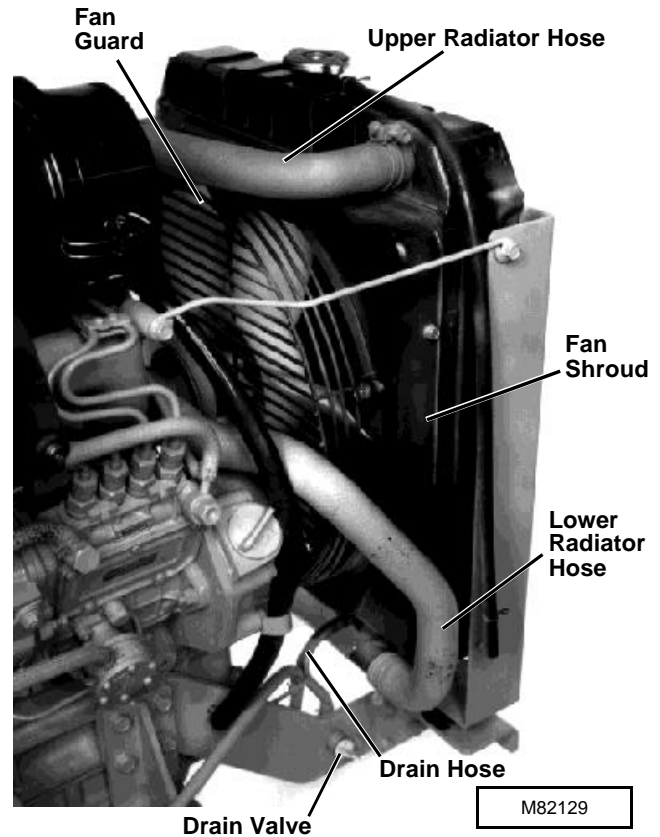
Explosive release of fluids from pressurized cooling system can cause serious burns.

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.

NOTE: Approximate cooling system capacity is:

3009	.....	3.5 L (3.7 qt)
3011	.....	3.7 L (3.9 qt)
3014	.....	4.0 L (4.2 qt)
4019	.....	4.7 L (4.9 qt)

1. Remove radiator cap and open drain valve to drain cooling system.
2. Remove fan guard.
3. Remove four fan shroud mounting cap screws, and place shroud over fan.
4. Remove upper and lower radiator hoses.
5. Disconnect drain hose.

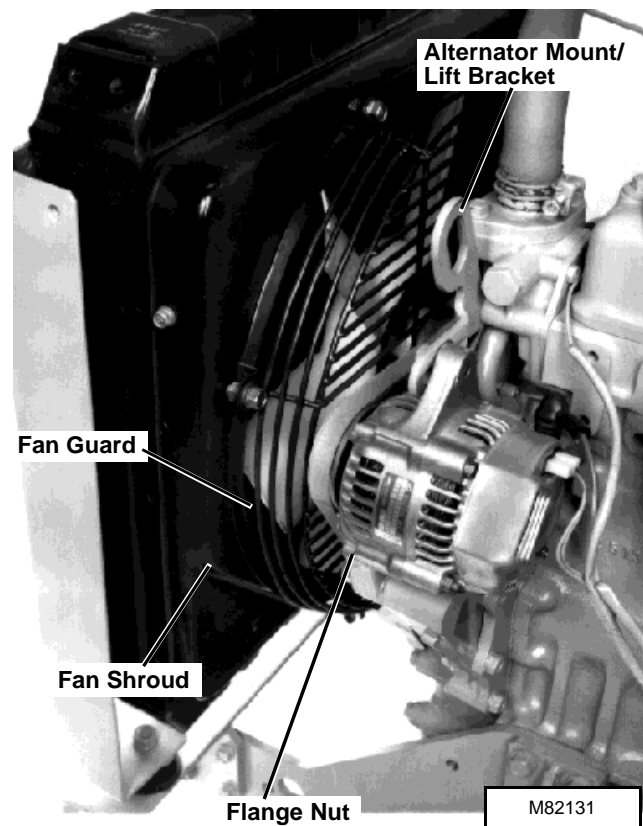
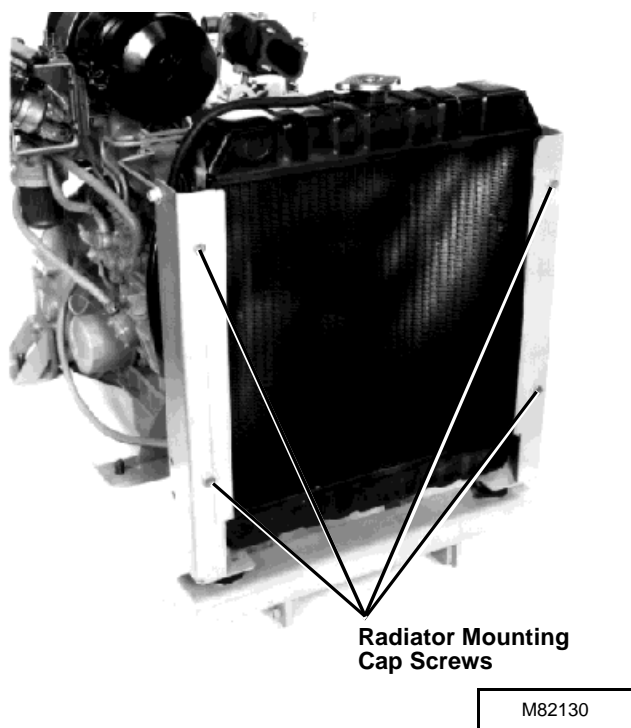


6. Support bottom of radiator and remove four mounting cap screws.
7. Remove radiator.

CAUTION

Reduce compressed air to less than 210 kPa (30 psi) when using for cleaning purposes. Clear area of bystanders, guard against flying chips, and wear personal protection equipment including eye protection.

8. Check radiator for debris lodged in fins. Clean radiator using compressed air or pressure washer.
9. Inspect radiator for bent fins, cracks and damaged seams. Repair as necessary.



Installation

Installation is done in the reverse order of removal.

- Close drain valve and fill radiator with proper coolant to top of filler neck. (See *SPECIFICATIONS AND GENERAL INFORMATION* section.)
- Start engine and allow it to reach proper operating temperature. Check radiator, hoses and connections for leaks. Adjust coolant level in recovery tank.

COOLING FAN

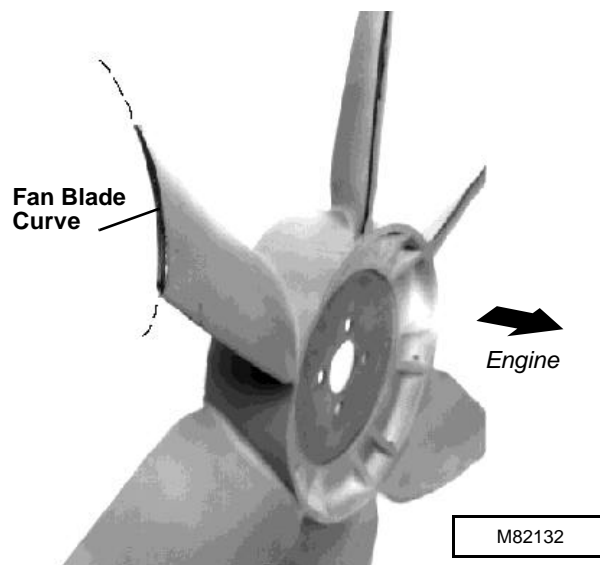
Removal

1. Remove fan guard, if equipped.
2. Loosen alternator mount/lift bracket cap screws and flange nut.
3. Remove four fan shroud mounting cap screws, if equipped, and move shroud toward engine.
4. Remove four cap screws, fan and spacer, if equipped.

Installation

Installation is done in the reverse order of removal.

- Install fan with blade curve facing AWAY from engine.
- Adjust belt tension. (See procedure in this group.)

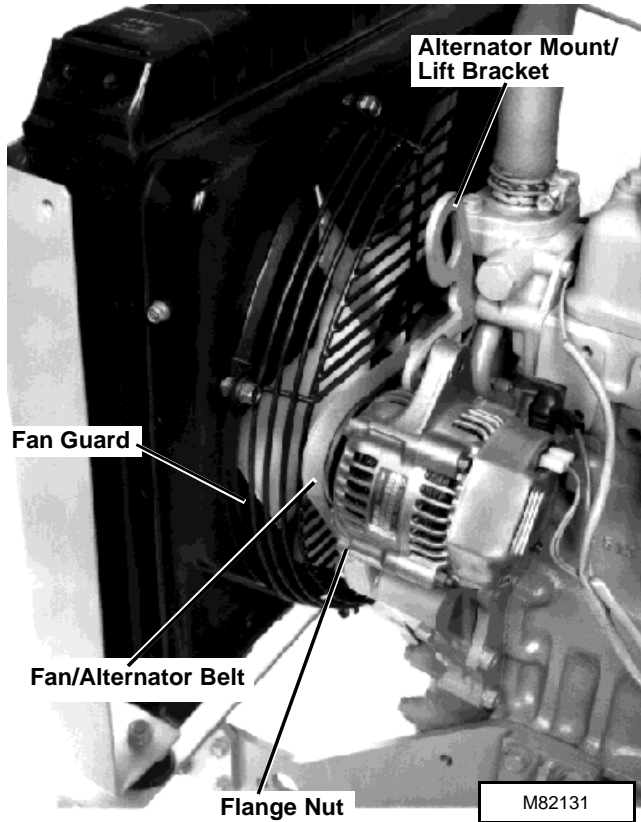


Cooling System

FAN/ALTERNATOR BELT

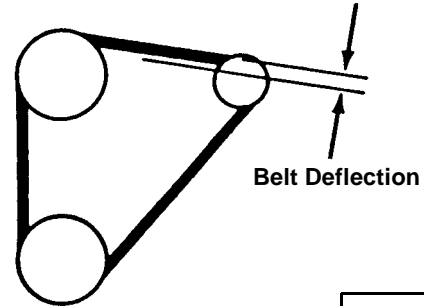
Replacement

1. Remove fan guard, if equipped.
2. Loosen alternator mount/lift bracket cap screws and flange nut.
3. Replace belt.
4. Adjust belt tension. (See *Adjustment* procedure.)



Adjustment

1. Use JDG529 or JDST28 Belt Tension Gauge and a straight edge to check belt deflection between fan and alternator pulleys.



Specifications:

Applied Force98 N (22 lb-force)

Belt Deflection 10 - 15 mm

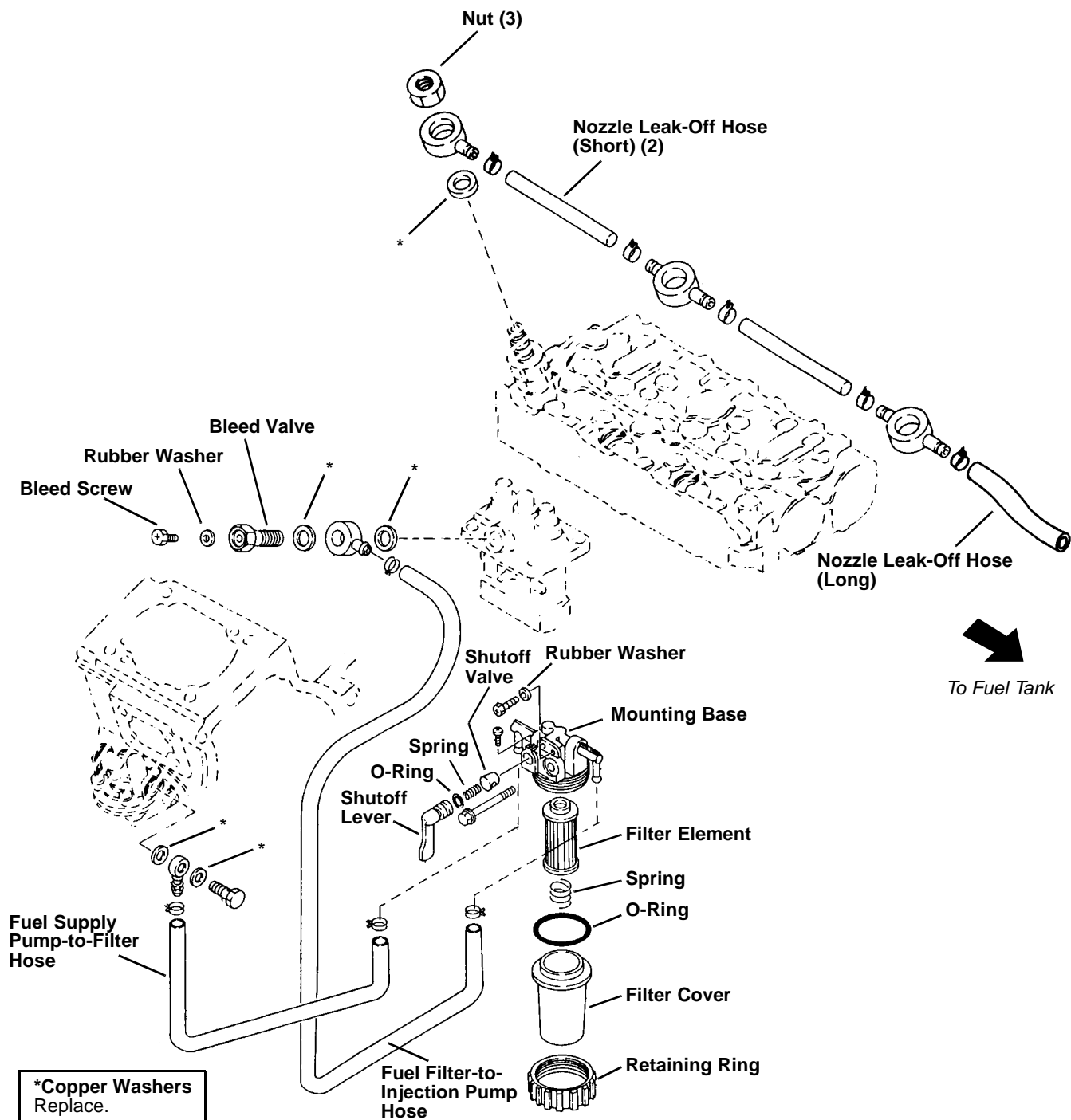
.....(0.400 - 0.600 in.)

If deflection is not according to specifications:

- Loosen alternator mounting cap screws and nut.
- Apply force to FRONT alternator housing only (near the belt) until tension is correct.
- Tighten cap screws and nut.

**FUEL FILTER ASSEMBLY - 3009
(3TNA72)**

IMPORTANT: Replace all copper and rubber washers. Damaged or used washers may leak.



***Copper Washers
Replace.**

M82133A

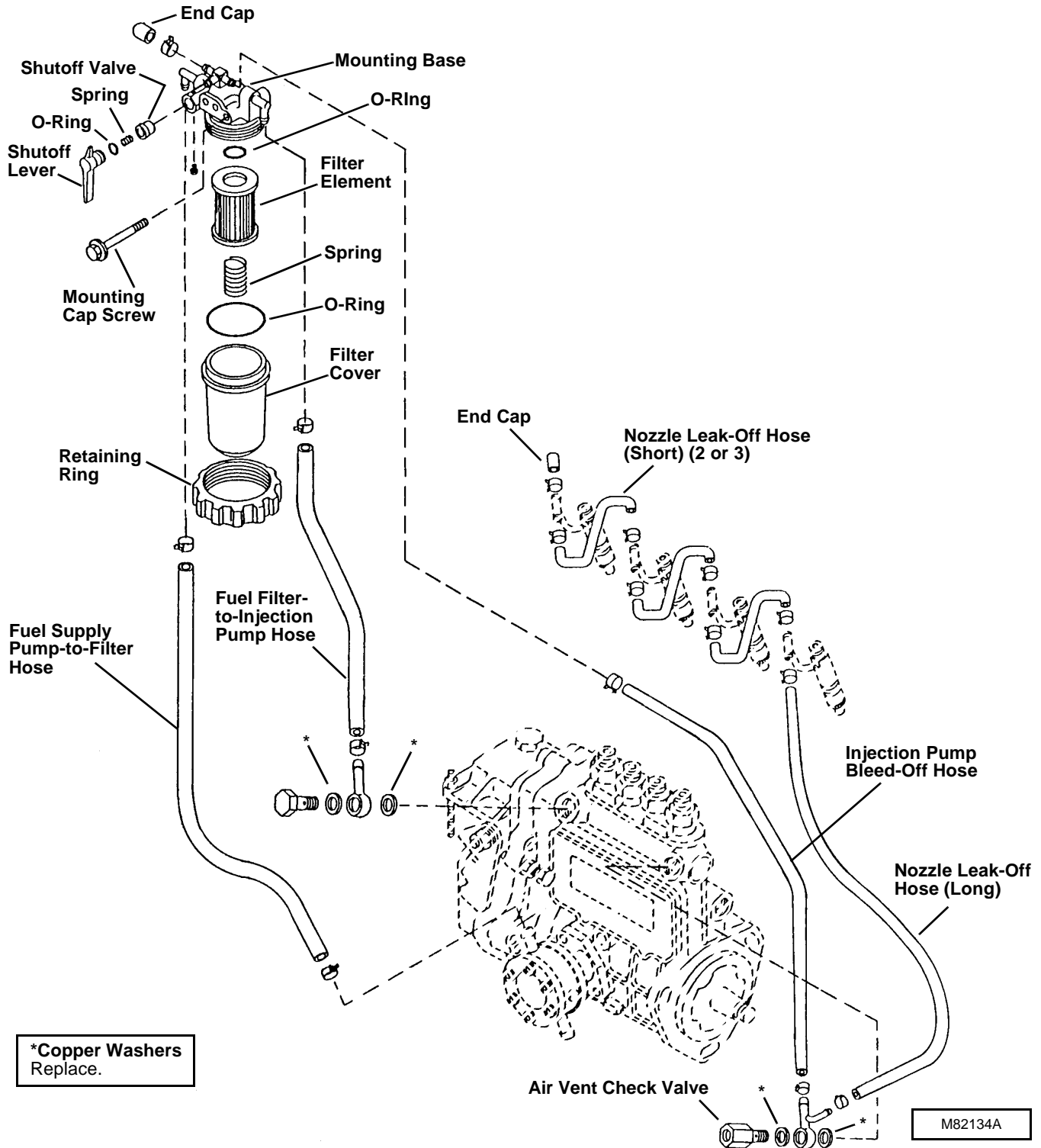
10

Fuel System

FUEL FILTER ASSEMBLY - 3011 (3TNC78), 3014 (3TN84) AND 4019 (4TN84)

IMPORTANT: Replace all copper and rubber washers. Damaged or used washers may leak.

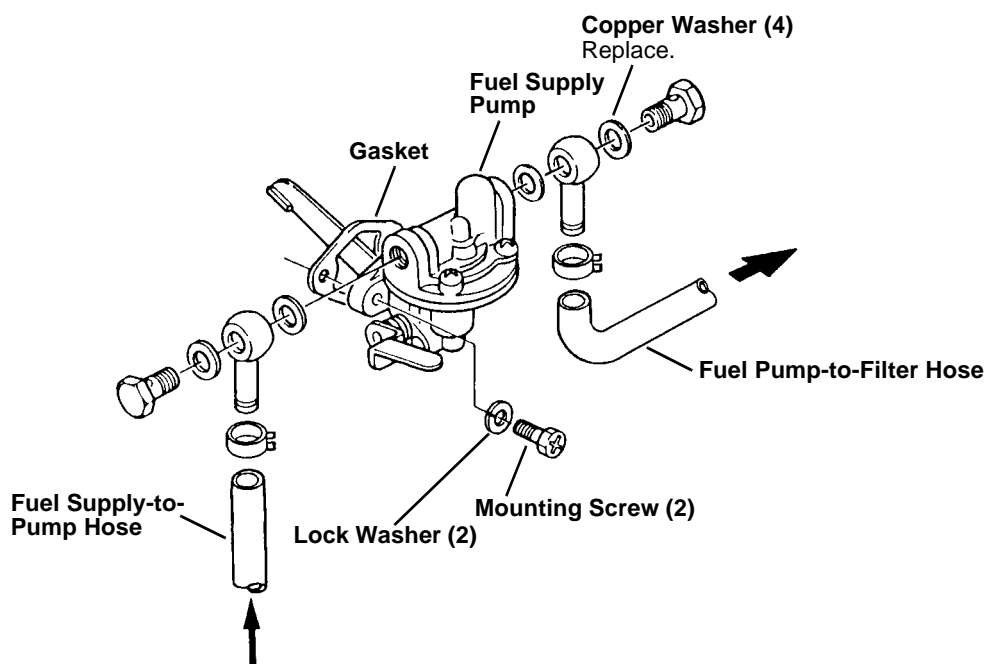
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FUEL SUPPLY PUMP - 3009 (3TNA72)

Removal/Installation

IMPORTANT: Replace all copper washers.
Damaged or used washers may leak.

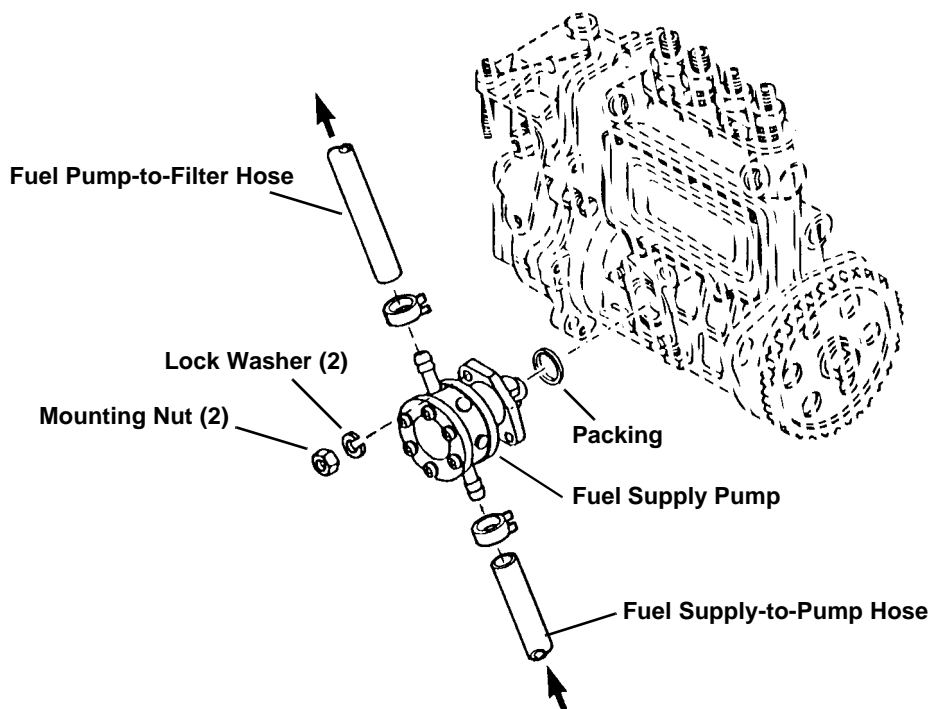


M82135A

Fuel System

FUEL SUPPLY PUMP - 3011 (3TNC78), 3014 (3TN84) AND 4019 (4TN84)

Removal/Installation



0

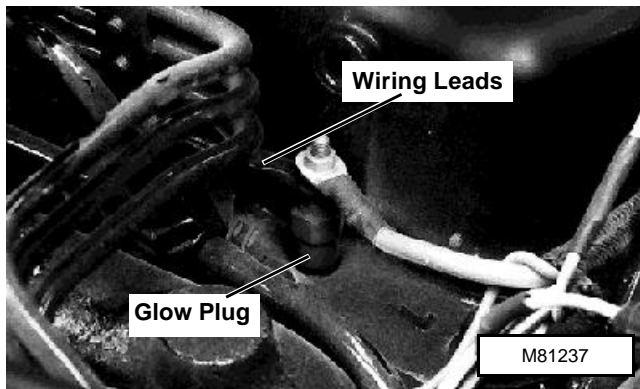
M82136A

GLOW PLUGS - IF EQUIPPED

Removal/Installation

1. Remove air cleaner assembly. (See *Intake and Exhaust System* in this section.)
2. Disconnect wiring leads and remove glow plug.
3. Test glow plugs. (See *Test* procedure.)

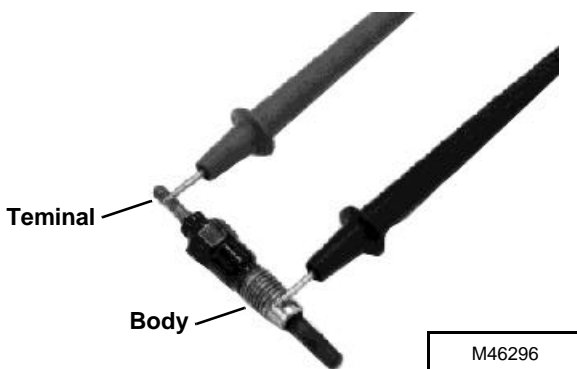
Installation is done in the reverse order of removal.



Test

NOTE: Test glow plug using an ohmmeter.

Touch one probe of tester to glow plug terminal and the other probe to body. If resistance is not within **1.35 - 1.65 ohms**, replace glow plug.

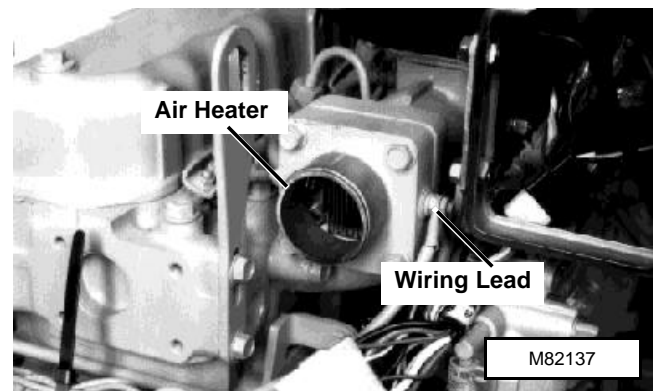


AIR HEATER - IF EQUIPPED

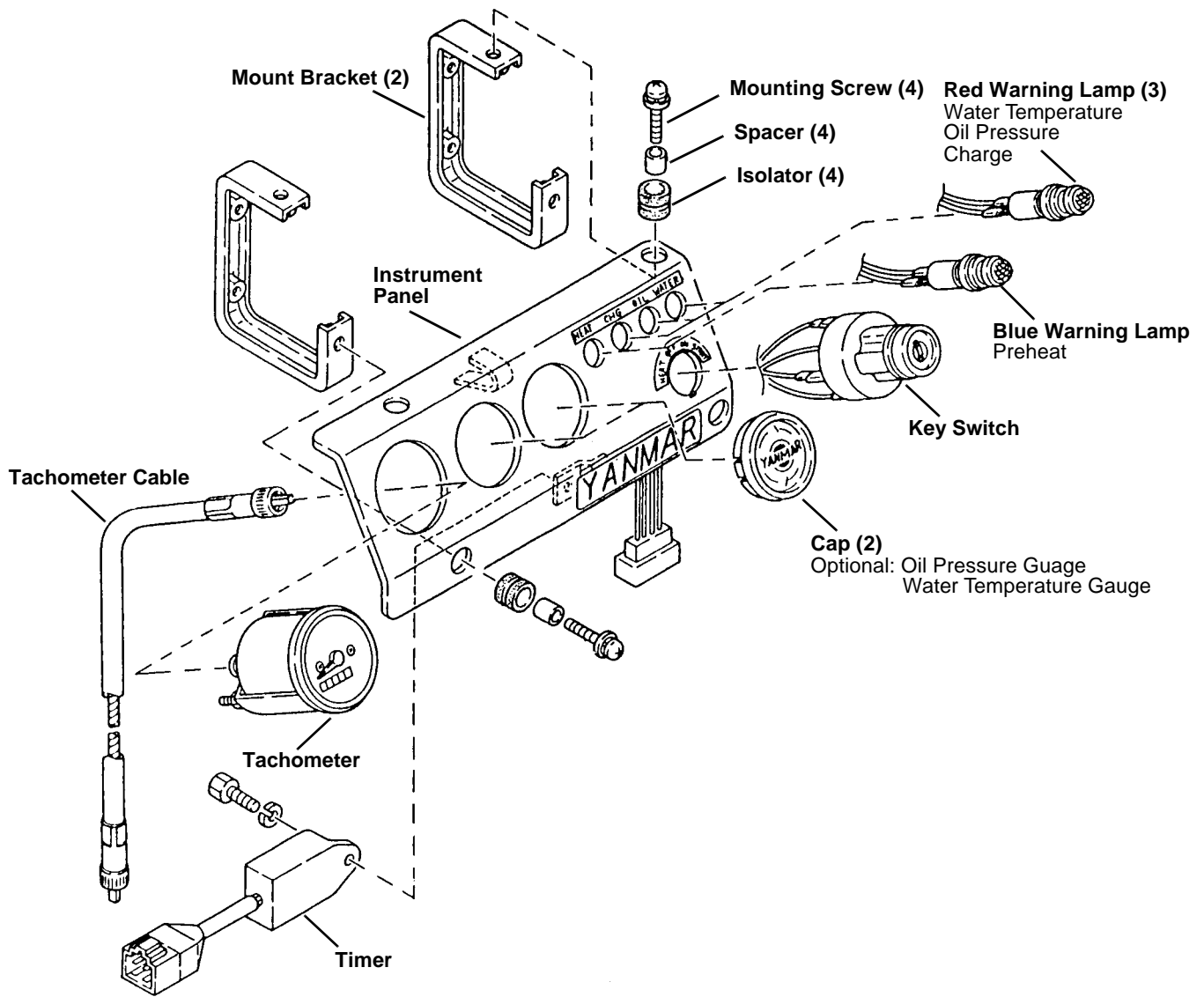
Removal/Installation

1. Remove air intake hose.
2. Disconnect wiring lead.
3. Scribe a mark across heater and intake manifold to aid in installation.
4. Remove four cap screws, heater and gasket.

Installation is done in the reverse order of removal.



INSTRUMENT PANEL

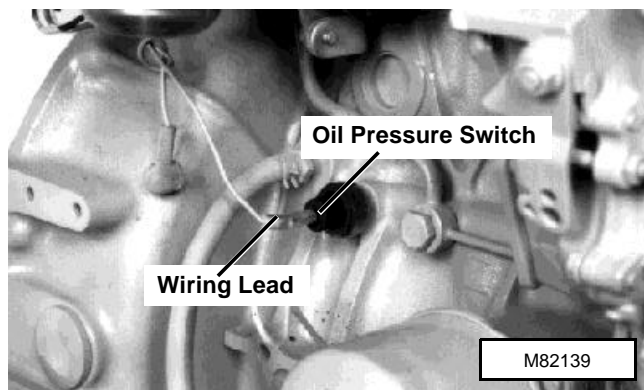


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M82138A

OIL PRESSURE SWITCH

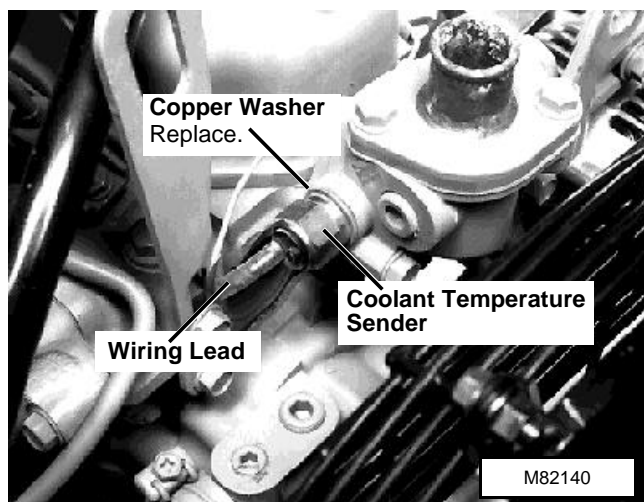
Replacement



COOLANT TEMPERATURE SENDER

Replacement

IMPORTANT: Replace copper washer.
 Damaged or used washer may leak.



Test

Equipment:

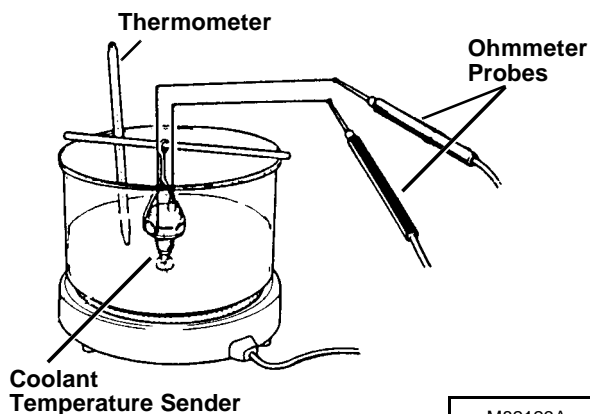
- Thermometer
- Glass Container
- Heating Unit
- Ohmmeter

Procedure:

CAUTION

DO NOT allow sender or thermometer to rest against the side or bottom of glass container when heating water. Either may rupture if overheated.

1. Connect lead wires from ohmmeter probes, to sender terminal and body.
2. Suspend sender and a thermometer in a container of water.
3. Heat and stir the water. Observe water temperature when continuity occurs. If continuity does not occur at **110° C (230° F)**, replace sender.

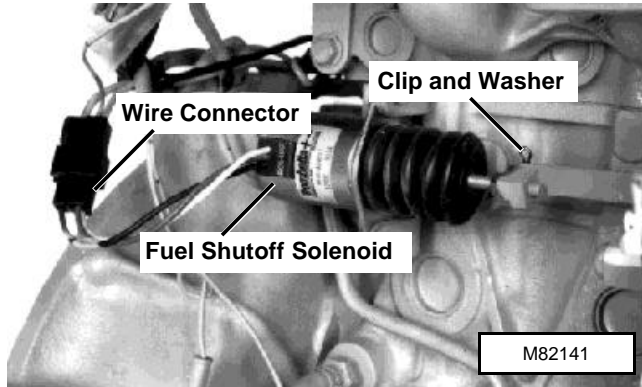


FUEL SHUTOFF SOLENOID

Replacement

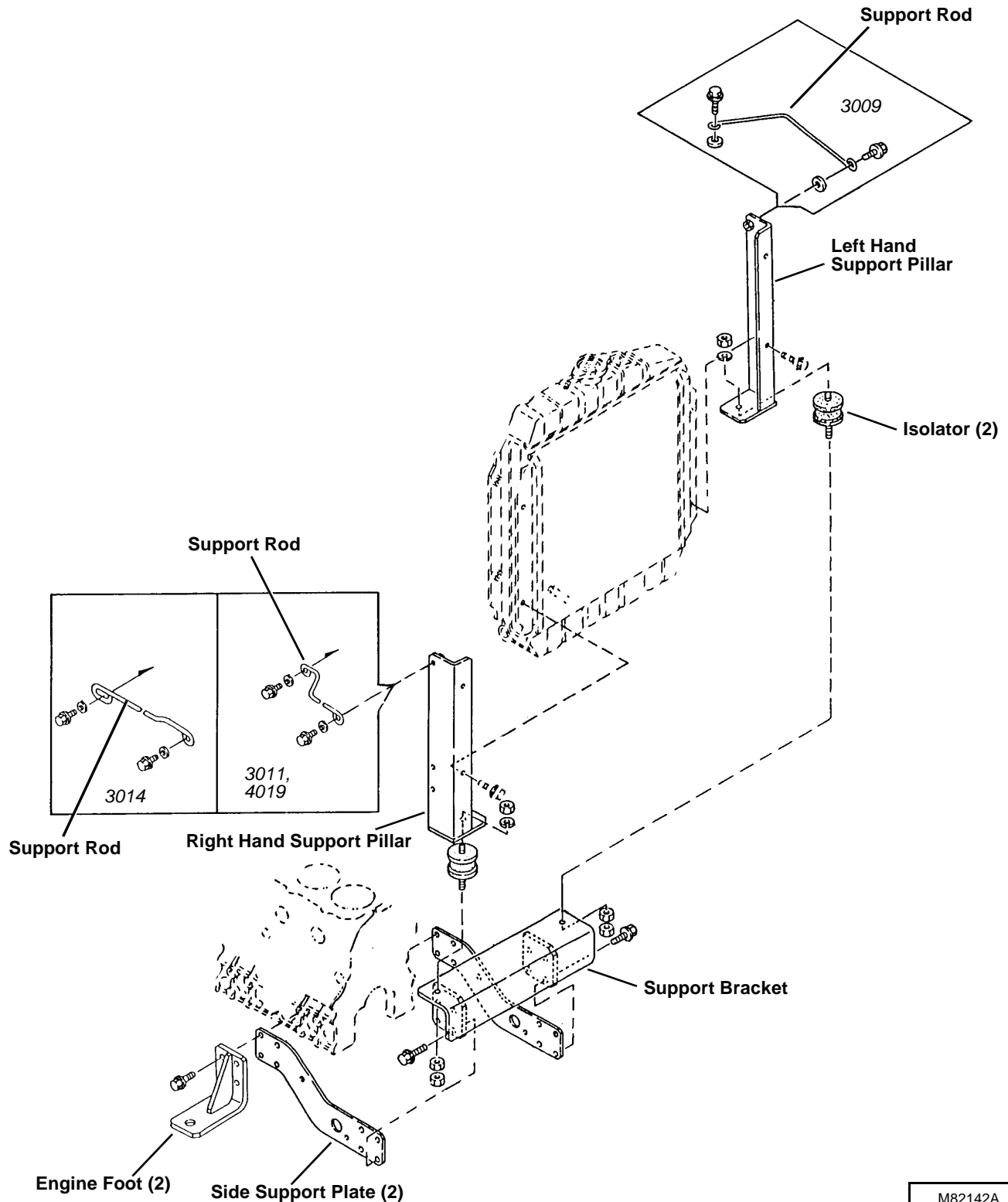
NOTE: 3011 (3TNC78), 3014 (3TN84), 4019 (4TN84) shown. 3009 (3TNA72) is similar.

- Ajust. (See *Operational Tests and Adjustments* in this section.)



RADIATOR MOUNT - IF EQUIPPED

- Inspect isolators for cracks, wear or damage.
Replace if necessary.



10

M82142A

Engine Tune-Up

GENERAL TUNE-UP RECOMMENDATIONS

The following services are recommended each time a tune-up is performed:

- Change oil and filter. (See Operator's Manual.)
- Replace fuel filter and clean sediment bowl. (See *Fuel System* in this section.)
- Clean crankcase vent tube. (See this group.)
- Check air intake system. Replace air cleaner elements. (See Operator's Manual)
- Check exhaust system. (See this group.)
- Check and service engine cooling system. (See this group.)
- Check electrical system. (See this group.)
- Check fuel injection system. Check engine/injection pump timing: check and adjust speed advance, clean injection nozzles and adjust injection nozzle opening pressure. (See *Fuel System* in the appropriate *ENGINE* section.)
- Check engine oil pressure. Adjust if necessary. (See *Operational Tests and Adjustments* in this section.)
- Check engine valve clearance. Adjust if necessary. (See *Checks, Tests and Adjustments* in the appropriate *ENGINE* section.)
- Check engine speeds. Adjust if necessary. (See *Operational Tests and Adjustments* in this section.)
- Check engine performance on dynamometer. (See *Operational Tests and Adjustments* in this section.)

ALTITUDE COMPENSATION GUIDELINES

High elevations may affect engine performance. As a general rule, these guidelines will apply:

Naturally Aspirated Engines

Four percent power reduction per 300 m (1000 ft) rise in elevation above sea level. Engine may have to be defueled when a substantial percentage of operating time occurs at 1500 m (5000 ft) or higher.

Turbocharged Engines

Three percent power reduction per 300 m (1000 ft) rise in elevation above sea level. Engine may have to be defueled when a substantial percentage of operating time occurs at 2250 m (7500 ft) or higher.

If engine required less fuel for acceptable performance at higher elevation, contact your local authorized fuel injection pump repair station for service.

PRELIMINARY ENGINE TESTING

Before tuning up an engine, determine whether a tune-up will restore operating efficiency. When there is doubt, the following preliminary tests will help to 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, carefully 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.

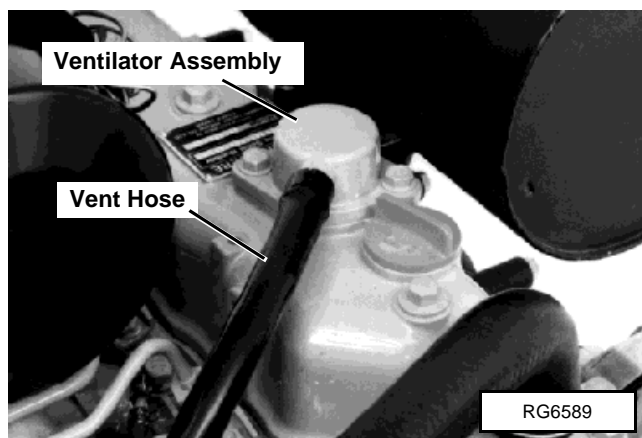
2. With engine stopped, inspect engine coolant for an oil film. With engine running, inspect coolant for air bubbles. (See Radiator Bubble Test in *Operational Tests and Adjustments* in this section.) Either condition would indicate problems which require engine repairs rather than just a tune-up.
3. Perform a dynamometer test and record power output. (See *Operational Tests and Adjustments* in this section.) Repeat dynamometer test after tune-up, so power output before and after tune-up can be compared.
4. Perform compression test. (See *Operational Tests and Adjustments* in this section.)

CRANKCASE VENTILATION SYSTEM

Check

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 hose with solvent and compressed air if restricted.
3. 3009 (3TNA72): Remove rocker arm cover and clean crankcase ventilator.

3011 (3TNC78), 3014 (3TN84) and 4019 (4TN84): Remove and clean crankcase ventilator assembly.



All Except 3009 (3TNA72) Shown

AIR INTAKE SYSTEM

Check

1. Replace air cleaner filter element(s).
2. Check condition of air intake hose(s). Replace any hose that is cracked, split, or otherwise in poor condition.
3. Check hose clamps for tightness. Replace any clamp that cannot be properly tightened. This will help prevent dust from entering the air intake system which could cause serious engine damage.

EXHAUST SYSTEM

Check

1. Inspect exhaust system for leaks or restrictions. Check manifold for cracks. Repair or replace as necessary.

COOLING SYSTEM

Check and Service

1. Remove any trash that has accumulated on the radiator.
2. Visually inspect entire cooling system for leaks or damage. Repair or replace as necessary.
3. Remove and check thermostat. (See *Cooling System* in the appropriate *ENGINE* section.)

CAUTION

Do not drain coolant until the coolant temperature is below operating temperature. Always loosen drain cock slowly to relieve any excess pressure.

4. Drain cooling system by opening drain cocks on radiator and engine block.

Engine Tune-Up

5. Close drain cocks and fill cooling system with clean water.
6. Run engine until it reaches operating temperature (about 10 minutes) to stir up possible rust or sediment.
7. Stop engine and immediately drain the water before rust and sediment settle.
8. Close drain cocks and fill the cooling system with a good commercial radiator cleaner and water. Follow the instructions with the cleaner.
9. After cleaning the cooling system, fill with water to flush the system. Run the engine about 10 minutes, then drain out flushing water.

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

10. Fill cooling system with coolant. (See *SPECIFICATIONS AND GENERAL INFORMATION* section.)

0 11. Run engine until it reaches operating temperature. This mixes solution uniformly and circulates it through the entire system. The normal engine coolant temperature range is **70° - 80° C (160° - 180° F)**.

NOTE: Coolant level should be approximately 19 mm (3/4 in.) below bottom of radiator filler neck.

12. After running engine, check coolant level and entire cooling system for leaks.
13. Check system for holding pressure. (See *Cooling System Pressure Test in Operational Tests and Adjustments* in this section.)

FAN/ALTERNATOR BELT

Inspection

Check condition of fan/alternator belt and replace if cracked, frayed or excessively worn. Check belt tension and adjust as necessary. (See *Cooling System* in this section.)

ELECTRICAL SYSTEM

Check

1. Clean battery 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 battery. If battery is not near full charge, try to find out why.
4. On low-maintenance batteries, check level of electrolyte in each cell of battery. 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 battery appears to be either undercharged or overcharged, check alternator and charging circuit.
6. Check tension of fan/alternator drive belt. (See *FAN/ALTERNATOR BELT-Adjustment* in *Cooling System* in this section.)
7. Check operation of starting motor and gauges.

DYNAMOMETER TEST

NOTE: High elevations may affect engine performance. (See ALTITUDE COMPENSATION GUIDELINES in Engine Tune-up in this section.)

1. Connect engine to dynamometer using manufacturer's instructions.
2. Operate engine at one-half load until coolant and crankcase oil temperatures are up to normal.
3. Run engine at fast idle.
4. Gradually increase load on engine until speed is reduced to rated speed rpm.
5. Read horsepower on dynamometer.
6. Compare readings taken with power rating level for your engine application listed in the following chart.

DYNAMOMETER TEST SPECIFICATIONS

Engine Model	Pump Option Code	Injection Pump Assembly Part Number	Governor Regulation	Rated Speed (rpm)	Fast Idle (rpm)	Power Rating* kW (BHP)
3009DF001	1601	RG60070	STD	3000	3300	15.4 (20.7)
3009DF005	1601	RG60070	STD	3000	3300	15.4 (20.7)
3009DF007	1601	RG60132	3-5%	3600	3800	14.2 (19.0)
3011DF001	1601	RG60187	STD	3000	3300	20.2 (27.1)
3011DF005	1601	RG60187	STD	3000	3300	20.2 (27.1)
3011DF006	1601	RG60464	3-5%	1800	1900	13.0 (17.4)
3014DF001	1601	RG60269	STD	3000	3300	24.9 (33.5)
3014DF005	1601	RG60269	STD	3000	3300	24.9 (33.5)
3014DF006	1601	RG60293	3-5%	1800	1900	16.0 (21.5)
4019DF001	1601	RG60330	STD	3000	3300	33.4 (44.8)
4019DF005	1601	RG60330	STD	3000	3300	33.4 (44.8)
4019DF006	1601	RG60410	3-5%	1800	1900	22.0 (29.5)
4019TF001	1601	RG60425	STD	3000	3300	40.3 (54.0)
4019TF005	1601	RG60425	STD	3000	3300	40.3 (54.0)
4019TF006	1601	RG60459	3-5%	1800	1900	27.2 (36.5)

**Industrial Intermittent Gross or Generator Standby Net.*

Operational Tests and Adjustments

RADIATOR BUBBLE TEST

Reason:

To determine if compression pressure is leaking from cylinder.

Equipment:

- JDG560 Adapter

Procedure:

1. With coolant at proper level and radiator cap tight, run engine for 5 minutes to bring to operating temperature.
2. Remove cap from recovery tank.
3. Check for bubbles coming from overflow hose at bottom of tank.

If bubbles are present, isolate source of compression leak:

- Remove injection nozzles.
- Install JDG560 Adapter in injection port of cylinder to be tested.
- Move piston to bottom of stroke with intake and exhaust valves closed.
- Connect hose from compressed air source to adapter.
- Apply the specified maximum air pressure into cylinder:

3009 (3TNA72) 2455 kPa (356 psi)

3011 (3TNC78),

3014 (3TN84),

4019 (4TN84) 2158 kPa (313 psi)

- Check for bubbles in recovery tank or air escaping from muffler, air cleaner or oil fill opening.
- Repeat for each cylinder.

Results:

- If bubbles are present, check for cracks in cylinder head and block. Check for damaged head gasket.

- If air escapes from muffler, check for worn exhaust valve.
- If air escapes from air cleaner, check for worn intake valve.
- If air escapes from engine oil fill, check for worn piston rings.

COOLING SYSTEM PRESSURE TEST

Reason:

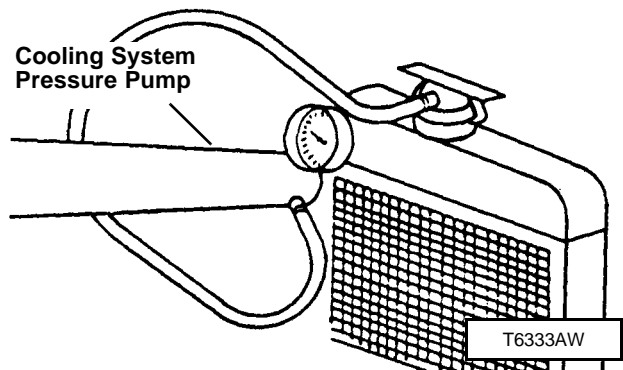
Inspect cooling system for leaks.

Equipment:

- D05104ST Cooling System Pressure Pump

Procedure:

1. Remove cap and attach pressure pump to radiator.
2. Apply **97 kPa (14 psi)** maximum pressure.
3. Check for leaks throughout cooling system.



Specifications:

Minimum Pressure

after 10 seconds 88 kPa (12.8 psi)

Results:

- Pressure should hold to specifications. If pressure decreases, check for leaks. Repair leaks or replace parts as necessary.
- If pressure test still indicates leakage after all external leaks have been stopped, a defective head gasket, cracked block, or cylinder head may be the cause. Perform *RADIATOR BUBBLE TEST*.

RADIATOR CAP PRESSURE TEST

Reason:

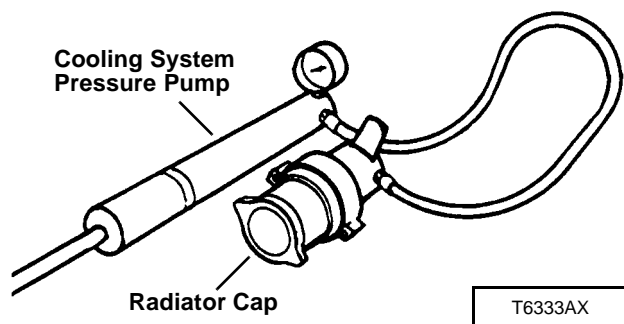
Test radiator cap for operating in correct pressure range.

Equipment:

- D05104ST Cooling System Pressure Pump

Procedure:

1. Install radiator cap on pressure pump.
2. Apply pressure. Pressure valve in cap should open at **88 kPa (12.8 psi)**.



Results:

- If cap leaks, retighten and test again. Replace cap if pressure is not within specification.

CYLINDER COMPRESSION PRESSURE TEST - 3009 (3TNA72)

Reason:

To determine the condition of the pistons, rings, cylinder walls and valves.

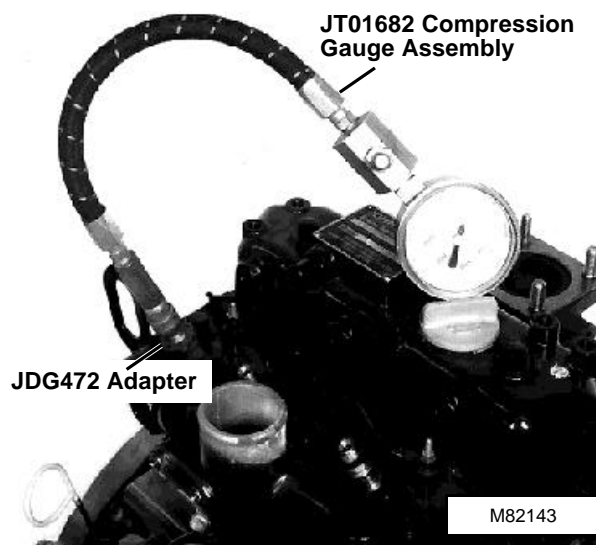
Equipment:

- JT01682 Compression Gauge Assembly
- JDG472 Adapter

Procedure:

1. Run engine for 5 minutes to bring to operating temperature. Shut off engine.
2. Remove air cleaner assembly. (See *Intake and Exhaust System* in this section.)

3. Remove injection nozzles. (See Fuel System in the appropriate *ENGINE* section.)
4. Install Adapter and Compression Gauge Assembly.
5. Disconnect fuel shutoff solenoid connector.
6. Crank engine for five seconds with starter.
7. Record pressure reading for each cylinder.



Specifications:

Compression Pressure . . . 2455 kPa (356 psi)
Maximum Difference
Between Cylinders 490 kPa (71 psi)

NOTE: Pressure listed is for 300 m (1000 ft) above sea level. Reduce specification an additional four percent for each additional 300 m (1000 ft) of altitude.

Results:

- If pressure reading is below specification, squirt approximately two teaspoons of clean engine oil into cylinders through injector ports and repeat test.
- If pressure increases significantly, check piston, rings and cylinder walls for wear or damage.
- If pressure does not increase significantly after retest, check for leaking valves, valve seats or cylinder head gasket.

Operational Tests and Adjustments

CYLINDER COMPRESSION PRESSURE TEST - 3011 (3TNC78), 3014 (3TN84) AND 4019 (4TN84)

Reason:

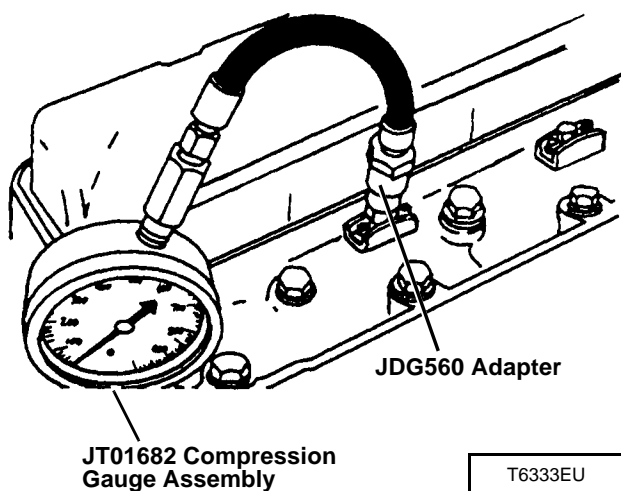
To determine the condition of the pistons, rings, cylinder walls and valves.

Equipment:

- JT01682 Compression Gauge Assembly
- JDG560 Adapter

Procedure:

1. Run engine for 5 minutes to bring to operating temperature. Shut off engine.
2. Remove air cleaner assembly. (See *Intake and Exhaust System* in this section.)
3. Remove injection nozzles. (See *Fuel System* in the appropriate *ENGINE* section.)
4. Remove heat protector from end of injector and install on Adapter.
5. Install Adapter and Compression Gauge Assembly in injector port. Install retaining plate and tighten nuts to 4.5 N•m (39 lb-in.)
6. Disconnect fuel shutoff solenoid connector.
7. Crank engine for five seconds with starter.
8. Record pressure reading for each cylinder.



Specifications:

Compression Pressure . . . 2158 kPa (313 psi)
Maximum Difference
Between Cylinders 490 kPa (71 psi)

NOTE: Pressure listed is for 300 m (1000 ft) above sea level. For naturally aspirated engines, reduce specification an additional four percent for each additional 300 m (1000 ft) of altitude. For turbocharged engines, reduce specification an additional three percent for each additional 300 m (1000 ft) of altitude.

Results:

- If pressure reading is below specification, squirt approximately two teaspoons of clean engine oil into cylinders through injector ports and repeat test.
- If pressure increases significantly, check piston, rings and cylinder walls for wear or damage.
- If pressure does not increase significantly after retest, check for leaking valves, valve seats or cylinder head gasket.

ENGINE OIL PRESSURE TEST

Reason:

To determine if engine bearings or lubrication system components are worn.

Equipment:

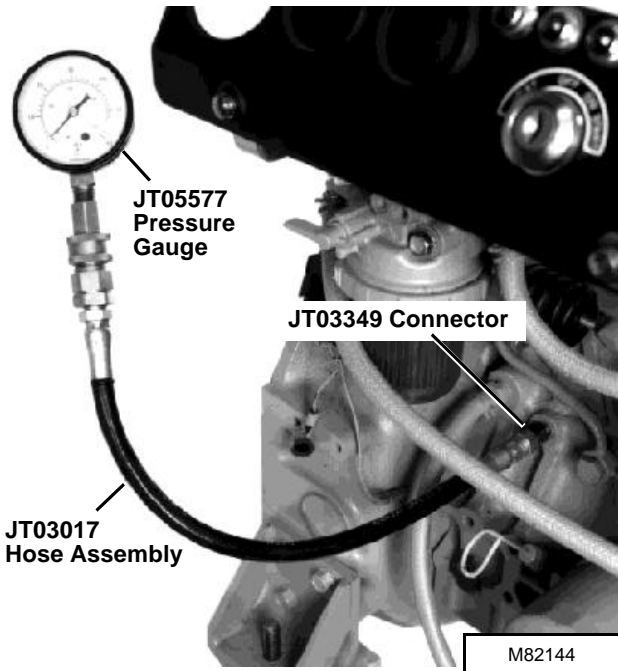
- JT03349 Connector
- JT03017 Hose Assembly
- JT05577 Pressure Gauge (100 psi)

Procedure:

1. Remove oil pressure sender.
2. Install Connector.
3. Connect Hose Assembly and Pressure Gauge.

IMPORTANT: Do not run engine if no pressure present.

4. Start engine. If pressure reading is below **69 kPa (10 psi)**, STOP ENGINE.
5. Run engine approximately five minutes to heat oil, then check oil pressure at low idle.



Specifications:
Low Idle Speed

Industrial Application

All 1300 rpm

Generator Application

3009 (3TNA72) 1300 rpm

3011 (3TNC78), 3014 (3TN84),

4019 (4TN84) 1200 rpm

Engine Oil Pressure 147 kPa (21 psi)

Results:

- If oil pressure is not within specifications, inspect oil pressure regulating valve parts for wear or damage. Add or remove shims as necessary. (See Lubrication System in the appropriate *ENGINE* section.)
- If oil pressure does not increase, see “Engine Has Low Oil Pressure” in Diagnosis in the appropriate *ENGINE* section.

AIR INTAKE SYSTEM LEAKAGE TEST

Reason:

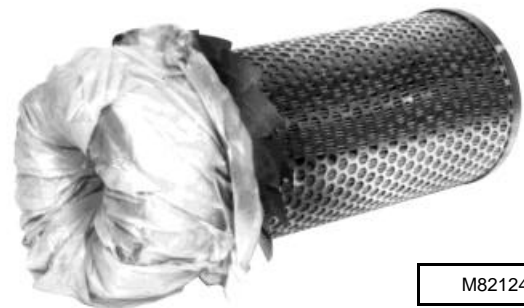
Check for leaks in air intake system.

Equipment:

- Air Pressure Regulator

Procedure:

1. Remove air cleaner restriction indicator, if equipped, and install test fitting.
2. Connect air pressure regulator to manifold using hose and fitting from air cleaner.
3. Remove air cleaner cover and main filter element.
4. Put large plastic bag into and over end of main filter element. Install main filter element and cover.
5. Pressurize air intake system within **34 - 69 kPa (5 - 10 psi)**. If air intake system cannot be pressurized, turn engine slightly to close valves.
6. Spray soap solution over all connections from air cleaner to intake manifold or turbocharger, if equipped, and check for leaks.



Results:

- Find leaks and repair or replace parts as necessary.

Operational Tests and Adjustments

FUEL SUPPLY PUMP PRESSURE TEST

Reason:

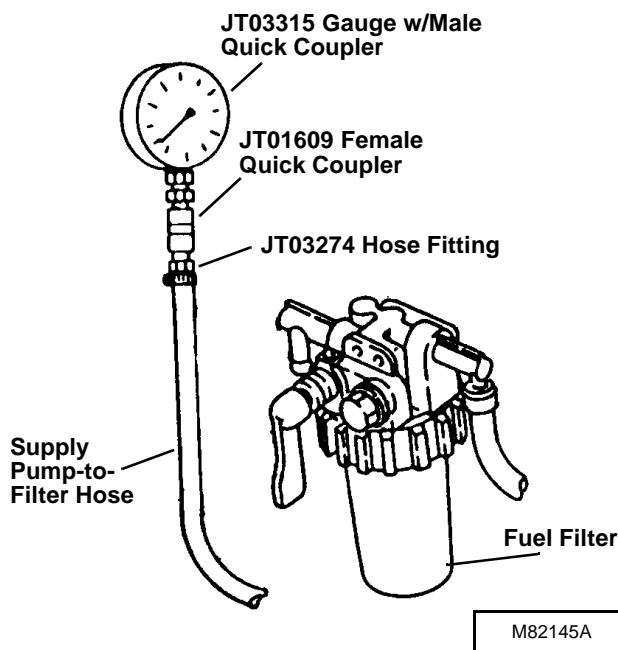
To determine supply pump operating pressure.

Equipment:

- JT03274 Hose Fitting
- JT01609 Female Quick Coupler
- JT03115 Gauge w/Male Quick Coupler (0 - 150 psi)

Procedure:

1. Disconnect supply pump-to-filter hose.
2. Install Hose Fitting, Coupler and Gauge.
3. Disconnect fuel shutoff solenoid connector.
4. Crank engine using the starter. Do not run starter for more than 10 seconds at a time. Gauge should read more than **29 kPa (4.3 psi)**.



Results:

- If pressure is below specification, repair or replace fuel supply pump.

FUEL DRAIN BACK TEST

Reason:

Determines if air is entering the fuel system at connections, allowing fuel to siphon back to tank.

Procedure:

1. Disconnect fuel supply line and 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 fuel supply pump, injection pump, filter(s) and water separator, if equipped.
3. Plug end of fuel return hose.
4. Pressurize fuel system, at fuel supply line, to a maximum pressure of **103 kPa (15 psi)**.
5. Apply liquid soap and water solution to all joints and connections in the fuel system and inspect for leaks.

Results:

- Find leaks and repair or replace parts as necessary.

BLEED FUEL SYSTEM - 3009 (3TNA72)

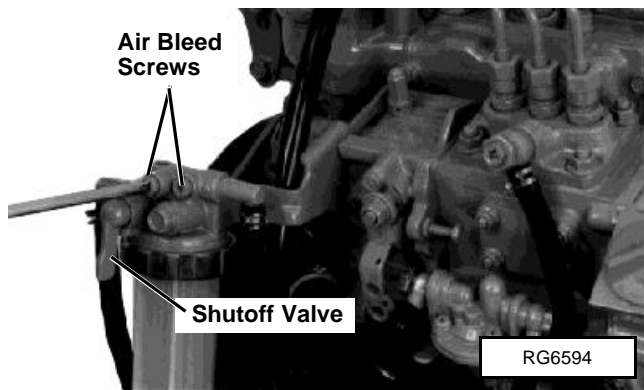
Reason:

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.

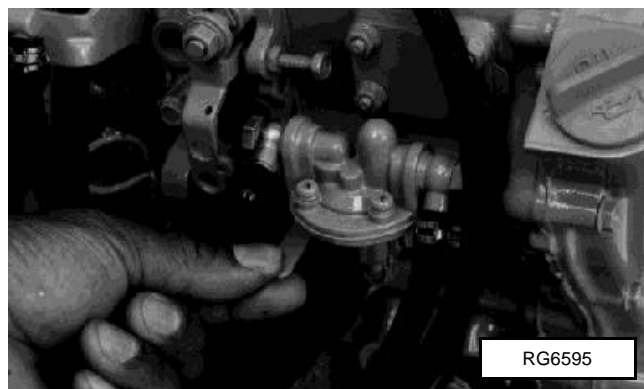
Procedure:

IMPORTANT: Modification or alteration of the injection pump, pump timing, or the injection nozzles in any way not approved by the manufacturer will terminate the warranty obligation.

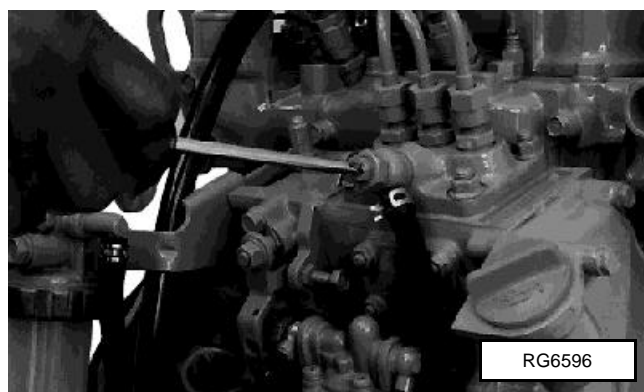
1. Turn fuel filter shutoff valve to "OPEN" position.
2. Loosen both air bleed screws on fuel filter base.



3. Turn ignition switch to "ON" position.
4. Operate hand primer lever of fuel supply pump until fuel flows free of air bubbles. Tighten bleed screws.



5. Loosen bleed screw on injection pump. Operate hand primer and tighten bleed screw when fuel flows free of air bubbles.
6. Start engine. If engine does not start after several attempts, proceed with steps 7 through 10.



7. Loosen all three injector line nuts using a 17 mm wrench. Be sure not to loosen bottom nut of injector.
8. Crank engine over with starter.

9. When fuel appears at injectors, tighten line nuts.
10. Start engine. If engine does not start, repeat bleed procedure.



BLEED FUEL SYSTEM - 3011 (3TNC78), 3014 (3TN84) AND 4019 (4TN84)

IMPORTANT: Modification or alteration of the injection pump, pump timing, or the injection nozzles in any way not approved by the manufacturer will terminate the warranty obligation.

All engines are equipped with an automatic air venting system which makes the fuel system self-bleeding.

- Assure that all fuel line connections are securely tightened.
- Add fuel to fuel tank.
- Crank engine to allow fuel system to bleed itself.

SLOW IDLE SPEED ADJUSTMENT

Reason:

To achieve proper slow idle rpm setting. Provides adequate rpm to keep engine running smoothly without stalling.

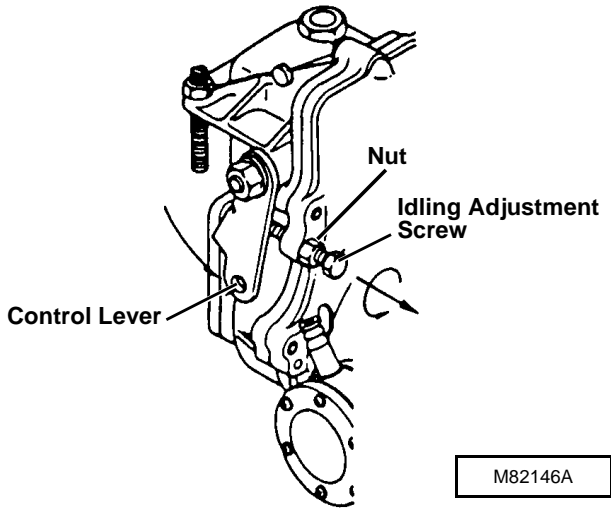
Equipment:

- JT05719 Hand-Held Digital Tachometer

Operational Tests and Adjustments

Procedure:

1. Start engine and run for five minutes.
2. Visually check that injection pump throttle lever is against slow idle stop screw.
3. Check engine speed at flywheel using the Digital Tachometer.



Specifications:

Industrial Application

All 1300 rpm

Generator Application

3009 (3TNA72) 1300 rpm

3011 (3TNC78), 3014 (3TN84),

4019 (4TN84) 1200 rpm

Results:

- If slow idle rpm is not according to specifications, loosen nut and turn screw. After adjustment, tighten nut.

FAST IDLE SPEED ADJUSTMENT - 3009 (3TNA72)

Reason:

To achieve proper fast idle rpm setting. Provides proper speed for PTO operation and insures that engine is running at proper rpm's for peak performance.

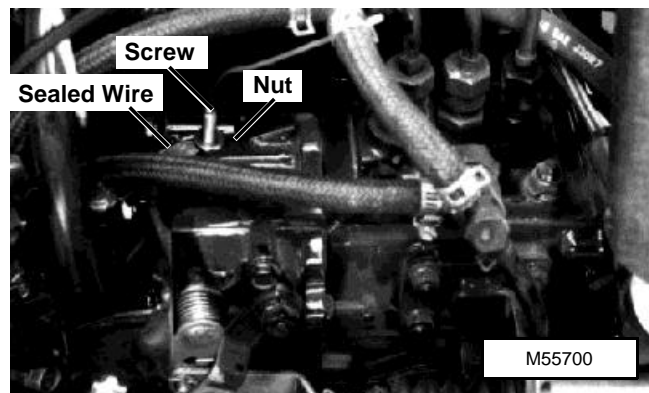
Equipment:

- JT05719 Hand-Held Digital Tachometer

Procedure:

NOTE: Make sure air cleaner is clean and not restricted. Clean or replace air cleaner element(s) as necessary.

1. Start engine and run for five minutes.
2. Push against injection pump throttle lever to insure it is against fast idle stop screw.
3. Check engine speed at flywheel using the Digital Tachometer.



Specifications:

Industrial Application 3300 rpm

Generator Application 3800 rpm

Results:

NOTE: Some adjustment can be made without removing sealed wire. Attempt to make the adjustment before removing wire.

- If fast idle rpm is not according to specifications, loosen nut and turn screw until fast idle speed is correct. After adjustment, tighten nut.
- If engine still does not meet fast idle specifications, have pump inspected by a diesel injection service.

FAST IDLE SPEED ADJUSTMENT - 3011 (3TNC78), 3014 (3TN84) AND 4019 (4TN84)

Reason:

To achieve proper fast idle rpm setting. Provides proper speed for PTO operation and insures that engine is running at proper rpm's for peak performance.

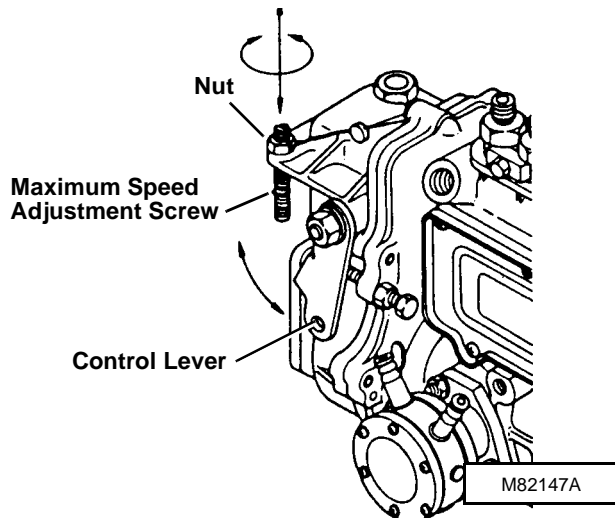
Equipment:

- JT05719 Hand-Held Digital Tachometer

Procedure:

NOTE: Make sure air cleaner is clean and not restricted. Clean or replace air cleaner element(s) as necessary.

1. Start engine and run for five minutes.
2. Push against injection pump throttle lever to insure it is against fast idle stop screw.
3. Check engine speed at flywheel using the Digital Tachometer.



Specifications:

Industrial Application 3300 rpm
Generator Application 1900 rpm

Results:

- If fast idle rpm is not according to specifications, loosen nut and turn screw until fast idle speed is correct. After adjustment, tighten nut.
- If engine still does not meet fast idle specifications, have pump inspected by a diesel injection service.

FUEL SHUTOFF SOLENOID AMPERAGE TEST

Reason:

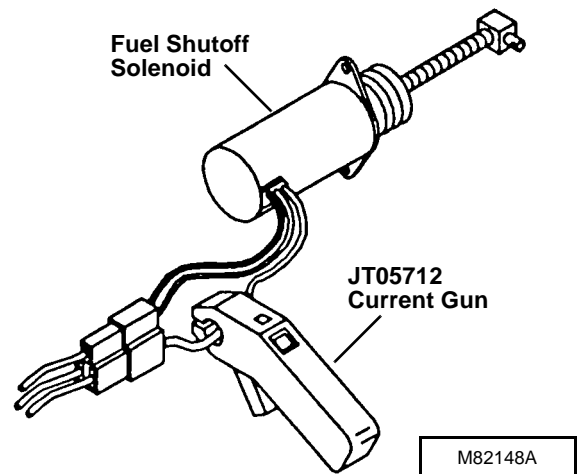
To test condition of fuel shutoff solenoid windings and check for fuel pump linkage binding creating excessive current draw.

Equipment:

- JT05712 Current Gun

Procedure:

1. Test system ground connections and battery.
2. Perform circuit tests to ensure voltage at solenoid.
3. Attach current gun to white wire of fuel shutoff solenoid.
4. Set current gun for DC current.
5. Turn key switch ON.
Maximum pull-in amperage should be 50 amps for 1/2 second.
6. Move current gun to red wire.
Maximum hold-in amperage should be 1 amp continuous.



Results:

- If readings do not meet specifications, check for binding linkage and adjust as needed or replace solenoid.

Operational Tests and Adjustments

FUEL SHUTOFF SOLENOID ADJUSTMENT

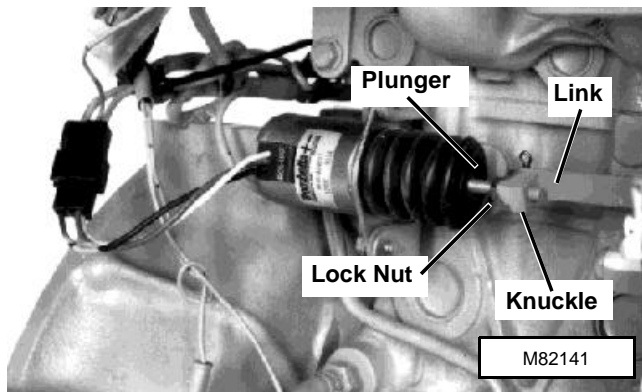
Reason:

To ensure that fuel shutoff solenoid retracts fully, moving the injection pump shutoff control lever far enough to allow full rack travel.

Procedure:

1. Loosen lock nut.
2. Disconnect link from solenoid.
3. Hold solenoid plunger bottomed in solenoid body.
4. Move link toward solenoid until it stops.
5. Turn plunger rod in or out of knuckle until knuckle and link holes line up. Turn out two additional turns. The additional turns insure that the solenoid bottoms out before the linkage.
6. Assemble and check for free movement when key switch is turned ON. Also check that linkage returns completely to the STOP position when key switch is turned OFF.

0



STARTER AMP DRAW/RPM TEST

Reason:

To determine the amperage required to crank the engine and check starter motor operation under load.

Equipment:

- JT05685 Battery Load Tester
- JT05719 Hand-Held Digital Tachometer

IMPORTANT: Turn load knob fully counterclockwise before making connections.

NOTE: Engine should be at normal operating temperature when performing this test for an accurate amperage reading.

Procedure:

1. Turn load knob fully counterclockwise.
2. Connect Battery Load Tester to battery.
3. Disconnect fuel shutoff solenoid connector.
4. Check system ground connections. Be sure battery is fully charged.
5. Crank engine. Read and record voltage at meter.
6. Use Tachometer to read and record cranking rpm.
7. Turn key switch to OFF position. Adjust load knob until battery voltage is the same as when engine is cranking.
8. Read amperage on meter.

Specifications:

3009 (3TNA72) 200 Amps at 300 rpm
3011 (3TNC78) and
3014 (3TN84) 230 Amps at 300 rpm
4019 (4TN84) 350 Amps at 1100 rpm

9. Turn load knob fully counterclockwise.

Results:

- If amp reading is not to specification, or to specification but rpm is low, perform STARTER NO-LOAD AMP DRAW/RPM TEST.

STARTER NO-LOAD AMP DRAW/RPM TEST

Reason:

To determine condition of starter.

Equipment:

- JT05712 Current Gun
- JT05719 Hand-Held Digital Tachometer

Procedure:

1. Remove starter from engine.

NOTE: Check that battery is fully charged and of proper size to ensure accuracy of test.

2. Connect jumper cables to battery.
3. Connect positive (+) cable to positive (battery) terminal on starter.

4. Connect negative (-) cable to starter body. Attach Current Gun to positive (+) cable.

IMPORTANT: Complete this test in 20 seconds or less to prevent starter damage.

5. Use a jumper wire to briefly connect positive (+) starter terminal to solenoid.
6. Measure starter amperage and rpm.

Specifications:

3009 (3TNA72) 60 Amps at 7000 rpm

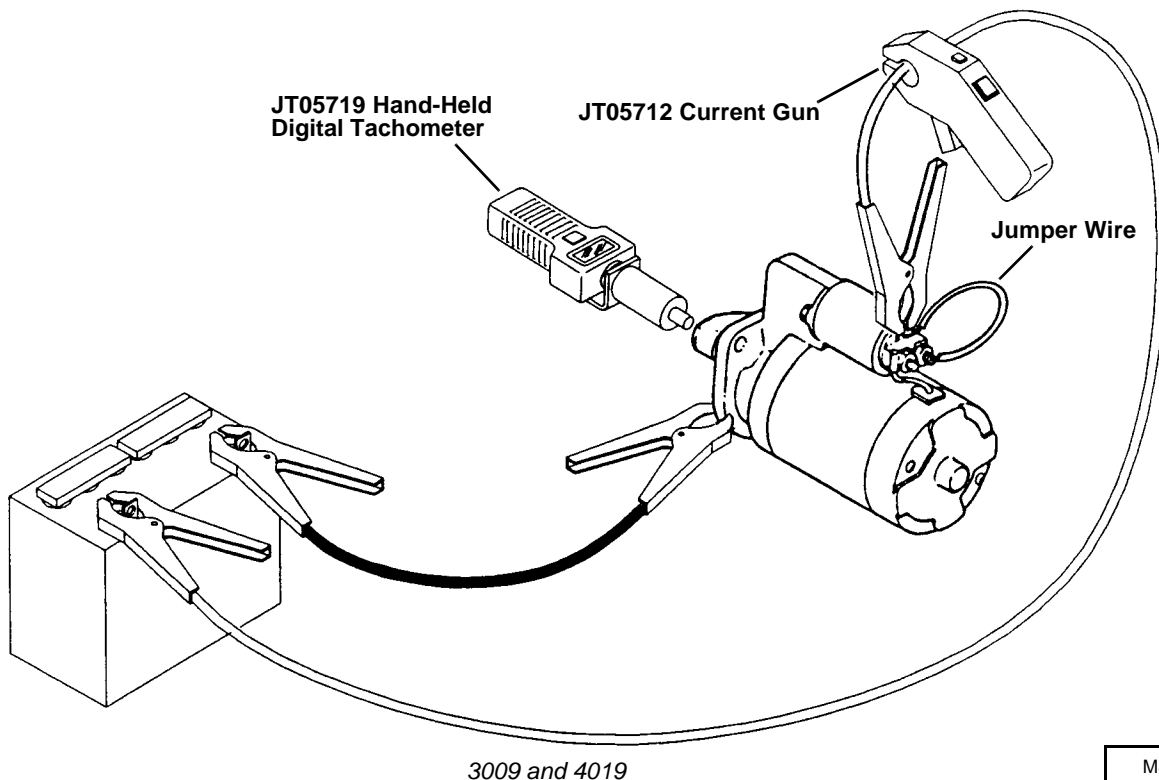
3011 (3TNC78) and

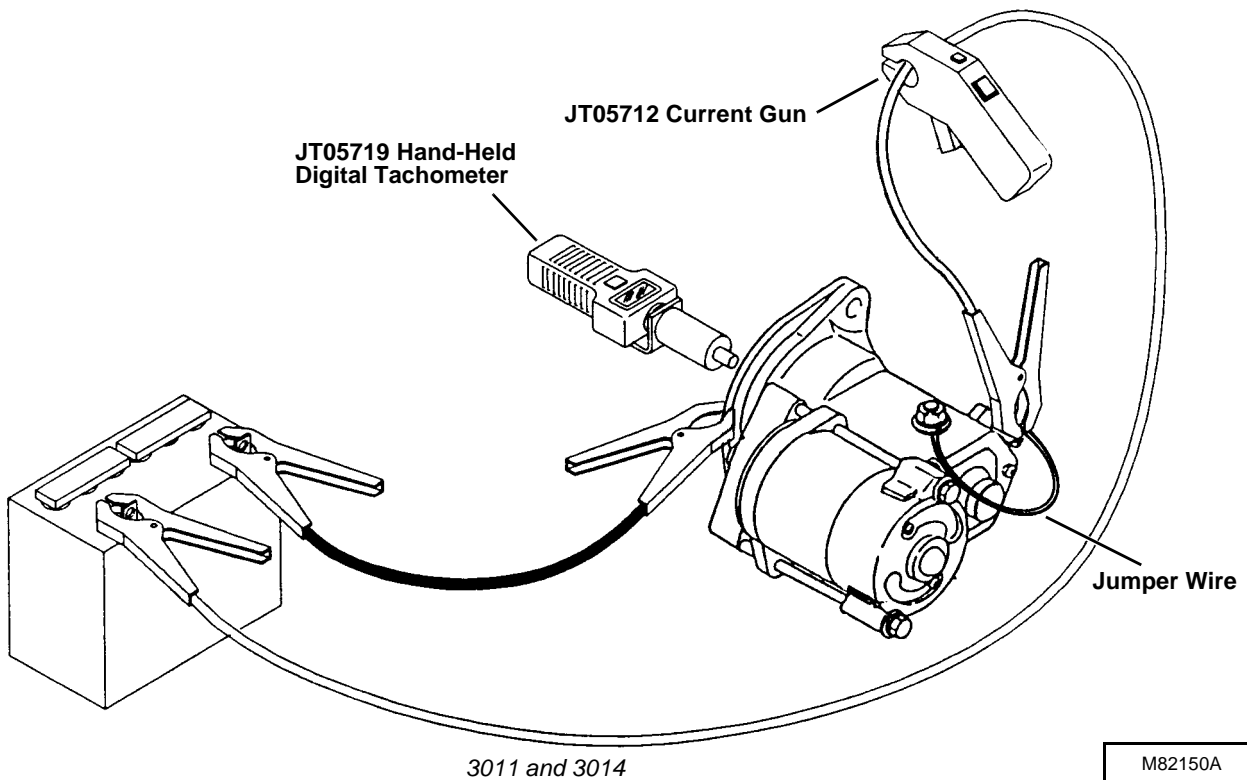
3014 (3TN84) 90 Amps at 3000 rpm

4019 (4TN84) 90 Amps at 3500 rpm

Results:

- If starter amps or rpm are not to specification, repair or replace starter.





0 STARTER SOLENOID TEST

Reason:

To determine if starter solenoid or starter motor is defective.

Equipment:

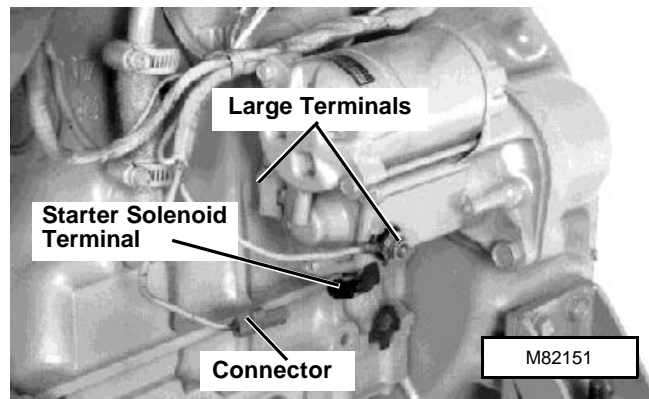
- Jumper Wire

Procedure:

1. Disconnect fuel shutoff solenoid connector.
2. Disconnect single wire connector from starter solenoid.
3. Connect jumper wire to positive (+) battery terminal and briefly jump to starter solenoid terminal.
 - Starter runs: Solenoid is good.
 - Starter does not run: Go to step 4.
4. Remove rubber boots from starter solenoid large terminals.

5. Connect jumper wire between terminals.

- Starter runs: Replace solenoid.
- Starter does not run: Check battery cables then replace starter.



3011 and 4019 Shown

REGULATED AMPERAGE TEST

Reason:

To determine regulated charging output of the alternator.

Equipment:

- JT05712 Current Gun
- JT05685 Battery Load Tester

Procedure:

1. Turn load knob of Battery Tester fully out (counterclockwise) before connecting to battery.
2. Connect Battery Tester to battery.
3. Attach Current Gun to alternator red wire. Set Current Gun for DC current.

IMPORTANT: Perform this test quickly to prevent damage to battery tester. DO NOT apply full load to battery for more than 10 seconds.

4. Start and run engine at fast idle (full throttle).

Fast Idle Speed Specifications:

Industrial Application

All 3300 rpm

Generator Application

3009 (3TNA72) 3800 rpm

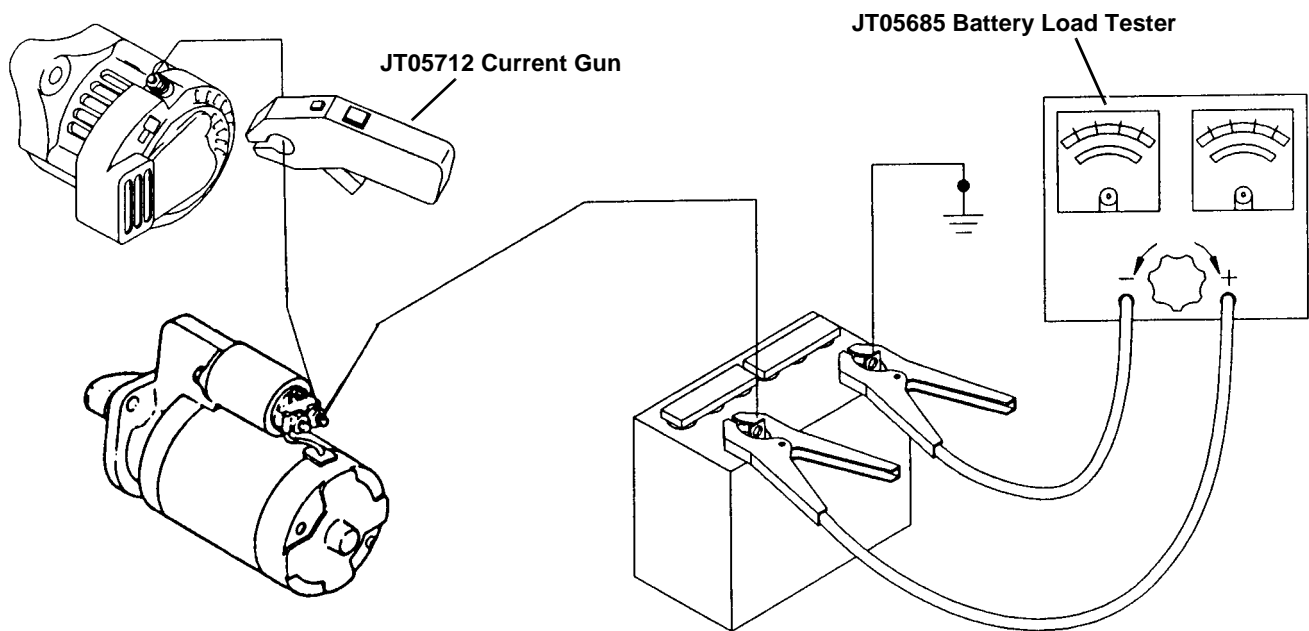
3011 (3TNC78), 3014 (3TN84),

4019 (4TN84) 1900 rpm

5. Turn load knob in until voltage read on the tester voltage scale is 11 volts and read amperage on Current Gun. **Minimum regulated amperage should be 35 amps.**

Results:

- If reading is less than specifications, verify voltage at the alternator regulator terminal and good alternator ground. If voltage and ground are OK, perform UNREGULATED AMPERAGE TEST to determine if alternator or voltage regulator is defective.



M82152A

Operational Tests and Adjustments

UNREGULATED AMPERAGE TEST

Reason:

To determine charging output of the alternator stator.

Equipment:

- JT05712 Current Gun

Procedure:

1. Attach Current Gun to alternator red wire. Set Current Gun for DC current.

IMPORTANT: Perform this test quickly to prevent damage to battery. DO NOT apply full load to battery for more than 10 seconds.

2. Start and run engine at fast idle (full throttle).

Fast Idle Speed Specifications:

Industrial Application

All 3300 rpm

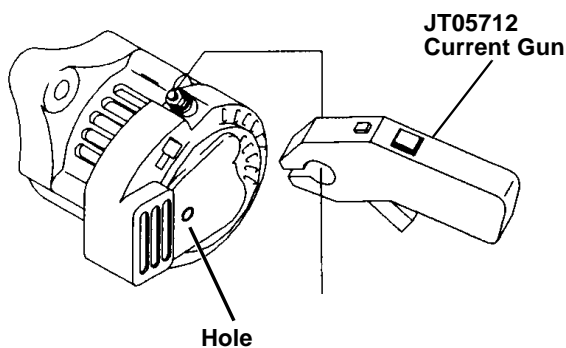
Generator Application

3009 (3TNA72) 3800 rpm

3011 (3TNC78), 3014 (3TN84),

4019 (4TN84) 1900 rpm

3. Insert a Phillips screwdriver through hole in rear cover of alternator, to ground the regulator to the rear cover. Read amperage on current gun. **Minimum regulated amperage should be 35 amps.**



Results:

- If reading is less than specifications, verify voltage at the alternator regulator terminal and good alternator ground. If voltage and ground are OK, replace the alternator.
- If reading meets the specification, replace the regulator.

REGULATED VOLTAGE TEST

Reason:

To determine regulated voltage output of the alternator regulator.

Equipment:

- Voltmeter

Procedure:

1. Remove surface charge from battery by placing a small load on the battery for 15 seconds.
2. Set voltmeter to DC volts scale.
3. Connect meter red lead to positive (+) battery terminal.
4. Connect meter black lead to negative (-) battery terminal.
5. Start and run engine at fast idle (full throttle).

Fast Idle Speed Specifications:

Industrial Application

All 3300 rpm

Generator Application

3009 (3TNA72) 3800 rpm

3011 (3TNC78), 3014 (3TN84),

4019 (4TN84) 1900 rpm

6. Read meter several times during five minutes of running time. **Regulated voltage should be within 12.2 - 14.7 VDC.**

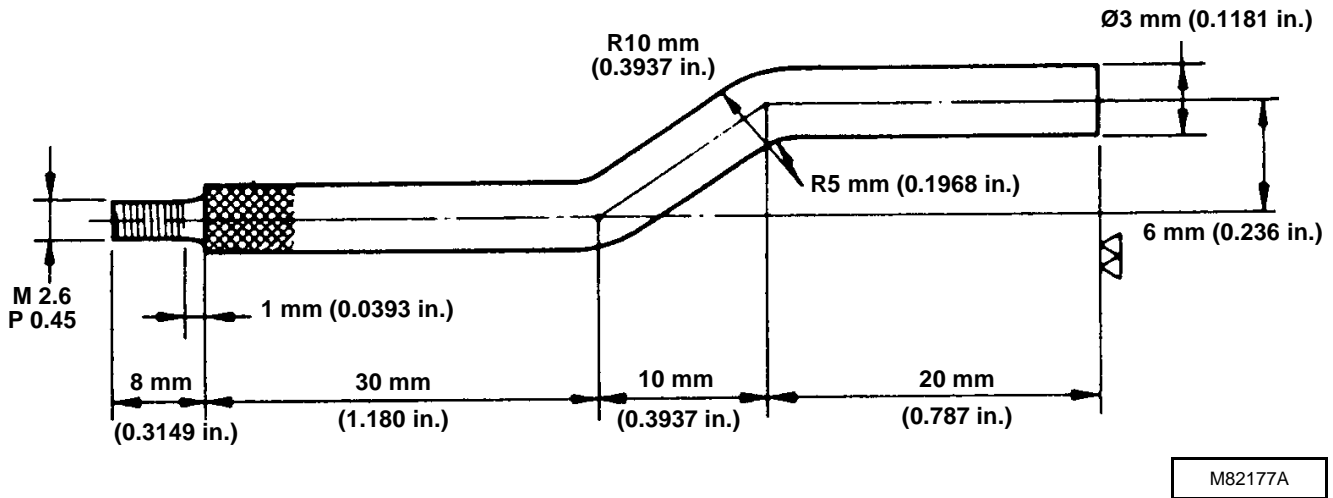
IMPORTANT: Do not allow the battery voltage to exceed 15.5 volts or the battery and charging system will be damaged.

Results:

- If the DC voltage stays below the minimum specification, verify voltage at the alternator regulator terminal and good alternator ground. If voltage and ground are OK, perform **UNREGULATED AMPERAGE TEST** to determine if alternator or voltage regulator is defective.
- If the DC voltage goes above the maximum specification, replace the regulator.

Dealer Fabricated Tools

DFRG1 EXTENDED INDICATOR TIP (RHB3)



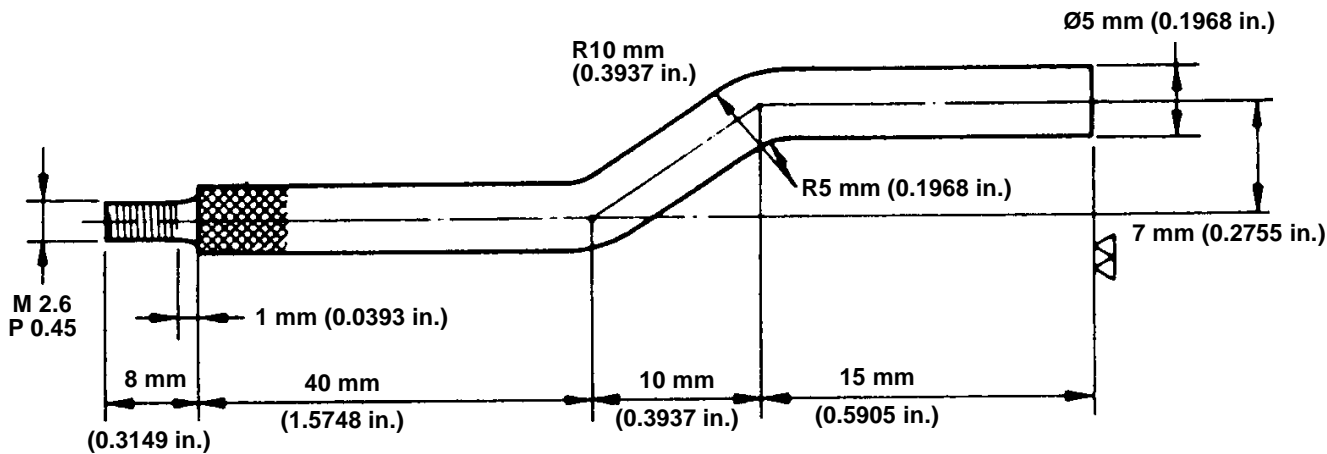
Extended indicator tip is used to check radial play of turbocharger rotor shaft. Attach extended tip to a dial indicator gauge.

Material required:

Extended indicator tip from a local supplier. Approximately 0.118 in. dia. x 3 in. long. Heat and bend to size shown.

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**DFRG2 EXTENDED INDICATOR TIP
(RHB5)**



M82177A

Extended indicator tip is used to check radial play of turbocharger rotor shaft. Attach extended tip to a dial indicator gauge.

Material required:

Extended indicator tip from a local supplier. Approximately 0.197 in. dia. x 3 in. long. Heat and bend to size shown.

Dealer Fabricated Tools

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ENGINE, AIR INTAKE AND FUEL SYSTEM

Component Location	20-1
Theory of Operation	20-4

Section 20

INTRODUCTION

This section provides an overview of the compact three and four cylinder in-line diesel engines used in John Deere Grounds Care and Industrial products. These compact engines are also available as OEM stand-alone power packs.

The TN Series diesel engines are offered as base engines only and are mainly used in tractor applications.

The Series 220 diesel engines are offered as OEM units with three different configurations available. A base industrial engine, an industrial power unit, and a generator drive unit. Features on the power units include an air cleaner kit, muffler, radiator kit and instrument panel.

NOTE: The Series 220 engines are NOT repower engines for tractor application.

While most parts in the TN Series Engines are identical and interchangeable with Series 220 Engines, specifications are not always the same. General appearance, repair procedures, and operation of sub-systems are similar and often even identical.

There are two “types” of engines; Indirect Injection - 3TN66 and 3TNA72 (3009) and Direct Injection - All except 3TN66 and 3TNA72 (3009).

The following is a complete engine listing with the approximate horsepower ratings:

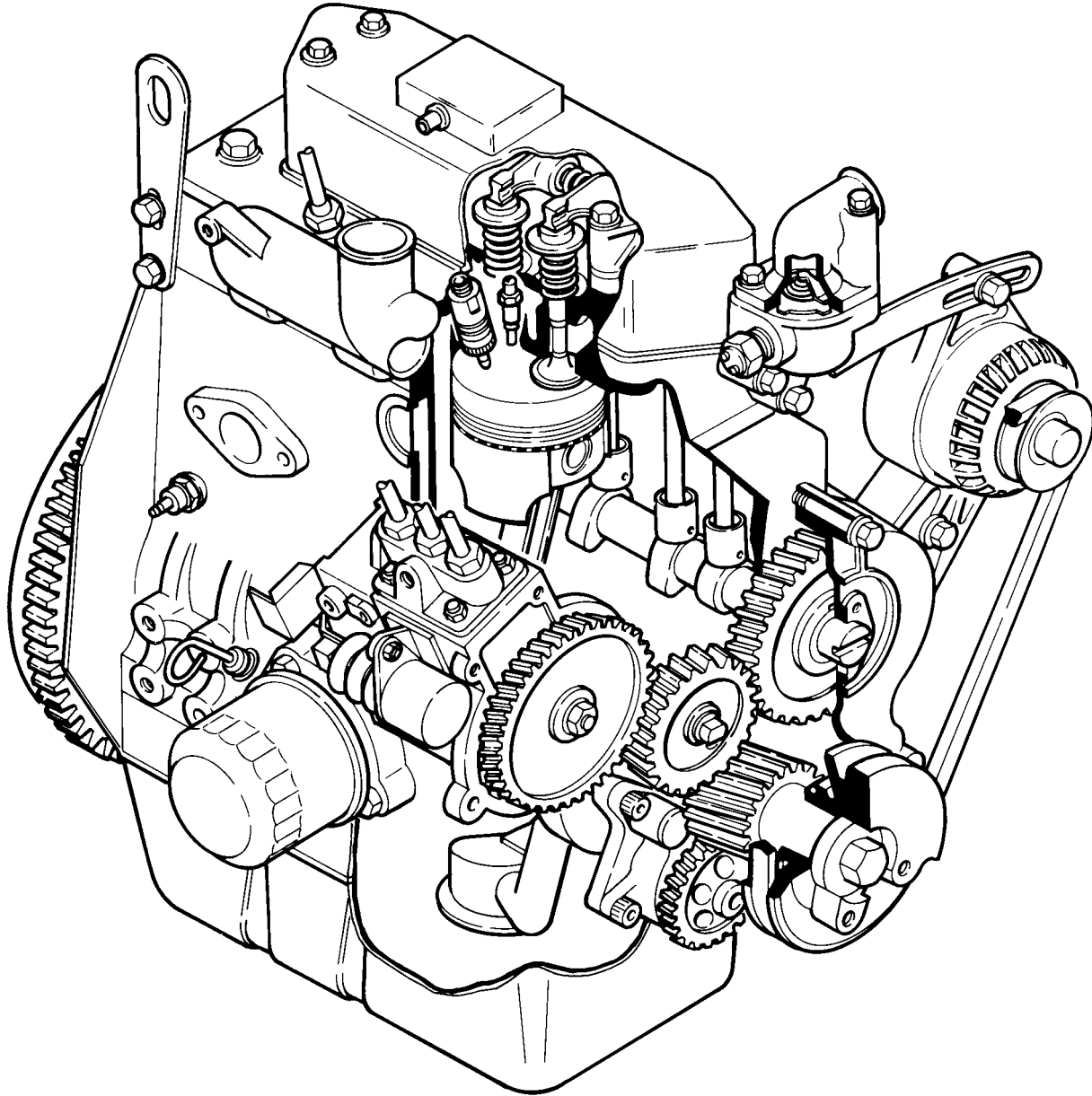
NOTE: The TN Series horsepower ratings are averages as a result of the numerous tractor applications for each engine.

TN Series Engines

<u>Model Number</u>	<u>kW (hp) Rating</u>
3TN6611.9 (16) SAE Net @ 3200 rpm	
3TNA7216.4 (22) SAE Net @ 3600 rpm	
3TN7517.9 (24) SAE Net @ 3200 rpm	
3TN7817 (23) SAE Net @ 2500 rpm	
3TN8221.4 (28.7) SAE Net @ 2800 rpm	
3TNA8217.2 (24) SAE Net @ 2600 rpm	
3TN8420.9 (28) SAE Net @ 2600 rpm	
4TN78T29 (39) SAE Net @ 2650 rpm	
4TN8228.9 (38.8) SAE Net @ 2800 rpm	
4TN8428.7 (38.5) SAE Net @ 2600 rpm	
4TN10041 (55) SAE Net @ 2200 rpm	

Series 220 Engines (OEM)

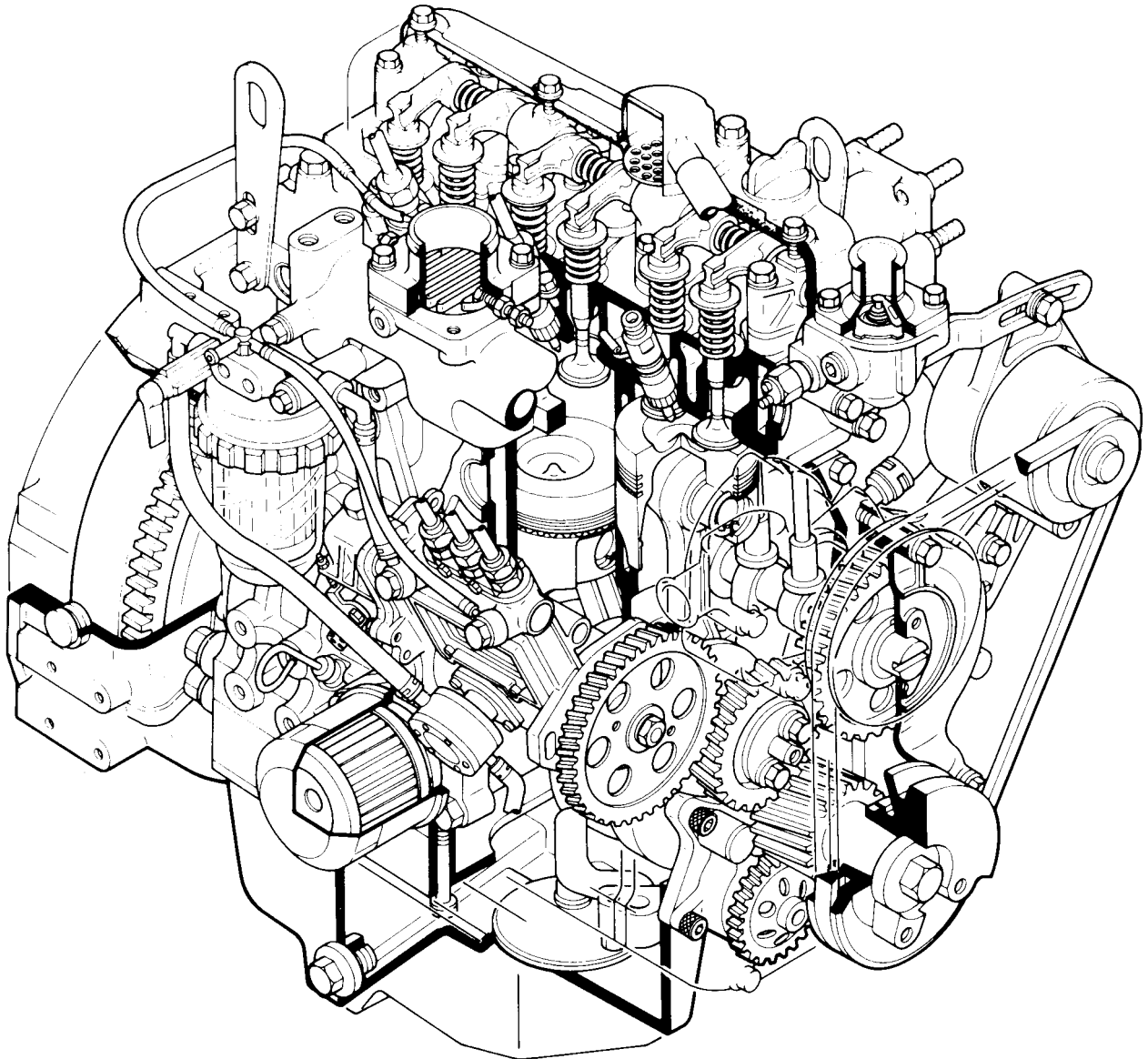
<u>Model (Engine)</u>	<u>Intermittent Gross Power, kW (hp) @ 3000 rpm</u>
3009 (3TNA72).....	15.4 (20.7)
3011 (3TNC78).....	20.2 (27.1)
3014 (3TN84).....	24.9 (33.5)
4019D (4TN84).....	33.4 (44.8)
4019T (4TN84T).....	40.3 (54)



INDIRECT INJECTION (IDI) ENGINE COMPONENTS

M82000A

20



DIRECT INJECTION (DI) ENGINE COMPONENTS

M82001A

20

Theory of Operation

ENGINE BALANCER OPERATION - 4TN82 and 4TN84

Function:

To minimize engine vibrations resulting from unbalanced movements.

NOTE: TN Series 4TN82 and 4TN84 engines are fitted with balancer shafts, because the engines are used as rigid-mount, structural members. Series 220 OEM 4019D (4TN84) and 4019T (4TN84T) engines are "loose" engines and do not have balancer shafts. These engines may be "soft" mounted if vibration is a concern.

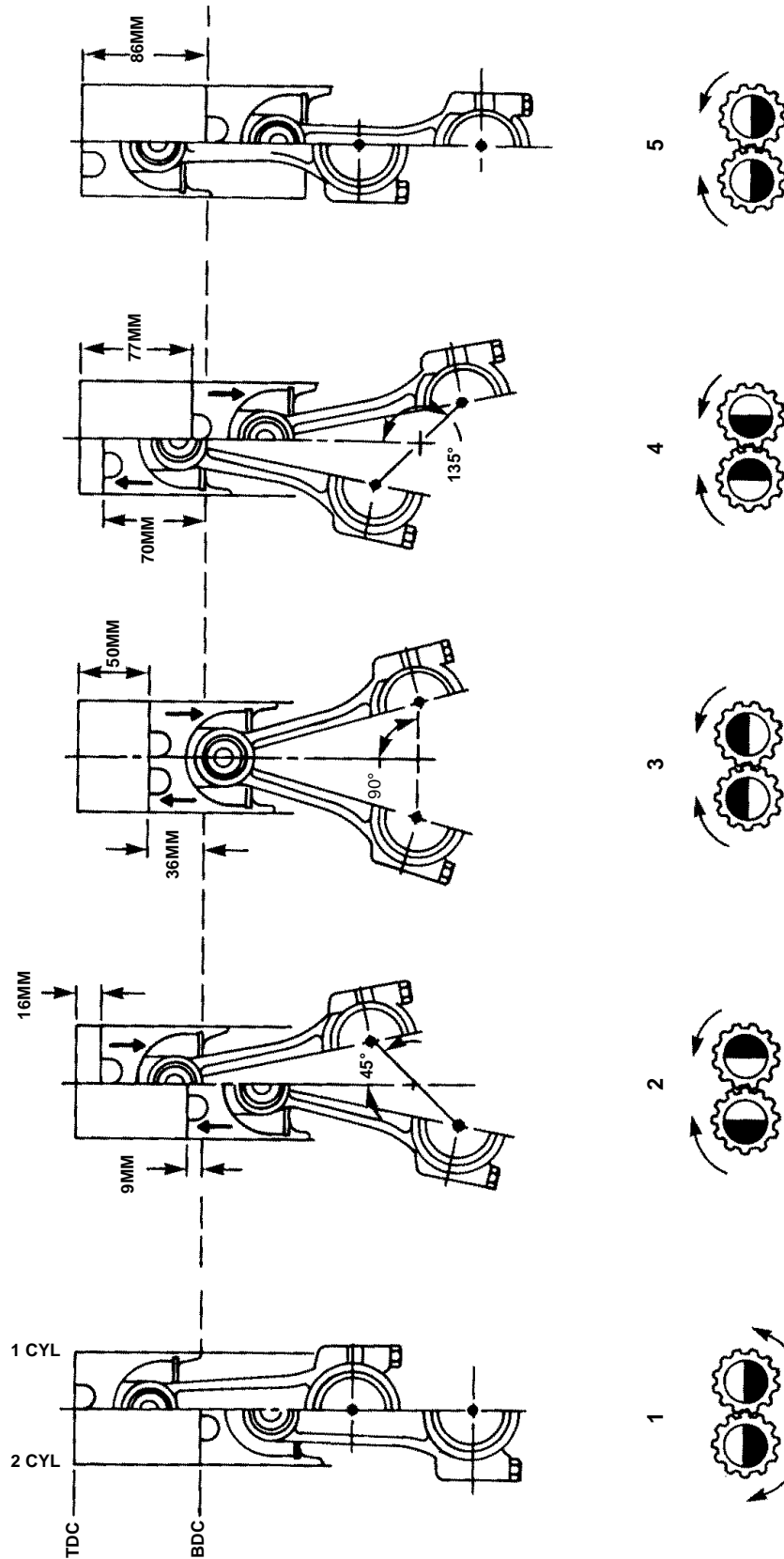
Theory of Operation:

In-line 4 cylinder engines with crankshaft throws 180° apart have some unbalanced forces of the reciprocating parts. Most of these forces are offset by parts moving in opposite directions.

However, the forces are not entirely cancelled. During each 45° segment of crankshaft rotation, the No. 1 piston and connecting rod moves a different distance than the No. 2 piston and connecting rod. Since the crankshaft throws move at equal speed, the parts moving farther must also move faster. As engine speeds increase and/or parts get heavier, vibrations resulting from the unbalanced movements may become objectionable.

To minimize these vibrations the engines have a balancer assembly mounted to the block, below the crankshaft. It is driven by a gear on the crankshaft. The balancer has two shafts, counter-rotating, with balancing weights, turning at double crankshaft RPM.

The balancer weights are timed to the crankshaft so that when No. 1 piston travels downward from TDC to horizontal crankshaft position, the balancer weights both move upward. The weights are then positioned so they can move downward as the No. 2 piston moves up from horizontal crankshaft position to TDC.



ENGINE BALANCER OPERATION - 4TN82 and 4TN84

M82002A

COOLING SYSTEM OPERATION

Function:

The coolant pump circulates coolant through the cooling system, drawing hot coolant from the engine block, circulating it through the radiator for cooling.

Theory of Operation:

The pressurized cooling system includes the radiator, water pump, fan and thermostat.

During the warm-up period, the thermostat remains closed and coolant is directed through a by-pass tube to the suction side of the coolant pump. The coolant then circulates through the cylinder block providing a fast warm-up period.

Once the engine has reached operating temperature, the thermostat opens and coolant is pumped from the bottom of the radiator via the lower radiator hose into the cylinder block. Here it circulates through the block and around the cylinders.

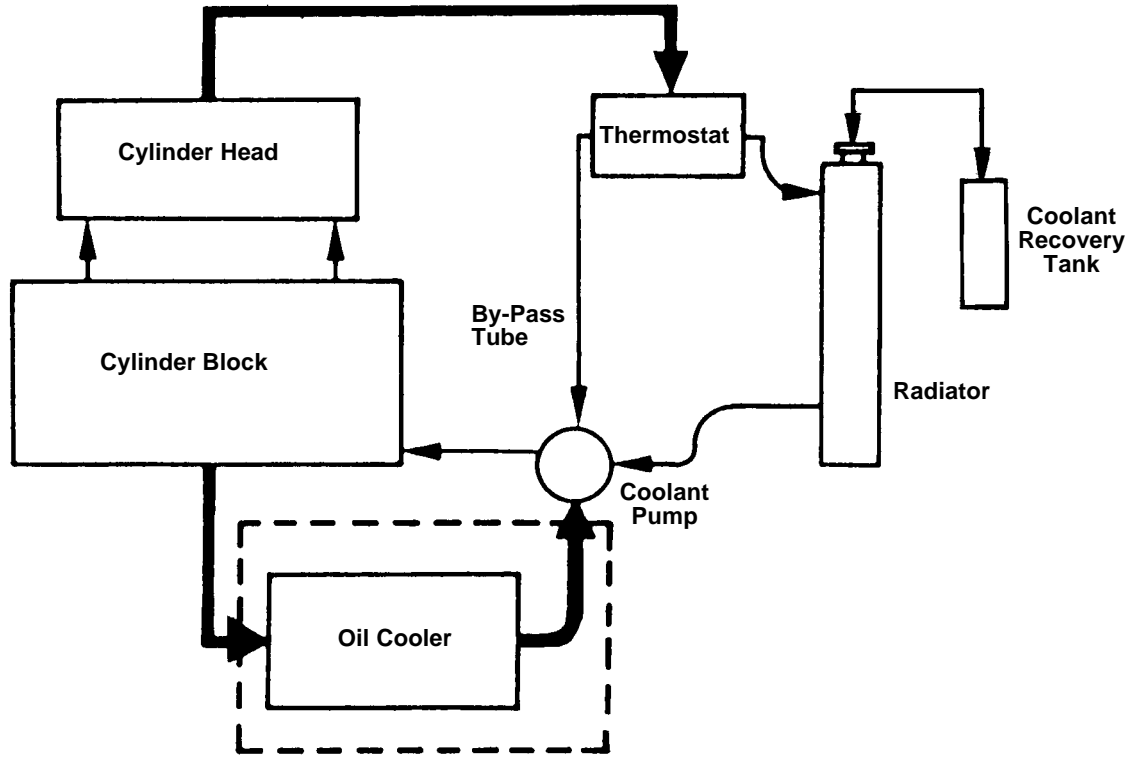
From the block, coolant is then directed through the cylinder head, and into thermostat housing. With the thermostat open, **82° C (180° F)**, warm engine coolant passes through the housing into the top of the radiator where it is circulated to dissipate heat.

When coolant system pressure exceeds **48 kPa (7 psi)**, a valve in the radiator cap opens to allow coolant to discharge into the coolant recovery tank.

When temperature is reduced, a vacuum is produced in the radiator and coolant is drawn back out of the coolant recovery tank through a valve in the radiator cap.

3TN84UJ, 4TN78T, 4TN84T (4019T) and 4TN100 are equipped with an oil cooler. The oil cooler is used to help reduce the temperature of engine oil. Pressurized oil enters the oil cooler and passes through a network of tubing surrounded by engine coolant. Heat transfers from the oil to the coolant, thus reducing oil temperature.

A coolant temperature sender senses critical coolant temperature and sends a signal to an indicator light and/or gauge in the instrument panel.

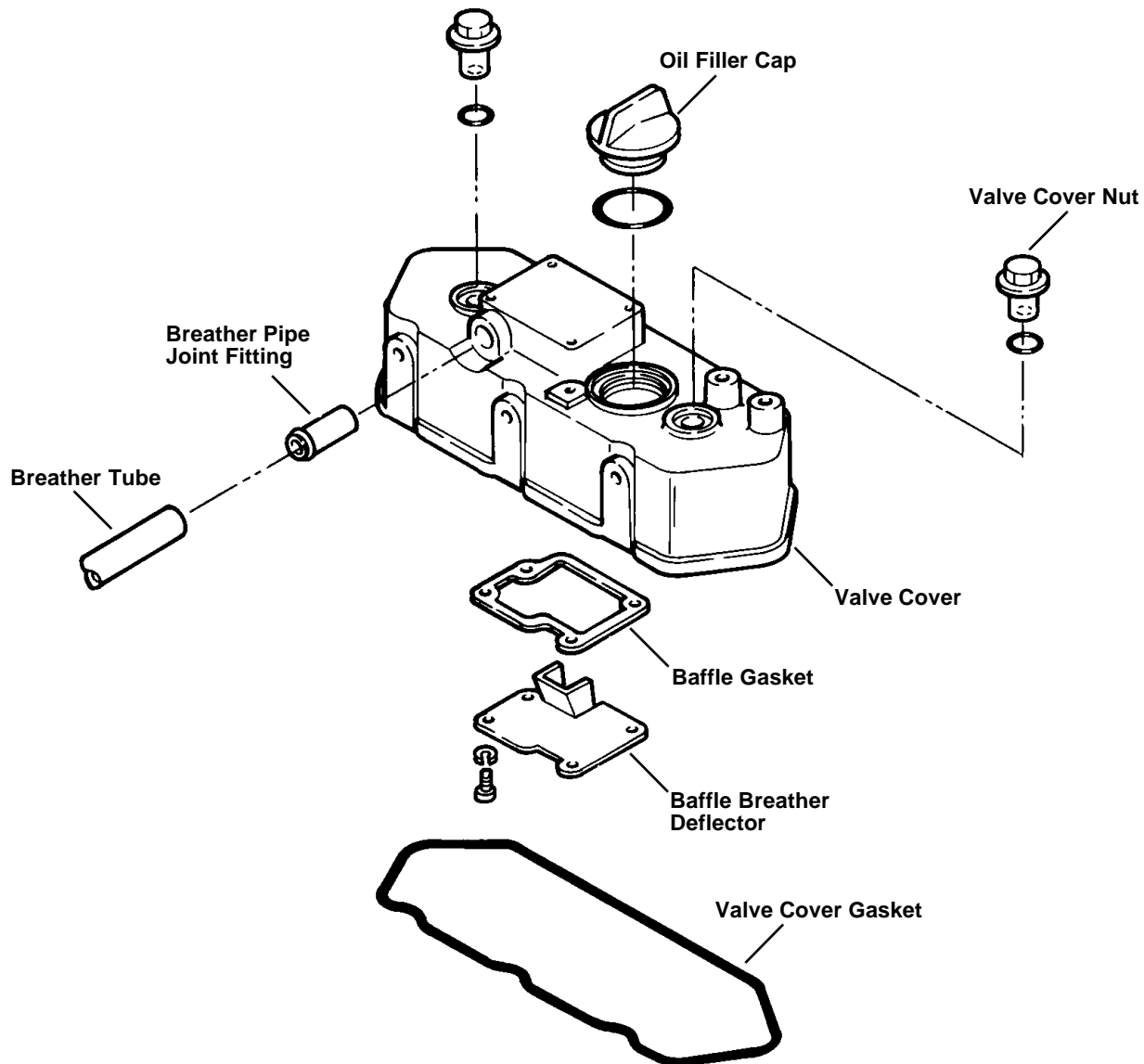


COOLING SYSTEM OPERATION

M82003A

Theory of Operation

CRANKCASE BREATHER OPERATION - 3TN66, 3TNA72 (3009) and 4TN100



CRANKCASE BREATHER OPERATION - 3TN66, 3TNA72 (3009) and 4TN100

M82004A

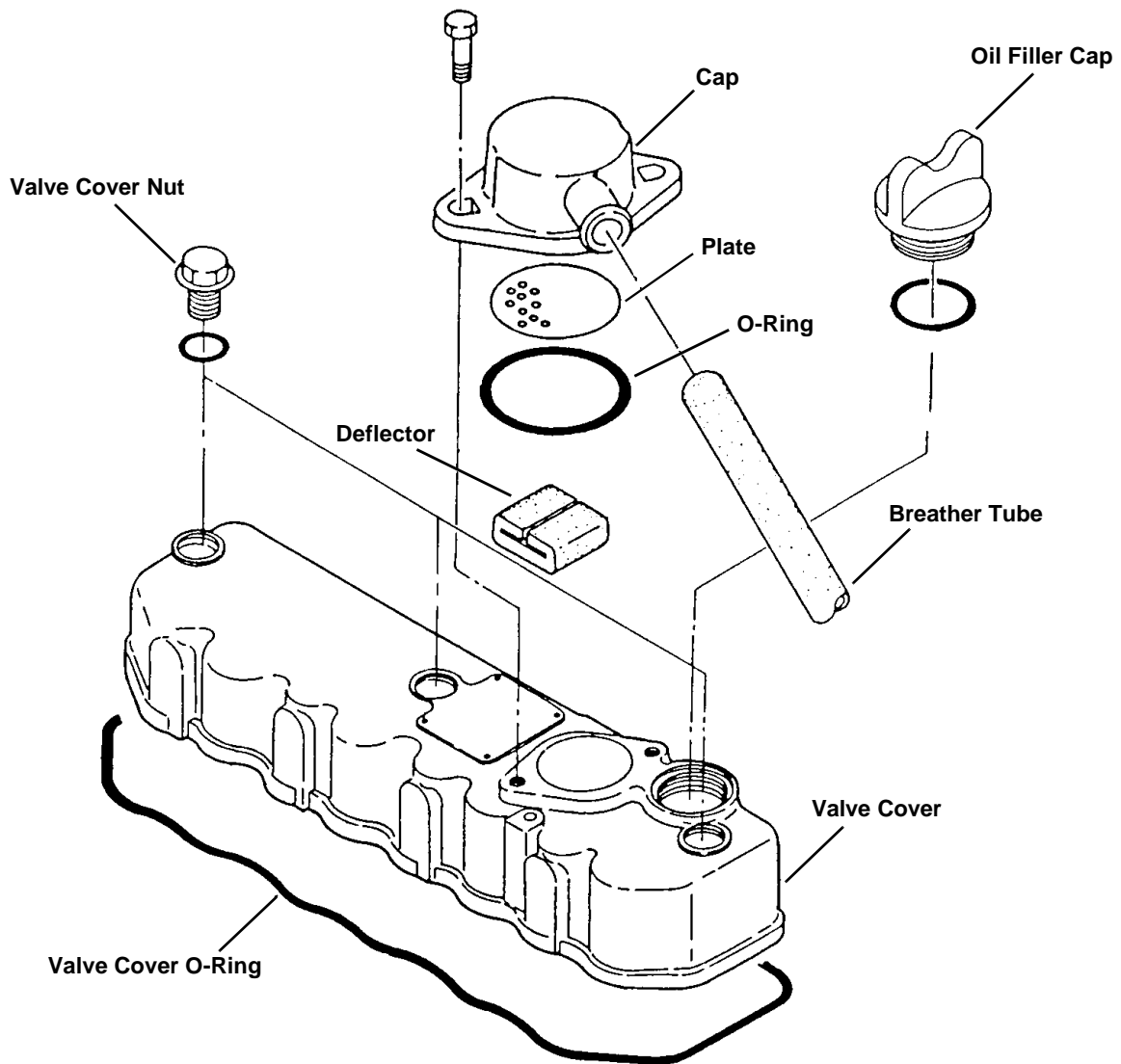
Function:

Vents crankcase fuel and water vapor out of engine without losing engine oil, controls the pressurization of the crankcase.

Theory of Operation:

During normal engine operation, unburned fuel vapors and water vapors, tend to contaminate the crankcase. Most of these vapors are expelled by the exchange of air which is controlled by the breather. The crankcase is slightly pressurized by the leakage of compression around the pistons. The air is circulated by the movement of the pistons.

CRANKCASE BREATHER OPERATION - ALL EXCEPT 3TN66, 3TNA72 (3009) and 4TN100



CRANKCASE BREATHER OPERATION - ALL EXCEPT 3TN66, 3TNA72 (3009) and 4TN100

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Function:

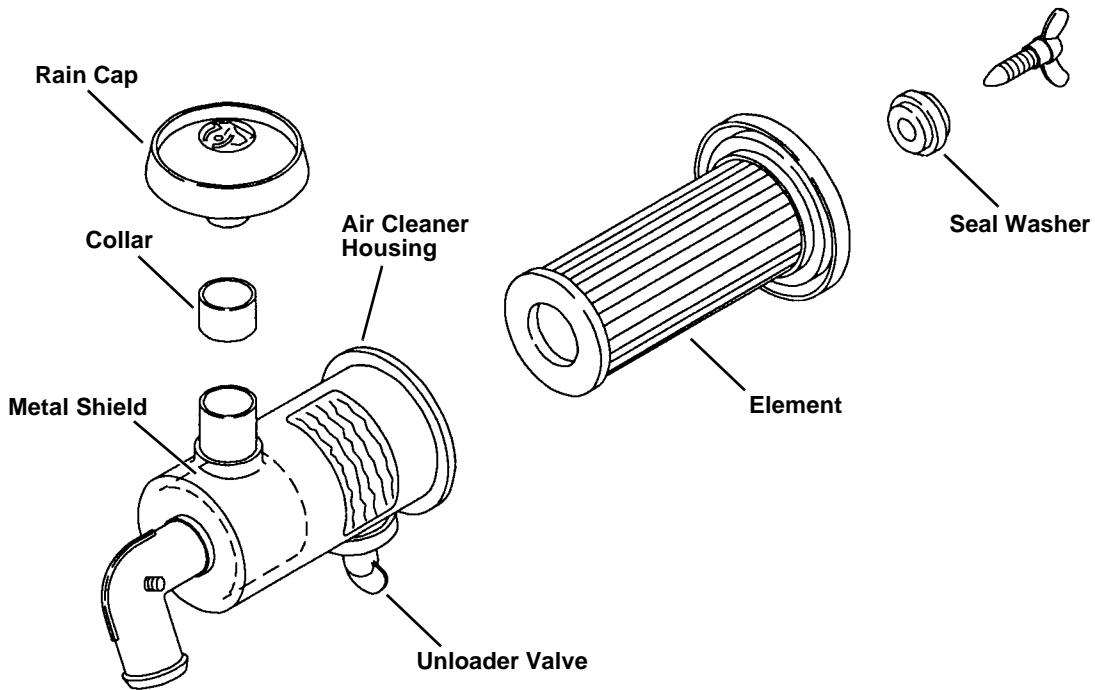
Vents crankcase fuel and water vapor out of engine without losing engine oil, controls the pressurization of the crankcase.

Theory of Operation:

During normal engine operation, unburned fuel vapors and water vapors tend to contaminate the crankcase. Most of these vapors are expelled by the exchange of air which is controlled by the breather. The crankcase is slightly pressurized by the leakage of compression around the pistons. The air is circulated by the movement of the pistons.

Theory of Operation

AIR CLEANER OPERATION - 3009 (3TNA72)



AIR CLEANER OPERATION - 3009 (3TNA72)

M82006AE

Function:

20 Air cleaner filters air needed for combustion.

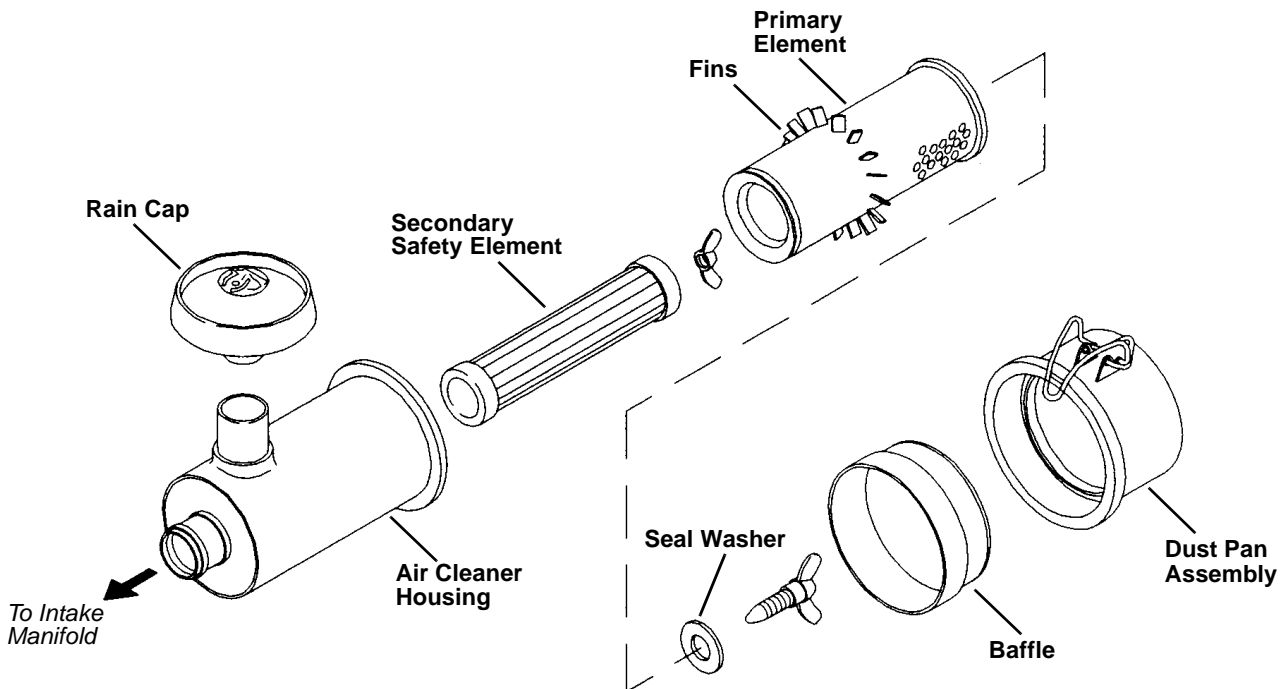
Theory of Operation:

Air enters the air cleaner inlet and is directed into the side of a metal shield. This starts a high-speed centrifugal motion of air which continues around the element until it reaches the far end of the air cleaner housing, to an unloader valve.

Most of the dust is separated from the air by centrifugal force that causes heavy dust particles to enter the opening at the top of the unloader valve. The remaining air enters the element.

The dirt that is deposited in the unloader valve is removed by the rubber diaphragm at the base of unloader valve. When the engine is running, a pulsing action is created in the intake system by each intake stroke of engine. This pulsing action causes the rubber diaphragm to open and close, thus emptying the unloader valve.

AIR CLEANER OPERATION - 3011 (3TNC78), 3014 (3TN84), 4019D (4TN84) and 4019T (4TN84T)



AIR CLEANER OPERATION - 3011 (3TNC78), 3014 (3TN84), 4019D (4TN84) AND 4019T (4TN84T)

M82007AE

Function:

Air cleaner filters air needed for combustion.

Theory of Operation:

Air enters the air cleaner inlet and is forced into a high-speed centrifugal motion by fins on the primary element. When the air reaches the end of the air cleaner housing, the dirt passes through a slot in top of the dust pan assembly.

Most of the dust is separated from the air by centrifugal force that causes the heavy dust particles to enter the opening at the top of the dust pan assembly. The remaining air enters the primary element, then secondary safety element to cylinder head.

Remove the baffle to empty dust pan assembly. Dust pan should be emptied daily.

Theory of Operation

TURBOCHARGER OPERATION - 4TN78T, 4TN84T (4019T) and 4TN100

Function:

To force more air into the engine cylinders to allow the engine to efficiently burn more fuel, thereby producing more power.

Theory of Operation:

The turbocharger provides additional air to burn more fuel and produce more power without increasing the size of the engine. In the thinner air of high altitudes, the turbocharger turbine wheel may turn as fast as 186,000 rpm to maintain power.

Exhaust gases from the engine pass through a turbine housing, causing a shaft to rotate before the exhaust gas is discharged.

A compressor wheel, also mounted on the shaft, rotates in the compressor housing. Inlet air is drawn into the housing, where it is compressed and delivered to engine cylinders.

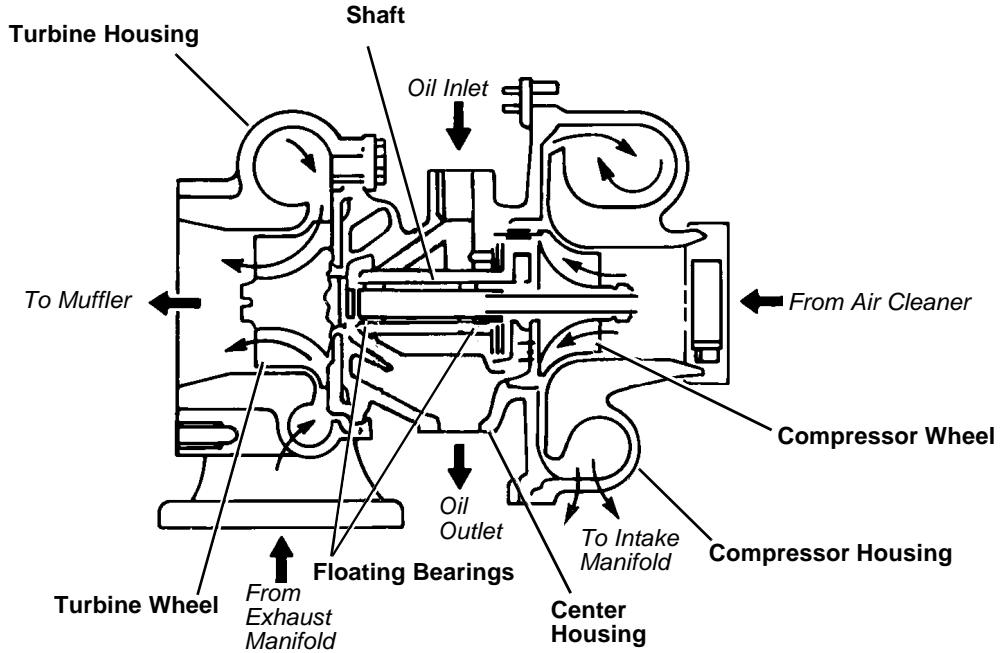
Engine oil under pressure from the engine lubrication system is pumped through passages in the bearing housing and directed to the bearings.

The turbocharger contains two floating bearings that have clearance between the bearing O.D. and housing wall as well as a clearance between the bearing I.D. and the shaft O.D.

These clearances are lubricated by the oil supply and the bearings are protected by a cushion of oil.

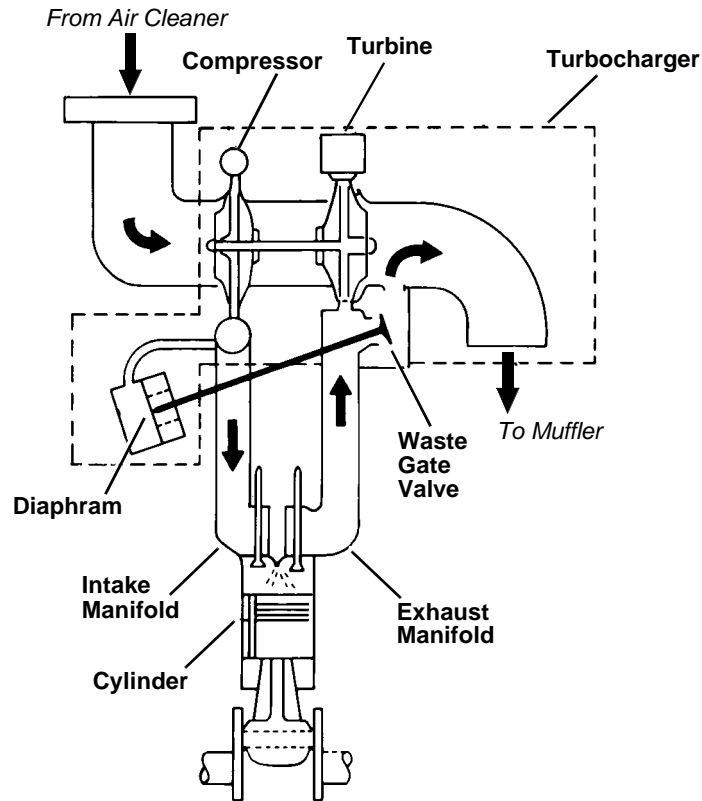
The pressure-free oil drains by gravity from the center housing to the engine crankcase.

The turbocharger may be equipped with a waste gate. If the turbocharger goes above specified pressure, a diaphragm sensing inlet pressure from the compressor, opens a waste gate valve to allow excess exhaust gases to bypass the turbine. The waste gate valve limits boost pressure at high rpm to prevent damage to the engine.



TURBOCHARGER OPERATION - 4TN78T, 4TN84T (4019T) AND 4TN100

M82008A



M82019A

Theory of Operation

LUBRICATION SYSTEM OPERATION

Function:

A full pressure system lubricates engine parts with clean oil.

NOTE: Safety valve and oil cooler are on 3TN84UJ, 4TN78T, 4TN84T (4019T) and 4TN100 engines only.

Piston cooling nozzles are on 4TN78T, 4TN84T (4019T) and 4TN100 engines only.

Theory of Operation:

The pressure lubrication system consists of a positive displacement gear-driven pump, oil strainer, full flow oil filter, oil pressure regulating valve and an electrical pressure warning switch. Some models are also equipped with an oil cooler, safety valve and piston cooling nozzles.

The pump draws lubrication oil from the oil pan through a strainer and a suction tube. The oil is then pumped through an oil passage to the oil filter, oil cooler, if equipped, and through the engine block main oil galley.

From the main oil galley, oil is forwarded under pressure to the crankshaft main bearing journals, idler gear shaft and piston cooling nozzles, if equipped. Drilled cross-passages in the crankshaft distribute the oil from the main bearings to connecting rod bearings.

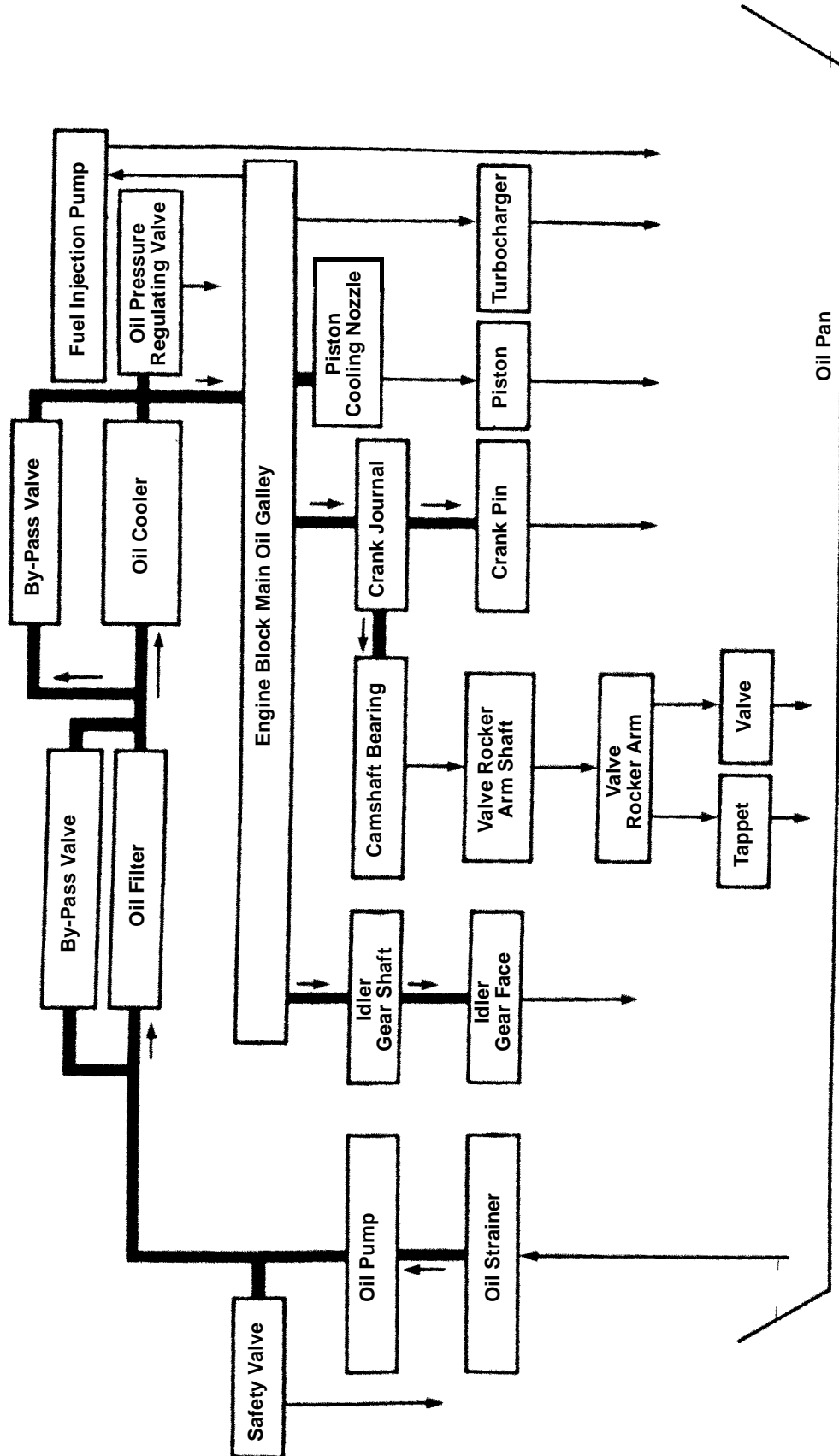
Lube oil holes in main bearing oil grooves are provided to direct oil to the camshaft bearings.

A drilled passage from the rear camshaft bearing through the cylinder block and cylinder head supplies lubricating oil to the rocker arm shaft. The hollow shaft distributes oil to the rocker arms, tappets and valves.

Oil passages direct from the main oil galley, through external oil lines, route lubricating oil to the fuel injection pump and turbocharger, if equipped.

An oil pressure switch activates an indicator light to alert the operator to shut down the engine if oil pressure drops below a specification.

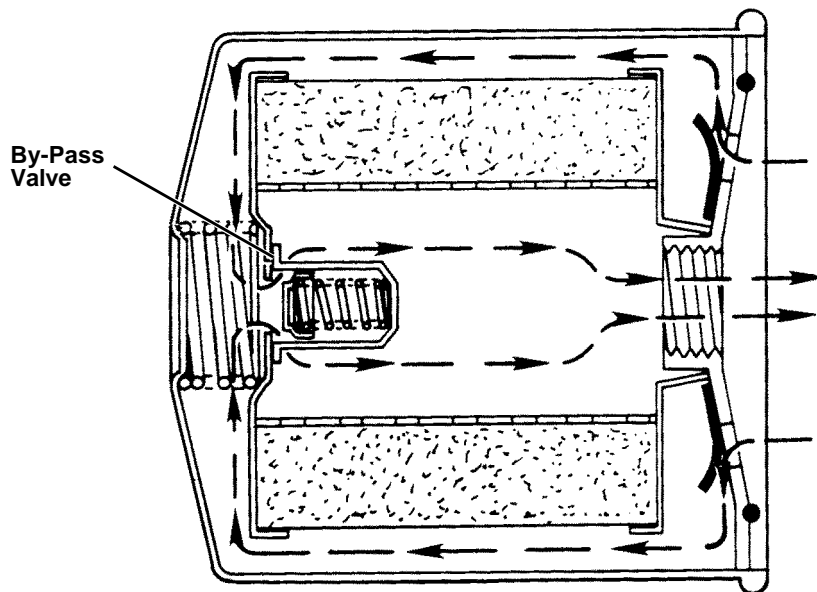
A safety valve (by-pass) (3TN84UJ, 4TN78T, 4TN84T (4019T), 4TN100 only) is located in the oil pump housing. Should the difference between the pressure in the main oil galley and oil pump become excessive, this valve would open and let oil bypass the filter and oil cooler to reach the main galley faster. This valve has a permanent setting which cannot be changed.



LUBRICATION SYSTEM OPERATION

M82009A

OIL FILTER OPERATION



OIL FILTER OPERATION

M53983

Function:

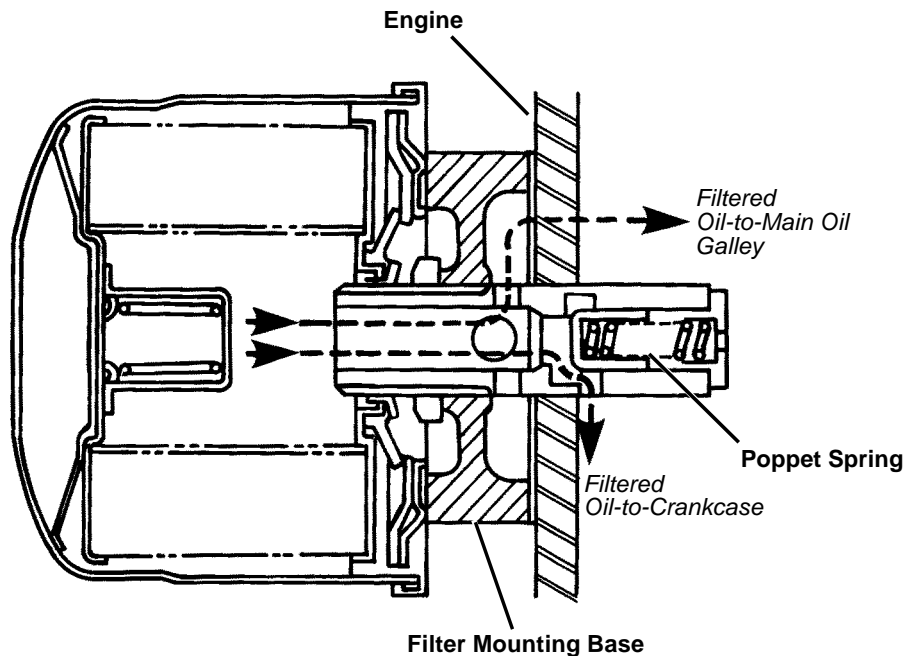
20 Filters contaminants from the oil between oil/filter changes.

Theory of Operation:

Pressurized oil is directed from the oil pump to the oil filter. Oil flows through the filter element to the main oil galley and to the engine components.

The oil filter is equipped with a bypass valve to ensure adequate engine lubrication if the filter is clogged or oil viscosity is too heavy to properly flow through the filter. Bypass valve opens at **96 kPa (14 psi)** pressure differential.

OIL PRESSURE REGULATING VALVE OPERATION



OIL PRESSURE REGULATING VALVE OPERATION

M53993

Function:

Regulates engine oil pressure.

Theory of Operation:

The oil pressure regulating valve is located in the oil filter mounting base stud. Filtered oil passes through the pressure regulating valve to the main oil galley.

If oil pressure is higher than the valve is set for, a poppet spring is overcome, opening the relief valve. When opened, a passage is opened to route oil back to the crankcase.

The oil pressure regulating valve is set to maintain a pressure of **294 - 440 kPa (43 - 64 psi)**.

NOTE: All pressure regulating valves operate the same. The most common mounting location is shown. 4TN100 valve is located in the oil cooler housing and 4TN78T and 4TN84T (4019T) valve is located in oil filter and cooler mounting bracket.

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Theory of Operation

OIL COOLER OPERATION - 3TN84UJ, 4TN78T, 4TN84T (4019T) AND 4TN100

NOTE: 4TN78T and 4TN84T (4019T) is shown. Oil cooler assembly on 3TN84UJ and 4TN100 engines is different in shape, but operation is the same.

Function:

The oil cooler helps reduce the temperature of engine oil.

Theory of Operation:

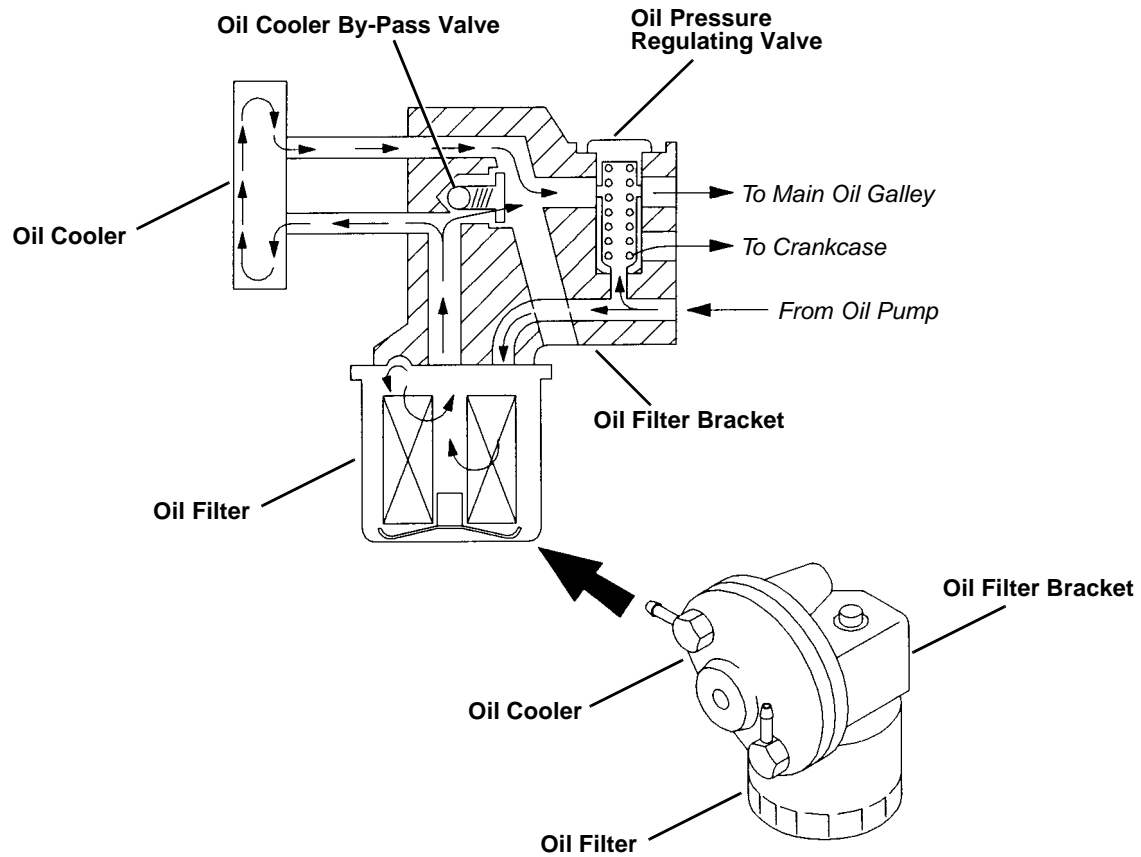
After passing through the oil filter, pressurized oil enters the oil cooler and passes through a network of tubing surrounded by engine coolant. Prior to entering the oil cooler, the engine coolant passes through the radiator, which transfers much of the coolant's heat into the surrounding air.

The coolant, its temperature now reduced, enters the oil cooler and passes over the warmer tubing. Heat transfers from the oil to the coolant, thus reducing oil temperature. Oil then flows into the engine block main oil galley through the filter bracket.

The oil cooler keeps the maximum oil temperature below **115° C (175° F)**.

The oil filter bracket on 4TN78T and 4TN84T (4019T) (cooler housing on 4TN100), contains a by-pass valve for the oil cooler. If the oil cooler would become plugged, pressure would build to exceed the spring force, opening the valve and directing oil to the engine block, by-passing the oil cooler.

The oil filter bracket also contains an oil pressure regulating valve. See *OIL PRESSURE REGULATING VALVE OPERATION*.



OIL COOLER OPERATION - 3TN84UJ, 4TN78T, 4TN84T (4019T) AND 4TN100

M82010AE

Theory of Operation

PISTON COOLING NOZZLE OPERATION - 4TN78T, 4TN84T (4019T) and 4TN100

Function:

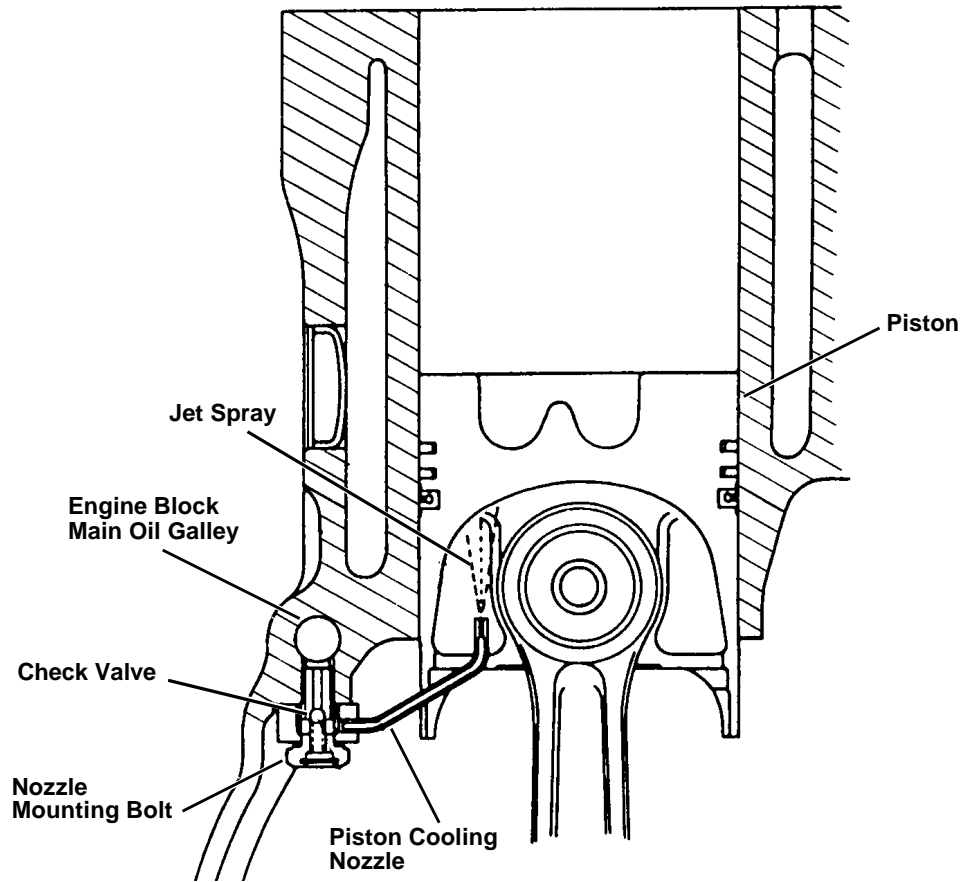
Cooling nozzles direct lube oil to underside of pistons to lower piston temperature and thermal load. Cooling the pistons also reduces thermal expansion and carbon deposits in the piston ring grooves.

Theory of Operation:

Lube oil from the engine block main oil galley passes a check valve in the nozzle mounting bolt, then flows through a small steel pipe creating a jet spray. This jet spray coats the underside of the piston, cooling the piston as a whole.

The check valve's opening pressure is factory set at **148 - 245 kPa (21.5 - 35.5 psi)**.

The oil spray amount is **21.3 L/min (5.6 gal/min)** at an oil pressure of **343 kPa (50 psi)**.



**PISTON COOLING NOZZLE OPERATION - 4TN78T,
4TN84T (4019T) AND 4TN100**

M82011A

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Theory of Operation

FUEL SYSTEM OPERATION

NOTE: On 3TNA72 (3009) IDI engine, fuel supply pump is part of the engine (attached to fuel injection pump) for OEM application only.

On 3TN82, 3TN78, 4TN78T and some 4TN82 DI engines, the fuel supply pump is separate from the engine.

Function:

Fuel system supplies fuel to injection nozzles.

Theory of Operation:

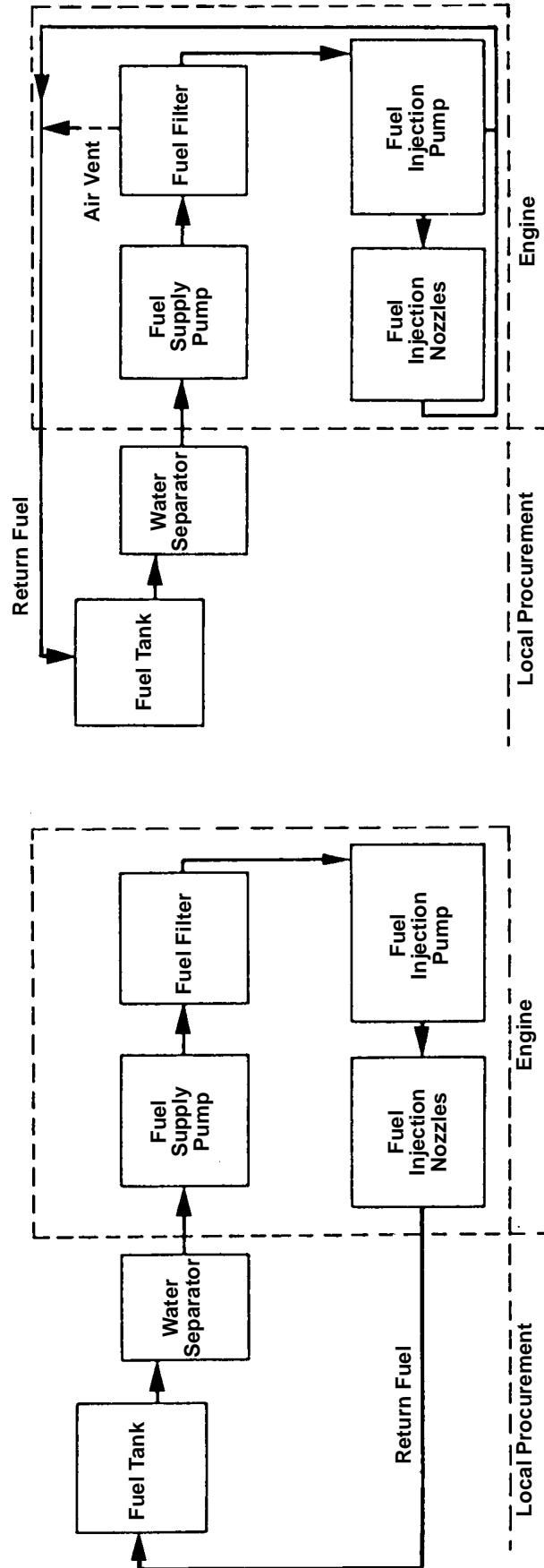
Fuel supply pump draws fuel from a vented fuel tank through a water separator and directs fuel through a fuel filter to the fuel gallery of an injection pump. The injection pump meters fuel as determined by the governor and delivers it at high pressure to the injection nozzles.

The injection nozzle prevents flow until high pressure is reached, opening the valve and spraying atomized fuel into the combustion chamber. Injection lines have trapped fuel whenever injection is not taking place.

3TN66 and 3TNA72 (3009) (IDI engine): A small amount of fuel leaks past the nozzle valve to lubricate the fuel injection nozzle. This leakage is then returned to the fuel tank.

All except 3TN66 and 3TNA72 (3009) (DI engine): A small amount of fuel leaks past the nozzle valve to lubricate the fuel injection nozzle. This leakage combines with excess fuel from the injection pump and is returned to tank.

Any air in the fuel system is bled out with return fuel to the fuel tank.



DI Engine - All Except 3TN66 and 3TNA72 (3009)

IDI Engine - 3TN66 and 3TNA72 (3009)

FUEL SYSTEM OPERATION

M82012A

FUEL INJECTION PUMP OPERATION

Function:

Injection pump regulates fuel flow from fuel supply pump to injectors.

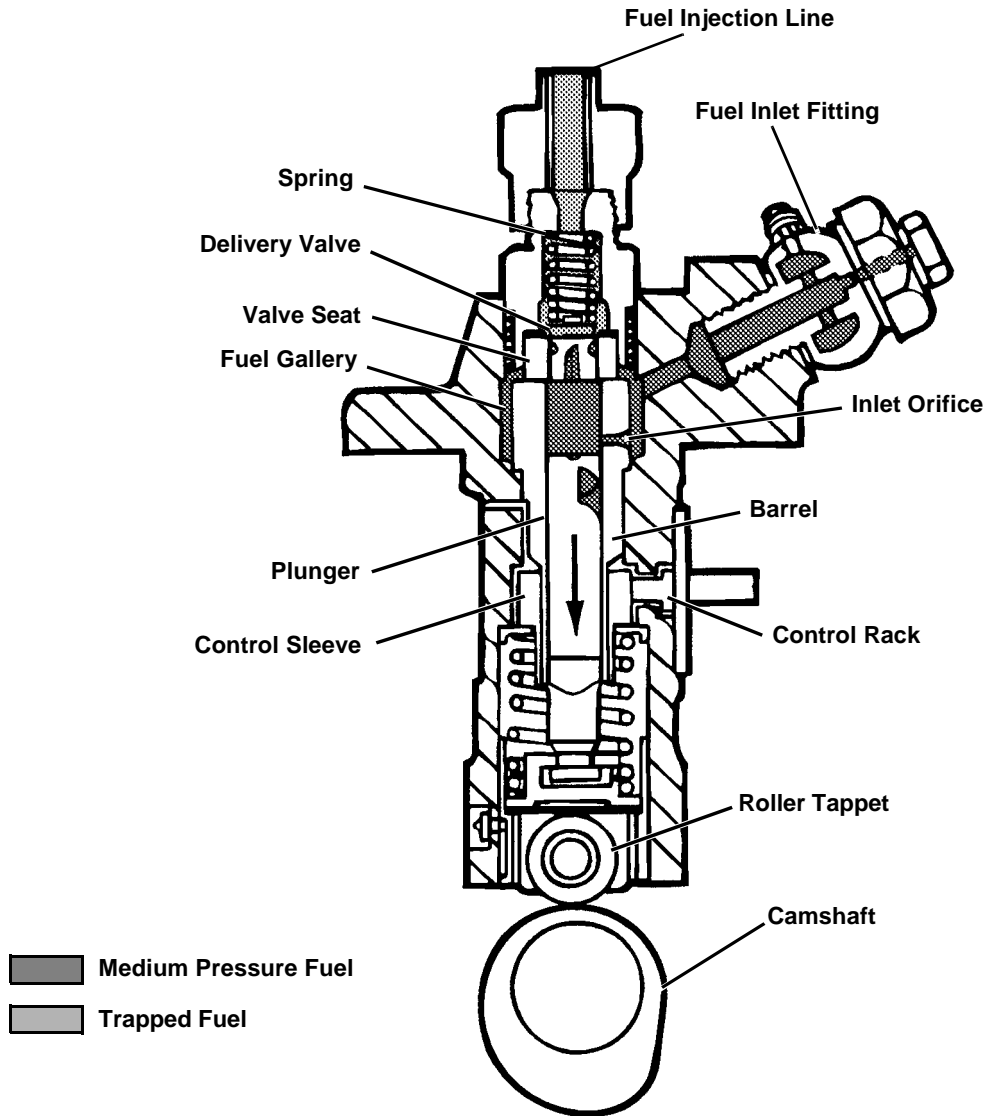
Theory of Operation:

Bottom of Plunger Stroke:

The fuel injection pump is a variable-displacement, in-line plunger-type pump. It is located on the right side of the engine. The pump is driven by a camshaft which turns at one-half engine speed.

When the plunger is in the downward position, filtered medium pressure fuel from the fuel supply pump flows through the fuel inlet fitting, to the fuel gallery. Fuel flows from the fuel gallery through the inlet orifice and fills the plunger area.

Whenever the plunger is in the downward position, the delivery valve is held closed against the valve seat, by spring pressure and trapped fuel pressure. In this position, fuel flow to the fuel injection line and nozzle is blocked.



FUEL INJECTION PUMP OPERATION (BOTTOM OF PLUNGER STROKE)

M82013AE

Theory of Operation

Theory of Operation - Continued:

Top of Plunger Stroke:

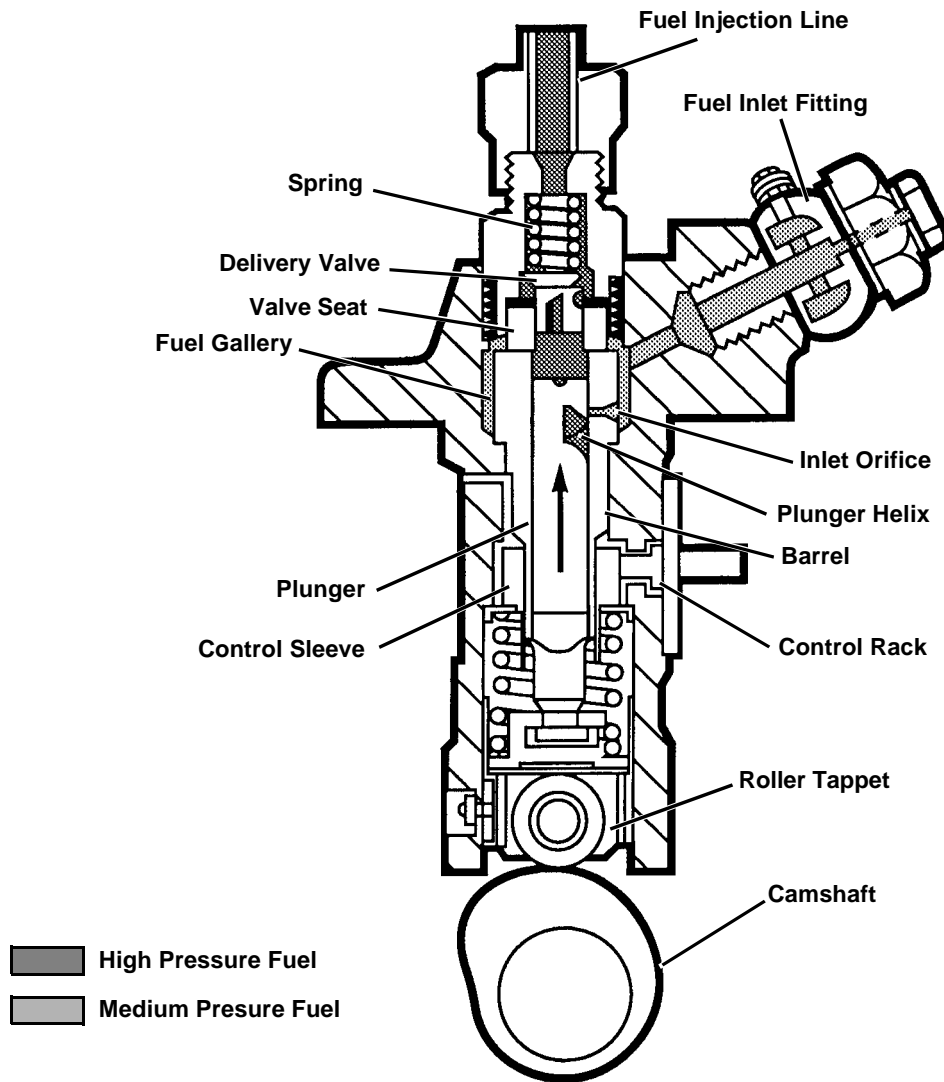
When the roller tappet is moved up by the camshaft, the inlet orifice is blocked by the plunger. Fuel in the plunger area is compressed and forced against the delivery valve.

When fuel pressure is high enough to overcome the spring, the delivery valve is lifted upward off the valve seat. High pressure fuel flows past the delivery valve to the fuel injection line and then to the fuel injection nozzle. The delivery valve is held open only when the fuel pressure in the plunger area is greater than the delivery valve spring pressure.

As the plunger continues moving upward, the plunger helix aligns with the inlet orifice. The pressure in the plunger area is higher than the pressure in the fuel gallery. This causes fuel to flow from the plunger area, through the plunger helix and inlet orifice to the fuel gallery.

Fuel flow through the inlet orifice causes pressure in the plunger area to decrease. With pressure equal on both sides of the delivery valve, spring force closes the delivery valve and stops the fuel flow to injection nozzle.

A governor-operated control rack is connected to the control sleeve and plunger to regulate the quantity of fuel delivery to the nozzles. The control sleeve turns the plunger and increases or decreases the amount of plunger movement before the plunger helix and inlet orifice are aligned.



FUEL INJECTION PUMP OPERATION (TOP OF PLUNGER STROKE)

M82014AE

Theory of Operation

GOVERNOR OPERATION

Function:

Governor maintains a set engine speed under varying loads.

Theory of Operation:

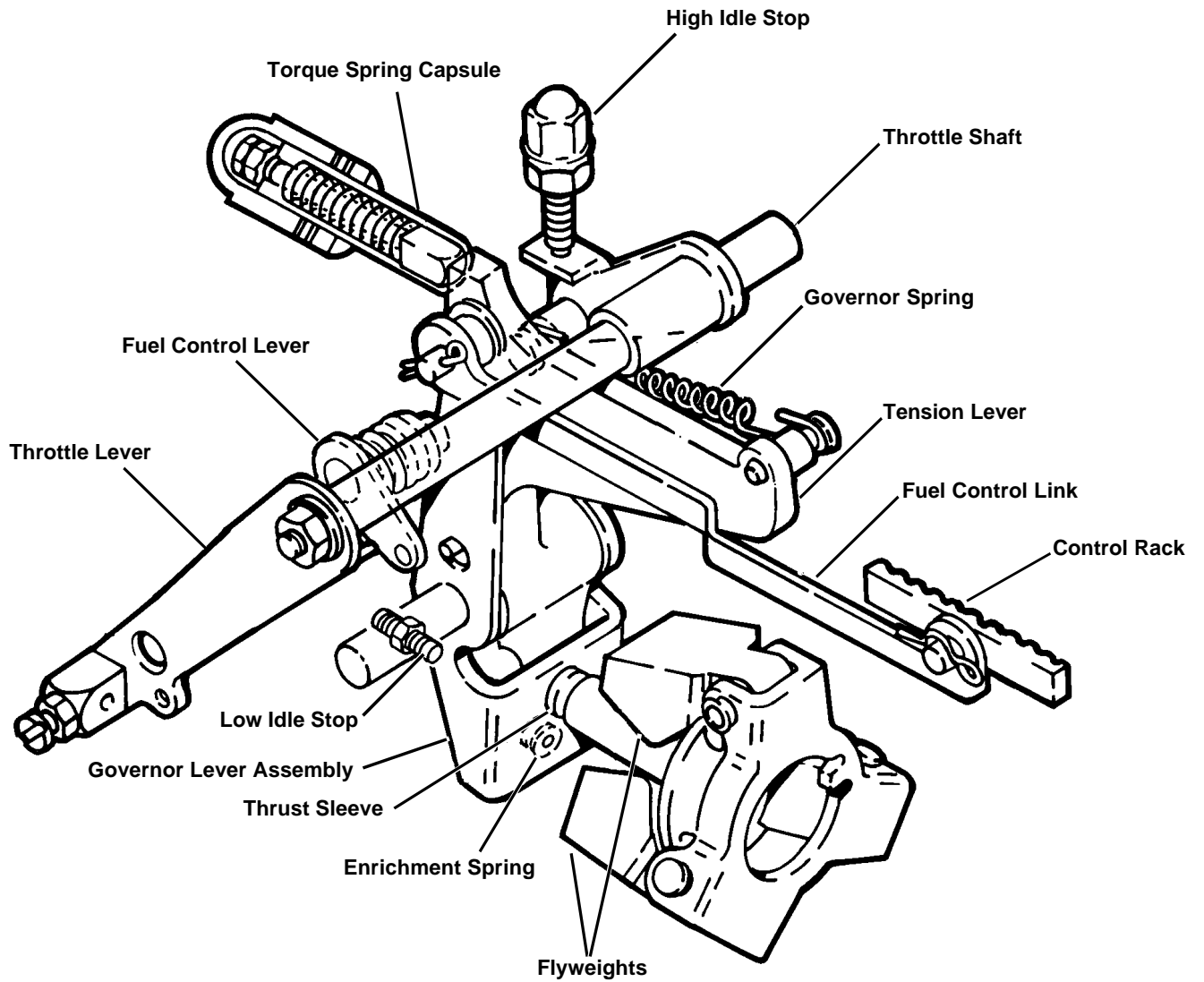
The injection pump governor is a mechanical centrifugal flyweight type. On 3TN66 and 3TNA72 (3009) (IDI) engines, it is contained in a housing mounted to the timing gear case and is serviced separately from the injection pump. On all except 3TN66 and 3TNA72 (3009) (DI) engines, the governor is assembled to the injection pump and serviced with the pump. Governor internal components and operation are similar.

The flyweights are mounted on the injection pump camshaft. The flyweights move the thrust sleeve in and out with changes in engine RPM. The thrust sleeve works against a button on the governor lever. The governor lever is connected to the injection pump control rack by the fuel control link. The governor spring connects the tension lever assembly to the throttle lever.

NOTE: Due to the variety and number of tractor applications, information on all horsepower ratings for TN Series engines are not available. Refer to individual machine Technical manual for proper horsepower ratings.

Series 220 Engines (OEM)

<u>Model</u>	<u>NET Power</u>	<u>kW (hp) @Rated rpm</u>
3009DF001.....	Continuous	12.8 (17.1) @ 3000
3009DF005.....	Intermittent	14.2 (19.0) @ 3000
3009DF007.....	Generator	14.2 (19.0) @ 3600
3011DF001.....	Continuous	16.9 (22.7) @ 3000
3011DF005.....	Intermittent	18.8 (25.2) @ 3000
3011DF006.....	Generator	10.2 (13.7) @ 1800
3014DF001.....	Continuous	21.3 (28.6) @ 3000
3014DF005.....	Intermittent	23.5 (31.5) @ 3000
3014DF006.....	Generator	12.9 (17.3) @ 1800
4019DF001.....	Continuous	28.1 (37.7) @ 3000
4019DF005	Intermittent	30.9 (41.4) @ 3000
4019DF006	Generator	18.7 (25.0) @ 1800
4019TF001.....	Continuous	34.4 (46.1) @ 3000
4019TF005.....	Intermittent	37.8 (50.7) @ 3000
4019TF006.....	Generator	24.6 (33.0) @ 1800



GOVERNOR OPERATION

M54070

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Theory of Operation

Theory of Operation - Continued:

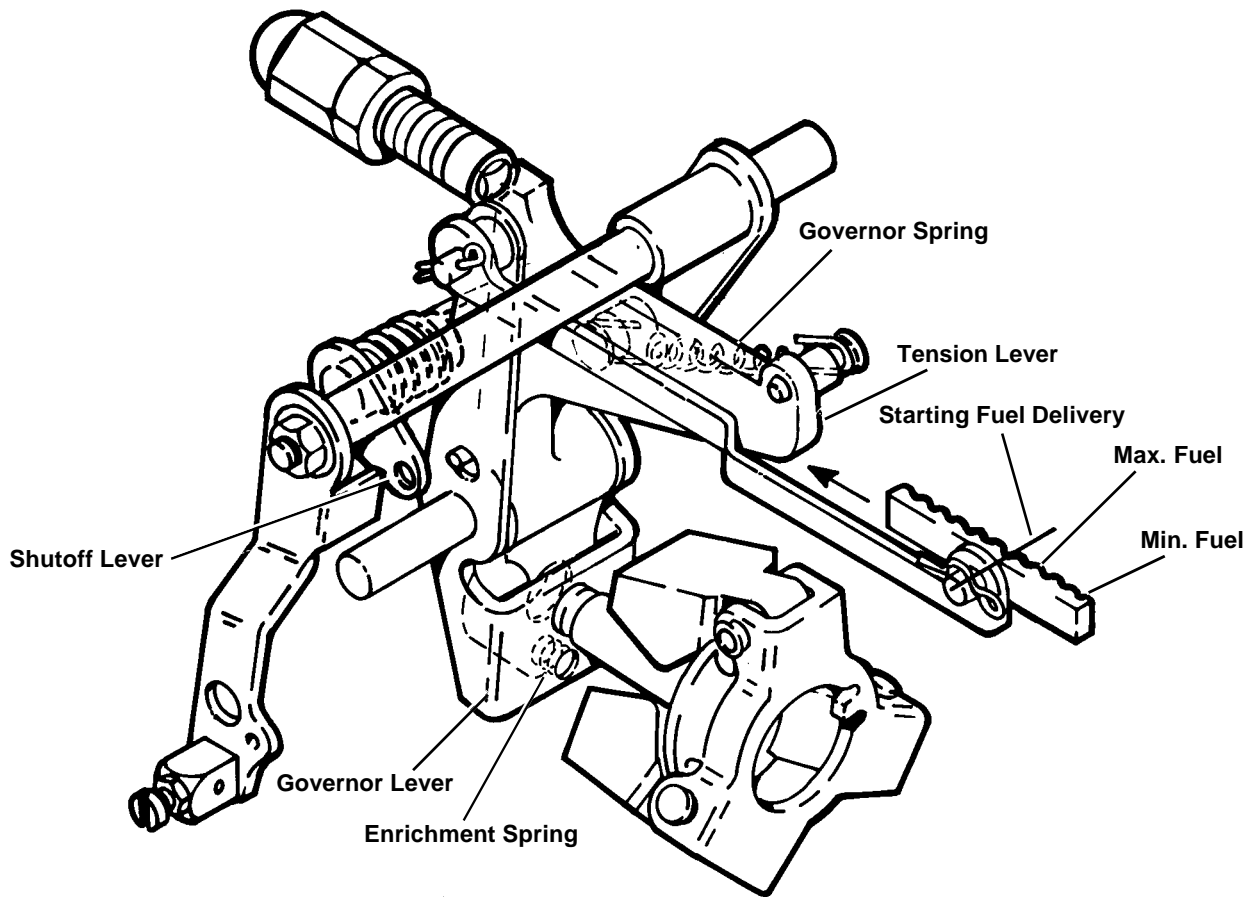
Starting:

When the key switch is turned to “ON”, a fuel solenoid pulls the shutoff lever to the “RUN” position. This permits the governor spring to move the tension lever, pulling the control rack left. The enrichment spring extends, pulling the rack an additional amount to give starting fuel delivery.

After the engine starts as speed increases, centrifugal force moves the flyweights outward forcing the thrust sleeve against the button on the governor lever. The enrichment spring compresses and remains compressed while the engine is running.

The forces generated by the flyweights against the governor lever overcome governor spring tension, pushing the rack to the right. This reduces fuel delivery to an amount that will maintain the RPM established by the speed control lever setting.

When the key is turned “OFF”, the fuel control solenoid is de-energized. The spring on the shutoff lever rotates the shaft so the high spot moves the governor lever to the right, pushing the rack to a “NO” fuel position, stopping the engine.



GOVERNOR OPERATION - STARTING

M48495

Theory of Operation

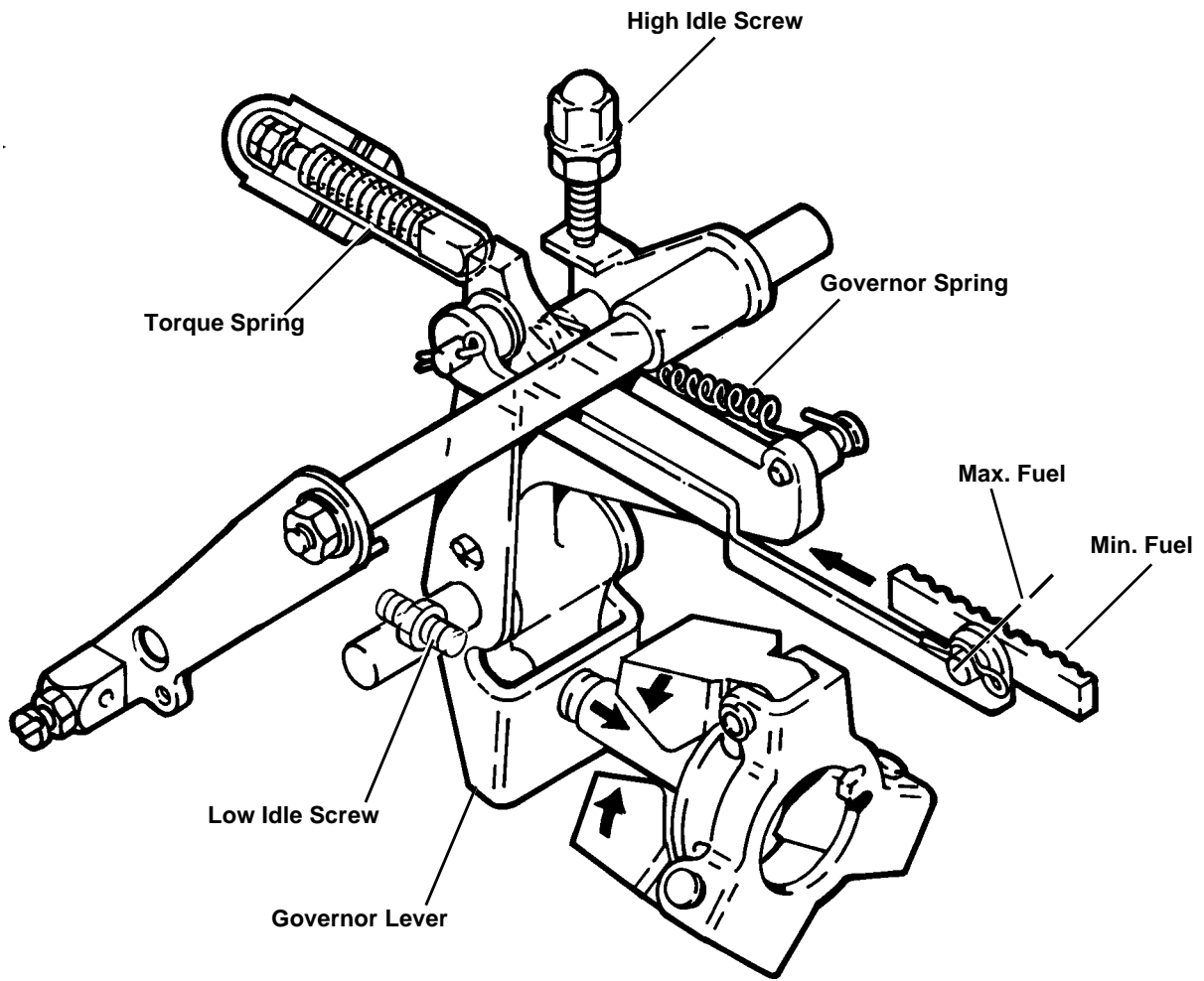
Theory of Operation - Continued:

High Idle, Maximum Torque:

When a load is applied, decreasing engine speed, the flyweight force is reduced against the governor lever. The spring can then pull the lever assembly and the rack to increase fuel delivery and bring RPM back up to preset speed.

Additional load would further reduce the flyweight force permitting the governor spring to pull tension lever against the torque spring, compressing it and moving the rack to the maximum torque fuel delivery.

A high idle adjusting screw and low idle screw, provide stops for the speed control lever.



GOVERNOR OPERATION - HIGH IDLE, MAXIMUM TORQUE

M48496

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Theory of Operation

INDIRECT INJECTION NOZZLE OPERATION (PINTLE TYPE) - 3TN66 and 3TNA72 (3009)

Function:

Injection nozzle injects fuel in an atomized form into a precombustion chamber.

Theory of Operation:

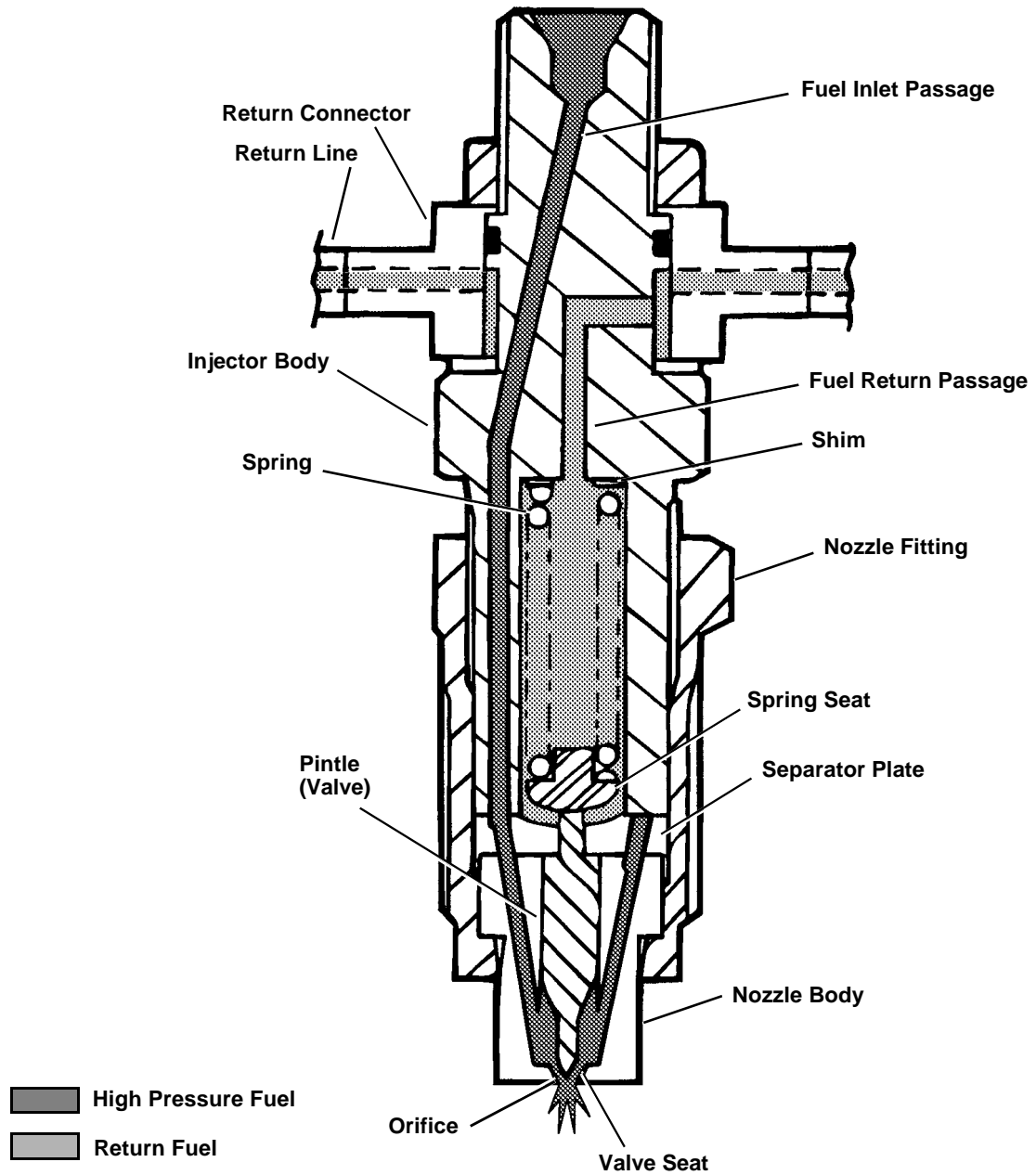
The pintle type nozzle is used on indirect injection engines 3TN66 and 3TNA72 (3009). It is different from the hole-type nozzle in that it is threaded into the cylinder head.

The fuel injection nozzle has an inward opening pintle-type valve.

High pressure fuel from the pump flows through an inlet passage to the pintle valve. When pressure against the valve increases above spring tension, the valve is lifted off its seat, permitting fuel to be forced through a nozzle body orifice in an atomized form into the precombustion chamber.

A small amount of fuel leaks past the pintle valve to lubricate valve and body, then flows through a return passage to return lines and tank.

The pintle valve is shim adjustable to regulate the opening pressure.



INDIRECT INJECTION NOZZLE OPERATION (PINTLE TYPE)

M82015AE

Theory of Operation

DIRECT INJECTION NOZZLE OPERATION (HOLE TYPE) - ALL EXCEPT 3TN66 and 3TNA72 (3009)

Function:

Injection nozzle injects fuel in an atomized form into the combustion chamber.

Theory of Operation:

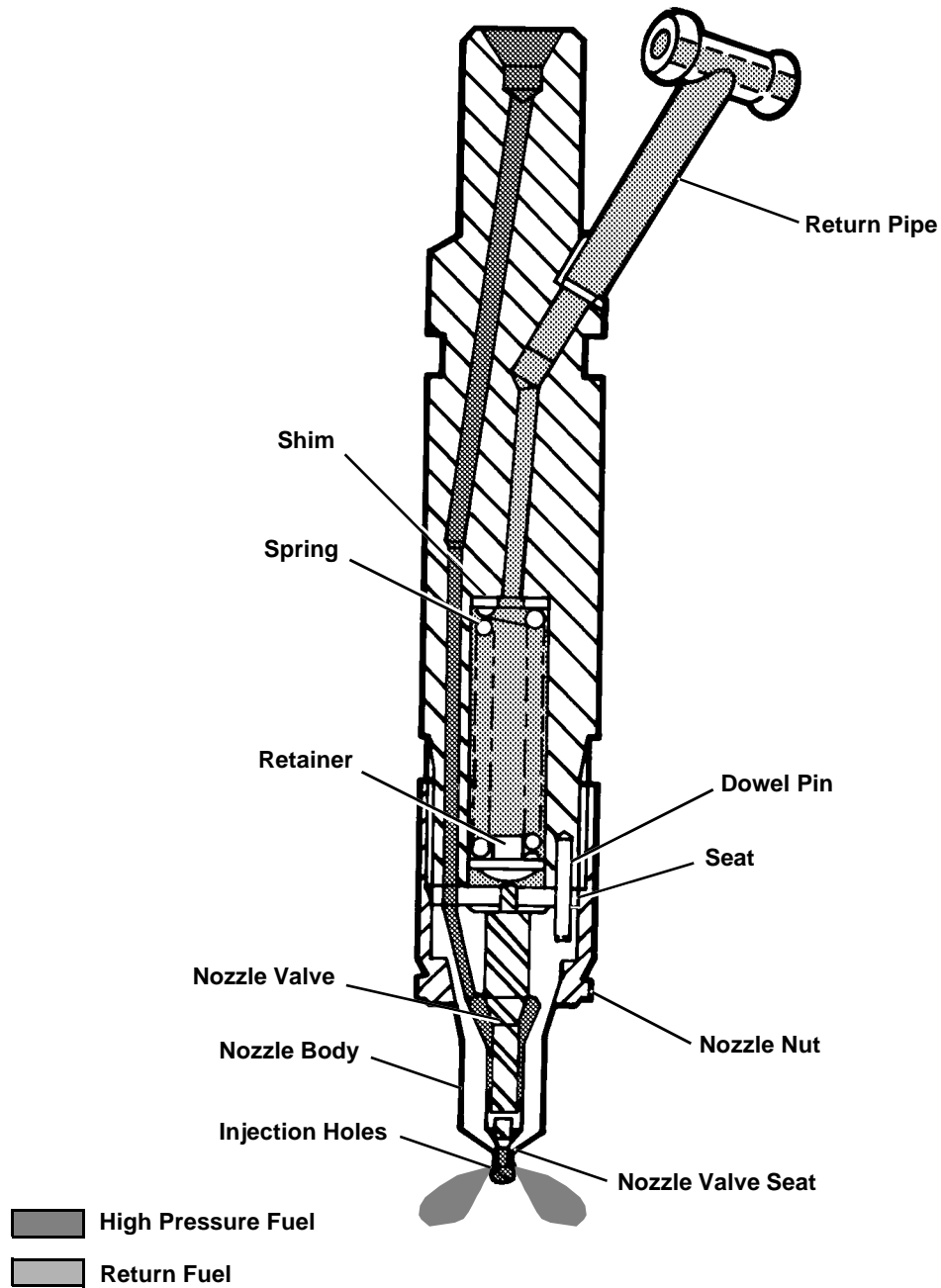
The hole type nozzle is used on direct injection engines 3TN75 and larger. It is different from the pintle type nozzle in that it is held in the cylinder head by a retaining bracket instead of being threaded.

High pressure fuel from the injection pump flows through a fuel inlet passage. Pressure builds beneath the nozzle valve. When the fuel pressure reaches specified pressure it overcomes the nozzle spring tension. The nozzle valve retracts into the nozzle body and fuel is injected into the engine.

The nozzle valve is automatically pushed down by the nozzle spring and closed after fuel is injected.

Leakage (return fuel) flows from between the nozzle valve and nozzle body to the hole on top of the nozzle spring through the return pipe and back into the fuel tank.

The nozzle valve is shim adjustable to regulate the opening pressure.



DIRECT INJECTION NOZZLE OPERATION (HOLE TYPE)

M82016A

Theory of Operation

PRECOMBUSTION CHAMBER OPERATION (INDIRECT INJECTION) - 3TN66 and 3TNA72 (3009)

Function:

The precombustion chamber is a small turbulent area where the fuel is injected, mixed with a limited amount of air, and the start of ignition takes place.

Theory of Operation:

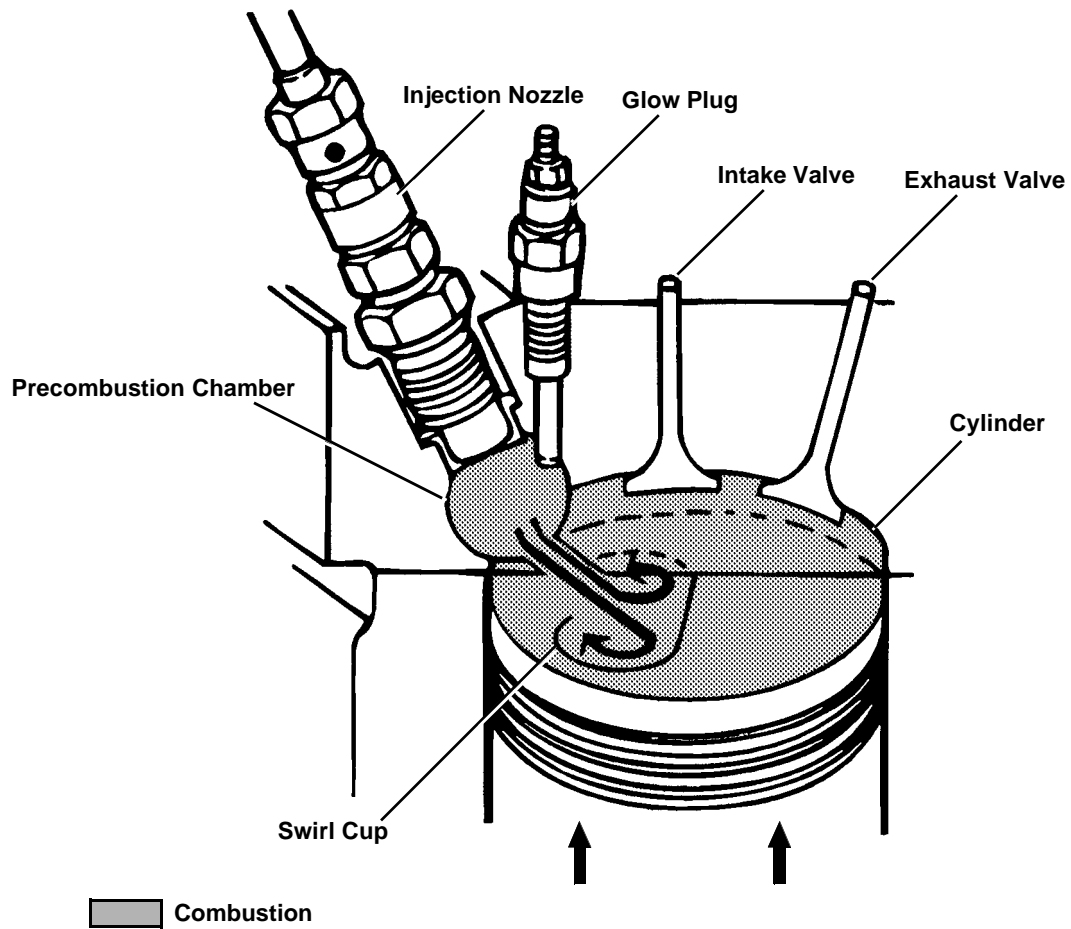
A precombustion chamber is located in the cylinder head with a small opening into the cylinder.

As the piston comes up on the compression stroke, some of the air is forced through the opening into the precombustion chamber. The opening is shaped to direct this air flow into a turbulent action as it is being compressed and heated.

At 16° BTDC crankshaft rotation, injection of fuel begins. The injection nozzle sprays atomized fuel into the precombustion chamber turbulent air. Heat from the compressed air ignites the fuel, increasing pressure in the precombustion chamber forcing the burning mixture into the cylinder where it mixes with the air in the piston swirl cup.

Expansion for the burning mixture forces the piston down on its power stroke.

When starting a cold engine, compression pressure may not provide enough heat to ignite the fuel when injected into a cold precombustion chamber. An electrically operated glow plug is installed into the precombustion chamber to provide added heat to ignite the fuel as it is injected. The glow plugs are energized during starting, and also may be pre-heated by turning key switch counterclockwise and holding for up to 30 seconds.



**PRECOMBUSTION CHAMBER OPERATION
(INDIRECT INJECTION)**

M82017AE

Theory of Operation

COMBUSTION CHAMBER OPERATION (DIRECT INJECTION) - ALL EXCEPT 3TN66 and 3TNA72 (3009)

Function:

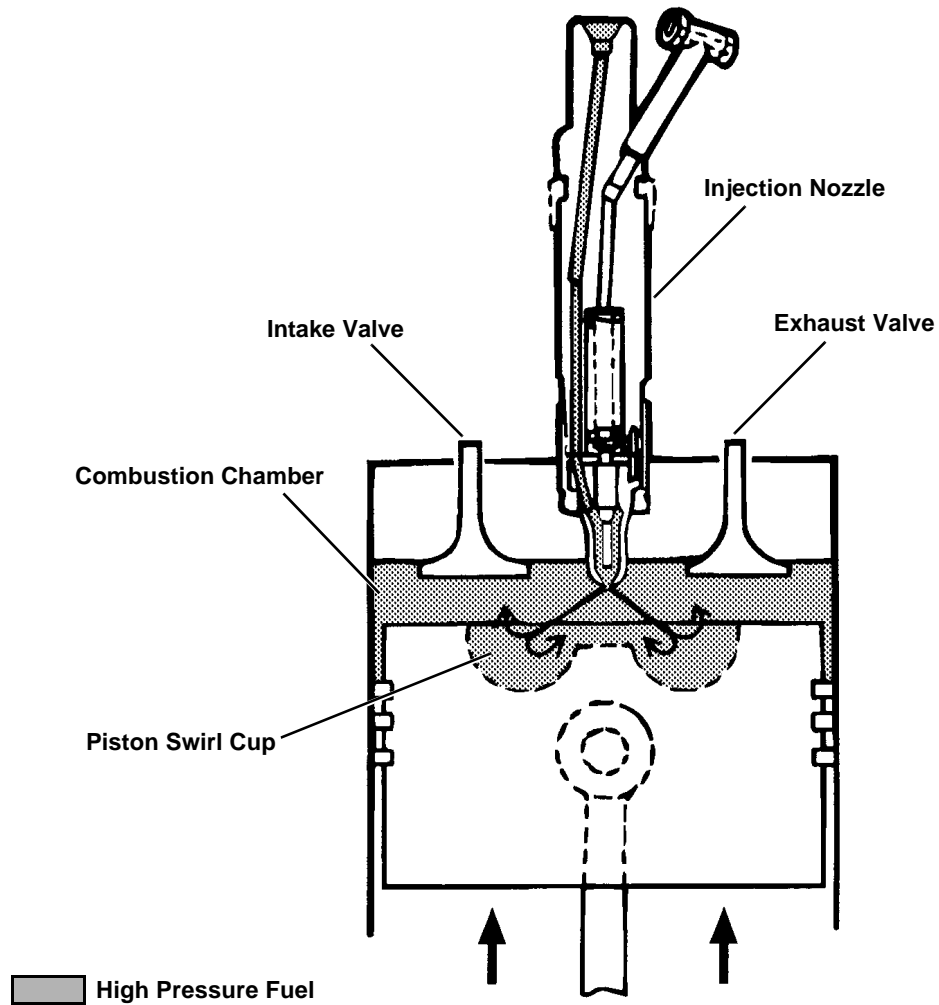
The combustion chamber is an area where the fuel is injected, mixed with a limited amount of air, and the start of ignition takes place.

Theory of Operation:

A swirl cup is formed in the head of the piston. As the piston travels upward on its compression stroke, the shape of the cup causes the air to swirl as it is compressed and heated.

At 16° BTDC crankshaft rotation, fuel is injected by the multi-hole injection nozzle. The swirling action of the air thoroughly mixes the atomized fuel and air for complete burning, as the piston travels into the power stroke.

When starting a cold engine, compression of ambient temperature air may not provide enough heat for ignition. To aid cold temperature starting, an electrically operated heater element is located at the intake manifold inlet. The heater is energized during starting and also may be pre-heated by turning key switch counterclockwise and holding for up to 30 seconds.



COMBUSTION CHAMBER OPERATION (DIRECT INJECTION)

M82018AE

ELECTRICAL SYSTEM SERIES 220 POWER UNIT ENGINES

Electrical System	21-1
Component Location	21-2
Schematics	21-4

Section 21

INTRODUCTION

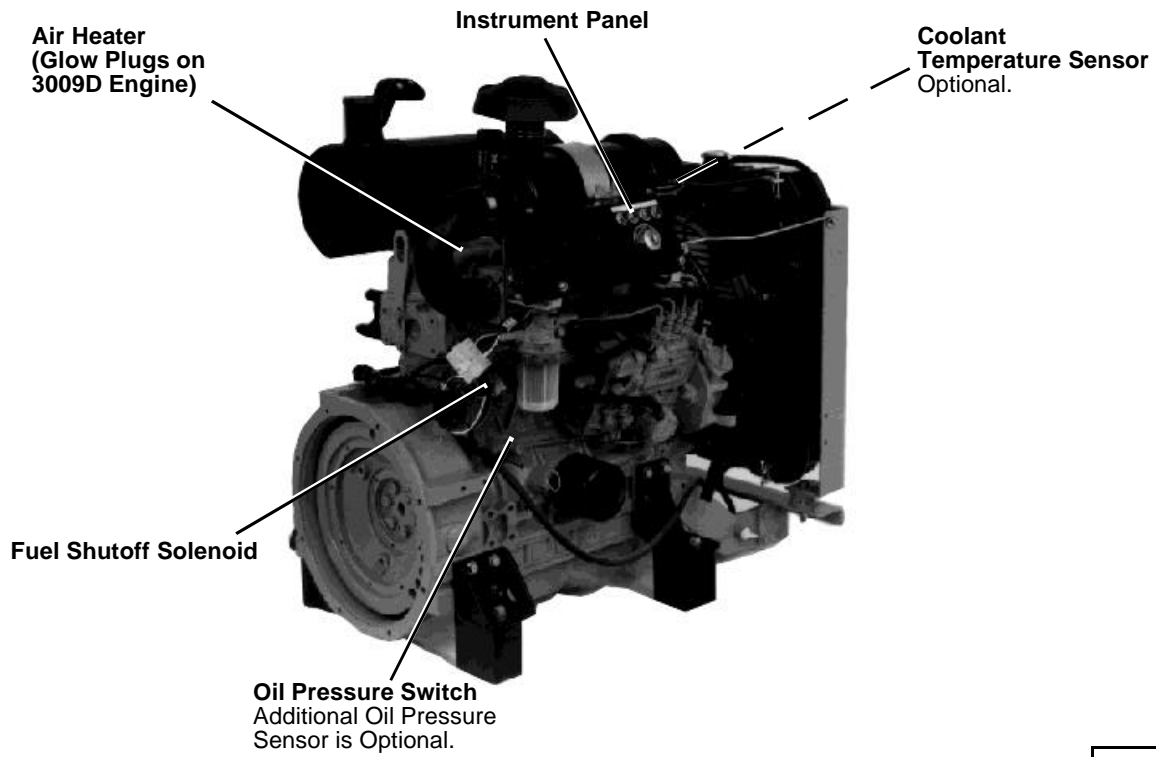
This section provides component location and schematics of the electrical system used on OEM stand-alone power packs.

The Series 220 diesel engines are offered as OEM units with two different power unit configurations available for each model. Features on the power units include an air cleaner kit, muffler, radiator kit and instrument panel.

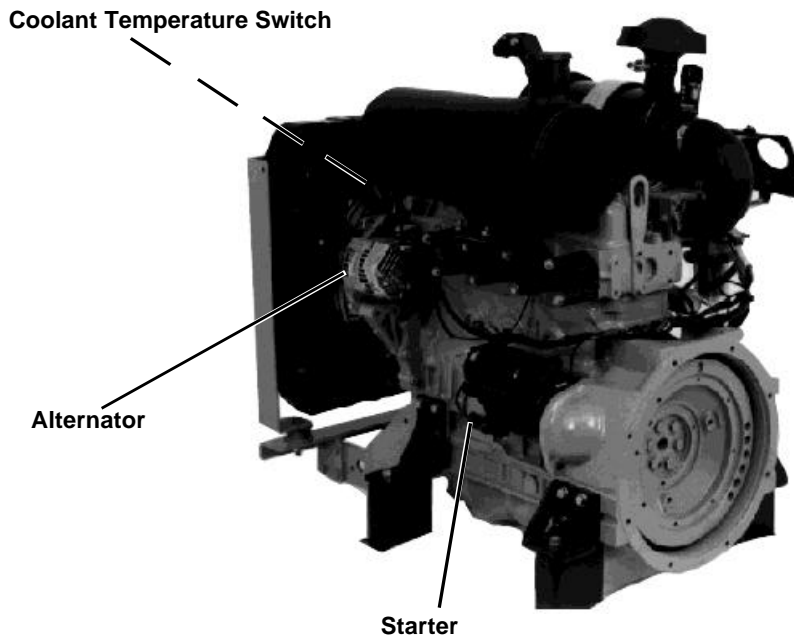
The following is a complete engine listing of all Series 220 Power Units:

Power Unit Model Number	Engine Model Number	Description
3009DF005	3TNA72	Industrial Power Unit
3009DF007	3TNA72	3600 rpm gen-set Power Unit
3011DF005	3TNC78	Industrial Power Unit
3011DF006	3TNC78	1800 rpm gen-set Power Unit
3014DF005	3TN84	Industrial Power Unit
3014DF006	3TN84	1800 rpm gen-set Power Unit
4019DF005	4TN84	Industrial Power Unit
4019DF006	4TN84	1800 rpm gen-set Power Unit
4019TF005	4TN84T	Industrial Power Unit
4019TF006	4TN84T	1800 rpm gen-set Power Unit

Component Location

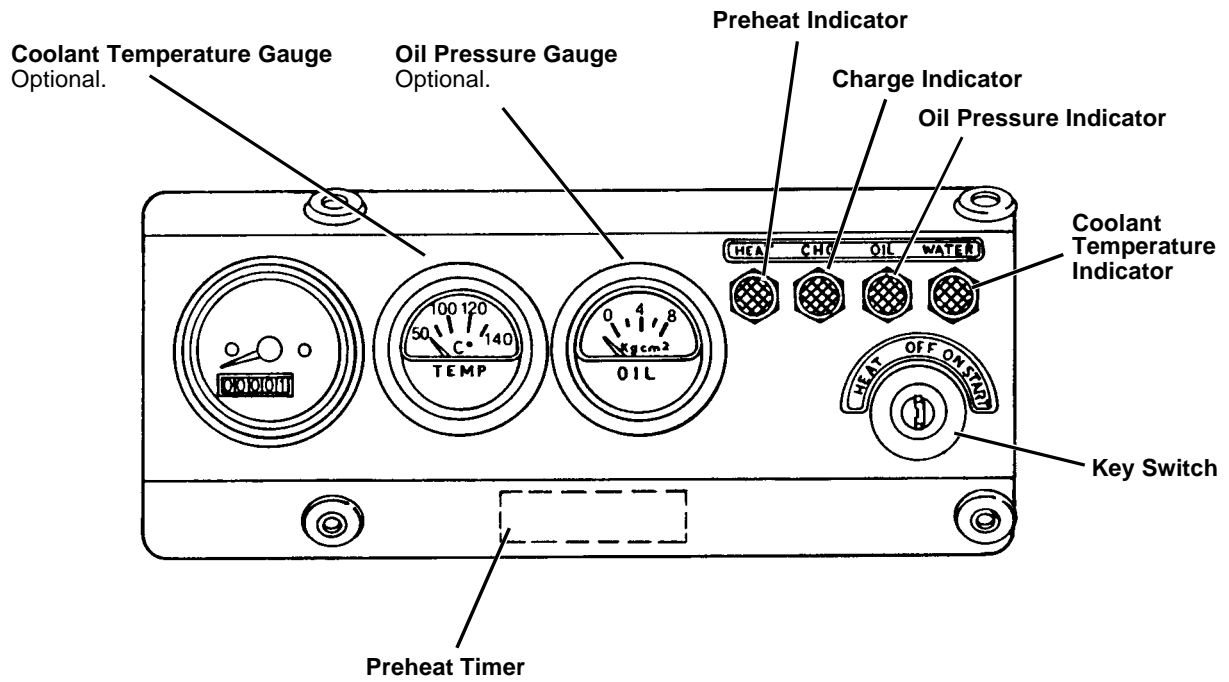


RG6604



RG6605

ENGINE ELECTRICAL COMPONENTS



M82178A

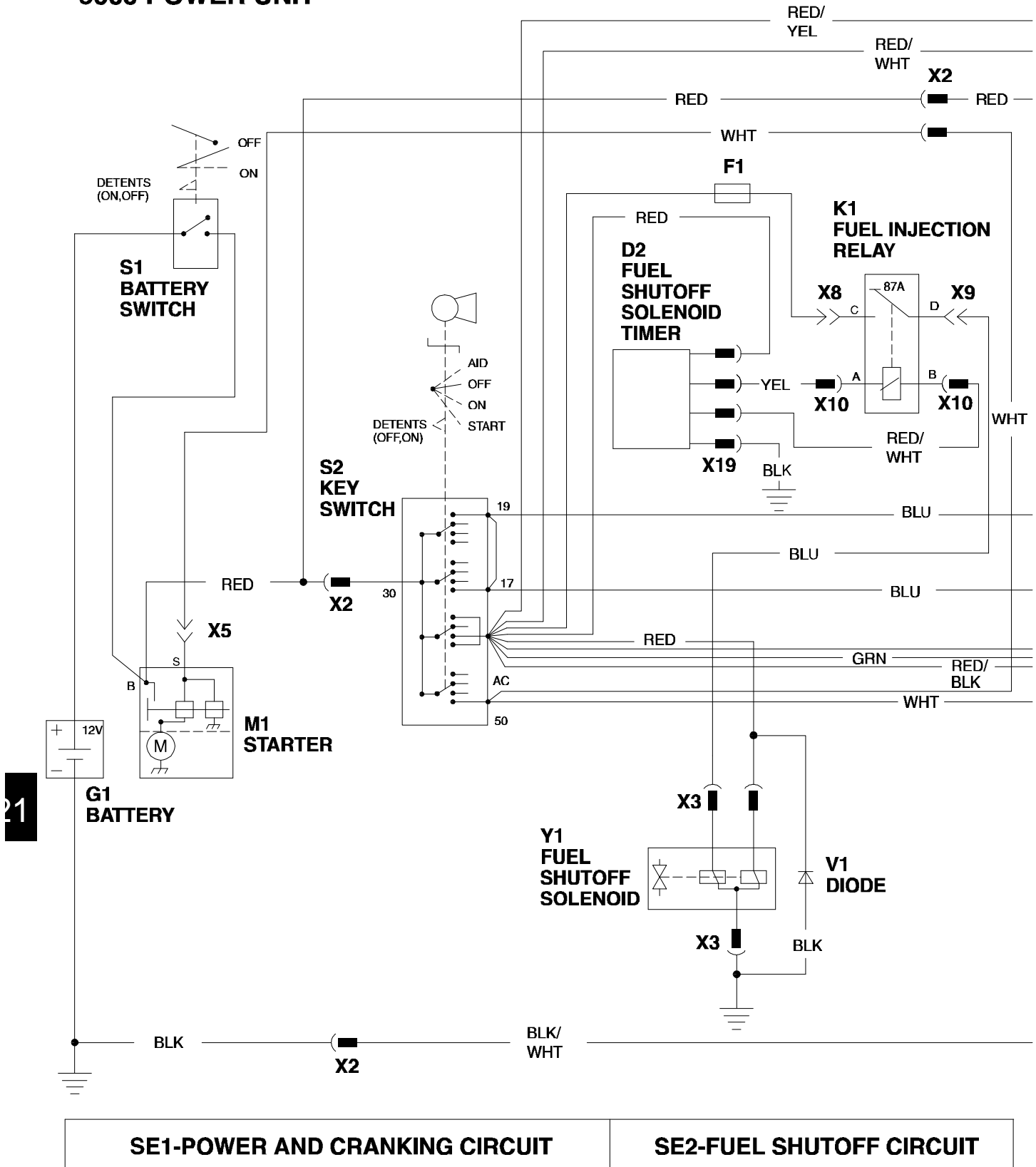
INSTRUMENT PANEL COMPONENTS

Schematics

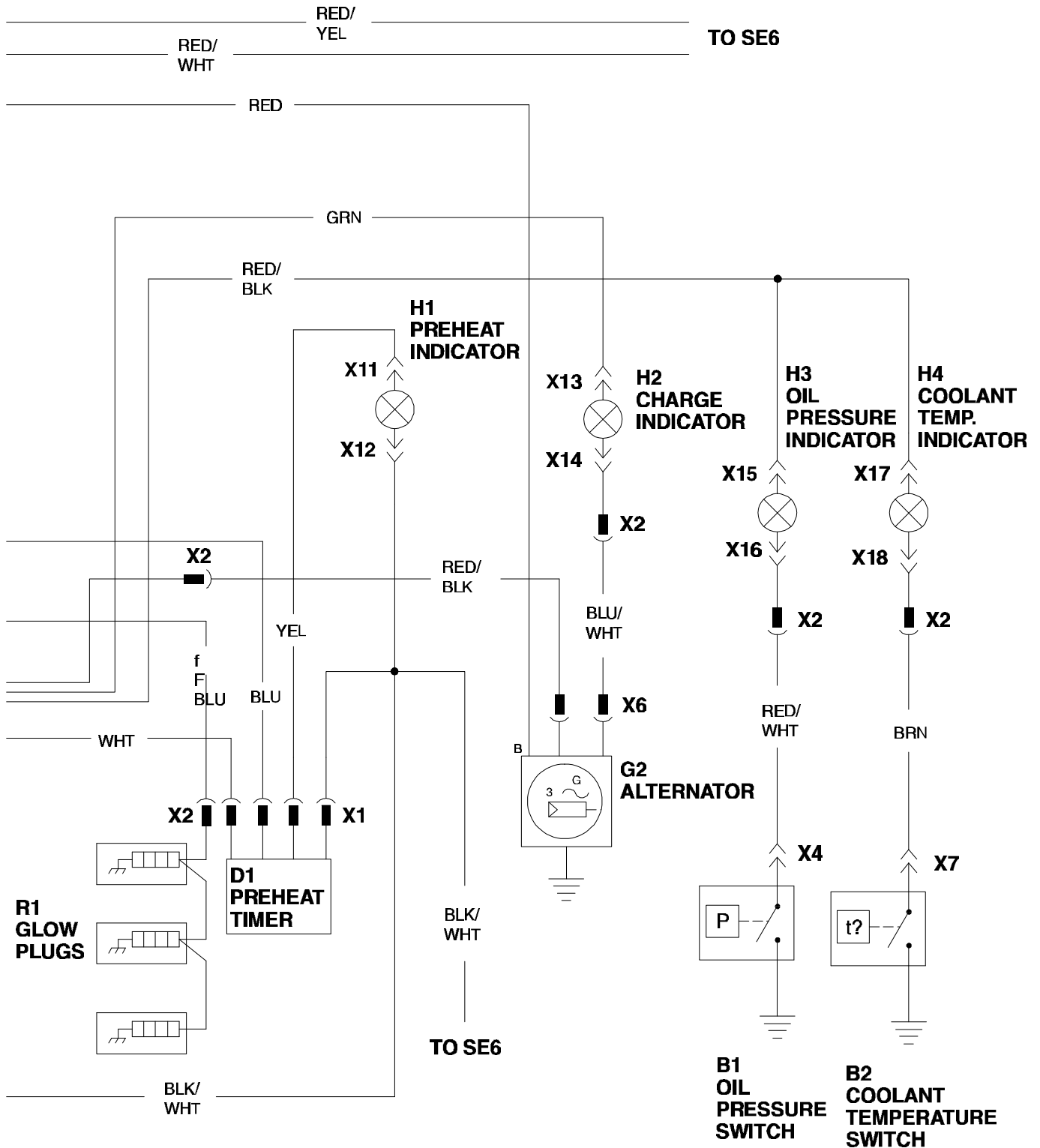
LEGEND FOR ELECTRICAL SCHEMATIC - 3009 POWER UNIT

- B1 - Oil Pressure Switch
- B2 - Coolant Temperature Switch
- D1 - Preheat Timer
- D2 - Fuel Shutoff Solenoid Timer
- F1 - 30-amp Fuse
- G1 - 12-volt Battery
- G2 - Alternator
- H1 - Preheat Indicator
- H2 - Charge Indicator
- H3 - Oil Pressure Indicator
- H4 - Coolant Temperature Indicator
- K1 - Fuel Injection Relay
- M1 - Starter
- R1 - Glow Plugs
- S1 - Battery Switch
- S2 - Key Switch
- V1 - Diode
- X1 - 4-Wire Connector, at Preheat Timer
- X2 - 10-Wire Connector, Main Harness-to-Instrument Panel
- X3 - 3-Wire Connector, at Fuel Shutoff Solenoid
- X4 - 1-Wire Bullet Connector, at Oil Pressure Switch
- X5 - 1-Wire Connector, at Starter
- X6 - 2-Wire Connector, at Alternator
- X7 - 1-Wire Bullet Connector, at Coolant Temperature Switch
- X8 - 1-Wire Connector, Fuel Injection Relay-to-Fuse
- X9 - 1-Wire Connector, at Fuel Injection Relay-to-Shutoff Solenoid
- X10 - 2-Wire Connector, at Fuel Injection Relay
- X11 - 1-Wire Bullet Connector, Preheat Indicator Positive Lead
- X12 - 1-Wire Bullet Connector, Preheat Indicator Negative Lead
- X13 - 1-Wire Bullet Connector, Charge Indicator Positive Lead
- X14 - 1-Wire Bullet Connector, Charge Indicator Negative Lead
- X15 - 1-Wire Bullet Connector, Oil Pressure Indicator Positive Lead
- X16 - 1-Wire Bullet Connector, Oil Pressure Indicator Negative Lead
- X17 - 1-Wire Bullet Connector, Collant Temperature Indicator Positive Lead
- X18 - 1-Wire Bullet Connector, Collant Temperature Indicator Negative Lead
- X19 - 4-Wire Connector, at Fuel Shutoff Solenoid Timer
- Y1 - Fuel Shutoff Solenoid

3009 POWER UNIT



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21

SE3-PREHEAT CIRCUIT	SE4-CHARGING CIRCUIT	SE5-INDICATOR LIGHTS CIRCUIT
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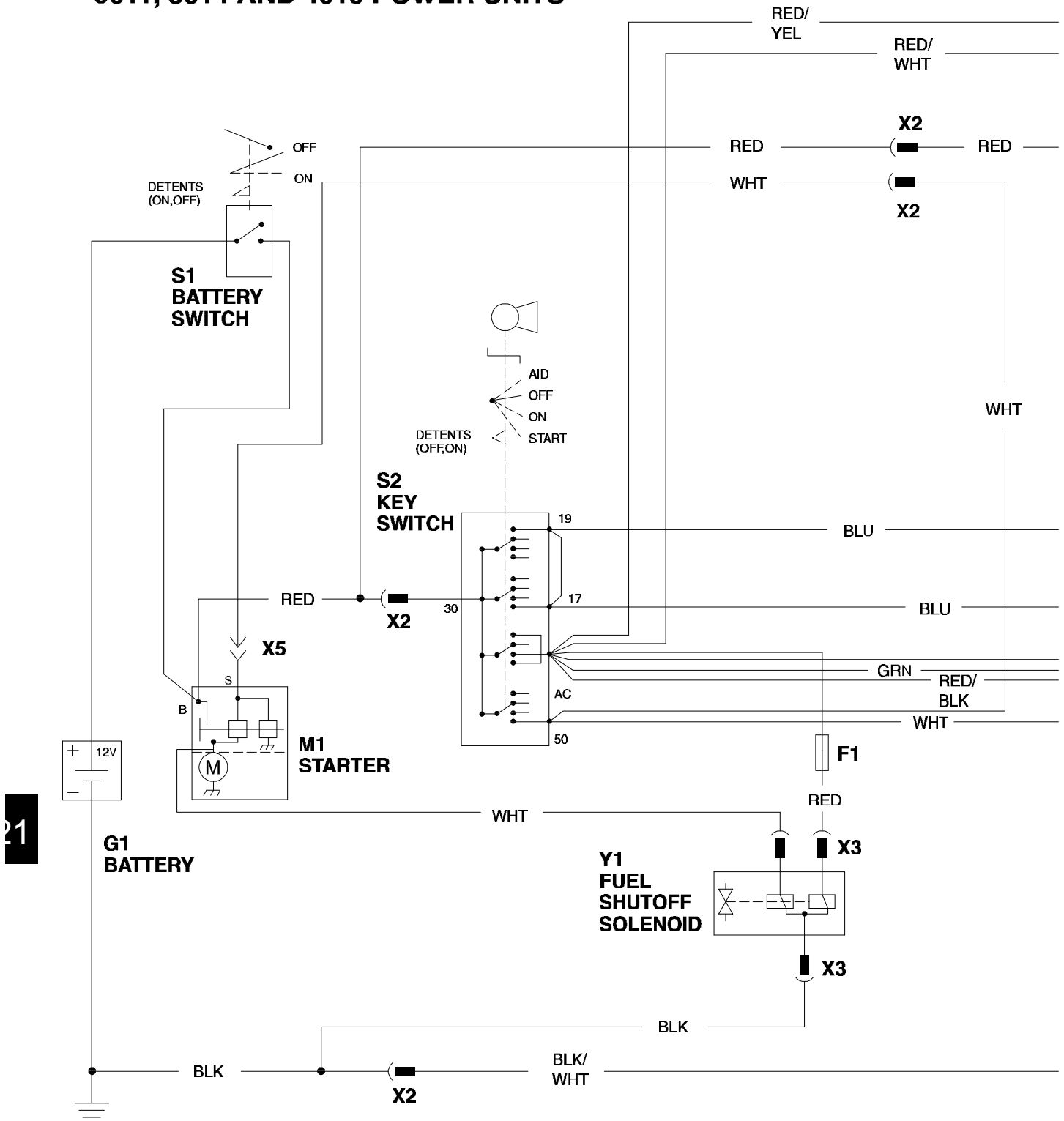
M82179AF

Schematics

LEGEND FOR ELECTRICAL SCHEMATIC - 3011, 3014 AND 4019 POWER UNITS

- B1 - Oil Pressure Switch
- B2 - Coolant Temperature Switch
- D1 - Preheat Timer
- D2 - Fuel Shutoff Solenoid Timer
- F1 - 10-amp Fuse
- G1 - 12-volt Battery
- G2 - Alternator
- H1 - Preheat Indicator
- H2 - Charge Indicator
- H3 - Oil Pressure Indicator
- H4 - Coolant Temperature Indicator
- M1 - Starter
- R1 - Air Heater
- S1 - Battery Switch
- S2 - Key Switch
- X1 - 4-Wire Connector, at Preheat Timer
- X2 - 10-Wire Connector, Main Harness-to-Instrument Panel
- X3 - 3-Wire Connector, at Fuel Shutoff Solenoid
- X4 - 1-Wire Bullet Connector, at Oil Pressure Switch
- X5 - 1-Wire Connector, at Starter
- X6 - 2-Wire Connector, at Alternator
- X7 - 1-Wire Bullet Connector, at Coolant Temperature Switch
- X8 - 1-Wire Bullet Connector, Preheat Indicator Positive Lead
- X9 - 1-Wire Bullet Connector, Preheat Indicator Negative Lead
- X10 - 1-Wire Bullet Connector, Charge Indicator Positive Lead
- X11 - 1-Wire Bullet Connector, Charge Indicator Negative Lead
- X12 - 1-Wire Bullet Connector, Oil Pressure Indicator Positive Lead
- X13 - 1-Wire Bullet Connector, Oil Pressure Indicator Negative Lead
- X14 - 1-Wire Bullet Connector, Coolant Temperature Indicator Positive Lead
- X15 - 1-Wire Bullet Connector, Coolant Temperature Indicator Negative Lead
- Y1 - Fuel Shutoff Solenoid

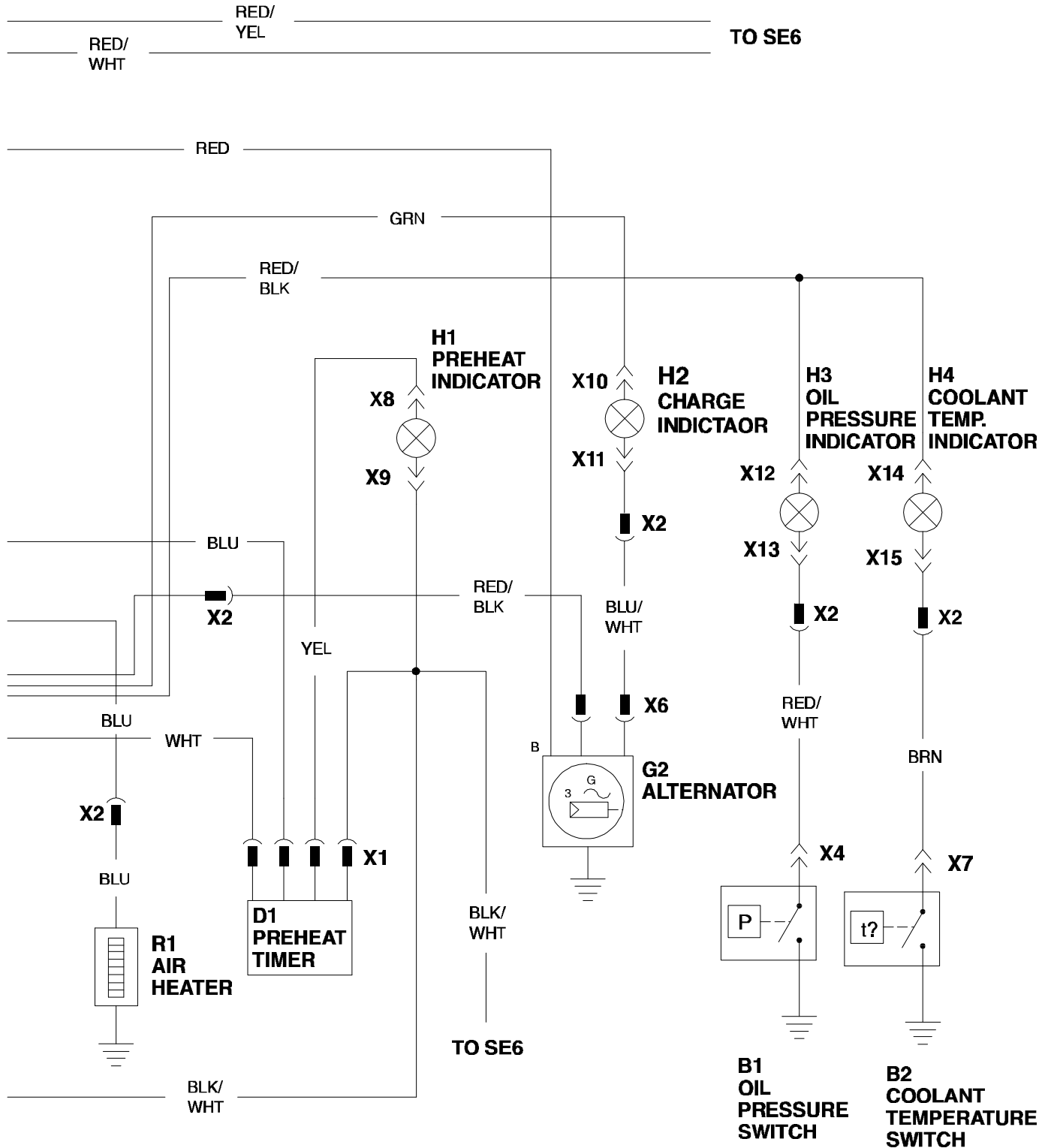
3011, 3014 AND 4019 POWER UNITS



21

SE1-POWER AND CRANKING CIRCUIT **SE2-FUEL SHUTOFF CIRCUIT**

M82180AE



21

SE3-PREHEAT CIRCUIT	SE4-CHARGING CIRCUIT	SE5-INDICATOR LIGHTS CIRCUIT
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M82180AF

Schematics

LEGEND FOR ELECTRICAL SCHEMATIC - OPTIONAL EQUIPMENT

B3 - Coolant Temperature Sender

B4 - Oil Pressure Sender

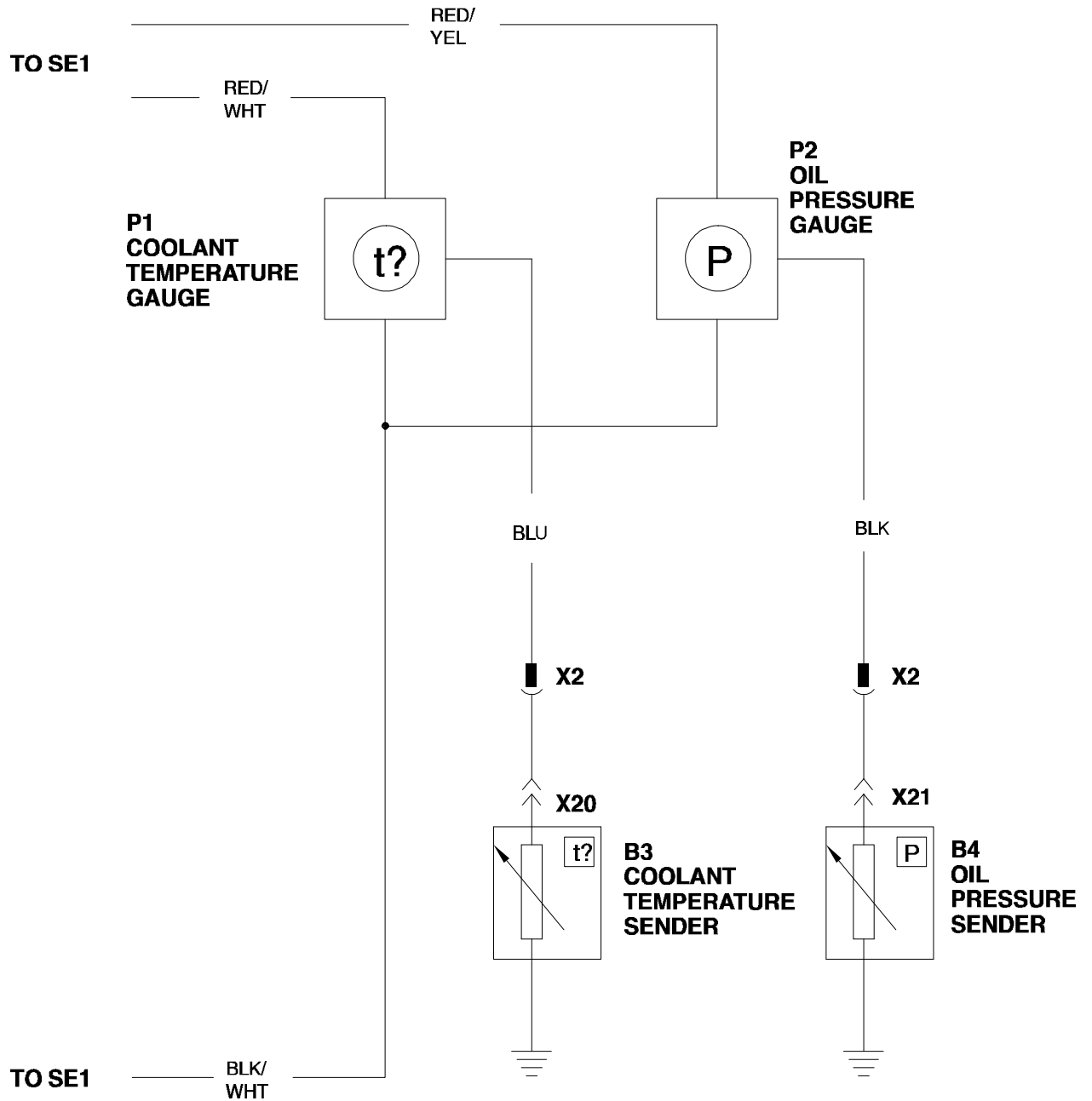
P1 - Coolant Temperature Gauge

P2 - Oil Pressure Gauge

X2 - 10-Wire Connector, Main Harness-to-Instrument Panel

X20 - 1-Wire Bullet Connector, at Coolant Temperature Sender

X21 - 1-Wire Bullet Connector, at Oil Pressure Sender



21

SE6 - OPTIONAL EQUIPMENT CIRCUITS

M82181AE

A

- Air Cleaner Operation
 3009 (3TNA72) 20-10
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 (Nippondenso 40A)
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 (Nippondenso 35A)
 Assembly 2-110
 Disassembly 2-108
 Inspection/Test 2-110
- Alternator - 3TN75, 3TNC78 (3011), 3TN82
 (575 SSL), 3TN84 (955 CUT, 3014 OEM)
 (Nippondenso 40A)
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 Inspection/Test 2-114
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 (Hitachi 25A)
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