



Service Manual

MDJA

MDJB

MDJC

MDJE

MDJF

**Marine Diesel
GenSet Engines**

Safety Precautions

It is recommended that you read your engine manual and become thoroughly acquainted with your equipment before you start the engine.

⚠ WARNING *This symbol is used throughout this manual to warn of possible serious personal injury.*

⚠ CAUTION *This symbol refers to possible equipment damage.*

Fuels, electrical equipment, batteries, exhaust gases and moving parts present potential hazards that could result in serious, personal injury. Take care in following these recommended procedures.

Safety Codes

- All local, state and federal codes should be consulted and complied with.
- This engine is not designed or intended for use in aircraft. Any such use is at the owner's sole risk.

General

- Provide appropriate fire extinguishers and install them in convenient locations. Use an extinguisher rated ABC by NFPA.
- Make sure that all fasteners on the engine are secure and accurately torqued. Keep guards in position over fans, driving belts, etc.
- If it is necessary to make adjustments while the engine is running, use extreme caution when close to hot exhausts, moving parts, etc.

Protect Against Moving Parts

- Do not wear loose clothing in the vicinity of moving parts, such as PTO shafts, flywheels, blowers, couplings, fans, belts, etc.
- Keep your hands away from moving parts.

Batteries

- Before starting work on the engine, disconnect batteries to prevent inadvertent starting of the engine.
- DO NOT SMOKE while servicing batteries. Lead acid batteries give off a highly explosive hydrogen gas which can be ignited by flame, electrical arcing or by smoking.
- Verify battery polarity before connecting battery cables. Connect negative cable last.

Fuel System

- DO NOT fill fuel tanks while engine is running.

- DO NOT smoke or use an open flame in the vicinity of the engine or fuel tank. Internal combustion engine fuels are highly flammable.
- Fuel lines must be of steel piping, adequately secured, and free from leaks. Piping at the engine should be approved flexible line. Do not use copper piping for flexible lines as copper will work harden and become brittle enough to break.
- Be sure all fuel supplies have a positive shutoff valve.

Exhaust System

- Exhaust products of any internal combustion engine are toxic and can cause injury, or death if inhaled. All engine applications, especially those within a confined area, should be equipped with an exhaust system to discharge gases to the outside atmosphere.
- DO NOT use exhaust gases to heat a compartment.
- Make sure that your exhaust system is free of leaks. Ensure that exhaust manifolds are secure and are not warped by bolts unevenly torqued.

Exhaust Gas Is Deadly!

Exhaust gases contain carbon monoxide, a poisonous gas that might cause unconsciousness and death. It is an odorless and colorless gas formed during combustion of hydrocarbon fuels. Symptoms of carbon monoxide poisoning are:

- Dizziness
- Headache
- Weakness and Sleepiness
- Vomiting
- Muscular Twitching
- Throbbing in Temples

If you experience any of these symptoms, get out into fresh air immediately, shut down the unit and do not use until it has been inspected.

The best protection against carbon monoxide inhalation is proper installation and regular, frequent inspections of the complete exhaust system. If you notice a change in the sound or appearance of exhaust system, shut the unit down immediately and have it inspected and repaired at once by a competent mechanic.

Cooling System

- Coolants under pressure have a higher boiling point than water. DO NOT open a radiator pressure cap when coolant temperature is above 212 degrees F (100 degrees C) or while engine is running.

Keep The Unit And Surrounding Area Clean

- Make sure that oily rags are not left on or near the engine.
- Remove all unnecessary grease and oil from the unit. Accumulated grease and oil can cause overheating and subsequent engine damage and present a potential fire hazard.

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WARNING

INCORRECT SERVICE OR REPLACEMENT OF PARTS MIGHT RESULT IN SEVERE PERSONAL INJURY AND/OR EQUIPMENT DAMAGE. SERVICE PERSONNEL MUST BE QUALIFIED TO PERFORM ELECTRICAL AND/OR MECHANICAL SERVICE.

General Information

INTRODUCTION

This manual deals with specific mechanical and electrical information needed by engine mechanics for troubleshooting, servicing, repairing, or overhauling the engine.

Use the table of contents for a quick reference to the separate engine system sections.

Use the separate Parts Catalogs available at the dealer level, for parts identification and for establishing their proper location on assemblies.

The *TROUBLESHOOTING GUIDE* provides a quick reference for locating and correcting engine trouble.

The illustrations and procedures presented in each section apply to the engines listed on the cover. The flywheel end of the engine is the front end, so right and left sides are determined by viewing the engine from the front.

The disassembly section contains major overhaul procedures for step by step removal, disassembly, inspection, repair and assembly of the engine components.

If a major repair or an overhaul is necessary, a competent mechanic should either do the job or supervise and check the work of the mechanic assigned to do the job to ensure that all dimensions, clearances and torque values are within the specified tolerances.

The wiring diagram shows how the electrical components are interconnected.

A parts catalog (available at the dealer level) contains detailed exploded views of each assembly and the individual piece part numbers and their proper names for ordering replacement parts.

Use only Genuine Onan replacement parts to ensure quality and the best possible repair and overhaul results. When ordering parts, always use the complete Model and Spec number in addition to the Serial number shown on the nameplate.

ENGINE MODEL REFERENCE

Identify your model by referring to the MODEL and SPEC (specification) NO. as shown on the unit nameplate. Always use this number and the engine serial number when making reference to your engine.

How to interpret MODEL and SPEC NO. on generator set engines.

12.0MDJC - 3R / 96 A
1 2 3 4

1. Factory code for general identification purposes.
2. Specific TYPE, as follows.
 - R - REMOTE type. Electric starting. Optional accessory equipment can be connected for 2 wire remote control of starting and stopping
 - E - ELECTRIC start type. Electric starting at the plant only.
3. Factory code for specific optional equipment supplied.
4. Specification (Spec Letter). Advances with factory production modifications.

Specifications

All dimensions in U.S. customary units of measure (metric in parentheses) unless otherwise specified.

| SPECIFICATION | UNIT OF MEASURE | MDJA | MDJB | MDJC | MDJE | MDJF |
|---|-----------------|---------------------------|------------------|---------------------------|------------------|------------------|
| Number of Cylinders | | 1 | 2 | 4 | 2 | 4 |
| Diesel Fuel | | ASTM2-D | ASTM2-D | ASTM2-D | ASTM2-D | ASTM2-D |
| Bore | in (mm) | 3.25 (82.55) | 3.25 (82.55) | 3.25 (82.55) | 3.50 (88.9) | 3.50 (88.9) |
| Stroke | in (mm) | 3.625 (92.07) | 3.625 (92.07) | 3.625 (92.07) | 3.625 (92.07) | 3.625 (92.07) |
| Displacement | cu in litre | 30 (0.5) | 60 (0.98) | 120 (1.9) | 70 (1.2) | 140 (2.3) |
| Compression Ratio | | 19 to 1 | 19 to 1 | 19 to 1 | 19 to 1 | 19 to 1 |
| Firing Order | | | | 1-2-4-3 | | 1-2-4-3 |
| Crankshaft Rotation (viewed from flywheel) | | Clockwise | Clockwise | Clockwise | Clockwise | Clockwise |
| Governor | | Variable Speed Mechanical | | Variable Speed Mechanical | | |
| Valve Clearance (Cold) | | Spec A-C Begin Spec D | | | | |
| Intake | in (mm) | 0.020 (0.51) | 0.010 (0.25) | 0.015 (0.38) | 0.011 (0.28) | 0.017 (0.43) |
| Exhaust | in (mm) | 0.020 (0.51) | 0.010 (0.25) | 0.013 (0.33) | 0.016 (0.41) | 0.017 (0.43) |
| Oil Filter | | Full Flow | Full Flow | Full Flow | Full Flow | Full Flow |
| Crankcase Capacity with filter change | qt (litre) | 3 (2.8) | 3.5 (3.3) | 6.5 (6.2) | 3.5 (3.3) | 6.5 (6.2) |

Dimensions and Clearances

All clearances given at room temperature of 70°F (21°C).
All dimensions in inches (millimeters in parentheses) unless otherwise specified.

CAMSHAFT

| | |
|--|-------------------------------|
| Bearing Journal Diameter, Front..... | 2.2500-2.2505 (57.150-57.163) |
| Bearing Journal Diameter, Center (4 cylinder)..... | 1.2580-1.2582 (31.953-31.958) |
| Bearing Journal Diameter, Rear..... | 1.1875-1.1880 (30.163-30.175) |
| Bearing Clearance Limit (Original)..... | .0015-.0030 (.038-.076) |
| Bearing Clearance Limit (Replacement)..... | .0012-.0049 (.030-.123) |
| End Play..... | .007-.039 (0.2-1.0) |
| Cam Tappet Diameter (Prior to Spec P)..... | .7475-.7480 (18.987-18.999) |
| Cam Tappet Hole Diameter (Prior to Spec P)..... | .7507-.7515 (19.068-19.088) |
| Cam Tappet Diameter (Begin Spec P)..... | .8725-.8730 (22.162-22.174) |
| Cam Tappet Hole Diameter (Begin Spec P)..... | .8755-.8765 (22.238-22.263) |

CONNECTING RODS

| | |
|---|---------------------------------|
| Large Bore Diameter..... | 2.1871-2.1876 (55.5523-55.5650) |
| Small Bore Diameter..... | 1.043-1.045 (26.4922-26.543) |
| Large Bearing Bore to Small Bearing Bore (Center-to-Center)..... | 5.998-6.002 (152.3492-152.4508) |
| Connecting Rod End Play..... | .002-.016 (.05-.41) |

CYLINDER

| | |
|---|-------------------------------|
| Bore Honed Diameter (MDJA, MDJB, MDJC)..... | 3.2495-3.2505 (82.537-82.563) |
| Bore Honed Diameter (MDJE, MDJF)..... | 3.4995-3.5005 (88.887-88.913) |
| Maximum Allowable Taper..... | 0.005 (0.127) |
| Maximum Allowable Out-of-Round..... | 0.001 (0.025) |

CRANKSHAFT

| | |
|---|-------------------------------|
| Main Bearing Journal Diameter (1 & 2 cylinder)..... | 2.2437-2.2445 (56.99-57.01) |
| Main Bearing Journal Diameter (4 cylinder)..... | 2.2427-2.2435 (56.965-56.985) |
| Center Main Bearing Clearance (4 cylinder)..... | .0024-.0052 (.061-.132) |
| Front and Rear Main Bearing Clearance (Original) (4 cylinder)..... | .0030-.0043 (.076-.109) |
| Front and Rear Main Bearing Clearance (Replacement) (4 cylinder)..... | .0024-.0062 (.06-.16) |
| Main Bearing Clearance (Original) (1 & 2 cylinder)..... | .002-.0033 (.051-.084) |
| Main Bearing Clearance (Replacement) (1 & 2 cylinder)..... | .0014-.0052 (.04-.13) |
| Connecting Rod Journal Diameter..... | 2.0597-2.0605 (52.316-52.337) |
| Rod Bearing Clearance..... | .001-.0033 (.025-.084) |
| End Play..... | .010-.015 (.254-.381) |

PISTONS AND RINGS

| | |
|---|---------------------------|
| Clearance in Cylinder | |
| Measure 90° to pin, just below oil ring (Prior to Spec P)..... | .0050-.0070 (.127-.178) |
| (Begin Spec P)..... | .0055-.0075 (.140-.191) |
| Ring Groove Width | |
| Top..... | .0970-.0980 (2.464-2.489) |
| No. 2..... | .0965-.0975 (2.451-2.477) |
| No. 3..... | .0965-.0975 (2.451-2.477) |
| No. 4..... | .1880-.1897 (4.775-4.818) |
| Ring Gap..... | .010-.020 (.25-.51) |

PISTON PIN

| | |
|---------------------------------------|-------------------------|
| Clearance in Piston..... | Thumb-push Fit |
| Connecting Rod Bushing Clearance..... | .0002-.0007 (.005-.018) |

STARTING MOTOR (Prestolite)

| | |
|--|-----------------------|
| Rotation..... | Counterclockwise |
| Pinion Clearance to Pinion Stop (Solenoid Plunger Bottomed)..... | .070-.120 (1.78-3.05) |
| Armature End Play..... | .005-.030 (.030-.760) |

VALVE—INTAKE

| | |
|---------------------------------|---------------------------|
| Stem Diameter (Stem is tapered) | |
| **Center | .3401-.3411 (8.639-8.664) |
| **Face | .3386-.3396 (8.601-8.626) |
| Valve Face | 42° |
| Guide Clearance | .0015-.003 (.038-.076) |

VALVE—EXHAUST

| | |
|-----------------------|---------------------------|
| Stem Diameter | .3405-.3415 (8.649-8.674) |
| Guide Clearance | .0030-.0050 (.076-.127) |
| Valve Face | 45° |

VALVE GUIDE

| | |
|------------------------------------|-------------------------------|
| Length | 1.7812 (45.2424) |
| Outside Diameter | .4690-.4695 (11.9126-11.9253) |
| Inside Diameter (after reaming) | |
| Exhaust | .3445-.3455 (8.750-8.776) |
| Intake | .3425-.3435 (8.700-8.725) |
| Cylinder Block Bore Diameter | .467-.468 (11.8618-11.8872) |

VALVE SEATS

| | |
|---------------------------------------|-------------------------------|
| Valve Seat Bore (Diameter) | |
| Intake | 1.547-1.548 (39.29-39.32) |
| Exhaust | 1.361-1.362 (34.570-34.595) |
| Depth (from Cylinder Head Face) | .433-.439 (10.99-11.15) |
| Seat Outside Diameter | |
| Exhaust | 1.364-1.365 (34.6456-34.6710) |
| Intake | 1.550-1.551 (39.37-39.39) |
| Seat Width | .047-.062 (1.19-1.57) |
| Angle | 45° |
| Available Insert Oversizes | .002 (.0508) |
| | .005 (.127) |
| | .010 (.254) |
| | .025 (.635) |

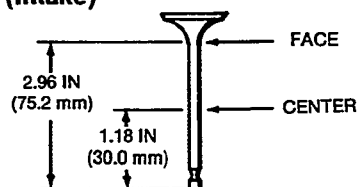
VALVE SPRINGS

| | |
|---|-----------------------|
| Load—Valve Closed | 45-49 lb (200-218 N*) |
| Load—Valve Open (Prior to Spec P) | 83-93 lb (369-414 N*) |
| Load—Valve Open (Begin Spec P) | 87-97 lb (388-432 N*) |

*Newton — Base unit of force.

**Measure intake valve stem at points indicated.

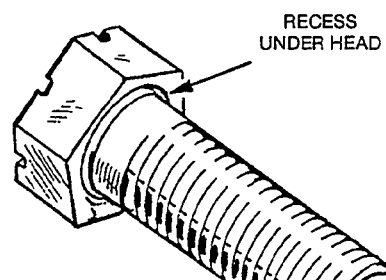
Valve Stem Diameter (Intake)



Assembly Torques and Special Tools

The assembly torques given here will assure proper tightness without danger of stripping threads. If a torque wrench is not available, estimate the degree of tightness necessary for the stud, nut, or screw. Be careful not to strip threads. Use only reasonable force and a wrench of normal length.

Specially designed place bolts do not require a lock-washer or gasket. Do not attempt to use a lockwasher with these bolts; it will defeat their purpose. Check all studs, nuts, and screws often and tighten as needed to keep them from working loose.



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SPECIAL TOOLS

These tools are available from Onan to aid service and repair work.

| | |
|---|----------|
| Diesel Nozzle Tester | 420-0184 |
| Diesel Pintle Nozzle Cleaning Tool Set (includes injection nozzle centering tool) | 420-0208 |
| Driver, Center Camshaft Bearing (RDJF only) | 420-0254 |
| Driver, Valve Seat | 420-0270 |
| Oil Seal Guide and Driver | 420-0456 |
| Nozzle Centering Sleeve | 420-0321 |
| Delivery Valve Test Fixture | 420-0322 |
| Combination Main and Cam Bearing Driver | 420-0326 |
| Diesel Compression Tester | 420-0283 |
| Valve Spring Compressor Tool | 420-0119 |
| Valve Seat Remover | 420-0311 |
| Flywheel Puller | 420-0100 |
| Crankshaft Gear Puller | 420-0072 |
| Crankshaft Gear Pulling Ring | 420-0248 |
| Tool Catalog | 900-0019 |

| TORQUE SPECIFICATIONS | Ft.-Lb. | N•m |
|---|---------------------------------|-----------|
| Center main bolt (4 cylinder) ... | 97-102 | (131-138) |
| Connecting rod bolt..... | 27-29 | (37-39) |
| Rocker-Box cover..... | 8-10 | (11-14) |
| Cylinder head bolt | 44-46 | (60-62) |
| Exhaust manifold nuts..... | 13-15* | (18-20) |
| Flywheel mounting screw..... | 65-70 | (88-95) |
| Fuel pump mounting screws | 15-20 | (20-27) |
| Gear case cover | 18-20 | (24-27) |
| Glow plug | 10-15 | (18-20) |
| Injection nozzle mounting screws | 20-21 | (27-28) |
| Injection pump mounting screws | 15-16 | (20-22) |
| Intake manifold | 13-15 | (18-20) |
| Oil base mounting screws | 45-50 | (61-68) |
| Oil filter | Hand tight plus 1/4 to 1/2 turn | |
| Oil pump mounting screws | 15-20 | (20-27) |
| Rear bearing plate | 40-45 | (54-61) |
| Rocker arm nut | 4-10** | (5-13) |
| Rocker arm stud | 35-40 | (48-54) |

* - Exhaust nuts must be tightened evenly.

** - This torque is due to friction between the threads only and locks the nuts in place. Use the rocker arm nut to adjust valve lash.

Engine Troubleshooting

[illegible]

Service and Maintenance

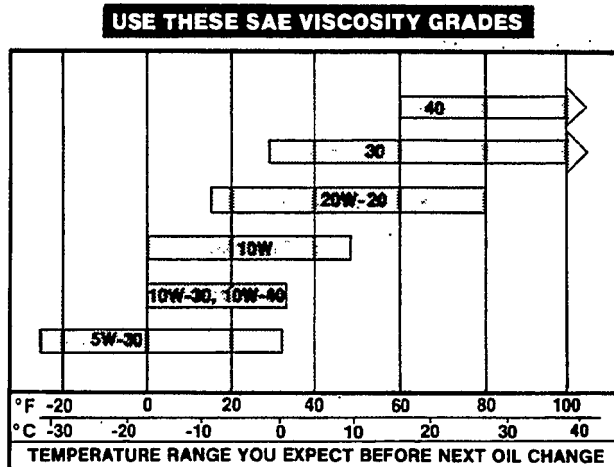
PRE-STARTING

Preparations for the initial and each additional starting operation should include careful checks of the oil, fuel, cooling, and electrical systems.

Before engine is put in operation, check all components for mechanical security. If an abnormal condition, defective part, or operating difficulty is detected, repair or service as required. The engine should be kept free of dust, dirt, and spilled oil or fuel. Be sure proper operating procedure is followed.

Crankcase Oil

Multi-grade oils (such as 5W-30) are recommended for service in ambient temperatures of 32°F and colder. On Onan J Diesel liquid cooled engines, SAE 15W-40 or 20W-40 oils (CD/SE Service Designation) may be used in an ambient temperature range of 15°F (-10°C) through 90°F (32°C). Refer to the oil chart below for recommended viscosity grades at various temperature ambients.



Use oil with an API classification of CD/SE (all viscosity grades) or CC/SE (grades 10W-30, 10W-40, or 5W-30 only).

When adding oil between oil changes, it is preferable to use the same brand, as various brands of oil may not be compatible. Refer to Maintenance Schedule for recommended oil change intervals and procedures.

WARNING

Crankcase pressure could blow out hot oil and cause serious burns. Do NOT check oil while the engine is operating.

Recommended Fuel

Use ASTM 2-D or 1-D fuel with a minimum Cetane number of 45*. Number 2 diesel fuel gives the best economy for most operating conditions; however, use ASTM 1-D fuel during the following conditions:

1. When ambient temperatures are below 32°F (0°C);
2. During long periods of light engine load; or no load.

***NOTE:** Fuels with Cetane numbers higher than 45 may be needed in higher altitudes or when extremely low ambient temperatures are encountered to prevent misfires.

Use low sulfur content fuel having a pour point (ability to filter) of at least 10°F below the lowest expected temperature. Keep the fuel clean and protected from adverse weather. Leave some room for expansion when filling the fuel tank.

CAUTION

Due to the precise tolerances of diesel injection systems, it is extremely important the fuel be kept clean. Dirt in the system can cause severe damage to both the injection pump and the injection nozzles.

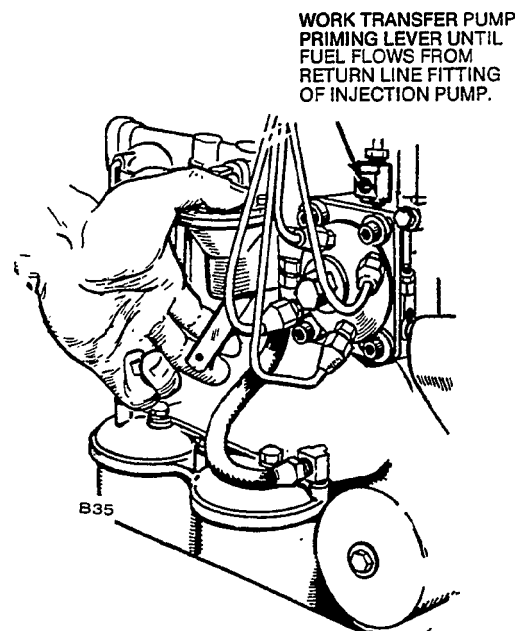


FIGURE 1. BLEED FUEL SYSTEM

If the camshaft pump lobe is up, crank engine one revolution to permit hand priming. When finished, return priming lever inward (disengaged position) to permit normal pump operation.

Bleeding Fuel System

Bleed air from fuel system as follows: Disconnect fuel return line, Figure 1. Operate hand priming lever on fuel transfer pump until fuel flowing from fuel return line is free of air bubbles. Then reconnect the fuel return line.

PRE-HEATING AND STARTING

Preheating for 60 seconds is recommended on all DJ-Series Diesels at 55°F (13°C) or lower, and 30 seconds for temperatures above 55°F (13°C). Refer to *Onan Diesel Starting Guide*, for additional starting guidelines.

WARNING

Inhalation of exhaust gases might result in serious personal injury or death. Be sure deadly exhaust gas is piped outside and away from windows, doors, or other inlets to building.

WARNING

Use of ether as a starting aid might cause an explosion resulting in severe personal injury and engine damage. Do not use ether as a starting aid; heat or compression or heat from the glow plugs may cause a sudden ignition of the ether vapor.

1. Engage PREHEAT switch for the time period recommended below:
30 seconds if above 55°F (13°C) -
60 seconds if below 55°F (13°C).
2. Engage START switch while continuing preheat. Hold until engine comes up to speed.
3. If engine fails to start in 15-20 seconds, repeat

steps 1 & 2. Absence of blue exhaust smoke during cranking indicates no fuel being delivered. Determine cause.

4. In extreme cold it may be necessary to maintain preheating up to 2 minutes after the engine starts to obtain firing or to smooth out all cylinders, especially at no load or light loads.

CAUTION

Do not exceed the one minute preheat periods to prevent heater burn out and conserve the battery. Longer preheating time prior to cranking the engine can ruin the manifold heater and glow plugs because there is no incoming air flow to cool them. Additional operation of the preheaters for a few seconds during cranking in cold weather may help to preheat the incoming combustion air and prevent misfires as the engine starts running.

5. Verify that oil pressure gauge reads at least 20 psi after engine reaches speed (pressure relief valve is not adjustable).

CAUTION

Do not apply overvoltage to the starting circuit at any time. Overvoltage will destroy the glow plugs and air heater. If it becomes necessary to use an additional source of power to start the set, use a 12 volt battery connected in parallel.

STOPPING

1. Push fuel solenoid switch to Stop position.
2. Release switch when set stops. If stop circuit fails, close fuel valve.

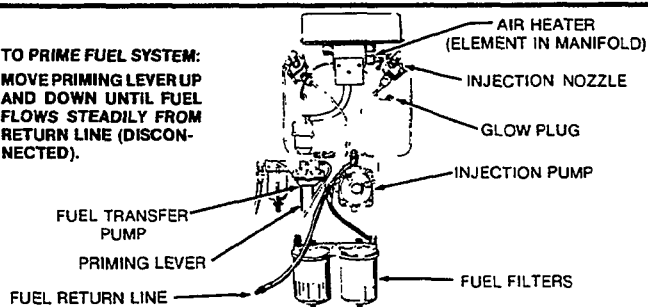
ONAN DIESEL STARTING GUIDE - INDUSTRIAL ENGINES

BEFORE STARTING:

CHECK FUEL SUPPLY.
BE SURE SHUTOFF VALVES ARE OPEN.

PRIME FUEL SYSTEM IF: FUEL FILTERS WERE DRAINED OR CHANGED,
SYSTEM WAS JUST INSTALLED, FUEL TANK RAN DRY.

TO PRIME FUEL SYSTEM:
MOVE PRIMING LEVER UP
AND DOWN UNTIL FUEL
FLOWS STEADILY FROM
RETURN LINE (DISCON-
NECTED).



TO START:

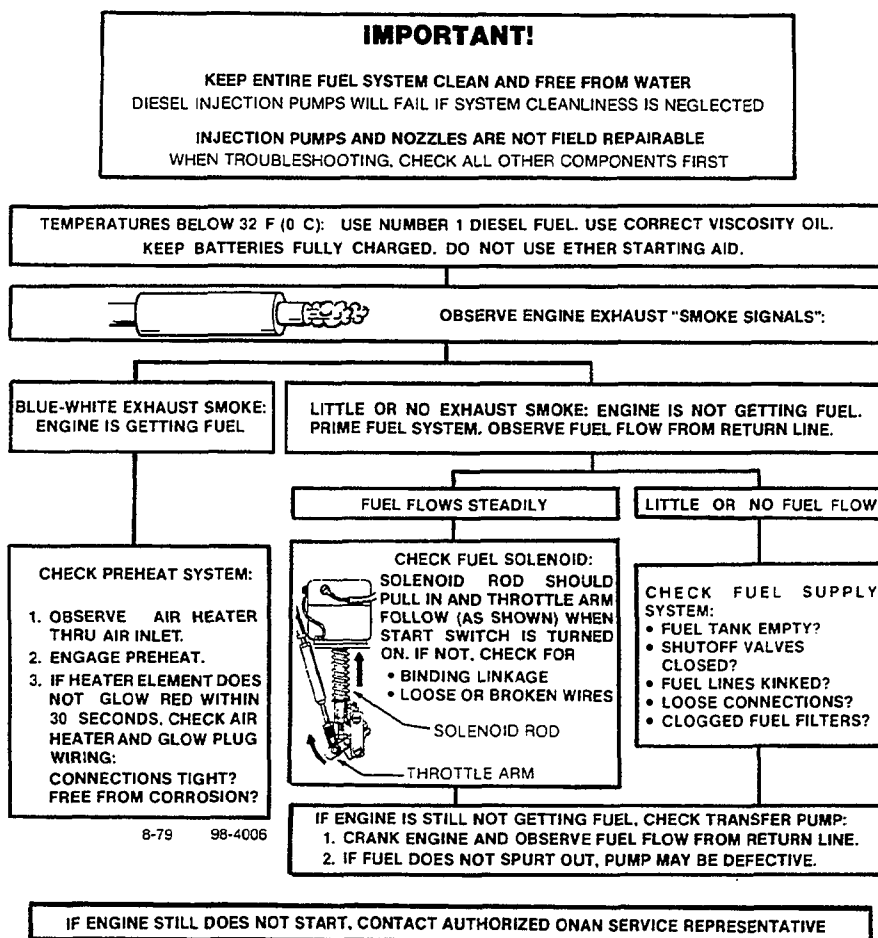
PREHEAT COLD ENGINE: PUSH PREHEAT SWITCH AND HOLD —
• 30 SECONDS IF ABOVE 55°F (13°C);
• 60 SECONDS IF BELOW 55°F (13°C).
NEVER PREHEAT MORE THAN 60 SECONDS.

ENGAGE FUEL SOLENOID SWITCH IF SO EQUIPPED

ENGAGE START SWITCH WHILE CONTINUING PREHEAT

IF ENGINE FIRES BUT DOES NOT START, REPEAT ABOVE PROCEDURES, INCLUDING PREHEAT. LIMIT CRANKING TO 15 TO 20 SECONDS TO CONSERVE BATTERY. IF ENGINE STILL DOES NOT START, SEE "IF ENGINE FAILS TO START" INFORMATION.

IF ENGINE FAILS TO START:



AUTOMATIC STARTING AND STOPPING

Optional controls may be used for automatic start and stop, but must provide engine preheating.

The automatic control should have a time delay relay to preheat glow plugs and the manifold heater for at least 20 seconds before cranking occurs. The time delay relay prevents immediate engagement of the starter in case the load is reapplied before the engine stops.

APPLYING LOAD

If practicable, allow engine to warm up before connecting a heavy load. Continuous overloading causes high operating temperatures that can damage the engine. The exhaust system may form carbon deposits during operation at light loads; apply full load occasionally before shut-down to prevent excessive carbon accumulations.

Try to apply the load in steps instead of full load at one time.

BREAK-IN PROCEDURE

The unit should be run in the following sequence:

1. One half hour at 1/2 load.
2. One half hour at 3/4 load.
3. Full load.

Continuous running under one half load during the first few hundred hours may result in poor piston ring seating, causing higher than normal oil consumption and blowby.

Drain and replace the crankcase oil after first 50 hours of operation; drain while the engine is still hot.

INSPECTION

Check for alignment of engine and load. Misalignment will cause excessive vibration and bearing wear. Make a visual inspection of the entire installation.

WARNING

Contact with rotating machinery might cause serious personal injury or death. Stay clear of rotating components and ensure that protective shields and guards are in place and secured before operating machinery.

VENTILATION

Good ventilation is needed to cool the engine and to support combustion. Avoid recirculation of ventilating air.

WARNING *Inhalation of exhaust gases might result in serious personal injury or death. Do not use exhaust heat to warm a room, compartment or storage area.*

EXHAUST

Pipe exhaust gas outside any enclosure: exhaust gas is poisonous. Exhaust pipes must not terminate near inlet vents. Avoid sharp bends. Use sweeping, large-radius elbows. Use a section of seamless, flexible tubing between the engine and any rigid pipe to restrict vibration.

BATTERIES

Check the condition of the starting batteries at least every two weeks. See that connections are clean and tight. A light coating of non-conductive grease will retard corrosion at terminals. Keep the electrolyte at the proper level above the plates by adding distilled water. Check specific gravity; recharge if below 1.260.

DUST AND DIRT

1. Keep inlet screen free of dirt, etc.
2. Service air cleaner as frequently as necessary.
3. Change crankcase oil every 50 operating hours.
4. Keep oil and fuel in dust-tight containers.
5. Keep governor linkage clean.

HIGH ALTITUDE

Maximum power will be reduced approximately 4 percent for each 1000 feet (310 m) above sea level, after the first 1000 feet (310 m).

LOW TEMPERATURES

1. Use correct SAE No. oil for temperature conditions. Change oil only when engine is warm. If an unexpected temperature drop causes an emergency, move engine to a warm location or apply heated air (never use open flame) externally until oil flows freely.
2. Use fresh fuel. Protect against moisture condensation.
3. Keep fuel system clean, and batteries in a well charged condition.
4. Use additional preheat cycles during cold starts.

CAUTION *Do not exceed one minute preheat periods; longer periods can ruin the heater elements.*

OPERATOR AND SERVICE MAINTENANCE SCHEDULE

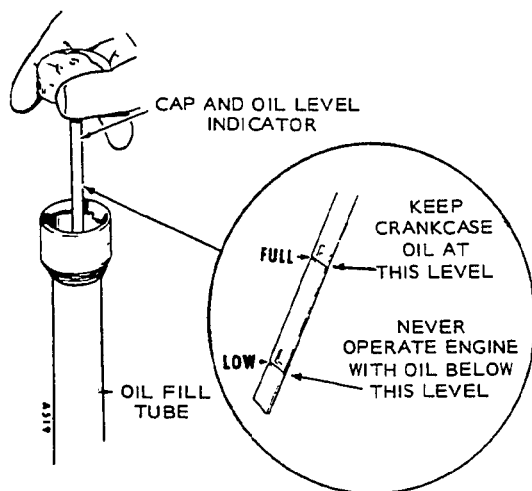
| HOURS OF OPERATION | MAINTENANCE TASK |
|-------------------------------------|---|
| 8 | <ul style="list-style-type: none">• Inspect exhaust system• Inspect engine• Check fuel supply, see Note 1• Check oil level. See Figure 2. |
| 50 (more often in dusty conditions) | <ul style="list-style-type: none">• Check air cleaner. |
| 100 | <ul style="list-style-type: none">• Clean governor linkage• Change crankcase oil• Drain fuel condensation traps in lines and filters, see Note 1 |
| 200 | <ul style="list-style-type: none">• Replace oil filter• Check battery condition |
| 500 | <ul style="list-style-type: none">• Clean breather standpipes• Check start-disconnect circuit• Check valve clearances |
| 600 | <ul style="list-style-type: none">• Change primary fuel filter |
| 2000 | <ul style="list-style-type: none">• Grind valves (if required)• Clean holes in rocker box oil line orifices• Check nozzle spray pattern, see Note 2 |
| 3000 | <ul style="list-style-type: none">• Change secondary fuel filter |
| 5000 | <ul style="list-style-type: none">• General overhaul (if required) see Note 3 |

- NOTE 1.** Water or foreign material in fuel can ruin the injection system. If daily inspection shows water or excessive dirt in sediment bowl fuel, handling and storing facilities should be checked and situation corrected. Primary and secondary fuel filters must be replaced following correction of fuel contamination problem.
2. This service must be conducted by trained diesel injection equipment personnel with suitable test facilities. Omit this service until these conditions can be met.
 3. Tighten head bolts and adjust valve clearance after first 50 hours on an overhauled engine.

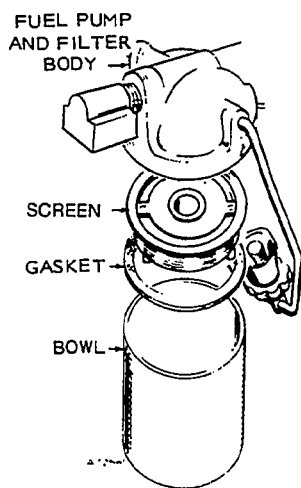
OIL FILTER CHANGE

Place pan under old filter and remove by turning counterclockwise. Clean filter mounting area. Lubricate gasket on new filter with oil and screw filter on clockwise until gasket touches mounting base, then tighten 1/2 turn.

WARNING Crankcase pressure could blow out hot oil and cause serious burns. Do NOT check oil while the engine is operating.



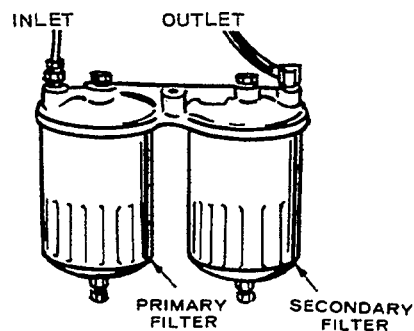
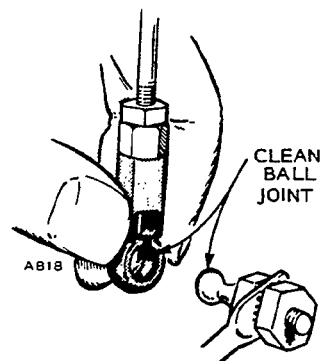
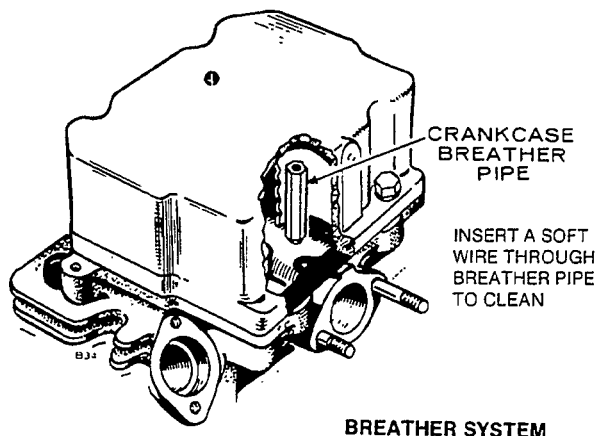
OIL LEVEL INDICATOR



FUEL TRANSFER PUMP

OIL DRAIN EXTENSION

For service convenience, install a short (less than 10 inches [254 mm]) oil drain extension made from standard pipe and fittings, in the 1/2-inch (12.70 mm) pipe-tapped oil drain hole in the base.



DUAL FUEL FILTER SYSTEM

FIGURE 2. MAINTENANCE PROCEDURES

OUT-OF-SERVICE PROTECTION

The natural lubricating qualities of No. 2 diesel fuel should protect a diesel engine for at least 30-days when unit is not in service. To protect an engine that will be out of service for more than 30 days, proceed as follows:

1. Run engine until thoroughly warm; under at least 50 percent load.
2. Shut down engine and drain oil base while still warm. Refill and attach a warning tag indicating viscosity of oil used.
3. Remove glow plugs. Pour 1-ounce of rust inhibitor (or SAE #10 oil) into each cylinder. Install glow plugs.

CAUTION *Crank engine by hand only to distribute oil in cylinder. Starter cranking is too fast; oil or inhibitor fluid will fire if cranked with starter at normal room temperature.*

4. Service air cleaner per *Maintenance Schedule*.
5. Clean throttle and governor linkage and protect by wrapping with a clean cloth.
6. Plug exhaust outlets to prevent entrance of moisture, bugs, dirt, etc.
7. Clean and wipe entire unit. Coat parts susceptible to rust with a light coat of grease or oil.
8. Disconnect battery and follow standard battery storage procedure.

Returning a Unit to Service

1. Remove cover and all protective wrapping. Remove plug from exhaust outlet.
2. Check warning tag on oil base and verify that oil viscosity is still correct for existing ambient temperature.
3. Clean and check battery. Measure specific gravity (1.260 at 77° F [25° C]) and verify level is at split ring. If specific gravity is low, charge until correct value is obtained. If level is low, add distilled water and charge until specific gravity is correct. **DO NOT OVERCHARGE.**

WARNING *Ignition of explosive battery gases might cause severe personal injury. Do not smoke while servicing batteries.*

4. Check that fuel injectors and fuel lines are secure and correctly torqued.
5. Clean heat exchanger.
6. Connect batteries.
7. Verify that no loads are connected to engine.

WARNING *Inhalation of exhaust gases might result in serious personal injury or death. Be sure deadly exhaust gas is piped outside and away from windows, doors, or other inlets to building.*

8. Start engine.

After engine has started, excessive amount of blue smoke will be exhausted until the rust inhibitor or oil has burned away.

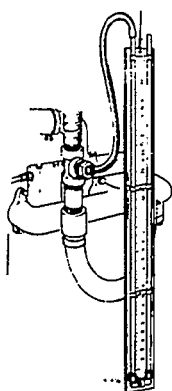
WARNING *Accidental starting of the engine might cause severe personal injury or death. Disconnect the battery cable when repairs are made to the engine, controls, or generator.*

Exhaust System

GENERAL

The exhaust system must efficiently expel all engine combustion products and muffle exhaust noises with minimum back pressure. If back pressure is too high, volumetric efficiency of the engine is reduced, fuel economy drops, exhaust temperature increases, and valve life is shortened.

Back pressure must not exceed 27 inches (686 mm) of water column for the rated load when measured with a manometer at the exhaust manifold, Figure 3.



| Units of Measurement | Full Load |
|----------------------|-----------|
| Inches of Water | 27 |
| Inches of Mercury | 2 |
| Ounces | 15.6 oz. |

FIGURE 3. BACK PRESSURE TEST WITH MANOMETER

EXHAUST SMOKE

A light gray or light blue smoke may be a result of low ambient temperature and light load. This smoke is unburned fuel (not harmful to the engine) and disappears when more load is applied.

Black smoke indicates overfueling (more fuel than oxygen) and is usually caused by overloading. The smoke or unburned fuel becomes carbon when raised to a high temperature. Carbon contributes to engine damage because it contaminates the lubricating oil.

WARNING

Inhalation of exhaust gases might result in serious personal injury or death. Do not use exhaust heat to warm a room, compartment, or storage area.

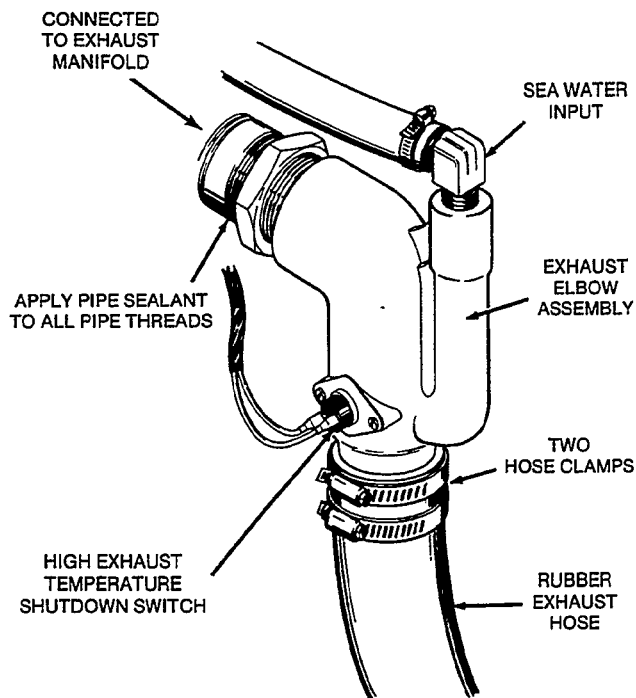
Vent exhaust gases outside. Use flexible tubing only between the engine exhaust outlet and rigid piping.

WARNING

Inhalation of exhaust gases might result in serious personal injury or death. Inspect exhaust system audibly and visually for leaks daily. Repair any leaks immediately.

WATER COOLED EXHAUST

Marine exhaust systems are designed so that a minimum amount of heat will be radiated from the exhaust system components. This is done to keep the heat build-up in the engine compartment to a minimum. Exhaust heat is dissipated by using a water cooled exhaust manifold and a water injected exhaust pipe and muffler system. The exhaust manifold is encased in a shell through which engine coolant or sea water is circulated. Just beyond the exhaust manifold, a special elbow (see Figure 4) is fitted which allows the output water from the sea water system to be injected into the exhaust pipe. The injected sea water is carried out through the exhaust system and discharged into the flotation water.



EXS-1014

FIGURE 4. EXHAUST ELBOW

Typical Installations

All water injected exhaust systems must be designed so that the discharge water will not flow back into the engine. There are several methods that can be used to keep water out of the engine. All are based on injecting the water at a point a few inches approximately 4 inches (102 mm) below the exhaust manifold outlet and installing a sharp drop in the exhaust line that water cannot normally flow over. These methods are divided into two general categories: above water line and below water line installation.

Above Water Line: The exhaust manifold must be one foot or more above the load water line and the water must be injected near the exhaust manifold. The exhaust pipe is pitched downward 1/2 inch per foot (13 mm per 305 mm) to allow draining in the line whether the generator set is running or stopped.

Below Water Line: An Onan Aqualift muffler may be used for below the water line installations if the lift height is no greater than four feet (1220 mm). A siphon break is required when the water injection elbow is below the water line (see Figure 5) to prevent water from being siphoned into the exhaust manifold. The siphon break will be mounted at least 12 inches (305 mm) above the load water line.

If the lift height is greater than four feet (1220 mm), a riser exhaust system will be used. The exhaust system will run in a loop above the water line to a point 12 to 18 inches (305 to 457 mm) above the boat load water line. A water jacket encloses the loop and

the water is injected on the outlet side at a point four inches (102 mm) above the bottom of the loop. A condensation trap is usually installed at the bottom of the dry exhaust line section. Drain the trap at regular intervals to remove condensation.

Generally, exhaust systems should be as short as possible with a minimum number of bends. The radius of any bend in the exhaust pipe should be at least 5 times the diameter of the pipe. The dry sections of exhaust line should be either insulated or water jacketed.

CAUTION Be sure the slotted opening in the vacuum relief valve is open to atmospheric pressure. The siphon break will not function if the relief valve slot is closed in any way.

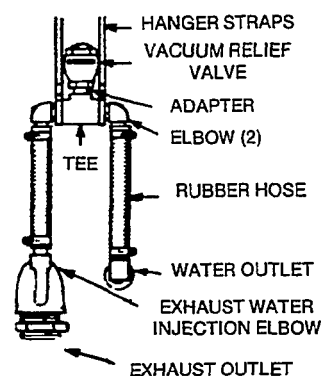


FIGURE 5. SIPHON BREAK

WARNING

EXHAUST GAS IS DEADLY!

Exhaust gases contain carbon monoxide, a poisonous gas that might cause unconsciousness and death. It is an odorless and colorless gas formed during combustion of hydrocarbon fuels. Symptoms of carbon monoxide poisoning are:

- Dizziness
- Headache
- Weakness and Sleepiness
- Vomiting
- Muscular Twitching
- Throbbing in Temples

If you experience any of these symptoms, get out into fresh air immediately, shut down the unit and do not use until it has been inspected.

The best protection against carbon monoxide inhalation is proper installation and regular, frequent inspections of the complete exhaust system. If you notice a change in the sound or appearance of exhaust system, shut the unit down immediately and have it inspected and repaired at once by a competent mechanic.

Cooling System

INSPECTION

As a part of standard maintenance procedures, the entire cooling system should be inspected for signs of leakage and checked for worn components. Inspect the water pump bearings, impeller (neoprene), and seals for signs of wear, and check for correct drive belt tension. Locate the source of any leaks and correct as required. Inspect the zinc pencils on heat-exchanger cooled engines, and note the amount of deterioration. Refer to the appropriate section for recommended service procedures.

As a final check, run the engine at full load and verify that the engine can maintain an operating temperature of approximately 180°F (82°C). An engine that operates significantly above or below this value should be tested for malfunctions.

IMPORTANCE OF REGULAR MAINTENANCE

The entire cooling system, including the block and radiator, heat exchanger, or keel cooler should be cleaned and flushed out at least once a year. This is especially important in cold weather conditions or when preparing the unit for extended storage (over 30 days). The cooling system can work efficiently only when it is clean. A build-up of rust and scale in the cooling system will slow down heat absorption and restrict water flow.

DRAINING COOLING SYSTEM

Open all drains and hose connections where coolant may be trapped when changing the antifreeze solution or when preparing a unit for storage in freezing conditions. Open the fill vent valve when draining heat-exchanger cooled engines. The following drain plugs and hoses must be removed to drain the cooling system completely:

WARNING

Contact with hot coolant might result in serious burns. Do not bleed hot, pressurized coolant from a closed cooling system.

Engine Block: J-Series—Remove drain plug on left front side of engine. (See Figure 6).

Water Pumps (All Units): Remove drain plug under pump or loosen pump cover (Figure 6).

Exhaust Manifold: Remove plug from underside of exhaust manifold (Figure 6).

Expansion Tank: Remove plug from front side of expansion tank (Figure 6).

Heat Exchanger (Draining Raw Water or Sea Water): Remove drain plug from underside, loosen end cover, or loosen and remove hose to drain heat exchanger.

Tank Heater: Loosen and remove lower hose to drain tank heater.

Aqualift Muffler: The Aqualift muffler has relatively little water in it during normal operation and does not have to be drained during freezing weather.

Replace and tighten all plugs, fittings, and clamps when draining is finished.

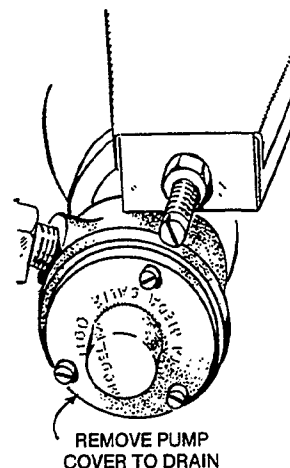
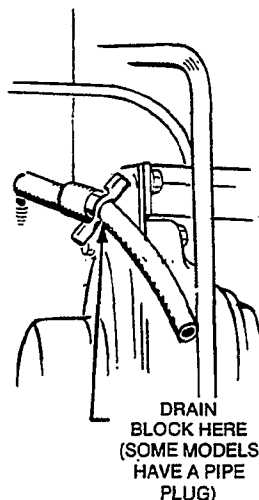
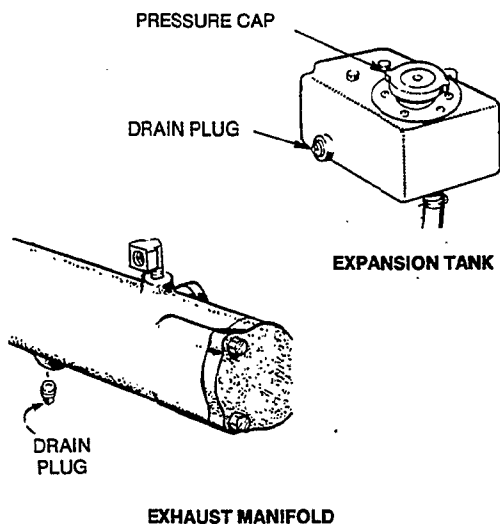


FIGURE 6. DRAINING COOLING SYSTEM

CLEANING AND FLUSHING THE COOLING SYSTEM

To clean rust and scale deposits from captive water systems, drain the system (as previously described), and then fill with clean water and cleaner solution. Use an approved chemical cleaner (such as the type used for cleaning automotive cooling systems), and follow the instructions provided by the supplier.

Chemical cleaners cannot be used with direct sea water cooled marine engines.

WARNING *Cleaning solutions typically contain strong chemicals that may cause injury if used improperly. Read all warning labels before using.*

When cleaning is complete, drain the cleaning solution and flush the system. For best results the engine and heat exchanger should be reverse-flushed. Allow the engine to cool as much as possible before flushing with cold water.

CAUTION *Never pour cold water into a hot engine. Doing so may crack the head or the cylinder block. Do not operate engine without coolant for even a few minutes.*

Flush system if engine operation indicates clogged passages or overheating.

To flush the engine:

1. Drain heat exchanger, cylinder block and exhaust manifold. Remove thermostats.
2. Remove the inlet and outlet hoses between the engine and heat exchanger.
3. Close all drain plugs and attach the flushing gun nozzle to the water outlet, as near the exhaust manifold as practical. Restrict the normal inlet line opening until the system fills with water, then apply air pressure gradually. Repeat the process until the flow of water from the cylinder block is clean.
4. Remove flushing gun.
5. Reinstall thermostats, hoses, and drain plugs and refill the system with the proper coolant.
6. When flushing is completed, check the system thoroughly for any leaks uncovered by the cleaning operations.

To flush heat exchanger:

1. Flush the engine water jacket as previously discussed.
2. First remove water outlet hose between engine water jacket to the heat exchanger.
3. Flush both fresh water side and raw water side of heat exchanger.

4. Remove rubber impeller pump cover to flush raw water side.
5. Flush the water-cooled exhaust manifold.
6. When flushing is completed, check the system thoroughly for leaks.

FILLING COOLING SYSTEM

All closed or captive water cooling systems should be filled with 50/50 mixture of antifreeze and clean water. This is the amount recommended for satisfactory corrosion protection and boil-over protection.

In extremely low temperatures (-25°F or lower), it may be necessary to increase the percentage of antifreeze to provide adequate protection against freezing. Follow the recommendation of the supplier to determine the amount of antifreeze needed for the lowest temperature expected. The antifreeze solution must be able to protect the cooling system during the coldest winter weather. Table 1 shows the capacities of the various cooling systems.

**TABLE 1.
COOLING SYSTEM CAPACITIES**

| UNIT | CAPACITY IN QUARTS ENGINE AND HEAT EXCH. |
|------|---|
| MDJA | 2.3 (2 L) |
| MDJB | 4.5 (4.3 L) |
| MDJC | 9.5 (9 L) |
| MDJE | 4.5 (4.3 L) |
| MDJF | 9.5 (9 L) |

Heat Exchanger Filling

Improper filling of the heat exchanger (Figure 7) can cause overheating of the engine. To prevent this possibility, follow these instructions whenever adding coolant to the heat exchanger:

1. Remove fill cap.
2. Open fill vent valve (turn counterclockwise).
3. Remove vent plug (older city water cooled units only).
4. Fill with coolant until vents begin to overflow.
5. Close fill vent valve (turn clockwise).
6. Replace vent plug (older city water cooled units only).
7. Replace fill cap (prime pump on marine units).
8. Operate unit 10 minutes at full load; watch for leaks.
9. Shut down unit.

WARNING

Contact with hot coolant might result in serious burns. Do not bleed hot, pressurized coolant from a closed cooling system.

10. Slowly open pressure cap and check water level.
11. Fill system to top with coolant.

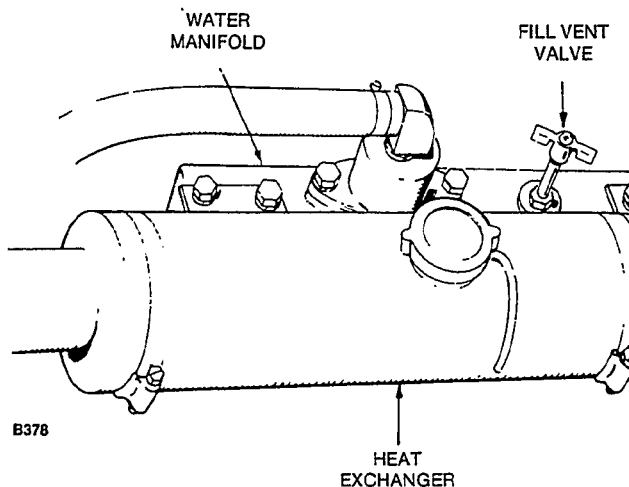


FIGURE 7. HEAT EXCHANGER FILLING

MARINE COOLING SYSTEMS

Three types of marine cooling systems are in general use today: direct sea water cooling, heat exchanger cooling, and keel or skin cooling.

Direct sea water cooling systems use an engine mounted pump to draw flotation water and pump it through the engine and out through the exhaust system. The flotation or sea water comes in direct contact with the engine water jacket.

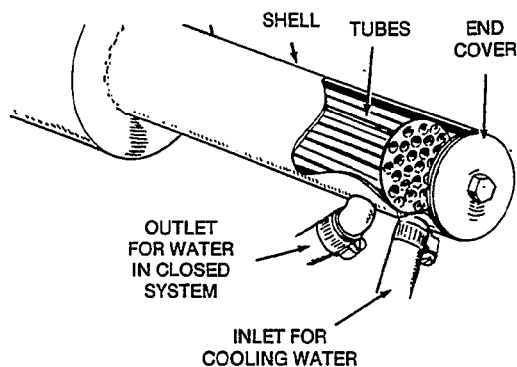


FIGURE 8. HEAT EXCHANGER

The heat exchanger and keel cooling systems were developed to keep sea water, and the resulting sediment deposits (salt, silt, etc.), from the engine cooling jacket. Both systems have a fixed quantity of captive water in a closed system to cool the engine. Sea water cools the captive water in the heat exchanger or keel cooler. Sea water and captive water are kept separated, so the engine water jacket stays clean. Figure 8 shows a typical marine heat exchanger.

Because marine generator sets operate typically in very small compartments, it is important that the heat radiated from the exhaust system be kept to a minimum. To accomplish this, the heated sea water is usually discharged through the exhaust system. Special mufflers, pumps, and anti-siphon devices are required to avoid interference with the passage of exhaust gases and to prevent entry of water into the combustion chamber.

Direct Cooling System

Onan engine generator sets constructed for direct sea water cooling are equipped with a sea water pump and are normally installed with a water filter, water inlet valve (sea cock), and strainer.

A through-the-hull flush-type fitting is used for a water inlet. Heated sea water flows past the thermostat to the exhaust manifold (water cooled) and is discharged through the exhaust system. The discharged water cools the entire exhaust system and greatly reduces the amount of heat that would normally radiate from the muffler and exhaust pipe (see Figure 9). Although this system is the simplest and has the lowest initial cost, it is not recommended for salt water or water that contains silt and debris.

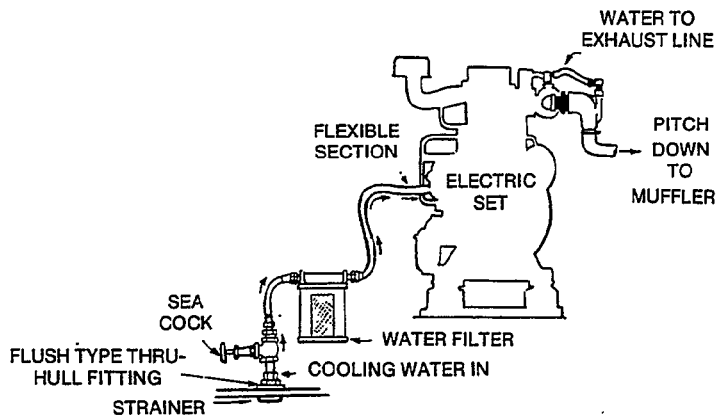


FIGURE 9. DIRECT SEA WATER COOLING

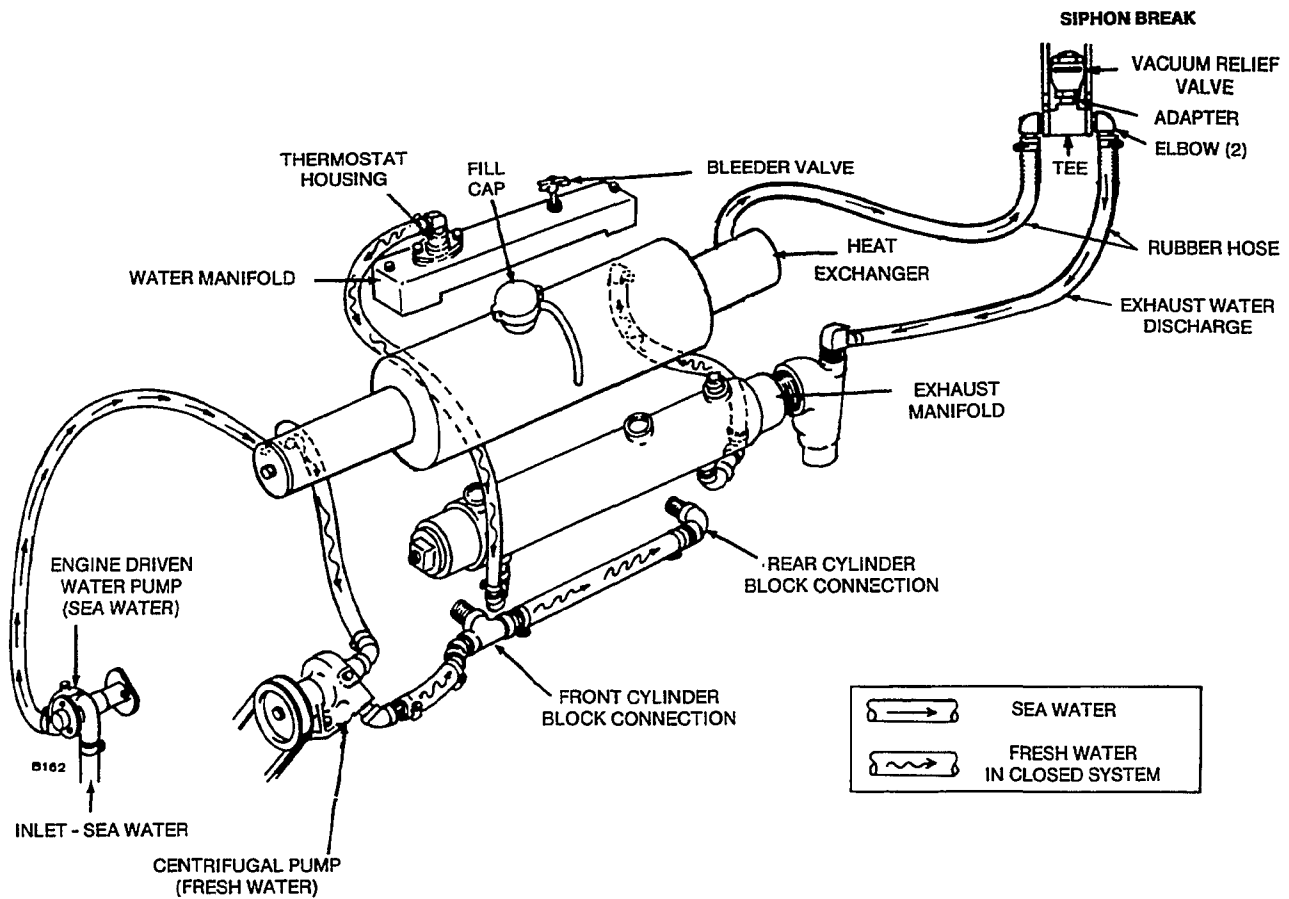


FIGURE 10. HEAT EXCHANGER COOLING

Heat Exchanger Cooling System

Marine heat exchanger cooling systems work using the same principle as city water heat exchanger systems. Cool water from an unlimited source (flotation water) is circulated by the sea water pump through a set of tubes encased within a surrounding shell (Figure 10). Engine coolant is circulated through the shell but is not mixed with the sea water. A second water pump is used to circulate the engine coolant in the captive system. The sea water passing through the heat exchanger tubes absorbs the heat from the engine coolant. The heated sea water is discharged through the exhaust system. Figure 10 shows a schematic of a typical marine heat exchanger cooling system.

Keel Cooling System (Or Skin Cooling)

Keel coolers are comprised of a series of finned tubes through which heated engine coolant is circulated. The keel cooler is attached to the underside of the boat (keel) so that flotation water can pass between the fins. The heat from the engine coolant is transferred to the finned tubes and absorbed by the flotation water. Keel coolers function similar to radiators except that the heat is dissipated to the flotation water instead of to the air. An engine-driven pump is used to circulate the coolant through the water jacket and cylinder heads to the keel cooler.

A second pump is sometimes used to draw flotation water and discharge it through the exhaust system. This cools the muffler and exhaust pipe and reduces the amount of heat radiated from these components. As with heat exchanger systems, the sea water is never mixed with the engine coolant. Figure 11 shows a schematic of a keel cooler system.

Skin coolers function similar to keel coolers except that a section of the hull with an extra skin is used to dissipate the heat. Engine coolant passes between the hull of the boat and the exterior skin. The heat is transferred to the skin and absorbed by the flotation water. The remainder of the system operates the same as a keel cooler system.

Keel coolers must be designed to provide adequate cooling when the water flowing through the fins is at a minimum and the temperature of the flotation water is at its maximum. This is necessary because the engine is often required to operate at its heaviest load when the boat is not moving. For this reason a larger keel cooler is required for the generator set than would be required for a propulsion engine of equal size.

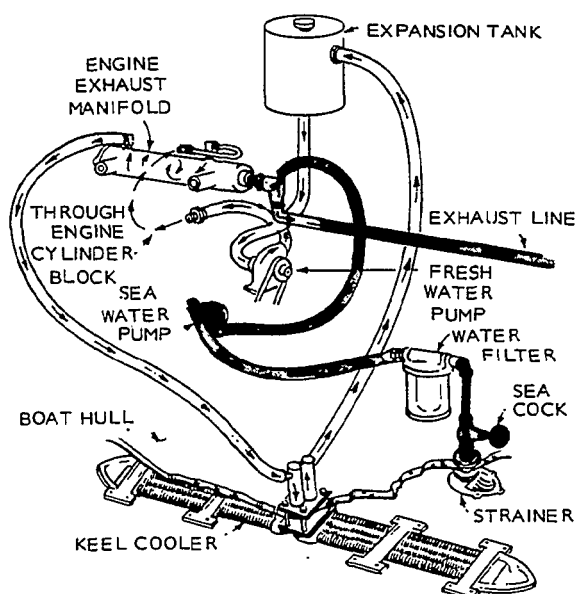


FIGURE 11. KEEL COOLER

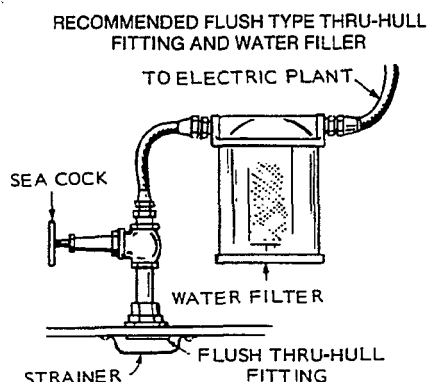
WATER FLOW

During normal operation, marine cooling systems intake a greater amount of dirt and sediment than would be expected with radiator or city water cooling systems. This contributes greatly to water pump wear and increases the chances that water passages will become clogged or restricted. It is important with marine cooling systems that the water flow be checked frequently to insure that adequate cooling is maintained.

Sea Water

All marine cooling systems (except keel coolers with dry stack exhaust) require a continuous flow of sea water for adequate cooling. Anything that reduces or blocks the flow of water in the sea water system may cause overheating. Remove the filter screen (Figure 12) from the water filter on a periodic basis and clean away any accumulations of dirt and sediment. Flush clean water through the screen before replacing the filter. Also, check all hoses and pipes to make sure there are no kinks or bends that could restrict water flow.

When the boat is dry docked, the water inlet strainer (located on outside of hull) should also be checked for accumulations of debris and cleaned if necessary. The water inlet should not be directly in line with other water inlets as this could reduce the amount of water received by the unit when the boat is underway. If more than one inlet is present, they should be staggered.



WARNING: DO NOT USE SCOOP TYPE WATER INLET FITTINGS ON ELECTRIC PLANTS USING AQUALIFT MUFFLER SYSTEMS.

FIGURE 12. TYPICAL MARINE WATER FILTER

CAUTION

Do not use a scoop-type water inlet fitting. When the boat is underway and the generator set is not running, sufficient ram pressure can force water past the sea water pump, flooding the exhaust system, and possibly flooding the engine cylinders.

Before starting operation, the sea water pump should be primed and checked for water flow. The pump is primed by removing a priming plug on the top of the pump (not necessary with metal impeller pumps) or by removing the outlet hose from the pump connection. Fill the pump and hose with water and replace the components. With the set running, check the exhaust outlet to verify that the pump is delivering water. An insufficient flow of water indicates that there are obstructions in the system, the water pump belt is loose, or the water pump is faulty. Inspect and replace any hoses or pipes that have become restricted or blocked. Refer to the section on *Water Pumps* for water pump service procedures.

The minimum water flow requirements (in GPM) for sea water systems are given in Table 2. If necessary, a test can be made to determine if the water flow is adequate. Run the engine and use a pail to catch the water that is discharged at the outlet connection on the exhaust elbow during a 15 second period. Measure the number of gallons collected and multiply that amount times 4 to obtain the flow rate in gallons per minute. Compare with the amount shown in Table 2 to determine if the flow rate is sufficient.

CAUTION

Do not run the generator set for more than one minute if the cooling system is faulty. Doing so can result in damage to water-cooled exhaust system components as well as to the engine.

TABLE 2. COOLING REQUIREMENTS

| MODEL | *kW RATING (MARINE DUTY) | MINIMUM ENGINE WATER FLOW (GPM) | | HEAT EXCHANGER COOLING AVAILABLE FROM ONAN | COOLING SYSTEM CAPACITY (PT) WITH HEAT EXCHANGER |
|----------|-----------------------------------|---|---|---|--|
| | | Direct Cooling (Sea Water System) | Heat Exchanger or Keel Cooler (Sea Water System) | | |
| 3.0MDJA | 3,000 | 3.4 | 3.66 | YES | 4.5 |
| 6.0MDJB | 6,000 | 3.8 | 3.0 | YES | 9 |
| 7.5MDJE | 7,500 | 3.8 | 3.0 | YES | 9 |
| 12.0MDJC | 12,000 | 4.0 | 4.7 | YES | 19 |
| 15.0MDJF | 15,000 | 4.0 | 4.7 | YES | 19 |

* Test at full load

Captive Water

A second pump (metal impeller type) is required for the captive water system on engines that have heat exchangers or keel coolers. This pump circulates engine coolant continuously through the water jacket to the heat exchanger or keel cooler. Check all hoses for kinks or bends that could restrict the water flow and correct as required.

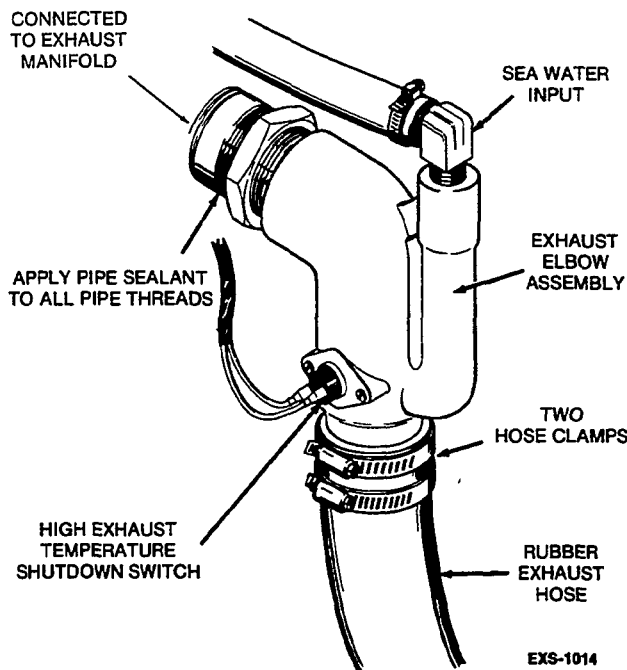


FIGURE 13. EXHAUST ELBOW

WATER COOLED EXHAUST

Marine exhaust systems are designed so that a minimum amount of heat will be radiated from the exhaust system components. This is done to keep the heat build-up in the engine compartment to a minimum. Exhaust heat is dissipated by using a water cooled exhaust manifold and a water injected exhaust pipe and muffler system. The exhaust manifold is encased in a shell through which engine coolant or sea water is circulated. Just beyond the exhaust manifold, a special elbow (see Figure 13) is fitted which allows the output water from the sea water system to be injected into the exhaust pipe. The injected sea water is carried out through the exhaust system and discharged.

Typical Installations

All water injected exhaust systems must be designed so that the discharge water will not flow back into the engine. There are several methods that can be used to keep water out of the engine. All are based on injecting the water at a point a few inches (approximately 4 [102 mm]) below the exhaust manifold outlet and installing a sharp drop in the exhaust line that water cannot normally flow over.

SIPHON BREAK

A siphon break is used with all marine installations where the exhaust water injection elbow is **BELOW** the load water line. The siphon break (see Figure 14) is a vacuum operated vent valve that opens the exhaust water discharge line to the atmosphere when the engine shuts down. The open valve prevents flotation water from being siphoned into the exhaust manifold. The siphon break is mounted no less than 12 inches (305 mm) above the water line. If space is limited it may be remotely mounted but must be within 5 feet more than (1.5 m) of the exhaust water injection elbow. In all installations the siphon break must be mounted vertically with the threaded end pointing down.

CAUTION *Be sure the slotted opening in the vacuum relief valve is open to atmospheric pressure. The siphon break will not function if the relief valve slot is closed in any way.*

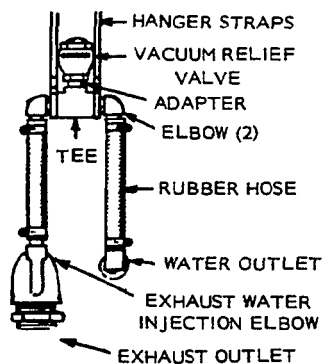


FIGURE 14. SIPHON BREAK

HEAT EXCHANGERS

Several types of heat exchangers are currently in use with marine cooling systems. The front mount type of heat exchanger shown in Figure 15 is used with the MDJA and MDJB and was used with earlier models of the MDJE, and MDJF. It is mounted at the front of the engine perpendicular to the engine center line. The end caps are removable for cleaning and a separate expansion tank is required. The sea water side of these heat exchangers is protected from corrosion with either one or two zinc pencils (mounted on pipe plugs) that are placed in one end of the heat exchanger.

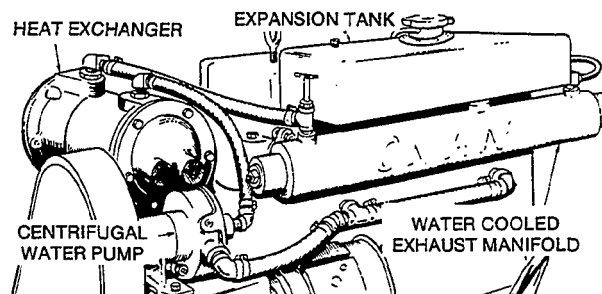


FIGURE 15. FRONT MOUNT HEAT EXCHANGER

The side mount type of heat exchanger shown in Figure 16 is used with later models of the MDJC, MDJE, and MDJF. It is mounted on the side of the engine just above the exhaust manifold. The end caps are removable for cleaning and the expansion tank is incorporated with the outside shell. On some models, the sea water side of the heat exchanger is protected from corrosion with a zinc pencil located close to the sea water inlet. Other models may not have zinc pencils.

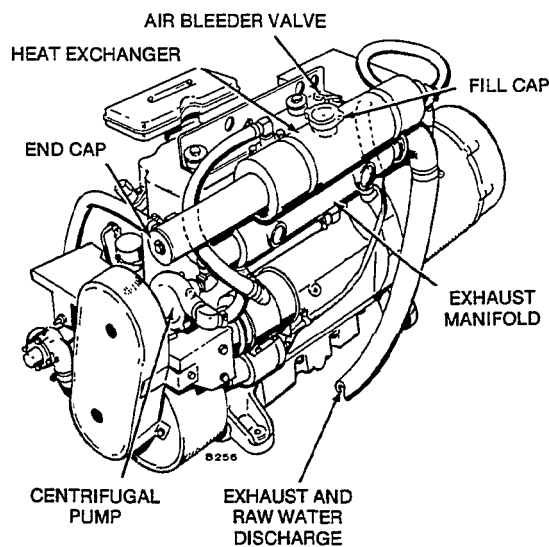


FIGURE 16. SIDE MOUNT HEAT EXCHANGER

Sea Water Side

Remove and inspect the zinc pencils that are used for corrosion protection every two months. Replace if the pencils are deteriorated to less than one half their original size.

The sea water side of the heat exchanger should be inspected and cleaned on a yearly basis. Remove the two end caps and flush out any deposits that may have accumulated in the tubes. Be certain to note the position of the gaskets when removing the heat exchanger ends. On some models the gaskets direct the water flow and when replaced must be positioned the same way they were when removed.

Captive Water Side

The captive water side of the heat exchanger should be protected from corrosion and scale formation by filling the engine cooling system with a 50/50 mixture of antifreeze and water. If not protected, rust and scale will form on the walls of the engine water jacket. The rust and scale will combine to form an insulation layer on the water jacket which will reduce the efficiency of heat transfer to coolant. This can lead to overheating and subsequent damage to the engine.

Rusty water or rusty solutions of antifreeze indicate the formation of rust on the water jacket. If this is the case, the engine water jacket and heat exchanger should be cleaned and thoroughly flushed out, as described in the *MAINTENANCE* section. Use a chemical cleaner to remove rust and scale deposits, following the procedure recommended by the supplier.

KEEL COOLERS

Keel cooling (see Figure 17) is available as an option on the MDJA, MDJB, MDJC, MDJE, and MDJF generator sets. The captive water pump, mounting bracket, belt guard, hose, and fittings are supplied by Onan. Some sets may also have a sea water pump for injecting water into the exhaust system, while other sets may use a dry stack exhaust. The keel cooler, expansion tank, and plumbing must be supplied by customer.

The keel cooler should be protected from corrosion and scale formation by filling the engine cooling system with a 50/50 mixture of antifreeze and water. Follow the same service procedures recommended for the captive water side of heat exchangers (see previous section) to remove rust or scale formations.

With some keel cooler systems, a sea water pump is used for injecting water into the exhaust system. Check the water filter after every 100 hours of operation. Change sooner if the unit is used under exceptionally dirty water conditions. When the boat is dry docked, inspect the keel cooler and remove any accumulation of sediment or debris.

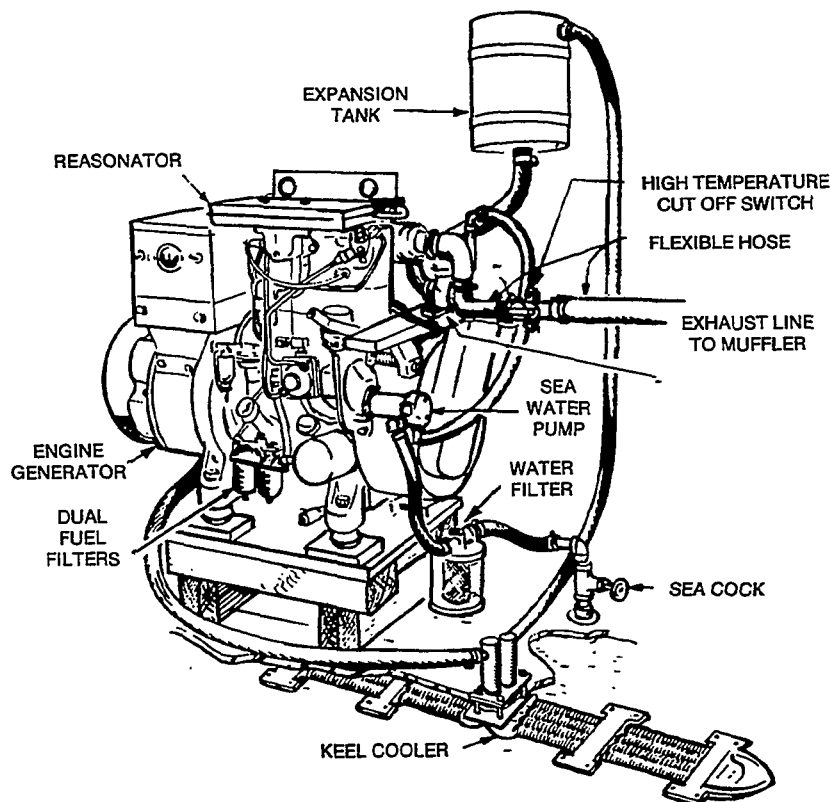


FIGURE 17. KEEL COOLER INSTALLATION

MARINE WATER PUMPS

Two types of marine water pumps are in general use: the metal impeller pump and the neoprene impeller pump. Each pump has certain advantages and disadvantages (see Table 3) and both are used extensively with marine cooling systems. Two types of pumps are necessary because water pumps are used to perform different functions, depending on the type of cooling system and the operating conditions. Metal impeller pumps provide no suction lift but can operate in hot, cold, or dirty water. Neoprene impeller pumps provide a suction lift, but can be used only with clean, cool water.

The metal impeller pumps are used for captive water systems, and the neoprene impeller pumps are used for sea water systems. All captive water system pumps (metal impeller) are driven by a V-belt from the engine crankshaft. All sea water pumps (neoprene impeller) for the J-series (except MDJE, Spec AB) are gear driven.

Captive Water Pump

Periodically check the captive water pump for wear or signs of leakage from the shaft seal. Loosen the drive belt and move the water pump pulley back and forth. The pulley should be tight on the shaft and only a slight amount of bearing play should be felt. Rebuild the pump if wear is excessive or if the seal leaks. Refer to the section on *Water Pumps* for water pumps service procedures.

Sea Water Pump

Periodically check the sea water pump for signs of leakage from the shaft seal. A leaking shaft seal may allow water to enter the crankcase and contaminate the engine oil. Remove the pump end cover (see Figure 18) and inspect the impeller for cracking or signs of wear. The impeller deteriorates with time because of continuous flexing and must be periodically replaced. If the impeller fails, check for pock marks on its end surfaces. This indicates that air has been entering cooling system, reducing pump lubrication and causing overheating. Check all hose connections for leaks that could admit air, and tighten as required. If the impeller fails after short service (under 500 hours), check for possible defects. If impeller blades have broken, locate and remove the particles or they will impede water flow. When re-installing, coat the impeller with grease, and make certain the impeller cover is air-tight. Tighten the cover screws to 15-17 inch-pounds (1.70-1.92 Nm). Refer to the section on *Water Pumps* for water pump service procedures.

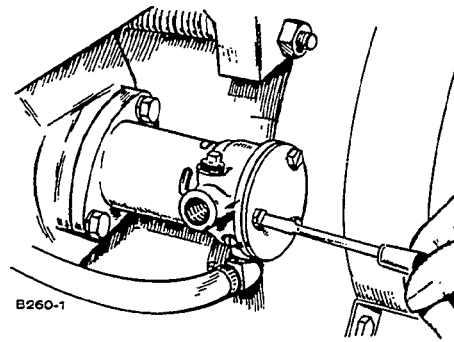


FIGURE 18. END COVER REMOVAL

WATER PUMP REPAIR

This section covers removal, repair, and installation procedures for all metal impeller and neoprene impeller water pumps used with Onan marine liquid-cooled engines. Repair Kits are available for most water pumps. Table 3 shows the water pumps used with Onan marine liquid-cooled engines. Metal impeller pumps are required for circulating HOT engine coolant. They are most commonly used with marine cooling systems that use a heat exchanger. Neoprene impeller pumps may be used only for pumping COOL water because the impeller deteriorates rapidly in hot water. They are most commonly used for pumping sea water in marine cooling systems.

TABLE 3. WATER PUMPS

| METAL IMPELLER PUMPS | |
|--|--------------------------------------|
| 132-0110 With Heat Exchanger | 132-0074 With Keel Cooler |
| MDJA (Also for Keel Cooler Models) MDJB MDJC MDJE MDJF | MDJB MDJC MDJE MDJF |

| NEOPRENE IMPELLER PUMPS | | | | |
|--------------------------------|---|---|-------------------------------------|---|
| 131-0257 | 131-0152 | 132-0115 | 132-0147 | 132-0059 |
| MDJE Begin Spec AB | MDJA Begin Spec E MDJB Begin Spec L MDJC Begin Spec D w/o heat exchanger Spec D-R with heat exchanger MDJE Spec A-AA MDJF w/o heat exchanger | MDJC Spec S w/heat exchanger MDJF before 1976 w/heat exchanger | MDJF Begin 1976 with heat exchanger | MDJA Spec A-D MDJB Spec A-K MDJC Spec A-C |

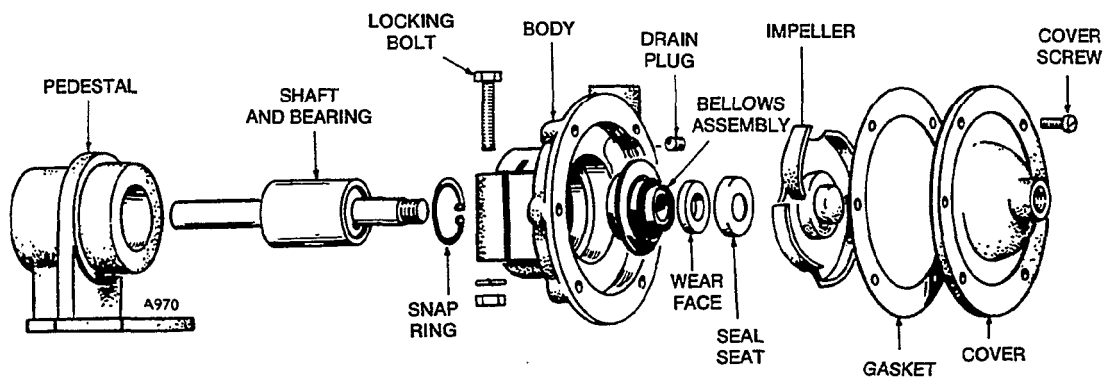


FIGURE 19. PUMPS #132-0110 AND #132-0074

WATER PUMPS #132-0110 and #132-0074

Pumps #132-0110 and #132-0074 are centrifugal pumps with metal impellers (Figure 19).

Disassembly

1. Remove the water inlet fitting, drive belt pulley, cover screws, and pump cover gasket.
2. Unscrew the threaded impeller from the pump shaft by turning the impeller in a counterclockwise direction (when facing impeller).
3. Slide the seal seat, wear face, and bellows assembly off the shaft. Loosen the clamp screw and slide the pump body off the pedestal.
4. Remove the bearing lock ring and drive the shaft and bearing assembly out of the pedestal. The bearing is press fit on the shaft and comes off in one integral part. The bearing is packed with a lifelong lubricant and is sealed at each end.

Assembly

Replace all worn components such as bearings, seals, wear face, and impeller and use a new cover gasket. Assembly sequence is the reverse of the disassembly procedure.

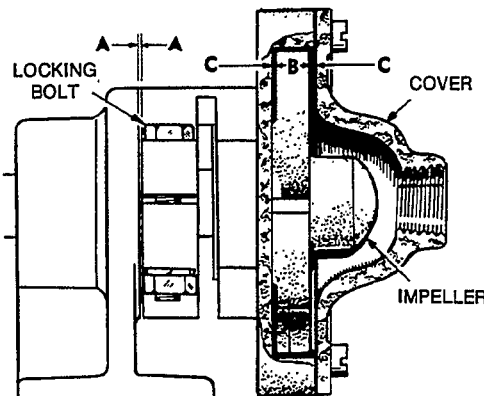


FIGURE 20. WATER PUMP CLEARANCES

Centering Pump Body

After the pump has been assembled (see Figure 20), the impeller (B) must be centered in the body cover space (C-C). Adjustment is made by moving the pump body fore and aft until the shaft can be rotated freely by hand, without binding. The pump must be adjusted with the drive belt off. If not centered properly, the impeller will rub on the body or cover and quickly overheat. Clearance (A-A) may vary from zero to 1/16 inch (1.6 mm). Tighten lock screw when adjustment is correct, being careful not to alter setting.

When the pump is reinstalled on the engine, check to see that the pump pulley is aligned with the crankshaft pulley and adjust as required.

WATER PUMP #131-0152

Water pump #131-0152 is a neoprene impeller type pump (Figure 21).

Disassembly

1. Remove the pump end plate screws, end plate, and gasket as shown in Figure 21, step a.
2. Pull out neoprene impeller with a pair of pliers (Step b).
3. If further disassembly is required, disconnect the hoses and remove the two cap screws holding the pump to the engine (Step c). Lift pump from engine.
4. Loosen the set screw on the side of the pump and tap it lightly to free the cam from the pump body. Lift out cam and wear plate (Step d).
5. Remove the retaining ring (using a screwdriver) as shown in Step e, and slide the seat assembly (O-ring and ceramic seal) off the pump shaft.
6. Pry the bellows assembly out of the pump body by inserting a screwdriver through the drain slots (Step f).
7. Drive the shaft and bearing assembly out of the pump body using a bearing driver or press. The bearing is press fit on the shaft and comes off in one integral part.

Assembly

Inspect the pump housing for wear, rough surfaces, or pitting, and replace if any of these conditions exist. Replace any other worn components such as bearings, seals, or impeller and use a new end plate gasket.

1. Apply sealing compound to the sealing lip around the edge of the bellows seal. Place the bellows seal in the pump body and drive it into place (Step g).
2. Apply a small amount of Loctite or equivalent on the outside surface of the bearing (Step h).
3. Place the bearing and shaft assembly in the pump bore and drive into place (Step i). Strike outer race only to avoid damage to pump shaft and bearing.
4. Lubricate both sides of the seat assembly (ceramic seal and O-ring) with lubricating oil and slide assembly over pump shaft. The ceramic portion of the seat assembly should contact the bellows. Compress the seat assembly against the bellows, and at the same time push the retaining ring into its groove on the pump shaft.
5. Place wear plate and cam so notch in wear plate lines up with tang on cam (Step j). Fasten cam to housing with screw.
6. Align the flat spot in the center of the impeller with the flat spot on the pump shaft. Bend back the impeller blades nearest the cam and push the impeller onto the shaft. Do not remove the factory coating of oil from the new impeller before installing.

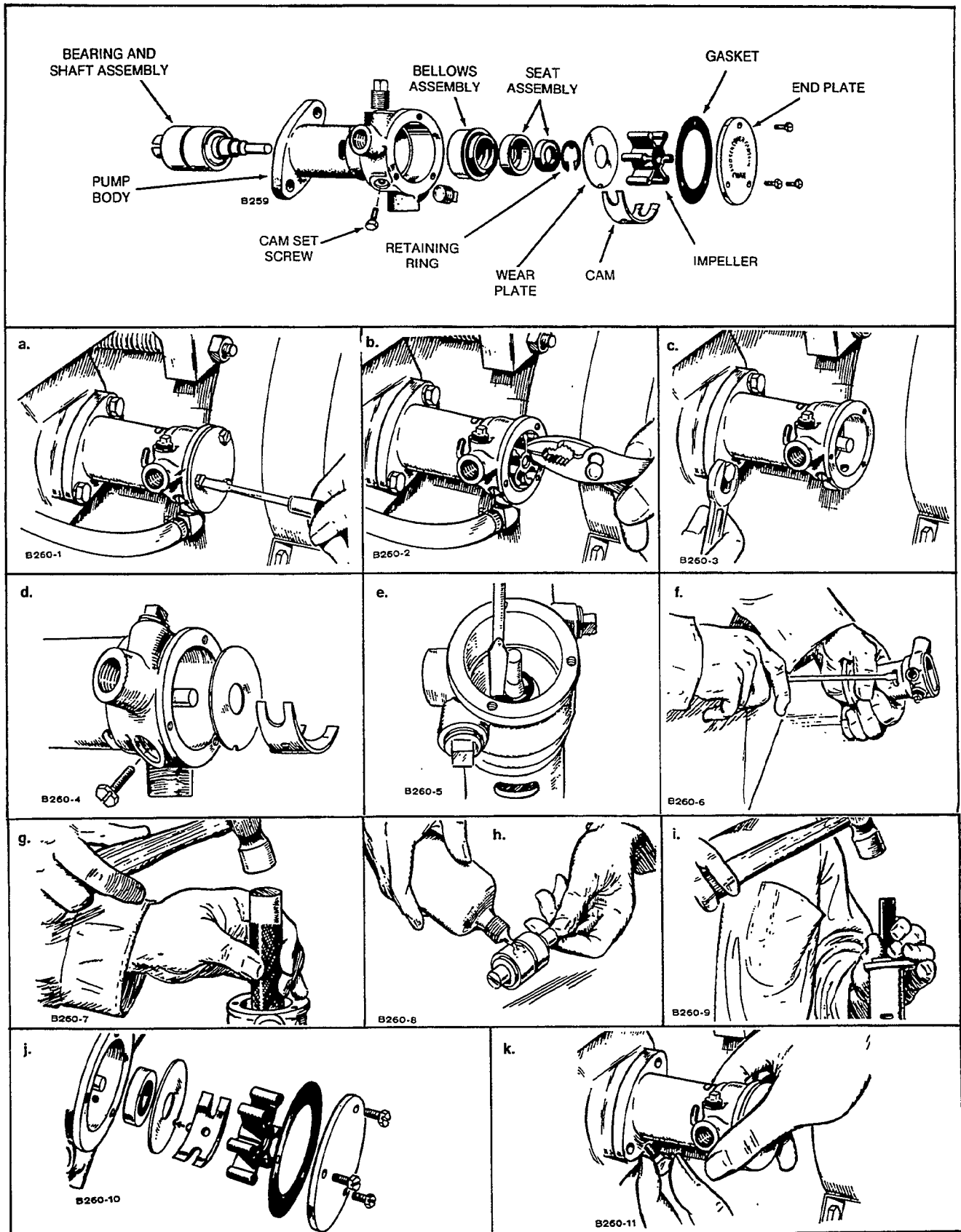


FIGURE 21. PUMP #131-0152

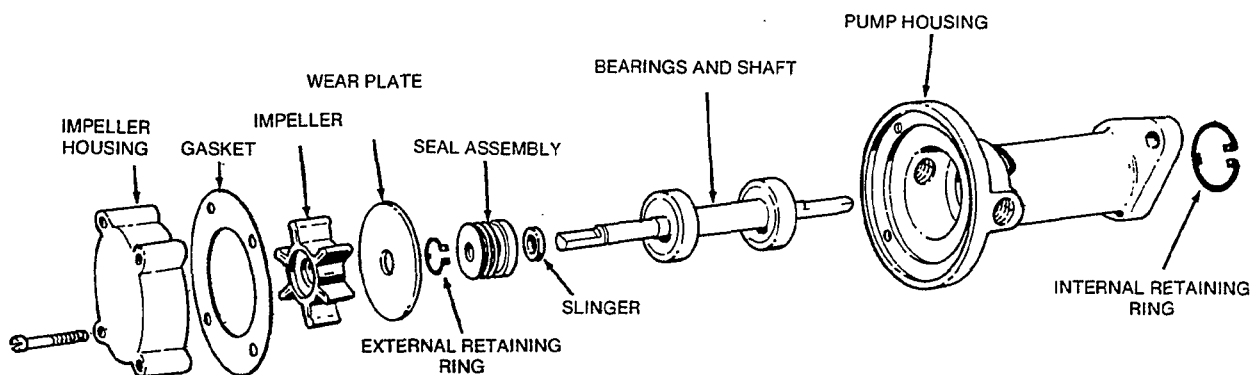


FIGURE 22. PUMP #131-0257

7. Install the pump end plate using a new gasket and tighten end plate screws to 15-17 inch pounds (1.7-1.9 Nm).
8. Install pump on engine (Step k) and attach hoses.

WATER PUMP #131-0257

Water pump #131-0257 is a neoprene impeller type pump (see Figure 22).

Disassembly

1. Disconnect all hoses and remove the pump from the engine.
2. Loosen the pulley set screw and remove the pulley from the pump shaft.
3. Remove the impeller housing screws, impeller housing, and gasket.
4. Pull the impeller out of the impeller housing.
5. Remove the wear plate from the pump housing, using a screwdriver to pry the plate loose if necessary.
6. Remove the external retaining ring from the impeller end of the water pump shaft.
7. Remove the two piece seal assembly. The spring portion of the seal is removed first. The second portion of the seal can be loosened and removed with a screwdriver or needle-nose pliers.
8. Remove the internal retaining ring from the drive pulley end of the pump housing.
9. Carefully drive out the shaft and bearing assembly from the impeller end of the housing.
10. Remove the slinger from the water pump shaft.

Assembly

Inspect the impeller housing for wear, rough surfaces, or pitting, and replace if any of these conditions exist. Replace any other worn components, such as bearings, seals, or impeller and use a new impeller housing gasket.

1. Install the new slinger on the water pump shaft.
2. Install the ceramic part of the two piece seal assembly in the pump housing. The rubber side of the seal should be toward the bearings.
3. Coat the inside of the water pump housing and the outside of the ball bearing races with grease.
4. Insert the water pump shaft into the pump housing and install the internal retaining ring in the drive pulley end of the housing.
5. Install the spring portion of the two piece seal on the pump shaft and secure in place with the external retaining ring.
6. Install the wear plate so that the notch in the plate fits into the machining in the pump housing.
7. Coat the inside of the impeller housing with grease.
8. Install the impeller in the impeller housing by twisting it clockwise while pushing it into place.
9. While holding the gasket in place against the pump housing, install the impeller housing securing it with four screws removed during disassembly.
10. Mount the pump on the engine and attach the hoses.
11. Align the pump drive pulley with the crankshaft drive pulley and tighten the set screw.

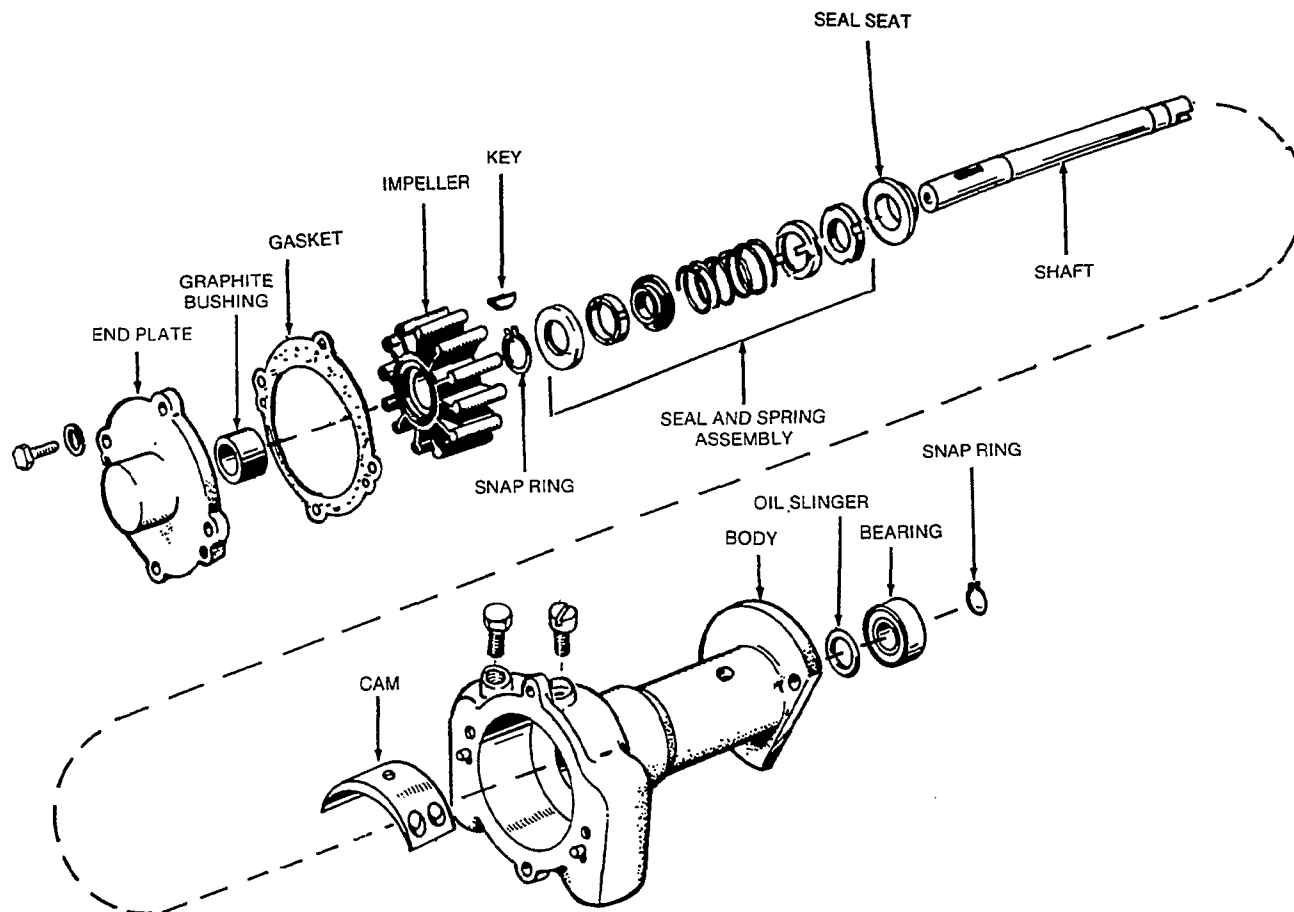


FIGURE 23. PUMP #132-0115

WATER PUMP #132-0115

Water pump #132-0115 is a neoprene impeller type pump (see Figure 23). An alternate pump was occasionally used for part number 132-0115. Refer to the rebuild procedures for pump #132-0146 if the pump being serviced does not match the pump shown in Figure 23.

Disassembly

1. Remove the pump end plate screws and lock washers, end plate, and gasket.
2. Pull out neoprene impeller with a pair of pliers, being careful not to damage the pump body.
3. If further disassembly is necessary, disconnect the hoses and remove the two cap screws holding the pump to the engine. Lift pump from engine.
4. Remove the snap ring from the drive end of the pump shaft.
5. Remove the shaft assembly by tapping lightly on the drive end of the shaft. Use a brass or wood dowel to avoid damaging the shaft.
6. Slide the seal and spring assembly off the drive end of the shaft.

7. Insert the drive end of the shaft into the impeller end of the pump. Guide the shaft through the seal until the shaft shoulders against the bearing. Tap lightly on the shaft with a brass or wood dowel until the bearing is out. Also remove the oil slinger or O-ring.
8. Insert the impeller end of the shaft into the engine end of the pump and guide it through until the snap ring shoulders against the seal seat. Tap lightly on the shaft until the seal seat is out.
9. The graphite bushing in the end plate may be removed by drilling. Do not drill through the end of the cover plate.

Assembly

Inspect the pump housing for wear, rough surfaces, or pitting and replace if any of these conditions exist. Replace any other worn components such as bearings, bushings, seal, seal seat, and impeller. Use a new end plate gasket when reassembling. A new bushing may be pressed into the end plate after cleaning. Pump assembly is the reverse of disassembly.

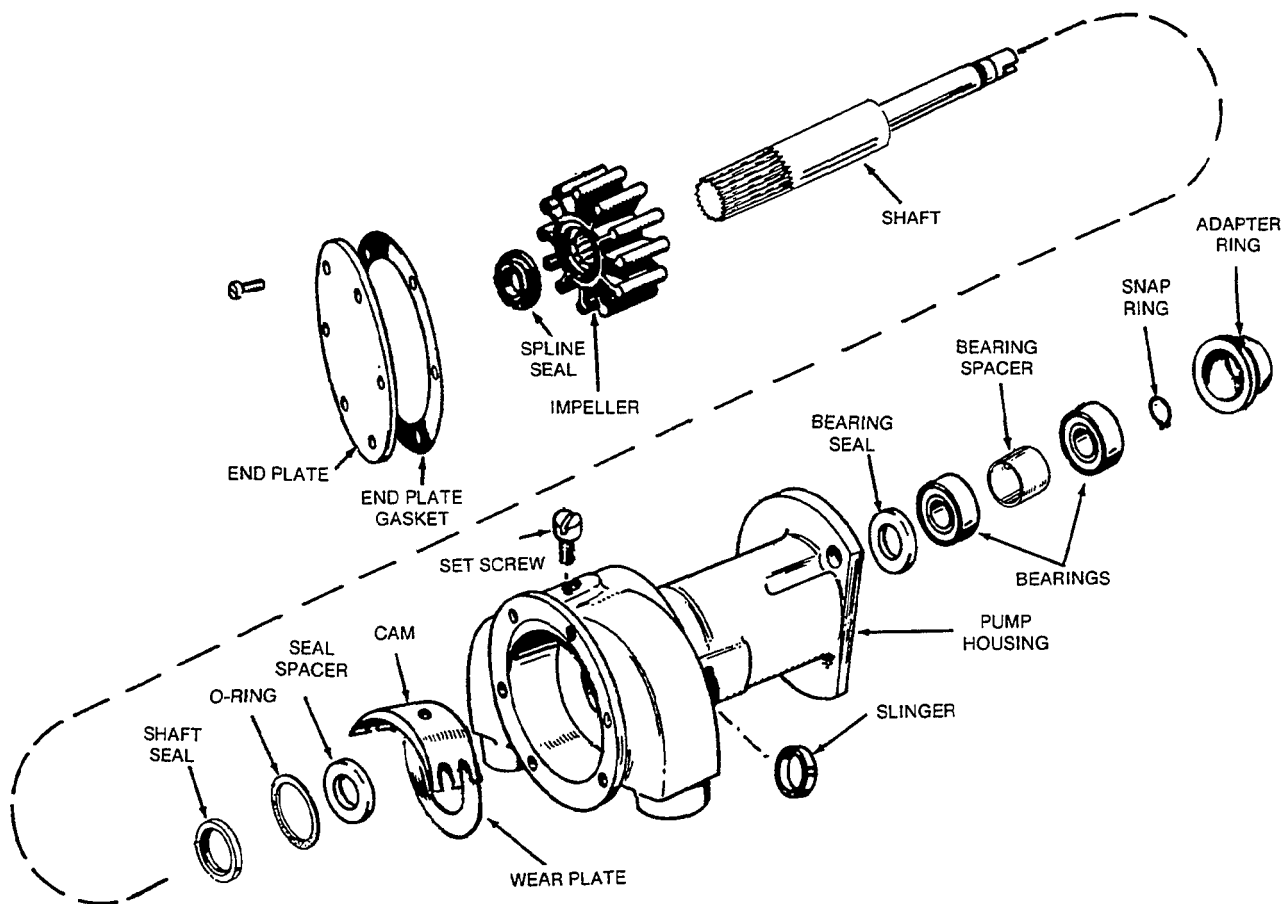


FIGURE 24. PUMPS #132-0146 AND #132-0147

WATER PUMPS #132-0146 and #132-0147

Water pumps #132-0146 and #132-0147 are neoprene impeller type pumps (see Figure 24).

Disassembly

1. Remove the pump end plate screws, end plate, and gasket.
2. Pull out the neoprene impeller with a pair of pliers, being careful not to damage the pump body.
3. If further disassembly is necessary, disconnect the hoses and remove the cap screws holding the pump to the engine. Lift pump from engine.
4. Force out the shaft assembly and adapter ring from the pump body by pressing on the impeller end of the shaft.
5. Remove the set screw from the side of the pump and lift out the cam and wear plate.
6. Carefully pry the bearing seal out of the bearing bore using a screwdriver.
7. Press out the shaft seal from the pump body by forcing it toward the impeller bore.
8. Remove the O-ring, seal spacer, and slinger from the impeller bore.

Assembly

Inspect the pump housing for wear, rough surfaces, or pitting and replace if any of these conditions exist.

Replace any other worn components such as bearings, seal, seal seat, and impeller. Use a new end plate gasket when reassembling.

1. Press the bearing seal into the bearing bore with the lip towards the bearing side.
2. Insert the impeller end of the shaft into the drive end of the pump housing and press the shaft and bearing assembly into the bearing bore.
3. Press the adapter ring into the drive end of the pump body.
4. Install the slinger on the shaft and place the seal spacer in the seal cavity.
5. Install the O-ring in the seal bore and press the seal into the seal bore with the lip toward the impeller side.
6. Coat the top of the cam and the cam set screw threads with sealer and install the wear plate and cam assembly. Be sure that the cam is flush with the end cover before tightening the set screw.
7. Lubricate the impeller bore with grease and install the impeller and spline seal.
8. Lubricate the impeller face with grease. Hold the new end cover gasket against the pump housing and install the end cover, securing it with six screws.
9. Mount the assembled pump on the engine and attach the hoses.

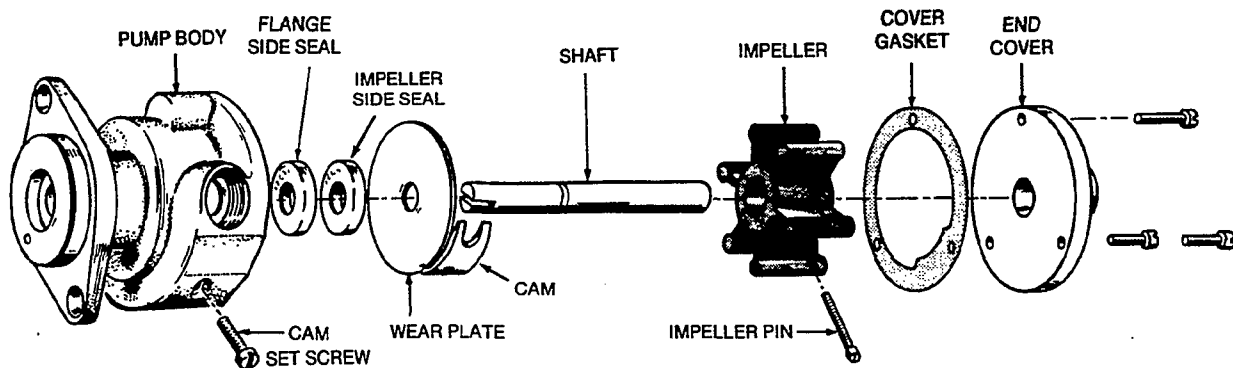


FIGURE 25. PUMP #132-0059

WATER PUMP #132-0059

Water pump #132-0059 is a neoprene impeller type pump (Figure 25).

Disassembly

1. Disconnect the hoses and remove the cap screws holding the pump to the engine. Lift pump from engine.
2. Remove the end cover screws, end cover and gasket.
3. Pull the impeller and shaft assembly from the pump body.
4. Remove the impeller pin and slide the impeller off the shaft.
5. Loosen the cam set screw on the side of the pump and tap it lightly to free the cam from the pump body. Lift out cam and wear plate.
6. Working from the mounting flange end, use a small drift punch to drive the seals out toward the impeller. Remove the seal next to the impeller bore first. Be careful not to damage the bore area around the seal.

Assembly

Inspect the pump housing for wear, rough surfaces, or pitting and replace if any of these conditions exist. Replace any other worn components such as seals or impeller. Use a new end cover gasket when reassembling.

1. Install the impeller side seal with the seal lip facing away from the impeller bore. Lubricate the seal lip with grease.
2. Install the flange side seal with the seal lip facing away from the mounting flange. Lubricate the seal lip with grease.
3. Place the wear plate in the bottom of the impeller bore with the raised portion of the dimple facing up.
4. Coat the top of the cam and cam set screw threads with sealer. Line up the dimple in the wear plate with the hole in the cam and then tighten the set screw.
5. Slide the impeller over the shaft and secure with the impeller pin. Lubricate the shaft with grease. Check shaft to make sure it is free of burrs.
6. Lubricate the impeller bore with grease and then install the shaft and impeller assembly. Use a twisting motion when fitting the impeller into the impeller bore.
7. Hold the new end cover gasket against the pump housing and install the end cover, securing it with three screws.
8. Mount the assembled pump on the engine and attach the hoses.

COOLING SYSTEM HOSES

Leakage is the most common cooling system trouble. Besides losing coolant, leaks may also admit air. This can result in premature failure of the water pump impeller.

Test all hoses by squeezing and replace any that have become cracked and brittle or overly soft. Verify that all clamps and connections are tight and check for leakage. White, rusty, or colored stains indicate points of previous leakage.

With the generator set running, observe the water that is discharged from the exhaust outlet.* The presence of air bubbles indicates that air is being admitted into the sea water system. Tighten all hose connections as required.

*Cannot be observed if Aqualift muffler is used.

EXHAUST SYSTEM HOSES

Inspect all exhaust system hoses for leaks and replace any hoses that are cracked and brittle or overly soft. Rubber hose should be used only in the water cooled sections of the exhaust. When replacing, use only rubber hose designed and approved for marine exhaust use. Provide adequate support for rubber hose to prevent sagging, bending, and formation of water pockets. Automotive type tail pipe hangers should be used to prevent vibration from being transmitted to the hull. Use two hose clamps, having a minimum width of 1/2 inch (12.7 mm), at each end of the hose.

WARNING

Inhalation of exhaust gases might result in serious personal injury or death. Do not make any sharp bends in rubber exhaust hose when installing as it might cause hose failure and gas leakage.

The exhaust line should be at least as large as the engine exhaust outlet and increased one pipe size for each ten feet of length.

WARNING

Inhalation of exhaust gases might result in serious personal injury or death. Pipe exhaust outside the hull and do NOT terminate exhaust pipe near any window or bulkhead door openings.

ENGINE WATER JACKET AND CYLINDER HEAD

External coolant leakage may occur at any of the joints in the engine water jacket such as the drain plugs, core hole plugs, or cylinder head joints. Since expansion or contraction can aggravate leakage, the block should be inspected both hot and cold while the engine is running.

Internal leakage occurs when coolant passes into the engine oil through a loose cylinder head joint, worn water pump shaft seal, or a cracked or porous casting. The leakage is not visible but can cause extensive damage to the engine. The coolant mixes with the oil to form sludge which causes lubrication failure. Heavy sludge accumulations followed by sticking piston rings, valves, and valve lifters are symptoms of internal leakage.

Sometimes internal leaks are tight enough to prevent coolant leakage but permit exhaust gases to enter the cooling system. The exhaust gases dissolve in the coolant, depleting the rust inhibitors and forming acid which causes corrosion.

A leaking water pump shaft seal can allow water to enter the crankcase on J-series engines with water pump #132-0147. Refer to *WATER PUMP REPAIR* section for pump repair procedure.

DRIVE BELTS

A V-belt is used to drive all captive water system pumps. Belt tension is adjusted by changing the position of the pump.

Inspect the belt periodically and replace if worn or glazed. Also check to see if the pulleys are properly aligned and if the belt tension is sufficient.

To adjust the belt, remove the belt guard and loosen the water pump mounting bolts. Slide the pump back and forth in the mounting base slots until the correct belt tension is obtained. There should be a 1/2 inch (12.7 mm) deflection when a 15 lb (67 N) force is applied at the midpoint of the belt. Tighten the mounting bolts when the correct tension is reached and reinstall the belt guard.

EXPANSION TANK

An expansion tank is required with heat exchanger and keel cooler cooling to allow for coolant expansion and to provide for separation of air from the coolant. With front-mount heat exchangers and keel coolers a separate expansion tank is required. With side mount heat exchangers the expansion tank is an integral part of the heat exchanger. A pressure cap is fitted to the top of the tank to maintain system pressure.

PRESSURE CAP

The pressure cap increases the boiling point of the coolant by allowing pressure to build up in the cooling system. The increase in boiling point reduces the chances for coolant loss due to boil over. A 15 psi (103.5 kPa) pressure cap will raise the boiling point of water to 250°F (122°C) and the boiling point of a 50/50 mixture of water and antifreeze to 265°F (132°C).

Inspect the pressure cap periodically for freedom of operation and verify that the spring applies a fairly stiff tension and is not easily compressed. Peel the pressure cap gasket back and check for wear and cracking. Excessive dripping from the overflow tube may indicate a faulty cap. Replace the cap if it malfunctions or is worn.

WARNING

Contact with hot coolant might result in serious burns. Do not bleed hot, pressurized coolant from a closed cooling system.

Pressure caps should be inspected regularly for gasket wear and spring action. A pressure tester may be used if available to verify that the cap can hold its rated pressure value. The pressure ratings for the various caps are shown in Table 4.

Refer to the appropriate Parts Catalog for the pressure cap part number.

**TABLE 4
PRESSURE CAP TEST**

| PART NUMBER | RATED PRESSURE PSI | ACCEPTABLE LIMITS PSI |
|-------------|--------------------|------------------------|
| 130-0589 | 14 (97 kPa) | 12-15 (83-98 kPa) |
| 130-0661 | 7 (48 kPa) | — |
| 130-0824 | 15 (98 kPa) | — |
| 130-0553 | 4 (28 kPa) | 3.5-4.5 (24-31 kPa) |

HIGH TEMPERATURE CUT-OUT SWITCH

A high temperature cut-off switch shuts down the engine if the coolant in the water jacket reaches a dangerously high temperature. This normally closed switch is a safety device designed to protect the engine from damage caused by overheating (see Figure 26).

J-SERIES WITH SEA WATER COOLING
OR KEEL COOLER

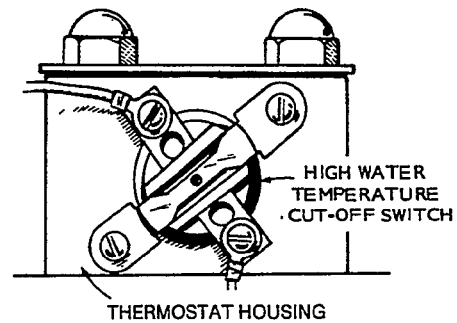


FIGURE 26. HWTKO SWITCH

When engine temperature rises beyond a specific point the switch opens breaking B+, allowing fuel solenoid to close on diesel engines. When coolant temperature lowers to a safe operating range the switch closes, permitting engine restarting.

A second high temperature cut-off switch is sometimes used with generator sets that have a water injected exhaust system. The second switch is mounted on the exhaust elbow (see Figure 13). If the exhaust system overheats, the switch shuts down the generator set before the exhaust system components are damaged. The two switches are wired together in series so that opening either switch will shut down the engine.

Stopping of the engine due to action of the high temperature cut-off switch is not a normal condition. Examine the cooling system to determine the cause of the overheating and repair as required. The opening and closing temperatures for each switch are shown in Table 5. Refer to the appropriate Parts Catalog for the part number of the high temperature cut-out switch used in the engine being serviced.

**TABLE 5
HIGH TEMP CUT-OUT SWITCH**

| PART NUMBER | TEMPERATURE °F | |
|-------------|-------------------|--------------------|
| | OPEN | CLOSE |
| 309-0259 | 230° ± 7° (110°C) | 190° ± 9° (88°C) |
| 309-0179 | 190° (88°C) | 215° ± 5° (102°C) |
| 309-0178 | 180° (83°C) | 205° ± 5° (97°C) |
| 309-0002 | 160° ± 5° (71°C) | 200° ± 7° (93°C) |
| 309-0151 | 200° ± 5° (93°C) | 160° ± 7° (71°C) |
| 309-0156 | 250° ± 5° (121°C) | 230° ± 7° (110°C) |
| 309-0252 | 200° ± 5° (93°C) | 160° ± 7° (71°C) |
| 309-0192 | 290° ± 8° (143°C) | 250° ± 12° (121°C) |

THERMOSTAT

The thermostat is a heat operated valve that controls engine temperature by regulating the amount of heated coolant that is discharged (direct flow) or recirculated (heat exchanger and keel cooler). As the engine temperature increases, the thermostat opens and allows coolant to circulate. Prior to the thermostat opening, a small amount of coolant circulates through an internal by-pass. The continuous circulation of the coolant through the by-pass allows the various parts of the engine to warm up at a uniform rate and avoids localized hot spots.

When the thermostat is not operating properly, the engine may run too hot or too cold. Overheating may damage the thermostat so that the valve will not function properly. Also, rust or corrosion may interfere with its operation.

Two thermostats are used on the 4 cylinder J-series generator sets with front mount heat exchangers. One thermostat is used on the 1 and 2 cylinder J-series (all), and on 4 cylinder J-series generator sets with side mounted heat exchangers. Figure 27 shows the thermostat locations.

If a faulty thermostat is suspected, remove it and test it for proper opening and closing.

Testing

A defective thermostat may cause the engine to run too hot or too cold and must be replaced if faulty. Thermostats should be tested for proper opening and closing. If a sticking or faulty thermostat is suspected, test as follows:

1. Remove thermostat from the cylinder head.
2. Heat a pan of water to the opening temperature specified in Table 6. Check temperature using a thermometer immersed in water.
3. With the thermostat suspended in water at the specified opening temperature, check to see that the thermostat begins to open. It should be possible to slip a 0.003 inch (0.08 mm) feeler gauge between the valve and thermostat body.
4. Continue heating the water until the temperature specified for full opening is reached. Check to see that the thermostat is open by the amount specified in Table 6.
5. Remove the thermostat from the hot water and allow it to cool in the surrounding air. The thermostat should close within a short time.
6. If the thermostat sticks or does not operate properly, replace it with a new one.
7. Always install a new gasket when replacing the thermostat.

Refer to the appropriate parts catalog for the thermostat part number.

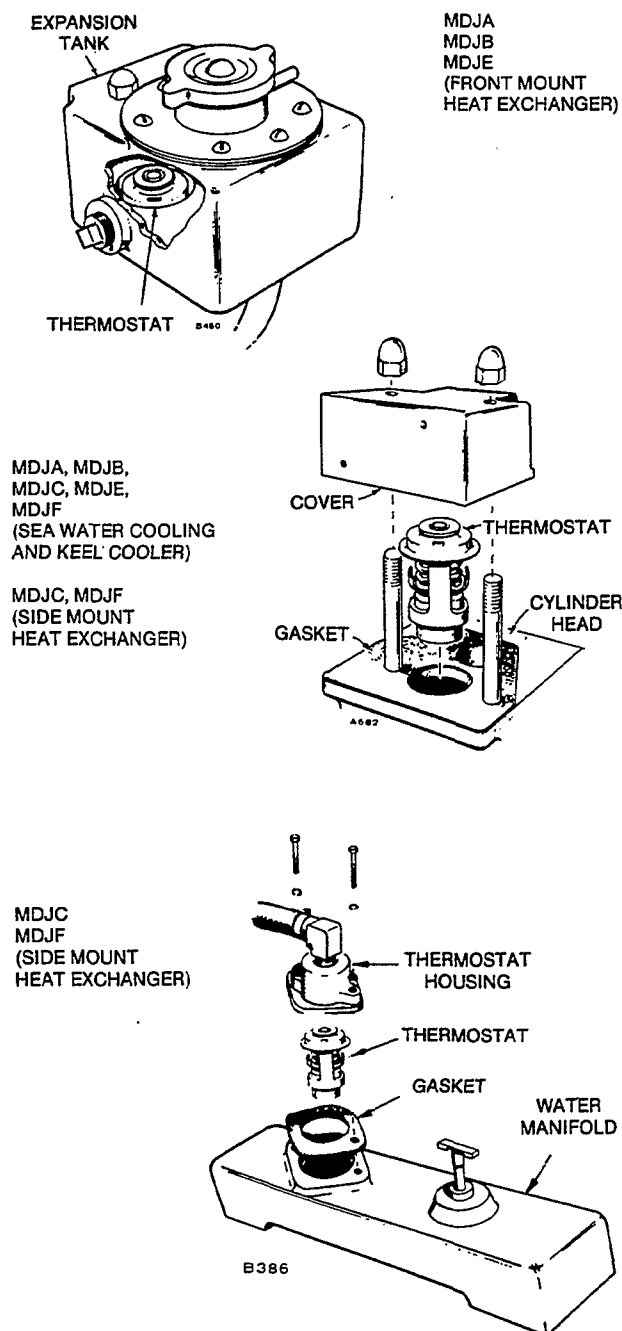


FIGURE 27. THERMOSTAT LOCATIONS

TABLE 6
THERMOSTAT TEST

| PART NUMBER | OPENING TEMP. °F | WIDE OPEN TEMP. °F/MIN. STROKE |
|-------------|-------------------------------|---------------------------------|
| 309-0054 | 147° to 154° (64° to 68°C) | 150°/.360 in. (66°C/9.14 mm) |
| 309-0298 | 157° to 164° (70° to 74°C) | 184°/.360 in. (85°C/9.14 mm) |
| 309-0130 | 140° to 145° (60° to 63°C) | 165°/.130 in. (74°C/3.30 mm) |
| 309-0289 | 175° to 182° (80° to 84°C) | 202°/.096 in. (95°C/2.44 mm) |

MARINE MUFFLERS

A marine muffler is used to silence the generator set. Some mufflers have an integral water injection inlet, while others are cooled by water through the exhaust line.

Placement of the muffler in the exhaust line depends on the type of muffler used. Usually some tailpipe is left to improve silencing. Refer to the manufacturer's installation instructions if the muffler does not function properly.

All mufflers must be well supported, and in the case of a neoprene muffler, completely separated from the hull of the boat. If a neoprene muffler touches the vessel, it increases exhaust noise.

WARNING

Do not use the manifold as a muffler support because it puts excessive strain on the connecting exhaust line and can cause it to break or leak, resulting in the escape of deadly exhaust gases.

Fuel System

FUEL RECOMMENDATIONS

Fill the fuel tank with a good quality fuel obtained from a reputable supplier. The quality of fuel used is important in obtaining dependable performance and satisfactory engine life. Fuels must be clean, completely distilled, well refined, and non-corrosive to fuel system parts.

WARNING

Fuel vapors create fire and explosion hazards which might result in severe personal injury or death. Do not add gasoline, gasohol, or alcohol to diesel fuel. Do not permit any flame, cigarette, or other igniter near the fuel system.

CAUTION

Due to the precise tolerances of diesel injection systems, it is extremely important the fuel be kept clean and free of water. Dirt or water in the system can cause severe damage to both the injection pump and the injection nozzles.

Use ASTM2-D (No. 2 Diesel) or ASTM1-D (No. 1 Diesel) fuel with a minimum Cetane number of 45*. Number 2 diesel fuel gives the best economy and performance under most operating conditions. At temperatures below 32°F (0°C), Number 2-D fuel may pose operating problems. At colder temperatures, use Number 1-D fuel (if available) or use a "winterized" Number 2-D (a blend of Number 1-D and Number 2-D). The blended fuel is normally called Number 2-D also, but can be used in colder temperatures than non "winterized" Number 2-D fuel.

CAUTION

Do not add gasoline, gasohol, or alcohol to diesel fuel. Damage to fuel injection system or engine may result.

***NOTE:** Fuels with Cetane numbers higher than 45, may be needed in higher altitudes or when extremely low ambient temperatures are encountered to prevent misfires and resultant excessive smoke.

Use low sulfur content fuel having a cloud point of at least 10 degrees below the lowest expected fuel temperature. Cloud point is the temperature at which wax crystals begin to form in diesel fuel.

WARNING

Spilled fuel might ignite and cause serious personal injury or death. Never fill the fuel tank when the engine is running.

WARNING

Fuel leaks create fire and explosion hazards which might result in severe personal injury or death. Always use a length of flexible tubing between engine and the fuel supply line to avoid line failure and leaks due to vibration. The fuel system must meet applicable codes.

FUEL SYSTEM

The fuel system consists of a sediment bowl, fuel transfer pump, primary filter, secondary filter, injection pump, injectors, and the connecting fuel lines.

The fuel system, located on the service side of the engine, uses a transfer pump to deliver fuel from the tank to a high pressure injection pump at about 12 to 14 psi (83-97 kPa); 5-6 psi on MDJA (35-41 kPa). The injection lines deliver fuel to the injectors at high pressure and act as fuel distributors to the injectors.

The time interval between injection of individual injectors is varied in the pump by engine speed. From the injection pump, metered fuel is forced through a delivery valve to the injector lines at about 1900 psi (13,110 kPa). As the cylinder air reaches about 1000°F (538°C) on the compression stroke, the injector sprays fuel into the hot compressed air where it ignites. The delivery valve in the injection pump and a pintle valve in the injector assist the precision timed injection of fuel into the cylinder.

FILTER SYSTEM

The sediment bowl has a fine mesh screen which blocks dirt and water entry into the transfer pump, Figure 28, 29. The dirt and water remain in the sediment bowl which should be removed for cleaning as required. The spin-on primary and secondary fuel filters are replaceable units, that clean the fuel of extremely fine particles before it goes to the injection pump.

These filters are mounted on a common casting which bolts to the oil fill tube. Positive filtration is assured because the engine will not run if either filter is loose or missing.

Average pore size of the second filter is 0.0005 inch (0.0127 mm) smaller than the first filter. This means most particles escaping the first filter are trapped in the second filter.

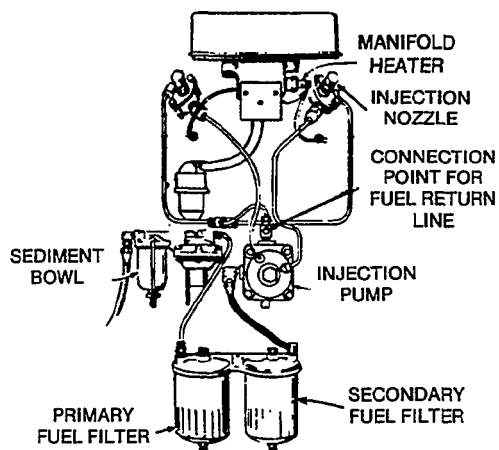


FIGURE 28. FUEL SYSTEM—LATEST MODELS

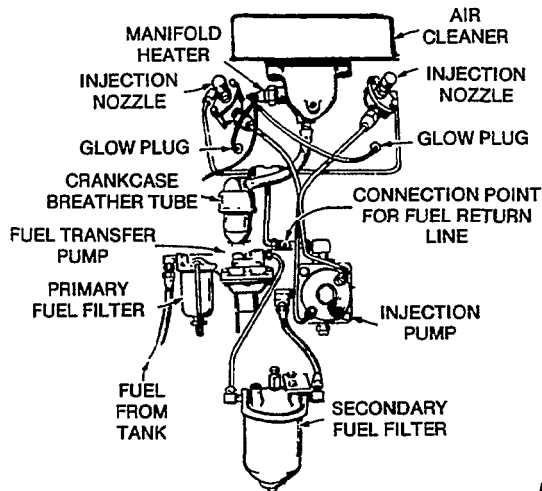


FIGURE 29. FUEL SYSTEM—OLDER MODELS

FUEL TRANSFER PUMP

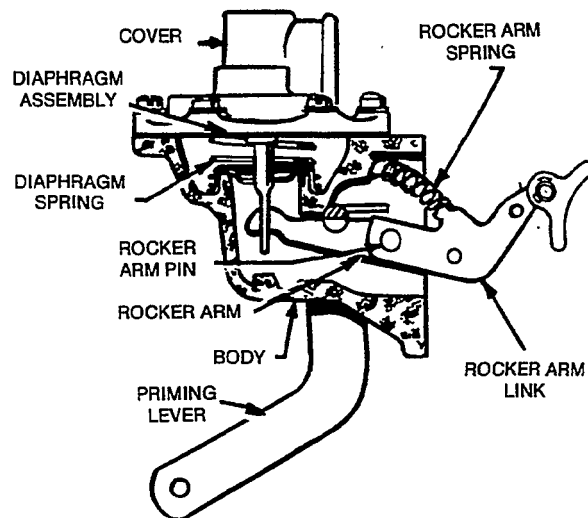
The fuel transfer pump (Figure 30) is a diaphragm and check valve type pump operated by a cam lobe on the engine camshaft. The pump cam follower has a wide surface to prevent wear as it rides on the camshaft lobe. The priming lever is manually operated to prime and bleed the system.

The diaphragm spring maintains required fuel pressure to the injection pump. Fuel pressure should be as follows when operating at 1800 rpm:

| | |
|---------------------|----------------------------------|
| MDJA | 5 to 6 psi (34.5 to 41.4 kPa) |
| * MDJB, MDJE | 12 to 14 psi (83 to 97 kPa) |
| ** MDJC, MDJF | 12 to 14 psi (83 to 97 kPa) |

* Prior to 1962 and October through December 1964 — 2 to 3 psi (14 to 21 kPa).

** Prior to 1962 — 2 to 3 psi (14 to 21 kPa).



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FIGURE 30. FUEL TRANSFER PUMP

Fuel pump pressure may be checked by connecting a pressure gauge and tee at the fuel outlet. A vacuum gauge connected at the fuel inlet will show whether the pump has enough capacity to lift fuel about 6 feet (1.86 m). The fuel pump should produce 15 to 18 inches (381 to 457 mm) of vacuum at sea level.

Fuel Pump Removal Disassembly

1. Remove pump inlet and outlet lines. Remove two capscrews holding pump to engine and lift it off.
2. Notch the pump cover and body with a file so they can be reassembled in same relative positions, and remove six screws holding them together.
3. Tap body with a screwdriver to separate two parts. Do not pry them apart; this would damage diaphragm.
4. Drive out rocker arm hinge pin.
5. Remove rocker arm, spring, and link.
6. Lift out diaphragm assembly and diaphragm spring.

Repair

A kit is available for replacement of the diaphragm and spring. If the diaphragm is leaking or broken, check for diluted crankcase oil. If necessary, replace diaphragm. Occasionally, a worn rocker arm pin will cause crankcase oil leakage. If this is the case, the pump should be replaced.

Assembly

1. When installing a new diaphragm, soak it in fuel before assembling. Insert diaphragm spring and soaked diaphragm into pump body.
2. Insert link and rocker arm into body and hook it over diaphragm pull rod. Align rocker arm with rocker arm pin hole and drive in pin. The priming lever must be in position shown in Figure 30 when installing rocker arm.
3. Compress rocker spring and install between the body and rocker arm.
4. Assemble cover to body, with notch marks lined up. Install screws but do not tighten.

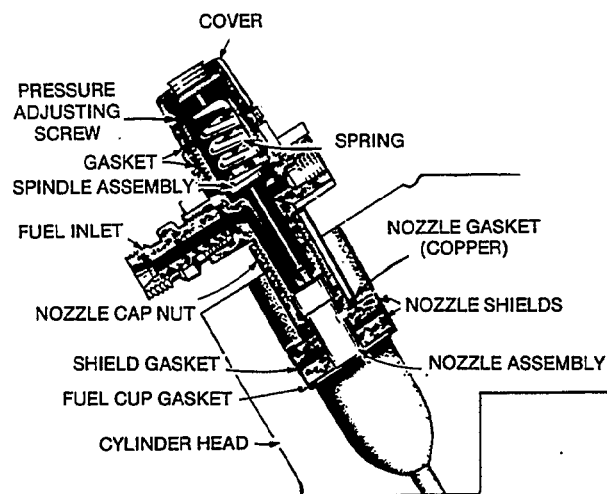
WARNING *Fuel leakage is a fire and explosion hazard that might cause severe personal injury or death. Use care when reassembling fuel pump. All parts must align perfectly or pump will leak fuel.*

5. Push rocker arm in one full stroke and hold in this position to flex diaphragm.
6. Tighten cover screws alternately and securely, then release rocker arm.
7. Install pump on the engine and repeat pressure test.

INJECTION NOZZLES

Onan diesel engines use hydraulically operated, pintle-type injection nozzles, Figure 31. They are factory adjusted to open at 1900 to 1950 psi (13,110 to 13,455 kPa). However, after several hundred hours of operation the nozzle pressure will decrease to about 1750 psi (12,075 kPa).

Refer to the throttling pintle type nozzle information at the end of this section for information regarding MDJE engines using Bryce/-Kiki fuel systems.



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FIGURE 31. INJECTOR NOZZLE ASSEMBLY INSTALLATION

Operating Principle

Nozzle operation is as follows:

1. High pressure fuel from the injection pump enters the fuel inlet stud and flows down drilled passages in the body of nozzle holder, Figure 32.
2. Fuel enters fuel duct and pressure chamber of nozzle assembly. When fuel pressure overcomes preset pressure of the adjusting spring, the pintle is forced upward off its seat and a fine mist of fuel is injected into the pre-combustion chamber, where the vaporized fuel mixes with the hot compressed air.
3. If compression temperatures are high enough, the fuel-air mixture ignites. Injection continues until the spill port clears the top of the metering sleeve in the injection pump and dumps the high pressure fuel into the sump, allowing the pressure spring to close the injector and cut off fuel injection to the cylinder.

CAUTION *Do not disturb the injector pressure adjusting screw; it cannot be reset without proper equipment.*

Bypass fuel is returned to the tank after each injection cycle by a return line from the nozzle. A fuel return fitting combines the return fuel from the injectors with the flow-through fuel from the injection pump bleed valve. A return line connected at this point returns the combined fuel to the fuel supply tank.

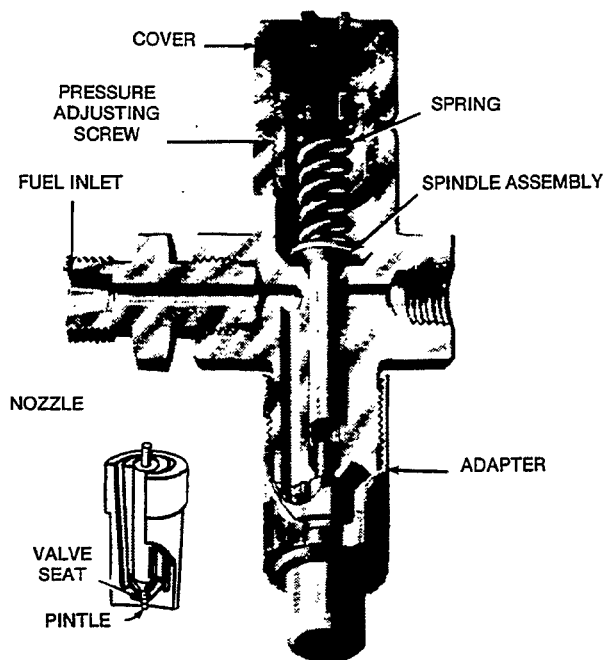


FIGURE 32. INJECTOR NOZZLE AND HOLDER ASSEMBLY

Nozzle Spray Pattern

A nozzle suspected of misfiring can be checked in the field by removing it from the engine and reconnecting it to the high pressure line. The spray pattern (Figure 33) can be observed as the engine is cranked.

WARNING *Fuel penetration of the skin might cause severe personal injury. Do not let the nozzle high-pressure fuel spray against skin surfaces.*

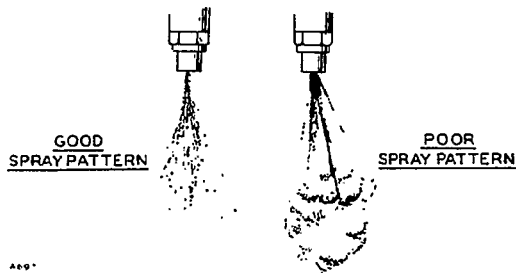


FIGURE 33. NOZZLE SPRAY PATTERN

If streamers are visible, the pattern is badly distorted; or if the nozzle drips before it reaches opening pressure, it is defective and must be cleaned or replaced.

Cleaning is the most important part of nozzle maintenance. Make sure the work area and equipment are exceptionally clean.

A second method for identifying a misfiring nozzle is to remove the exhaust manifold, run the engine, and observe the exhaust ports for the following conditions:

Heavy Load - Black smokey exhaust from any one cylinder could indicate poor nozzle condition.

Light or No Load - Blue/white smoke from any one cylinder could indicate poor nozzle condition.

Adjustment: To adjust the opening pressure, remove each nozzle from the engine. Remove the plug from the center of the cap nut, and loosen the cap nut. Install the nozzle to be tested on a static-fuel, nozzle testing fixture (may be purchased from Onan). Following the instructions on the tester, adjust the opening pressure to 1750 psi (12,075 kPa) by turning the adjusting screw. Clockwise adjustment increases the pressure; counterclockwise decreases it. Do not try to adjust the pressure without a testing fixture.

Disassembly: When removing and disassembling nozzles, separate and label all components of each nozzle. Never interchange components between nozzles.

1. Remove each nozzle assembly from engine and remove fuel inlet and return lines.
2. Clamp nozzle holder body in a vise and remove nozzle cap nut and nozzle.
3. Install nozzle cap nut loosely to protect lapped surface of the holder body.
4. If necessary, to disassemble nozzle further, reverse pressure adjusting screw and lift out spring and spindle assembly.

CAUTION *Do not attempt to disassemble the nozzles or adjust nozzle pressure without the proper test equipment. A nozzle pressure tester is essential to do a satisfactory job.*

The cleaning procedure (Figure 35) is extremely important when disassembling injection equipment. Always rinse in clean fuel before reassembling.

Injection Nozzle Tester

Testing and adjustment can be performed only with a nozzle tester, Figure 34. Do not attempt to disassemble the nozzles or adjust nozzle pressure without the proper test equipment.

Opening pressure, leakage, and spray pattern can be checked using the tester. If any of the above conditions appear (except opening pressure), inspect the nozzle valve and seat with a magnifying glass for erosion, scoring, etc. If cleaning with solvent does not correct the condition, a new nozzle tip will be required. The opening pressure can then be set and spray pattern checked.

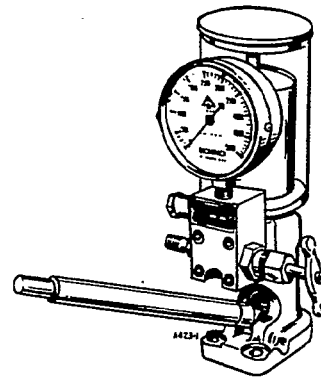
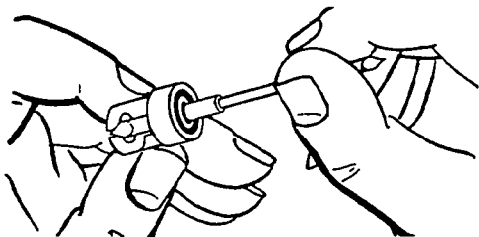


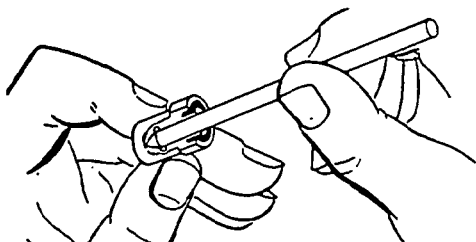
FIGURE 34. INJECTION NOZZLE TESTER

CAUTION *Never use hard or sharp tools, emery paper, grinding powder, or abrasives of any kind on nozzles or they may be damaged.*

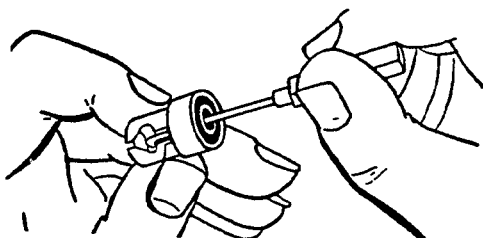
Soak each nozzle in fuel to loosen dirt. Then clean inside with a small strip of wood soaked in oil. Clean spray hole with a wood splinter. If necessary, clean the outer surfaces of the nozzle body with a brass brush but do not attempt to scrape carbon from the nozzle surfaces. This can severely damage the spray hole. Use a soft oil-soaked rag or mutton tallow and felt to clean the nozzle valve.



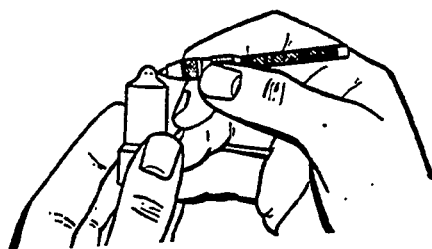
1. Use a brass type scraper tool to remove hard carbon deposits from nozzle body valve seat.



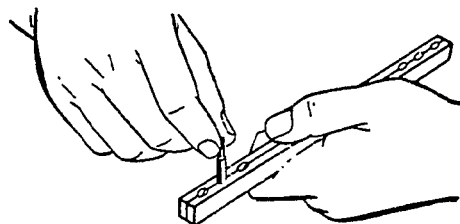
2. After scraping the carbon, polish the valve seat by using a round pointed stick dipped in tallow. Polishing should restore seat to its original finish unless it is scored.



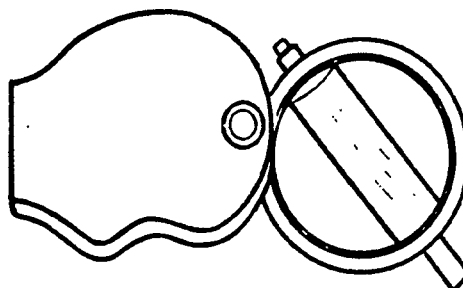
3. Use a special hooked type scraper to clean the nozzle pressure chamber gallery. The hooked end of scraper is inserted into the gallery and then carefully rotated.



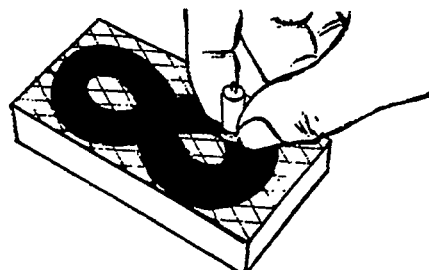
4. Small holes in tip of nozzle body can be cleaned with a fine wire slightly smaller than the size of the hole.



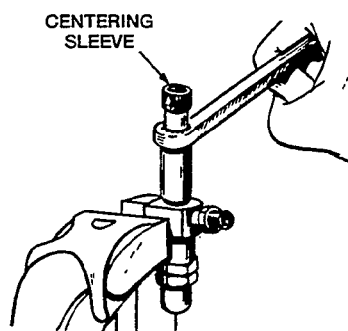
5. Clean nozzle valve and polish with tallow and a wooden polishing fixture. Take care to remove all traces of tallow when finished.



6. Examine nozzle valve and body with a magnifying glass. If erosion and scoring conditions are found, replace the valve and body.



7. Use a lapping plate and compound for flat lapping of nozzle parts which depend on a lapped surface for sealing. A figure "8" motion is used.



8. It is essential that the nozzle body be perfectly centered in the cap nut when reassembling nozzle. A centering sleeve, as shown, is used for this purpose.

FIGURE 35. NOZZLE CLEANING

NOZZLE REPAIR

If cleaning will not eliminate a nozzle defect, replace the nozzle or take it to an authorized diesel service station. Do not attempt to replace parts of the nozzle except for nozzle and pintle assembly.

Assembly

Rinse both valve and nozzle thoroughly before assembly and coat with diesel fuel. The valve must be free in the nozzle. Lift it about 1/3 out of the body. It should slide back to its seat without aid when the assembly is held at a 45-degree angle. If necessary, work the valve into its body with clean mutton tallow.

1. Clamp nozzle holder body in a vise.
2. Set valve in body and set nozzle over it.
3. Install nozzle cap nut loosely.
4. Place centering sleeve over nozzle for initial tightening. Then remove centering sleeve to prevent it from binding between nozzle and cap nut.
5. Tighten nozzle cap nut to 50-55 ft.-lb. (68-75 Nm).

NOZZLE INSTALLATION

Before installing the injection nozzles in the engine, thoroughly clean each mounting recess.

A dirty mounting surface could permit blow-by, causing nozzle failure and a resulting power loss.

1. Install a new heat shield to head gasket in cylinder head recess.
2. Install heat shield, heat shield gasket, second heat shield, and nozzle gasket.
3. Insert nozzle assembly into recess. Do not strike tip against any hard surface.
4. Install nozzle flange and two capscrews. Tighten capscrews alternately to avoid cocking nozzle assembly. Tighten each to 20-21 ft.lb. (27-28 Nm).

FUEL SOLENOID

The fuel shutoff solenoid (Figure 36) is also referred to as a governor solenoid, as it over-rides the governor during shutdown. The solenoid is mounted on a bracket and controls the injection pump operating lever. When energized, the plunger pulls into the solenoid body. When de-energized, the solenoid spring forces the plunger out against the operating lever to hold it in the fuel shutoff position.

The solenoid has two coils. Both are energized for pulling the plunger up. When the plunger reaches the top, it opens a set of contacts, de-energizing the pull-in coil. The other coil holds the plunger up while the engine is running and de-energizes when the engine shuts down.

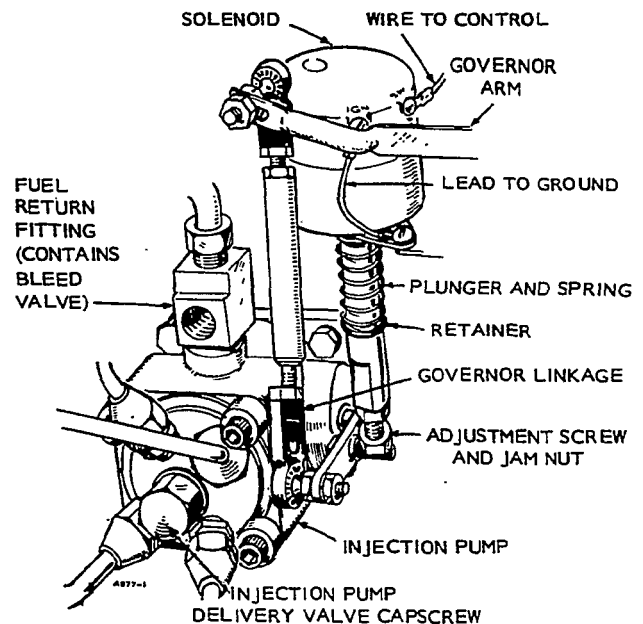


FIGURE 36. FUEL SOLENOID

To test the solenoid, check plunger operation and current draw with 12-volt input. Current draw with the plunger up should be about 1 amp. If it is much greater, the contacts did not open.

The solenoid plunger should be adjusted so it fully stops injection when in the de-energized position. To adjust the plunger length, turn the screw and jam nut on the plunger bottom in or out. If the plunger sticks, remove the solenoid from its mounting plate and clean the plunger and recess in the solenoid.

FUEL INJECTION PUMPS

Onan DJ series diesels are equipped with American Bosch fuel injection pumps. Single cylinder engines use the model PLB; the four cylinder engines use the model PSU pump. Until recently, the two cylinder diesel engines have been using a PSU pump. Now, the MDJE engines use either a Bryce or a Kiki fuel injection pump. For Bryce/Kiki pump information, turn to the back of this section. The fuel injection pumps are constant stroke, lapped plunger type and operated by the engine camshaft. They deliver an accurately measured quantity of fuel under high pressure to the injection nozzles.

A constant bleed-check valve is furnished with all PLB and PSU pumps. The bleed valve automatically bleeds off a restricted amount of fuel, fuel vapors, and small quantities of air to prevent air accumulation in the fuel sump area of the pumps. This valve should open at pressures between 0.9 and 3.0 psi (6.2 and 20.7 kPa).

The port closing (PC) mark is not stamped on replacement flywheels. Therefore, the PC mark must be established by measuring the piston drop with the cylinder head removed prior to injection pump timing. Since injection occurs at the port closing position, the PC mark can be located only by comparing the old flywheel with the new one, or by measuring the piston drop from its top center position on the compression stroke of number one cylinder. Piston drop data is given in Table 7.

TABLE 7. PISTON DROP DATA

| PISTON DROP | | ENGINE | PORT CLOSING |
|-------------|------|----------------------------------|--------------|
| Inches | mm | | BTC |
| 0.102 | 2.59 | MDJA | 17 degrees |
| 0.128 | 3.25 | | 19 degrees |
| 0.155 | 3.94 | MDJB & MDJC (Begin Spec P) | 21 degrees |
| 0.128 | 3.25 | MDJB & MDJC (Prior to Spec P) | 19 degrees |
| 0.115 | 2.9 | MDJE Spec A-AA | 18 degrees |
| 0.128 | 3.25 | MDJE Begin Spec AB | 19 degrees |
| 0.128 | 3.25 | MDJF | 19 degrees |

CAUTION Replace any injection pump that troubleshooting procedures prove to be malfunctioning. Do not attempt unauthorized repair procedures on the injection pumps.

Fuel injection pumps must pass stringent quality inspections, and tests with precise settings and adjustments, in order to meet Onan's performance and reliability requirements. Therefore, it must be clearly understood by the owners and by Onan service personnel that tampering or inept repair attempts can cause irreparable damage to the pumps that will not be covered by the manufacturers' warranties or exchange agreements. Contact an authorized American Bosch Service station or Distributor for expert repair service on injection pumps.

The Repair service should include cleaning, part replacement, static pressure tests for internal and external leaks, internal pump timing, and calibration and adjustment to the manufacturer's specifications.

MDJA INJECTION PUMP

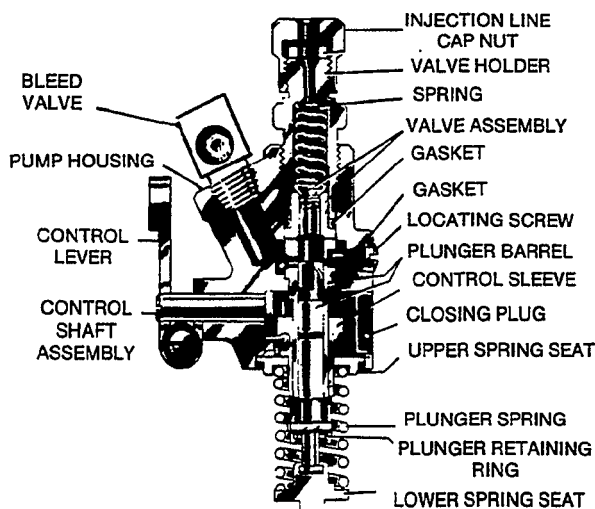


FIGURE 37. PLB INJECTION PUMP COMPONENTS

A PLB injection pump (Figure 37) is used on the MDJA Series engines. The cross-sectional view shows the internal parts and the operating lever and control shaft.

The pump consists of a housing, pump plunger and barrel, the plunger return spring with its seats, and the control sleeve and its operating shaft. The housing contains the fuel sump, delivery valve assembly, delivery valve holder, and the union nut for connection of the high pressure discharge tubing.

Repair

Most fuel system troubles are not due to a faulty injection pump. Test the rest of the fuel system before condemning the injection pump.

Onan discourages field repair of the injection pump because of the exceptionally close tolerances between parts and the specialized equipment necessary for repair. The injection pump is an expensive part of the unit and even a particle of dirt as fine as talcum powder could score its working surfaces. If the rest of the fuel system is in working order and fuel delivery is abnormal, remove the pump for replacement or repair.

Removal

Remove the pump inlet and outlet lines. Remove the two capscrews holding the pump to the engine and lift it off. Do not lose the shims. They time the injection pump to the engine. Cap all openings in the pump and fuel lines to keep dirt out of the fuel system.

Timing

Timing the pump to the engine determines the port closing point (17 degrees BTC) PC mark on flywheel. See Figure 38. The helix position controls port opening and is, in turn, controlled by the throttle setting.

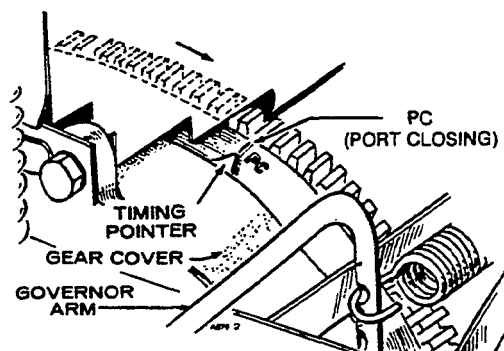


FIGURE 38. INJECTION PUMP TIMING

The most accurate method of injection pump timing is with a depth micrometer (*Method 1*). However, if a depth micrometer is not available, time it by *Flowing the Pump* (*Method 2*).

Injection pump must be timed on the compression stroke, not on the exhaust stroke.

Method 1. Depth Micrometer:

1. Install pump tappet in its recess and position flywheel on the port closing mark (PC) of the compression stroke.
2. Using a depth micrometer, measure the distance from the pump mounting pad on the crankcase to the tappet center. See Figure 39.
3. Subtract from the port closing dimension of the pump 1.670-inch (42.42 mm) the depth obtained in step 2. The result is the thickness of shims necessary to time the pump correctly.

Thickness of shims may vary from 0.006 to 0.052-inch (0.15 to 1.82 mm). If it does not fall within these limits, check camshaft and tappet for excess wear or improper assembly.

4. Select the correct shims for the required thickness.
5. Install the pump.

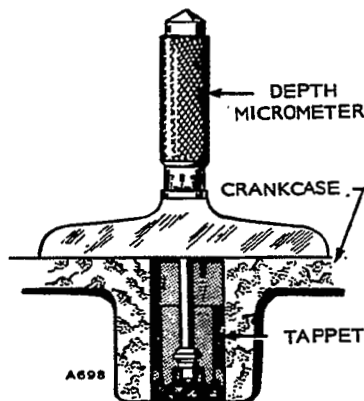


FIGURE 39. DEPTH MICROMETER

Method 2. Flowing the Pump:

1. Install pump with 0.006-inch (0.15 mm) shims between pump and pad.
2. Loosen the delivery valve holder to relieve pressure on spring. See Figure 40.
3. Rotate the flywheel to about 15 degrees before the port closing (PC) point. Blow in the pump inlet and rotate the flywheel slowly clockwise until air stops coming out of the pump outlet. This is the port closing point.
4. Measure the distance from the point where port closing occurs to the PC mark on the flywheel. Find the thickness of shims to be added from the table that follows.
5. Install the pump.

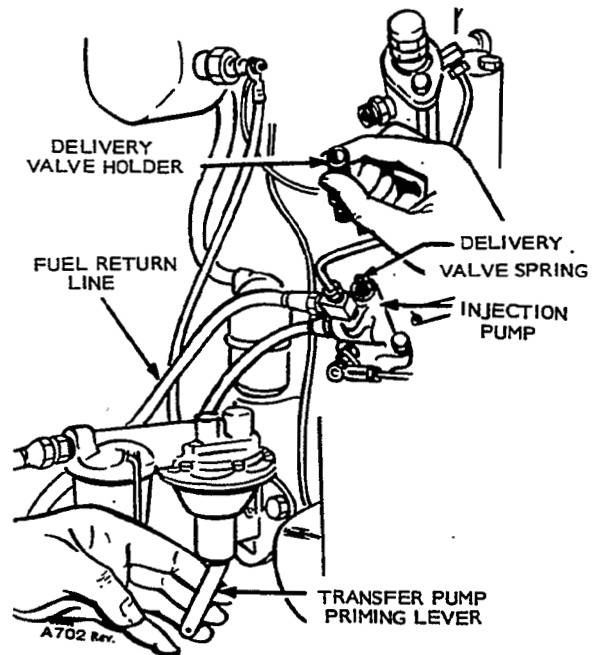


FIGURE 40. LOOSENING DELIVERY VALVE HOLDER

Installation

Prior to mounting the injection pump to the cylinder block, follow steps 1 through 3.

1. Slide the shim or shims (using proper thickness of shims for correct timing) over the pilot until they are flat on the pump flange. See Figure 41.
2. Dip the seal (O-ring) in engine lubricating oil.
3. Slide the seal over the pilot until tight against the shim or shims.

SHIM SELECTION

| USE THIS CHART WITH METHOD 2. (All dimensions are in inches) | | | |
|---|-----------------------|--------------------------------|-----------------------|
| DISTANCE MEASURED STEP 4 | ADD THESE SHIMS | DISTANCE MEASURED STEP 4 | ADD THESE SHIMS |
| 0.1 | 0.010 | 0.7 | 0.034 |
| 0.2 | 0.014 | 0.8 | 0.038 |
| 0.3 | 0.018 | 0.9 | 0.042 |
| 0.4 | 0.022 | 1.0 | 0.046 |
| 0.5 | 0.026 | 1.1 | 0.050 |
| 0.6 | 0.030 | | |

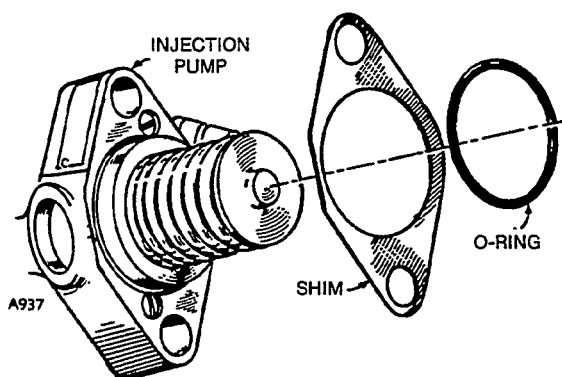


FIGURE 41. SHIMMING THE PILOT

With shims and seal in place insert the pump into cylinder block mounting pad, and insert mounting screws. Torque the mounting screws (tighten alternately) to 18-21 ft.-lb. (24-28 Nm).

Install the fuel inlet line and governor linkage. Bleed the pump, and then install the fuel outlet line (see *INSTALLATION* section).

PSU OR MODEL 50 INJECTION PUMP

The PSU or model 50 injection pump (Figure 42) is used on Onan 2- and 4-cylinder water-cooled diesels. Pumps that are almost identical, with only two injector line outlet ports, are used on the two cylinder models. The function of the pump as a distributor and its location on the service side of the engine are the same on both 2- and 4-cylinder engines.

Repair

Internal repairs on the injection pumps require special tools and step-by-step procedures for disassembly and reassembly.

CAUTION Replace with a new pump any pump that troubleshooting procedures prove to be malfunctioning. Do not attempt unauthorized repair procedures on injection pumps.

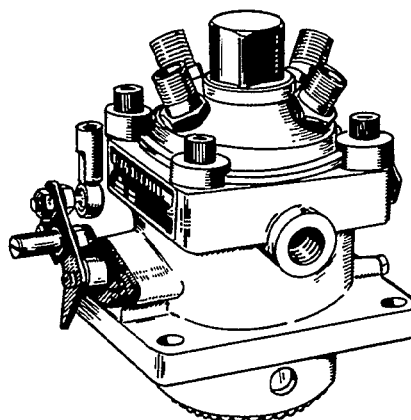


FIGURE 42. INJECTION PUMP

Pump Operation

The pump face gear mates with and is rotated by a drive gear on the engine camshaft, Figure 43. The face gear, pilot ring, and the reciprocating plunger in the pump are rotated continually to assure positive fuel distribution. A multi-lobed cam on the camshaft rides on a tappet assembly in the pump and drives the plunger up and down.

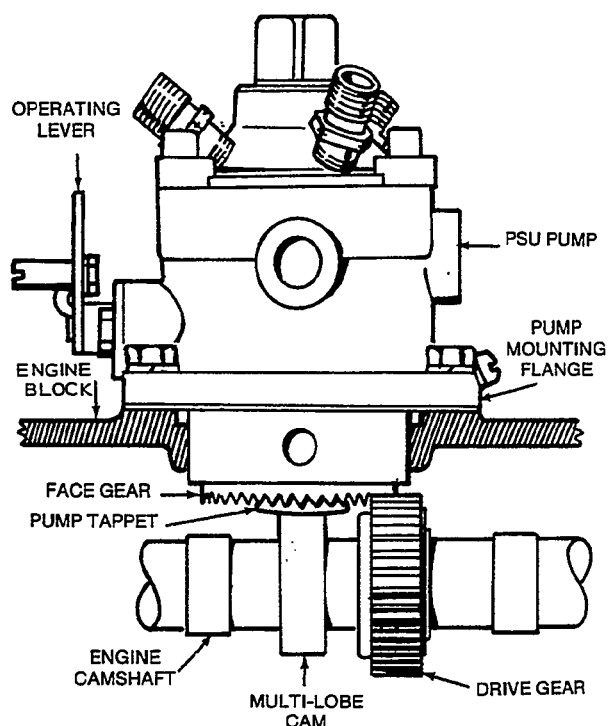


FIGURE 43. INJECTION PUMP TO CAMSHAFT RELATIONSHIP

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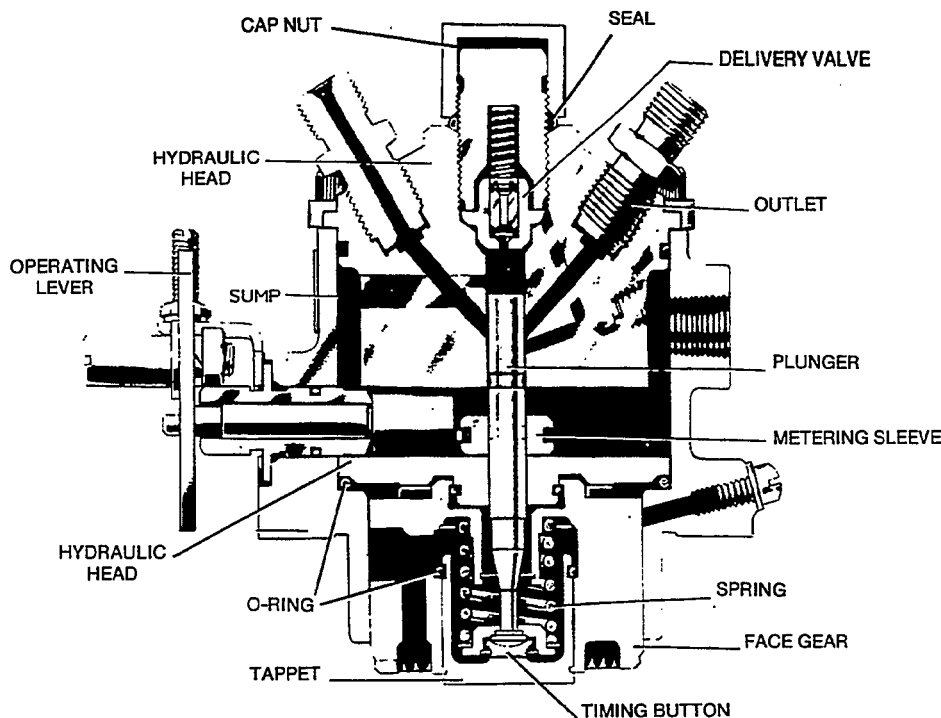


FIGURE 44. INJECTION PUMP (CUTAWAY VIEW)

Pump Cutaway View

The cutaway view in Figure 44 shows the control unit operating lever, metering sleeve, delivery valve, plunger, and drilled passages to the plunger and injection lines.

A timing button of very precise thickness transmits motion from the tappet to the plunger and adjusts plunger timing for the fuel pumped to each injector during operation. Plunger reciprocation and rotation are phased so that only one fuel injector is served during the affective portion of each plunger up stroke. The high hydraulic pressure developed is required to open the pressure operated fuel injector nozzles, which inject the fuel in a fine mist into the combustion chamber. Fuel delivery control, full load, and shutoff are regulated by the up-and-down movement of the fuel metering sleeve. The sleeve is controlled by the operating lever on the outside of the pump. Fuel is injected only during the high velocity portion of each plunger up stroke.

When the tappet slips off each lobe of the camshaft, the spring loaded plunger is forced down, opening the fuel supply port to the fuel sump. This allows fuel under low pressure from the transfer pump and fuel sump to fill the cavity between the top end of the plunger and the delivery valve. The plunger is then ready for the up stroke.

Metering Sleeve Operation

The metering sleeve is positioned by the operating lever of the governor control unit, Figure 45. An eccentric pin on the end of the control shaft engages a slot in the metering sleeve so that a slight rotation of the control shaft causes the sleeve to ride up or down on the plunger. As the camshaft and face gear rotate, the drive key and a vertical slot in the face gear transmit rotation to the plunger. Rotating the plunger aligns outlet groove with the appropriate injection line outlet for the injector to fire on each pump stroke.

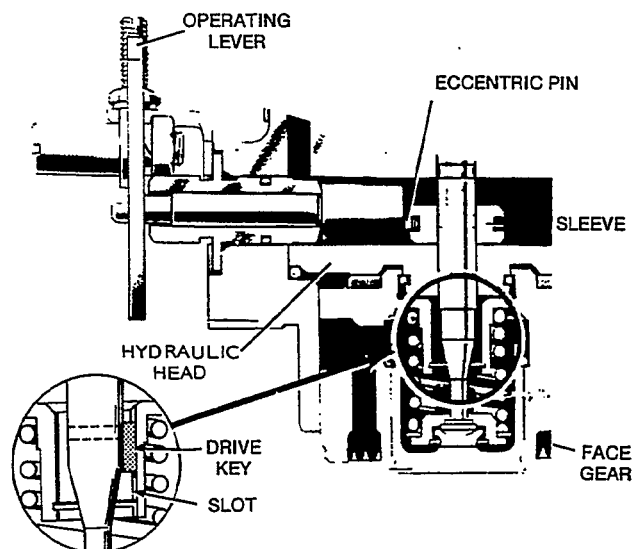


FIGURE 45. METERING CONTROL

Delivery Valve Function

The delivery valve maintains 300 to 600 psi (2070 to 4140 kPa) line pressure in the injector lines with the engine running, Figure 46. This pressure increases to about 1900 psi (13110 kPa) on each stroke of the injection pump plunger. The trapped fuel is held in the lines at all times, even though the pressure bleeds off during shutdown periods. When the lines are full of fuel, only a couple turns of the crankshaft are required to build up enough line pressure for firing the injectors.

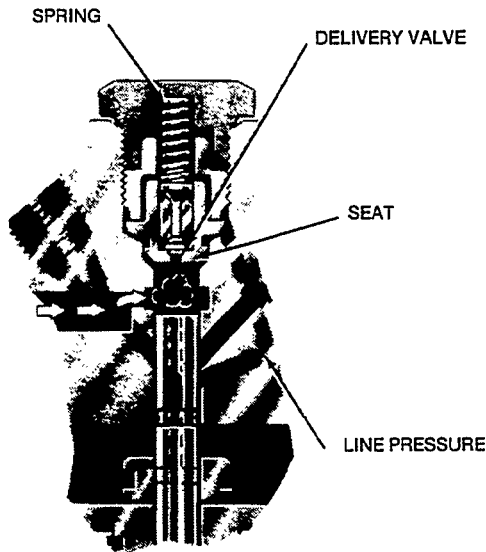


FIGURE 46. DELIVERY VALVE CLOSED - PLUNGER DOWN

CAUTION

Keeping the fuel system clean is extremely important. A fine particle of dirt can ruin the injection system in a very short time. If the fuel system is opened for any reason, cap all openings and place the parts removed in clean diesel fuel. Before installing new or used parts, wash them in clean fuel and install them wet.

CAUTION

Preservative oil applied to the new injection pump during assembly may cause the pump to stick. Forcing the plunger or gear will damage the pump. Dissolve preservative by soaking pump in clean filtered diesel fuel for 15 to 30 minutes.

TIMING BUTTON CODE

The timing button has a code number or letter stamped on it that corresponds to its dimension in thousandths of an inch. See Table 8. Figure 47 shows the timing button. One button will provide the correct port closing.

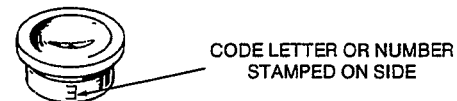


FIGURE 47. TIMING BUTTON CODE

TIMING BUTTON THICKNESS

Injection pump kits include a pump and four buttons which will time most of the engines. The button and retainer ring are not assembled.

The injection pump on each engine must be timed to that engine by using a timing button of specific thickness. Each new pump has its port closing dimension stamped on the pump mounting flange. The port closing dimension is measured at the factory using a number 11 or standard button.

Pump timing is critical. use one of the two timing methods to determine correct new button thickness. If the correct button is not supplied with the replacement pump refer to Table 8 and order the correct one from your Onan dealer.

TABLE 8. TIMING BUTTONS

| Code | Part No. | Size | | Code | Part No. | Size | | Code | Part No. | Size | |
|---------|----------|------|-------|------------|----------|------|-------|---------|----------|------|-------|
| | | Inch | mm | | | Inch | mm | | | Inch | mm |
| 16 or S | 147-0186 | .134 | 3.404 | 1 or A | 147-0147 | .119 | 3.023 | 6 or F | 147-0152 | .101 | 2.565 |
| 15 or R | 147-0187 | .131 | 3.357 | 2 or B | 147-0148 | .116 | 2.946 | 7 or H | 147-0153 | .098 | 2.489 |
| 14 or P | 147-0188 | .128 | 3.251 | 3 or C | 147-0149 | .113 | 2.870 | 8 or I | 147-0154 | .095 | 2.413 |
| 13 or N | 147-0189 | .125 | 3.175 | 4 or D | 147-0150 | .110 | 2.794 | 9 or K | 147-0155 | .092 | 2.337 |
| 12 or M | 147-0190 | .122 | 3.099 | 5 or E | 147-0151 | .107 | 2.718 | 10 or L | 147-0156 | .089 | 2.261 |
| | | | | 11 or Std. | 147-0161 | .104 | 2.642 | | | | |

TIMING PSU OR MODEL 50 INJECTION PUMPS

One of two methods can be used to determine the proper timing button to time the fuel injection pump correctly to the engine.

Method 1-Timing by Calculation

This procedure is used, when all dimensions are available for replacing an old pump, before the pump is installed. Timing by calculation requires the port closing dimension and button thickness from the pump being replaced. It also requires the port closing dimension of the new pump. Put the dimensions in the PORT CLOSING FORMULA and calculate the new button thickness. After determining the timing button thickness find the button code in Table 8.

If injection pump is removed from the engine, make sure the steel shims between pump and cylinder block mounting remain the same. These shims maintain proper gear backlash.

CAUTION *Do not change the pump mounting shim's total thickness or the proper pump gear to camshaft gear mesh will be affected. The shim thickness is established at the factory during engine assembly and does not change unless a new cylinder block is installed.*

Port Closing Formula: The procedure for determining the proper port closing (PC) timing button for a new or replacement pump is as follows:

1. Remove old pump.
2. Determine port closing dimensions and original button thickness from old pump.
 - A. Write down port closing dimension given on old pump flange and port closing dimension given on new pump flange. See example.
 - B. Use a pair of channel lock pliers or screwdriver to remove tappet, retaining ring, and timing button from old injection pump (Figure 48). Use number or letter code on timing button to obtain dimension of old timing button from Table 8. This code should be the same as the code number stamped on injection pump (Figure 48).

CAUTION *On all PSU pumps be sure to hold the pump drive gear securely against the pump body when removing the tappet. If not, the pump will come apart and be difficult to assemble. The metering sleeve will drop off the plunger if the gear and plunger are removed. If the plunger port is not closed by the sleeve, there will be no fuel delivery and the pump will not operate.*

3. Add dimension on old pump flange to timing button dimension. See example.

| Example: | Inches | (mm) |
|---------------------------------------|--------------|-----------------|
| Port closing dimension of old pump | 1.109 | (28.169) |
| Button thickness of old pump | + .107 | (2.719) |
| Total | 1.216 | (30.887) |
| Port closing dimension of new pump | -1.094 | (27.788) |
| Required button thickness of new pump | .122 | (3.099) |

4. Subtract port closing dimension given on new pump flange from total dimension for old pump.
5. Use dimension calculated to select new timing button that is nearest the calculated dimension. Install new timing button in pump and install tappet on pump.
6. Install injection pump. Refer to **INJECTION PUMP INSTALLATION**.

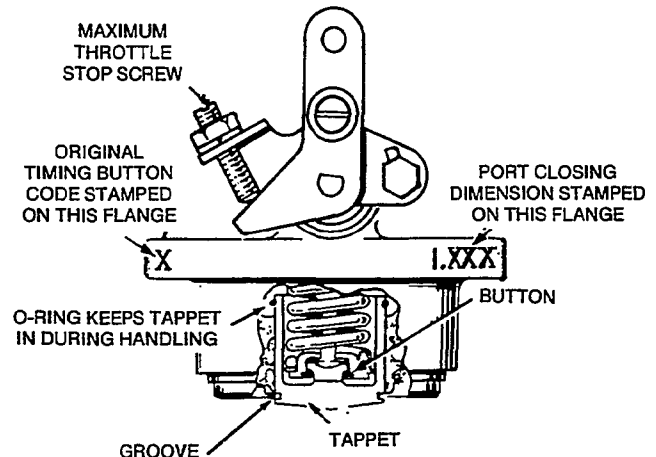


FIGURE 48. TAPPET REMOVAL

Method 2-Flow Timing Injection Pump

This procedure is used when dimensions from the old pump are lost or when a new cylinder block is installed. Clean diesel fuel is used, when flow timing, to determine if the proper timing button has been installed.

If the pump is removed from the engine, be sure the steel shims between the pump and the cylinder block mounting are the same. These shims maintain proper gear backlash. The number stamped on the cylinder block injection pump mounting pad indicates the proper shim thickness. This thickness does not change when a new pump is installed. It changes only when a new cylinder block is installed.

1. Install No. 12 timing button in new injection pump. Remove delivery valve cap nut and holder, take out spring and replace valve holder and cap nut (Figure 49 and 50).

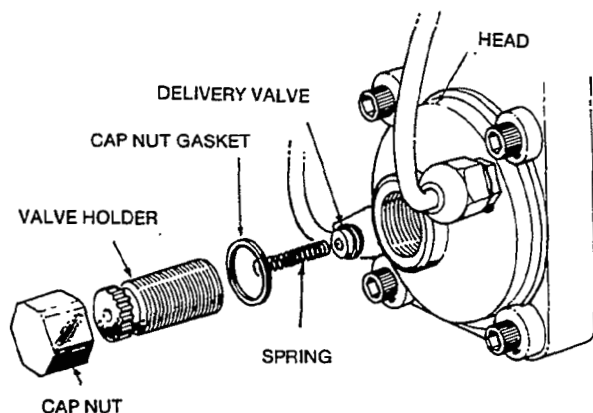


FIGURE 49. LATE MODEL DELIVERY VALVE ASSEMBLY

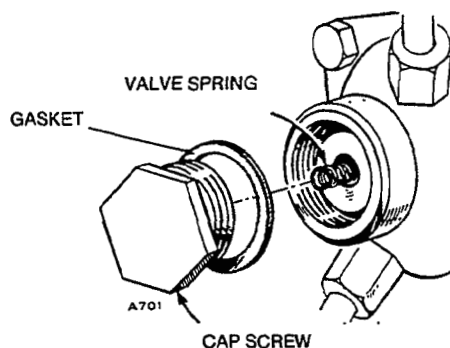


FIGURE 50. EARLY MODEL DELIVERY VALVE HOLDER

2. Install new injection pump. Refer to **INJECTION PUMP INSTALLATION**.
3. Remove No. 1 injection line. Install No. 1 injection line with top end of line in pump outlet. Place an open container under open end of No. 1 injection line (Figure 51).
4. Disconnect governor linkage at ball joint and hold control arm up at maximum fuel position.

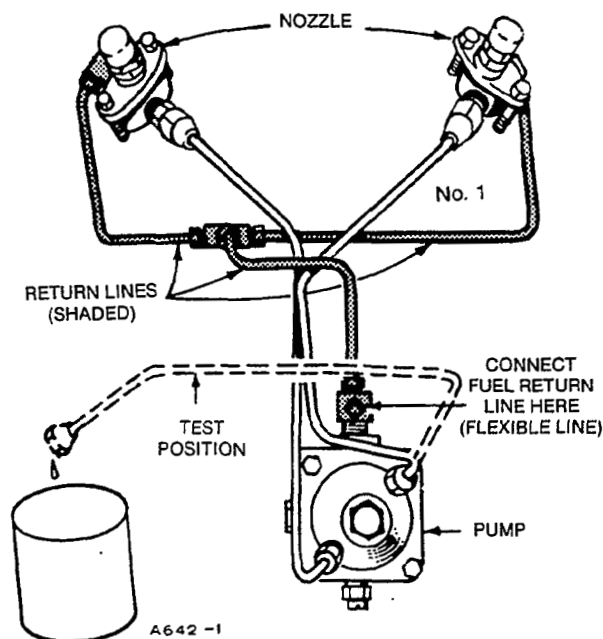


FIGURE 51. FUEL LINE TO INJECTORS

5. Rotate flywheel clockwise (when facing front of engine [Figure 52] to point where PC mark on flywheel is about 15 degrees (1.25 to 1.50 inch [32-38 mm]) before timing pointer on gear cover (compression stroke of No. 1 cylinder).

Make sure that both rocker arms on No. 1 cylinder are free to move indicating the valves are closed.

If fuel tank is disconnected, use a separate container of fuel and connect a short fuel line between the transfer pump inlet and the fuel container. The pump has enough suction to pull fuel out of the container.

WARNING Ignition of fuel might cause serious personal injury or death by fire or explosion. Do not permit any flame, cigarette, or other igniter near the fuel system.

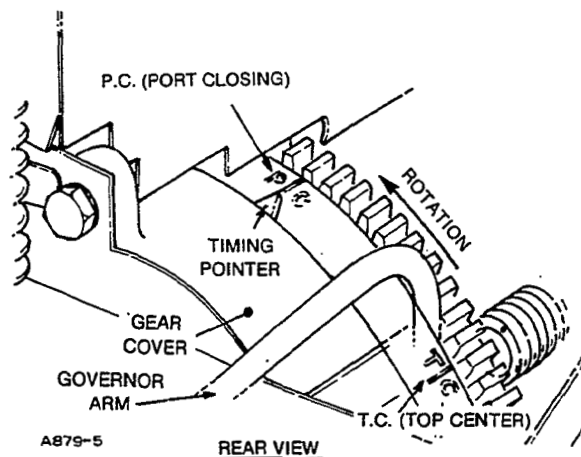


FIGURE 52. PORT CLOSING POSITION

6. Manually operate fuel transfer pump (Figure 53) until fuel, free of air, flows from open end of No. 1 injection line into container (Figure 51).

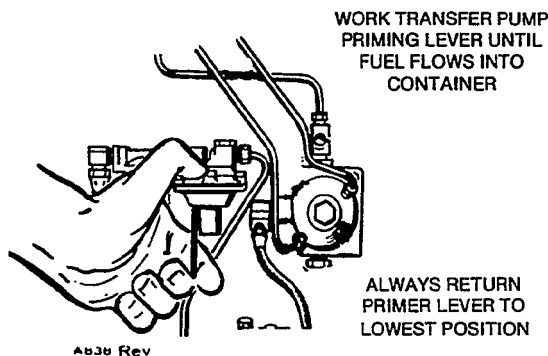


FIGURE 53. OPERATING TRANSFER PUMP MANUALLY

7. Continue operating transfer pump while assistant rotates flywheel slowly in clockwise direction. Stop flywheel rotation at exact point that fuel stops flowing from No. 1 injection line (one drop in 2 to 5 seconds is allowed). This point is the injection pump plunger port closing, regardless of flywheel position.

Timing is correct if port closing occurs when PC mark on flywheel aligns with timing pointer (Figure 52). If the marks do not line up, timing is either early or late and the timing button must be changed.

If Step 7 indicates port closing is incorrect (late or early) proceed as follows (See Examples):

- A. Mark flywheel in 0.1 inch (2.54 mm) graduations (about five marks each direction) from PC mark for calculating required change in button thickness, Figure 54.

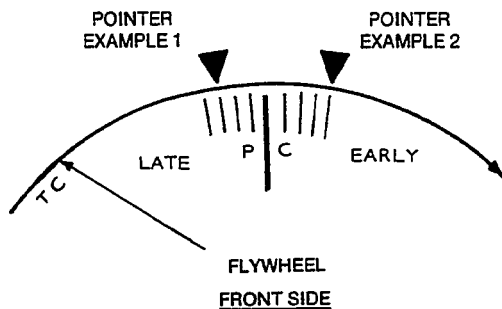


FIGURE 54. TIMING MARKS

- B. Measure distance in tenths of an inch (or mm) from PC mark on flywheel to point of actual port closing found in Step 7.

- C. Multiply distance measured times .003 inch (.076 mm) to determine the difference in thickness required for new button.

One degree of crankshaft rotation equals the 0.1-inch graduation or .003-inch button thickness for timing.

Example 1. The port closing time is late by 0.3-inch (7.6 mm) measurement ($3 \times .003" = .009" [3 \times .076 = .229 \text{ mm}]$).

Since 0.1 inch (2.54 mm) equals .003 inch (.076 mm) in button thickness, the installed button is too thin by .009 inch (0.229 mm). This means a button .009 inch (0.229 mm) thicker than the one installed is required to time port closing so that PC mark on flywheel aligns at the timing pointer when fuel flow stops.

Example 2. If PC timing is too early by 0.4-inch (10.2 mm), multiply $4 \times .003 = .012$ inch ($4 \times .076 \text{ mm} = 0.305 \text{ mm}$). In this case, a button .012 inch (0.305 mm) thinner than the one installed is required.

- D. After determining which timing button is required, remove injection pump and install the correct button.
8. Install new injection pump with No. 1 injection line connected to injection nozzle.
9. On early model (Figure 50) injection pumps, remove capscrew and install valve spring and capscrew with gasket. Torque capscrew to 75 to 89 ft.-lb. (102-120 Nm).
10. On late model (Figure 49) injection pumps, remove delivery valve capnut and holder to install spring. Before installing delivery valve spring, push delivery valve back onto its seat using your little finger. Install spring and valve holder.

CAUTION *If the spring is not seated properly the valve holder can be tightened only about one-fourth of the way down. When the spring is properly seated the valve holder can be tightened about three-fourths of the way down by hand. Make certain that the spring is seated properly in the valve holder and on the delivery valve before torquing.*

Torque valve holder to 70 to 75 ft.-lb. (95 to 102 Nm). Loosen valve holder and retorque to 65 to 70 ft.-lb. (88 to 95 Nm). Install and torque capnut with gasket to 50 to 55 ft.-lb. (70 to 75 Nm). Loosen capnut and retorque to 60 to 65 ft.-lb. (81 to 88 Nm).

INJECTION PUMP INSTALLATION

Be sure the steel shims between the pump and the cylinder block mounting are the same. These shims maintain proper gear backlash. The number stamped on the cylinder block injection pump mounting pad indicates the proper shim thickness. This thickness does not change when a new pump is installed. It changes only when a new cylinder block is installed.

1. Turn engine in direction of rotation (clockwise when viewed from the front of engine) until number one cylinder is on a compression stroke and the PC mark on flywheel lines up with timing pointer on gearcase (Figure 52). Rotation clockwise also takes out all gear backlash in that direction.

Look into injection pump mounting hole to verify that one intake lobe points outward and down 45 degrees.

2. Remove screw (Figure 55) on side of injection pump. Rotate drive gear until a 0.125 inch (3.175 mm) brass rod can be inserted into drive gear slot. This locks the gear in position when installing injection pump on engine.

ROTATE GEAR UNTIL BRASS ROD
SLIPS INTO PLACE, LOCKING GEAR

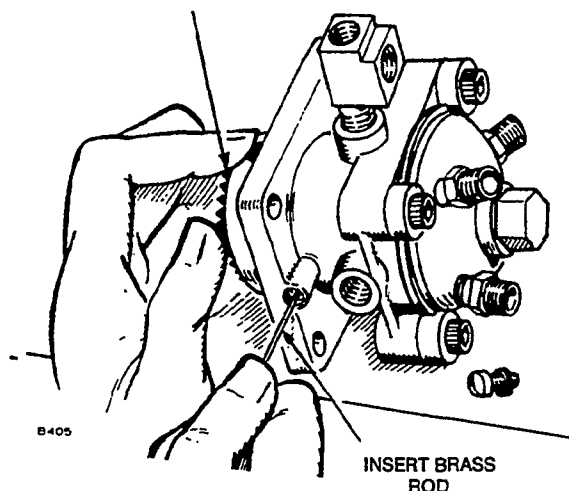
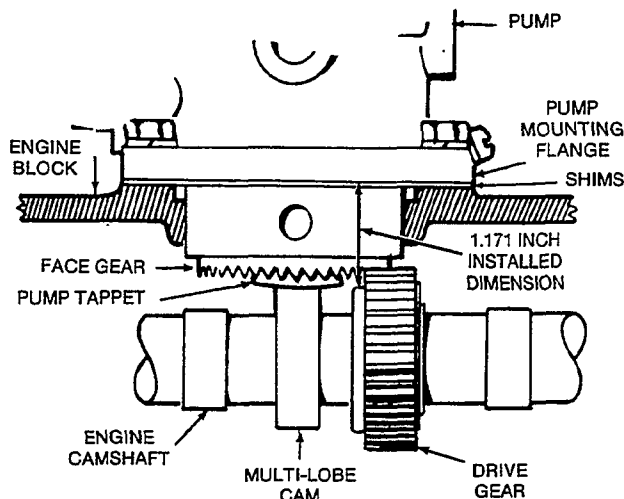


FIGURE 55. LOCKING THE DRIVE GEAR

3. With injection pump drive gear locked, place pump in mounting hole. Hold pump firmly against cylinder block. A slight spring pressure indicates that the pump and camshaft gears are meshed (Figure 56).



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FIGURE 56. PUMP INSTALLED

4. If gears mesh, secure pump using a flat washer, lock washer, and nut on each stud. Torque nuts evenly to 15 to 16 ft.-lb. (20 to 22 Nm).
5. Remove brass rod and install timing hole washer and screw.

BRYCE/KIKI FUEL SYSTEM

The Bryce or Kiki fuel injection system (Figure 57) is located near the center on the left side of the engine crankcase on MDJE engines. The pump is mounted on an adapter casting. Two lobes of the cam shaft operate the pump plungers, one plunger and cam lobe for each cylinder. The fuel is pumped at high pressure by the plungers through the delivery valves to the injection nozzles.

The Bryce/Kiki injection pumps operate on the same pumping and metering principles as the American Bosch PLB pump described earlier in this section. Fuel control from idle to maximum speed and power is accomplished by rotating the helix on each pump plunger. Both pump plungers and barrel assemblies are rotated (0 to 180 degrees) by a fuel control arm, yoke, and a rack gear. Rotating the reciprocating plunger changes the effective length of the plunger strokes, and hence, the amount of fuel it delivers to the injection nozzle.

The fuel transfer pump and the primary and secondary fuel filters in this system are identical to those described for and used on the other DJ-series engines.

Nozzles

The MDJE fuel injection system uses either a Diesel Kiki or C.A.C. throttling-pintle type nozzle. The nozzle holders are either Yanmar or Diesel Kiki and have a plated nozzle retaining nut that distinguishes them from Bosch nozzle holders, which have a black oxide finish. The nozzle tips are interchangeable in Kiki and Yanmar holders, but internal components of these holders are not interchangeable. The opening pressure for new nozzles should be 2100 to 2200 psi (14480-15169 kPa).

High Pressure Injection Lines

Both high pressure fuel lines between the injection pump and the two nozzles are designed to be installed without any bending. Lines that fit on Bryce pump installations also fit on Kiki pump installations, and vice versa. Whenever the lines must be removed, disconnect both ends. Do not bend the lines.

Bleeding Fuel System

After replacing or cleaning the filters, bleed the fuel system of air. Bleed air from fuel system as follows:

1. Disconnect fuel return line at the tee near the transfer pump. Use container to catch fuel.
2. Operate hand priming lever on diaphragm type fuel transfer pump until there are no air bubbles in fuel flowing from the fuel return line, Figure 58.

If fuel tank is disconnected, use a separate container of fuel and connect a short hose line between the transfer pump inlet and the fuel container. The pump has enough suction to pull the fuel out of the container.

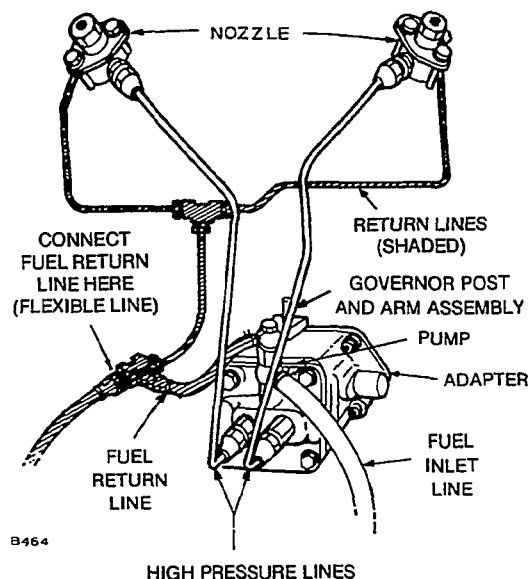


FIGURE 57. FUEL LINES TO INJECTORS

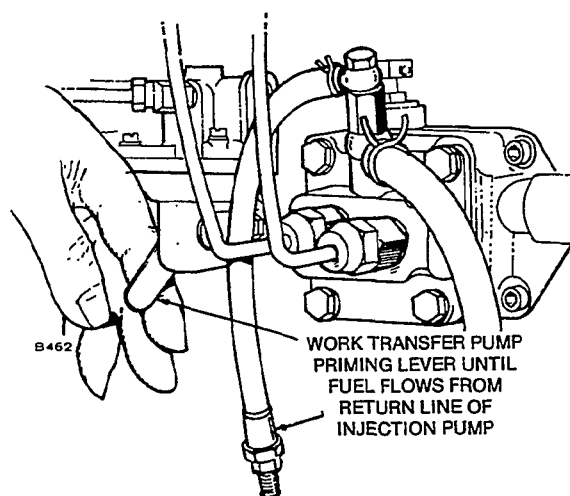


FIGURE 58. BLEEDING FUEL SYSTEM

If the camshaft transfer pump lobe is up, crank engine one revolution to permit hand priming. When finished, return priming lever inward (disengaged position) to permit normal pump operation.

3. Connect the fuel return line at tee.

CAUTION A diesel engine cannot tolerate dirt in the fuel system. Dirt is one of the major causes of diesel engine failure. A tiny piece of dirt in the injection system may stop your unit. When opening any part of the fuel system beyond the secondary fuel filter, place all parts in a pan of clean diesel fuel as they are removed. Before installing new or used parts, flush them thoroughly with clean fuel and install while still wet.

BRYCE/KIKI FUEL INJECTION PUMPS

The Bryce/Kiki Injection Pumps are similar in design, appearance, and performance, Figure 59. Both units mount two plunger and barrel assemblies in a single housing and use a common rack (gear) to rotate the control sleeves and regulate the fuel output of both pumps. Although the pumps are interchangeable on the MDJE engines, internal components of the Bryce and Kiki Pumps are not interchangeable. One external difference is that the Bryce Pump uses an alignment dowel pin to fit it on the adapter assembly.

The delivery valves on both pumps are also similar, but the Bryce has one copper sealing gasket while the Kiki uses a combination sandwich type seal that requires a special delivery valve pulling tool to remove it.

Both pumps use roller type tappets as cam followers, which are held in place by pins and lock wire. Each pump has an air bleed fitting to vent air and permit easy priming.

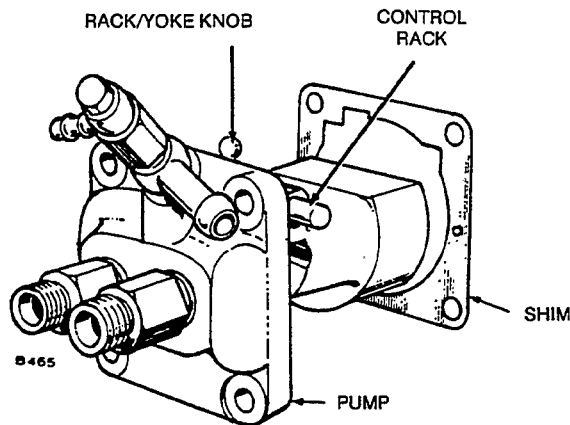


FIGURE 59. INJECTION PUMP

Repair

Most fuel system troubles are not due to a faulty injection pump; test the rest of the fuel system before condemning the injection pump.

Onan discourages field repair of the injection pump because of the exceptionally close tolerances between parts and because of the need for the specialized equipment necessary for repair. The injection pump is an expensive part of the unit, and even a particle of dirt as fine as talcum powder could score its working surfaces.

Removal

If the rest of the fuel system is in working order and fuel delivery abnormal, remove the pump for replacement or repair.

1. Locate injection pump on service side of engine, and remove necessary sheet metal and hardware to make pump accessible.
2. Remove fuel inlet and return line, Figure 57.
3. Remove high pressure lines between pump and injector nozzles (both ends).
4. Cap all lines and fittings, using extreme care to keep all fuel system components clean.
5. Remove four socket head screws holding pump to adapter assembly.
6. Position fuel control shaft and yoke as shown in Figure 61. Then, lift pump off of adapter assembly.
7. Carefully clean injection pump assembly and place it in a clean place. Retain shims between pump and adapter, as they are needed for reassembly.

INJECTION PUMP ADAPTER

The cast iron adapter (Figure 60) is the crankcase mounting fixture for the fuel injection pump and its fuel control arm, yoke, and overfueling control device. A composition gasket is used between the adapter and the crankcase.

The fuel control arm and the shaft and yoke assembly transmit governor action to the injection pump control rack. The overfueling device provides maximum (excess) fuel during engine starting and limits the maximum amount of fuel and engine power output to protect the engine from excessive loading.

CAUTION Do not change the adjustment of this device unless absolutely required. The warranty may be voided if the fuel stop is intentionally altered to increase engine power above 10 percent overload at rated speed and load.

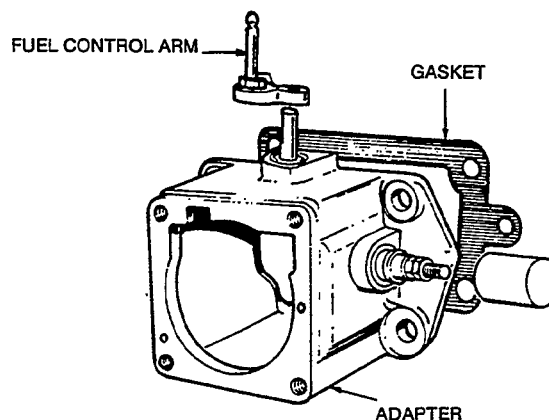


FIGURE 60. ADAPTER ASSEMBLY

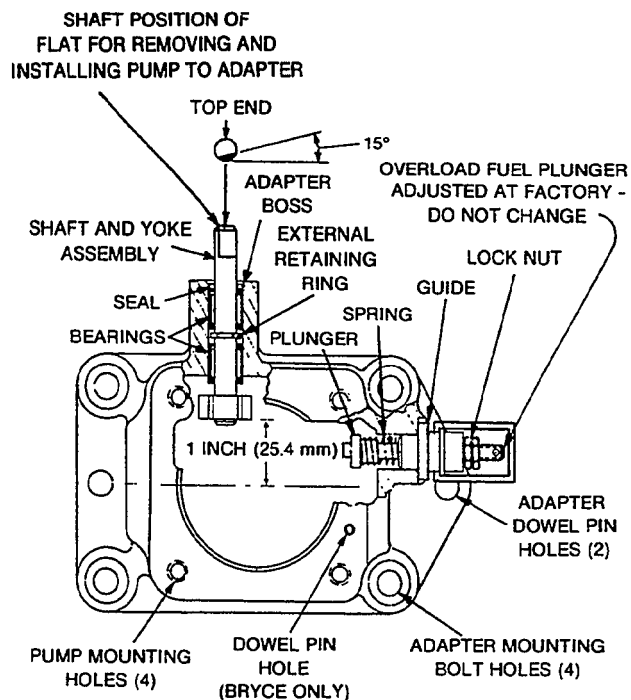


FIGURE 61. INJECTION PUMP ADAPTER ASSEMBLY

CAUTION *A diesel engine cannot tolerate dirt in the fuel system. Dirt is one of the major causes of diesel engine failure. A tiny piece of dirt in the injection system may stop your unit. When opening any part of the fuel system beyond the secondary fuel filter, place all parts in a pan of clean diesel fuel as they are removed. Before installing new or used parts, flush them thoroughly, and install while still wet.*

Removal

1. Remove fuel control arm.
2. Remove four mounting bolts and lift adapter, assembly off of engine block. It may be necessary to tap assembly with lead or plastic hammer in order to loosen adapter from gasket.
3. Discard old gasket and clean area on engine block. A new gasket is required for reassembly of adapter to prevent oil leaks.
4. Thoroughly clean adapter assembly before replacing new bearings and oil seal.
5. Place adapter assembly in suitable holder for removing and installing bearings and seal.

CAUTION *Do not clamp in a vise unless machined surfaces are protected from damage by the jaws of the vise.*

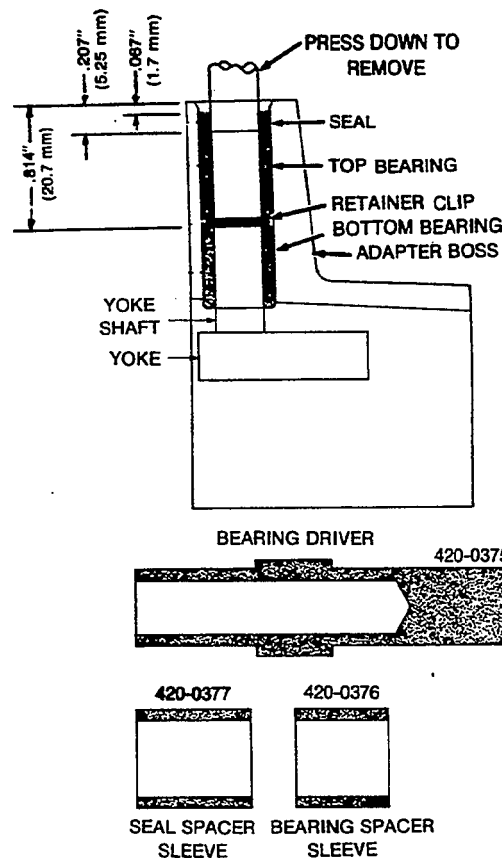


FIGURE 62. BEARING INSTALLATION AND TOOL PACKAGE (420-0374)

Bearing and Seal Replacement Procedure

After adapter assembly has been removed from the engine, replace the bearings and seal on the yoke shaft as follows:

1. Referring to Figure 62, press shaft and yoke assembly towards center of adapter until shaft and bottom bearing slips out bottom end.
2. Using solid end of bearing driver, press top bearing and seal out bottom end.
3. Remove external retaining ring and slide bearing off yoke shaft.
4. Thoroughly clean and oil yoke and shaft assembly and adapter for installing new bearings and seal.
5. Install bottom bearing from top of adapter casting, using hollow end of bearing driver. Make sure "lettered" side of bearing faces upward and that tool bottoms against top of adapter boss.
6. Slide yoke and shaft assembly up through bearing, then support yoke and shaft assembly for installing the retaining ring.

7. Using hollow end of bearing driver, press retaining ring on shaft, far enough so ring snaps into groove on shaft.
8. Slide bearing spacer sleeve (shortest sleeve) over hollow end of bearing driver; then use tool to press top bearing into adapter. Make sure tool bottoms against top of adapter boss and that "lettered" side of the bearing faces upward.
9. Replace bearing spacer sleeve with seal spacer sleeve (longest sleeve) and then use tool to press oil seal over shaft at top of adapter. Make sure seal is installed with "lettered" side down, facing the bearing, and that tool bottoms against top of adapter boss.
10. Reinstall adapter and injection pump assemblies.

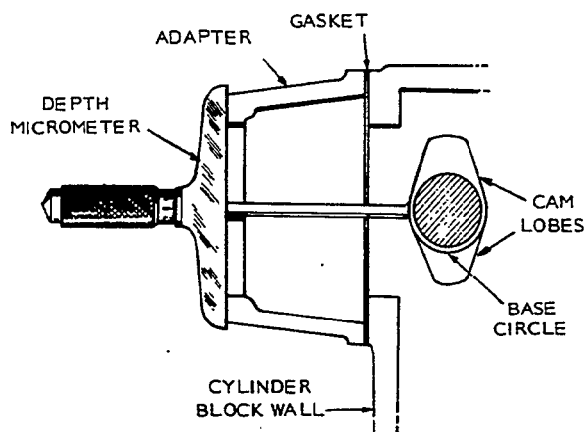


FIGURE 63. MEASURING DEPTH FOR SHIM THICKNESS

Installation

Proceed as follows:

1. Place new gasket on engine block dowel pins and install adapter using four socket head screws and lock washers; torque screws to 20 to 24 ft.-lb. (27 to 33 Nm).
2. Determine shim thickness required between pump and adapter, because the new gasket may not be the same thickness as the original one. See Figure 63.

The proper shim thickness is stamped on the block for the shim combination required during the original factory installation of the injection pump.

3. To measure for shim thickness:

A. Rotate crankshaft to position injection pump cam lobes on the camshaft in a vertical position so the base circle of each lobe faces the adapter opening.

- B. Using a depth micrometer, measure the distance from the mounting face of the adapter to the base circle of either cam lobe.

The shim kit contains shims in the following thicknesses: 0.002, 0.003, 0.006, 0.010, 0.014, and 0.018 inches. If one shim is not enough, the required shim thickness (between 0.004 and 0.020) can be obtained within 0.001 inch by combining two of the above shims. The thickness in inches is stamped on each shim. For the greatest accuracy, measure the total shim thickness with a micrometer.

4. To calculate the shim thickness, determine the following:

Standard installation depth

of pump is3.2598* inches (82.8 mm)

Distance from adapter flange to cam

lobe base circle as measured

(subtract from above) _____ inches (mm)

Required shim

thickness = _____

* Many earlier spec AB MDJE engines have an installation dimension of 3.2540 inch (82.652 mm). On these units, a silkscreen print indicates this dimension. If so, 3.2540 should be substituted for 3.2598 in Step 4.

INJECTION PUMP INSTALLATION

Install injection pump on adapter assembly as follows:

1. Rotate crankshaft to position camshaft so that the pump rollers contact the camshaft base circle (low point of the pump cam lobes). One lobe should be up, the other lobe down. See Figure 63.
2. Using proper shim thickness (Figure 64), install pump to adapter with four socket head capscrews and lockwashers. Torque to 20 to 24 ft.-lb. (27 to 33 Nm).

CAUTION

Be sure the control rack ball fits between the yoke fingers for proper operation. If the rack ball is not properly placed in the yoke, engine operation will be uncontrollable and must be stopped immediately. In such as emergency, the engine can be stopped by blocking the air intake, or by loosening (just cracking) the fuel injector line fittings at the pump end.

3. Connect flexible fuel inlet line to pump inlet.
4. Connect each high pressure fuel line to proper pump outlet and nozzle inlet. Torque nuts to 16 to 18 ft.-lb. (22 to 24 Nm).
5. Reinstall fuel control arm on yoke and shaft assembly, Figure 64. Tighten socket head screw, but do not over tighten.

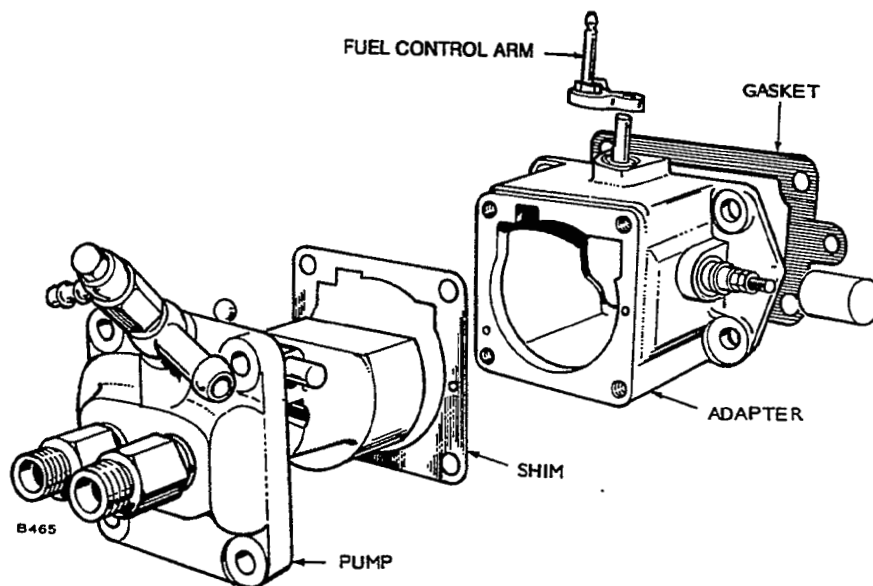


FIGURE 64. PUMP AND ADAPTER ASSEMBLY

6. Adjust fuel solenoid plunger so that a 0.010 to 0.030 inch (0.25 to 0.76 mm) clearance exists (see Figure 65) between the plunger adjustment screw and the fuel control arm with the solenoid in de-energized position. To adjust the plunger length, hold the plunger and adjust the screw on the plunger lever pin at the fuel shutoff position. Retighten locknut.

occur at $18^\circ \text{ BTC} \pm 4^\circ$ on MDJE engines. If piston drop is measured to determine the PC point, the nominal value is 0.115 inch (2.9 mm); the allowable range is 0.171 to 0.070 inch (4.3 to 1.8 mm).

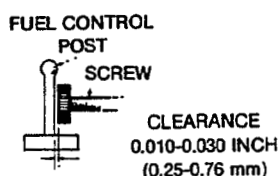


FIGURE 65. FUEL SOLENOID ADJUSTMENT

Flow Timing - Troubleshooting Only

Flow timing is performed at either injection line to establish or confirm the port closing (PC) point of each fuel injection cycle. The PC point should be about the same for each cylinder, but an allowable difference between cylinders is 2.5 crankshaft degrees of rotation, measured on the flywheel rim. Approximately 0.1-inch (2.54 mm) is equivalent to 1 degree of rotation. At 1500 and 1800 rpm, PC should

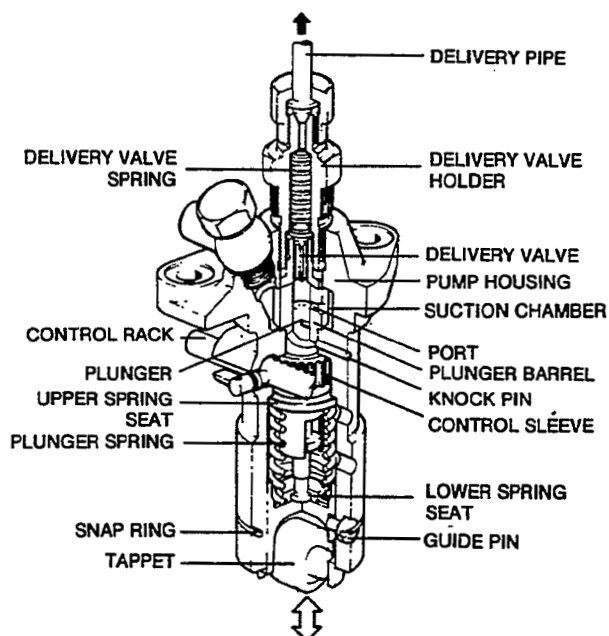


FIGURE 65a. SINGLE INJECTION PUMP ASSEMBLY

Flow Timing Procedure

To determine PC, proceed as follows:

1. Remove one high pressure line (both ends), and the corresponding delivery valve holder, spring, volume reducer, and delivery valve, Figure 65a. Leave gasket and seat in pump.

Place the spring and volume reducer in a clean container of fuel until re-installed.

2. Re-install delivery valve holder (without spring and volume reducer).
3. Install high pressure line on delivery valve outlet so that drops of fuel can be easily counted and collected in a receptacle at the open end of the line.
4. Move the fuel control arm toward the front of the engine to full fuel range.

The fuel solenoid must be energized or held (blocked) to keep the plunger out of the way.

5. Manually operate transfer pump lever to provide fuel pressure to injection pump.
6. Rotate flywheel clockwise very slowly by hand until fuel stops flowing from open line, even though transfer pump operation is continued.
7. Rotate flywheel counterclockwise until fuel flows freely; then, clockwise very slowly to position where fuel drops can be counted at one drop per second with the transfer pump operating.

This is the PC point; it should be marked on the flywheel opposite the timing pointer.

8. After flow timing is completed, remove high pressure line and delivery valve holder; then, reinstall delivery valve, spring, and volume reducer.

CAUTION *Make sure all parts are clean.*

9. Reinstall delivery valve holder and torque Bryce holder to 29 to 33 ft.-lb. (39 to 44 Nm). Torque Kiki holder to 44 to 47 ft.-lb. (60-64 Nm). If fuel leakage occurs, replace the delivery valve gasket.
10. Reinstall high pressure line between pump and nozzle.
11. Using the same procedure, flow timing can be performed on the other cylinder to determine PC or the difference in degrees between cylinders; 2.5 degrees is allowable.

Engine Performance

Engine performance at 1500 and 1800 rpm varies within acceptable limits when PC occurs between 14° and 22° BTC. Generally, retarded timing results in lower smoke but higher fuel consumption; and the opposite is the case when timing is advanced.

Torque Instructions

The following torque instructions are for Bryce/Kiki Injection Systems on Onan MDJE Engines, Figure 66.

Bryce Pump Model FAOBRO70E0686
Kiki Pump Model NP-PFR2K70/1NP22 and 1NP23.

- Delivery Valve Retainer
Bryce: 28.5 to 32 ft.-lb. (39 to 43 Nm)
Kiki: 43.5 to 47 ft.-lb. (60 to 64 Nm)

When using a new delivery valve gasket on Kiki pumps, tighten the valve to full torque value and loosen twice; then, torque retainer a third time to seat the gasket finally.

- Fuel Inlet Stud (both) 15 to 18 ft.-lb. (20 to 24 Nm).
- Bleed Fitting Retainer (both) 35 to 52 lb. inch (47 to 70 Nm).
- All Adapter & Pump Mounting Screws 20 to 24 ft.-lb. (27 to 33 Nm).

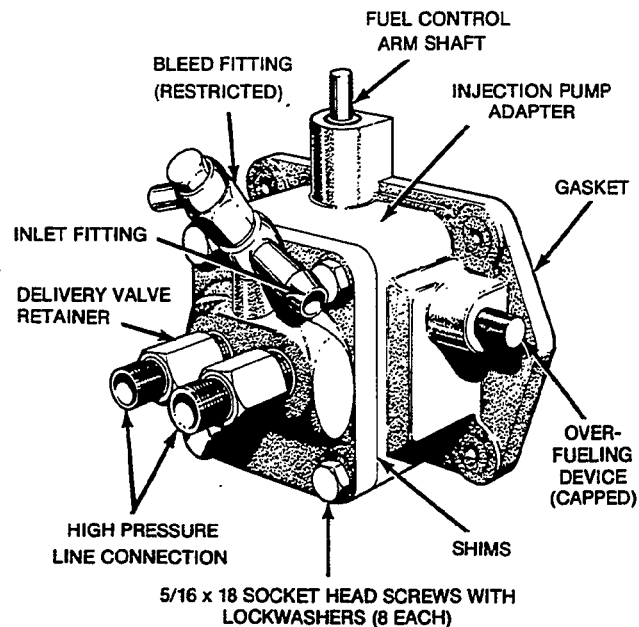


FIGURE 66. BRYCE/KIKI PUMP AND ADAPTER ASSEMBLY

TROUBLESHOOTING PUMP PROBLEMS

Normally, little goes wrong with the injection pump after it is installed on the engine as long as timing is correct and clean fuel is used continually.

The most common problem is caused by a delivery valve that may be held open by dirt or metal chips that entered the pump or fuel system during assembly and installation. That is the reason protective covers must be used to keep foreign matter out of unassembled fuel system components.

If the pump is suspected of causing misfires or poor operation:

- Check the temperature of each nozzle holder and exhaust port; the coolest cylinder is the faulty one.

WARNING *Fuel penetration of the skin might cause severe personal injury. Do not let the nozzle high-pressure fuel spray against skin surfaces.*

- Loosen (crack) the high pressure injection lines, one cylinder at a time (like disconnecting a spark plug wire), to determine the faulty cylinder; the cylinder that loses the least power is misfiring, or not firing.

Pump disassembly by unqualified personnel is not authorized and may void the pump warranty.

Return all faulty pumps to the Onan factory for repairs, or replacement if still under warranty. Otherwise, refer all Service problems to authorized Bryce/Lucas and Diesel Kiki service centers.

THROTTLING PINTLE NOZZLE TESTS

The following tests will determine nozzle conditions using a manually operated test stand. Each nozzle must be removed from the engine for testing. Prior to testing, each nozzle must be cleaned, decarboned, and inspected, as described for non-throttling pintle type nozzles earlier in this section. New or reconditioned nozzles must be thoroughly cleaned in cleaning solvent or test oil to remove all traces of preservative grease before testing.

The nozzle valve and nozzle body are lap-fitted together and must not be interchanged.

Visual Check

Using Illuminated Magnifier:

1. Inspect nozzle valve for damaged or rough seat.
2. Inspect pintle for wear, damage, or out-of-round spray hole.
3. Check nozzle body for damaged or carboned seat.

Slide Test

1. Dip clean nozzle valve in filtered diesel fuel or test oil.
2. Insert valve in nozzle body, Figure 67.
3. Holding body almost vertically, pull valve out to one-third of its engaged length; then release valve.
4. The released valve (because of its weight) should slide down to its seat.

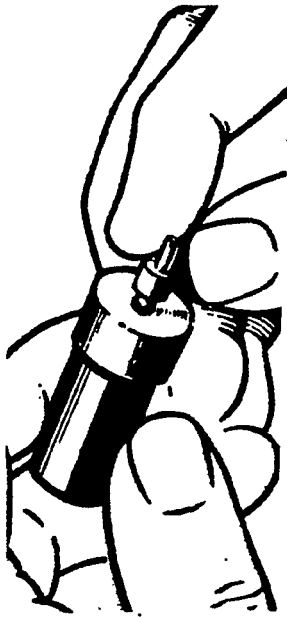


FIGURE 67. SLIDE TEST

Testing Nozzles with Hand Operated Tester

The proper tester can be used to check opening pressure, leak-down rate, chatter, and spray pattern. Install cleaned and inspected nozzle in tester and proceed as follows:

1. Place nozzle in holder.
2. Tighten nozzle nut finger tight, then using proper size wrench, tighten nut to 45 to 50 ft.-lb. (61 to 68 Nm).
3. Connect delivery line between nozzle holder and test stand; be sure that fittings match properly.
4. Test nozzle for jamming:
 - A. Bypass pressure gauge.
 - B. Press nozzle tester hand lever down quickly so that nozzle opens 6 to 8 times per second.
 - C. Nozzle should chatter with a shrill whistling sound, if valve moves properly.

WARNING *Fuel penetration of the skin might cause severe personal injury. Do not let the nozzle high-pressure fuel spray against skin surfaces.*

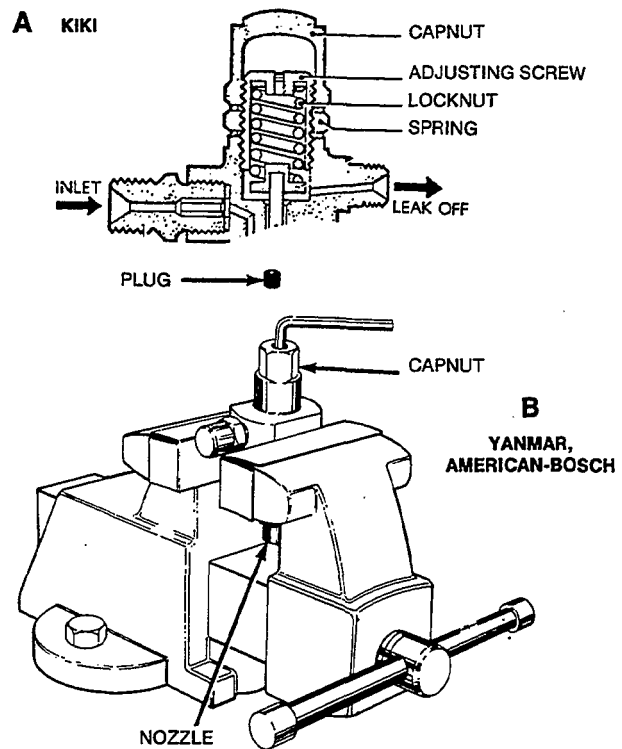


FIGURE 68. NOZZLE ADJUSTMENT

KIKI NOZZLE ADJUSTMENT

If the opening pressure is incorrect, connect nozzle to a tester and hold the nozzle in a suitable holder or smooth jaw vise.

1. Remove cap nut, Figure 68.
2. Loosen locknut.
3. Turn adjusting screw to desired opening pressure.
4. Tighten locknut to 45 to 50 ft.-lb. (61 to 68 Nm).
5. Tighten cap nut to 45 to 50 ft.-lb. (61 to 68 Nm).
6. Remove nozzle from tester and holder.

YANMAR-AMERICAN BOSCH NOZZLE ADJUSTMENT

If the opening pressure is incorrect, connect nozzle to tester and hold nozzle in a suitable holder or smooth jaw vise.

1. Remove plug from cap nut, Figure 68.
2. Loosen locknut.
3. Turn adjusting screw to desired opening pressure.
4. Tighten cap nut to 45 to 50 ft.-lb. (61 to 68 Nm).
5. Install plug using a thread sealant.
6. Remove nozzle from tester and holder.

OPENING PRESSURE

The correct opening pressure should be 2100-2200 psi (14480-15169 kPa) for new nozzles. It may be about 200 psi (1380 kPa) less after the nozzles have operated a few hundred hours. Open pressure gauge to obtain reading.

Leakage Test

1. Slowly depress hand lever until nozzle test gauge indicates 285 psi (1966 kPa) below specified opening pressure.
2. Consider nozzle leak-proof if no fuel (not even one drop) emerges from nozzle tip within 10 seconds.

Chatter Test

1. Operate hand lever downward (1 or 2 nozzle opening cycles per second) until nozzle ejects a stream of fuel with a soft chattering sound.
2. Take pressure readings from gauge.
3. Slightly increase hand lever movements (2 or 3 nozzle opening cycles per second), the stream velocity should increase and create a hissing sound.
4. Accelerate lever movements to 4 to 6 nozzle opening cycles per second. The nozzle should create a shrill whistling sound and a spray pattern.

SPRAY PATTERN

The spray pattern must be compact and well atomized at full lift to be correct. The pressures between nozzle opening and full lift causes the fuel to emerge in a stream, change to flag-like formations, and finally reach atomized spray pattern at full lift, with lever movements producing 4 to 6 nozzle opening cycles per second. See Figure 69.

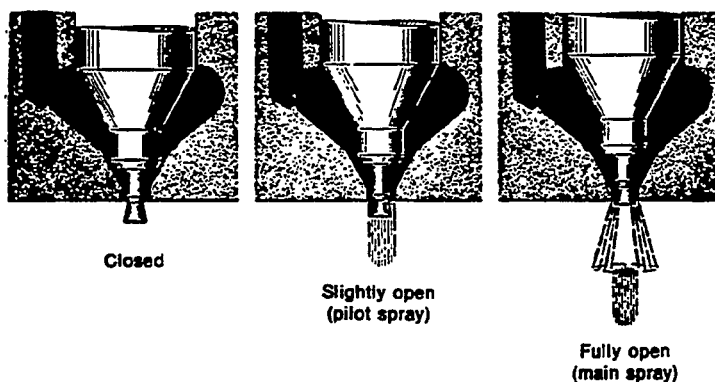


FIGURE 69. NOZZLE SPRAY ACTION

BLEEDING FUEL SYSTEM

Bleed fuel system whenever the filters are changed or when there is air in the lines.

Procedure:

Manually actuate fuel transfer pump until air bubbles are all out and clear fuel flows from the bleed valve automatically, Figure 70.

If the transfer pump cam lobe is on the high side, the priming lever will not operate the pump. Rotate the flywheel one revolution before operating the priming lever.

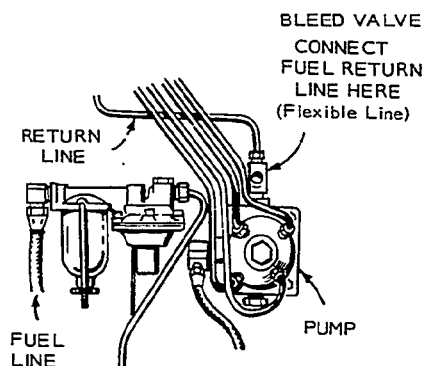


FIGURE 70. BLEEDING FUEL SYSTEM

PREHEATING CIRCUIT

This 12 volt battery circuit consists partly of manifold heaters that raise the combustion air temperature at the intake manifold and a glow plug in each cylinder that heats the precombustion chamber for engine starting, Figure 71. The manifold heater and glow plugs are wired in parallel and are controlled by a preheat switch on the control box.

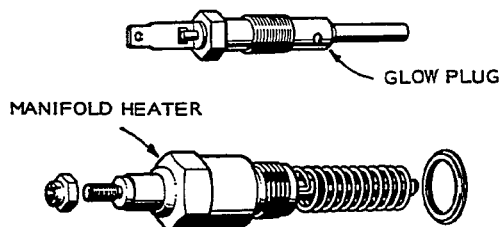


FIGURE 71. GLOW PLUG AND MANIFOLD HEATER

Governor System

The purpose of the engine governor is to maintain a constant engine speed during changes in power demands. A governor responds to changes in power demands by varying the throttle position. A constant-speed governor is standard on marine engines.

GOVERNORS

The constant-speed governor maintains engine speed up to 2400 rpm. The speed-sensing device is a ball and cup mechanism on the camshaft gear. A yoke, resting on the cup, is connected to the throttle lever. Any change in engine speed is transmitted from the cup to the yoke, and on to the throttle.

Tension on the governor spring determines the speed at which the engine is controlled. A stud screwed into the spring is used to vary the number of effective coils for getting the desired sensitivity—the speed drop from no-load to full-load.

Maintenance

Periodically lubricate the metal governor linkage with lubricating graphite or light non-gumming oil. Also, inspect the governor linkage for binding or excessive slack or wear. Plastic ball joint socket does not need lubrication.

Adjustments (MDJB, MDJC, MDJE, and MDJF)

Prior to Spec R, both the governed speed and the governor sensitivity are adjusted with the stud and nut on the front of the engine (Figure 72). Beginning Spec R, the sensitivity is adjusted with an adjusting ratchet.

Speed Adjustment (Prior to Spec R): To adjust the governed speed, hold the governor spring stud in position and turn the governor spring nut with a wrench. For accurate speed adjustment, use a reed frequency meter on the AC output. (A mechanical tachometer is not as accurate.) On generator set frequency and speed according to the nameplate.

Sensitivity Adjustment (Prior to Spec R): To adjust the sensitivity, turn the governor spring stud; counterclockwise gives more sensitivity (less speed drop). If the governor is too sensitive, a hunting condition occurs (alternately increasing and decreasing speed). Adjust for maximum sensitivity without hunting. See the engine nameplate for speed and sensitivity settings. After sensitivity adjustment, the speed may require readjustment.

Speed Adjustment (Begin Spec R): Adjust engine speed by turning governor speed adjusting nut (Figure 72). Turn nut clockwise to increase speed, counterclockwise to decrease speed.

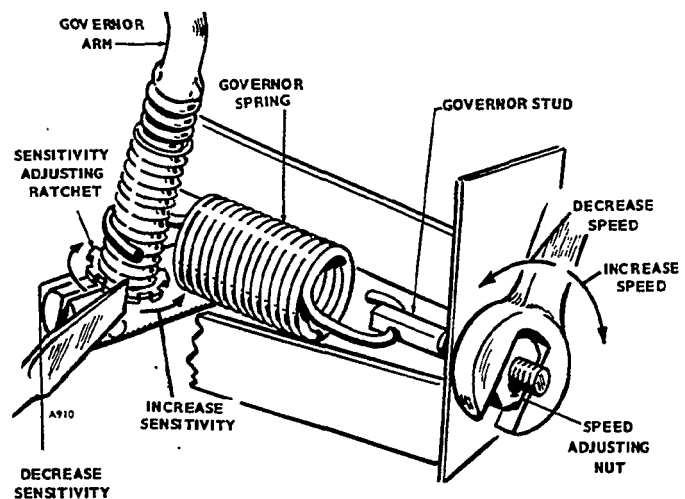
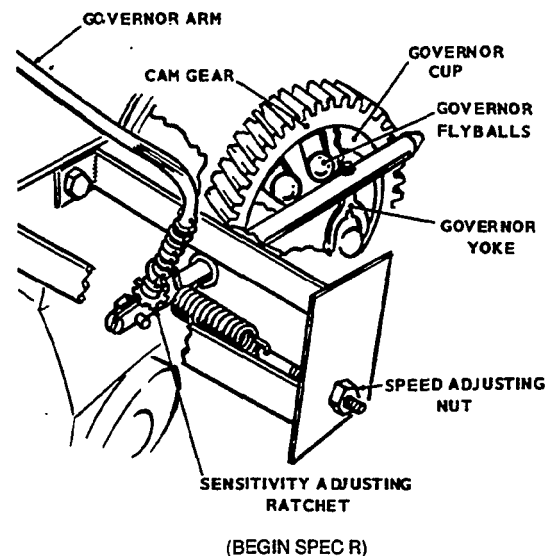
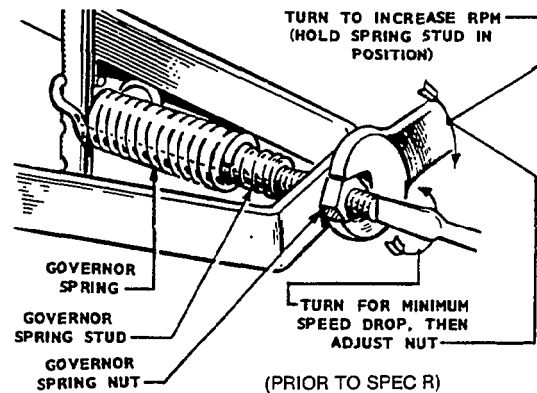


FIGURE 72. GOVERNOR ADJUSTMENTS

Sensitivity Adjustment (Begin Spec R): Adjust sensitivity (no-load to full-load speed drop) by turning the sensitivity adjusting ratchet nut. If speed drops too much when a full load is applied, turn the ratchet nut counterclockwise. An oversensitive adjustment, approaching no speed drop when load is applied, may result in hunting condition (alternate increase and decrease in speed).

MDJA Governor System

Adjust engine speed by turning governor speed adjusting nut (Figure 73 prior to SPEC R and Figure 74 SPEC R). Turn nut clockwise to increase speed, counterclockwise to decrease speed.

Adjust sensitivity (no-load to full-load speed drop) by turning the sensitivity adjusting ratchet nut. If speed drops too much when full load is applied, turn the ratchet nut counterclockwise. An oversensitive adjustment, approaching no speed drop when load is applied, may result in a hunting condition (alternate increase and decrease in speed). Adjust for maximum sensitivity without hunting. The use of a reed-type frequency meter will give the most accurate results. On generator sets, it should be possible to adjust for a sensitivity of less than 3 hertz; 2 hertz is usually attainable.

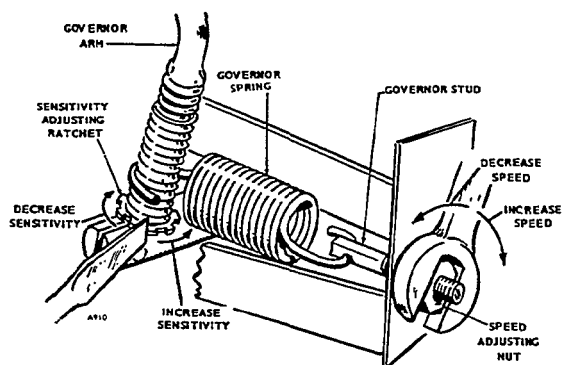


FIGURE 74. MDJA (BEGIN SPEC R)
GOVERNOR ADJUSTMENTS

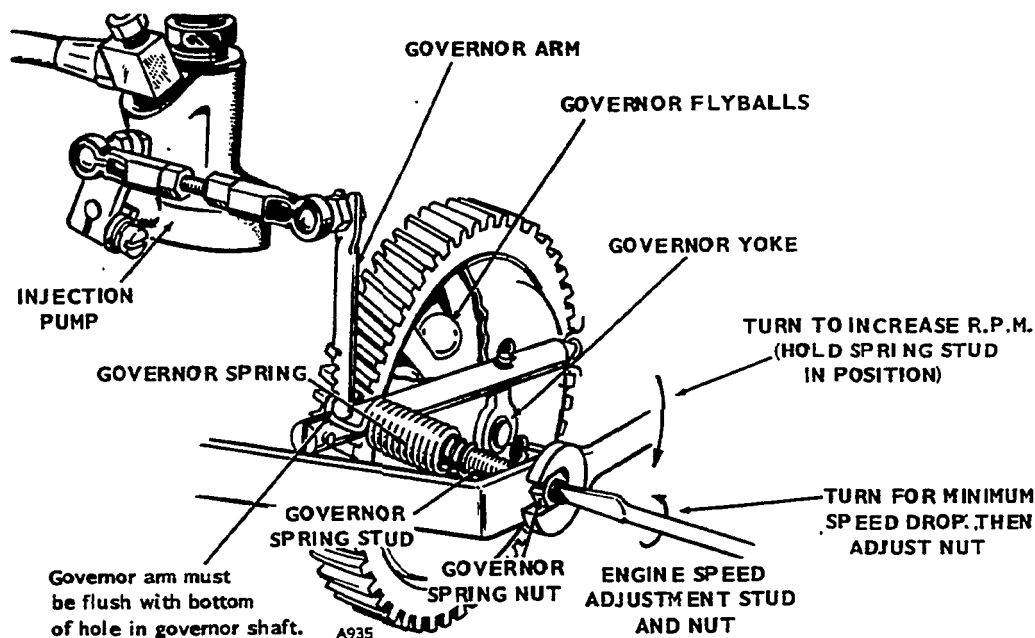


FIGURE 73. MDJA GOVERNOR ASSEMBLY (PRIOR TO SPEC R)

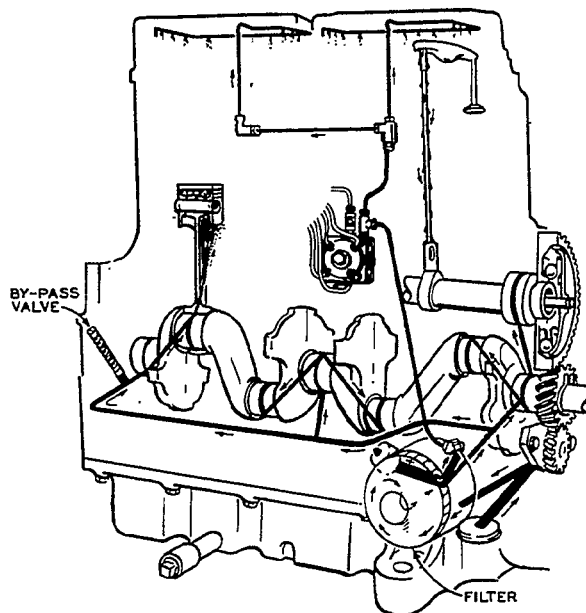
Oil System

Onan diesel engines have pressure lubrication to all bearing surfaces of the engine. The oil system includes an oil intake cup, a gear-type oil pump, a by-pass valve, a full-flow oil filter and passages and drillings through the block for oil delivery.

Figure 75 shows the pressure oil system.

A thin film of oil from the crankcase lubricates the cylinder walls, and the rings wipe the excess oil off to prevent passage of oil to the combustion chamber. The upper portion of the cylinders are partially lubricated by the fuel. The connecting rod bearings are critically in need of lubrication because of the high pressures and high rotating speeds. Bearing lubrication and cooling are very important to the life of an engine.

Normal oil pressure should be 25 psi (172.5 kPa) or higher when the engine is at operating temperature. If pressure drops below 20 psi (138 kPa) at governed speed, inspect the oil system for faulty components.



LS-1013

OIL PUMP

The oil pump is mounted on the front of the crankcase behind the gear cover, and is driven by the crankshaft gear.

The pump draws oil from the crankcase and delivers it through the oil filter to the rocker housing, through the crankcase drillings to the crankshaft bearings, camshaft front bearing, crankshaft passages to connecting rod bearings and connecting rod passages to piston pin bushings.

Removal

1. Remove gear cover and oil base. (See *ENGINE DISASSEMBLY*.)
2. Unscrew intake cup from pump.
3. Remove crankshaft lock ring and gear-retaining washer.
4. Loosen two capscrews holding pump and remove pump.

FIGURE 75. OIL PRESSURE SYSTEM

Repair

Except for the gaskets, component parts of the pump are not individually available. If the pump is defective or excessively worn, replace it. Disassemble the pump by removing the two capscrews holding the pump cover to the body. Inspect for excessive wear in gears and shafts. To improve pump performance, adjust the gear-end clearance by changing the gasket thickness between the pump body and cover. Use the thinnest gasket that permits free movement of the pump shafts. Oil all parts when assembling the pump.

Installation

Before installing, fill the pump intake and outlet with oil to be sure it is primed. Mount the pump on the engine and adjust the 0.005-inch (0.127 mm) lash between the pump gear and crankshaft gear. Mount the intake cup on the pump so it is parallel to the bottom of the crankcase.

BYPASS VALVE

Located on the outside of the rear bearing plate, the bypass valve (Figure 76) controls oil pressure by allowing excess oil to flow directly back to the crankcase. Normally the valve begins to open at about 25 psi (172.5 kPa). It is non-adjustable, and normally needs no maintenance.

To determine if high oil pressure is caused by the plunger sticking closed, or low oil pressure by the plunger sticking open, clean and inspect the valve.

To remove the valve, unscrew the recessed plug in the rear bearing plate and lift out the spring and plunger assembly. Determine proper valve operation by checking the spring and plunger against the given values:

Plunger Diameter 0.3365 inch to 0.3380 inch
(8.5471 to 8.5852 mm)

Spring
Free Length 2-5/16 inches, + 1/16 inch
(74.613, + 1.588 mm)
2.225 lb. at 1-3/16 inches (compressed)
(1.01 kg) at (30.163 mm) (compressed)

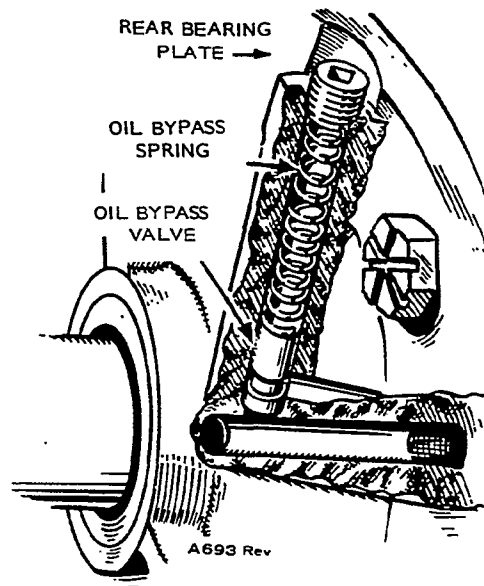
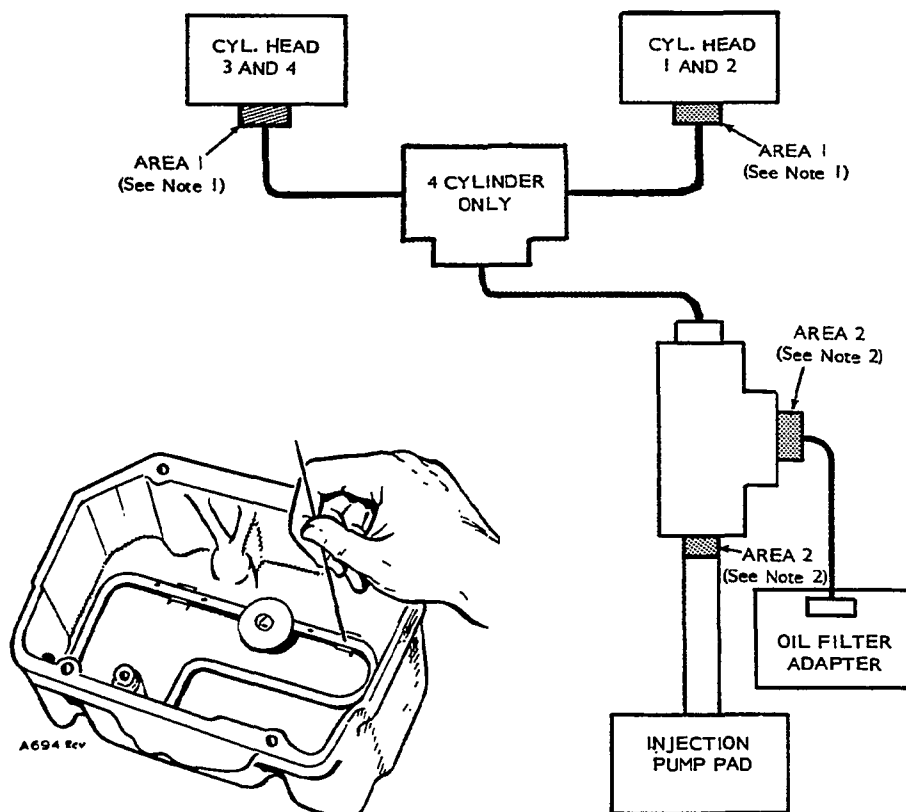


FIGURE 76. BYPASS VALVE



Note 1 - Use a #70 drill bit (.028 in. [1.17 mm]) for cleaning being careful not to enlarge hole. These are restricted flow fittings. If holes are enlarged, valve deck will receive excess oil. If holes are plugged, valve train will run dry and wear out.

Note 2 - Use a #56 drill bit for cleaning being careful not to enlarge hole. It is critical that fittings be kept open. If restriction is plugged, injection pump tappet, bottom, and plunger will wear out.

FIGURE 77. CLEANING ROCKER BOX OIL LINE AND RESTRICTION ORIFICES

OIL LINES

At overhaul time the rocker box oil line should be flushed with fuel and a fine wire used to clean the small holes, Figure 77. Clean standpipe breather on four cylinder engines.

Clean out all other oil lines and drillings with compressed air whenever the engine is disassembled or overhauled. The oil gauge passage may be reached by removing the oil filter mounting plate.

External oil lines, the rocker box oil line, and the internal oil line to the rear bearing are replaceable.

Restriction orifices are placed in the external oil lines to regulate the quantity of oil delivered to the injection pump gearing and tappet and to the rocker arm and valve train areas. Two orifices are located in the Tee fitting at the injection pump, and one orifice is located in the inlet fitting to each cylinder head.

CAUTION *To prevent injection pump or valve train damage from lack of lubrication, ensure that all restriction orifices are kept open. Cleaning can be done using a fine wire or drill bit and compressed air.*

0.028 inch size at heads (0.71 mm)
0.046 inch size at Tee (1.17 mm)

OIL FILTER (Full Flow)

The oil filter is mounted on the filter plate at the left side of crankcase (Figure 78). It requires replacement every 200 hours of normal operation. Remove filter by turning counterclockwise, using a filter wrench. Install new filter finger-tight plus 1/4 to 1/2 turn.

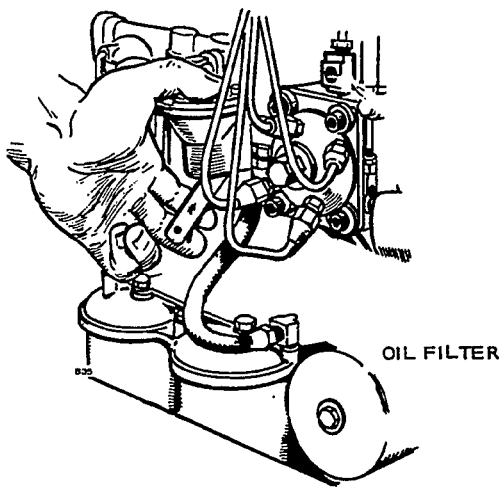


FIGURE 78. FULL FLOW OIL FILTER

WARNING *Hot crankcase oil can cause burns if it is spilled or splashed on skin. Keep fingers and hands clear when removing the oil filter and wear protective clothing.*

CRANKCASE BREATHER

**MDJA Begin Spec R,
MDJB Begin Spec S, and MDJE**

These engines are equipped with a ball check valve for maintaining crankcase vacuum. The only maintenance required is to clean the components periodically. Remove the hose clamp, breather hose, and breather cap clamp to release the breather cap and valve assembly. Wash cap and valve assembly and the baffle in suitable solvent and reinstall.

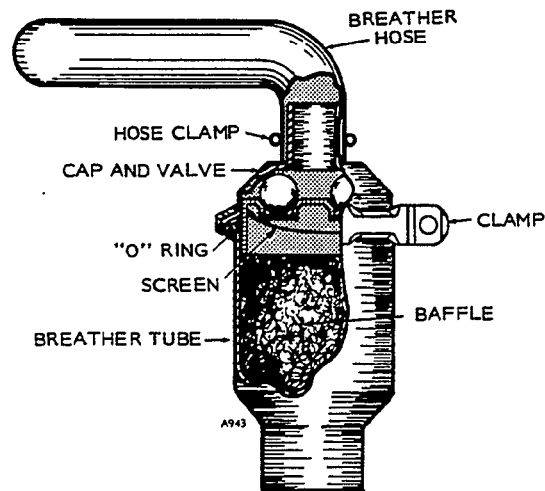


FIGURE 79. CRANKCASE BREATHER

CRANKCASE BREATHER

MDJC, MDJF Begin Spec T

These engines are equipped with a crankcase breather pipe that vents crankcase fumes directly from the rocker box cover to the cylinder head intake port (see Figure 80). The crankcase breather pipe must be removed and cleaned after every 500 hours of engine operation. A clogged breather pipe may result in oil leakage at the rocker box gaskets and oil filter seal.

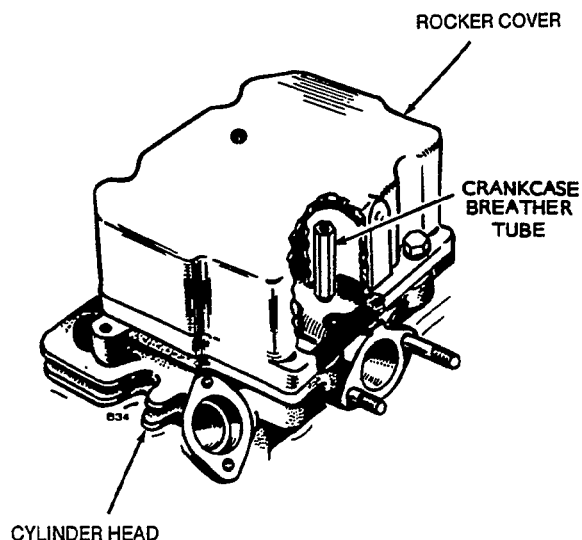


FIGURE 80. CRANKCASE BREATHER PIPE

CRANKCASE BREATHER

MDJA Prior to Spec R

The crankcase breather is located in the left rear corner of the crankcase and maintains a partial vacuum in the crankcase during engine operation. Its purpose is to ventilate the crankcase and control oil loss. It consists of a metal filter packed into the tube on the crankcase, a rubber cap with flapper valve, and a hose connecting it to the engine air horn.

To disassemble, remove the rubber cap from the crankcase tube and pry the valve out of the cap. Wash the valve in fuel at regular intervals and, if defective, replace it. At the same time, pull the baffle out of the breather tube and clean it. Install the valve with the perforated disk toward the engine. Figure 81 shows the crankcase breather.

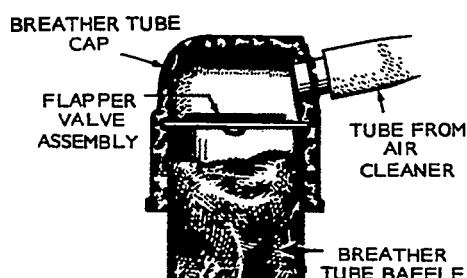


FIGURE 81. CRANKCASE BREATHER

PULSATION DAMPER

MDJC Begin Spec S and MDJF

These engines are equipped with a pulsation damper which serves two major functions. It dampens pulsations which originate in the intake manifold and which contribute to oil carry-over. It also acts as an oil separator to condense oil vapor and small oil droplets (in the blowby fumes) to prevent them from getting into the intake manifold and combustion chamber.

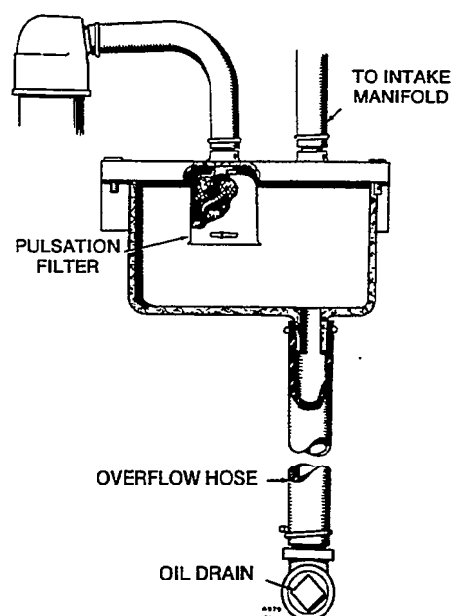


FIGURE 82. PULSATION DAMPER

OIL PRESSURE GAUGE

Some engines have an oil pressure gauge. If faulty, replace it. Remove with a wrench and install a new gauge. Check for a plugged oil passage.

The nonadjustable oil pressure switch controls the decompression solenoid in the starting system, allowing it to energize only when the switch closes. This allows the engine to build up speed, during starting, before compression occurs. The switch closes at about 5 psi (35 kPa) under increasing oil pressure.

CAUTION

This is not a low oil pressure protection switch. It will not protect the engine against slowly decreasing oil pressure.

On MDJA engines if the decompression switch does not energize, check switch operation. Short the switch to ground when the engine has built up speed during starting. The governor solenoid should energize immediately and the engine should start.

CAUTION

When the engine starts, check immediately for oil pressure. Shut the engine down if oil pressure does not build up within a few seconds. In this case, the lack of oil pressure is causing faulty operation, not the switch.

LOW OIL PRESSURE CUT-OFF SWITCH

The switch (Figure 83) is located on the oil filter adapter plate below the oil filter. A special start switch jumpers the cut-off switch during starting to allow engine to build up oil pressure and close the switch. The switch closes at 13 to 15 psi (90 to 104 kPa), under increasing pressure. If oil pressure falls below 13 psi (90 kPa), the switch opens.

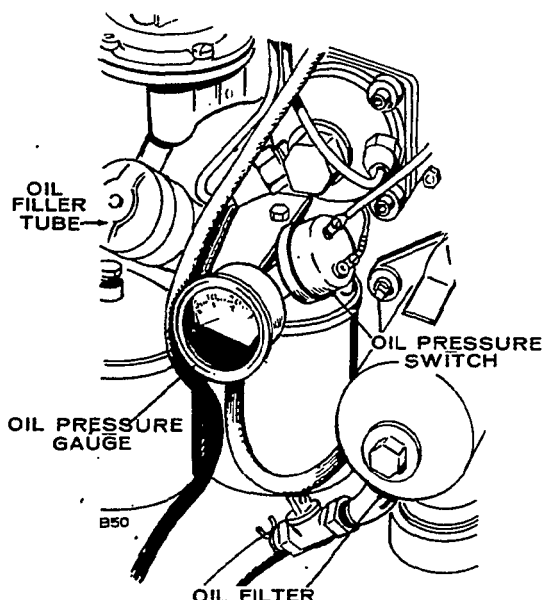


FIGURE 83. LOW OIL PRESSURE SWITCH

CENTRIFUGAL SWITCH

This switch (Figure 84) is mounted on the gear cover backplate and operates directly off the camshaft gear. Normally open, the switch closes when engine speed builds up to about 900 rpm. This allows the engine to build up sufficient oil pressure so that it can be started.

For correct operation, maintain the switch gap at 0.020 inch (0.51 mm). See Figure 85.

Check the contacts for dirt or pitting when adjusting the gap. Clean the contacts with paper or replace if they are badly pitted.

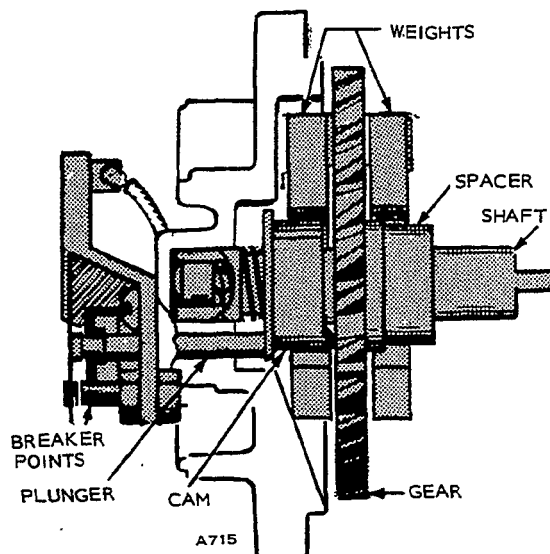


FIGURE 84. CENTRIFUGAL SWITCH ASSEMBLY

Disassembly

1. Disconnect the battery to prevent accidental shorts.
2. Remove the switch cover, to reveal the point set.
3. Remove the point set assembly by removing the screws holding it to the plate. Pull out the plunger and plunger diaphragm.
4. Remove the centrifugal switch plate, to reveal the cam and weight assembly.
5. Pull out the cam and weight assembly.

CAUTION Be careful not to lose the spacer mounted on the gear shaft behind the gear.

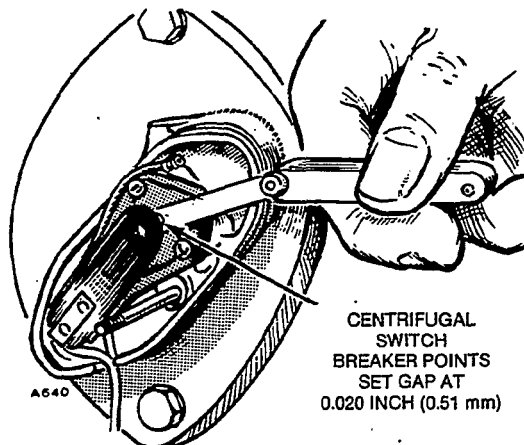


FIGURE 85. BREAKER POINTS

Repair

Thoroughly clean the gear and cam assembly, the bearing surfaces in the gear case and breaker plate, and the oil trickle holes to these bearings. Check the oil spray hole in the gear case to be sure it is open.

Check for wear in the spacer, fiber plunger, and the spring loaded shaft plunger. The spacer must be at least 0.35 inch (8.89 mm) long. If it is not, replace it immediately. Push the weights outward; they should move freely. If they do not, or if any part of the assembly is sticking or worn, replace the cam and weight assembly. If the cam is loose on the gear shaft, replace the assembly.

If the breaker gap cannot be maintained at .020 inch (0.51 mm), check the fiber plunger and spacer for wear.

Assembly

1. Install the spacer on the shaft and install the shaft assembly into the gear case. Match it with the cam gear.
2. Install the spring and plunger into the end of the shaft.
3. Install the breaker plate.
4. Install the plunger and diaphragm.
5. Install the breaker points on the breaker plate and set the gap at 0.020 inch (0.51 mm).
6. Install the switch cover and reconnect the battery.

Starting System

These models use a separate 12 volt starting motor mounted on the right hand side of the engine to drive the flywheel. It is a standard automotive starting motor with a solenoid for engaging the pinion and an over-running clutch. When the solenoid is energized, its core pulls in, shifting the pinion into engagement with the flywheel ring gear. At the same time, contacts in the solenoid close to provide a circuit for the starter motor. The starting motor remains engaged until the starting switch is released.

If engine is equipped with a start-disconnect switch, the starter motor will automatically disengage flywheel gear when engine speed reaches about 900 rpm.

The starter is protected from over-speed by an over-running clutch which permits the engine to run faster than the starter before the pinion is disengaged. Figure 86 shows the starting circuit.

MAINTENANCE

Periodically check the starting circuit wiring for loose or dirty connections. Inspect the starter commutator, and if it is dirty, clean with number 00 sandpaper (do not use emery cloth or emery paper). Check the brushes for poor seating on the commutator and for excessive wear.

TESTING

Poor cranking performance can be caused by a faulty starting motor, defective battery, or high resistance in the starting circuit.

Check the charge condition of the battery with a hydrometer.

WARNING Ignition of explosive battery gases might cause severe personal injury. Do not smoke while servicing batteries.

Specific gravity should be between 1.290 and 1.225 when 75 percent charged. If not, recharge the battery. Check electrolyte level. If battery will not recharge, replace it. Keep battery connections tight and clean.

With the starting motor operating, check the voltage drops (1) from the battery ground terminal post (not the cable clamp) to the cylinder block, (2) from the cylinder block to the starting motor frame and (3) from the battery positive post to the battery terminal stud on the solenoid. Normally, the voltage drops at (1) and (3) should never exceed 0.6 V each, even under the most severe conditions (extreme cold). The voltage drop at (2) should never be permitted to exceed 0.3 V under the same severe conditions. Thoroughly clean all connections in any part of the circuit showing excessively high voltage drops.

If starting motor tests are required, remove the motor from the engine and test it on a bench. Test the free-running voltage and current.

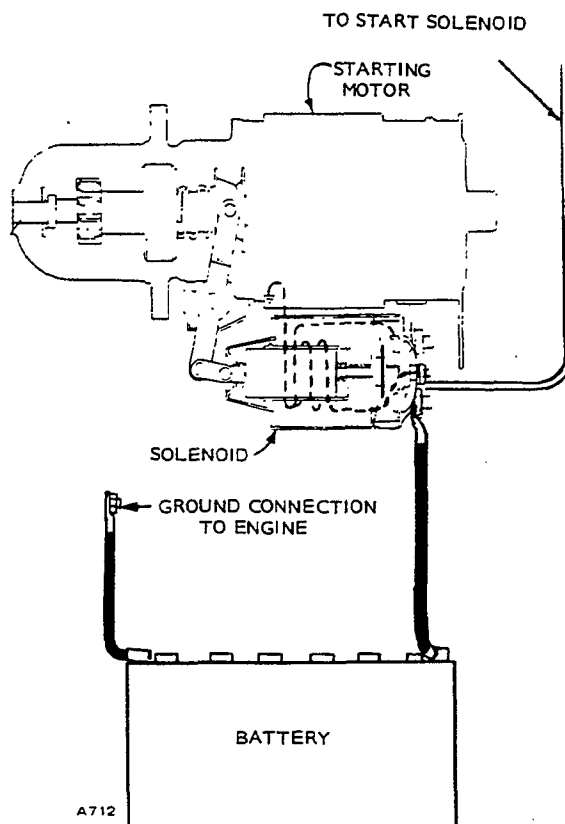


FIGURE 86. STARTING SYSTEM

Using a spring scale and torque arm, test the stall torque, Figure 87. Multiply the spring scale reading by the arm length for the torque valve.

If free running speed is low, and starter has a high current draw with low stall torque, check for tight, dirty or worn bushings, bent armature shaft, or loose field pole screws, allowing armature to drag. Check also for shorted or grounded armature and field.

A low free speed with low torque and low current draw indicates an open field winding, high internal resistance due to poor connections, defective leads, broken or worn brushes, or scored, worn, or dirty commutator.

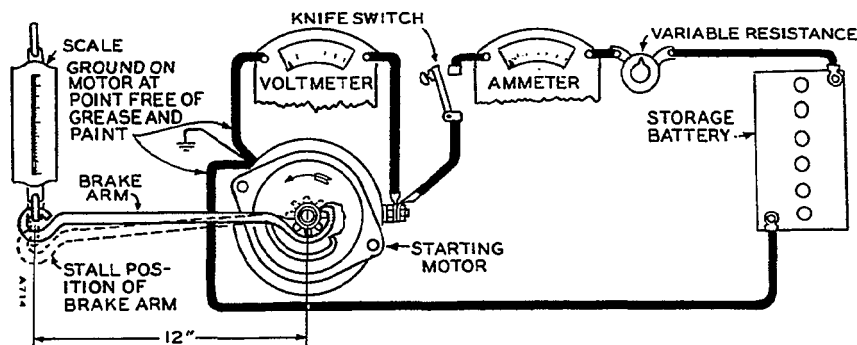


FIGURE 87. TESTING STALL TORQUE

High free speed with low developed torque and high current draw indicates shorted fields. Since there is no easy way to detect shorted field coils, replace and check for improved performance.

The voltage drop across the solenoid on the starting motor should be less than 0.3 volts. If not, remove it for repair.

BATTERY

Engines with a separate cranking motor normally use a single 12 volt battery of at least 62 amp-hour capacity.

The battery charging system maintains the batteries at or near full charge at all times. Inspect the battery charging system and adjust the charge rate if batteries appear to be continually discharged.

Adding accessories that draw battery current requires an adjustment of the charge rate.

If discharge or failure to charge cannot be traced to the battery charging system, thoroughly inspect and test the battery, and replace it as necessary.

REPAIR

Armature

Inspect the armature for mechanical defects before checking for grounds or shorted coils.

To test for grounds, use a 12 volt test lamp and check between each segment of the commutator and the shaft. Do not touch probes to the commutator brush surfaces, as this will burn the smooth surfaces.

A growler is necessary to test for shorted coils. With the armature on the growler, run a steel strip over the armature surfaces. If a coil is shorted, the steel strip will become magnetized and vibrate. Rotate the armature slightly and repeat the test. Do this for one complete revolution of the armature. If the armature has a short or ground, replace it.

If the commutator is only dirty or discolored, clean it with 00 or 000 sandpaper. Blow sand out of rotor after cleaning. If, however, it is scored, rough or worn, turn it down in a lathe.

Field Coils

Using a test lamp and probes, check the field coils for grounding to the motor frame or open circuit. Inspect all connections to be sure they are properly clinched and soldered. Inspect the insulation for evidences of damage. The only way to check for field coil shorts is to use the starting motor test.

Bearings

If either the front or rear bearings show excessive wear, replace them. Drive the old bearings out, and using an arbor press and the proper arbor, press new bearings into place.

Brushes

Check the brushes for wear or improper seating. They should slide freely in their holders. Check the brush spring tension with a spring scale. To change spring tension, twist the spring at the holder with long nosed pliers.

Replace Prestolite brushes when excessively worn, or when worn to 5/8 inch in length. Replace Mitsubishi, brushes when excessively worn or when worn to 7/16 inch in length. Some brushes are soldered to the field coil. To remove these brushes, unsolder the lead and open the loop in the field coil lead. Insert the new brush pigtail completely into the loop and clinch before resoldering. A good soldering job is necessary to ensure good contact and low voltage drop across the connection.

Over-Running Clutch

Clean the clutch thoroughly but do not dip in solvent. It cannot be repacked with grease.

It should slide easily on the armature shaft with no binding. Turn the pinion; it should rotate smoothly, but not necessarily freely. Reverse the direction a few times and it should instantly lock and unlock. Replace the clutch if operation is defective or pinion is worn or damaged.

Shifting Solenoid

See that the plunger moves freely in the coil. Check pull-in coil continuity between the solenoid control terminal and the solenoid connection to the motor. Check the hold-in coil continuity between the solenoid control terminal and ground on the motor.

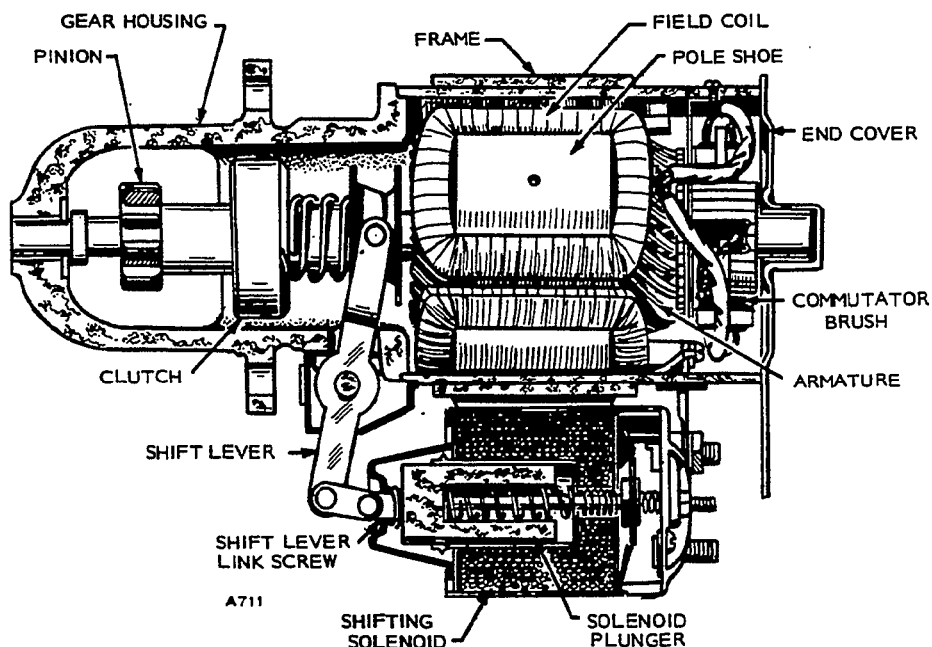


FIGURE 88. STARTING MOTOR

PRESTOLITE STARTER REMOVAL AND DISASSEMBLY

1. Remove connections to controls and battery at shifting solenoid. See Figure 88.
2. Remove nut-holding rear mounting bracket to engine.
3. Remove three capscrews holding starting motor flange to engine and pull out motor.
4. Remove link pin holding the shift lever to solenoid plunger and remove shift lever center pin.
5. Remove through bolts from commutator end of motor. Pull off end cover and lift brushes off their seats.
6. Pull pinion housing from front end of motor and lift armature and clutch out of motor frame.
7. To remove over-running clutch from armature, drive retainer away from lock ring near front end of shaft, remove lock ring and pull assembly off. Do not attempt to disassemble clutch assembly.
8. If necessary to service solenoid, remove four capscrews and electrical connection holding it to motor frame. Remove two screws on rear of solenoid to reach switch contacts.
9. Mount starter motor to engine by a direct reversal of the removal procedure (Figure 89). Connect battery cable and wires to starter.
10. Connect battery cables to battery. Connect ground last.

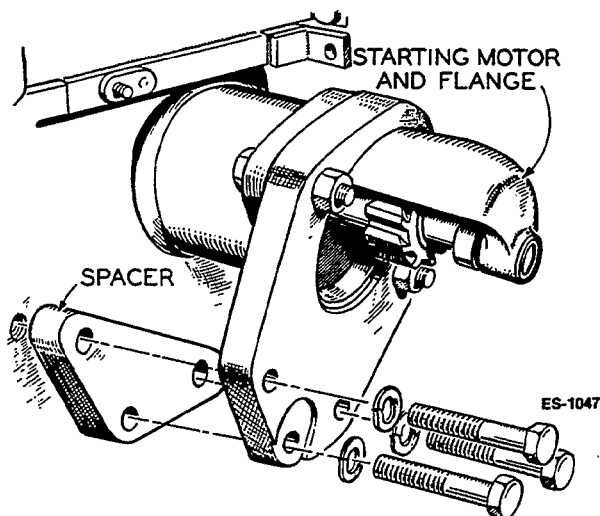


FIGURE 89. STARTING MOTOR FLANGE

PRESTOLITE STARTER ASSEMBLY

Before assembling, soak the bronze bearings in oil. They are absorbent bearings, designed to hold up to 25 percent of their own weight in oil. Be sure the felt oil pad is in the outer end of the commutator end bearing.

When the motor is assembled, check the armature end play. It should be between 0.005-inch (0.127 mm) and 0.030-inch (0.762 mm). Adjust end play by adding or removing washers on the commutator end of the armature.

Before installing, check the pinion clearance. Proper clearance is important to ensure starter engagement. Press on solenoid core to shift the pinion into full mesh and measure the clearance between pinion and pinion stop, Figure 90. This should be between 0.07 inch and 0.12 inch (3.05 mm) (as near to 0.070 inch [1.78 mm] as possible). Adjust the link screw on the end of the solenoid plunger for proper clearance.

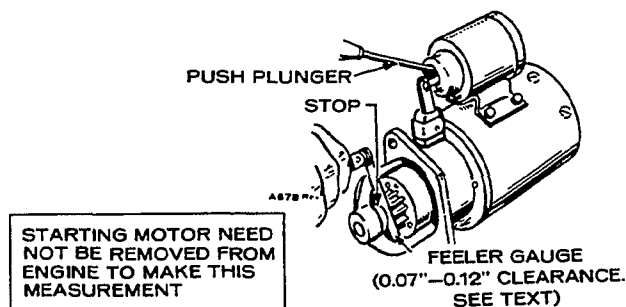


FIGURE 90. PINION CLEARANCE

MITSUBISHI STARTER REMOVAL AND INSTALLATION

1. Remove both battery cables from battery. Disconnect ground cable first.
2. Disconnect battery cable and electrical lead wires from starter.
3. Remove capscrews and flat washers that attach starter to mounting bracket.
4. Remove starter.
5. Mount starter motor to engine by a direct reversal of the removal procedure. Connect battery cable and wires to starter.
6. Connect battery cables to battery. Connect ground last.

MITSUBISHI STARTER DISASSEMBLY

1. Remove "M" terminal nut and wire lead from solenoid.
2. Remove the two solenoid mounting screws and remove solenoid.
3. Remove the two through bolts and brush holder retaining screws. Remove rear bracket (Figure 91).

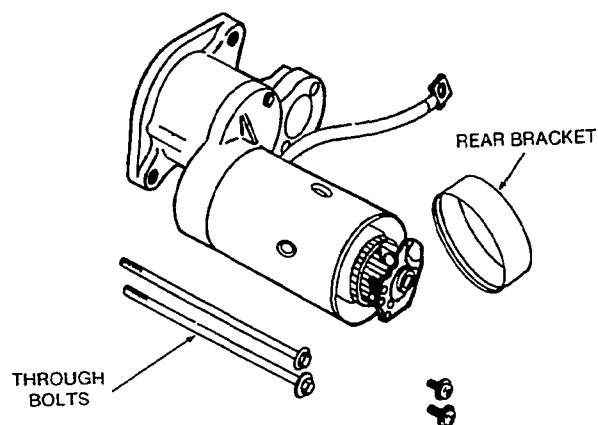


FIGURE 91. REMOVING REAR BRACKET

4. Remove frame assembly, and brush holder assembly while pulling the brushes upward. Then remove armature assembly.
5. Remove cover assembly, (snap ring and washer) from the pinion shaft (Figure 92).

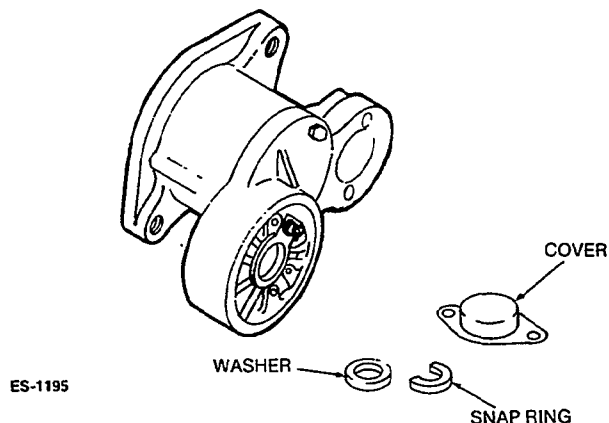


FIGURE 92. REMOVING SNAP RING AND WASHER

6. Remove capscrew that secures center bracket to front bracket. Remove the center bracket; several washers used to adjust pinion shaft end play can now be removed (Figure 93).

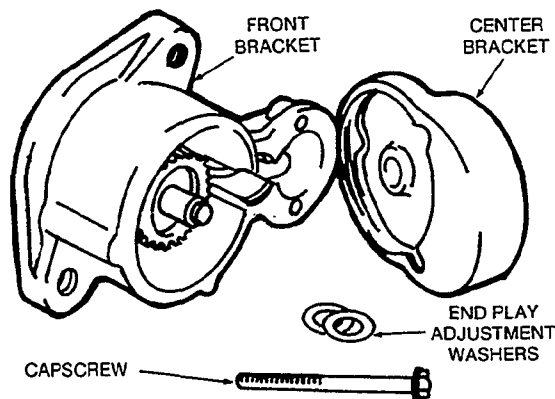
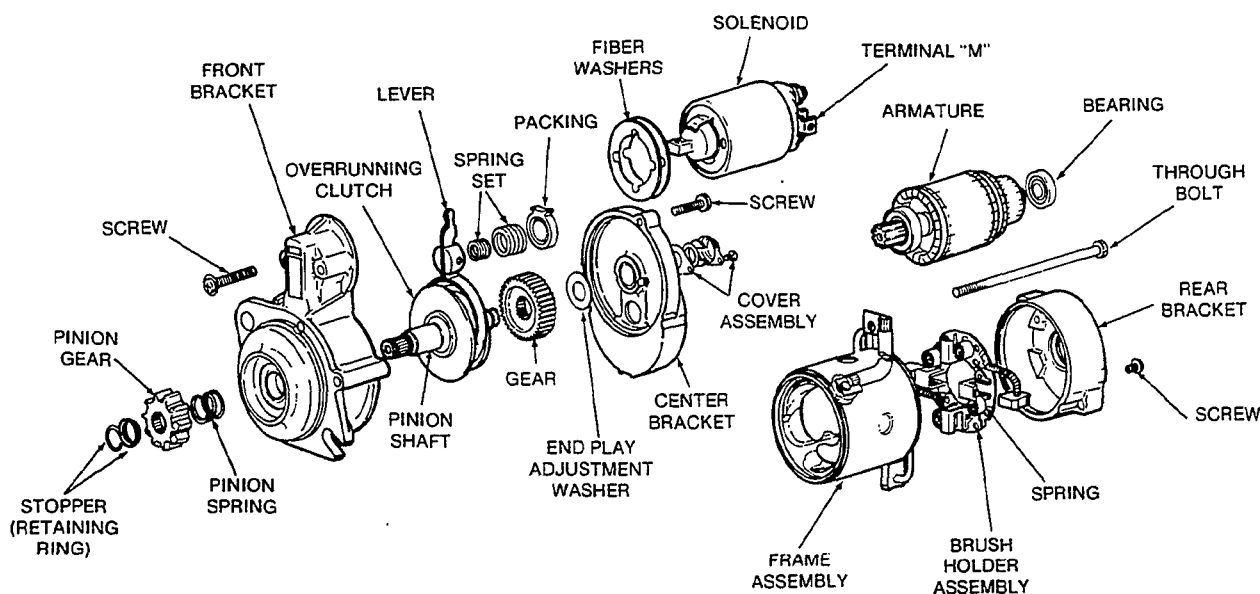


FIGURE 93. REMOVING CENTER BRACKET

7. Remove gear, spring set and lever assembly from front bracket. Note direction in which the lever assembly is installed.
8. Push pinion gear and stopper down and remove retaining ring. Remove stopper, pinion gear, spring, and pinion shaft assembly.

9. Inspect ball bearings. If they are rough or noisy when rotated replace them. The front bearing is not replaceable and must be replaced with the bracket.



XES-1255

FIGURE 94. MITSUBISHI STARTER

MITSUBISHI STARTER ASSEMBLY

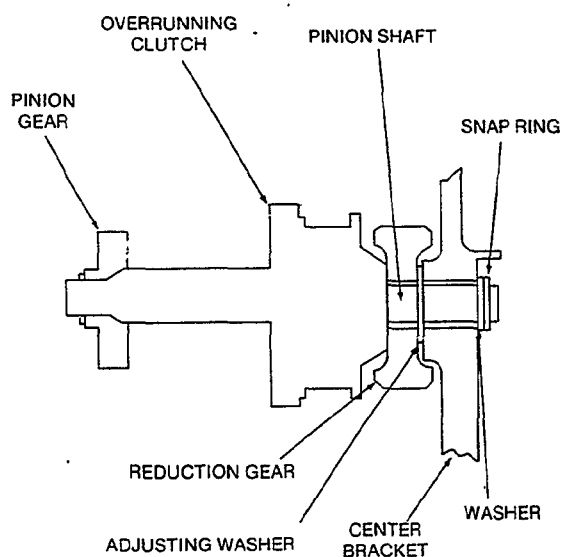
For assembly reverse the disassembly procedure, but note the following items. See Figure 94.

Whenever starter motor is disassembled apply grease to each of the following points. (Recommended grade; Multemp PS No. 2.)

- Armature shaft gear
- Reduction gear
- Ball bearing (Both ends of armature)
- Stopper on pinion shaft
- Sleeve bearing
- Pinion gear
- Sliding portion of lever

Pinion Shaft End Play Adjustment

Adjust end play so that it is 0.1 to 0.8 mm (0.0039 to 0.0315 inch) with the adjusting washers placed between center bracket and reduction gear (Figure 95).



ES-1191

FIGURE 95. ADJUSTING PINION SHAFT END PLAY

With pinion gear removed, install reduction gear onto pinion shaft. Place pinion shaft into center bracket and secure with washer and snap ring. Measure the end play with a feeler gauge between center bracket and gear. If necessary, adjust end play by adding or removing adjusting washers.

If pinion gear has not been removed, place pinion shaft and reduction gear between front bracket and center bracket. With lever spring removed and bolt tightened, push pinion shaft out and measure end play. Adjust end play, if necessary, by adding or removing shims.

Pinion Gear Installation

Place spring and pinion gear onto pinion shaft. Slide stop ring onto pinion shaft and install retaining ring in groove. Pull stop ring over retaining ring (Figure 96).

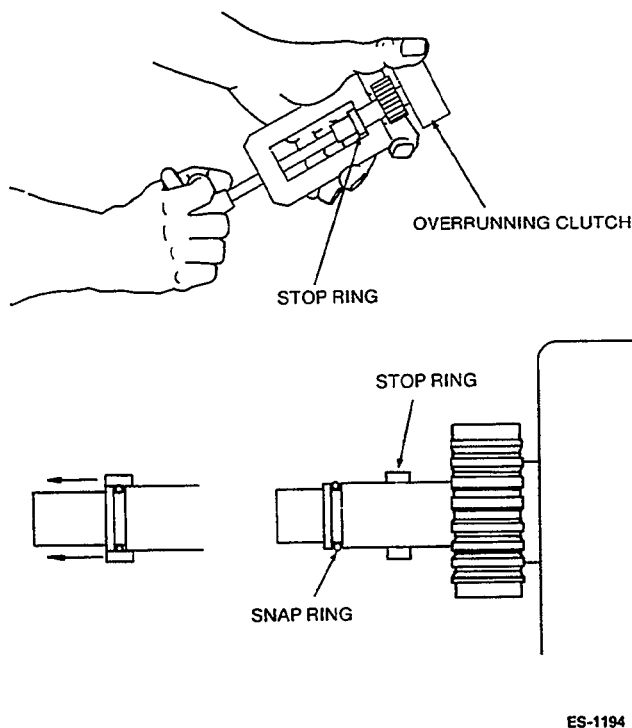
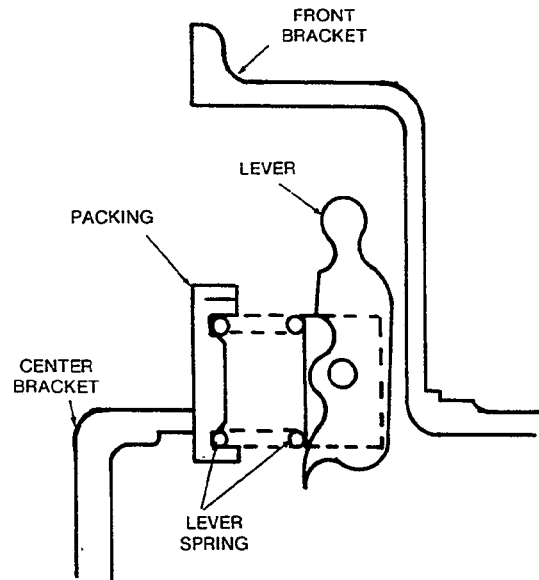


FIGURE 96. PINION GEAR INSTALLATION

Lever Assembly Installation

Figure 97 shows the correct method of installing the lever assembly, spring, and packing. Note direction of lever.



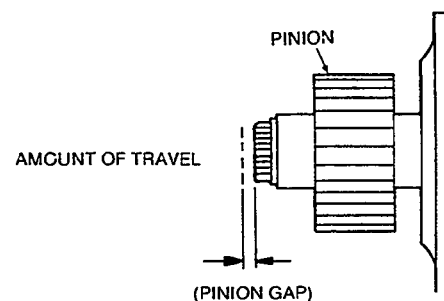
ES-1185

FIGURE 97. LEVER INSTALLATION

Pinion Gap Adjustment

After assembling starter motor, adjust pinion gap.

1. Remove "M" terminal nut and wire from solenoid.
2. Connect positive terminal of battery to "S" terminal on solenoid and negative terminal to starter body. With battery connected pinion gear will shift into the cranking position.
3. Gently push pinion shaft back towards front bracket and measure the amount of travel (Figure 98).



ES-1192

FIGURE 98. PINION GAP ADJUSTMENT

4. The pinion gap should be 0.3 to 2.0 mm (0.018 to 0.0787 inch). Adjust by changing the number of fiber washers used on solenoid mounting surface, increasing the number of fiber washers decreases clearance. Decreasing the number of washers increases clearance.

BELT DRIVEN (35 AMP) BATTERY CHARGING ALTERNATOR (Optional)

This information is presented for field use only. Major repair should be done in the shop.

Brush Assembly Removal

Remove brushes as follows:

1. Remove three screws which fasten voltage regulator to alternator.
2. Disconnect regulator leads and remove regulator.
3. Remove two screws on phenolic cover and lift out cover and gasket.
4. Pull brush assembly straight up and lift out.
5. Reverse procedure for assembly (Figure 99).

Brush Assembly Tests

Test brush assembly as follows:

1. Connect an ohmmeter or test lamp (12 volts) to the field terminal and to the bracket. The test lamp should not light or resistance reading should be high (infinite). If not, there is a short and the assembly must be replaced.
2. Move one ohmmeter lead from the bracket to insulated brush. Use an alligator clip directly on the brush. Be careful not to chip it. Resistance reading should be zero (continuity).
3. Connect ohmmeter leads to the grounded brush and the bracket. Resistance should be zero (continuity).

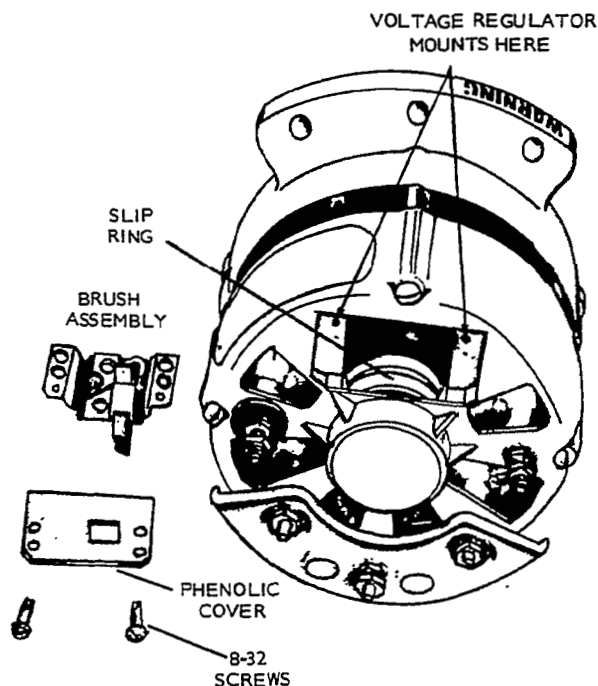


FIGURE 99. OPTIONAL, BATTERY CHARGING, EXTERNAL ALTERNATOR

Engine Disassembly

ENGINE REBUILDING

When engine disassembly is necessary, remove complete assemblies (tear down individual components like fuel pump, breaker mechanism, etc., as bench jobs). *Use special tools available.*

Disassembly

Common sense will dictate proper order of disassembly. As disassembly progresses, the order may be changed, as will become self-evident.

A suggested procedure would be as follows:

1. Radiator, water pump.
2. Flywheel—using puller or pry-bar method.
3. Gear Cover—protect oil seal from keyway damage.
4. Crank Gear—use puller and gear puller ring.
5. Loosen accessories such as fuel pumps and oil filter.
6. Starter motor.
7. Drain oil—discard oil removed.
8. Cylinder head.
9. Valves, springs, rocker arms.
10. Camshaft and gear, rear bearing plate, oil pump.
11. Piston, connecting rod bearings.
12. Crankshaft.
13. Try to analyze reasons for any parts failure and necessity of the repair.
14. Cleanliness and neat, orderly work area makes job easier to do.
15. Use proper meters and gauges. Observe if cylinder requires boring, crankshaft needs grinding, or if other major shop work is necessary.

Assembly (Use Genuine Onan Parts)

1. Engine assembly procedure is normally the reverse of disassembly — observing proper clearances of bearings, connecting rod, proper fitting and sizing of piston, rings, etc..
2. Follow proper recommended procedure for fit of valves, adjusting clearances, and torque of all special items. Use a torque wrench to assure proper tightness without danger of stripping threads.
3. As each internal engine part is assembled, use a wrench to rotate crankshaft, making certain it turns freely. If tightness is noted after any operation, you then know your last step is responsible.
4. As each internal engine part is assembled, coat it heavily with oil (same grade used in crankcase). During first few critical moments of operation, the engine will depend on this lubrication.
5. After you have internal engine parts reassembled, the engine should turn freely. If reasonable care and attention have been given, the engine will operate efficiently.
6. At this point, it is a matter of mechanically adding outside accessory items to the block assembly. *Order of assembly is reverse of disassembly.*
7. When engine is complete, install controls. Check the tagged wires. Use wiring diagram to connect leads to control and leads from control to engine. All wires are marked for correct identification. If the unit is to work properly, wires must be connected correctly.
8. The engine is now ready for starting. Before final adjustments, run the engine about 15 minutes under light load to reach normal operating temperature.

ASSEMBLY SUGGESTIONS (Things to Keep in Mind During Engine Assembly)

1. See Onan Tool Catalog (900-0019) - many items require a *special tool* for correct installation. Some of these tools are:
 - Oil seal driver and guide, bearing driver.
 - Valve spring compressor, valve lock replacer, valve guide driver, and valve seat remover.
 - Gear puller and gear puller rings.
 - Piston ring spreader and compressor.
 - Flywheel puller, pry bar, armature puller.
 - Torque wrench, plastigauge (for correct bearing clearance).
 - Armature growler, gas pressure gauge (or manometer).
2. Wet holes in crankcase (holes through crankcase) - always use copper (gasket) washers.
3. Nuts, bolts and screws that do not require exact torque should be tightened snugly, then 1/4 extra turn.
4. Select proper length of any screw or bolt and position in hole. Make sure they do not *bottom*.
5. Gasket kits sometimes cover more than one engine. Therefore, select gasket of correct size and shape for part being used. Always use new gaskets.

6. When disassembling engine, *make* bearing plate gasket thickness. Then select proper shim thickness for correct end play.

Shims establish end play. Only one thickness gasket is included in kit.

7. When assembling crankshaft, make sure bearing thrust washers are in proper position supported by bearing stop pins. Use cup grease to hold in place.
8. When adjusting valve lash, tap rocker arm so it is straight when checking with feeler gauge.
9. Crank gears are easier to remove and install if heated a slight amount.

CAUTION Do not overheat or temper may be lost and shaft may expand.

10. See *FUEL SYSTEM* section for correct engine timing.
11. Allow some gear lash, approximately 0.005 inch (0.13 mm) in oil pump. Do not install gears tightly against each other!.

TESTING AND ADJUSTING ENGINES

Preparation

Check the following:

1. Put proper oil in crankcase.
2. Service air cleaner.
3. Connect fuel line.
4. Connect load.
5. Connect fully charged battery.
6. Check ventilation for proper cooling.

Operation

1. Start engine - (see *Diesel Starting Guide*).
2. Check oil pressure.
3. Run unit 15 minutes to bring it up to operating temperature.
4. Check for oil leaks, loose electrical connections, tight fuel lines, and tight exhaust connections.

Adjustments

Adjust governor for speed and sensitivity.

IMPORTANT: For complete customer satisfaction, repaint unit (Onan White, spray can 525-0216) and apply instructions from Marine Kit.

Maintenance

Check the valve clearances at regular intervals (see *OPERATORS MANUAL*). In addition, clean the combustion chambers and valve seats, as required if engine loses power or has low compression.

Valve Clearance Adjustments

After engine has reached a stable temperature condition the valve clearances may be adjusted. It is recommended that the valve clearance be set with engine at room temperature (about 75°F [24°C]). Allow at least two hours cooling time after engine operation.

1. To adjust valve clearance on two-cylinder J Series engine proceed as follows:
 - A. Turn flywheel until cylinder which is to have its valve adjusted is on a compression stroke, which follows closing of intake valve.
 - B. Turn flywheel until TC (top center) mark on flywheel lines up with timing pointer on gear cover. Then turn flywheel in a clockwise direction for an additional 10 to 45 degrees. The timing mark for this position must be established. In this position, the piston will be in its power stroke with both valves completely closed.
 - C. Using a feeler gauge, check clearance between rocker arm and valve, Figure 100. Increase or reduce clearance until proper gap is established; adjust with lock nut which secures rocker arm to cylinder head, Figure 101. Refer to *SPECIFICATIONS* for correct valve clearance setting for your particular engine.

Adjust valve lash after 50 hours of operation following engine overhaul.

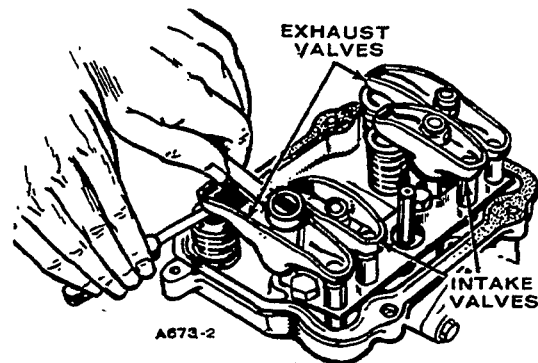


FIGURE 100. CHECKING VALVE CLEARANCES

2. To adjust valve clearance on four-cylinder J Series engine proceed as follows:
 - A. Adjust valve clearance in firing order (1-2-4-3) sequence. After the cooling period, adjust number 1 cylinder according to Steps 1A and 1B. After timing the number 1 cylinder, adjust valve clearance according to Steps 1C.

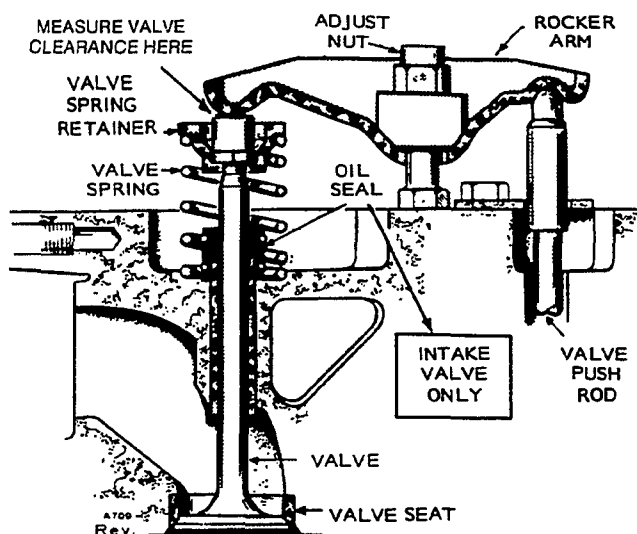


FIGURE 101. SETTING VALVE CLEARANCE

- B. To adjust valve clearance for number 2 cylinder, turn flywheel in a clockwise direction 180 degrees (1/2 revolution) from position used in Step 2A. The flywheel position should be between 10 degrees and 45 degrees past the bottom center (BC).

IMPORTANT: Four-cylinder engines do not have a BC mark on the flywheel.

- C. After timing number 2 cylinder, adjust valve clearance according to Step 1C.
- D. To adjust valve clearance for the number 4 cylinder, turn flywheel in a clockwise direction 180 degrees (1/2 revolution). The flywheel should be between 10 degrees and 45 degrees past flywheel TC mark.
- E. After timing number 4 cylinder, adjust valve clearance according to Step 1C.
- F. To adjust valve clearance for the number 3 cylinder, turn flywheel in a clockwise direction 180 degrees (1/2 revolution). The flywheel should be between 10 degrees and 45 degrees past BC.
- G. After timing number 3 cylinder, adjust valve clearance according to Step 1C.

Testing

The cylinder compression test can be used to determine the condition of valves, pistons, piston rings, and cylinders.

To check compression, run the engine until thoroughly warm. Stop engine and remove all injection nozzles. Insert the compression gauge in one nozzle hole. Crank the engine and note the reading. To check for piston blow-by, squirt a small amount of SAE 50 oil into the cylinder and repeat the check. An increase in compression with oil in the cylinder indicates piston blow-by.

Compression of a standard new engine cranking at about 300 rpm is about 300-350 psi (2070 to 2415 kPa)

prior to Spec P and 350-400 psi (2415 to 2760 kPa) Spec P and later. Compression should be fairly uniform; normally with less than 10 psi (69 kPa) difference between the highest and lowest cylinder, taken at the same cranking rpm. Excessively high readings indicate carboned combustion chambers.

Compression readings will deviate considerably from the above readings because of differences in cranking speed, altitude, and ambient temperature conditions. Therefore, the specification is given only as a guide. The best indication of leakage is the pressure difference between cylinders or a compression increase when oil is added to the cylinder.

CYLINDER HEADS, VALVES DISASSEMBLY

Each cast iron cylinder head assembly has alloy hardened-faced valves, release-type rotators, alloy hardened inserts, guides, rocker arms, injection nozzles, and glow plugs. The push rods run through shields.

Keep rocker arms, rocker arm nuts, push rods, and tappets in order so they go back in the same valve train position.

1. Remove rocker box cover, fuel nozzles, and connecting oil lines to cylinder heads.
2. Remove intake and exhaust manifold.
3. Remove capscrews holding each cylinder head to cylinder block.
4. Remove each head. If it sticks, rap it sharply with a soft hammer. Do not use a pry.
5. Remove rocker arms and push rods.
6. Using a valve spring compressor, disassemble the valve assemblies.

Repair

Thoroughly clean all components of the cylinder head assemblies. Remove all the carbon deposits from the intake and exhaust ports, and clean all gasket surfaces.

Valves: Remove all carbon and check each valve for burning, pitting, or a warped stem. Refinish valves that are slightly pitted or burned. Use an accurate valve grinder. Refinish intake valves to a 42 degree angle and exhaust valves to a 45 degree angle. If they are badly pitted or have a thin edge when refacing, replace them.

Check refinished valves for a tight seal to the valve seat with an air-pressure-type testing tool or by applying Prussion Blue to the valve face and rotating it against the seat.

Valve Guides: Check valve guide to valve clearance. See the *DIMENSIONS AND CLEARANCES* section. If the proper clearances cannot be obtained by replacing the valves, replace the valve guides. Drive the old valve guides into the valve chambers. Drive new guides in until they protrude 11/32 inch (8.731 mm) from the rocker box side of the head. Ream the new valve guide to obtain the proper clearance.

Valve Seats: If valve seats are pitted, refinish them. Using conventional seat-grinding equipment, reface each seat to a 45 degree angle and a seat width of 0.047 to 0.062 inch (1.191 to 1.588 mm). You should be able to reface each seat several times before it becomes necessary to replace it.

If the valve seats are loose or cannot be refaced, replace them.

Use Onan tool number 420-0272 in a drill press (Figure 102) to remove each valve seat. Adjust the tool to cut 1/64 inch (0.397 mm) from the edge of the seat. Oil the pilot to prevent it from seizing in the valve guide. Cut each seat down to a narrow ring on edges and bottom and break it out with a sharp tool. Be careful not to cut into the counterbore bottom.

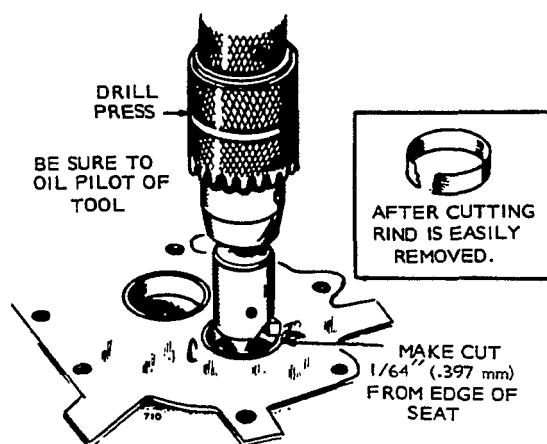


FIGURE 102. REMOVING VALVE SEATS

Thoroughly clean the valve seat counterbore, and remove any burrs from the edges. If the counterbore is damaged, it will have to be machined for an over-size seat. Oversize seats are available in 0.002 inch, 0.005 inch, 0.010 inch and 0.025 inch (0.051, 0.127, 0.254, and 0.635 mm). Otherwise, install new standard size seat inserts.

Drive the new valve seat inserts into place. Be certain that each seat rests solidly on the bottom of the counterbore at all points. To make installation easier, heat the cylinder head in an oven at 325°F (162°C) for about 1/2 hour and cool the valve seats in dry ice.

Face each new seat to a 45 degree angle and a width of approximately 3/64 inch (1.191 mm). The finished seat face should contact the approximate center of the valve face. Use Prussian Blue on each valve face to check this. Make any corrections on the seat, not the valve face.

When the new seats are installed and faced, insert the valve into each, and check the clearance from the valve head to the face of the cylinder head. This must be at least 0.025 inch (0.64 mm). If it is not, regrind the seat.

Valve Springs: Check the valve springs on an accurate compression scale. Valve spring data is given in the *DIMENSIONS AND CLEARANCES* section. Replace any spring that is weak, cracked or pitted, or that has ends out-of-square.

VALVE AND HEAD ASSEMBLY

Use the following procedure on all J Series engines and generator sets, regardless of which valve stem oil seal is used.

Apply SAE 50 engine oil to valve stem oil seals (before installing valve), valves and valve stems.

1. Support valve stem seal when installing valves. Spring retainer should never contact valve stem seal when valve springs are being compressed to install spring retainer locks.

IMPORTANT: Units built before June 1962 had no valve seals.

2. Oil stem of each valve lightly and insert each in its own guide.
3. Check each valve for a tight seat with an air-pressure type tester. If a tester is not available, make pencil marks at intervals on valve face; observe if marks rub off uniformly when valve is rotated part of a turn in seat. If seat is not tight, regrind valves.
4. Using a valve spring compressor, compress each valve spring and insert valve spring retainer and retainer locks.
5. Install head assembly and gasket to cylinder block. Tighten head bolts to 44 to 46 ft.-lb. (60-62 Nm). Follow sequence in Figure 103 and Steps A through C.

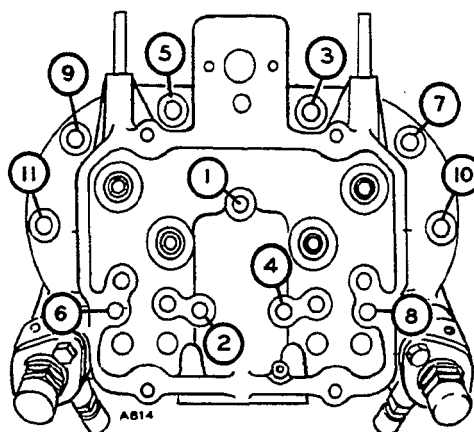


FIGURE 103. HEAD BOLT TORQUE SEQUENCE

Use Never-Seez, Fel-Pro C5-A or equivalent thread lubricant when installing cylinder head bolts.

- A. Tighten cylinder head bolts finger-tight.
- B. Install exhaust manifold and tighten (four cylinder models only).

Installing manifold now aligns all four exhaust ports with the exhaust manifold before the heads are torqued down.

Add exhaust manifold lock tabs to prevent manifold nuts from coming loose.

- C. Tighten cylinder head bolts in sequence shown in Figure 103 to 25-30 ft.-lb. (34-41 Nm).
 - D. Tighten cylinder head bolts in same sequence to 44-46 ft.-lb. (60-62 Nm).
 - E. After 60 seconds, retighten cylinder head bolts in sequence to 44-46 ft.-lb. (60-62 Nm). This step compensates for the compress of the cylinder gasket.
6. Install intake manifold, nozzles, glow plugs, and oil lines.
 7. Install valve stem cap.
 8. Install push rods, rocker arms, and rocker arm nuts.
 9. Set valve clearance. See Figure 101.

IMPORTANT: After the first 50 hours of operation, retighten the cylinder head bolts and check valve clearance.

VALVE ROTATOR CLEARANCE

Both the intake and the exhaust valves on all Onan J Series engines are equipped with release-type valve rotators. The cap covering each valve tip releases keeper tension as the valve is pushed off its seat. This allows the valve to float in its guide. Engine vibration and cylinder air flow cause the valve to rotate while floating.

To assure proper operation of this system, valve stem tip-to-cap clearance should be checked every 5000 hours, or whenever the parts are exposed or removed. Clearance must be maintained at 0.001 to 0.005 inch (0.025 to 0.127 mm). Too little clearance will prevent valve rotation, increasing the possibility of valve leakage and engine power loss. Too much clearance can lead to valve breakage.

To check the clearance, refer to Figure 104 and proceed as follows:

1. Remove the cap from the valve tip and measure the depth of the cavity in the cap with a depth micrometer.
2. Measure the valve tip height from the cavity depth to determine the clearance. It should be between 0.001 and 0.005 inch (0.025 and 0.127 mm).
3. If the clearance is not within specifications, replace the cap and keepers as a set. When replacing the keepers, check for wear on the valve spring retainer where it contacts the keepers. If wear is over 0.003 inch (0.076 mm) replace the retainer. After replacement of parts, recheck the clearance. If it is still not within specifications, replace the valve.

Anytime the valves are to be removed, these measurements should be carried out first. Keep each valve assembly together as a set. When reassembling, install the keepers with wear in original position. Keepers can be inverted to use the unworn side, but the clearance must then be rechecked. Place a drop of engine oil on the valve stem before replacing the cap.

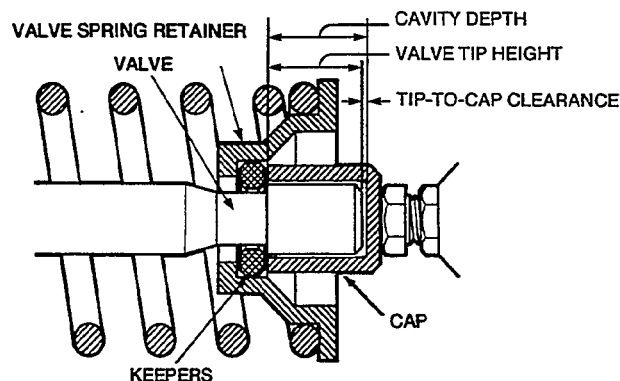


FIGURE 104. MEASURING VALVE TIP-TO-CAP CLEARANCE

MDJA DECOMPRESSION RELEASE

The decompression release mounts on the cylinder head with a solenoid on the rocker box cover. It holds the exhaust valve open to allow the engine to build up speed during starting before compression occurs, and to stop engine. The mechanism holds the exhaust valve open when the solenoid is de-energized. If the release is defective, replace any worn parts; otherwise, adjust it, following the instructions below:

NOTE: Before adjusting the decompression mechanism, the valves must be adjusted for the correct clearance.

Figure 105 shows the decompression release in detail. The release must operate properly for dependable engine starting and stopping.

1. With the piston 10 to 45 degrees past TDC on the power stroke, hold the arm in the decompression position (tension against spring). Turn the set screw so it just touches the exhaust rocker arm. The release arm must be tight against the snap ring during adjustment. Then, turn the screw exactly one revolution clockwise. The original factory setting is marked with white or yellow paint.

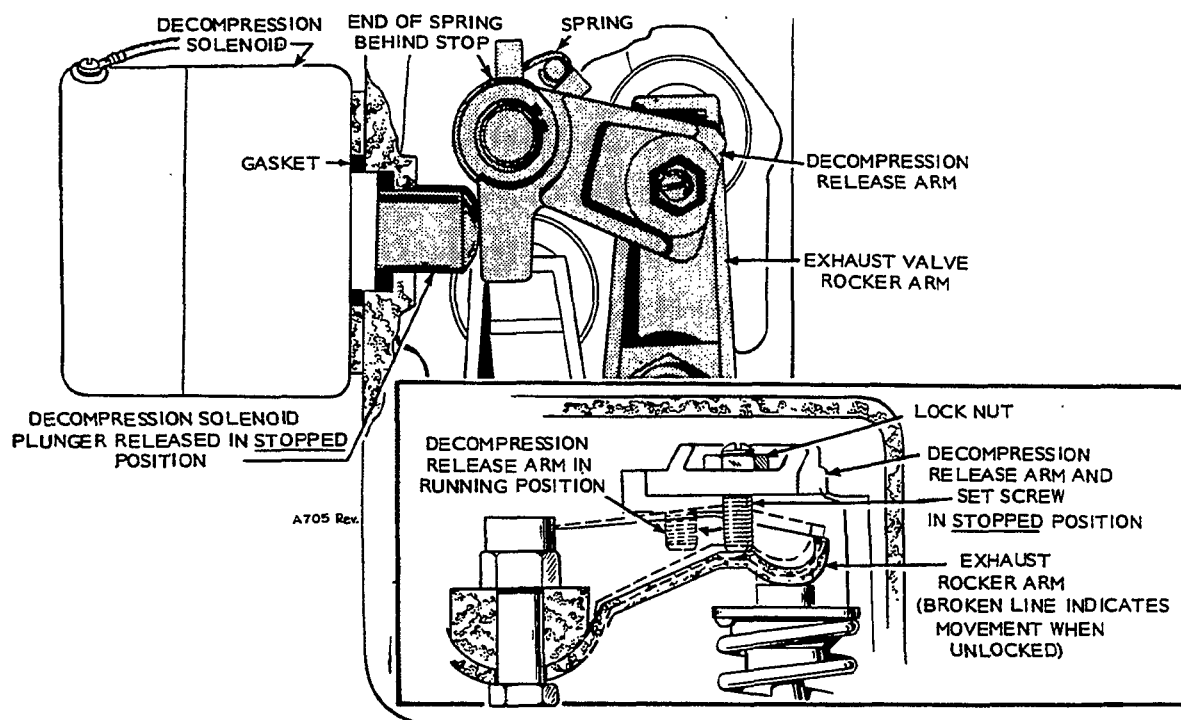


FIGURE 105. DECOMPRESSION RELEASE

NOTE: If the screw is tightened more than one turn, the exhaust valve could hit the piston.

Hold the set screw and lock it into position with the attached nut. Turn the nut finger tight plus 1/4 to 1/2 turn to lock the mechanism.

2. Release the mechanism to allow compression. Check the clearance between the screw and rocker arm. Insert a feeler gauge between valve and rocker arm to take up valve clearance for this check. If there is no clearance, back off the set screw until it just clears the rocker arm.

When reassembling the rocker cover, remove the solenoid, dip the plunger O-ring in oil and reinstall when cover is on the engine. Align solenoid so terminal SW is above terminal IGN.

INTERNAL DISASSEMBLY

If engine disassembly is necessary, observe the following order (i.e. Flywheel, Gear Cover...). As disassembly progresses, the order may be changed somewhat as will be self-evident. The engine assembly procedure is the reverse of disassembly. Any special assembly instructions for a particular group are included in the applicable section. When reassembling, check each section for these special assembly instructions or procedures.

FLYWHEEL

Remove the blower housing. The flywheel is a tapered fit on the crankshaft. Improvise a puller, using at least a 7/16 inch (11.113 mm) bar, and drill two 7/16 inch (11.113 mm) holes 2-7/8 inches (73.025 mm) between centers. Loosen the flywheel mounting screw a few turns. Place bar against the flywheel screw and attach bar, using two 3/8-16 thread screws in the holes provided in flywheel. Alternately tighten the screws until flywheel is free.

REPLACEMENT

Replacement flywheels are supplied without the timing markings because each flywheel must be fitted to its engine. The only accurate method of determining the top dead center (TDC) and port closing (PC) points is to measure the piston travel. This is a critical measurement and should be attempted only with accurate, reliable equipment.

With the flywheel mounted, remove the head and install a depth gauge over the front piston. Rotate the flywheel to find the TDC position on the compression stroke, and mark this point on the flywheel. Next, turn the flywheel counterclockwise until the piston drop is as specified in Table 9. Mark both TDC and piston drop to PC point on the flywheel.

TABLE 9. PISTON DROP DATA

| PISTON DROP | | ENGINE | PORT CLOSING |
|-------------|------|----------------------------------|--------------|
| Inches | mm | | BTC |
| 0.102 | 2.59 | MDJA | 17 degrees |
| 0.128 | 3.25 | MDJB & MDJC (Begin Spec P) | 19 degrees |
| 0.155 | 3.94 | MDJB & MDJC (Prior to Spec P) | 21 degrees |
| 0.128 | 3.25 | MDJE Spec A-AA | 19 degrees |
| 0.115 | 2.9 | MDJE Begin Spec AB | 18 degrees |
| 0.128 | 3.25 | MDJF | 19 degrees |

Ring Gear: To remove a damaged ring gear, saw part way through, then break it using a cold chisel and heavy hammer.

To install a new ring gear, place it in an oven heated to 380°F - 400°F (192° to 204°C) for 30 to 40 minutes.

CAUTION *Do not heat ring gear to a bright red as ring gear may warp and the heat treatment will be destroyed.*

When properly heated, ring will fall into place on flywheel. If it does not go on all the way by itself, drive it into place with a hammer. Do it fast and do not damage the gear teeth. Ring will contract rapidly and may shrink to the flywheel before it is in place. If this occurs, a new ring gear may be required.

GEAR COVER

To remove the gear cover, detach the upper governor ball joint. Remove the governor speed-adjustment nut and governor spring bracket.

Remove the screws holding the gear cover to the crankcase. To loosen the gear cover, tap it with a soft hammer.

Governor Shaft

The governor shaft is supported by two sets of needle bearings. To remove the shaft, remove the yoke and pull the shaft from the gear cover. If the shaft is binding, clean the bearings. If loose, replace the bearings. To remove the larger bearing, drive both bearing and oil seal out from the outside of the gear cover. Remove the smaller bearing with an Easy-Out or similar tool. Press new bearings and oil seal into place. See Figure 106.

Gear Cover Oil Seal

Replace the oil seal if damaged or worn. Drive the oil seal out from inside the gear cover. Lay the cover on a board so the seal boss is supported. Using an oil seal driver, insert the new seal from the inside with rubber lip toward outside of gear cover (open side of seal inward) and drive it flush with the outside surface. During gear cover installation, use the driver to protect the oil seal. See Figure 107.

Assembly, Gear Cover

1. Work governor shaft to check for binding and see that the governor shaft end-thrust ball is in place (Figure 106). Later models have larger ball which will not fall out.
2. Turn governor yoke so smooth side is toward governor cup.
3. Turn governor cup so stop pin in gear cover will fit into one of the holes in the cup surface (Figure 108). Measure distance from end of stop pin to mounting face of cover. It should be 25/32 inch (19.844 mm). If it is not, replace pin. Pin should be positioned with open end facing crankshaft seal.
4. Coat oil seal lip with oil or grease. Set a piece of shim stock over the crankshaft keyway to protect seal and install gear cover. Tighten mounting screws to 15 to 20 ft.-lb. (20 to 27 Nm). Before tightening screws, be sure the stop pin is in governor hole.

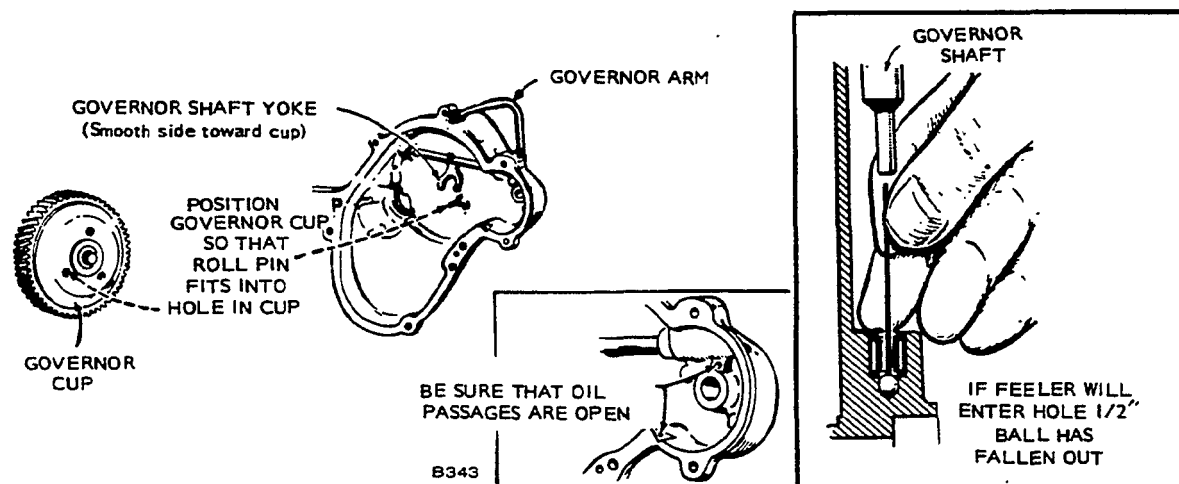


FIGURE 106. GEAR COVER ASSEMBLY

GOVERNOR CUP

To remove the governor cup, remove the snap ring from the camshaft center pin and slide the cup off. Be sure to catch the ten flyballs that will fall out when the cup is removed. Figure 108 shows the governor cup.

Repair

Replace any flyballs that have flat spots or grooves. Replace the cup if the race surface is grooved or rough. The governor cup must be a free spinning fit on the camshaft center pin, but should be replaced if excessively loose or wobbly.

The camshaft center pin extends out $\frac{3}{4}$ inch (19 mm) from the end of the camshaft. This distance provides an in-and-out travel distance of $\frac{7}{32}$ inch (5.6 mm) for the governor cup, as illustrated. Hold the cup against the flyballs when measuring. The camshaft center pin cannot be pulled outward or removed without damage. If the center pin extends out too far, the cup will not hold the flyballs properly. If the distance is less than $\frac{7}{32}$ inch (5.6 mm), the engine will race, especially at no load; remove the center pin and press in a new pin.

Installation

To install the governor assembly, tip the front of the unit upward. Set the flyballs in their recesses and position the governor cup on its shaft. Finally, brush with heavy grease and install the snap ring on the center pin.

PISTONS, RINGS, CONNECTING RODS

DJ engines use cam-ground aluminum pistons. Each piston is tapered and fitted with three compression rings and an oil control ring. Full-floating piston pins connect the piston to its connecting rod. The pins are held in place with a snap ring at each end. The lower end of each connecting rod contains half-shell precision bearings; the upper end, semi-finished bushings.

Some engines are fitted with 0.005 inch (0.127 mm) oversize pistons at the factory. These engines are marked with an E following the engine serial number. Use 0.005 inch (0.127 mm) oversize rings for these pistons.

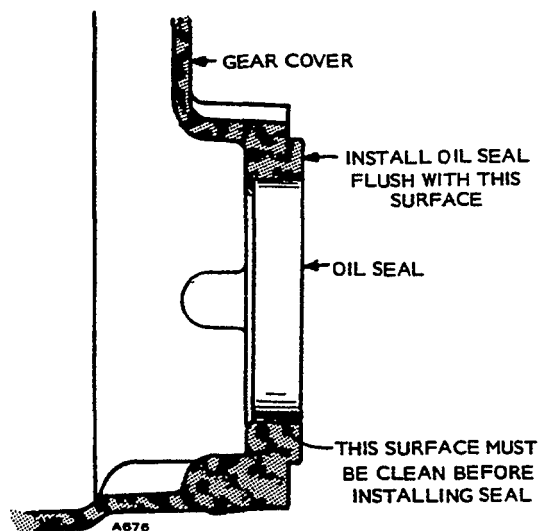


FIGURE 107. GEAR COVER OIL SEAL

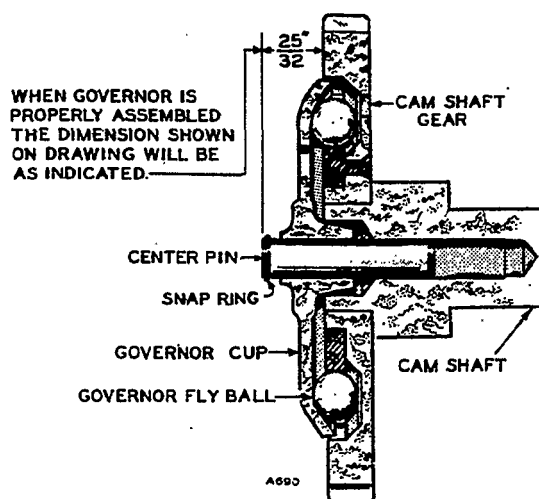


FIGURE 108. GOVERNOR CUP

Removal and Disassembly

On 2- and 4-cylinder engines, the connecting rod and cap are stamped for installation in the proper cylinder. When removing piston assemblies, check the marking so each can be installed in the proper cylinder.

1. Drain crankcase oil and remove oil base.
2. Remove cylinder heads.
3. Before pushing pistons out, scrape carbon at top of cylinder bore.
4. Remove cap from each connecting rod and push assembly through top of cylinder bore. Replace cap and bearing inserts in proper assembly.
5. Using a ring expander, remove rings from each piston.
6. Remove two retaining rings and push piston pin from each piston.

Cylinders

The cylinder walls should be free of scratches, pitting, and scuffing. Check each with an inside reading micrometer for out-of-round and wear. The bore measurement should be as specified and be less than 0.001 inch (0.0254 mm) out-of-round.

If necessary, rebore the cylinder to fit the next available oversize piston. Pistons and rings are available in 0.005, 0.010, 0.020, 0.030, and 0.040 inch (0.127, 2.540, 0.508, 0.762, 1.016 mm) oversize. If the cylinders do not need refinishing, remove any existing ridges from the top of the walls with a fine stone.

Pistons

Clean thoroughly and inspect each piston. Clean the carbon from the ring grooves and be sure all oil holes are open. If any piston is badly scored or burred, loose in the cylinder, has badly worn ring grooves or otherwise is not in good condition, replace it. See Figure 109.

CAUTION *Install pistons with valve relief recess facing the camshaft side of engine to match valve positions.*

Check the clearances 90 degrees from the axis of the piston pin and below the oil control ring. Clearance should be 0.005 to 0.007 inch (0.127 to 0.178 mm). If not, replace the piston and check the cylinder for possible reconditioning.

PISTON PINS

Each piston pin should be a thumb push fit into its piston at room temperatures. If the pin is excessively loose, install a new one. If the condition is not corrected, install the next oversize pin. If the piston is worn enough so that the oversize pin will not fit, replace it.

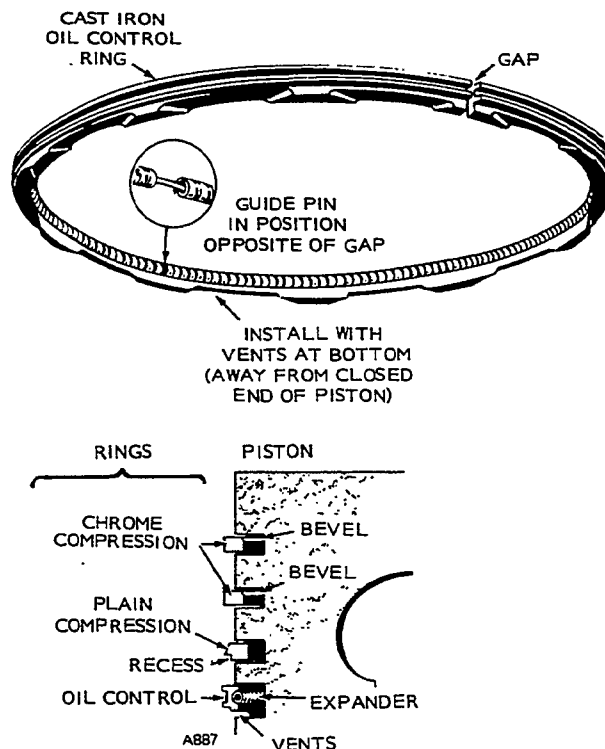


FIGURE 109. PISTON RINGS

RINGS

Inspect each ring carefully for fit in the piston grooves and for seating on the cylinder wall. Fit each ring to the cylinder wall at the bottom of its travel, using a piston to square the ring in the bore. Check the gap with a feeler gauge. It should be 0.010 to 0.020 inch (0.254 to 0.0508 mm). The practice of filing ring ends to increase the end gap is not recommended. If the ring end gap does not meet specifications, check for the correctness of ring and bore sizes. A cylinder bore that is 0.001 inch (0.03 mm) under size will reduce the end gap 0.003 inch (0.08 mm). If oversize pistons are used, use the correct oversize rings.

CONNECTING RODS

Clean the connecting rods and check each for defects. Check the connecting rod bushings for proper clearance with the piston pin. Clearance should be 0.0002 to 0.0007 inch (0.0051 to 0.0178 mm).

If the bushings are excessively worn, press them out and install one new bushing from each side of the bushing bore. Press the new bushings only until flush with the sides of the rod to leave 1/16 to 7/64 inch (1.588 to 2.776 mm) oil groove in the center. See Figure 110.

CONNECTING ROD BEARINGS

Inspect the connecting rod bearings for burrs, breaks, pitting and wear. Measure the clearance between bearings and the crankshaft journal. The clearance should be 0.001 to 0.003 inch (0.0254 to 0.076 mm). If necessary, replace with new standard or oversize precision bearings.

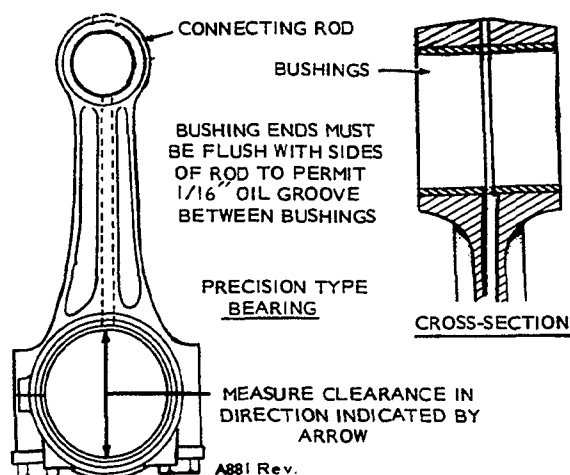


FIGURE 110. CONNECTING ROD BUSHINGS

ASSEMBLY AND INSTALLATION

1. Install connecting rods on each piston with pins and retaining rings. If new bushings were installed, check to see that ends are flush with connecting rod to provide for oil recess in center.
2. Install all rings on each piston. All compression rings will be marked *top* or identified in some other manner. Place this mark toward closed end of piston. Space ring gaps 1/4 of way around piston from one another. No gap should be in line with the piston pin.
3. Position a bearing half in each connecting rod. Be sure there is no dirt under bearing. This could cause high spots and early bearing failure.
4. Oil cylinder walls. Install each piston in proper cylinder using a suitable installer. Each assembly should be installed with stamp on piston facing same direction as when removed.
5. Position each connecting rod on crankshaft, oil the journal, and install its rod cap and bearing half. When installing rod cap, position so raised witness mark on forging matches mark on connecting rod. See Figure 111.
6. Tighten capscrews to specified torque.
7. Crank engine over by hand to see that all bearings are free.
8. Install oil base with a new gasket.
9. Install cylinder heads using proper bolt tightening sequence.
10. Replace oil.

CAMSHAFT

The camshaft is a one-piece machine casting, driven through gears by the crankshaft. It rides on sleeve bearings pressed into the crankcase.

In addition to providing a means of opening and closing the valves, the camshaft operates the injection pump and fuel transfer pump.

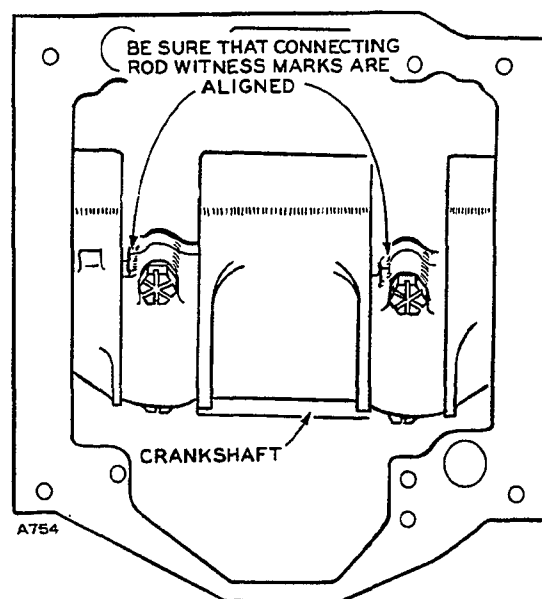


FIGURE 111. CONNECTING ROD CAP

Removal

1. Remove rocker arms and push rods from valve chambers.
2. Remove injection pump and fuel transfer pump from engine.
3. Remove crankshaft gear retaining washer by removing lock ring on crankshaft.
4. Lay engine on its side to avoid dropping tappets and remove camshaft assembly as a group. If necessary, pry it out using a screwdriver between camshaft gear and crankcase.
5. Remove valve tappets. These can be removed only from the camshaft end of the push rod holes.

Repair: If a lobe has become slightly scored, dress it smooth with a fine stone. If the camshaft is badly worn or scored, replace it. After installing a new camshaft, time the injection pump to the engine. Never install a new camshaft with old tappets.

Camshaft Gear: This gear is a pressed fit on the camshaft and drives it at 1/2 the crankshaft speed. To remove the gear, use a hollow tool or pipe that will fit inside the gear bore and over the center pin. Press the camshaft out of the gear bore. Be careful not to damage the center pin.

Camshaft Bearings: The camshaft bearings should be replaced if the clearance to the camshaft is greater than specified, the bearings show cracks, breaks, burrs, excessive wear, or other defects. To check the rear bearing, remove the expansion plug at the rear of the crankcase.

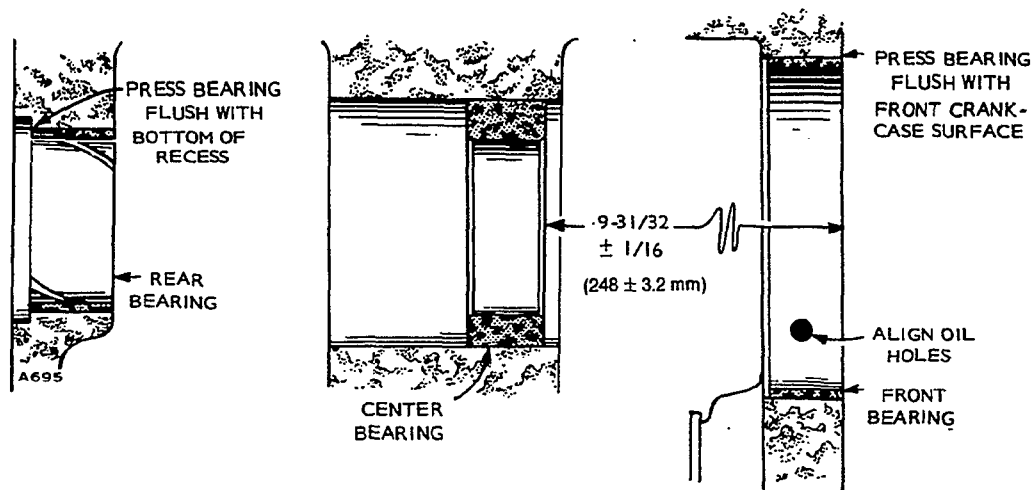


FIGURE 112. CAMSHAFT BEARINGS

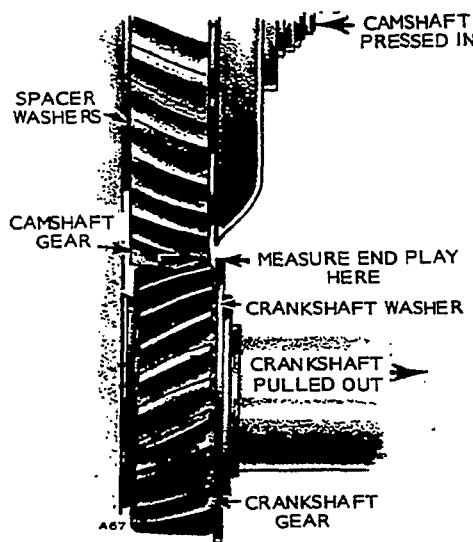


FIGURE 113. CAMSHAFT ENDPLAY

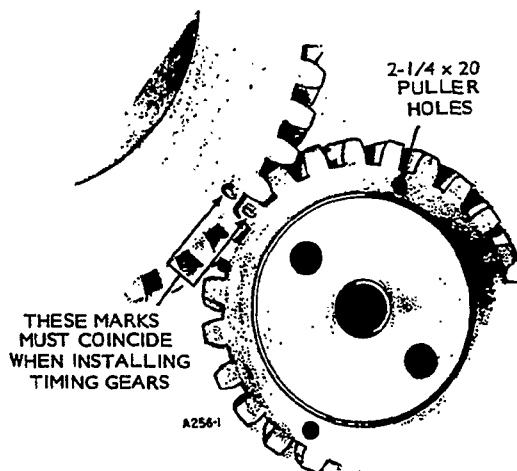


FIGURE 114. TIMING MARKS

Press new bearings into place, Figure 112. Press the rear bearing flush with the bottom of the expansion plug recess. Press the front bearing in flush with the crankcase front surface so the oil passages are aligned. Do not attempt to ream the bearings as they are a precision type. After rear bearing is installed, insert a new expansion plug in the recess, using sealing compound, and expand it into place with sharp blows at its center.

Installation, Camshaft Assembly

1. Install key and press camshaft gear on camshaft until it bottoms on flange with no clearance.
2. Install governor components.
3. Slide thrust washer onto shaft. Measure camshaft end play; it should be 0.007 to 0.039 inch (0.178 to 0.991 mm). See Figure 113.
4. Lay engine on its side or end and insert push rod tappets.
5. Install camshaft assembly in engine. Align timing marks on camshaft gear and crankshaft gear. See Figure 114.
6. Replace push rods and fuel transfer pump.
7. When engine is reassembled, install injection pump following the steps for *Injection Pump Installation* in the *FUEL SYSTEM* section. This step is critical.

CRANKSHAFT

The DJ Series engines use a counter-balanced ductile iron crankshaft. To increase shaft fatigue durability, all crankpin fillets are shot-peened during manufacture. The two-cylinder crankshafts ride on two lead-bronze bearings; the front one is housed in the crankcase, and the rear one is in the bearing plate. The four-cylinder model uses an additional main bearing with a split-center.

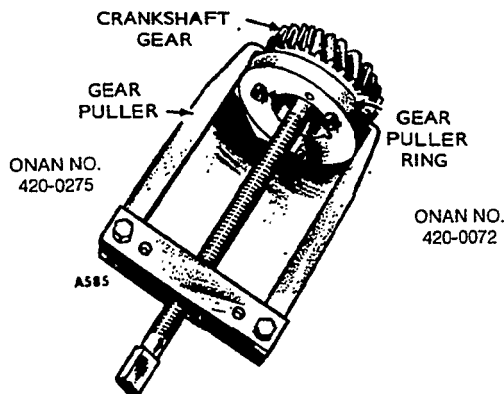


FIGURE 115. REMOVING CRANKSHAFT GEAR

Removal

1. Remove lock ring and retaining washer in front of crankshaft gear.
2. Pull off crankshaft gear. It has two 1/4-20 UNC tapped holes for attaching a gear pulling ring. Use care not to damage teeth if the gear is to be reused. See Figure 115.
3. Remove oil pan, pistons and connecting rods.
4. Remove bearing cap from center main bearing.
5. Remove rear bearing plate from crankcase.
6. Remove crankshaft through rear opening in crankcase. Catch upper half of center main bearing support as it slides off its mounting surface.

Inspection: Clean the crankshaft and blow out all oil passages. Check journals for out-of-round, taper, grooving or ridges. Pay particular attention to ridges or grooves on either side of the oil hole areas. Unusual conditions here often point to previous neglect of oil changes.

If journal dimensions are not within limits, or the journals are scored, regrind the crankshaft.

Crankshaft Grinding: Crankshaft grinding requires a trained, experienced operator working with precision equipment. Procedures which may be satisfactory for some spark-ignition engines may well be unsatisfactory for diesel applications, resulting in expensive failures.

Special procedures must be observed when reworking diesel crankshafts. In addition to machining, the crankshaft must be shot-peened and super-finished. Failure to *shot-peen* the crankpin fillets is likely to cause early failure. When the shaft is machined, follow the directions and dimensions given in Figure 116 to shot-peen each crankpin fillet.

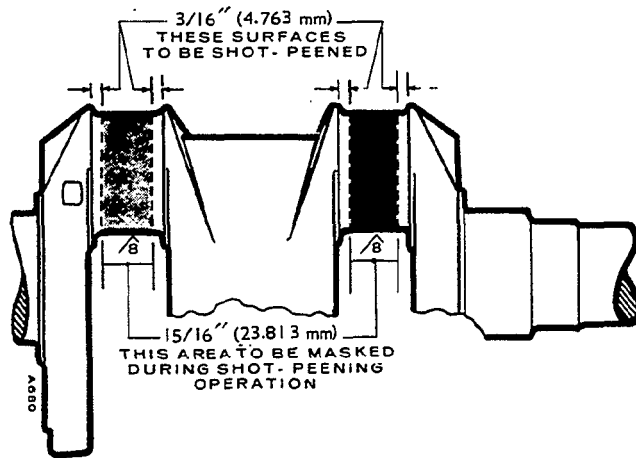


FIGURE 116. SHOT-PEENING THE CRANKSHAFT

1. Almen gauge reading 0.012-A (0.305).
2. Peen with 0.019 inch (0.482 mm) diameter cast steel shot.
3. Peen for 30 seconds on each crankpin fillet.
4. Mask off connecting rod bearing areas.

Undersize bearings and connecting rods are available to rework the shaft to 0.010 inch (0.254 mm), 0.020 inch (0.508 mm), and 0.030 inch (0.762 mm) undersize.

Main Bearings: Replace main bearings if clearances are greater than limits or if the bearings are worn, grooved, or broken.

Precision replacement inserts and thrust washers are available for all main bearings. Do not ream the bearings.

Align the oil holes and press the new bearings into the front and rear housings. Insert the center bearing when the crankshaft is re-installed.

Rear Oil Seal: The rear oil seal is in the rear bearing plate. If damaged, drive it out from the inside of the plate. Using the oil seal installing tool (Onan No. 420-0250), install a new seal with the rubber lip facing outward (open side of seal inward). See Figure 117. Drive the new seal flush with the rear surface of the bearing plate. Leave the seal installer on during bearing plate installation to protect the oil seal.

Installation: After each installation step, check the crankshaft to be sure it is not frozen into place.

1. Press front and rear main bearings into place, then align bearing and bearing housing oil holes. Do not attempt to drive a bearing into a cold block or rear bearing plate.
2. Install thrust washers and locking pins.
3. Oil bearing surfaces and install crankshaft from rear of crankcase through rear bearing plate hole.

4. Mount and secure rear bearing plate.
5. Heat timing gear on an electric burner or oven to about 350°F (175°C). Install key on crankshaft, then drive gear into place. Install retaining washer and lock ring.
6. Set upper half of center main housing on crankshaft and rotate it into place. See Figure 118. Be sure it is installed with the side marked *front* toward crankshaft gear. Set the two positioning dowels on the upper bearing mount. Install center main bearing cap and torque bolts to 97-102 ft.-lb. (131-138 Nm).
7. Check crankshaft end play. Use enough rear bearing plate shims and gaskets to provide 0.010 inch (0.254 mm) to 0.015 inch (0.381 mm) end play. If gaskets of more than 0.015 inch (0.381) total thickness are required, use a steel shim of proper thickness and a thin gasket on each side of shim. This avoids excessive gasket compression and maintains bolt torque.
8. Install piston assemblies.

Crankcase

If the crankcase requires replacement, a new set of injection pump shims will be furnished with the new crankcase. These must be used and, in addition, the injection pump must be re-timed to the engine. If, on the four cylinder models, the center main bearing support requires replacement, the whole crankcase must be replaced or returned to the factory to have a new housing fitted.

Break-In Period

Whenever new rings or pistons are installed or the cylinder refinished, the engine must be run-in before regular operation can be resumed. Run the engine for 15 to 20 minutes at no load, about 30 minutes at 1/3 load, and 2 to 3 hours at 2/3 load. Regular operation can then be resumed. Avoid light load operation during the following several hours for best ring seating and to prevent oil consumption.

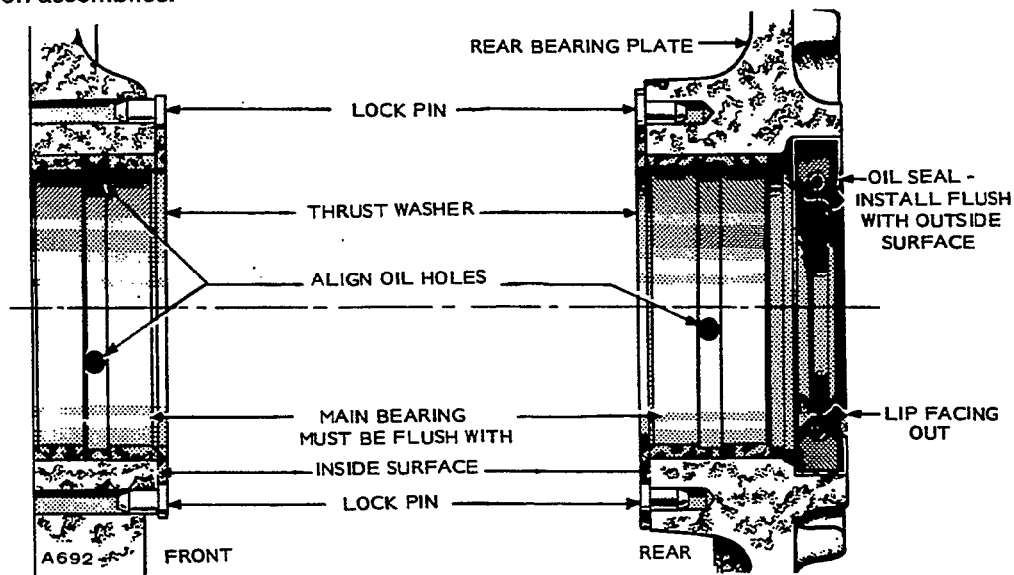


FIGURE 117. MAIN BEARING INSTALLATION

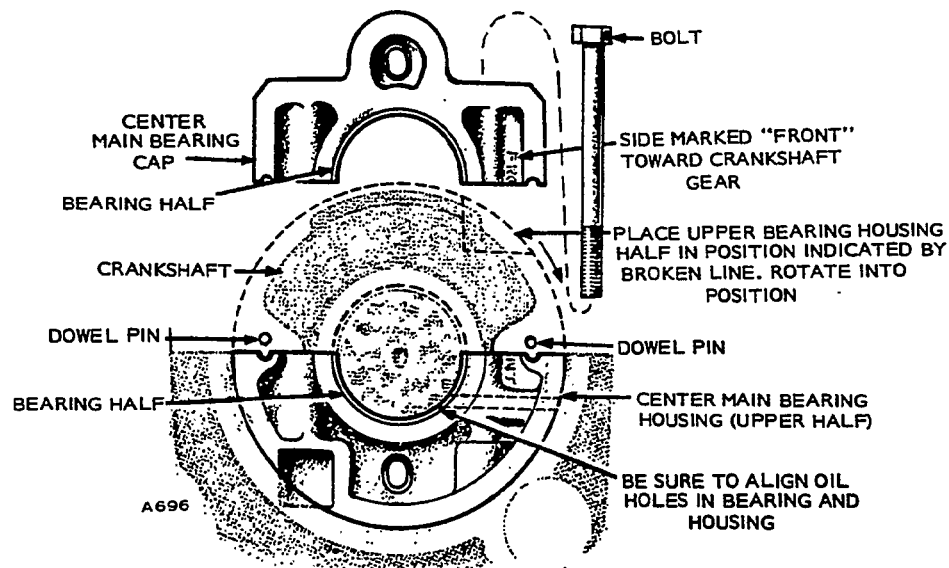


FIGURE 118. CENTER MAIN BEARING HOUSING



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