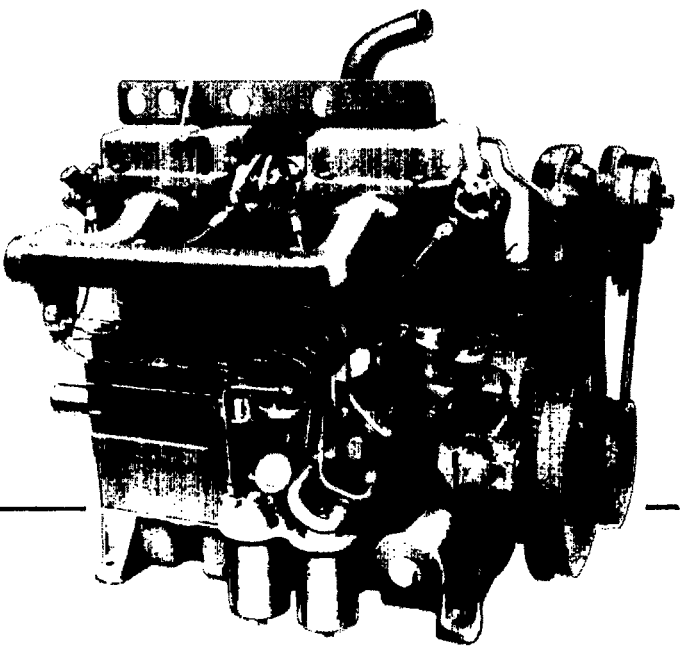
Onan

Service Manual

RDJC
RDJF
Diesel Engines



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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° F (100° 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.

Table of Contents

WARNING

INCORRECT SERVICE OR REPLACEMENT OF PARTS MIGHT RESULT IN SEVERE PERSONNAL 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 is provided as 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 on the last page of the manual shows how the electrical components are interconnected.

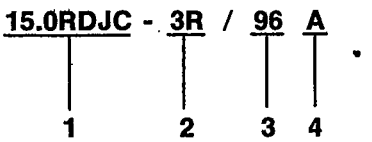
A parts catalog (available at the dealer level) contains detailed exploded views of each assembly, the individual piece part numbers, and their proper names, for ordering replacement parts.

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 as well as the Serial number shown on the nameplate.

ENGINE MODEL REFERENCE

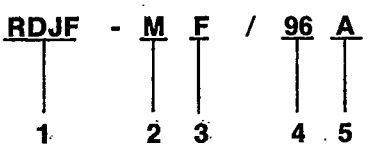
Identify your model by referring to the MODEL and SPEC (specification) NO. as shown on the unit nameplate. Always use this number and the engine serial number when making reference to your engine.

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



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. A two (2) wire automatic line transfer control is available for standby service.
   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.

How to interpret *MODEL* and *SPEC NO. on industrial engines.*



1. Factory code for general identification purposes.
2. Starter TYPE, as follows:
   M-ELECTRIC start type.
   S-MANUAL start type.
3. PTO TYPE, as follows:
   F - CLUTCH
   A - STUB SHAFT
4. Factory code for specific optional equipment supplied.
5. Specification (Spec Letter). Advances with factory production modifications.

Specifications

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

SPECIFICATION	UNIT OF MEASURE	SERIES RDJC	SERIES RDJF
Number of Cylinders		4	4
Diesel Fuel		ASTM2-D	ASTM2-D
Bore	in (mm)	3.250 (82.55)	3.500 (88.90)
Stroke	in (mm)	3.625 (92.08)	3.625 (92.08)
Displacement	cu in (litre)	120 (2.0)	140 (2.3)
Compression Ratio		19.0 to 1	19.0 to 1
Firing Order		1-2-4-3	1-2-4-3
Crankshaft Rotation (viewed from flywheel)		Clockwise	Clockwise
Governor		Adjustable Mechanical	
Valve Clearance (Cold)			
Intake	in (mm)	0.011 (0.279)	0.017 (0.432)
Exhaust	in (mm)	0.016 (0.406)	0.017 (0.432)
Oil Filter		Full Flow	Full Flow
Crankcase Capacity with filter change	Qt (litre)	6.5 (6.15)	6.5 (6.15)

Battery Requirements:

Ambient Temp. Range	Quantity Required	Voltage	BCI Group Size	Cranking Perf. (Amps) at 0° F	Amp Hr Cap (20 Hr. Rate)
32° F and warmer	2	6	2	565	135
0° F and warmer	2	6	5D	800	190
-25° and warmer				1080	222

Dimensions and Clearances

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

CAMSHAFT	
Bearing Journal Diameter, Front	2.2500-2.2505 (57.150-57.163)
Bearing Journal Diameter, Center	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 (RDJC Prior to Spec P)	.7475-.7480 (18.987-18.999)
Cam Tappet Hole Diameter (RDJC Prior to Spec P)	.7507-.7515 (19.068-19.088)
Cam Tappet Diameter (RDJF, RDJC Begin Spec P)	.8725-.8730 (22.162-22.174)
Cam Tappet Hole Diameter (RDJF, RDJC 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	3.2495-3.2505 (82.537-82.563)
Maximum Allowable Taper	0.005 (0.127)
Maximum Allowable Out-of-Round	0.001 (0.025)
CRANKSHAFT	
Main Bearing Journal Diameter	2.2427-2.2435 (56.965-56.985)
Front and Rear Main Bearing Clearance (Original)	.0030-.0043 (.076-.109)
Center Main Bearing Clearance (Original)	.0024-.0052 (.061-.132)
Front and Rear Main Bearing Clearance (Replacement)	.0024-.0062 (.06-.16)
Center Main Bearing Clearance (Replacement)	.0024-.0052 (.061-.132)
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	.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-.0030 (.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

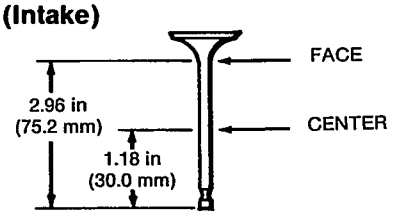
Bore Diameter	1.361-1.362 (34.570-34.595)
Insert Outside Diameter	1.364-1.365 (34.6456-34.6710)
Seat Width	.047-.062 (1.19-1.57)
Angle	45°
Available Insert Oversizes	.002 (.0508)
	.005 (.127)
	.010 (.254)
	.025 (.635)

VALVE SPRINGS

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

*N. Base unit, Newtons. Unit of force.
**Measure intake valve stem at points indicated.

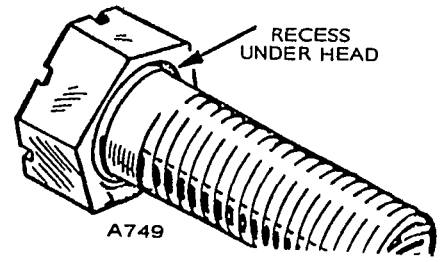
Valve Stem Diameter (Intake)



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 reasonable force only and a wrench of normal length.

Specially designed place bolts do not require a lockwasher 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.



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	420-0250
Wrench, Oil Filter (for Purolator full flow filter)	420-0268
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

Service and Maintenance

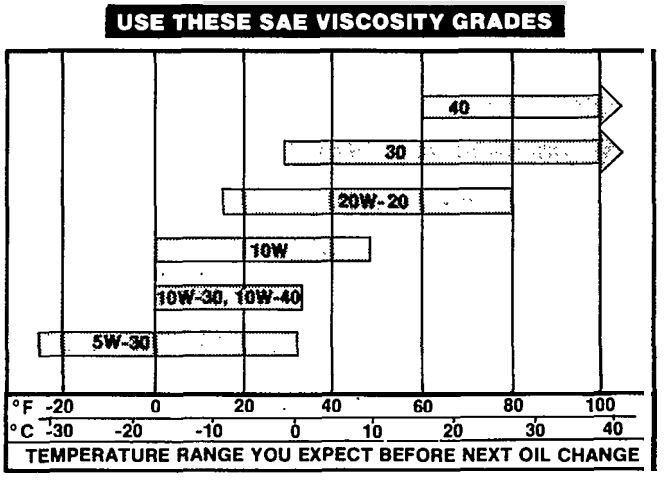
PRE-STARTING

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 together. Refer to the Operator and Service Maintenance Schedule on page 11 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° 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 that the fuel be kept clean. Dirt in the system can cause severe damage to both the injection pump and the injection nozzles.***

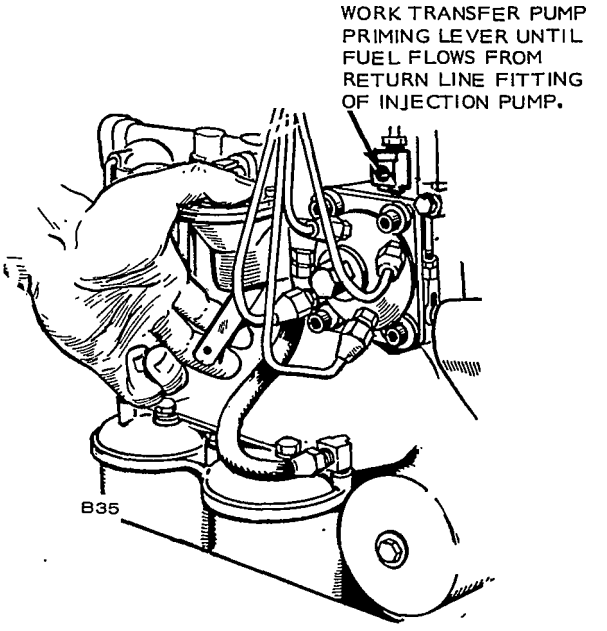


FIGURE 1. BLEED FUEL SYSTEM

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 ***To prevent heater burnout and conserve battery, do not exceed the one minute preheat periods. 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.

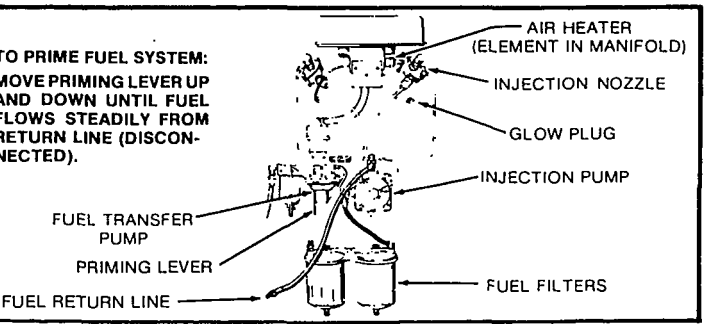
ONAN DIESEL STARTING GUIDE - INDUSTRIAL ENGINES

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 (DISCONNECTED).



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).

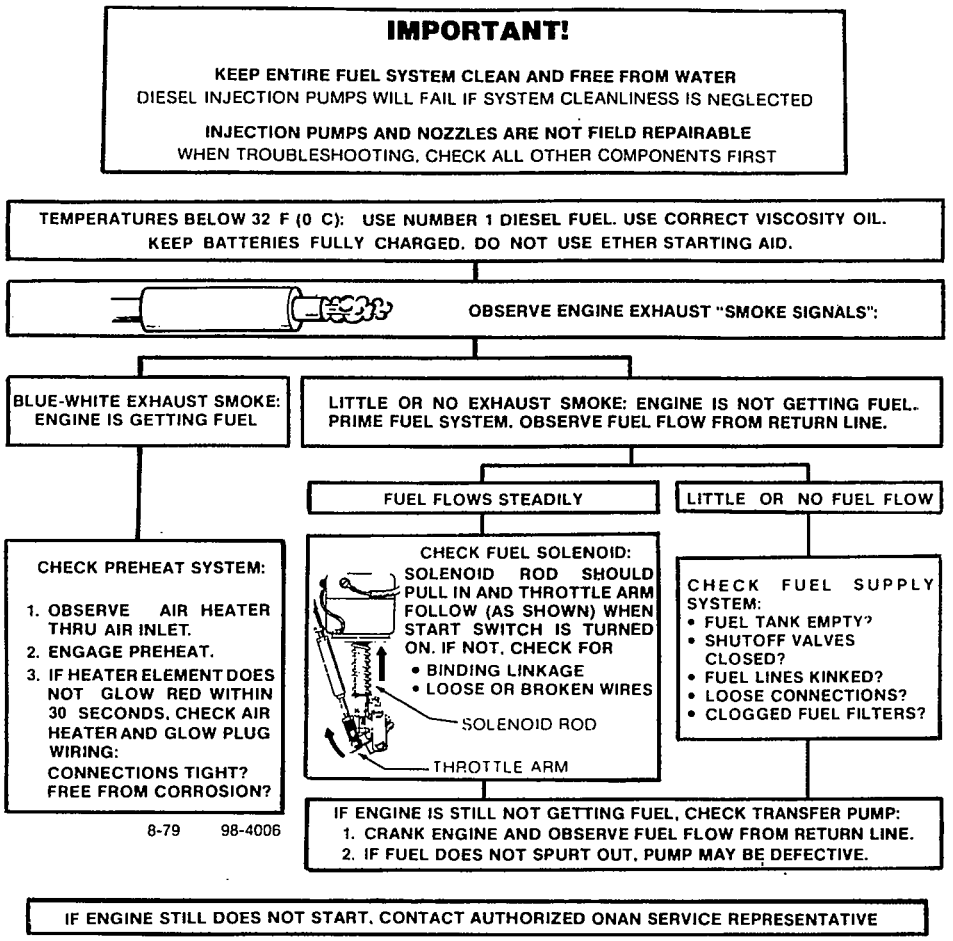
NEVER PREHEAT MORE THAN 60 SECONDS.

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 burn out the heater elements.***

OPERATOR AND SERVICE MAINTENANCE SCHEDULE

HOURS OF OPERATION	MAINTENANCE TASK
8	• Inspect exhaust system • Inspect engine • Check fuel supply, see Note 1 • Check oil level. See Figure 2.
50 (more often in dusty conditions)	• Check air cleaner.
100	• Clean governor linkage • Change crankcase oil • Drain fuel condensation traps in lines and filters, see Note 1
200	• Replace oil filter • Check battery condition
500	• Clean breather standpipes • Check start-disconnect circuit • Check valve clearances
600	• Change primary fuel filter
2000	• Grind valves (if required) • Clean holes in rocker box oil line orifices • Check nozzle spray pattern, see Note 2
3000	• Change secondary fuel filter
5000	• 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.

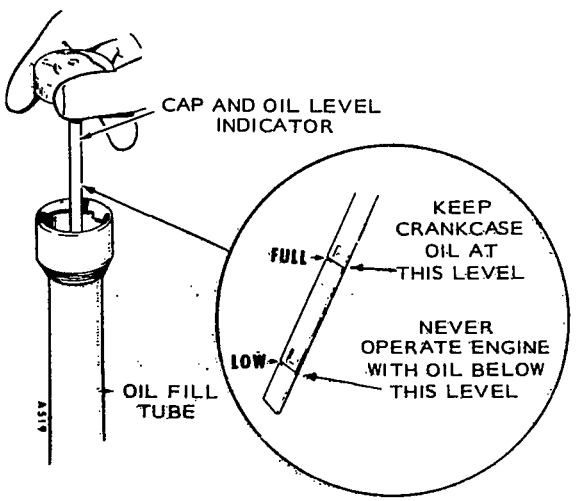
OIL FILTER CHANGE

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.

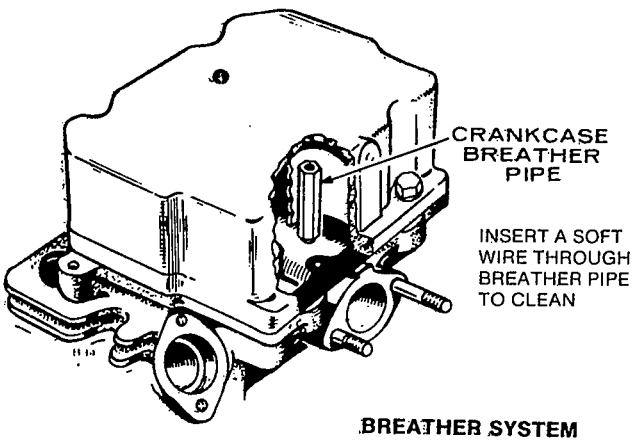
WARNING ***Crankcase pressure could blow out hot oil and cause serious burns. Do NOT check oil while the engine is operating.***

OIL DRAIN EXTENSION

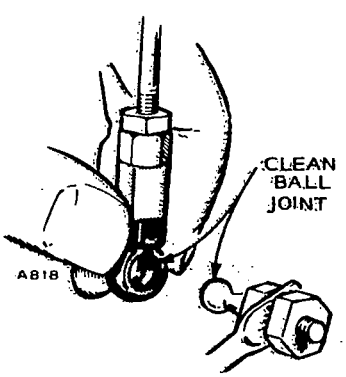
For service convenience, install a short (less than 10 inches [254 mm]) oil drain extension made from standard pipe and fittings, in the 1/2-inch (12.70 mm) pipe-tapped oil drain hole in the base.



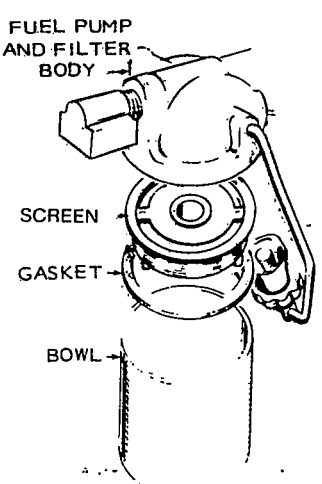
OIL LEVEL INDICATOR



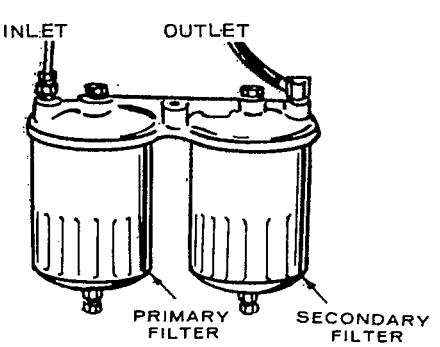
BREATHER SYSTEM



BALL JOINT



FUEL TRANSFER PUMP



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 ***To distribute oil in cylinder, crank (or turn over) engine by hand. 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, the 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.

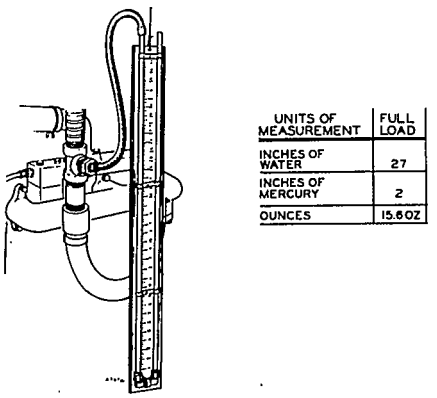


FIGURE 3. BACK PRESSURE TEST WITH MANOMETER

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.***

INSTALLATION TIPS

Points to remember when installing an exhaust system are:

- Exhaust pipes should be as short as possible with a minimum of fittings.
- The muffler must be as close to the engine as possible. Mufflers which are too far from the manifold remain cool and collect carbon residue.
- Pitch exhaust pipe upward from exhaust outlets to avoid entrapment of raw diesel fumes in muffler at shutdown.
- Avoid sharp bends by using large radius elbow.
- Check back pressure with a mercury or water column type manometer.
- Position the exhaust outlet away from the engine air intake.

Exhaust noise can be suppressed or reduced by:

- Using a heavy duty exhaust system with a more efficient muffler.
- Avoiding use of flexible lines.
- Installing a deflector at the exhaust outlet to direct exhaust toward the ground, but away from the operator.
- Using a resonator in addition to a muffler.

The importance of exhaust systems (normally supplied by the customer) cannot be overemphasized. A poor or clogged system causes low power, overheating and engine damage. A poor exhaust system increases back pressure which reduces efficiency.

CAUTION ***If the manufacturer tailors his own exhaust system, an Onan applications engineer must approve the installation for warranty purposes.***

INDOOR INSTALLATIONS

Locate exhaust outlet far from air inlet to avoid recirculation. The engine exhaust is tapped for 1-1/2 inch thread. Use flexible tubing to connect the engine exhaust to rigid pipe or muffler. Shield the line if it passes through a combustible wall (Figure 4). If turns are necessary, use sweeping (large radius) elbows. If pitched upward, install a condensation trap at point of rise, Figure 5.

As the exhaust pipe length and number of bends increases, larger pipe is required to eliminate excessive exhaust restriction and back pressure.

The chart below shows the maximum equivalent exhaust pipe length for exhaust systems using 1-1/2 through 3 inch pipe. Also shown are the equivalent lengths of various pipe fittings. The TOTAL exhaust system equivalent length (including all fittings and muffler) should not exceed the length shown in the chart for the size of pipe used. Use a manometer to verify that back pressure does not exceed 27 inches (686 mm) H_2O.

MAXIMUM EQUIVALENT EXHAUST PIPE LENGTH—ONE CRITICAL MUFFLER INCLUDED

PIPE SIZE (INCHES)	1.5	1.75	2.0	2.5	3
LENGTH IN FEET AND METRES (1.5-Inch Muffler)	4 (1.2)	9 (2.7)	18 (5.5)	49 (15)	160 (49)
LENGTH IN FEET AND METRES (2-Inch Muffler)	17 (5.2)	35 (11)	70 (21)	188 (57)	614 (187)

EQUIVALENT LENGTHS OF PIPE FITTINGS

TYPE OF FITTING (INCHES)	1.5	2	2.5	3
STANDARD ELBOW Feet (Metres)	4.4 (1.34)	5.3 (1.62)	6.4 (1.95)	8.1 (2.47)
LONG RAD. ELBOW Feet (Metres)	2.8 (0.85)	3.5 (1.07)	4.2 (1.28)	5.2 (1.58)
MED. RAD. ELBOW Feet (Metres)	3.6 (1.10)	4.6 (1.40)	5.4 (1.64)	6.8 (2.07)
STANDARD TEE Feet (Metres)	9.3 (2.83)	13 (3.96)	14 (4.27)	17 (5.18)

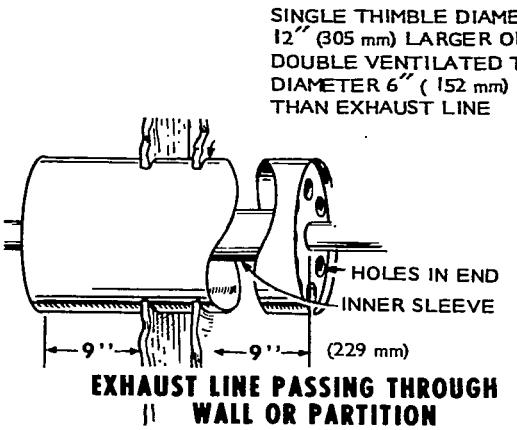


FIGURE 4. EXHAUST SHIELD

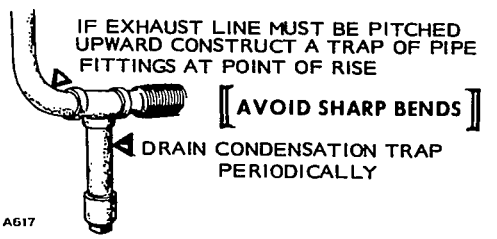


FIGURE 5. CONDENSATION TRAP

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

PURPOSE OF COOLING SYSTEM

Purpose of the cooling system is to carry heat away from hot engine components in order to maintain proper running conditions and clearances. Overheating can severely damage engines. The cooling system must carry off the excess heat.

Regulating coolant temperature helps keep the engine at the optimal heat level for each operating condition. After starting, the engine must warm up quickly. During periods of peak output, it must be adequately cooled.

ANTI-FREEZE AND CORROSION

Corrosion can shorten an engine's life by plugging up radiator cores, building up around hot spots near the exhaust valves, and settling in low areas of the block. The corrosive sediment insulates against proper heat transfer and holds heat in. Most of the metals used in cooling systems are susceptible to corrosion damage that causes coolant leaks and the temperature to rise above safe, normal limits.

To prevent corrosion, a mixture of anti-freeze and water should always be used as an engine coolant, even when freezing temperatures are not expected. Besides preventing coolant freeze up, anti-freeze contains rust inhibitors that prevent corrosion. Most anti-freeze manufacturers recommend a minimum 50-50 mix of ethylene glycol anti-freeze and water for winter and summer in closed water systems with a complete change every year to avoid corrosion and more expensive damage.

HIGH TEMPERATURE CUT-OFF SWITCH

The high temperature cut-off switch shuts down the engine if the coolant reaches a dangerously high temperature. This normally closed switch senses coolant temperature in the engine cooling jacket. When engine temperature rises beyond a specific point the switch opens, breaking the circuit to the fuel solenoid. When coolant temperature falls to a safe operating range the switch closes, permitting engine restarting.

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.

COOLING SYSTEM MAINTENANCE

The cooling system including the block and radiator should be cleaned and flushed at least once a year. This is especially true in cold weather conditions or when preparing unit for extended storage (over 30 days or more)!

The cooling system can work efficiently only when it is clean. Scale and rust in the cooling system slow down heat absorption and restrict water flow.

The thermostat is calibrated to open at 150° F ± 2° F. It should be checked also.

An appropriate anti-freeze mixture should be used in colder climates as necessary.

Check the fan belt tension periodically. For proper operation of the water pump, the fan belt should be tight enough to prevent slipping.

Check the water pump for wear periodically. Loosen the fan belt and move the fan and water pump pulley back and forth. If wear is excessive, replace the bearing.

Cleaning and Flushing Cooling System

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

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

WARNING ***Cleaning solutions typically contain strong chemicals that can cause burns or other injury if used improperly. Read all warning labels carefully before using.***

When cleaning is complete, drain cleaning solution and flush system. For best results engine and radiator, or heat exchanger, should be reverse flushed. Allow 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.

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 joint. 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 or a cracked or porous casting. The leakage is not visible but may cause extensive damage to the engine. Coolant mixes with the oil to form sludge which causes lubrication failure. Heavy sludge accumulations followed by sticking piston rings, valves, and tappets are symptoms of internal leakage.

Sometimes internal leaks are small 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.

Thermostat

Replace thermostat if it is broken, corroded, or sticks in the open or closed position. If engine overheats or does not reach and maintain a minimum operating temperature, the thermostat should be removed and tested as a possible cause.

1. Remove thermostat from cylinder head.
2. Heat a pan of water to approximately 150°F. Check temperature using a thermometer immersed in water.
3. With thermostat suspended in water at temperature of 150°F, thermostat should start to open.
4. After thermostat has opened completely, remove it from hot water and allow it to cool in surrounding air. The thermostat should close within a short time.
5. If the thermostat sticks or does not operate properly, replace it with a new one.
6. Always install a new gasket when replacing the thermostat.

Draining Cooling System

Whenever draining the cooling system for changing anti-freeze solution or for out-of-service protection when only water is used, be sure to open all drains and hose connections where water could be trapped.

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

The following drain plugs must be removed to allow complete flushing of the cooling system.

Radiator: One petcock lower right front corner.

Engine Block: One drain plug left front near water pump.

Water Pumps: One drain plug under cover or by loosening cover.

If an optional water jacket tank heater is used it should be drained and flushed also. The lower hose must be disconnected at the tank heater. There is no drain plug.

After making repairs on the cooling system, tighten all connections thoroughly. Use Permatex or thread sealing compound on all threaded connections to prevent leaks or the entry of air into the system.

Read instructions on Permatex Sealer can before applying sealer to engine parts.

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 anti-freeze to 265°F (132°C). Pressure caps should be inspected periodically for freedom of operation and the gasket should be checked for proper sealing. Replace the pressure cap if it malfunctions.

RADIATOR COOLED SYSTEM

On radiator cooled models (Figure 6), the water pump draws cooled water from the radiator through the bottom hose and forces it into the cylinder water jacket at the front of the engine. The water circulates through the cylinder water jacket up through the cylinder heads to the thermostat and flows through the outlet hose into the top of the radiator. It circulates down through the radiator while the fan blows cooling air across the radiator. The water is drawn from the bottom of the radiator by the pump to be recirculated.

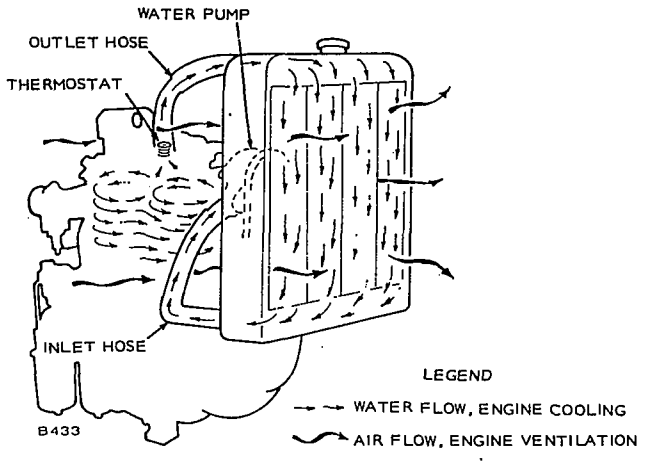


FIGURE 6. RADIATOR COOLING SYSTEM

During engine warmup, when the thermostat is closed, the water bypasses the radiator. It flows through a bypass line from the water outlet housing to the pump and recirculates through the engine. When water in the engine block reaches normal operating temperature, the thermostat opens. This permits heated water to flow into the radiator to be cooled.

Recirculation ensures both rapid and even temperature increase of all engine parts during warmup.

Ventilation for radiator cooled models requires an inlet opening for fresh air and an outlet opening for hated air to prevent recirculation of heated air. The openings should be at least the size of the radiator.

CAUTION ***An expansion area in the closed cooling system maintains proper coolant level by preventing overflow and loss of coolant when engine heats up.***

Water Pump

A centrifugal type water pump (Figure 6a) circulates coolant through cooling system. The water pump is secured to cylinder block with capscrews and is belt driven from the crankshaft pulley. Coolant is drawn through pump inlet opening by the impeller and forced through outlet opening in backside of pump into cylinder block. A gasket on water pump outlet assures a leakproof connection.

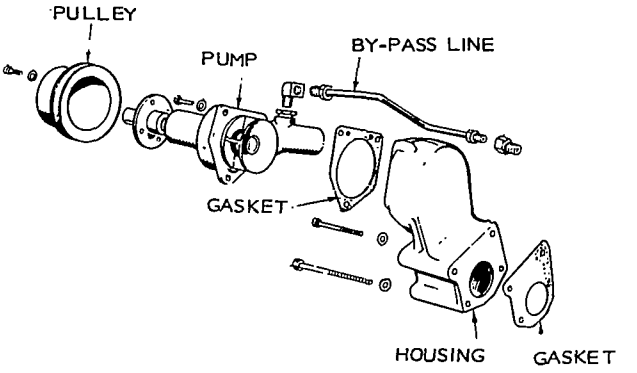


FIGURE 6a. WATER PUMP—EXPLODED VIEW

The water pump is constructed to provide long life with a minimum amount of attention when proper corrosion preventive coolant is used. Care must be taken to keep grit and abrasive material from being circulated through cooling system. Water containing scale-forming materials is especially harmful to pump parts.

The pump cannot be rebuilt and must be replaced as a unit. Check condition of bearing and shaft assembly by turning water pump pulley. If bearing feels rough or binds, seal is leaking, or housing is cracked, the pump must be replaced.

Removal and Installation

1. Drain cooling system at radiator and engine block.
2. Remove housing from radiator as necessary.
3. Disconnect both hoses from radiator.
4. Remove radiator.
5. Loosen fan belt.
6. Remove fan and water pump pulley.
7. Disconnect by-pass line and radiator lower hose from pump.
8. Remove water pump from water pump housing.
9. Installation is the reverse of removal.

CITY WATER COOLED

On city water cooled models (Figure 7) the lockshield valve is manually adjusted with a key for the required minimum rate of water flow for cooling. Whenever the ignition is turned on, the solenoid valve opens the pressurized water inlet line.

During operation, water from the pressurized source flows through the lockshield valve and solenoid valve and the inlet line and enters at the bottom of the cylinder water jacket at two places, one entry for each pair of cylinders. The water circulates around and up the cylinder jacket through the cylinder heads where it leaves the engine through a thermostat and cover at each of the two cylinder heads. From the thermostat covers, the water passes through the exhaust manifold and is drained from the engine cooling system.

During engine warmup, when the thermostats are closed, a water by-pass line controls the amount of water through the cylinder water jacket until the thermostats open. The by-pass line also continues to function during operation because it contains the high water temperature cut-off switch and the water temperature sender unit.

Ventilation for these models is necessary for sufficient fresh air movement to cool the generator and support combustion for the engine.

Check the thermostat opening and closing with the thermostat immersed in a water bath. The thermostat should start to open when the water temperature reaches 145°F and should be fully open at 165°F. Take the thermostat out of the water and it should close in approximately 60 seconds. If it does not operate properly, replace it.

HEAT EXCHANGER COOLING (Optional)

ONAN heat exchanger cooling is available either factory installed or as a kit for customer installation. A complete heat exchanger installation (Figure 7a) contains two independent water systems:

1. A closed water system
2. An open (raw) water system

In the closed water system, a centrifugal pump draws the water from an expansion tank and pumps it through cooling tubes in a heat exchanger and into the engine water jacket where it circulates out through a thermostat back into the expansion tank for recirculation. In the open water system, pressurized water is forced around the cooling tubes through the heat exchanger and through the exhaust manifold from where it is discharged.

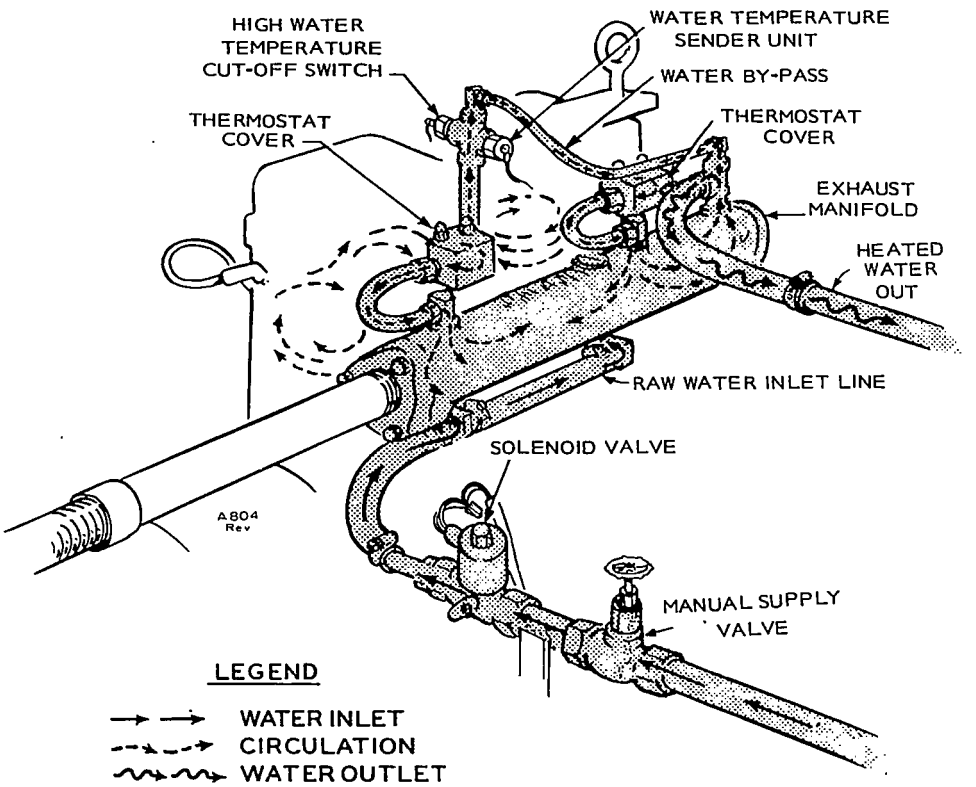


FIGURE 7. CITY WATER COOLING SYSTEM

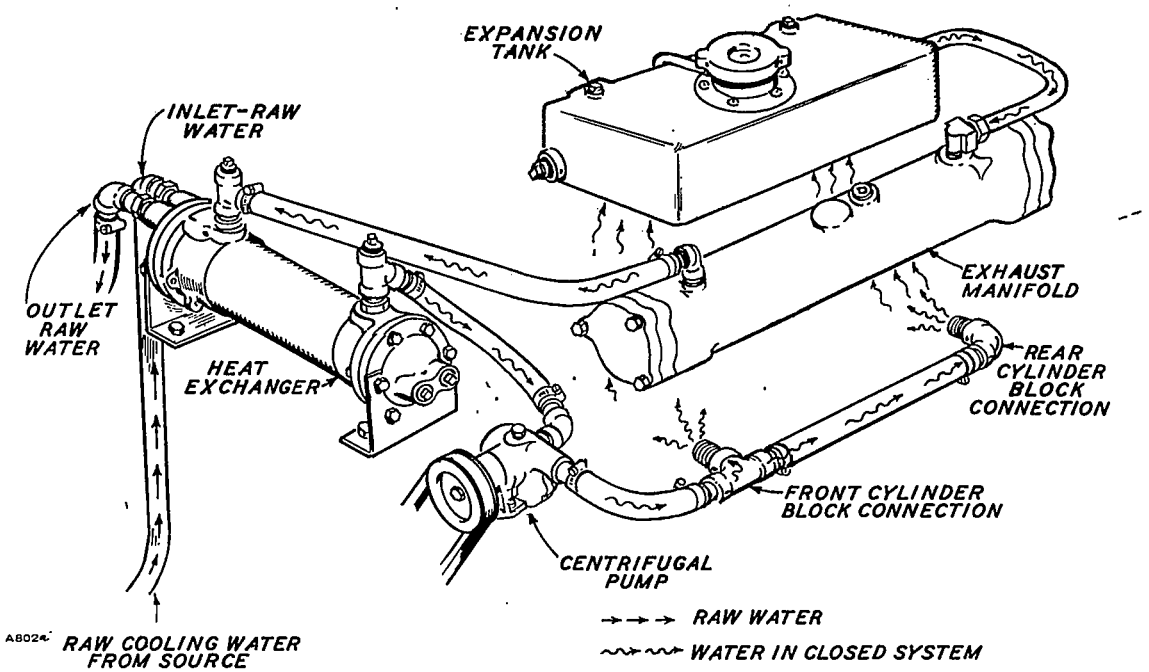


FIGURE 7a. HEAT EXCHANGER COOLING SYSTEM

Maintenance of the closed water system is the same as a radiator cooled system. Clean and flush it once a year and use an anti-freeze if there is danger of freezing. Use a rust inhibitor in the expansion tank (closed water system).

In the open water system, check periodically for air leaks, wear or damage, or restricted lines.

The open water portion of the heat exchanger is protected from corrosion by a zinc pencil mounted on a pipe plug in one end of the heat exchanger. Inspect the pencil at least every two months and replace if deteriorated to less than one half original size (Figure 7b.).

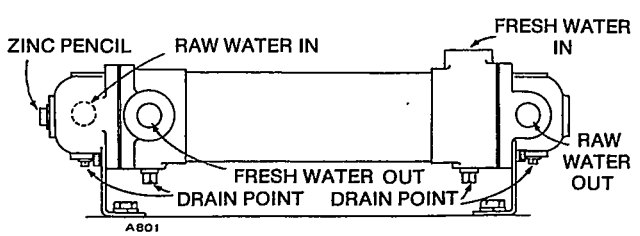


FIGURE 7b. HEAT EXCHANGER AND ZINC PENCIL

Clean and flush the cooling system if conditions warrant. To clean the closed water system, drain and refill with radiator cleaner. When chemical cleaning is completed, according to the cleaner manufacturer's instructions, flush the cooling system to wash out deposits loosened by the chemical cleaning.

Flush the engine water jacket. The hose from engine water jacket to heat exchanger should be removed from the water outlet. Flush both closed water portion and raw water poriton of the heat exchanger. Remove the lockshield valve and solenoid valve to flush the raw water portion. Also flush the water cooled exhaust manifold. When flushing is completed, check the system thoroughly for any leaks uncovered by the cleaning operations.

Repair and test raw water system for air leaks and insufficient water flow.

Heat exchanger repair, if it should become clogged, consists of removing the ends and cleaning out the tubes.

Water Pump

Pump repair is necessary if pump is leaking or bearings are worn. Disassemble pump and replace worn components (Figure 7c.).

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.

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.

After the pump has been assembled (see Figure 7d.), 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 the lock screw when the adjustment is correct being careful not to alter the 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.

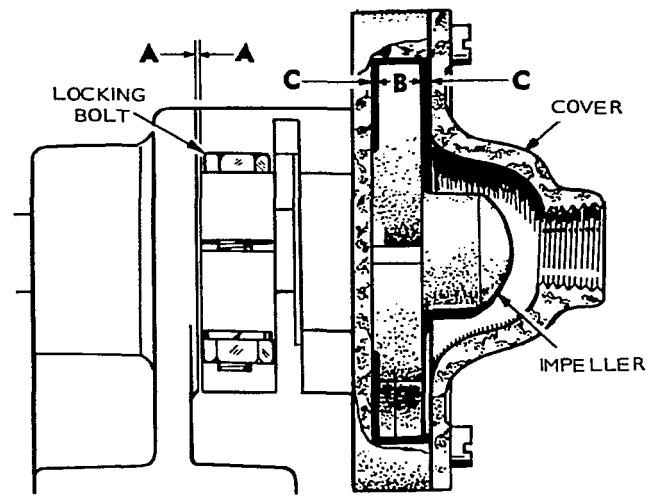


FIGURE 7d. WATER PUMP CLEARANCES

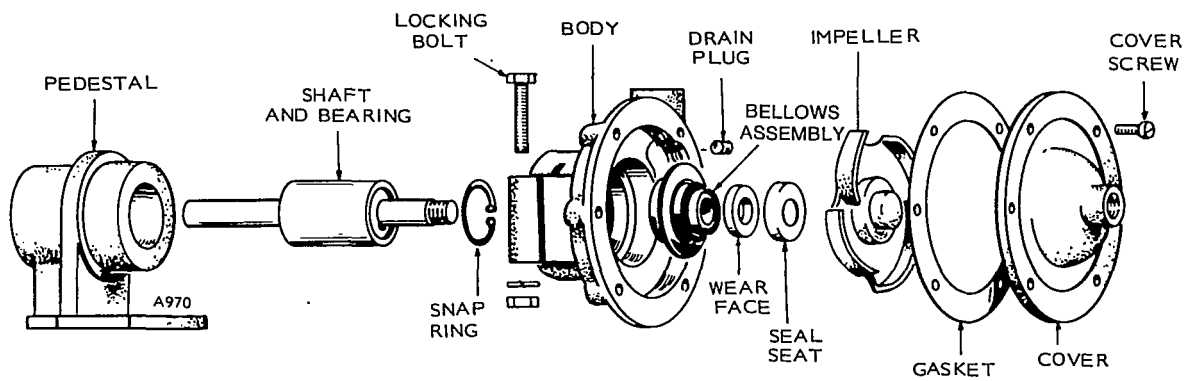


FIGURE 7c. WATER PUMP ASSEMBLY

Fuel System

DIESEL FUEL

Diesel fuel, like gasoline and most gaseous fuels, is a product of crude oil refining. Its heat content is somewhat higher than that of gasoline.

In a diesel engine, fuel is sprayed into the combustion chamber as the piston approaches the top of its compression stroke. The fuel is ignited by the intense heat that develops as the air within the engine cylinder is compressed. No electrical ignition system is necessary.

Diesel fuel requirements vary with engine size, speed and load, and with ambient temperature. Factors which must be considered include the fuel's cetane number, pour point, viscosity, volatility, and the amount of sediment, residues, and sulfur in the fuel.

The American Society for Testing Materials (ASTM) has used these and other characteristics to define three basic diesel fuel grades. Refer to the *Service and Maintenance* section for the recommended grade of fuel to use in the engine.

Cetane Rating

Cetane number is a measure of how quickly diesel fuel will ignite under heat and pressure. For proper engine operation, diesel fuel should ignite almost immediately after entering the engine combustion chamber. If ignition is delayed, too much fuel will ignite at once, causing sudden explosions. These explosions produce the familiar cackle heard when a diesel engine is cold or at idle. If the cackle does not disappear as the engine is warmed or placed under load, it is a sign that the cetane rating of the fuel may be too low, which could cause serious engine damage.

Pour Point

The temperature at which a diesel fuel will cease to flow is known as its pour point. As diesel fuels approach their pour point, waxes form and plug fuel filters causing fuel starvation. For this reason, if low ambient temperatures are possible, diesel fuel with a pour point at least 10 degrees F (6° C) below the lowest expected temperature should be specified.

Keeping Diesel Fuel Clean and Free From Water

It is essential that diesel fuel be kept clean and free from water. Diesel injection pumps and nozzles are precision-made units requiring extremely close tolerances. They are very sensitive to any abrasive materials and are easily damaged by corrosion resulting from the introduction of water into the system.

To keep fuel contamination to a minimum, the fuel storage and system maintenance procedures outlined below must be followed.

1. Do not use zinc or galvanized storage tanks as harmful compounds may form as a result of reactions with diesel fuel impurities.
2. Pitch fuel tanks away from the fuel outlet and provide a drain cock to drain off water and sediment. The fuel outlet should be located several inches above the bottom of the tank, Figure 8.
3. Keep fuel tanks as near full as possible to minimize condensation within the tank.
4. Drain sediment traps and change fuel filters on a regular basis as recommended by the engine manufacturer.

KEEP FUEL

CLEAN!

•

DIRTY FUEL IS ONE OF THE MAJOR CAUSES OF ENGINE FAILURE

•

REMEMBER- EVEN A TINY PARTICAL OF DIRT IN THE INJECTION SYSTEM MAY STOP YOUR ENGINE!

•

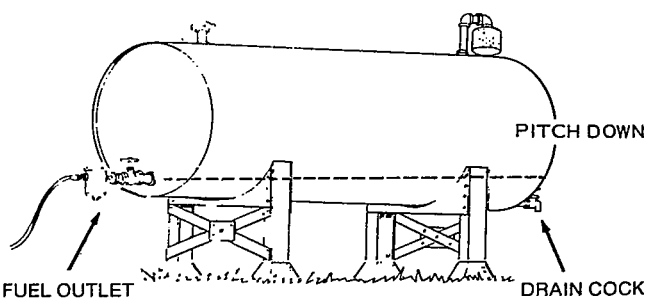


FIGURE 8. FUEL STORAGE

FUEL SYSTEM

The fuel system (Figure 9) consists of a glass 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). The injection lines deliver fuel to the injectors at high pressure and act as fuel distributors to the injectors. The time interval between 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). When the cylinder air is heated 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 assists the precision timed injection of fuel into the cylinder.

Nozzle leak-off fuel is returned to the tank after each injection cycle by a fuel return line from the nozzle. An adapter combines the leak-off fuel with the flow-through fuel from the injection pump. A return line connected at this point returns the combined fuel back to the fuel supply tank.

CAUTION ***A diesel engine cannot tolerate dirt or water in the fuel system. It 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.***

FILTER SYSTEM

The sediment bowl has a fine mesh screen which keeps water and some of the coarse dirt from entering the transfer pump, Figure 9. The dirt and water remain in the sediment bowl which should be removed for cleaning as required. The 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 when either filter is loose or missing.

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

Water in Fuel Filters: Drain water periodically as required from both filters. Replace primary filter every 600 hours and secondary filter every 3000 hours. When replacing filter, tighten screw until gaskets touch base, then tighten screw 1 to 1-1/2 turns.

FUEL TANK AND LINES

Where a separate fuel tank is used, install so the vertical distance from bottom of the tank to the fuel pump does not exceed six feet. Auxiliary fuel pumps are available to provide an additional eight-foot lift.

Avoid gravity feed of fuel to the engine. Provide a siphon break if tank is above pump. When sharing a fuel tank, do not connect to an existing line at a point above the fuel supply level.

These diesel engines require a fuel supply line and a separate return line. Install the fuel supply line from tank to the 7/16-24 NPTF inlet in the fuel pump. Connect fuel return line to fitting at injection pump. See Figure 10. Use approved flexible fuel lines at the engine to absorb vibration. Be sure there are no air leaks in the suction line.

Install a shut-off valve in the tank for service convenience.

WARNING ***Fuel leakage might cause an explosion or fire resulting in severe personal injury or death. Do not use dissimilar metal lines, fittings, and fuel tanks in the fuel system. Electrolytic corrosion might cause hazardous fuel leaks.***

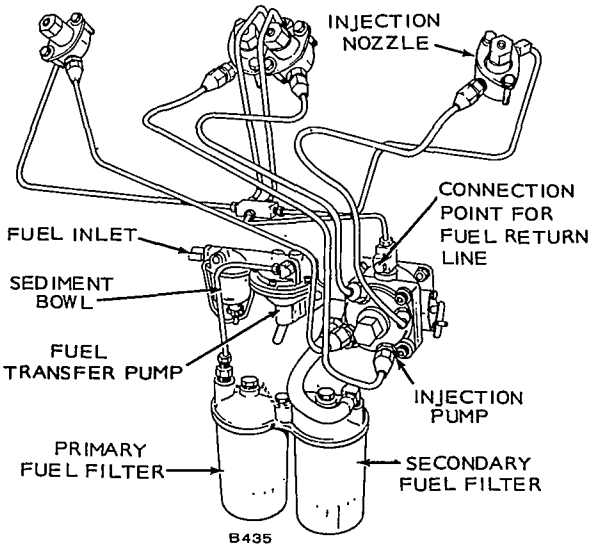


FIGURE 9. FUEL SYSTEM

FUEL TRANSFER PUMP

The fuel transfer pump (Figure 10) 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 diaphrgam spring maintains required fuel pressure to the injection pump. Fuel pressure should be 12-14 psi (83-97 kPa) when operating at 1800 rpm.

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 (1.83 m). The fuel pump should produce 15 to 18 inches (381 to 457 mm) of vacuum at sea level.

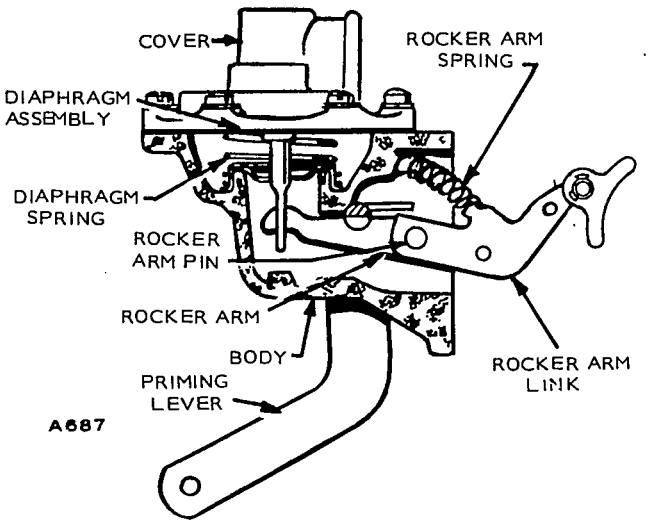


FIGURE 10. FUEL TRANSFER PUMP

Fuel Pump Removal Disassembly

1. Remove pump inlet and outlet lines. Remove two cap screws 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 and replace if necessary. 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 10 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.
5. Push rocker arm in 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 11. 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).

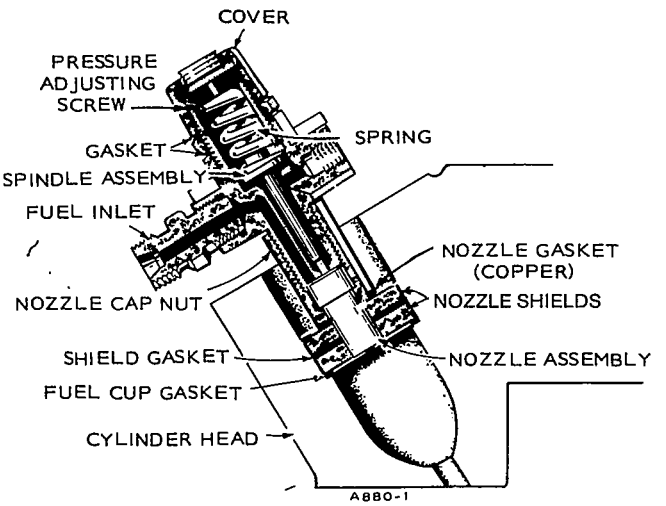


FIGURE 11. INJECTOR NOZZLE ASSEMBLY INSTALLATION

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 12.

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 it atomizes and 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 back to the fuel supply tank.

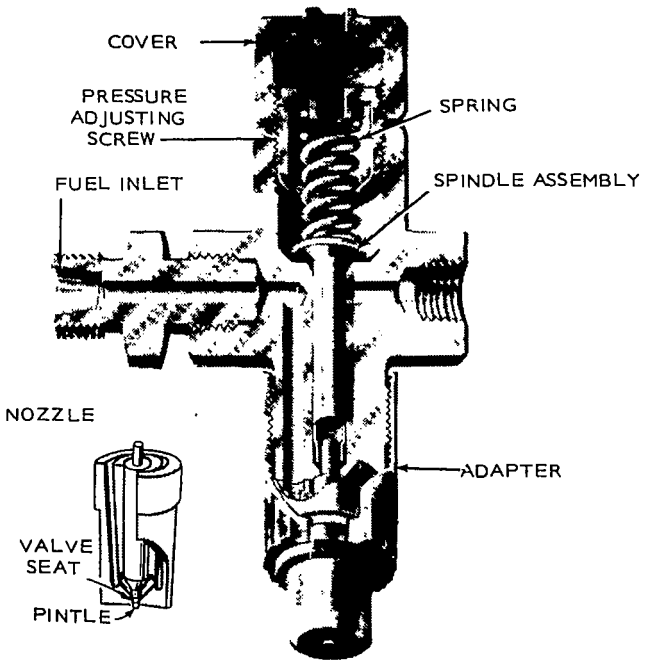


FIGURE 12. INJECTOR NOZZLE AND HOLDER ASSEMBLY

Nozzle Spray Pattern

A suspected nozzle can be checked in the field by removing it from the engine and reconnecting it to the high pressure line. The spray pattern (Figure 13) 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.***

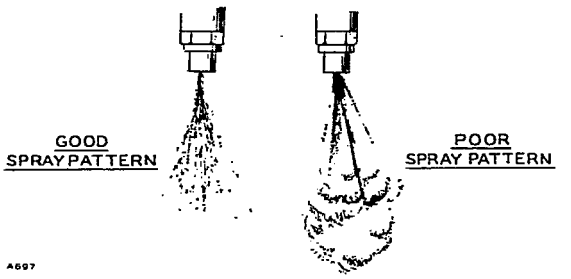


FIGURE 13. NOZZLE SPRAY PATTERN

If streamers are visible, the pattern is badly distorted or 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 determining 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 increases the pressure and 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 for the holder body.
4. If necessary to disassemble the nozzle further, reverse pressure adjusting screw and lift out spring and spindle assembly.

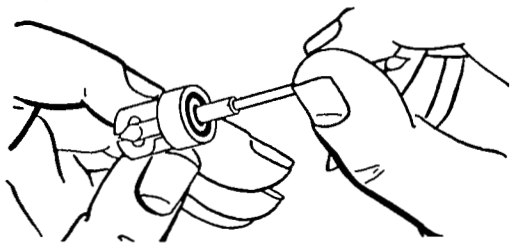
CAUTION ***Do not attempt to disassemble the nozzles or adjust nozzle pressure without the proper test equipment. A nozzle pressure tester is essential to do a satisfactory job.***

The cleaning procedure (Figure 14) is extremely important when disassembling injection equipment. Always rinse in clean fuel before reassembling.

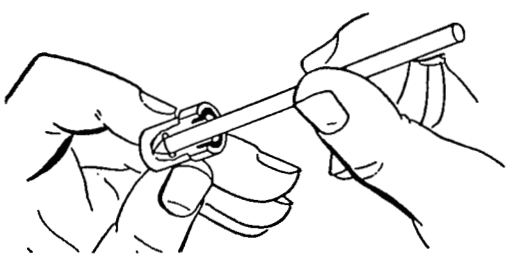
Injection Nozzle Tester

Testing and adjustment can be performed only with a nozzle tester, Figure 15. Do not attempt to disassemble the nozzles or adjust nozzle pressure without the proper test equipment.

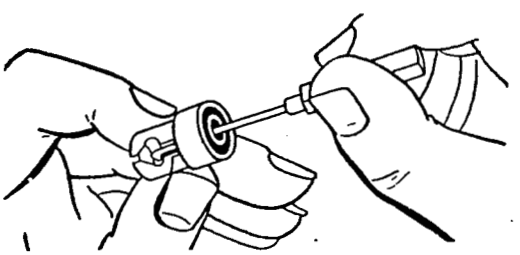
Opening pressure, leakage and spray pattern can be checked using the tester. If any of the above malfunctions appear (except opening pressure), the nozzle valve and seat can be inspected with a magnifying glass for erosion, scoring, etc. If cleaning with solvent does not correct the malfunctions, a new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



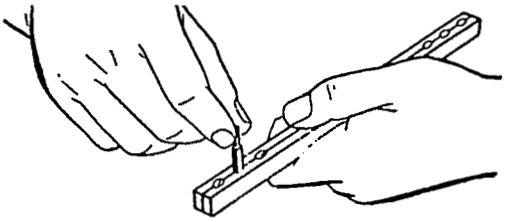
1. Use a brass type scraper tool to remove hard carbon deposits from nozzle body valve seat.



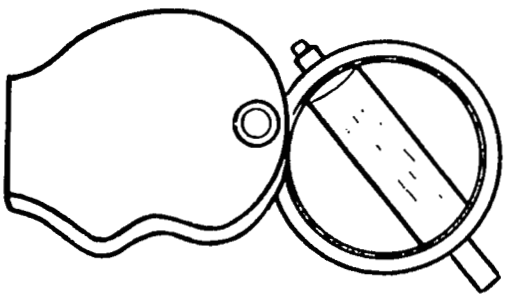
2. After scraping the carbon, polish the valve seat by using a round pointed stick dipped in tallow. Polishing should restore seat to its original finish unless it's scored.



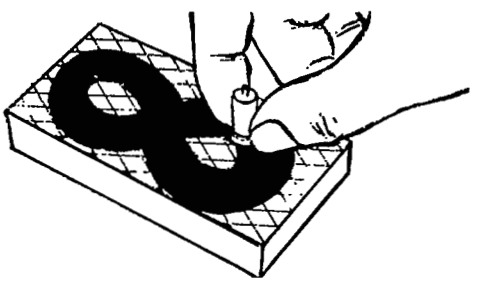
3. Use a special hooked type scraper to clean the nozzle pressure chamber gallery. The hooked end of scraper is inserted into the gallery and then carefully rotated.



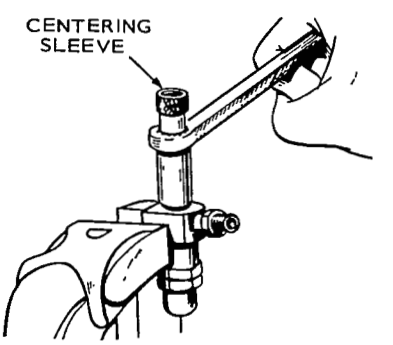
4. Clean nozzle valve and polish with tallow and a wooden polishing fixture. Take care to remove all traces of tallow when finished.



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



6. 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.



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

FIGURE 14. NOZZLE CLEANING

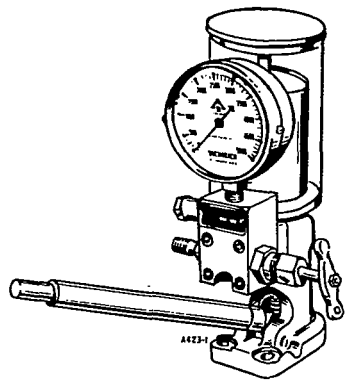


FIGURE 15. INJECTION NOZZLE TESTER

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

Soak each nozzle in fuel to loosen dirt. Then clean the inside with a small strip of wood soaked in oil and the 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.

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 N•m).

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 cap screws. Tighten cap screws alternately to avoid cocking nozzle assembly. Tighten each to 20-21 foot-pounds (27-28 N•m).

FUEL SOLENOID

The fuel shutoff solenoid (Figure 16) 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.

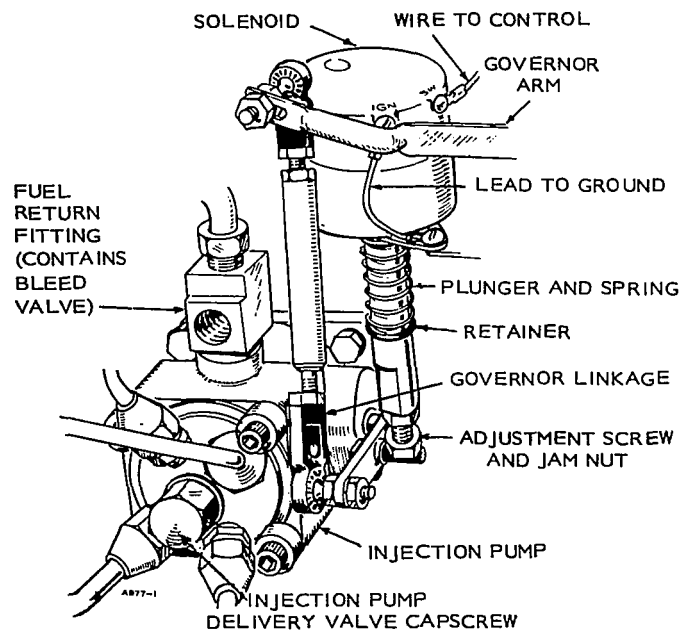


FIGURE 16. FUEL SOLENOID

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.

PREHEATING CIRCUIT

This 12 volt battery circuit consists partly of manifold heaters that heat the combustion air at the intake manifold and a glow plug in each cylinder that heats the precombustion chamber for engine starting, Figure 17. The manifold heater and glow plugs are wired in parallel and are controlled by a preheat switch on the control box.

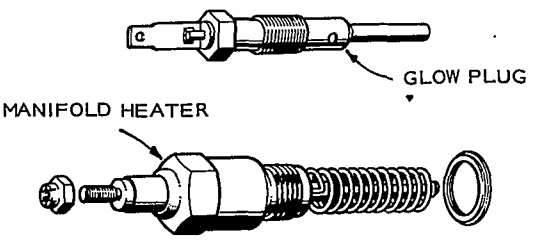


FIGURE 17. GLOW PLUG AND MANIFOLD HEATER

Check each heater by removing its lead, operating the preheat switch, and touching the lead to its terminal. If it sparks, there is continuity and the heater is working. If any components of this circuit fail, replace them. Do not attempt repairs on individual components. If there is still a question, check the component for heating.

FUEL INJECTION PUMPS

The diesel is equipped with the model PSU fuel injection pumps.

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 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).

INJECTION PUMP REPAIR

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

CAUTION ***Replace with new pumps injection pumps that troubleshooting procedures prove to be malfunctioning. Do not attempt unauthorized repair procedures on the injection pumps. Refer to Diesel Starting Guide, page 9.***

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 servicemen that tampering or inept repair attempts can cause irrepairable damage to the pumps that will not be covered by the manufacturer's warranties or exchange agreements. Contact an authorized American Bosch Service station or Distributor for expert repair service on the 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.

PSU INJECTION PUMP

The PSU injection pump (Figure 18) is used on Onan 4-cylinder water-cooled diesels.

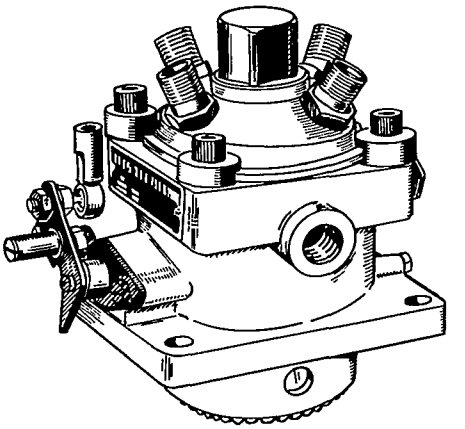


FIGURE 18. PSU INJECTION PUMP

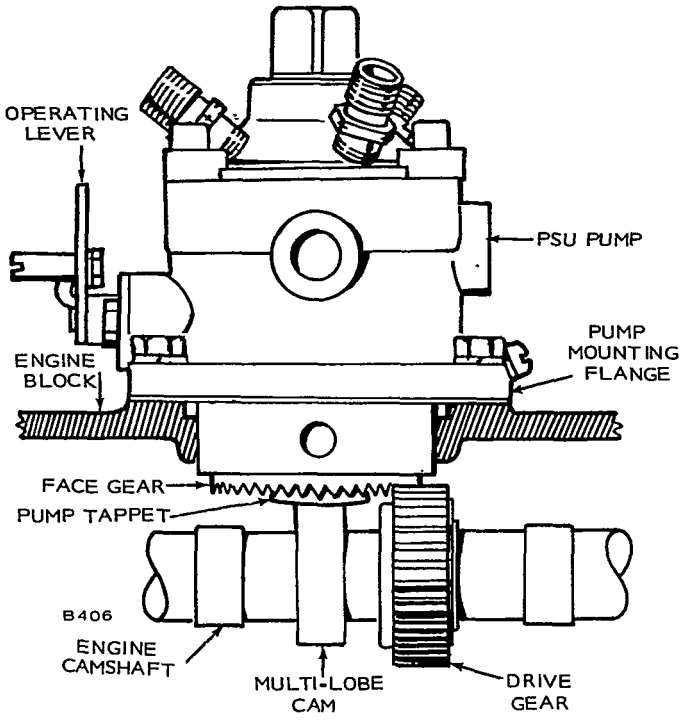


FIGURE 19. INJECTION PUMP TO CAMSHAFT RELATIONSHIP

PSU Pump Operation

The pump face gear mates with and is rotated by a drive gear on the engine camshaft, Figure 19. The face gear, pilot ring, and the reciprocating plunger in the pump are rotated continually to assure positive fuel distribution. The plunger is reciprocated up and down by a multi-lobed cam on the camshaft which bears against a tappet assembly on the pump.

Pump Cutaway View

The cutaway view in Figure 20 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 so phased 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.

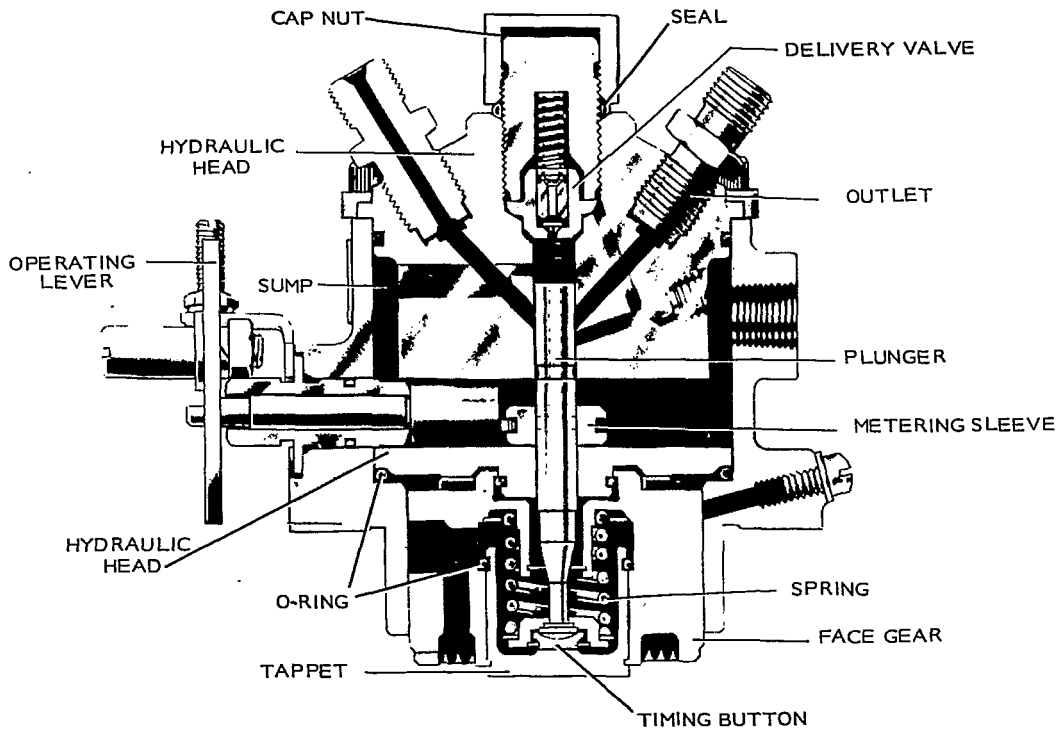


FIGURE 20. PSU PUMP (CUTAWAY VIEW)

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 21. 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 the plunger outlet groove with the proper injection line outlet for the injector to be fired on each pump stroke.

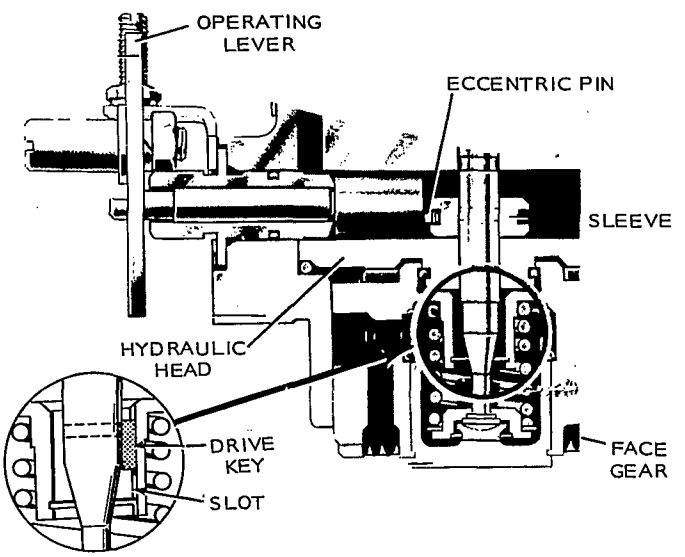


FIGURE 21. METERING CONTROL

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 1. Figure 22 shows the timing button. One button will provide the correct port closing.

FIGURE 22. 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 1 and order the correct one from your Onan dealer.

TABLE 1. 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 1.

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's thickness is established at the factory during engine assembly and does not change unless a new cylinder block is installed.***

Port Closing Formula: The formula 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 23). Use number or letter code on timing button to obtain dimension of old timing button from Table 1. This code should be the same as the code number stamped on injection pump (Figure 23).

CAUTION ***On all PSU pumps be sure to hold the pump drive gear securely to 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 enclosed 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.*

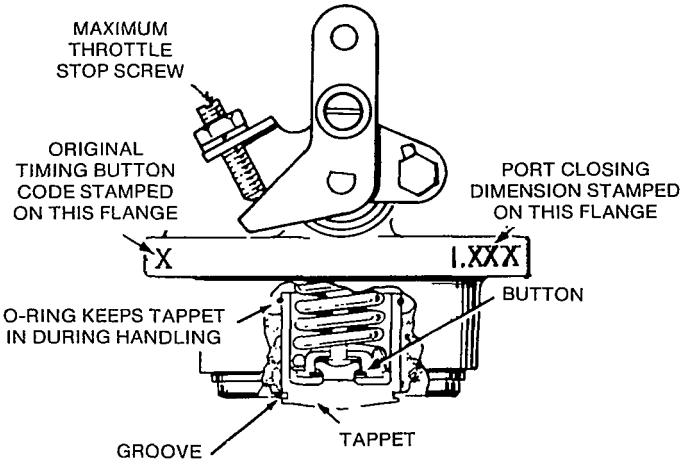


FIGURE 23. TAPPET REMOVAL

Method 2 Flow Timing Injection Pump

This procedure is used when dimensions from old pump are lost or 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 24 and 25).

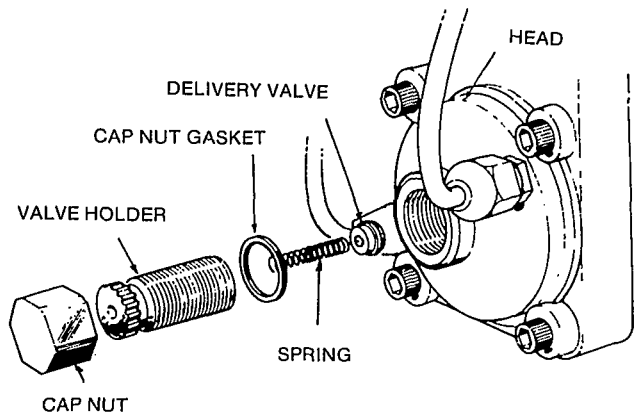


FIGURE 24. LATE MODEL DELIVERY VALVE ASSEMBLY

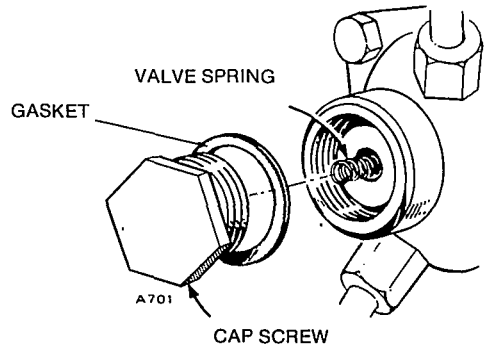


FIGURE 25. EARLY MODEL DELIVERY VALVE HOLDER

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 26).

4. Disconnect governor linkage at ball joint and hold control arm up at maximum fuel position.

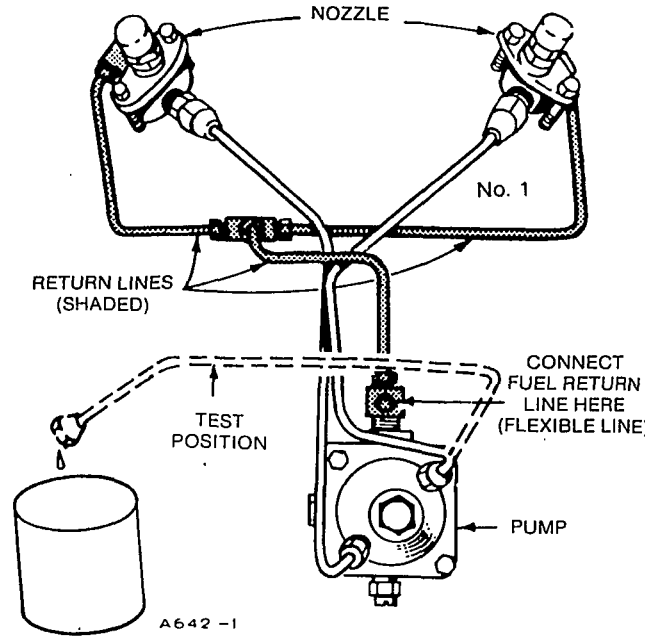


FIGURE 26. FUEL LINE TO INJECTORS

5. Rotate flywheel clockwise (when facing front of engine [Figure 27] to point where PC mark on flywheel is about 15 degrees (1.25 to 1.50 inch) before timing pointer on gear cover (compression stroke of No. 1 cylinder).

   Make sure that both rocker arms on number one 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.***

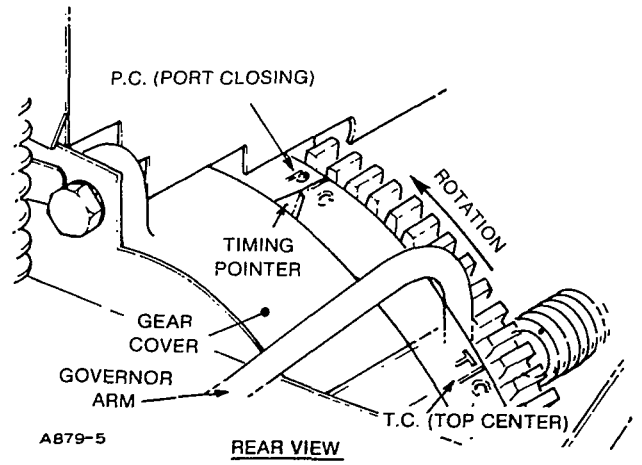


FIGURE 27. PORT CLOSING POSITION

6. Manually operate fuel transfer pump (Figure 28) until fuel, free of air, flows from open end of No. 1 injection line into container (Figure 26).

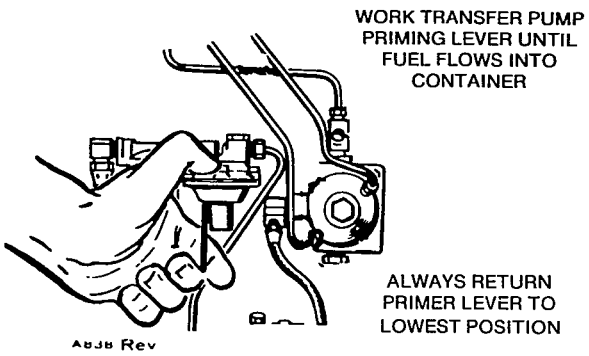


FIGURE 28. OPERATING TRANSFER PUMP MANUALLY

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 27). 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 29.

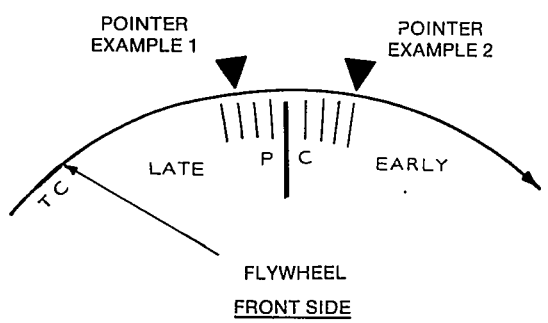


FIGURE 29. TIMING MARKS

   B. Measure distance in tenths (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 × .003" = .009" [3 × .076 = .229 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 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 × .003 = .012 inch (4 × .076 mm = 0.305 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 25) injection pumps, remove capscrew and install valve spring and capscrew with gasket. Torque capscrew to 75 to 89 ft.-lb. (102 to 120 Nm).

10. On late model (Figure 24) 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 only changes 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 27). 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 30) 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.

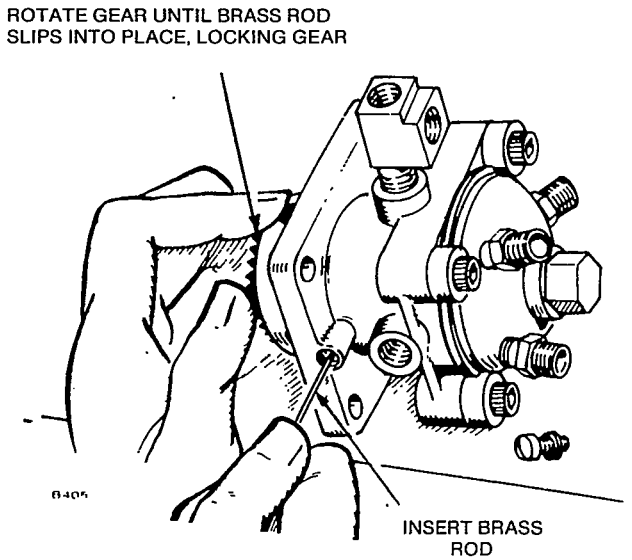


FIGURE 30. LOCKING THE DRIVE GEAR

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 31).

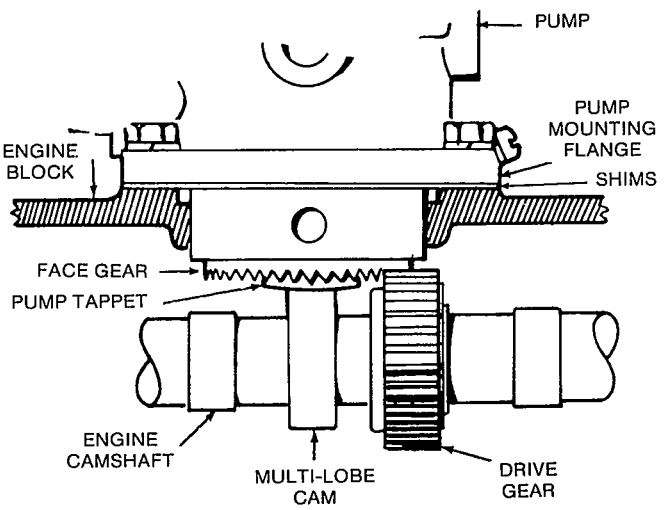


FIGURE 31. PUMP INSTALLED

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.

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 32. 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.

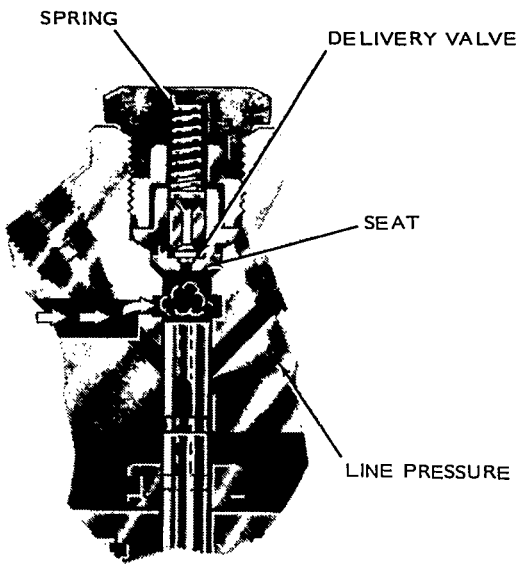


FIGURE 32. DELIVERY VALVE CLOSED - PLUNGER DOWN

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 33.

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.

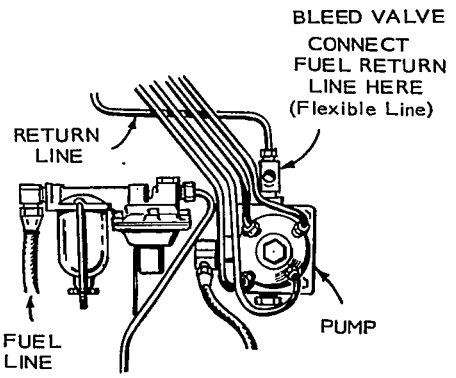


FIGURE 33. BLEEDING FUEL SYSTEM

Oil System

Onan diesel engines have pressure lubrication to all working parts 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 36 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.

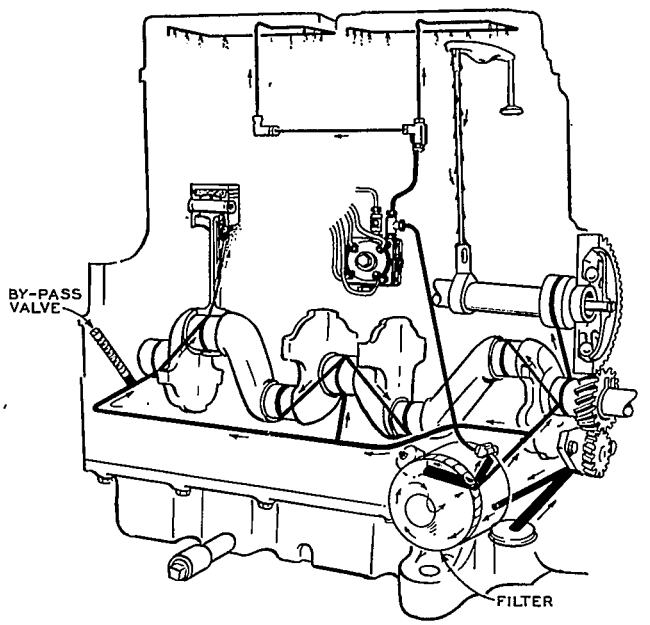


FIGURE 36. OIL PRESSURE SYSTEM

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, drillings through the crankcase 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 cap screws holding pump and remove pump.

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 cap screws 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 37) 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. 0.11 lb. at 1-3/16 inches (compressed) (1.01 kg) (0.05 kg) at (30.163 mm) (compressed)

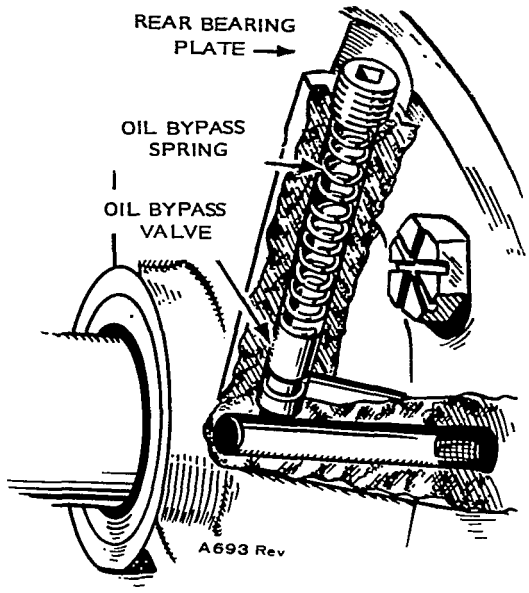
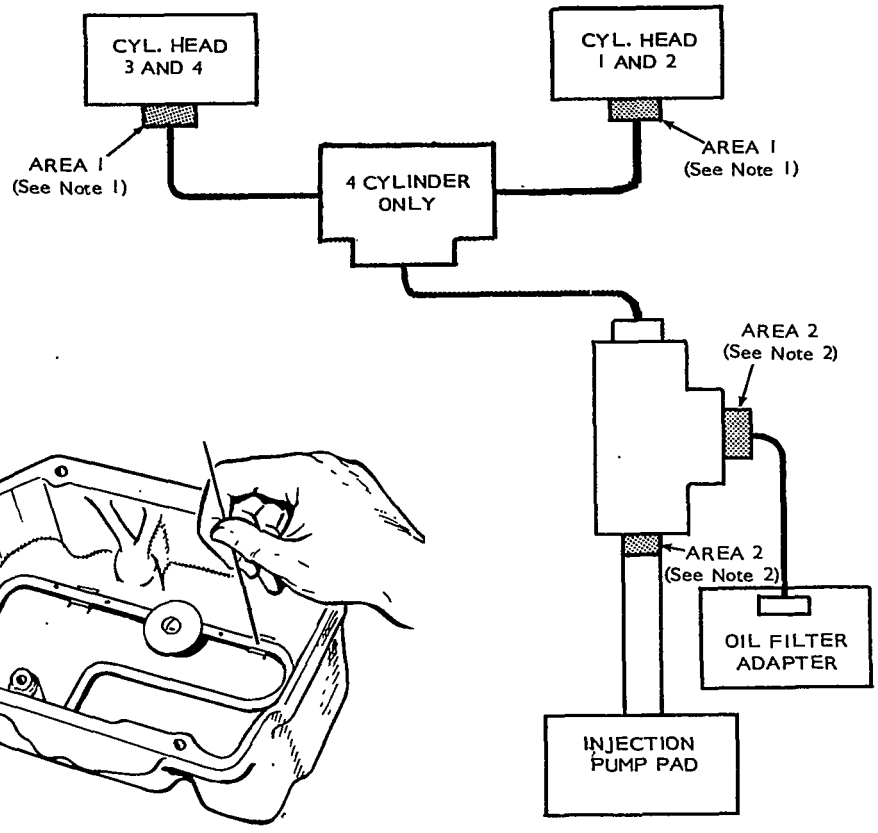


FIGURE 37. BYPASS VALVE



FLUSH ROCKER BOX OIL LINE WITH FUEL AND CLEAN HOLES WITH FINE WIRE.

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 38. 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 38. 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. Reach the oil gauge passsage 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. If damaged they should be replaced.

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.

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

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.***

OIL FILTER (Full Flow)

The oil filter is mounted on the filter plate at the left side of crankcase (Figure 39). 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.

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.***

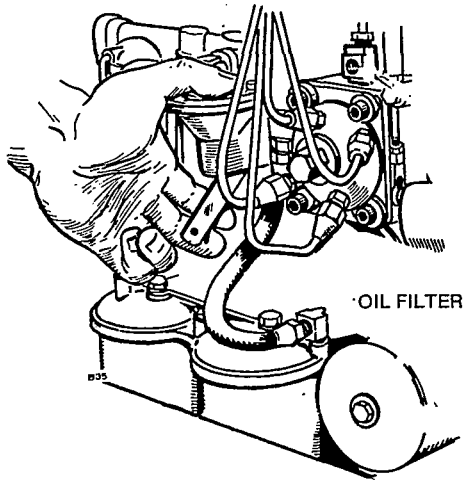


FIGURE 39. FULL FLOW OIL FILTER

CRANKCASE BREATHER

Late model engines are equipped with a crankcase breather pipe that vents crankcase fumes directly from the rocker box cover to the cylinder head intake port. The crankcase breather pipe must be cleaned after every 500 hours of engine operation by inserting a soft wire (Figure 40).

RDJC Spec S engines use a breather system with a breather pulsation damper that serves two major functions. It dampens pulsations which originate in the intake manifold and contribute to oil carryover. It also acts as an oil separator to condense oil vapor and small oil droplets to prevent them from getting into the intake manifold and combustion chamber and causing excessive coke deposits in the valve ports.

To disassemble, remove the breather cap from the breather tube. At the same time, pull the baffle out of the breather tube and clean it.

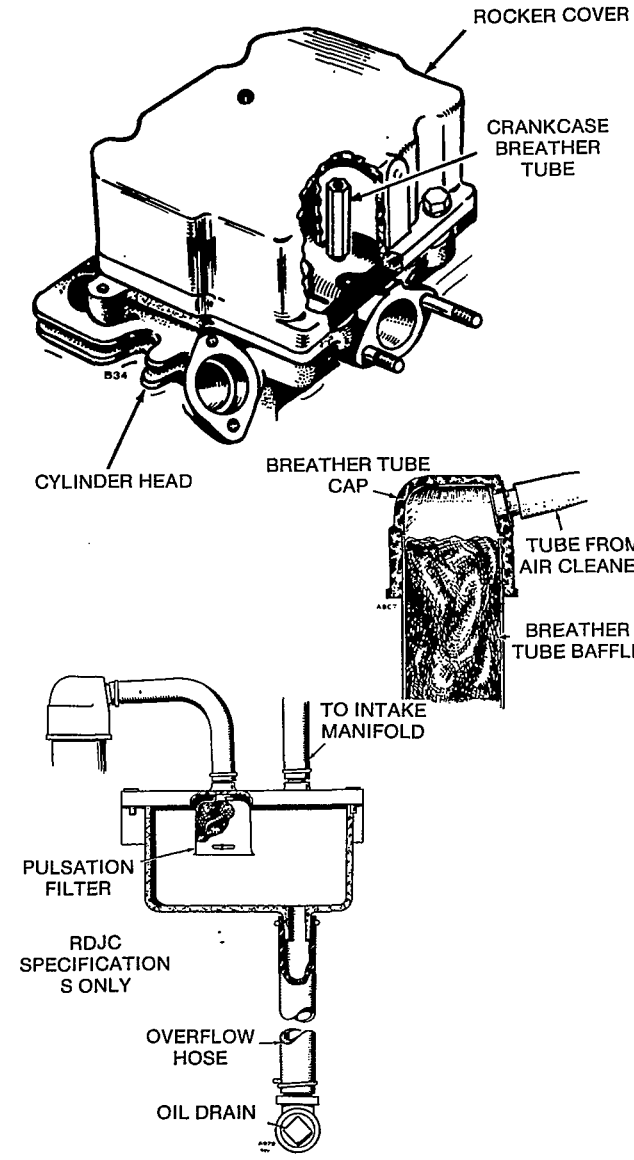


FIGURE 40. CRANKCASE BREATHER

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 industrial engines.

GOVERNORS

The constant-speed governor (Figure 41) 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 governor arm which, in turn, 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 governed. 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: The linkage must be able to move freely through its entire travel. Periodically lubricate the ball joints with graphite. Also, inspect the linkage for binding, excessive slack, and wear.

Testing and Repair: Removing the gear cover for access to the governor cup and other internal governor parts is covered in the *ENGINE DISASSEMBLY* section. External service and repair is limited to testing spring tension and checking ball joints.

To test spring rates, use a spring-type scale. Compare the measured rates with those in Table 2.

TABLE 2. GOVERNOR SPRING DATA

Engine Model	Governor Type	Spring Number	Free Length	Spring Rate
RDJF	Constant	150-1084	3.0 in. (76.2 mm)	69 lbs/in (12.09 N/mm)

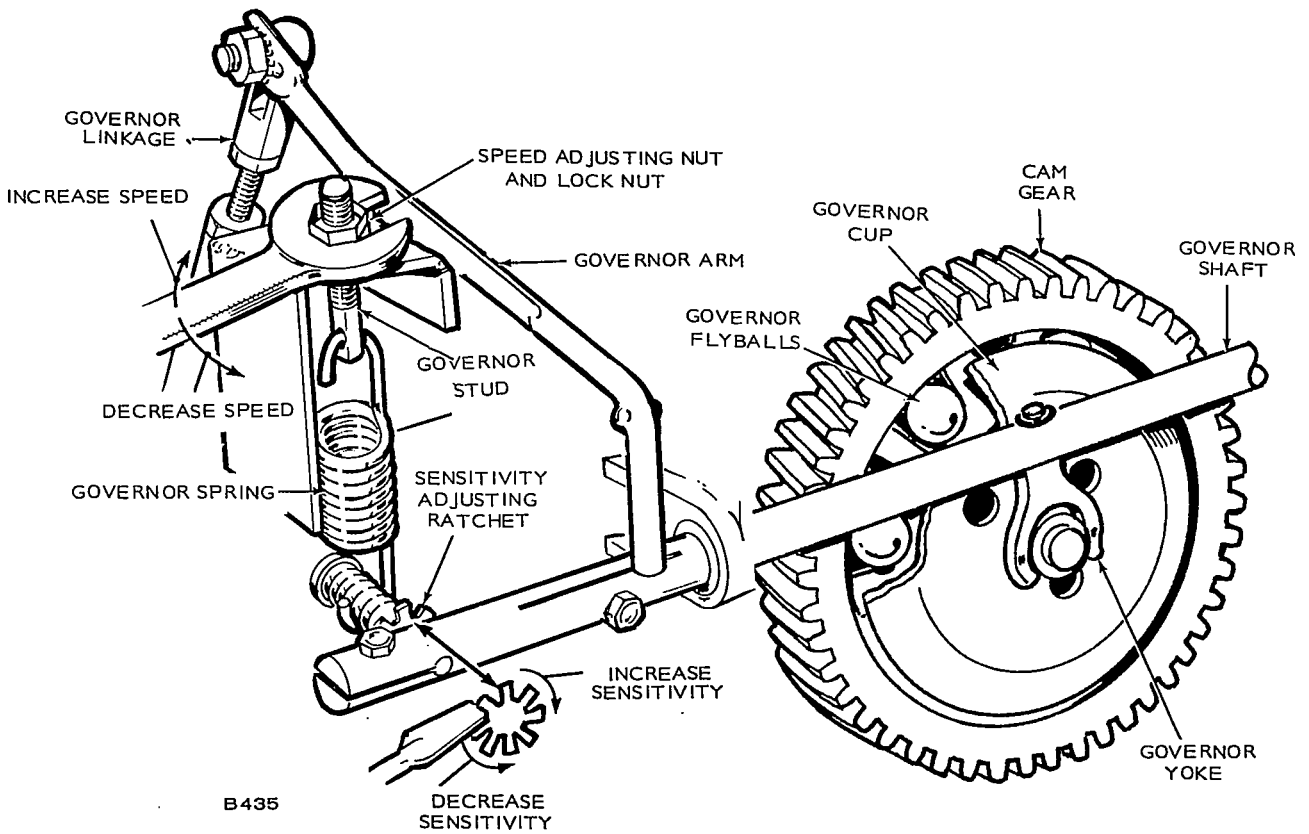


FIGURE 41. GOVERNOR ASSEMBLY AND ADJUSTMENTS

ADJUSTMENTS

Speed Adjustment: To change the governor speed, change the spring tension by turning the governor spring nut (Figure 42). Turn the nut clockwise (more spring tension) to increase RPM and counterclockwise to reduce governed speed. Hold a tachometer against flywheel cap screw.

Sensitivity Adjustment: To adjust governor sensitivity (no load to full load speed droop) turn the sensitivity adjusting ratchet accessible through a covered access hole on the side of the blower housing. Counterclockwise gives more sensitivity (less speed drop when full load is applied), clockwise gives less sensitivity (more speed drop). If the governor is too sensitive, a rapid hunting condition occurs (alternate increasing and decreasing speed). Adjust for maximum sensitivity without hunting. After sensitivity adjustment, the speed will require readjustment. After adjusting the governor, secure speed stud lock nut.

Excessive droop may be caused by engine misfiring. Correct this condition before adjusting governor.

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.***

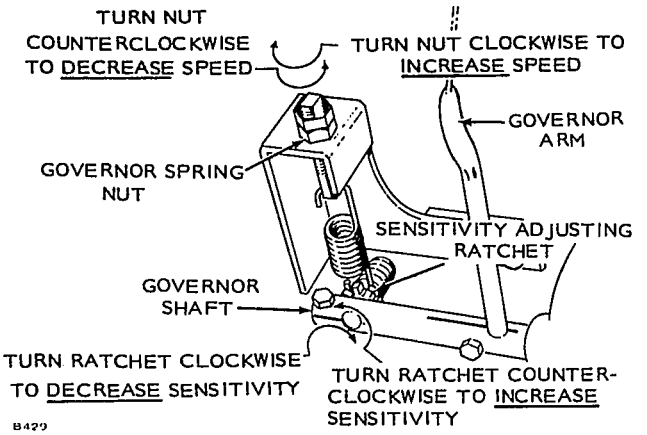


FIGURE 42. GOVERNOR ADJUSTMENTS

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 43 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.

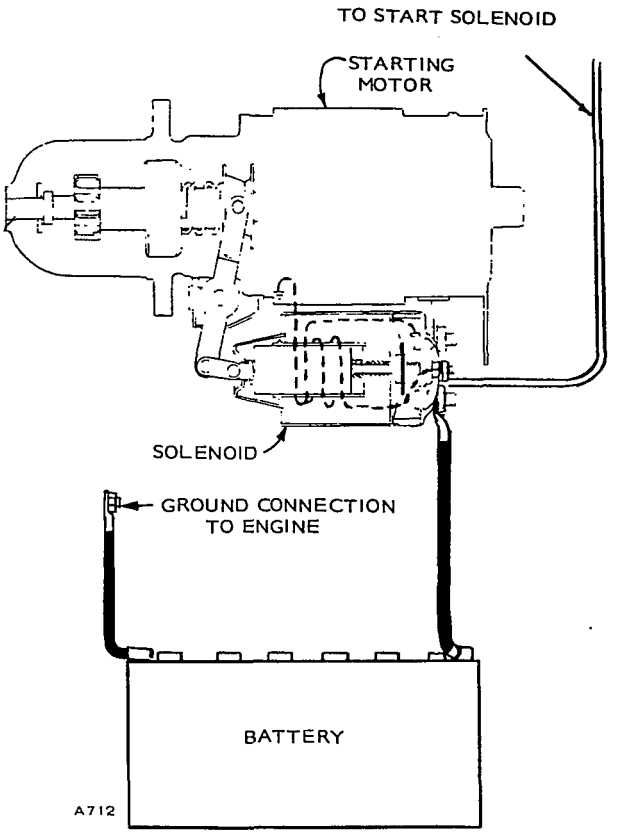


FIGURE 43. STARTING SYSTEM

Using a spring scale and torque arm, test the stall torque, Figure 44. Multiply the spring scale reading by the arm length for the torque value.

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.

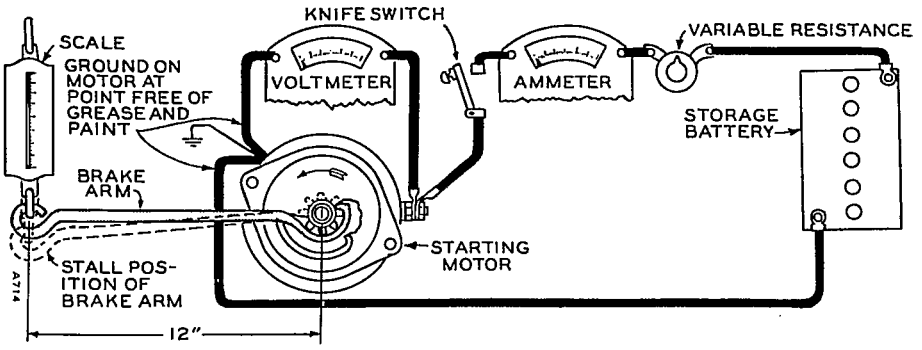


FIGURE 44. TESTING STALL TORQUE

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 in 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 the sand out of the motor 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.

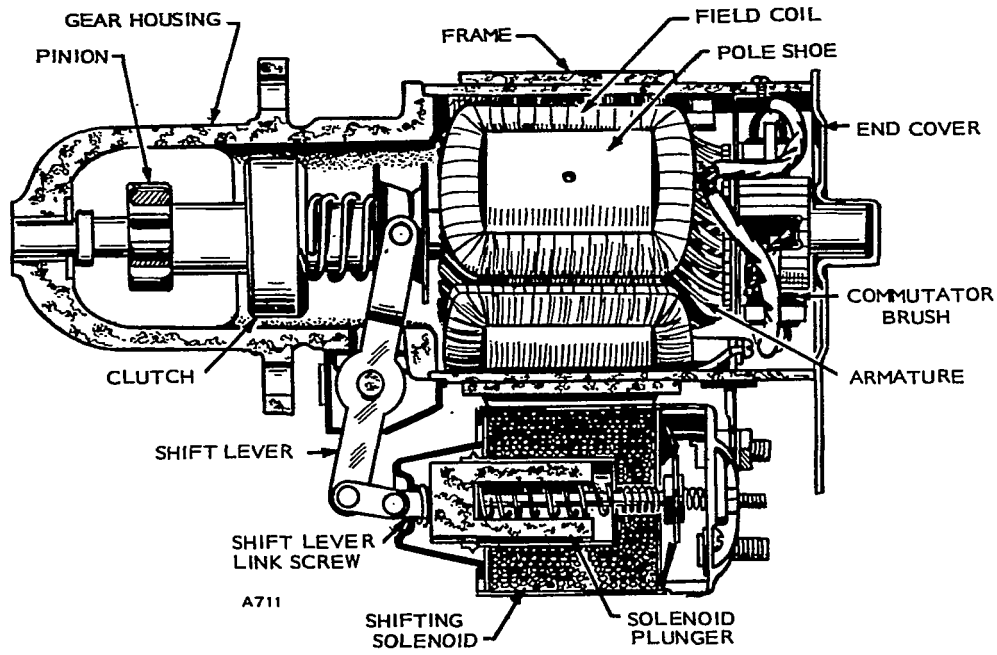


FIGURE 45. STARTING MOTOR

PRESTOLITE STARTER REMOVAL AND DISASEMBLY

1. Remove connections to controls and battery at shifting solenoid. See Figure 45.
2. Remove nut-holding rear mounting bracket to engine.
3. Remove three cap screws 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 cap screws 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 46). Connect battery cable and wires to starter.
10. Connect battery cables to battery. Connect ground cable last.

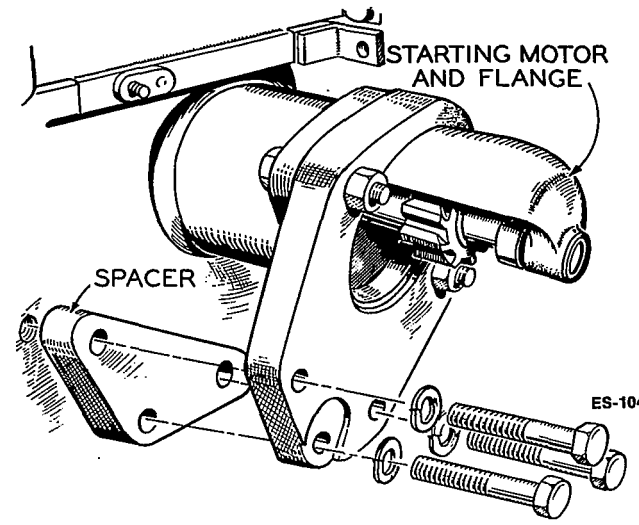


FIGURE 46. STARTING MOTOR FLANGE

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 47. 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.

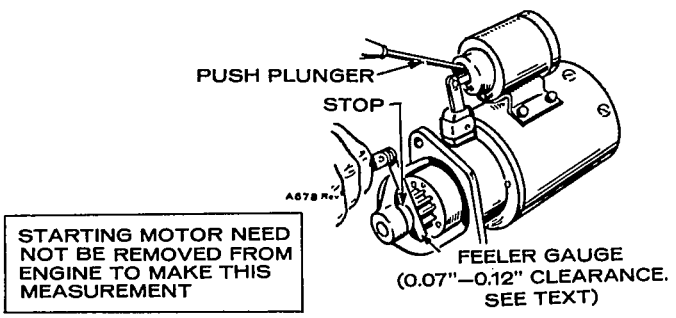


FIGURE 47. PINION CLEARANCE

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 cable 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 47a).

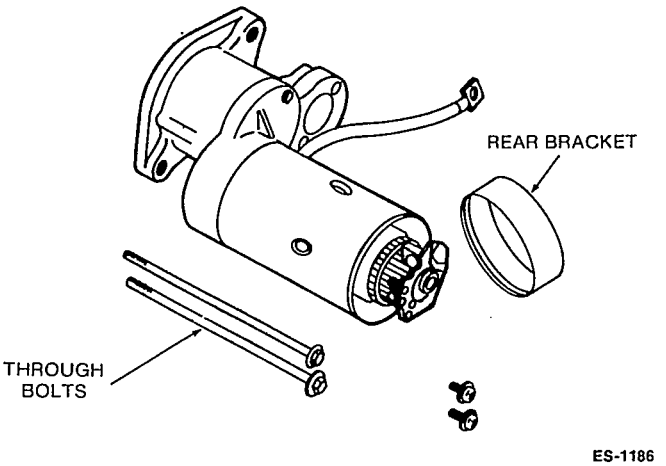


FIGURE 47a. REMOVING REAR BRACKET

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 47b).

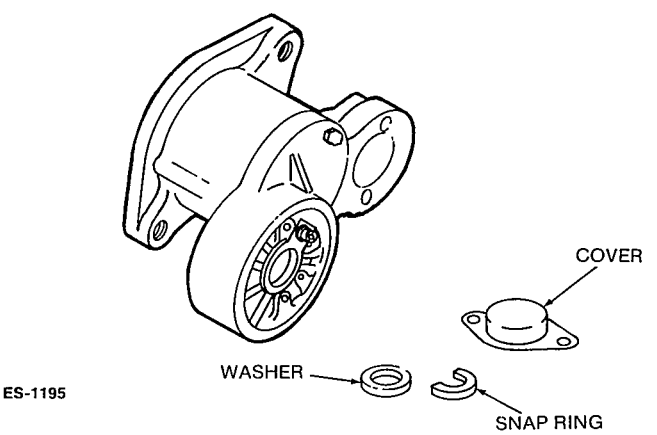


FIGURE 47b. REMOVING SNAP RING AND WASHER

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 47c).

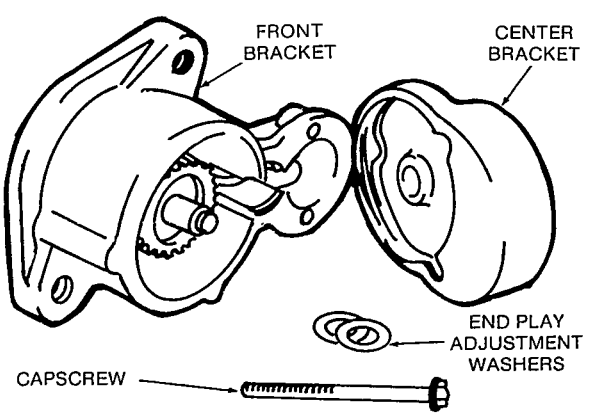


FIGURE 47c. REMOVING CENTER BRACKET

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.

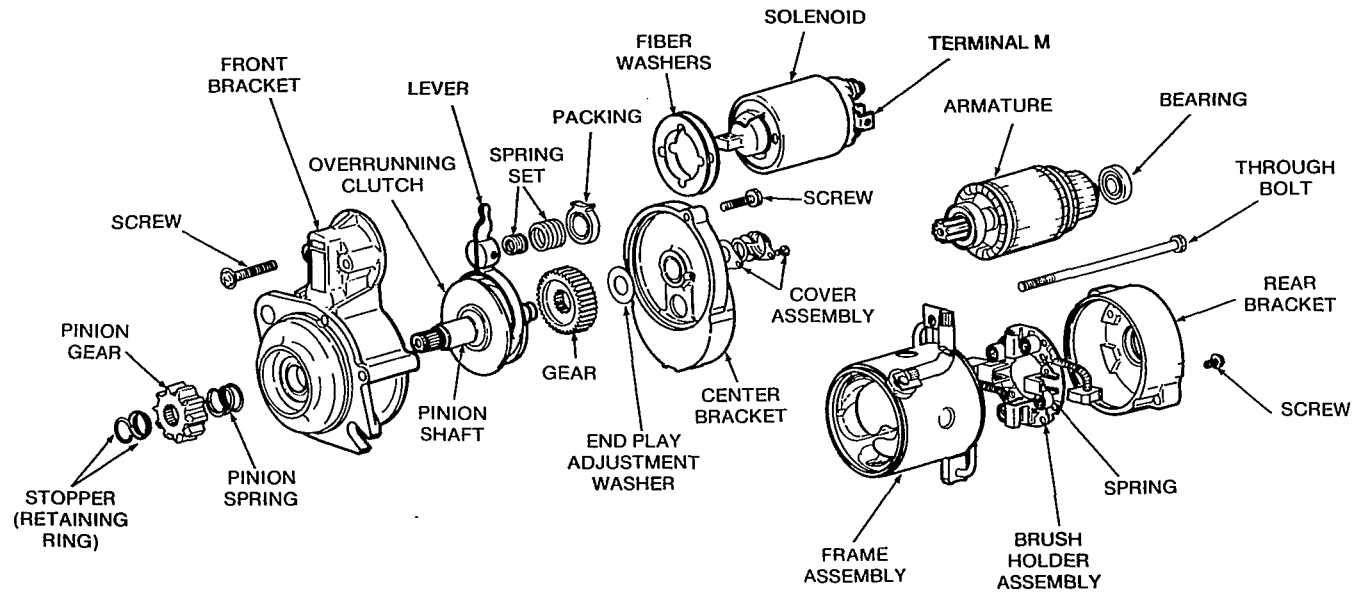


FIGURE 47d. MITSUBISHI STARTER

MITSUBISHI STARTER ASSEMBLY

For assembly reverse the disassembly procedure, but note the following items. See Figure 47d.

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 47e).

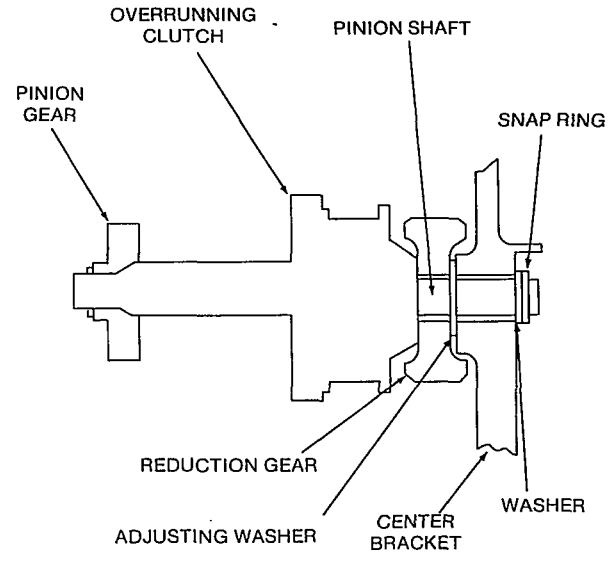


FIGURE 47e. ADJUSTING PINION SHAFT END PLAY

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 47f).

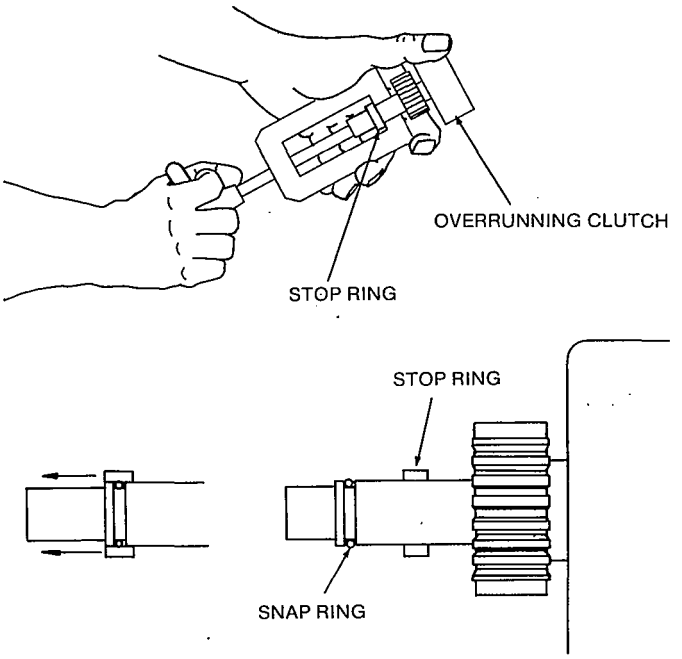


FIGURE 47f. PINION GEAR INSTALLATION

Lever Assembly Installation

Figure 47g shows the correct method of installing the lever assembly, spring, and packing. Pay close attention to direction of lever.

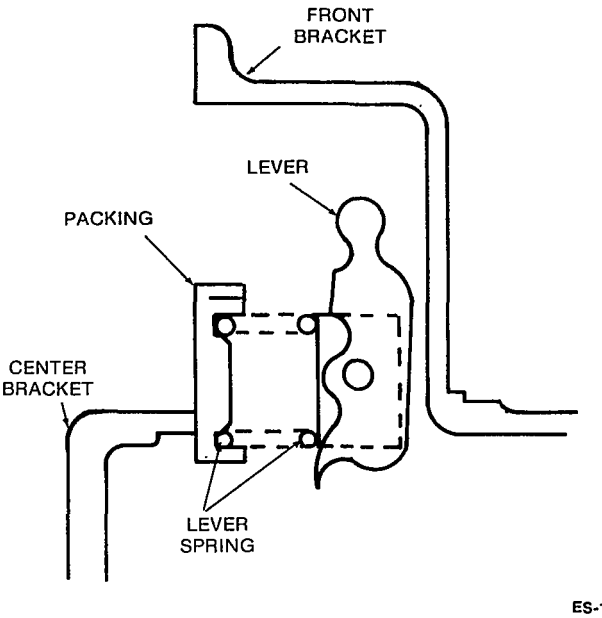


FIGURE 47g. LEVER INSTALLATION

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 47h).

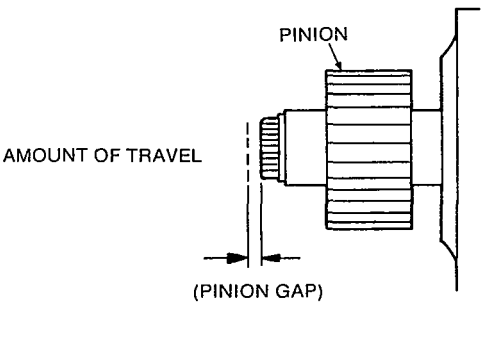


FIGURE 47h. PINION GAP ADJUSTMENT

4. The pinion gap should be 0.3 to 2.0 mm (0.0118 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 48).

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).

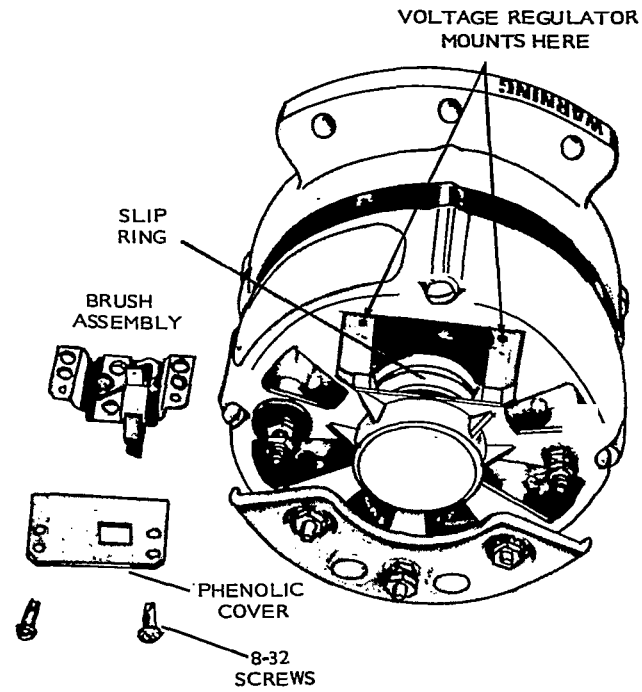


FIGURE 48. OPTIONAL, BATTERY CHARGING, EXTERNAL ALTERNATOR

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:

1. Common sense will dictate proper order of disassembly. As disassembly progresses, the order may be changed, as will become self-evident.
2. A suggested procedure would be as follows:
   a. Radiator, water pump.
   b. Flywheel—using puller or pry-bar method.
   c. Gear Cover—protect oil seal from keyway damage.
   d. Crank Gear—use puller and gear puller ring.
   e. Loosen accessories such as fuel pumps and oil filter.
   f. Starter motor.
   g. Drain oil — discard oil removed.
   h. Cylinder head.
   i. Valves, springs, rocker arms.
   j. Camshaft and gear, rear bearing plate, oil pump.
   k. Piston, connecting rod bearings.
   l. Crankshaft.
   m. Try to analyze reasons for any parts failure and necessity of the repair.
   n. Cleanliness and neat, orderly work area makes job easier to do.
   o. 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. Using wiring diagram to connect leads to control, and 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 testing. Follow suggestions given on *Testing and Adjusting Engines.* Before final test and 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:
   a. Oil seal driver and guide, bearing driver.
   b. Valve spring compressor, valve lock replacer, valve guide driver, and valve seat remover.
   c. Gear puller and gear puller rings.
   d. Piston ring spreader and compressor.
   e. Flywheel puller, pry-bar, armature puller.
   f. Torque wrench, plastigauge (for correct bearing clearance).
   g. 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, *mike* 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) 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 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 Green, spray can 525-0137, or Onan White, spray can 525-0216) and apply instructions from Kit 98-1100C or Marine Kit 98-1807.

CYLINDER HEADS, VALVES

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.

Maintenance:

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

VALVE CLEARANCE ADJUSTMENTS

The valves are adjusted cold. After the cooling period, adjust No. 1 cylinder first and the rest in the firing order.

To adjust valve clearance, proceed as follows:

1. Rotate flywheel clockwise until cylinder number 1 is up on a compression stroke and the TC mark on the flywheel lines up with the timing pointer on the gear cover, then turn 10-45 degrees past TC to be sure lifter moves off ramp of cam.

   In this position, both valves will be closed and the rocker arms are free to move slightly indicating maximum clearance.

2. Using a feeler gauge, check clearance between rocker arm and valve (see Figure 49). Increase or reduce clearance until proper gap is established; adjust with lock nut which secures rocker arm to cylinder head.

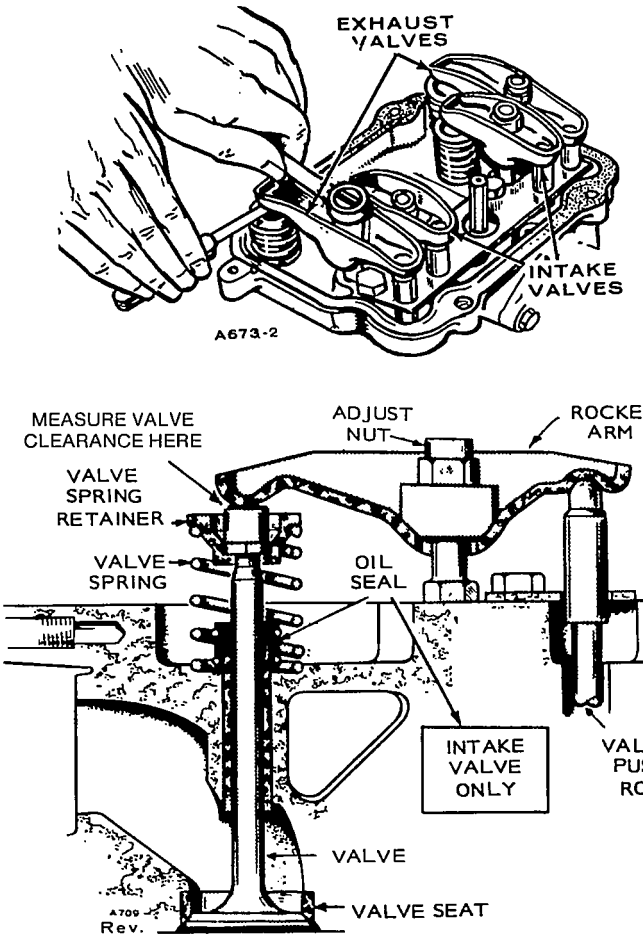


FIGURE 49. SETTING VALVE CLEARANCES

3. To adjust valve clearance for number 2 cylinder, turn flywheel in a clockwise direction 180 degrees (1/2 revolution) from position used in Step 1. 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.
4. After timing number 2 cylinder, adjust valve clearance according to step 2.
5. To adjust valve clearance for 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.
6. After timing number 4 cylinder, adjust valve clearance according to Step 2.
7. To adjust valve clearance for 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.
8. After timing number 3 cylinder, adjust valve clearance according to Step 2.

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.

Compression of a standard new engine cranking at about 300 rpm is about 350-400 psi (2415 to 2760 kPa). RDJC prior to Spec P 300-350 psi (2068 to 2413 kPa). Compression should be fairly uniform, normally with less than 30 psi (207 kPa) difference between the highest and lowest cylinder, taken at the same cranking rpm.

Compression readings may deviate 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.

Disassembly:

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 cap screws 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 on 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 seat to the valve seat with an air-pressure-type testing tool or by applying Prussian Blue on 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 the 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 inch to 0.062 inch (1.19 to 1.57 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 420-0311 in a drill press (Figure 50) 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 rind on edges and bottom and break it out with a sharp tool. Be careful not to cut into the counterbore bottom.

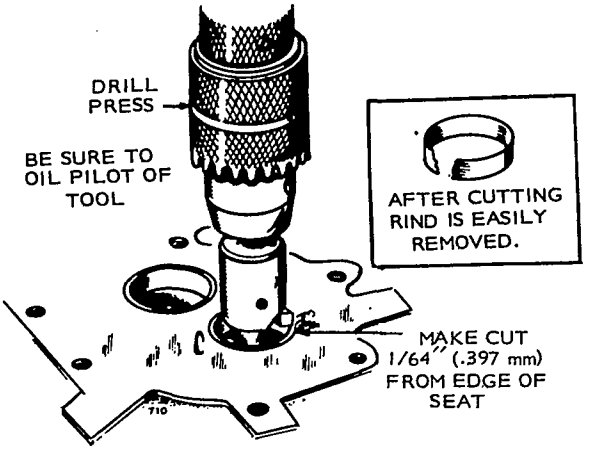


FIGURE 50. REMOVING VALVE SEATS

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 oversize seat. Oversize seats are available in 0.002 inch, 0.005 inch, 0.010 inch and 0.025 inch (0.58, 0.056, 0.068, and 0.09 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 0.030 inch (0.762 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 has ends out-of-square.

VALVE AND HEAD ASSEMBLY

Installation

1. Push a valve seat stem oil seal onto each intake valve guide and clamp in place. Then oil inside surface of each seal using SAE 50 engine oil.
2. Oil stem of each valve lightly (SAE 50 oil) 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. After seal has been installed, do not remove valve stem without protecting seal from sharp edges on keeper area of valve stem.
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 foot-pounds (60-62 N•m). Follow sequence in Figure 51 and Steps a. through c.

   a. Tighten cylinder head bolts finger-tight.
   b. Install exhaust manifold and tighten

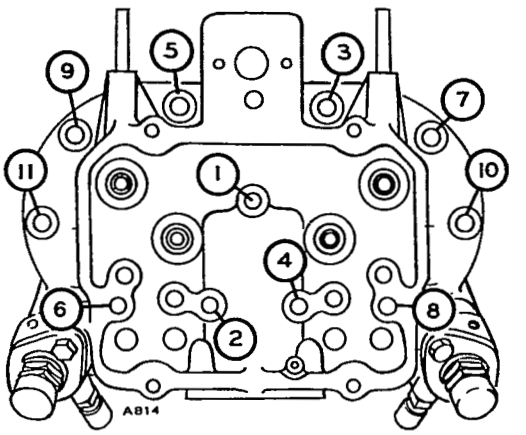


FIGURE 51. HEAD BOLT TORQUE SEQUENCE

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

   c. Tighten cylinder head bolts in sequence shown in Figure 51 to 25-30 foot-pounds (34-41 N•m).
   d. Tighten cylinder head bolts in same sequence to 44-46 foot-pounds (60-62 N•m).
   e. After 60 seconds, retighten cylinder head bolts in sequence to 44-46 foot-pounds (60-62 N•m). 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 49.

CAUTION ***Cylinder head bolts must be retightened and valve clearance must be adjusted after the first 2 hours to 50 hours of operation.***

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

The flywheel is a tapered fit on the crankshaft. Use a flywheel puller (Onan tool number 420-0100) to remove the flywheel.

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.

FLYWHEEL 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, dependable equipment.

Use the following procedure to locate the TDC and PC marks on the flywheel:

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 drops exactly 0.128 inch (3.25 mm). RDJC prior to Spec P, 0.155 inch (3.94 mm). Mark both TDC and piston drop to PC point on the flywheel.

Ring Gear: To remove the ring gear, if damaged, 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 with a torch or ring gear may be warped.***

When heated properly, the ring will fall into place on the 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. The 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 52.

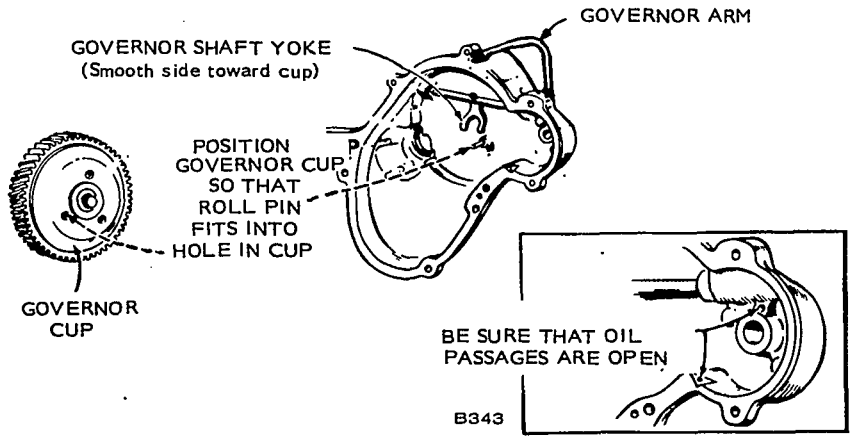


FIGURE 52. GEAR COVER ASSEMBLY

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 53.

Assembly, Gear Cover:

1. Work governor shaft to check for binding and see that the governor shaft end-thrust ball is in place, Figure 52.
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 52). 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. Apply a piece of masking tape over the crankshaft keyway to protect seal and install gear cover. Tighten mounting screws to 15 to 20 foot-pounds (20 to 27 Nm). Before tightening screws, be sure the stop pin is in governor hole. See Figure 53.

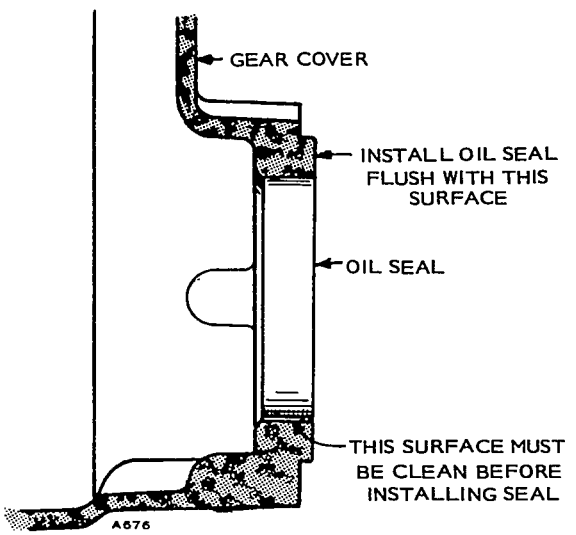


FIGURE 53. GEAR COVER OIL SEAL

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 five (some models have ten) flyballs that will fall out when the cup is removed. Figure 54 shows the governor cup.

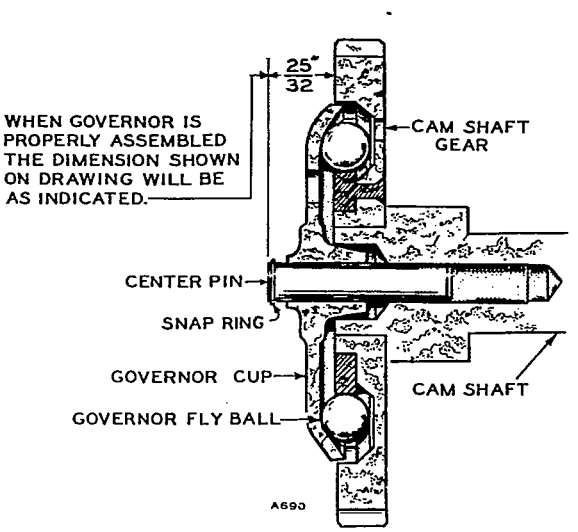


FIGURE 54. GOVERNOR CUP

Repair: Replace any flyballs that have flat spots or grooves. The flyball spacer is attached to the camshaft gear with three flathead screws. Check to see that the spacer screws are tight. 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 3/4 inch (19 mm) from the end of the camshaft. This distance provides an in-and-out travel distance of 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 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 (space five balls in every other slot) 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

Onan diesel 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 and 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.

Removal and Disassembly

On 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, remove ridge 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. RDJF bore should measure between 3.4995 inches (88.8873 mm) and 3.5005 inches (88.9127 mm) and be less than 0.001 inch (0.0243 mm) out-of-round. RDJC bore should measure between 3.2495 inches (82.537 mm) and 3.2505 inches (82.563 mm) and be less than 0.001 inch (0.0243 mm) out-of-round.

If necessary, rebore the cylinder to fit the next available oversize piston. Pistons and rings are available in 0.005 inch (0.127 mm), 0.010 inch (2.540 mm), 0.020 inch (0.508 mm) 0.030 inch (0.762 mm) and 0.040 inch (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 55.

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 just below the oil control ring. Clearance should be 0.0055 inch to 0.0075 inch (0.140 to 0.191 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.

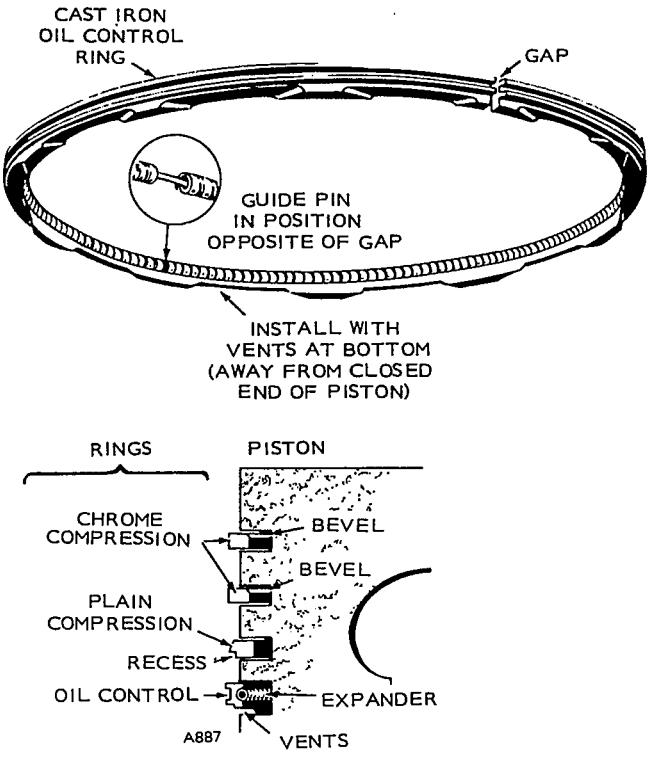


FIGURE 55. PISTON RINGS

RINGS

Inspect each ring carefully for fit in the piston grooves and 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 inch to 0.020 inch (0.25 to 0.51 mm). If the gap is too small, file the butt ends of the rings. Do not use rings that need a lot of filing. They will not seat right on the cylinder walls. 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 inch to 0.0007 inch (0.0051 to 0.018 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 inch to 7/64 inch (1.588 to 2.776 mm) oil groove in the center. See Figure 56.

CONNECTING ROD BEARINGS

Inspect the connecting rod bearings for burrs, breaks, pitts and wear. Measure the clearance between bearings and the crankshaft journal. The clearance should be 0.0010 inch to 0.0033 inch (0.025 to 0.084 mm). If necessary, replace with new standard or oversize precision bearings.

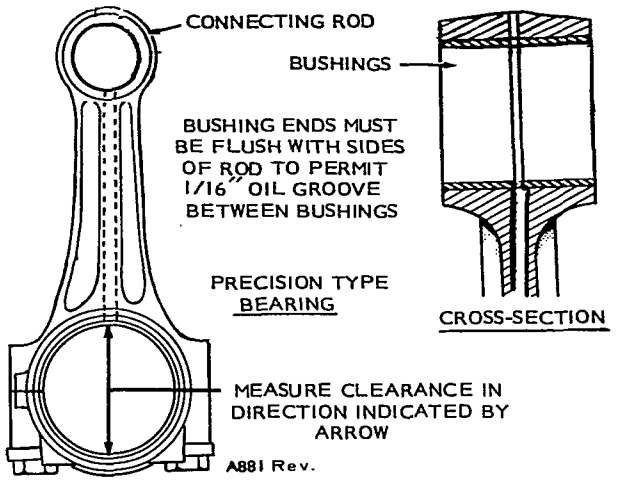


FIGURE 56. CONNECTING ROD BUSHINGS

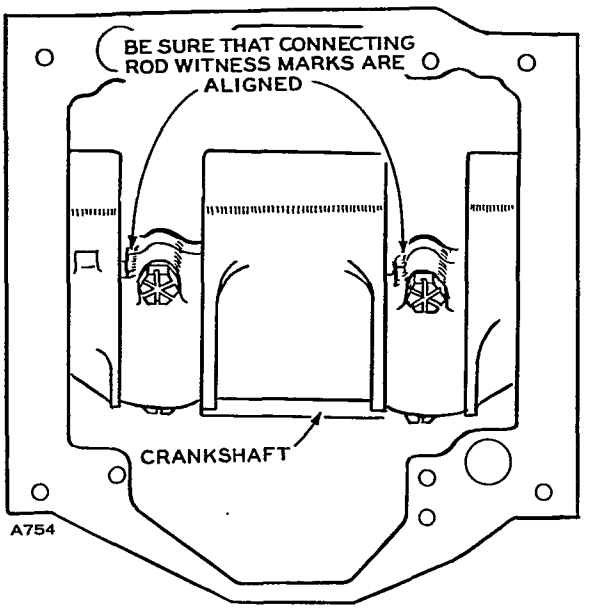


FIGURE 57. CONNECTING ROD CAP

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 with bearing half. When installing rod cap, position so raised witness mark on forging matches mark on connecting rod. See Figure 57.
6. Tighten cap screws 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.

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 with 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, retime 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.

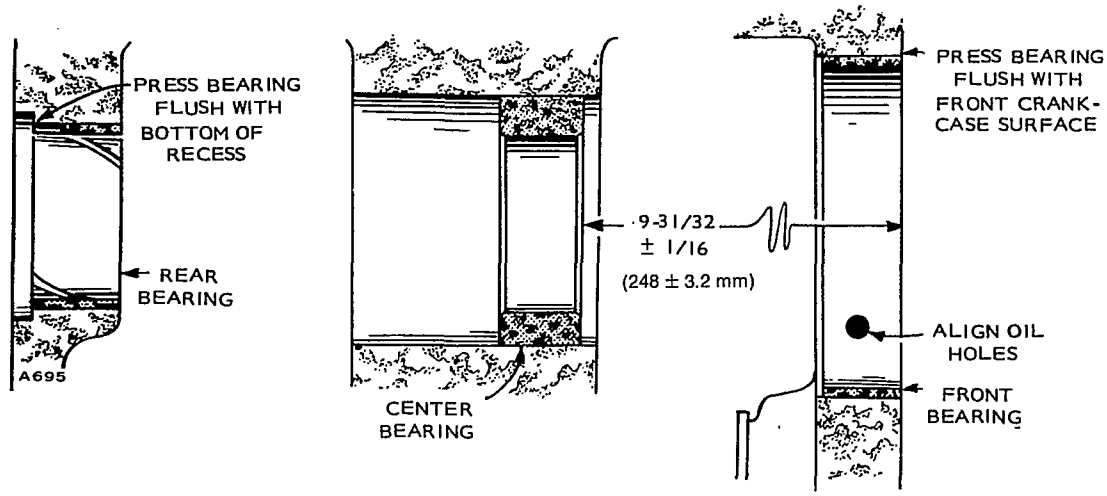


FIGURE 58. CAMSHAFT BEARINGS

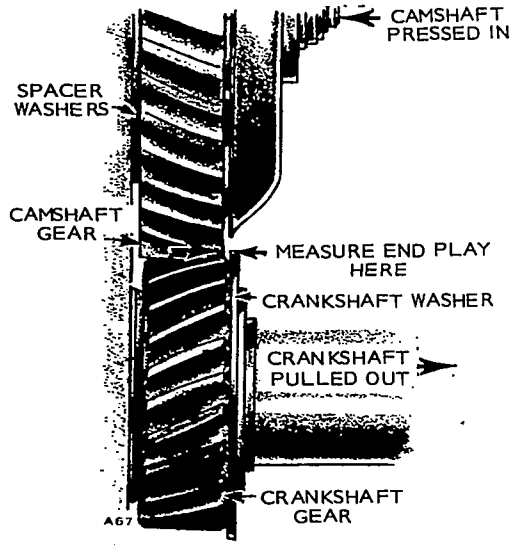


FIGURE 59. CAMSHAFT ENDPLAY

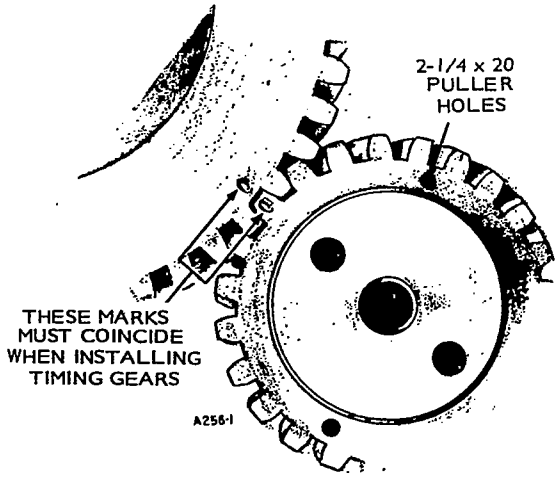


FIGURE 60. TIMING MARKS

Press new bearings into place, Figure 58. 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 the 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 inch to 0.039 inch (0.178 to 0.991 mm). See Figure 59.
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 60.
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

Onan diesel engines use a counter-balanced, ductile iron crankshaft. To increase the shaft fatigue durability, all crankpin fillets are shot-peened during manufacture. The four-cylinder model uses an additional split-center main bearing.

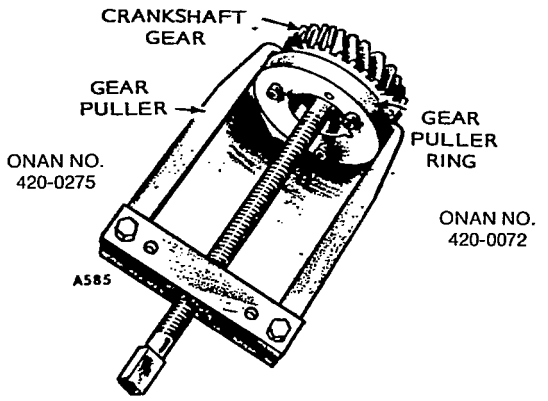


FIGURE 61. REMOVING CRANKSHAFT GEAR

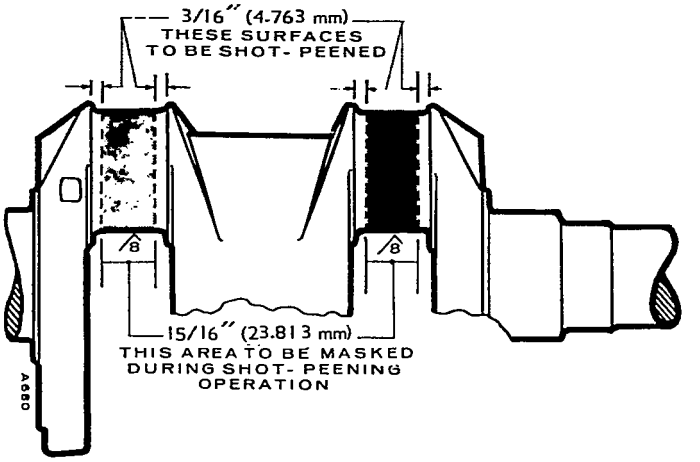


FIGURE 62. SHOT-PEENING THE CRANKSHAFT

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 61.
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. Onan emphasizes that if facilities or trained personnel are not available, the crankshaft may be sent to the factory.

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 this data and Figure 62 to shotpeen each crank pin fillet.

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 0.010inch (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 reinstalled.

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 63. 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, 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 64. 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 foot-pounds (131-138 N•m).
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 mm) 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 retimed 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 to prevent oil consumption.

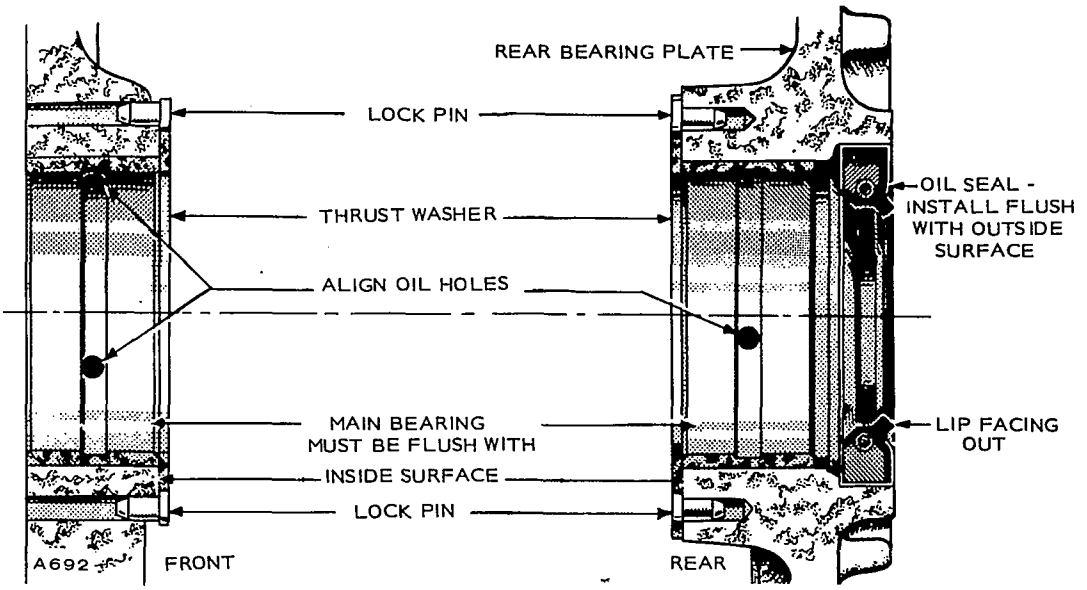


FIGURE 63. MAIN BEARING INSTALLATION

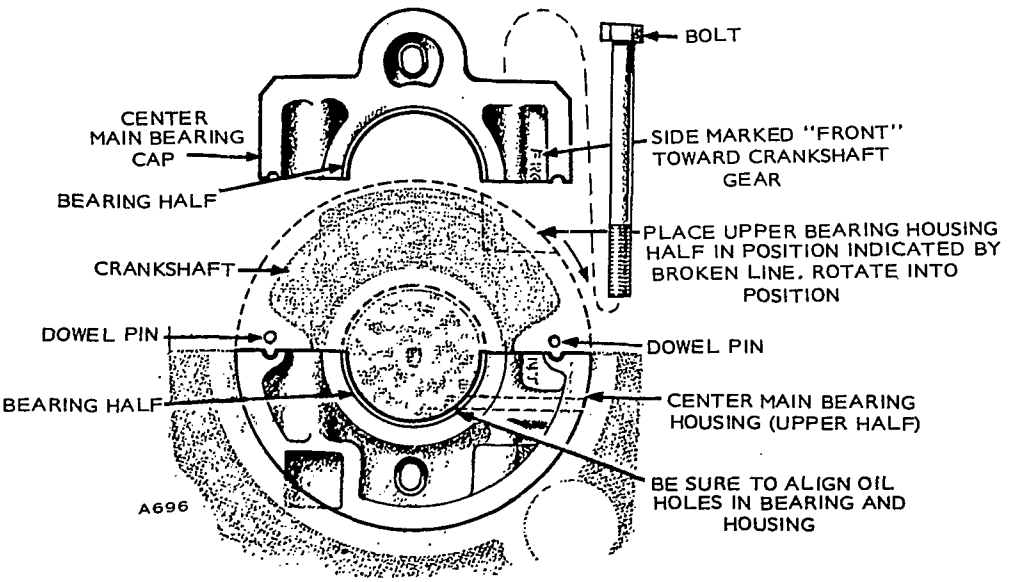


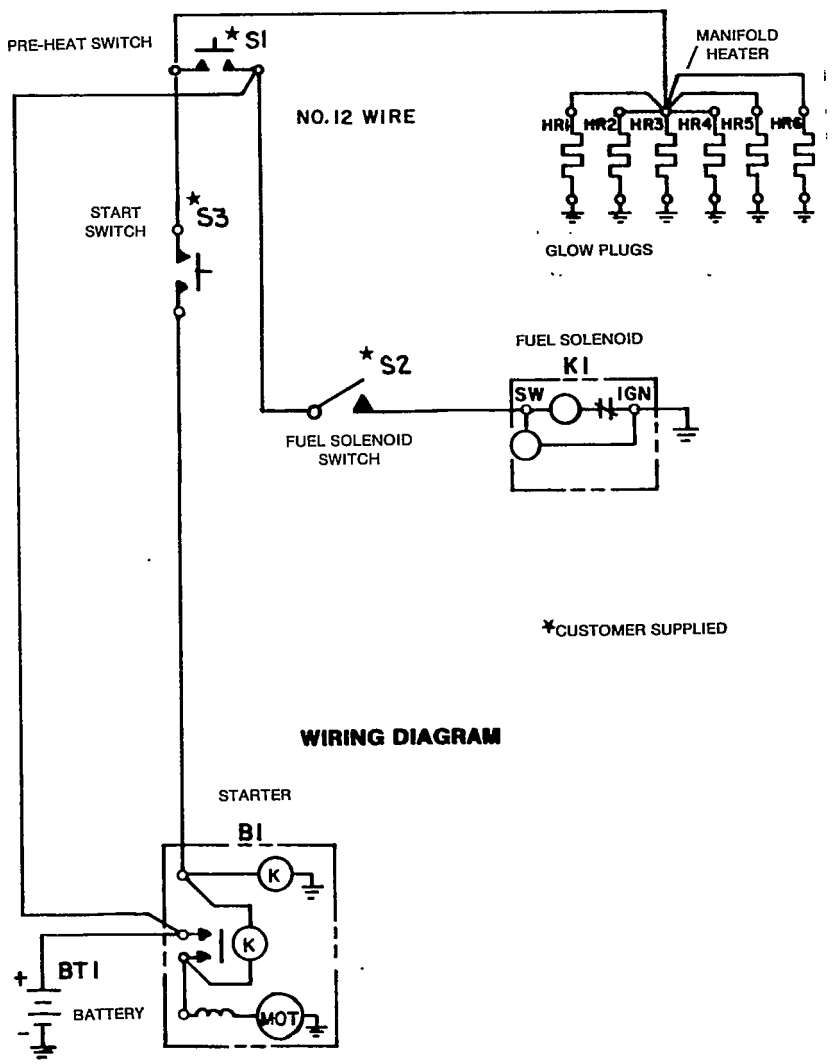
FIGURE 64. CENTER MAIN BEARING HOUSING

Control System

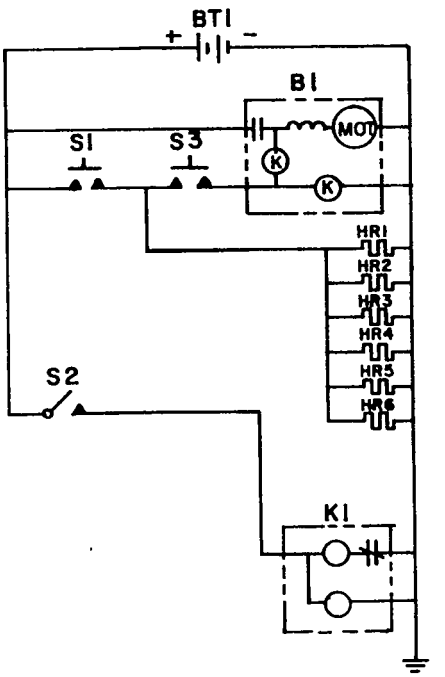
Due to the wide variety of uses to which these engines are adapted, operating controls are not supplied with the engines. In most cases, the engines are used for prime power to operate other manufacturers equipment. Installation nearly always differs. Therefore, the manufacturer or fabricator generally provides a control for the complete unit.

MAINTENANCE

Periodically check all connections and contacts in the control system to be sure they are tight and clean.



WIRING DIAGRAM



SCHEMATIC

TYPICAL STANDARD ENGINE

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