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.
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.
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 The familiar “modular” layout has been replaced by a two-column “floating text” format.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.

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RECOGNIZE SAFETY INFORMATION

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

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

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.
**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.
Safet y

**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.

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

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<td>Engine Specifications</td>
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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**

- **Number of cylinders**: 3
- **Liter designation**: 0.9
- **Aspiration code**: D
- **User code**: F0
- **Application code**: 01

<table>
<thead>
<tr>
<th>Aspiration Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>D .................... Naturally aspirated</td>
</tr>
<tr>
<td>T .................... Turbocharged</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>User Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>F0 .................. OEM</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Application Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 ................ Bare industrial engine</td>
</tr>
<tr>
<td>05 ................ Industrial power pack</td>
</tr>
<tr>
<td>06 ................ Gen set power pack</td>
</tr>
</tbody>
</table>

**ENGINE APPLICATION CHART - LAWN AND GROUNDS CARE EQUIPMENT**

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

*430 Lawn and Garden Tractors were built with two slightly different versions of 3TNA72UJ engines. In this manual, 3TNA72UJ engines, Serial Numbers (1 - 5000), are referred to as “Early 3TNA72”. Engines with Serial Numbers (5001 - ) are referred to as “Later 3TNA72”.*
## ENGINE APPLICATION CHART - INDUSTRIAL EQUIPMENT

<table>
<thead>
<tr>
<th>Machine Model No.</th>
<th>Engine Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EXCAVATORS</strong></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>3TN72UBJ</td>
</tr>
<tr>
<td>25</td>
<td>3TN78RJB</td>
</tr>
<tr>
<td>30</td>
<td>3TN82RJB</td>
</tr>
<tr>
<td>50</td>
<td>4TN78TRJB</td>
</tr>
<tr>
<td><strong>LOADERS</strong></td>
<td></td>
</tr>
<tr>
<td>84</td>
<td>4TN100RJF</td>
</tr>
<tr>
<td>244E</td>
<td>4TN100LFB</td>
</tr>
</tbody>
</table>

## ENGINE APPLICATION CHART - OEM APPLICATION

<table>
<thead>
<tr>
<th>Machine Model No.</th>
<th>Engine Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>3009</td>
<td>3TNA72</td>
</tr>
<tr>
<td>3011</td>
<td>3TNC78</td>
</tr>
<tr>
<td>3014</td>
<td>3TN84</td>
</tr>
<tr>
<td>4019D</td>
<td>4TN84</td>
</tr>
<tr>
<td>4019T</td>
<td>4TN84T</td>
</tr>
</tbody>
</table>
## GENERAL ENGINE SPECIFICATIONS

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

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

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

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

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

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

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

* 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.
Fuels, Lubricants and Coolant

- 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**

<table>
<thead>
<tr>
<th>Item</th>
<th>Parts Per Million</th>
<th>Grains Per Gallon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorides (maximum)</td>
<td>40</td>
<td>2.5</td>
</tr>
<tr>
<td>Sulfates (maximum)</td>
<td>100</td>
<td>5.9</td>
</tr>
<tr>
<td>Total Dissolved Solids (maximum)</td>
<td>340</td>
<td>20</td>
</tr>
<tr>
<td>Total Hardness (maximum)</td>
<td>170</td>
<td>10</td>
</tr>
<tr>
<td>pH Level</td>
<td></td>
<td>5.5 - 9.0</td>
</tr>
</tbody>
</table>

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.

- 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.

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.

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

<table>
<thead>
<tr>
<th>Property Class and Head Markings</th>
<th>Class 4.8</th>
<th>Class 8.8 or 9.8</th>
<th>Class 10.9</th>
<th>Class 12.9</th>
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</thead>
<tbody>
<tr>
<td>Property Class and Nut</td>
<td>4.8</td>
<td>8.8</td>
<td>10</td>
<td>12</td>
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<table>
<thead>
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<th>Size</th>
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<th>Dry</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td>lb-ft</td>
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<td>lb-ft</td>
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<td>11.5</td>
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</tr>
<tr>
<td>M8</td>
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<td>M14</td>
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<td>125</td>
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<td>330</td>
<td>250</td>
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<td>M22</td>
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<td>250</td>
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<td>475</td>
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<td>310</td>
<td>650</td>
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</tr>
<tr>
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<td>625</td>
<td>450</td>
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<tr>
<td>M30</td>
<td>675</td>
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<td>850</td>
<td>625</td>
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<td>950</td>
<td>1650</td>
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</tr>
<tr>
<td>M33</td>
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<td>675</td>
<td>1150</td>
<td>850</td>
<td>1750</td>
<td>1300</td>
<td>2200</td>
<td>1650</td>
</tr>
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<td>M36</td>
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<td>850</td>
<td>1450</td>
<td>1075</td>
<td>2250</td>
<td>1650</td>
<td>2850</td>
<td>2100</td>
</tr>
</tbody>
</table>

**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.

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**UNIFIED INCH BOLT AND CAP SCREW TORQUE VALUES**

<table>
<thead>
<tr>
<th>SAE Grade and Head Markings</th>
<th>No Marks</th>
<th>1 or 2&lt;sup&gt;b&lt;/sup&gt;</th>
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<th>Grade 1</th>
<th>Grade 2&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Grade 5, 5.1 or 5.2</th>
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<td>Lubricated&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Dry&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Lubricated&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>lb-ft</td>
<td>Nm</td>
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<td>3.7</td>
<td>2.8</td>
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<td>7.7</td>
<td>5.5</td>
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<tr>
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<td>1-1/2</td>
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<td>725</td>
<td>1250</td>
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- **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.
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.)
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.)

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.)
### Specifications

#### 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
  - Reboxing: 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.)
## 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.)
- **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**: 29.97 - 30.03 mm (1.180 - 1.182 in.)
  - **Wear Limit**: 29.75 mm (1.171 in.)

### Journal O.D.
- **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.)

### Bushing I.D.
- **Clearance**
  - **Standard**: 0.18 mm (0.007 in.)
- **Bore I.D.**
  - **Clearance**
    - **Standard**: 0.032 - 0.068 mm (0.0013 - 0.0027 in.)
    - **Wear Limit**: 18.05 mm (0.711 in.)

### Cam Followers
- **O.D.**
  - **Standard**: 17.950 - 17.968 mm (0.7067 - 0.7074 in.)
  - **Wear Limit**: 17.93 mm (0.706 in.)
- **Bore I.D.**
  - **Clearance**
    - **Standard**: 0.15 mm (0.0059 in.)
    - **Wear Limit**: 20.08 mm (0.791 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.)
- **Crankshaft Pulley Cap Screw Torque**: 115 N•m (85 lb-ft)

### 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**
    - **Standard**: 20.00 - 20.021 mm (0.787 - 0.788 in.)
    - **Wear Limit**: 20.08 mm (0.791 in.)
### Specifications

#### Timing Gear Housing Cap Screw Torque
- Aluminum Housing-to-Block: \( 9 \text{ N} \cdot \text{m} \) (78 lb-in.)
- Cast Iron Housing-to-Block: \( 11 \text{ N} \cdot \text{m} \) (96 lb-in.)

#### Oil Pan and Strainer Mounting Cap Screw Torque
- Oil Pan-to-Block: \( 11 \text{ N} \cdot \text{m} \) (96 lb-in.)
- Oil Pan-to-Seal Case: \( 9 \text{ N} \cdot \text{m} \) (78 lb-in.)
- Oil Pan-to-Timing Gear Housing: \( 9 \text{ N} \cdot \text{m} \) (78 lb-in.)
- Oil Strainer-to-Block: \( 11 \text{ N} \cdot \text{m} \) (96 lb-in.)

#### Oil Pump
- Mounting Cap Screw Torque: \( 25 \text{ N} \cdot \text{m} \) (18 lb-ft)
- Rotor Shaft O.D.-to-Backing Plate I.D. Clearance:
  - Standard: \( 0.015 - 0.048 \text{ mm} \) (0.0006 - 0.0035 in.)
  - Wear Limit: \( 0.20 \text{ mm} \) (0.0078 in.)
- Rotor Recess
  - Wear Limit: \( 0.25 \text{ mm} \) (0.010 in.)
- Outer Rotor-to-Pump Body Clearance:
  - Standard: \( 0.03 - 0.09 \text{ mm} \) (0.0011 - 0.0035 in.)
  - Wear Limit: \( 0.13 \text{ mm} \) (0.0057 in.)
- Inner-to-Outer Rotor Clearance
  - Wear Limit: \( 0.15 \text{ mm} \) (0.0059 in.)

#### Oil Pressure Regulating Valve
- Spring
  - Compressed Length: \( 14.70 \text{ mm} \) (0.580 in.) @ \( 12 \text{ N} \) (2.7 lb-force)
  - Free Length: \( 21.90 - 24.50 \text{ mm} \) (0.860 - 0.960 in.)
- Housing-to-Valve Body Retaining Nut Torque: \( 30 \text{ N} \cdot \text{m} \) (22 lb-ft)

#### Thermostat
- Thermostat Cover Cap Screw Torque: \( 9 \text{ N} \cdot \text{m} \) (78 lb-in.)

#### Water Pump
- Mounting Cap Screw Torque: \( 26 \text{ N} \cdot \text{m} \) (226 lb-in.)
- Fan Mounting Cap Screw Torque: \( 11 \text{ N} \cdot \text{m} \) (96 lb-in.)
- Plate-to-Housing Screw Torque: \( 9 \text{ N} \cdot \text{m} \) (78 lb-in.)

#### Fuel Injection Pump
- Mounting Nut Torque: \( 20 \text{ N} \cdot \text{m} \) (180 lb-in.)

#### Fuel Injection Pump Camshaft
- Bearing Retaining Screw Torque: \( 20 \text{ N} \cdot \text{m} \) (180 lb-in.)
- Minimum Lobe Height: \( 30.90 \text{ mm} \) (1.217 in.)

#### Fuel Control and Governor Linkage
- Governor Shaft O.D. (Minimum): \( 7.90 \text{ mm} \) (0.311 in.)
- Governor Shaft Bore I.D.
  - Wear Limit: \( 8.15 \text{ mm} \) (0.321 in.)
  - Clearance: \( 0.18 \text{ mm} \) (0.007 in.)
- Sleeve I.D. (Maximum): \( 8.20 \text{ mm} \) (0.323 in.)
- Injection Pump Camshaft O.D.
  - Clearance: \( 0.15 \text{ mm} \) (0.006 in.)
  - Wear Limit: \( 7.90 \text{ mm} \) (0.311 in.)

#### Fuel Injection Nozzles
- Mounting Nut Torque: \( 40 \text{ N} \cdot \text{m} \) (30 lb-ft)
- Nozzle Fitting Torque: \( 40 \text{ N} \cdot \text{m} \) (30 lb-ft)
- Nozzle Torque: \( 50 \text{ N} \cdot \text{m} \) (37 lb-ft)
- Separator Plate Nozzle Contact Surface Maximum Wear: \( 0.10 \text{ mm} \) (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)

Alternator - Nippondenso 35A (655 CUT)
- Attaching Screw Torque .......................... 4 N•m (31 lb-in.)

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 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 .......................... 0.020 - 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.)
- 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
Specifications

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)
- 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 psi
  - 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)
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.)
### Specifications

#### 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
- 0.61 - 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.)

#### 0.25 mm (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.)

### 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 (1.731 - 1.731 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.)
Specifications

Stub Shaft (430 LGT, F925/35 FM)

<table>
<thead>
<tr>
<th>Component</th>
<th>Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stub Shaft-to-Flywheel Cap Screw Torque</td>
<td>59 N•m (44 lb-ft)</td>
</tr>
<tr>
<td>Cover-to-Block Cap Screw Torque</td>
<td>49 N•m (36 lb-ft)</td>
</tr>
<tr>
<td>Nut Torque</td>
<td>88 N•m (65 lb-ft)</td>
</tr>
<tr>
<td>Cover-to-Plate Cap Screw Torque</td>
<td>26 N•m (226 lb-in.)</td>
</tr>
</tbody>
</table>

Flywheel

<table>
<thead>
<tr>
<th>Component</th>
<th>Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Distortion</td>
<td>0.02 mm (0.0008 in.)</td>
</tr>
<tr>
<td>Mounting Cap Screw Torque</td>
<td>83 N•m (61 lb-ft)</td>
</tr>
</tbody>
</table>

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

Camshaft

<table>
<thead>
<tr>
<th>Component</th>
<th>Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mounting Cap Screw Torque</td>
<td>11 N•m (96 lb-in.)</td>
</tr>
</tbody>
</table>

Camshaft Side Gap

<table>
<thead>
<tr>
<th>Component</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>0.05 - 0.15 mm (0.0020 - 0.0060 in.)</td>
</tr>
<tr>
<td>Wear Limit</td>
<td>0.40 mm (0.016 in.)</td>
</tr>
<tr>
<td>Maximum Camshaft Bend</td>
<td>0.02 mm (0.001 in.)</td>
</tr>
</tbody>
</table>

Lobe Height

<table>
<thead>
<tr>
<th>Component</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>33.95 - 34.05 mm (1.337 - 1.341 in.)</td>
</tr>
<tr>
<td>Wear Limit</td>
<td>33.75 mm (1.329 in.)</td>
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</tbody>
</table>

Journal O.D.

<table>
<thead>
<tr>
<th>Component</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>39.94 - 39.96 mm (1.5724 - 1.5732 in.)</td>
</tr>
<tr>
<td>Wear Limit</td>
<td>39.85 mm (1.5689 in.)</td>
</tr>
<tr>
<td>Intermediate</td>
<td>39.91 - 39.94 mm (1.5713 - 1.5724 in.)</td>
</tr>
<tr>
<td>Wear Limit</td>
<td>39.85 mm (1.5689 in.)</td>
</tr>
</tbody>
</table>

Bushing I.D.

<table>
<thead>
<tr>
<th>Component</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>40.00 - 40.065 mm (1.575 - 1.577 in.)</td>
</tr>
<tr>
<td>Wear Limit</td>
<td>40.10 mm (1.579 in.)</td>
</tr>
</tbody>
</table>

Bore I.D.

<table>
<thead>
<tr>
<th>Component</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearance</td>
<td>0.18 mm (0.007 in.)</td>
</tr>
<tr>
<td>Standard</td>
<td>40.00 - 40.025 mm (1.575 - 1.576 in.)</td>
</tr>
<tr>
<td>Wear Limit</td>
<td>40.10 mm (1.579 in.)</td>
</tr>
</tbody>
</table>

Cam Followers

<table>
<thead>
<tr>
<th>Component</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>O.D.</td>
<td>20.927 - 20.960 mm (0.8239 - 0.8252 in.)</td>
</tr>
<tr>
<td>Wear Limit</td>
<td>20.93 mm (0.824 in.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Component</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearance</td>
<td>0.040 - 0.094 mm (0.0016 - 0.0037 in.)</td>
</tr>
<tr>
<td>Standard</td>
<td>21.00 - 21.021 mm (0.8268 - 0.8276 in.)</td>
</tr>
<tr>
<td>Wear Limit</td>
<td>21.05 mm (0.829 in.)</td>
</tr>
</tbody>
</table>

Timing Gear Cover

<table>
<thead>
<tr>
<th>Component</th>
<th>Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fan Mounting Cap Screw Torque</td>
<td>11 N•m (96 lb-in.)</td>
</tr>
<tr>
<td>Cover Mounting Cap Screw Torque</td>
<td>9 N•m (78 lb-in.)</td>
</tr>
<tr>
<td>Crankcase Extension Housing-to-Cover Cap Screw Torque</td>
<td>22 N•m (195 lb-in.)</td>
</tr>
<tr>
<td>Crankshaft Pulley Cap Screw Torque</td>
<td>88 N•m (65 lb-ft)</td>
</tr>
<tr>
<td>Early 3TNA72 (430 LGT)</td>
<td>115 N•m (85 lb-ft)</td>
</tr>
</tbody>
</table>

4/7/95

1-11
### Idler Gear

<table>
<thead>
<tr>
<th>Specification</th>
<th>Standard Range</th>
<th>Wear Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaft O.D.</td>
<td>19.959 - 19.980 mm (0.786 - 0.787 in.)</td>
<td>19.93 mm (0.785 in.)</td>
</tr>
<tr>
<td>Bushing I.D.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clearance</td>
<td>0.15 mm (0.0059 in.)</td>
<td></td>
</tr>
<tr>
<td>Standard</td>
<td>20.00 - 20.021 mm (0.787 - 0.788 in.)</td>
<td>20.08 mm (0.791 in.)</td>
</tr>
</tbody>
</table>

### 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 (0.0006 - 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**: 0.25 mm (0.010 in.)
- **Rotor Shaft O.D.-to-Backing Plate I.D. Clearance**: 0.015 - 0.048 mm (0.0006 - 0.0035 in.)
- **Wear Limit**: 0.20 mm (0.0078 in.)
Specifications

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 .......................................................... 0.15 mm (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.)

Starter Motor - Nippondenso 1.0 kW (All Except 3009 OEM)
- Minimum Brush Length: 8.5 mm (0.300 in.)

Alternator - Kokosan 20A (670 CUT, 15 EX)
- Flywheel Assembly-to-Coil Plate Assembly Nut Torque: 27 N•m (20 lb-ft)

Alternator - Nippondenso 35A (430 LGT, 670 CUT, 755/56 CUT, F925/35 FM)
- 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 - 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.)
- New Brush Length: 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.)
- 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.)
- 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.)
Specifications

Timing Gear Backlash - Later 3TNA7

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
- Hitachi 0.8 kW: 60 Amps at 7000 rpm
- Nippondenso 1.0 kW: 90 Amps at 3000 rpm

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
- Total Shim Pack Thickness (New Shims): 2.62 mm (0.100 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)

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)

455 LGT
Idle Speed
Fast ............................................................ 3350 ± 100 rpm
Slow .......................................................... 1650 ± 50 rpm
Engine Oil Pressure ........................................... 294 - 440 kPa (43 - 64 psi)

430 LGT, 755/56 CUT, 670 CUT
Fast Idle Speed ............................................. 3425 ± 25 rpm
Engine Oil Pressure ........................................... 365 ± 69 kPa (53 ± 10 psi)

15 EX
Idle Speed
Fast ............................................................ 2425 ± 25 rpm
Slow .......................................................... 800 ± 25 rpm
Engine Oil Pressure ........................................... 117 - 345 kPa (17 - 50 psi)

3009 OEM
Low Idle Speed ............................................... 1300 rpm
Engine Oil Pressure ........................................... 147 kPa (21 psi)

Air Intake System Holding Pressure ........................................... 34 - 69 kPa (5 - 10 psi)
Minimum Fuel Supply Pump Pressure (670 CUT, 3009 OEM) ............... 29 kPa (4.3 psi)
Fuel System Holding Pressure (Maximum) ..................................... 103 kPa (15 psi)
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
ROCKER ARM COVER

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

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.)
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.
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:

<table>
<thead>
<tr>
<th>Standard</th>
<th>0.05 mm (0.002 in.) or less</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wear Limit</td>
<td>0.15 mm (0.006 in.)</td>
</tr>
</tbody>
</table>

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 - 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.)

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 \textbf{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 A \hspace{1cm} 20 \text{ mm (0.787 in.)}
Distance B \hspace{1cm} 40 \text{ mm (1.575 in.)}

Intake Valve
Standard \hspace{1cm} 5.46 - 5.48 \text{ mm (0.2149 - 0.2157 in.)}
Wear Limit \hspace{1cm} 5.40 \text{ mm (0.2126 in.)}

Exhaust Valve
Standard \hspace{1cm} 5.44 - 5.46 \text{ mm (0.2142 - 0.2149 in.)}
Wear Limit \hspace{1cm} 5.40 \text{ mm (0.2126 in.)}

Valve Stem O.D. - 3TNA72 (3009):
Distance A \hspace{1cm} 25 \text{ mm (0.984 in.)}
Distance B \hspace{1cm} 45 \text{ mm (1.772 in.)}

Intake and Exhaust Valves
Standard \hspace{1cm} 6.94 - 6.96 \text{ mm (0.2732 - 0.2740 in.)}
Wear Limit \hspace{1cm} 6.90 \text{ mm (0.2717 in.)}

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

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

Valve Springs:
- Measure spring free length. Replace spring if measurement exceeds specification.
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.

EXHAUST MANIFOLD - 3TN66
- Remove muffler and gasket, if equipped.
- Tighten all mounting hardware to 11 N•m (97 lb-in.).
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.).
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.)

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.).
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.


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.
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 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 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.

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.
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.

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.)

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.)
Piston Ring Groove Clearance - 3TNA72 (3009):

**First Compression Ring**
- Standard: 0.075 - 0.110 mm
- Wear Limit: 0.20 mm

**Second Compression Ring**
- Standard: 0.030 - 0.065 mm
- Wear Limit: 0.20 mm

**Oil Ring**
- Standard: 0.020 - 0.055 mm
- Wear Limit: 0.20 mm

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: 0.15 - 0.35 mm
- and Oil Ring: 0.15 - 0.35 mm
- Second Compression Ring: 0.25 - 0.40 mm
- Wear Limit: 1.50 mm

Piston Ring End Gap - 3TNA72 (3009):

**Standard**
- First Compression Ring: 0.10 - 0.25 mm
- Second Compression Ring: 0.25 - 0.40 mm
- Oil Ring: 0.15 - 0.35 mm
- Wear Limit: 1.50 mm

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:

<table>
<thead>
<tr>
<th>Standard</th>
<th>19.991 - 20.00 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wear Limit</td>
<td>19.975 mm (0.786 in.)</td>
</tr>
</tbody>
</table>

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

8. Measure piston pin bore diameter in piston.

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

<table>
<thead>
<tr>
<th>Standard</th>
<th>20.991 - 21.00 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wear Limit</td>
<td>20.975 mm (0.825 in.)</td>
</tr>
</tbody>
</table>

Piston Pin Bore I.D. - 3TN66:

<table>
<thead>
<tr>
<th>Standard</th>
<th>20.00 - 20.008 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wear Limit</td>
<td>20.02 mm (0.788 in.)</td>
</tr>
<tr>
<td>Clearance</td>
<td>0.045 mm (0.0018 in.)</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Standard</th>
<th>21.00 - 21.009 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wear Limit</td>
<td>21.02 mm (0.828 in.)</td>
</tr>
<tr>
<td>Clearance</td>
<td>0.045 mm (0.0018 in.)</td>
</tr>
</tbody>
</table>

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 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.)

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

0.25 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.)
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.

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.
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.) and 0.50 mm (0.020 in.) oversize. (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.

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

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<th>Number</th>
<th>Name</th>
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<tr>
<td>TY15130/</td>
<td>John Deere Form-In-Place Gasket</td>
<td>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.</td>
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SERVICE PARTS KITS

The following kits are available through your parts catalog:

- Cylinder Block Gasket Kit
- Undersized Main Bearing Inserts

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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.)
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.)
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.
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.

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.)
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.

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.
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.
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. - 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.

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.
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.)
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.

**FLYWHEEL HOUSING - 3TNA72**

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

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

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

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<th>Number</th>
<th>Name</th>
<th>Use</th>
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<td>LOCTITE® PRODUCTS</td>
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<tr>
<td>U.S./</td>
<td>John Deere Form-In-Place Gasket</td>
<td>Seals camshaft plug, timing gear cover and housing to engine block.</td>
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<td>TY9370/</td>
<td>Thread Lock and Sealer</td>
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<td>TY9477/</td>
<td>(Medium Strength)</td>
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<td>#242</td>
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<tr>
<td>TY9369/</td>
<td>Thread Lock and Sealer</td>
<td>Apply to threads of studs in timing gear housing.</td>
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SERVICE PARTS KITS

The following kits are available through your parts catalog:

- Cylinder Head Gasket Kit
- Cylinder Block Gasket Kit

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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.

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.

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.
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.)

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.)
Camshaft and Timing Gear Train

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:


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.) |

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.

  ![Normal Contact vs Abnormal Contact](image)

- Measure cam follower diameter.

  ![Measuring Cam Follower Diameter](image)

- **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.

  ![Measuring Cam Follower Bore Diameter](image)

- **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**

1. Remove alternator and belt.
2. Remove fan, spacer, 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.
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.)
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.
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.)

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.
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.)
Apply thread lock and sealer (medium strength) to threads. 115 N•m (85 lb-ft)
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.:

<table>
<thead>
<tr>
<th>Standard</th>
<th>19.959 - 19.980 mm</th>
<th>(0.786 - 0.787 in.)</th>
</tr>
</thead>
</table>

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.:

<table>
<thead>
<tr>
<th>Standard</th>
<th>20.00 - 20.021 mm</th>
<th>(0.787 - 0.788 in.)</th>
</tr>
</thead>
</table>

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.

### 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.
**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.
**Camshaft and Timing Gear Train**

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

**Cap Screw (4)**
- M8 x 12

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

**Spring Pin (2)**

**Gasket**

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

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

**Cap Screw (2)**
- M6 x 14

**Alignment Dowel (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.)

**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**

**455 LGT**

**Cover**
- (15 EX Only)
  - M8 x 12

**15 EX, 670 CUT**

**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.)

**Cover**
- (15 EX Only)
  - M8 x 12

**15 EX, 670 CUT**
<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>TY15130/</td>
<td>John Deere Form-In-Place</td>
<td>Seals oil pan/plate to crankcase extension</td>
</tr>
<tr>
<td>NA/#395</td>
<td>Gasket</td>
<td>housing and/or block.</td>
</tr>
</tbody>
</table>

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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.)

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

Drain Plug

Washer

Replace.

Cap Screw (10)
M6 x 10
11 N•m (96 lb-in.)

Cap Screw (2)
M6 x 12
11 N•m (96 lb-in.)

O-Ring

Replace.

Oil Pan-to-Seal Case Cap Screw (2)
M6 x 12
9 N•m (78 lb-in.)

Oil Pan-to-Timing Gear Housing Cap Screw (4)
M6 x 12
9 N•m (78 lb-in.)

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

1-74

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.
7. Remove sealing wire.
8. Loosen jam nut. Turn slow idle adjustment screw counterclockwise several turns.
9. Disconnect spring from governor linkage.
10. Remove governor shaft, washer and spacer.
11. Remove governor linkage assembly.
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.)

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.).

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.

• Measure outer rotor bore and outer rotor diameters.

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 rotor shaft diameter.

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 inner rotor O.D. and outer rotor I.D.
Lubrication

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.)

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.

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.

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.

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:**

<table>
<thead>
<tr>
<th>Description</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free Length</td>
<td>21.90 - 24.50 mm</td>
</tr>
<tr>
<td></td>
<td>(0.860 - 0.960 in.)</td>
</tr>
<tr>
<td>Compressed Length</td>
<td>14.70 mm (0.580 in.)</td>
</tr>
<tr>
<td></td>
<td>@ 12 N (2.7 lb-force)</td>
</tr>
</tbody>
</table>

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:**

<table>
<thead>
<tr>
<th>Description</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free Length</td>
<td>39.50 - 40.50 mm</td>
</tr>
<tr>
<td></td>
<td>(1.550 - 1.590 in.)</td>
</tr>
<tr>
<td>Compressed Length</td>
<td>30 mm (1.180 in.)</td>
</tr>
<tr>
<td></td>
<td>@ 29.4 ± 3.1 N (6.6 ± 0.7 lb-force)</td>
</tr>
</tbody>
</table>

**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.

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

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.
## OTHER MATERIALS

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOCTITE® PRODUCTS</td>
<td></td>
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<tr>
<td>U.S./</td>
<td></td>
<td></td>
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<td>Canadian/</td>
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<tr>
<td>LOCTITE No.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TY9375/</td>
<td>John Deere Pipe Sealant</td>
<td>3TNA72 (15 EX, 755/56 CUT): Apply</td>
</tr>
<tr>
<td>TY9480/</td>
<td>with TEFLEX®</td>
<td>to threads of plug in water pump</td>
</tr>
<tr>
<td>#592</td>
<td></td>
<td>housing.</td>
</tr>
</tbody>
</table>

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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.)
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.

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

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.

**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.
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.)
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.*
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.).

![Diagram of water pump and related parts with labels indicating instructions for removal and installation.](M82318A)
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.

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

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.

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.

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

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

<table>
<thead>
<tr>
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<td>TY9369/ Thread Lock and Sealer</td>
<td>Apply to threads of fuel shutoff</td>
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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.
FUEL FILTER ASSEMBLY - IF EQUIPPED

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.

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 knowledgable source. Such information is available from the Deere & Company Medical Department in Moline, Illinois, U.S.A.

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.

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.

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.

**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.)

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.
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.)


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.

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

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 puller 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.

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.)

---

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

**Bearing Retaining Screw**

20 N•m (180 lb-in.)

---

**Camshaft**
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.

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.

9. Loosen lock nut and remove fast idle adjustment screw and seal.

10. Loosen lock nut and remove fuel controller and seal.
11. Disconnect spring from throttle lever regulator.

12. Remove nut, throttle lever, regulator and o-ring.

13. Remove set screw and fuel shutoff lever.


15. Remove governor shaft, bronze washer and spacer.

16. Turn governor weights until one weight is toward the engine. Remove governor linkage assembly.
17. Remove spring pin.

18. Remove e-clip, pin and spring.

19. Remove sleeve, governor weights and thrust washer.

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.

2. Install spring, pin and e-clip.

3. Install spring pin.
4. Turn governor weights until one weight is toward the engine. Install governor linkage assembly.

5. Install spacer and new bronze washer on governor shaft.

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


8. Align groove in fuel shutoff lever with hole in timing gear housing and install lever. Make sure groove is visible through hole.

9. Apply thread lock and sealer (low strength) on threads of set screw. Install and tighten set screw.

10. Install new o-ring on regulator.

11. 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.


**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.

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.
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**

*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.

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.

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.

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.

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.)
Disassembly

1. Remove spring.
2. Remove seal and sealing wire.

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.

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.

NOTE: Washer is on 670 CUT, 455 LGT and 3009 OEM only.

NOTE: Shims are on all engines except 670 CUT and 3009 OEM applications.
11. Remove cover, gasket, fuel controller assembly, fast idle stop and slow idle stop.

12. Disassemble governor linkage assembly.

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.
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 knowledgable 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.

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.
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.)
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.
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.
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.

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.

   **IMPORTANT:** Do not clean armature with solvent. Solvent can damage insulation on windings. Use only mineral spirits and a brush.


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.

---

**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.)
Assemble

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.
IMPORTANT: Do not clean armature with solvent. Solvent can damage insulation on windings. Use only mineral spirits and a brush.


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:
Bears 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.

2. Separate clutch housing from solenoid/motor assembly.

3. Remove plunger spring and gear, if equipped.

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.

**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.
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

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.

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.

Assembly
Assembly is done in the reverse order of disassembly.
ALTHERNATOR - 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.

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: Bearing and flywheel are press fit on shaft.

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.
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.


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.
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.
• 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.

• 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.

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.

**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.

• 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.

*NOTE: Each of the three outer terminals on the rectifier is connected to two diodes permitting current flow in only one direction.*

*NOTE: Each of the three outer terminals on the rectifier is connected to two diodes permitting current flow in only one direction.*
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.

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).
- Check continuity between brush and terminal “A”. Check continuity between brush and terminal “B”. There should be continuity only at these points.

Brush Length Specifications

New.............. 10.50 mm (0.410 in.)
Wear Limit......... 4.50 mm (0.170 in.)

- 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.
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.

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

<table>
<thead>
<tr>
<th>PROBLEM OR SYMPTOM</th>
<th>CHECK OR SOLUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel pump screen, fuel filter, or fuel line restricted. Fuel dirty, contains water or wrong grade.</td>
<td>( \bullet )</td>
</tr>
<tr>
<td>Air filter elements dirty or plugged. Replace.</td>
<td>( \bullet )</td>
</tr>
<tr>
<td>Fuel shut-off valve turned off, or restricted. Solenoid linkage misadjusted. See adjustment.</td>
<td>( \bullet )</td>
</tr>
<tr>
<td>Muffler or exhaust manifold leak.</td>
<td>( \bullet )</td>
</tr>
<tr>
<td>Defective glow plugs.</td>
<td>( \bullet )</td>
</tr>
<tr>
<td>Injection pump or governor malfunctioning. Injection pump timing incorrect.</td>
<td>( \bullet )</td>
</tr>
<tr>
<td>Defective cranking components or connectors.</td>
<td>( \bullet )</td>
</tr>
<tr>
<td>Low compression from worn rings, cylinder bore, piston, valves or warped head.</td>
<td>( \bullet )</td>
</tr>
<tr>
<td>Valve clearance incorrect.</td>
<td>( \bullet )</td>
</tr>
<tr>
<td>Burned or warped valves and valve seats. Defective valve spring.</td>
<td>( \bullet )</td>
</tr>
<tr>
<td>Starter cranking rpm too slow. Damaged starter. Excessive engine load.</td>
<td>( \bullet )</td>
</tr>
<tr>
<td>Fuel pump leaking or not operating. See Fuel Supply Pump Pressure Test.</td>
<td>( \bullet )</td>
</tr>
<tr>
<td>Engine oil viscosity or level incorrect.</td>
<td>( \bullet )</td>
</tr>
<tr>
<td>Injector pressure incorrect or leaking.</td>
<td>( \bullet )</td>
</tr>
<tr>
<td>Cylinder head gaskets leaking or damaged.</td>
<td>( \bullet )</td>
</tr>
<tr>
<td>Radiator.</td>
<td>( \bullet )</td>
</tr>
</tbody>
</table>
# ENGINE SYSTEM DIAGNOSIS

**Conditions:**
- Engine mounted on level surface.
- Key switch off unless indicated otherwise.

<table>
<thead>
<tr>
<th>Test Location</th>
<th>Normal</th>
<th>If Not Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Coolant tank and radiator.</td>
<td>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.</td>
<td>Add proper coolant mix.</td>
</tr>
<tr>
<td>5. Fuel shutoff solenoid. (Key in RUN position.)</td>
<td>Fuel shutoff solenoid must pull in and stay in. Solenoid must bottom out. Shutoff shaft must still move slightly.</td>
<td>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.</td>
</tr>
<tr>
<td>6. Glow plug indicator light. (Key in RUN position.)</td>
<td>Indicator light should come on up to 15 seconds depending on air temperature.</td>
<td>See Glow Plug Circuit Test Points in ELECTRICAL section of Machine TM.</td>
</tr>
</tbody>
</table>
## ENGINE SYSTEM DIAGNOSIS - Continued

<table>
<thead>
<tr>
<th>Test Location</th>
<th>Normal</th>
<th>If Not Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Fuel filter, fuel pump. (Key switch in RUN position.)</td>
<td>Fuel level increases in filter. Fuel pump operating - listen for humming sound. Fuel present in return hose at fuel pump.</td>
<td>See Fuel Pump Circuit Test Points in ELECTRICAL section of Machine TM. Test fuel pump pressure. (See Operational Tests in this section.) Replace fuel filter.</td>
</tr>
<tr>
<td>8. Throttle lever and cable.</td>
<td>Linkage not binding and adjusted correctly.</td>
<td>Repair, replace or adjust cable.</td>
</tr>
<tr>
<td>10. Fuel at injectors. (Key in START position - engine cranking.)</td>
<td>Crack fuel injection lines at injectors. Fuel shutoff solenoid pulled in. Engine must crank.</td>
<td>Check spray pattern and cracking pressure. (See Checks, Tests and Adjustments in this section.) Replace injectors. See Cranking Circuit Test Points in ELECTRICAL section of Machine TM.</td>
</tr>
<tr>
<td>11. Injector ports. (Key in START position.)</td>
<td>Cylinder compression within specification. Pressure difference between cylinders within specification.</td>
<td>Perform cylinder compression test. (See Operational Tests in this section.)</td>
</tr>
<tr>
<td>12. Flywheel and starter.</td>
<td>Minimum cranking rpm within specification.</td>
<td>See Starter Amp Draw Test in ELECTRICAL section of Machine TM.</td>
</tr>
<tr>
<td>13. Injection pump timing inspection. (Key OFF.)</td>
<td>Timing should be correct. Remove pump as the LAST possible solution.</td>
<td>Perform injection pump static timing adjustment. (See Checks, Tests and Adjustments in this section.) Have pump tested by a qualified Service Repair Shop.</td>
</tr>
<tr>
<td>15. Oil pressure sender port.</td>
<td>Oil pressure in specification.</td>
<td>Test engine oil pressure. (See Operational Tests in this section.)</td>
</tr>
<tr>
<td>16. Thermostat. (Engine at operating temperature.)</td>
<td>Clean from corrosion, rust, or debris. Opening temperature within specification.</td>
<td>Replace thermostat. Perform thermostat opening test. (See Checks, Tests and Adjustments in this section.)</td>
</tr>
</tbody>
</table>
VALVE CLEARANCE, CHECK AND ADJUSTMENT - EARLY 3TNA72 (430 LGT)

Reason:
To achieve correct engine operation.

Equipment:
• 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.
- 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.

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. 2 cylinder at TDC compression stroke.

7. Measure and adjust valve clearance on the valves (arrows) with No. 2 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 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.

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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 . . . . . . 0.090 - 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.
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
- Wear Limit . . . . . . . . . . 0.15 mm (0.0059 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:

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:
• Dial Indicator

Procedure:
1. Measure backlash between meshing gears.

Specifications:
Standard Backlash
Fuel Injection Pump Gear-to-Oil Pump Gear ............... 0.11 - 0.19 mm
........................................ (0.0043 - 0.0075 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.

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, 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:

<table>
<thead>
<tr>
<th>Gear Type</th>
<th>Standard Backlash</th>
<th>Wear Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crankshaft Gear-to-Oil Pump Gear</td>
<td>0.11 - 0.19 mm (0.0043 - 0.0075 in.)</td>
<td>0.20 mm (0.0079 in.)</td>
</tr>
</tbody>
</table>

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.
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 knowledgable 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:


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.
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 ............... Fine Stream
.......................... Spray Pattern

Fast Hand
Lever Movement ............... Fine Atomized
.......................... Spray Pattern
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

Procedure:

1. Suspend thermostat and a thermometer in a container of water.
3. Remove thermostat and observe its closing action as it cools.

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.

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.

COOLANT TEMPERATURE SENSOR TEST

Reason:
To determine operating temperature of sensor.

Equipment:
- Thermometer
- Glass Container
- Heating Unit
- Ohmmeter
Procedure:

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.

**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.

---

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.

---

STARTER NO-LOAD AMP DRAW/RPM TEST

Reason:

To determine if starter is binding or has excessive amperage draw under no load.
Checks, Tests and Adjustments

JT05719 Hand-Held Digital Tachometer

JT05712 Current Gun

Jumper Wire

Hitachi 0.8 kW

JT05719 Hand-Held Digital Tachometer

JT05712 Current Gun

Jumper Wire

Nippondenso 1.0 kW
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.
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.

<table>
<thead>
<tr>
<th>Shim Pack:</th>
<th>Approximate Timing Change on Crankshaft Pulley</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shim Size</td>
<td></td>
</tr>
<tr>
<td>0.2 mm (0.007 in.)</td>
<td>2° or 2 mm (5/64 in.)</td>
</tr>
<tr>
<td>0.3 mm (0.012 in.)</td>
<td>3° or 3 mm (1/8 in.)</td>
</tr>
<tr>
<td>0.5 mm (0.020 in.)</td>
<td>5° or 5 mm (13/64 in.)</td>
</tr>
</tbody>
</table>

- 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\(\cdot\)m (31 lb\(\cdot\)ft).

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.

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.

\textit{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

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.

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.
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 OEM: ................. 2448 kPa (355 psi)
    - 3009 OEM: ................. 2455 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 Seconds ................. 90 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.
Specifications:

Compression Pressure

3TN66 . . . . . . . . . . . . . . . . . . . 2448 kPa (355 psi)
3TNA72
    All Except
    3009 OEM . . . . . . . . . . . . . 2448 kPa (355 psi)
    3009 OEM . . . . . . . . . . . . . 2455 kPa (356 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.

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.

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).
Operational Tests

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.
3TN75, 3TN78, 3TNC78 (3011)
3TN82, 3TNA82, AND
3TN84 (3014)
ENGINES

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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
- **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
- **Standard**: 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.)
Specifications

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 (0.010 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.)

  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: 26 N•m (226 lb-in.)
  - Seal Case-to-Extension: 27 N•m (20 lb-ft)
  - Extension-to-Block: 22 N•m (165 lb-in.)
  - Extension-to-Timing Gear Cover: 26 N•m (186 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)

**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.)
## Specifications

### Cam Followers

<table>
<thead>
<tr>
<th>Component</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stem O.D.</td>
<td>Standard: 11.975 - 11.990 mm (0.471 - 0.472 in.)</td>
</tr>
<tr>
<td></td>
<td>Wear Limit: 11.93 mm (0.470 in.)</td>
</tr>
<tr>
<td>Bore I.D.</td>
<td>Clearance: 0.10 mm (0.004 in.)</td>
</tr>
<tr>
<td></td>
<td>Standard: 12.000 - 12.018 mm (0.472 - 0.473 in.)</td>
</tr>
<tr>
<td></td>
<td>Wear Limit: 12.05 mm (0.474 in.)</td>
</tr>
</tbody>
</table>

### 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

<table>
<thead>
<tr>
<th>Component</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaft O.D.</td>
<td>Standard: 45.950 - 45.975 mm (1.809 - 1.810 in.)</td>
</tr>
<tr>
<td></td>
<td>Wear Limit: 45.93 mm (1.808 in.)</td>
</tr>
<tr>
<td>Bushing I.D.</td>
<td>Clearance: 0.15 mm (0.0059 in.)</td>
</tr>
<tr>
<td></td>
<td>Standard: 46.00 - 46.025 mm (1.811 - 1.812 in.)</td>
</tr>
<tr>
<td></td>
<td>Wear Limit: 46.03 mm (1.812 in.)</td>
</tr>
</tbody>
</table>

### Oil Pan and Strainer Mounting Cap Screw Torque: 26 N·m (226 lb-in.)

### Oil Pump

<table>
<thead>
<tr>
<th>Component</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mounting Cap Screw Torque</td>
<td>25 N·m (18 lb-ft)</td>
</tr>
<tr>
<td>Rotor Shaft O.D.-to-Backing Plate I.D. Clearance</td>
<td>Standard: 0.015 - 0.048 mm (0.0006 - 0.0035 in.)</td>
</tr>
<tr>
<td></td>
<td>Wear Limit: 0.20 mm (0.0078 in.)</td>
</tr>
<tr>
<td>Rotor Recess</td>
<td>Standard: 0.05 - 0.10 mm (0.0020 - 0.0039 in.)</td>
</tr>
<tr>
<td></td>
<td>Wear Limit: 0.15 mm (0.0059 in.)</td>
</tr>
<tr>
<td>Outer Rotor-to-Pump Body Clearance</td>
<td>Standard: 0.09 - 0.16 mm (0.0035 - 0.0063 in.)</td>
</tr>
<tr>
<td></td>
<td>Wear Limit: 0.25 mm (0.0098 in.)</td>
</tr>
<tr>
<td>Inner-to-Outer Rotor Clearance</td>
<td>Standard: 0.02 - 0.04 mm (0.0008 - 0.0016 in.)</td>
</tr>
<tr>
<td></td>
<td>Wear Limit: 0.15 mm (0.0059 in.)</td>
</tr>
</tbody>
</table>

### Oil Pressure Regulating Valve

#### Spring

<table>
<thead>
<tr>
<th>Component</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressed Length</td>
<td>27.50 mm (1.080 in.) @ 20.5 N (4.6 lb-force)</td>
</tr>
<tr>
<td>Free Length</td>
<td>46 mm (1.810 in.)</td>
</tr>
<tr>
<td>Housing-to-Valve Body Retaining Nut Torque</td>
<td>30 N·m (22 lb-ft)</td>
</tr>
<tr>
<td>Housing-to-Engine Block Cap Screw Torque</td>
<td>27 N·m (20 lb-ft)</td>
</tr>
</tbody>
</table>

### Thermostat and Housing - 3TN78

<table>
<thead>
<tr>
<th>Component</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermostat Cover Cap Screw Torque</td>
<td>20 N·m (180 lb-in.)</td>
</tr>
<tr>
<td>Plate-to-Housing Cap Screw Torque</td>
<td>9 N·m (78 lb-in.)</td>
</tr>
<tr>
<td>Housing Mounting Cap Screw Torque</td>
<td>26 N·m (226 lb-in.)</td>
</tr>
</tbody>
</table>

### Thermostat - 3TN75, 3TNC78 (3011)

<table>
<thead>
<tr>
<th>Component</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cover Cap Screw Torque</td>
<td>20 N·m (180 lb-in.)</td>
</tr>
</tbody>
</table>

### Water Pump - 3TN78

<table>
<thead>
<tr>
<th>Component</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fan Mounting Cap Screw Torque</td>
<td>11 N·m (96 lb-in.)</td>
</tr>
<tr>
<td>Mounting Cap Screw Torque</td>
<td>26 N·m (226 lb-in.)</td>
</tr>
<tr>
<td>Plate-to-Housing Screw Torque</td>
<td>15 N·m (134 lb-in.)</td>
</tr>
<tr>
<td>Plug-to-Housing Torque</td>
<td>15 N·m (130 lb-in.)</td>
</tr>
</tbody>
</table>
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.)

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.)

Starter Motor - 3TN75, 3TNC78 (3011) (Nippondenso 1.0 kW)
- Minimum Brush Length: 8.5 mm (0.335 in.)

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.)
<table>
<thead>
<tr>
<th>Specifications</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Checks, Tests and Adjustments, continued</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Connecting Rod Bearing Clearance</strong></td>
<td></td>
</tr>
<tr>
<td>Standard Clearance</td>
<td>0.038 - 0.090 mm (0.0015 - 0.0035 in.)</td>
</tr>
<tr>
<td>Wear Limit</td>
<td>0.16 mm (0.0063 in.)</td>
</tr>
<tr>
<td><strong>Crankshaft End Play</strong></td>
<td></td>
</tr>
<tr>
<td>Standard Clearance</td>
<td>0.090 - 0.271 mm (0.004 - 0.011 in.)</td>
</tr>
<tr>
<td>Wear Limit</td>
<td>0.33 mm (0.0129 in.)</td>
</tr>
<tr>
<td><strong>Crankshaft Main Bearing Clearance</strong></td>
<td></td>
</tr>
<tr>
<td>Main Bearing Cap Cap Screw Torque</td>
<td>79 N•m (58 lb-ft)</td>
</tr>
<tr>
<td>Standard Clearance</td>
<td>0.038 - 0.090 mm (0.0015 - 0.0035 in.)</td>
</tr>
<tr>
<td>Wear Limit</td>
<td>0.06 mm (0.0063 in.)</td>
</tr>
<tr>
<td><strong>Valve Lift (Intake and Exhaust)</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8.8 mm (0.350 in.)</td>
</tr>
<tr>
<td><strong>Camshaft End Play</strong></td>
<td></td>
</tr>
<tr>
<td>Standard Clearance</td>
<td>0.05 - 0.20 mm (0.0020 - 0.0079 in.)</td>
</tr>
<tr>
<td>Wear Limit</td>
<td>0.40 mm (0.016 in.)</td>
</tr>
<tr>
<td><strong>Timing Gear Backlash</strong></td>
<td></td>
</tr>
<tr>
<td>All Except Crankshaft Gear-to-Oil Pump Gear</td>
<td>0.04 - 0.12 mm (0.0016 - 0.0047 in.)</td>
</tr>
<tr>
<td>Crankshaft Gear-to-Oil Pump Gear</td>
<td>0.11 - 0.19 mm (0.0043 - 0.0075 in.)</td>
</tr>
<tr>
<td>Wear Limit</td>
<td>0.20 mm (0.0079 in.)</td>
</tr>
<tr>
<td><strong>Fuel Injection Nozzle</strong></td>
<td></td>
</tr>
<tr>
<td>Opening Pressure</td>
<td>19600 ± 480 kPa (2843 ± 70 psi)</td>
</tr>
<tr>
<td>Leakage at 17640 kPa (2558 psi)</td>
<td>Minimum of 5 Seconds</td>
</tr>
<tr>
<td>Chatter and Spray Pattern at 19600 ± 480 kPa (2843 ± 70 psi)</td>
<td></td>
</tr>
<tr>
<td>Slow Hand Lever Movement</td>
<td>Chatter Sound</td>
</tr>
<tr>
<td>Slow Hand Lever Movement</td>
<td>Fine Stream Spray Pattern</td>
</tr>
<tr>
<td>Fast Hand Lever Movement</td>
<td>Fine Atomized Spray Pattern</td>
</tr>
<tr>
<td><strong>Thermostat</strong></td>
<td></td>
</tr>
<tr>
<td>Begin Opening</td>
<td>71° C (160°F)</td>
</tr>
<tr>
<td>Fully Open</td>
<td>85° C (184°F)</td>
</tr>
<tr>
<td>Minimum Lift Height</td>
<td>8 mm (0.310 in.)</td>
</tr>
<tr>
<td><strong>Coolant System Switch Continuity</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>107 - 113° C (225 - 235° F)</td>
</tr>
<tr>
<td><strong>Starter No-Load Amp Draw/RPM</strong></td>
<td></td>
</tr>
<tr>
<td>Hitachi 2.0 kW</td>
<td>110 Amps at 4500 rpm</td>
</tr>
<tr>
<td>Nippondenso 1.0 kW</td>
<td>90 Amps at 3000 rpm</td>
</tr>
<tr>
<td><strong>Fuel Injection Pump Static Timing</strong></td>
<td></td>
</tr>
<tr>
<td>Injection Pump Timing</td>
<td>16° ± 1°BTDC (Before Top Dead Center)</td>
</tr>
<tr>
<td>Engine Crankshaft Position</td>
<td>No. 1 Cylinder on TDC Compression Stroke</td>
</tr>
<tr>
<td><strong>Fan/Alternator Drive Belt Tension</strong></td>
<td></td>
</tr>
<tr>
<td>Applied Force</td>
<td>98 N (22 lb-force)</td>
</tr>
<tr>
<td>Deflection</td>
<td>10 - 15 mm (0.400 - 0.600 in.)</td>
</tr>
<tr>
<td><strong>Operational Tests</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Radiator, Bubble Test</strong></td>
<td></td>
</tr>
<tr>
<td>Maximum Air Pressure Into Cylinder</td>
<td></td>
</tr>
<tr>
<td>3TN75, 3TN78</td>
<td>2448 kPa (355 psi)</td>
</tr>
<tr>
<td>3TN78C78 (3011)</td>
<td>2158 kPa (313 psi)</td>
</tr>
<tr>
<td><strong>Cooling System</strong></td>
<td></td>
</tr>
<tr>
<td>3TN75</td>
<td></td>
</tr>
<tr>
<td>Maximum Pressure</td>
<td>117 kPa (17 psi)</td>
</tr>
<tr>
<td>Minimum Pressure after 15 Seconds</td>
<td>90 kPa (13 psi)</td>
</tr>
</tbody>
</table>
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, 3TN78**: 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.)
### Cylinder Head and Valve Specifications

#### 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 mm (0.315 - 0.316 in.)
    - **Wear Limit**: 8.10 mm (0.319 in.)
  - **Valve Guide Height**: 15 mm (0.591 in.)
- **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.)

#### 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
- **Standard**: 0.64 - 0.82 mm (0.025 - 0.032 in.)

#### Piston and Connecting Rod Cap Screw Torque
- **Standard**: 47 N•m (35 lb-ft)
## 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 - 0.80 mm (0.018 - 0.031 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 Pin End Gap

#### 3TN82, 3TNA82
- **Standard**: 0.25 - 0.40 mm (0.010 - 0.016 in.)
- **Oil Ring**: 0.20 - 0.35 mm (0.008 - 0.014 in.)
- **Wear Limit**: 1.50 mm (0.0591 in.)

#### 3TN84 (3014)
- **Standard**: 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 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.)
- **Standard Size Piston**: 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**: 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)**: 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

### Reboxing

- 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**: 0.5000 - 0.50045 mm (1.969 - 1.970 in.)
- **Wear Limit**: 0.5010 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
- **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.)

### Gear Housing and Flywheel Ends
- **Journal O.D.**
  - **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.)

### Oil Pan-to-Cover Cap Screw Torque
- **Torque**: 22 N•m (155 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.)
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.)

Starter Motor - 3TNA82, 3TN84 (3014) (Nippondenso 1.0 and 1.2 kW)
- Minimum Brush Length: 8.5 mm (0.335 in.)

Starter Motor - 3TN82 (575 SSL) (Nippondenso 1.4 kW)
- Minimum Brush Length: 8.5 mm (0.335 in.)

Alternator - 3TNA82, 3TN84 (870 CUT) (Kokosan 20A)
- Flywheel Assembly-to-Coil Plate Assembly Nut Torque: 27 N•m (20 lb-ft)

Alternator - 3TN82 (30 EX) (Hitachi 25A)
- Attaching Screw Torque: 4 N•m (31 lb-in.)
- 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 - 3TN82 (575 SSL), 3TNA82, 3TN84 (870 CUT, 955 CUT) (Nippondenso 35A)
- Attaching Screw Torque: 4 N•m (31 lb-in.)
- 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 - 3TN82 (575 SSL), 3TN84 (955 CUT, 3014 OEM) (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.)
- 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.)
Specifications

Checks, Tests and Adjustments, continued

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.)

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
  - 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)
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)

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)
- 3TNA82, 3TN84 (870 CUT)
  - Fast Idle: 2750 - 2800 rpm
  - Oil Pressure: 365 ± 69 kPa (53 ± 10 psi)
- 3TN84 (955 CUT)
  - Fast Idle: 3425 ± 25 rpm
  - Oil Pressure: 365 ± 69 kPa (53 ± 10 psi)
- 3TN84 (3014 OEM)
  - Low Idle Speed
    - Industrial: 1300 rpm
    - Generator: 1200 rpm
  - Oil Pressure: 147 kPa (21 psi)

Air Intake System Holding Pressure: 0.34 - 0.69 kPa (5 - 10 psi)
Minimum Fuel Supply Pump Pressure: 29 kPa (4.3 psi)
Fuel System Holding Pressure (Maximum): 103 kPa (15 psi)
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
ROCKER ARM COVER

- Wash packing in a safe solvent and blow dry with air pressure. If packing comes apart or is deteriorated, replace it.
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.

**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.
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 - 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)

**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.
2

- 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 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 Stem O.D. - 3TN82, 3TNA82, 3TN84 (3014):

- 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.)

- 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

Valve Springs:
- Measure spring free length. Replace spring if measurement exceeds wear limit.

**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.)
• Measure spring inclination. Replace spring if measurement exceeds specification.

**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.).

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.)

**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.

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.
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.)

All Except 3TN75
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.)
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.
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.

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.)
Pistons, Rods and Cylinder Block

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

9. Measure piston pin bushing diameter in connecting rod.

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.
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.)
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. - 3TN83, 3TNA83:
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.)

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.
### Pistons, Rods and Cylinder Block

<table>
<thead>
<tr>
<th>Cylinder Bore I.D. - 3TN78, 3TNC78 (3011):</th>
<th>Cylinder Bore I.D. - 3TN84 (3014):</th>
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</thead>
<tbody>
<tr>
<td><strong>0.25 mm (0.010 in.) Oversize Bore</strong></td>
<td><strong>0.50 mm (0.020 in.) Oversize Bore</strong></td>
</tr>
<tr>
<td>Standard .................................. 75.25 - 75.28 mm</td>
<td>(575 SSL Only) Standard .................. 82.50 - 82.53 mm</td>
</tr>
<tr>
<td>........................................... (2.963 - 2.964 in.)</td>
<td>........................................... (3.248 - 3.249 in.)</td>
</tr>
<tr>
<td>Wear Limit ............................. 75.45 mm (2.970 in.)</td>
<td>Wear Limit ............................. 82.70 mm (3.256 in.)</td>
</tr>
<tr>
<td>Clearance ....................... 0.22 mm (0.009 in.)</td>
<td>Clearance ....................... 0.22 mm (0.009 in.)</td>
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<tr>
<th><strong>0.50 mm (0.020 in.) Oversize Bore</strong> (F1145 FM Only)</th>
<th><strong>Cylinder Bore I.D. - 3TN82, 3TNA82:</strong></th>
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<tbody>
<tr>
<td>Standard .................................. 75.50 - 75.53 mm</td>
<td><strong>Standard Size Bore</strong></td>
</tr>
<tr>
<td>........................................... (2.972 - 2.974 in.)</td>
<td>Standard .................................. 84.00 - 84.03 mm</td>
</tr>
<tr>
<td>Wear Limit ............................. 75.70 mm (2.980 in.)</td>
<td>........................................... (3.307 - 3.308 in.)</td>
</tr>
<tr>
<td>Clearance ....................... 0.22 mm (0.009 in.)</td>
<td>Wear Limit ............................. 84.20 mm (3.315 in.)</td>
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<tr>
<th><strong>0.25 mm (0.010 in.) Oversize Bore</strong></th>
<th><strong>0.50 mm (0.020 in.) Oversize Bore (3011 OEM Only)</strong></th>
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<tbody>
<tr>
<td>Standard .................................. 78.25 - 78.28 mm</td>
<td>Standard .................................. 84.50 - 84.53 mm</td>
</tr>
<tr>
<td>........................................... (3.081 - 3.082 in.)</td>
<td>........................................... (3.327 - 3.328 in.)</td>
</tr>
<tr>
<td>Wear Limit ............................. 78.45 mm (3.089 in.)</td>
<td>Wear Limit ............................. 84.70 mm (3.335 in.)</td>
</tr>
<tr>
<td>Clearance ....................... 0.22 mm (0.009 in.)</td>
<td><strong>Clearance ....................... 0.35 mm (0.014 in.)</strong></td>
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<thead>
<tr>
<th><strong>0.50 mm (0.020 in.) Oversize Bore</strong></th>
<th><strong>Cylinder Bore I.D. - 3TN78, 3TNC78 (3011):</strong></th>
</tr>
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<tbody>
<tr>
<td>Standard .................................. 78.00 - 78.03 mm</td>
<td>Standard Size Bore</td>
</tr>
<tr>
<td>........................................... (3.071 - 3.072 in.)</td>
<td>Standard .................................. 84.25 - 84.28 mm</td>
</tr>
<tr>
<td>Wear Limit ............................. 78.20 mm (3.079 in.)</td>
<td>........................................... (3.317 - 3.318 in.)</td>
</tr>
<tr>
<td>Clearance ....................... 0.22 mm (0.009 in.)</td>
<td>Wear Limit ............................. 84.45 mm (3.325 in.)</td>
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<table>
<thead>
<tr>
<th><strong>0.25 mm (0.010 in.) Oversize Bore</strong></th>
<th><strong>0.50 mm (0.020 in.) Oversize Bore (3014 OEM Only)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard .................................. 78.50 - 78.53 mm</td>
<td>Standard .................................. 84.50 - 84.53 mm</td>
</tr>
<tr>
<td>........................................... (3.091 - 3.092 in.)</td>
<td>........................................... (3.327 - 3.328 in.)</td>
</tr>
<tr>
<td>Wear Limit ............................. 78.70 mm (3.099 in.)</td>
<td>Wear Limit ............................. 84.70 mm (3.335 in.)</td>
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</tbody>
</table>

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.
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 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.


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/ | John Deere Form-In-Place     | Seals crankcase extension housing, rear oil seal case and flywheel housing to engine block. |
| NA/    | Gasket                        |                                                      |
| #395   |                               |                                                      |

SERVICE PARTS KITS

The following kits are available through your parts catalog:

- Cylinder Block Gasket Kit
- Undersized Main Bearing Inserts

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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.

4. Remove remaining cap screws and extension housing.

Installation is done in the reverse order of removal.
3. Remove seal case-to-extension cap screws and flywheel plate/housing-to-extension cap screws.

4. Remove remaining cap screws and extension housing.

Installation is done in the reverse order of removal.

---

**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 3TN78, 3TN82 (30 EX), 3TNA82, 3TN84 (870 CUT): All nine seal case cap screws are M8 x 30 long.
CRANKSHAFT, MAIN BEARINGS AND FLYWHEEL

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.)

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.

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.
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:**

- 3TN75, 3TN78, 3TNC78 (3011)  . . . . . . . . . . . . . . 39 N•m (29 lb-ft)
- 3TN82, 3TNA82, 3TN84 (3014)  . . . . . . . . . . . . . . 47 N•m (35 lb-ft)

**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.)
**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.
- 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.

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.)
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.)

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.

1. 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.)

2. 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.
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.)
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)

Mounting Cap Screw (8)  
M10 x 20  
49 N•m (36 lb-ft)
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

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Use</th>
</tr>
</thead>
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<tr>
<td>LOCTITE® PRODUCTS</td>
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<td>U.S./Canadian/LOCTITE No.</td>
<td></td>
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<tr>
<td>TY15130/NA/#395</td>
<td>John Deere Form-In-Place</td>
<td>Seals camshaft plug, timing gear cover and plate to engine block.</td>
</tr>
<tr>
<td>TY9370/</td>
<td>Thread Lock and Sealer</td>
<td>Apply to threads of crankshaft pulley cap screw.</td>
</tr>
<tr>
<td>TY9477/</td>
<td>(Medium Strength)</td>
<td></td>
</tr>
<tr>
<td>#242</td>
<td></td>
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</tbody>
</table>

SERVICE PARTS KITS

The following kits are available through your parts catalog:

- Cylinder Head Gasket Kit
- Cylinder Block Gasket Kit

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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 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.

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.

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.
4. Measure camshaft lobe height.

![Lobe Height Diagram]

**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.

![Journal Diagram]

**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.

![Bushing Diagram]

**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:


**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

- 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.

**Abnormal Contact**

**Normal Contact**

**M82075A**

- 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

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.

   ![Diagram of Idler Gear and Shaft](M82209A)

   Idler Gear (43T)
   Idler Gear Shaft
   Cap Screw (2) M8 x 45

Inspection/Replacement

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

   ![Diagram of Idler Gear Bushing](M82210A)

   Idler Gear
   Bushing
   Idler Gear Shaft

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.
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

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>TY15130/</td>
<td>John Deere Form-In-Place</td>
<td>Seals oil pan/plate to crankcase extension housing.</td>
</tr>
<tr>
<td>NA/ #395</td>
<td>Gasket</td>
<td></td>
</tr>
</tbody>
</table>

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Lubrication System

OIL PAN AND STRAINER

Removal/Installation

- 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.)
Oiling System

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.)
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.

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:

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard</th>
<th>Wear Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.015 - 0.048 mm</td>
<td>0.20 mm</td>
</tr>
<tr>
<td></td>
<td>(0.0006 - 0.0035 in.)</td>
<td>(0.0078 in.)</td>
</tr>
</tbody>
</table>

Rotor Recess - 3TN75, 3TN78, 3TNC78 (3011):

- Standard ............... 0.05 - 0.10 mm
- Wear Limit .............. 0.15 mm

Rotor Recess - 3TN82, 3TNA82, 3TN84 (3014):

- Standard ............... 0.03 - 0.09 mm
- Wear Limit .............. 0.15 mm

- Check rotor recess. If rotors are below face of pump housing more than wear limit, replace rotor assembly.

- Check rotor recess. If clearance is more than wear limit, replace rotor assembly.
Lubrication System

Outer Rotor-to-Pump Body Clearance - 3TN75, 3TN78, 3TNC78 (3011):

- Standard ...................... 0.09 - 0.16 mm
- Wear Limit .................... (0.0035 - 0.0063 in.)

Outer Rotor-to-Pump Body Clearance - 3TN82, 3TNA82, 3TN84 (3014):

- Standard ...................... 0.10 - 0.17 mm
- Wear Limit .................... (0.0039 - 0.0067 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
- Wear Limit .................... (0.0008 - 0.0016 in.)

Inner-to-Outer Rotor Clearance - 3TN82, 3TNA82, 3TN84 (3014):

- Standard ...................... 0.05 - 0.105 mm
- Wear Limit .................... (0.0019 - 0.0041 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.
3. Inspect all parts for wear or damage. Replace complete regulating valve if necessary.

Installation is done in the reverse order of removal.

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

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>TY9375/</td>
<td>John Deere Pipe Sealant</td>
<td>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.</td>
</tr>
<tr>
<td>TY9480/</td>
<td>with TEFLO N®</td>
<td></td>
</tr>
<tr>
<td>#592</td>
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<td></td>
</tr>
</tbody>
</table>

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

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.
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.)
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.
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.

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 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.

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 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.

*Copper Washers Replace.
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 knowledgable source. Such information is available from the Deere & Company Medical Department in Moline, Illinois, U.S.A.

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.
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.


**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.

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.
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 knowledgable 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.

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.
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.)
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.
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.

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Rated Output</th>
<th>Motor Outside Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hitachi</td>
<td>2.0 kW</td>
<td>80 mm (3.150 in.)</td>
</tr>
<tr>
<td>Nippondenso</td>
<td>1.0 kW</td>
<td>68 mm (2.680 in.)</td>
</tr>
<tr>
<td>Nippondenso</td>
<td>1.2 kW</td>
<td>72 mm (2.835 in.)</td>
</tr>
<tr>
<td>Nippondenso</td>
<td>1.4 kW</td>
<td>76 mm (3.000 in.)</td>
</tr>
</tbody>
</table>
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.)

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.
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.

NOTE: Test armature windings using an ohmmeter or test light.


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.

STARTER OVERRUNNING CLUTCH - HITACHI 2.0 kW

Disassembly
1. Disconnect wiring lead.
2. Remove two cap screws.
3. Remove starter motor assembly.
4. Remove three cap screws.
5. Separate clutch housing assembly from starter housing. Remove gasket.

STARTER MOTOR ASSEMBLY - HITACHI 2.0 kW

Disassembly
1. Disconnect wiring lead.
2. Remove two cap screws.
3. Remove starter motor assembly.
4. Remove three cap screws.
5. Separate clutch housing assembly from starter housing. Remove gasket.

To replace bearings:
Bearing 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.
6. Remove ring, retainer, spring, clutch assembly and clutch shaft from clutch housing.

7. 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.
- 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.

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.

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.)

**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.

**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.

   *IMPORTANT: Do not clean armature with solvent. Solvent can damage insulation on windings. Use only mineral spirits and a brush.*

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.

   *NOTE: Test field coil using an ohmmeter or test light.*


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.

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.
2. Separate clutch housing from solenoid/motor assembly.
3. Remove plunger spring and gear, if equipped.

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.

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.

7. Put clutch (housing) assembly into a soft-jawed vise, 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

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.
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 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.


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.

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.

**NOTE:** Test armature windings using an ohmmeter or test light.
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.

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### 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.

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.

**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.

**NOTE:** *Remove bearing only if replacement is necessary.*
VOLTAGE REGULATOR - HITACHI 25A

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.
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.


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.*

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**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 - NIPPON DENSO 35A**

**Disassembly**

1. Remove three attaching screws.

**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 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.
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).

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.

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.

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.

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).

**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.
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.

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.
## Diagnosis

### ENGINE AND FUEL SYSTEM TROUBLESHOOTING CHART

<table>
<thead>
<tr>
<th>PROBLEM OR SYMPTOM</th>
<th>CHECK OR SOLUTION</th>
<th>Engine will not crank.</th>
<th>Engine cranks but will not start or starts hard.</th>
<th>Engine will not stay running, or stalls frequently.</th>
<th>Engine runs rough, misses, noisy, vibrates or low on power. Fuel in oil. Oil level high.</th>
<th>Engine surges, or has uneven or uncontrolled rpm.</th>
<th>Oil in the coolant or coolant in the oil.</th>
<th>Engine has low oil pressure.</th>
<th>Engine operating temperature is incorrect.</th>
<th>Lack of fuel at injection pump.</th>
<th>Exhaust smoke blue or uses too much oil.</th>
<th>Exhaust smoke black or grey or uses too much fuel.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel pump screen, fuel filter, or fuel line restricted. Fuel dirty, contains water or wrong grade.</td>
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<td>Air filter elements dirty or plugged. Replace.</td>
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<td>Fuel shut-off valve turned off, or restricted. Solenoid linkage misadjusted. See adjustment.</td>
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<td>Muffler or exhaust manifold leak.</td>
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<td>Defective manifold heater.</td>
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<td>Injection pump or governor malfunctioning. Injection pump timing incorrect.</td>
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<td>Defective cranking components or connectors.</td>
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<td>Low compression from worn rings, cylinder bore, piston, valves or warped head.</td>
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<td>Valve clearance incorrect.</td>
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<tr>
<td>Burned or warped valves and valve seats. Defective valve spring.</td>
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<td>Starter cranking rpm too slow. Damaged starter. Excessive engine load.</td>
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<tr>
<td>Fuel pump leaking or not operating. See Fuel Supply Pump Pressure Test.</td>
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<tr>
<td>Engine oil viscosity or level incorrect.</td>
<td></td>
<td>✔</td>
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<tr>
<td>Injector pressure incorrect or leaking.</td>
<td></td>
<td>✔</td>
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</tr>
<tr>
<td>Cylinder head gaskets leaking or damaged.</td>
<td></td>
<td>✔</td>
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</tr>
<tr>
<td>Radiator/oil cooler leak.</td>
<td></td>
<td>✔</td>
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</tr>
</tbody>
</table>
## ENGINE SYSTEM DIAGNOSIS

**Conditions:**
- Engine mounted on level surface.
- Key switch off unless indicated otherwise.

### Test Location | Normal | If Not Normal
--- | --- | ---
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. |
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. |
## ENGINE SYSTEM DIAGNOSIS - Continued

<table>
<thead>
<tr>
<th>Test Location</th>
<th>Normal</th>
<th>If Not Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Fuel filter, fuel pump. (Key switch in RUN position.)</td>
<td>Fuel level increases in filter. Fuel pump operating - listen for humming sound. Fuel present in return hose at fuel pump.</td>
<td>See Fuel Pump Circuit Test Points in ELECTRICAL section of Machine TM. Test fuel pump pressure. (See Operational Tests in this section.) Replace fuel filter.</td>
</tr>
<tr>
<td>8. Throttle lever and cable.</td>
<td>Linkage not binding and adjusted correctly.</td>
<td>Repair, replace or adjust cable.</td>
</tr>
<tr>
<td>10. Fuel at injectors. (Key in START position - engine cranking.)</td>
<td>Crack fuel injection lines at injectors. Fuel shutoff solenoid pulled in. Engine must crank.</td>
<td>Check spray pattern and cracking pressure. (See Checks, Tests and Adjustments in this section.) Replace injectors. See Cranking Circuit Test Points in ELECTRICAL section of Machine TM.</td>
</tr>
<tr>
<td>11. Injector ports. (Key in START position.)</td>
<td>Cylinder compression within specification. Pressure difference between cylinders within specification.</td>
<td>Perform cylinder compression test. (See Operational Tests in this section.)</td>
</tr>
<tr>
<td>12. Flywheel and starter.</td>
<td>Minimum cranking rpm within specification.</td>
<td>See Starter Amp Draw Test in ELECTRICAL section of Machine TM.</td>
</tr>
<tr>
<td>13. Injection pump timing inspection. (Key OFF.)</td>
<td>Timing should be correct. Remove pump as the LAST possible solution.</td>
<td>Perform injection pump static timing adjustment. (See Checks, Tests and Adjustments in this section.) Have pump tested by a qualified Service Repair Shop.</td>
</tr>
<tr>
<td>15. Oil pressure sender port.</td>
<td>Oil pressure in specification.</td>
<td>Test engine oil pressure. (See Operational Tests in this section.)</td>
</tr>
<tr>
<td>16. Thermostat. (Engine at operating temperature.)</td>
<td>Clean from corrosion, rust, or debris. Opening temperature within specification.</td>
<td>Replace thermostat. Perform thermostat opening test. (See Checks, Tests and Adjustments in this section.)</td>
</tr>
</tbody>
</table>
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.

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.

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. 2 cylinder at TDC compression stroke.

7. Measure and adjust valve clearance on the valves (arrows) with No. 2 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:**
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:
   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.

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 . . . . . . 0.038 - 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.

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.
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.

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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.)
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.
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 knowledgable 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:


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.
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
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

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 over heated.

1. Suspend thermostat and a thermometer in a container of water.
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 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.
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).

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

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

**JT05719 Hand-Held Digital Tachometer**

*All Except Nippondenso 1.0 kW and 1.2 kW*

**JT05712 Current Gun**

*Nippondenso 1.0 kW and 1.2 kW*
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.

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.
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.

### Specifications:

**Injection Pump Timing Mark**

<table>
<thead>
<tr>
<th>Engine Code</th>
<th>Timing Mark</th>
<th>Before Top Dead Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>3TN75 (F1145 FM, 855/56 CUT)</td>
<td>16° ± 1° BTDC</td>
<td>(Before Top Dead Center)</td>
</tr>
<tr>
<td>3TN78 (25 EX)</td>
<td>16° ± 1° BTDC</td>
<td></td>
</tr>
<tr>
<td>3TNC78 (3011 OEM)</td>
<td>16° ± 1° BTDC</td>
<td></td>
</tr>
<tr>
<td>3TN82 (575 SSL)</td>
<td>17° ± 1° BTDC</td>
<td></td>
</tr>
<tr>
<td>3TNA82 (770 CUT)</td>
<td>16° ± 1° BTDC</td>
<td></td>
</tr>
<tr>
<td>3TN84 (870 CUT, 955 CUT, 3014 OEM)</td>
<td>16° ± 1° BTDC</td>
<td></td>
</tr>
</tbody>
</table>

**Engine Crankshaft Position**

<table>
<thead>
<tr>
<th>No.1 Cylinder</th>
<th>on TDC Compression Stroke</th>
</tr>
</thead>
</table>

**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 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.

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.
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.

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 - 3TNC78 (3011), 3TN84 (3014):
Low Idle Speed
   Industrial . . . . . . . . . . . . . . . . . . . 1300 rpm
   Generator . . . . . . . . . . . . . . . . . . . . 1200 rpm

Oil Pressure . . . . . . . . . . . . . . . . . . . 147 kPa (21 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)
Operational Tests

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 - 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).

**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
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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.)
Maxiumum 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: 0.12 mm (0.047 in.)

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.)

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: 0.59 - 0.77 mm (0.023 - 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 (0.0078 in.)

Piston Ring End Gap
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 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: 0.018 mm (0.0007 in.)
- Standard: 23.00 - 23.009 mm (0.9055 - 0.9059 in.)
- Wear Limit: 23.02 mm (0.906 in.)
Specifications

Piston Pin, continued

Bushing I.D.

<table>
<thead>
<tr>
<th>Clearance</th>
<th>Standard</th>
<th>Wear Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>23.025 - 23.038 mm (0.9065 - 0.9070 in.)</td>
<td>23.10 mm (0.909 in.)</td>
</tr>
</tbody>
</table>

Piston O.D.

<table>
<thead>
<tr>
<th>Distance A</th>
<th>Standard Size Piston</th>
<th>Wear Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 mm (0.905 in.)</td>
<td>77.895 - 77.925 mm (3.067 - 3.068 in.)</td>
<td>77.81 mm (3.063 in.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>0.25 mm (0.010 in.) Oversize Piston</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
</tr>
<tr>
<td>78.15 - 78.18 mm (3.076 - 3.077 in.)</td>
</tr>
</tbody>
</table>

Cylinder Bore I.D.

<table>
<thead>
<tr>
<th>Standard Size Bore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearance</td>
</tr>
<tr>
<td>0.22 mm (0.009 in.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>0.25 mm (0.010 in.) Oversize Bore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
</tr>
<tr>
<td>78.25 - 78.28 mm (3.081 - 3.082 in.)</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Wear Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>42.952 - 42.962 mm (1.6910 - 1.6914 in.)</td>
<td>42.91 mm (1.689 in.)</td>
</tr>
</tbody>
</table>

Main Bearing Journal O.D.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Wear Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>46.952 - 46.962 mm (1.8485 - 1.8489 in.)</td>
<td>46.91 mm (1.847 in.)</td>
</tr>
</tbody>
</table>

Main Bearing I.D.

<table>
<thead>
<tr>
<th>Clearance</th>
<th>Standard</th>
<th>Wear Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.16 mm (0.006 in.)</td>
<td>47.00 - 47.045 mm (1.850 - 1.852 in.)</td>
<td>47.10 mm (1.8541 in.)</td>
</tr>
</tbody>
</table>

Flywheel

<table>
<thead>
<tr>
<th>Maximum Distortion</th>
<th>Mounting Cap Screw Torque</th>
<th>Flywheel Housing Mounting Cap Screw Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.02 mm (0.0008 in.)</td>
<td>83 N•m (61 lb-ft)</td>
<td>49 N•m (36 lb-ft)</td>
</tr>
</tbody>
</table>

4/7/95
# 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
- **Standard**: 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**: 44.92 - 44.95 mm (1.769 - 1.770 in.)
- **Intermediate**: 44.91 - 44.94 mm (1.768 - 1.769 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.**: 11.975 - 11.990 mm (0.471 - 0.472 in.)
- **Wear Limit**: 11.93 mm (0.470 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.**: 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.)

## Idler 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.)
# Specifications

## 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.)

## 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
Specifications

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)

**Operational Tests**

**Radiator, Bubble Test**
- **Maximum Air Pressure Into Cylinder**: 2448 kPa (355 psi)

**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)

**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 ± 48 kPa (50 ± 7 psi)
- **Slow Idle**: 214 kPa (31 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 - 4TN82, 4TN84(T) (4019)

**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 - 15.95 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.)

**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.)

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.)

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.)

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
- 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: 0.075 - 0.110 mm (0.0030 - 0.0043 in.)
  - Standard: 0.077 - 0.107 mm (0.0030 - 0.0042 in.)
  - Wear Limit: 0.25 mm (0.0098 in.)
- Second Compression Ring: 0.45 - 0.080 mm (0.018 - 0.031 in.)
  - Standard: 0.45 - 0.080 mm (0.018 - 0.031 in.)
  - Wear Limit: 0.25 mm (0.0098 in.)
- Oil Ring: 0.025 - 0.060 mm (0.0010 - 0.0024 in.)
  - 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: 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: 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: 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.)
- **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.)

**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 (0.10 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 ...................... 27 N•m (20 lb-ft)
  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

<table>
<thead>
<tr>
<th>Part Description</th>
<th>Standard</th>
<th>Wear Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Journal O.D.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gear Housing and Flywheel Ends</td>
<td>44.92 - 44.95 mm (1.769 - 1.770 in.)</td>
<td>44.80 mm (1.764 in.)</td>
</tr>
<tr>
<td><strong>Intermediate</strong></td>
<td></td>
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</tr>
<tr>
<td>Gear Housing and Flywheel Ends</td>
<td>44.91 - 44.94 mm (1.768 - 1.769 in.)</td>
<td>44.80 mm (1.764 in.)</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Part Description</th>
<th>Standard</th>
<th>Wear Limit</th>
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<tr>
<td><strong>Bushing I.D.</strong></td>
<td></td>
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</tr>
<tr>
<td>Clearance</td>
<td>0.20 mm (0.0079 in.)</td>
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<tr>
<td>Standard</td>
<td>44.990 - 45.055 mm (1.771 - 1.744 in.)</td>
<td>45.10 mm (1.776 in.)</td>
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<tr>
<td>Wear Limit</td>
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</table>

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<thead>
<tr>
<th>Part Description</th>
<th>Standard</th>
<th>Wear Limit</th>
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<tbody>
<tr>
<td><strong>Bore I.D.</strong></td>
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<tr>
<td>Clearance</td>
<td>0.18 mm (0.007 in.)</td>
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<tr>
<td>Standard</td>
<td>45.00 - 45.025 mm (1.772 - 1.773 in.)</td>
<td>45.10 mm (1.776 in.)</td>
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<td>Wear Limit</td>
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#### Cam Followers

<table>
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<tr>
<th>Part Description</th>
<th>Standard</th>
<th>Wear Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stem O.D.</strong></td>
<td>11.975 - 11.990 mm (0.471 - 0.472 in.)</td>
<td>11.93 mm (0.470 in.)</td>
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<tr>
<td>Wear Limit</td>
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</table>

<table>
<thead>
<tr>
<th>Part Description</th>
<th>Standard</th>
<th>Wear Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bore I.D.</strong></td>
<td></td>
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<tr>
<td>Clearance</td>
<td>0.10 mm (0.004 in.)</td>
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<tr>
<td>Standard</td>
<td>12.000 - 12.018 mm (0.472 - 0.473 in.)</td>
<td>12.05 mm (0.474 in.)</td>
</tr>
<tr>
<td>Wear Limit</td>
<td></td>
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</tr>
</tbody>
</table>

#### Timing Gear Cover

<table>
<thead>
<tr>
<th>Part Description</th>
<th>Standard</th>
<th>Wear Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fan Mounting Cap Screw Torque</strong></td>
<td>11 N•m (96 lb-in.)</td>
<td></td>
</tr>
<tr>
<td><strong>Cover Mounting Cap Screw Torque</strong></td>
<td>26 N•m (226 lb-in.)</td>
<td></td>
</tr>
<tr>
<td><strong>Crankcase Extension Housing-to-Cover Cap Screw Torque</strong></td>
<td>22 N•m (195 lb-in.)</td>
<td></td>
</tr>
<tr>
<td><strong>Crankshaft Pulley Cap Screw Torque</strong></td>
<td>115 N•m (85 lb-ft)</td>
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</tbody>
</table>

#### Idler Gear

<table>
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<tr>
<th>Part Description</th>
<th>Standard</th>
<th>Wear Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shaft O.D.</strong></td>
<td>45.950 - 45.975 mm (1.809 - 1.810 in.)</td>
<td>45.93 mm (1.808 in.)</td>
</tr>
<tr>
<td>Wear Limit</td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Part Description</th>
<th>Standard</th>
<th>Wear Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bushing I.D.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clearance</td>
<td>0.15 mm (0.0059 in.)</td>
<td></td>
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<tr>
<td>Standard</td>
<td>46.00 - 46.025 mm (1.811 - 1.812 in.)</td>
<td>46.08 mm (1.814 in.)</td>
</tr>
<tr>
<td>Wear Limit</td>
<td></td>
<td></td>
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</tbody>
</table>

#### Timing Gear Cover Mounting Plate Cap Screw Torque

<table>
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<tr>
<th>Part Description</th>
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<th>Wear Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Oil Pan and Strainer Mounting Cap Screw Torque</strong></td>
<td>26 N•m (226 lb-in.)</td>
<td></td>
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</table>

#### Oil Pump

<table>
<thead>
<tr>
<th>Part Description</th>
<th>Standard</th>
<th>Wear Limit</th>
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<tbody>
<tr>
<td><strong>Mounting Cap Screw Torque</strong></td>
<td>25 N•m (18 lb-ft)</td>
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</tr>
<tr>
<td><strong>Rotor Shaft O.D.-to-Backing Plate I.D. Clearance</strong></td>
<td>0.015 - 0.048 mm (0.0006 - 0.0035 in.)</td>
<td>0.20 mm (0.0078 in.)</td>
</tr>
<tr>
<td>Wear Limit</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Rotor Recess</strong></td>
<td>0.03 - 0.09 mm (0.0011 - 0.0035 in.)</td>
<td>0.15 mm (0.0059 in.)</td>
</tr>
</tbody>
</table>
Specifications

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.)

Starter Motor - 4TN82RJK, 4TN84RJK (Nippondenso 1.0 kW)
- Minimum Brush Length: 8.5 mm (0.335 in.)

Starter Motor - 4TN82ESP, 4TN84(T) (4019) (Nippondenso 1.4 kW)
- Minimum Brush Length: 8.5 mm (0.335 in.)

Alternator - 4TN82RJK, 4TN84RJK (Kokosan 20A)
- Flywheel Assembly-to-Coil Plate Assembly Nut Torque: 27 N•m (20 lb-ft)

Alternator - 4TN82, 4TN84RJK (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 - 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.)
- 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.)
Specifications

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)
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
ROCKER ARM COVER

- Wash packing in a safe solvent and blow dry with air pressure. If packing comes apart or is deteriorated, replace it.
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.

Rocker Arm Shaft O.D.:

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.

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:

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.
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 - 4TN78T:
- **First:** 22 N•m (18 lb-ft)
- **Second:** 43 N•m (32 lb-ft)
- **Final:** 69 N•m (51 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.

- Measure valve recession. (See procedure in this group.)
- Measure valve seat width.

**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.
• 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. - 4TN78T:
- Distance A ............... 30 mm (1.181 in.)
- Distance B ............... 50 mm (1.969 in.)

**Intake and Exhaust Valves**

**Intake Valve**
- Standard .................. 6.94 - 6.96 mm
- Wear Limit ................ 6.90 mm (0.2717 in.)

**Exhaust Valve**
- Standard .................. 7.96 - 7.98 mm
- 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

Valve Springs:

- **Measure spring free length. Replace spring if measurement exceeds wear limit.**

**Spring Free Length:**

- **Standard**: 40 mm (1.575 in.)
- **Wear Limit**: 39.50 mm (1.550 in.)
• Measure spring inclination. Replace spring if measurement exceeds specification.

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.)
Exhaust Manifold

Nut (4)
M8
26 N•m (226 lb-in.)

Cap Screw (2)
M8 x 60
26 N•m (226 lb-in.)

Cap Screw
Long
26 N•m (226 lb-in.)

Stud (4)

Exhaust Manifold

Gasket

4TN82RJK, 4TN84RJK

Exhaust Manifold

Gasket

4TN82ESP/RJE, 4TN84(4019D)

Cap Screw
M8 x 80
26 N•m (226 lb-in.)

Nut (2)
M10
26 N•m (226 lb-in.)

Cap Screw (4)
M8 x 100
26 N•m (226 lb-in.)

Exhaust Manifold

Gasket

Cap Screw (3)
M8 x 65
26 N•m (226 lb-in.)

4TN78T, 4TN84T(4019T)

Intake Manifold

Gasket

Cap Screw (5)
M8 x 35
26 N•m (226 lb-in.)

4TN78T, 4TN82, 4TN84

4TN84(T)(4019)

Cap Screw (5)
M8 x 35
26 N•m (226 lb-in.)

Intake Manifold

Gasket

4TN84(4019)
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.


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.)

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:**

- **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 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 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:

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.
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.

4. Measure connecting rod bearing diameter.

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.

Connecting Rod Cap Screw Torque Specifications:
- 4TN78T — 39 N•m (29 lb-ft)
- 4TN82, 4TN84(T) (4019) — 47 N•m (35 lb-ft)

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.)

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.)
Pistons, Rods and Cylinder Block

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 (0.018 - 0.031 in.)
- Wear Limit: 0.25 mm (0.0098 in.)

Oil Ring

- Standard: 0.025 - 0.060 mm (0.010 - 0.024 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.)

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

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.

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.

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
- **Wear Limit**: 77.81 mm (3.063 in.)

#### 0.25 mm (0.010 in.) Oversize Piston

- **Standard**: 78.15 - 78.18 mm
- **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
- **Wear Limit**: 81.80 mm (3.220 in.)

#### 0.25 mm (0.010 in.) Oversize Piston

- **Standard**: 82.15 - 82.18 mm
- **Wear Limit**: 82.05 mm (3.230 in.)

#### 0.50 mm (0.020 in.) Oversize Piston

- **Standard**: 82.40 - 82.42 mm
- **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
- **Wear Limit**: 83.80 mm (3.299 in.)

#### 0.25 mm (0.010 in.) Oversize Piston

- **Standard**: 84.15 - 84.18 mm
- **Wear Limit**: 84.05 mm (3.309 in.)
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

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.

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 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 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.)

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.


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

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<td>TY15130/</td>
<td>John Deere Form-In-Place</td>
<td>Seals crankcase extension housing, rear oil seal case and flywheel housing to engine block.</td>
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<tr>
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<td>Gasket</td>
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### SERVICE PARTS KITS

The following kits are available through your parts catalog:

- Cylinder Block Gasket Kit
- Undersized Main Bearing Inserts

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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. 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.)
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.

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.)
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.)
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.)

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.
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.)
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.
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Crankshaft, Main Bearings and Flywheel

**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: \( 39 \text{ N} \cdot \text{m (29 lb-ft)} \)
- 4TN82, 4TN84(T)(4019): \( 47 \text{ N} \cdot \text{m (35 lb-ft)} \)

**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.
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.

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: \[ 79 \text{ N\cdot m (58 lb-ft) } \]
- 4TN82, 4TN84(T)(4019): \[ 98 \text{ N\cdot m (72 lb-ft) } \]

6. Measure main bearing diameter.

**Main Bearing I.D. - 4TN78T:**
- Standard \[ 47.00 - 47.045 \text{ mm (1.850 - 1.852 in.) } \]
- Wear Limit \[ 47.10 \text{ mm (1.8541 in.) } \]
- Clearance \[ 0.16 \text{ mm (0.006 in.) } \]

**Main Bearing I.D. - 4TN82, 4TN84(T)(4019):**
- Standard \[ 50.00 - 50.045 \text{ mm (1.969 - 1.970 in.) } \]
- Wear Limit \[ 50.10 \text{ mm (1.972 in.) } \]
- Clearance \[ 0.16 \text{ mm (0.006 in.) } \]
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.
FLYWHEEL HOUSING - 4TN78T, 4TN82RJE, 4TN82ESP, 4TN84(T) (4019 DF/TF005 and 006)

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

NOTE: 4TN84(T)(4019 DF/TF001) engines are equipped with a flywheel plate in place of a housing. (See procedure in this group.)

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

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<td>TY15130/NA/#395</td>
<td>John Deere Form-In-Place Gasket</td>
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<tr>
<td>TY9370/TY9477/#242</td>
<td>Thread Lock and Sealer (Medium Strength)</td>
<td>Apply to threads of crankshaft pulley cap screw.</td>
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SERVICE PARTS KITS

The following kits are available through your parts catalog:

- Cylinder Head Gasket Kit
- Cylinder Block Gasket Kit

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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 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/replacement 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.

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.

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.

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.)
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:

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.
Camshaft and Timing Gear Train

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.

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.

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.

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. 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.)
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.)

3. Rotate crankshaft and align timing marks.

4. Remove two cap screws, shaft and gear.

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.
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** .............. 46.08 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.
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.
### OTHER MATERIALS

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>TY15130/</td>
<td>John Deere Form-In-Place</td>
<td>Seals oil pan to crankcase extension housing.</td>
</tr>
<tr>
<td>NA/</td>
<td>Gasket</td>
<td></td>
</tr>
<tr>
<td>#395</td>
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<td></td>
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<tr>
<td>TY9375/</td>
<td>John Deere Pipe Sealant</td>
<td>4TN78T and 4TN84T (4019TF001 and 005): Apply to threads of plug in oil mounting block.</td>
</tr>
<tr>
<td>TY9480/</td>
<td>with TEFLON®</td>
<td></td>
</tr>
<tr>
<td>filter</td>
<td>#592</td>
<td></td>
</tr>
</tbody>
</table>
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.)
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

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)

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
seved seperately. 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.)
**OIL PRESSURE REGULATING VALVE - 4TN78T AND 4TN84T (4019TF001 and 005)**

**Removal/Installation**
- Inspect all parts for wear or damage. Replace as necessary.

![Diagram of OIL PRESSURE REGULATING VALVE - 4TN78T AND 4TN84T](Image)

**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.
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

<table>
<thead>
<tr>
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<td>TY9375/</td>
<td>John Deere Pipe Sealant</td>
<td>4TN78T, 4TN82RJE, 4TN82ESP and 4TN84(T)(4019): Apply to threads of plug and nipple in thermostat housing and pipe plug in water pump housing.</td>
</tr>
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<td>TY9480/</td>
<td>with TEFiON®</td>
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<td>#592</td>
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<td></td>
</tr>
</tbody>
</table>

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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 - 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.)

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.
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.

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.
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.)
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.
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.

**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 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.)
FUEL SYSTEM

FUEL FILTER ASSEMBLY - IF EQUIPPED

NOTE: Fuel filter assemblies will be slightly different for each engine model depending on engine application. 4TN84(T) (4019 OEM) shown.

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

* Copper Washers Replace.
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 knowledgable source. Such information is available from the Deere & Company Medical Department in Moline, Illinois, U.S.A.

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.

Fuel Injection Line Connectors (4)
Fuel Injection Lines
Fuel Supply Pump-to-Filter Hose
Fuel Filter-to-Injection Pump Hose
Fuel Shutoff Solenoid Link
Line Clamp(s)
Delivery Valve (4)
Nozzle Leak-Off Hose
Injection Pump Bleed-Off-to-Filter Hose
External Lube Line
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.


**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.

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.
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 knowledgable 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.

7. Test injection nozzles. (See Checks, Tests and Adjustments in this section.)

Installation is done in reverse order of removal.
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.)
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.
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.

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Rated Output</th>
<th>Motor Outside Diameter</th>
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</thead>
<tbody>
<tr>
<td>Hitachi</td>
<td>0.8 kW</td>
<td>N/A</td>
</tr>
<tr>
<td>Hitachi</td>
<td>2.0 kW</td>
<td>80 mm (3.150 in.)</td>
</tr>
<tr>
<td>Nippondenso</td>
<td>1.0 kW</td>
<td>68 mm (2.680 in.)</td>
</tr>
<tr>
<td>Nippondenso</td>
<td>1.4 kW</td>
<td>76 mm (3.000 in.)</td>
</tr>
</tbody>
</table>
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.)**

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.

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.
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.

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.)
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.

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.


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.

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**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.)

**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.
IMPORTANT: Do not clean armature with solvent. Solvent can damage insulation on windings. Use only mineral spirits and a brush.


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:
Bearing 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.
4. Remove three cap screws.
5. Separate clutch housing assembly from starter housing. Remove gasket.
6. Remove ring, retainer, spring, clutch assembly and clutch shaft from clutch housing.
7. 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.
- 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.
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.

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.


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.

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.

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.

CAUTION
Shaft could be propelled from clutch unit with considerable force if spring is not allowed to extend fully while in vise.

Starter with 44 or 44.5 (1.732 or 1.752 in.) Drive Gear Shown

Starter with 44 or 44.5 mm (1.732 or 1.752 in.) drive gear only.
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.

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 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.


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:
Bears 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.
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 - 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.

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: Bearing and flywheel are press fit on shaft.

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.

NOTE: Remove bearing only if replacement is necessary.
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 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.


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).
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 \textbf{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 \textit{VOLTAGE REGULATOR REPLACEMENT} in this group.)

\textbf{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.

\textbf{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 \textbf{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.

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 - NIPPO DENSO 35A

Replacement
1. Remove three attaching screws.

Attaching Screw (3)
M5
4 N·m (31 lb-in.)

2. Remove end frame-to-rectifier nut.

3. Remove nuts and insulators.

End Frame-to-Rectifier Nut
M5
4 N·m (31 lb-in.)

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.

IMPORTANT: Do not pry against stator wires.

2. Use a screwdriver to separate rotor assembly from stator assembly.

Installation is done in the reverse order of removal.

- If additional solder is needed, use ONLY 60-40 rosin-core solder.

**ALTERNATOR - NIPPO DENSO 35A**

**Disassembly**

1. Remove three attaching screws.

2. Use a screwdriver to separate rotor assembly from stator assembly.


4. Put front frame on open jaws of vise. 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.
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).

**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 \textbf{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 \textbf{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.

\textbf{NOTE: If additional solder is needed, use ONLY 60-40 rosin-core solder.}

\textbf{Stator:}

- Inspect stator for defective insulation, discoloration or a burned odor. If any of these defects are found, replace stator.

\textbf{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.

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.

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.).

**Brushes:**

- 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).

**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.
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.

**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.
## Diagnosis

### ENGINE AND FUEL SYSTEM TROUBLESHOOTING CHART

<table>
<thead>
<tr>
<th>PROBLEM OR SYMPTOM</th>
<th>CHECK OR SOLUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine will not crank.</td>
<td>●</td>
</tr>
<tr>
<td>Engine cranks but will not start or starts hard.</td>
<td>●</td>
</tr>
<tr>
<td>Engine will not stay running, or stalls frequently.</td>
<td>●</td>
</tr>
<tr>
<td>Engine runs rough, misses, noisy, vibrates or low on power. Fuel in oil. Oil level high.</td>
<td>●</td>
</tr>
<tr>
<td>Engine surges, or has uneven or uncontrolled rpm.</td>
<td>●</td>
</tr>
<tr>
<td>Oil in the coolant or coolant in the oil.</td>
<td>●</td>
</tr>
<tr>
<td>Engine has low oil pressure.</td>
<td>●</td>
</tr>
<tr>
<td>Engine operating temperature is incorrect.</td>
<td>●</td>
</tr>
<tr>
<td>Lack of fuel at injection pump.</td>
<td>●</td>
</tr>
<tr>
<td>Exhaust smoke blue or uses too much oil.</td>
<td>●</td>
</tr>
<tr>
<td>Exhaust smoke black or grey or uses too much fuel.</td>
<td>●</td>
</tr>
</tbody>
</table>

- **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**
## 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 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. | 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. |
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. |
### ENGINE SYSTEM DIAGNOSIS - Continued

<table>
<thead>
<tr>
<th>Test Location</th>
<th>Normal</th>
<th>If Not Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>7.</strong> Fuel filter, fuel pump. (Key switch in RUN position.)</td>
<td>Fuel level increases in filter. Fuel pump operating - listen for humming sound. Fuel present in return hose at fuel pump.</td>
<td>See Fuel Pump Circuit Test Points in ELECTRICAL section of Machine TM. Test fuel pump pressure. (See Operational Tests in this section.) Replace fuel filter.</td>
</tr>
<tr>
<td><strong>8.</strong> Throttle lever and cable.</td>
<td>Linkage not binding and adjusted correctly.</td>
<td>Repair, replace or adjust cable.</td>
</tr>
<tr>
<td><strong>10.</strong> Fuel at injectors. (Key in START position - engine cranking.)</td>
<td>Crack fuel injection lines at injectors. Fuel shutoff solenoid pulled in.</td>
<td>Check spray pattern and cracking pressure. (See Checks, Tests and Adjustments in this section.) Replace injectors. See Cranking Circuit Test Points in ELECTRICAL section of Machine TM.</td>
</tr>
<tr>
<td><strong>11.</strong> Injector ports. (Key in START position.)</td>
<td>Cylinder compression within specification. Pressure difference between cylinders within specification.</td>
<td>Perform cylinder compression test. (See Operational Tests in this section.)</td>
</tr>
<tr>
<td><strong>12.</strong> Flywheel and starter.</td>
<td>Minimum cranking rpm within specification.</td>
<td>See Starter Amp Draw Test in ELECTRICAL section of Machine TM.</td>
</tr>
<tr>
<td><strong>13.</strong> Injection pump timing inspection. (Key OFF.)</td>
<td>Timing should be correct. Remove pump as the LAST possible solution.</td>
<td>Perform injection pump static timing adjustment. (See Checks, Tests and Adjustments in this section.) Have pump tested by a qualified Service Repair Shop.</td>
</tr>
<tr>
<td><strong>14.</strong> Injection pump idle settings. (Engine running).</td>
<td>Engine runs smooth under load. Engine rpm to specification.</td>
<td>See Slow Idle and Fast Idle Adjustments in ENGINE section of Machine TM.</td>
</tr>
<tr>
<td><strong>15.</strong> Oil pressure sender port.</td>
<td>Oil pressure in specification.</td>
<td>Test engine oil pressure. (See Operational Tests in this section.)</td>
</tr>
<tr>
<td><strong>16.</strong> Thermostat. (Engine at operating temperature.)</td>
<td>Clean from corrosion, rust, or debris. Opening temperature within specification.</td>
<td>Replace thermostat. Perform thermostat opening test. (See Checks, Tests and Adjustments in this section.)</td>
</tr>
<tr>
<td><strong>17.</strong> Muffler.</td>
<td>Not restricted.</td>
<td>Replace muffler.</td>
</tr>
</tbody>
</table>
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 0.20 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.
9. Remove PLASTIGAGE.

Specifications:

<table>
<thead>
<tr>
<th>Standard Clearance</th>
<th>Wear Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.038 - 0.090 mm</td>
<td>0.16 mm</td>
</tr>
<tr>
<td>(0.0015 - 0.0035 in.)</td>
<td>(0.0063 in.)</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Standard Clearance</th>
<th>Wear Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.090 - 0.271 mm</td>
<td>0.33 mm</td>
</tr>
<tr>
<td>(0.004 - 0.011 in.)</td>
<td>(0.0129 in.)</td>
</tr>
</tbody>
</table>

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.
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:
   - 4TN78T ..................... 79 N•m (58 lb-ft)
   - 4TN82, 4TN84(T)(4019) ... 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.

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### 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.
Checks, Tests and Adjustments

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 - 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.
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:


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.
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
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

**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.
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 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.
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).

Results:
- If continuity does not occur within temperature listed, replace sender.
Checks, Tests and Adjustments

STATER 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
- 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.
Checks, Tests and Adjustments

JT05712 Current Gun

JT05719 Hand-Held Digital Tachometer

Jumper Wire

All Except Nippondenso 1.0 kW

JT05712 Current Gun

JT05719 Hand-Held Digital Tachometer

Jumper Wire

Nippondenso 1.0 kW
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.

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 Plate** ............ 2.5° 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.

4TN84(T)(4019): 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.

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° ± 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
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 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.

ENGINE OIL COOLER LEAKAGE TEST - 4TN78T AND 4TN84T (4019TF001 and 005)

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.
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)
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.

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:
Valve Opening Pressure
4TN78T, 4TN82RJK, 4TN84RJK, 4TN84(T)(4019) .............. 88 kPa (12.8 psi)
4TN82RJE, 4TN82ESP ......... 55 kPa (8 psi)
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.

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)

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.

FUEL SUPPLY PUMP PRESSURE TEST - IF EQUIPPED

**NOTE:** 4TN87T, 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 Couple
- JT03115 Gauge w/Male Quick Coupler (0 - 150 psi)

Results:

- Find leaks and repair or replace parts as necessary.
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).

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

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## 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.**: 11.50 mm (0.453 in.)
## Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Unit 1</th>
<th>Unit 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Clearance</td>
<td></td>
<td>0.20 mm (0.008 in.)</td>
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<tr>
<td>Standard</td>
<td>9.00 - 9.02 mm (0.354 - 0.355 in.)</td>
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<td><strong>Valve Springs</strong></td>
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<tr>
<td>Maximum Spring Tension</td>
<td>41.50 mm (1.634 in.) at 12.6 N (5.7 lb force)</td>
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<td>Spring Free Length</td>
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<tr>
<td>Maximum Spring Inclination</td>
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<td><strong>Exhaust Manifold</strong></td>
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<tr>
<td>Mounting Cap Screw Torque</td>
<td>26 N•m (226 lb-in.)</td>
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<tr>
<td><strong>Intake Manifold</strong></td>
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<tr>
<td>Mounting Cap Screw Torque</td>
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<td><strong>Valve Seat Angles</strong></td>
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<td>Lower Seat Surface</td>
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<tr>
<td>Upper Seat Surface</td>
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<tr>
<td>Valve Seat Surface</td>
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<td>Exhaust Valve</td>
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<td>Intake Valve</td>
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<td><strong>Piston-to-Cylinder Head Clearance</strong></td>
<td>0.71 - 0.89 mm (0.028 - 0.035 in.)</td>
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<td><strong>Connecting Rod Bearing I.D.</strong></td>
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<tr>
<td>Clearance</td>
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<tr>
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<tr>
<td>Wear Limit</td>
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<td><strong>Piston Ring Groove Clearance</strong></td>
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<tr>
<td>First Compression Ring</td>
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<td>Second Compression Ring</td>
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<td><strong>Piston Ring End Gap</strong></td>
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<td>Compression Rings</td>
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<td><strong>Piston Pin</strong></td>
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<tr>
<td>Clearance</td>
<td>0.061 mm (0.0024 in.)</td>
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</tbody>
</table>
### Specifications

**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.)

**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\(\cdot\)m (145 lb-ft)

### Flywheel Housing Mounting Cap Screw Torque
- 49 N\(\cdot\)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\(\cdot\)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 (0.5579 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\(\cdot\)m (226 lb-in.)
- **Fan Mounting Cap Screw Torque**: 65 N\(\cdot\)m (47 lb-ft)
- **Fan Spacer-to-Water Pump Socket-Head Cap Screw Torque**: 11 N\(\cdot\)m (96 lb-in.)
- **Crankshaft Pulley Cap Screw Torque**: 115 N\(\cdot\)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.)
Specifications

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

<table>
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<tr>
<th>Component</th>
<th>Specification</th>
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<tr>
<td>Separator Plate Nozzle Contact Surface Maximum Wear</td>
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<tr>
<td>Starter Minimum Brush Length</td>
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<td>Rotor Assembly</td>
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<tr>
<td>Pulley Nut Torque</td>
<td>49 N•m (36 lb-ft)</td>
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<tr>
<td>Retainer-to-Front Frame Screw Torque</td>
<td>2 N•m (16 lb-in.)</td>
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<tr>
<td>Rotor-to-Stator Assembly Attaching Screw Torque</td>
<td>4 N•m (31 lb-in.)</td>
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<td>End Frame-to-Rectifier Nut Torque</td>
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<td>Stator-to-Rectifier Lead Wire Distance</td>
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<td>Camshaft End Play</td>
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<td>Standard Clearance</td>
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<td>Wear Limit</td>
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<td>107 - 133° C (225 - 235° F)</td>
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<td>Thermostat</td>
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<td>Minimum Lift Height</td>
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<td>Crankshaft End Play</td>
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<td>Crankshaft Main Bearing Clearance</td>
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<td>Main Bearing Cap Cap Screw Torque</td>
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<td>Applied Force</td>
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<td>Deflection</td>
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<td>Fuel Injection Nozzle</td>
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<td>Chatter and Spray Pattern at 20100 ± 490 kPa (2915 ± 71 psi) Pressure</td>
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<td>Slow Hand Lever Movement</td>
<td>Chatter Sound</td>
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<td>Slow Hand Lever Movement</td>
<td>Fine Stream Spray Pattern</td>
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<td>Fast Hand Lever Movement</td>
<td>Fine Atomized Spray Pattern</td>
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<td>Leakage</td>
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<td>Opening Pressure</td>
<td>19615 kPa (2850 psi)</td>
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<td>Injection Pump Static Timing</td>
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<tr>
<td>Distance on Outer Surface of Flywheel per 1° of Rotation</td>
<td>3.5 mm (0.130 in.)</td>
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<tr>
<td>Engine Crankshaft Position</td>
<td>No. 1 Cylinder on TDC Compression Stroke</td>
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<tr>
<td>Injection Pump Timing</td>
<td>16° BTDC (Before Top Dead Center)</td>
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<tr>
<td>Timing Lines on Pump Mounting Plate</td>
<td>2° Apart</td>
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Specifications

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

<table>
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<th>Use</th>
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<td>John Deere Pipe Sealant</td>
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<td>TY9480/</td>
<td>with TEFLON®</td>
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SERVICE PARTS KITS

The following kits are available through your parts catalog:

- Cylinder Head Gasket Kit
ROCKER ARM COVER

- Oil Fill Cap
- O-Ring
- Cap Screw (10) M8 x 25, 26 N•m (226 lb-in.)
- Crankcase Breather Tube
- Gasket

M82020A
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.)
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 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.
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.

**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.

**Torque Specifications:**

First ...................... 49 N•m (36 lb-ft)
Second ...................... 98 N•m (72 lb-ft)
Final ......................... 157 N•m (116 lb-ft)
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.

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.

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.
- 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.
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.

Valve Springs:

- Measure spring free length. Replace spring if measurement exceeds wear limit.

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

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

**Spring Free Length:**

- Standard ................. 43 mm (1.693 in.)
- Wear Limit ............... 42.50 mm (1.673 in.)
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

EXHAUST MANIFOLD WITH TURBOCHARGER

M82037A
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.
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.


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.

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

4. 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.)

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.

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.)
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.

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.

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

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.

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.
Piston Ring End Gap:

Compression Rings:

Standard .................. 0.25 - 0.40 mm

Wear Limit ............... 1.50 mm (0.0591 in.)

Oil Ring:

Standard .................. 0.30 - 0.50 mm

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

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 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.

**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 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.*

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.

**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.)
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.

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

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOCTITE® PRODUCTS U.S./Canadian/LOCTITE No.</td>
<td>TY15130/NA/#395</td>
<td>John Deere Form-In-Place Gasket</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seals crankcase extension housing and rear oil seal case to engine block.</td>
</tr>
</tbody>
</table>

SERVICE PARTS KITS

The following kits are available through your parts catalog:

- Cylinder Block Gasket Kit
- Undersized Main Bearing Inserts
- Flywheel Mounting Cap Screws

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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.*
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.

2. Remove rear oil seal. (See procedure in this group.)

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.
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.
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**

**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.)
**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.

---

**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.:**

- **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.)

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.

- 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.

Pilot Bearing (4TN100RJF only)

Flywheel Mounting Cap Screw (6)
Replace.
Apply clean engine oil on threads.
196 N•m (145 lb-ft)
FLYWHEEL HOUSING

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

2. Remove starter.

- Housing-to-Block Cap Screw (8)
  M10 X 25
  49 N•m (36 lb-ft)

- Housing-to-Extension Cap Screw (4)
  M10 X 30
  49 N•m (36 lb-ft)
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

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<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Use</th>
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<td>LOCTITE® PRODUCTS</td>
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<tr>
<td>U.S./</td>
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<td>LOCTITE No.</td>
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<tr>
<td>TY15130/</td>
<td>John Deere Form-In-Place Gasket</td>
<td>Seals camshaft plug, timing gear cover and housing to engine block.</td>
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<td>NA/</td>
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<td>#395</td>
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<tr>
<td>TY9370/</td>
<td>Thread Lock and Sealer (Medium Strength)</td>
<td>Apply to threads of crankshaft pulley cap screw.</td>
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<td>TY9477/</td>
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<td>#242</td>
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SERVICE PARTS KITS

The following kits are available through your parts catalog:

• Cylinder Head Gasket Kit
• Cylinder Block Gasket Kit

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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.

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.

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.

**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.
Camshaft and Timing Gear Train

Lobe Height:

<table>
<thead>
<tr>
<th>Standard</th>
<th>48.435 - 48.565 mm (1.9069 - 1.9120 in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wear Limit</td>
<td>48.20 mm (1.897 in.)</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Standard</th>
<th>56.91 - 56.94 mm (2.2406 - 2.2417 in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wear Limit</td>
<td>56.80 mm (2.2362 in.)</td>
</tr>
</tbody>
</table>

Intermediate:

<table>
<thead>
<tr>
<th>Standard</th>
<th>56.89 - 56.92 mm (2.2398 - 2.2409 in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wear Limit</td>
<td>56.80 mm (2.2362 in.)</td>
</tr>
</tbody>
</table>

6. Measure camshaft bushing diameter at gear housing end.

Camshaft Bushing I.D.:

<table>
<thead>
<tr>
<th>Standard</th>
<th>56.98 - 57.05 mm (2.2433 - 2.2461 in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wear Limit</td>
<td>57.10 mm (2.2480 in.)</td>
</tr>
</tbody>
</table>

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.

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.
Camshaft and Timing Gear Train

• 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.

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.)

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.
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.)

3. Rotate crankshaft and align timing marks.
4. Remove two cap screws, shaft and gear.

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.
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** ................. 45.95 - 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.)

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**

**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.
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

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<td>John Deere Form-In-Place</td>
<td>Seals oil pan to crankcase</td>
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<tr>
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<td>Gasket</td>
<td>extension housing.</td>
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<td>#395</td>
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<tr>
<td>TY9375/</td>
<td>John Deere Pipe Sealant with TEFLOW®</td>
<td>Apply to threads of plug in oil cooler.</td>
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<tr>
<td>TY9480/</td>
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</tbody>
</table>

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®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.)
**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.)

**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.

- 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.
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 Length .............. 63 mm (2.480 in.)
Compressed Length ...... 37 mm (1.450 in.)
.............................................. @ 3.75N (0.840 lb force)
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.

- 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.

- Replace nozzle. 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)
## OTHER MATERIALS

<table>
<thead>
<tr>
<th>Number</th>
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<tr>
<td>LOCTITE® PRODUCTS</td>
<td>U.S./Canadian/LOCTITE No.</td>
<td></td>
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<tr>
<td>TY9375/</td>
<td>John Deere Pipe Sealant with TEFLON®</td>
<td>Apply to threads of coolant temperature sender, heater hose fitting and adapter fitting.</td>
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<tr>
<td>TY9480/</td>
<td></td>
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<td>#592</td>
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<tr>
<td>TY9370/</td>
<td>Thread Lock and Sealer (Medium Strength)</td>
<td>Apply to threads of fan-to-spacer cap screws.</td>
</tr>
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<td></td>
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<tr>
<td>#242</td>
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</table>
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.

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.)
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.

Heater Hose Fitting
Apply Pipe Sealant with TEFLOK to threads.

Adapter Fitting
Apply Pipe Sealant with TEFLOK to threads.

23 N•m (199 lb-in.)

15 N•m (134 lb-in.)

10 N•m (91 lb-in.)
6. Apply extreme heat to pulley flange. Remove flange using a knife-edge puller set and two small nuts.

7. 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.

8. Remove impeller from bearing shaft using a knife-edge puller, a 3/8 in. cap screw and a press.

9. Remove shaft seal, ceramic seal and seal cup.

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

**Assembly**

**NOTE:** Replace shaft seal, ceramic seal, seal cup, gaskets and copper washer.

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 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.

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 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.).

6. Install new gasket, plate, six screws, two cap screws and nuts.

7. Install new gasket, adapter and screws.

8. Install coolant temperature sender. (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 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

- Supply Pump-to-Filter Hose
- Hose Clamp
- Fitting
- Copper Washer
- Fitting
- O-Ring
- Spring (2)
- Valve (2)
- Lock Washer (3)
- Mounting Nut (3)  
  11 N•m (96 lb-in.)

- Cover
- Hand Primer Assembly
- Copper Washer
- Gasket
- Retaining Wire
- Roller
- Shaft
- Washer (2)
- Slide Pivot (2)

- Pump Body
- Plunger
- Spring
- Plug
- Copper Washer
- Holder
- Seal
- Slide Pivot (2)
- Washer (2)
- Retaining Wire
FUEL FILTER ASSEMBLY

IMPORTANT: Replace all copper washers. Damaged or used washers may leak.
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 knowledgable source. Such information is available from the Deere & Company Medical Department in Moline, Illinois, U.S.A.

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.
Fuel System

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.

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.)
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 knowledgable 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.

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.)

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.
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.

**NOTE:** To clean nozzles properly, JDF13 Nozzle Cleaning Kit is recommended. The Cleaning Kit is available through the John Deere SERVICEGARD™ Catalog.
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.

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.


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.
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.
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.
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.
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.

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

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.

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.


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 (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.

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.

• 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.)

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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 six diodes are defective.

- To replace rectifier, melt solder from connection.

**NOTE:** If additional solder is needed, use ONLY 60-40 rosin-core solder.
## ENGINE AND FUEL SYSTEM TROUBLESHOOTING CHART

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<td>Engine will not stay running, or stalls frequently.</td>
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<td>Engine surges, or has uneven or uncontrolled rpm.</td>
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<td>Oil in the coolant or coolant in the oil.</td>
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<td>Engine has low oil pressure.</td>
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<tr>
<td>Engine operating temperature is incorrect.</td>
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<tr>
<td>Lack of fuel at injection pump.</td>
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<td>Exhaust smoke blue or uses too much oil.</td>
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<tr>
<td>Exhaust smoke black or grey or uses too much fuel.</td>
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</tbody>
</table>
# ENGINE SYSTEM DIAGNOSIS

**Conditions:**
- Engine mounted on level surface.
- Key switch off unless indicated otherwise.

<table>
<thead>
<tr>
<th>Test Location</th>
<th>Normal</th>
<th>If Not Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Coolant tank and radiator.</td>
<td>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.</td>
<td>Add proper coolant mix. Add proper coolant mix.</td>
</tr>
<tr>
<td>- Cooling System Check</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Fuel System Check</td>
<td></td>
<td>Replace fuel tank check valve.</td>
</tr>
<tr>
<td>- Air Intake System Check</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Fuel shutoff solenoid. (Key in RUN position.)</td>
<td>Fuel shutoff solenoid must pull in and stay in. Solenoid must bottom out. Shutoff shaft must still move slightly.</td>
<td>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.</td>
</tr>
<tr>
<td>6. Air heater indicator light. (Key in RUN position.)</td>
<td>Indicator light should come on up to 15 seconds depending on air temperature.</td>
<td>See Air Heater Circuit Test Points in ELECTRICAL section of Machine TM.</td>
</tr>
</tbody>
</table>
**ENGINE SYSTEM DIAGNOSIS - Continued**

<table>
<thead>
<tr>
<th>Test Location</th>
<th>Normal</th>
<th>If Not Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Throttle lever and cable.</td>
<td>Linkage not binding and adjusted correctly.</td>
<td>Repair, replace or adjust cable.</td>
</tr>
<tr>
<td>9. Intake and exhaust valves.</td>
<td>Cold engine valve clearance of 0.30 mm (0.012 in.). Valves not sticking.</td>
<td>Check and adjust. (See Checks, Tests and Adjustments in this section.) Check valve guides and stems.</td>
</tr>
<tr>
<td>11. Injector ports.</td>
<td>Minimum compression of 2942 kPa (427 psi) with a 588 kPa (85 psi) maximum difference between cylinders.</td>
<td>Perform cylinder compression test. (See Operational Tests in this section.)</td>
</tr>
<tr>
<td>12. Flywheel and starter.</td>
<td>Minimum cranking rpm - 300 rpm.</td>
<td>See Starter Amp Draw Test in ELECTRICAL section of Machine TM.</td>
</tr>
<tr>
<td>13. Injection pump timing</td>
<td>Timing should be correct. Remove pump as the LAST possible solution.</td>
<td>Perform injection pump static timing adjustment. (See Checks, Tests and Adjustments in this section.) Have pump tested by a qualified Service Repair Shop.</td>
</tr>
<tr>
<td>15. Oil pressure sender port.</td>
<td>Minimum oil pressure at 900 rpm is 98 kPa (14 psi).</td>
<td>Test engine oil pressure. (See Operational Tests in this section.)</td>
</tr>
<tr>
<td>16. Thermostat.</td>
<td>Clean from corrosion, rust, or debris. Opening temperature 71°C (160°F) or 85°C (184°F).</td>
<td>Replace thermostat.</td>
</tr>
</tbody>
</table>

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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.

3. Zero the dial indicator.

4. Using a bar, gently pry the crankshaft as far forward as possible.

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.

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.
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 196 N•m (145 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 . . . . . .0.036 - 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:
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 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.)
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.
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 knowledgable 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:**


**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 . . . . . 19615 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:
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
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.

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.
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 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.
COOLANT TEMPERATURE SENDER TEST

Reason:
To determine operating temperature of sender.

Equipment:
- Thermometer
- Glass Container
- Heating Unit
- Ohmmeter

Procedure:

1. Connect lead wires from ohmmeter probes, to sender terminal and body.

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.

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 Amperage: 90 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.

![Diagram of starter test setup](LV066AE)
INJECTION PUMP STATIC TIMING ADJUSTMENT

Reason:
To make sure that injection pump timing is set to manufacturer's 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: 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

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.

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.
**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 (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.

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.
• 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:
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 Idle .......................... 2375 ±50 rpm
Slow Idle ......................... 900 ±50 rpm

Engine Oil Pressure:
Fast Idle ........................ 343 - 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
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
- Standard: 1 N•m (9 lb-in.)

Seal Plate-to-Center Housing Screw Torque
- Standard: 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
- Standard: 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.)
## Specifications

Oil Thrower Seal Ring Groove Widths, Small End - continued

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard (mm)</th>
<th>Wear Limit (mm)</th>
</tr>
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<tbody>
<tr>
<td>RHB5</td>
<td>1.02 - 1.03</td>
<td>1.11</td>
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### Large End

<table>
<thead>
<tr>
<th>Type</th>
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<th>Wear Limit (mm)</th>
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<tbody>
<tr>
<td>RHB3</td>
<td>1.02 - 1.03</td>
<td>1.04</td>
</tr>
<tr>
<td>RHB5</td>
<td>1.22 - 1.23</td>
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### Seal Plate I.D.s

**Side Without Slot**

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard (mm)</th>
<th>Wear Limit (mm)</th>
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<tbody>
<tr>
<td>RHB3</td>
<td>7.968 - 8.00</td>
<td>8.015</td>
</tr>
<tr>
<td>RHB5</td>
<td>10.00 - 10.02</td>
<td>10.05</td>
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<table>
<thead>
<tr>
<th>Type</th>
<th>Standard (mm)</th>
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</thead>
<tbody>
<tr>
<td>RHB3</td>
<td>9.987 - 10.02</td>
<td>10.04</td>
</tr>
<tr>
<td>RHB5</td>
<td>12.40 - 12.42</td>
<td>12.45</td>
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</table>

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard (mm)</th>
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<tbody>
<tr>
<td>RHB3</td>
<td>3.632 - 3.642</td>
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</tr>
<tr>
<td>RHB5</td>
<td>4.04 - 4.05</td>
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**Thrust Bushing Shoulder Length**

<table>
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<th>Type</th>
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<tbody>
<tr>
<td>RHB3</td>
<td>3.59 - 3.61</td>
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<tr>
<td>RHB5</td>
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**Thrust Bearing Thickness**

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<tbody>
<tr>
<td>RHB3</td>
<td>6.275 - 6.285</td>
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<tr>
<td>RHB5</td>
<td>8.01 - 8.03</td>
<td>8.04</td>
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**Journal Bearing I. D.**

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard (mm)</th>
<th>Wear Limit (mm)</th>
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**Oil Thrower Seal Ring Groove Widths, Small End - continued**

<table>
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<tr>
<th>Type</th>
<th>Standard (mm)</th>
<th>Wear Limit (mm)</th>
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<tr>
<td>RHB3</td>
<td>1.02 - 1.03</td>
<td>1.04</td>
</tr>
<tr>
<td>RHB5</td>
<td>1.22 - 1.23</td>
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### Side With Slot

<table>
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<tbody>
<tr>
<td>RHB3</td>
<td>9.987 - 10.02</td>
<td>10.04</td>
</tr>
<tr>
<td>RHB5</td>
<td>12.40 - 12.42</td>
<td>12.45</td>
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<table>
<thead>
<tr>
<th>Type</th>
<th>Standard (mm)</th>
<th>Wear Limit (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RHB3</td>
<td>4.04 - 4.05</td>
<td>4.07</td>
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</table>

**Thrust Bearing Thickness**

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard (mm)</th>
<th>Wear Limit (mm)</th>
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<tr>
<td>RHB3</td>
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<td>3.58</td>
</tr>
<tr>
<td>RHB5</td>
<td>3.99 - 4.01</td>
<td>3.98</td>
</tr>
</tbody>
</table>

## Unit Conversion

- 1 mm = 0.04 in.
- 1 in. = 25.4 mm
Specifications

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 .................................. 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

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Use</th>
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<tbody>
<tr>
<td>LOCTITE® PRODUCTS</td>
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</tr>
<tr>
<td>U.S./</td>
<td>LOCTITE No.</td>
<td></td>
</tr>
<tr>
<td>TY9370/</td>
<td>Thread Lock and Sealer (Medium Strength) Apply to threads of turbocharger thrust bearing and seal plate mounting screws.</td>
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<tr>
<td>TY9477/</td>
<td>John Deere Form-In-Place Gasket</td>
<td>Seals turbocharger seal plate and compressor housing to center housing.</td>
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<tr>
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<td>TY15130/</td>
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<tr>
<td>#395</td>
<td></td>
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</tbody>
</table>

* Fabricated tool, dealer made. (See Dealer Fabricated Tools in this section for instruction to make tools.)

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Intake and Exhaust Systems

AIR CLEANER - 3009 (3TNA72)

Inspection

- Isolator Pad (2)
- Mounting Bracket
- Air Cleaner Housing
- Collar
- Element
- Rain Cap
- Seal Washer
- Hose Clamp (2)
- Air Cleaner-to-Intake Manifold Hose
- Flywheel End

M82182A
AIR CLEANER - 3011(3TNC78), 3014 (3TN84) AND 4019D (4TN84)

Inspection
AIR CLEANER - 4019T (4TN84T)

Inspection
CAUTION

Muffler may be hot. Allow muffler to cool before removing. A hot muffler can cause serious burns.

MUFFLER - 3009 (3TNA72)

Removal/Installation
CAUTION

Muffler may be hot. Allow muffler to cool before removing. A hot muffler can cause serious burns.
MUFFLER - 4019T (4TN84T)

Removal/Installation

**CAUTION**

Muffler may be hot. Allow muffler to cool before removing. A hot muffler can cause serious burns.
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 moments 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, etc. 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.

**Ingestion of Foreign Objects**

The third cause of turbo damage is the ingestion of foreign objects. Foreign objects or particles can be ingested and cause damage to the turbo on both compressor and turbine sides. This is easy to avoid.

On the compressor side, foreign objects usually take the form of dust, sand, or shreds of air cleaner element that enter through improperly installed air cleaner elements. Leaky air inlet piping (loose clamps or torn rubber joints) or torn pleats in dry-type air cleaner elements also create problems.

The result is erosion of compressor blades that can cause the delicately balanced wheel to wobble.

**IMPORTANT:** Whenever an internal engine failure (valve, valve seat, piston) occurs, a thorough inspection of the turbocharger MUST BE performed before returning engine to service.

**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.
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.
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)**

<table>
<thead>
<tr>
<th>Standard</th>
<th>Wear Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.022 - 0.053 mm</td>
<td>0.07 mm (0.0028 in.)</td>
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</tbody>
</table>

**With Waste Gate (RHB5)**

<table>
<thead>
<tr>
<th>Standard</th>
<th>Wear Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.03 - 0.06 mm</td>
<td>0.09 mm (0.0035 in.)</td>
</tr>
</tbody>
</table>

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.)
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.

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.
6. Coat journal bearing and thrust bushing with clean engine oil and install in center housing.

7. Install thrust bearing and mounting screws.

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.


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.


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.
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.


22. Prelube turbocharger: Fill oil inlet or drain port with clean oil and turn rotating assembly (by hand) to properly lubricate bearings.

**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  
Wear Limit .............. 6.250 mm (0.2461 in.)

**RHB5**

Standard ............... 7.99 - 8.00 mm  
Wear Limit .............. 7.980 mm (0.3142 in.)

**Shaft Seal Ring Groove Width:**

**RHB3**

Standard ............... 1.038 - 1.062 mm  
Wear Limit .............. 1.070 mm (0.0421 in.)

**RHB5**

Standard ............... 1.250 - 1.280 mm  
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.
10. Measure thrust bearing thickness.

Thrust Bearing Thickness:

<table>
<thead>
<tr>
<th></th>
<th>RHB3</th>
<th>RHB5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>3.59 - 3.61 mm (0.1413 - 0.1421 in.)</td>
<td>3.99 - 4.01 mm (0.1571 - 0.1579 in.)</td>
</tr>
<tr>
<td>Wear Limit</td>
<td>3.58 mm (0.1409 in.)</td>
<td>3.98 mm (0.1567 in.)</td>
</tr>
</tbody>
</table>

If shoulder length is more than wear limit, replace thrust bushing.

7. Measure thrust bearing thickness.

Thrust Bushing Shoulder Length:

<table>
<thead>
<tr>
<th></th>
<th>RHB3</th>
<th>RHB5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>3.632 - 3.642 mm</td>
<td>4.04 - 4.05 mm</td>
</tr>
<tr>
<td>Wear Limit</td>
<td>3.650 mm (0.1437 in.)</td>
<td>4.07 mm (0.1602 in.)</td>
</tr>
</tbody>
</table>

8. Measure outside and inside diameters of journal bearings.

Journal Bearing I.D.:

<table>
<thead>
<tr>
<th></th>
<th>RHB3</th>
<th>RHB5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>6.275 - 6.285 mm</td>
<td>8.01 - 8.03 mm</td>
</tr>
<tr>
<td>Wear Limit</td>
<td>6.290 mm (0.2476 in.)</td>
<td>8.04 mm (0.3165 in.)</td>
</tr>
</tbody>
</table>

9. Inspect center housing for cracks or damage. Measure inside diameters (seal ring surface and journal bearing surfaces) of center housing.

Journal Bearing O.D.:

<table>
<thead>
<tr>
<th></th>
<th>RHB3</th>
<th>RHB5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>9.940 - 9.946 mm</td>
<td>12.32 - 12.33 mm</td>
</tr>
<tr>
<td>Wear Limit</td>
<td>9.930 mm (0.3909 in.)</td>
<td>12.31 mm (0.4846 in.)</td>
</tr>
</tbody>
</table>

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.
<table>
<thead>
<tr>
<th>Seal Ring Surface I.D.:</th>
<th>Journal Bearing Surface I.D.:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RHB3</strong></td>
<td><strong>RHB3</strong></td>
</tr>
<tr>
<td>Standard ..............</td>
<td>Standard ..................</td>
</tr>
<tr>
<td>11.00 - 11.018 mm</td>
<td>9.995 - 10.005 mm</td>
</tr>
<tr>
<td>(0.4331 - 0.4338 in.)</td>
<td>(0.3935 - 0.3939 in.)</td>
</tr>
<tr>
<td>Wear Limit. ...........</td>
<td>Wear Limit. ...............</td>
</tr>
<tr>
<td>11.03 mm (0.4343 in.)</td>
<td>10.01 mm (0.3941 in.)</td>
</tr>
</tbody>
</table>

| **RHB5**               | **RHB5**                      |
| Standard .............. | Standard ..................   |
| 15.00 - 15.02 mm      | 12.40 - 12.41 mm             |
| (0.5906 - 0.5913 in.)  | (0.4882 - 0.4886 in.)         |
| Wear Limit. ........... | Wear Limit. ...............   |
| 15.05 mm (0.5925 in.)  | 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.
## TURBOCHARGER FAILURE ANALYSIS

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible Cause</th>
<th>Suggested Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Compressor Housing Inlet Defects</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foreign Object Damage</td>
<td>Objects left in intake system.</td>
<td>Disassemble and inspect intake system for foreign objects.</td>
</tr>
<tr>
<td></td>
<td>Leaking and/or defective intake system.</td>
<td>Inspect engine for internal damage.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inspect air intake system connections and air cleaner. Repair or replace as necessary.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inspect air intake related engine components.</td>
</tr>
<tr>
<td>Compressor Wheel Rub</td>
<td>Failure of journal bearings and/ or thrust bushing and bearing.</td>
<td>Determine if engine and/or operator contributed to lack of lubrication, contaminated lubrication, excessive temperature, or debris generating engine failure in progress.</td>
</tr>
<tr>
<td></td>
<td>Manufacturing defects.</td>
<td>Correct as required. (See Disassembly and Inspection procedures in this group.)</td>
</tr>
<tr>
<td><strong>Compressor Housing Outlet Defects</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil and/or Dirt in Housing</td>
<td>Restricted air intake system.</td>
<td>Inspect and clean air cleaner.</td>
</tr>
<tr>
<td></td>
<td>Prolonged periods of low RPM engine idling.</td>
<td>Check with operator to confirm conditions. (See Operators manual.)</td>
</tr>
<tr>
<td></td>
<td>Defective seal ring on oil thrower or defective seal around seal plate.</td>
<td>Repair as necessary. (See Disassembly and Inspection in this group.)</td>
</tr>
<tr>
<td></td>
<td>Restricted oil drain line.</td>
<td>Inspect and clear oil drain line as required.</td>
</tr>
<tr>
<td><strong>Turbine Housing Inlet Defects</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil in Housing</td>
<td>Internal engine failure.</td>
<td>Inspect and repair engine as required.</td>
</tr>
<tr>
<td></td>
<td>Oil leaking from turbine shaft seal ring.</td>
<td>Repair as necessary. (See Disassembly and Inspection in this group.)</td>
</tr>
<tr>
<td>Internal Walls Deteriorated</td>
<td>Excessive operating temperature.</td>
<td>Check for restricted air intake.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check engine for overfueling.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check injection pump timing.</td>
</tr>
</tbody>
</table>
### Intake and Exhaust Systems

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible Cause</th>
<th>Suggested Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Turbine Housing Outlet Defects</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbine Wheel Rub</td>
<td>Failure of journal bearings and/or thrust bushing and bearing.</td>
<td>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 <em>Disassembly</em> and <em>Inspection</em> procedures in this group.)</td>
</tr>
<tr>
<td>Foreign Object Damage</td>
<td>Internal engine failure.</td>
<td>Inspect and repair engine as required. Objects left in intake system. Disassemble and inspect air intake system. (See <em>AIR CLEANER</em> in this group.) Leaking air intake system. Correct as required.</td>
</tr>
<tr>
<td>Oil and/or Excessive Carbon</td>
<td>Internal engine failure.</td>
<td>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.</td>
</tr>
<tr>
<td><strong>Engine Center Housing and Joint Defects</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaks from Casting</td>
<td>Defective casting.</td>
<td>Replace turbocharger. Loose attaching screws. Tighten to specifications. (See <em>Assembly</em> procedures in this group.)</td>
</tr>
<tr>
<td>Leaks from Joints</td>
<td>Defective heat shield or deteriorated sealant.</td>
<td>Inspect and repair as required. (See <em>Disassembly</em> and <em>Assembly</em> procedures in this group.)</td>
</tr>
<tr>
<td><strong>Internal Center Housing Defects</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excessive Carbon Build-up in Housing or on Shaft</td>
<td>Hot engine shut-down.</td>
<td>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 &amp; loads immediately after start-up. Idle engine for a few minutes to allow oil to reach bearings before applying heavy loads.</td>
</tr>
</tbody>
</table>
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 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.

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.
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.
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.

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.
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.
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 Force ............ 98 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.
FUEL FILTER ASSEMBLY - 3011 (3TN84), 3014 (3TN84) AND 4019 (4TN84)

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

*Copper Washers Replace.*
FUEL SUPPLY PUMP - 3009 (3TNA72)

Removal/Installation

IMPORTANT: Replace all copper washers. Damaged or used washers may leak.
FUEL SUPPLY PUMP - 3011 (3TNC78), 3014 (3TN84) AND 4019 (4TN84)

Removal/Installation
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.
Electrical System

INSTRUMENT PANEL

- Mount Bracket (2)
- Mounting Screw (4)
- Spacer (4)
- Isolator (4)
- Red Warning Lamp (3)
  Water Temperature
  Oil Pressure
  Charge
- Blue Warning Lamp
- Preheat
- Key Switch
- Cap (2)
  Optional: Oil Pressure Gauge
  Water Temperature Gauge
- Tachometer Cable
- Tachometer
- Timer
- Instrument Panel
Electrical System

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.

- Adjust. (See Operational Tests and Adjustments in this section.)
RADIATOR MOUNT - IF EQUIPPED

- Inspect isolators for cracks, wear or damage. Replace if necessary.
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.

4. 3011 (3TNC78), 3014 (3TN84) and 4019 (4TN84): Remove and clean crankcase ventilator assembly.

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.
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.)
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

<table>
<thead>
<tr>
<th>Engine Model</th>
<th>Pump Option Code</th>
<th>Injection Pump Assembly Part Number</th>
<th>Governor Regulation</th>
<th>Rated Speed (rpm)</th>
<th>Fast Idle (rpm)</th>
<th>Power Rating* kW (BHP)</th>
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</thead>
<tbody>
<tr>
<td>3009DF001</td>
<td>1601</td>
<td>RG60070</td>
<td>STD</td>
<td>3000</td>
<td>3300</td>
<td>15.4 (20.7)</td>
</tr>
<tr>
<td>3009DF005</td>
<td>1601</td>
<td>RG60070</td>
<td>STD</td>
<td>3000</td>
<td>3300</td>
<td>15.4 (20.7)</td>
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<td>3009DF007</td>
<td>1601</td>
<td>RG60132</td>
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<td>3600</td>
<td>3800</td>
<td>14.2 (19.0)</td>
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<td>RG60187</td>
<td>STD</td>
<td>3000</td>
<td>3300</td>
<td>20.2 (27.1)</td>
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<tr>
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<td>1601</td>
<td>RG60187</td>
<td>STD</td>
<td>3000</td>
<td>3300</td>
<td>20.2 (27.1)</td>
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<tr>
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<td>3-5%</td>
<td>1800</td>
<td>1900</td>
<td>13.0 (17.4)</td>
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<td>1601</td>
<td>RG60269</td>
<td>STD</td>
<td>3000</td>
<td>3300</td>
<td>24.9 (33.5)</td>
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<td>1601</td>
<td>RG60269</td>
<td>STD</td>
<td>3000</td>
<td>3300</td>
<td>24.9 (33.5)</td>
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<td>1800</td>
<td>1900</td>
<td>16.0 (21.5)</td>
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<td>33.4 (44.8)</td>
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<td>1900</td>
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<td>40.3 (54.0)</td>
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<td>40.3 (54.0)</td>
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<td>RG60459</td>
<td>3-5%</td>
<td>1800</td>
<td>1900</td>
<td>27.2 (36.5)</td>
</tr>
</tbody>
</table>

*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 (3TN78), 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:
• 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 (3TN87), 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.
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.

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 (3TN78) 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.
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.

REGULATED AMPERAGE TEST

Reason:
To determine regulated charging output of the alternator.
Operational Tests and Adjustments

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.
4. Start and run engine at fast idle (full throttle).

IMPORTANT: Perform this test quickly to prevent damage to battery tester. DO NOT apply full load to battery for more than 10 seconds.

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.
**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 (3TN78), 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 (3TN78), 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.
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.
DFRG2 EXTENDED INDICATOR TIP (RHB5)

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.
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.

TN Series Engines

Model Number

<table>
<thead>
<tr>
<th>Model Number</th>
<th>kW (hp) Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>3TN6611.9 (16) SAE Net @ 3200 rpm</td>
<td></td>
</tr>
<tr>
<td>3TNA7216.4 (22) SAE Net @ 3600 rpm</td>
<td></td>
</tr>
<tr>
<td>3TN7517.9 (24) SAE Net @ 3200 rpm</td>
<td></td>
</tr>
<tr>
<td>3TN7817 (23) SAE Net @ 2500 rpm</td>
<td></td>
</tr>
<tr>
<td>3TN8221.4 (28.7) SAE Net @ 2800 rpm</td>
<td></td>
</tr>
<tr>
<td>3TNA8217.2 (24) SAE Net @ 2600 rpm</td>
<td></td>
</tr>
<tr>
<td>3TN8420.9 (28) SAE Net @ 2600 rpm</td>
<td></td>
</tr>
<tr>
<td>4TN78T29 (39) SAE Net @ 2650 rpm</td>
<td></td>
</tr>
<tr>
<td>4TN8228.9 (38.8) SAE Net @ 2800 rpm</td>
<td></td>
</tr>
<tr>
<td>4TN8428.7 (38.5) SAE Net @ 2600 rpm</td>
<td></td>
</tr>
<tr>
<td>4TN10041 (55) SAE Net @ 2200 rpm</td>
<td></td>
</tr>
</tbody>
</table>

Series 220 Engines (OEM)

Model (Engine) | Intermittent Gross Power, kW (hp) @ 3000 rpm |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3009 (3TNA72)</td>
<td>15.4 (20.7)</td>
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<tr>
<td>3011 (3TN78)</td>
<td>20.2 (27.1)</td>
</tr>
<tr>
<td>3014 (3TN84)</td>
<td>24.9 (33.5)</td>
</tr>
<tr>
<td>4019D (4TN84)</td>
<td>33.4 (44.8)</td>
</tr>
<tr>
<td>4019T (4TN84T)</td>
<td>40.3 (54)</td>
</tr>
</tbody>
</table>

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.
INDIRECT INJECTION (IDI) ENGINE COMPONENTS
DIRECT INJECTION (DI) ENGINE COMPONENTS
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.
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

Diagram showing the cooling system operation:
- Cylinder Head
- Cylinder Block
- Thermostat
- Coolant Recovery Tank
- Radiator
- Coolant Pump
- Oil Cooler
- By-Pass Tube
- Coolant

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.
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.
Function:
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.
**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.
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
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.
Theory of Operation

OIL FILTER OPERATION

Function:
Filters contaminates 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.
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.
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
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
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.
FUEL SYSTEM OPERATION

IDI Engine - 3TN66 and 3TNA72 (3009)

DI Engine - All Except 3TN66 and 3TNA72 (3009)
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)
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)
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)

<table>
<thead>
<tr>
<th>Model</th>
<th>NET Power</th>
<th>kW (hp) @ Rated rpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>3009DF001</td>
<td>Continuous</td>
<td>12.8 (17.1) @ 3000</td>
</tr>
<tr>
<td>3009DF005</td>
<td>Intermittent</td>
<td>14.2 (19.0) @ 3000</td>
</tr>
<tr>
<td>3009DF007</td>
<td>Generator</td>
<td>14.2 (19.0) @ 3600</td>
</tr>
<tr>
<td>3011DF001</td>
<td>Continuous</td>
<td>16.9 (22.7) @ 3000</td>
</tr>
<tr>
<td>3011DF005</td>
<td>Intermittent</td>
<td>18.8 (25.2) @ 3000</td>
</tr>
<tr>
<td>3011DF006</td>
<td>Generator</td>
<td>10.2 (13.7) @ 1800</td>
</tr>
<tr>
<td>3014DF001</td>
<td>Continuous</td>
<td>21.3 (28.6) @ 3000</td>
</tr>
<tr>
<td>3014DF005</td>
<td>Intermittent</td>
<td>23.5 (31.5) @ 3000</td>
</tr>
<tr>
<td>3014DF006</td>
<td>Generator</td>
<td>12.9 (17.3) @ 1800</td>
</tr>
<tr>
<td>4019DF001</td>
<td>Continuous</td>
<td>28.1 (37.7) @ 3000</td>
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<tr>
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<td>Intermittent</td>
<td>30.9 (41.4) @ 3000</td>
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<td>Generator</td>
<td>18.7 (25.0) @ 1800</td>
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<td>Continuous</td>
<td>34.4 (46.1) @ 3000</td>
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<td>Intermittent</td>
<td>37.8 (50.7) @ 3000</td>
</tr>
<tr>
<td>4019TF006</td>
<td>Generator</td>
<td>24.6 (33.0) @ 1800</td>
</tr>
</tbody>
</table>
GOVERNOR 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
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

- High Idle Screw
- Governor Spring
- Torque Spring
- Governor Lever
- Low Idle Screw
- Max. Fuel
- Min. Fuel
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)
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)
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)
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)
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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:

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<th>Power Unit Model Number</th>
<th>Engine Model Number</th>
<th>Description</th>
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<td>3009DF005</td>
<td>3TNA72</td>
<td>Industrial Power Unit</td>
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<tr>
<td>3009DF007</td>
<td>3TNA72</td>
<td>3600 rpm gen-set Power Unit</td>
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<tr>
<td>3011DF005</td>
<td>3TNC78</td>
<td>Industrial Power Unit</td>
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<td>3011DF006</td>
<td>3TNC78</td>
<td>1800 rpm gen-set Power Unit</td>
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<tr>
<td>3014DF005</td>
<td>3TN84</td>
<td>Industrial Power Unit</td>
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<td>1800 rpm gen-set Power Unit</td>
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<td>4019TF006</td>
<td>4TN84T</td>
<td>1800 rpm gen-set Power Unit</td>
</tr>
</tbody>
</table>
Component Location

Air Heater (Glow Plugs on 3009D Engine)

Instrument Panel

Coolant Temperature Sensor Optional.

Fuel Shutoff Solenoid

Oil Pressure Switch
Additional Oil Pressure Sensor is Optional.

ENGINE ELECTRICAL COMPONENTS
INSTRUMENT PANEL COMPONENTS

Coolant Temperature Gauge
Optional.

Oil Pressure Gauge
Optional.

Preheat Indicator

Charge Indicator

Oil Pressure Indicator

Coolant Temperature Indicator

Key Switch

Preheat Timer
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
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

Schematic

SE1-POWER AND CRANKING CIRCUIT

SE2-FUEL SHUTOFF CIRCUIT

M82180AE

21-10

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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
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<td>Removal</td>
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