PDF

SERVICE MANUAL

DETROIT



SERVICE • REPAIR • MAINTENANCE

INSTANT DOWNLOAD

The Series 149 Service **Manual has** *been completely* **updated.** *Sections revised since the last manual release (No. 42 dated June,* **1987)** *are as follows:*

SECTION	PAGES	REMARKS
'Gen. Info.	**4**	*Parts Replacement section added.*
Gen. Info.	**6**	*Model Description Chart* **revised.**
Gen. Info.	**8-9**	*Option label information added; Fig. 6 added (S.I.* **22-149-85)**
Gen. **Info.**	**10-12**	*New work safety information and CAUTIONS added.*
Gen. Info.	*12*	*Info. Added: Fabricating, Altering, Removing, Disposing of Gaskets (S.I.* **13-149-85).**
Built -win Parts Book	-	*Section removed.*
i. i	**1**	*Engine front lifter bracket* **CAUTION** *added.*
1.1	**1**	*New* **cylinder** *blocks with strengthened intermediate main bearing journals (S.I.* **1-149-88).**
1.1	**3**	**Block** *cleaning* **CAUTION added.**
1.1	**8**	*Fig.* **9** *revised.*
1.1	**11**	*Steps* **7** *thru 8 revised.*
1.1	*12*	**Step 21 revised:** *Install injector rack guard* **screens on** *12V,* **16V** *engines (S. I. 12-149-86).*
1.2	**1**	*Short slot* **cylinder** *head info, added (S.I. 15-149-83)*
1.2	**3**	*Integral* **head-io-block** *water seal installation info, added (S.I.* **17-149-86).**
1.2	**6**	**Cylinder** *head sealant recommendation* **added** *(S.I. 3-149-87).*
1.2	**6**	**Step 1: Do not Use** *RTV* **sealant on cylinder** *head cup plugs, valve bridge guides; use Permatex 98D, 9 8X.*

1.2	7-9	*Cylinder head* installation ' *instructions revised..*
1.2	10	Fig. 3 added.
1.2.1	2	New *valve button retainer on 125 hp/cylinder engines.*
1.2.1	*2*	*Step 4 revised, Notice added: DDC does not* recommend reusing flared end fuel pipes.
1.2.2	*2*	*Exhaust valve spring testing and qualifying procedure added.*
1.2.2	*4*	*Info, added: Exhaust valve guides smaller and* no *bridge guides on 125 hp/cylinder engines.*
1.2.2	6-10	*Pyromet exhaust* valves on 149 *engines; Fig. 13 revised (S.I.* 7-149-86).
1.2.2	7	*Info, added: 125 hp/cylinder engine valve diameter.*
1.2.2	9	*Info added: New exhaust valve rocker arm, valve* lock, spring cap.
1.2.2	9-10	*Info, added: 125 hp/cylinder engine uses teflon-lip valve seal, free-floating* exhaust *valve bridge, different valve seats, caps, locks.*
1.2.4	1	Inspection, *Installation sections,* added. '
1.3	6-7	New *crankshafts with 1/2" -14* Vibraseal-coated *pipe plugs* (S.I. 6-149-86); Fig. 10 added.
1.3.2	1	Fig. 2 revised.
1.3.2	1	*Unidirectional, fluoroelastomer-lip front and rear oil seals (S.I. 2-149-86,* 8-149-87).
1.3.5	2	Step & *revised.*
1.3.5.1	2	- *Step 6 revised.*
1.3.5.1	1	*Grooveless outboard support bearing (S.I.* 16-149-86).

1.3.5.2	4	Steps 7, 8 *revised.*
1.3.5.2	1	*Grooveless outboard support bearing* (S.I. 16-149-86).
1.3.6	*1-2*	*Vibration damper safety shield i n f o , added.*
1.4	3	*S t e p 8 offlywheel mounting procedure revised.*
1.5	1	*Specially drilled and tapped flywheel housings used on high torque rise* 12V *engines (S . I .* 6-149-85)
1.6	6	*New crosshead piston domes with revised piston bowl strut configurations (S. I. 1-149-89).*
1.6	9	*Lubrication recommendation (S . I . 12-149-87).*
1.6.1	1	*S t e p 3 : DDC does not recommend reuse of piston pin bolts.*
1.6.1	3	*Connecting rod checking fixture supplier (Sergeant Industries) added.*
1.6.3	3	*Master ring gage temperature i n f o . ,* Notice added: When *measuring liner[A] take measurements with parts at* 65° to 75°F (18.3° to 23.9°C) to *insure accuracy.*
1.7.1	3-4	Figs. 4, 5, 6 *revised.*
1.7.2 s	2	Fig. 1 *revised.*
1.7.2	6	*F i g .* 5 added
1.7.2	7	*Steps 17,19 (Check end play) added.*
1.7.3	3-4	*Gear, hub, and bearing assembly procedure revised (S. I. 15-149-85).*
1.7.5	3	*Steps 3, 4 revised.*
1.7.7	5	*Install drive gear step 1 revised.*
1.0	7	*Rework flywheel housing for high torque rise engine magnetic pickup (S . I . 6-149-85).*

1.0	8-9	*Block plugging chart minor revisions.*
1.0	13	*Wide gap ring specifications added.*
1.0	16	*Idler gear, cam gear locknut torques added.*
1.0	18-19	*Tool numbers added, revised (S.I. 7-149-87)*
2.1.1	7	*Injector* bodies, nuts, *filter* caps no *longer blued (S. I.* 3-149-88).
2.1.1		Calibration *limits* change (S.I. *23-149-85).*
2.1.1	12-13	Blued and non-blued *injector nut, filter cap torque specifications (S.I.* 3-149-88).
2.1.1	15	*Notice added: DDC recommends flared end fuel pipes not be reused.*
2.2	7	*Steps 1, 4, 5 revised.*
2.3	1, 3	*Spin-on fuel strainer* and *filter* information *added (S. I.* 18-149-86).
2.8.1	1, 2	Hydraulic governor reservoir *information added (S. I. 2-149-83).*
2.8.2	1, 2	*Hydraulic governor reservoir information added (S. I.* 2-149-83).
2.8.4	1, 2	*Horizontal-mount governor info, added; Fig. 3 revised* (S.I. 1-149-88)
2.9	1	*Information added: Different colored control tube lever return springs on engines with hydraulic or electric governors and mechanical governors.*
2.9	1	*Injector rack guard screen notice, Fig. 3 added* (S.I. 12-149-86).
2.0	5	*Table 1 revised; increased* 145 *injector* output (S.I. 4-149-87).
2.0	13	*Notice added: DDC recommends flared end fuel pipes not be reused. Fuel jumper line maintenance section rewritten*
2.0	20	Blued, *non-blued injector nut, filter*

		cap *torque specifications* (S.I. 3-149-88).
2.0	21, 22	Tool *numbers* added, revised
3	2	*Piston style blower bypass* valve changepoint (S.I. 2-149-89).
3.3	2, 5	New *hose and clamp on turbocharged engines* (S.I. 4-149-86).
3.4	2	Steel oil *supply tube on rear blower end plates (S. I. 9-149-87).*
3.4	7, 8, 13	Blower rear end plate oil *supply tube disassembly, assembly (S. I.* 9-149-87).
3.4	8	*Bypass blower valve lever stop plate on* 8V *engines with flapper style* bypass valve (S.I. 8-149-86).
3.4	14	Step l. added.
3.4	16	Fig. 21 *revised.*
3.4.2	1-6	*New section added:* Blower *bypass valve (S . I . 2-149-89).*
3.5	3	*Notice added: Do* not permit *turbocharger "drafting."*
3.5	13	*New hose and clamp on turbocharged engines (S. I.* 4-149-86).
3.5	14	*CAUTION added: Do not hold compressor* wheel while *engine is running.*
3.5.2	*1-4*	*Section rewritten:* Aramid *fiber intercooler core pads replace felt pads (S . I . 5-149-87).*
3.5.2	1, 2	*Coolant strainer info: added*
3.0	7	Tool added (S.I. 2-149-89) .
4.1.1	*1-4*	*Section rewritten; new 70 psi (483 kPa) and 50 psi (345* kPa) oil pressure *relief* valves (S.I. 10-149-86).
4 . 1 . 1	*3*	*Oil pressure regulator, relief* CAUTION added.

4.2	1	*Multi-pack lube oil filter info, added.*
4.2	2	*Optional finer lube oil filter available (S.I.* 11-149-87).
4.2	3	*Notice added: Do not hot tank multi-pack oil filter adaptors.*
4.4	1	*New 30-plate stainless steel* lube *oil cooler core (S. I.* 9-149-86).
4.4	5	*New water inlet housing and seal in tube and shell oil cooler assemblies (S.I.* 14-149-86).
4.4	5-10	Tube and shell oil cooler *installation procedures added.*
4.4	10	*Tube and shell oil cooler bypass* valve *info,* added.
4. 0	3	Tube *and shell oil cooler water inlet housing* rework *instructions (S.I.* 14-149-86).
4. 0	4	Tube and shell oil *cooler mounting* bracket *alignment tool added.*
5	3-5	Cooling *system requirements for direct* radiator-cooled *engines (S.I. 3-149-86).*
5	5	*CAUTION added; Table 1 revised.*
5	7	*Recommendation changed: Use DPMto contaminated clean lubrication system.*
5	9	*Note added to chart.*
5.1	*1-2*	*Water pump assembly procedure* revised (S.I. 11-149-85).
5.2.1	1-3	*Section rewritten. Info added: Thermostat operation, type, installation, preventive maintenance (S.I. 1-149-87).*
5.3	2	CAUTIONS added.
5.3.1	1	*Section rewritten.*

5.5	**3**	**CAUTION added.**
5.6	**1-6**	***Section rewritten: New raw water pumps with replaceable cam/liners* (S.I. 3-149-89).**
5.0	**2-4**	***Thermostat function testing* (1-149-87).**
5.0	**5**	**Find *coolant leaks with fluorescent dy e, black light (S. I.* 5-149-86).**
5.0	**7**	**Tool *number added:* J 34034.**
6.1	**1-2**	**Section *rewritten: New two-piece exhaust manifolds with seal rings and expanders; new drain* hole *plugs (S. I. 10-149-84,1-149-87).***
6.1.1	**1-2**	***Section rewritten: Coolant flow path i n f o , added.***
7.1	**1-2**	***Section rewritten.***
7.1.1		***Section removed. Obsolete.***
7.2	**1-3**	**Section *rewritten. Battery installation,* testing *information added.***
7.3	**1-2**	***Minor changes.***
7.4	**1-8**	***Section rewritten: Crankcase pressure monitor operation, wiring, overhaul, and test* procedures (S.I. 6-149-84, *16-149-85,1-149-86).***
7.4.2	**1-3**	***Minor changes***
7.0	**1-5**	***Minor changes.***
8.1	**1-4**	***CAUTIONS added. Inf o, added: Use 1 , 1 , 1 trichlorethane to clean oil* cooler *core.***
9.5.5	**1-2**	***CAUTIONS added. I n f o added: Use 1 , 1 , 1* trichlorethane *t o* clean oil cooler core.**
12.0	**1**	***Service tool section added* (S.I. 7-149-87).**
13.1	**1-5**	***Section completely rewritten; air starter, hydrostarter information***

		added.
13.2	9	12V-149TI engine with TV7511 *turbos,* 240 *injectors added.*
13.2	14	16V-149TI *engine with 8402* turbos, 240 *injectors* added.
13.2	15-18	*Cooling system requirements— Direct radiator-cooled engines (S.I. 3-149-86).*
13.2.1	2-4	*Info, added:* Block oil *filter bypass before initial start-up and dynamometer test of* rebuilt *engines (S. I. 6-149-87); tables 1, 2 revised.*
13.3	1-9	*Lubricating* oil, *fuel, filter recommendations revised.*
13.3	10-14	*Coolant specifications rewritten; maximum coolant change interval added.*
14	2	CAUTIONS added.
14.2	1	*Table 1 (Injector timing) revised.*
15.1	1-11	*Preventive maintenance interval chart revised,* section *rewritten, information added.*
15.2	1-17	*Minor revisions.*

The following CAUTION on *compressed air usage has been* added to *numerous sections throughout this manual:*

> CAUTION: To *prevent* possible *injury,* wear adequate eye *protection and do not exceed 40psi (276* kPa) air *pressure.*

The ***following service information bulletins are now obsolete and may be removed from your f i l e s :***

6-149-85	*1-149-86*	*1-149-87*	**1-149-88**
8-149-85	*2-149-86*	*2-149-87Rev.*	*2-149-1*
10-149-85	**3-149-86**	**3-149-87**	**3-149-88**
1 1 - 1 4 9 - 8 5	*4-149-86*	*4-149-87*	**4-149-88**
13-149-85	**5-149-86**	*5-149-87*	
15-149-85	**6-149-86**	**6-149-87**	**1-149-89**
16-149-85	*7-149-86*	*7-149-87*	*2-149-89*
17-149-85	*8-149-86*	*8-149-87*	*3-149-89*
18-149-85	**9-149-86**	**9-149-87**	
19-149-85	**10-149-86**	**10-149-87**	
20-149-85	**11-149-86**	*1 1 - 1 4 9 - 8 7*	
21- 149-85	**12-149-86**	**12-149-87**	
22- 149-85	*13- 149-86*		
23- 149-85	*14- 149-86*		
	15- 149-86 Rev.		
	16- 149-86		
	17- 149-86		
	18- 149-86		
	19- 149-86		
	20- 149-86 Rev.		

DETROIT DIESEL

Series 149 Service Manual

DETROIT DIESEL

CORPORATION

13400 Outer Drive, West / Detroit, Michigan 48239-4001
Telephone: 313-592-5000
Telex: 4320091 / TWX: 810-221 -1649

6SE313 8903 © Detroit Diesel Corporation Litho in USA

FOREWORD

This manual contains instructions on the overhaul, maintenance and operation of the basic Series 149 Detroit Diesel Engines.

Full benefit of the long life and dependability built into these engines can be realized through proper operation and maintenance. Of equal importance is the use of proper procedures during engine overhaul.

Personnel responsible for engine operation and maintenance should study the sections of the manual pertaining to their particular duties. Similarly, before beginning a repair or overhaul job, the serviceman should read the manual carefully to familiarize himself with the parts or subassemblies of the engine with which he will be concerned.

The information, specifications and illustrations in this publication are based on the information in effect at the time of approval for printing. This publication is revised and reprinted periodically. It is recommended that users contact an authorized *Detroit Diesel Corporation Service Outlet* for information on the latest revisions. The right is reserved to make changes at any time without obligation.

CAUTION

To reduce the chance of personal injury and/or property damage, the following instructions must be carefully observed.

Proper service and repair are important to the safety of the service technician and the safe, reliable operation of the engine. If part replacement is necessary, the part must be replaced with one of the same part number or with an equivalent part. Do not use a replacement part of lesser quality.

The service procedures recommended by Detroit Diesel Corporation and described in this service manual are effective methods of performing service and repair. Some of these procedures require the use of tools specially designed for the purpose.

Accordingly, anyone who intends to use a replacement part, service procedure or tool, which is not recommended by Detroit Diesel Corporation, must first determine that neither his safety nor the safe operation of the engine will be jeopardized by the replacement part, service procedure or tool selected.

It is important to note that this manual contains various "Cautions" and "Notices" that must be carefully observed in order to reduce the risk of personal injury during service or repair or the possibility that improper service or repair may damage the engine or render it unsafe. It is also important to understand that these "Cautions" and "Notices" are not exhaustive, because it is impossible for Detroit Diesel Corporation to warn of all the possible hazardous consequences that might result from failure to follow these instructions. See more specific cautions under "Cautions, Work Safely" in the General Information section.

TABLE OF CONTENTS

SUBJECT

GENERAL INFORMATION AND CAUTIONS

ENGINE (less major assemblies)

FUEL SYSTEM AND GOVERNORS

AIR INTAKE SYSTEM

LUBRICATION SYSTEM

COOLING SYSTEM

EXHAUST SYSTEM

ELECTRICAL EQUIPMENT, INSTRUMENTS AND PROTECTIVE SYSTEMS

POWER TAKE-OFF AND TORQMATIC CONVERTER

TRANSMISSION

SPECIAL EQUIPMENT

OPERATION

TUNE-UP

PREVENTIVE MAINTENANCE, TROUBLESHOOTING AND STORAGE

© Detroit Diesel Corporation

SCOPE AND USE OF THE MANUAL

This manual covers the basic Series 149 Diesel Engines built by the Detroit Diesel Corporation. Complete instructions on operation, adjustment (tune-up), preventive maintenance and lubrication, and repair (including complete overhaul) are covered. The manual was written primarily for persons servicing and overhauling the engine and, in addition, contains all of the instructions essential to the operators and users. Basic maintenance and overhaul procedures are common to all Series 149 engines and therefore, apply to all engine models.

The manual is divided into numbered sections. The first section covers the engine (less major assemblies). The following sections cover a complete system such as the fuel system, lubrication system or air system. Each section is divided into subsections which contain complete maintenance and operating instructions for a specific subassembly on the engine. For example, Section 1, which covers the basic engine, contains subsection 1.1 pertaining to the cylinder block, subsection 1.2 covering the cylinder head, etc. The subjects and sections are listed in the Table of Contents on the preceding page. Pages are numbered consecutively, starting with a new Page 1 at the beginning of each subsection. The illustrations are also numbered consecutively, beginning with a new Fig. 1 at the start of each subsection.

Information regarding a general subject, such as the lubrication system, can best be located by using the Table of Contents. Opposite each subject in the Table of Contents is a section number which registers with a tab printed on the first page of each section throughout the manual. Information on a specific subassembly or accessory can then be found by consulting the list of contents on the first page of the section. For example, the cylinder liner is part of the basic engine. Therefore, it will be found in Section 1. Looking down the list of contents on the first page of Section 1, the cylinder liner is found to be in subsection 1.6.3. An Alphabetical Index at the back of the manual has been provided as an additional aid for locating information.

SERVICE PARTS AVAILABILITY

Genuine Detroit Diesel service parts are available from authorized Detroit Diesel distributors and service dealers throughout the world. A complete list of all distributors and dealers is available in the Worldwide Distributor and Dealer Directory, 6SE280. This publication can be ordered from any authorized distributor.

CLEARANCES AND TORQUE SPECIFICATIONS

Clearances of new parts and wear limits on used parts are listed in tabular form at the end of each section throughout the manual. It should be specifically noted that the “New Parts” clearances apply only when all new parts are used at the point where the various specifications apply. This also applies to references within the text of the manual. The column entitled “Limits” lists the amount of wear or increase in clearance which can be tolerated in used engine parts and still assure satisfactory performance. It should be emphasized that the figures given as “Limits” must be qualified by the judgment of personnel responsible for installing new parts. These wear limits are, in general, listed only for the parts more frequently replaced in engine overhaul work. For additional information, refer to the paragraph entitled *Inspection* under *General Procedures* in this section.

Bolt, nut and stud torque specifications are also listed in tabular form at the end of each section.

.PARTS REPLACEMENT

Before installing a new or used part, check it thoroughly to make sure it is the proper part for the job. The quality of the replacement part must be equivalent to the quality of the original Detroit Diesel component being replaced and must meet DDC specifications for new or reusable parts.

Parts must also be clean and not physically damaged or defective. For example, bolts and bolt hole threads must not be damaged or distorted. Gasketing must have all holes completely punched through with no residual gasket material left clinging to the top or bottom. Flatness and fit specifications in the service manual must be strictly adhered to.

CAUTION: Failure to inspect parts thoroughly before installation, failure to install the proper parts, or failure to install parts properly can result in component or engine malfunction and/or damage and may also result in personal injury.

 © Detroit Diesel Corporation

PRINCIPLES OF OPERATION

The diesel engine is an internal combustion power unit, in which the heat of fuel is converted into work in the cylinder of the engine.

In the diesel engine, air alone is compressed in the cylinder; then, after the air has been compressed, a charge of fuel is sprayed into the cylinder and ignition is accomplished by the heat of compression.

The Two-Cycle Principle

In the two-cycle engine, intake and exhaust take place during part of the compression and power strokes respectively (Fig. 1). In contrast, a four-cycle engine requires four piston strokes to complete an operating cycle.

A blower is provided to force air into the cylinders for expelling the exhaust gases and to supply the cylinders with fresh air for combustion. The cylinder wall contains a row of ports which are above the piston when it is at the bottom of its stroke. These ports admit the air from the blower into the cylinder as soon as the rim of the piston uncovers the ports (Fig. 1 - scavenging).

The unidirectional flow of air toward the exhaust valves produces a scavenging effect, leaving the cylinders full of clean air when the piston again covers the inlet ports.

As the piston continues on the upward stroke, the exhaust valves close and the charge of fresh air is subjected to compression (Fig. 1 - compression).

Shortly before the piston reaches its highest position, the required amount of fuel is sprayed into the combustion chamber by the unit fuel injector (Fig. 1 - power). The intense heat generated during the high compression of the air ignites the fine fuel spray immediately. The combustion continues until the injected fuel has been burned.

The resulting pressure forces the piston downward on its power stroke. The exhaust valves are again opened when the piston is about half way down, allowing the burned gases to escape into the exhaust manifold (Fig. 1 - exhaust).

Shortly thereafter, the downward moving piston uncovers the inlet ports and the cylinder is again swept with clean scavenging air. This entire combustion cycle is completed in each cylinder for each revolution of the crankshaft, or, in other words, in two strokes; hence, it is a “two-stroke cycle”.

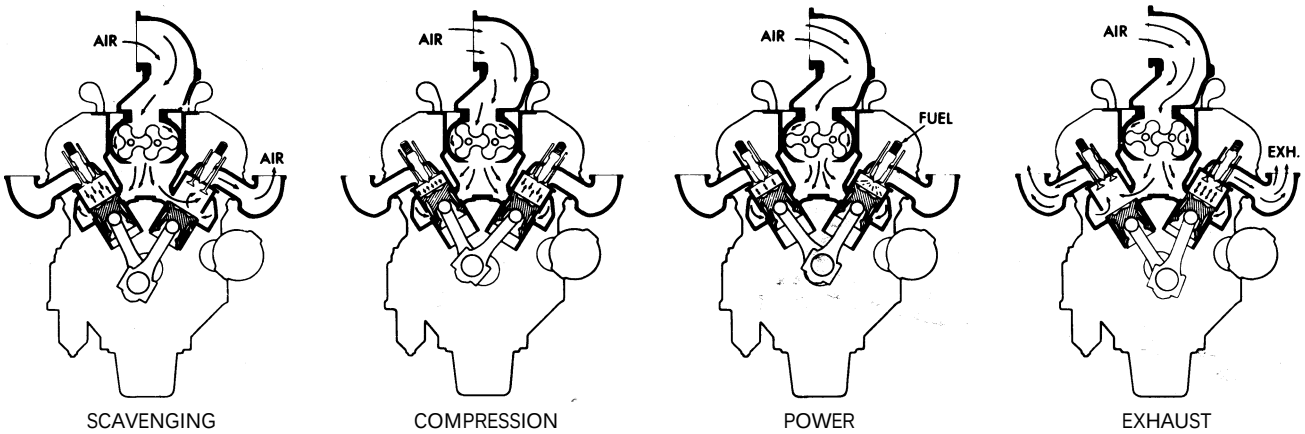


Fig. 1 - The Two-Stroke Cycle

GENERAL DESCRIPTION

The Series 149 Diesel engine is a "V" type, two cycle engine. A low weight-to-horsepower ratio, full scavenging air system, individual cylinder heads, free floating pistons and unit fuel injection are all incorporated to allow trouble-free maintenance and to provide desirable operating features for many applications.

Gear trains located at both the front and rear ends of the engine provide ample locations from which accessories may be driven.

Fuel is drawn from the supply tank and through a strainer by a gear-type fuel pump; then it is forced through the filter, the fuel inlet manifold and into the injectors. Excess fuel is returned to the supply tank through the fuel outlet manifold and connecting lines. Since fuel is constantly circulating through the injectors, it serves to cool the injectors and to carry off any air in the fuel system.

Air for scavenging and combustion is supplied by a blower(s) which pumps air into the engine cylinders via the air box and cylinder liner ports. All air entering the blower first passes through an air cleaner or silencer and, on some models, a turbocharger.

Cooling is accomplished by circulating fresh water through the engine water jacket by a centrifugal pump mounted on the engine front cover.

Full pressure lubrication is supplied to all main, connecting rod and camshaft bearings and to other moving parts.

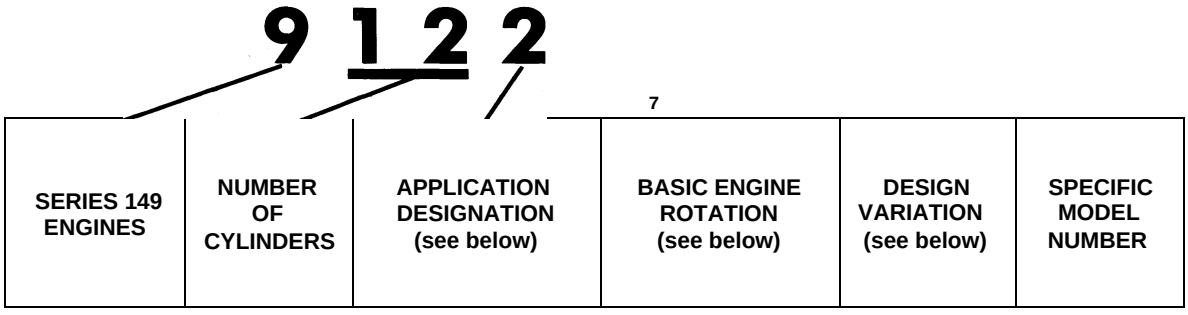
A gear-type pump draws oil from the oil pan through a screen and delivers it to the oil filter. From the filter, the oil flows to the oil cooler and then enters a longitudinal oil gallery in the cylinder block where the supply divides.

Part of the oil goes to the camshaft bearings and up through the rocker arm assemblies; the remainder of the oil goes to the main bearings and connecting rod bearings via the drilled oil passages in the crankshaft.

Engine starting is provided by either a pneumatic starting system or an electric starting motor energized by a storage battery. A battery-charging alternator serves to keep the battery charged.

Dependable speed regulation of the engine is provided by either a mechanical or hydraulic governor.

Fig. 2 illustrates a complete breakdown on model designation including application, design variation and basic engine rotation.



APPLICATION DESIGNATION:

9122- 7300	MARINE
9123- 7300	INDUSTRIAL F-F

BASIC ENGINE ROTATION:

9122-3300	LEFT-HAND
9122-7300	RIGHT-HAND

DESIGN VARIATION:

9122-7000	NON-TURBO
9122-7300	TURBO OR TURBO-INTERCOOLED
9122-7400	TURBO-AFTERCOOLED

Rotation: L (Left) and R (Right) designates
Rotation as viewed from the front of the engine:

11921 -A

Fig. 2 - Series 149 Engine Model Description Chart

 © Detroit Diesel Corporation

GENERAL SPECIFICATIONS

	8V	12V	16V
Type	2 Cycle	2 Cycle	2 Cycle
Number of Cylinders..... 8		12	16
Bore (inches).....	. 5.75	5.75	5.75
Bore (mm).....	146	146	146
Stroke (inches).....	5.75	5.75	5.75
Stroke (mm).....	146	146	146
Total Displacement - (cubic inches).....	1195	1792	2389
Total Displacement - (liters).....	19.6	29.39	39.18
Compression Ratio (standard and turbocharged engines).....		17:1	17:1
Compression Ratio (intercooled turbocharged engines)*.....	. 16:1	16:1	16:1

*Note: Certain high output turbocharged — intercooled engines also have 14:1 and 15:1 compression ratios.

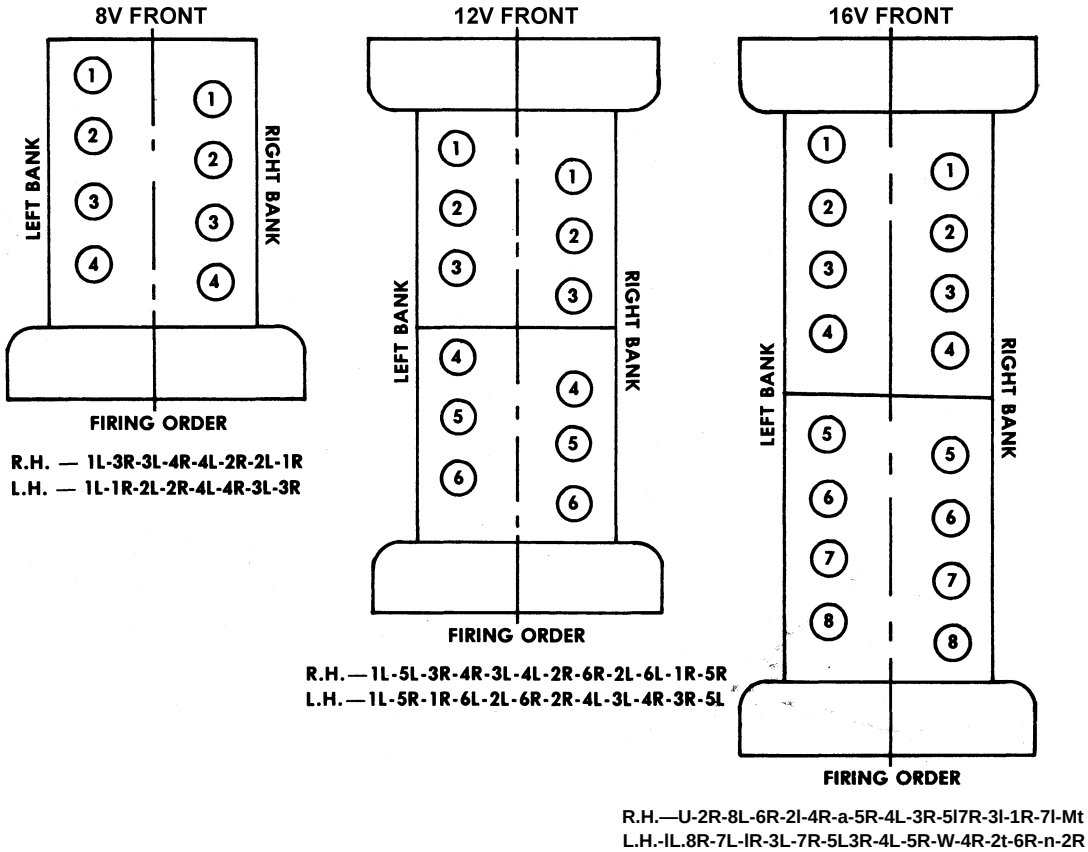


Fig. 3 - Cylinder Designation and Firing Order

ENGINE MODEL. SERIAL NUMBER AND OPTION PLATE

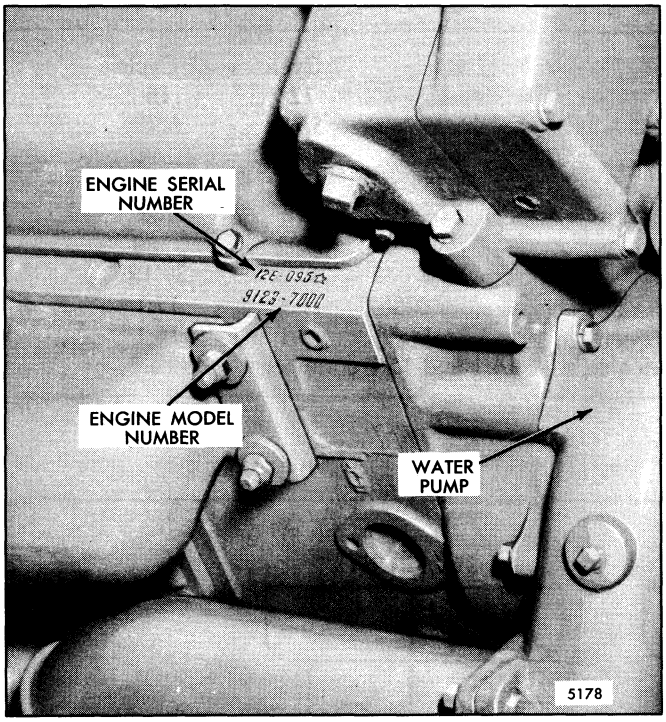


Fig. 4 - Engine Serial and Model Number Identification

• The unit serial number on 8V engines is stamped on the rocker cover rail at the left, rear corner of the block. The unit serial number on 12 V and 16V engines is stamped on the rocker cover rail at the right, front corner of the block (Fig. 4).

Option Plate (Metal Labels)

A metal option plate, attached to one of the valve rocker covers (Fig. 5), was formerly used to carry the engine serial number and model number and list the optional equipment used on the engine.

Option Plate (Paper Labels)

A paper/laminate engine option label (Fig. 6) is currently used to carry the engine serial number and model number, and list any optional equipment used on the engine. This label is attached to one of the valve rocker covers along with a disclaimer label and a bar code label which contains the engine serial number and customer specification number. • • •

• Distributors will provide their own label(s) in order to notify the customer of any distributor-made changes to Detroit Diesel manufactured engines. Distributor-typed label(s) will indicate the distributor name, address and the group/type revisions that reflect their changes to engines as originally manufactured by Detroit Diesel.

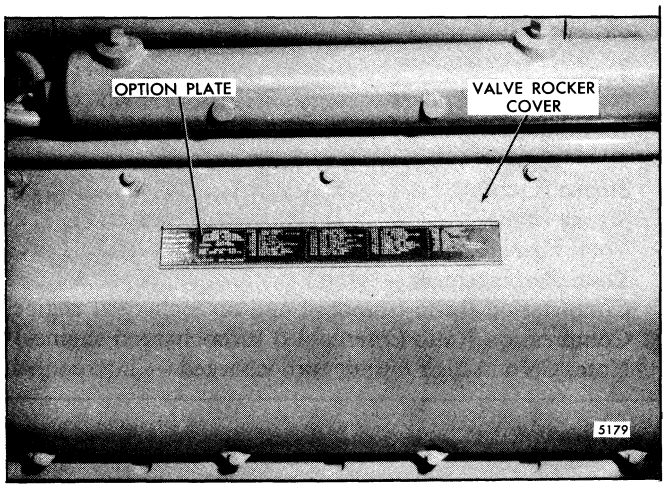


Fig. 5 – Option Plate

Attaching Labels

Labels must be placed on rocker covers. Labels are designed to fit in the same space provided for the former stamped or current cast rocker cover option plate holder. Replacement option labels can be placed directly over existing option labels. Make certain the labels are applied to clean, dry, oil-free surfaces to assure adhesion and retention. Laminate should completely cover the label to provide a good seal.

The option plate holder on cast rocker covers is held to the cover by rivets in blind holes. Therefore, the option plate holder can be removed and the labels applied directly to the rocker covers.

NOTICE: Extreme heat from components such as turbocharger exhaust piping can cause the labels to darken, discolor or deteriorate over a period of time. Therefore, labels should be installed at alternate rocker cover locations.

With any- order for parts, the engine model number and serial number must be given. In addition, if a type number is shown on the option plate covering the equipment required, this number should also be included on the parts order.

All groups of parts used on a unit are *standard* for the model, unless otherwise listed on the option label.

Power take-off assemblies, torque converters, marine gears, etc. may also carry name plates. The information on these name plates is also useful when ordering replacement parts for these assemblies.

 © Detroit Diesel Corporation

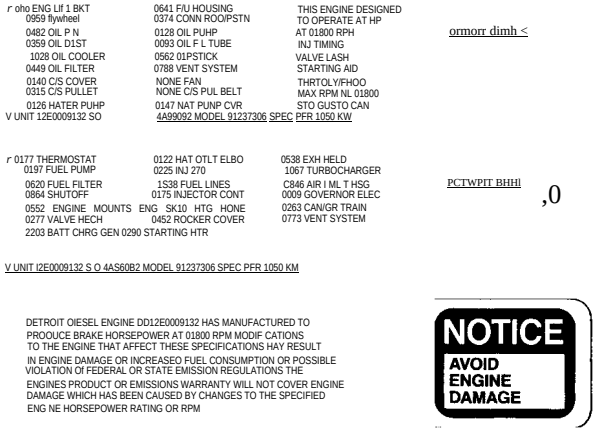


Fig. 6 Typical Option Label

Certain component parts used on a given engine model or in a particular engine type may be superseded or replaced at the discretion of DDC. In most cases when this occurs, only the newer part is available for service. Parts catalogs are revised periodically to reflect any changes.

GENERAL PROCEDURES

In many cases, a Service Technician is justified in replacing parts with new material rather than attempting repair. However, there are times when a slight amount of reworking or reconditioning may save a customer considerable added expense. Crankshafts, cylinder liners and other parts are in this category. For example, if a cylinder liner is only slightly worn and within usable limits, a honing operation to remove the glaze may make it suitable for reuse, thereby saving the expense of a new part. Exchange assemblies such as injectors, fuel pumps, water pumps and blowers are also desirable service items.

Various factors such as the type of operation of the engine, hours in service and next overhaul period must be considered when determining whether new parts are installed or used parts are reconditioned to provide trouble-free operation.

For convenience and logical order in disassembly and assembly, the various subassemblies and other related parts mounted on the cylinder block will be treated as separate items in the various sections of the manual.

DISASSEMBLY

Before any major disassembly, the engine must be drained of lubricating oil, coolant, and fuel. On engines cooled by a heat exchanger, the fresh water system and raw water system must both be drained. Lubricating oil should also be drained from any transmission attached to the engine.

CAUTION: To avoid being burned by the hot liquid, allow the engine to cool before draining the coolant.

To perform a major overhaul or other extensive repairs, the complete engine assembly, after removal from the engine base and drive mechanism, should be supported on a level surface; then the various subassemblies should be removed from the engine.

Parts removed from an individual engine should be kept together so they will be available for inspection and assembly. Those items having machined faces, which might be easily damaged by steel or concrete, should be stored on suitable wooden racks or blocks, or a parts dolly.

BetterManuals.net

CLEANING

Before removing any of the subassemblies from the engine (but after removal of the electrical equipment), the exterior of the engine should be thoroughly cleaned. Then, after each subassembly is removed and disassembled, the individual parts should be cleaned. Thorough cleaning of each part is absolutely necessary before it can be satisfactorily inspected. Various items of equipment needed for general cleaning are listed below.

The cleaning procedure used for all ordinary cast iron parts is outlined under *Clean Cylinder Block* in Section 1.1; any special cleaning procedures will be mentioned in the text wherever required.

Steam Cleaning

A steam cleaner is a necessary item in a large shop and is most useful for removing heavy accumulations of grease and dirt from the exterior of the engine and its subassemblies.

Solvent Tank Cleaning

A tank of sufficient size to accommodate the largest part that will require cleaning (usually the cylinder block) should be provided and provision made for heating the cleaning solution to 180-200°F (82-90°C).

Fill the tank with a commercial heavy-duty solvent which is heated to the above temperature. Lower large parts directly into the tank with a hoist. Place small parts in a wire mesh basket and lower them into the tank. Immerse the parts long enough to loosen all of the grease and dirt.

Rinsing Bath

Provide another tank of similar size containing hot water for rinsing the parts.

Drying

Parts may be dried with compressed air. The heat from the hot tanks will quite frequently complete drying of the parts without the use of compressed air.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Rust Preventive

If parts are not to be used immediately after cleaning, dip them in a suitable rust preventive compound. The rust preventive compound should be removed before installing the parts in an engine.

 © Detroit Diesel Corporation

INSPECTION

The purpose of parts inspection is to determine which parts can be used and which must be replaced. Although the engine overhaul specifications given throughout the text will aid in determining which parts should be replaced, considerable judgment must be exercised by the inspector.

The guiding factors in determining the usability of worn parts, which are otherwise in good condition, is the clearance between the mating parts and the rate of wear on each of the parts. If it is determined that the rate of wear will maintain the clearances within the specified maximum allowable until the next overhaul period, the reinstallation of used parts may be justified. Rate of wear of a part is determined by dividing the amount the part has worn by the hours it has operated.

Many service replacement parts are available in various undersize and/or oversize as well as standard sizes. Also, service kits for reconditioning certain parts and service sets which include all of the parts necessary to complete a particular repair job are available.

A complete discussion of the proper methods of precision measuring and inspection are outside the scope of this manual. However, every shop should be equipped with standard gages such as dial bore gages, dial indicators, and inside and outside micrometers.

In addition to measuring the used parts after cleaning, the parts should be carefully inspected for cracks, scoring, chipping and other defects.

ASSEMBLY

Following cleaning and inspection, the engine should be assembled using new parts as determined by the inspection.

Use of the proper equipment and tools make the job progress faster and produces better results. Likewise, a suitable working space with proper lighting must be provided. The time and money invested in providing the proper tools, equipment and space will be repaid many times.

Keep the working space, the equipment, tools and engine assemblies and parts clean at all times. The area where assembly operations take place should, if possible, be located away from the disassembly and cleaning operation. Also, any machining operations should be removed as far as possible from the assembly area.

Particular attention should be paid to storing of parts and subassemblies, after removal and cleaning and prior to assembly, in such a place or manner as to keep them clean. If there is any doubt as to the cleanliness of such parts, they should be recleaned.

When assembling an engine or any part thereof, refer to the table of torque specifications at the end of each section for proper bolt, nut and stud torques.

To ensure a clean engine at time of rebuild, it is important that any plug, fitting or fastener (including studs) that intersects with a through hole and comes in contact with oil, fuel or coolant must have a sealer applied to the threads.

A number of universal sealers are commercially available. It is recommended that Loctite J 26558-97 *pipe sealer with teflon,* or equivalent, be used.

NOTICE: Certain plugs, fittings and fasteners available from the Parts Depot already have a sealer applied to the threads. This pre-coating will not be affected when the pipe sealer with teflon is also applied.

The sealer information above must not be confused with International Compound No. 2, which is a lubricant applied before tightening certain bolts. Use International Compound No. 2 only where specifically stated in the manual.

CAUTIONS

WORK SAFELY

The service procedures recommended by Detroit Diesel Corporation and described in this service manual are effective methods of performing service and repair. Some of these procedures require the use of tools specially designed for the purpose.

Accordingly, anyone who intends to use a replacement part, service procedure or tool, which is not recommended by Detroit Diesel Corporation, must first determine that neither his safety nor the safe operation of the engine will be jeopardized by the replacement part, service procedure or tool selected.

It is important to note that this manual contains various "Cautions" and "Notices" that must be carefully observed in order to reduce the risk of personal injury during service or repair or the possibility that improper service or repair may damage the engine or render it unsafe. It is also important to understand that these "Cautions" and "Notices" are not exhaustive, because it is impossible for Detroit Diesel Corporation to warn of all the possible hazardous consequences that might result from failure to follow these instructions.

© Detroit Diesel Corporation

A serviceman can be severely injured if caught in the pulleys, belts or fan of an engine that is accidentally started. To avoid such a misfortune take these precautions before starting to work on an engine:

1. Disconnect the battery from the starting system by removing one or both of the battery cables. With the electrical circuit disrupted, accidental contact with the starter button will not produce an engine start.
2. Make sure the mechanism provided at the governor for stopping the engine is in the stop position. This will mean the governor is in the no-fuel position. The possibility of the engine firing by accidentally turning the fan or, in the case of vehicle application, by being bumped by another vehicle is minimized.

Some Safety Precautions To Observe When Working On The Engine

1. Consider the hazards of the job and wear protective gear such as safety glasses, safety shoes, hard hat, etc. to provide adequate protection.
2. When lifting an engine, make sure the lifting device is fastened securely. Be sure the item to be lifted does not exceed the capacity of the lifting device.

• 3. The front engine lifter bracket is not designed to lift more than the basic engine. When lifting the engine with marine gear or generator attached or when removing a haul truck engine module, the proper hook points on the engine cradle or mounting rails *must* be used. Do not use the front lifter bracket alone under these circumstances. Failure to observe this precaution can result in personal injury and/or serious engine damage.

4. Always use caution when using power tools.

• 5. When using compressed air to clean a component, such as flushing a radiator or cleaning an air cleaner element, use a safe amount of air. Recommendations regarding the use of air are indicated throughout the manual. Too much air can rupture or in some other way damage a component and create a hazardous situation that can lead to personal injury. Always wear adequate eye protection (safety glasses, safety face shield) when working with compressed air.

.6. To avoid possible personal injury when working with chemicals, steam and/or hot water, wear adequate protective clothing (face shield, rubber apron, gloves, boots, etc), work in a well ventilated area, and exercise caution.

• 7. Avoid the use of carbon tetrachloride, carbon disulfide, methylene, chloride, perchloroethylene and trichloroethylene as cleaning agents because of harmful vapors they release. Use 1,1,1-Trichloroethane. However, while less toxic than other chlorinated solvents, use it with caution. Be sure the work area is adequately ventilated and use protective gloves, goggles or face shield and an apron. Follow chemical manufacturer's use and safety recommendations.

Exercise caution against chemical burns when using acids (Oxalic, phosphoric and nitric) and alkaline cleaners. Use protective gloves, goggles or face shield and an apron.

CAUTION: Mineral spirits or mineral spirits based solvents are highly flammable. They must be stored and used in "No Smoking" areas away from heat, sparks and open flames.

8. Use caution when welding on or near the fuel tank. Possible explosion could result if heat build-up inside the tank is sufficient.
9. Avoid excessive injection of ether into the engine during start attempts. Follow the instructions on the container or by the manufacturer of the starting aid.

,10. Failure to inspect parts thoroughly before installation, failure to install the proper parts, or failure to install parts properly can result in component or engine malfunction and/or damage and may also result in personal injury.

11. When working on an engine that is running, accidental contact with the hot exhaust manifold can cause severe burns. Remain alert to the location of the rotating fan, pulleys and belts. Avoid making contact across the two terminals Of a battery which can result in severe arcing.

. FABRICATING, ALTERING, REMOVING AND DISPOSING OF GASKETS

Many gasket materials contain bonded asbestos, which in itself presents no health hazard when handled properly. A health hazard may exist, however, if the asbestos in such materials is liberated and becomes airborne. This may occur if gaskets are fabricated or altered using the following improper methods: drilling, grinding, saw cutting or using practically all types of power operated machines and hand tools.

Gasket manufacturers and industrial hygienists prescribe specific methods for handling gasket material. The following guidelines are based on their recommendations. Detroit Diesel recommends that these guidelines be followed when fabricating or altering any gaskets.

1. Unless it is known otherwise, treat all gasket material as though it contains asbestos.

 © Detroit Diesel Corporation

2. When cutting strips or blocks from sheets (blanking), hand cut with scissors, knife or paper cutter. Avoid creating dust.
3. Form outside dimensions with a punch die or hand cut with scissors, knife or compass.
4. For internal hubs use a punch die, hand cut with scissors, knife or compass, or punch by hand with a ballpeen hammer or ball bearing.
5. When stripping gaskets from parts, do not grind or file off the material or abraid it off with a wire brush or wheel. Use a putty knife to remove the gasket after it has been wetted with water or oil.
6. After fabricating or altering a gasket, clean the area to remove any particles which may have been generated. This should be done by wiping the area with a rag wetted with water or a water-based detergent. If large areas need to be cleaned, remove gasket dust and debris using an "HEPA" (High Efficiency Particulate Arrestor) vacuum cleaner. Do not clean the area by blowing with compressed air or brushing.

Place the rags containing the waste and any scrap gasket material in an impervious container labeled with the OSHA (Occupational Health and Safety Administration) designated caution (Fig. 6) and dispose of it in a solid waste disposal facility (land fill) which will accept asbestos material. Heavy plastic garbage bags (6 mills thick), each sealed separately, or other closed and impermeable container may be used.

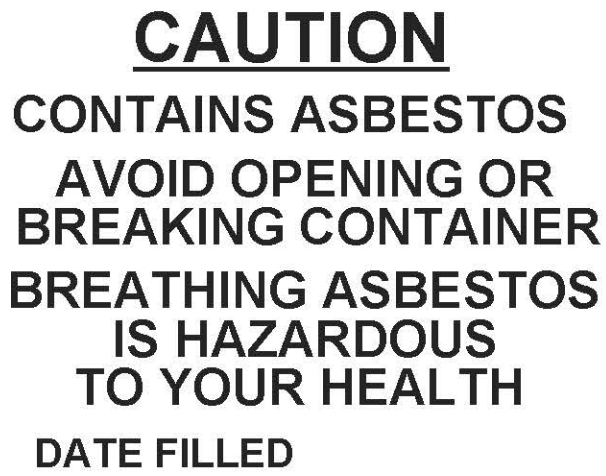
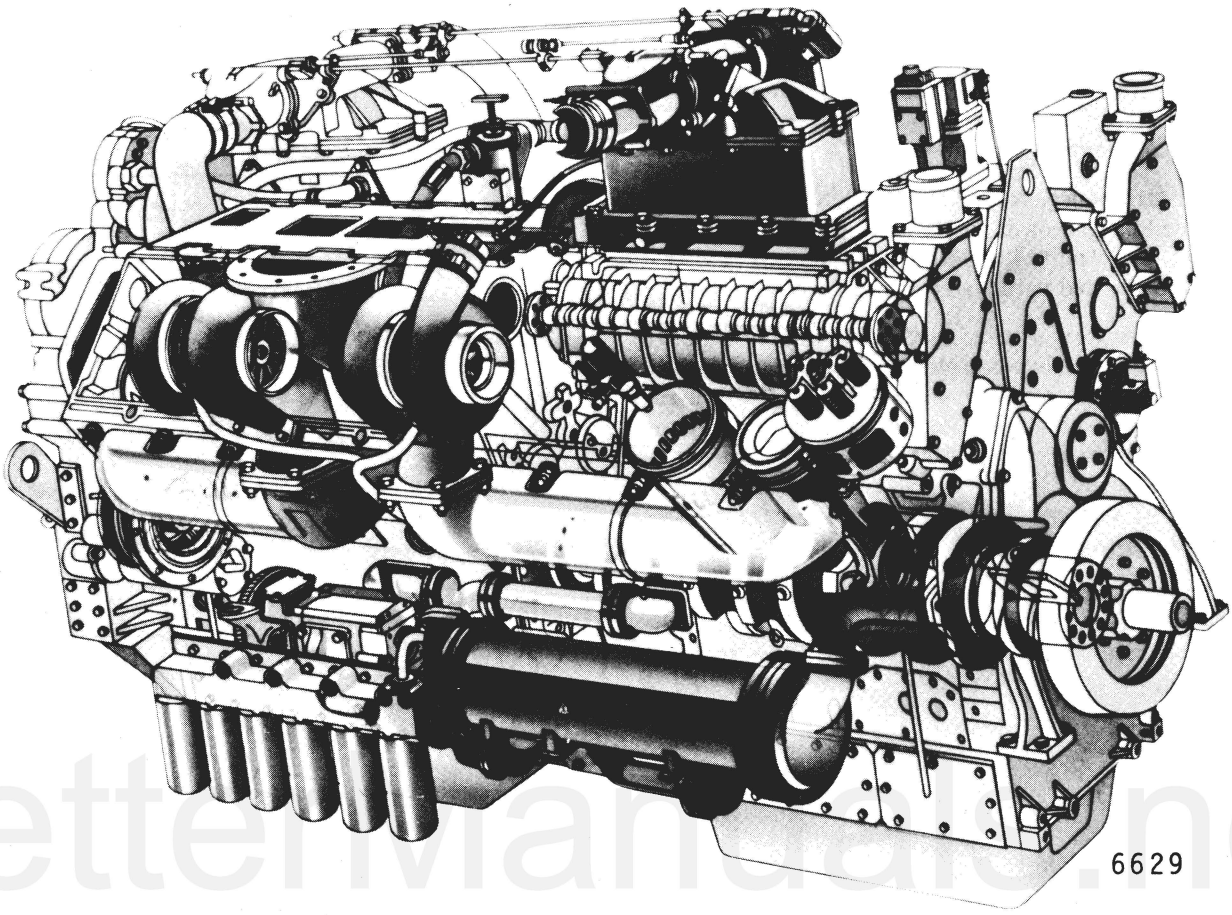


Fig. 6 - Caution Label

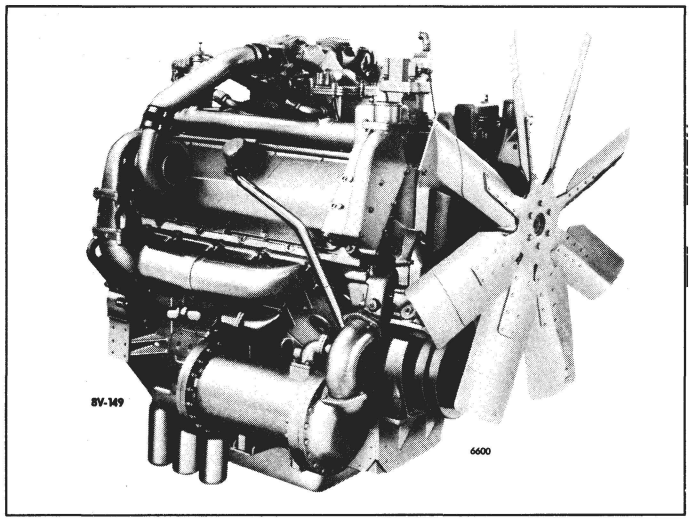
BetterManuals.net



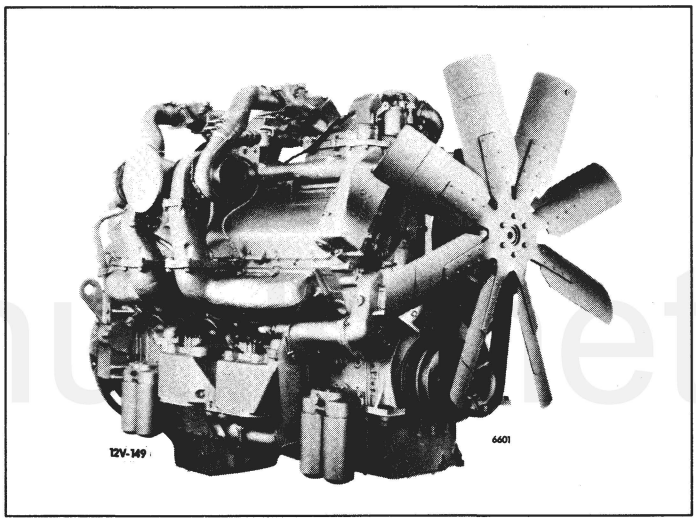
Three Quarter Cross Section View of 16V-149 Engine

BetterManuals.net

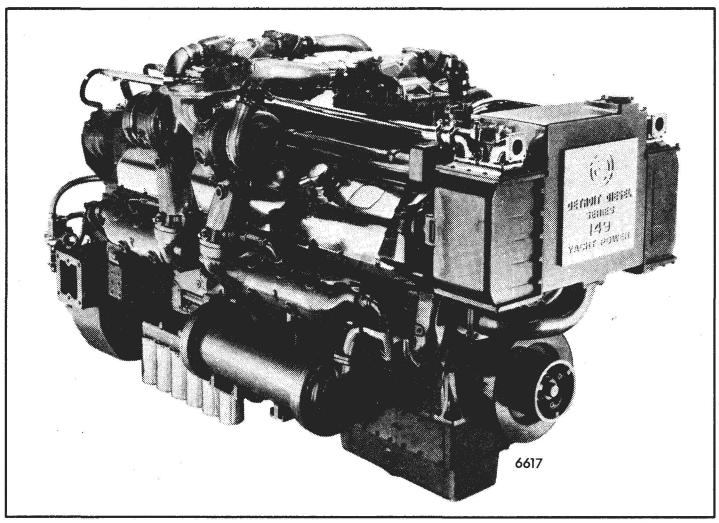
 © Detroit Diesel Corporation



Turbocharged - Intercooled Engine Typical 8V-149



Turbocharged - Intercooled Engine Typical 12V-149



Turbocharged - Intercooled Engine Typical 16V-149

BetterManuals.net

SECTION 1

ENGINE (LESS MAJOR ASSEMBLIES)

CONTENTS

Cylinder Block..... 1.1
Air Box Drains..... 1.1.2

Cylinder Head..... 1.2
Valve and Injector Operating Mechanism..... 1.2.1
Exhaust Valves..... 1.2.2
Valve Rocker Cover..... 1.2.4

Crankshaft..... 1.3
Crankshaft Oil Seals..... 1.3.2
Crankshaft Main Bearings..... 1.3.4
Engine Front Cover..... 1.3.5
Crankshaft Outboard Bearing Support (Front)..... 1.3.5.1
Crankshaft Outboard Bearing Support (Rear)..... 1.3.5.2
Crankshaft Vibration Damper..... 1.3.6
Crankshaft Pulley..... 1.3.7

Flywheel..... 1.4

Flywheel Housing..... 1.5
Flywheel Housing Adaptor..... 1.5.1

Piston and Piston Rings..... ,1.6
Connecting Rod..... 1.6.1
Connecting Rod Bearings..... 1.6.2
Cylinder Liner..... 1.6.3

Engine Balance and Balance Weights..... 1.7
Gear Train and Engine Timing..... 1.7.1
Camshafts and Bearings..... 1.7.2
Camshaft Gears and Idler Gears..... 1.7.3
Crankshaft Timing Gears..... 1.7.5
Blower Drive Gear and SupportAssembly..... 1.7.6
Accessory Drives..... 1.7.7

Shop Notes - Trouble ShootingSpecifications - Service Tools..... 1.0

BetterManuals.net

CYLINDER BLOCK

The cylinder block serves as the main structural part of the engine (Fig. 1). The various subassemblies and parts must be removed from the cylinder block when an engine is overhauled.

New service replacement cylinder block assemblies include the crankshaft main bearing caps, bolts and washers and the camshaft bearing caps and bolts. The necessary dowel pins and plugs are also included.

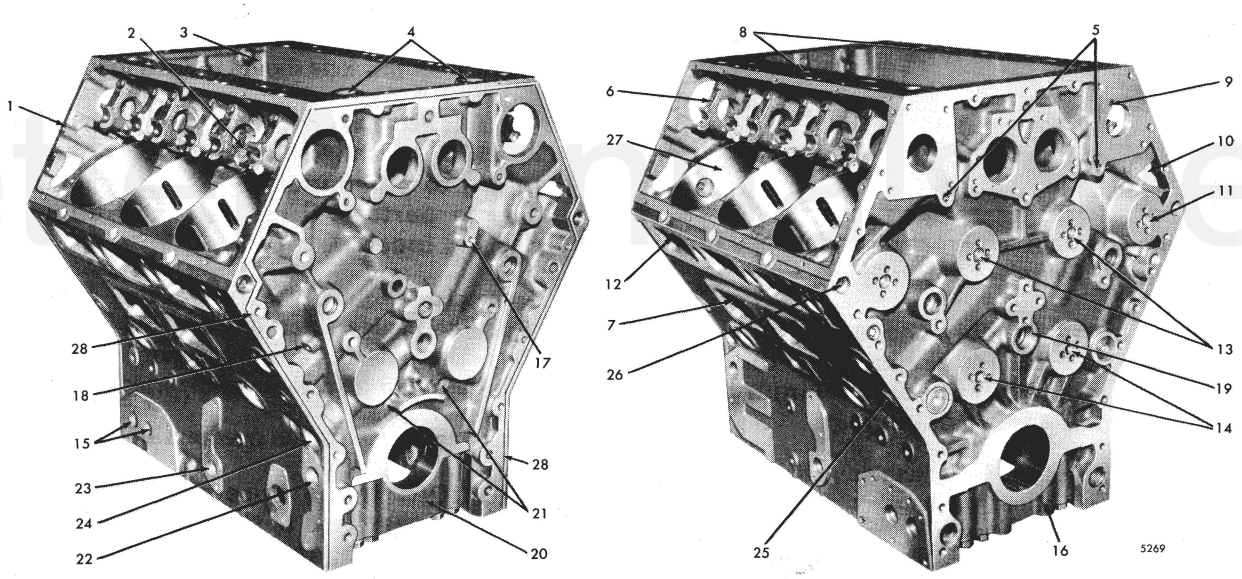
Effective with engine serial numbers 12E-5672 and 16E-5308, new cylinder block air box cover plates are being used on all engines in conjunction with the new cast breather body assembly (Section 4.8). The new cover plates are required due to the elimination of the two 1.56" diameter breather system holes. Both the former and new cover plates are serviced.

• Effective with engine serial numbers 8E02613, 12E09006, and 16E09109 new cylinder blocks with strengthened intermediate main bearing journals are used. The new blocks are similar to the former, except that intermediate main bearing journal web areas are cast thicker. The thicker journals are at the No. 2 and 3 positions on 12V-149 block halves, and at the No. 2, 3, and 4 positions on the 8V-149 block and the 16V-149 block halves. The new blocks can be distinguished from the former by the wider cast webs and broadened yokes above the strengthened journals (Fig. 2).

NOTICE: During an in-frame overhaul, use cylinder bore plug set J 34727 to help prevent solvent and debris from entering the crankcase while cleaning the air box.

Remove And Disassemble Engine

•CAUTION: The front engine lifter bracket is not designed to lift more than the basic engine. When lifting the engine with marine gear or generator attached or when removing a haul truck engine module, the proper hook points on the engine cradle or mounting rails *must* be used. Do not use the front lifter



1. Cylinder Block
2. Camshaft Oil Supply Holes
3. Air Box
4. Crankcase Breather Pipe Bores
5. Upper Oil Galleries
6. Camshaft Bearing Cap
7. Air Box Inspection Holes
8. Upper Water Passage Holes
9. Camshaft Gear Oil Supply
10. Oil Drain Hole
11. Accessory Drive Gear Oil Supply
12. Exhaust Ports
13. Upper Idler Gear Oil Supply
14. Lower Idler Gear Oil Supply
15. Oil Filter Supply Holes
16. Rear Main Bearing Cap
17. Cross Hole to Blower Oil Feed Hole
18. Blower Oil Drain
19. Main Oil Gallery
20. Front Main Bearing Cap
21. Crankcase Breather Holes
22. Oil Cooler Oil Return
23. Oil Cooler Oil Supply
24. Turbocharger Oil Supply
25. Air Box Drain
26. Exhaust Port Water Cooling Hole
27. Cylinder Head Bore
28. Seal Groove (rear block only)

Fig. 1 - Cylinder Block (12V-149 Rear Block Shown)

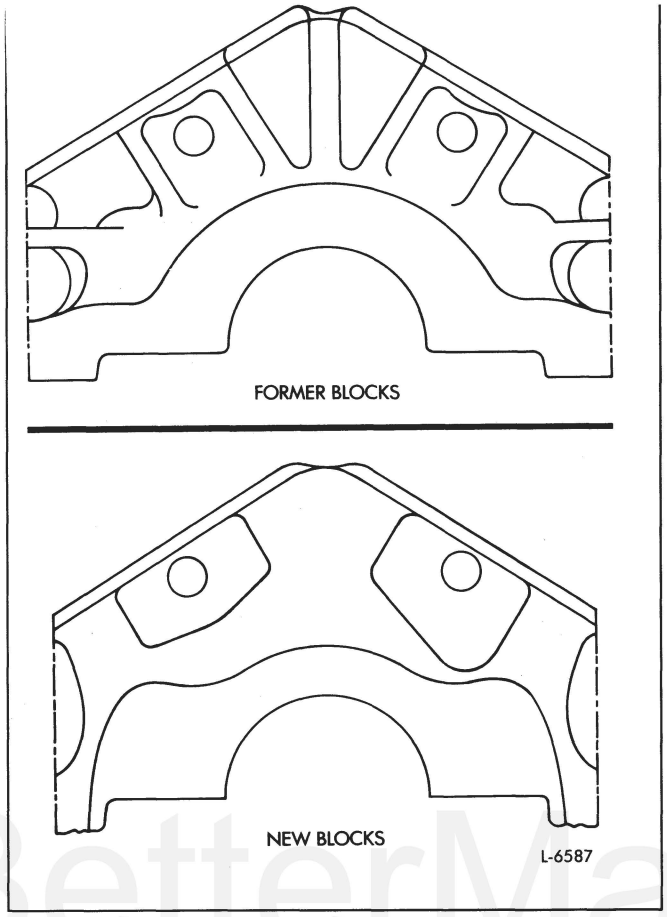


Fig. 2 - Bearing Journal Web Areas on Former and New Cylinder Blocks

bracket alone under these circumstances. Failure to observe this precaution can result in personal injury and/or serious engine damage.

Details for removing and disassembling the engine will vary from one application to another. However, the following steps will be necessary.

1. Drain the cooling system.
2. Drain the lubricating oil.
3. Disconnect the fuel lines.
4. Remove the air silencer or air cleaner and mounting bracket.
5. ' Remove the turbochargers, if used.
6. Disconnect the exhaust piping and remove the exhaust manifolds.
7. Disconnect the throttle controls.
8. Disconnect and remove the starting motor, battery-charging generator or alternator and other electrical equipment.
9. Remove the air compressor, if used.
10. Remove the radiator and fan guard, or the heat exchanger and other related cooling system parts.
11. Remove the air box drain tubes and fittings.
12. Remove the air box covers.
13. Disconnect any other lubricating oil lines, fuel lines or electrical connections.
14. Separate the engine from the transmission or other driven mechanism. For instructions on removal of the various transmissions used, see the instruction manual for the particular transmission on the unit.
15. Remove the bolts that fasten the engine to the equipment which it powers.
16. Use a spreader bar with a suitable sling and adequate chain hoist to lift the engine from its base (Fig. 3). To prevent bending of the engine lifter brackets the lifting device should be adjusted so the lifting hooks are vertical. To ensure proper weight distribution, all engine lifter brackets should be used to lift the engine.

CAUTION: Do not lift an engine by any opening in the cylinder block. Severe injury to personnel and destruction of engine parts will result if the engine casting breaks.

A complete electric drive truck module must never be lifted with the engine lifter brackets. This could affect alignment between the engine and generator. A module must be lifted in the same manner it is supported in the vehicle.

17. Mount the engine on an overhaul stand.

CAUTION: Make sure the engine is securely fastened to the overhaul stand before releasing the lifting sling. Severe injury to personnel and destruction of engine parts will result if the engine breaks "away from the overhaul stand.

18. Remove all of the remaining subassemblies and parts from the cylinder block.

The procedure for removing each subassembly from the cylinder block, together with disassembly, inspection, repair and reassembly of each, will be found in the various sections of this manual.

After stripping, the cylinder block must be thoroughly cleaned and inspected.

BetterManuals.net

 © Detroit Diesel Corporation

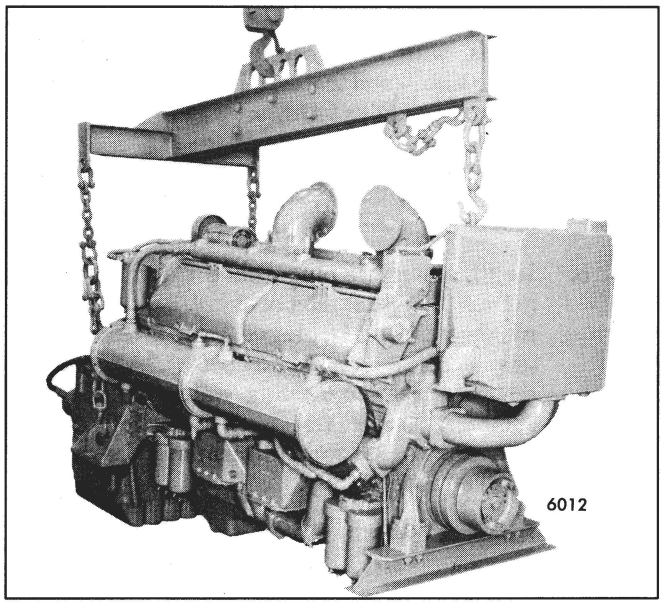


Fig. 3 - Lifting Engine with Spreader and Sling

Clean Cylinder Block

Scrape all gasket material from the cylinder block. Then, remove all of the plugs (except cup plugs) from the block. Also, remove all of the core hole plugs to allow the cleaning solution to contact the inside of the water and oil passages. This will permit more efficient cleaning and eliminate the possibility of the cleaning solution attacking the aluminum water hole plug gaskets which would result in internal leaks and eventual engine damage.

After a cylinder block has been in service, water hole plugs may be difficult to remove. To facilitate removal, hold a drift against the plug and give it a few sharp blows with a one pound hammer. Exercise care when striking the drift so as not to damage the cylinder block. After the core hole plugs have been loosened, they can be easily removed and installed with tool J 23019.

Clean the cylinder block as follows:

• CAUTION: To avoid personal injury when using steam or chemicals to clean an engine or engine component, always wear adequate face and body protection (faceplate, gloves, boots, waterproof apron, etc.)- In addition, when using chemical solutions, make sure the cleaning area is properly ventilated and follow chemical manufacturer's use and safety recommendations.

1. Remove the grease and oil by placing the cylinder block in a hot bath of commercial heavy-duty alkaline cleaner solution.
2. Rinse the block in hot water or steam clean it to remove the alkaline solution.
3. If the water jackets are heavily scaled, proceed as follows:
   a. Place the block in a bath of inhibited phosphoric acid.
   b. Allow the block to remain in the acid bath until the bubbling action stops (approximately 30 minutes).
   c. Lift the block, allow it to drain and reimmerse it in the same acid solution for ten (10) minutes.
   d. Repeat Step "c" until all scale is removed.
   e. Rinse the block in clear hot water to remove the acid solution.
   f. Neutralize the remaining acid that may cling to the casting by immersing the block in an alkaline bath.
   g. Wash the block in a bath of clean water or steam clean it.
4. Dry the cylinder block with compressed air.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

5. Make certain that all of the water passages, oil galleries, cylinder liner seal ring grooves and air box drain openings have been thoroughly cleaned to permit the cooling and lubricating systems to function efficiently.

The above cleaning procedure may be used on all ordinary cast iron and steel parts of the engine. Mention will be made of special cleaning precautions whenever necessary.

6. After the cylinder block has been thoroughly cleaned and dried, coat the threads of the plugs with sealant and, using new gaskets, install the core hole plugs. Tighten the plugs to 150-180 lb—ft (204-244 N#m) torque.

Lubricate the threads and washer face of the 1 3/4"-16 plugs in the end of the block with International Compound No. 2, or equivalent, and tighten the plugs to 150-200 lb—ft (204-271 N#m) torque.

Coat the threads and washer face of the 2 1/2"-16 plugs in the air box with a good grade of coolant resistant sealant and tighten the plugs to 220-250 lb—ft (298-339 N«m) torque.

Boat Manuals.net

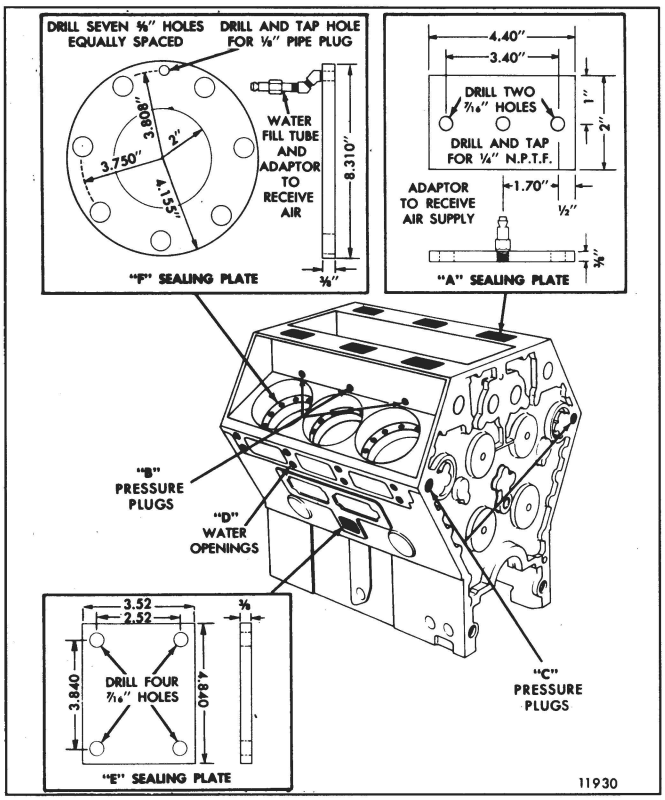


Fig. 4 - Instructions For Sealing Block For Pressure Test

Coat the threads of the 3/4"-14 brass plugs in the end of the block with Loctite Pipe Sealant with Teflon (J 26558-92) or equivalent. Tighten the plugs to 75-80 lb-ft (102-108 N«m) torque. The plugs must be water tight and must be flush or below the surface. If the block was equipped with 3/4"-14 steel pipe plugs, install new brass pipe plugs which are precoated with Vibra-seal thread sealant. Do not remove this coating.

Pressure Test Cylinder Block

When a cylinder block is suspected of being cracked or when there is a noticeable loss of coolant with no obvious cause, the block should be pressure tested. There are two methods to pressure test a cylinder block. The first method (A) is to submerge the entire block in a water tank and apply air pressure inside the block, The second method (B) is to place a mixture of antifreeze and water inside the block and apply air pressure. With either method it will be necessary to seal all of the water openings in the cylinder block with appropriate plugs, seals and plates (pressure testing tool set J 24051). Fig. 4 indicates the types of plugs, seals and plates required and their relative location for sealing during the pressure test.

METHOD A

This method is recommended when there is a water tank available large enough to submerge the block.

1. With the cylinder block completely stripped of all components, with the exception of plugging, studs, etc., refer to Fig. 4 and seal off all of the water inlet and outlet holes air tight as follows:

   a. Position a plate (A) and rubber gasket over each "A" water outlet opening along the top of the block.

   b. Install a pressure plug from tool set J 24051-B in each "B" water inlet opening (8 plugs - 8 V, 12 plugs - 12 V and 16 plugs - 16V). If desired, it is only necessary to use one set of "A" and "B" seals as their connecting water jacket is not common to the rest of the cooling system. Regardless, each compartment must be pressure checked individually.

   c. Install a pressure plug in each "C" water opening.

   d. If the exhaust manifold studs were removed, use suitable seal rings and 20 (8V), 32 (12V) or 40 (16V) l/2"-13xl^{M} bolts to seal each "D" water opening.

   e. Position a plate (E) and suitable rubber gasket over each oil cooler to cylinder block "E" water opening and secure each plate using four 3/8M—16 x 1-1/4" bolts.

   f. Apply hydrogenated vegetable type shortening to 16 (8V), 24 (12V) or 32 (16V) seal rings and position two (2) in the seal ring grooves within each "F" cylinder opening.

   g. Slide another seal ring over a spare cylinder liner and position a cylinder liner in each "F" cylinder opening, using care not to dislodge the seal rings. If possible, use only the top half of cylinder liners which are cut at the port locations. With only half of the liner in the cylinder block, it will be easier to note any leak in the lower area.

   h. Place seven (7) water seal rings in each set of cylinder block to cylinder head water inlet openings.

   i; Position an "F" seal ring plate over the cylinder liner and seal rings of each cylinder and secure each plate with seven (7) 9/16"-18 x 2-1/4" bolts.

2. Make sure all of the plugs and seals are tight and apply 40 psi (276 kPa) air pressure to the cylinder block water jacket.

3. Immerse the cylinder block for twenty (20) minutes in a tank of water heated to 18O-2o0t (82-93°C). Observe the water tank for air bubbles indicating cracks or leaks.

Boat Manuals.net

 © Detroit Diesel Corporation

4. After the pressure test is completed, blow out the passages with dry compressed air. Replace the cylinder block if leaks or cracks are detected in the water or oil passages.

METHOD B

This method may be used when a large tank is unavailable or when it is desired to check the block for cracks without removing the engine from the equipment which it powers. However, it is necessary to remove as many of the internal and external components as possible.

1. Attach the sealing plates and plugs as outlined in Step 1 of Method "A".

2. Loosen up the pipe plugs in the "F" seal ring plates and fill the block water jacket with a mixture of water and two (2) gallons of antifreeze. *Do not use methoxy propanol base antifreeze as it is detrimental to the water seals.*

The water passages between each set of "A" and "B" openings will have to be filled separately since these passages are separate from the rest of the cooling system.

3. When the block is completely filled and the air is vented through the pipe plugs, tighten the pipe plugs securely. Apply 40 psi (276 kPa) air pressure to the cooling system. Maintain this air pressure for at least two hours to allow the water and antifreeze mixture ample time to work its way through any cracks which may exist.

4. At the end of this period, examine the cylinder bores, airbox, oil passages, crankcase and exterior of the block for presence of the water and antifreeze mixture which will indicate cracks.

5. After the test is completed, remove the plates, plugs and seal rings, drain the cooling system and blow out the passages with dry compressed air.

Inspect Cylinder Block

After cleaning and pressure testing, inspect the cylinder block.

1. Make sure the seal ring grooves in the block bores are thoroughly clean. Then, inspect the grooves and lands for evidence of pitting and erosion. Seal rings are used in the two grooves above the air inlet ports. If the grooves are eroded to the extent that sealing is affected, the block must be replaced. A .01(T oversize cylinder liner to cylinder block water seal ring is available as a service item. Refer to Section 1.0 for the cylinder block rework dimensions.

2. Measure each cylinder block bore, at the positions indicated in Fig. 5, on axis 90° apart. If the diameter does not exceed 6.5260" at position "A", 6.5050" at position "B" and 6.4040" at positions "C" and "D" and a sealing problem has not occurred at position "B", the block may be reused. Also, the taper and out-of-roundness must not exceed .0015". Dial bore gage setting master fixture J 23059-01 may be used to set bore gage J 5347-B and dial bore gage extension J 5347-2 to zero.

3. When replacing cylinder kits, always inspect the cylinder liner flange seating surface in the cylinder block for nick, dents or corrosion damage. Coolant leakage can occur if the liner flange seating area is damaged or if the seat for the water sleeve and spacer seal ring is eroded. Carefully, remove all corrosion scale deposits from the seating surface and seal seating area with a wire brush, being careful not to cause further damage by excess use of the brush. Excessive wire brushing could cause another leak path. Inspect both seating surfaces for signs of pitting, fretting, nicks, dents and/or corrosion erosion. Corrosion damage can occur if coolant inhibitor strength is not properly maintained or if there are minor leaks.

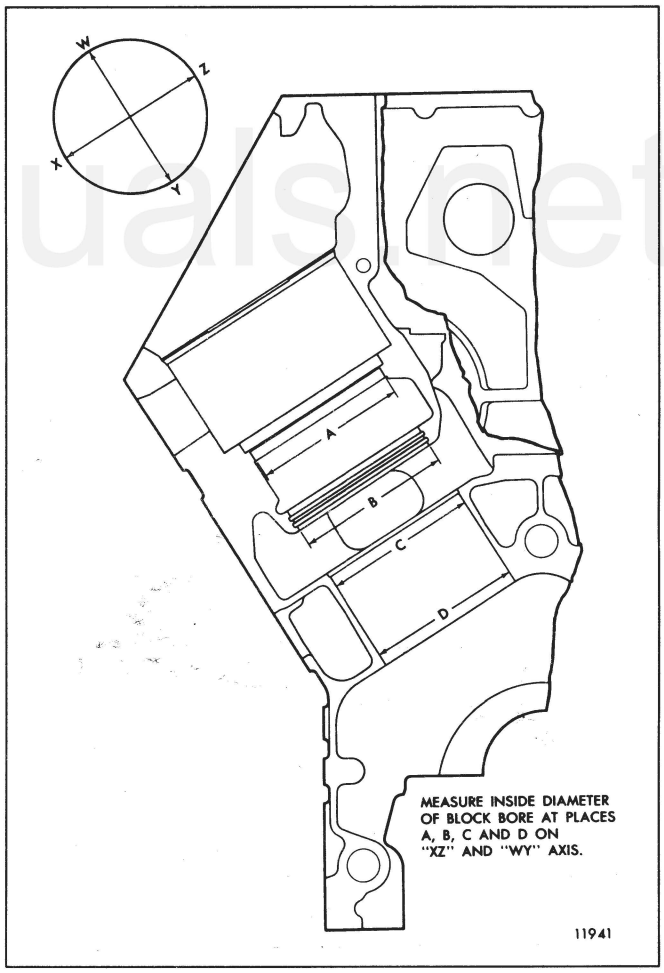


Fig. 5 – Block Bore Measurement Locations

BetterManuals.net

NOTICE: Avoid damaging the liner flange seating surface by completely loading one cylinder kit at a time. This procedure, as outlined in Section 1.6.3, is more desirable than setting the kits into the counterbores and allowing them to rest on the seating surfaces of the cylinder block waiting for complete loading. If kits are set into the counterbores and allowed to rest on the seating surfaces of the block until the technician can lower each kit into its bore, the seating surfaces can become nicked or dented without the knowledge of the technician.

Two methods can be used to check for liner seating surface damage (a leak path):

In both methods lightly blue the underside of a new liner flange with a small, short-bristle brush. Spread the Prussian blue thinly and evenly around the full circumference of the liner flange. Do not use excessive Prussian blue.

a. Install the liner in the block. Reinstall the cylinder head with a compression gasket and lightly snug down the cylinder head bolts. The use of a liner-to-block seal or head-to-block seal is not necessary for this check, but a new or used compression gasket must be used. Remove the head and liner and inspect the block counterbore.

b. Following the bluing procedure above, install the liner in the block (a block-to-liner seal is not required for this test). Press down firmly and evenly on top of the liner, then rotate the liner approximately 15° in each direction two or three times. Remove the liner and inspect the block counterbore.

After either method is used, inspection of the liner sealing surface will reveal leak paths where the Prussian blue did not transfer from the underside of the liner flange.

If inspection of the block indicates that the cylinder liner seat or water sleeve and spacer seal ring seat requires resurfacing, the crankshaft center line-to-cylinder liner seat distance must be measured before machining. This can be done using tool PT-5075B with kit PT-5071A. The current dimension is 17.895"—17.910" (Fig. 6). Although most cylinder blocks are factory machined to the side of this specification, only the minimum amount of material should be removed during the initial resurfacing operation (Fig. 7). This allows for additional resurfacing at future overhauls. Detroit Diesel recommends that this resurfacing operation be performed only by a competent machine shop.

NOTICE: Overmachining can cause improper piston-to-cylinder head clearance. This can result in serious engine damage.

4. In the former *counterbored* cylinder blocks, effective with approximate engine serial numbers 12E-1490 and 16E-233, a 3/8" x 1.20" long crimped-type sleeve (Fig. 8) is installed in each cylinder block water hole supplying coolant to the cylinder head. This prevents the possibility of the water hole seal ring from becoming dislodged from the counterbore in the cylinder liner flange area of the cylinder block.

If there is evidence of a crack at the cylinder liner flange fillet through to the water hole, remove the crimped sleeve and install a non-crimped sleeve (Fig. 8).

Install a *non-crimped* water hole sleeve as follows:

a. Ream the cylinder head-to-block water holes in the cylinder block. Use a 25/64" reamer to increase the hole diameter from 3/8" to 25/64". To facilitate reaming, grind a 3/8" diameter pilot 1/2" in length on the end of the reamer.

b. Clean the reamed holes and the counterbores thoroughly with a solvent.

c. Apply HVV "Loctite" pipe sealant to the surfaces of the newly reamed holes.

d. Install the water hole sleeves in the water holes with sleeve installer J 24233-01. The tool will install the sleeves to the proper depth so they will extend up into the counterbores sufficiently to retain the seal rings.

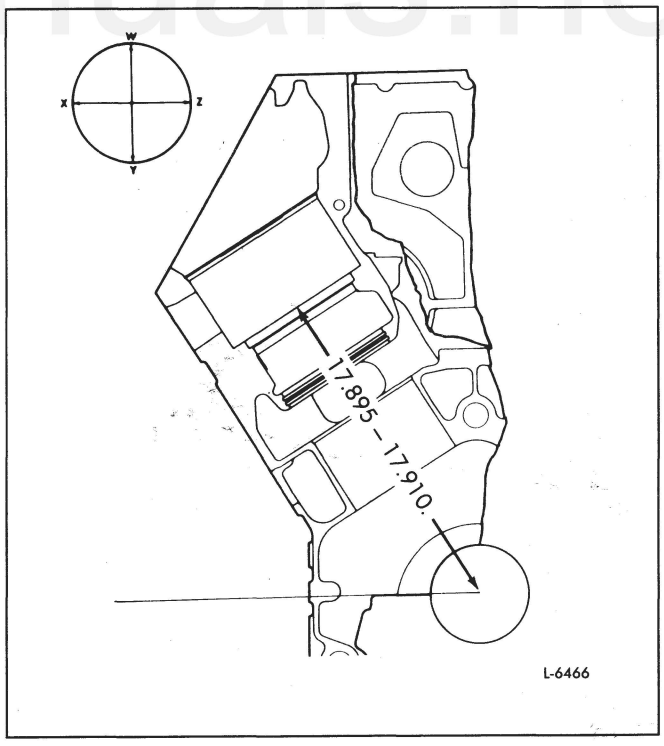


Fig. 6 - Crankshaft Center-to-Liner Seat Dimension

BetterManuals.net

 © Detroit Diesel Corporation

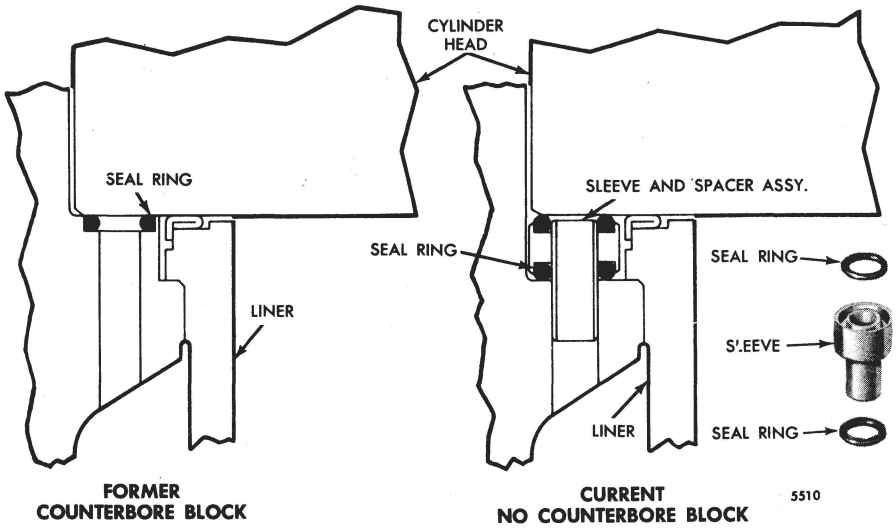


Fig. 7 - Former and Current Cylinder Block and Seal Rings

e. Clean the *Loctite* thoroughly from the counterbores.

f. Slip new red seal rings, which have an oval cross-section, over the sleeves and into the counterbores.

On engines built prior to the above serial numbers, a water hole sleeve must be installed the first time that the cylinder head is removed. Install a non-crimped sleeve whenever there is evidence of a crack or a leak at the cylinder liner flange fillet. Install the non-crimped sleeve when adequate facilities are available to insure the proper removal of all metal chips caused by the reaming process. Install crimped sleeves in water holes without leaks or cracks for "in-frame" overhauls.

Install *crimped* water hole sleeves as follows:

a. Clean the water holes and the seal counterbores thoroughly with a solvent.

b. Install the water hole sleeves in the water holes with sleeve installer J 24233-01. The tool will install the sleeves to the proper depth so the sleeves will extend up into the counterbore sufficiently to retain the seal rings.

In the current cylinder block, effective with engine serial numbers 12E-1703 and 16E-361, the counterbore for the cylinder liner was eliminated (Fig. 7). With the elimination of the counterbore for the cylinder liner, the small counterbores at the coolant holes were also eliminated. To conform with this change, a new coolant hole sleeve and spacer (serviced as a unitized assembly) is also used. In the current no-counterbore cylinder block, two seal rings are used at each coolant hole, one against the cylinder block and one against the cylinder head. The former counterbored cylinder block, with or without sleeves, used only one seal ring at each coolant hole.

The current sleeve is made from stainless steel and can be reused. Replace the seal rings each time the cylinder head is removed.

During extended engine operation, corrosion may build up in the water passages below the sleeves and prevent a new sleeve from seating properly. To properly clean the cylinder block water holes at engine overhaul, remove the old sleeve and use a hand or power driven 3/8" straight reamer. *Do not remove any cylinder block material.* Do not use a drill, abrasive paper or a wire brush. The reamer, with its straight flutes, will pilot in the undamaged portion of the water hole and will only remove the build up of corrosion. After cleaning the water hole, insert a new sleeve and spacer assembly without the lower seal ring. If the sleeve will hot bottom without forcing, repeat the cleaning operation.

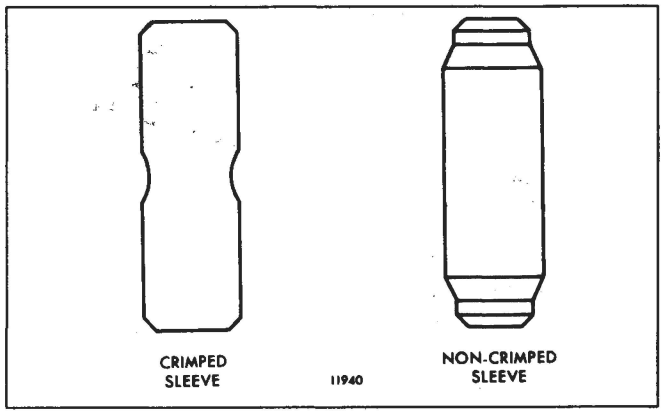
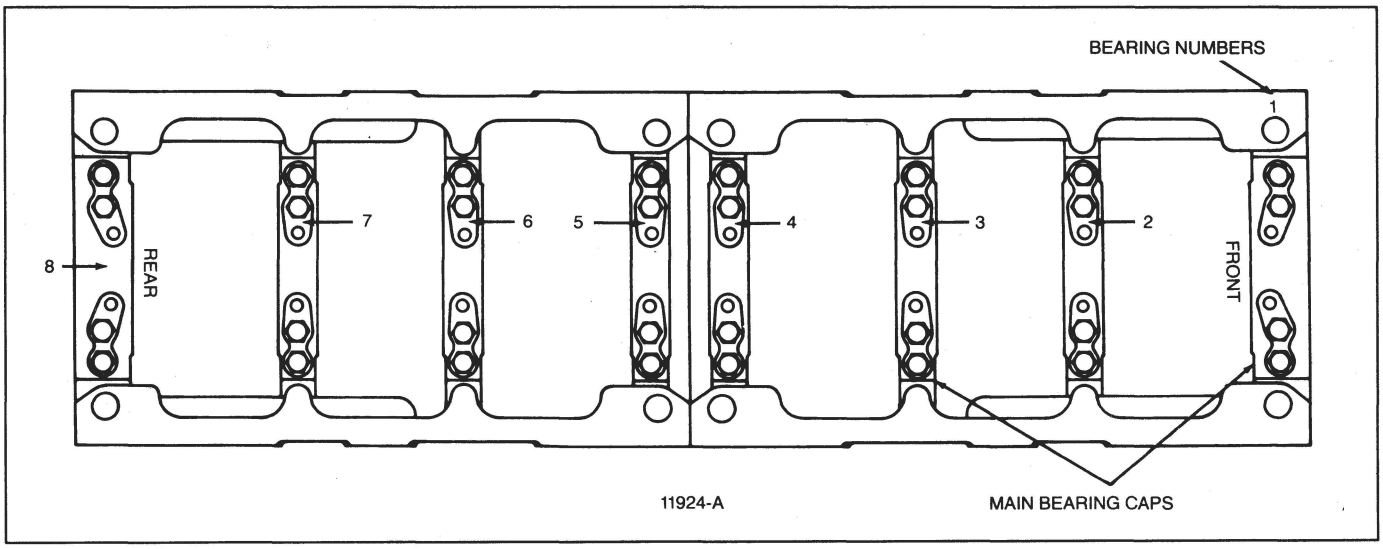


Fig. 8 - Water Hole Sleeves (Counterbored Cylinder Block)



• Fig. 9 - Typical Cylinder Block Markings

Only the current *no-counterbore* front and rear cylinder blocks are serviced. When replacing a former *counterbored* front or rear cylinder block with the current *no-counterbore block*, an additional seven (7) coolant hole seal rings per cylinder (14 per cylinder total) and seven (7) sleeve and spacer assemblies per cylinder are required.

The current *no-counterbore* block halves can be mixed with the former *counterbored* block halves in an engine.

5. Check the main bearing bores as follows:

   a. Check the bore diameters with the main bearing caps in their original positions. Bearing caps are numbered to correspond with their respective positions in the cylinder block. *It is imperative that the bearing caps are reinstalled in their original positions to maintain the main bearing bore alignment The number of front main bearing cap is also stamped on the face of the oil pan mounting flange of the cylinder block, adjacent to its permanent location in the engine as established at the time of manufacture.* The No. 1 main bearing cap is always located at the end opposite the flywheel end of the cylinder block (Fig. 9). Lubricate the bolt threads and bolt head contact areas with a small quantity of International Compound No. 2, or equivalent. Then, install and tighten the bolts to the specified torque (Section 1.0). The specified standard bore diameter is 5.1870" to 5.1880". If the bores do not fall within these limits, refer to *Shop Notes* in Section 1.0. Main bearing cap bolts are especially designed for this purpose and must not be replaced by ordinary bolts.

   b. Finished and unfinished main bearing caps are available for replacing broken or damaged caps. When fitting a *finished* replacement bearing cap, it may be necessary to try several caps before one will be found to provide the correct bore diameter and bore alignment. *If a replacement bearing cap is installed, be sure to stamp the correct bearing position number on the cap.* Use the unfinished bearing caps for the *front and intermediate bearing* positions. The finished bearing caps, machined for the crankshaft thrust washers, are to be used in the *rear bearing* position.

   c. Main bearing bores are line-bored with the bearing caps in place and thus are in longitudinal alignment. Bearing bores may be considered properly aligned with one another if the crankshaft can be rotated freely by hand after new bearing shells have been installed and lubricated and the bearing caps have been secured In place and the bolts tightened to the specified torque (Section 1.0). Misalignment may be caused by a broken crankshaft, excessive heat or other damage.

   d. If the main bearing bores are not in alignment when a replacement bearing cap is used, the block must be line-bored. *Install the bearing caps in their original positions and tighten the bolts to the specified torque (Section 1.0).* After boring, all bores must be within the specified limits of 5.1870" to 5.1880". However, if it is necessary to line bore the cylinder block oversize, refer to *Shop Notes* in Section 1.0.

BetterManuals.net

 © Detroit Diesel Corporation

6. Refer to the *Cylinder Block Plugging Charts* in Shop Notes - Section 1.0 and install necessary nut and dowels.

7. Air box top cover plates on all 16V-149TI engines built between engine serial numbers 16E-5376 and 16E-6261 should be visually inspected during shceduled maintenance. If the top cover plate is cracked, it must be replaced and the "T" shaped inspection hole cover and gasket installed in place of the square cover. If the top cover plate is not damaged, the square inspection hole cover should still be removed and replaced with the "T" shaped cover and gasket. Make sure that dirt, debris or moisture do not enter the engine during air box top cover plate inspection and installation.

8. Cup plugs are used to seal the breather holes in the cylinder block on current turbocharged engines using rocker cover breathers. To install cup plugs in early engines, refer to *Shop Notes* in Section 1.0.

9. Replace loose or damaged dowel pins. The dowels at the ends of the cylinder block must extend .6800". The dowels used to retain the crankshaft thrust washers on the rear main bearing cap must extend .110" to .120" from the surface of the bearing cap.

10. Check the cylinder block machined surfaces and threaded holes. Check all of the mating surfaces or mounting pads for flatness, nicks and burrs. Clean-up damaged threads in the tapped holes with a tap or install helical threaded inserts, if necessary.

11. After inspection, if the cylinder block is not to be used immediately, spray the machined surfaces with engine oil. If the block is to be stored for an extended period of time, spray or dip it in a rust preventive compound. Castings free of grease or oil will rust when exposed to the atmosphere.

Assemble And Install Engine

After the cylinder block has been cleaned and inspected, assemble the engine as follows:

Before a reconditioned or new service replacement cylinder block is used, thoroughly clean it to remove the rust preventive and blow out the oil galleries with compressed air.

1. If a new service replacement block is used, stamp the engine serial number and model number on the new block. Also, stamp the position numbers on the main bearing caps and the position of the No. 1 bearing on the oil pan mounting flange of the block.

2. Install all of the required cylinder block plugs and drain cocks. Use a good grade of non-hardening sealant on the threads of the plugs and drain cocks. Install the plugs flush with or below the surface of the block.

3. Clean and inspect all engine parts and subassemblies and, using new parts as required, install them on the cylinder required, install them on the cylinder block by reversing the sequence of disassembly. The procedures for inspecting and installing the various parts and subassemblies are outlined in the following sections of this manual.

4. Use a chain hoist and suitable sling to transfer the engine to a dynamometer test stand.

5. Complete the engine build-up by installing all remaining accessories, fuel lines, electrical connections, controls etc.

6. Operate the engine on a dynamometer, following the *run-in* procedure as outlined in Section 13.2.1.

7. Reinstall the engine in the equipment which it powers.

CYLINDER BLOCK DISASSEMBLY AND ASSEMBLY PROCEDURE (12V OR 16V ENGINES)

Disassemble Cylinder Block

1. Attach suitable lifting brackets to the end of the front cylinder block (Fig. 10).

• CAUTION: NEVER use eyebolts or any other commonly purchased hardware to lift the cylinder block. Due to the weight of the blocks, it is important that the lifting brackets are constructed (Fig. 10) and that all weld joints are magnafluxed prior to and periodically after initial use.

2. Attach a chain hoist to the brackets. Lift the cylinder blocks into a *vertical* position and rest the end of the rear cylinder block on a clean flat surface.

3. Refer to Fig. 11 and remove the fifteen (15) bolts securing the two (2) cylinder blocks together.

4. Remove four (4) 5/16"-18 x 5/8" bolts and lockwashers from the two (2) center upper cylinder block drain screens, located in the cylinder head area between both blocks. Remove both drain screens.

5. Lift the front cylinder block off of the rear cylinder block and remove the seal strip and seal rings from the rear block.

Better Manuals.net

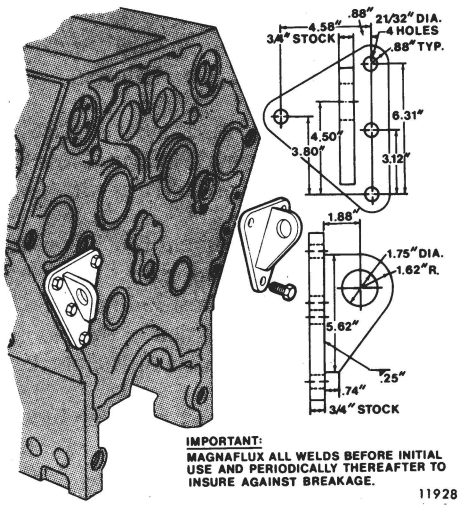


Fig. 10 - Details of Cylinder Block Lifting Plates

Inspection

Clean the cylinder blocks as outlined under *Clean Cylinder Block* in this section.

Examine the entire contact surface of each cylinder block. Remove any burrs with a suitable file or stone.

Check and clean the attaching bolt holes in each cylinder block with compressed air.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Examine and clean the cylinder block attaching bolts. Replace any of the bolts that are damaged or rusted.

Refer to the *Cylinder Block Plugging Chart* in Shop Notes - Section 1.0 and install the necessary plugs and dowels.

Assemble Cylinder Block

1. Place the rear cylinder block on a clean flat surface with the inter-block seal groove in the front end of the block facing up.

2. Check and clean the seal grooves and the entire top surface of the cylinder block.

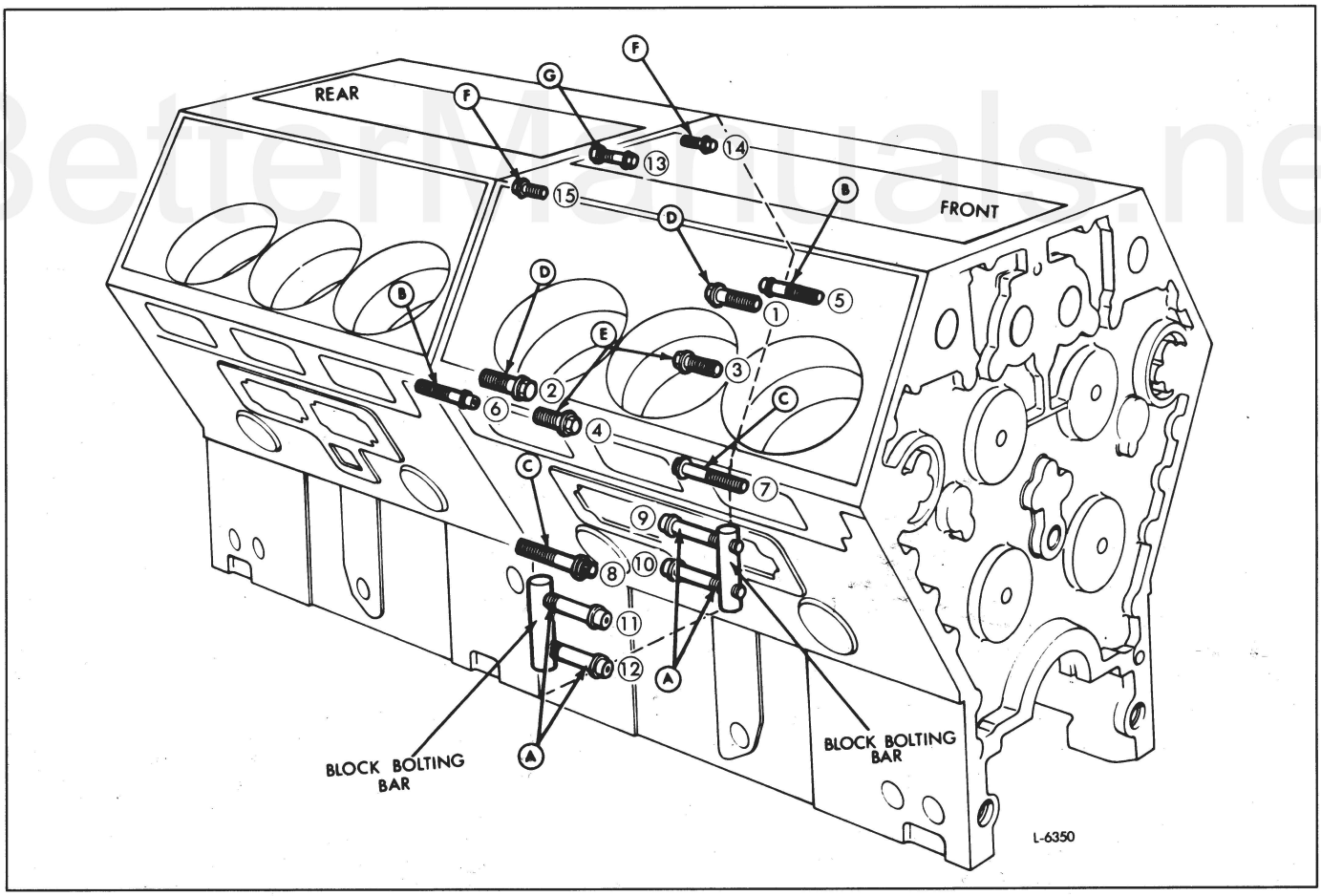


Fig. 11 – Location, Size and Tightening Sequence of Cylinder Block Attaching Bolts

BetterManuals.net

 © Detroit Diesel Corporation

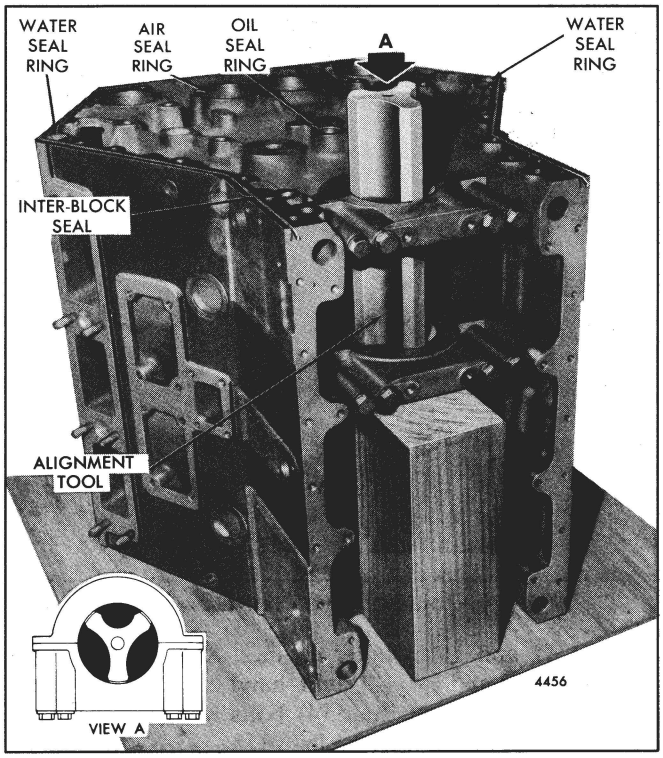


Fig. 12 - Positioning Crankshaft Bore Alignment Tool

3. Support the cylinder block bore aligning tool J 22486 (Fig. 12) and secure it to the block with two main bearing caps. Tighten the main bearing cap bolts to 280-290 lb—ft (379-393 N*m) torque. Place the cylinder block alignment tool in the main bearing bore with the three contact points of the tool located as shown in Fig. 12.

• 4. Apply a thin coat of Permatex High Tack Adhesive in the first 9" of the seal groove at the bottom of the block. Then, place a new inter-block seal in the groove in the block. Apply a thin coat of grease on the exposed flat surface of the inter-block seal. The inter-block seal must lay flat in the groove and must not be twisted.

#5. Apply a thin coat of spray adhesive around the edge of the oil gallery opening and place a new seal ring in position (Fig. 13).

• 6. Apply a thin coat of spray adhesive around the edge of the exhaust port coolant holes (Fig. 13) and place a new water seal ring in position in both holes.

• 7. Apply a thin coat of spray adhesive around the edge of the blower drive coupling hole (Fig. 12) and place a new air seal ring in position. Engines built prior to 12E-1040 and 16E-057 did not use the air seal ring. On these engines, apply a thin coat of sealant around the blower drive coupling hole.

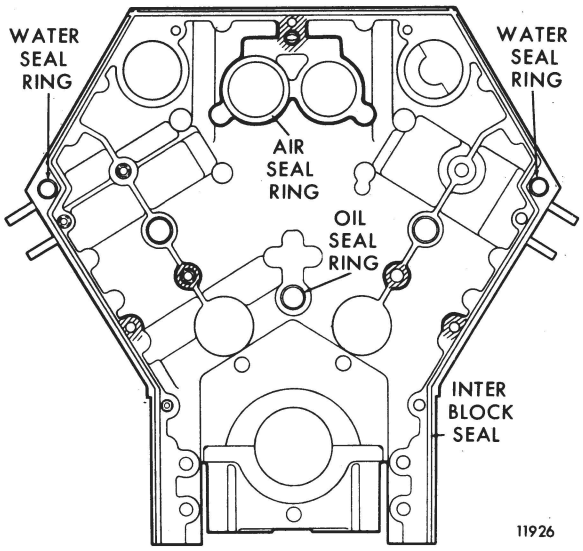


Fig. 13 - Locations For Sealant Application

• 8. Apply a thin coat of Loctite No. 515 Gasket Eliminator to the cylinder block as indicated by the shaded areas (Fig. 13). Clean any excess gasket eliminator from the cylinder block.

9. Attach the lifting brackets to the rear end of the front cylinder block (Fig. 10).

10. Attach a chain hoist to the brackets and lift the cylinder block approximately four feet off of the floor. Check and clean the entire lower end of the cylinder block. Carefully, position the front cylinder block over the rear cylinder block with the aligning tool against the crankshaft bore of the front block and the diamond-shaped dowel pin, pressed in the rear block, engaged with the dowel pin hole of the front block.

11. Place the rear main bearing cap of the front cylinder block in position over the alignment tool and against the cylinder block. Install the four main bearing cap bolts and tighten them to approximately 280-290 lb—ft (379-393 N«n) torque.

12. Move the sled gage J 22273-01 across the bottom faces (oil pan rails) of the cylinder blocks at the joint between the two blocks. The mismatch, if any, between the bottom faces of the two blocks must not exceed .003" on either side.

13. Fubricate the threads and the contact face of the cylinder block attaching bolts (except "G"-l/2"-20 x 2" bolt) with International Compound No. 2 or equivalent.

14. Position the two block bolting bars (Fig. 11) into the cylinder block and install the four (4) attaching bolts (A) and washers. Be sure to install cup plugs in the bolting bar holes.

Best Manuals

Bolt	Size	Torque	
		lb-ft	Nm
A	3/4"-10 Socket Head	.270-290	366-393
B	1/2"-13 Socket Head	75-85	102-115
C	5/8"-l 1, 12-Point	160-175	217-238
D	3/4"-10 x 3" Hex Head	270-290	366-393
E	3/4"-1 0 x 2-1/2" Hex Head	270-290	366-393
F	1 /2"-13, 12-Point	75-85	102-115
G	l/2"-20 Hex Head	85-95	115-129

Block Attaching Bolt Torques

15. Install the bolts and washers (B) through (F). A flat washer was used with the former socket head "B" f* bolts. Use torque wrench adaptor J 24533 when tightening "C" bolts. Refer to Section 1.3 for the IRr formular.

16. Install bolt, washer and nut (G) with the washer located on the bolt head side.

17. First snug all the bolts in sequence (Fig. 11). Then, tighten the bolts in the same sequence to the torque given in the Chart.

NOTICE: When tightening bolt (G), turn the bolt instead of the nut. Turning the nut will result in damage to the cylinder block.

18. Cut off the excess lengths of the block seal strip flush with the bottom face of the block.

19. Remove the cylinder block alignment tool.

20. Lift the cylinder block assembly with a chain hoist and place it in a horizontal position on a clean flat surface.

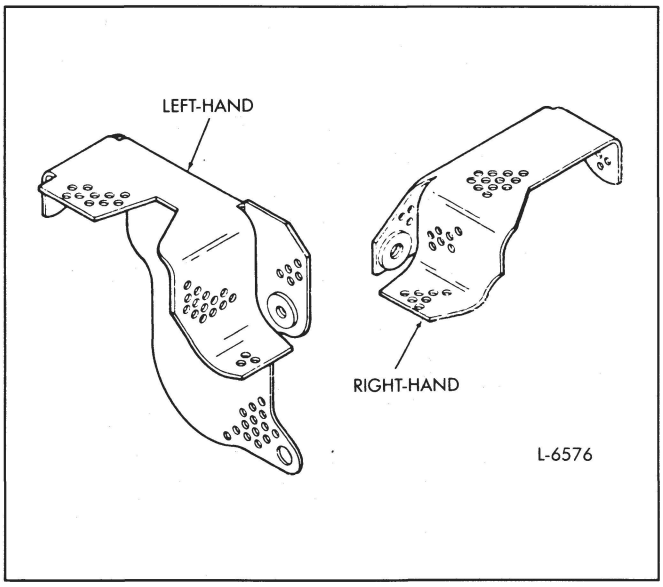


Fig. 14 – Injector Rack Guard Screens

• 21. On 12 and 16 cylinder engines, install the two (2) left-hand and two (2) right-hand injector rack guard screens (Fig. 14), four (4) bolts and lock washers. Tighten bolts to 13 - 17 lb—ft (18 - 23 N#m) torque.

NOTICE: Injector rack guard screens (Fig. 14) are used in place of cylinder block drain screens on all current 12V-149 and 16V-149 engines. Guard screens protect the injector control tube linkage passing through the front and rear block halves by preventing debris from wedging between the block and the injector control tube lever, jamming the racks. If racks are jammed at *full-fuel,* an overspeed condition and serious engine damage may result. *Guard screens must be replaced if removed.*

BetterManuals.net

 © Detroit Diesel Corporation

AIR BOX DRAINS

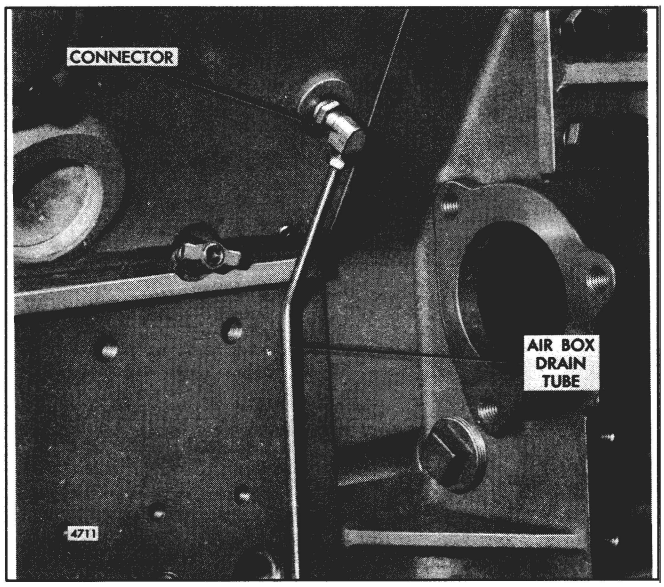


Fig. 1 - Typical Air Box Drain Tube

During normal engine operation, water vapor from the air charge, as well as a slight amount of fuel and lubricating oil fumes, condenses and settles on the bottom of the air box. This condensation is removed by air box drain tubes (Fig. 1) mounted on the sides of the cylinder block. One air box drain tube is installed in each corner of the cylinder block on 12 and 16V-149 engines. On 8V-149 engines, two rear drain tubes are used.

The air box drains must be kept open at all times, otherwise water and oil that may accumulate will be drawn into the cylinders.

Inspection

A periodic check for air flow from the air box drain tubes should be made (refer to Section 15.1).

BetterManuals.net

CYLINDER HEAD

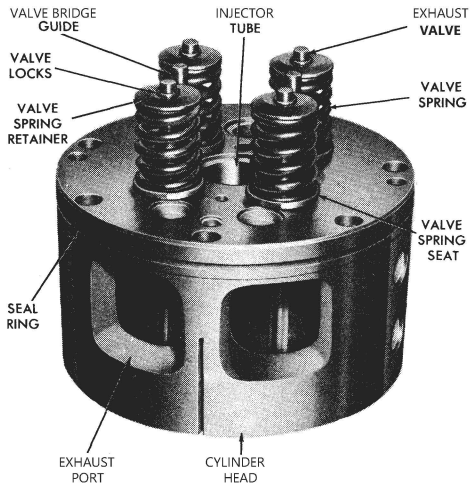


Fig. 1 - Cylinder Head Assembly

The 149 engines utilize an individual cylinder head (pot head) for each cylinder. Each cylinder head is recessed into the cylinder block and secured with seven special bolts and lock washers.

The cylinder head is a one-piece casting which houses the exhaust valves and the fuel injector (Fig. 1).

Exhaust valve seat inserts, pressed into the cylinder head, permit accurate seating of the valves under varying conditions of temperature and materially prolong the life of the cylinder head.

To ensure efficient cooling, the fuel injector is installed in a thin-walled tube which passes through the water jacket in the cylinder head. The lower end of the injector tube is pressed into the cylinder head and flared over; the upper end is flanged and sealed with a neoprene seal. The sealed upper end and flared lower end of the injector tube prevent water and compression leaks.

The exhaust passages from the exhaust valves of each cylinder head lead through two openings in the cylinder head, out through a single port in the cylinder block and then to the exhaust manifold. The exhaust passages are completely surrounded by engine coolant.

• To relieve thermal stresses, the current cylinder head incorporates a machined slot in the strut area between the exhaust ports. The former cylinder head had a 2.35" long slot. The current head has a 1" long slot.

A laminated metal gasket is used to seal compression between the cylinder head and the cylinder liner. Water passages between the cylinder head and cylinder block are sealed with a fluoroelastomer seal ring. The former Red silicone seal ring and the new Black fluoroelastomer seal ring are different in material, color and design. The new seal ring is larger in diameter to provide a larger sealing area. The former and new seal rings are interchangeable in an engine, however, only the black fluoroelastomer seal ring will be serviced.

Engines used in standby service, generator sets, fire pumps or other units in storage which were originally built (before 12E-5329 and 16E^{A}-4813) or subsequently overhauled using red silicone cylinder head-to-block seals should have these seals replaced with the black fluoroelastomer seals as a preventive maintenance measure to prevent the possibility of an internal coolant leak.

Cylinder Head Maintenance

The engine operating temperature should be maintained between 160-185°F (71-85°C) and the cooling system should be inspected daily and kept full at all times. When necessary, add water *slowly* to a hot engine to avoid rapid cooling which can result in distortion and cracking of the cylinder head (and cylinder block).

Abnormal operating conditions or neglect of certain maintenance items may cause cracks to develop in the cylinder head. If this type of failure occurs, a careful inspection should be made to determine the cause and to avoid a recurrence of the failure.

Unsuitable water in the cooling system may result in lime and scale formation which prevent proper cooling. At time of cylinder head overhaul, the cylinder head should be inspected around the exhaust valve water jackets. This can be done by removing an injector tube. Where inspection discloses such deposits, use a reliable noncorrosive scale remover to remove the deposits from the cooling system of the engine, since a similar condition will exist in the cylinder block and other components of the engine. Refer to Section 13.3 for engine coolant recommendations.

Loose or improperly seated injector tubes may result in compression leaks into the cooling system and also result in loss of engine coolant. The tubes must be tight to be properly seated. Refer to Section 2.1.4.

Remove Cylinder Head

Certain service operations on the engine require removal of the cylinder head:

1. Remove and install piston.
2. Remove and install cylinder liner.
3. Remove and install exhaust valves.
4. Remove and install exhaust valve guides.
5. Recondition exhaust valves and valve seat inserts.
6. Replace fuel injector tube.
7. Install new cylinder head gaskets and seals.

BellonManuals

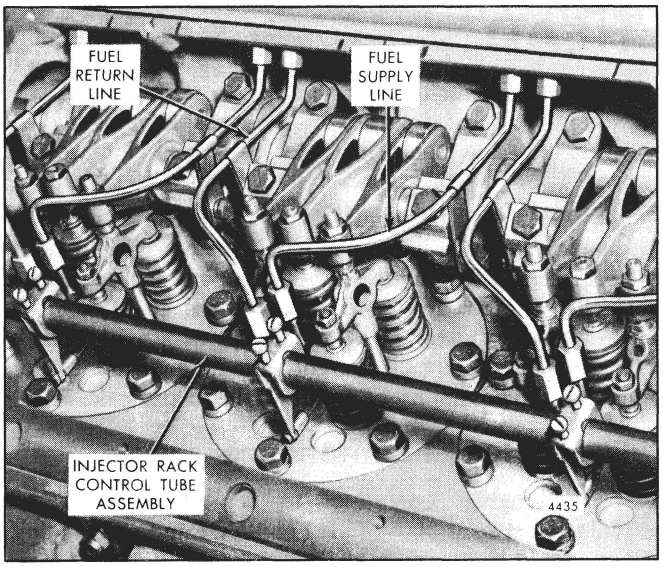


Fig. 2 - Location of the Injector Rack Control Tube Assembly

Due to various optional and accessory equipment used on the different engine models, only the general steps for removal of the cylinder head are covered. If the engine is equipped with special accessories that affect cylinder head removal, note the position of each before disconnecting or removing them to ensure correct reinstallation. Then, remove the cylinder head as follows:

1. Drain the cooling system.
2. Clean and remove the valve rocker cover.
3. Remove the clevis pin securing the fuel rod to the injector rack control tube (Fig. 2).
4. Remove the four bolts and lock washers securing the injector rack control tube assembly to the cylinder block and remove the control tube assembly.
5. Disconnect the fuel pipe support clips and remove the fuel supply and return pipes as follows:
   a. Disconnect the fuel pipe at the injector.
   b. Move the nut back on the pipe and slide a 3/8" I.D. hose over the open end of the pipe, being careful to avoid fuel spillage.

NOTICE: It will be necessary to loosen the fuel pipe nut at the fuel manifold a few turns to permit the fuel pipe to swing away from the injector.

   c. Drain the fuel into a container. This will prevent the fuel in the manifold from draining onto the cylinder head. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings.

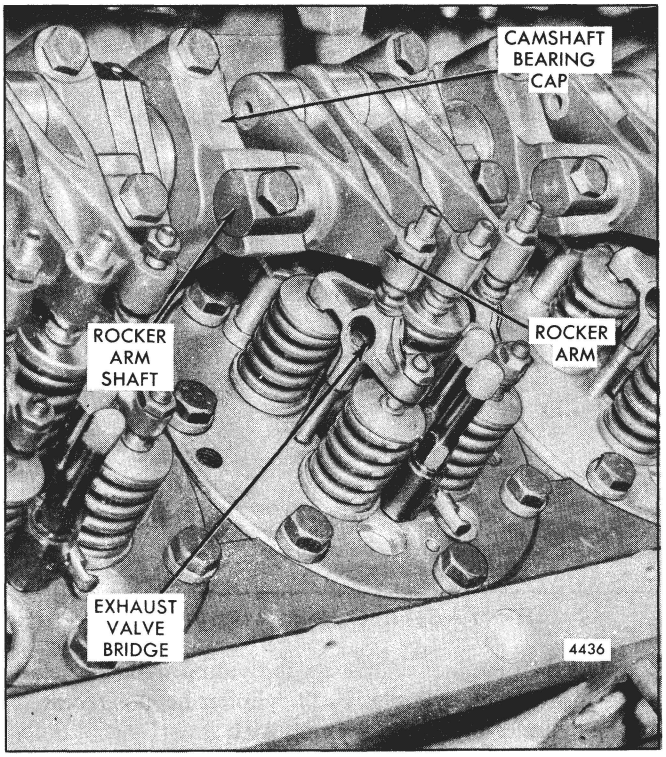


Fig. 3 - Rocker Arm Mechanism

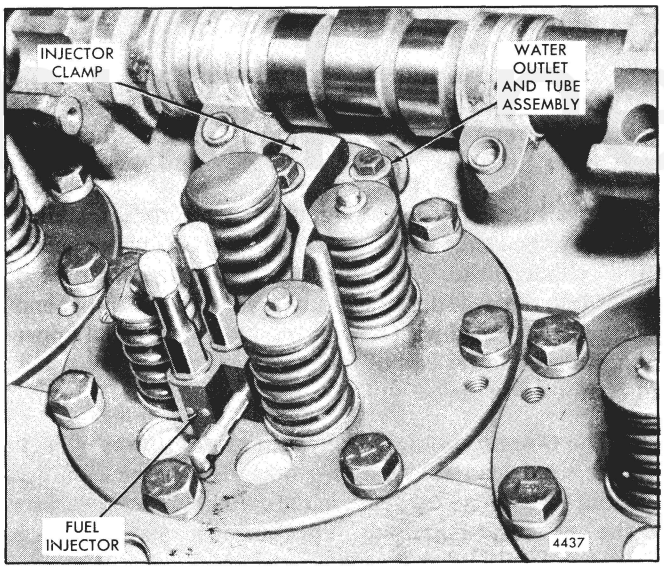


Fig. 4 - Location of the Fuel Injector and Water Outlet Elbow

   d. Cover the injector fuel inlet and outlet with protective caps.

6. Remove the two bolts securing the rocker arm shaft to the camshaft bearing caps and remove the shaft and rocker arm mechanism (Fig. 3).
7. Remove the two exhaust valve bridges from the exhaust valve bridge guides.

 © Detroit Diesel Corporation

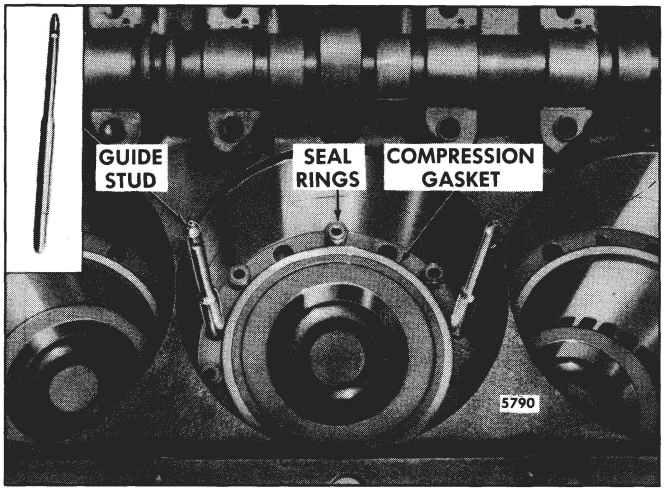


Fig. 5 - Location of Cylinder Head Compression Gasket and Seal Rings

8. Remove the fuel injector clamp and remove the fuel injector.

9. Remove the cylinder head water outlet elbow and tube assembly from the cylinder head and block (Fig. 4).

10. Remove the two camshaft bearing caps from the cylinder block. When removing the upper camshaft bearing caps and bearing inserts, matchmark their positions before removing.

11. Remove the seven special bolts and washers securing the cylinder head to the cylinder block and remove the cylinder head assembly, using cylinder lifting handles (Section 1.0) or tool J 24232. Be sure that the camshaft lobes are clear of the cylinder head before attempting removal.

12. Attach the cylinder head to cylinder head holding fixture J 23741-A.

#13. On former counterbored blocks, remove seal rings from counterbores. On current no-counterbore blocks, remove sleeve and spacer assemblies. Discard used seal rings. Remove and discard compression gasket.

If an integral head-to-block water seal assembly is used (no counterbore block), remove it *carefully* and discard the compression gasket. A seal assembly with low part hours (generally, up to 500 hours) may be reused *if it is not damaged.* Before reusing the seal assembly, the compression gasket (identified with red dye on the outside diameter) must be replaced. Compression gaskets are not reusable.

14. After the cylinder head has been removed, drain the lubricating oil from the engine. Draining the oil at this time will remove any coolant that may have worked its way to the oil pan when the head was removed.

Disassemble Cylinder Head

If complete disassembly of the cylinder head is necessary, proceed as follows:

1. Remove and discard the seal ring (Fig. 1) from the upper perimeter of the cylinder head.

2. Refer to Section 1.2.2 for removal of the exhaust valves and related parts.

Clean Cylinder Head

After the cylinder head has been stripped of all its component parts and all of the plugs have been removed, thoroughly have been removed, thoroughly steam clean the head. If the water passages are heavily coated with scale, remove the injector tube and clean the head in the same manner as outlined for cleaning the cylinder block (Section 1.1).

Clean all of the cylinder head components with fuel oil and dry them with compressed air.

CAUTIONrTo prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Inspect Cylinder Head

1. Before a cylinder head can be reused, it must be inspected for cracks. Five prescribed methods for checking a cylinder head for cracks are as follows:

If any method reveals cracks, the cylinder head should be considered unacceptable for reuse.

Magnetic Particle Method: The cylinder head is magnetized and then covered with a fine magnetic powder or solution. Flaws, such as cracks, form a small local magnet which cause the magnetic particles in the powder or solution to gather there, effectively marking the crack. The cylinder head must be demagnetized after the test.

Fluorescent Magnetic Particle Method: This method is similar to the magnetic particle method, but is more sensitive since it uses fluorescent magnetic particles which glow under a "Black Light". Very fine cracks, especially on discolored or dark surfaces, that may be missed using the Magnetic Particle Method will be disclosed under the "Black Light".

Fluorescent Penetrant Method: A highly fluorescent liquid penetrant is applied to the area in question. Then, the excess penetrant is wiped off the surface and the part is dried. A developing powder is then applied which helps to draw the penetrant out of the flaws by capillary action. Inspection to find the crack is carried out using a "Black Light".

BetterManuals.net

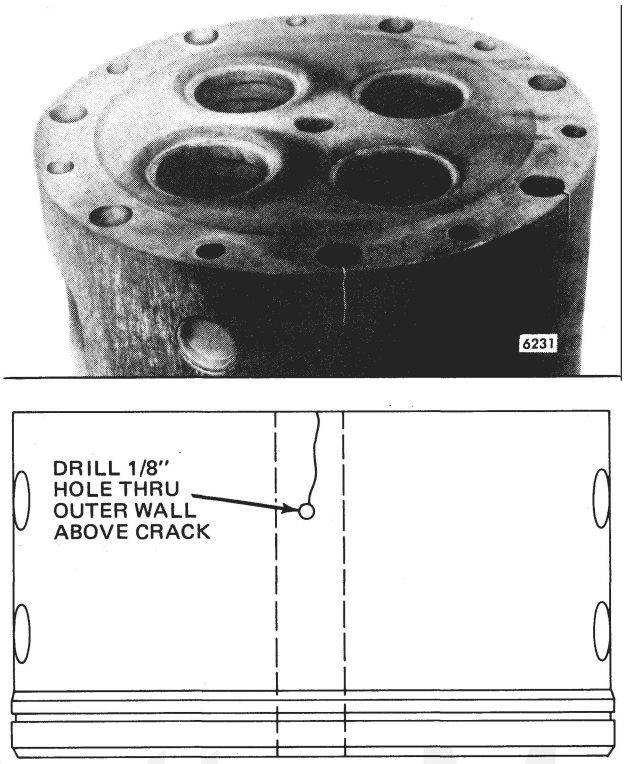


Fig. 6 - Outside Edge Bolt Hole Cracking (Head Reusable)

Non-Fluorescent Penetrant Method: The test area being inspected is sprayed with "Spotcheck" or Dye Check. Allow one to thirty minutes to dry. Remove the excess surface penetrant with clean cloths premoisened with cleaner/remover. DO NOT flush surface with cleaner/remover because this will impair sensitivity. Repeat this procedure with additional wipings until residual surface penetrant has been removed. Shake developer thoroughly until agaitator rattles. Invert spray can and spray short bursts to clear valve. Then spray this developer film evenly over the test area being inspected. Allow developer film to dry completely before inspecting. Recommended developing time is 5 to 15 minutes.

The above four methods provide basic instructions. Specific details should be obtained from the supplier of the equipment or material.

Pressure Check Method: Pressure check the cylinder head and inspect it for indications of cracking as follows:

a. Seal off the water holes in the head with suitable plates and gaskets. Drill and tap one of the plates for an air hose connection.

b. Install a scrap or dummy injector to ensure proper seating of the injector tube. A dummy injector can be made from an old injector nut and body — the spray tip is not necessary. Tighten the injector clamp bolt to 46-50 lb—ft (62-68 N#m) torque.

c. Apply 40 psi (276 kPa) air pressure to the water jacket. Then, immerse the cylinder head in a tank of water, previously heated to 180-200°F (82-93°C), for about twenty minutes to thoroughly heat the head. Observe the water in the tank for bubbles which indicate a leak or crack.

d. Relieve the air pressure and remove the cylinder head from the water tank. Then remove the plates, gaskets and injector and dry the head with compressed air.

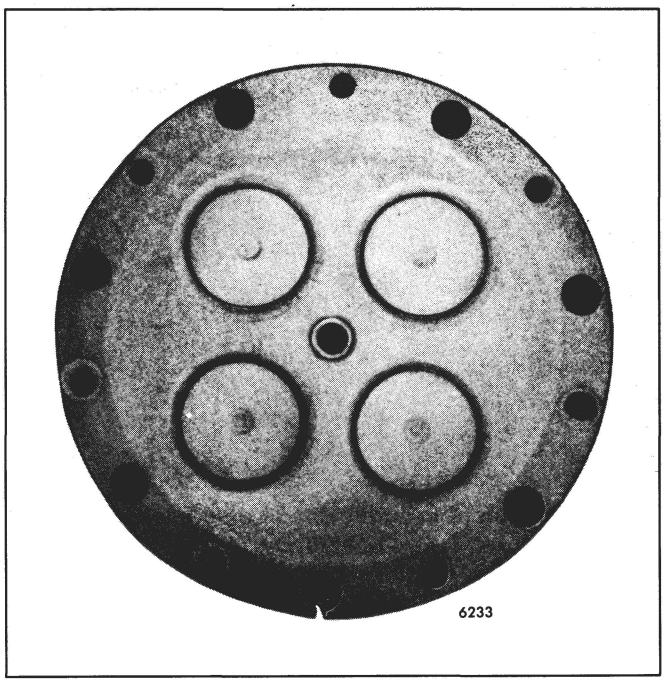


Fig. 7 - Sunburst Cracks (Head Reusable)

Minor cracking found on the surface of the cylinder head does not necessarily affect the reliability of the head. Since inspection reveals harmless as well as harmful cracking, interpretation of the cracking is the most important step.

The following is Detroit Diesel's position regarding the reuse of Series 149 cylinder heads which show evidence of cracking:

a. Cylinder heads with outside edge bolt hole cracking can be reused ifa 1/8" hole is drilled through the outer wall above the crack into the bolt hole (Fig. 6). This stops the progression of the crack.

BetterManuals.net

 © Detroit Diesel Corporation

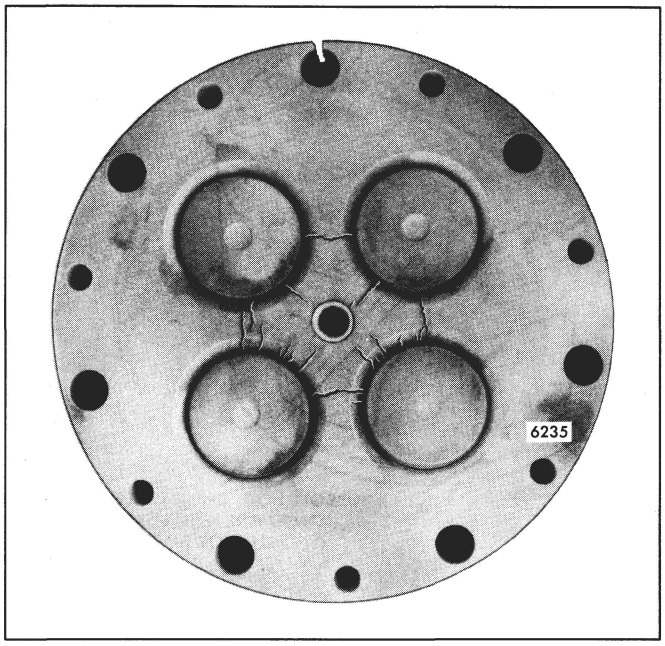


Fig. 8 - Valve-to-Valve or Valve-to-Injector Tube Hole Cracks (Head Not Usable)

b. Cylinder heads with valve hole sunburst checking can be reused without resurfacing cylinder heads. However, if any valve hole sunburst cracks intersect with each other, with an adjacent valve hole or with the injector tube hole, the cylinder head must be resurfaced before it can be reused. If resurfacing removes the cracks (Fig. 7), the cylinder head may be reused. If the cracks are still present after resurfacing, the cylinder head should be replaced.

c. Cylinder heads with cracks that extend from valve-to-injector tube hole (Fig. 8) should be considered unacceptable for reuse. The progression of these types of cracks may cause coolant leakage into the cylinder areas, resulting in severe engine damage.

d. Cylinder heads with cracks in the inside edge of the exhaust port bolt hole can be reused if the following criteria are met:

1. The head is cracked in the bolt hole only and the crack does not extend onto the firedeck surface (Fig. 9).
2. The head is cracked in the bolt hole and extends onto the firedeck surface when first checked, but the crack is so minor that, after resurfacing the firedeck, the crack is no longer detectable on the flat surface (Fig. 10).
3. After resurfacing the cylinder head firedeck, break the sharp edge of each bolt hole (7 places) to the following specification: .005"-.025" x 45° ± 5°.

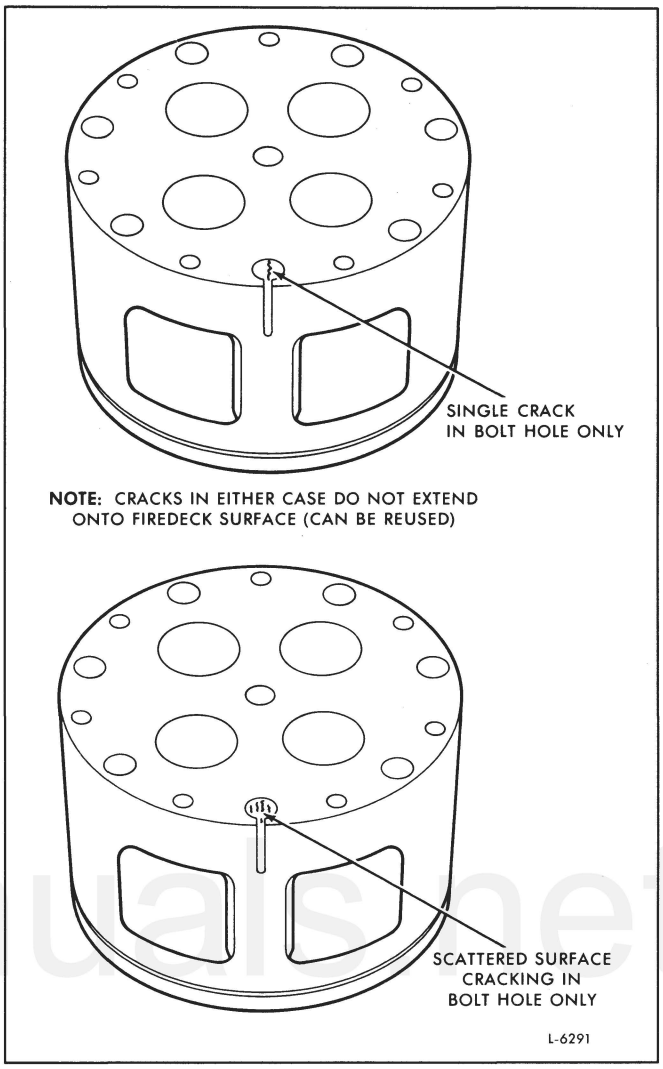


Fig. 9 – Bolt Hole Crack (Head Reusable)

4. Heads should not be reused if the bolt hole cracking extends onto the firedeck and *cannot* be removed with normal resurfacing (Fig. 11).

The Series 149 cylinder head will provide satisfactory service life provided the cooling system is properly maintained. Operating an engine with scale deposits in the cooling system, a leaking cooling system, aerated coolant, a low coolant level or inadequate coolant inhibitor may allow the engine to overheat. This can cause head cracking and/or serious engine damage.

2. Check the bottom (fire deck) of the cylinder head for flatness with a heavy, accurate straight edge and feeler gages. The surface must be held flat within .004". If it becomes necessary to reface the cylinder head, remove the injector tube prior to machining. The distance from the fire deck to the machined surface at the top of the head must not be less than 4.7350". The height of a new cylinder head is 4.7450" to 4.7550".

Betta Manuals.net

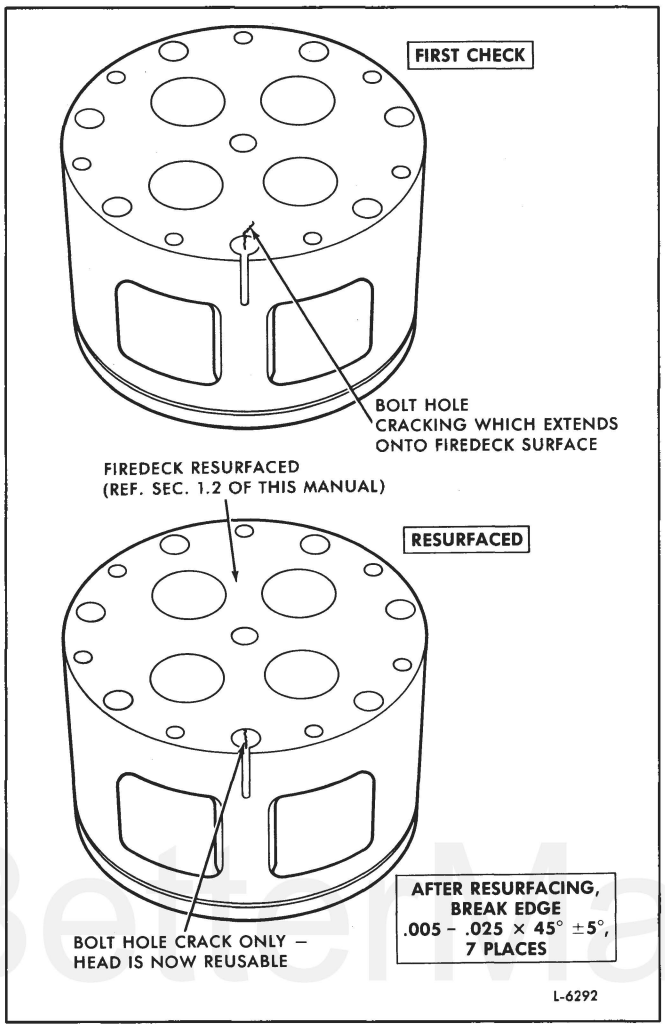


Fig. 10 - Bolt Hole Crack into Firedeck (Head Reusable - Resurfacing removes Crack)

NOTICE: When a cylinder head has been refaced, critical dimensions such as the protrusion of valve seat inserts, exhaust valves, injector tube and injector spray tip must be checked and corrected.

3. Install a new injector tube (Section 2.1.4) if the old tube leaked or the cylinder head was refaced.

4. Inspect the valve seat inserts and valve guides (refer to Section 1.2.2).

5. Inspect all other components removed from the cylinder head.

If a service replacement cylinder head is to be installed, it must be thoroughly cleaned of all rust preventive compound. Immerse the cylinder head in solvent, mineral spirits or fuel oil, then scrub the head and go through all of the openings with a soft bristle brush. After cleaning, dry the cylinder head with compressed air.

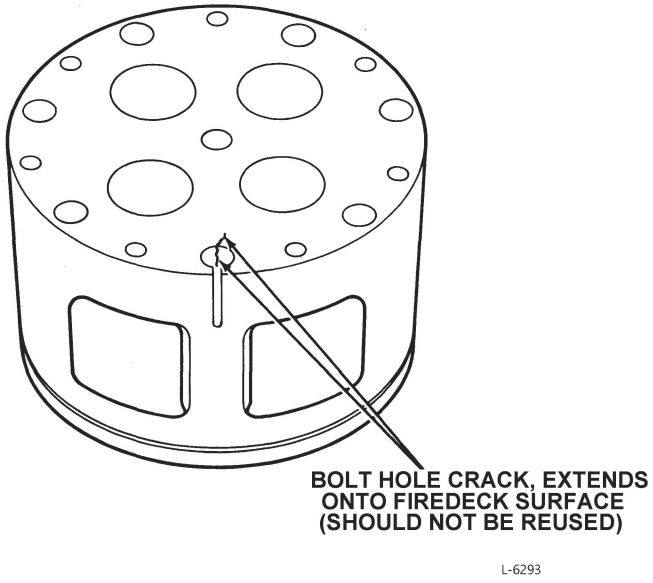


Fig. 1 1 - Bolt Hole Crack into Firedeck (Head Not Reusable - Resurfacing does not remove Crack)

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

A service replacement cylinder head includes the exhaust valve guides, valve seat inserts, bridge guides, injector tube and the necessary plugs.

Assemble Cylinder Head

After cleaning and inspection, assemble the cylinder head as follows:

• 1. Apply a thin, continuous coat of Permatex High Tack Adhesive Sealant 98D or 98H (or equivalent) to the outside diameter of all cup plugs and exhaust valve bridge guides. *Do not use R TV silicone sealan t in these areas, since RTVmay not provide a proper seal.* Refer to the table and install plugs to the proper depth below the surface 6f the cylinder head.

Size Plug	Quantity	Depth below surface of head
1 /2" did. .889" dia. 1" dia.	1 6 2	.090" .095"-.105" .095"-.! 10"

TABLE 1

 © Detroit Diesel Corporation

2. Install the exhaust valves, valve seat inserts and springs (Section 1.2.2).

3. Make sure the seal ring groove at the upper perimeter of the head is clean. Then, lubricate a new seal ring with vegetable shortening and place it in the cylinder head groove (Fig. 1).

Pre-Installation Inspection

Make the following inspections just prior to installing the cylinder head whether the head was removed to service the head only or to facilitate other repairs to the engine.

1. Check the cylinder liner flange height with relationship to the cylinder block (Section 1.6.3).

2. Make sure the piston crown is clean and free of foreign material.

3. Check to ensure that the compression gasket area of the cylinder head is free of nicks.

4. Inspect the cylinder head bolt holes in the block for accumulation of water, oil or any foreign material. Clean the bolt holes thoroughly and check for damaged threads.

5. Uncoated cylinder head mounting bolts replaced coated bolts approximately July 1, 1983, on all Series 149 engines for production and service. When replacing a former cylinder head mounting bolt with the new, all the bolts in a cylinder must be changed. Always install new cylinder head attaching bolts at time of engine overhaul.

Install Cylinder Head

1. Refer to Fig. 5 and install the seal rings and compression gasket as follows:

   a. Place a new compression gasket on top of the cylinder liner. Never install used compression gaskets or seal rings.

   • b. On former counterbored blocks (Fig. 12) place a new seal in each block counterbore, On current no-counterbored blocks, place a new seal on each end of the sleeve and spacer assemblies and install in block.

   If an integral head-to-block water seal assembly (Fig. 13) is used, make sure the compression gasket (identified with red dye on the O.D. surface) is installed on the seaL A seal assembly removed from an engine with low part hours (generally, up to 500 hours), may be reused if it is not damaged. When checking the seal, look especially for splits or tears in the seven cylinder head bolt sealing areas. Compression gaskets are not reusable and must be replaced.

   Apply a light coating of clean engine oil to the circumference (O.D.) of the seal assembly. With the DDC logo and part number facing up and the narrow edge of the compression gasket pointing down, place the seal assembly into the block bore and more it down until it rests on the cylinder block liner flange surface. If a reusable seal assembly is being installed, make sure the best bolt hole seal is at the 6:00 (exhaust port bolt hole) position.

   NOTICE: Seals must drop into position without forcing or bending and must rotate easily for approximate alignment with bolt holes. This is necessary to avoid seal damage when the cylinder head is installed. If a seal hangs up or appears not to fit well, try rotating and moving it as it is being installed. If a seal must be bent or forced into place, remove and do not reuse it.

.2. Install two guide studs (set J 28511-A) at approximately the 9:30 and 2:30 positions in the cylinder block (Fig. 5). These studs ensure correct cylinder head-to-water seal alignment. The lower shaft diameter of the guide studs pilots on the inside diameter of the bolt hole threads.

NOTICE: Before installing guide studs on engines with integral head-to-block water seal assemblies, inspect the bottom (larger diameter) ends for burrs which may damage the seal. If necessary remove the burrs with a stone or extra fine emery cloth.

To install guide studs on engines with integral head-to-block water seal assemblies, lubricate the larger diameter ends with clean engine oil and insert these ends through the seal. Work studs into the bolt holes in the block until they bottom.

• 3. Lubricate a new cylinder head seal ring with clean engine oil and install it in the upper seal ring groove in the cylinder head.

4. Attach cylinder head lifting tool J 24232 or lifting handles.

5. Make a final visual check of the compression gasket and seal rings to ensure that they are in place and that the camshaft lobes are clear.

• 6. Wipe the bottom of the cylinder head clean and lower it over the guide studs and into place in the cylinder block. Allow it to slide into the bore as far as it can go.

• 7. Using a plastic or rubber mallet, rap the top of the cylinder head a few times to ensure that the head is all the way down. *Avoid contacting any mechanism on top of the head.*

Beta Manuals

• 8. Apply a small quantity of International Compound No. 2, or equivalent, to the threads and the underside of the head of each cylinder head attaching bolt. Then install the bolts and washers finger tight. When integral head-to-block water seal assemblies are installed, place five of the seven bolts (with washers) into the bolt holes, allowing them to stand on top of the seal. To'avoid damaging the seal, *Do Not Push Bolts Through.* Thread the bolts through the seal into the head. Run bolts down snug just short of moving the cylinder head downward.

• **NOTICE:** DDC does not recommend reusing cylinder head bolts at major overhaul. Use new bolts. The cylinder head attaching bolts are identified by the dark shank (heat treated) and six *raised* marks on the bolt heads. *Do not use any other type bolts* or severe stretching or bolt breakage may result when the bolts are drawn down to the specified torque. The machined surface under the head of the current bolts has a minimum diameter of .798" to provide additional bolt to washer clamping area.

• 9. After the head is in place, remove the guide studs (by pulling and rotating, if necessary) and the cylinder head lifting tool, and install the remaining bolts and washers. Run all bolts down snug tight with a speed handle - 15-20 lb-ft (20-27 N*m) torque. Use a cross-pattern sequence.

10. Draw the cylinder head down gradually and uniformly to ensure a good seal between the head and the block. Tighten every other bolt gradually and uniformly in 50 lb-ft (68 N*m) increments until all of the bolts are tightened to 140-150 lb-ft (190-204 N*m) torque. Apply a steady pressure for two or three seconds at the prescribed torque to allow the bolts to turn while the gaskets yield to their final designed thickness.

NOTICE: Tightening the cylinder head bolts will not correct a leaking compression gasket or seal. The head must be removed and the damaged gasket or seal replaced.

.11. Assemble two (2) seal rings to cylinder head water outlet tube. Coat seal rings with Crisco after installation.

.12, Place one (1) water outlet elbow seal in the counterbore in the cylinder head. Install one end of the tube into the water outlet elbow. Install the other end of the tube in the cylinder block and secure the elbow to the cylinder head with two (2) bolts. Tighten bolts to 13-17 lb-ft (18-23 N«m) torque

13. Install the upper camshaft bearing inserts in the upper bearing caps (if removed) and lubricate them with clean engine oil. Place the camshaft bearing caps over the camshaft and secure them with the top bolts. Do not tighten the bolts at this time.

14. Place the fuel injector in the cylinder head injector tube _ and secure it with the injector retainer clamp and bolt (Fig. 4). Tighten the clamp bolt to 46-50 lb-ft (62-68 N*m) torque. Make sure there is clearance between the injector clamp and the injector spring.

15. Position the two exhaust valve bridges over the bridge guides (Fig. 3). Refer to Section 1.2.2 for the exhaust valve bridge adjustment procedure.

16. Place the rocker arm mechanism in position and secure it to the camshaft bearing cap with two bolts (Fig. 3). Tighten all four camshaft bearing cap bolts to 90-100 lb-ft (122-136 N*m) torque.

17. Install the fuel supply and fuel return pipes (Fig. 2).

NOTICE: DDC recommends that the original flared end fuel pipes not be reused. New flared end fuel pipes should be installed.

Use adaptor J 21545 and an appropriate torque wrench and tighten the fuel pipe-to-injector nuts to 18-22 lb-ft (24—30 N*m) torque. Tighten the fuel pipe-to-fuel manifold connector nuts to 18-22 lb-ft (24-30 N*m) torque using fuel line wrench set J 26617. Install the fuel line clips.

NOTICE: Do not exceed the specified torque. Excessive tightening will twist or fracture the flared ends of the fuel pipes and result in leaks. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings (refer to *Fuel Jumper Line Maintenance and Pressurize Fuel System-Check for Leaks* in Shop Notes-Section 2.0)

*18. Place the injector rack control tube assembly (Fig. 2) in position, with the control tube levers engaged with the injector racks, and secure it with four bolts and lock washers. Tighten to 13-17 lb-ft (18-23 N«m) torque. Adjust assembly until there is no bind.

19. Install the fuel rod-to-injector rack control tube clevis pin.

20. Fill the cooling system and check for leaks.

21. Prime the fuel system, using primer tool J 5956 or a comparable priming device.

22. Refer to Section 13.1 under *Preparation for Starting Engine First Time* and fill the cooling system and lubrication system.

23. Before starting the engine, perform an engine tune-up as outlined in Section 14.

It will only be necessary to perform the engine tune-up on ihe individual cylinder head that was worked on. However, check the adjustment of all injector racks of the cylinder bank to make sure the adjustments have not changed.

 © Detroit Diesel Corporation

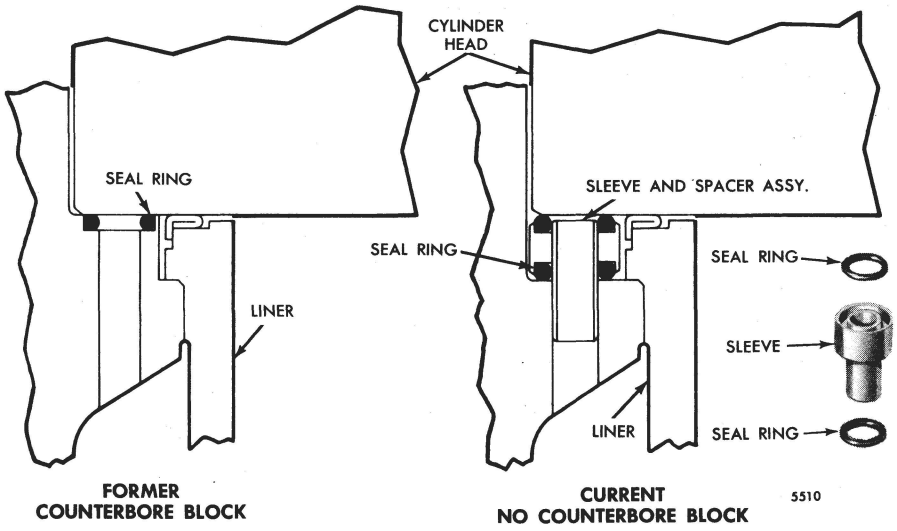
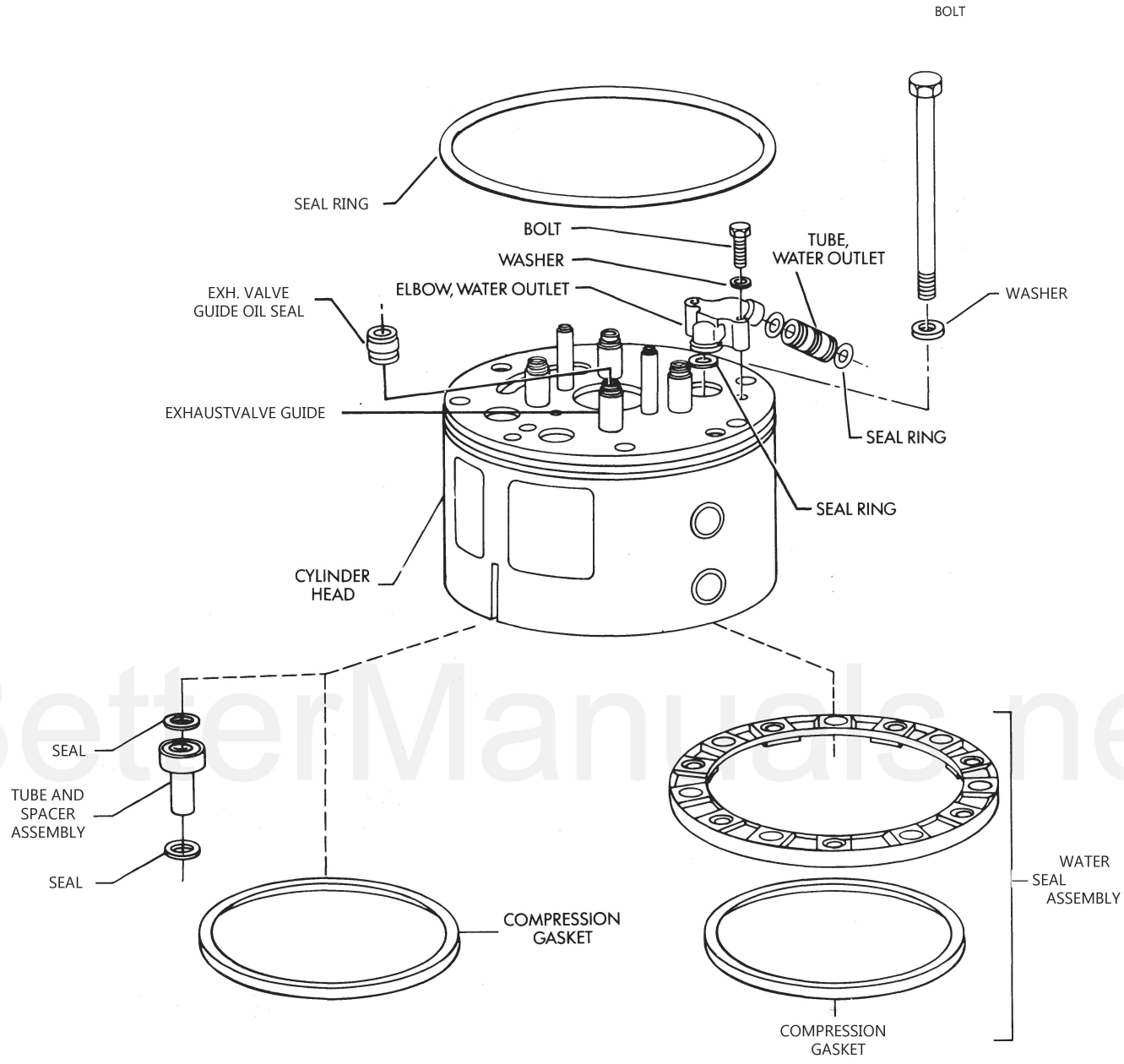


Fig. 12 - Former and Current Cylinder Blocks and Seal Rings

BetterManuals.net



• Fig. 13 - Standard and Optional Cylinder Head-to-Block Seal Seals

BetterManuals.net

 © Detroit Diesel Corporation

VALVE AND INJECTOR OPERATING MECHANISM

Three rocker arms are provided for each cylinder; the wo outer arms operate the exhaust valves and the center arm operates the fuel injector (Fig. 1).

Each set of three rocker arms pivots on a shaft supported by two camshaft bearing caps. Two bolts secure the shaft to the bearing caps. Removal of the bolts permits removal of the rocker arm assembly and easy access to the fuel injector and exhaust valve springs.

Each rocker arm has a hardened roller at one end which rides directly on the camshaft lobe to actuate an exhaust valve or the fuel injector. This overhead camshaft arrangement gives a positive direct contact of camshaft-to-rocker arm with fewer parts.

To minimize wear, the rocker arms contain bushings for both the rocker arm shaft and the roller pins.

One end of the rocker arm has an adjusting screw, lock nut, valve button and valve button retainer. The valve button offers a positive flat seating surface against the exhaust valve bridge pallet or injector follower. It also reduces wear as it is lubricated from the engine lubricating system.

Lubrication

The valve and injector operating mechanism is lubricated from the camshaft bearing caps where the lubricating oil is picked up from the grooves in the camshaft bearings. The lubricating oil enters the rocker arm shaft through drilled passages in the bearing caps. From there the oil follows the drilled shaft to each rocker arm where it enters a drilled passage leading to the valve adjusting screw. Lubricating oil is then directed through another drilled passage in the valve adjusting screw where it lubricates the frictional surfaces between the base of the adjusting screw and the valve button.

The contact surface between the camshaft lobes and the rocker arm rollers is lubricated by jets machined into the bearing caps which spray oil onto the rollers.

Remove Valve And Injector Operating Mechanism

1. Clean and remove the valve rocker cover.

2. Remove the fuel supply and fuel return pipes as follows:

   a. Disconnect the fuel pipe at the injector.

   NOTICE: Immediately after removing the fuel pipes, cover the injector fuel inlet and outlet openings with shipping caps to prevent dirt or foreign material from entering.

   b. Move the nut back on the pipe and slide a 3/8" I.D. hose over the open end of the pipe, being careful to avoid fuel spillage.

   NOTICE: It will be necessary to loosen the fuel pipe nut at the fuel manifold a few turns to permit the fuel pipe to swing away from the injector.

   c. Drain the fuel into a container. This will avoid the fuel in the manifold from draining onto the cylinder head. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings.

3. Remove the two bolts securing the rocker arm shaft to the camshaft bearing caps and lift off the valve and injector operating mechanism.

   NOTICE: After removing the rocker arms, tag all of the parts so they may be reinstalled in their original positions.

4. Remove the two valve bridges from the exhaust valves and guides.

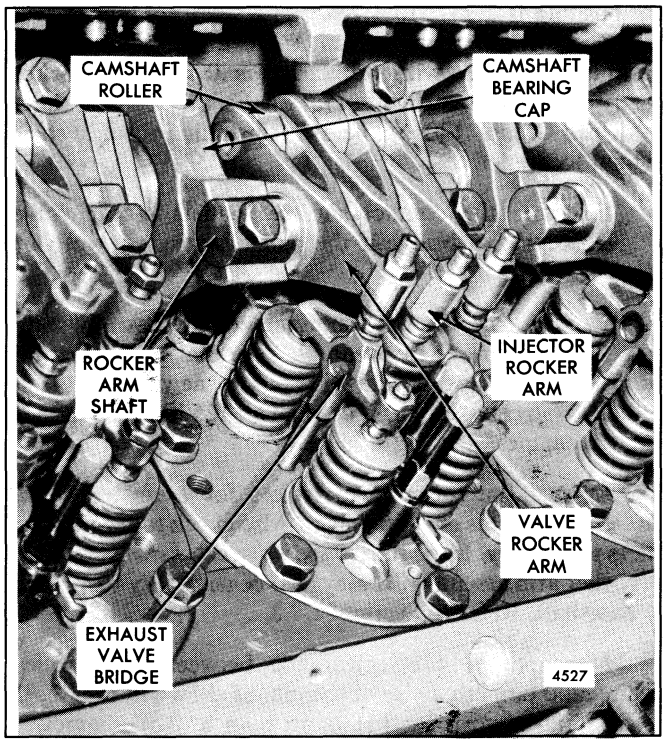


Fig. 1 - Valve and Injector Operating Mechanism

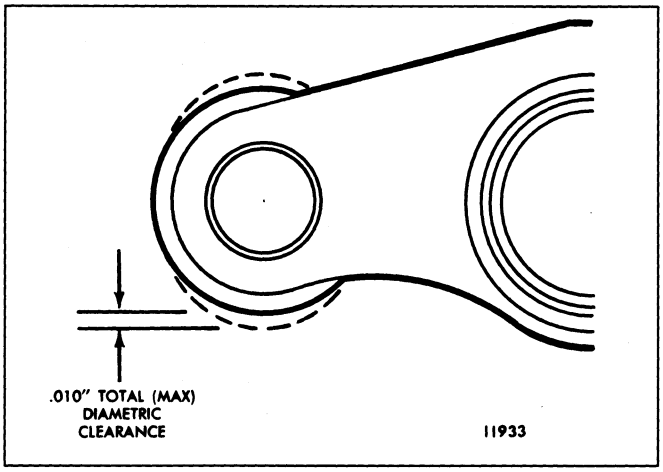


Fig. 2 - Rocker Arm Roller Wear and Clearance Diagram

Inspection

Wash the rocker arm assemblies with lubricating oil or Cindol 1705 and wipe dry. *Do not use fuel oil.* Fuel oil working its way in between the roller bushing and pin may cause scoring on initial start-up of the engine since fuel oil does not provide adequate lubrication. Wash the rocker arm shaft and valve bridges in clean fuel oil and dry them with compressed air. Make certain all of the drilled oil passages are open and clean.

Inspect the rocker arm shaft and rocker arm bushings for excessive wear. The diameter of a new rocker arm shaft is 1.2295" to 1.2300" and the inside diameter of a new rocker arm bushing is 1.231" to 1.232". The shaft-to-rocker arm clearance with new parts is .0010" to .0025" and the maximum clearance with worn parts is .004". If the rocker arm assemblies are satisfactory for further service, coat them with clean Cindol 1705 oil before reinstalling them in their original locations.

Examine the contact surface (pallet) of the valve bridges. Replace a bridge if the pallet is severely worn or galled.

• Examine the valve button, retainer and valve adjusting screw contact surface for wear. Be sure that the drilled oil passage in the adjusting screw is open. A new valve button retainer (crab claw design) is used on all 125 horsepower per cylinder engines.

Inspect the rocker arm rollers for excessive wear. Check for flat spots or scuff marks. Also check to see that the rollers turn freely. If the rollers are worn excessively, replace the rocker arm assembly. It may also be necessary to replace the camshaft. Refer to Section 1.7.2. <

Measure. the total clearance between each roller bushing and pin, crosswise of the pin, as shown in Fig. 2. If the bushing is worn so that more than a .010" diametric clearance exists, replace the rocker arm assembly.

Install Valve And Injector Operating Mechanism

If new rocker arm assemblies are to be installed, remove the preservative by washing with Cindol 1705 and wipe dry. *Do not use fuel oil.*

Before rocker arm assemblies are installed, immerse them in clean Cindol 1705 heated to 100-125T (38-52°C) for at least one hour to ensure initial lubrication of the roller pins and bushings. Rotate the rollers during the soaking period to purge any air from the bushing-roller area. The heated Cindol oil results in better penetration as it is less viscous than engine oil and flows more easily between the roller bushing and pin.

After the rocker arm assemblies are removed from the heated Cindol 1705, the cooling action of any air trapped in the busing and pin area will tend to pull the lubricant into the cavity.

NOTICE: Heat the Cindol 1705 in a small pail with a screen insert. The screen will prevent the rocker arms from touching the bottom of the pail and avoid the possibility of contamination.

1. Lubricate the valve bridge guides with sulphurized oil (E.P. type) and position the valve bridges in place on the guides. Refer to *Exhaust Valve Bridge Adjustment* in Section 1.2.2 and adjust the valve bridges.
2. Apply clean engine oil to the rocker arm shaft.
3. Slide the rocker arm shaft through the rocker arm assemblies. Place the rocker arm shaft in position on the camshaft bearing caps and secure it with two bolts. Tighten the bolts to 90-100 lb—ft (122-136 Nwn) torque. Install used rocker arm assemblies in their original locations.
4. Install new fuel supply and fuel return pipes. Use wrench set J 26617 and tighten the fuel pipe to fuel injector nuts to 18-22 lb—ft (24-30 N#m) torque. Tighten the fuel pipe to fuel manifold connector nuts to 18-22 lb—ft (24-30 N#m) torque. Install the fuel line support clips.

• NOTICE: DDC recommends that the original flared-end fuel pipes not be reused. New flared-end fuel pipes should be installed.

NOTICE: Do not exceed the specified torque. Excessive tightening will twist or fracture the flared ends of the fuel pipes and result in leaks. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings.

5. Adjust the exhaust valve clearances and time the fuel injector as outlined in Section 14.1 and 14.2 before starting the engine.

 © Detroit Diesel Corporation

EXHAUST VALVES

Four exhaust valves are provided for each cylinder (Fig. 1). The valve heads are heat treated and ground to the proper seat angle and diameter. The valve stems are ground to size and hardened at the end which contacts the exhaust valve bridge. The exhaust valve stems are contained within valve guides which are pressed into the cylinder head.

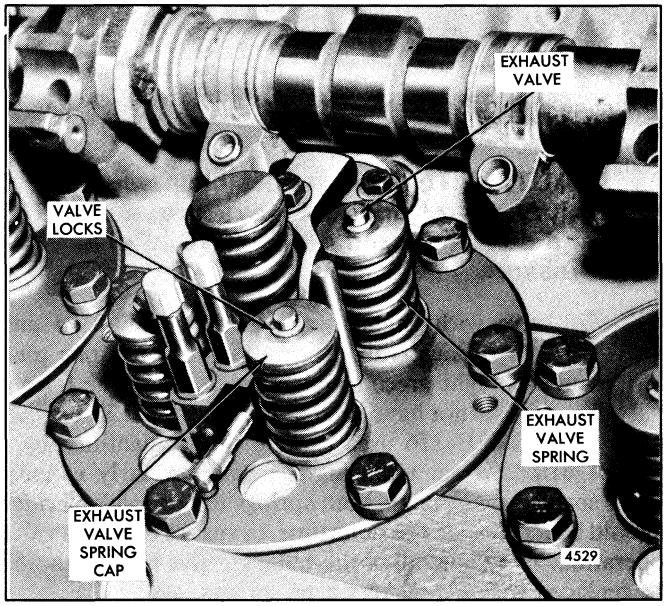


Fig. 1 - Location of Exhaust Valves

Exhaust valve seat inserts, pressed into the cylinder head, permit accurate seating of the exhaust valves under varying conditions of temperature and materially prolong the life of the cylinder head.

The exhaust valve springs are held in place by the valve spring caps and tapered two-piece valve locks.

Excess oil from the rocker arms lubricates the exhaust valve stems. The valve heads are cooled by the flow of air from the blower past the valve heads each time the air inlet ports are uncovered.

Exhaust Valve Maintenance

Efficient combustion in the engine requires that the exhaust valves be maintained in good operating condition. Valve seats must be true and unpitted to assure leakproof seating, valve stems must work freely and-smoothly within the valve guides and the correct valve clearance (Section 14.1) must be maintained.

Proper maintenance and operation of the engine is important to long valve life. Engine operating temperatures should be maintained between 160°-185°F (71°-85°C). Low operating temperatures (usually due to extended periods of idling or light engine loads) result in incomplete combustion, formation of excessive carbon deposits and fuel lacquers on valves and related parts, and a greater tendency for lubricating oil to sludge.

Unsuitable fuels may also cause formation of deposits on the valves, especially when operating at low temperatures.

When carbon deposits, due to partially burned fuel, build up around the valve stems and extend to that portion of the stem which operates in the valve guide, sticking valves will result. Thus the valves cannot seat properly and pitted and burned valves and valve seats and loss of compression will result.

Lubricating oil and oil filters should be changed periodically to avoid the accumulation of sludge.

Valve sticking may also result from valve stems which have been scored due to foreign matter in the lubricating oil, leakage of antifreeze (glycol) into the lubricating oil which forms a soft sticky carbon that gums the valve stems and bent or worn valve guides. Sticking valves may eventually be struck by the piston.

It is highly important that injector timing and valve clearance be accurately adjusted and checked periodically. Improperly timed injectors or tightly adjusted valves will have adverse effects upon combustion.

Remove Exhaust Valve Spring (Cylinder Head Installed)

An exhaust valve spring may be removed, without removing the cylinder head, as follows:

1. Clean and remove the valve rocker cover. Discard the gaskets.
2. Rotate the crankshaft with tool J 22582 to bring the valve and injector rocker arms in line horizontally. Tool J 22582 bolts to the flywheel housing in the same position as the engine starter. Gear teeth on one end of the topi mesh with the flywheel ring gear. The engine can then be rotated by hand with the aid of a 3/4” drive and ratchet.

   CAUTION: To reduce the risk of personal injury when barring over or "bumping" the starter, personnel should keep their hands and clothing away from the engine as there is a remote possibility the engine could start.

3. Disconnect and remove the fuel pipes from the injector and the fuel connectors as follows:

   a. Disconnect the fuel pipe at the injector.

b. Move the nut back on the pipe and slide a 3/8" I.D. hose over the open end of the pipe, being careful to avoid fuel spillage. It will be necessary to loosen the fuel pipe nut at the fuel manifold a few turns to permit the fuel pipe to swing away from the injector.

c. Drain the fuel into a container. This will prevent the fuel in the manifold from draining onto the cylinder head. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings.

NOTICE: Immediately after removing the fuel pipes, cover each injector opening with a shipping cap to prevent dirt or other foreign matter from entering the injector.

4. Remove the two bolts holding the rocker arm shaft to the camshaft bearing cap and remove the rocker arms and shaft.

5. Remove the exhaust valve bridges.

6. Remove the cylinder block air box cover so that piston travel may be observed, then turn the crankshaft until the piston is at the top of its stroke.

7. Thread the valve spring compressor J 22693-01 into the tapped hole in the cylinder head. Then, compress the valve spring and remove the two-piece valve lock.

8. Release the tool and remove the spring cap, valve spring and spring seat.

Remove Exhaust Valves And Springs (Cylinder Head Removed)

With the cylinder head removed from the engine, remove the exhaust valves and springs, as follows:

1. With the cylinder head holding fixture J 23741-A attached to a work bench (Fig. 2), bolt the cylinder head in the fixture. ,

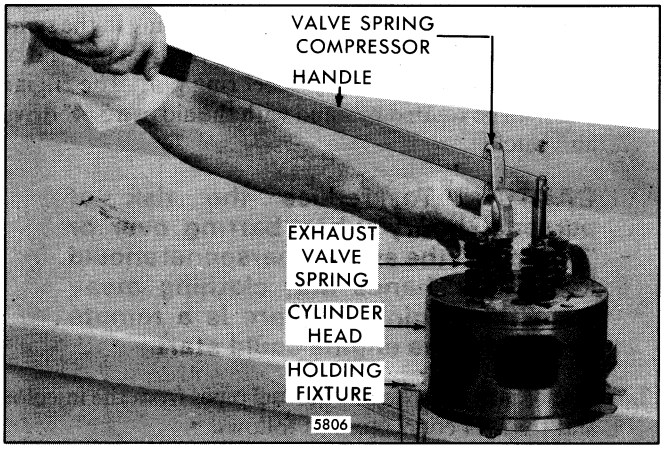


Fig. 2 - Removing Exhaust Valve Spring

2. Remove the exhaust valve springs, using valve spring compressor J 22693-11 with handle J 22693-9. Adjust the valve spring compressor to compress the valve spring just enough to remove the exhaust valve locks.

3. If the valves are to be reused, number each valve to facilitate reinstallation in the same location. Then, withdraw the valves from the cylinder head.

Inspection

Clean the springs with fuel oil, and dry with compressed air. Inspect springs. Replace a pitted or fractured spring.

CAUTIONrTo prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Effective with engine serial number 12E-5304 and 16E—4743, an exhaust valve spring identified by one pink stripe and one light green stripe is being used. The former valve spring does not have an identifying stripe. 12V engines built prior to 12E-176 used a valve spring identified by a yellow stripe. When replacing a former or early exhaust valve spring in an engine, both springs under a valve bridge should be replaced at the same time, to ensure balanced valve operation. At rebuild all of the exhaust valve springs should be replaced with the current type springs.

The exhaust valve spring and injector follower spring are similar in appearance and if interchanged, serious engine damage may result. The exhaust valve spring is made from ,224/.226" diameter wire and has 6-1/2 coils with the ends of the spring 160-180° opposite each other. The injector follower spring is made from .237/.241" diameter wire and has 6 coils with the ends of the spring directly in line.

• Use spring tester J 22738-02 (Fig. 3) to check the spring load of *new and used* exhaust valve springs before installing them on a cylinder head. Replace an exhaust valve spring if a load of less than 54 lbs will compress it to a length of 2.05". Springs passing this test must then be compressed to 1.54" on spring tester J 22738-02 (refer to Table 1). The force "X-lbs") required to compress the spring to 1.54" must result in the recoil pressure **("Y")** shown. If "X-lbs^{M} and **"Y"** readings for a *new or used" spring do not match, the spring must be replaced.*

X-lbs	Y	X-lbs	Y
54	250.5 — 260.5		
55	251.5 — 261.5	60	256.5 — 266.5
56	252.5 — 262.5	61	257.5 — 267.5
57	253.5 — 263.5	62	258.5 — 268.5
58	254.5 — 264.5	63	259.5 — 269.5
59	255.5 — 265.5	64	260.5 — 270.5

Table 1

 © Detroit Diesel Corporation

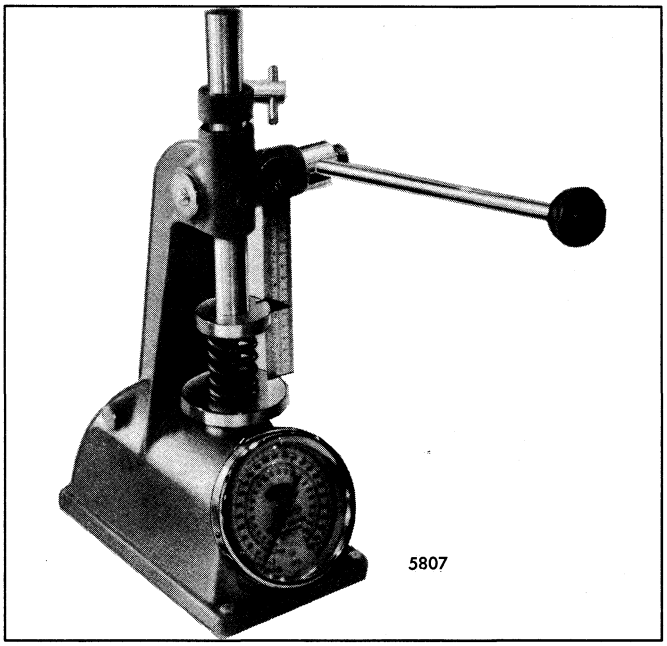


Fig. 3 - Testing Exhaust Valve Spring using Tool J 22738-02

• Inspect the valve spring seats and caps for wear. If worn, replace them. *Valve springs, seats, and caps for 125 hp per-cylinder engines are different from the current 100 and 112 hp per-cylinder design.*

Examine the contact surfaces of the exhaust valve bridge guides, bridges and adjusting screws for wear. Replace excessively worn parts.

A new exhaust valve bridge with a .391" drilled cross-hole replaces the former valve bridge with a forged center hole (.500" to .535" diameter). The old and new bridges are interchangeable and only the new bridge will be serviced.

Clean the inside diameter of the valve guides with brush J 5585 (Fig. 4). This brush will remove all gum or carbon deposits from the guides, including the spiral grooves.

Inspect the valve guides for fractures, chipping, scoring or excessive wear. Measure the valve guide inside diameter with a pin gage or inside micrometer and record the readings. After inspecting and cleaning the exhaust valve, measure the outside diameter of the valve stem with a micrometer and record the readings. Compare the readings to obtain the valve-to-guide clearance. If the clearance exceeds .006", replace the valve guides.

Carbon on the face of a valve could indicate blow-by due to a faulty seat. Black carbon deposits extending from the valve seats to the valve guides may result from cold operation due to light loads or the use of too heavy a grade of fuel. Rusty brown valve heads with carbon deposits forming narrow collars near the valve guides is evidence of high operating temperatures. High operating temperatures are normally due to overloads, inadequate cooling or improper timing which results in carbonization of the lubricating oil.

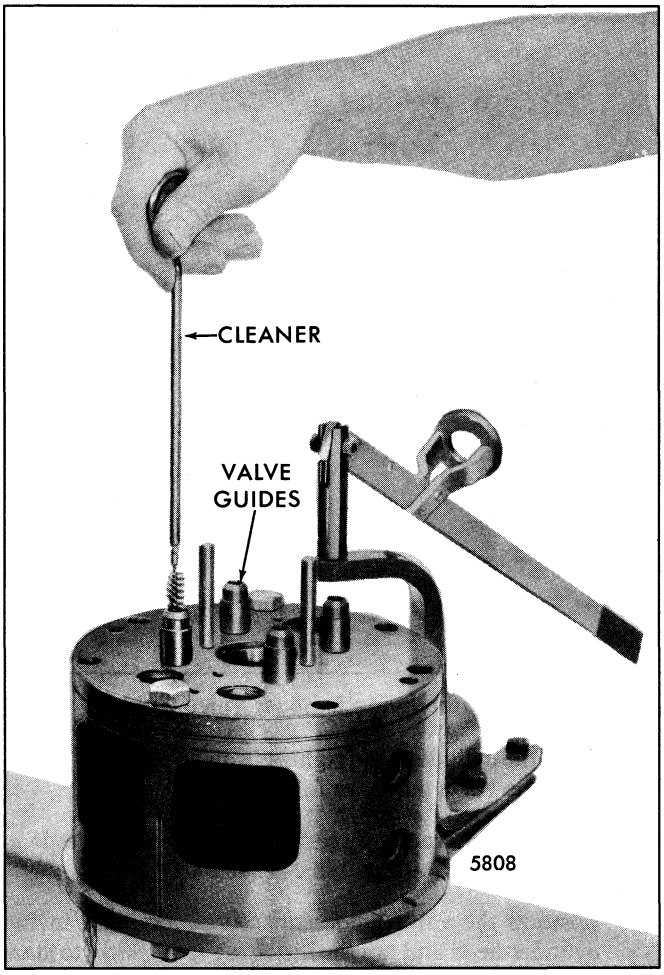


Fig. 4 - Cleaning Exhaust Valve Guides

Clean the carbon from the valve stems and wash the valves with fuel oil. The valve stems must be free from scratches or scuff marks and the valve faces must be free from ridges,, cracks or pitting. If necessary, reface the valves or install new valves. If the valve heads are warped, replace the valves.

Inspect the exhaust valve seat inserts for excessive wear, pitting or cracks.

Replace Exhaust Valve Guide

Remove an exhaust valve guide, as follows:

1. Remove and discard the oil seal.
2. Drive or press the valve guide out from the bottom of the cylinder head with tool J 23458 (Fig. 5).

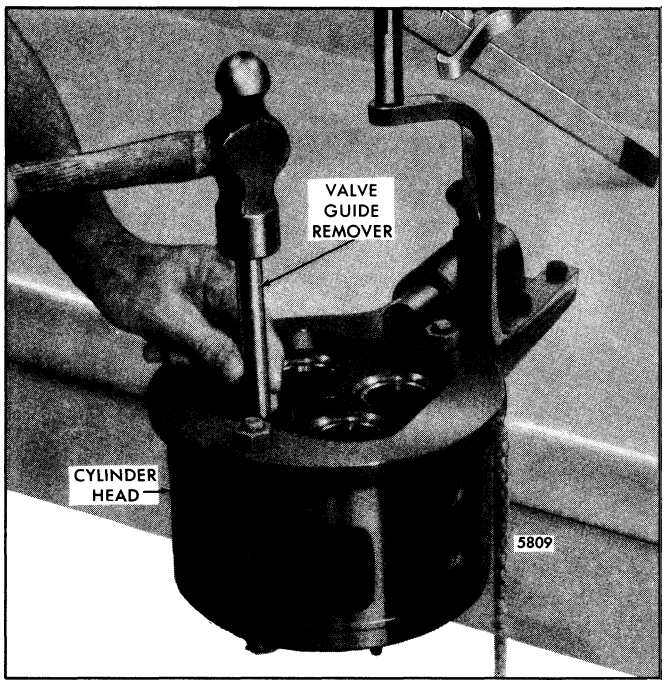


Fig. 5 - Removing Exhaust Valve Guide

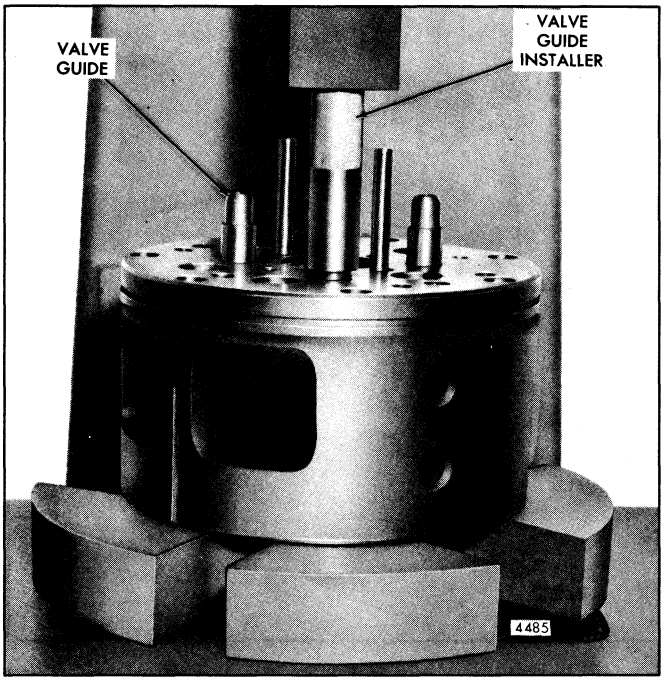


Fig. 6 - Installing Exhaust Valve Guide

Turn the cylinder head right side up on the work bench and install the valve guide, as follows:

1. Insert the internally threaded end of the valve guide in valve guide installing tool J 22082-01.

• 2. Position the valve guide squarely in the bore in the cylinder head and tap the installing tool gently to start the guide in place. Then, press the guide in until the tool contacts the cylinder head (Fig. 6). This will position the valve guide to the proper height of 1 • 140"—1.180". *On 125 hp-per-cylinder engine, the valve guides are smaller in diameter than those on the current 100 and 112 hp-per-cylinder engines.*

NOTICE: Do not use the valve guides or the valve bridge guides as a means of turning the cylinder head over or in handling the cylinder head. Do not lean the head on the valve bridge guides.

Service replacement valve guides are completely finish reamed during manufacture and, therefore, do not require reaming after installation.

Remove Exhaust Valve Bridge Guide

1. Grind a notch 1/16" deep in the side of the bridge guide approximately 1 1/2" from the upper end of the bridge guide (Fig. 7).

2. Slide the washer J 7091-3 and bridge guide remover tool J 7091-5 on the bridge guide and tighten the socket head screw in the side of the tool.

3. Place spacer tools J 7091-2 or J 7091-4 over remover J 7091-5.

4. Thread the nut on the remover J 7091-5. Turn the nut clockwise to remove the bridge guide from the cylinder head.

To remove a broken valve bridge guide, drill a hole approximately 1/2" deep in the end of the guide with a No. 3 (.2130") drill (Fig. 8). Then, tap the guide with a l/4"-28 bottoming tap. Thread the remover J 7453 into the guide and attach slide hammer J 2619-01 to the remover tool. One or two sharp blows with the puller weight against the head of the rod will remove the broken guide.

Install Exhaust Valve Bridge Guide

• 1. Apply a *Thin,* continuous coat of Permatex High Tack Adhesive sealant 98D or 98H (or equivalent) to the exhaust valve bridge guide.

2. Locate the exhaust valve bridge guide squarely in the cylinder head and tap it gently to start it into place.

• 3. With the guide properly started, place the valve bridge guide installer J 22487 over the guide and drive the guide into the cylinder head (Fig. 9). The tool properly positions the guide in the cylinder head. *The 125 hp-per-cylinder head has no bridge guides.*

 © Detroit Diesel Corporation

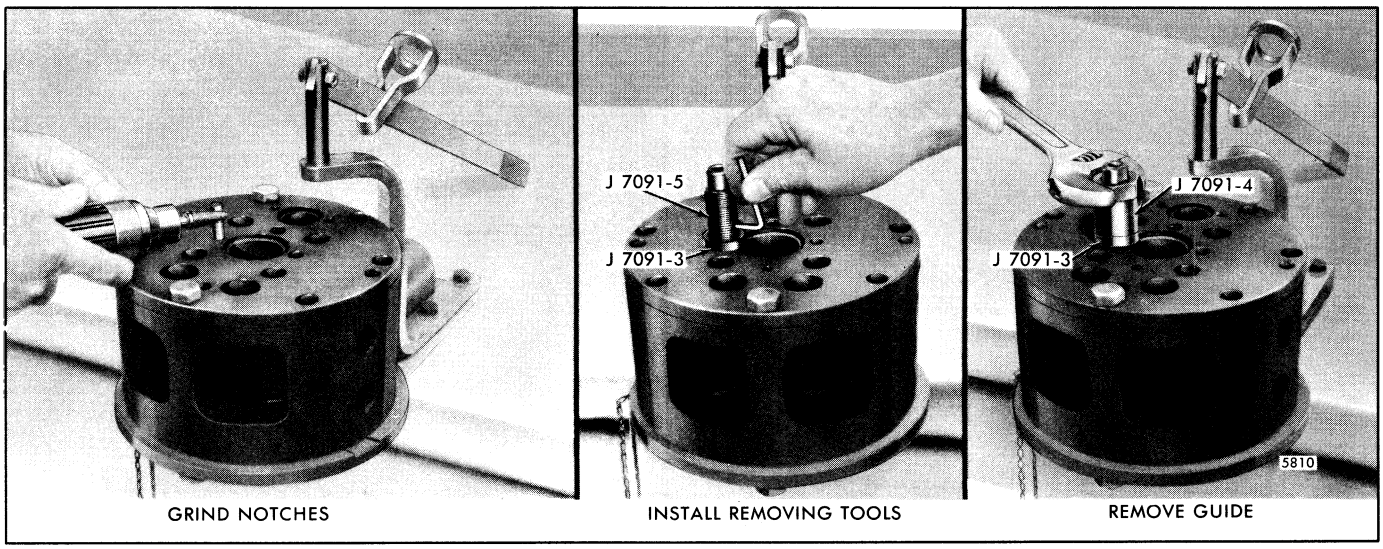


Fig. 7 - Removing Exhaust Valve Bridge Guide

Inspect Exhaust Valve Seat Insert

Inspect the valve seat inserts for excessive wear, pitting, cracking or an improper seat angle. The proper angle for the seating face of the valve is 30° and the angle for the insert is 31°. When a valve seat insert has been ground to such an extent that the grinding wheel will contact the cylinder head, install a new insert.

Remove Exhaust Valve Seat Insert

The valve seat inserts are pressed into the cylinder head and must be removed as outlined in the following procedure to avoid damage to the cylinder head.

1. Bolt the cylinder head in the holding fixture J 23741-A (Fig. 10).
2. Place the collet of the valve seat insert remover J 23479-D inside of the valve seat insert so that the bottom of the collet is flush with the bottom of the insert.
3. Press down on the handle to remove the valve insert from the cylinder head.

Install Exhaust Valve Seat Insert

Great care must be used during the installation of a valve seat insert since this part has a press fit in the cylinder head.

If required, a cylinder head may be reworked to accept .010" oversize exhaust valve seat inserts (refer to Section 1.0).

Install the insert in the following manner:

1. Wash the cylinder head with clean fuel oil and dry it with compressed air.

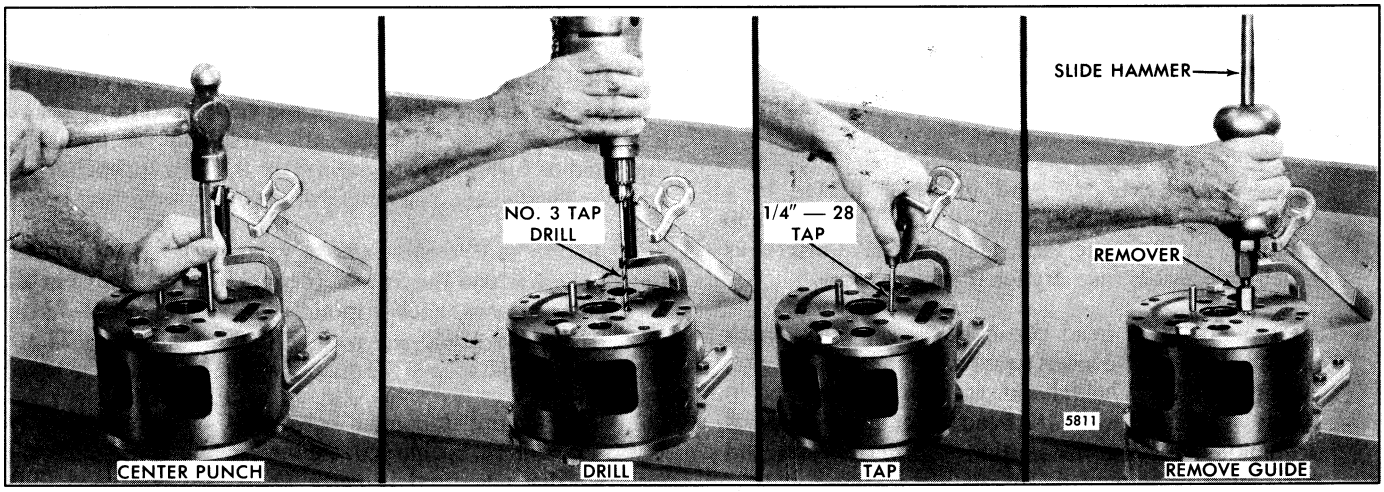


Fig. 8 - Removing Broken Exhaust Valve Bridge Guide

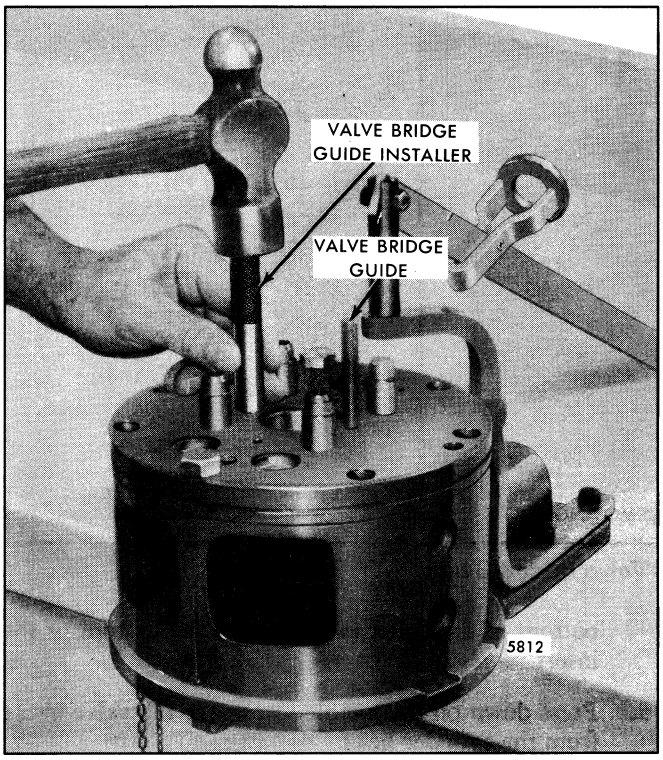


Fig. 9 - Installing Exhaust Valve Bridge Guide

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

2. Clean the cylinder head insert counterbores and valve inserts with 1,1,1-trichloroethane. Dry the counterbores and inserts with compressed air.

3. Check the valve seat insert counterbores in the cylinder head for cleanliness, concentricity, flatness and cracks.

4. The counterbore in the cylinder head has a diameter of 1.8965” to 1.8975” and a depth of .401” to .406”. The counterbores must be concentric with the valve guides within .003” total indicator reading.

5. Immerse the cylinder head in water heated to a temperature of 180-200°F (82-93°C) for at least 30 minutes. At the same time, cool the valve inserts as much as possible (use dry ice if available).

6. Rest the cylinder head bottom-up on a work bench and locate the valve insert squarely in the counterbore, seating face up. The valve insert must be installed in the cylinder head while the head is hot and the inserts are cold, otherwise installation will be difficult and parts may be damaged. Inserts are installed with a press fit of .0005” to .0025”.

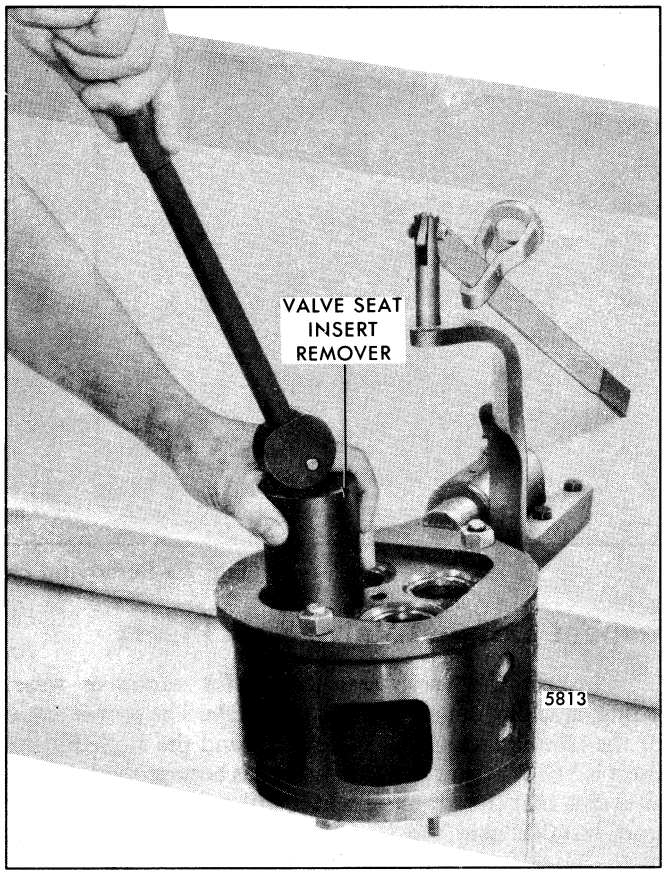


Fig. 10 – Removing Valve Seat Insert

7. Drive the valve insert with installer J 22711 until it seats solidly in the cylinder head (Fig. 11).

8. Grind the valve seat insert and check it for concentricity in relation to the valve guide as outlined below.

Recondition Exhaust Valve And Valve Seat Insert

• Reface an exhaust valve which is to be reused (Figs. 12 and 13). The edge of the valve at the valve head must not be less than .030” irr thickness after refacing for naturally aspirated or turbocharged engines or .070” for turbocharged intercooled engines. The proper angle of the valve seat is 30°.

• In 1985 a Pyromet exhaust valve replaced the former Inconnel valve and the former Inconnel-Stellite valve in all Series 149 engines, except models 9083-7316, 9123-7316, and 9163-7316 equipped with 270 mm injectors. These engines continue to use the Inconnel-Stellite valve.

• The former Inconnel valve was used in naturally aspirated and turbocharged engines, while the Inconnel-Stellite valve was used in turbo-charged-intercooled (TI) models.

 © Detroit Diesel Corporation

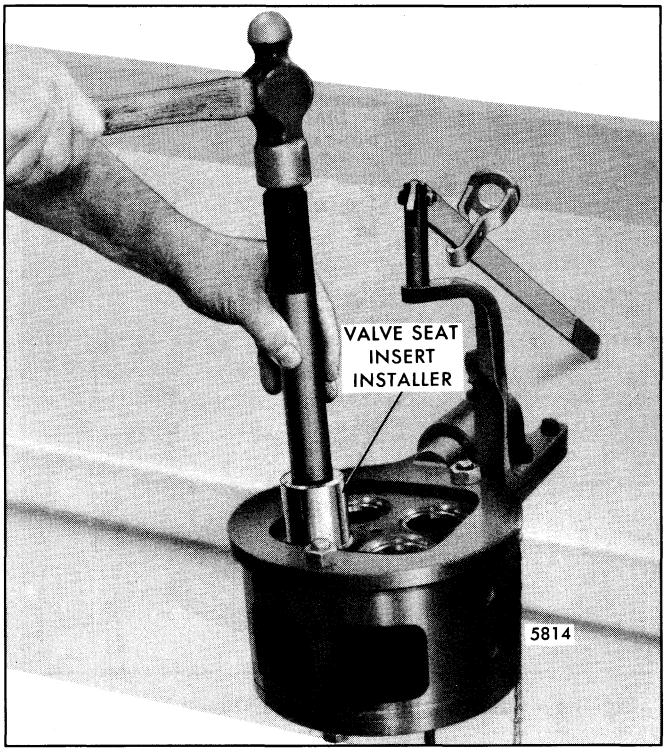


Fig. 11 – Installing Valve Seat Insert

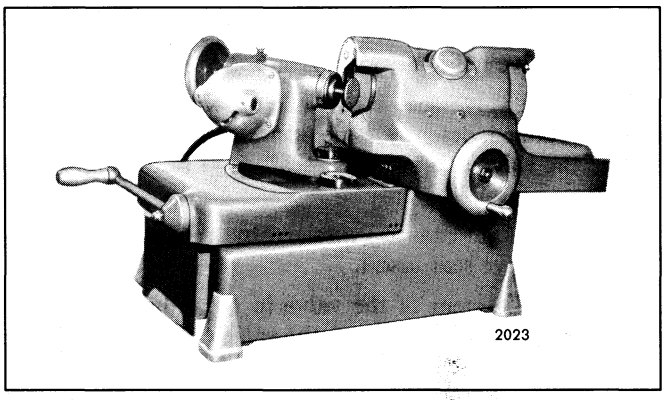


Fig. 12 – Refacing Exhaust Valve

• The Pyromet valve is identified by the letter "U" forged in the center recess of the valve face (Fig. 13). The former Inconnel valve was identified by "J," "J2," or "J4," while the Inconnel-Stellite valve had a "TI" or "J6" identification.

> **NOTICE:** The *stellite faced* valves must be ground in oil. Water coolant or dry grinding can result in cracking of the stellite faced material. After grinding, the valve face should be either dye-checked or zyglo inspected for cracks. Do not magnaflux. •

• *Valves on the 125 hp-per-cylinder head are .034" in diameter with radius bead keeper groove, whereas valves on the 100 and 112 hp-per-cylinder heads are .03Tin diameter.*

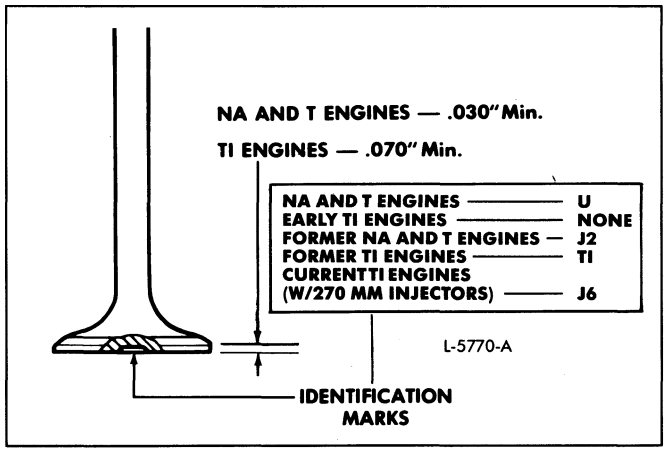


Fig. 13 - Exhaust Valve Regrind Limits and Identification Marks

Before installing either a new or used valve, examine the valve seat insert in the cylinder head for proper valve seating. The proper angle for the seating face of the valve insert is 31°.

When a new valve seat insert is installed or an old insert is reconditioned, the work must be done with a grinding tool as illustrated in Fig. 14.

The eccentric grinding method for reconditioning a valve seat insert is recommended. This method produces a finer, more accurate finish since only one point of the grinding wheel is in contact with the valve seat at any time. A micrometer feed permits the operator to feed the grinding wheel into the work .001" at a time.

The eccentric valve seat grinder set J 7040-A used to recondition or grind the valve seat inserts consists of a grinder J 8165-1 and a dial gage J 8165-2. The adaptor set J 4627-02 must be used in conjunction with the grinder set J 7040-A. The adaptor set consists of the following:

1. Pilot J 4627-3.
2. Grinding wheel (15°) J 4627-5.
3. Grinding wheel (31 °) J 4627-2.
4. Grinding wheel (60°) J 4627-4.

Grind the inserts as follows:

1. Apply the 31° grinding wheel on the valve seat insert.
2. Use the 60° grinding wheel to open the throat of the insert.
3. Grind the top surface of the insert with the 15° wheel to narrow the width of the seat to approximately 1/16". Do not permit the grinding wheel to contact the cylinder head when grinding the inserts. If necessary, the grinding wheel may be dressed to the correct seat angle with the tool provided in the grinder set (Fig. 15).

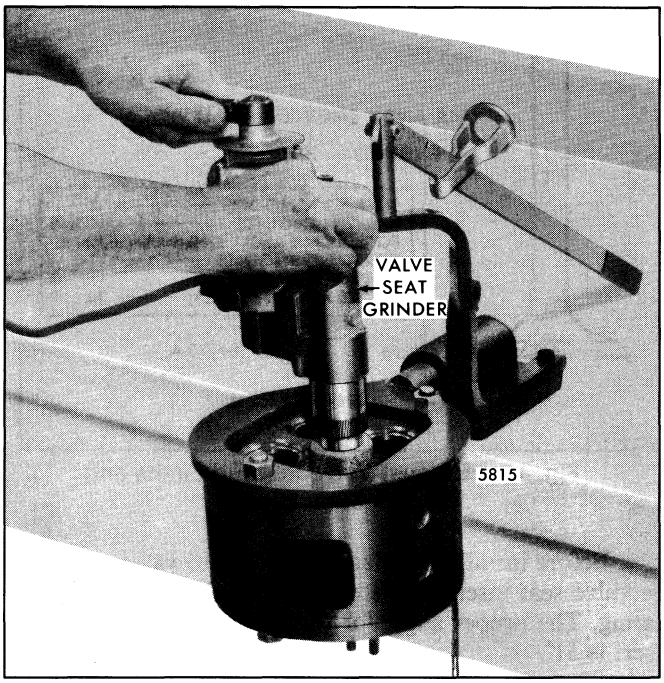


Fig. 14 - Grinding Valve Seat Insert

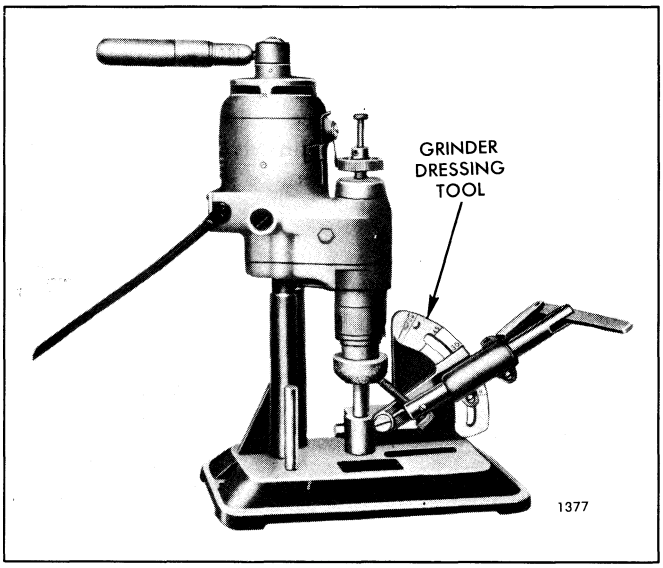


Fig. 1 5 - Grinding Wheel Dressing Tool

4. Grinding will reduce the thickness of the valve seat insert and cause the valve to recede into the cylinder head. Check the depth of the valve with depth gage J 22273-01 (Fig. 16). If, after several grinding operations, the valve recedes more than .032" below the surface of the cylinder head, replace the valve seat insert.

5. After the grinding has been completed, clean the valve seat insert thoroughly with fuel oil and dry it with compressed air. Set the dial indicator J 8165-2 in position as shown in Fig. 17 and rotate it to determine the concentricity of each valve seat insert relative to the valve guide. Total runout should not exceed .002". If a runout of more than .002" is indicated, check for a bent valve guide before regrinding the insert.

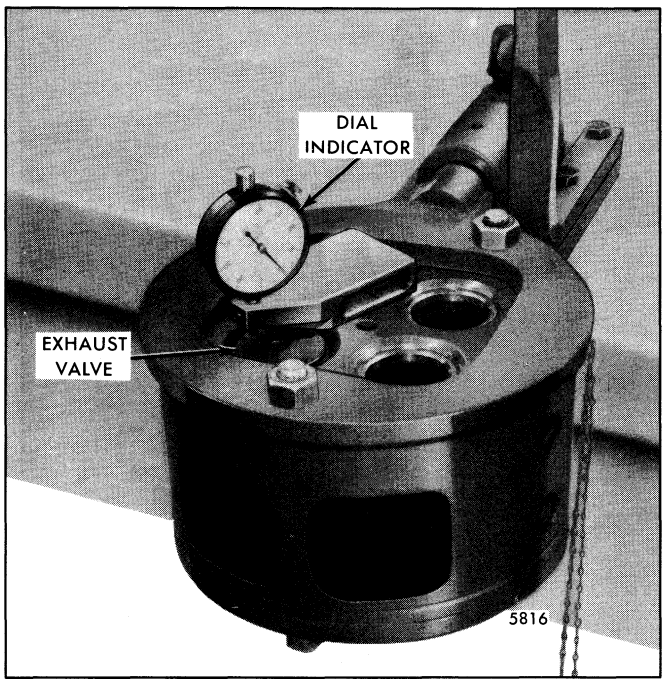


Fig. 16 - Relationship Between Exhaust Valve and Cylinder Head

When a valve seat insert runout within the desired limits is obtained, determine the position of the contact area between the valve and the valve seat insert in the following manner:

1. Apply a light coat of Prussian blue, or a similar paste, to the valve seat insert.

2. Lower the stem of the valve in the valve guide and bounce, but do not rotate, the valve on the insert. This procedure will indicate the area of contact on the valve face. The most desirable area of contact is at the center of the valve face.

NOTICE: Use of valve lapping compound is not recommended.

After the valy.e seat inserts have been ground and checked thoroughly, clean the cylinder head before installing the valves.

Install Exhaust Valves And Springs

1. Clean the valve guides.

2. Lubricate the valve stems and valve bridge guides with sulphurized oil (E.P. type) and slide the valves all the way into the guides. If reconditioned valves are used, install them in the same relative location from which they were removed.

 © Detroit Diesel Corporation

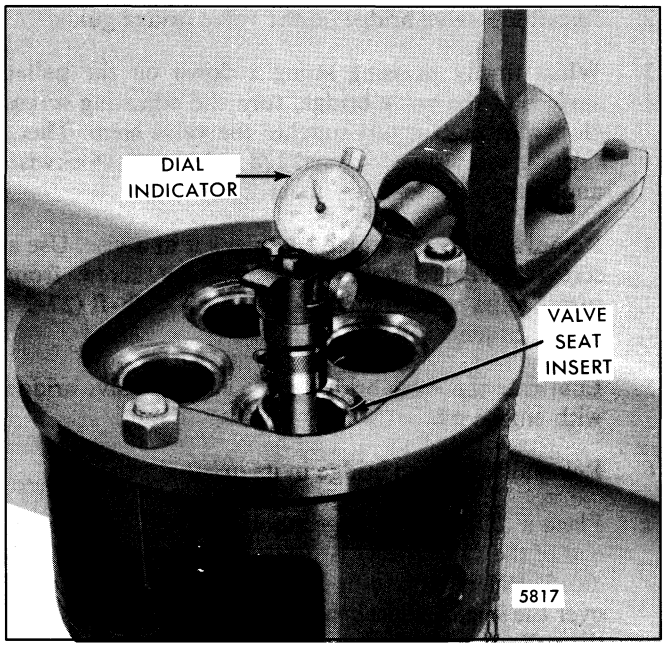


Fig. 17 - Checking Relative Concentricity of Valve Seat Insert with Relation to Valve Guide

3. Install the valve spring seats.

4. Install the valve guide oil seals as follows:

   a. Place the plastic seal protector cap on the end of the valve stem. If the cap extends more than 1/16" below the groove on the valve stem, remove the cap and cut off the excess length.

   b. Lubricate the protector cap with clean engine oil and start the seal carefully over the valve stem. Push the seal down slowly until the seal rests on the top of the valve guide (Fig. 18). Tool J 25251 can be used to facilitate installing the seal.

      A new Teflon-lip valve seal is used on the 125 hp-per-cylinder engine.

   c. Remove the plastic protector cap.

5. Install the valve springs and valve spring caps.

• A new exhaust valve rocker arm assembly, new valve lock and new spring cap marked with yellow dye have been released for Series 149 engines. The new spring cap is also identified by a machined spiral in the top of the cap. The new valve rocker arm assembly, is completely interchangeable with the former assembly when the new valve lock and spring cap are also used and only the new components will be serviced. The new valve lock and spring cap may be used with the former rocker arm assembly, but the former valve lock and spring cap should never be used with the new rocker arm assembly. The former valve locks and spring caps should be replaced with the new at time of major engine overhaul. Also, at overhaul, replace all the valve springs with new valve springs.

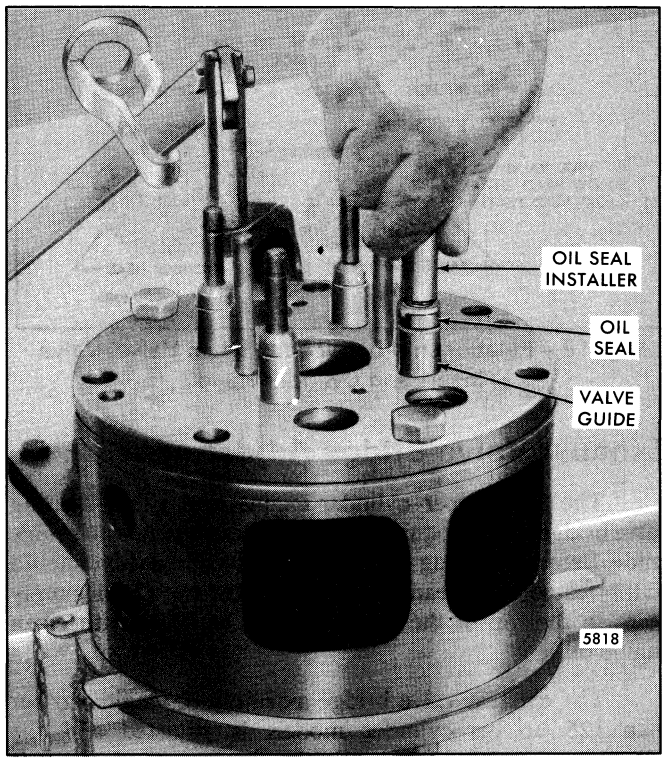


Fig. 18 - Installing Valve Guide Oil Seal

6. Refer to Fig. 2 and compress the exhaust valve spring with tool J 22693-11 and install the two-piece tapered valve lock. Exercise care to avoid scoring the valve stem with the valve cap when compressing the spring. Tap the end of the valve stem lightly with a plastic hammer to seat the valve locks.

• The 125 hp-per-cylinder engine has different seats, caps and locks than 112 hp-per-cylinder and smaller engines.

NOTICE: Compress the valve spring only enough to permit installation of the valve locks. Compressing the spring too far may result in damage to the valve guide oil seal.

7. Release the tool and install the valve locks on the remaining exhaust valves in the same manner.

   NOTICE: After the valves have been installed, make sure the valve heads are flush or no more than .017" (new) or .032" (used) below the surface of the cylinder head when the valves are fully closed (Fig. 19).

8. Assemble the cylinder head as outlined in Section 1.2.

9. Install the cylinder head. Refer to *Pre-Installation Inspection* and *Install Cylinder Head* in Section 1.2.

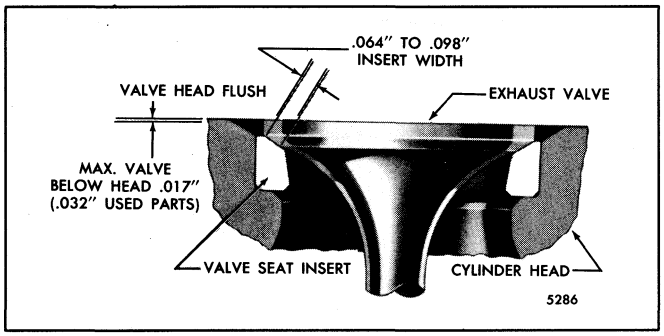


Fig. 19 - Relationship between Exhaust Valve, Valve Insert and Cylinder Head

Exhaust Valve Bridge Adjustment

• The 125 hp-per-cylinder engine uses a free-floating valve bridge which requires no adjustment and has no bridge guide. Before installing the bridge, the top of the valve should be lubricated with clean engine oil and the two (2) oil supply holes in the top of the bridge should be filled with clean engine oil.

• The exhaust valve bridge assembly on engines other than 125 hp per-cylinder models is adjusted and the adjustment screw is locked securely after the cylinder head is installed on the engine. Until wear occurs, or the cylinder head is reconditioned, no further adjustment is required on the valve bridge. A complete valve bridge adjustment is performed as follows:

1. Place the valve bridge in a vise or bridge holding fixture J 21772 and loosen the locknut on the bridge adjusting screw.

   NOTICE: Loosening or tightening the locknut with the bridge in place may result in a bent bridge guide or bent rear valve stem.

2. Install the valve bridge on the valve bridge guide.
3. While firmly pressing straight down on the pallet surface of the valve bridge, turn the adjusting screw clockwise until it just touches the valve stem. Then, turn the screw an additional 1/8 to 1/4 turn clockwise and tighten the locknut finger tight.
4. Remove the valve bridge and place it in a vise. Use a screw driver to hold the adjustment screw from turning and tighten the locknut to 20-25 lb—ft (27-34 N#m) torque.
5. Lubricate the valve bridge guide and the valve bridge with engine oil.
6. Reinstall the valve bridge in its *original* position.
7. Place a .0015" feeler gage (tool J 23185) under each end of the valve bridge or use a narrow strip cut from .0015" feeler stock to fit in the bridge locating groove over the inner exhaust valve. While pressing down on the pallet surface of the valve bridge, both feeler gages must be tight. If both of the feeler gages are not tight, readjust the adjusting screw as outlined in Steps 3 and 4.
8. Remove the valve bridge and reinstall it in its *original* position.
9. Adjust the remaining valve bridges in the same manner.
10. Swing the rocker arm assembly into position, making sure the valve bridges are properly positioned on the rear valve stems. This precaution is necessary to prevent valve damage due to mislocated valve bridges. Tighten the rocker arm shaft bracket bolts to the torque specified in Specifications - Section 1.0.

 © Detroit Diesel Corporation

VALVE ROCKER COVER

A valve rocker cover completely encloses each bank of cylinder heads and the valve and injector rocker arm mechanism (Fig. 1). Each rocker cover is sealed against oil leakage by a gasket.

An option plate is inserted in a retainer attached to one of the covers.

The valve rocker cover assembly on certain engines may include a breather assembly or an oil filler, depending upon the engine application.

Studs are located at each end of the inboard side (top rail) of the cover for ease in locating the cover on the cylinder block. Current covers also have a lifting tab cast into each side of the cover for easier handling.

Effective with engine serial numbers 12E-5672 and 16E-5308 new valve rocker covers are being used in conjunction with the new cast breather body assembly (Section 4.8, Fig. 1). The new covers are required because of breather and turbocharged interference. The new covers are the same as the former covers except the 19.36" dimension locating the breather mounting pad is now 10.08". Both the former and new rocker covers are serviced.

Remove Valve Rocker Cover

Clean the valve rocker covers and around the covers before removing them from the engine to keep dust or dirt from entering the valve mechanism. Then remove the bolts and washers and stud nuts and washers from the cover and lift each cover straight away from the cylinder block.

• Inspection

Remove the gasket from the rocker cover and inspect the cover for gouges in the gasket sealing area. Check the cover for flatness and for cracks.

• Installation

Install a new gasket over the two (2) studs located in the top corners of the block. Install the cover over the studs, and install the required 5/16" - 18 bolts and washers and the two (2) 5/16" - 24 nuts and washers on the studs. Using a crossing pattern from the center of the cover to the edges, tighten the bolts to 13 - 17 lb—ft (18-23 N«m) torque. Then tighten the 5/16" - 24 nuts to 15 - 19 lb—ft (20 - 26 N»m) torque.

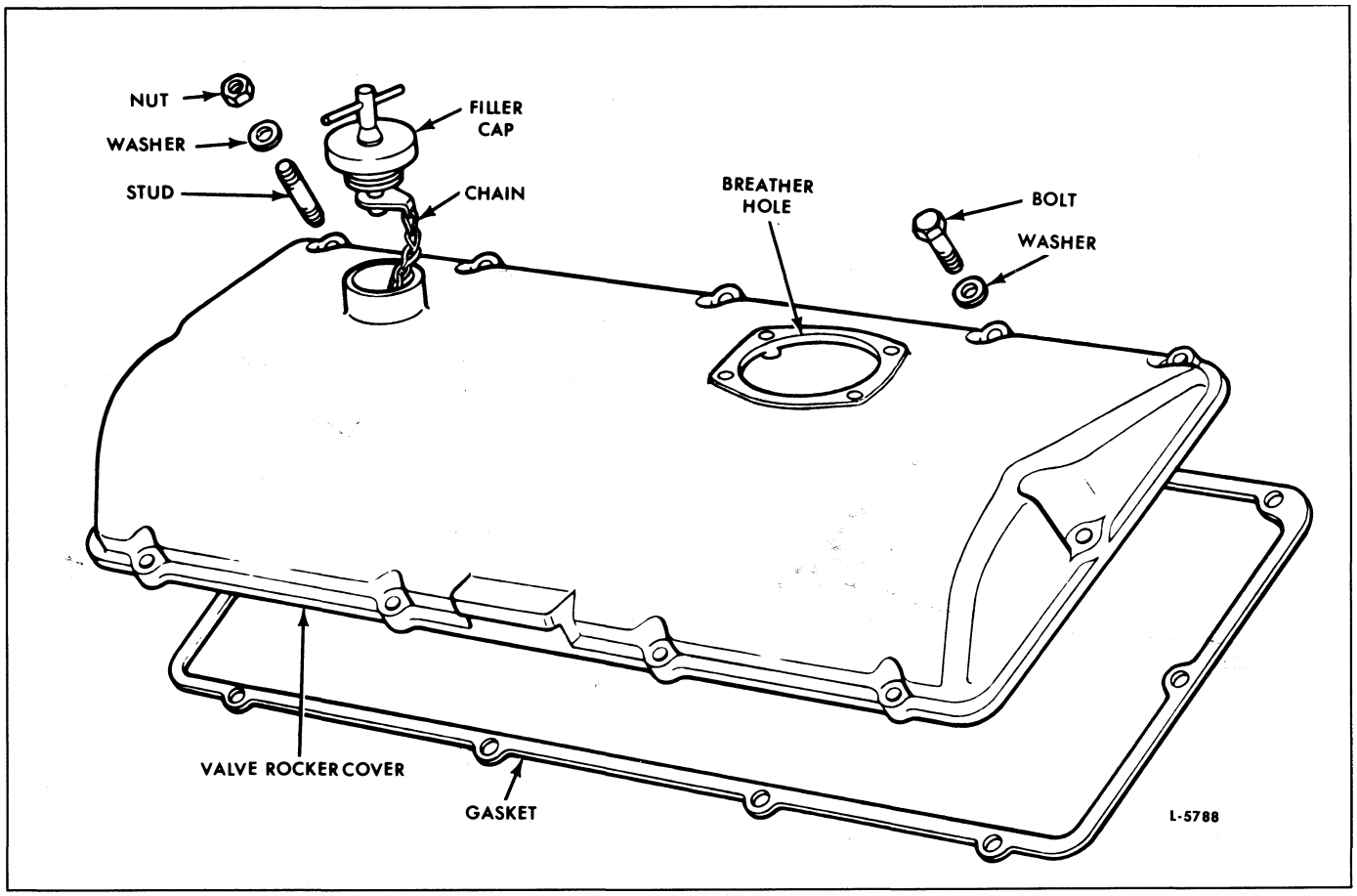


Fig. 1 – Typical Valve Rocker Cover

CRANKSHAFT

The crankshaft is a steel forging, heat-treated to ensure strength and durability. The two halves of the 12V and 16V crankshafts are bolted together (Fig. 1).

To strengthen the crankshaft, the fillets of the current 12 V crankshaft are induction hardened at the No. 1,2,7 and 8 main journals and the No. 1 and 6 rod journals and the 16V crankshaft fillets are induction hardened at the No. 1, 2, 9 and 10 main journals and the No. 1 and 8 rod journals. These positions are determined from a complete crankshaft assembly.

Complete static and dynamic balance of the crankshaft has been achieved by counterweights incorporated in the crankshaft.

The crankshaft end play is controlled by thrust washers located at the rear main bearing cap of the engine. Full pressure lubrication to all connecting rod and main bearings is provided by drilled passages within the crankshaft and the cylinder block.

Each main bearing journal is 4-7/8” in diameter and each connecting rod journal is 3-7/8” in diameter.

Remove Crankshaft

When removal of the crankshaft becomes necessary, first remove the transmission, then proceed as follows:

1. Clean the exterior of the engine.
2. Drain the cooling system.
3. Drain the engine crankcase.
4. Remove all accessories with attaching parts, as necessary, to permit the engine to be placed upside down on an overhaul stand.
5. Remove the valve rocker covers, valve and injector operating mechanism and the cylinder heads.
6. Install suitable retainers to temporarily hold the pistons and cylinder liners in place. Fig. 2 shows a typical retainer in place and the instructions for its fabrication.
7. Remove the engine from its base and position it upside down on an engine overhaul stand.
8. Remove the lower oil pan, oil pump, brackets and tubing.
9. Remove *the upper oil pan.
10. Remove the flywheel and flywheel housing.
11. Remove the crankshaft cap or pulley retaining bolt and washer at the front end of the crankshaft.
12. Remove the vibration damper, water pump and thermostat housings.
13. Remove the heat exchanger, if so equipped.
14. Remove the outboard bearing support and seal assembly from the front cover.
15. Remove the front cover.
16. Remove the connecting rod bearing caps.
17. Remove the main bearing caps.

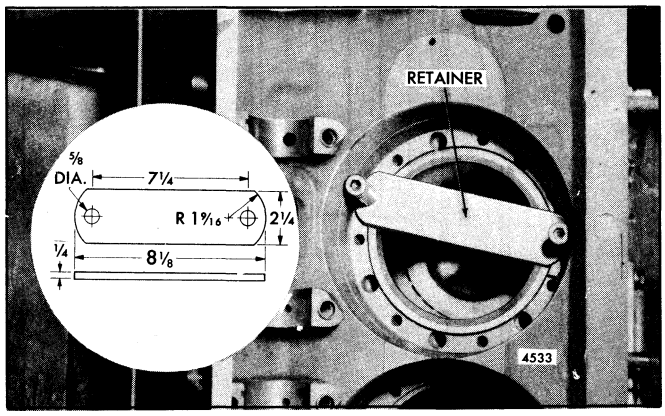


Fig. 2 - Cylinder Liner Retainer and Instructions for Fabrication

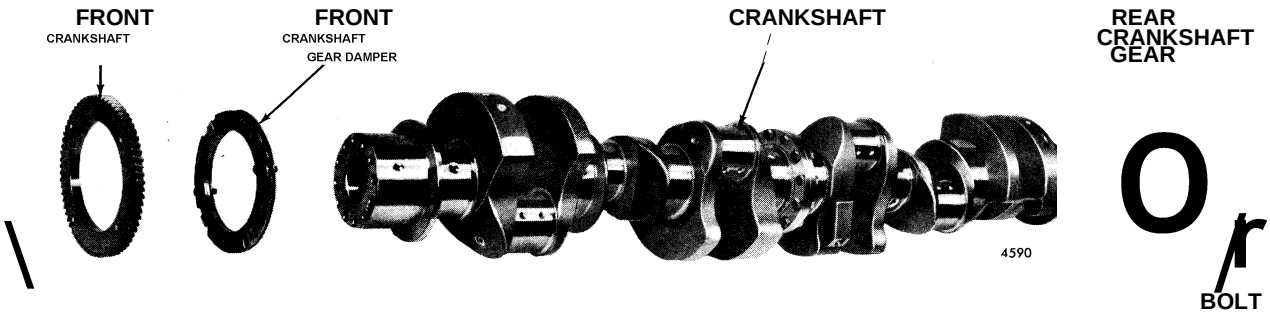


Fig. 1 - Crankshaft Details and Relative Location of Parts (12V-149)

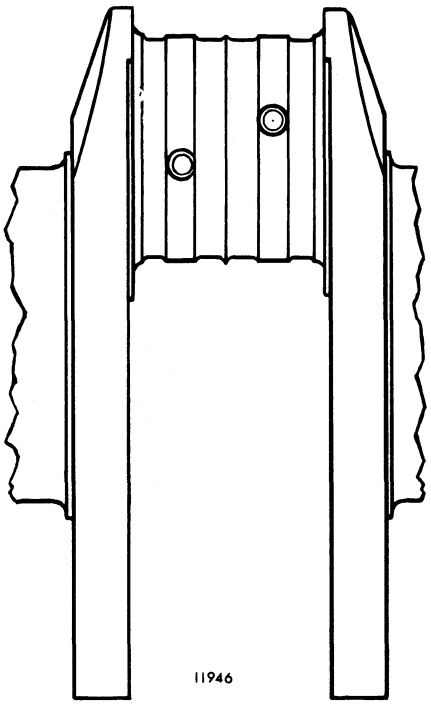


Fig. 3 - Typical Ridging of Crankshaft

18. Remove the thrust washers from the rear main bearing cap and the cylinder block.

19. Remove the crankshaft, timing gears (front and rear) and front timing gear damper as an assembly.

20. Remove the crankshaft timing gears and damper from the crankshaft (Section 1.7.5).

Inspection

After the crankshaft has been removed, clean and inspect it thoroughly before reinstalling it in the engine.

Remove the plugs and clean out the oil passages thoroughly with a stiff wire brush. Clean the crankshaft with fuel oil and dry it with compressed air. Then, reinstall the plugs.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

If the crankshaft shows evidence of excessive overheating, replace the crankshaft since the heatTreatment has probably been destroyed.

Used crankshafts will sometimes show a certain amount of ridging caused by the groove in the upper main bearing shell or lower connecting rod bearing shell (Fig. 3). Ridges exceeding .0002” must be removed. If the ridges are not removed, localized high unit pressures on new bearing shells will result during engine operation.

On current engines, the rear oil seal is pressed into the outboard bearing support and seals on a replaceable sleeve that is pressed on the flywheel or flywheel coupling assembly.

On former 12 V and 16V engines, carefully inspect the rear end of the crankshaft in the area of the oil seal contact surface for evidence of a rough or grooved condition. Any imperfections of the oil seal contact surface will result in oil leakage at this point. The front oil seal rides on a replaceable sleeve.

If the crankshaft oil seal contact surface on the crankshaft is excessively worn or grooved, install an oil seal sleeve, which provides a replaceable wear surface for the seal. An oversize oil seal will be required with use of the sleeve. Refer to Section 1.3.2 for replacement of the oil seal sleeve.

Check the crankshaft thrust surfaces for excessive wear or grooving. If only slightly worn, the surfaces may be dressed with a stone. Otherwise it will be necessary to regrind the thrust surfaces.

Check the crankshaft timing gear for worn or chipped teeth. Replace the gear, if necessary.

Inspect the crankshaft for cracks as outlined under *Inspection for Cracks.*

Crankshaft Measurements

Support the crankshaft on its front and rear journals in the cylinder block and check the alignment at the adjacent intermediate main journals with a dial indicator.

When the high spots of runout on the adjacent journals is in opposite directions, the sum must not exceed .003” total indicator reading. When the high spots of runout on the adjacent journals is in the same direction, the difference must not exceed .003” total indicator reading. When the high spots of runout on the adjacent journals are at right angles to each other, the sum must not exceed .004” total indicator reading, or .002” on each journal. Crankpins must be parrallel with the main journals within .0005” in length of crankpin journal. If the runout limit 4s greater than that given in Table 1, the crankshaft must be replaced.

Measure all of the main and connecting rod bearing journals (Fig. 4). Mesure the journals at several places on the circumference so that taper, out-of-round and bearing clearances can be determined. If the crankshaft is worn so that the clearance with new connecting rod bearing shells or new main bearing shells exceeds .0045” and .0062” respectively, the crankshaft must be reground. Measurements of the crankshaft should be accurate to the nearest .0002”. Also, if the journal taper of a used crankshaft exceeds .0015” or the out-of-round exceeds .0010”, the shaft must be reground.

 © Detroit Diesel Corporation

ENGINE	JOURNALS SUPPORTED ON	JOURNALS MEASURED	MAX. RUNOUT (TOTAL INDICATOR READING)
8V	No. 1 &No.5	Outboard No. 2 & No. 4 No. 3	oc£ CCJc
12V	No. 1 8c No.	No. 4 & No. 5 8 No. 3 & No. 6 No. 2 & No. 7	°°g °° °g
16V	No. 1 &N° .IO	No. 5 & No. 6 No. 4 & No. 7 No. 3 & No. 8 No. 2& No. 9	.008" .006" .004" .002"
CRANKSHAFT HALVES			
12V	No. 1 8c No.	4 Outboard 4No. 2 8c No. 3	.001" .002"
16V	No. 1 8c No.	Outboard 5No. 2 8c No. 4 No. 3	.001" .002" .004"

TABLE 1 - CRANKSHAFT RUNOUT

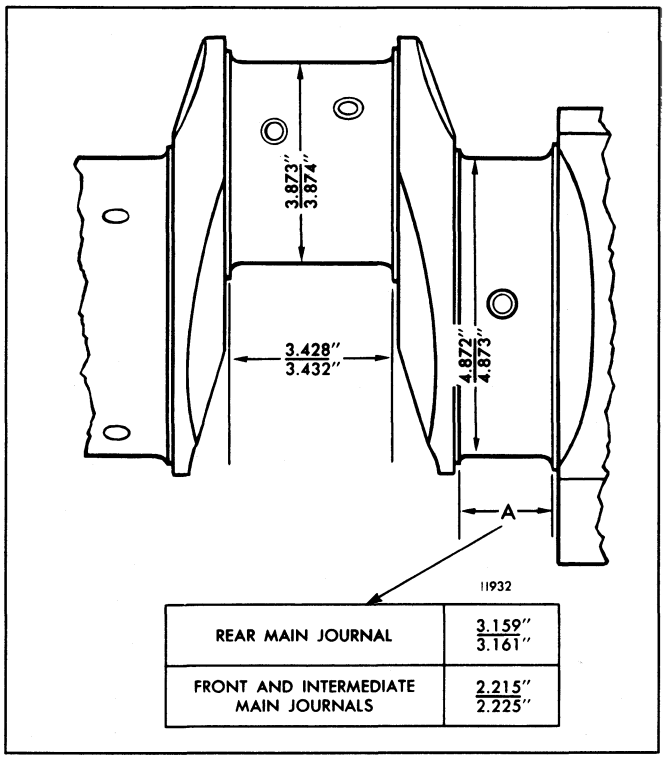


Fig. 4 – Dimensions of Crankshaft Journals

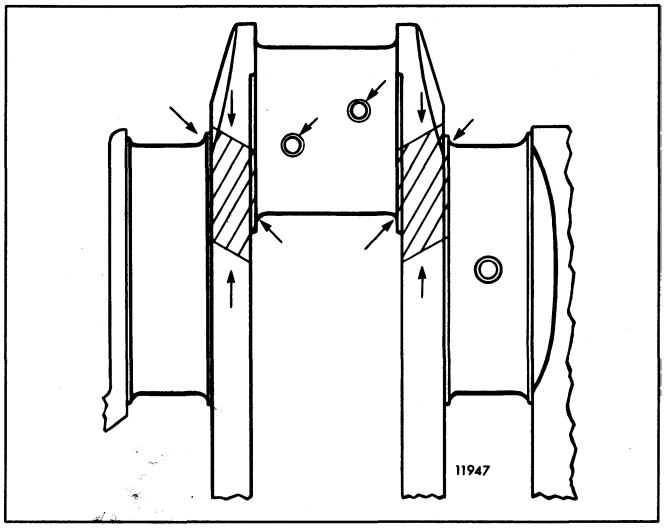


Fig. 5 – Critical Crankshaft Loading Zones

Inspection For Cracks

Carefully check the crankshaft for cracks which start at an oil hole and follow the journal surface at an angle of 45° to the axis. Any crankshaft with such cracks must be rejected. Several methods of determining the presence of minute cracks not visible to the eye are outlined below.

Magnetic Particle Method: The part is magnetized and then covered with a fine magnetic powder or solution. Flaws, such as cracks, form a small local magnet which causes the magnetic particles in the powder or solution to gather there, effectively marking the crack. The crankshaft must be demagnetized after the test.

Fluorescent Magnetic Particle Method: This method is similar to the magnetic particle method, but is more sensitive since it employs magnetic particles which are fluorescent and glow under "Black Light". Very fine cracks that may be missed under the first method, especially on discolored or dark surfaces, will be disclosed under the "Black Light".

Fluorescent Penetrant Method: This is a method which may be used on both *non-magnetic and magnetic* materials. A highly fluorescent liquid penetrant is applied to the part. Then, the excess penetrant is removed from the surface and the part is dried. A developing powder is then applied which helps to draw the penetrant out of the flaws by capillary action. Inspection is carried out under "Black Light".

A majority of indications revealed by the above inspection methods are normal and harmless and only in a small percentage of cases is reliability of the part impaired when indications are found. Since inspection reveals the harmless indications with the same intensity as the harmful ones, detection of the indications is but a first step in the procedure. **Interpretation** of the indications is the most important step.

All Detroit Diesel Corporation crankshafts are magnetic particle inspected after manufacture to ensure against any shafts with harmful indications getting into the original equipment or factory parts stock.

Crankshaft failures are rare and when one cracks or breaks completely, it is very important to make a thorough inspection for contributory factors. Unless abnormal conditions are discovered and corrected, there will be a repetition of the failure.

There are two types of loads imposed on a crankshaft in service — a *bending* force and a *twisting* force. The design of the shaft is such that these forces produce practically no stress over most of the surface. Certain small areas, designated as critical areas, sustain most of the load (Fig. 5).

Bending fatigue failures result from bending of the crankshaft which takes place once per revolution.

The crankshaft is supported between each of the cylinders by a main bearing and the load imposed by the gas pressure on top of the piston is divided between the adjacent bearings. An abnormal bending stress in the crankshaft, particularly in the crank fillet, may be a result of misalignment of the main bearing bores, improperly fitted bearings, bearing failures, a loose or broken bearing cap, or unbalanced pulleys. Also, drive belts which are too tight may impose a bending load upon the crankshaft.

Failures resulting from bending start at the pin fillet and progress throughout the crank cheek, sometimes extending into the journal fillet. If main bearings are replaced due to one or more badly damaged bearings, a careful inspection must be made to determine if any cracks have started in the crankshaft. These cracks are most likely to occur on either side of the damaged bearing.

Torsional fatigue failures result from torsional vibration which takes place at high frequency.

A combination of abnormal speed and load conditions may cause the twisting forces to set up a vibration, referred to as torsional vibration, which imposes high stresses at the locations shown in Fig. 5.

Torsional stresses may produce a fracture in either the connecting rod journal or the crank cheek. Connecting rod journal failures are usually at the fillet at 45° to the axis of the shaft.

A loose, damaged or defective vibration damper or the introduction of improper or additional pulleys or couplings are usual causes of this type of failure. Also, overspeeding of the engine or resetting the governor at a different speed than intended for the engine application may be contributory factors.

As previously mentioned, most of the indications found during inspection of the crankshaft are harmless. The two types of indications to look for are circumferential fillet cracks at the critical areas and 45° cracks (45° with the axis of the shaft) starting from either the critical fillet locations or the connecting rod journal holes (Fig. 6). Replace the crankshaft when cracks of this nature are found.

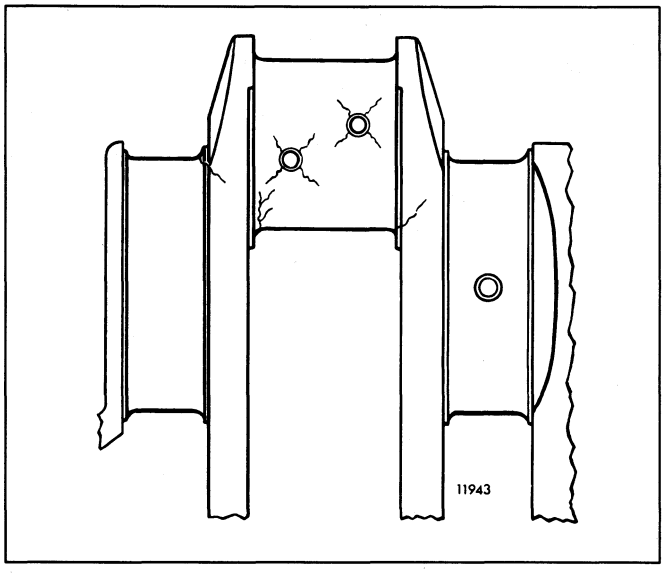


Fig. 6 – Crankshaft Fatigue Cracks

Crankshaft Grinding

In addition to the standard size main and connecting rod bearings, .002", .010", .020" and .030" undersize bearings are available. The .002" undersize bearings are used only to compensate for slight wear on crankshafts on which regrinding is unnecessary.

If a 12V or 16V crankshaft is to be reground, remove the bolts securing the two crankshaft halves together and proceed as follows:

The 12V and 16V crankshaft outboard bearing surface *must not* be reduced in diameter. The drive hub to crankshaft tolerance must be maintained to provide the proper fit between the mating parts.

Connecting rod and/or main bearing journals which exhibit discoloration due to excessive overheating from bearing failure are *not* acceptable for rework.

1. Compare the crankshaft journal measurements taken during inspection with the dimensions in Table 2 and Fig. 4 and determine the size to which the journals are to be reground.

Bearing Size	Conn. Rod Journal Dia.	Main Bearing Journal Did.
Standard	3.873"/3.874"	4.872"/4.873"
.002" U.S.	3.871 73.872"	4.87074.871"
.010" U.S.	*3.86373.864"	*4.86274.863"
.020" U.S.	*3.853*73.854"	*4.852*74.853"
.030" U.S.	*3.84373.844"	*4.842*74.843"

'Dimension of reground crankshaft.

TABLE 2 - CRANKSHAFT GRINDING CHART

 © Detroit Diesel Corporation

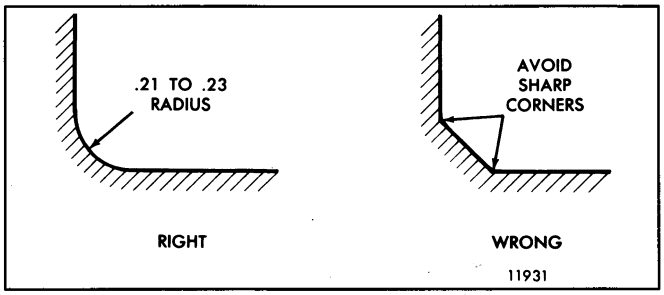


Fig. 7 – Crankshaft Journal Fillets

EXAMPLE - If the main journal measurement of a used crankshaft is 4.865", the crankshaft should be ground to accommodate .010" undersize bearings. However, if the measurements of the main journal are below 4.863", the journals should be ground to accept .020" undersize bearings.

2. If one or more main or connecting rod journals require grinding, then grind all of the main journals or all of the connecting rod journals to the same required size.

3. All journal fillets must have a .210" to .230" radius between the crank cheek and the journal and must not have any sharp grind marks (Fig. 7). The fillet must blend smoothly into the journal and the crank cheek and must be free of scratches. The radius may be checked with a fillet gage.

4. Care must be taken to avoid localized heating which often produces grinding cracks. Cool the crankshaft while grinding, using coolant generously. Do not crowd the grinding wheel into the work.

5. If the thrust surfaces of the crankshaft are worn or grooved excessively, they must be reground and polished. Care must be taken to leave a .210" to .230" radius between each thrust surface and the bearing journal.

6. Stone the edge of all oil holes in the journal surfaces smooth to provide a radius of approximately 3/32".

7. After grinding has been completed, inspect the crankshaft by the magnetic particle method to determine whether cracks have originated due to the grinding operation.

8. Demagnetize the crankshaft.

9. Remove the plugs and clean the crankshaft and oil passages thoroughly with fuel oil. Dry the shaft with compressed air and reinstall the plugs.

Assemble Crankshaft Halves (12V And 16V)

If a new crankshaft is to be installed, steam clean it to remove the rust preventive, blow out the oil passages with compressed air and install the plugs.

Unless an additional cylinder block is available for crankshaft assembly, prepare the cylinder block being worked on, following Steps 3, 4 and 5 under *Install Crankshaft.*

Assemble the two 12 V or 16V crankshaft halves, using the cylinder block for alignment, as follows:

1. Refer to Section 1.3.4 for main bearing details and install the upper *grooved* main bearing shells in the cylinder block.

2. Apply clean engine oil to all crankshaft journals and place each crankshaft half in position in the cylinder block.

3. Install the upper halves of the crankshaft thrust washers on each side of the rear main bearing support and the doweled lower halves on each side of the rear bearing cap. *The grooved side of the thrust washers must face toward the crankshaft thrust surface.*

4. With the lower main bearing shells (refer to Section 1.3.4) installed in the bearing caps, lubricate the bolt threads and bolt head contact areas with a small quantity of International Compound No. 2, or equivalent. Install all of the bearing caps, **except the two center caps,** and draw the bolts up snug. Then, rap the caps sharply with a soft hammer to seat them properly.

5. Tighten each set of main bearing cap bolts, starting with the bolts on the outside of the bearing cap and proceeding with the two inner bolts, to approximately 100 lb—ft (136 N«m) torque. Then, using the same sequence, tighten each bolt to 280-290 lb—ft (379-393 N#m) torque. If the bearings have been installed properly, the crankshaft halves will turn freely with the main bearing cap bolts drawn to the specified torque.

6. Position a dial indicator on each of the two journals (No. 4 and No. 5 on 12V or No. 5 and No. 6 on 16 V). Then, check the journal runout (Fig. 8) on each crankshaft half with one end of the cylinder block elevated to pre-load the thrust area.

7. Rotate the crankshaft halves until the crankshaft timing jnarks are in alignment on the two crankshaft end flanges (Fig. 8). Coat the intermediate flange bolt threads with International Compound No. 2 (or equivalent). Wipe excess compound from the bolt threads and install the 7/16" bolts in the crankshaft.

8. Install two 1/2" bolts and nuts 120° apart and 120° from the 7/16" bolt and nut.

9. Snug up the three bolts and nuts and, while slowly rotating the crankshaft, tap the flanges to bring the runout between the two center adjacent journals to within .001".

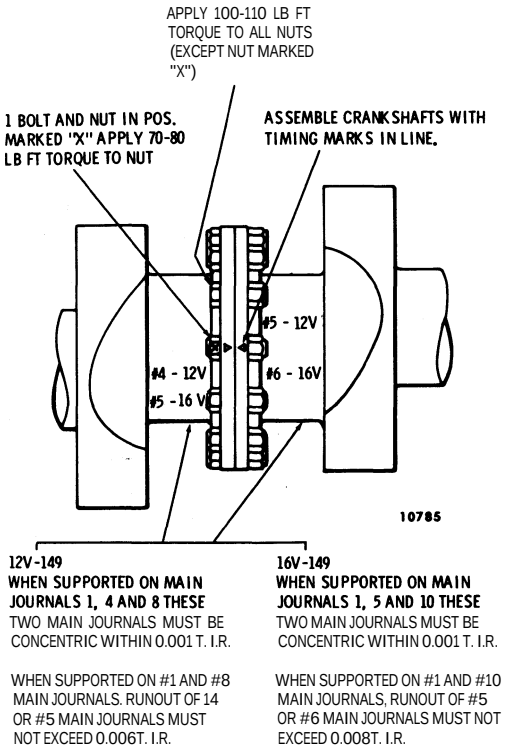


Fig. 8 - Crankshaft Assembly Instructions

10. Install the remaining bolts and nuts. Alternately torque each nut (180° apart) until all nuts have been tightened. Tighten the 7/16” nut to 70-80 lb—ft (95-108 Nem) torque and the 1/2” nuts to 100-110 lb—ft (136-150 Nem) torque. However, because of the space limitations, a torque wrench adaptor set J 22897 must be used and the torque wrench reading must be adjusted due to the increase in length of the torque wrench with the adaptor in place. Use the following formula to determine the adjusted torque reading.

$$Tw = Ta \left(\frac{\quad}{1 + a}\right) \quad \ldots\ldots\ldots\ldots\ldots 1$$

EXAMPLE - If the effective length of the wrench (L) is 22” and the adaptor (A) is 3” long, you should have a reading of 66 lb—ft (89 N#m) on the wrench to have the bolt tightened to 75 lb—ft (102 N#m) torque (Fig. 9):

$$Tw = 75 \left(\frac{22}{22 + 3}\right)$$

$$Tw = 75\ (22/25)$$

$$Tw = 66$$

11. Install the crankshaft oil passage plugs as follows:

The plugs are shipped loose with a service crankshaft.

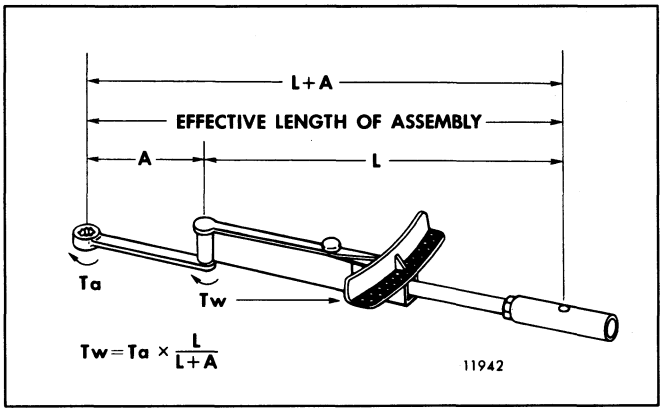


Fig. 9 - Calculating Torque with an Adaptor

a. On current engines, the 1/4” pipe plug must be deleted from the rear crankshaft half to allow for lubrication of the rear outboard bearing support. On former engines without a rear outboard bearing support, install the 1/4” pipe plug in the rear end of the crankshaft. The oil passage in the front end of the crankshaft is to lubricate the front outboard bearing support.

• b. The ends of former crankshafts were counterbored to receive 3” cup plugs (Fig. 10). A limited number of former crankshafts were produced with 3 1/8” or 3 1/4” cup plugs. The ends of current crankshafts are drilled and tapped to accept 1/2” - 14 Vibraseal-coated pipe plugs. A few crankshafts were also produced with 3/4” plugs.

Apply a thin coat of Loctite Vibraseal, or an equivalent non-hardening sealant, to the outside diameter of all plugs before installing. Install required plugs in each end of the crankshaft. Tighten current 1/2” pipe plugs to 80 lb—ft (108 N#m) torque. Vacuum test *cup plugs* using cup plug tester J 34728 with vacuum pump J 23738.

c. Install the 3/8” pipe plugs in each crankshaft throw (6 in the 12V engine or 8 in the 16V engine).

Install Crankshaft

• If a new crankshaft is to be installed, steam clean it to remove the rust preventive, blow out the oil passages with compressed air and install the pipe plugs. Apply a thin coat of non-hardening sealant to the outside diameter of the 1/2” pipe plug(s), install the plug(s), and tighten to 80 lb—ft (108 N»m) torque. Then, install the crankshaft as follows:

When a new or reground crankshaft is installed, ALL new main and connecting rod (upper and lower) bearing shells and new thrust washers must also be installed.

 © Detroit Diesel Corporation

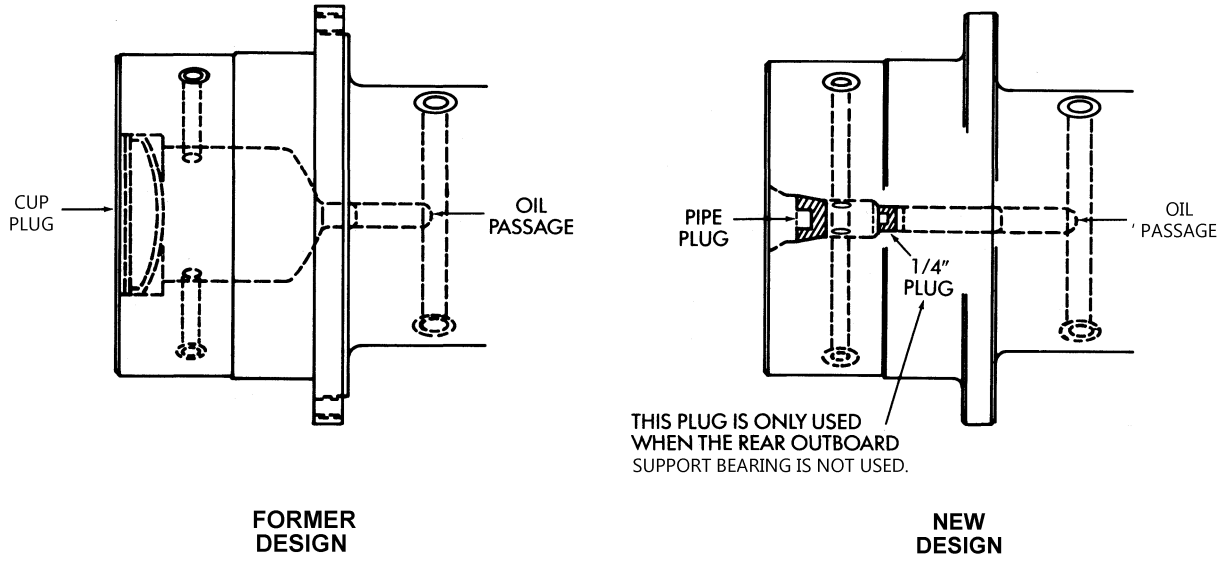


Fig. 10 - Former and Current Series 49 Engine Crankshaft End Designs

1. Assemble the crankshaft timing gears and front timing gear damper (Section 1.7.5).

2. Turn the engine so the front end is facing down.

   NOTICE: Be careful not to damage the gear train.

3. Remove the piston and cylinder liner retainers.

4. Remove the pistons, connecting rods and cylinder liners from the cylinder block.

5. Turn the engine upside down on the overhaul stand.

6. Refer to Section 1.3.4 for main bearing details and install the upper *grooved* main bearing shells in the block. If the old bearing shells are to be used again, install them in the same locations from which they were removed. The two (2) wide bearings are installed at the ends of the cylinder block.

7. Apply clean engine oil 360° around all crankshaft bearing journals and install the crankshaft in place so that the timing marks on the crankshaft timing gear and the idler gear match. Refer to Section 1.7.1 for the correct method of timing the gear train.

8. Install the upper halves of the crankshaft thrust washers on each side of the rear main bearing support and the doweled lower halves on each side of the rear main bearing cap. *The grooved side of the thrust washers must face toward the crankshaft thrust surfaces.* If the crankshaft thrust surfaces were reground, it may be necessary to install oversize thrust washers on one or both sides of the rear main journal. Refer to Fig. 6 and Table 3.

Nominal Size	Thrust Washer Thickness	
	Min.	Max.
Standard	.1630"	.1660"
.005" Oversize	.1680"	.1710"
.010" Oversize	.1730"	.1760"

TABLE 3 - THRUST WASHER SIZE

9. Install the lower main bearing shells (no oil grooves) in the bearing caps. If the old bearing shells are to be used again, install them in the same bearing caps from which they were removed.

10. Install the bearing caps and lower bearing shells as outlined under *Install Main Bearing Shells* in Section 1.3.4. If the bearings have been installed properly, the crankshaft will turn freely with all of the main bearing cap bolts drawn to the specified torque.

11. Check the crankshaft end play by moving the crankshaft toward the gage with a small (less than 12") pry bar (Fig. 11). Keep a constant pressure on the pry bar and set the dial indicator to zero. Then, remove and insert the pry bar on the other side of the bearing cap. Force the crankshaft in the opposite direction and note the amount of end play on the dial. The end play

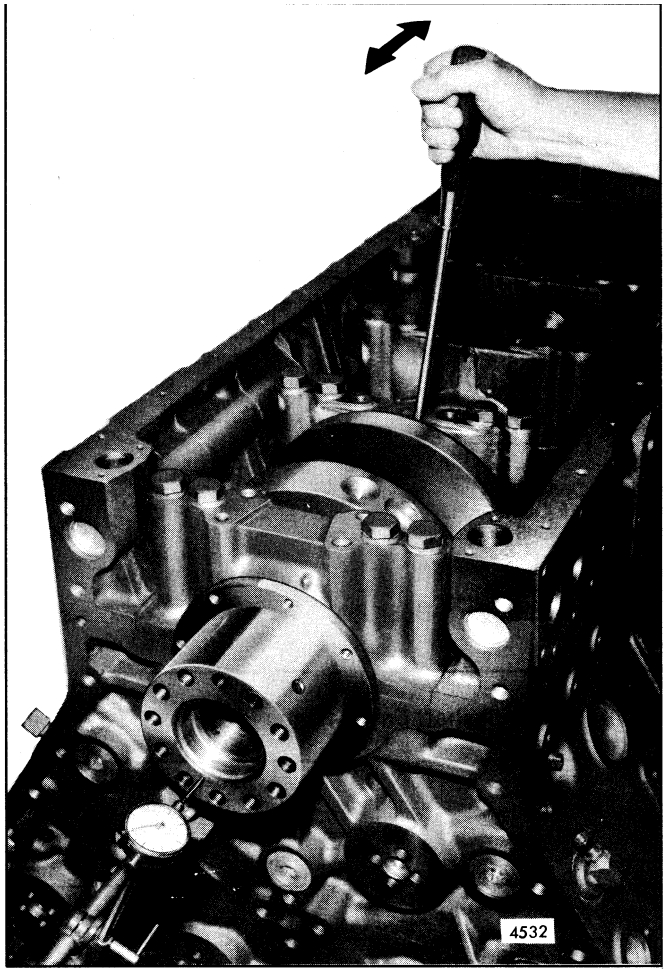


Fig. 1 1 - Checking Crankshaft End Play

should be .004M to .014" with new parts or a maximum of .018" with used parts. Insufficient end play can be the result of a misaligned rear main bearing or a burr or dirt on the inner face of one or more of the thrust washers. Crankshaft end play must be checked again after installation of the power takeoff assembly, transmission, marine gear or power generator.

12. Position the engine with the front face down, on the overhaul stand, using care not to damage the gear train.

13. Install the pistons, connecting rods and cylinder liners (Section 1.6.3).

14. Install the cylinder liner retainers.

15. Turn the engine right side up on the overhaul stand.

16. Install the front cover (Section 1.3.5).

17. Install the outboard bearing support and seal assembly on the front cover (Section 1.3.5.1).

18. Install the heat exchanger, if so equipped.

19. Install the thermostat housings, water pump and vibration damper.

20. Install the crankshaft cap or pulley retaining bolt and washer at the front end of the crankshaft.

21. Install the flywheel housing (Section 1.5) outboard bearing support - current engines (Section 1.3.5.2) and the flywheel assembly (Section 1.4).

22. Check the crankshaft for **distortion** (bending) at the rear connecting rod journal counterweights *before* and *after* installing a power takeoff assembly, marine gear, transmission or power generator. If improperly installed these components can distort the crankshaft and cause a crankshaft malfunction. Overtightening drive belts can also cause crankshaft distortion. See Section 15.1 for recommended belt tensions.

While in each case one must be guided by the individual circumstances and facts that evolve, generally speaking Detroit Diesel Corporation cannot be responsible for system damage caused by engine-to-driven component interference and/or distortion. Consequently, the engine crankshaft end play check and crankshaft distortion check are *musts.*

Check the crankshaft distortion as follows:

a. Rotate the crankshaft clockwise until the crankshaft counterweights at the rear connecting rod journal are in the six (6) o'clock position.

b. Center punch a hole in the inside face of each counterweight cheek, one quarter of an inch from the lower end of each counterweight, to support the gage.

c. Install a gage (Starrett Co. No. 696 dial gage, or equivalent) in the center punch holes in the cheek of each counterweight (Fig. 12).

d. Set the dial indicator at zero, then rotate the crankshaft approximately 90° in both directions. Do not allow the gage to contact the connecting rod caps or bolts. Note and record the dial indicator readings at the 3, 6 and 9 o'clock crankshaft counterweight positions. The maximum allowable variation is .0045" total indicator reading. Remove the tool that was used to rotate the crankshaft when taking the dial indicator readings. >

e. If the reading on the gage exceeds .0045", check the power takeoff assembly, transmission, marine gear, or power generator for improper installation and realign as necessary.

23. Install the upper oil pan (Section 4.7).

 © Detroit Diesel Corporation

24. Install the oil pump, brackets, tubing and lower oil pan (Section 4).

25. Remove the engine from the overhaul stand and place it on its base.

26. Install all of the accessories which were previously removed.

27. Remove the cylinder liner retainers.

28. Install the cylinder heads, valve and injector operating mechanism, and valve rocker covers using new gaskets.

29. After the engine has been completely reassembled, refer to the *Lubrication Recommendations* in Section 13.3 and refill the crankcase to the proper level on the dipstick.

30. Fill the cooling system (Section 5).

31. After replacing the main or connecting rod bearings or installing a new or reground crankshaft, operate the engine as outlined in the *run-in* schedule (Section 13.2.1).

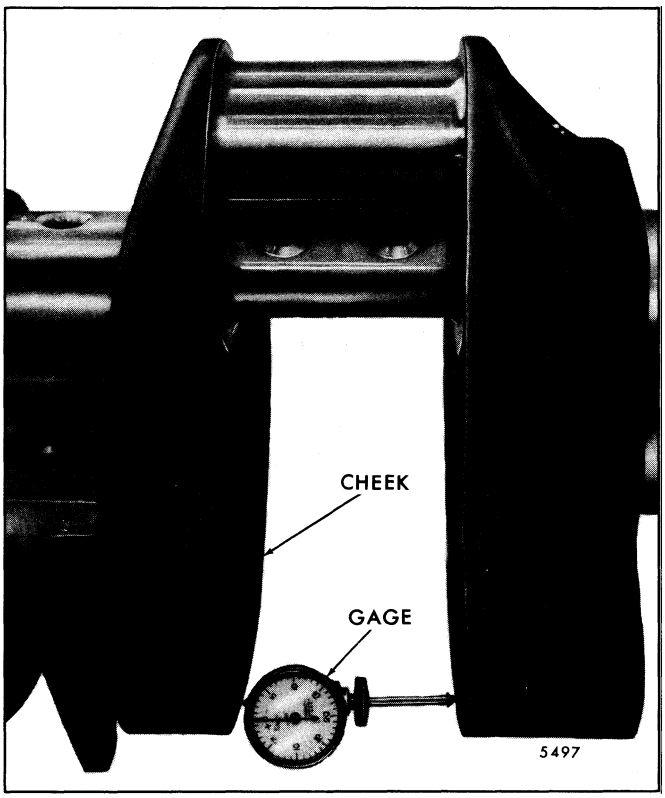


Fig. 12 - Crankshaft Distortion Measuring Gage Mounted on Crankshaft

CRANKSHAFT OIL SEALS

An oil seal is used at each end of the crankshaft to retain the lubricating oil in the crankcase. The sealing lips of the oil seals are held firmly, but not tight, against the crankshaft sealing surfaces by a coil spring.

• Effective with unit serial numbers 8E0002524, 12E0008668, and 16E0008435, fluoroelastomer front and rear oil seals are used in all Series 149 engines. The sealing lips of the new seals are made of a wear-resistant fluoroelastomer rubber material and are *unidirectional* That is, they seal in only one direction of crankshaft rotation. To insure proper installation, the direction of crankshaft rotation is stamped on the seal cases. The former seals had silicone rubber sealing lips and were bi-directional.

> • **NOTICE:** Failure to install the correct seal in relation to the direction of crankshaft rotation can result in seal damage, oil leakage, and possible engine damage caused by a reduced oil level.

• Oil seals are pre-lubricated with a special lubricant. *Do not remove this lubricant* Keep the sealing lip(s) clean and free from scratches. A plastic coating which acts as a sealant is applied to the outer surface of the casing. *Do not remove this coating.* To prevent seal lip damage at start-up, new seals must be lubricated with clean engine oil at assembly.

The front oil seal (Fig. 1) is pressed into the outboard bearing support and seals on a replaceable sleeve pressed on the vibration damper hub adaptor (Section 1.3.6). On current engines, the rear oil seal is pressed into the outboard bearing support and seals on a replaceable sleeve pressed on the flywheel (Fig. 2). The former rear oil seal is pressed into the flywheel housing and seals on the crankshaft (Fig. 3).

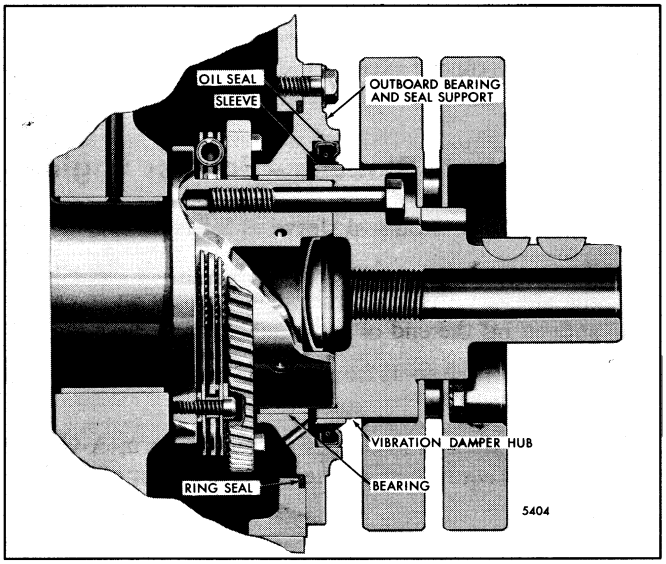


Fig. 1 - Crankshaft Front Oil Seal

Oil seals may become worn or damaged due to improper installation, excessive main bearing clearances, excessive flywheel housing bore runout or grooved sealing surfaces on the crankshaft or oil seal sleeve.

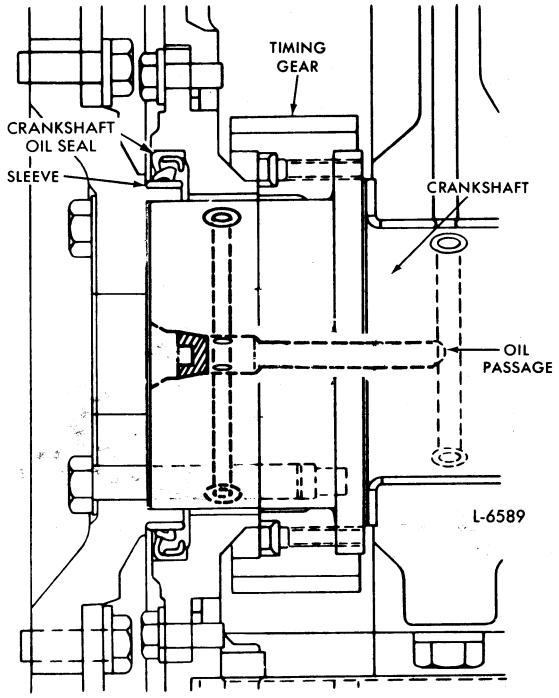
Remove Crankshaft Front Oil Seal Current And Former

1. Remove the vibration dampers (Section 1.3.6) from the front end of the crankshaft hub.
2. Remove the outboard bearing support from the engine front cover (Section 1.3.5.1).
3. Support the inner face of the outboard bearing support on wood blocks. Then pry the oil seal out of the support.

Remove Crankshaft Rear Oil Seal

Remove the flywheel (Section 1.4) from the engine. Remove the rear crankshaft oil seal from the flywheel housing as follows:

1. Current rear oil seal:
   a. Remove the outboard bearing support from the flywheel housing (Section 1.3.5.2).



• Fig. 2 - Crankshaft Rear Oil Seal - Current

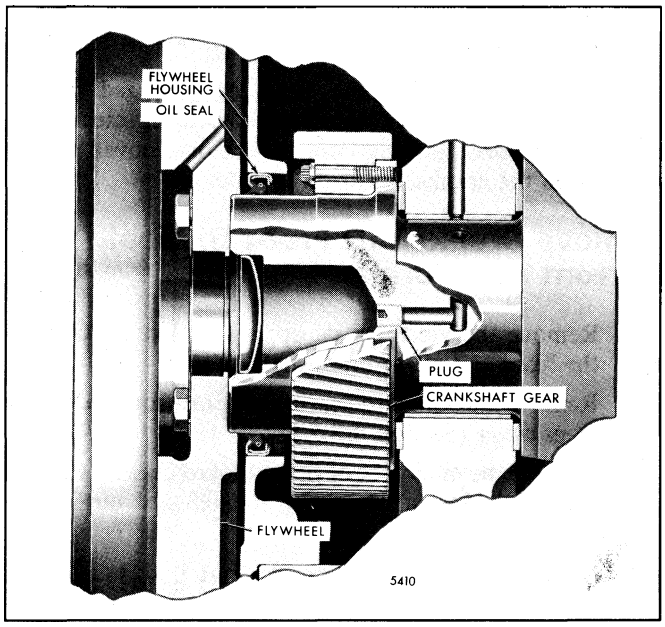


Fig. 3 - Crankshaft Rear Oil Seal - Fonner

b. Support the inner face of the outboard bearing support on wood blocks. Then pry the oil seal out of the support.

2. Former rear oil seal:

a. Drill two diametrically opposite holes in the oil seal casing.

b. Thread a metal screw with a flat washer into each hole.

c. Use a pry bar against each of the flat washers to remove the oil seal.

Install On Seal Sleeves - Current Engines

• To ensure proper sealing, replace the oil seal sleeve whenever a new oil seal is installed. An oversized oil seal must be used with the sleeve.

NOTICE: Before installing the crankshaft oil seal sleeve (front or rear), check for sharp corners, scratches, inclusions or nicks. If the sleeve is damaged, replace it.

To remove a worn sleeve, peen the outside diameter of the sleeve until it stretches sufficiently so it can be slipped off the end of the crankshaft.

Install the front oil seal sleeve:

1. Support the front vibration damper hub on the bed of an arbor press.
2. Using tool J 22518, press the oil seal sleeve flush with the vibration damper hub.

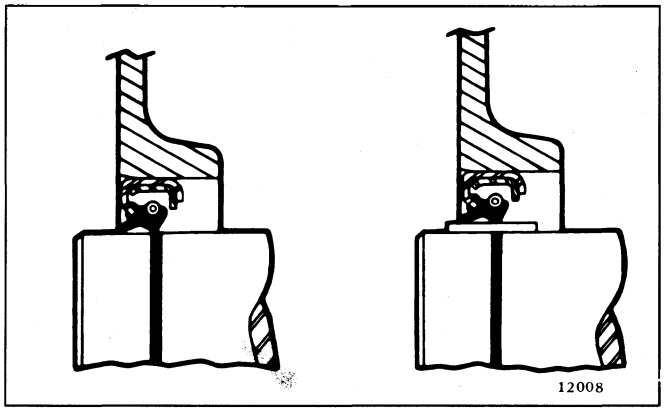


Fig. 4 - Crankshaft Oil Seal Sleeve - Former

Install the rear oil seal sleeve:

1. Support the flywheel or flywheel coupling assembly on the bed of a suitable press.
2. Using tool J 22518, press the oil seal sleeve until it seats on the flywheel or flywheel coupling assembly.

Inspection - Former ReaftSeal

Inspect the rear end of the crankshaft for wear caused by the rubbing action of the oil seal, dirt build-up or fretting by the action of the flywheel. The crankshaft surface must be clean and smooth to prevent damaging the seal lip when a new oil seal is installed. Slight ridges may be removed from the crankshaft as outlined under *Inspection* in Section 1.3.

The maximum runout of the oil seal bore in the flywheel housing is .008". The bore may be checked with a dial indicator mounted on the end of the crankshaft in a manner similar to the procedure for checking the flywheel housing concentricity as outlined in Section 1.5. This check must be made with the flywheel housing or the outboard bearing support in place on the engine and the oil seal removed. If the runout exceeds the maximum limits refer to Section 1.5 *Install Flywheel Housing.*

Install Oil Seal Sleeves - Former Engines

Install the rear oil seal sleeve as follows:

1. To remove a worn sleeve, peen the outside diameter of the sleeve until it stretches sufficiently so it can be slipped off the end of the crankshaft.
2. Stone the high spots from the oil seal contact surface of the crankshaft.

• 3. Apply a thin, even coat of Permatex Form-A-Gasket No. 2, or equivalent, to the inside diameter of the wear sleeve.

4. Drive the sleeve squarely on the shaft with oil seal sleeve installer J 22767-1 and guide pins J 22767-2.

 © Detroit Diesel Corporation

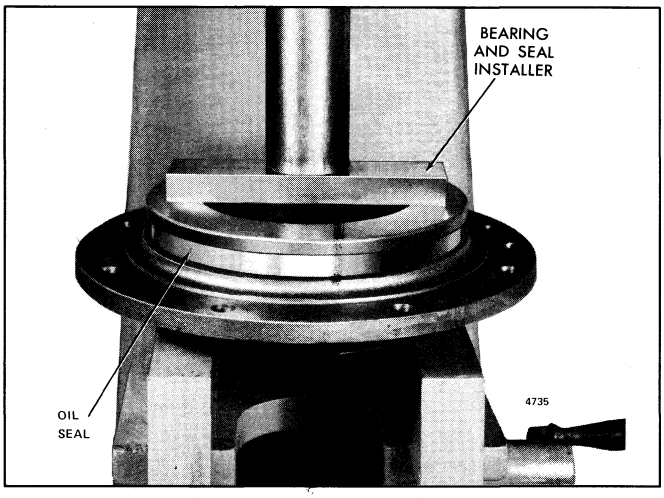


Fig. 5 - Installing Seal in Outboard Bearing Support

5. Wipe off any excess sealant.
6. Liberally lubricate the outside diameter of the oil seal sleeve with clean engine oil.

Install the front oil seal sleeve as follows:

• 1. Apply a thin, even coat of Permatex Form-A-Gasket No. 2, or equivalent, to the inside diameter of the wear sleeve.

2. Support the front vibration damper hub on the bed of an art[A]or press.
3. Using tool J 22518, press the oil seal sleeve flush with the vibration damper hub.

Install Crankshaft Front Oil Seal Current And Former

1. Place the bearing support on the bed of an arbor press. Coat the oil seal bore with a non-hardening sealant, unless the seal case is already pre-coated. Press the new crankshaft oil seal into the outboard bearing support with the lip of the seal facing in towards the bearing with seal installer J 22518 (Fig. 5).
2. Install the outboard bearing support assembly (Section 1.3.5.1).
3. Install the vibration dampers (Section 1.3.6).

Install Crankshaft Rear Oil Seal Current Seal

1. Place the bearing support on the bed of an arbor press. Coat the oil seal bore with a non-hardening sealant, unless the seal case is already pre-coated. Press the new crankshaft oil seal into the bearing support until it contacts the bottom of the counter bore in the bearing support, using tool J 22518 (Fig. 5).
2. Install the rear outboard bearing support assembly (Section 1.3.5.2).
3. Install the flywheel or flywheel coupling assembly (Section 1.4).

Install Crankshaft Rear Oil Seal (Flywheel Housing Installed) Former Seal

1. Remove the cup plug from the end of the crankshaft.

’ 2. Remove the pipe plug located inside of the crankshaft end bore.

3. Position the seal expander J 22605 (standard size seal) or J 22766 (oversize seal) against the crankshaft end and thread retainer bolt J 22604-4A through the expander and into the crankshaft pipe plug hole. Tighten the nut against the seal expander to hold it in position.

NOTICE: To ensure proper sealing, replace the rear (if used) oil seal sleeve whenever a new oil seal is installed.

4. Slide the seal, with the spring-loaded lip of the oil seal facing inward, over the seal expander and rear hub until the seal is up against the flywheel housing.
5. Remove the seal expander and place the seal installer J 22604-B up against the seal. Thread the bolt J 22604—A through the installer and into the crankshaft pipe plug hole.
6. Draw up the bolt forcing the nut against the installer. Turn the nut while lightly tapping around the edge of the installer with a soft hammer until the seal is properly seated in the flywheel housing bore.
7. Install the pipe plug inside of the crankshaft end bore.
8. Install the cup plug in the end of the crankshaft (Section 1.3).

Install Crankshaft Rear Oil Seal (Flywheel Housing Removed) Former Seal

If the flywheel housing is removed from the engine, a new oil seal can be installed using seal installer J 22518 and spacer J 22518-4. Refer to Section 1.5 when installing the flywheel housing with the oil seal installed.

NOTICE: To ensure proper sealing, replace the rear (if used) oil seal sleeve whenever a new oil seal is installed.

CRANKSHAFT MAIN BEARINGS

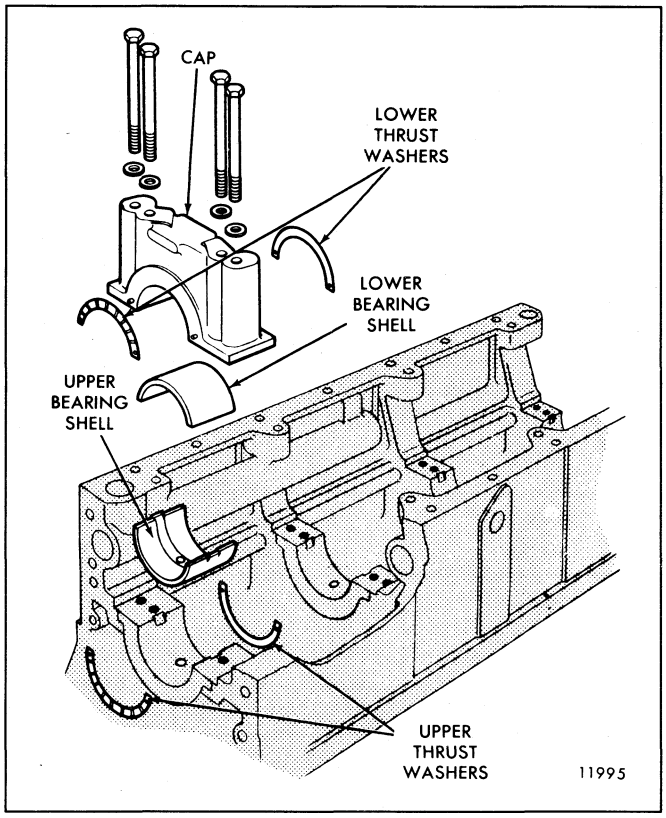


Fig. 1 - Main Bearing Shells, Bearing Caps and Crankshaft Thrust Washers

The crankshaft main bearing shells (Fig. 1) are precision made and are replaceable without machining. They consist of an upper bearing shell seated in each cylinder block main bearing support and a lower bearing shell seated in each main bearing cap. The upper and lower bearing shells are located in the respective block and bearing cap by a tang at the parting line at one end of each bearing shell. The tangs on the lower bearing shells are off-center and the tangs on the upper bearing shells are centered to aid correct installation.

An oil hole in the groove of each upper end bearing shell and the slot in each current intermediate upper bearing shell (Fig. 2), midway between the parting lines, registers with a vertical oil passage in the cylinder block. Lubricating oil, under pressure, passes from the cylinder block oil gallery by way of the bearing shells to the drilled passages in the crankshaft, then to the connecting rods and connecting rod bearings.

The lower main bearing shells have no oil grooves; therefore, the upper and lower bearing shells must not be interchanged.

Thrust washers (Fig. 1), on each side of the rear main bearing, absorb the crankshaft thrust. The lower halves of

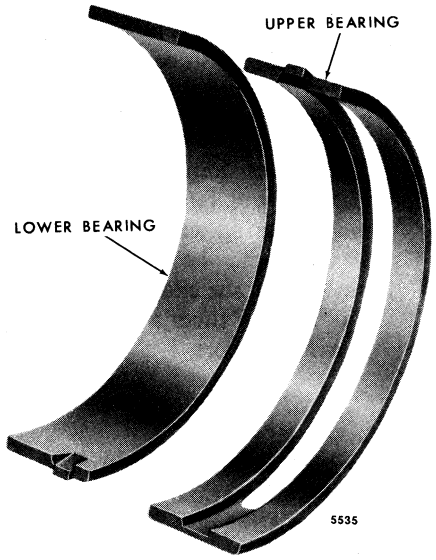


Fig. 2 - Current Intermediate Main Bearing Shells

the two-piece washers are doweled to the bearing cap; the upper halves are not doweled.

All of the main bearing load is carried on the lower bearings; therefore, wear will occur on the lower bearing shells first. The condition of the lower main bearing shells may be observed by removing the main bearing caps.

If main bearing trouble is suspected, remove the oil pan, then remove the main bearing caps, one at a time, as outlined below and examine the bearing shells.

Remove Main Bearing Shells (Crankshaft In Place)

The bearing caps are numered 1, 2, 3, etc., indicating their respective positions, and, when removed, must always be reinstalled in their *original* position.

RemoVA the main bearing shells as follows:

1. Drain and remove the oil pan to expose the main bearing caps.
2. Remove the oil pump and oil inlet pipe assembly. If shims are used between the oil pump and the main bearing caps, save the shims so that they may be reinstalled in exactly the same location.
3. Remove one main bearing cap at a time and inspect the bearing shells as outlined under *Inspection.* Reinstall each bearing shell and bearing cap before removing another bearing cap.

a. To remove the upper main bearing shell, insert a 5/16" x 1" bolt with a 1/2" diameter and 1/16" thick head (made from a standard bolt) into the crankshaft journal oil hole. Then revolve the shaft to the right (clockwise) and roll the bearing shell out of position. The head of the bolt must not extend beyond the outside diameter of the bearing shell.

b. The lower halves of the crankshaft thrust washers will be removed along with the rear main bearing cap. The upper halves of the washers can be removed for inspection by pushing on the ends of the washers with a small rod, forcing them around and out of the main bearing support.

Inspection

Bearing failures may result from deterioration (acid formation) or contamination of the oil or loss of oil. An analysis of the lubricating oil may be required to determine if corrosive acid and sulphur are present which cause acid etching, flaking and pitting. Bearing seizure may be due to low oil or no oil.

Check the oil filter elements and replace them, if necessary. Also, check the oil bypass valve to make sure it is operating freely.

After removal, clean the bearings and inspect them for scoring, pitting, flaking, etching or signs of overheating. If any of these defects are present, the bearings must be discarded. The lower bearing shells, which carry the load, will normally show signs of distress before the upper bearing shells.

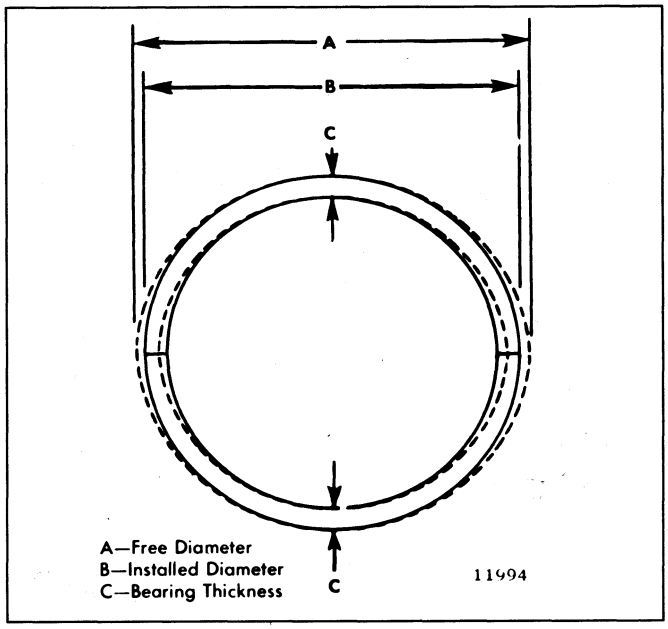


Fig. 3 – Main Bearing Measurements

Inspect the backs of the bearing shells for bright spots which indicate they have been moving in the bearing caps or bearing supports. If such spots are present, discard the bearing shells.

Measure the thickness of the bearing shells at point "C", 90° from the parting line, as shown in Figs. 3 and 4. Tool J 4757, placed between the bearing shell and a micrometer, will give an accurate measurement. The bearing shell thickness will be the total thickness of the steel ball in the tool and the bearing shell, less the diameter of the ball. This is the only practical method for measuring the bearing thickness, unless a special micrometer is available for this purpose. The minimum thickness of a worn standard main bearing shell is . 1544" and, if any of the bearing shells are thinner than this dimension, replace all of the bearing shells. A new standard bearing shell has a thickness of .1550" to .1555". Refer to Table 1.

Bearing Size	Bearing Thickness	Minimum Thickness
Standard	.1 550"/.1 555"	.1544"
.002" Undersize	.15607.1 565"	.1554"
!010" Undersize	.16007.1605"	.1594"
.020" Undersize	.1 650"/.1 655"	.1644"
.030" Undersize	.1700"/.1705"	.1694"

TABLE 1

In addition to the thickness measurement, check the clearance between the main bearings and the crankshaft journals. This clearance may be determined with the crankshaft in place by means of a soft plastic measuring strip which is squeezed between the journal and the bearing (refer to *Shop Notes* in Section 1.0). With the crankshaft removed measure the outside diameter of the crankshaft main bearing journals and the inside diameter of the main bearing shells when installed in place with the proper torque on the bearing cap bolts.

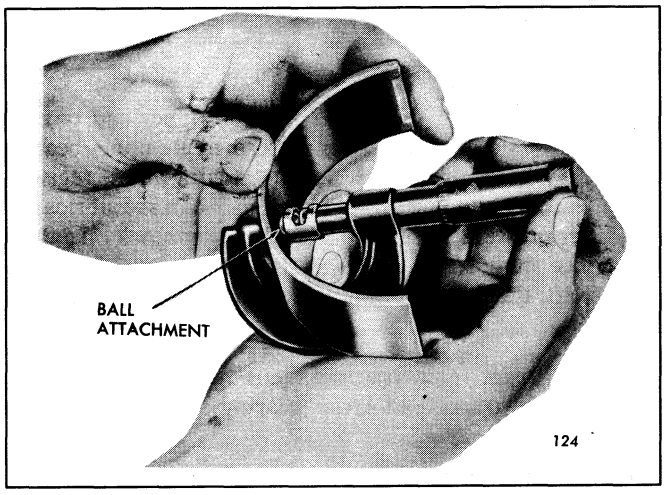


Fig. 4 - Measuring Thickness of Bearing Shell

 © Detroit Diesel Corporation

When installed, the bearing shells are .001" larger in diameter at the parting line than 90° from the parting line.

The bearing shells do not form a true circle when not installed. When installed, the bearing shells have a squeeze fit in the main bearing bore and must be tight when the bearing cap is drawn down. This *crush* assures a tight, uniform contact between the bearing shell and the bearing seat. Bearing shells that do not have sufficient crush will not have uniform seat contact, as shown by shiny spots on the back, and must be replaced. If the clearance between any crankshaft journal and its bearing shells exceeds .0072", all of the bearing shells must be discarded and replaced. This clearance is .0030" to .0062" with new parts.

Before installing new replacement bearings, it is very important to thoroughly inspect the crankshaft journals. Very often, after prolonged engine operation, a ridge is formed on the crankshaft journals in line with the journal oil holes. If this ridge is not removed before the new bearings are installed, then, during engine operation, localized high unit pressures in the center area of the bearing shell will cause pitting of the bearing surface. Also, damaged bearings may cause bending fatigue and resultant cracks in the crankshaft. Refer to Section 1.3 under *Crankshaft Inspection* for removal of ridges and inspection of the crankshaft.

Do not replace one main bearing shell alone. If one bearing shell requires replacement, install all new upper and lower bearing shells. Also, if a new or reground crankshaft is used, install all new bearing shells.

Bearing shells are available in .002", .010", .020" and .030" undersize for service with reground crankshafts. To determine the size bearings required, refer to *Crankshaft Grinding* in Section 1.3. Undersize bearings (.002") are available to compensate for slight journal wear where it is unnecessary to regrind the crankshaft.

Bearing shells are also available in .020" and .040" oversize on the *outer diameter* for use in cylinder blocks which have been line bored. Bearing shells are NOT reworkable from one undersize to another under any circumstances.

Inspect the crankshaft thrust washers. If the washers are scored or worn excessively or the crankshaft end play is excessive, they must be replaced. Improper clutch adjustment can contribute to excessive wear on the thrust washers. Inspect the crankshaft thrust surfaces. Refer to *Install Crankshaft* in Section 1.3. If, after dressing or regrinding the thrust surfaces, new standard size thrust washers do not hold the end play within the specified limits, it may be necessary to install oversize thrust washers on one or both sides of the rear main bearing. A new standard size thrust washer is .1630" to .1660" thick. Thrust washers are available in .005" and .010" oversize.

Install Main Bearing Shells (Crankshaft In Place)

Make sure all of the parts are clean. Then, apply clean engine oil 360° around each crankshaft bearing journal and install the upper main bearing shells by reversing the sequence of operations given for removal.

Six (6) - (12V) or eight (8) - (16V) narrow intermediate upper and lower main bearing shells and two wide end upper and lower main bearing shells are used in a cylinder block assembly. The end bearing shells are 2.70" wide and the intermediate bearing shells are 1.80" wide.

The upper and lower main bearing shells are not alike. The upper end bearing shells (2.70" wide) are grooved and drilled for lubrication; the upper intermediate bearing shells (1.80" wide) are slotted for lubrication (Fig. 2). The lower main bearing shells are not grooved or drilled. Be sure to install the grooved and drilled bearing shells in the cylinder block and the plain bearing shells in the bearing caps, otherwise the oil flow to the bearings and to the upper end of the connecting rods will be blocked off. Used bearing shells must be reinstalled on the same journal from which they were removed.

1. When installing an upper main bearing shell with the crankshaft in place, start the plain end of the bearing shell around the crankshaft journal so that, when the bearing is in place, the tang will fit into the groove in the bearing support.

2. Install the lower main bearing shell so that the tang on the bearing fits into the groove in the bearing cap.

3. Assemble the crankshaft thrust washers before installing the rear main bearing cap. Clean both halves of each thrust washer carefully and remove any burrs from the washer seats — the slightest burr or particle of dirt may decrease the clearance between the washers and the crankshaft beyond the specified limit. Slide the upper halves of the thrust washers into place. Then, assemble the lower halves over the dowel pins in the bearing cap. The main bearing caps are bored in position and marked 1,2, 3, etc. They must be installed in their *original positions. The grooved side of the thrust washers must face toward the crankshaft thrust surfaces*,

4. With the lower bearing shells installed in the bearing caps, apply a small quantity of International Compound No. 2, or equivalent, to the bolt threads and the bolt head contact areas. Install the bearing caps and draw the bolts up snug. Then, rap the caps sharply with a soft hammer to seat them properly.

5. Use tool J 35371 to tighten each set of main bearing cap bolts, starting with the bolts on the outside of the bearing cap and proceeding with the two inner bolts, to approximately 100 lb—ft (136 N*m) torque. Then,

using the same sequence, tighten all bolts (except the rear main bearing bolts) to 280-290 lb—ft (379-393 N*m) torque starting with the center bearing cap bolts and working alternately towards both ends of the block. Strike both ends of the crankshaft two or three sharp blows with a soft hammer to insure proper positioning of the rear main bearing cap in the block saddle. Retorque all bearing bolts to 280-290 lb—ft (379-393 N*m). Do not exceed the specified torque. the bearings have been installed properly, the crankshaft will turn freely with all of the main bearing cap bolts drawn to the specified torque.

6. Check the crankshaft end play as outlined under 10. *Install Crankshaft* in Section 1.3.

7. Install the lubricating oil pump intake pipe assembly and oil pump. If shims were used between the pump mounting brackets and the bearing caps, install them in their *original* positions. Then, check the oil pump gear clearance (Section 4.1).

Install the upper and lower oil pans, using a new seal ring.

If g Fill the crankcase to the proper level on the dipstick with *heavy-duty* lubricating oil of the recommended grade and viscosity (refer to *Lubrication Specifications* in Section 13.3).

After installing new bearing shells, operate the engine on a *run-in* schedule as outlined in Section 13.2.1.

 © Detroit Diesel Corporation

ENGINE FRONT COVER

The engine front cover (Fig. 1) is mounted against the cylinder block at the front end of the engine. The front cover provides mounting positions for the water pump, contains cast water manifolding between the water pump and water manifolds, provides a support for the crankshaft outboard bearing and has provisions for front engine mounts. On former engines, the front cover also served as a housing for the left and right-hand fuel control rods.

Remove Engine Front Cover

1. Drain the engine cooling system (Section 5).
2. Remove the heat exchanger or engine cooling fan.
3. Remove the engine front lifter bracket.
4. Disconnect the water manifolds and hoses and remove the thermostat housing assemblies from the front cover.
5. Remove the coolant filter and conditioner (if used).
6. Remove the water pump (Section 5.1).
7. Remove the crankshaft pulley and/or vibration damper from the crankshaft (Section 1.3.6).
8. With the engine suitably supported, remove the trunnion mount and hub from the front cover.
9. Remove the crankshaft outboard bearing support (Section 1.3.5.1).
10. On engines with the former style governor and fuel control rod linkage, remove the governor and fuel control rods from the engine.
11. Remove the bolts and lock washers securing the upper oil pan to the front cover.
12. Loosen the upper oil pan-to-cylinder block attaching bolts to allow removal of the front cover without dislodging the oil pan seal strip.
13. Remove the bolts and lock washers securing the engine front cover to the cylinder block and remove the front cover and seal strip.

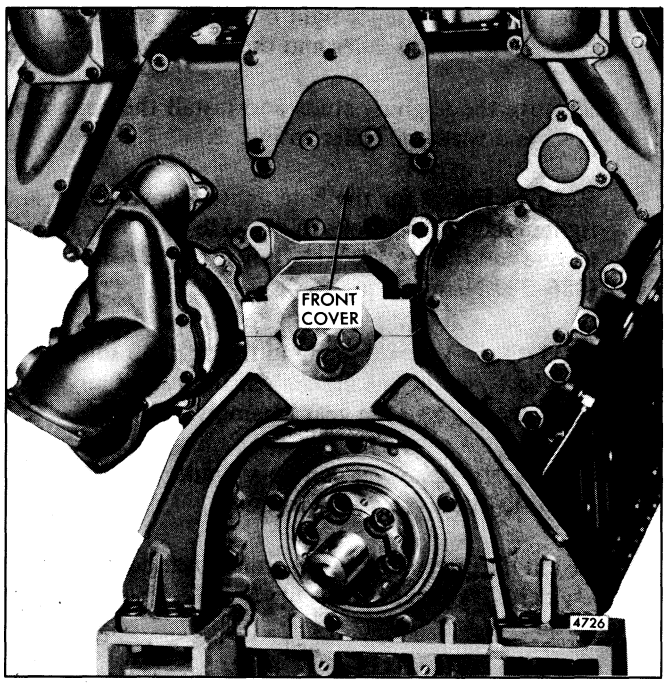


Fig. 1 - Front Cover Mounting on 1 2V-149 Engine

Inspection

Wash the front cover with fuel oil and dry it with compressed air.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Inspect the cover for cracks or other damage. Pressure test the water manifolding within the front cover. Apply 50 psi (345 kPa) air pressure and check for signs of cracks or leaks.

Inspect the seal strip groove for nicks and burrs. Replace the front cover if extensive damage is found.

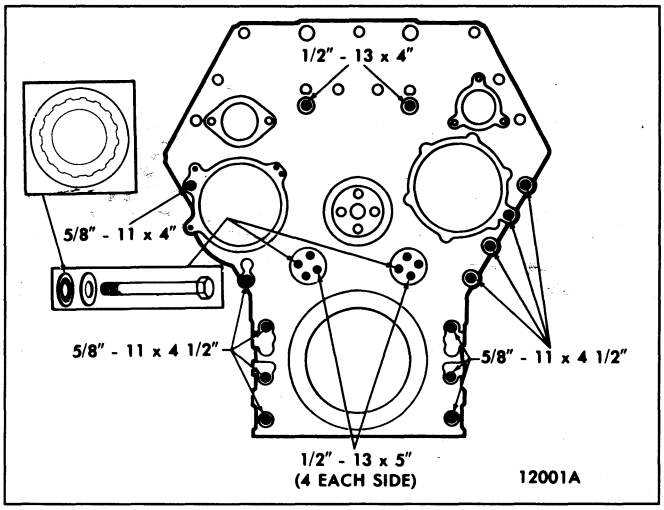


Fig. 2 – Front Cover Bolt Locations

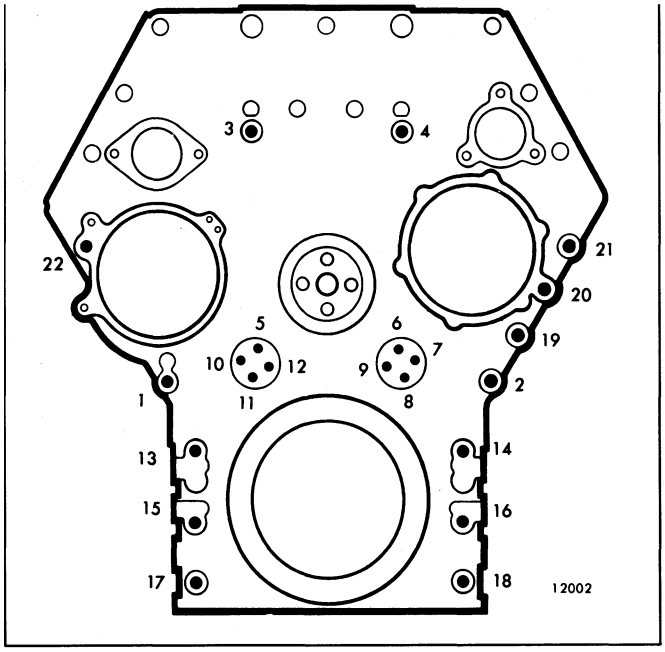


Fig. 3 – Bolt Tightening Sequence

NOTICE: The 3 1/8" cup plug is no longer included in a service front cover assembly. The plug is only used on remote mounted transmission torque converter units.

Install Engine Front Cover

1. Thread two aligning studs into the cylinder block to guide the front cover into position.

   NOTICE: Apply cup grease to the thrust washers on the front idler gear hubs to maintain their position when installing the front cover over the guide pins.

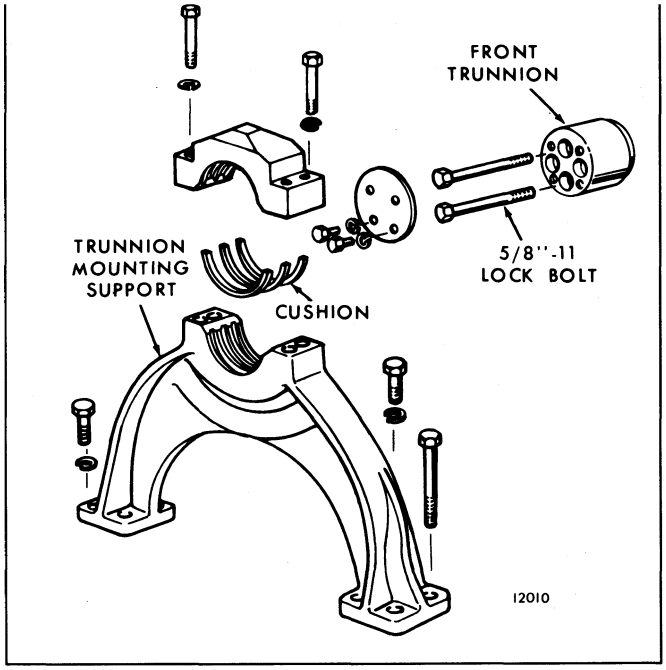
2. Make sure the cylinder block and front cover mating surfaces are clean and free of nicks and burrs.

3. Apply a thin coat of grease in the seal strip groove in the front cover. Then place a new seal strip in the groove in the cover. Cut away the excess seal strip at the bottom of the front cover.

4. Install the O-ring seals in the counterbores of the front cover at the water passages.

   NOTICE: The seal strip must lay flat in the groove and must not be twisted.

• 5. Apply a thin coat of spray adhesive on the exposed flat surfaces of the seal strip and O-rings.



4 - Front Trunnion Mounting (Current Engines)

6. Position the front cover in place over the aligning studs and up against the cylinder block, aligning the dowel pins in the cylinder block with the dowel pin holes in the front cover.

7. Refer to Fig. 2 and install the 1/2M—13 self-locking bolts and *new* 1/2" seal washers in the holes of the idler gear hubs (finger tight only). The seal washer is between the flat washer and the front cover.

8. Remove the aligning studs and install the remaining bolts and washers. Refer to Fig. 2.

9. Refer to Fig. 3 for the bolt tightening sequence and tighten the l/2"-13 bolts to 71-75 lb-ft (96-102 N«m) torque and the 5/8"-ll bolts to 137-147 lb-ft (186-200 N«m) torque.

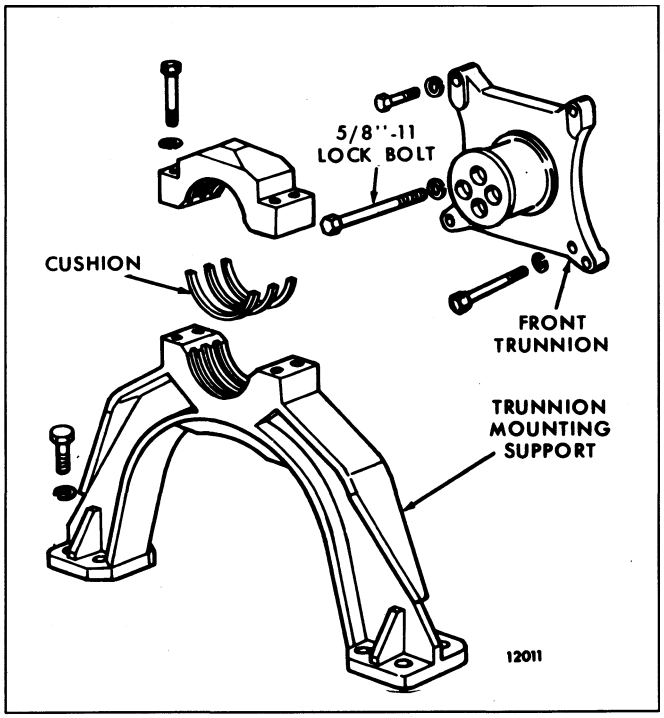
   NOTICE: * When tightening the l/2"-13 idler gear bolts, rotate the crankshaft to prevent any bind occurring in the gear assembly.

10. Tighten the upper oil pan-to-cylinder block bolts to 45-50 lb-ft (61-68 N«m) torque.

11. Install the upper oil pan-to-front cover bolts and lock washers. Tighten the bolts to 45-50 lb-ft (61-68 N#m) torque.

12. On former engines, install the governor and fule control rods.

 © Detroit Diesel Corporation



5 – Front Trunnion Mounting (Former Engines)

13. Install the crankshaft outboard bearing support (Section 1.3.5.1).

14. Install the front trunnion mounting support and trunnion (Figs. 4 and 5). Tighten the 5/8"—11 lock bolts to 137-147 lb—ft (186-200 N#m) torque.

15. Install the crankshaft pulley and/or vibration damper on the crankshaft.

16. Install the water pump (Section 5.1).

17. Install the coolant filter and conditioner (if used).

18. Install the thermostat housing assemblies and connect the water manifolds and hoses.

NOTICE: Alternately tighten the thermostat housing-to-front cover bolts to 30-35 lb—ft (41-47 N«m) torque.

19. Install the engine front lifter bracket.

20. Install the heat exchanger or engine cooling fan.

21. Fill the cooling system (Section 5.).

CRANKSHAFT OUTBOARD BEARING SUPPORT (FRONT)

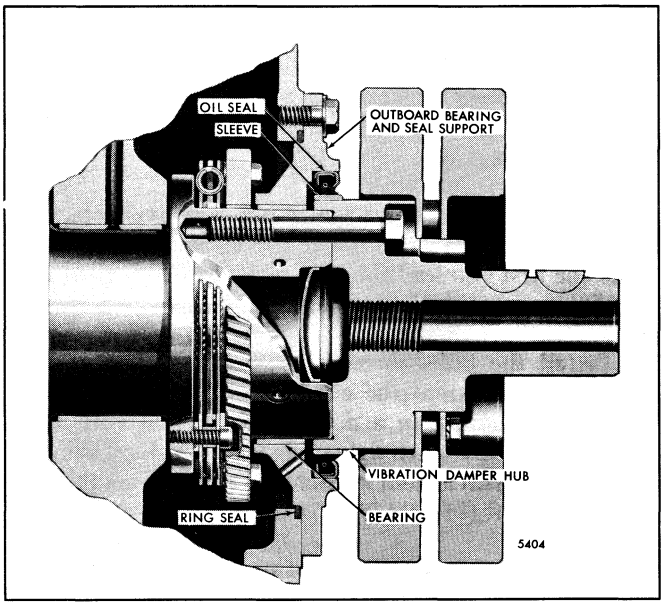


Fig. 1 – Outboard Bearing and Seal Support Mounting

The crankshaft outboard bearing support (Fig. 1) houses the crankshaft front outboard bearing (bushing) and the crankshaft front oil seal. The support is a one-piece casting which bolts directly to the engine front cover, providing easy access for removing and installing the oil seal and bearing.

• The bearing is pressure lubricated from the oil supply hole drilled in the front end of the crankshaft. Oil returns through four drilled holes at the bottom of the bearing support. The former outboard support bearing had four (4) grooves. The current bearing is grooveless.

The bearing support must be removed when replacement of the bearing or the crankshaft oil seal is required.

Remove Outboard Bearing Support

1. Remove the crankshaft pulley (Section 1.3.7) and/or vibration dampers (Section 1.3.6) from the crankshaft.
2. Remove the seven (7) bolts and flat washers securing the outboard bearing support to the engine front cover and remove the support and the seal ring.

Inspection

Oil leaks are indications of worn or damaged oil seals.

Inspect the vibration damper hub oil seal sleeve for wear due to the rubbing action of the oil seal or dirt buildup. If the seal is worn, install a new oil seal and oil seal sleeve. Refer to Section 1.3.2.

Inspect the bearing for scoring or excessive wear. The inside diameter of a new bearing (installed) is 6.0033* to 6.0087* and the crankshaft journal outside diameter is 5.9990” to 6.000*. This provides a crankshaft to bearing clearance of .0033* to .0097* with new parts.

If the crankshaft is to be reground, *the outboard bearing area must not be reduced in diameter.* The drive hub to crankshaft tolerances must be maintained to permit the proper fit between the mating parts.

To replace the bearing, first remove and discard the crankshaft oil seal. Then, press the old bearing from the support. Place the bearing support on the bed of an arbor press. Coat the oil seal bore in the support with a non-hardening sealant, unless the seal case is already pre-coated. Press a new crankshaft oil seal into the support until it contacts the bottom of the counterbore in the bearing support, using installer J 22518 (Fig. 2).

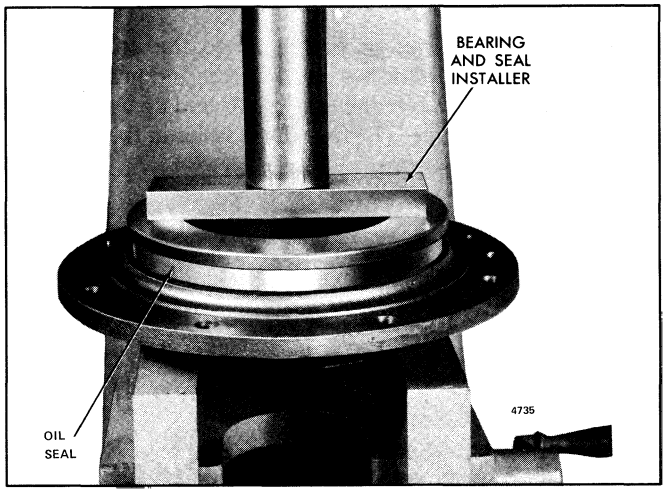


Fig. 2 - Installing Seal in Outboard Bearing Support

Turn the support over on the bed of the arbor press and coat the bearing bore with a thin coat of Lubriplate, or equivalent. Position the new bearing in the bore of the support, with the split line 90° from the oil drain holes. Then, press the bearing flush with the inside face of the support, using installer J 22518 (Fig. 3).

Install Outboard Bearing Support

1. Apply a thin film of Lubriplate, or equivalent, over a new oil seal ring and place the seal ring over the collar on the back side of the bearing support.

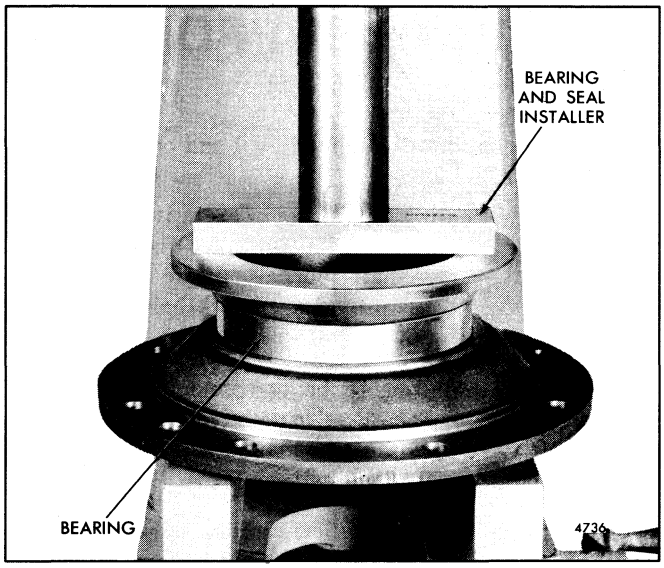


Fig. 3 - Installing Bearing in Outboard Bearing Support

NOTICE: To ensure proper sealing, replace the front (if used) oil seal sleeve whenever a new oil seal is installed. Before installing the front crankshaft oil seal sleeve, check for sharp corners, scratches, inclusions or nicks. If the sleeve is damaged, replace it.

2. Apply a light coat of engine oil to the area of the crankshaft where the bearing will ride and position the bearing support over the crankshaft and up against the engine front cover. The four drain holes in the support 7. will be at the bottom.

3. Make sure the mating flange surfaces are clean and dry.

4. Slide new, hardened flat washers (.530”-.940” x .120”) on the seven special support attaching bolts. The threads of these special high-tensile strength bolts are coated with an epoxy /graphite locking compound to ensure torque retention. Use new bolts and washers each time the bolts are distrubed for any reason and at time of overhaul.

If the special coated bolts are not available, use standard GM 300M bolts. Coat the threads of the bolts (except the first two lead threads) with Loctite Sealant 271 (J 26558) or an equivalent sealant.

5. Install the bolts through the bearing support and thread them into the engine front cover. Hold the bearing support in a *downward* position with light hand pressure when tightening the bolts. First snug all the bolts with a hand wrench and then tighten them to 71-75 lb—ft (96-102 N*m) torque.

• 6. Check the bearing-to-crankshaft clearance with a 1/4” wide feeler gage. The bearing should be installed so that a *minimum* of .001” clearance exists at the top of the outboard bearing support. The clearance at the bottom of the crankshaft *must not be less than* .0033” or more than .0097” with the bearing support in the downward position.

Install the vibration dampers (Section 1.3.6) and crankshaft pulley (Section 1.3.7).

 © Detroit Diesel Corporation

CRANKSHAFT OUTBOARD BEARING SUPPORT (REAR)

The rear outboard bearing support is mounted in the flywheel housing to improve the ability of the rear main bearings to sustain loads and bending forces externally induced by driven components.

The rear outboard bearing support assembly also replaces the outboard bearing support assembly presently in the front cover (Fig. 1). The outboard bearing is indexed in the support so that the split line is to the right or left on the horizontal axis. The old front outboard bearing support assembly *cannot* be used in the flywheel housing. The oil seal, seal ring and attaching bolts and washers are the same for both the former and new outboard bearing assemblies.

• The former outboard support bearing had four (4) grooves. The current bearing is grooveless.

The flywheel housing is counterbored to accomodate the new outboard bearing support assembly (Fig. 2). The former flywheel housings will continue to be serviced.

The new R.H. and L.H. flywheel assemblies and flywheel coupling assembly (Fig. 3) incorporate an oil seal sleeve, as the rear crankshaft oil seal seals on a sleeve mounted on the new flywheel or flywheel coupling and not on the crankshaft. The former R.H. and L.H. flywheel assemblies will continue to be serviced; however, only the new flywheel coupling assembly will be serviced.

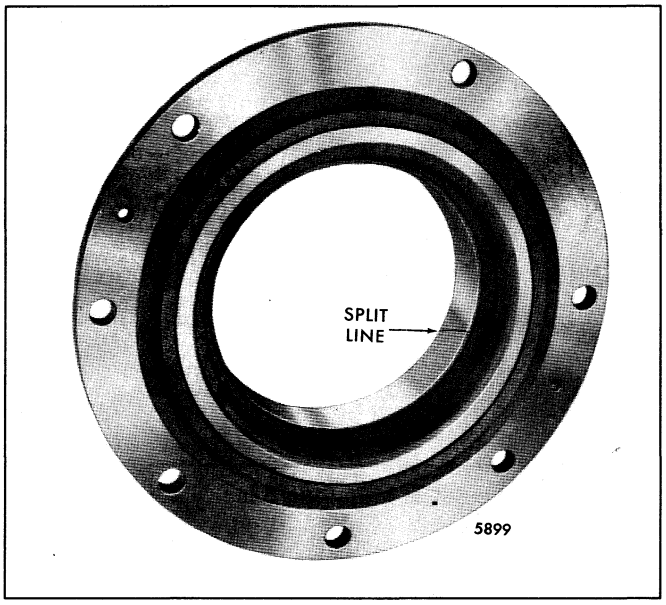


Fig. 1 - Rear Outboard Support Bearing Assembly

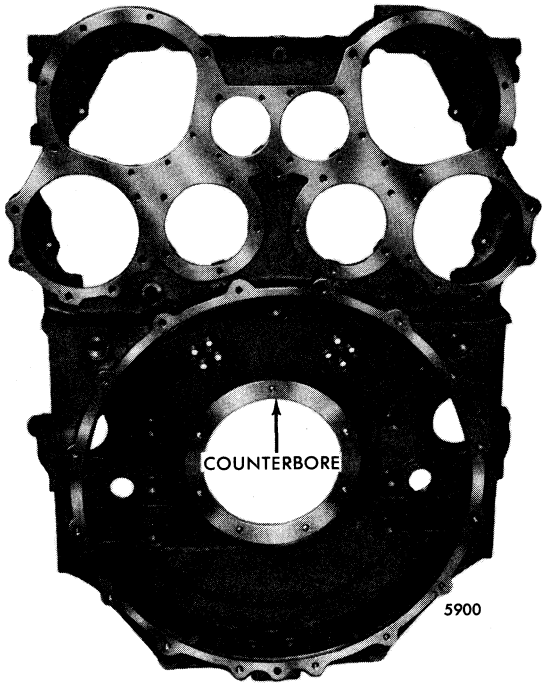
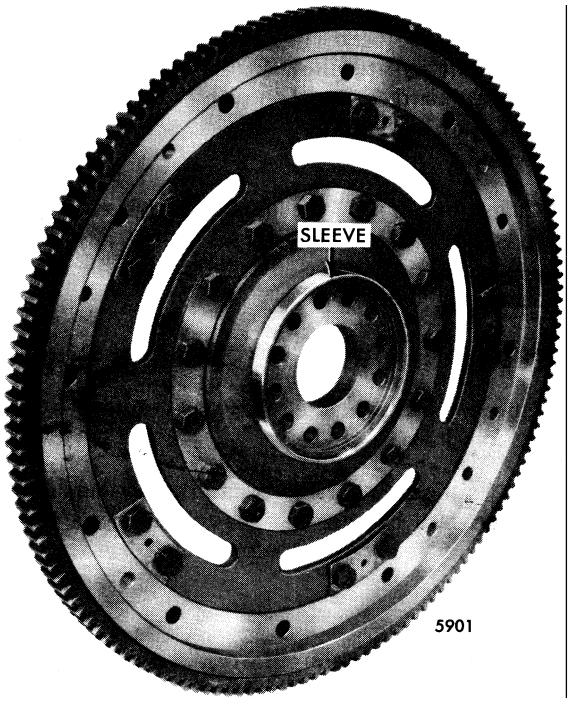


Fig. 2 - Flywheel Housing with Counterbore



Fig, 3 - Flywheel Coupling Assembly

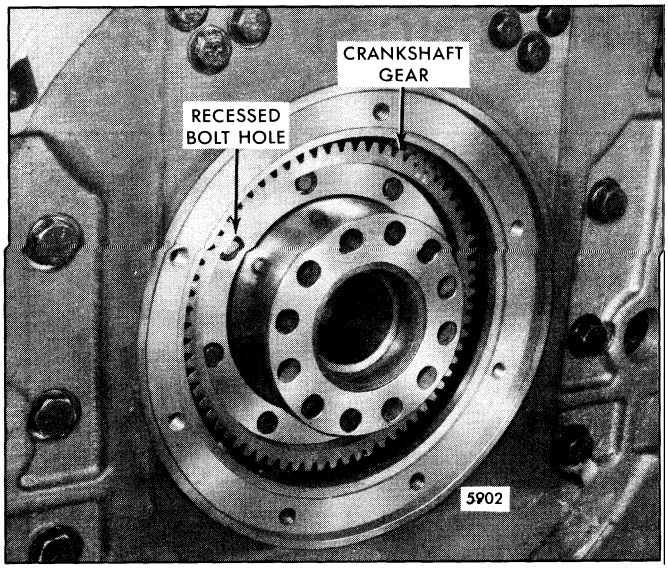


Fig. 4 - Rear Crankshaft Tinning Gear

The rear crankshaft timing gears (Fig. 4) have the bolt holes counterbored for the shorter attaching bolts (3/8"-24 x 1.62") which are required to provide clearance for the rear outboard support bearing assembly. The former attaching bolts were 3/8"-24" x 2". The former and new crankshaft timing gear are interchangable on an engine. Only the new crankshaft gears will be serviced; however, the shorter bolts (1.62") must be used with the new rear crankshaft gears.

> **NOTICE:** The former and new crankshafts are the same except that the 1/4" pipe plug (Fig. 5) has been deleted from the rear crankshaft half to allow for lubrication of the rear outboard support bearing. The former crankshaft assemblies will continue to be serviced.

When a former flywheel housing, flywheel or flywheel coupling is replaced on an engine with a new flywheel housing, flywheel or flywheel coupling, all of the new parts must be used together.

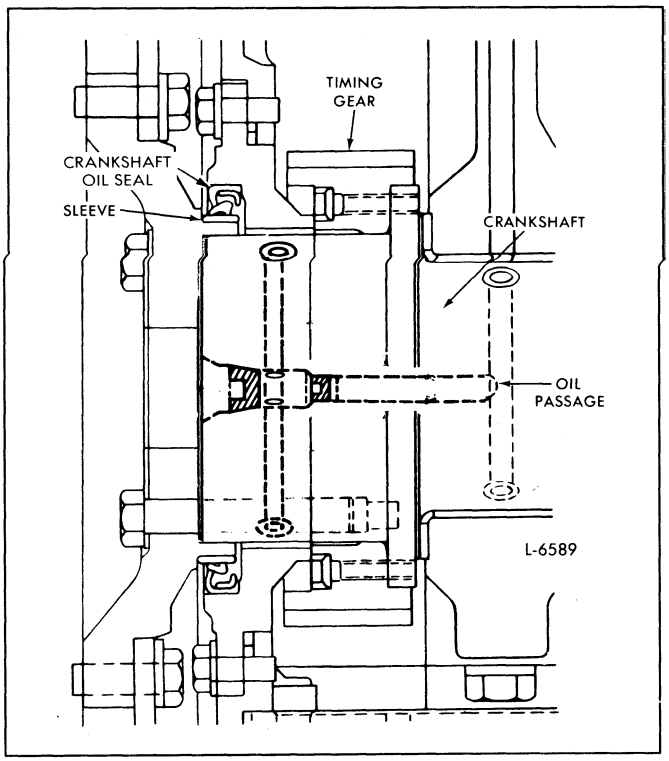
Remove Rear Outboard Bearing Support

1. Remove the flywheel or flywheel coupling assembly (Section 1.5).

2. Remove the seven (7) bolts and flat washers securing the outboard bearing support to the engine flywheel housing and remove the support and seal ring.

Inspection

Oil leaks are indications of worn or damaged oil seals. Inspect the flywheel or flywheel coupling assembly oil seal sleeve for wear due to the rubbing action of the oil seal or dirt build up. If the seal is worn, install a new oil seal and oil seal sleeve (refer to Section 1.3.2).



• Fig. 5 - Lubrication of the Rear Outboard Support Bearing (Current Engines)

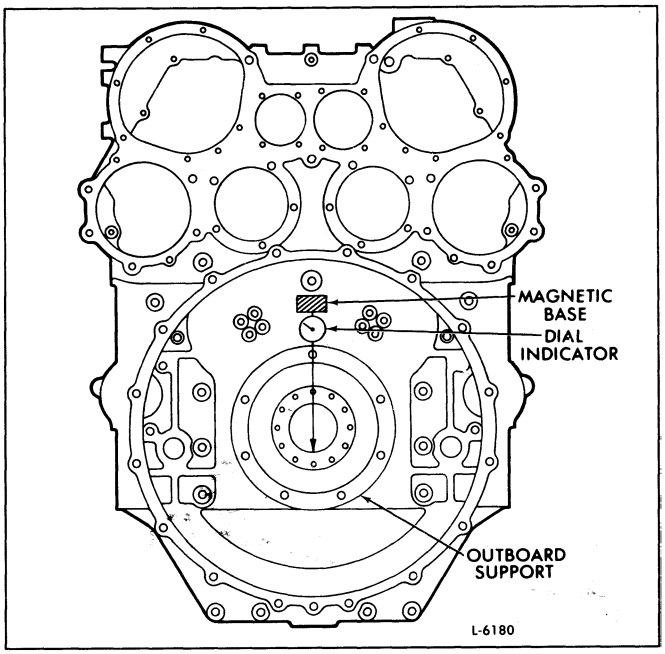


Fig. 6 - Placement of Magnetic Base Dial Indicator

> **# NOTICE:** To ensure proper sealing, replace the oil seal sleeve whenever a new oil seal is installed. If a unidirectional seal is used, make sure the correct seal in relation to engine rotation is installed.

 © Detroit Diesel Corporation

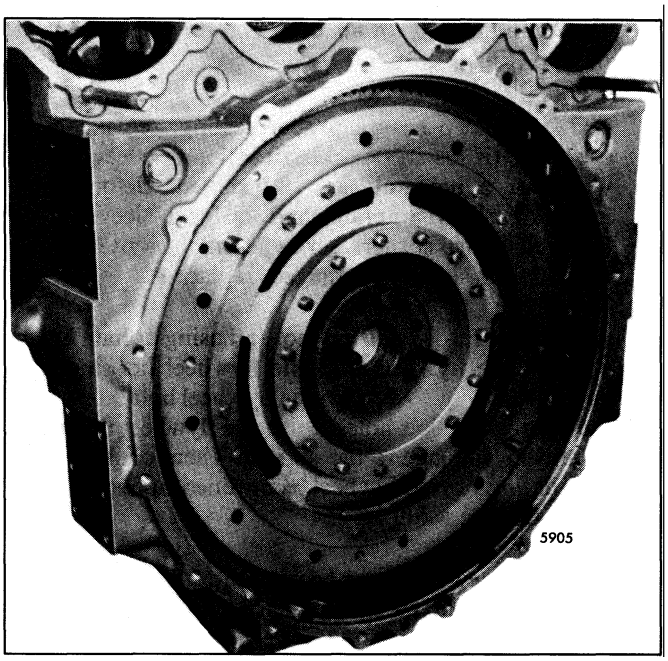


Fig. 7 - Position Flywheel Using Guide Studs

Install Rear Outboard Bearing Support

If the engine was originally built with a rear outboard bearing support, proceed to Step 3. If the engine was *not* originally built with a rear outboard bearing support:

1. Remove the 1/2” pipe plug (current crankshaft) or 3” cup plug (former crankshaft) in the rear of the crankshaft and remove the 1/4” pipe plug in the crankshaft oil passage. This provides pressure oil lubrication to the outboard bearing support. Reinstall the 1/2” pipe plug or 3” cup plug with a suitable sealer.

2. Install a new crankshaft timing gear with counterbored bolt holes as outlined in Section 1.7.1 (Engine Timing). Tighten the 1.62” long bolts to 35-39 lb—ft (47-53 N*m) torque.

3. Install the flywheel housing as outlined in Section 1.5. The oil seal expander will not be required.

4. After verifying the bore and face run outs on the flywheel housing, apply a thin film of Lubriplate, or equivalent over a new seal ring and place the seal ring on the back of the bearing support and install it in the counterbore of the flywheel housing.

5. The outboard bearing support is adjustable in the flywheel housing. The assembly should be positioned upward to the crankshaft when the engine is in the upright position, without lifting the crankshaft.

To ensure the crankshaft is not lifted off of the rear main bearing, place a magnetic base dial indicator on the flywheel housing above the vertical axis of the crankshaft with the indicator probe positioned on the crankshaft cup plug counterbore (Fig. 6).

NOTICE: The indicator reading must remain at zero while adjusting the outboard bearing. Under no circumstances should the indicator show the crankshaft has been moved.

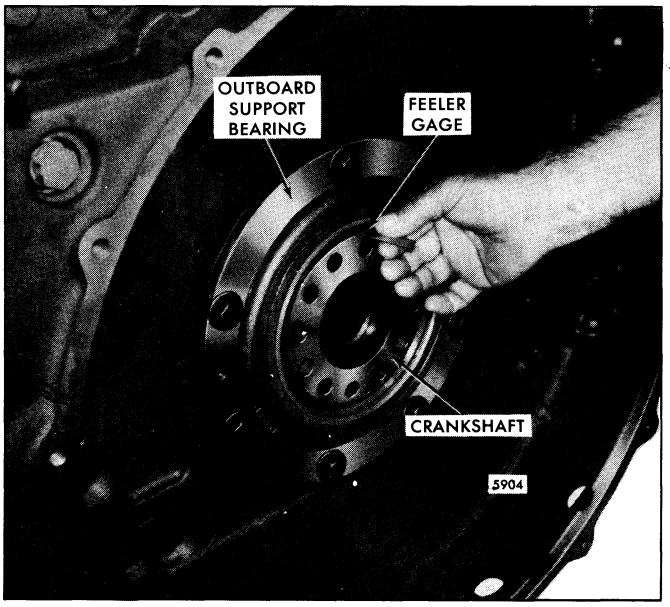


Fig. 8 - Checking the Clearance Between the Crankshaft and Outboard Bearing

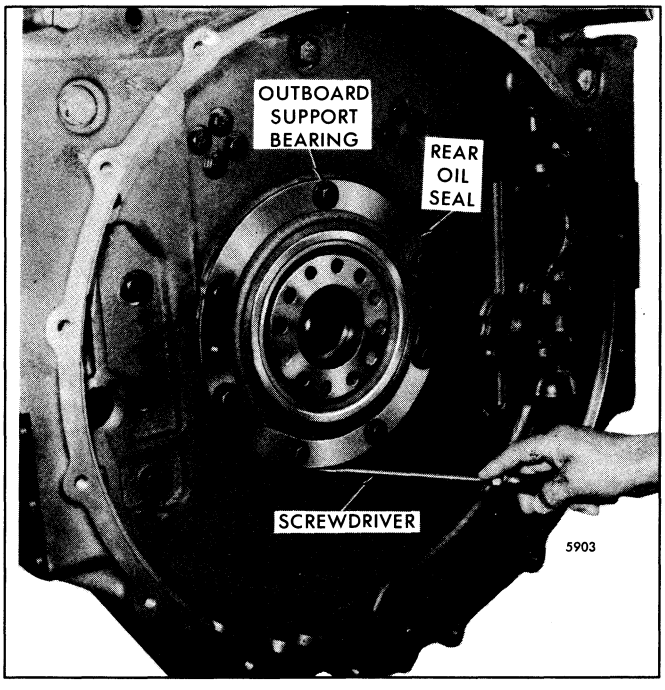


Fig. 9 - Tightening the Outboard Bearing Support Attaching Bolts

6. Slide new, hardened flat washers (.530"-.940" x .120") on the seven special support attaching bolts. The threads of these special high-tensile strength bolts are coated with an epoxy/graphite locking compound to ensure torque retention. Use new bolts and washers each time the bolts are disturbed for any reason and at time of overhaul.

   NOTICE: If the special coated bolts are not available, use standard GM 300M bolts. Coat the threads of the bolts (except the first two lead threads) with Loctite Sealant 271 (J 26558) or an equivalent sealant.

7. Apply a light upward pressure by prying with a screwdriver (Fig. 7) between the flywheel housing counterbore and the support assembly outside diameter, while tightening the bolts to 71-75 lb—ft (96-102 N*m) torque. Check the clearance between the crankshaft and outboard bearing with a 1/4" feeler gage. The clearance should be a minimum of .001" at the bottom of the crankshaft and not be less than .0033" and no more than .0097" on the vertical axis at the top (Fig. 8).

   NOTICE: To ensure proper sealing, replace the rear (if used) crankshaft oil seal sleeve whenever a new oil seal is installed. Before installing the rear crankshaft oil seal sleeve, check for sharp comers, scratches, inclusions or nicks. If the sleeve is damaged, replace it.

8. Attach the flywheel lifting tool and using a chain hoist, position the flywheel into the flywheel housing (see guide studs, Fig. 9). Align the flywheel bolt holes with the crankshaft bolt holes. Push the flywheel in evenly to prevent damage to the oil seal. Then, continue the installation of the flywheel as outlined in Section 1.4 of the Service Manual.

   Install the new outboard bearing support in the engine front cover the same as stated in Section 1.3.5.1 of the Service Manual.

 © Detroit Diesel Corporation

CRANKSHAFT VIBRATION DAMPER

Vibration dampers (two 12” diameter/one or two 18” diameter viscous type) (Fig. 1) are mounted on the front end of the crankshaft to reduce crankshaft stresses to a safe value. The new 12” and 18” nylon coated flywheel style vibration dampers are now being used on all engines. Only the current nylon coated flywheel style vibration dampers will be serviced. The vibration damper is bolted to a hub which is retained on the front end of the crankshaft.

• Two 18” diameter dampers are used on 16V marine engines when prolonged operation near 1200 rpm is required. Besides standard damper arrangements, other arrangements may be used on engines in other applications.

The vibration damper consists of an inertia mass (flywheel) enclosed in a fluid-tight outer case. A thin wall of viscous liquid separates the outer case from the inertia mass. This viscous liquid is not affected by temperature changes and tends to dampen excessive torsional vibrations in the crankshaft due to its frictional ability to resist any movement of the inertia mass.

The vibration damper(s) must be removed whenever the crankshaft, crankshaft front oil seal, outboard bearing -and seal support or front cover is removed.

Remove Vibration Damper

8V AND 12V ENGINES (12” Diameter Dampers):

1. Remove the crankshaft pulley (Section 1.3.7).
2. Remove the six bolts and lock washers securing the inner and outer vibration dampers to the vibration damper hub and remove the vibration dampers and spacer (Fig. 2)

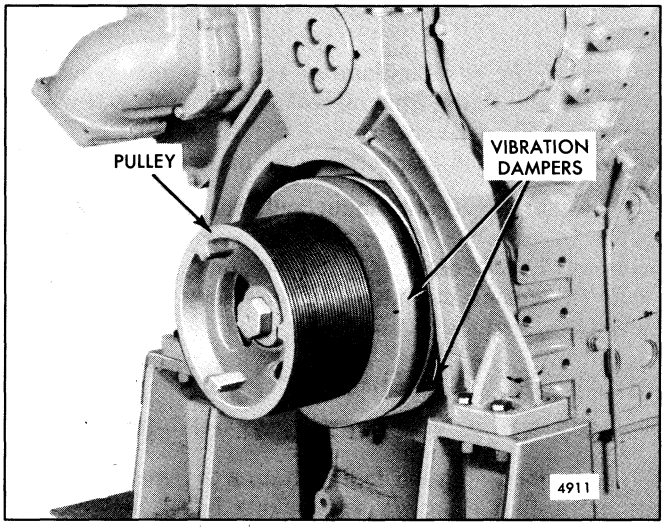


Fig. 1 - Crankshaft Vibration Damper Mounting

• **NOTICE:** Use care when handling the vibration damper. *Do not pound on the damper with a hammer or pry with other tools when removing a viscous type damper from the crankshaft.* Dents in the damper outer case may render the damper ineffective. The damper cannot be repaired.

3. Remove the six bolts securing the vibration damper hub and sleeve assembly to the crankshaft and remove the hub and sleeve assembly.

16V ENGINES (18” Diameter Damper):

1. Remove the crankshaft pulley (Section 1.3.7).
2. Remove the eight bolts and lock washers securing the vibration damper to the vibration damper hub and remove the damper (Fig. 3).

. **NOTICE:** Use care when handling the vibration damper. *Do not pound on the damper with a hammer or pry with other tools when removing a viscous type damper from the crankshaft.* Dents in the damper outer case may render the damper ineffective. The damper cannot be repaired.

3. Remove the six bolts securing the vibration damper hub and sleeve assembly to the crankshaft and remove the hub and sleeve assembly.

• Vibration Damper Safety Shields

The need for a vibration damper safety shield is mandatory in certain industrial and marine applications in which the engine operates without a hood or in an open or unprotected area. A properly designed and installed safety shield prevents direct physical contact with the damper during engine operation. It also keeps the damper from “walking off the crankshaft and causing property damage or injury to personnel working near the engine if the crankshaft pulley bolt should loosen and become detached during engine operation.

Detroit Diesel Corporation does not manufacture, sell, or install vibration damper safety shields as it has no control over the great variety of installations in which DDC engines are applied. Space restrictions in these numerous applications make the supply of a properly designed and shaped vibration damper safety shield the responsibility of the OEM (original equipment manufacturer) or distributor designing and/or manufacturing products in which they apply Detroit Diesel engines. However, DDC believes that the following guidelines should be followed when fabricating or installing shields:

1. Shields should be made from 1/8” to 3/16” perforated steel or heavy steel screen.

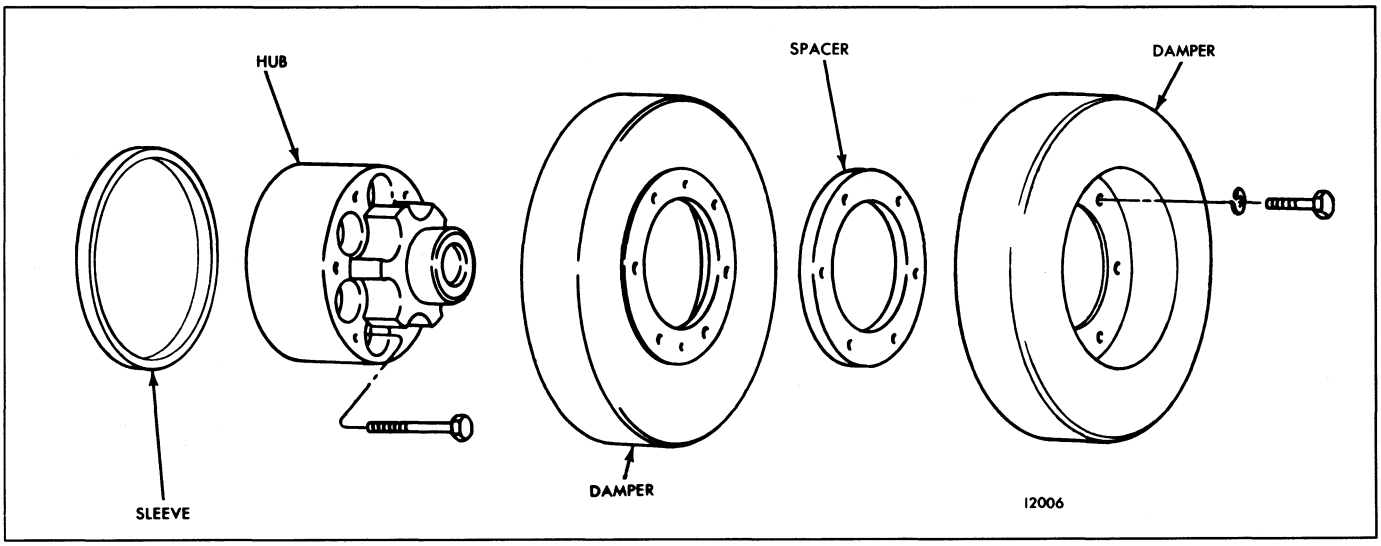


Fig. 2 - Vibration Damper, Hub and Sleeve Assembly Details and Relative Location of Parts (12V Engine)

2. The perforated or open screen area of the shield should be equal to, or greater than, the total area of both sides of the damper and its circumference.

3. Shields should be no closer than 1/2" from the damper when installed.

4. In all cases, safety shields *must* permit the vibration damper to be well ventilated during engine operation to prevent vibration damper overheating.

Inspection

Inspect the vibration damper for leaks, dents, nicks or bulges in the outer casing. Any indications of the above are sufficient for cause for replacement of the damper. Due to close clearances between the damper internal flywheel and the outer casing, dents may render the damper ineffective. Bulges or splits indicate fluid in the damper has deteriorated and has bulged or forced the casing open at its crimped edges.

• **NOTICE:** Shielded vibration dampers are frequently difficult to inspect visually because of the design of the shield and/or end *items* in which the engine is installed. As a result, it is important for OEM's and distributors to supply written instructions to users of their products, cautioning them to periodically inspect the viscous vibration damper for evidence of a split seam, bulged cover, leaks, dents, etc. Any such evidence is sufficient cause for replacement because these conditions can prevent vibration dampers from functioning properly and, as a result, cause serious engine damage.

Regardless of its condition, the vibration damper on marine engines must be replaced at 10,000 hours of operation. For industrial engines replace the vibration damper at 20,000 hours or at the time of major engine overhaul. Replace the vibration damper on industrial or power generator engines at time of major overhaul to provide maximum protection for the crankshafts.

NOTICE: When two dampers are used, both must be replaced at the same time.

If damage to the vibration damper is extensive, inspect the crankshaft, as outlined in Section 1.3. A loose or defective vibration damper, after extended operation, may result in a cracked crankshaft.

Inspect the vibration damper spacer, hub and the end of the crankshaft for galling or burrs. Slight scratches or burrs may be removed with emery cloth. If seriously damaged, replace the parts and refinish the end of the crankshaft.

Check the outside diameter of the oil seal sleeve for wear at the crankshaft front oil seal contact surface. If worn, replace the oil seal and sleeve. Refer to Section 1.3.2 for installation of anew crankshaft front oil seal.

Also, a loose engine mount could damage the vibration damper by allowing the engine to move slightly during operation. Therefore, it is good practice to periodically inspect the engine mounts to be sure they are not loose, cracked or deteriorated.

Install Vibration Damper

8V AND 12V ENGINES (12" Diameter Dampers):

1. Install the vibration damper hub on the front end of the crankshaft using six self-locking bolts. Tighten the bolts to 180-190 lb—ft (244-258 N»m) torque.

 © Detroit Diesel Corporation

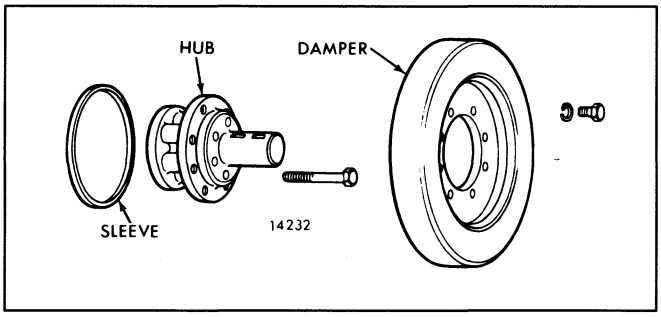


Fig. 3 - Vibration Damper Hub and Sleeve Assembly (16V Engine)

NOTICE: Use care when positioning the vibration damper hub to avoid damage to the lip of the crankshaft front oil seal.

2. Position the inner vibration damper, spacer and outer vibration damper over the hub and secure them in place with the six 7/16" bolts and lock washers (Fig. 2). Tighten the bolts to 57-61 lb—ft (77-83 N#m) torque.

3. Install the crankshaft pulley as outlined in Section 1.3.7.

16V ENGINES (18" Diameter Damper):

1. Install the vibration damper hub on the front end of the crankshaft using six self-locking bolts. Tighten the bolts to 180-190 lb—ft (244-258 N«m) torque.

NOTICE: Use care when positioning the vibration damper hub to avoid damage to the lip of the crankshaft front oil seal.

2. Position the vibration damper over the hub and secure it in place with the eight 1/2" bolts and lock washers (Fig. 3). Tighten the bolts to 71-75 lb-ft (96-102 N»m) torque.

3. Install the crankshaft pulley, as outlined in Section 1.3.7.

CRANKSHAFT PULLEY

The engines are equipped with a cone mounted, poly-V belt type pulley which is keyed to the vibration damper hub (Section 1.3.6) and secured with a retainer and bolt (Fig. 1).

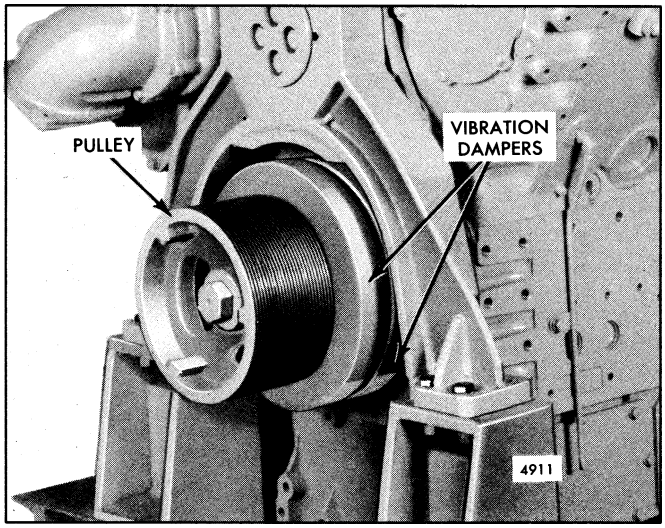


Fig. 1 - Crankshaft Pulley Mounting

Remove Crankshaft Pulley

1. On engines equipped with a crankshaft pulley bolt retaining plate, remove the three bolts and lock washers securing the plate to the pulley. Remove the plate.
2. Remove the pulley retaining bolt and retainer (Fig. 2).
3. Use a soft hammer and tap around the front face of the pullley to loosen the pulley cone.

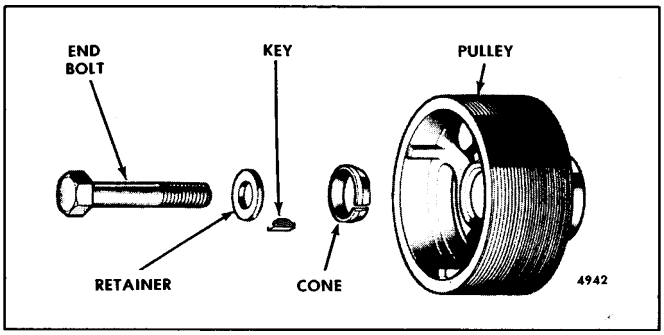


Fig. 2 - Crankshaft Pulley Details and Relative Location of Parts

4. Remove the pulley cone and slide the pulley from the hub.
5. Remove the Woodruff key(s) from the slots in the hub.

Install Crankshaft Pulley

1. Place the Woodruff key(s) in the key slots in the hub.
2. Slide the crankshaft pulley over the hub, aligning the key with the key way in the pulley.
3. Place the cone over the hub and into position against the pulley.
4. Place the pulley retainer on the pulley retaining bolt and thread the bolt into the end of the hub.
5. Tighten the pulley retaining bolt as follows:
   a. Tighten the bolt to approximately 400 lb-ft (542 N«m) torque.
   b. Strike the end of the bolt a sharp blow with a 2 or 3 pound lead hammer.
   c. Tighten the bolt to 450-500 lb-ft (610-678 N#m) torque. *Do not hit the crankshaft end bolt after the last tightening because the clamping effect will be reduced.*

The damper must be securely fastened to the crankshaft. When the bolt is drawn up to the specified torque, the cone will hold the damper rigidly in place.

NOTICE: *Do not bar the engine over by turning the crankshaft bolt in a counter-clockwise direction. The bolt may back out slightly, resulting in loosening of the pulley and subsequent engine damage.*

CAUTION: To reduce the risk of personal injury when barring over or "bumping" the starter, personnel should keep- their hands and clothing away from the engine as there is a remote possibility the engine could start.

• 6. On engines equipped with a crankshaft pulley retaining plate, install the plate and three bolts and lock washers. Tighten the bolts to 30 - 35 lb-ft (41-47 N*m) torque.

FLYWHEEL

The flywheel is attached to the rear end of the crankshaft with twelve self-locking bolts (Fig. 1). A scuff plate is used between the flywheel and the bolt heads to prevent the bolt heads from scoring the flywheel surface.

Current flywheel and flywheel coupling assembly incorporate an oil seal sleeve, as the rear crankshaft oil seal seals on this sleeve, not on the crankshaft (Fig. 2). A steel ring gear, which meshes with the starting motor pinion, is shrunk onto the rim of the flywheel.

The flywheel is machined to provide true coupling alignment for flexible drive lines or a coupling and ring gear adaptor for power generator applications.

The flywheel must be removed for other service operations such as replacing the starter ring gear, crankshaft or flywheel housing.

Remove Flywheel (Transmission Removed)

1. Remove two diametrically opposite flywheel attaching bolts and install two 5/8”-18 x 6” guide bolts.
2. Remove the ten remaining flywheel attaching bolts.
3. Slide the flywheel out against the heads of the two guide bolts.
4. Place the flywheel lifting tool in position against the flywheel with the lower end of the tool inserted through the center bore of the flywheel as shown in Fig. 3. *Figure 4 illustrates the fabrication of a suitable flywheel lifting tool.*
5. Use a suitable chain hoist to support the flywheel and remove the two guide bolts. Then remove the flywheel from the flywheel housing.

Inspection

Replace the ring gear if the gear teeth are excessively worn or damaged.

Check the butt end of the crankshaft and flywheel contact surface. If necessary, lightly stone the crankshaft end and the flywheel contact surface to remove any fretting or brinnelling.

Inspect the flywheel or flywheel coupling assembly oil seal sleeve for wear. Replace if necessary (refer to Section 1.3.2).

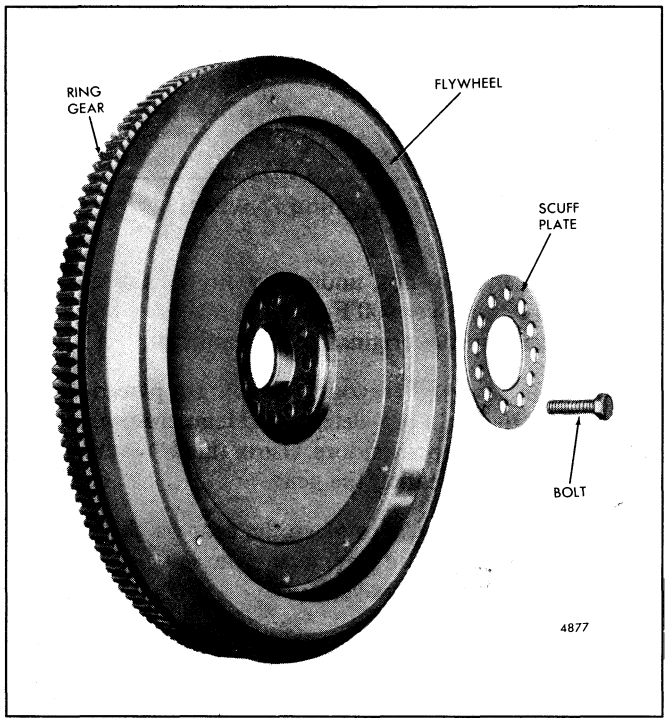


Fig. 1 - Typical Flywheel Assembly - Former

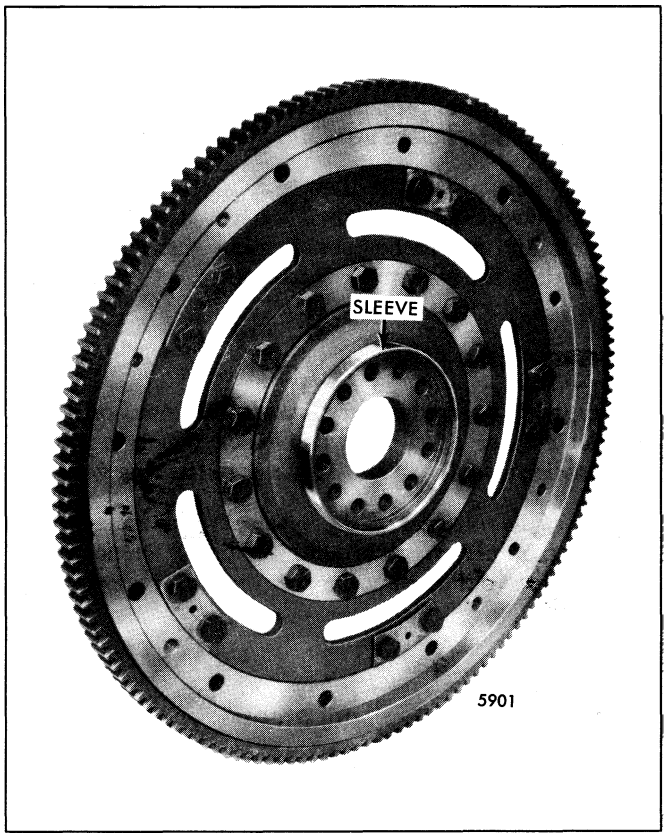


Fig. 2 - Flywheel Coupling Assembly - Current

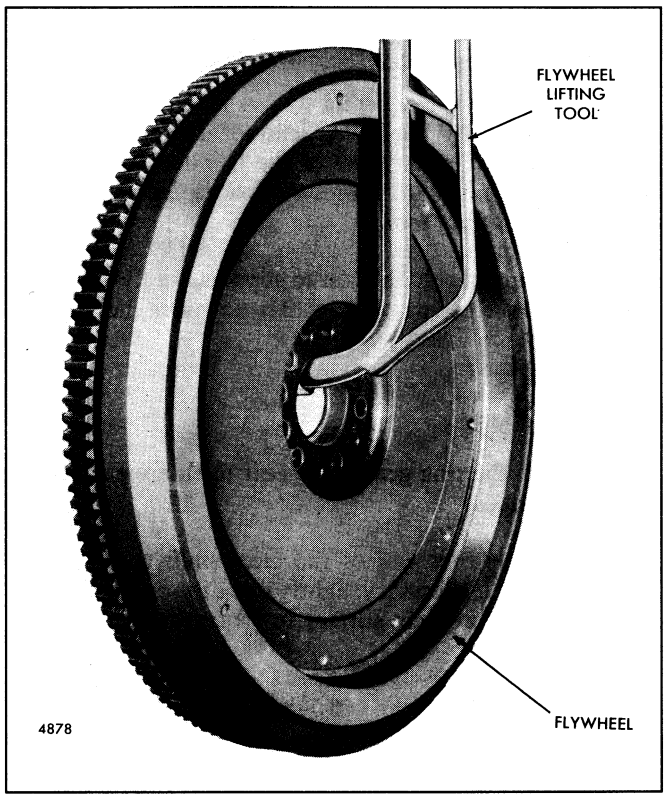


Figure 3 - Removing Flywheel

Make sure that the crankshaft and flywheel contact surfaces and the bolt threads in the crankshaft end are clean and dry, to insure proper metal-to-metal contact and maximum friction, before attaching the flywheel.

New bolts should be used to mount or remount the flywheel. However, if the original bolts are determined to be serviceable and are to be reused, clean them thoroughly before starting the assembly procedure.

Remove Ring Gear

1. Support the flywheel, crankshaft side down, on a solid flat surface or a hardwood block which is slightly smaller than the inside diameter of the ring gear.

2. Drive the ring gear off the flywheel with a suitable drift and hammer. Work around the circumference of the gear to avoid binding the gear on the flywheel.

Install Ring Gear

1. Support the flywheel, ring gear side up, on a solid flat surface.

2. Rest the ring gear on a flat **metal surface** and heat the gear uniformly with an acetylene torch, keeping the torch moving around the gear to avoid hot spots.

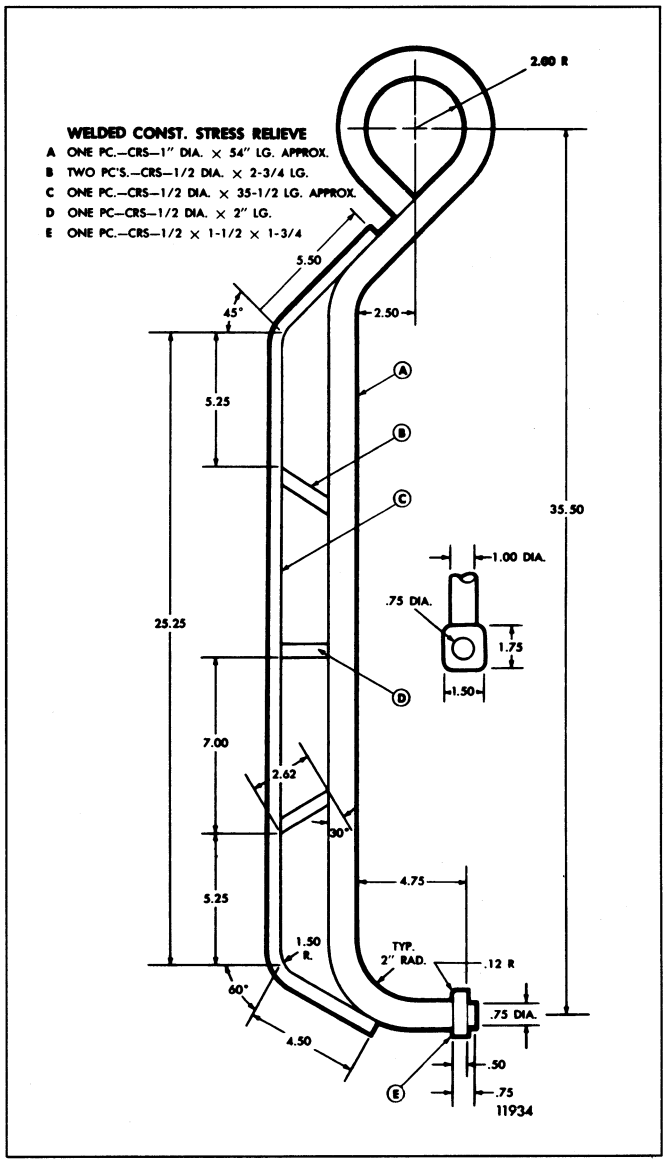


Fig. 4 – Details for Fabricating Flywheel Lifting Tool

NOTICE: Do not, under any circumstances, heat the gear over 400°F (204°C); excessive heat may destroy the original heat treatment.

Heat indicating "crayons", which are placed on the ring gear and melt at a pre-determined temperature, may be obtained from most tool vendors. Use of these "crayons" will ensure against overheating the gear.

3. Use a pair of tongs to place the gear on the flywheel with the chamfer, if any, facing the same direction as on the gear just removed.

4. Tap the gear in place against the shoulder on the flywheel. If the gear cannot be tapped into place readily so that it is seated all the way around, remove it and apply additional heat, noting the above note.

 © Detroit Diesel Corporation

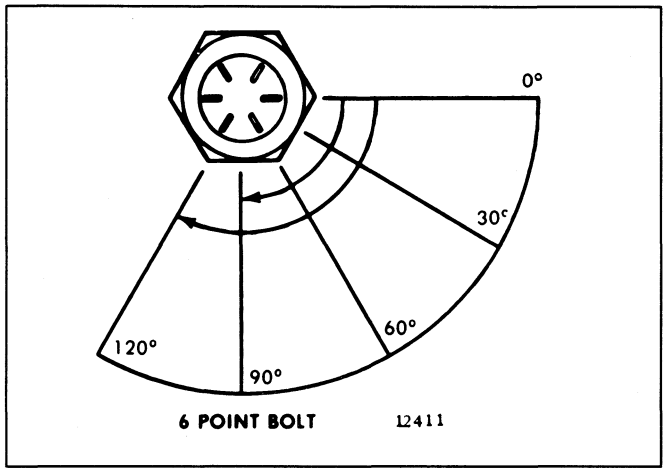


Fig. 5 – Torque–Turn

Install Flywheel

1. Attach the flywheel lifting tool and, using a chain hoist, position the flywheel in the flywheel housing (use guide studs (4). Align the flywheel bolt holes with the crankshaft bolt holes.

2. Install the clutch pilot bearing (if used).

3. Install two bolts through the scuff plate 180° from each other. Snug the bolts to hold the flywheel and scuff plate to the crankshaft. Remove the guide bolts.

4. Remove the flywheel lifting tool.

5. Apply International Compound No. 2, or equivalent, to the threads and to the bolt head contact area (underside) of the remaining bolts. The bolt threads must be completely filled with International Compound No. 2 and any excess wiped off.

   NOTICE: International Compound No. 2 must never be used between two surfaces where maximum friction is desired, as between the crankshaft and the flywheel.

6. Install the remaining bolts and run them in snug.

7. Remove the two bolts used temporarily to retain the flywheel, apply International Compound No. 2 as described above, then reinstall them.

8. Use an accurately calibrated torque wrench and tighten the bolts to 50 lb—ft (68 N*m) torque. Then rotate bolts as follows:

BOLT SIZE	ADDITIONAL ROTATION (DEGREES)
5/8" — 18 x 4" L **5/8" — 18 x 4.75" L** **3/4" — 16x4" L** **3/4" 16 x 4.75" L**	**120 — 130°** **140 — 150°** **120— 130°** **120— 1 30°**

N OTICE: Since the *torque-turn method* provides more consistent clamping than the former method of flywheel installation, bolt torque values should be ignored.

When a clutch pilot bearing is installed, index the flywheel bolts so that the corners of the bolt heads do not overlap the pilot bearing bore in the flywheel. Thus, one of the flats of each bolt head will be in line with the bearing bore. Always rotate bolts in the *increased* clamp direction to prevent underclamping.

9. Mount a dial indicator on the flywheel housing and check the runout of the flywheel at the clutch contact face. The maximum allowable runout is .001” total indicator reading per inch of radius. The radius is measured from the center of the flywheel to the outer edge of the clutch contact face of the flywheel.

FLYWHEEL HOUSING

• The flywheel housing (Fig. 1) is a one-piece casting, mounted against the rear end of the cylinder block, which provides a cover for the gear train and the flywheel. It also serves as a support for the starting motors and the adaptor for the generator, PTO, marine gear, or transmission.

The new flywheel housings are counterbored to accommodate the new outboard bearing support assembly (see Section 1.3.2 or 1.3.5.2).

The crankshaft rear oil seal, which is pressed into the housing, may be removed or installed without removing the housing (Section 1.3.2 or 1.3.5.2).

• A specially drilled and tapped flywheel housing is used on high torque rise 12V-149T and TI engines to permit installing the magnetic pickup components required on these units (refer to Shop Notes in section 1.0).

Remove Flywheel Housing

1. Remove the engine and place it on an engine overhaul stand.

2. Remove the starting motors, outboard bearing support and all of the accessories and cover plates attached to the flywheel housing.

3. Loosen the bolts securing the upper oil pan to the cylinder block and remove the four (4) bolts, lock washers and shims (if used) attaching the flywheel housing to the oil pan. Record the amount of shims removed. Lower the oil pan just enough to allow removal of the flywheel housing. When removing the flywheel housing in this manner, be careful not to dislodge the upper oil pan O-ring seal.

4. Remove the fly wheel (Section 1.4).

5. Remove the camshaft drive gear assemblies (Section 1.7.3).

6. Remove the seventeen (17) bolts located in the bell of the housing. Install two (2) pilot studs to guide the housing until it clears the crankshaft during removal. Then, remove the remaining bolts around the upper portion of the flywheel housing.

NOTICE: The two (2) pilot studs can be fabricated from two (2) 5/8”-l 1 x 8-1/2” bolts. Cut off the heads of the bolts and cut a screwdriver slot in the non-threaded end.

7. Support the flywheel housing by its lifter brackets with a chain hoist, strike the front face of the flywheel housing alternately on each side to free it from the dowels and remove the flywheel housing and seal strip from the engine.

Inspection

Clean the flywheel housing and inspect it for cracks or any damage. Inspect the oil seal and oil seal sleeve (if used) for wear. If worn, install a new oil seal and oil seal sleeve as outlined in Section 1.3.2.

Install Flywheel Housing

1. Apply a thin coat of spray adhesive in the flywheel housing seal strip groove and place a new seal strip in the groove.

NOTICE: The seal strip must lay flat in the groove and must not be twisted. Cut the excess seal strip flush at the bottom of the flywheel housing on each side.

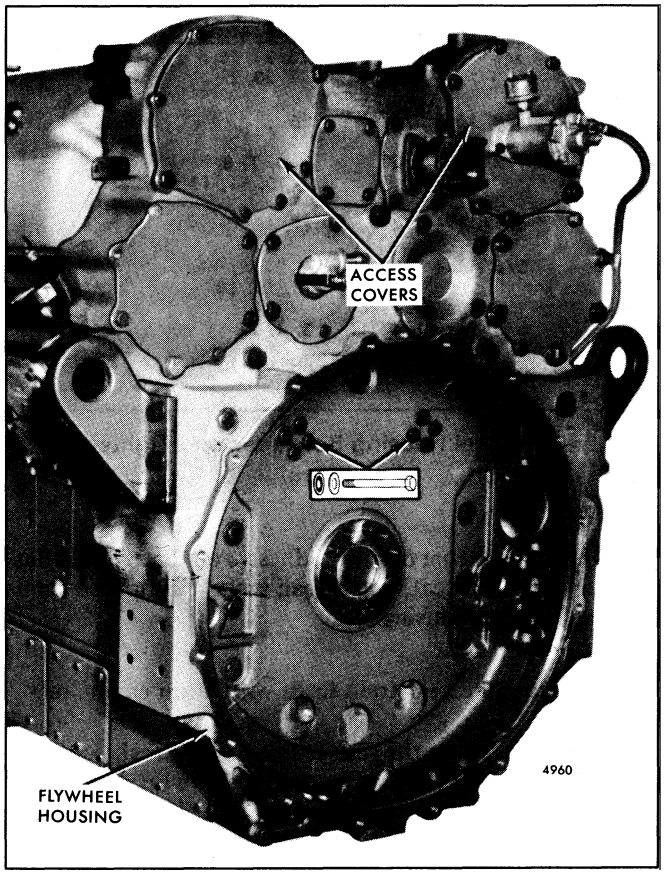
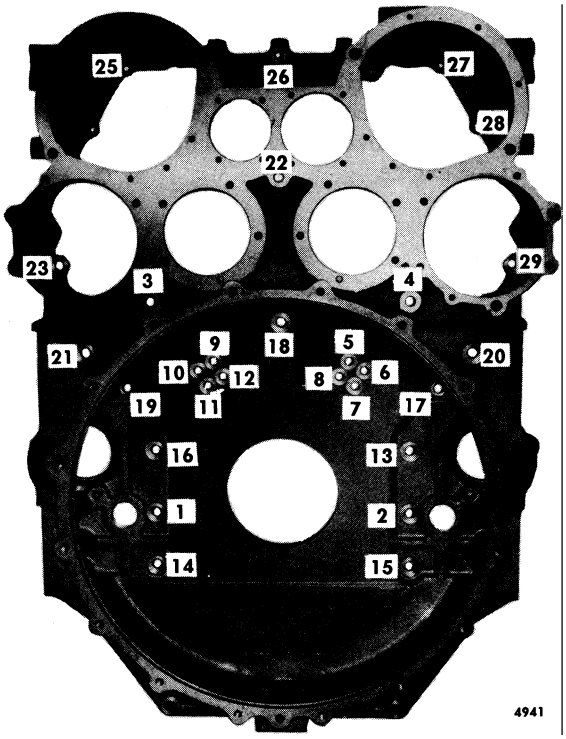


Fig. 1 - Flywheel Housing Installed on Engine



BOIT SIZE		LOCATION
3/8"-16xl	1/8"	23, 24, 25 27, 28, 29
3/8"-16x5 3/4		26
1 /2"-13x5	1/2"	5, 6, 7, 8, 9, 10, 11,]
5/8"-11 x4	1/4"	17 , 19
5/8"-11x4	1/2"	1, 2, 13, 15, 16, 18
5/8"-11x6	1/4"	3, 4, 22
5/8"-11x8	1/2"	20, 21

Fig. 2 - Flywheel Housing Bolt Sizes and Tightening Sequence

2. Apply a thin coat of spray adhesive on the exposed flat surface of the seal strip. Clean any excess grease from the flywheel housing.

3. Lubricate the gear train teeth with clean engine oil.

4. Before installing the rear crankshaft oil seal* coat the cavity between the dust lip and the main lip around the entire circumference of the seal with clean engine oil. Failure to adequately lubricate this area during seal installation can result in seal lip damage at engine start-up.

5. Thread the two (2) pilot studs into the cylinder block to guide the housing in place. Use oil seal expander J 22605 on the end of the crankshaft to pilot the oil seal on the crankshaft. Expander adaptor J 23341 can be used when the rear crankshaft cup plug is in place. If further information is required, refer to Section 1.3.2.

6. With the housing suitably supported, position it over the crankshaft and up against the cylinder block. Remove the oil seal expander.

7. Refer to Fig. 2 and install the eight (8) l/2”-13 x 5-1/2” self-locking bolts, *new* flat washers and *new* 1/2” seal washers in the holes of the crankshaft idler gear hub and idler gear hole spacer, finger tight. The seal washer is between the flat washer and the flywheel housing. To prevent oil leakage, use new, flat washers and seal washers each time the bolts are reinstalled (positions 5-12).

8. Remove the pilot studs and install the seven (7) 5/8”—11 x 4-1/2” housing-to-cylinder block bolts with flat washers, finger tight.

9. Install the remaining flywheel housing attaching bolts with washers, finger tight.

10. Draw the bolts up snug following the bolt tightening sequence (Fig. 2).

11. Refer to Fig. 2 for the final bolt tightening sequence and, starting at number 1, tighten the 5/8”—11 bolts to 137-145 lb—ft (186-197 N-m) torque, the 3/8”-16 bolts to 30-35 lb—ft (41-47 N*m) torque and the 1/2”—13 bolts to 71-75 lb-ft (96-102 N-m) torque.

12. Install outboard bearing support, if used (refer to Section 1.3.5.2).

13. Install the flywheel (Section 1.4).

14. Check the flywheel housing concentricity and bolting flange face with tool set J 9737-C as follows:

    a. Thread the base post J 9737-3 tightly into one of the tapped holes in the flywheel. Then, assemble the dial indicators on the base post.

    b. Position the dial indicators straight and square with the flywheel housing bell face and inside bore of the bell. Make sure each indicator has adequate travel in each direction.

    c. Pry the crankshaft toward one end of the’block to ensure end play is in one direction only.

    d. Adjust each dial indicator to read zero at the *twelve o'clock* position. Then, rotate the crankshaft one full revolution, taking readings at 45° intervals (8 readings each for the bore and the bolting flange face).

 © Detroit Diesel Corporation

- The hex head of the front crankshaft bolt may be used to turn the crankshaft. However, the barring operation should ALWAYS be performed in a clockwise direction. It is very important to make certain that the bolt has not been loosened.

- Serious engine damage may result if the vibration damper or pulley is not securely fastened to the crankshaft.

• CAUTION: To reduce the risk of personal injury when barring over or "bumping" the starter, personnel should keep their hands and clothing away from the engine as there is a remote possibility the engine could start.

Stop and remove the wrench or cranking bar before recording each reading to ensure accuracy. The maximum total indicator reading must not exceed .013" for either the bore or the face.

e. If the runout exceeds the maximum limits, remove the flywheel housing and check for dirt or foreign material between the flywheel housing and cylinder block which may result in warpage.

f. Reinstall the flywheel housing and flywheel and tighten the attaching bolts in the proper sequence and to the specified torque. Then, recheck the runout. If necessary, replace the flywheel housing.

15. Install the camshaft gear and hub assembly. Since the camshaft gears, idler gears and crankshaft gear in each gear train must be in time with the crankshaft, timing marks are located on the gears. Refer to Section 1.7.1 for timing mark alignment and Section 1.7.3 for installation.

16. Tighten the upper oil pan-to-cylinder block bolts (Section 4.7).

17. Install the four flywheel housing-to-oil pan bolts, lock washers and the same amount of shims (if required) that were removed at the time of disassembly.

18. Install all of the accessories and cover plates removed in Step 2 of *Remove Flywheel Housing.*

FLYWHEEL HOUSING ADAPTOR

The flywheel housing adaptor (Fig. 1) provides a means of attaching the power generator (Section 7.5) to the engine flywheel housing. The current adaptor ring, made from ductile iron, is interchangeable with the former adaptors.

Remove Flywheel Housing Adaptor

1. Refer to Section 7.5 and remove the generator from the engine.
2. Remove the drive coupling assembly from the crankshaft (Section 7.5).
3. Remove the sixteen attaching bolts which retain the flywheel housing adaptor to the flywheel housing and remove the adaptor.

Install Flywheel Housing Adaptor

It is recommended that the former flywheel housing adaptor (with three pilot plates) be replaced by the current flywheel housing adaptor (with pilot) at the time of assembly. *Locating tool NDD-4875 is not required when installing the current flywheel housing adaptor.*

1. Clean the mating surfaces of the flywheel housing and the flywheel housing adaptor.
2. Position the flywheel housing adaptor against the flywheel housing with two of the spot-faced holes on each side of the flywheel housing above the centerline of the crankshaft and one spot-faced hole on each side of the flywheel housing below the centerline of the crankshaft and towards the engine.
3. Apply a small amount of International Compound No. 2, or equivalent, to the threads and install the sixteen l/2”-13 x 1 1/2 self-locking bolts. Tighten the bolts to 71-75 lb—ft (96-102 N#m) torque.
4. On engines equipped with the former design adaptor, position the three pilot plates around the face of the adaptor (120° apart) and secure them loosely with 3/8”-16 bolts and washers. Use pilot plate locating tool NDD-4875 (Fig. 2) to adjust the pilot plates, as follows:
   a. Place the locating tool over the rear end of the crankshaft, with the outer end located in the adaptor pilot plate slots (Fig. 2), and secure it loosely to the crankshaft with two crankshaft bolts and spacers. Slide the tool forward so that the key located at the base of the tool is against the O.D. of the crankshaft. Then tighten the knurled knob at the front end of the base until the locating tool is tight on the end of the crankshaft. Tighten the two crankshaft bolts.

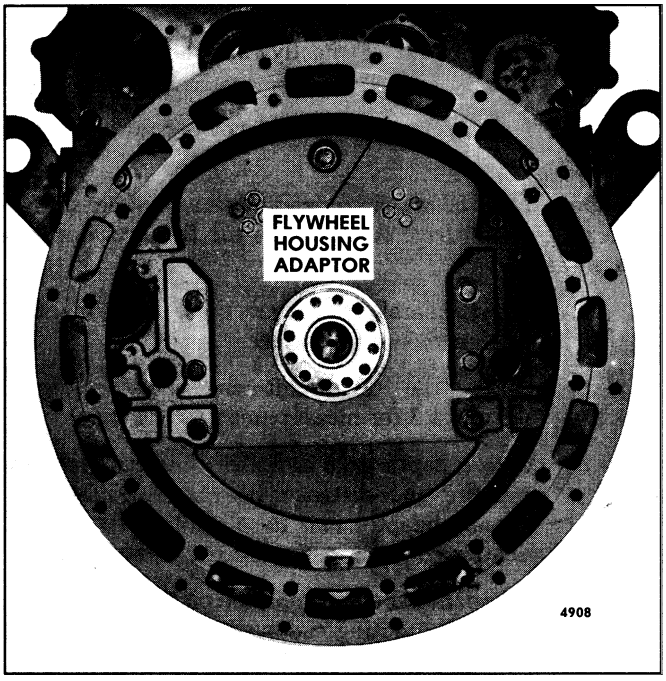


Fig. 1 - Flywheel Housing Adaptor Mounting

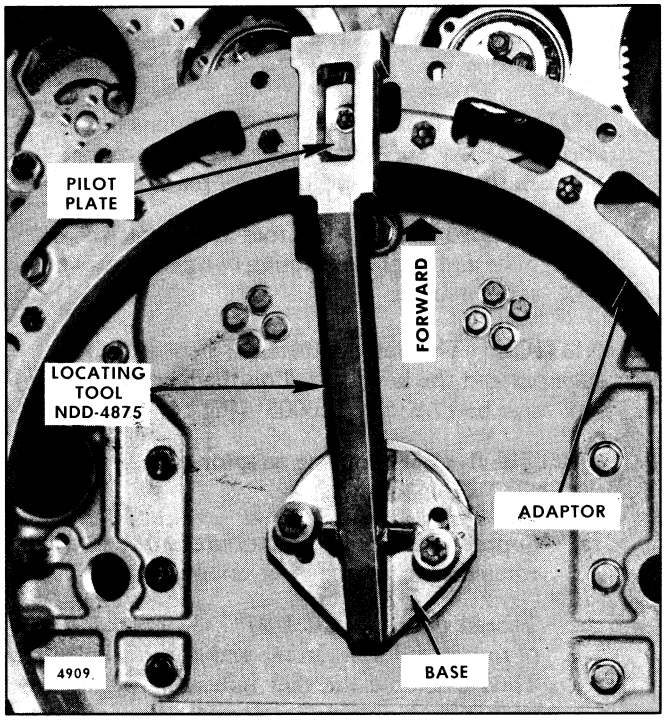


Fig. 2 - Locating Tool (NDD-4875) Positioned on Crankshaft and Flywheel Housing Adaptor (Former Adaptor)

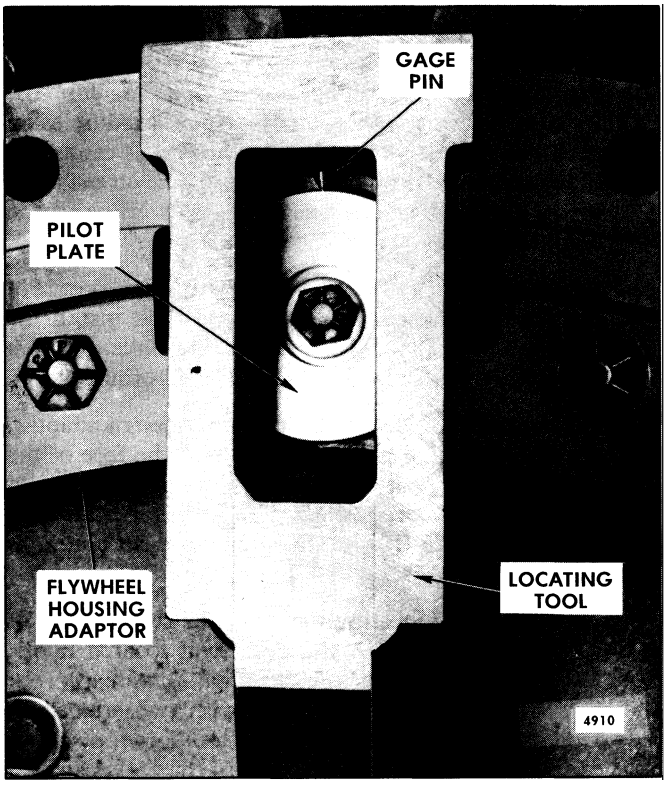


Fig. 3 - Pilot Plate in Position Against Gage Pin (Former Adaptor)

b. With the locating tool in position, slide the pilot plate up against the gage pin (Fig. 3). Tighten the pilot plate bolt to 30-35 lb-ft (41-47 N#m) torque.

NOTICE: After tightening the pilot plate bolt, check to make sure that there is no clearance between the gage pin and the pilot plate.

c. Remove the locating tool from the first pilot plate and set the remaining two pilot plates in the same manner.

NOTICE: The set-up distance between the gage pin and the key located on the base of the tool must be 17.936" ± .0005" (Fig. 4).

5. Check the flywheel housing adaptor runout with tool set J 9737-C, as follows:

a. Support the engine so that the crankshaft can be rotated with a wrench or cranking bar.

b. Thread the base post J 9737-3 tightly into one of the tapped holes in the end of the crankshaft. Then assemble the dial indicator on the base post.

c. Position the dial indicator point on the flywheel 6. housing adaptor machined face.

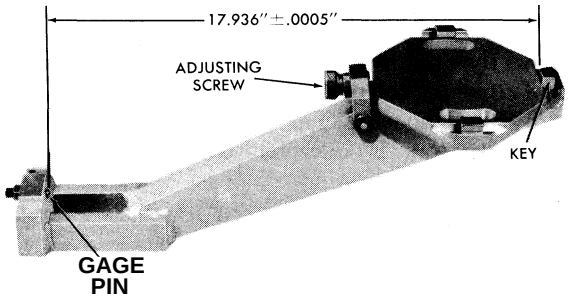


Fig. 4 - Locating Tool Set-Up Dimension

d. Rotate the crankshaft.

NOTICE: If a bolt or nut is used to rotate the crankshaft, always turn it in a tightening direction.

e. As the dial indicator is rotated, determine the total runout of the flywheel housing adaptor face.

f. The face runout should not exceed a total of .026".

g. Position the dial indicator point on the flywheel housing adaptor machined bore.

h. Rotate the crankshaft.

NOTICE: If a bolt or nut is used to rotate the crankshaft, always turn it in a tightening direction.

'*** i. As the dial indicator is rotated, determine the total runout of the flywheel housing adaptor bore.

j. The bore runout should not exceed a total of .026".

Determine the maximum and minimum dimension of the flexible plate (drive coupling) to the flywheel housing adaptor, as follows:

a. Mount a parallel bar across the flywheel housing adaptormounting surface.

b. Center the crankshaft end play (refer to Section *1.3Tor measurement of end play).

c. With a depth gage mounted on a parallel bar, measure the distance between the flywheel housing adaptor and the flexible plate at four locations 90° apart. Record the measurements.

d. Stamp the average dimension on the inside of the flywheel housing adaptor in an accessible location.

Refer to Section 7.5 and install the drive coupling assembly and the power generator.

 © Detroit Diesel Corporation

PISTON AND PISTON RINGS

FLOATING-SKIRT PISTON

The non-turbocharged (naturally aspirated) and turbocharged engines use a 17.1 to 1 compression ratio piston. The turbocharged intercooled engines use a 16 to 1 compression ratio piston. These malleable iron pistons are two piece or "floating" pistons, consisting of a piston body and a piston pin carrier (Fig. 1). The top of the piston pin carrier is positioned in a counterbore in the piston body, close to the piston crown. A snap ring, located near the base of the piston, secures the carrier within the piston body. A thrust plate is used between the piston pin carrier and the top of the piston body. This design allows the piston body to rotate freely during engine operation.

A bushing (Fig. 1) is located at the top of the piston pin opening in the piston pin carrier and is prevented from moving endwise by two tangs.

Four compression rings and two oil control rings are used on the piston (Fig. 2). Equally spaced drain holes are located at the oil control ring groove area to permit excess oil, scraped from the cylinder walls, to return to the crankcase.

Internal parts of the piston are lubricated and cooled by the crankcase oil. Oil is forced through a drilled passage in the connecting rod, up through the piston pin, then through the center hole of the bushing and carrier to the underside of the piston. A portion of the oil flows along the grooved passages of the bushing to lubricate the piston pin. Some oil is trapped between the carrier and the piston where it "sloshed" back and forth during piston reciprocation, with most of the oil being drained away through four holes drilled in the skirt of the carrier allowing the oil to return to the crankcase.

Inspect Piston Rings

When an engine is hard to start, runs rough or lacks power, worn or sticking compression rings may be the cause. Replacing the rings will aid in restoring engine operation to normal.

The compression rings may be inspected through the ports in the cylinder liners after the air box covers have been removed. If the rings are free and are not worn to a point where the plating or grooves are gone, the compression should be within operating specifications. The procedure for checking the compression pressure is covered in Section 15.2.

Remove Piston And Connecting Rod

1. Drain the cooling system.
2. Drain the oil and remove the lower oil pan and the hand hole covers on the upper oil pan (Section 4.7).
3. Remove the oil pump and inlet and outlet pipes, if necessary (Section 4.1).
4. Remove the cylinder head (Section 1.2).
5. Remove the carbon deposits from the upper inner surface of the cylinder liner.
6. Remove the bearing cap and lower bearing shell from the connecting rod. Then, push the piston and rod assembly out through the top of the cylinder block. The piston cannot be removed from the bottom of the cylinder block.
7. Reassemble the bearing cap and lower bearing shell to the connecting rod.

Disassemble Piston And Connecting Rod

Note the condition of the piston and rings. Then, remove the rings and disassemble the piston as follows:

1. Secure the connecting rod in a vise equipped with soft jaws and remove the piston rings with tool J 22405-02 (Fig. 3).
2. Remove the two bolts and spacers securing the connecting rod to the piston pin and remove the connecting rod.

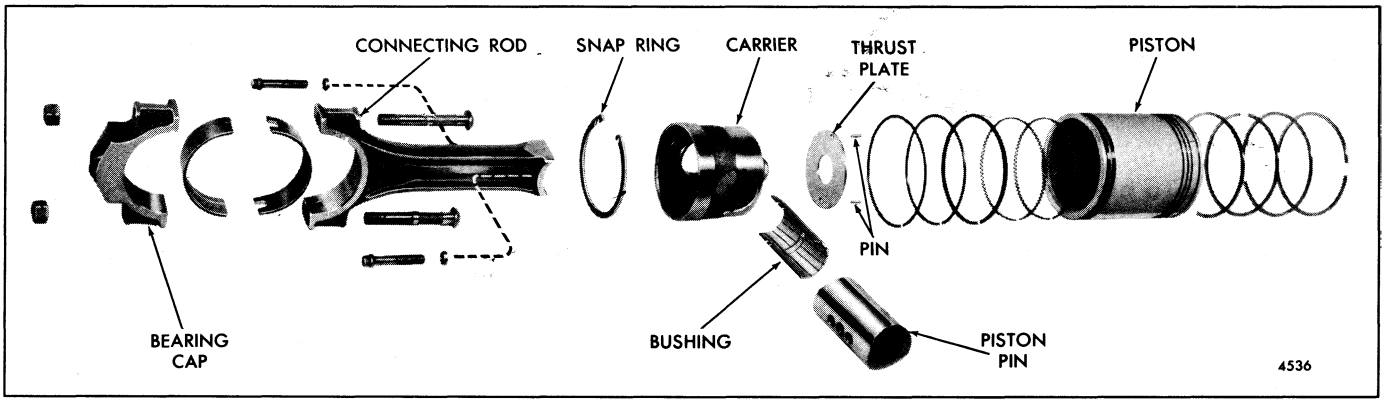


Fig. 1 - Piston and Connecting Rod and Relative Location of Parts (Piston for Turbocharged Engine Shown)

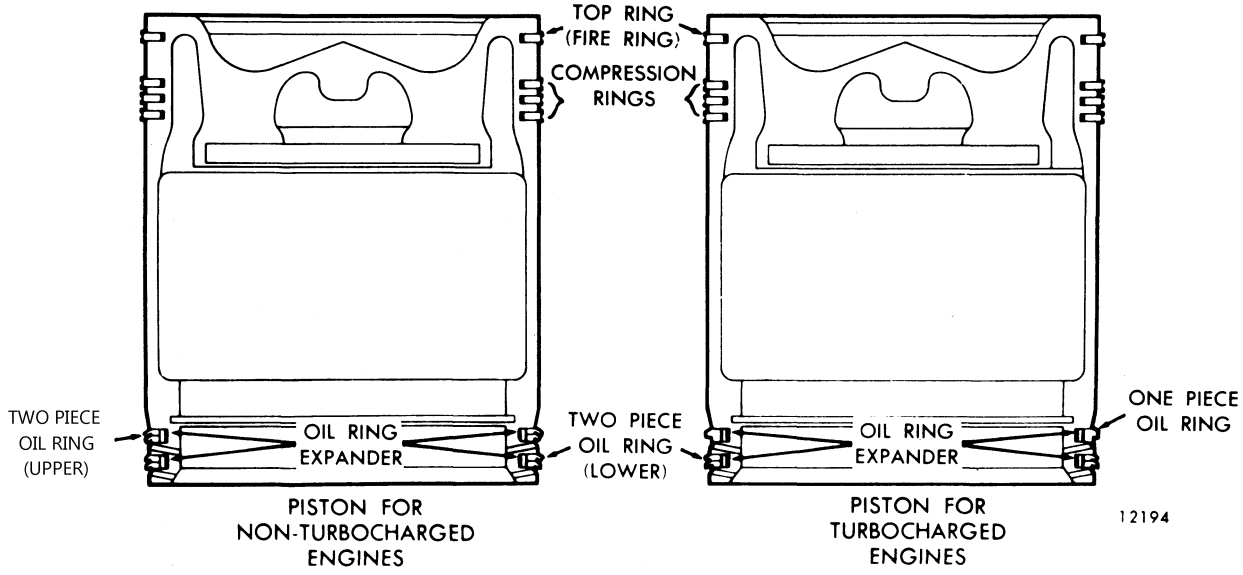


Fig. 2 - **Piston Ring Installation**

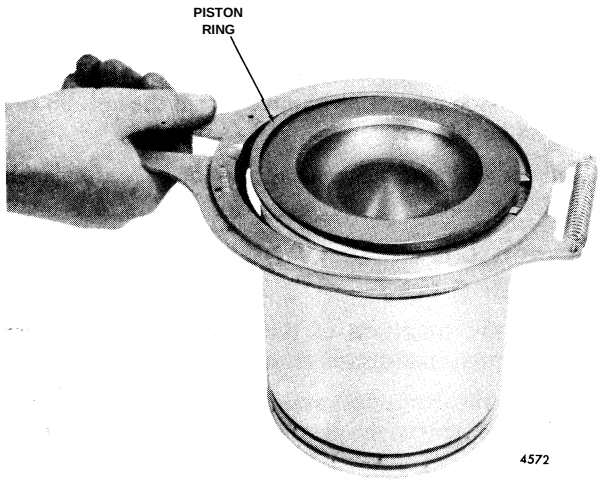


Fig. 3 - Removing or Installing Piston Rings using Tool
J 22405-02

Cleaning

Clean the parts with fuel oil and dry them with compressed air.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

If the fuel oil does not remove the carbon deposits, use a chemical solvent that will not harm the tin-plate on the piston. If a chemical solvent is used, refer to the container for "Safe Use Instructions".

The upper part of the piston, including the compression ring lands and grooves, is not tin-plated and may be wire-brushed to remove any hard carbon. However, care must be taken to avoid damaging the tin-plating on the piston skirt. Clean the ring grooves with a suitable tool or a piece of an old compression ring that has been ground to a bevel edge.

Clean the inside surfaces of the piston and the oil return holes in the lower half of the piston skirt. Exercise care to avoid enlarging the holes while cleaning them.

Disassemble Piston And Carrier

After the connecting rod and piston rings have been removed from the piston, disassemble the piston as follows:

1. Remove the snap ring from the piston body and withdraw the piston pin carrier and thrust plate (Fig. 4).

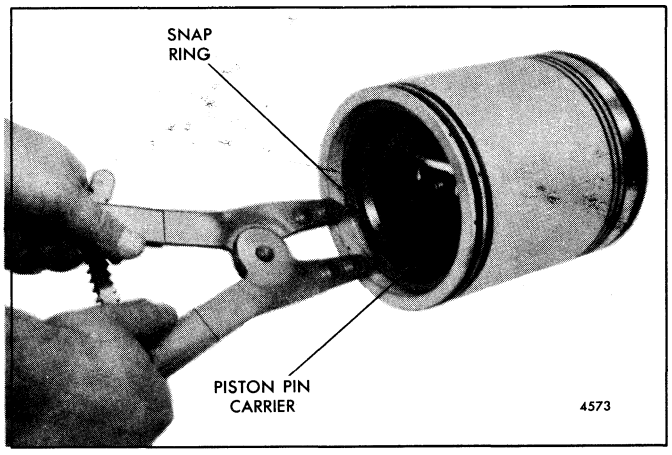


Fig. 4 - **Removing Piston Pin Carrier From Piston**

 © Detroit Diesel Corporation

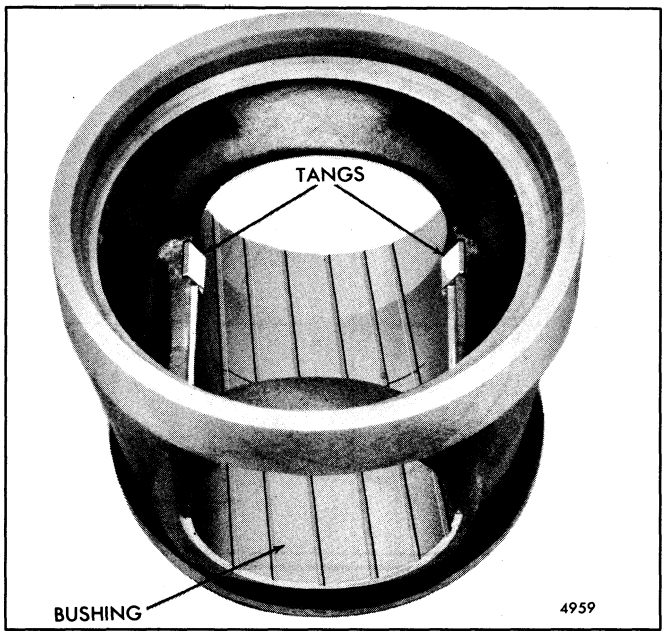


Fig. 5 - Piston Carrier and Bushing

2. Remove the piston pin from the carrier.

3. Visually inspect the piston pin bushing. If the babbitt overlay is worn to the point that copper is visible, the bushing must be replaced. If replacement of the bushing is required, straighten the tangs and remove the bushing (Fig. 5). Once the tangs have been straightened and the bushing is removed, it cannot be reused.

Inspection

If the tin-plate on the piston and the original grooves in the piston rings are intact, it is an indication of very little wear.

Excessively worn or scored pistons, rings or cylinder liners may be an indication of abnormal maintenance or operating conditions which should be corrected to avoid recurrence of the failure. The use of the correct types and proper maintenance of the lubricating oil filters and air cleaners will reduce to a minimum the amount of abrasive dust and foreign material introduced into the cylinders and will reduce the rate of wear.

Long periods of operation at idle speed and the use of improper lubricating oil or fuel must be avoided, otherwise a heavy formation of carbon may result and cause the rings to stick. ”

Keep the lubricating oil and engine coolant at the proper levels to prevent overheating of the engine.

Examine the piston for score marks, cracks, damaged ring groove lands or indications of overheating. A piston with light score marks which can be cleaned up may be reused. Any piston that has been severely scored or overheated must be replaced. Indications of overheating or burned spots may be the result of an obstruction in the connecting rod oil passage.

If any cracks are found in the piston, the piston must be replaced. Use the magnetic particle inspection methods outlined in Section 1.3 under *Crankshaft Inspection* for locating cracks in the piston.

Other factors that may contribute to piston failure include oil leakage into the air box, oil pull-over from the air cleaner, dribbling injectors, combustion blow-by and low oil pressure (dilution of the lubricating oil).

Check the connecting rod and piston pin as outlined in Section 1.6.1. The current piston pin has a thicker wall and requires 1/4” longer pin bolts. When replacing a former piston pin with the current pin, include two l/2”-20 x 2” pin bolts. The former and current piston pins can be mixed in an engine. However, it is recommended that all current pins be installed at time of overhaul on early engines.

Inspect the thrust plate for cracks, wear or any other damage. A new thrust plate is .0995”-. 1010” thick. Replace the plate when it is worn to .0945” in thickness.

Inspect the piston pin carrier thrust plate platform. Slight ridges, gouges or scuffing may be cleaned up. However, the height from the bottom of the carrier to the thrust platform must not be less than 3.605”. This height on a new carrier is 3.606M-3.609” (Fig. 6). The thrust washer surface must be square with the axis through the two finished diameters within .002” total indicator reading.

If replacement of the former 180° piston pin carrier or bushing (Fig. 6) is required, the current 150° carrier and bushing must be installed. The former 180° carrier and bushing are not serviced.

Effective with engine serial numbers 12E-221 and 16E-001, the thrust plate is drilled and retained by dowel pins located in the piston. Inspect the dowel pins for wear. The installed height that a new dowel pin extends from the thrust washer seating surface is .075”-.080” with new parts. If replacement is required, drive the old pins out with a suitable punch and install the new pins with tool J 23574. After installation, the new pin must withstand a 250 pound load without.moving.

Effective” with approximate engine serial numbers 12E-1490 and 16E-233, the piston pin carrier and thrust plate have hardened mating surfaces to provide a more wear resistant thrust surface. The current carrier can be identified by its dull gray finish. The current thrust plate is steel with a nickel-cobalt plating and is tapered approximately .003” from the inside diameter to the outside diameter. The former flat thrust plate was bronze with a lead-tin overlay on the carrier side. Both the current carrier and thrust plate must be used together. One side of the thrust plate is stamped “Piston Side” to aid correct installation. Do not use former and current carriers and thrust plates together.

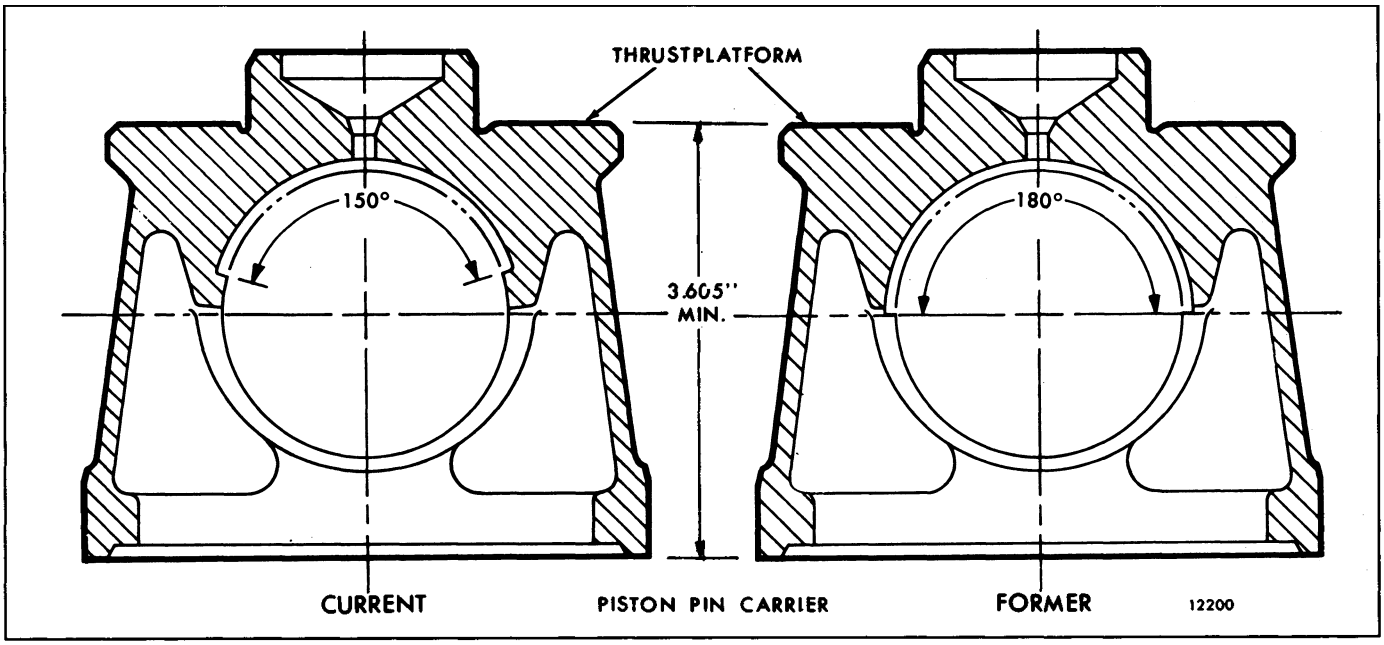


Fig. 6 - Piston Carrier Dimension

Check the cylinder liner (Section 1.6.3) and block bore (Section 1.1) for excessive out-of-round, taper or high spots which could cause piston failure.

Current cross-head piston assemblies and floating-skirt piston assemblies may be intermixed within an engine. At time of complete engine overhaul, it is recommended that all floating-skirt pistons in an engine be replaced by the cross-head pistons.

Fitting Piston

Measure the piston diameter and cylinder bore, preferably at room temperature (70°F or 21°C). Refer to Section 1.0 for the piston and liner specifications.

Effective with approximate engine serial numbers 12E-673 and 16E-016, a new piston with an increased outside diameter and a revised bottom oil control ring land and oil drain holes (Fig. 1) replaced the former piston. With the increased piston diameter, the piston-to-liner clearance was reduced. Effective with engine serial numbers 12E-1463 and 16E-218, the piston-to-liner clearance was further reduced (refer to Section 1.0) by increasing the tin plate thickness on the piston.

Fitting Piston Rings

Each piston is fitted with a fire ring, three compression rings and two oil control rings (Fig. 2).

The top (fire) ring and the upper compression ring (second groove) are pre-stressed. Both are identified by an oval mark on the top side. In addition, the grooved fire ring has a black or copper oxide coating and is marked "Top-F-GM" on top of the ring. The barrel-faced fire rings are identified with "Top-F-GM" and a circle on the top.The upper compression ring is marked "Top-GM" in addition to the oval mark. The compression ring used in the third and fourth grooves is identified by "Top-GM" only.

A two-piece non-slotted oil control ring (upper ring groove) and a two-piece slotted oil control ring (lower ring groove) are used in the pistons for turbocharged and non-turbocharged engines.

All new piston rings must be installed whenever a piston is removed, regardless of whether a new or used piston or cylinder liner is installed.

Insert one ring at a time inside of the cylinder liner and far enough down to be within the normal area of the ring travel. Use a piston to push the ring down to be sure it is parallel with the top of the liner. Then, measure the ring gap with a feeler gage (Fig. 7). Refer to Section 1.0 for ring gap specifications.

If the gap on a compression ring is insufficient, it may be increased by filing or stoning the ends of the ring. File or stone both ends of the ring so the cutting action is ffom the outer surface to the inner surface. This will prevent any chipping or peeling of the chrome plate on the ring. The ends of the ring must remain square and the chamfer on the outer edge must have a .005" to .020" radius which blends into the ring face.

Check the ring side clearance (Fig. 8). Refer to Specifications - Section 1.0 for piston ring clearance specifications.

 © Detroit Diesel Corporation

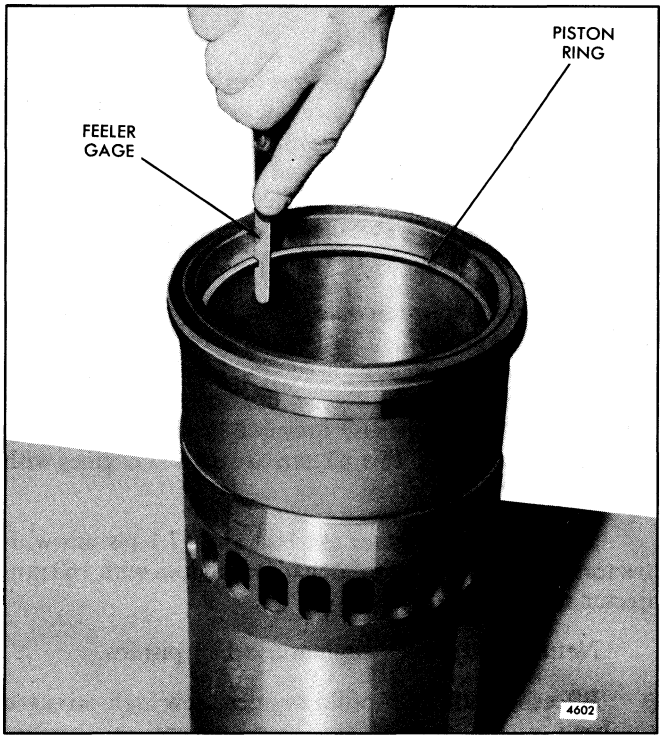


Fig. 7 - Measuring Piston Ring Gap

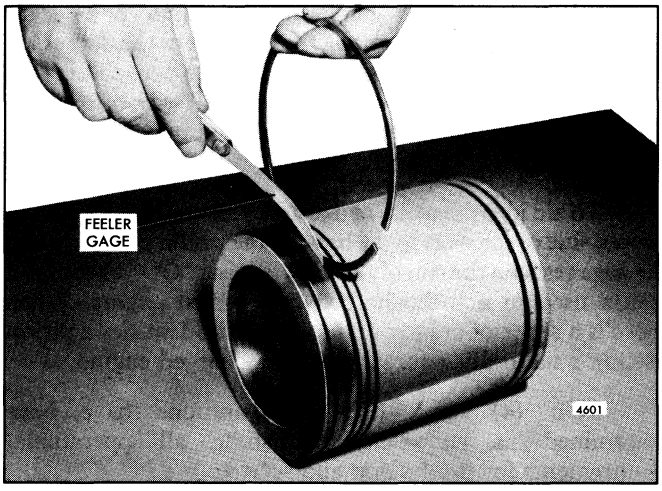


Fig. 8 - Measuring Piston Ring Side Clearance

Install Piston Rings

Before installing the piston rings, assemble the piston as outlined under *Assemble Connecting Rod to Piston* in Section 1.6.1. Then, refer to Figs. 2 and 3 and install the piston rings. Lubricate the piston rings and piston with engine oil before installing the rings.

COMPRESSION RINGS

1. Starting with the bottom ring, install the compression rings with tool J 22405-02 (Fig. 3). *To avoid breaking or overstressing the rings, do not spread them any more than necessary to slip them over the piston.* The compression rings have a tapered face. Make sure the side marked “TOP” is toward the top of the piston.

2. Stagger the ring gaps around the piston.

OIL CONTROL RINGS

The upper and lower oil control rings used on pistons for current *non-turbocharged* engines consist of two halves (upper and lower). The upper oil control ring used on pistons for *turbocharged* engines is a one-piece ring while the lower ring is a two-piece ring (upper and lower halves). Install the oil control rings as follows:

1. Install the ring expanders in the oil control ring grooves of the piston. When installing the oil control rings, use care to prevent overlapping the ends of the ring expanders. An overlapped expander will cause the oil ring to protrude beyond allowable limits and will result in breakage when the piston is inserted in the ring compressor during installation in the cylinder liner. Do not cut or grind the ends of the expanders to prevent overlapping. Cutting or grinding the ends will decrease the expanding force on the oil control ring and result in high lubricating oil consumption.

2. To install the one-piece ring (turbocharged engines), position it over the upper ring groove, using tool J 22405-02, with the gap 180° from the gap in the expander and the scraper edge facing down. Press the ring against the gap side of the expander to prevent the ends of the expander from overlapping, then align the ring with the groove and release the tension on the tool, permitting the ring to slip in position.

Install the upper and lower halves of the lower oil control ring by hand. Install the upper half with the gap 180° from the gap in the expander. Then, install the lower half with the gap 45° from the gap in the upper half of the ring. Make sure t£e scraper edges are facing down (toward the bottom of *the* piston). The scraper edges of all oil control rings must face downward (toward the bottom of the piston) for proper oil control.

3. Install the upper and lower halves of both oil control rings (non-turbocharged engines) as outlined above.

If there is noticeable resistance during installation of the piston, check for an overlapped ring expander.

CROSS-HEAD TYPE PISTON

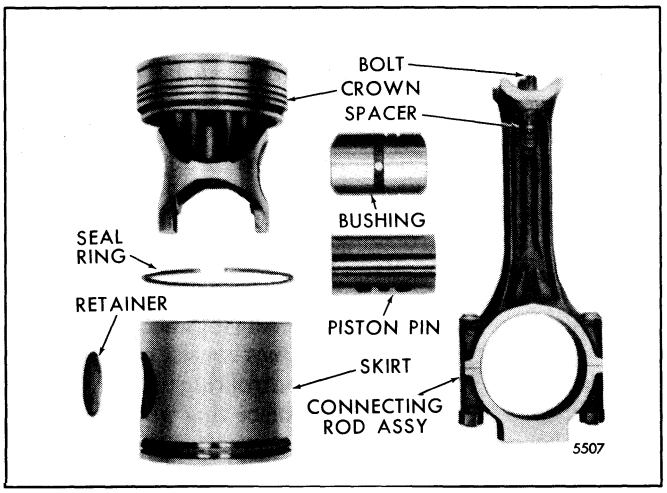


Fig. 9 - Cross-Head Piston and Connecting Rod Components

The cross-head piston (Fig. 9) is a two-piece piston consisting of a crown and skirt. An oil seal ring is used between the crown and skirt which are held together by the piston pin. Two bolts and spacers are used to attach the connecting rod (Section 1.6.1) to the piston pin.

Ring grooves are machined in the piston crown for a fire ring and three compression rings. The crown is also machined to accept a 150° slipper type bushing (bearing). The piston skirt incorporates two oil control ring grooves, piston pin holes and piston pin retainer counterbores. Naturally aspirated engines have equally spaced drain holes that are located in the oil ring groove area to permit excess oil, scraped from the cylinder walls, to return to the crankcase.

A new piston skirt and a new two piece upper oil control ring are used in the turbocharged and turbocharged intercooled engines. This is effective with engine serial numbers 12E-5613 and 16E-5212. The new turbocharged piston skirt has all of the drain holes eliminated and replaced with two pressure relief slots or scallops below the lower oil control ring groove, under the piston pin center lines. The former and new parts may be mixed in an engine; however, maximum oil consumption gain will not be realized. The former piston skirt and oil control ring expander (part of oil ring set) will continue to be serviced for naturally aspirated engines. The former one piece (Turbo) oil control ring and expander ring set will not be serviced.

Internal parts of the piston are lubricated and cooled by the engine lubricating oil. Oil is forced through a drilled passage in the connecting rod, up through the piston pin, then through the center hole in the bushing to the underside of the piston crown. A portion of the oil flows along the grooves in the bushing to lubricate the piston pin.

During engine operation, gas loads pushing down on the piston crown are taken directly by the piston pin and bushing. The piston skirt, being separate, is free from vertical load distortion; thermal distortion is also reduced as the piston crown expands. As the connecting rod swings to one side during downward travel of the piston, the major portion of the sideload is taken by the piston skirt.

- *Turbocharged-intercooled engines with blower bypass valves* use 14:1, 15:1, or 16:1 compression ratio pistons. 14:1 pistons are used in high output, 2200 horsepower engines, except generator sets, which use 15:1 pistons. 15:1 pistons are also installed in engines with 190 mm or larger injectors. 16:1 pistons are used in engines with less than 190 mm injectors.

- *Turbocharged engines* use 16:1 and 17:1 pistons with injectors up to 140 mm. Turbocharged engines with 160 mm injector use 16:1 pistons.

- *Naturally aspirated engines* use 17:1 pistons.

- Effective with 1988-build engines, new high-strength crosshead piston domes are used, except on engines requiring 16:1 compression ratio domes with wide fire ring grooves. The new domes are similar to the former domes, except that they have a redesigned piston bowl strut configuration (Fig. 11). Among the changes to the domes are an increased blend radius of strut-to-upper piston pin saddle and the elimination of strut taper. Former and new domes are completely interchangeable and may be mixed in an engine.

To aid identification of a piston, refer to Fig. 10. Fit the proper side of the gage in the bowl of the piston crown. When the gage rests on the rim of the crown, it is a “GO” check for a piston used in a turbocharged-intercooled engine. When there is a space of approximately .050”, it identifies a piston used in a naturally aspirated or turbocharged engine.

Four (4) basic ring configurations have been determined as sufficient to handle all operational requirements for production and service.

The first production ring arrangement uses the narrow grooved chrome fire ring and barrel-faced compression rings, along with what is now an across-the-board oil ring/expander package. This consists of slotted oil rings in the lower groove, non-slotted rings in the upper groove, and low tension (11-17#) expanders. This configuration can be used in engines equipped with 140 to 270 cmm injectors and operating with LOW sulfur fuel.

The second ring arrangement consists of the wide barrei-faced fire ring, grooved chrome compression rings and the standard oil ring package. This arrangement will be used in engines with 140 to 270 cmm injectors, but operating with HIGH sulfur fuel (sulfur content 0.5% and above).

 © Detroit Diesel Corporation

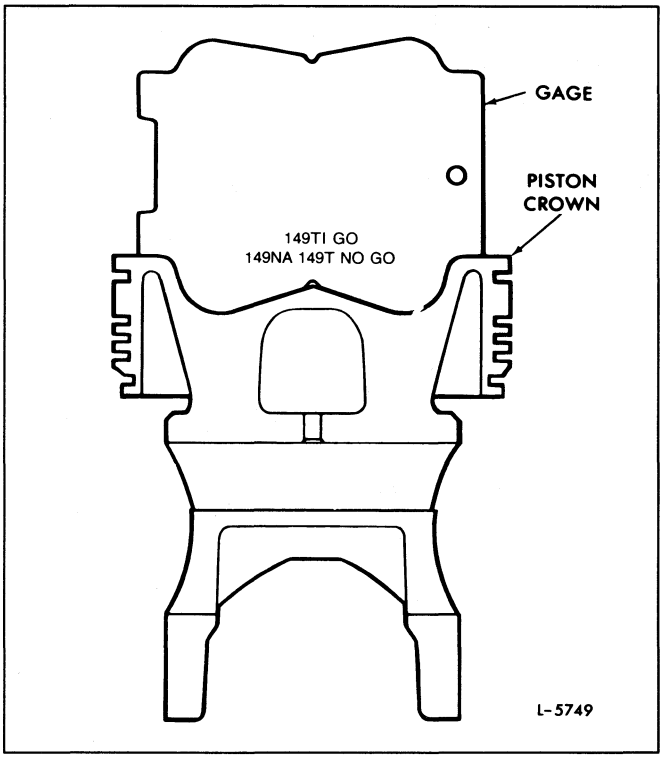


Fig. 10-Piston Identification using Gage J 25397

The third ring arrangement uses the wide barrel-faced fire ring and barrel-faced compression rings with the standard oil ring package. This arrangement is used only with 17:1 pistons in low output engines, which includes naturally aspirated engines and turbocharged engines using either 120 or 130 cmm injectors.

The fourth ring arrangement is the all-grooved ring set which uses narrow, grooved chrome fire and compression rings. The most commonly used ring set, it is installed in applications where fuel sulfur is below 0.5% and previous experience with this ring set has been satisfactory.

Inspect Piston Rings

When an engine is hard to start, runs rough or lacks power, worn or sticking compression rings may be the cause. Replacing the rings will aid in restoring engine operation to normal.

The compression rings may be inspected through the ports in the cylinder liners after the air box covers have been removed. If the rings are free and are not worn to a point where the plating or grooves are gone, the compression should be within operating specifications. The procedure for checking compression pressure is covered in Section 15.2.

Remove Piston And Connecting Rod

1. Drain the cooling system.
2. Drain the oil and remove the lower oil pan and the hand hole covers on the upper oil pan (Section 4.7).
3. Remove the oil pump and inlet and outlet pipes, if necessary (Section 4.1).
4. Remove the cylinder head (Section 1.2).
5. Remove the carbon deposits from the upper inner surface of the cylinder liner.
6. Remove the bearing cap and lower bearing shell from the connecting rod. Then, push the piston and rod assembly out through the top of the cylinder block. The piston cannot be removed from the bottom of the cylinder block.
7. Reassemble the bearing cap and lower bearing shell to the connecting rod.

Disassemble Piston And Connecting Rod

Note the condition of the piston and rings. Then remove the rings and disassemble the piston as follows:

1. Secure the connecting rod in a vise equipped with soft jaws and remove the piston rings with tool J 22405-02 (Fig. 3).
2. Punch a hole through the center of one of the piston pin retainers with a narrow chisel or punch and pry the retainer from the piston, being careful not to damage the piston or bushing. Remove the opposite retainer in the same manner.
3. Loosen the two bolts which secure the connecting rod to the piston pin. Then, remove the rod and piston assembly from the vise and place the assembly on the bench. Remove the two bolts and spacers and remove the connecting rod.
4. Withdraw the piston pin.
5. Separate the piston skirt from the piston crown.
6. Remove the seal ring from the piston crown.
7. Remove the piston pin bushing (bearing).

Cleaning

Clean the piston components with fuel oil and dry them with compressed air.

CAUTIONiTo prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 Kps) air pressure.

If the fuel oil does not remove the carbon deposits, use a chemical solvent that will not harm the tin-plate on the piston. If a chemical solvent is used, refer to the container for “Safe Use Instructions”.

The piston crown, including the compression ring grooves, is not tin-plated and may be wire-brushed to remove any hard carbon. *Do not wire-brush the piston skirt* Clean the ring grooves with a suitable tool or a piece of an old compression ring that has been ground to a bevel edge.

Clean the inside surfaces of the piston crown and skirt and the oil drain holes in the lower half of the piston skirt. Exercise care to avoid enlarging the holes while cleaning them.

Glass beading can be used to clean a piston crown. Mico Bead Glass Shot MS-M (.0029"-.0058M) is recommended. Allowable air pressure is 80-100 psi (552-689 kPa). After cleaning, do not leave glass beads in the piston crown.

NOTICE: Do not attempt to clean the piston skirt by glass beading, as it will remove the tin-plating.

Inspection

If the tin-plate on the piston skirt and the original grooves in the piston rings are intact, it is an indication of very little wear.

Excessively worn or scored piston skirts, rings or cylinder liners may be an indication of abnormal maintenance or operating conditions which should be corrected to avoid recurrence of the failure. The use of the correct types and proper maintenance of the lubricating oil filters and air cleaners will reduce to a minimum the amount of abrasive dust and foreign material introduced into the cylinders and will reduce the rate of wear.

Long periods of operation at idle speed and the use of improper lubricating oil or fuel must be avoided, otherwise a heavy formation of carbon may result and cause the rings to stick.

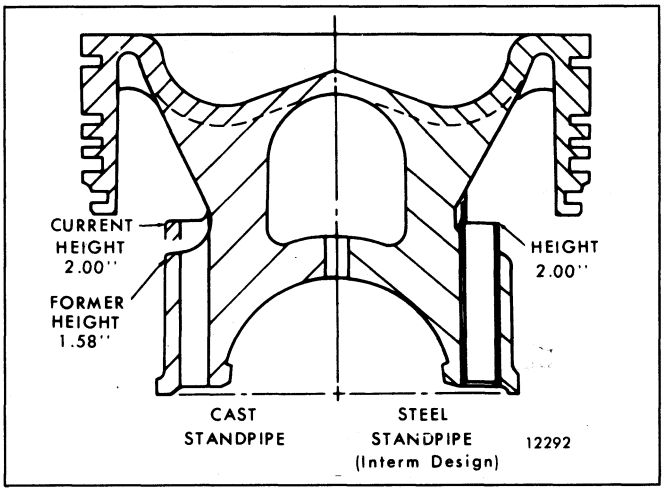


Fig. 11 - Piston Standpipe

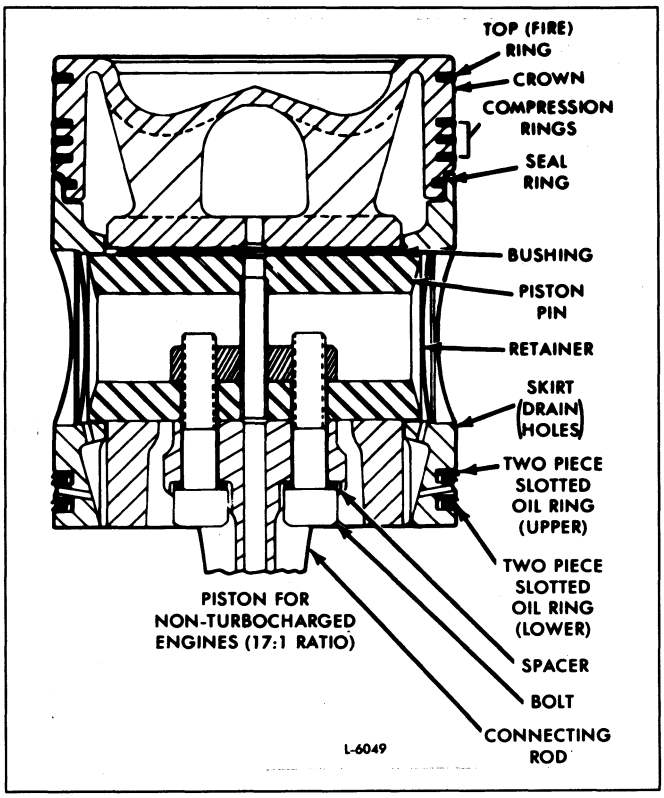


Fig. 12 - Piston Ring Arrangements (Naturally Aspirated Engines)

Keep the lubricating oil and engine coolant at the proper levels to prevent overheating of the engine.

Examine the piston skirt and crown for score marks, cracks, damaged ring groove lands or indications of overheating. Any piston that has been severely scored or overheated must be replaced. Indications of overheating or burned spots may be the result of an obstruction in the connecting rod oil passage.

The "standpipe" height in the current piston crown has been increased, thus raising the oil level in the piston to provide improved piston dome cooling. The former and revised piston crowns may be mixed in an engine. Current design pistons may be identified by referring to Figs. 11,12 and 13. . .

Check the cylinder liner and block bore for excessive out-of-round, taper or high spots which could cause failure of the piston (refer to Specifications - Section 1.0).

Inspection of the connecting rod, piston pin and piston pin bushing are covered in Section 1.6.1.

Other factors that may contribute to piston failure include oil leakage into the air box, oil pull-over from the air cleaner, dribbling injectors, combustion blow-by and low oil pressure (dilution of the lubricating oil).

 © Detroit Diesel Corporation

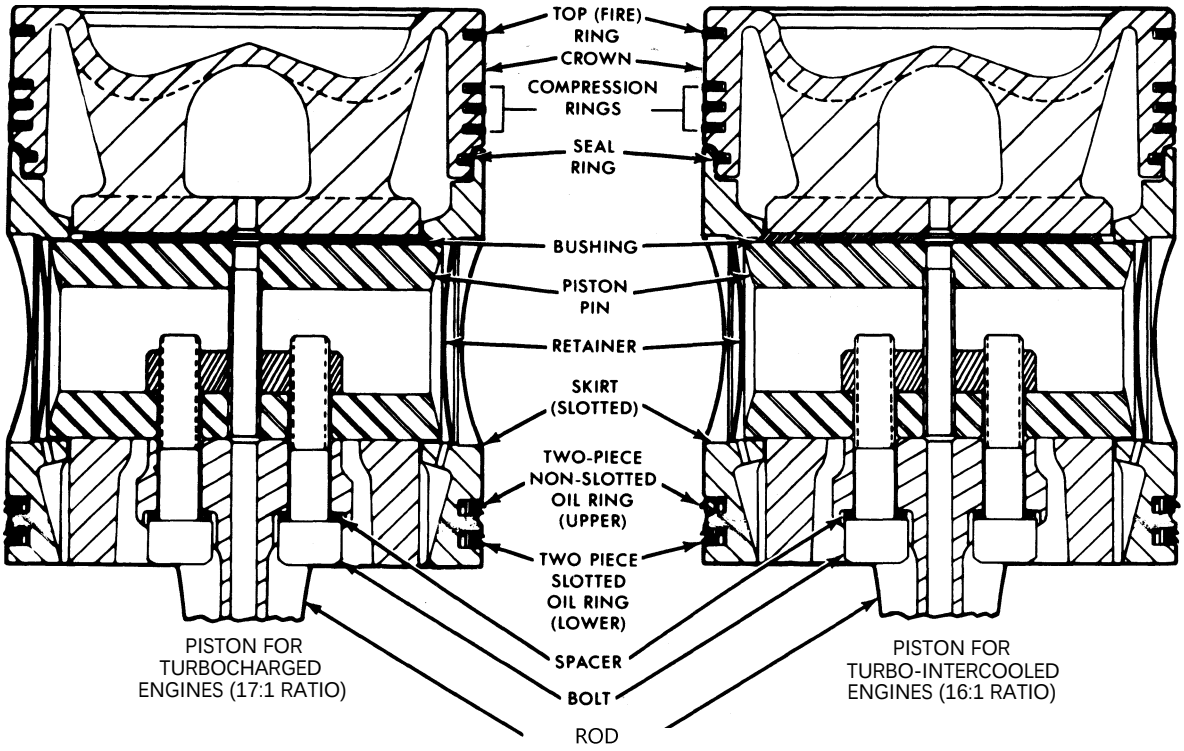


Fig. 13 - Piston Ring Arrangements (Turbocharged Engines)



Fig. 14 - Installing Seal Ring

•Lubrication

Use a mixture of clean engine oil and *STP* (or equivalent) on all moving parts of the cylinder kit during assembly. This mixture adheres to the parts for a longer period of time than plain engine oil, thus helping prevent scuffing of parts at engine start-up. The suggested mix ratio is 8:1 (8 parts engine oil to 1 part *STP*, or equivalent).

Assemble Piston And Connecting Rod

• 1. Install the bearing (bushing) in the piston crown. It should slide into the piston crown with hand applied force. The bearing must be installed before assembling the piston skirt and crown.

The current piston crown, which incorporates a piston bowl support system with eight cast-in struts, should be used in all engine models. The former crown had twelve cast-in *stmts.*

2. Lubricate the fluoroelastomer seal ring liberally with STP, or equivalent and install the seal ring in the piston crown (Fig. 14). *Excessive stretching should be avoided.* If the former metal seal ring is used, lubricate the seal ring (Fig. 13) with engine oil and install it with the face marked “top” facing the piston crown. If the ring is not marked, install it with the countergroove facing the top of the piston crown.

3. Compress the former seal ring with ring compressor J 24421 and push the skirt into position on the piston



Fig. 15 - Installing Piston Pin

crown. The fluoroelastomer ring can be compressed by hand before the skirt is pushed into position on the piston crown. *Excessive stretching should be avoided.* Before completely assembling the piston, check to make sure the seal ring does not stick in the ring groove. It is imperative for satisfactory engine operation that the seal ring is free in the piston crown groove. Check the full 360° circumference of the groove to be sure there are no tight spots. When the piston crown, seal ring and piston skirt are assembled, the skirt should spin freely on the crown (crown top down on the bench). If the ring sticks, remove high spots or nicks in the groove with a flat file. If this does not relieve sticking, replace the piston crown.

4. Lubricate the piston pin with the clean engine oil/STP mix and install it in the piston crown and skirt (Fig. 15). Line up the piston pin opening in the piston skirt with the bearing (bushing) opening in the piston crown to prevent damage to the pin or bushing.

5. Install the spacers on the two l/2”-20 x 2-1/4” connecting rod to piston pin attaching bolts.

6. Lubricate the threads and the underside of the heads of the bolts with a small amount of International Compound No. 2, or equivalent.

Effective with engine serial numbers 8E-2502, 12E-8523 and 16E-8110, a new cross-head piston pin and a new rod-to-pin bolt are being used in Series 149 engines. The new pin is machined from solid stock and has a drilled lube oil supply hole and two drilled and tapped piston pin bolt holes (Fig. 16).

• Since the former and the new piston pins and bolts are completely interchangeable and can be mixed in an engine, only the new will be serviced. Detroit Diesel recommends replacing the former piston pin and rod-to-pin bolts with the

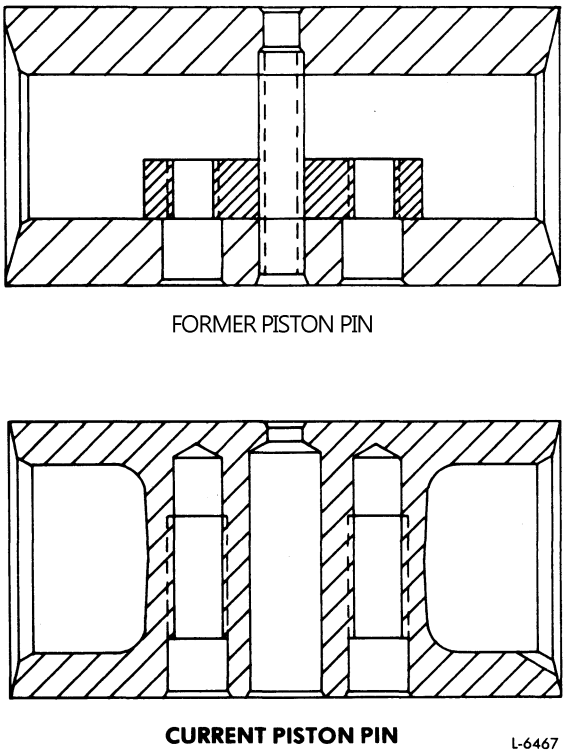


Fig. 16 - Former and Current Piston Pins

new piston pin, rod-to-pin bolts and spacers whenever a cylinder kit is *replaced or at time of major engine overhaul. Detroit Diesel does not recommend reuse of former or current piston pin bolts at time of cylinder kit replacement New bolts should be installed.*

7. Insert the bolts through the end of the connecting rod and thread fingertight into the piston pin. Then, clamp the connecting rod in a vise (Fig. 17) and tighten the bolts to 35-45 lb—ft (47-61 N*m) torque, followed by 60° to 80° additional rotation. This method also applies to the former bolts used with either the former or current piston pin.

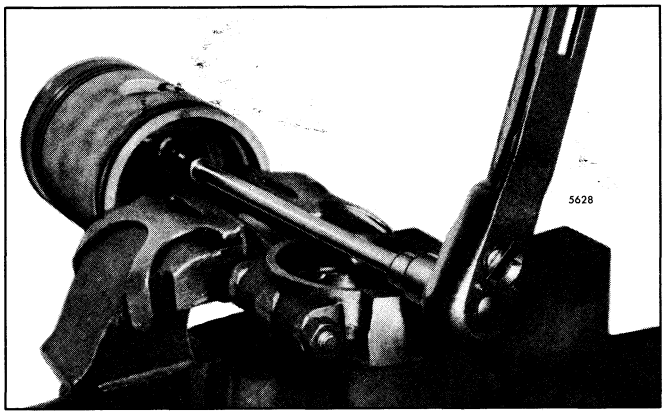


Fig. 17 - Tightening Connecting Rod to Piston Pin Bolts

 © Detroit Diesel Corporation

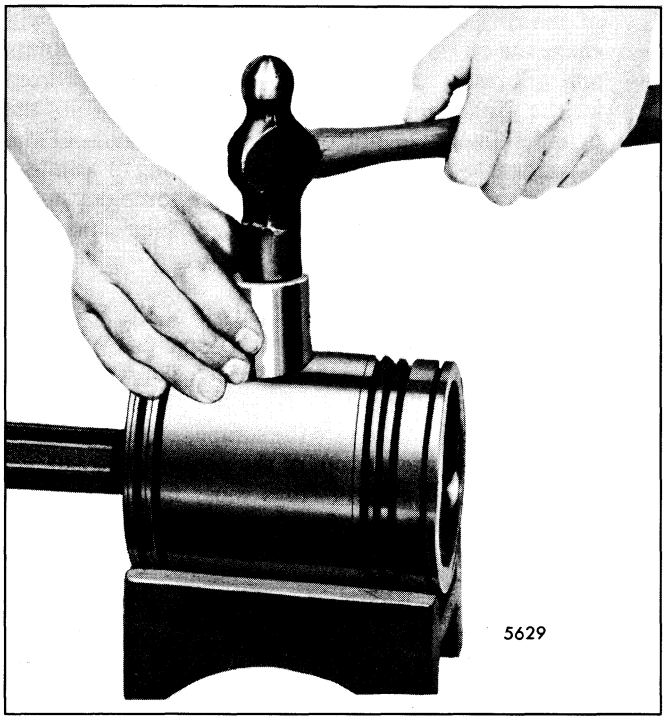


Fig. 1 8 - Installing Piston Pin Retainer using Tool J 24274-B

8. Place a new piston pin retainer in position. Then, place the crowned end of installer J 24274-B against the retainer and strike the tool just hard enough to deflect the retainer and seat it evenly in the piston (Fig. 18). The current piston pin retainer is .025M-.027M thick.

9. Install the second piston pin retainer in the same manner. Due to the size of the counterbore in the piston skirt, be careful when installing the piston pin retainers and inspect them to be sure they are not buckled and that they are fully seated in the counterbores. The width of the land should be even around the retainer.

10. One important function of the piston pin retainer is to prevent the oil, which cools the underside of the piston and lubricates the piston pin bushing, from reaching the cylinder walls. Check each retainer for proper sealing with leak detector J 23738 (Fig. 19) and vacuum cup J 24629. Place the suction cup over the retainer and hand operate the lever to pull a vacuum of ten (10) inches on the gage. A drop in the gage reading indicate air leakage at the retainer.

Fitting Piston

Measure the piston skirt diameter and cylinder liner bore, preferably at room temperature (70°F or 21°C). Refer to Specifications - Section 1.0 for the piston and liner specifications.

Fitting Piston Rings

Each piston is fitted with a fire ring, three compression rings and two oil control rings (Fig. 12 and 13).

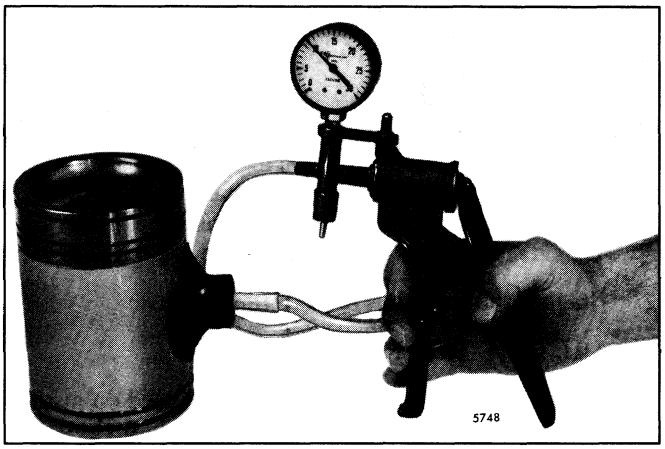


Fig. 19 - Checking Piston Pin Retainer for Proper Sealing using Tool J 23738 and Adaptor J 24629

• The top (fire) ring and the upper compression ring (second groove) are pre-stressed. Both are identified by an oval mark on the top side. In addition, the fire ring has a black or copper oxide coating and is marked “Top-F-GM” on top of the ring. The barrel-face fire rings are identified with “Top-F-GM” and a circle on the top. The upper compression ring is marked “Top-GM” in addition to the oval mark. The compression ring used in the third and forth ring grooves is identified by “Top-GM” only.

A two-piece non-slotted oil control ring (upper ring groove) and a two-piece slotted oil control ring (lower ring groove) are used in the pistons for turbocharged and non-turbocharged engines.

All new piston rings must be installed whenever a piston is removed, regardless of whether a new or used piston or cylinder liner is installed.

Insert one ring at a time inside of the cylinder liner and far enough down to be within the normal area of ring travel. Use a piston skirt to push the ring down to be sure it is parallel with the top of the liner. Then, measure the ring gap with a feeler gage (Fig. 7). Refer to Specifications - Section 1.6 for ring gap specifications.

If the gap on a compression ring is insufficient, it may be increased by filing or stoning the ends of the ring. File or stone both ends of the ring so the cutting action is from the outer surface to the inner surface. This will prevent any chipping or peeling of the chrome plate on the ring. The ends of the ring must remain square and the chamfer on the outer edge must have a .005” to .020” radius which blends into the ring face.

Check the ring side clearance (Fig. 8). Ring side clearances are specified in Specifications - Section 1.0.

Install Piston Rings

Lubricate the piston rings and piston with the clean engine oil/STP mix before installing the rings. Refer to Figs. 3, 12 and 13 and install the piston rings.

COMPRESSION RINGS

1. Starting with the bottom ring, install the compression rings with tool J 22405-02 (Fig. 3). To avoid breaking or overstressing the rings, do not spread them any more than necessary to slip them over the piston. The compression rings have a tapered face. Make sure the side marked “Top” is toward the top of the piston.
2. Stagger the ring gaps around the piston.

OIL CONTROL RINGS

The upper and lower oil control rings used on pistons for *non-turbocharged* and *turbocharged* engines consist of two halves (upper and lower). Install the oil control rings as follows:

1. Install the ring expanders in the oil control ring grooves in the piston skirt. When installing the oil control rings, use care to prevent overlapping the ends of the ring expanders. An overlapped expander will cause the oil ring to protrude beyond allowable limits and will result in breakage when the piston is inserted in the ring compressor during installation in the cylinder liner. Do not cut or grind the ends of the expanders to prevent overlapping. Cutting or grinding the ends will decrease the expanding force on the oil control ring and result in high lubricating oil consumption.
2. Install the upper and lower halves of the lower oil control ring by hand. Install the upper half with the gap 180° from the gap in the expander. Then, install the lower half with the gap 45° from the gap in the upper half of the ring. Make sure the scraper edges are facing down (toward the bottom of the piston). The scraper edges of all oil control rings must face downward (toward the bottom of the piston) for proper oil control.

If there is noticeable resistance during installation of the piston, check for an overlapped ring expander.

Install the piston and connecting rod assembly in the engine as outlined in Section 1.6.3.

 © Detroit Diesel Corporation

CONNECTING ROD

FLOATING-TYPE PISTON

The connecting rod (Fig. 1) is forged to an "I" section with an open or saddle type contour at the upper end and a bearing cap at the lower end. The bearing cap and connecting rod are forged in one piece and bored prior to separation.

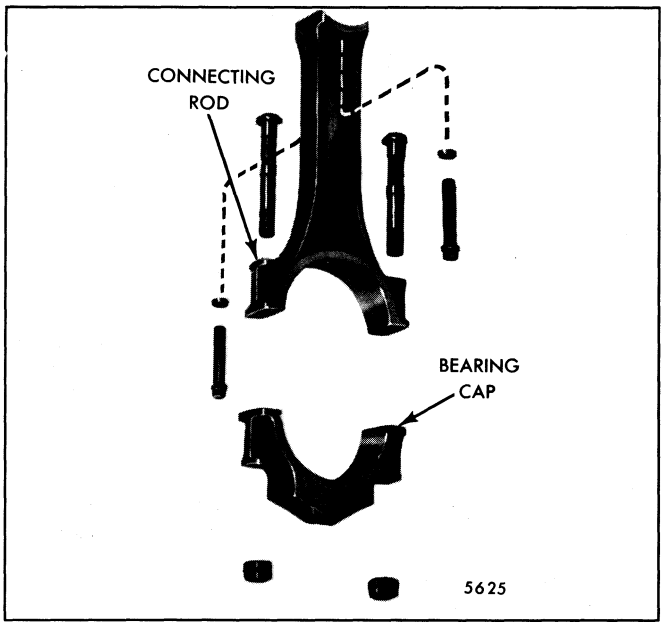


Fig. 1 - Connecting Rod Details and Relative Location of Parts

The upper end of the connecting rod is machined to match the contour of the piston pin. The piston pin is secured to the connecting rod with two self-locking bolts and spacers. The lower bearing cap is secured to the connecting rod by two specially machined bolts and special heat treated nuts.

The current connecting rod (stamped with a letter "O" on the side at the crankshaft bearing end) has an increased radius of .003" to reduce stress between the piston pin and the saddle area of the connecting rod.

Lubricating oil is forced through a drilled oil passage in the connecting rod to the piston pin and the bushing, then out around the carrier and piston.

A service connecting rod includes the bearing cap and the attaching bolts and nuts.

The replaceable connecting rod bearing shells are covered in Section 1.6.2.

Disassemble Connecting Rod From Piston

With the rod and piston assembly removed from the engine, disassemble the piston and connecting rod as outlined in Section 1.6.

Inspection

Clean the connecting rod and piston pin with fuel oil and dry them with compressed air. Blow compressed air through the oil passage in the connecting rod to be sure it is clear of obstructions.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Check the connecting rod for cracks (Fig. 2) by the magnetic particle method outlined in Section 1.3 under *Crankshaft Inspection.*

If a new service connecting rod is required, stamp the cylinder number on the connecting rod and cap (refer to Section 1.6.3).

Clean the rust preventive from a service replacement connecting rod and blow compressed air through the drilled oil passage to be sure it is clear of obstructions. Also make sure the split line (cap to rod) is thoroughly cleaned to avoid trapped contaminants from adversely affecting bearing shell "crush".

Inspect the piston pin for signs of fretting. When reusing a piston pin, the highly polished and lapped surface of the pin must not in any way be refinished. Polishing or refinishing the piston pin is not recommended as it could result in very rapid bushing wear.

The current piston pin has a thicker wall and requires 1/4" longer pin bolts. When replacing a former piston pin with the current pin, include two l/2"-20 x 2" pin bolts. The former and current piston pins can be mixed in an engine. However, it is recommended that all current pins be installed at time of overhaul on early engines.

Assemble Connecting Rod To Piston

Apply glean engine oil to the piston pin, bushing, thrust plate and carrier and assemble the connecting rod and piston as follows:

1. Position a new bushing in the carrier and lock it in place by bending the tangs on the bushing into slots in the carrier (Fig. 3).

2. Place the piston pin in the carrier.

• 3. Apply a small amount of International Compound No. 2, or equivalent, to the connecting rod-to-piston pin bolt threads and the underside of the bolt heads. *Detroit Diesel does not recommend reuse of piston pin bolts. Use new bolts.*

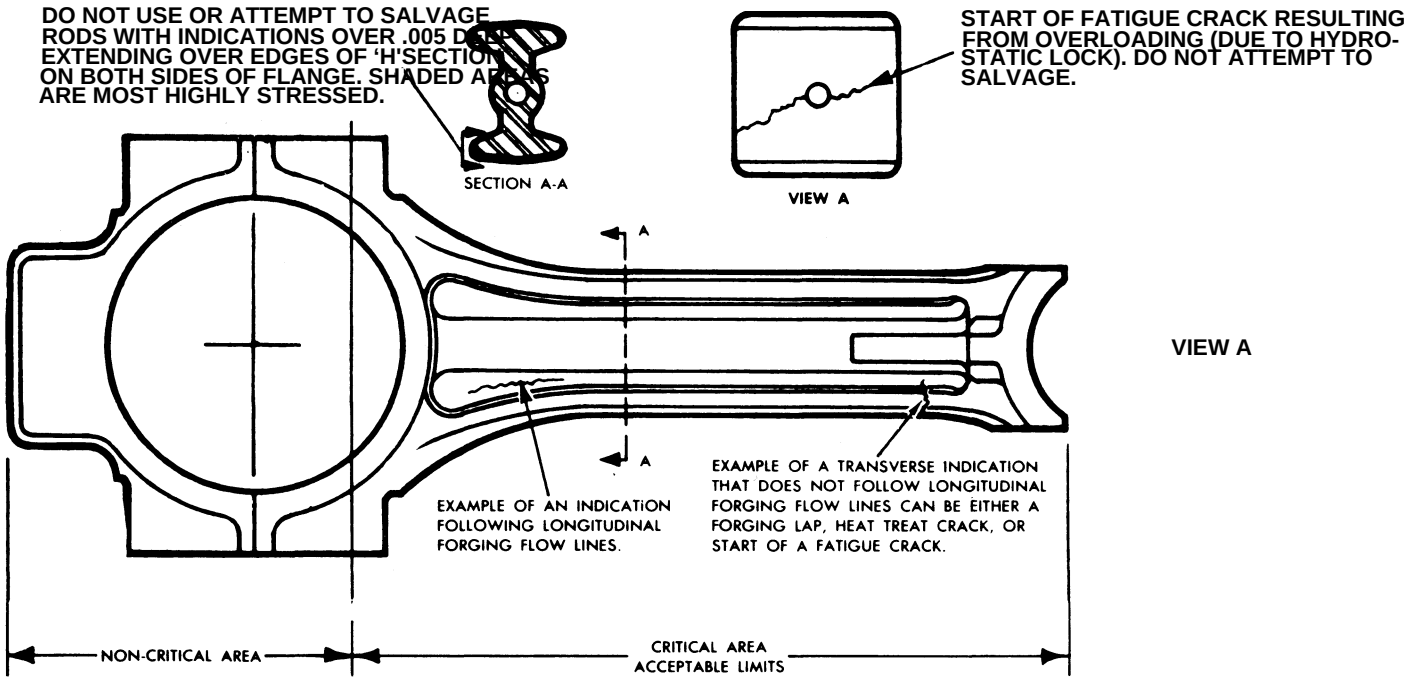


Fig. 2 - Magnetic Particle Inspection Limits for Connecting Rod

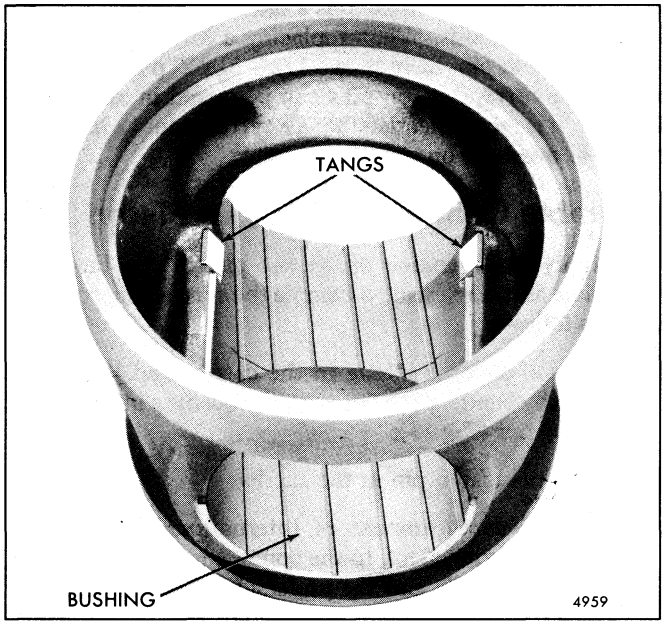


Fig. 3 - Piston Carrier and Bushing

4. Attach the connecting rod to the piston pin, using two spacers and two l/2”-20 self-locking bolts. Tighten the bolts to 90-100 lb—ft (122-136 N«m) torque.

   NOTICE: Use care when installing the self-locking bolts so that the socket does not bind against the side of the connecting rod, causing the bolts to bend. Do not over-torque.

5. Install the thrust plate in the piston and on the dowel pins, with the side stamped **Piston Side** toward the top of the piston.

6. Slide the carrier assembly into the piston. Secure the carrier in place with a snap ring. Check the snap ring-to-carrier clearance. The specified clearance is .003” to .013”.

7. Install the piston rings on the piston as outlined in Section 1.6.

8. Install the piston and connecting rod assembly in the engine as outlined in Section 1.6.3.

 © Detroit Diesel Corporation

CROSS-HEAD PISTON

The connecting rod (Fig. 1) used with the cross-head piston (Section 1.6) is similar to the connecting rod used with the floating-skirt piston, but is .401" shorter.

The upper end of the connecting rod is machined to match the contour of the piston pin. The piston pin is secured to the connecting rod with two self-locking bolts and spacers. The lower bearing cap is secured to the connecting rod by two specially machined bolts and special heat treated nuts.

Lubricating oil is forced through a drilled oil passage in the connecting rod to the piston pin and bushing.

A service connecting rod includes the bearing cap and the attaching bolts and nuts.

The replaceable connecting rod bearing shells are covered in Section 1.6.2.

Disassemble Connecting Rod From Piston

With the rod and piston assembly removed from the engine, disassemble the piston and connecting rod as outlined in Section 1.6.

Inspection

Clean the connecting rod and piston pin with fuel oil and dry them with compressed air. Blow compressed air through the oil passage in the connecting rod to be sure it is clear of obstructions.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Use crocus cloth, wet with fuel oil, to remove any trace of fretting and/or corrosion on the connecting rod saddle and piston pin contact surface before reassembly. Never use crocus cloth on the bushing (bearing) side of the piston pin.

Connecting rods being removed from an original engine can be reused as is, after considering the following:

1. Check for visual damage (bent).
2. A previous bearing(s) or related failure.
3. Is the connecting rod blue at the top or bottom end?
4. Fretting at split line between the connecting rod and cap.
5. Excessive pound-in of the bolt head or nut.

If the connecting rod has been subjected to any of the above, scrap the rod.

In qualifying a used connecting rod from a source other than the original engine, the following checks should be made in addition to the above.

1. Check for cracks (Fig. 4) by the magnetic particle method outlined in Section 1.3 under *Crankshaft Inspection.*

2. Determine average bore diameter of the rod, using a dial bore gage and master ring as follows (Fig. 5).

   a. Install the connecting rod cap on the connecting rod and tighten the bolt nuts to 60-70 lb—ft (81-95 N*m) torque.

   NOTICE: Do not over torque the connecting rod bolt nuts. Over torque may permanently distort the connecting rod cap.

   b. Measure diameter A and B (Fig. 5).

   c. Obtain average of A and B to obtain size at split line.

   $$\frac{A + B}{2} = X \text{ average of } A + B$$

   d. Measure C. The difference in the results of the measurements X and C gives average bore out-of-round and can be .0005" maximum.

   e. Add C with X and average to obtain average bore size.

   $$\frac{C+X}{2} = \text{average diameter of bore}$$

   which must be within 4.1860" to 4.1880".

   NOTICE: If the crosshead connecting rod bore is not to specifications, the rod must be scrapped and cannot be machined.

3. Determine taper as follows (Fig. 5):

   a. Substract D1 from D2 to find the difference.

   b. The difference can be .0005" maximum.

• 4. Determine length by finding the distance between El and E2 (Fig. 5). The length of the rod can be measured on connecting rod measurement fixtures marketed by: Sergent Industries, 6300 Stapleton South Drive, Denver, CO 80216.

Specifications: 11.500" to 11.504".

If a new service connecting rod is required, stamp the cylinder number on the connecting rod and cap (refer to Section 1.6.3).

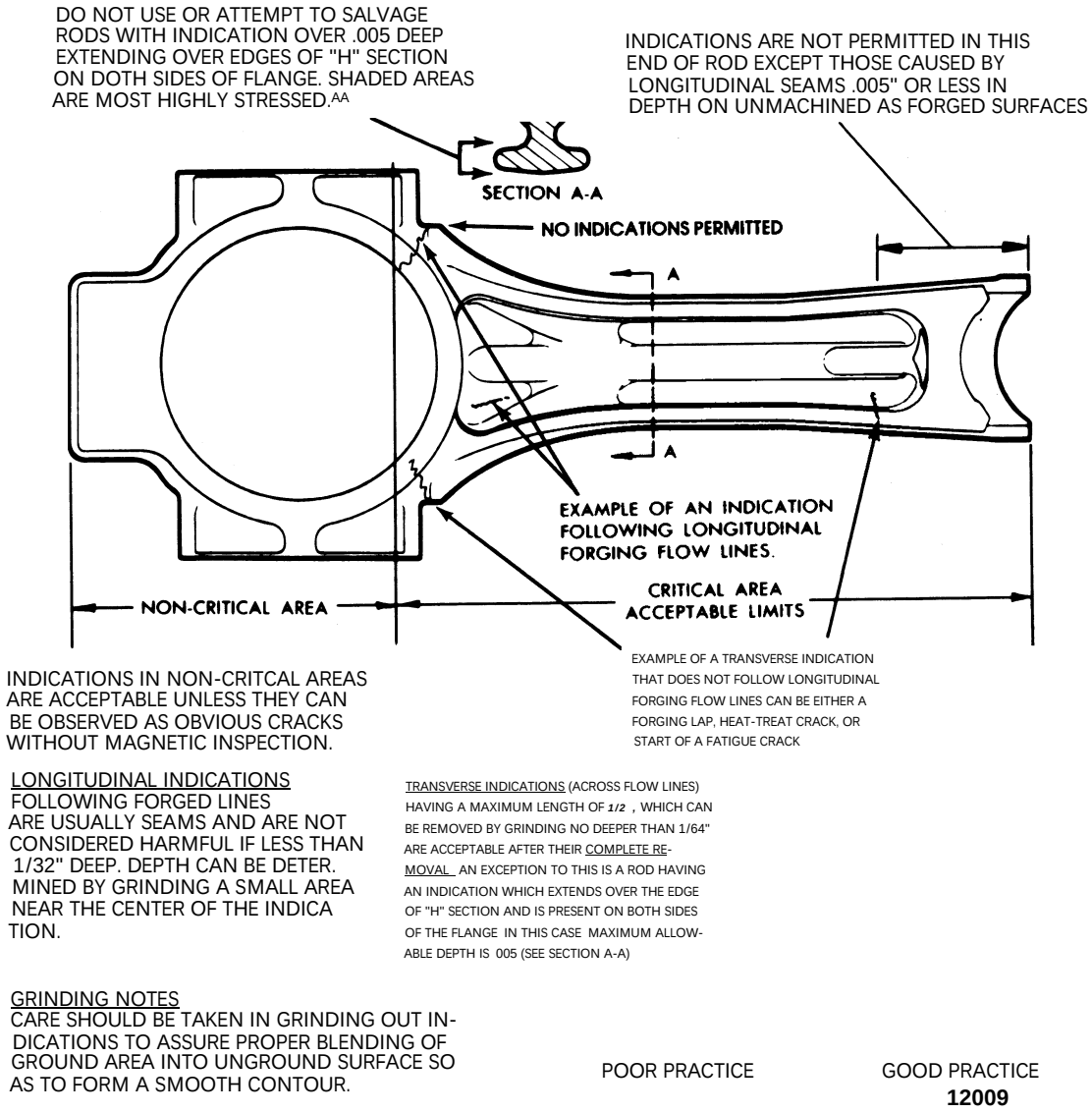


Fig. 4 - Magnetic Particle Inspection Limits for Connecting Rod

Clean the rust preventive from a service replacement connecting rod using fuel oil or a mineral spirits based solvent and blow compressed air through the drilled oil passage to be sure it is clear of obstructions. Also, make sure the split line (cap to rod) is thoroughly cleaned to avoid trapped contaminants from adversely affecting bearing shell “crush”.

Inspect the bushing (bearing) for indications of scoring, overheating or other damage. Measure the thickness of the bushing along the center. Replace the bushing if it is damaged or worn to a thickness of .0860” or less. A new bushing is .0870” to .0880” thick.

Inspect the piston , pin for signs of fretting. When reusing a piston pin, the highly polished and lapped surface of the pin must not in any way be refinished. Polishing or refinishing the piston pin is not recommended as it could result in very rapid bushing wear. A new piston pin has a diameter of 2.3873” to 2.3877”.

Assemble Connecting Rod To Piston

Refer to *Assemble Piston* in Section 1.6 for assembly of the connecting rod to the piston.

 © Detroit Diesel Corporation

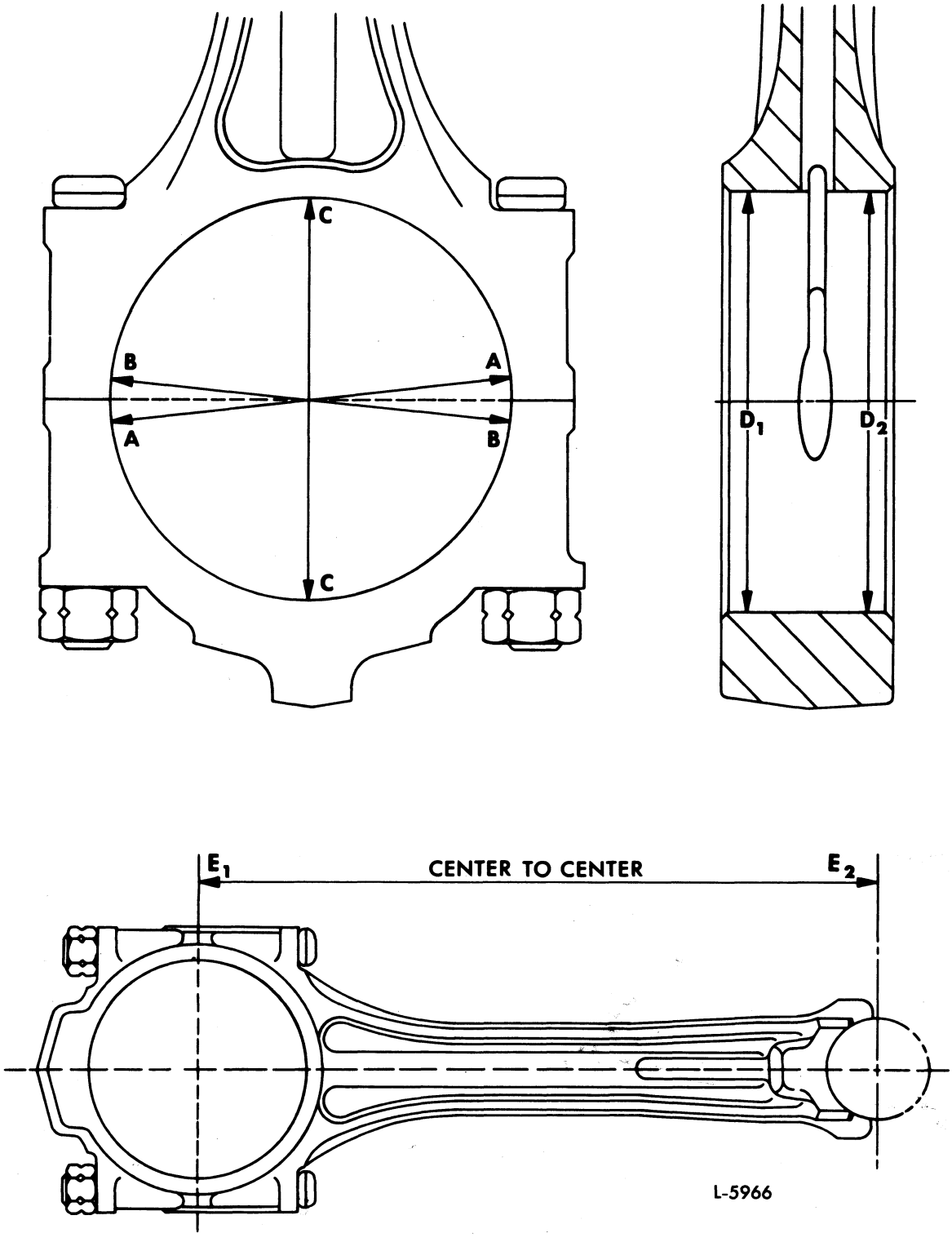


Fig. 5 - Dimensional Inspection of Cross-Head Piston Connecting Rods

CONNECTING ROD BEARINGS

The connecting rod bearing shells are precision made and are replaceable without shim adjustments (Fig. 1). They consist of an upper bearing shell seated in the connecting rod and a lower bearing shell seated in the connecting rod cap. The upper and lower bearing shells are located in the connecting rod by a tang at the parting line at one end of each bearing shell.

The upper and lower connecting rod bearing shells are different and are not interchangeable. The upper bearing shell is notched midway between the bearing edges for approximately 3/8 of an inch in from each parting line. In addition, the lower bearing shell has a circumferential oil groove that terminates at the ends of the bearing. The notches maintain registry with the oil hole in the crankshaft connecting rod journal, thereby providing a constant supply of lubricating oil to the connecting rod bearings and to the piston pin.

Remove Bearing Shells

The connecting rod bearing caps are numbered 1L, 1R, 2L, 2R, etc., with matching numbers and letters stamped on the connecting rods. When removed, each bearing cap and the bearing shells must always be reinstalled on the original connecting rod.

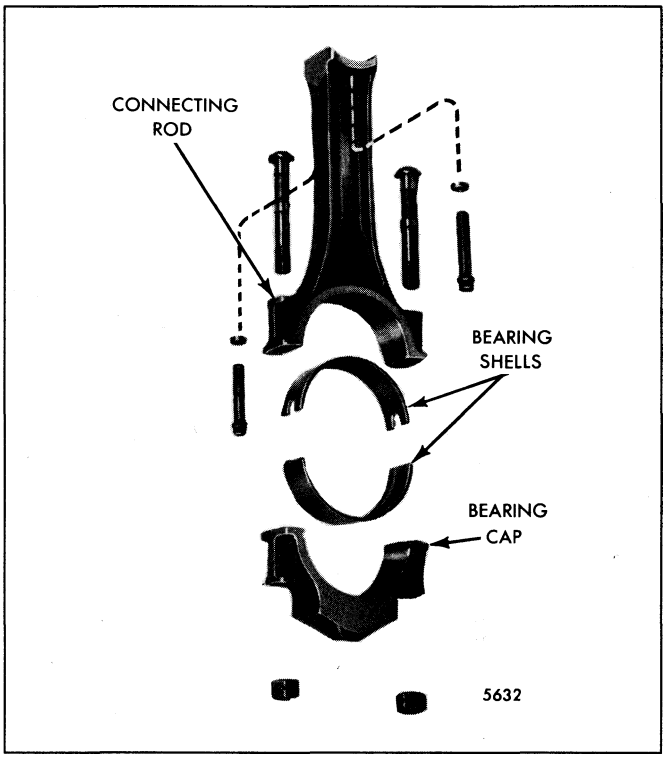


Fig. 1 - Connecting Rod and Bearing Shells

Remove the connecting rod bearings as follows:

1. Drain the oil and remove the lower oil pan and intermediate oil pan cover plates (Section 4.7).
2. Disconnect and remove the lubricating oil pump inlet pipe and screen assembly. Remove the oil pump as outlined in Section 4.1.
3. Remove one connecting rod bearing cap. Push the connecting rod and piston assembly up into the cylinder liner far enough to permit removal of the upper bearing shell. Do not pound on the edge of the bearing shell with a sharp tool.
4. Inspect the upper and lower bearing shells as outlined under *Inspection.*
5. Install the bearing shells and bearing cap before another connecting rod bearing cap is removed.

Inspection

Bearing failures may result from deterioration (acid formation) or contamination of the oil or loss of oil. An analysis of the lubricating oil may be required to determine if corrosive acid and sulphur are present which cause acid etching, flaking and pitting. Bearing seizure may be due to low oil or no oil.

After removal, clean the bearings and inspect them for scoring, pitting, flaking, chipping or signs of overheating.

If any of these defects are present, the bearings must be discarded. The upper bearing shells, which carry the load, will normally show signs of distress before the lower bearing shells do.

Inspect the backs of the bearing shells for bright spots which indicate they have been shifting in their supports.

If such spots are present, discard the bearing shells. Also inspect the connecting rod bearing bores for burrs, foreign particles, etc.

Bearing Size	*New Bearing Thickness	Minimum (Worn) Thickness
Standard	.15507.1555"	.1544"
.002" Undersize	15607.1565"	.1554"
.010" Undersize	.1600"/.! 605"	.1594"
.020" Undersize	.16507.1655"	.1644"
.030" Undersize	.17007.1705"	.1694"

'Thickness 90° from parting line of bearing.

TABLE 1

Measure the thickness of the bearing shells, using a micrometer and ball attachment J 4757, as described under *Inspection* in Section 1.3.4. The minimum thickness of a worn standard connecting rod bearing shell should not be less than. 1544" and, if either bearing shell is thinner than this dimension, replace both bearing shells. A new standard bearing shell has a thickness of .1550" to .1555". Refer to Table 1.

In addition to the thickness measurement, check the clearance between the connecting rod bearing shells and the crankshaft journal. This clearance may be checked by means of a soft plastic measuring strip which is squeezed between the journal and the bearing (refer to *Shop Notes* in Section 1.0). The maximum connecting rod bearing-to-joumal clearance with used parts is .0055".

Before installing the bearings, inspect the crankshaft journals (refer to *Inspection* in Section 1.3).

Do not replace one connecting rod bearing shell alone. If one bearing shell requires replacement, install both new upper and lower bearing shells. Also, if a new or reground crankshaft is to be used, install all new bearing shells.

Inspect the crankshaft journals, as outlined in Section 1.3, for wear before replacement bearings are installed.

Bearing shells are available in .002", .010", .020" and .030" undersize for service with reground crankshafts. To determine the size bearings required, refer to *Crankshaft Grinding* in Section 1.3. Undersize bearings (.002") are available to compensate for slight journal wear where it is unnecessary to regrind the crankshaft.

NOTICE: Bearing shells are NOT reworkable from one undersize to another under any circumstances.

Install Connecting Rod Bearing Shells

With the crankshaft and the piston and connecting rod assembly in place, install the connecting rod bearings as follows:

1. Rotate the crankshaft until the connecting rod journal is at the bottom of its travel, then wipe the journal clean and lubricate it with clean engine oil.
2. Install the upper bearing shell — the one *without* the continuous oil groove — in the connecting rod. Be sure the tang on the bearing shell fits in the groove in the connecting rod.
3. Pull the piston and rod assembly down until the upper rod bearing seats firmly on the crankshaft journal.
4. Note the number and letter stamped on the connecting rod and the bearing cap and install the lower bearing shell — the one with the continuous oil groove — in the bearing cap, with the tang on the bearing shell in the groove in the bearing cap.
- 5. Install the bearing and cap. When using new connecting rod bolts and nuts, make sure the protective rust preventive is removed before installing. Apply International Compound No. 2, or equivalent, to the bolt threads and the bearing cap and nut joint. Tighten the connecting rod cap bolt nuts as follows:
   - a. *When working through the sub-oil pan access hole,* tighten nuts to 130 - 140 lb—ft (177 - 190 N«m) torque.
   - b. *When sub-oil pan is removed and there is clear access to all connecting rods,* tighten nuts to 45 - 55 lb—ft (61 - 74 N*m) torque. Then rotate nuts and additional 130 - 150 degrees. This latter method provides more uniform clamp load.

   - **NOTICE:** Make sure the connecting rod bolt has not turned in the connecting rod before torque is applied to the nut. Failure to observe this precaution can result in serious engine damage.
6. Install the oil pump as outlined in Section 4.1. Install the lubricating oil pump inlet pipe and screen assembly.
7. Install the intermediate oil pan cover plates and install the lower oil pan (Section 4.7).
8. Refer to the *Lubrication Specifications* in Section 13.3 and fill the crankcase to the proper level on the dipstick.

If new bearings were installed, operate the engine on the *run-in* schedule rs outlined in Section 13.2.1.

 © Detroit Diesel Corporation

CYLINDER LINER

The cylinder liner is of the replaceable wet type, made of hardened alloy cast iron, and is a slip fit in the cylinder block (Fig. 1). The liner is inserted in the cylinder bore from the top of the cylinder block. The flange at the top of the liner rests on a counterbore in the top of the block.

Synthetic rubber seal rings, recessed in the cylinder block bore, are used between the liner and the block to prevent water leakage.

The upper half of the liner is directly cooled by water surrounding the liner. At the air inlet ports, the liner is cooled by the air introduced into the cylinder through equally spaced oval-shaped ports around the liner. The lower half of the liner is cooled by water inside the cylinder block water jacket surrounding the liner.

The air inlet ports in the liner are machined at an angle to create a uniform swirling motion to the air as it enters the cylinder. This motion persists throughout the compression stroke and facilitates scavenging and combustion.

The wear on a liner and piston is directly related to the amount of abrasive dust and dirt introduced into the engine combustion chamber through the air intake. This dust, combined with lubricating oil on the cylinder wall, forms a lapping compound and will result in rapid wear. Therefore, to avoid pulling contaminated air into the cylinder, the air cleaner must be serviced regularly according to the surroundings in which the engine is operating.

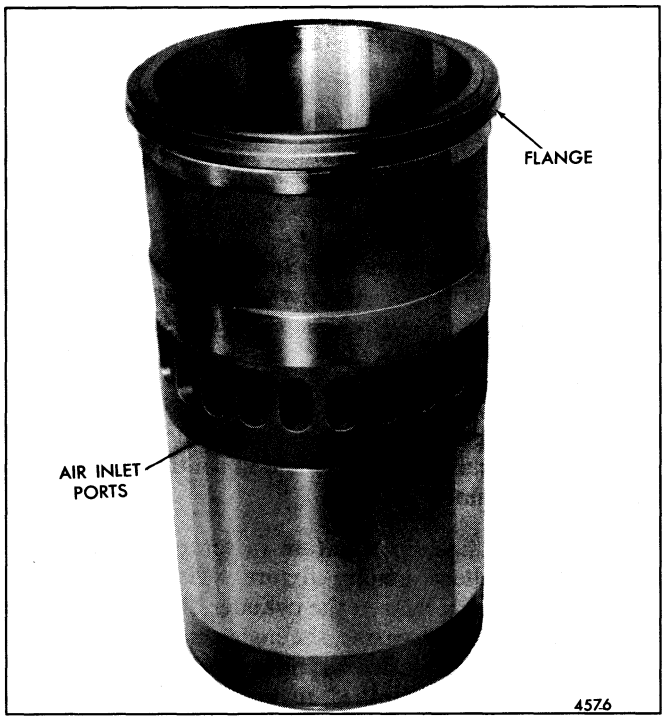


Fig. 1 - Cylinder Liner

Remove Cylinder Liner

It is very important that the proper method is followed when removing a cylinder liner. *Do not* attempt to push the liner out by inserting a bar in the liner ports and rotating the crankshaft, otherwise the piston may be damaged or the upper piston ring groove may collapse.

To remove a cylinder liner, refer to Fig. 2 and, proceed as follows:

1. Remove the piston and connecting rod assembly, as outlined in Section 1.6.
2. Remove the cylinder liner with tool set **J** 22431, as follows:
   a. Ease the lower shoe and bolt assembly down into the liner. Place the shoe on the bottom edge of the liner with the flat on the shoe parallel with the crankshaft bore.
   b. Hold the lower shoe and bolt assembly in the pulling position. Place the upper shoe with the flat in the same position as the lower shoe over the threaded end of the bolt. Thread the nut down on the bolt assembly and be sure that the pilots on both of the shoes are seated properly.
   c. Place the bridge assembly (open end down) over the upper shoe and down against the block.

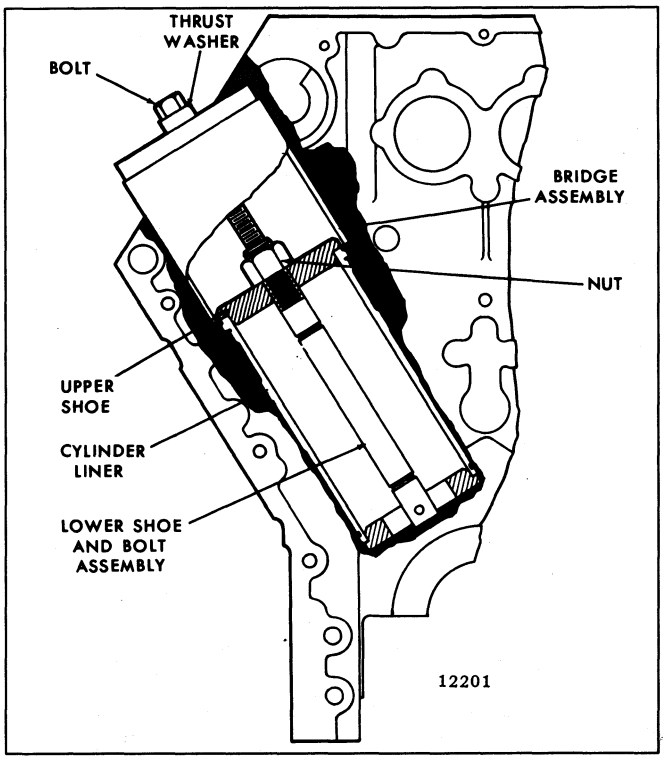


Fig. 2 – Removing Cylinder Liner

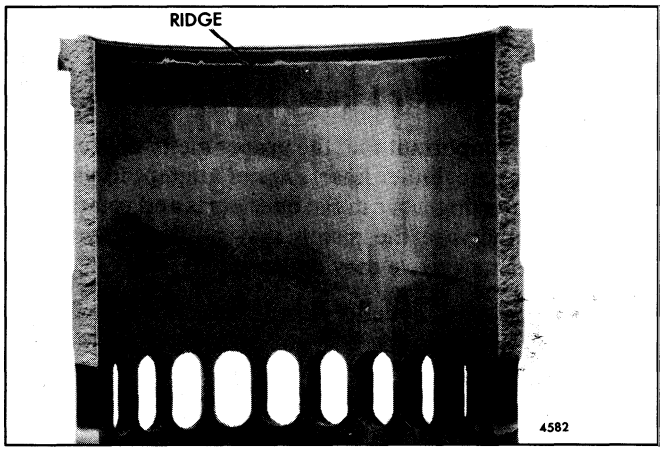


Fig. 3 - Cylinder Liner Ridge Due to Wear

d. With the thrust bearing on the bolt, install the bolt through the bridge assembly strap hole.

e. Thread the bolt into the female threaded portion of the bolt assembly.

f. Turn the bolt in a clockwise direction and withdraw the liner from the block. Then, remove the tool from the liner.

g. Remove and discard both cylinder liner seal rings from the grooves in the cylinder block bore.

NOTICE: After removing liners from an engine and prior to installing liners, always store them in an upright position until ready for use. Liners left on their side for any length of time can become egg-shaped and distorted, making installation in cylinder bores difficult or impossible.

If tool set J 22431-A is unavailable, tap the liner out with a hardwood block and hammer.

Inspect Cylinder Liner

When the cylinder liner is removed from the cylinder block, it must be thoroughly cleaned and then checked for:

1. Cracks
2. Scoring
3. Poor contact on outer surface
4. Flange irregularities
5. Inside diameter
6. Outside diameter
7. Out-of-round
8. Taper

A cracked or excessively scored liner must be discarded. A slightly scored liner may be cleaned-up and reused.

When removing the preservative from new liners, do not steam-clean. Instead, stand the liners upright in a metal basket and immerse in a suitable cold tank containing pure mineral spirits or fuel oil. Steam cleaning may cause internal engine parts to water spot and corrode. Placing liners on their sides for cleaning can lead to liner distortion.

Excessive liner-to-block clearance or block bore distortion will reduce heat transfer from the liner to the block and to the engine coolant.

Examine the outside diameter of the liner for fretting below the ports. Fretting is the result of a slight movement of the liner in the block bore during engine operation, which causes material from the block to adhere to the liner. These metal particles may be removed from the surface of the liner with a coarse, flat stone.

Measure the block bore as outlined in Section 1.1. Then, measure the outside diameter of the cylinder liner. To provide effective heat transfer and sealing, it is desirable to maintain the liner-to-block clearance close to the inimum specified (refer to Specifications in Section 1.0). If required, a cylinder liner which is .002” oversize on the outside diameter is available for service.

If an oversize (outside diameter) cylinder liner is used, stamp the amount of oversize on the cylinder block adjacent to the block bore.

A used cylinder liner must be honed for the following reasons:

NOTICE: Do not modify the surface finish in a new sepdcfe cylinder liner. Since the liner is properly finished at the factory, any change will advepely Afect seating of the piston rings.

1. To break-the glaze which results due to the rubbing action of the piston rings after long periods of operation. Unless this glaze is removed, the time required to seat new piston rings will be lengthened.

2. To remove the ridge formed at the top by the piston ring travel (Fig. 3). Otherwise, interference with the travel of the new compression rings may result in ring breakage.

Therefore, even though the taper and out-of-round are within the specified limits, the glaze and ridge must be removed by working a hone up and down the full length of the liner a few times.

Place the liner in a fixture (a scrap cylinder block makes an excellent honing fixture). However, if it is necessary to hone a liner in the cylinder block that is to be used in building up the engine, the engine must be dismantled and then, after honing, the cylinder block and other parts must be thoroughly cleaned to ensure that all abrasive material is removed.

 © Detroit Diesel Corporation

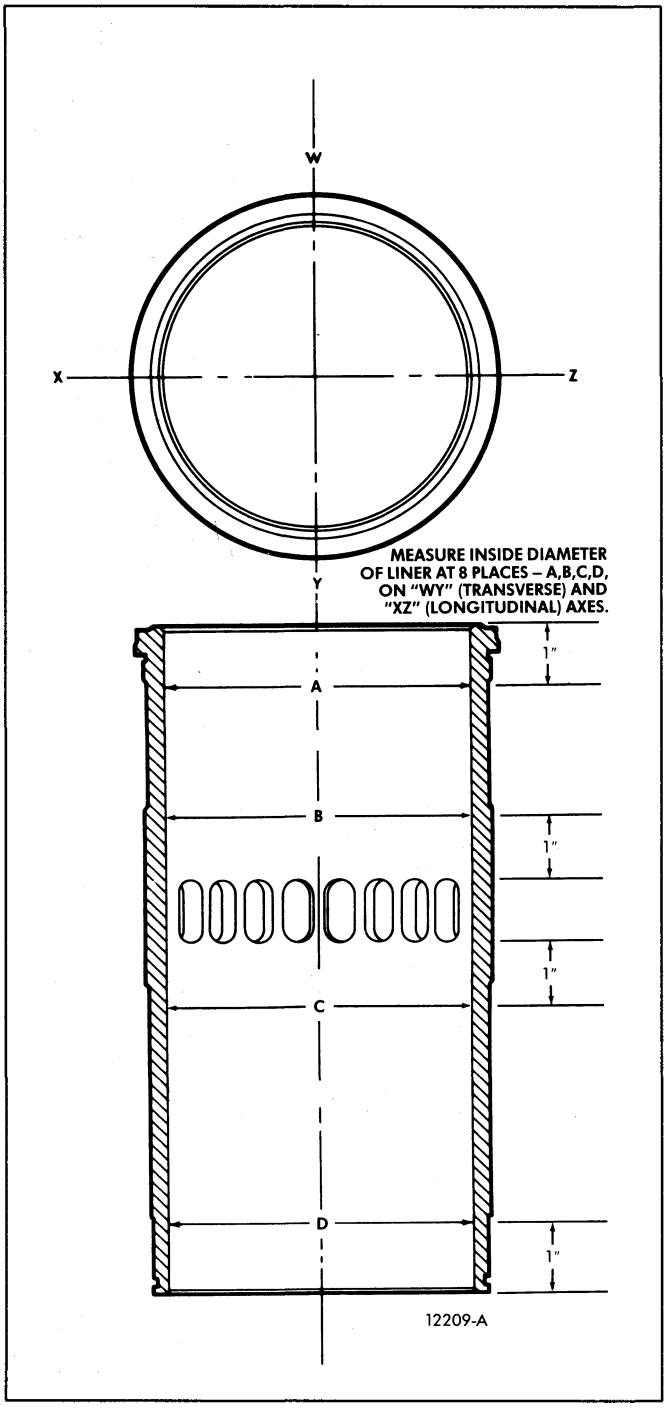


Fig. 4 – Cylinder Liner Measurement Diagram

The hone J 5902-01, equipped with 80 grit stones J 5902-13, should be worked up and down *(it* 300-400 rpm) the full length of the liner a few times in a criss-cross pattern that produces hone marks on a 45° axis.

After the liner has been honed, remove it from the fixture and clean it thoroughly. Then, dry it with compressed air and check the entire surface for burrs.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 Kps) air pressure.

After honing, the liner must conform to the same limits on taper and out-of-round as a new liner and the piston-to-liner clearance must be within the specified limits (Section 1.0).

Install the liner (new or used) in the proper bore of the cylinder block and measure the inside diameter at the various points (Fig. 4). When installing a new cylinder liner, select one which is as close to the minimum specified liner-to-block clearance (Section 1.1) as possible. The inside diameter of a new service cylinder liner is 5.7488”-5.7513”. Use cylinder bore gage J 5347-01, which has a dial indicator calibrated in .000T’ increments. Set the cylinder bore gage on zero in master ring gage J 22613. Also, check the liner for taper and out-of-round. Master ring gage J 22613 must be at the same temperature as the liner.

• **NOTICE:** To insure accuracy when measuring a cylinder liner, measurements must be taken with the liner at temperatures between 65 - 75° F (18.3-23.9° C)).

The piston-liner clearance must be within the specified limits (Section 1.0). Also, the taper and the out-of-round must not exceed .002” on a used liner. The taper and out-of-round must not exceed .001” on a new liner.

Fitting Cylinder Liner In Block Bore

1. Wipe the inside and outside of the liner clean and make sure the block bore is clean.
2. Check for and remove any burrs on the cylinder liner or in the cylinder bore.
3. Push or tap the cylinder liner in the cylinder block bore. Do not use excessive force to install the cylinder liner in the block bore.
4. On former counterbored cylinder blocks (Section 1.1), measure the distance from the gasket seating surface of the liner flange to the water hole deck of the block with a dial indicator or depth micrometer. When in place, the top of the gasket seating surface must be .039” to .045” below the water hole deck surface of the block. This step is not required on current non-counterbored blocks.
5. Matchmark the liner and the cylinder block with a felt pen so the liner may be reinstalled in the same position in the same block bore. Place the matchmark on the side opposite the camshaft.
6. Remove the liner from the cylinder block.

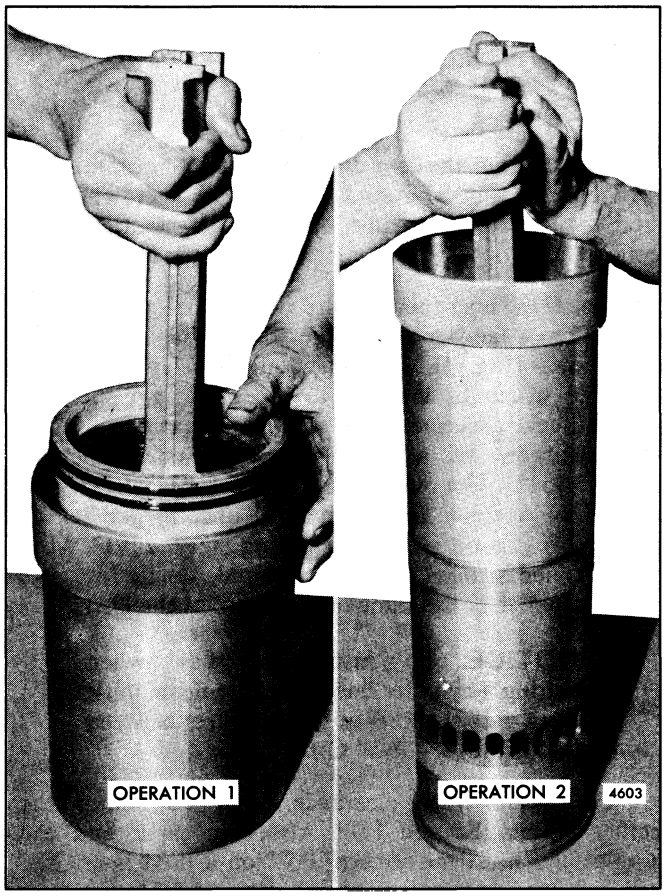


Fig. 5 - Installing Piston and Connecting Rod Assembly in Ring Compressor and Cylinder Liner

Install Piston And Connecting Rod Assembly

1. With the piston assembled to the connecting rod and the piston rings in place as outlined in Sections 1.6 and 1.6.1, apply clean engine oil to the piston, rings and the inside surface of the piston ring compressor J 22387.

   NOTICE: Inspect the ring compressor for nicks or burrs, especially at the non-tapered inside diameter end. Nicks or burrs on the inside diameter of the compressor will result in damage to the piston rings.

2. Place the piston ring compressor on a wood block, with the tapered end of the ring compressor facing up.

3. Position (stagger) the piston ring gaps properly on the piston. Make sure the ends of the oil control ring expanders are not overlapped.

4. Start the top of the piston straight into the ring 3. compressor. Then, push the piston down until it contacts the wood block ("Operation 1" of Fig. 5).

5. Note the position of the matchmark and place the liner, with the flange end down, on the wood block.

6. Place the ring compressor and the piston and connecting rod assembly on the liner so the numbers on the rod and cap are aligned with the matchmark on the liner ("Operation 2" of Fig. 5). The numbers on the side of the connecting rod and cap identify the rod with the cap and indicate the particular cylinder in which they are used. If a new service connecting rod is to be installed, the same identification numbers must be stamped in the same location as on the connecting rod that was replaced.

7. Push the piston and connecting rod assembly down into the liner until the piston is free of the ring compressor. Do not force the piston into the liner. The peripheral abutment type expanders apply considerable force on the oil ring. Therefore, extra care must be taken during the loading operation to prevent ring breakage.

8. Remove the connecting rod cap and the ring compressor. Then, push the piston down until the compression rings pass the cylinder liner ports.

Install Cylinder Liner, Piston And Connecting Rod Assembly

NOTICE: When installing a cylinder kit, which weighs over 80 pounds, it is very important that the cylinder liner contact area at the flange seating surface not be damaged in any way. Nicks or dents can lead to leaks between the liner flange and block bore and result in corrosion of the head bolts. Development of a major leak could result in hydrostatic lock. To avoid damage, do not allow a cylinder kit to rest on the seating surface of the block while completing installation in another cylinder.
Load and complete the installation for one cylinder at a time.

After the piston and connecting rod assembly have been installed in the cylinder liner, install the entire assembly in the engine, as follows:

1. Make sure the seal ring grooves in the cylinder block bore are elean. Then, install a new seal ring in each groove (Fig. 6). The current type seal rings tend to stiffen and shrink at temperatures below 40°F (4°C). Keep the seal rings at room temperature (approximately 70°F or 21°C) prior to installation.

2. Apply clean engine oil or an ethylene glycol base antifreeze to the inner surface of each seal ring.

   NOTICE: Do not use a methoxy propanol base antifreeze as it will damage the seal rings.

   If any of the pistons and liners are already in the engine, use hold-down clamps to retain the liners in place when the crankshaft is rotated.

 © Detroit Diesel Corporation

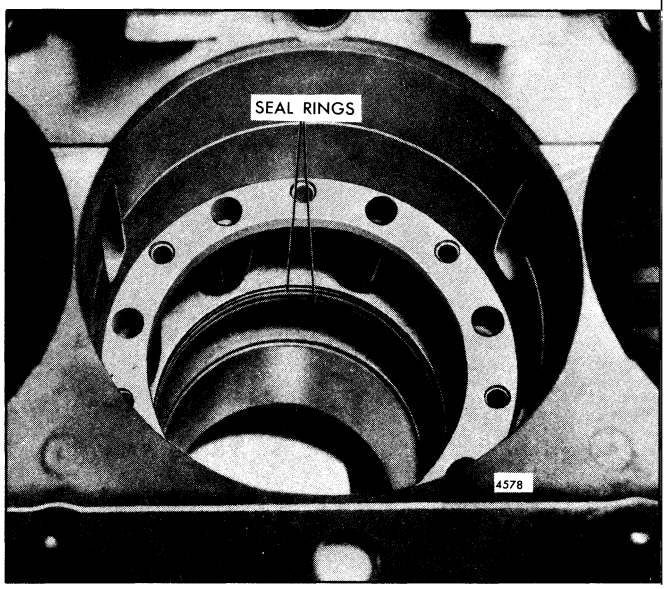


Fig. 6 - Location of Cylinder Block Bore Seal Rings

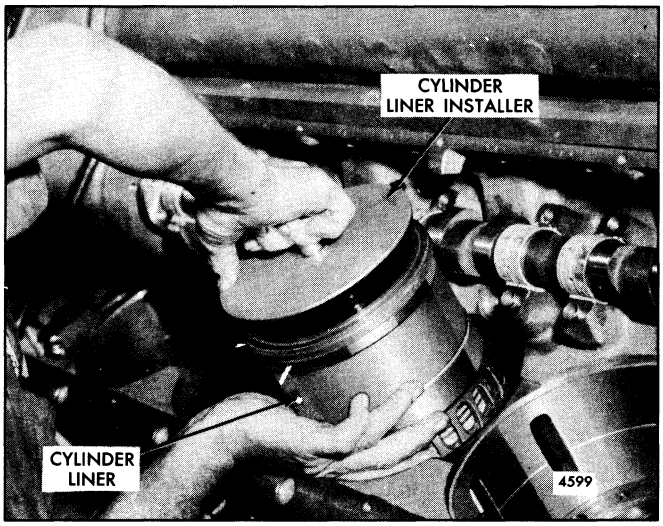


Fig. 7 - Installing Piston, Rod and Liner Assembly in Cylinder Block

4. Rotate the crankshaft with barring tool J 22582 until the connecting rod journal of the particular cylinder being worked on is at the bottom of its travel. Wipe the journal clean and lubricate it with clean engine oil.
5. Install the upper bearing shell—*the one without the continuous oil groove*—in the connecting rod. Lubricate the bearing shell with clean engine oil.
6. Use cylinder liner installer J 22641 and position the piston, rod and liner assembly in front of the cylinder block bore so that the identification number and letter on the connecting rod face the outer edge of the cylinder block and the matchmarks on the liner and the block are in alignment. Guide the end of the connecting rod through the block bore carefully to avoid damaging or dislodging the bearing shell. Then, slide the piston, rod and liner assembly straight into the block bore until the liner flange rests in the counterbore of the block (Fig. 7). Remove the air box covers to see if the seal rings were dislodged or damaged during liner installation. If the seal ring(s) were damaged, small cut pieces of the seal ring will be noticed.
7. Push or pull the piston and connecting rod into the liner until the upper bearing shell is firmly seated on the crankshaft journal. The distance from the vertical center line of the connecting rod bolts to the edges of the rod are not equal. Therefore, when installing the piston and connecting rod assembly, be sure that the narrow side of the two connecting rods on the crankshaft journal are together to avoid cocking of the rod.
8. Place the lower bearing shell — *the one with the continuous oil groove from one parting line to the other*— in the connecting rod cap, with the tang on the bearing shell in the notch in the connecting rod bearing cap. Lubricate the bearing shell with clean engine oil.
- 9. Install the bearing cap and the bearing shell on the connecting rod with the identification numbers on the cap and the rod adjacent to each other. When using new connecting rod bolts and nuts, be sure to remove the protective rust preventive. Apply International Compound No. 2 or equivalent to the bolt threads and the bolt cap and nut joint. Tighten the connecting rod bolt nuts to 130-140 lb—ft (170-190 N#m) torque.

   NOTICE: Be sure the connecting rod bolt has not turned in he connecting rod before torque is applied to the nut.
10. Check the connecting rod side clearance. The clearance between each pair of connecting rods should be .018” to .026” with new parts.
11. Install the remaining liner, piston and rod assemblies in the same manner. Use hold-down clamps to hold each liner in place.
12. After all of the liners and pistons have been installed, remove the hold-down clamps.
13. Install new compression gaskets and water seals as outlined in Section 1.2. Then, install the cylinder heads and any other parts which were removed from the engine.
14. After the engine has been completely reassembled, refer to the *Lubrication Recommendations* in Section 13.3 and refill the crankcase to the proper level on the dipstick.
15. Close all of the drains and fill the cooling system.
16. If new parts such as pistons, rings, cylinder liners or bearings were installed, operate the engine on the *run-in* schedule given in Section 13.2.1.

ENGINE BALANCE AND BALANCE WEIGHTS

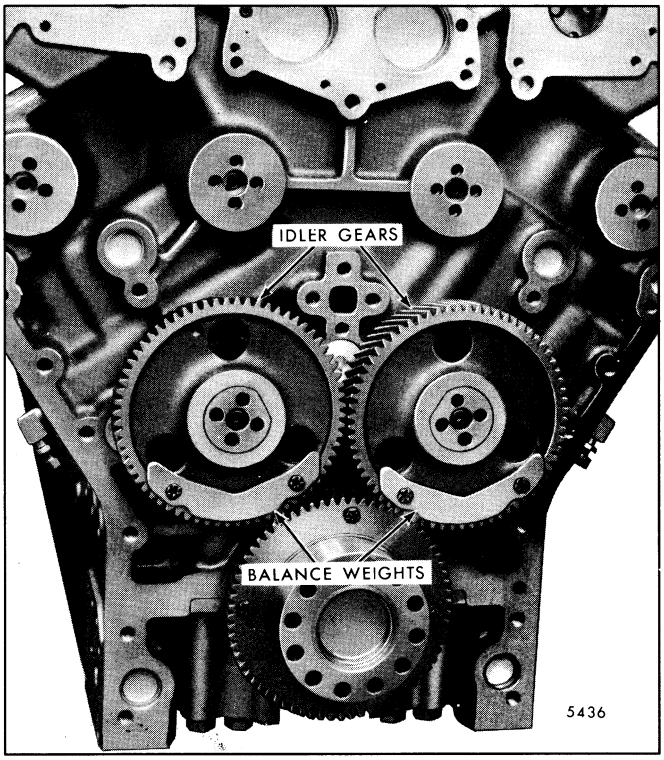
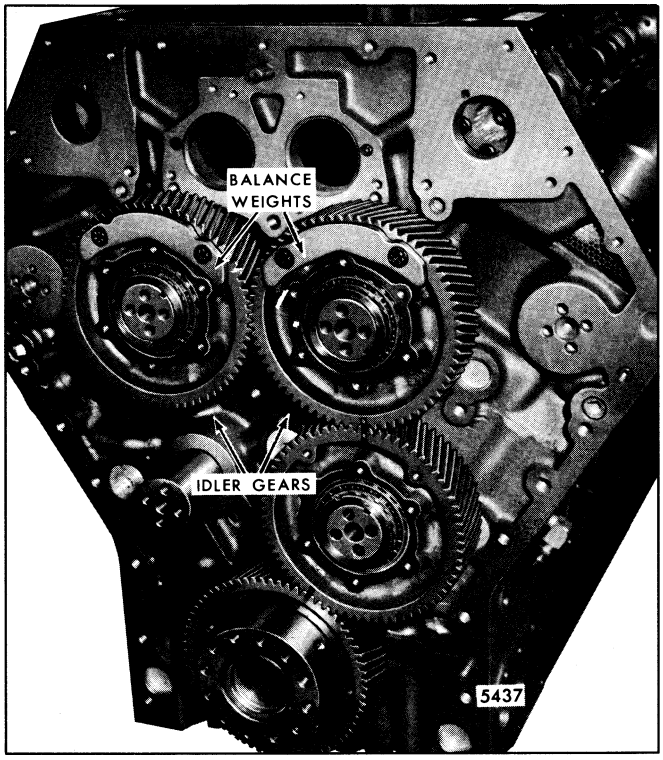


Fig. 1 - Typical Balance Weights on Front Idler Gears



Fig‘ 2 [11] Typical Balance Weights on Rear idler Gears

In the balance of the two-cycle engine, it is important to consider disturbances due to the reciprocating action of the piston masses. These disturbances are of two kinds: unbalanced forces and unbalanced couples. These forces and couples are considered as primary or secondary according to whether their frequency is equal to engine speed or twice engine speed. Although it is possible to have unbalanced forces or couples at frequencies higher than the second order, they are of small consequence in comparison to the primary forces and couples. Even the secondary forces and couples are usually of little practical significance.

The reciprocating masses (the piston and upper end of the rod) produce an unbalanced couple due to their arrangement on the crankshaft. This unbalanced couple tends to move the ends of the engine in an elliptical path. This couple is cancelled by incorporating an integral crankshaft balance component and by placing balance weights on each of the idler gears, front and rear (Figs. 1 and 2). This balance arrangement produces a couple that is equal and opposite in magnitude and direction to the primary couple.

On the idler gears, each set of bolt-on weights (weights on the outer ends of one cylinder bank comprise a set) rotate in an opposite direction with respect to the other. When the weights on either end of the engine are in a vertical plane, their centrifugal forces are in the same direction and oppose the primary couple. When they are in a horizontal plane, the centrifugal forces of these balance weights oppose each other and are, therefore, cancelled. The front balance weights act in a direction opposite to the rear balance weights; therefore, rotation will result in a couple effective only in a vertical plane. This couple, along with that built into the crankshaft, forms an elliptical couple which completely balances the primary couple.

Both the rotating and primary reciprocating forces and couples are completely balanced in the 149 engine. There are no secondary forces present. Consequently, the engine will operate smoothly and in balance throughout its entire speed range.

The bolt-on balance weights for 8V, 12V, and 16V engines are similar, except that the 8V and 12V engine weights are thicker and the bolt holes are counterbored (Fig. 2).

GEAR TRAIN AND ENGINE TIMING

GEAR TRAIN

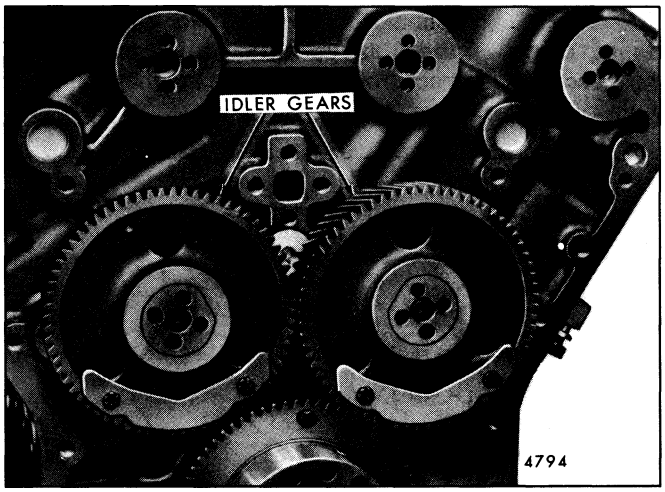


Fig. 1 - Typical Front Gear Train

The Series 149 engine utilizes two sets of gear trains - one on each end of the engine. The front gear train consists of a crankshaft gear and two idler gears (Fig. 1). One of the idler gears is used to drive the water pump. The rear gear train consists of a crankshaft gear, three idler gears and two camshaft gears (Fig. 2).

The crankshaft gear in the front gear train is bolted to a damper which is attached to the crankshaft front flange. The crankshaft gear in the rear gear train is bolted directly to the crankshaft rear flange. The idler gears, in both the front and rear gear trains, and the camshaft gears (in the rear gear train) are mounted on stationary hubs.

Since the camshafts must be in time with each other and the crankshaft, timing marks are stamped on the face of the gears to facilitate correct gear train timing. The timing marks stamped on the various gears are shown in Figs. 3, 4 and 5. When assembling the engine, it is important to line up the appropriate timing marks on the gears as each gear is installed on the engine.

The gear backlash between the various mating gears in the gear train should be .0015” to .008” with new parts and should not exceed .010” gear backlash between worn gears.

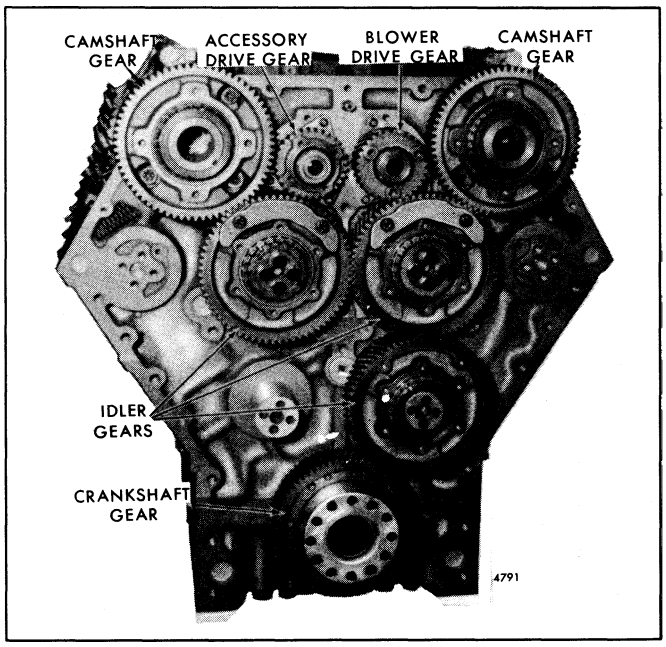


Fig. 2 - Typical Rear Gear Train

Gear train noise is usually an indication of excessive gear backlash, chipped, pitted or burred gear teeth or excessive bearing wear. Therefore, when noise develops in a gear train, the flywheel housing or front cover should be removed and the gear train and its bearings and bushings inspected. A rattling noise usually indicates excessive gear backlash, whereas a whining noise indicates too little gear backlash.

Lubrication

The gear train is lubricated by oil from the longitudinally drilled passages in the camshaft hubs, idler gear center retaining bolts and by oil splash from the oil pan. A certain $mount of oil also spills into the gear train compartment from the blower drive bearing and the idler gear bearings’! The idler gear bearings are lubricated by oil directly from the cylinder block oil gallery.

ENGINE TIMING

The correct relationship between the crankshaft and the two camshafts must be maintained to properly control fuel injection, the opening and closing of the exhaust valves and engine balance.

The crankshaft timing gears can be mounted in only one position since one attaching bolt hole is offset. Therefore, when the engine is properly timed, the timing marks on the various gears will match (Figs. 3,4 and 5). Early engines did not include a dot in the timing marks.

Special care should be exercised when aligning the timing marks of the front gear train idler gears as the difference in thickness of the two gears may give the appearance of misalignment.

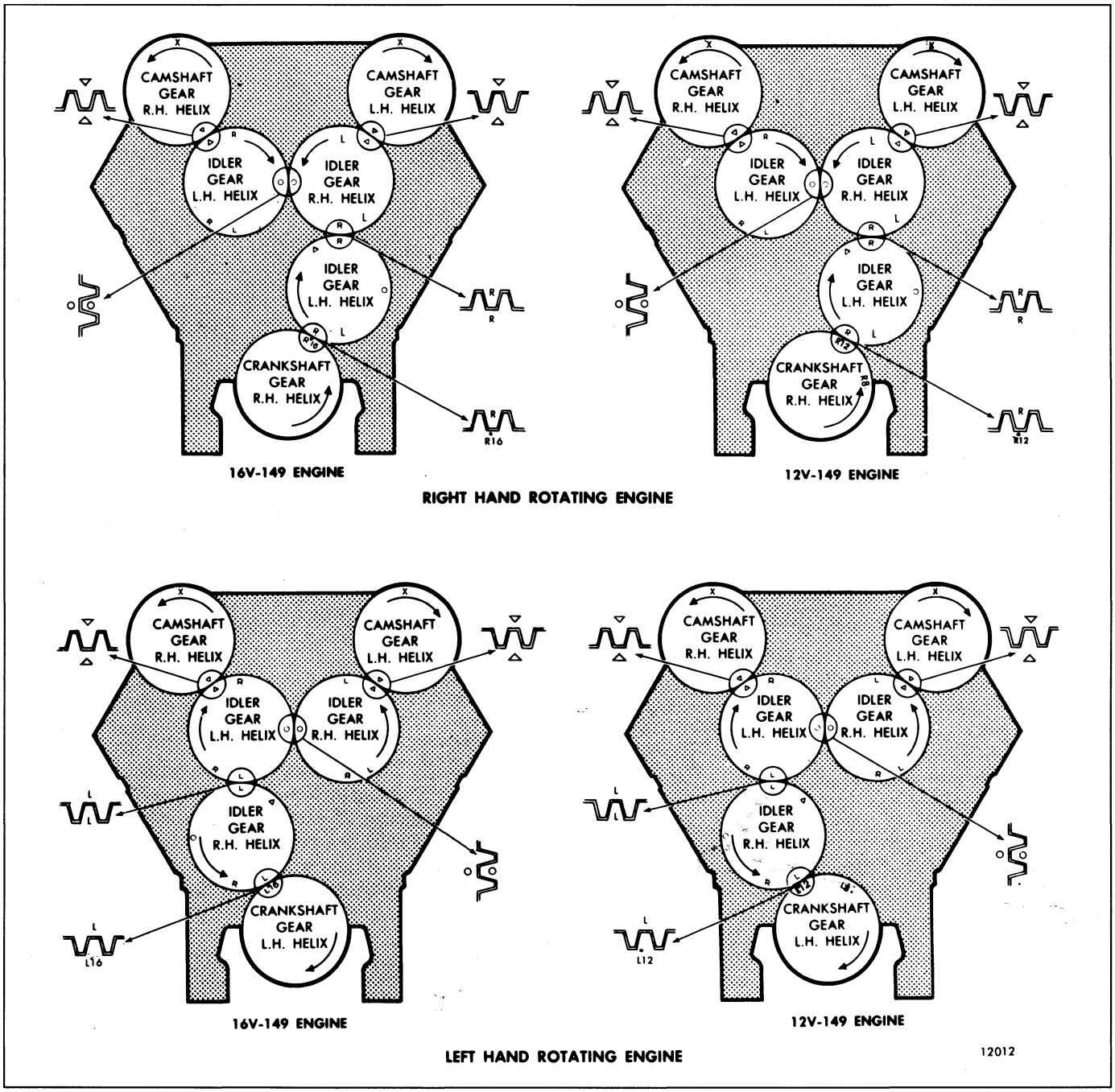
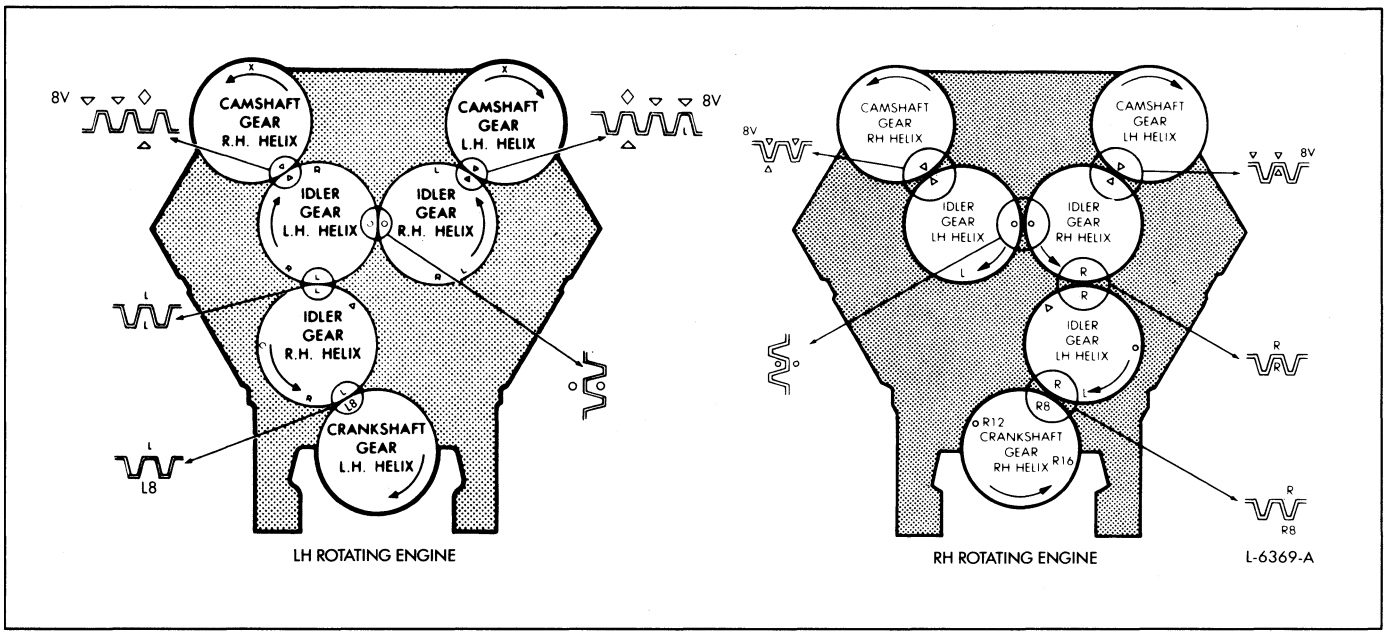


FIG. 3 – Rear Gear Train Timing Marks — 12V And 16V Engines

 © Detroit Diesel Corporation



• Fig. 4 – Rear Gear Train Timing Marks – 8V Engines

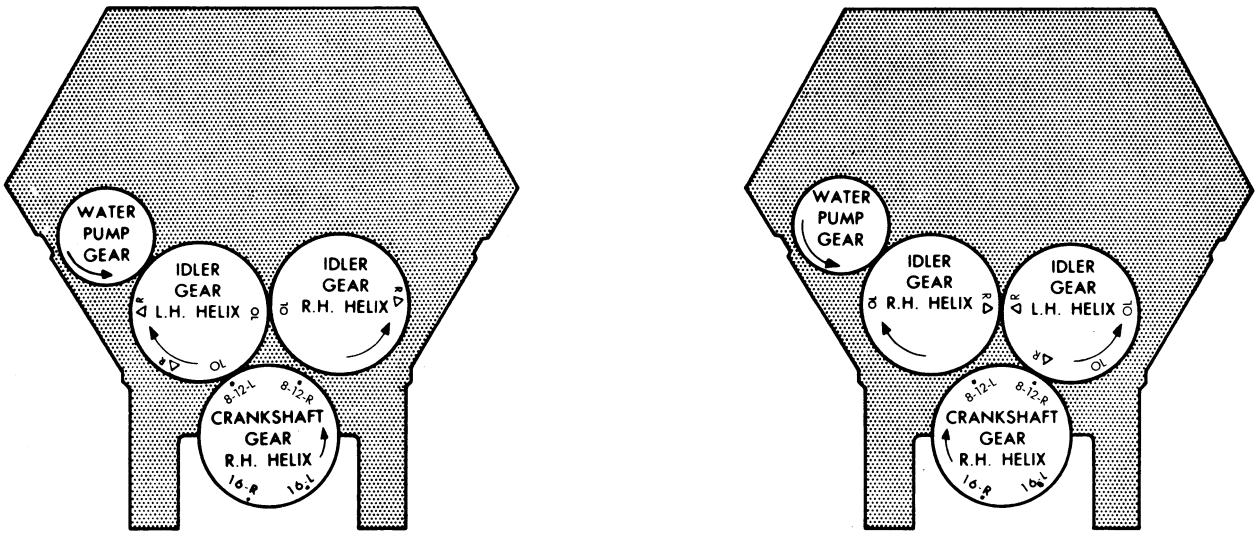
An engine which is *out of time* may result in preignition, uneven running and a loss of power.

When an engine is suspected of being out of time due to an improperly assembled gear train, a quick check can be made without having to remove the flywheel and flywheel housing by following the procedure outlined below.

Check Engine Timing

Access to the vibration damper or crankshaft pulley, to mark the top-dead-center position of the selected piston, and to the front end of the crankshaft (or to the flywheel), for turning the crankshaft, is necessary when performing the timing check. Then, proceed as follows:

1. Remove one valve rocker cover. Discard the gasket.
2. Select any cylinder for the timing check.
3. Remove the injector (at the cylinder selected) as outlined in Section 2.1.1.
4. Carefully slide a rod, approximately 12" long, through the injector tube until the end of the rod rests on top of the piston. Place the throttle in the *no-fuei* position. Then, turn the crankshaft slowly in the direction of engine rotation. Stop when the rod reaches the end of its upward travel. Remove the rod and turn the crankshaft, opposite the direction of rotation, between 1/16 and 1/8 of a turn.
5. Select a dial indicator with .001" graduations and a spindle movement of at least one inch. Provide an extension for the indicator spindle. The extension must be long enough to contact the piston just before it reaches the end of its upward stroke. Also, select suitable mounting attachments for the indicator so it can be mounted over the injector tube in the cylinder head.
6. Mount the indicator over the injector tube. Check to be sure the indicator spindle is free in the injector tube and is free to travel at least one inch.
7. Attach a suitable pointer to the engine front cover. The outer end of the pointer should extend over the top of the crankshaft pulley (or vibration damper).
8. Turn the crankshaft slowly in the direction of engine rotation until the indicator hand just stops moving. Continue turning the crankshaft until the indicator hand starts to move again.
9. Set the dial indicator to zero. Then, turn the crankshaft approximately .075" in the direction of engine rotation. Rotate the crankshaft in the opposite direction to .050" from the zero setting.
10. Scribe a line on the crankshaft pulley (or vibration damper) in line with the end of the pointer.
11. Turn the crankshaft in the opposite direction of engine rotation, through the point where the indicator stops, to approximately .075" from the zero setting. Rotate the crankshaft back in the direction of engine rotation to .050" from the zero setting.
12. Scribe a second line on the vibration damper (or crankshaft pulley) in line with the end of the pointer.



LEFT HAND ROTATING ENGINE

RIGHT HAND ROTATING ENGINE

• Fig. 5 - Front Gear Train Timing Marks - 1 2V and 1 6V Engines

13. Scribe a third line half way between the first two lines. This is top dead center. If the crankshaft pulley retaining bolt has loosened, tighten it to 450-500 lb—ft (610-678 N«m) torque.

14. Remove the dial indicator and rod from the engine.

15. Install the injector as outlined in Section 2.1.1. Then, adjust the valve clearance (Section 14.1) and time the injector (Section 14.2).

16. Turn the crankshaft, in the direction of engine rotation, until the exhaust valves in the selected cylinder are completely open. Reinstall the dial indicator so the indicator spindle rests on top of the injector follower. Set the indicator dial on zero, then, turn the crankshaft slowly, in the direction of engine rotation, until the center mark on the pulley is in line with the pointer.

17. Note the reading on the dial indicator and compare it with the following:

    1. If the indicator reading is .306” to .326”, the engine is in time.
    2. If the indicator reading is .268” to .288”, timing is retarded one tooth.
    3. If the indicator reading is .337” to .357”, timing is advanced one tooth.

18. After completing the timing check, remove the dial indicator. Also, remove the pointer from the engine front cover.

19. Using a new gasket, reinstall the valve rocker cover.

 © Detroit Diesel Corporation

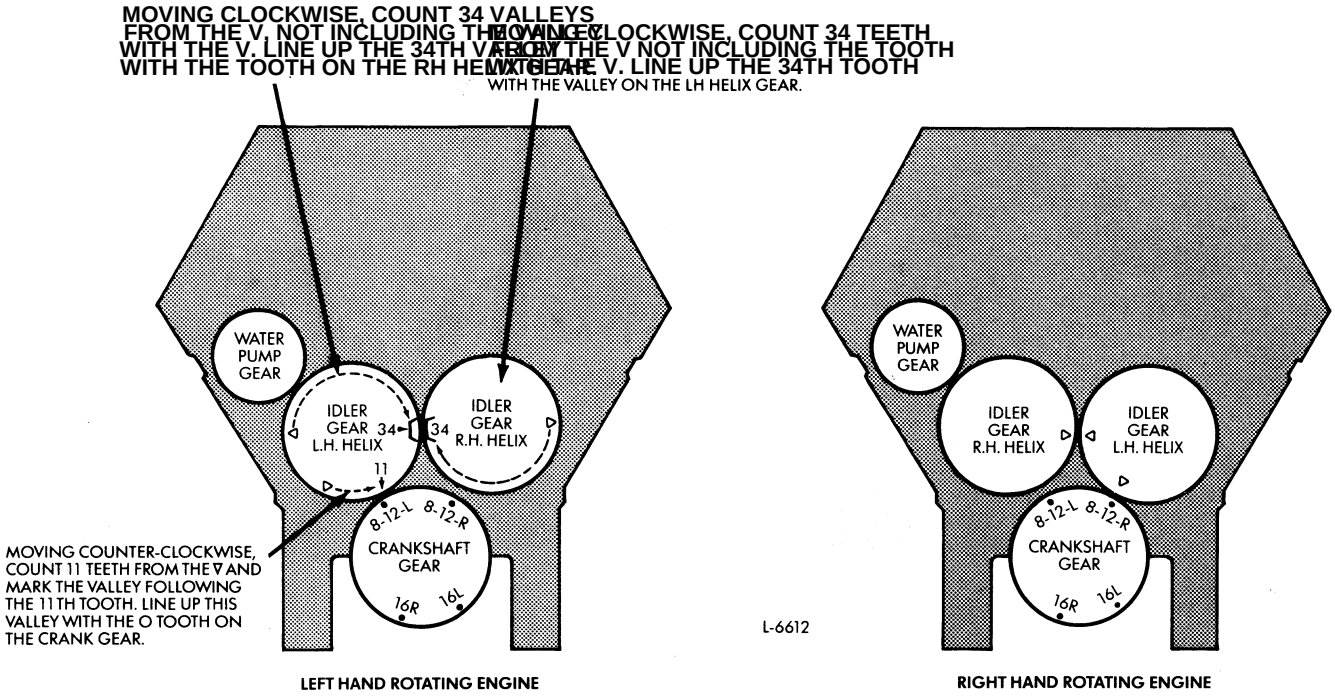


Fig. 6 - Front Gear Train Timing Marks - 8V-149 Engine

CAMSHAFTS AND BEARINGS

• The contrarotating camshafts are located near the top of the cylinder block. There is one set of camshafts in the 8V-149 engine. There are two sets of camshafts in the 12V-149 and 16V-149 engines (two camshafts in each cylinder bank). Each camshaft is supported on upper and lower camshaft bearings (shells) and retained by bearing caps. The camshaft end play on each bank of the camshafts is controlled by a thrust plate attached to one of the rear camshaft bearing caps. On former 12V-149 engines only (prior to engine 12E-705), a thrust plate was installed on each individual camshaft and attached to one of the bearing caps.

The front and rear camshaft in each bank of the 12V-149 and 16V-149 engines is connected by a flexible coupling attached to the flange end of each camshaft (Fig. 1).

On 12 V-149 engines (prior to 12E-705), the camshafts were connected by a splined shaft and two couplings attached to the flange end of each camshaft (Fig. 2).

The camshafts are driven by the rear gear train by flanges attached to the camshaft gear assemblies, couplings attached to the camshafts and splined drive shafts.

The two splined drive shafts at the rear of the engine differ in length; the right-bank drive shaft is 6.920" long and the left-bank drive shaft is 8.420" long. The two center (intermediate) splined drive shafts on former 12V-149 engines are 6.100" long.

Camshafts are etched with letters A, B, C, etc. at each flange end of the camshaft for proper installation at the time of assembly. Refer to Fig. 4 and 5 for detailed instructions.

Lubrication

Lubrication to the camshafts, bearings, thrust plates and drive shafts is supplied under pressure through drilled passages in the cylinder block. Oil from the main oil gallery flows through these drilled passages to each camshaft bearing. Oil from the bearings enters each camshaft to lubricate the thrust plates and the drive shafts.

Remove Camshafts (Current And Former)

Whenever an engine is to be completely reconditioned or the camshafts and bearings need replacing, remove the camshafts as follows:

1. Clean and remove the valve rocker covers.
2. Remove the fuel inlet and outlet pipes.
3. Remove the exhaust valve and injector operating mechanisms (Section 1.2.1).
4. Remove the flywheel housing camshaft gear covers (Section 1.5) or accessories attached to the flywheel, housing and driven by the camshaft drive gears (Section 1.7.7).
5. Remove the snap ring and retainer from the camshaft drive flange (Section 1.7.3).

   NOTICE: If removal of the entire camshaft assembly is required on either bank (12V-149 and 16V-149 engines), loosen the intermediate shaft coupling bolts prior to removing the rear camshaft drive shafts.

6. Withdraw the drive shaft from the camshaft and drive flange.
7. On 12V-149 and 16V-149 engines, remove the intermediate shaft couplings as follows:

   a. On current 12V-149 and 16V-149 flexible drive couplings, remove three 7/16"-20 x 1.200" self-locking bolts from the right-bank rear camshaft and left-bank front camshaft. Remove the spacer and note the number of shims (spring plates) when removing these parts.

   b. On former 12V-149 engines (prior to 12E-705) with splined intermediate drive shafts, remove five 7/16"-20 x 1-1/4” (12 pt.) self-locking bolts from the right-bank rear camshaft coupling and left-bank front camshaft coupling. Slide the couplings (toward the center of the block) on the shafts.

8. Remove the camshaft bearing caps and remove the camshafts from the engine.

   NOTICE: Camshaft bearing caps are stamped 1R, 2R, etc. or 1L, 2L, etc. from the front to the rear of the engine on each bank. The cylinder block is stamped with the same number as the bearing cap, directly above the cap, on the rocker cover gasket surface of the block. The bearing caps must be reinstalled in their original positions. Service cylinder blocks are not stamped for camshaft bearing cap location. Refer to the plugging chart in the back of the Service Manual.

9. If required, remove the shaft coupling spacer and spring plates from the camshafts.

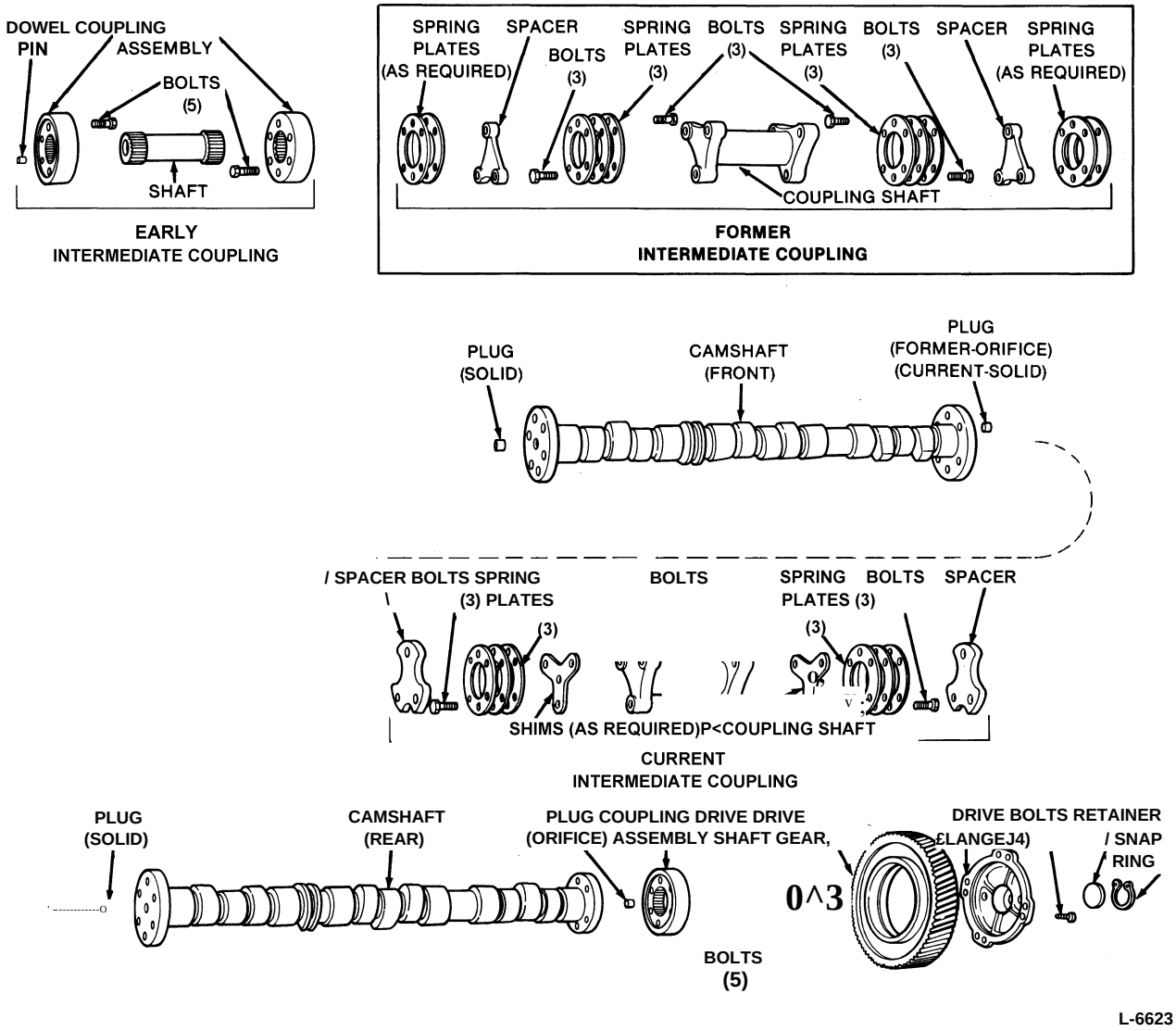


Fig. 1 - Camshaft Details and Relative Location of Parts

10. If removal of the camshaft end plugs is required for cleaning or inspection, remove the end plugs as follows:

    a. Clamp the flange end of the camshaft (with the orifice plug) in a vice equipped with soft jaws.

    b. Use the orifice hole in the plug as a center and drill a 5/16” hole through the plug, using a carboloy tip drill. Tap the drilled hole with a 3/8”-16 tap.

    c. Thread a 3/8”-16 adaptor, J 6471-2, into the plug. Then, attach a slide hammer J 6471-1 to the adaptor and remove the plug.

    d. To remove the solid plug at the opposite end of the camshaft, punch a hole as deep as possible with a center punch to break through the hardened surface.

    e. Use a 1/4” carboloy tip drill and drill a hole straight through the plug. Then, enlarge the hole with a 5/16” carboloy tip drill.

    f. Tap the drilled hole with a 3/8”—16 tap.

    g. Remove the plug as in Step c.

    h. Remove the plugs from the other camshafts in the same manner, if required.

 © Detroit Diesel Corporation

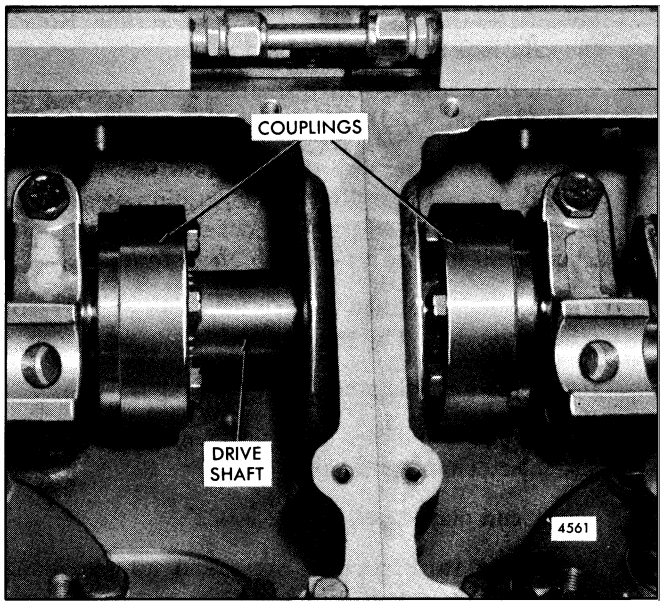


Fig. 2 - Camshaft Couplings and Intermediate Drive Shaft (Early 12V-149 Engines)

Inspection

Soak the camshafts and bearing caps in clean fuel oil. Then, run a wire brush through the oil gallery in the camshaft to remove any foreign material or sludge. Clean the exterior of the camshaft and bearing caps and blow out the oil gallery and the oil holes in the camshaft and the oil holes in the bearing caps with compressed air.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

On current engines, the drilled through oil passage in the center of the camshaft and the cross drilling for the intermediate bearing journals has been discontinued. The center hole is now drilled only deep enough from each end and cross drilled to supply oil to the camshaft rear drive coupling and spline shaft. Elimination of the oil holes does not change the supply of lubricating oil to the camshaft intermediate bearings, since they continue to receive oil through drilled holes in the cylinder block.

On former 12V-149 and 16V-149 engines that still have the splined center coupling, it will be necessary to continue to use the orifice plug at the rear of the front camshaft, if replacement of one orifice plug is necessary.

Inspect the cams and journals for wear or scoring. Check the wear on the cam lobes as follows:

NOTICE: Cam lobe wear can be checked with the camshaft in or out of the engine.

1. Measure the flat on the injector rise side of the cam lobes with a tapered leaf set of feeler gages (.0015”-.010”) and a piece of squared hard material 1/8” x 3/8” x 1” (Fig. 3).

2. If the flats measure less than .003” in depth and the camshaft is in otherwise good condition, the camshaft may be considered satisfactory for further service.

3. A slightly worn cam lobe, still within acceptable limits, may be stoned and smoothed over with a fine crocus cloth.

Examine both faces of the camshaft thrust plate. A new thrust plate is .368” to .372” thick. The clearance between the thrust plate and the thrust shoulder on the camshaft is .013” to .022” with new parts or a maximum of .026” with used parts. Check the shoulder surface on the camshafts that contact the thrust plate. Camshaft thrust surfaces that are not scratched too severely may be smoothed down with an oil stone. The distance between the two surfaces is .385” to .390” with new parts.

The face runout on the thrust plate surfaces of the camshaft must not exceed .002” total indicator reading.

Inspect the couplings and splined drive shaft for excessive wear.

Replace excessively scored or worn camshaft bearings. The clearance between the camshaft journals and the bearings is .0059” to .0084” with new parts.

With the camshaft mounted on the end bearing journals, the runout on the intermediate bearing journals must not exceed .002” total indicator reading.

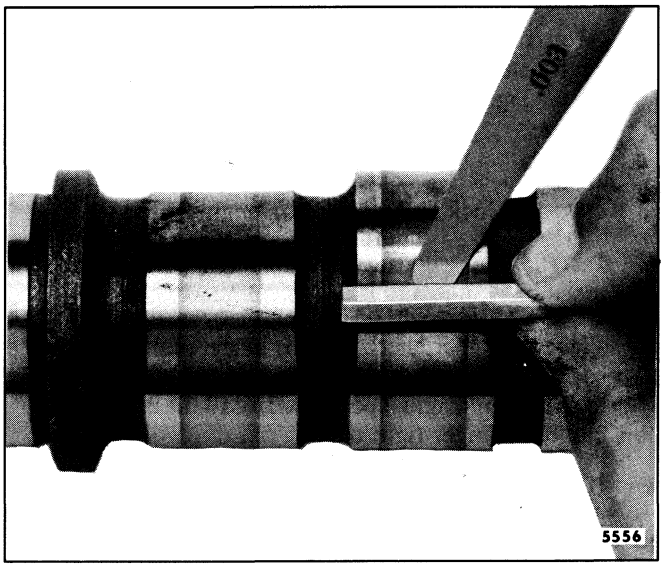


Fig. 3 - Checking Cam Lobe Wear

Inspect each camshaft bearing cap for brinelling at the bolt head surface for the short camshaft cap bolt. If brinelling is noted, use a hardened washer under each short bolt at the time of assembly.

NOTICE: Current camshaft bearing caps incorporate a drilled lubrication hole. Check the oil hole with compressed air to make sure it is not plugged.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Service camshaft bearing caps are not finished and must be line bored after installation. The finished bore dimension must be 2.151" to 2.152" with the caps in place. The axis of the bored holes must be parallel with the center line of the crankshaft bore within .004". Prior to boring the caps, tighten the retaining bolts to 90-100 lb—ft (122-136 N*m) torque.

On early 12V-149 engines (through 12E-027), the camshaft couplings were bolted to the flanges of the camshafts with five 3/8-24" bolts and one 5/16"-24 bolt. Tighten the 3/8"-24 bolts to 45-50 lb—ft (61-68 N*m) torque and the 5/16"-24 bolt to 20-24 lb—ft (27-33 N*m) torque.

After the camshafts and related parts have been inspected and worn parts replaced, refer to Fig. 5 and proceed as follows:

Install Camshafts (8V-149 Engine)

1. If removed for inspection or cleaning, install a new orifice plug in the rear end of each camshaft and install a solid plug in the front end of each camshaft.
2. Attach a drive coupling assembly to the rear end of each camshaft with five 7/16"-20 x 1-1/4" (12 pt.) bolts. Tighten the bolts to 57-61 lb—ft (78—83 N*m) torque.
3. Install new lower camshaft bearing shells in the cylinder block and apply clean engine oil to the shells.
4. Install the right-bank and left-bank camshaft assemblies in position in the cylinder block.
5. Place the upper bearing shells in the camshaft bearing caps, apply clean engine oil, and install the bearing caps in their original position. Install the upper bearing cap bolts finger tight only.
6. If removed, install the camshaft thrust plates and tighten the bolts.
7. Place the rocker arm shafts on the bearing caps and install the remaining bearing cap bolts. Tighten the bolts to 90-100 lb—ft (122-136 N*m) torque. Rotate the camshaft to be sure no bind exists.
8. Install the camshaft drive shafts, retainers and snap rings (Section 1.7.3).
9. Remove the rocker arm shaft to allow installation of the exhaust valve and injector operating mechanism (Section 1.2.1). Tighten the rocker arm shaft bolts again to 90-100 lb—ft (123-136 N*m) torque.
10. Install the camshaft gear accessory covers or accessories driven by the camshaft drive gears.
11. Install the fuel inlet and outlet pipes.
12. Check the valve clearance adjustment (Section 14.1) and injector timing (Section 14.2).
13. Check end play. Must be .013"-.022".
14. Install the valve rocker covers and all remaining equipment previously removed.

Install Former Flexible Drive Intermediate Camshafts (12V-149 and 16V-149 Engines)

After the camshafts and related parts have been inspected and worn parts replaced, refer to Fig. 4 and proceed as follows:

1. If removed for inspection or cleaning, install new end plugs in the camshafts. Refer to Fig. 4 for the proper location of the solid and orifice plugs.

NOTICE: The orifice plug is installed in the rear of each of the rear camshafts.

2. Install a drive coupling assembly on the rear drive flange camshafts, with five 7/16"-20 x 1-1/4" (12 pt.) bolts in each coupling assembly. Tighten the bolts to 57-61 lb-ft (77-83 N*m) torque as follows:

12V-149

a. R.H. rotation: **B** and **D** flange end.

b. L.H. -rotation: **A** and **C** flange end.

16V-149

a. R.H. rotation: **E** and **F** flange end.

b. L.H. rotation: **G** and **H** flange end.

• 3. Preassemble the center coupling shaft for each bank, with three spring plates and shim at each end of the coupling shaft. Install three 7/16"-20 x 1.38" self-locking bolts in each end. Former couplings use 1.200" bolts. Tighten the bolts to 57-61 lb-ft (77-83 N*m) torque.

 © Detroit Diesel Corporation

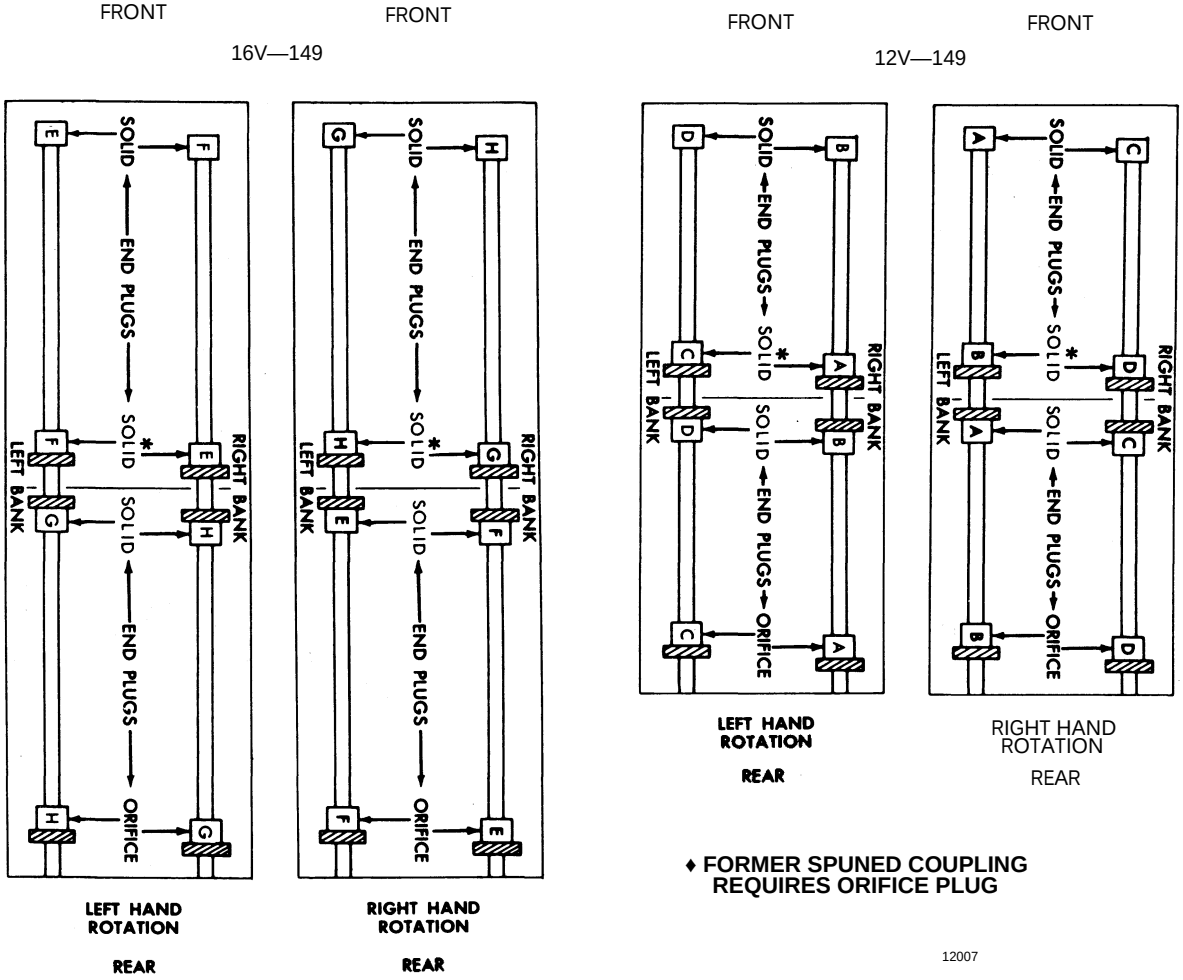


Fig. 4 - Location of Camshafts and Plugs - 12V, 16V-149

• 4. On former engines, attach the coupling shaft assembly, spacer and two spring plates (which act as shims) to the camshafts. On current engines, attach the coupling shaft assembly and spacer to the camshaft. Proceed as follows:

12V-149

a. R.H. rotation: **D** flange, right-bank front and **A** flange left-bank rear.

b. L.H. rotation: **A** flange, right-bank front and **D** flange left-bank rear.

16V-149

. a. R.H. rotation: **G** flange, right-bank front and **E** flange left-bank rear.

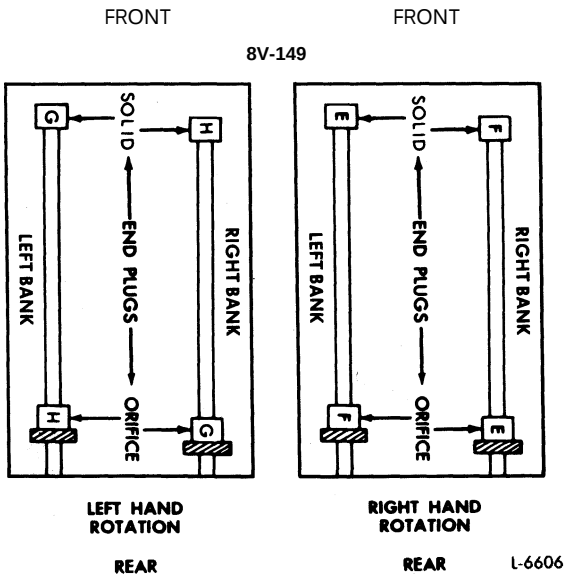
b. L.H. rotation: **E** flange, right-bank front and **G** flange left-bank rear.

• 5. Install three 7/16”-20 x 1.00” self-locking bolts (current coupling) or three 7/16”-20 x 1.200” self-locking bolts (former coupling). Because of space limitations between the coupling and the cylinder block, it is almost a necessity that torque wrench adaptor J 28462 be used. The torque wrench reading must be adjusted with the adaptor in place due to the increased length of the torque wrench and the adaptor. Usfe the following formula to determine the adjusted torque reading:

Tw = Ta (L/L + A)

If the effective length of the wrench (L) is 22” and the adaptor (A) is 2” long, you should have a reading of 55 lb—ft (75 N#m) on the wrench to have the bolt tightened to 60 lb—ft (81 N#m) torque (Fig. 6):

Tw=Ta (L/L + A)
Tw=60 (22/22 + 2)
Tw=60 (22/24)
Tw = 55



• Fig. 5 - Location of Camshafts and Plug - 8V-149

Tighten the bolts to 57A-61 lb—ft (77-83 N«m) torque.

NOTICE: It may be necessary to rotate the camshaft to align the three bolt holes.

6. Install new lower camshaft bearing shells in the block and apply clean engine oil to the lower bearing shells.

7. Install the right-bank front and left-bank rear camshaft assembly in position in the cylinder block. Refer to Fig. 4 and Step 4 for rotation and camshaft position.

8. Install the right-bank rear camshaft assembly and left-bank front camshaft in position in the cylinder block.

9. To determine the correct number of spring plates (shims) that will be required between the flange of the right-bank rear camshaft and the flange of the left-bank front camshaft, the following procedure will be required.

   a. Align the camshaft journal oil holes with the oil groove in the lower camshaft bearing shells on the front camshafts.

   b. If removed, install a thrust plate and spacer to the R-l 1 and L-8 bearing caps on a 12V-149 or R-15 and L-10 bearing caps on a 16V-149 engine (Fig. 7). Tighten the bolts. Install the thrust bearing caps in their original position on each bank; this locates the rear camshafts. Install and tighten the upper bearing cap bolts.

   c. Install the spacer and required number of spring plates (which act as shims) between the camshaft flange and coupling shaft spacer.

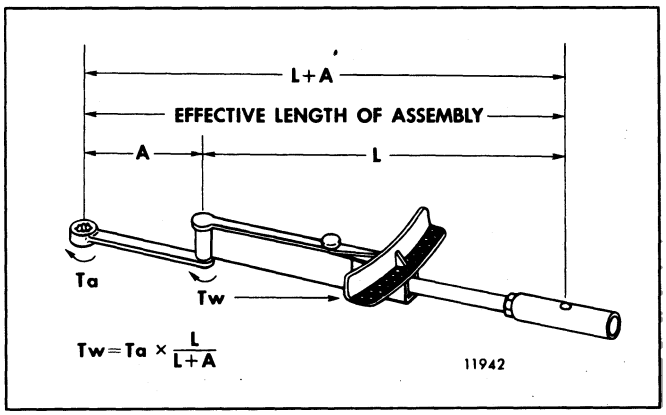


Fig. 6 - Calculating Torque with an Adaptor

NOTICE: When the correct number of shims have been determined, it may be necessary to equalize the amount of spring plates between the flange of the camshaft and the spacer at each end.

NOTICE: It may be necessary to rotate the camshaft to align the three bolt holes.

   d. Install three 7/16M-20x 1.200” self-locking bolts and tighten them to 57-61 lb—ft (77-83 N*m) torque.

NOTICE: Install the camshaft drive shafts to prevent the camshaft from turning while tightening the bolts.

10. Install the upper shells in the bearing caps and install the upper bearing caps in their original positions. Install the upper bearing cap bolts finger tight only.

11. Place the rocker arm shafts on the bearing caps and install the remaining bearing cap bolts. Tighten the bolts to 90-100 lb—ft (122-136 N#m) torque. Rotate the camshafts to be sure no bind exists.

12. Install the camshaft drive shafts, retainers and snap rings (Section 1.7.3).

13. Remove the rocker arm shaft to allow installation of the exhaust valve and injector operating mechanism (Section 1.2.1). Tighten the rocker arm shaft bolts again to 90-100 Ib-ft (122-136 N*m) torque.

14. Install the camshaft gear accessory covers or accessories driven by the camshaft drive gears.

 © Detroit Diesel Corporation

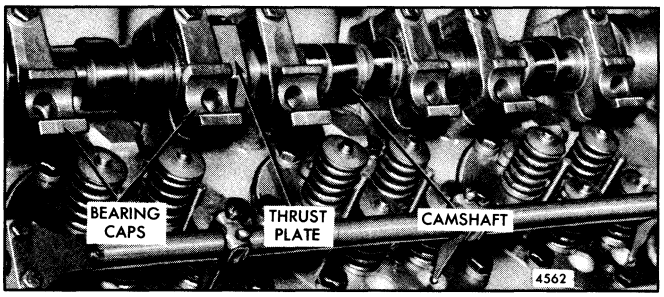


Fig. 7 - Camshaft Bearing Caps and Thrust Plate

15. Install the fuel inlet and outlet pipes.

16. Check the valve clearance adjustment (Section 14.1) and injector timing (Section 14.2).

. 17. Check end play. Must be .013”-.022”.

18. Install the valve rocker covers and all remaining equipment previously removed.

Install Early Solid Drive Intermediate Camshafts (Prior To 12E-705)

After the camshafts and related parts have been inspected and worn parts replaced, refer to Fig. 2 and proceed as follows:

1. If removed for inspection or cleaning, install the new end plugs in the camshafts. Refer to Fig. 4 for the proper location of the solid and orifice plugs.

   NOTICE: The orifice plugs are installed in the flange end of the camshafts, towards the rear of the engine.

2. Install a drive coupling assembly on the rear drive flange camshafts with five 7/16”-2o x 1-1/4” (12 pt.) bolts in each coupling assembly. Tighten the bolts to 57-61 lb—ft (77-83 N»m) torque as follows (Fig. 2):

   12V-149

   a. R.H. rotation: **B** and **D** flange end.

   b. L.H. rotation: **A** and **C** flange end.

3. Install drive coupling assemblies on the camshafts at , the intermediate positions as follows:

   12V-149

   a. R.H. rotation: **D** right-bank front, **A** left-bank rear.

   b. L.H. rotation: **A** right-bank front, **D** left-bank rear.

4. Install five 7/16”-20 x 1-1/4” bolts in each coupling assembly. Tighten the bolts to 57-61 lb—ft (77-83 N#m) torque.

5. Install the camshaft lower bearings shells in the block and apply clean engine oil to the shells.

6. Position the right-bank front and left-bank rear camshafts in place on the lower bearings shells. Refer to Fig. 4 for rotation and position of the camshafts.

7. Install the intermediate drive shafts (6.100” long) in the right-bank front camshaft coupling and the left-bank rear camshaft coupling.

8. Slide the coupling assemblies over the intermediate shafts, toward the center of the block.

9. Install the right-bank rear and left-bank front camshafts.

10. Slide the coupling assemblies against the flanges and install five 7/16”-2 x 1-1/4” (12 pt.) bolts. Tighten the bolts to 57-61 lb—ft (77-83 N#m) torque.

    NOTICE: Install the camshaft drive shafts to prevent the camshafts from turning while tightening the bolts.

11. Place the upper bearing shells in the bearing caps and install the bearing caps in their original positions. Install the upper bearing cap bolts finger tight only.

12. If removed, install the thrust plates and spacers to the R-5, L-2, R-ll and L-8 bearing caps (Fig. 7). Tighten the bolts.

13. Place the rocker arm shafts on the bearing caps and install the remaining bearing cap bolts. Tighten the bolts to 90-100 lb—ft (122-136 N#m) torque. Rotate the camshaft to be sure no bind exists.

14. Install the camshaft drive shafts, retainers and snap rings (Section 1.7.3).

15. Remove the rocker arm shaft to allow installation of the exhaust valve and injector operating mechanism (Section 1.2.1). Tighten the rocker arm shaft bolts again to 90-100 lb—ft (122-136 N«m) torque.

16. Install the camshaft gear accessory covers or accessories driven by the camshaft drive gears.

17. Install the fuel inlet and outlet pipes.

18. Check the valve clearance adjustment (Section 14.1) and injector timing (Section 14.2).

• 19. Check end play. Must be .013”-.022”.

20. Install the valve rocker covers and all remaining equipment previously removed.

CAMSHAFT GEARS AND IDLER GEARS

The right-bank and left-bank camshaft gears (Fig. 1) are mounted on double-row tapered roller bearings which are supported on identical stationary hubs. Each camshaft gear hub is held in position against the block by three (3) bolts. The gear and bearing assembly is held in position on the hub by a special locknut and lock washer.

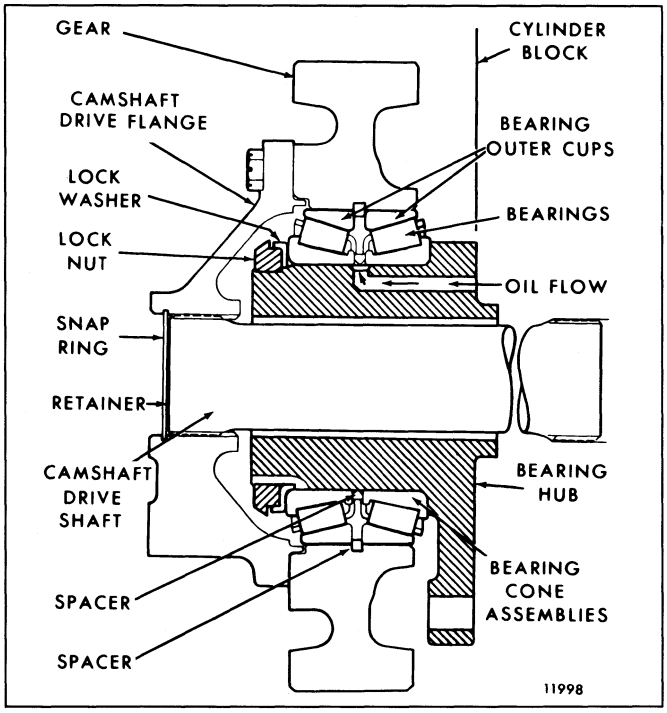


Fig. 1 – Camshaft Gear Mounting

The rear gear train camshaft idler gears and the crankshaft idler gear (Fig. 2) are mounted on double-row tapered roller bearings which are all mounted on identical stationary hubs. The two camshaft idler gear hubs are each held in position against the block by a special drilled center bolt and four outer bolts. The two camshaft idler gear and bearing assemblies are each held in position on the hub by a special locknut and lock washer. The crankshaft idler gear hub and dummy hub (which acts as a spacer for the flywheel housing) are each held in position by a special drilled center bolt and four (4) outer bolts which are installed through the flywheel housing and hubs into the block. The crankshaft idler gear and bearing assembly is also held in position by a special locknut and lock washer.

' The front gear train idler gears (Fig. 3), incorporating bushing type bearings, are used for balancing the engine and driving the water pump. Each idler gear hub is held in position by a special center drilled bolt and four (4) outer bolts which are installed through the front cover and hub and into the block. Two (2) thrust washers are used on each idler gear. The inner washer is held in position by the hub and the outer washer is held in position by the front cover.

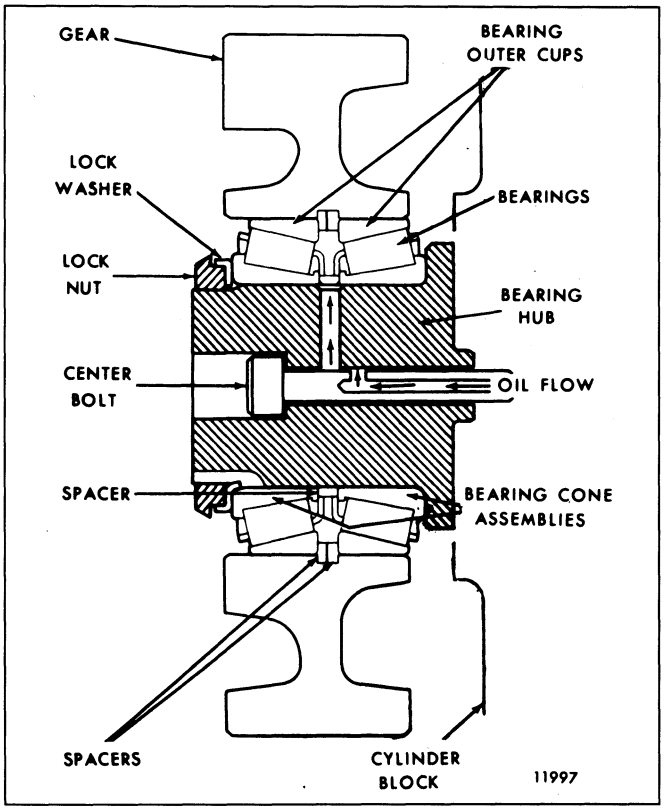


Fig. 2 - Camshaft Idler Gear and Crankshaft Rear Idler Gear Mounting

Current 16V turbocharged and intercooled engines use a nitrided hardened right-hand idler gear (68 teeth) and its mating blower drive gear (33 teeth). Both gears are identified by the grayish color taken on by the hardening process. When replacing the former non-hardened right-hand idler gear or its mating blower drive gear in the 16V turbocharged intercooled engine, both gears must be replaced at the same time with the new hardened gears. The former non-hardened right bank idler gear will continue to be used for all other Series 149 engines.

LubricatiQn

The caihshaft gear bearings are pressure lubricated by oil from tlie cylinder block oil gallery which enters the hub through a longitudinal drilled passage in the hub (Fig. 1). Excess oil leaving the camshaft bearings lubricates the camshaft gears.

The rear camshaft idler gear bearings, crankshaft idler gear bearing and front idler gear bushings are all pressure lubricated by oil from the cylinder block oil galleries. Oil enters all five (5) hubs through a special center drilled bolt on both front and rear gear train idler gears. A hole is drilled in the side of the center bolt allowing oil to flow through a transverse drilled passage in the idler gear hubs. Oil is

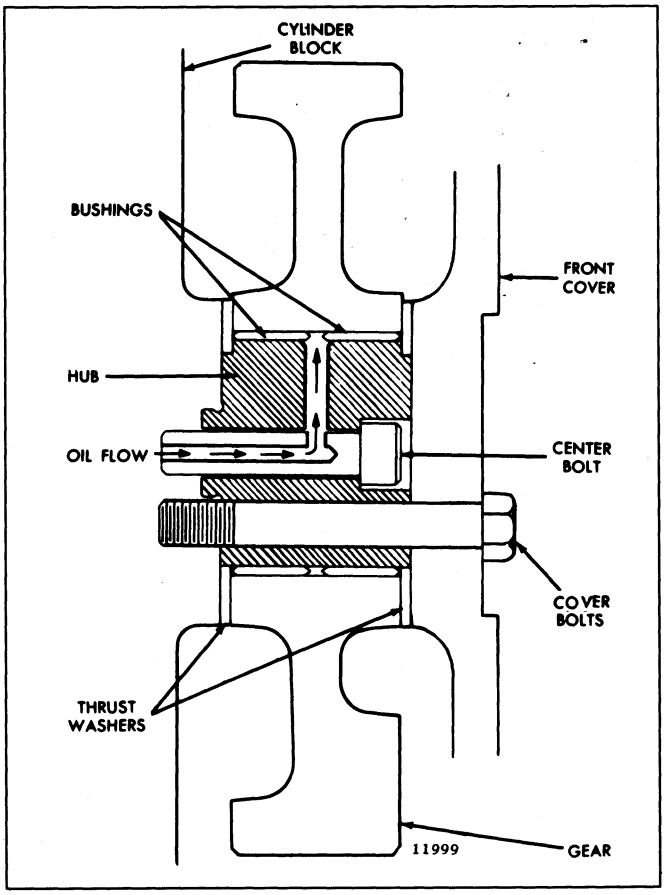


Fig. 3 – Front Gear Train Idler Gear Mounting

circulated around the roller bearings in the rear gear train and the bushings and thrust washers in the front gear train. Excess oil leaving the bearings and bushings lubricates the gears.

Remove Camshaft Gear Assemblies (Flywheel Housing Installed)

The camshaft gear, hub and bearing assemblies are removed with the flywheel housing in place. If the camshaft idler gear assemblies and crankshaft idler gear assembly must be removed, removal of the flywheel housing will be necessary. Remove the camshaft gear assemblies, as follows:

1. Remove the camshaft gear flywheel housing covers or accessory drive adaptors (Sections 1.5 and 1.7.7).
2. Remove the snap ring and retainer from the camshaft drive flange (Fig. 1).
3. Withdraw the camshaft drive shaft from the camshaft and drive flange.

NOTICE: Place a clean, lintless cloth in the flywheel housing, underneath the camshaft gear and bearing assembly, to prevent bolts from accidentally falling into the flywheel housing (when removing or installing bolts).

4. Remove the four (4) bolts securing the drive flange to the camshaft gear and remove the flange.

If disassembly of the camshaft gear assemblies is required, it is advisable to loosen the former locknuts with spanner wrench set J 22556 or the current hex nut set J 29744 before removing the gear assemblies from the engine.

NOTICE: When disassembling a cam gear bearing assembly, use a punch to drive the dimpled lip of the locknut out of the hub, before attmepting to remove the nut. Failure to observe this precaution may result in damage to the hub threads.

5. Rotate the camshaft gear until the holes in the gear align with the three (3) camshaft hub to block bolts and remove the bolts.
6. Remove the camshaft gear assembly through the opening in the flywheel housing.
7. Remove the opposite camshaft gear assembly in the same manner.

Remove Rear Camshaft Idler Gear Assemblies

1. Remove the camshaft gear assemblies as covered above.
2. Remove the flywheel and the flywheel housing (Sections 1.4 and 1.5).

If disassembly of the camshaft idler gear assemblies is required, loosen the former locknuts with spanner wrench set J 22556 or the current hex nut with wrench set J 29744 before removing the gear assemblies from the engine.

NOTICE: When disassembling a cam or idler gear bearing assembly, use a punch to drive the dimpled lip of the locknut out of the slot in the hub before attempting to remove the nut. Failure to observe this precaution may result in damage to the hub threads.

3. Remove the four (4) outer bolts and one center bolt securing the camshaft idler gear assembly.
4. Remove the assembly from the block.
5. Remove the opposite camshaft idler gear assembly in the same manner.

Remove Rear Crankshaft Idler Gear Assembly

1. Remove the camshaft gear assemblies as covered above.
2. Remove the flywheel and the flywheel housing (Sections 1.4 and 1.5).

 © Detroit Diesel Corporation

3. Remove the camshaft idler gear assemblies, if service is required, as covered above.

If disassembly of the crankshaft idler gear assembly is required, it is advisable to install a l/2"-13 x 5" bolt to hold the hub in position while loosening the former locknut with spanner wrench set J 22556 or current hex nut set J 29744.

NOTICE: When disassembling a cam or idler gear bearing assembly, use a punch to drive the dimpled lip of the locknut out of the slot in the hub before attempting to remove the nut. Failure to observe this precaution may result in damage to the hub threads.

4. Remove the center bolt and l/2”-l3 x 5” bolt from the crankshaft idler gear hub. Remove the gear assembly from the engine.

5. Remove the idler gear dummy hub if required.

Remove Front Idler Gear Assemblies

1. Remove the engine front cover (Section 1.3.5).

2. Remove the outer thrust washers and idler gears (Fig. 3).

3. Remove the center bolts securing the idler gear hubs to the cylinder block. Remove the hubs and thrust washers.

Disassemble Gear, Hub And Bearing Assemblies (Rear Gear Train)

The disassembly and assembly of the various gear, hub and bearing assemblies of the rear gear train are similar, therefore only one procedure will be covered for all assemblies.

Whenever tapered roller bearings are disassembled, all parts must be match marked and kept as a set to be reassembled in their *original* position.

1. Remove the locknut (previously loosened while the gear assembly was attached to the engine) and lock washer.

2. Press the hub from the gear and bearing assembly.

3. Remove the roller bearing cone assemblies and spacer from the gear.

4. Remove the bearing cups from the gear, as follows:

   a. Drive one cup from the gear, using a brass rod.

   b. Turn the gear over and drive the other cup out in the same manner.

5. Remove the spacer(s) from the gear.

Inspection

Wash all of the parts thoroughly in clean fuel oil and dry them with compressed air.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Examine the gear teeth for evidence of scoring, pitting or wear.

Examine the gear hub for wear or damage.

Examine the rear gear train bearings carefully for wear, pitting, scoring or flat spots on the rollers.

Examine the front idler gear bushings for scoring or wear. When replacing the bushings, install them flush to .010" below the face of the hub on both sides of the gear (refer to Section 1.0 for bushing and hub specifications).

Examine the front idler gear thrust washers for wear or scoring.

Replace all worn or damaged parts.

Assemble Gear, Hub And Bearing Assemblies

When assembling the various gear, hub and bearing assemblies, it is important that the inner race of the bearing and the inner face of the lock washer, used in conjunction with the two (2) camshaft gear bearing locknuts, three (3) idler gear bearing locknuts and accessory gear bearing locknuts, are perfectly dry and free of any lubricant. Before installing and tightening the locknut, apply a light coating of International Compound No. 2, or equivalent, to the threads of the shaft and the contact face of the nut that contacts the lock washer. This will allow the nut to turn freely on the lock washer.

1. Install and torque the current lipped locknuts as follows:

   a. Apply a small quantity of International Compound No. 2 or equivalent to the locknut threads and the face of the locknut that contacts the bearing inner race.

   b. Install the gear and bearingassembly components, then thread the locknut finger-tight onto the hub.

   • c. Using the appropriate socket from tool set J 29744 and an accurately calibrated torque wrench, tighten the locknut to 300-320 lb—ft (407-434 N*m) torque. Rotate the gear while tightening the locknut.

d. With a hammer and rounded punch, dimple the outer lip of the locknut into the slot in the hub to secure the locknut in position. The new cam and idler gear bearing locknuts are reusable and may be dimpled in the same location on the outer lip after being tightened to the proper torque.

2. Bend one or more of the tangs on the lock washer into the slots on the locknut.

3. Perform a bearing pre-load check. *

• 4. Install one outer, one inner spacer in *Former* camshaft and idler gear assembly (Fig. 1). Install two outer spacers and one inner spacer in idler gear assembly (Fig. 2). Assemble the bearing assemblies in the gears with reference to the match marks made during disassembly. The idler gear assemblies use two (2) outer spacers with the gaps installed 180° apart.

• **NOTICE:** On 8 V engines only, use one (1) outer spacer on the front idler gear and make sure spacer gap is aligned with the oil hole.

5. Support the gear in an arbor press. Place one of the bearing cups in the bore of the gear and, using a suitable installer, press the cup into the gear and against the spacer(s). Turn the gear over and install the remaining cup in the same manner.

6. Position the two (2) bearing and cone assemblies and the spacer ring in the gear.

7. Press the gear hub into the gear and bearing assembly, with the oil hole in the hub 180° from the gap in the spacer ring. The gear hub is a light press fit in the gear and bearing assembly.

• 8. On *non-lipped nuts* to be certain that the lock washer has not turned in the process of tightening the locknut, match mark the hub slot and the outer tang of the lock washer at the inner tang. After the nut is tightened to 280-300 lb—ft (379-407 N#m) torque, check to be sure that the match marks have not moved.

9. Position the former slotted lock washer and *castelated* locknut on the hub and against the bearing cone. Use spanner wrench set J 22556 and tighten the locknut to 280-300 lb-ft (379-407 N#m) torque. When tightening the locknut on the hub, it is advisable to install the gear assembly on the engine to hold it while tightening the locknut. *Rotate the gear white tightening the locknut.*

Check Bearing Pre-Load

The rollers in the bearing are loaded between the bearing cups and the bearing cones in accordance with design requirements to provide a rigid idler gear and bearing assembly. As the bearing cones are moved toward each other in a tapered roller bearing assembly, the rollers will be more tightly held between the cones and the cups. A slight pre-load is applied to the bearings, by means of a selected spacer ring between the bearing cones, to provide rigidity of the gear and bearing assembly when it is mounted on its hub. This method of pre-loading is measured, in terms of “pounds pull”, by the effort required at the outer diameter of the gear to turn the bearing cups in relation to the bearing cones.

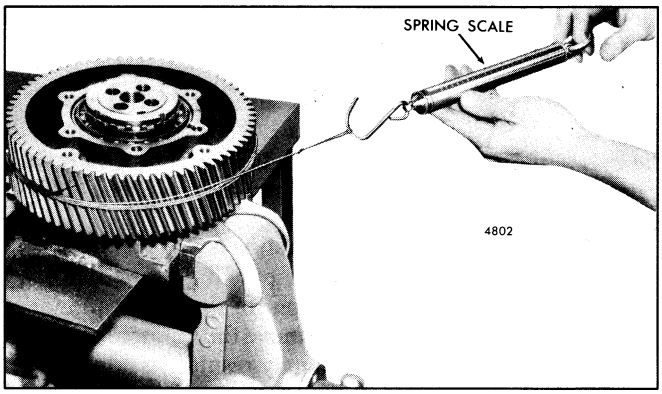


Fig. 4 - Checking Bearing Pre-Load with Spring Scale J 8129

Check the bearing pre-load whenever the camshaft or idler gear assemblies are removed from the engine for service or for an engine overhaul.

The bearings must be clean and lubricated with engine oil before checking the pre-load. If a new bearing has been installed, “work in” the bearing by rotating the gear back and forth several times.

Refer to Fig. 4 and tie one end of a piece of lintless cord around a 1/8” piece of wood (or soft metal stock). Place the wood between two of the gear teeth and wrap the cord around the gear several times. Attach the outer end of the cord to spring scale J 8129. Maintain a steady pull on the cord and scale 90° to the axis of the hub and note the pull, in pounds and ounces, required to start the gear rotating. Make several checks to obtain an average reading. If the pull is within 1 lb. minimum to 5 lbs. maximum and does not fluctuate more than 2 lbs. 11 ozs., the gear and bearing assembly is satisfactory for use.

• **NOTICE:** On 8Y engines only, the preload on idler gear is 1/2 to 3 lbs (maximum).

A scale reading which exceeds the specified maximum indicates binding of the bearing rollers or rollers improperly installed. The bearing must be disassembled and inspected. A new spacer may be installed to obtain the proper pre-load (various thickness spacers are available). If necessary, install a new bearing.

 © Detroit Diesel Corporation

Install Idler Gear, Hub And Bushing Assemblies (Front Gear Train)

1. Place the inner thrust washers (grooved side facing gears) and gear hubs in position on the cylinder block. Install the center special drilled bolts, but do not tighten the bolts at this time (Fig. 5).

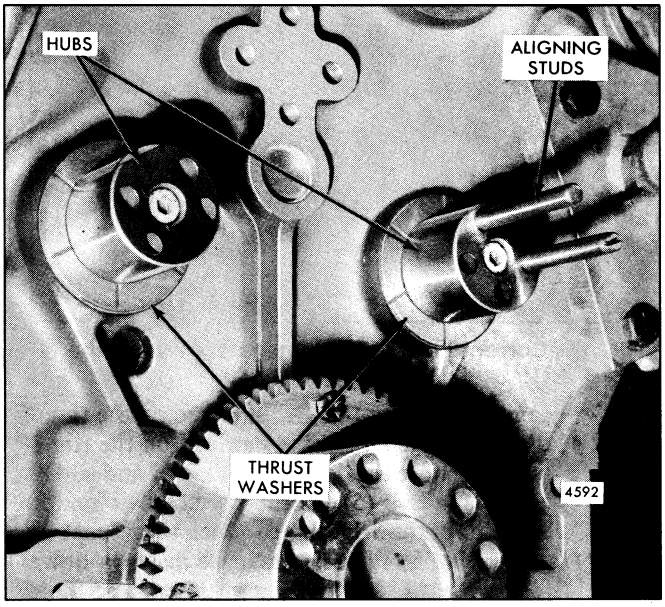


Fig. 5 - Aligning Front Gear Train Idler Gear Hubs

2. Fabricate two (2) aligning studs from two (2) 1/2M—13 x 4-3/4" bolts (cut off the heads of the bolts). Place the aligning studs through the hubs and thread them into the block. Tighten the center bolts to 80-90 lb—ft (108-122 N«m) torque (Fig. 6).

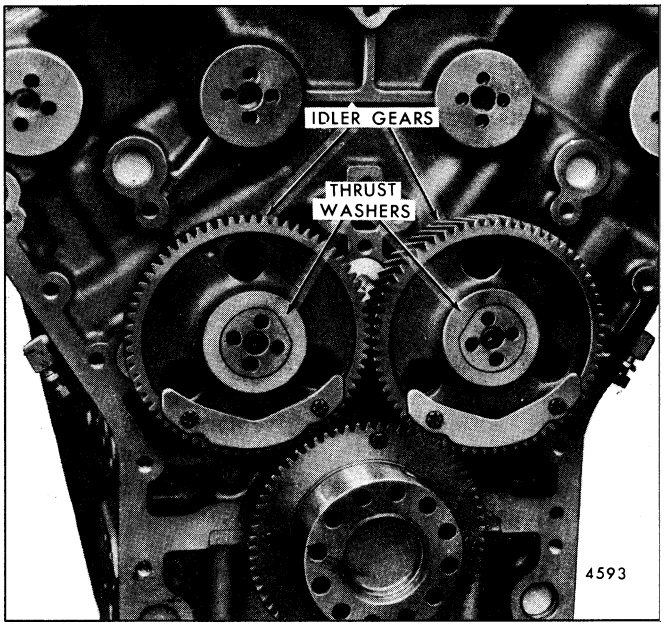


Fig. 6 - Front Gear Train Idler Gears

3. Remove the aligning studs.

4. Refer to Section 1.7.1 for the proper timing of the idler gears.

5. Place the two (2) idler gears (thin idler gear first) over the idler gear hubs. Position the outer thrust washers (grooved side facing gear) over the hubs.

6. Check the backlash between the mating gears. The specified backlash is .0015" to .0080" between new gears and must not exceed .0100" between used gears.

7. Install the front cover (Section 1.3.5).

Install Rear Crankshaft Idler Gear Assembly (Flywheel Housing Removed)

1. If removed, install the idler gear dummy hub; do not tighten the center bolt at this time.

2. Position the crankshaft idler gear, hub and bearing assembly against the block, align the timing marks, as outlined in Section 1.7.1, and install the special drilled center bolt finger tight.

3. Fabricate two (2) aligning studs from 1/2"-13 x4—3/4" bolts (cut off the heads of the bolts).

4. Install the aligning studs through the crankshaft idler gear hub outer bolt holes in the same manner, as shown in Fig. 5 for installing the front idler gear hubs.

5. Tighten the center bolt to 80-90 lb-ft (108-122 N#m) torque. Remove the aligning studs.

6. Install the dummy hub in the same manner, as outlined in Steps 4 and 5.

7. Check the backlash between the mating gears. The specified backlash is .0015" to .0080" between new gears and must not exceed .0100" between used gears.

Install Rear Camshaft Idler Gear Assemblies (Flywheel Housing Removed)

1. Position the camshaft idler gear, hub and bearing assemblies against the block with the timing marks in alignment (refer to Section 1.7.1). Install the special drilled center bolt finger tight. ...

2. Install the four (4) l/2"-13 x 4-3/4" bolts in each camshaft idler gear hub. Tighten the bolts to 71-75 lb-ft (96-102 N#m) torque.

3. Tighten the center bolts to 80-90 lb-ft (108-122 N#m) torque.

4. Check the backlash between the mating gears. The specified backlash is .0015" to .0080" between new gears and must not exceed .0100" between used gears.

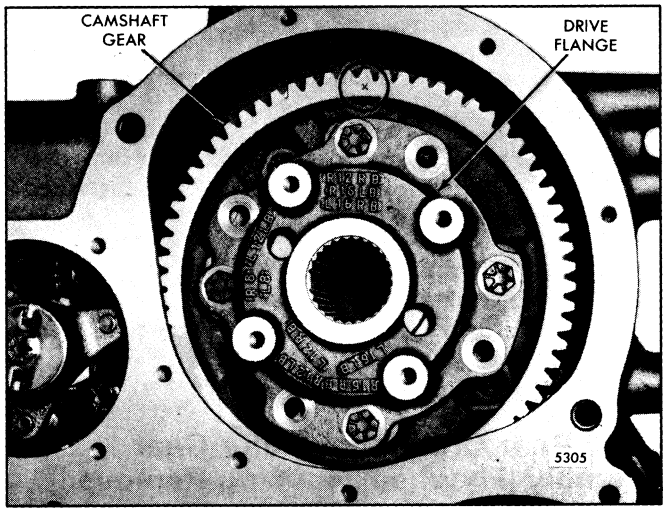


Fig. 7 - Current Right-Bank Camshaft Drive Flange

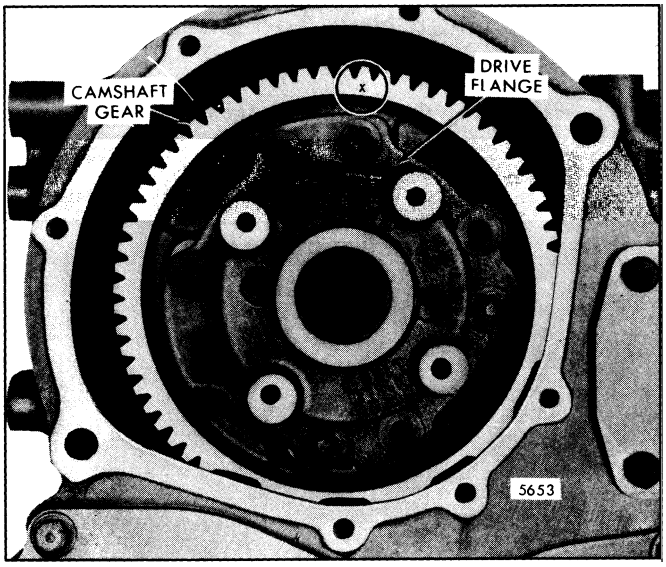


Fig. 8 - Current Left-Bank Camshaft Drive Flange

Install Camshaft Gears (Flywheel Housing Installed)

1. If removed, install the flywheel housing and flywheel (Sections 1.5 and 1.4).

2. Position the camshaft gear, hub and bearing assembly against the block with the timing marks in alignment (refer to Section 1.7.1).

3. Use Locktite #271 on the cam hub retaining bolts and install three (3) 7/161-14 x 1-1/41 self-locking bolts through the camshaft gear and bearing hub and into the block. Tighten the bolts to 60-65 lb—ft (81-88 NSm) torque.

4. Install the opposite gear in the samemanner, as outlined in Steps 2 and 3.

5. Check the backlash between the mating gears. The specified backlash is .0015” to .0080” between new gears and must not exceed .0100” between used gears.

6. Install the camshaft drive flanges on the right-bank and left-bank camshaft gear assemblies, as follows:

CURRENT DRIVE FLANGE

a. Determine engine rotation (as viewed from the front of the engine), number of cylinders and right or left bank camshaft (as viewed from the rear of the engine). Refer to the engine option plate for this information. The current universal drive flange is interchangeable with the former drive flanges and can be installed on either the right-bank or the left-bank camshaft gear.

b. With the gear train in time, locate the sleeve-type dowel which is pressed into the camshaft gear or the “X” stamped on the rim of the gear. A letter “X” is stamped on the rim of the gear above the dowel pin (Figs. 7 and and 8). There are five (5) counterbored holes on the backside of the drive flange which will accept the dowel pin. It will be necessary to mate the dowel pin with the appropriate counterbored hole, identified by the raised letters on the opposite side of the flange.

EXAMPLE - Refer to Fig. 7; “R” indicates right-hand rotation, “12” the number of cylinders and “RB” the right bank camshaft gear assembly.

c. Place a drive flange, with the appropriate counterbored hole in line with the dowel pin or “X”, against the right-bank camshaft gear. Install four (4) 7/16”-20 x 1-1/8” self-locking bolts and tighten them to 57-61 lb—ft (77-83 N#m) torque.

d. Install a drive flange on the left-bank camshaft * gear in the

same manner, as outlined above.

FORMER DRIVE FLANGE

a. The former camshaft drive flanges are stamped on the face of the flange (Fig. 8) to identify their proper location, either on the right-bank camshaft or left-bank camshaft.

EXAMPLE - A flange stamped “LB-RH-12V” must be installed on the left-bank (LB) of a right-hand rotation (RH) 12V engine (Fig. 9).

 © Detroit Diesel Corporation

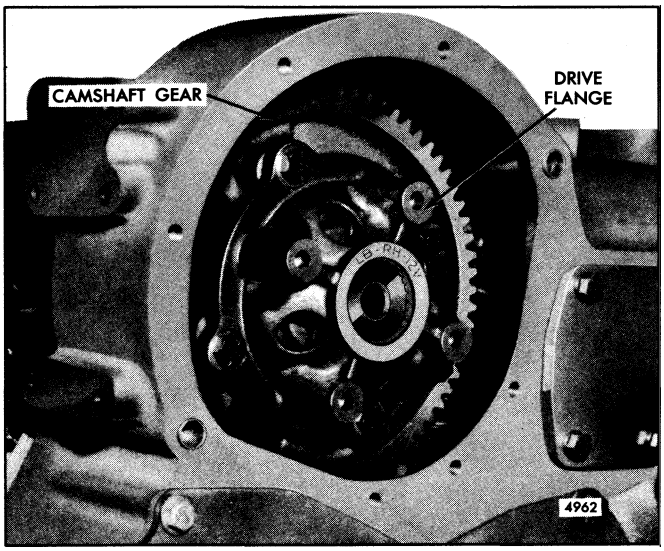


Fig. 9 - Former Camshaft Drive Flange

NOTICE: Do not interchange camshaft drive flanges under any circumstances. Should the drive flanges become installed incorrectly, engine timing would be affected and severe damage to the engine could result.

b. With the gear train in time, place the appropriate drive flange against the camshaft gear. The counterbored hole on the opposite side of the flange will fit over the sleeve-type dowel pin and will be in line with an "X" stamped on the rim of the gear. Install four (4) 7/16"-20 x 1-1/8" self-locking bolts and tighten them to 57-61 lb—ft (77-83 N#m) torque.

c. Install a drive flange on the opposite camshaft gear in the same manner.

7. Align the ommitted spline on the camshaft coupling by rotating the camshaft on the left bank, in alignment with the omitted spline on the drive flange. Carefully position the ommitted spline on the camshaft driveshaft (8.420") throughthe left-bank camshaft drive flange and into the camshaft coupling. Install the short camshaft drive shaft (6.920") in the same manner on the right-bank.

8. Install the retainers and snap rings.

9. Install the camshaft gear flywheel housing covers or accessory drive adaptors (Sections 1.5 and 1.7.7).

CRANKSHAFT TIMING GEARS

Two crankshaft timing gears are located on the crankshaft (Figs. 1 and 2). The rear gear is attached to the flange at the rear of the crankshaft. The front crankshaft gear assembly (gear and bushing) is attached to a damper assembly which is mounted on the flange at the front end of the crankshaft.

Since the camshafts must be in time with the crankshaft, timing marks are located on the rim of the idler gear with corresponding timing marks stamped on the crankshaft gear and camshaft gears (refer to Section 1.7.1).

Remove Crankshaft Rear Timing Gear

1. Remove the flywheel housing (Section 1.5) from the engine.
2. Remove the crankshaft rear oil seal sleeve, if used. To remove the sleeve, peen the outside diameter of the sleeve until it stretches sufficiently so it can be slipped off of the crankshaft.
3. Before removing the crankshaft gear, align the timing marks of the gear train and note their location so the gear can be reinstalled in its original position.
4. Remove the eight twelve-point bolts securing the rear timing gear to the crankshaft.
5. Utilizing the two 7/16”-20 tapped holes in the timing gear, use a suitable push puller and step plate adaptor to remove the gear from the crankshaft.

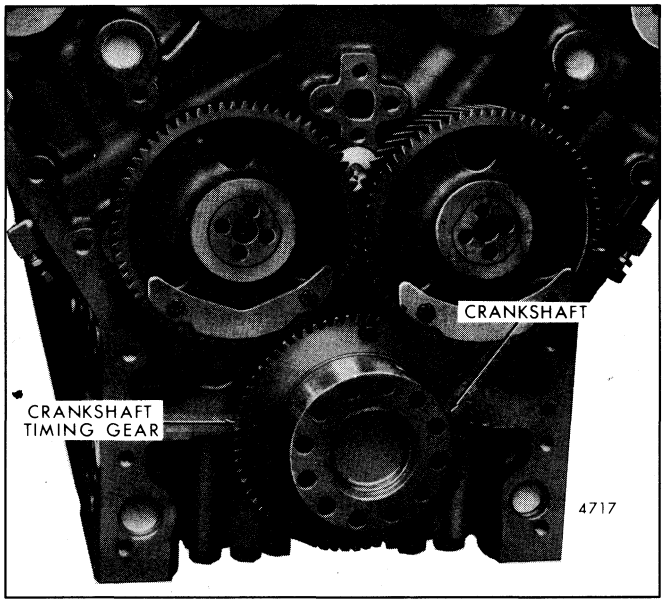


Fig. 1 - Front Crankshaft Timing Gear Mounting

Remove Crankshaft Front Timing Gear And Damper

1. Remove the front cover (Section 1.3.5) from the engine.
2. Remove the four bolts securing the timing gear to the damper and remove the timing gear and bushing assembly from the engine.
3. Remove the four bolts securing the damper to the crankshaft front flange and remove the damper.

Inspection

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

• Wash the gears in clean fuel oil and dry with compressed air. Inspect the gear teeth and the bushing in the front crankshaft gear for wear, pitting or scoring. The clearance between the crankshaft and the bushing in the front crankshaft gear is .001” to .003” with new parts. The inside diameter of a new gear bushing is 6.012” to 6.013”.

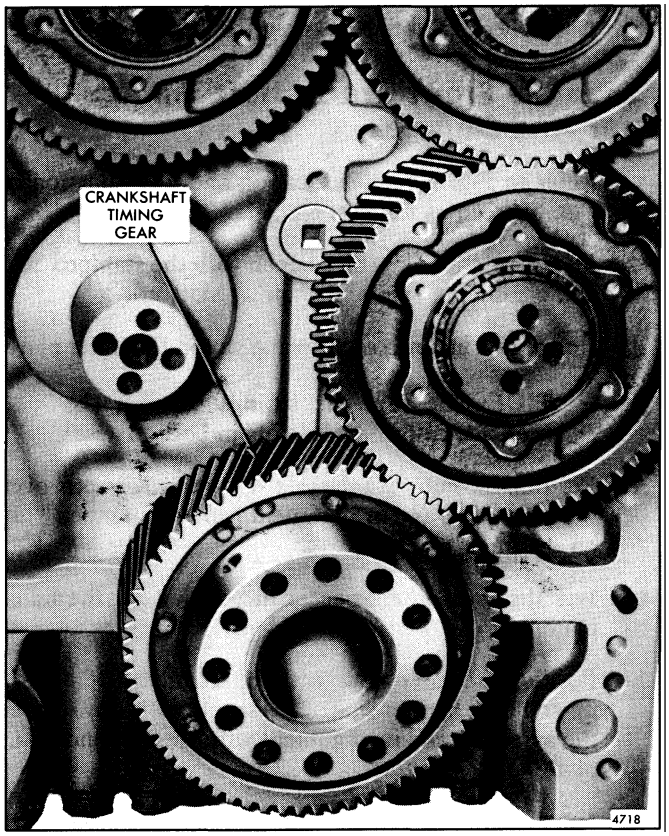


Fig. 2 - Rear Crankshaft Timing Gear Mounting

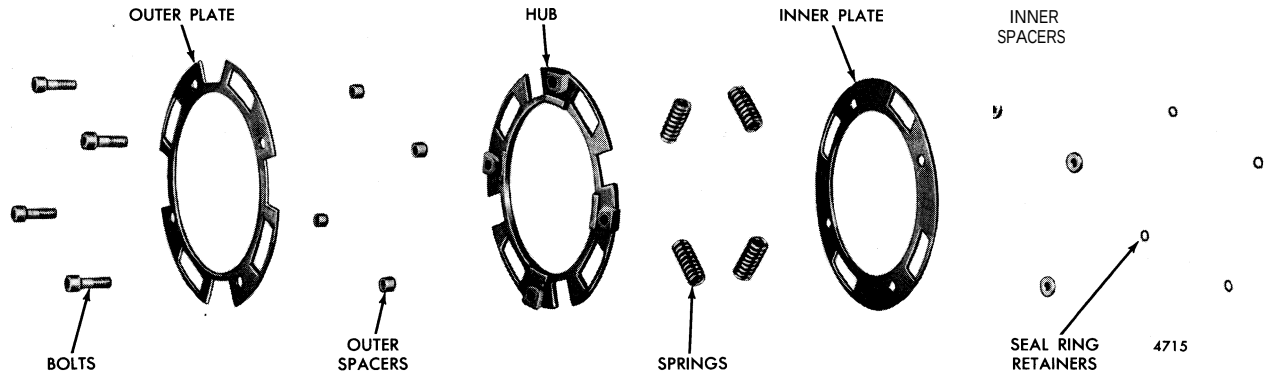


Fig. 3 - Front Timing Gear Damper Details and Relative location of Parts

Clean and disassemble the damper (Fig. 3). Examine the damper springs for pitted or fractured coils. Replace defective springs.

A backing plate (Fig. 3) is used in the current damper assembly in place of four inner spacers. Only the current damper assembly is available for service. However, the spacers will continue to be included in the damper overhaul kit for servicing the former damper assembly.

Also, check the other gears in the gear train.

Assemble Front Crankshaft Timing Gear And Damper

Refer to Fig. 3 for the location and identification of parts and, proceed as follows:

1. Place the inner plate on a bench with the stamped “O” and chamfered side of the spring slots up.
2. Insert a spring into each spring slot in the inner plate.

   NOTICE: Be sure the springs seat on the *chamfer side* of the spring slots in both plates.

3. Position the hub with the cast “O” up and directly over the inner plate and in alignment with the stamped “O” on the inner plate.
4. Lay the four outer spacers in position on the inner plate.
5. Position the outer plate, with the stamped *0” or “X” up and the chamfer side of the spring slots down, over the assembly and in alignment with the hub and inner plate.

   NOTICE: All three timing marks must coincide with each other.

6. Insert the four socket head bolts through all three plates and position the assembly upside down on the bench.
7. Install the backing plate or four inner spacers (counterbore up) over the bolts.
8. Secure the backing plate or inner spacers in position with the four seal ring retainers.

   NOTICE: Be sure the seal ring retainers are seated in the counterbores of the backing plate or inner spacers.

Install Crankshaft Front Timing Gear And Damper

Refer to Section 1.7.1 for position of the gear train timing marks and, proceed as follows:

1. Position the damper assembly up against the front crankshaft flange and thread the bolts into the crankshaft Aange. Tighten the bolts to 35-39 lb—ft (47-53 Ntm) torque.
2. Position the front timing gear and bushing assembly over the crankshaft front hub and up against the damper assembly. Secure the timing gear to the damper assembly with four bolts. Tighten the bolts to 35-39 lb-ft (47-53 N#m) torque.
3. Install the engine front cover. Refer to Section 1.3.5.
4. Check the backlash with the mating gear. The backlash should be .0015” to .008” with new gears or .010” maximum with used gears.

 © Detroit Diesel Corporation

Install Crankshaft Rear Timing Gear

Refer to Section 1.7.1 for position of the gear train timing marks and, proceed as follows:

1. Position the crankshaft rear timing gear over the crankshaft rear hub and up against the crankshaft flange.
2. Secure the timing gear to the crankshaft flange using eight twelve-point bolts. Tighten the bolts to 35-39 lb—ft (47-53 N*m) torque.

• 3. On former engines without rear outboard bearing supports install a new crankshaft rear oil seal sleeve, if required, as outlined in Section 1.3.2.

#4. Install the flywheel housing (Section 1.5). On current engines the rear oil seal sleeve is incorporated into the flywheel.

BLOWER DRIVE GEAR AND SUPPORT ASSEMBLY

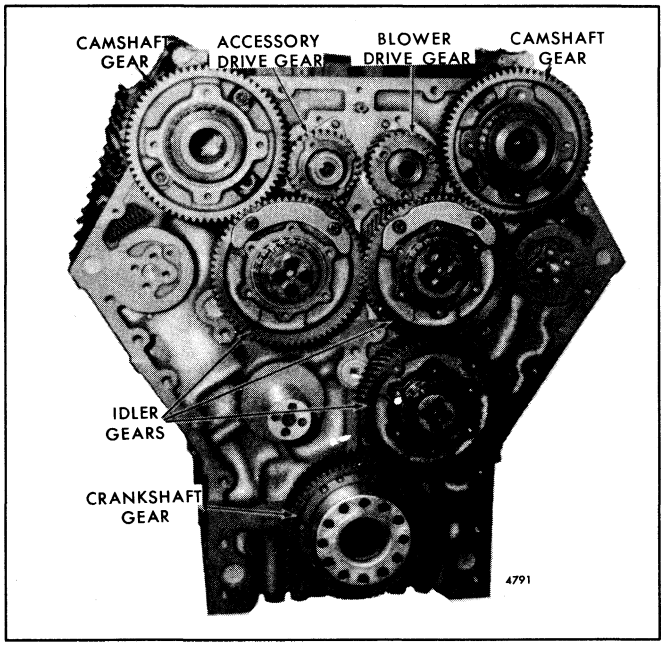


Fig. 1 - Blower Drive Gear Mounting

The blower drive gear and support assembly is mounted at the rear of the engine (Fig 1). The assembly consists of a blower drive gear and bushings, blower drive gear support hub, thrust washers, lock washer and nut (Fig. 2). The fuel pump drive coupling disc is bolted to the blower drive shaft.

The blower drive shaft is splined and drives the blower at approximately twice engine speed through a flexible coupling attached to the right-hand helix blower timing gear (Table 1). The other end of the shaft is splined also and is driven by the inner splines of the blower drive gear hub which is bolted to the blower drive gear through a flexible plate.

ENGINES	RATIO BLOWER TO ENGINE SPEED	NO. TEETH IN BLOWER DRIVE GEAR
12 and 16V Naturally Aspirated or Turbocharged	t2.06:l (16V)	30 33
'8V,*12V and 16V Turbo Intercooled TV8401 (8V-16V) TV7101 (12V) or TV8115 (16V)	2.06:1	33 -
12 and 16V Turbocharged Intercooled T18A40	2.26:1 (12V) 2.06:1 (16V)	30 33
* Effective with 12E-5873 and 16E-5426. fHigh efficiency - 16V turbocharged.		

TABLE 1

Lubrication

The blower drive support bushings are pressure lubricated through oil passages in the cylinder block and blower drive support. Excess oil drains back to the crankcase by way of the gear train.

Remove Blower Drive Gear And Support Assembly

The blower drive gear and support assembly may be removed from the engine with or without the flywheel housing installed.

To remove the blower drive gear and support assembly without removing the flywheel housing, refer to Fig. 2 and proceed as follows:

1. Remove the inspection cover from the rear air box cover plate.
2. Loosen the 12V hose clamps between the rear blower and the blower drive support. Loosen the retainer clip and slide the tube connection into the blower (8V) or rear blower (16V).
3. Slide the hose onto the rear blower (12V and 16 V) or the blower (8V).
4. Remove the fuel lines from the fuel pump. Then remove the pump and adaptor from the flywheel housing (Section 2.2).
5. Remove any accessory from the right bank camshaft and cover (tachometer drive, overspeed governor or accessory drive).
6. Remove the right camshaft drive gear cover.
7. Turn the crankshaft until the timing marks are in line on the camshaft drive gear and the idler gear.
8. Remove the snap ring and retainer from the camshaft drive flange.
9. Remove the cam drive shaft and camshaft drive flange.
10. Remove the camshaft drive gear.
11. Remove the 3/8”-24 x 1” self-locking bolt securing the fuel pump coupling disc to the blower drive shaft. Remove the pump coupling disc.
12. Remove the snap ring from the blower drive coupling hub. Then, thread a 3/8”-24 bolt into the end of the blower drive shaft and withdraw the shaft from the blower drive gear support assembly.
13. Remove the three (3) 7/16”-20 x 7/8” self-locking bolts and remove the spring plates and blower drive coupling hub.

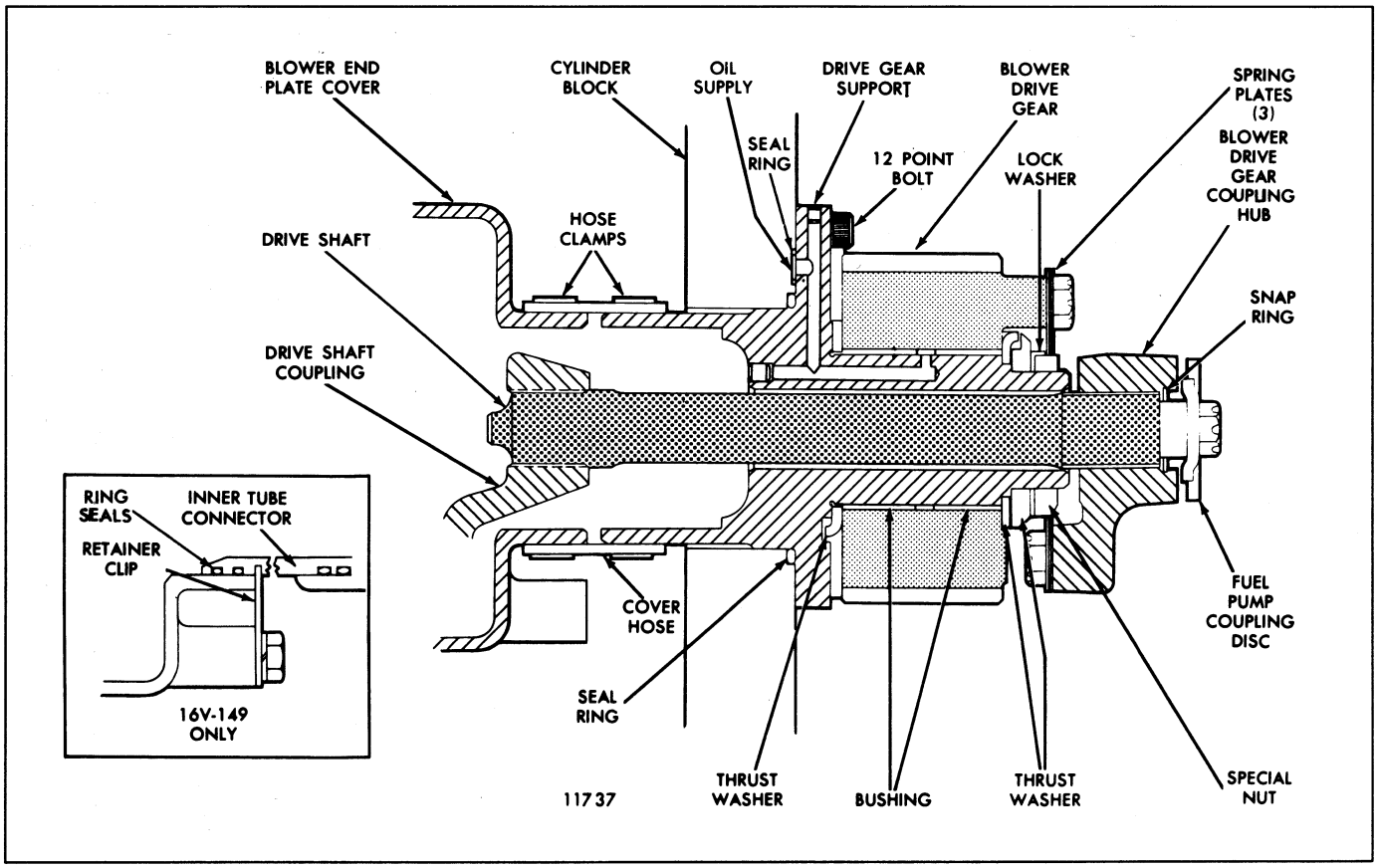


Fig. 2 – Blower Drive Support Assembly

14. Bend back the tabs of the lock washer and remove the nut, lock washer and thrust washers securing the blower drive gear on the hub with socket J 23641.

15. Remove the blower drive gear and remaining thrust washer. Be careful not to drop any of the parts into the flywheel housing.

16. Remove the three (3) 12-point bolts securing the blower drive support to the cylinder block.

17. Pull the blower drive support through the right bank camshaft gear opening in the flywheel housing. Discard the seal ring and the "O" ring located in the counterbore of the block at the oil supply hole.

Inspection

Clean all of the parts with fuel oil and dry them with compressed air.

CAUTIONrTo prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Be sure that the oil passage in the blower drive gear support is clean. Sludge accumulations, which might restrict the oil flow, must be removed.

Examine the faces of the gear thrust washers. The thickness of a new gear thrust washer is . 1190" to .1210". Replace excessively scored or worn parts.

Check the inside diameter of the blower drive gear bushings for wear. Also, check the outside diameter of the support hub. The inside diameter of new bushings is 1.877" to 1.878". The clearance between the bushings and support should be .001" to .0025" with new parts and a maximum of .005" with used parts. Install new parts whenever the *clearance* exceeds *the maximum.*

Current 12V and 16V turbocharged and intercooled engines use a nitrided hardened blower drive gear (33 teeth) and right-hand idler gear (68 teeth). Both gears are identified by the grayish color taken on by the hardening process. When replacing the former gear or its mating idler gear in the 12V or 16V turbocharged intercooled engines, both gears must be replaced at the same time with the new hardened gears.

Examine the teeth of the blower drive gear for evidence of scoring, pitting or wear. Replace the gear, if necessary.

 © Detroit Diesel Corporation

Assemble Blower Drive Gear And Support Assembly

After inspection, assemble the blower drive gear and support assembly as follows:

1. With the blower drive support clamped in the soft jaws of a bench vise, position the inner blower drive gear thrust washer on the support so that the tangs on the thrust washer register with the holes in the support.

2. Lubricate the hub of the support, the bushings in the gear, both thrust washers and the blower drive gear support thrust washer with clean engine oil.

3. Slide the gear on the hub with the flat side of the gear down.

4. Install the second thrust washer on the support with the tangs on the washer facing up (brass side toward the gear).

5. Position the blower drive support thrust washer on the support so that the slots in the thrust washer register with the tangs on the blower drive gear thrust washer.

6. Place the lock washer on the support and against the thrust washer with the small tang in the slot on the thrust washer. Install the locknut and tighten it to 50-60 lb—ft (68-81 N#m) torque and bend the tabs on the lock washer against the flats on the nut to secure the nut.

7. Check the clearance between the blower drive gear support thrust washer and the blower drive gear thrust washer (Fig. 3). The clearance should be .002"-.018".

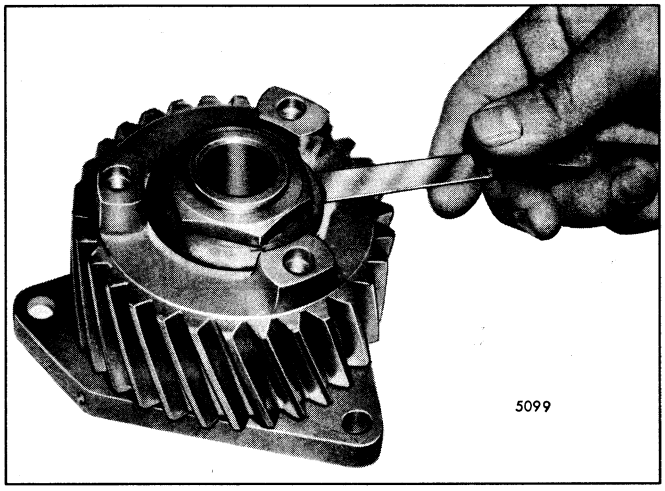


Fig. 3 - Checking End Play

Install Blower Drive Gear And Support Assembly

After the clearances have been obtained, disassemble the blower drive gear and support in order to reinstall the assembly (with the flywheel housing installed).

• 1. Install a new “O” ring in the counterbore of the block at the oil supply hole and a new seal ring on the blower drive support. Then, slip the blower drive gear support through the opening in the flywheel housing of the right bank camshaft gear and attach the support to the cylinder block with three (3) 12-point 3/8”-16 bolts. Coat bolts with Loctite #271 locking compound before installing. Tighten the bolts to 50-55 lb—ft (68-75 N#m) torque.

2. Install the thrust washers, gear, lock washer and nut as described in *Assembly Blower Drive Gear and Support Assembly.*

3. Position the blower drive spring plate and blower drive hub assembly on the blower drive gear and secure it with three (3) 7/16”-20 x 7/8” self-locking bolts. Tighten the bolts to 57-61 lb—ft (77-83 N#m) torque. Then, install the blower drive shaft and snap ring.

• 4. Check the backlash between the blower drive gear and the idler gear. Backlash should be .0015” to .008” with new parts and should not exceed .010” with used parts.

5. Install the fuel pump drive disc and tighten the 3/8”-24 x 1” self-locking bolt to 50-55 lb-ft (68-75 N#m) torque.

6. Install the fuel pump adaptor and the fuel pump (Section 2.2).

7. Slide the hose from the rear blower onto the blower drive support on the 12V engine. Tighten the hose clamps. On the 8 V and 16V engines, slide the inner tube connector into the blower drive support and tighten the retaining clip bolt.

8. Install the camshaft gear and drive flange (Section 1.7.3).

9. Install the cam drive cover and any accessory which may have been removed.

DUAL BLOWER DRIVE SYSTEM - HYDROFRACTURING UNITS

A new double-shaft drive system has been released to provide direct (shaft) drives to the rotors of both blowers used in Series 149 hydrofracturing units and certain marine applications (Fig. 4). Use of the dual drive system on these engines helps reduce and balance the stresses imposed on all blower drive components. This, in turn, results in increased blower drive component life and more trouble-free blower operation. Should either rear blower drive shaft break, the blower will continue to operate until the engine can be safely shut down.

Double Blower Drive Shaft Installation

1. Remove both blower assemblies from the engine.
2. Remove the inter-block cup plugs from the blower drive coupling hole on the left side of the front and rear block.
3. Place a shop rag dipped in solvent on the end of a small screwdriver to aid in removal of carbon and clean the inter-block O-ring (air) seal groove. Clean the groove well. A clean groove will make it easier to install the inter-block O-ring seal.
4. Lubricate the O-ring (air) seal and the groove with a silicone spray grease or similar lubricant, then install the seal. Start at the top and press the seal into the groove, working to the bottom. An “inchworm” of extra O-ring will form at the bottom. Work the O-ring

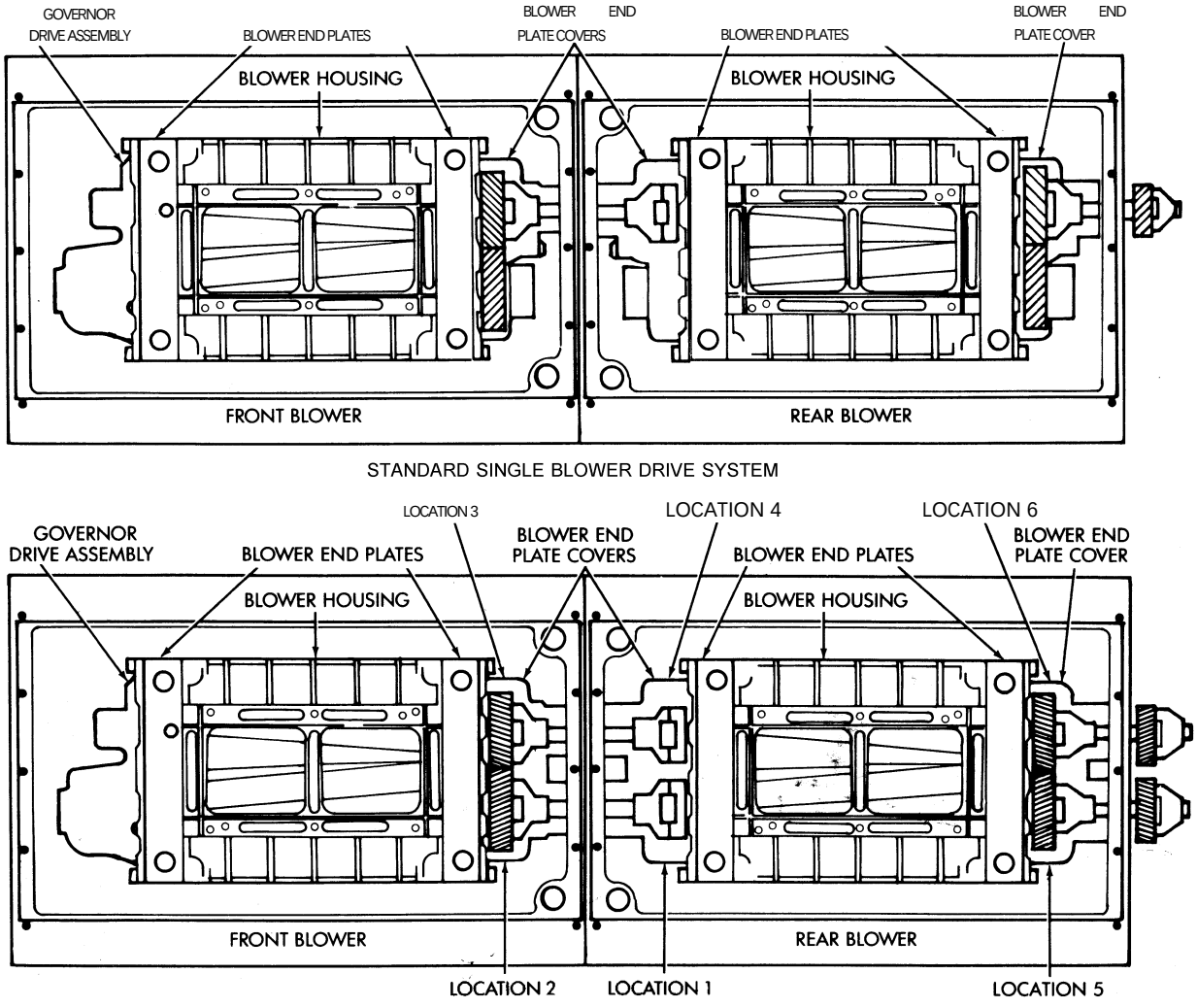


Fig. 4 - Single and Dual Blower Drive Systems

 © Detroit Diesel Corporation

around and up from the bottom until the "inchworm" disappears and the seal fits uniformly in the groove.

5. Remove the three end plate covers from the two blowers.

6. Rebuild the rear blower with the new left-side rotor assembly (see Section 3.4). Install a blower rotor coupling hub on the front of both left and right rotor shafts.

7. Refer to Fig. 1 and install new hubs, flex plates and bolts at locations 1, 2, 5 and 6.

8. Fabricate a blower alignment fixture (Fig. 5) and secure both blowers to the fixture. Install an intermediate blower drive shaft on the left side. Position blowers to achieve alignment and spacing, simulating engine installation.

9. Install the right-side intermediate blower drive shaft and flex plates as follows:

   a. Assemble a hub, spring plates (3) and bolts (3). Insert bolts through the holes (not slots) in the spring plates and tighten to 57-61 lb—ft (77-83 N»m) torque. Make sure the slots in all 3 flex plates line up.

   b. Place the hub and plate assembly in position at location 4 and install the right-side intermediate drive shaft. Obtain shaft-to-hub spline engagement at locations 1, 2, 3 and 4.

   c. Install the three flex plate-to-coupling hub attaching bolts. If bolts cannot be installed, disengage the drive shaft splines by sliding the right-side shaft forward and rotating the hub and plate assembly at location 4 approximately 120°. Do not rotate the blower rotors. Reengage the splines and install the bolts. If still unsuccessful, rotate the hub and plate assembly andother 120° in the same direction. If bolts still cannot be installed, disassemble the hub and plate assembly, turn the plates over and reassemble (see Step a). Repeat Step c until the slots in the spring plates line up and flex plate-to-coupling hub bolts can be installed by hand. Tighten bolts to 57-61 lb—ft (77-83 N#m) torque.

   d. After assembly, right and left intermediate drive shafts should be free to slide fore and aft by hand. Loosen bolts and retorque as necessary to achieve this condition.

   e. Paint the right-side shaft with oil-resistant yellow paint for identification.

   f. Remove the composite assembly of parts from the blower alignment fixture and complete the assembly of the blower by adding the end plate covers, clips, etc.

10. Remove the left-bank camshaft gear, accessory drive assembly and right-side blower drive gear from the engine. Blower drive gear removal is not absolutely necessary, but aids in installation of the new left-side blower/accessory drive gear.

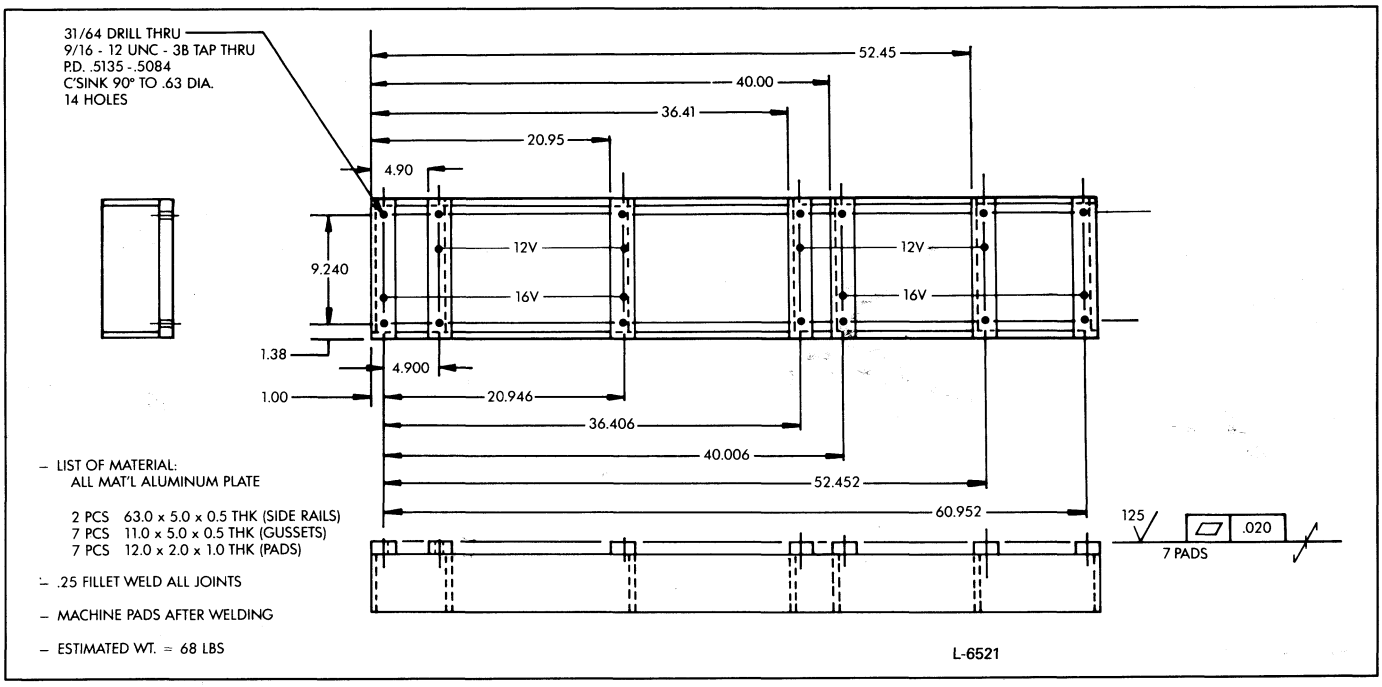


Fig. 5 – Blower Alignment Fixture

11. Assemble the new left-side accessory/blower drive hub and standard flex plates.

12. Position this assembly in the accessory drive hole on the left side. Let it stick out of the flywheel housing as far as possible.

13. Pack the flywheel housing under the accessory/blower drive position with shop rags to catch bolts in case they are dropped. Installation of the accessory/blower drive assembly may be difficult because of limited access to the three (3) bolts which hold the support to the block.

• 14. Install the left-side accessory blower drive assembly. (The extension is not installed yet). Position the three (3) flex plate bolt locations on the gear as accurately as possible in the relief areas of the flywheel housing. Be sure to install the two (2) blower drive support seals. Coat the accessory/blower drive assembly mounting bolts with Locite #271 locking compound and tighten to 50-55 lb—ft (68-75 N*m) torque.

15. Bolt the hub/flex plate assembly (Step 11) to the gear. If necessary to bar the engine over, be sure to install the left bank camshaft gear first. Use a 3/8" drive regular socket and an extension on the flex plate bolts. Tighten the bolts to 57-61 lb—ft (77-83 N*m) torque.

16. Install the blower drive gear support extension and O-ring seal.

17. Reinstall the left bank cam gear if this was not done in Step 15.

18. Reinstall the right-side blower drive gear without flex plates or drive hub if it was removed in Step 10.

19. Install the blowers and extension tubes. Make sure the right intermediate shaft is installed on the right side. Make sure there are extension tubes on both sides.

20. Install the left-side rear blower drive shaft and retaining hardware.

21. Install the right-side rear blower drive shaft, spring plates, hub, etc., as follows:

a. Assemble the hub, spring, plate and 7/16-20 x 7/8 bolt. Tighten the bolt to 57-61 lb—ft (77-83) N»m) torque. Assemble the RR blower drive shaft, retaining ring, fuel pump drive disc and 3/8-24 x 1 bolt. Tighten the bolt to 50-55 lb—ft (68-75) N*m) torque. Bolts are to be placed thru holes (not slots) in spring plates. Check that slots in all three plates line up.

b. Install the hub, plate and shaft assembly on the engine, engaging the blower hub splines and positioning the slots in the spring plates in line with bolt holes in the right-side blower drive gear. Install the remaining bolts (3). If the bolts cannot be installed, disengage the blower splines by sliding the hub, plate and shaft assembly rearward and rotate the assembly approximately 120°. Reengage the splines and install the bolts. If still unsuccessful, rotate the hub, plate and shaft assembly another 120° in the same direction as previously.

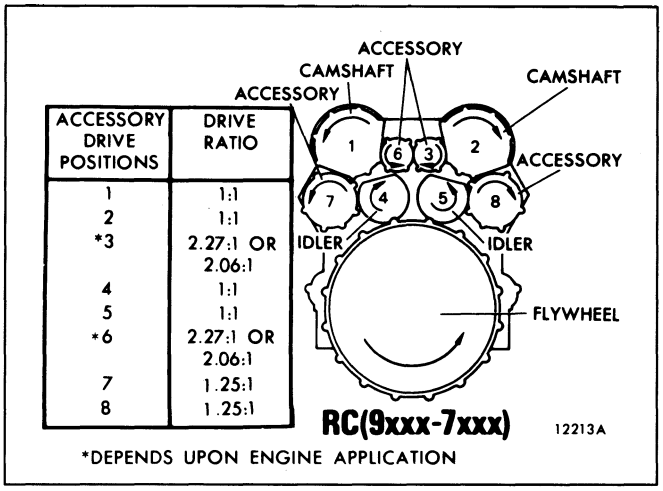
c. Reengage splines and install the bolts.

d. If still unsuccessful, remove the spring plates from the hub, plate and shaft assembly. Turn the plates over and reassemble. Repeat Steps b and c until slots in the spring plate line up with the bolt holes in the left-side blower drive gear and the bolts can be installed by hand. Tighten the bolts to 57-61 lb—ft (77-83 N«m) torque.

22. This completes double blower drive installation. Complete engine assembly by adding air system, fuel pump, alternator, etc.

 © Detroit Diesel Corporation

ACCESSORY DRIVES



ACCESSORY DRIVE POSITIONS	DRIVE RATIO
1	1:1
2	1:1
*3	2.27:1 OR 2.06:1
4	1:1
5	1:1
*6	2.27:1 OR 2.06:1
7	1.25:1
8	1.25:1

Fig. 1 – Accessory Drive Location

Accessory drives have been provided at the rear of the engine to accommodate both gear driven and belt driven accessories.

For the possible accessory drive locations, drive ratios and rotation of the drive at a particular position, refer to Fig. 1.

The drive for direct gear driven accessories, such as an air compressor or hydraulic pump, is flange mounted on the flywheel housing and is driven through a drive plate which is bolted to the camshaft gear drive flange and a drive coupling which is splined to both the drive plate and a drive hub which is keyed to the accessory drive shaft.

For a belt-driven accessory, a drive shaft is used in place of a drive coupling. One end of the drive shaft is splined to the drive plate with the opposite end supported by a bearing in the accessory drive retainer. The retainer is bolted to the accessory drive adaptor which in turn is bolted to the flywheel housing. An oil seal is pressed into the retainer to prevent oil escaping from the flywheel housing. A drive pulley is keyed to the outer end of the drive shaft and retained by a lock nut.

NOTICE: When an accessory drive gear is installed in positions 7 and/or 8 (Fig. 1), an external oil supply tube must be installed to provided proper lubrication to the gear(s). Failure to supply adequate lubrication can result in drive gear bearing damage.

Remove Accessory Drive

Remove the accessory drive (Figs. 2 and 3) used with a direct-drive accessory as follows:

1. Disconnect any external piping or hoses at the accessory.
2. Remove the bolts and lock washers securing the accessory to the flywheel housing. Pull the accessory straight out from the flywheel housing. Remove the gasket.
3. Remove the drive coupling.
4. Place a clean cloth in the flywheel housing opening (under the accessory drive plate) to prevent bolts from accidentally falling into the gear train. Then remove the four bolts (and lockwashers, if used) and withdraw the accessory drive plate.

Remove the accessory drive for a belt-driven accessory (Fig. 4) as follows:

1. Loosen the accessory mounting or adjusting bolts and remove the drive belts.
2. Remove the nut which retains the drive pulley on the accessory drive shaft.

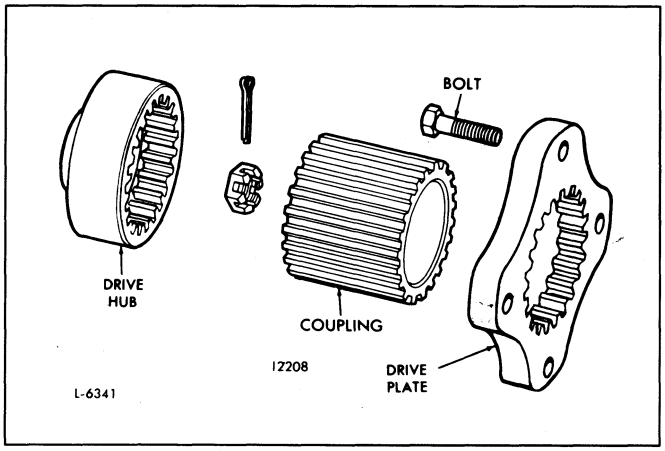


Fig. 2 – Air Compressor Drive

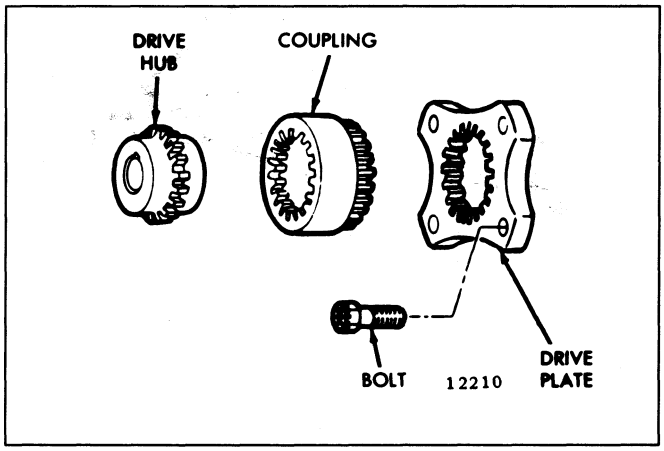


Fig. 3 - Hydraulic Pump Drive

3. Use a suitable gear puller and withdraw the pulley from the shaft. Remove the the key from the shaft.

4. Remove the bolts and washers and withdraw the accessory drive retainer assembly from the adaptor. Remove the gasket.

5. Remove the accessory drive shaft from the retainer.

6. Place a clean cloth in the flywheel housing opening (under the accessory drive plate) to prevent bolts from accidentally falling into the gear train. Then remove the four bolts and withdraw the drive plate.

7. Remove the snap ring and oil seal from the retainer, then press the bearing from the retainer.

Inspection

Wash all of the parts, except the bearings, with fuel oil and dry them with compressed air. The shielded type bearings cannot be washed because of the difficulty in draining out all of the solvent.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Inspect the bearings for rough spots by holding the inner race and revolving the outer race slowly by hand. Any indication of rough spots is sufficient cause for rejection of a bearing. Replace excessively worn or damaged parts.

Install Accessory Drive

Install accessory drive (direct drive) as follows:

1. Align the bolt holes in the accessory drive plate with the tapped holes in the camshaft gear. Then secure the drive plate with the four bolts (and lock washers, if used). Tighten the bolts to 45-50 lb—ft (61-68 N*m) torque.

2. Install the drive coupling.

3. Use a new gasket and position the accessory in place against the flywheel housing. Rotate it to align the teeth of the drive coupling with those in the drive hub. Then secure the accessory to the flywheel housing with bolts and lock washers.

Install accessory drive (belt driven) as follows:

1. Place the accessory drive retainer on a bench with the mounting flange side up. Lubricate the outside diameter of the bearing with engine oil, then press or tap it (with the protruding face of the inner race toward the retainer) straight in until it contacts the shoulder in the retainer. Then install the snap ring.

2. Turn the retainer over and coat the bore with sealant. Then press a new oil seal, if required, into the bore of the retainer with the lip of the seal facing the bearing. Wipe any excess sealant from the retainer.

3. Turn the retainer over again, bearing side up, lubricate the drive shaft and press it in the bearing until the shoulder on the shaft contacts the bearing.

4. Position the drive plate in the flywheel and install the four bolts (and lock washers, if used). Tighten the bolts to 35-39 lb—ft (47-53 N*m) torque.

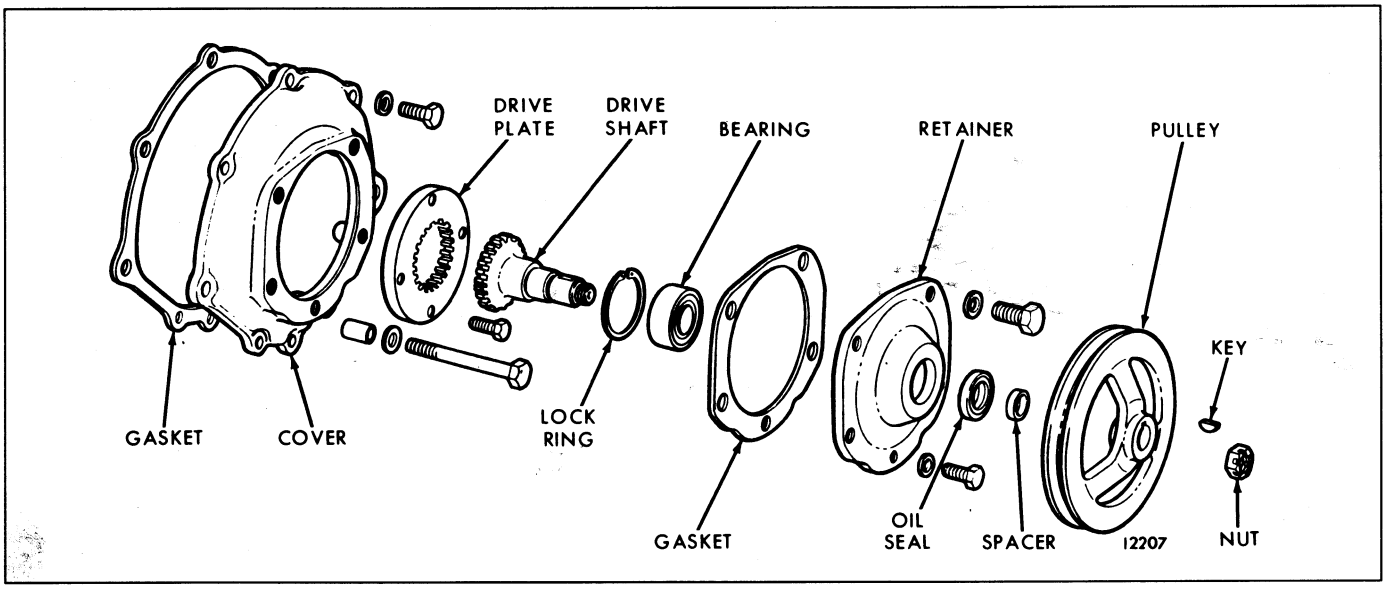


Fig. 4 – Accessory Drive (Belt–Driven)

 © Detroit Diesel Corporation

5. Affix a new gasket to the mounting flange on the retainer. Then position the retainer and shaft assembly against the flywheel housing; rotate the shaft slightly, if necessary, to permit the teeth of the shaft to mesh with the teeth in the accessory drive plate. Secure the retainer to the flywheel housing with five bolts and lock washers. Tighten the bolts to 45-50 lb—ft (61-68 N-m) torque.

6. Install the key on the shaft. Then start the pulley on the shaft and tap it into place. Install the 3/4"-16 retaining nut. Tighten the nut to 120-140 lb—ft (163-190 N-m) torque.

7. Slip the drive belts over the pulleys. Then position the accessory to provide the proper tension on the belts and secure it in place.

CAUTION:When installing or adjusting an accessory drive belt, be sure the bolt at the accessory adjusting pivot point is properly tightened, as well as the bolt in the adjusting slot.

ALTERNATOR DRIVE GEAR AND SUPPORT ASSEMBLY

The alternator drive gear and support assembly is mounted at the rear of the engine. The inner assembly consists of a drive gear and bushings, drive gear support, thrust washers, lock washer and nut (Fig. 5). The drive coupling is bolted to the drive gear.

The outer alternator drive assembly is bolted to the flywheel housing. The assembly consists of a drive pulley, housing, shaft, bearing, oil seal and a drive hub keyed to the drive shaft. The drive hub and the drive coupling are coupled by a drive disc.

Lubrication

The drive support bushings are pressure lubricated through oil passages in the cylinder block and drive support. Excess oil drains back to the crankcase by way of the gear train.

Remove Alternator Drive Gear And Support Assembly

The drive gear and support assembly may be removed from the engine with or without the flywheel housing installed.

To remove the inner drive gear with the flywheel housing installed, the left bank camshaft gear and drive flange will have to be removed (Section 1.7.3). This will allow removal of the drive gear support through the camshaft gear opening in the flywheel housing.

1. Loosen four 3/8"—16 x 1 1/4" bolts and remove the outer drive assembly and gasket from the flywheel housing. Discard the gasket.

2. Remove the coupling disc from the coupling.

3. Loosen four 5/16"—18 x 1 3/4" bolts and remove the drive coupling from the drive gear.

4. Bend back the tabs of the lock washer and remove the nut and lock washer securing the drive gear on the support hub.

5. Remove the drive gear and thrust washers.

CAUTION: Be careful not to drop any of the drive gear support parts in the flywheel housing.

6. Loosen three 3/8"-16 x 1 1/4" bolts and remove the inner drive gear and support assembly from the cylinder block. Remove and discard the seal ring. Also remove and discard the “O” ring in the counterbore of the block at the oil supply hole.

7. Clamp the gear and support in a vise and remove the gear from the support hub.

Disassemble Outer Drive Assembly

1. Remove the pulley retaining nut. Then remove the pulley and the key from the shaft.

2. Remove the oil seal spacer.

3. Press the shaft from the hub and remove the key from the shaft.

4. Remove the lock ring and bearing from the housing.

5. Press the oil seal from the housing with a suitable tool. Discard the oil seal.

Inspection

Clean all of the parts with fuel oil and dry them with compressed air.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

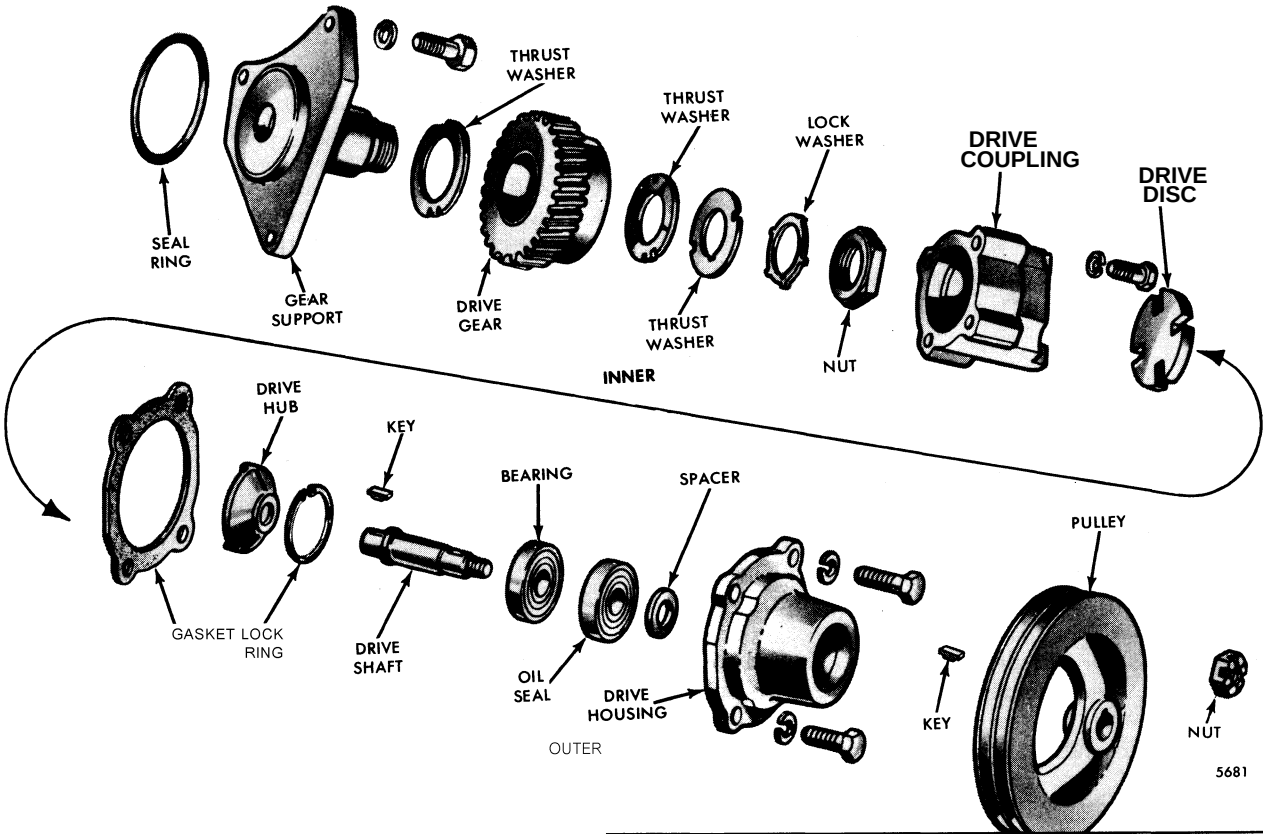


Fig. 5 - Alternator Drive Support Assembly

Replace excessively worn or damaged parts. Be sure that the oil passage in the drive gear support is clean. Sludge accumulation, which might restrict the oil flow, must be removed.

Inspect the ball bearing used to support the drive shaft. *Shielded bearings must not be washed,* dirt may be washed in and the cleaning fluid could not be entirely removed from the bearing. Wipe the outside of the bearing clean, then hold the inner race and revolve the outer race slowly by hand. If the bearing is worn or does not roll freely, replace it.

Examine the faces of the gear thrust washers. The thickness of a new gear thrust washer is .1190” to .1210”. Replace excessively scored or worn parts.

Check the inside diameter of the drive gear bushings for wear. Also check the outside diameter of the support hub. The inside diamter of new bushings is 1.877” to 1.878”. The clearance between the bushings and support should be .001” to .0025” with new parts and a maximum of .005* with used parts. Install new parts whenever the clearance exceeds the maximum.

Examine the teeth of the drive gear for evidence of scoring, pitting or wear. Replace the gear if necessary.

Assemble Alternator Drive Gear And Support Assembly

After inspection, assemble the drive gear and support assembly (Fig. 5) as follows:

1. With the drive support clamped in the soft jaws of a bench vise, position the inner drive gear thrust washer on the support so that the tangs on the thrust washer register with the holes in the support.

2. Lubricate the hub of the support, the bushings in the gear, both thrust washers and the drive gear support thrust washer with clean engine oil.

3. Install the gear on the hub with the flat side of the gear down.

4. Install the second thrust washer on the support with the tangs on the washer facing up (brass side toward the gear).

5. Position the drive support thrust washer on the support so that the slots in the thrust washer register with the tangs on the drive gear thrust washer.

 © Detroit Diesel Corporation

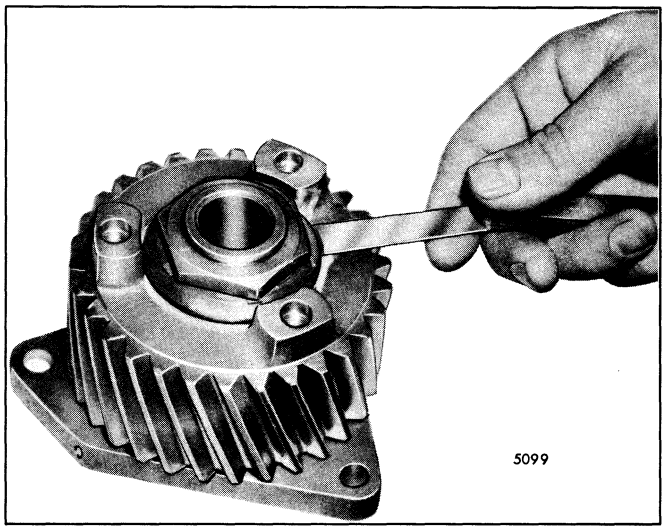


Fig. 6 – Checking End Play

6. Place the lock washer on the support and against the thrust washer with the small tang in the slot on the thrust washer. Install the lock nut and tighten it to 50-60 lb—ft (68-81 N-m) torque and bend the tabs on the lock washer against the flats on the nut to secure the nut.

7. Check the clearance between the drive gear support thrust washer and the drive gear thrust washer. The clearance should be ,002”-.018” (Fig. 6).

Install Drive Gear And Support Assembly

After the clearances have been obtained, disassemble the drive gear and support in order to reinstall the assembly (with the flywheel housing installed).

• 1. Install a new “O” ring in the counterbore of the block at the oil supply hole and a new seal ring on the drive support. Then slip the drive gear support through the opening in the flywheel housing of the left bank camshaft gear and attach the support to the cylinder block with three 3/8”-16 x 1 1/4” bolts. With Locite #271 locking compound applied to bolts, tighten the bolts to 30-35 lb—ft (41—47 N-m) torque.

2. Install the thrust washers, gear, lock washer and nut as described in *Assemble Alternator Drive Gear and Support Assembly.*

3. Check the backlash between the drive gear and the idler gear. Backlash should be .003” to .008” with new parts and should not exceed .010” with used parts*

4. Position the drive coupling on the drive gear and secure it with four 5/16”—18 x 1 3/4” self-locking bolts. Tighten the bolts to 13-17 lb—ft (18-23 N-m) torque.

5. Install the camshaft gear and drive flange (Section 1.7.3).

Assemble Outer Drive Assembly

1. Install the key in the hub end of the drive shaft. Lubricate the shaft and press the hub against the shoulder on the shaft.

2. Use a suitable tool and press a new oil seal in the drive housing.

3. Install the bearing and spacer in the drive housing, then install the lock ring.

4. Use a sleeve to support the inner race of the bearing, lubricate the shaft and press the hub and shaft assembly in the bearing until the shoulder on the shaft contacts the inner race of the bearing.

5. Install a key in the pulley end of the shaft. Lubricate the shaft and press the pulley on the shaft until it contacts the inner face of the oil seal spacer.

6. Install the 3/4”—16 pulley retaining nut and tighten it to 120-140 lb—ft (163-190 N-m) torque.

7. Place a new gasket on the mounting flange of the drive housing.

8. Place the slotted drive disc on the hub of the drive assembly. Then align the slots in the disc with the lugs on the drive hub which is attached to the drive gear and carefully position the drive against the flywheel housing. Secure the drive assembly to the flywheel housing with four 3/8”-16 x 1 1/4” bolts and lock washers.

9. Place the drive belts over the pulleys and adjust the tension on the belts. Then tighten the mounting bolts to 30-35 lb—ft (41-47 N-m) torque.

SHOP NOTES - TROUBLESHOOTING SPECIFICATIONS - SERVICE TOOLS

SHOP NOTES

DIMENSIONS FOR LINE-BORING CYLINDER BLOCK

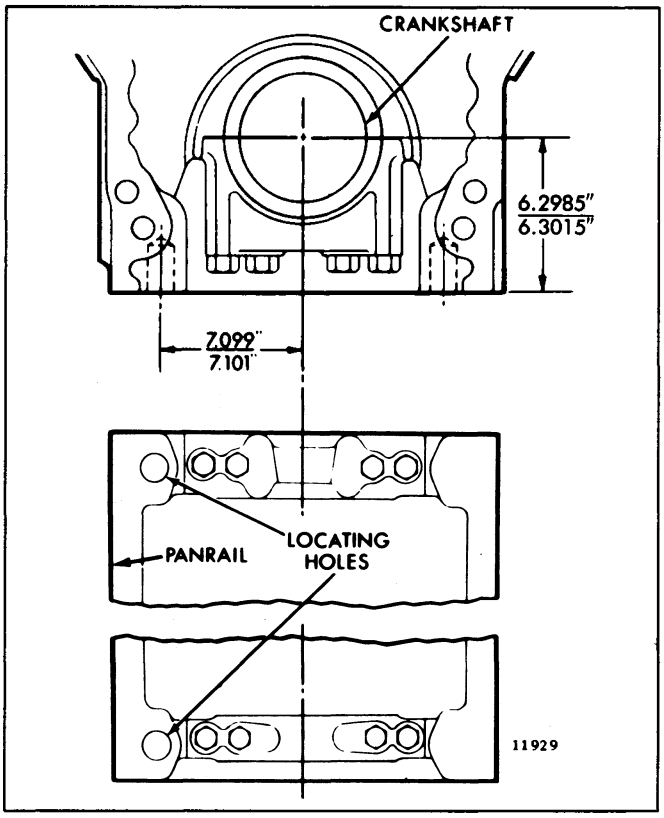


Fig. 1 – Line–Boring Dimensions

When a cylinder block becomes worn or damaged in the main bearing bores and it is desired to salvage the cylinder block by line-boring, there are critical dimensions that must be maintained.

In a given bore, the specified diameter is qualified through averaging. Three diameter measurements are taken at *10, 12 and 2 o'clock* positions, in a single plane located on either side of the oil hole for a particular bore. The three readings are averaged and that average must fall within 5.187”-5.188”. Any of the three individual readings can range between 5.187”-5.1885”. However, the minimum to maximum diameter must not exceed .001”.

Oversize on the outside diameter main bearing shells are available in .020” and .040” oversize only. The bore size diameters for the oversize main bearing shells are listed in Table 1.

Main Bearing	Main Bearing Bore
Standard	5.1 87" —5.188"
.020" oversize	5.207" —5.208"
.040" oversize	5.227" —5.228"

TABLE 1

1. The cylinder block assembly must be separated and each half-block line-bored separately. To be properly aligned during assembly, it is necessary that both halves of the cylinder block be bored to the same size.
2. The main bearing caps must be installed in the block and the bolts, with their hardened washers, torqued to 280-290 lb—ft (379-393 N#m) torque. The bearing caps must fit tight in the block. If they are loose they must be replaced. Main bearing cap bolts are specially designed and must not be replaced by ordinary bolts.

The surface from which all critical dimensions are measured for line-boring are the reamed locating holes (1.4365”-1.4380” in diameter) at each end of the right pan rail, looking from the gear train end of the cylinder block. The center line of the crankshaft is **7.099"-7.10r** in from the center line of the reamed locating holes and **6.2980”-6.3020”** up from the pan rail surface (Fig. 1).

4. The straightness of the finished bore must not vary more than .003” from end to end in the cylinder block.
5. Check and assemble the line-bored block halves. When the cylinder block has been bores .020” oversize, use alignment tool J 24542. When it has been bored .040” oversize, use alignment tool J 24543.
6. Stamp all main bearing caps to show they have been bored oversize and the amount (.020” or .040”).

Several diameter measurements are taken at the *12 o'clock* position, each in different planes to determine taper of an individual bore. Main bearing bore taper is a maximum of .001”.

Roundness is determined from the three readings taken for bore diameter. Main bearing bore out of round is a maximum of .001”.

When rebuilding, it is important to remember that cleaning the bores with a solvent type cleaner is acceptable, while further surface enhancement by means which would remove any metal is not acceptable and not recommended.

PROCEDURE FOR INSTALLING CYLINDER BLOCK COOLANT HOLE SLEEVES

1. Ream the cylinder head-to-block coolant holes in the cylinder block. Use a 25/64" reamer to increase the hole diameter from 3/8" to 25/64". To facilitate reaming, grind a 3/8" diameter pilot 1/2" in length on the end of the reamer.
2. Clean the coolant holes and the seal counterbores thoroughly with a solvent.
3. Apply HVV "Loctite" pipe sealant to the surfaces of the coolant holes.
4. Install the coolant hole sleeves in the coolant holes with sleeve installer J 24233-01. The tool will install the sleeves to the proper depth so the sleeves will extend up into the counterbore sufficiently to retain the seal rings.
5. Clean the "Loctite" thoroughly from the seal ring counterbores.

BREATHER HOLE PLUGS IN CYLINDER BLOCK

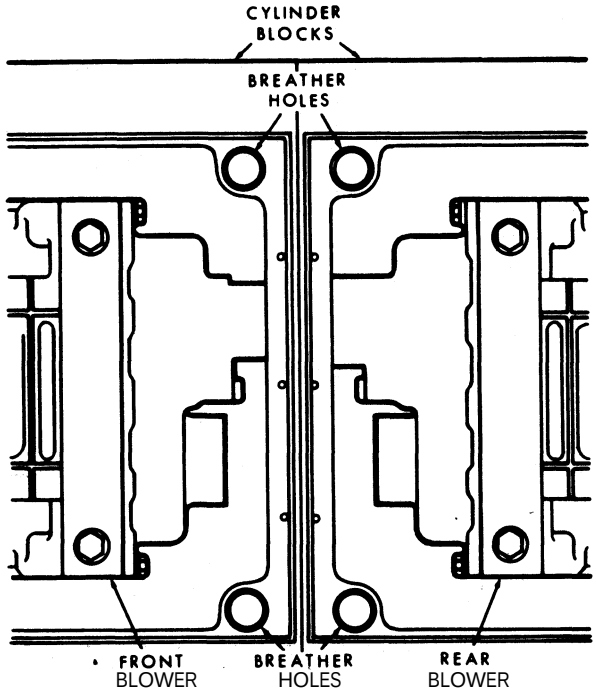


Fig. 2 - Location of Breather Holes in Cylinder Block

There are four 1.5625" diameter crankcase breather holes provided at the top of the cylinder block where the front and rear cylinder blocks are bolted together (Fig. 2). Seal rings are used between the air box cover plate and the cylinder block to keep the air from the air box from entering the crankcase.

When rocker cover breathers are used on turbocharged engines, flat plates are used to seal off the breather holes in the cylinder block.

Effective with approximate serial numbers 12E-2601 and 16E-2311, all cylinder blocks are machined to accept breather hole cup plugs. The cup plugs are used in place of the seal rings to seal off the breather holes when rocker cover breathers are used. Use of the cup plugs eliminates the possibility of seal rings being blown into the breather holes and resulting in high crankcase pressure.

To install cup plugs, where required, on former cylinder blocks, proceed as follows:

1. Remove the seal rings from the breather holes.
2. Machine the breather holes to 1.616"-1.620" diameter and .375" deep. Make sure all metal chips are removed after machining.
3. Install the cup plugs, using a suitable sealant, so the plugs are fliish with or slightly below the top of the cylinder Wock. These cup plugs are the same as the plug used in the rear oil gallery hole.

 © Detroit Diesel Corporation

CYLINDER BLOCK LINER SEAL RING GROOVE REWORK

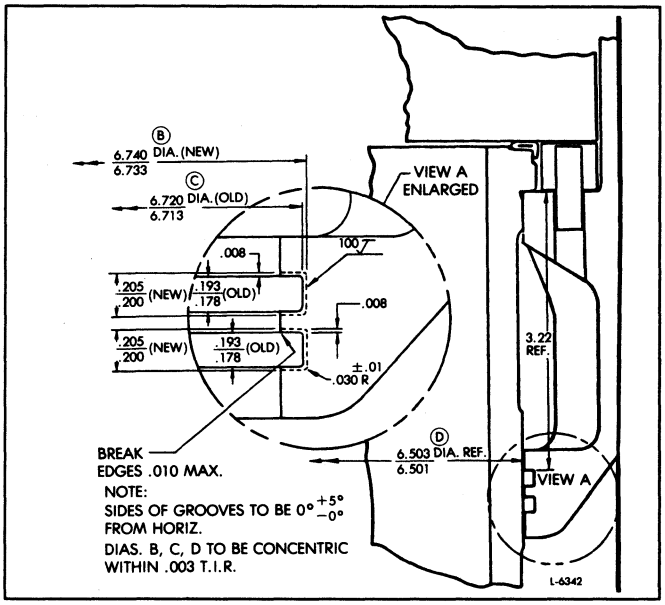


Fig. 3 - Liner O-Ring Groove Rework Dimensions

During overhaul of a Series 149 engine, inspection of the block may reveal erosion damage in the liner seal ring groove area. Erosion of the ring grooves can occur if the coolant inhibitor strength is not properly maintained. To permit reuse of the block and provide proper liner-to-block sealing under these circumstances, a .010" oversize seal ring may be used. However, before this seal can be installed, the cylinder block seal ring grooves must be machined larger to allow for the larger seal diameter.

Servicing facilities wishing to use oversize liner seal rings should contact a reliable local machining source and provide them with the liner groove rework dimensions (Fig. 3).

NEW STAINLESS STEEL CUP PLUGS FOR CYLINDER BLOCKS

Two new oversized O.D. (outside diameter) stainless steel cup plugs have been released for service installation in reworked cup plug holes in the sides of Series 149 engine cylinder blocks (Fig. 4). Standard size and new oversized O.D. plugs are shown in the Chart.

Measure the holes to determine the cup plugs required and make sure that the plugs and bores are clean and free of oil. Before installing cup plugs, apply a light coating of Loctite 277 or Loctite 11474 Sealant or equivalent to the block bores and the O.D. of the plugs. Install plugs flush to .013" below the surface of the boss and make sure they are watertight.

Cup Plug	Cup Plug Holes Should Measure
2-1/2" dia.	2.500-2.504
2-5/8" dia.	2.625-2.629
2-3/4" dia.	2.750-2.754

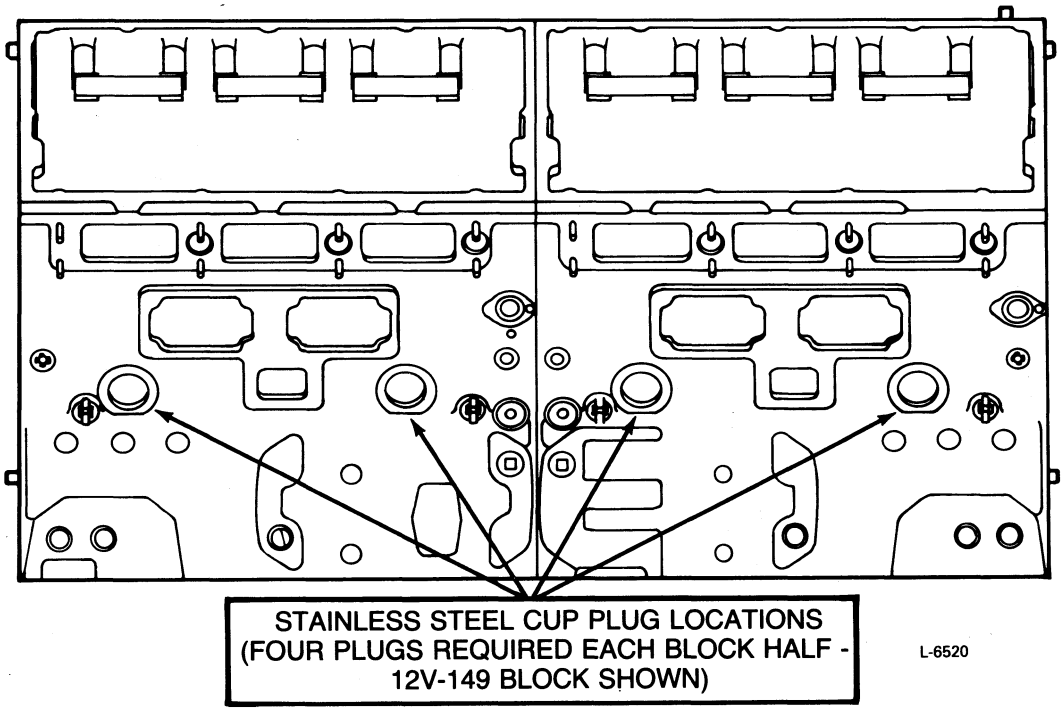


Fig. 4 - Location of Cup Plug

AIR BOX CORE PLUG HOLE THREAD REPAIR PROCEDURE

When minor core plug hole damage is discovered on an otherwise usable new cylinder block, a thread rework procedure is used in production to correct the condition before engine build. Ths procedure should also be used on existing blocks if the core plug hole threads are ever damaged. Core plug holes can be reworked whenever the engine is disassembled for overhaul.

Procedure:

1. Machine the existing core plug hole threaded opening to 2.9320"-2.9408M.

2. Using a 3.00-16 UN-3B thread tap (2.9594-2.9649 pitch diameter), thread the hole for installation of the service bushing.

NOTICE: Since metal particles from the machining and threading operationsa can damage cooling system components, make sure that all metal particles are contained and completely removed from the block after these operations.

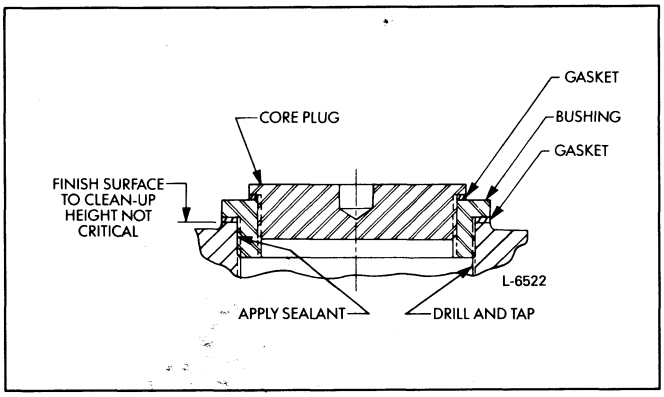


Fig. 5 - Air Box Core Plug Hole with Service Bushing and Plug Installed

3. With the new threads thoroughly clean and dry, apply Loctite grade AA thread locking sealant, Loctite 290 or equivalent sealant, to the threaded area.

4. Place the bushing-to-block gasket in place and install the service bushing (Fig. 5).

 © Detroit Diesel Corporation

5. Place the core plug-to-bushing gasket in place and install the core plug. Tighten the core plug to 230-270 lb-ft (312-366 N#m) torque. Allow the sealer to cure for two (2) hours before pressure testing the block. This will help ensure a leak-free installation.

6. Refer to Section 1.1, "Pressure Test Cylinder Block", to determine if the core plug-to-bushing and bushing-to-block threaded areas are providing an adequate coolant seal.

NOTICE: Hot tank cleaning of the cylinder block destroys the integrity of the core hole plug and bushing gaskets. Therefore, the core hole plugs, bushings and gaskets must be removed before the block is cleaned. Since the bushings and plugs may be damaged during removal, always use new bushings, plugs and gaskets when rebuilding the block.

CYLINDER HEAD LIFTING HANDLES

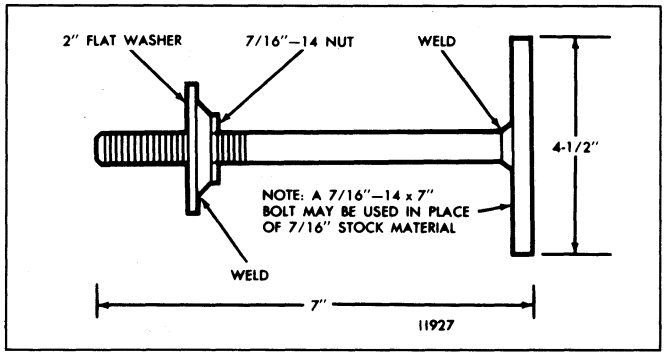


Fig. 6 – Cylinder Head Lifting Handles

Due to the recessed installation of the cylinder heads ("pot" heads) on the Series 149 engine, a pair of "T" handles (Fig. 6) may be fabricated to facilitate cylinder head handling if lifting tool J 24232 is unavailable.

The threaded ends of the lifting handles fit into tapped holes provided on the top of the cylinder head. The nut and washer assemblies provide a surface against which a pry bar can be used to loosen hard-to-budge cylinder heads.

A set of "T" handles will add greatly to the ease and safety with which the cylinder heads can be installed, removed or transferred from one place to another in the shop.

REWORK CYLINDER HEAD FOR OVERSIZE VALVE SEAT INSERT

.010" OVERSIZE O.D. COUNTERBORE	
Diameter	1.9065' - 1.9070'
Depth	.4010' - .4060'
Counterbore Runout/Guide	Within .001'
Taper of Counterbore	No Taper Allowed
Flatness of Counterbore	Parallel Within .002'
Runout of Insert	Within .002'
Press Fit	.0010' - .0025'

TABLE 2

A .010" oversize O.D. (outside diameter) exhaust valve seat insert may be used to extend cylinder head service life. A kit consists of an insert (not serviced separately) and complete installation instructions. An oversize insert is installed after the standard insert is removed and the cylinder head is reworked to the dimensions shown in Table 2.

Because of the critical tolerances involved and to prevent the possibility of cylinder head damage, the rework precedure should be performed by a reliable, professional machine shop.

WELDING OF ENGINE CYLINDER HEADS

The welding of cylinder heads has been used as a salvage procedure for several years. As a salvage procedure, the resultant product has not been considered as good as a new casting. The use of this procedure has caused some concern because of the differences in what has been called a welded cylinder head.

Detroit Diesel's position on the use of welded cylinder heads has been requested from several areas in the past. It is important to note that no data of statistical significance has been made available by welders or end users. Based on the inquiries received and the amount of cylinder heads being welded in the field, Detroit Diesel has investigated the methods of welding and resultant integrity of welded heads as compared to new cylinder heads used on Detroit Diesel engines. Since the procedure used when welding, subsequent machining and the rebuild methods of the cylinder head may result in unacceptable service life, there should be no implied approval of any welding source or welded components.

The following is Detroit Diesel's position on various aspects related to welded cylinder heads.

1. Welding is considered the process of elevating the original cylinder head casting to approximately 1100°F or 593°C (a temperature that is at least equivalent to stress relieving) and the addition of alloyed cast iron welding rod to the crack area while in the molten state. Low temperature, low voltage welding is considered a cosmetic salvage and should never be accepted., as a structural repair.

2. Mechanical plugging is a salvage procedure that usually results in excessive installation stresses at the repaired area and should never be confused with or accepted as equivalent to welding. This procedure should not be used on cylinder heads.

3. If properly performed, welding of a cylinder head may be a salvage procedure if the welding is done outside of the fire circle. Service life of a welded cylinder head, however, will not be equivalent to a new casting even if the fire circle area of the original casting has not been welded. A cracked casting is usually the result of an overheat and the casting may be damaged in areas other than the visible crack.

4. Comparative testing indicates that welding inside of the fire circle will result in a service life less than 50% of a new casting. This has resulted in the conclusion that welding in the fire circle should not be done. In order to eliminate potential future failures on DDC engines, cylinder heads cracked in the firecircle should be destroyed.

5. Series 149 heads are essentially all "fire circle", and should not be welded on the fire deck, nor in the area of the bolt hole located between the exhaust ports.Cracks in non-critical areas generally have not been observed to any extent.

6. Cylinder heads that have been welded should be checked for acceptability using Sections 1.2 through 1.2.2 of the Service Manual. This includes checking for cracks, thickness of the cylinder head,warpage, camshaft follower clearance and the press fit of all other components. Various conditions have been found with welded cylinder heads that could cause malfunctions of secondary components if these are not checked. If any discrepancy can not be repaired, such as cylinder head thickness, the part should not be used.

7. Components that are used with these cylinder heads should also be checked. Components that are not acceptable should not be used.

NOTICE: Secondary damage to other engine components could result from not checking these components.

CHECKING BEARING CLEARANCES

A strip of soft plastic squeezed between the crankshaft journal and the connecting rod bearing or main bearing may be used to measure the bearing clearances.

The strip is a specially molded plastic "wire" manufactured commercially, and is available in three sizes and colors. Type PG-1 (green) has a clearance range of .001" to .003", type PR-1 (red) has a range of .002" to .006", and type PB-1 (blue) has a range of .004" to .009".

The plastic strip may be used for checking the bearing clearances as follows:

1. Remove the bearing cap and wipe the oil from the bearing shell and crankshaft journal.

 © Detroit Diesel Corporation

NOTICE: When checking the main bearing clearances with the engine in a position where the main bearing caps are supporting the weight of the crankshaft and the flywheel, an erroneous reading can be eliminated by supporting the weight of the crankshaft with a jack under the counterweight adjoining the bearing being checked.

2. Place a piece of the plastic strip the full width of the bearing shell, about 1/4" off center (Fig. 7).

3. Rotate the crankshaft about 30° from bottom dead center and reinstall the bearing cap. Tighten the bolts to the specified torque.

4. Remove the bearing cap. The flattened plastic strip will be found adhering to either the bearing shell or the crankshaft.

5. Compare the width of the flattened plastic strip at its widest point with the graduations on the envelope (Fig. 7). The number within the graduation on the envelope indicates the bearing clearance in thousandths of an inch. Taper may be indicated when one end of the flattened plastic strip is wider than the other. Measure each end of the plastic; the difference between the readings is the approximate amount of taper.

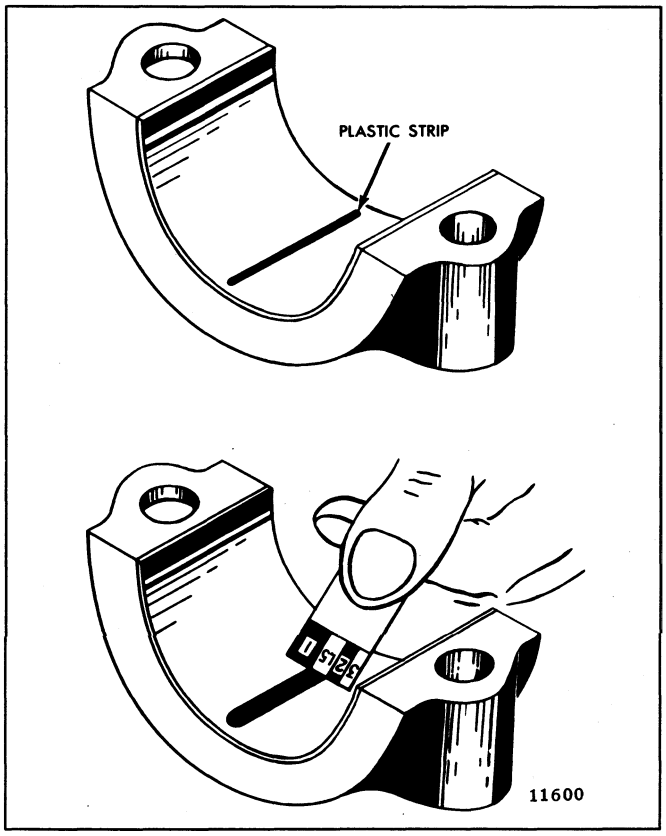
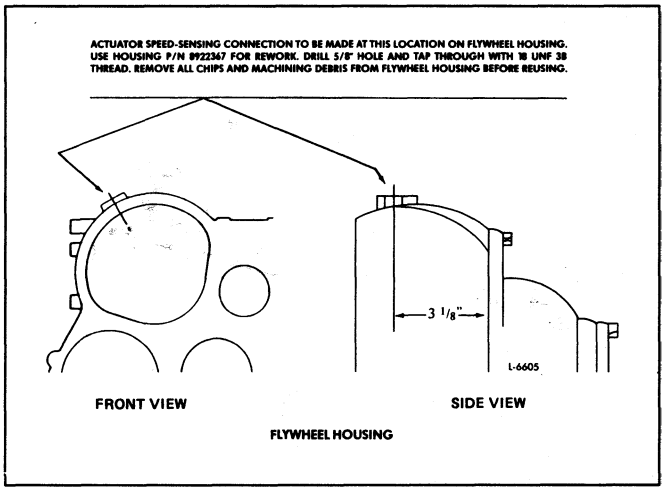


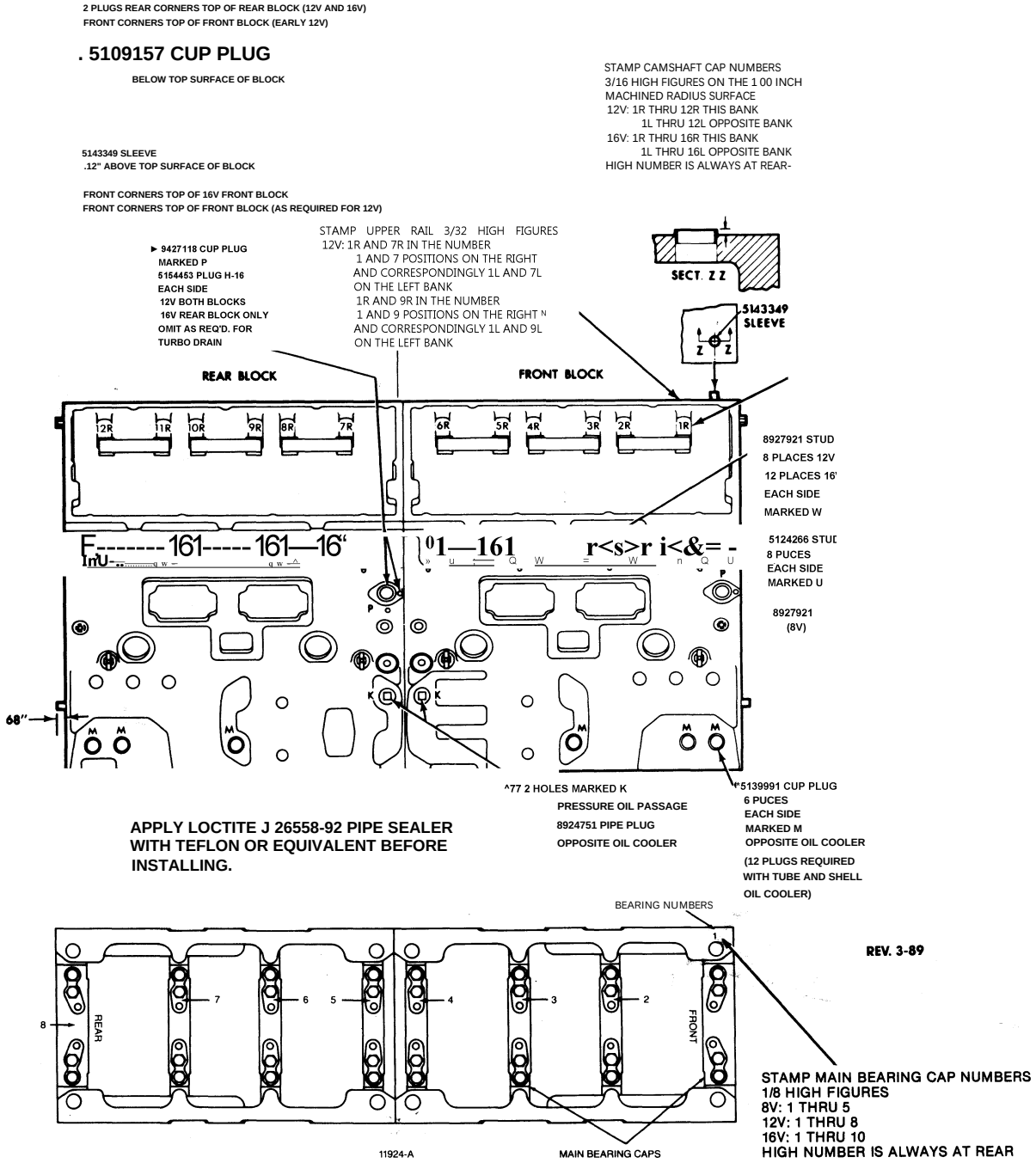
Fig. 7 - Measuring Bearing-to-Crankshaft Clearance with Plastic Strip

REWORK FLYWHEEL HOUSING FOR HIGH TORQUE RISE ENGINE MANGETIC PICKUP

When adding high torque rise features to existing 12V-149T and TI engine models 9123-7300 and 9123-7301, the flywheel housing must be modified as shown to permit installing the magnetic pickup components required on these units.

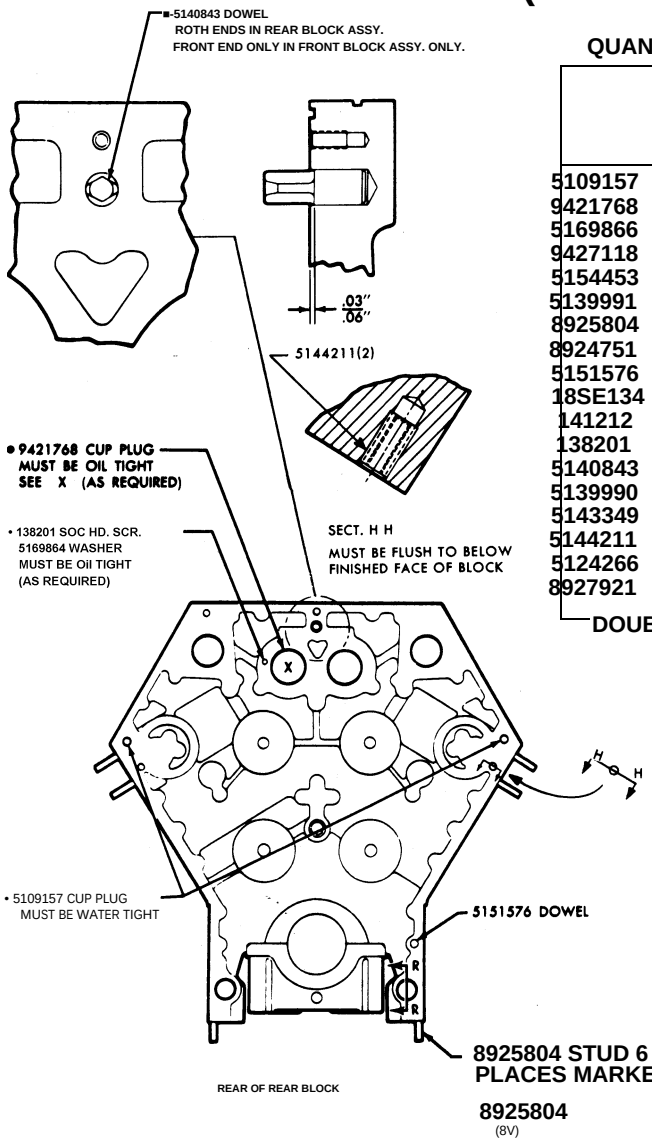


8V, 12V AND 16V CYLINDER BLOCK PLUGGING INSTRUCTIONS (12V-149 SHOWN)



 © Detroit Diesel Corporation

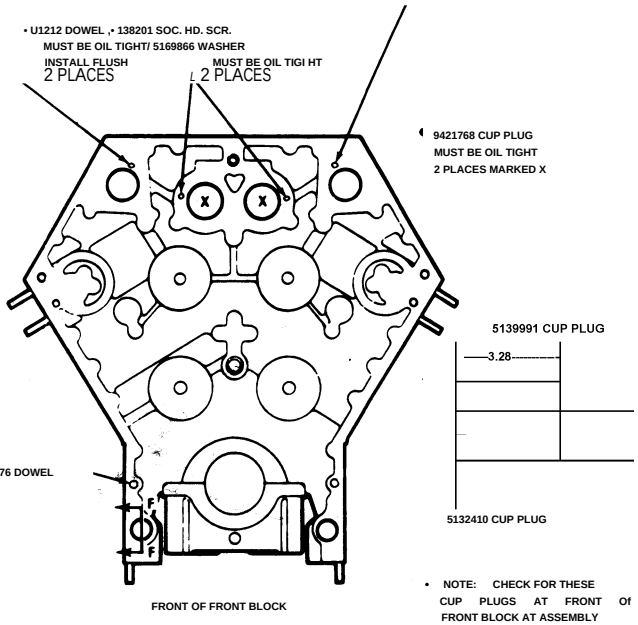
8V, 12V AND 16V CYLINDER BLOCK PLUGGING INSTRUCTIONS (12V-149 SHOWN)



QUANTITIES SHOWN ARE FOR A COMPLETE BLOCK ASSEMBLY

		FRONT 23501950 12V	23501951 16V	REAR 23501952 12V	23501953 16V	23501954 8V
5109157	PLUG, CUP			2	2	
9421768	PLUG, 3" CUP	2	2	1	1	1
5169866	WASHER 7„" COPPER (HOLE)	2	2	1	1	1
9427118	PLUG, 1%" CUP (TURBO)	2	2	2	2	
5154453	PLUG, 7." 16 (DRAINS)	2	2	2	2	
5139991	PLUG, 1 '/a" CUP (OIL COOLER HOLES)	3*	3*	3*	3*	
8925804	STUD, /i«x2/j* (OIL PAN RAILS)	3	3	3	3	1
8924751	PLUG, I%"x7," PIPE	1	1	1	1	
5151576	PIN, ViW," DOWEL	1	1	1	1	2
18SE134	INSTR. DRAWING	1	1	1	1	
141212	PIN, 5%,"x7„" DOWEL	2	2			
138201	SCREW 20.3/4"	2	2	1	1	1
5140843	PIN, SPECIAL DOWEL	1	1	2	2	2
5139990	PLUG, 1 7u" CUP	1	1	1	1	
5143349	SLEEVE, 1 „ DIA. (GOV. LINK HOLE)	2	2			2
5144211	REDUCER-THD. 7,-11 TO 7,-16			2	2	
5124266	STUD 16-"13-20x2.80" (EXH-ENDS)	8	8	8	8	
8927921	STUD V4 -"-13-20 x 2 '/a" (EXH-INTERMEDIA'	8	12	8	12	20

DOUBLE QUANTITY WHEN TUBE AND SHELL OIL COOLER IS INSTALLED.



APPLY LOCTITE J 26558-92 PIPE SEALER WITH TEFLON OR EQUIVALENT BEFORE INSTALLING.

3 28

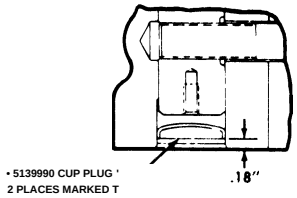
/ 5139991 CUP PLUG

XVXV^XXW V

5132410 CUP PLUG

SECT R R

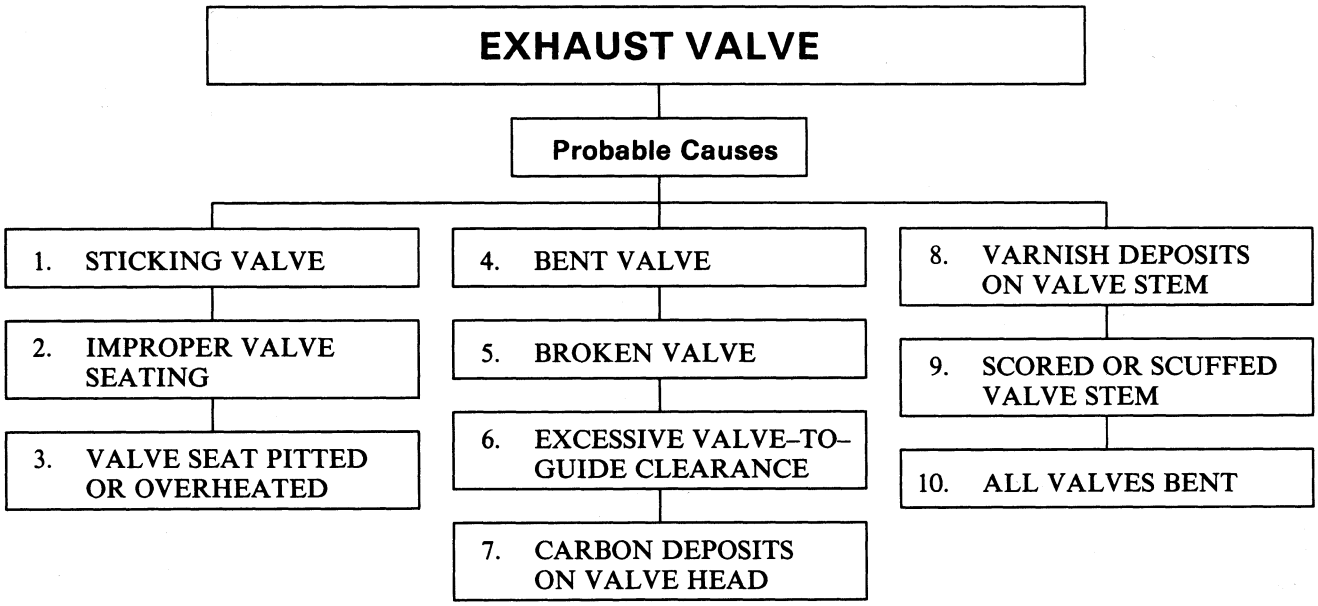
• NOTE ; CHECK FOR THESE
CUP PLUGS AT REAR OF
REAR BLOCK AT ASSEMBLY



REV. 3-89

UNLESS OTHERWISE NOTED, APPLY LOCTITE 230 SEALANT OR EQUIVALENT TO CUP PLUGS BEFORE INSTALLING.

TROUBLESHOOTING



SUGGESTED REMEDY

1. Check for carbon deposits, a bent valve guide, defective spring or antifreeze (glycol) in the lubricating oil. Replace a bent guide. Cleanup and reface the valve. Replace the valve, if necessary.

2. Check for excessive valve-to-guide clearance, bent valve guide or carbon deposits. Replace a bent or worn guide. Clean the carbon from the valve. Reface or replace the valve, if necessary.

3. Check the operating conditions of the engine for overload, inadequate cooling or improper timing. Reface the valve and insert. Replace the valve if it is warped or too badly pitted. Use a harder-face valve if the operating conditions warrant.

4. Check for contact between the valve head and the piston as a result of incorrect valve clearance, an improperly positioned exhaust valve bridge, or a defective spring. Check the valve guide, insert, cylinder head and piston for damage. Replace damaged parts.

5. Check for excessive valve-to-guide clearance, a defective valve spring or etching of the valve stem at the weld. Improper valve clearance is also a cause of this type of failure. Check the guide, insert, cylinder 10. head and piston for damage. Replace damaged parts.

6. Replace a worn valve guide. Check and replace the valve, if necessary.

7. Black carbon deposits extending from the valve seats to the guides indicates cold operation due to light loads or to the use of too light a fuel. Rusty brown valve heads with carbon deposits forming narrow collars near guides indicate hot operation due to overloads, inadequate cooling or improper timing which results in carbonization of the lubricating oil. Cleanup the valves, guides and inserts. Reface the valves and inserts or replace them if they are warped, pitted or scored.

8. Check for a worn valve guide or excessive exhaust back pressure. Replace a worn guide. Check the valve seat for improper seating. Reface the valve and insert or, if necessary, replace.

9. Check for a bent valve stem or guide, metal chips or dirt, or for a lack of lubrication. Cleanup the valve stem with crocus cloth wet with fuel oil or replace the valve. Replace the guide. When installing a valve, use care in depressing the spring so that the spring cap DOES NOT scrape the valve stem.

Check for a gear train failure or for improper gear train timing.

 © Detroit Diesel Corporation

SPECIFICATIONS

Specifications, clearances and wear limits are listed below. It should be specifically noted that the clearances apply only when all new parts are used at the point where the various specifications apply. This also applies to references within the text of the manual. The column entitled "Limits" in this Chart lists the amount of wear or increase in clearance which can be tolerated in used engine parts and still ensure satisfactory performance. It should be emphasized that the figures given as "Limits" must be qualified by the judgement of personnel responsible for installing new parts. These wear limits are, in general, listed only for the parts more frequently replaced in engine overhaul work. For additional information, refer to the text,

TABLE OF SPECIFICATIONS, NEW CLEARANCES AND WEAR LIMITS

These limits also apply to oversize and undersize parts.

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
CYLINDER BLOCK			
Block bore:			
Diameter (upper pilot)	6.5220"	6.5240"	6.5260"
Diameter (seal ring lands)	6.5010"	6.5030"	6.5050"
Diameter (water jacket)	6.4000"	6.4020"	6.4040"
Out-of-round		.0015"	
Taper		.0015"	
•Cylinder liner counterbore:			
Diameter	6.9080"	6.9140"	
Depth	.4920"	.4960"	
Main bearing bore:			
Inside diameter	5.1870"	5.1880"	
Camshaft bearing bore:			
Inside diameter (former)	2.1510"	2.1520"	
Inside diameter (current)	2.1505"	2.1525"	
CYLINDER HEAD .			
Exhaust valve seat counterbore:			
Diameter	1.8965"	1.8975"	
Depth	.4010"	.4060"	
Exhaust valve seat insert runout		.0020"	.0020"
Exhaust valve:			
Stem diameter	.3722"	.3730"	
Valve head-to-cylinder head	Flush	.017"recess	.032"recess
Exhaust valve guide:			
Height above cylinder head	1.1400"	1.1800"	
Diameter—inside	.3750"	.3760"	
Clearance—valve-to-guide	.0020"	.0038"	.0060"
Exhaust valve bridge guide:			
Height above cylinder head (press fit)	2.3900"	2.4100"	
ROCKER ARMS AND SHAFTS			
Diameter—rocker shaft	1.2295"	1.2300"	
Diameter—inside (rocker arm bushing)	1.2310"	1.2320"	
Clearance—shaft-to-bushing	.0010"	.0025"	.0040"
Clearance—cam roller bushing-to-pin			.0100"

•Prior to engines 12E-1703 and 16E-361.

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
CRANKSHAFT			
Journal diameter—main bearing	4.8720"	4.8730"	
Journal diameter—connecting rod bearing	3.8730”	3.8740”	
Journal diameter—outboard bearing	5.9990"	**60000”**	
Journal out-of-round		.00025"	**.0010”**
Journal taper		.0005"	.0015”
# Runout on journals—total indicator reading:			
12V (mounted on No. 1 and No. 8 journals):			
At No. 2 and No. 7 journals		**.0020'**	
At No. 3 and No. 6 journals		.0040"	
At No. 4 and No. 5 journals		.0060"	
16 V (mounted on No. 1 and No. 10 journals):			
At No. 2 and No. 9 journals		.0020"	
At No. 3 and No. 8 journals		.0040”	
At No. 4 and No. 7 journals		.0060"	
At No. 5 and No. 6 journals		.0080”	
Thrust washer thickness	.1630"	.1660"	
End play (end thrust clearance)	.0040"	.0140"	.0180
MAIN BEARINGS			
Inside diameter (vertical axis)	4.8760"	4.8782"	
Bearing-to-journal clearance	.0030”	.0062"	.0072'
Bearing thickness (90° from parting line)	.1550”	.1555”	.1544'
OUTBOARD BEARING			
■ Inside diameter (installed)	6.0033“	6.0087"	
'Clearance—bearing-to-journal	,d033"	.0097”	
fL			
ASTONS (FLOATING SKIRT)			
Pistdn:			
Height	6.6610”	6.6710"	
Diameter at top:			
Current	5.7030"	5.7050"	
Former	5.7010"	5.7030"	
Diameter of skirt (3" below top):			
Current (effective with 12E-1463 and 16E-218)	5.7394"	5.7416"	
(2E-673 to 12E-1463 and 16E-16 to 16E-218)	5.7388"	5.7410"	
Former 'V	5.7368"	5.7390"	
Clearance—piston skirt-to-liner:			
Current (effective with 12E-1463 and 16E-218)	.0074”	.0116"	
(2E-673 to 12E-1463 and 16E-16 to 16E-218)	.0080"	.0122"	
Former	.0100-	.0142"	
PISTON CARRIER (FLOATING SKIRT PISTON)			
Height (bottom to thrust platform)	3.6060”	3.6090”	3.6050'
Thrust plate thickness	.0995"	.1010"	.0945
Clearance—snap ring-to-carrier	.0030"	.0130"	

#Runout tolerance given for guidance when regrinding crankshaft. When runout on adjacent journals is in opposite direction, the sum must not exceed .003" total indicator reading. When runout on adjacent journals is in the same direction, the difference must not exceed .003" total indicator reading. When high spots of runout on adjacent journals are at right angles to each other, the sum must not exceed .004" total indicator reading, or .002" on each journal.

 © Detroit Diesel Corporation

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
PISTONS (CROSS-HEAD)			
Piston crown:			
Saddle-to-crown distance	2.7205”	2.7275"	
Diameter:			
At top edge	5.7040"	5.7070"	
Below both compression rings	5.7370”	5.7410”	
Above and below seal ring groove	5.4110"	5.4160"	
Above and below Bearing saddle	4.2200”	4.2250"	
Seal ring:			
Gap (in skirt counterbore)	.0020”	.0270"	
Side clearance	.0005”	.0030"	.0040”
Piston skirt:			
+ Diameter	5.7404"	5.7426"	
Clearance—skirt-to-liner (former)	.0064”	.0106"	
Clearance—skirt-to-liner (current)	.0066”	.0109"	
Seal ring bore	5.4400”	5.4450"	
Piston pin bore	2.3909”	2.3919"	
PISTON RINGS			
Compression rings:			
Gap (wide gap rings)	.0550"	.0750"	
Gap (standard rings)	.0450"	.0550"	
Clearance—ring-to-groove:			
No. 1 (top)	.0045"	.0081"	
No. 2	.0105"	.0130"	
No. 3	.0045”	.0070"	
No. 4	.0045"	.0070"	
Oil control rings:			
Gap	.0170"	.0320"	
Clearance—ring-to-groove:			
Upper	.0015"	.0055"	
Upper (turbocharged engine)	.0010"	.0035"	
Lower	.0015"	.0055"	
PISTON PIN			
Diameter	2.3873"	2.3877"	
Slipper bearing (bushing) thickness at center	.0870"	.0880"	.0860"
CONNECTING ROD			
Side clearance (normal) between rods	.0180"	.0260"	
CONNECTING ROD BEARINGS			
Inside diameter	3.8755”	3.8775"	
Bearing-to-journal clearance	.0015”	.0045"	.0055"
Bearing thickness (90° from parting line)	.1550"	.1555"	.1544"

+ Diameter above and below the piston may be 5.7370".

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
CYLINDER LINER			
Outside diameter:			
Upper pilot	6.5200"	6.5210"	
Below ports	6.3980"	6.3990"	
Inside diameter	5.7488"	5.7513"	
Clearance—liner pilot-to-block bore	.0010"	.0040"	
Out-of-round (inside diameter)		.0010"	.0020"
Taper (inside diameter)		.0010"	.0020"
♦Depth of flange BELOW block	.0390"	.0450"	
GEAR TRAIN			
Gear backlash (between all gears)	.0015"	.0080"	.0100'
Clearance—Crankshaft-to-bushing (in front crankshaft gear)	.0010"	.0030"	
CAMSHAFT			
Journal diameter	1.9940"	1.9945"	
Runout at intermediate journal (when mounted on end journals)		.0020"	
Thrust plate thickness	.3680”	.3720"	
Clearance—thrust plate-to-camshaft thrust shoulder	.0130"	.0220"	.0260"
CAMSHAFT BEARINGS			
Inside diameter (vertical axis)	2.0004”	2.0024"	
Clearance—bearing-to-shaft	.0059"	.0084"	.0100"
FRONT IDLER GEAR			
Inside diameter — bushing	2.6270"	2.6280"	
Outside diameter — idler gear hub	2.6240"	2.6250"	
BLOWER DRIVE GEAR			
Inside diameter—bushing	1.8770”	1.8780"	
Clearance—hub-to-gear bushing	.0010"	.0025"	.0050'
Thrust washer (drive support) thickness	.2350"	.2450"	
Thrust washer (gear) thickness	.1190"	.1210"	
End play (between thrust washers)	.0020"	.0180"	

Trior to engines 12E-1703 and 16E-361.

 © Detroit Diesel Corporation

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	260M BOLTS TORQUE (lb-ft)	Nam	THREAD SIZE	280M OR BETTER TORQUE (lb-ft)	Nam
1/4-20	5-7	- 7-9	1/4-20	7-9	10-12
1/4-28	6-8	- 8-11	1/4-28	8-10	11-14
5/16A8	10-13	- 14-18	5/1618	13-17	18-23
5/16-24	11-14	- 15-19	5/16-24	15-19	20-26
3/8-16	23-26	- 31-35	3/8-16	30-35	41-47
3/8-24	26-29	- 35-40	3/8-24	35-39	47-53
7/16-14	35-38	_ 47-51	7/16-14	46-50	62-68
7/16 20	43 46	- 58 62	7/16-20	57-61	77-83
1/2-13	53 56	- 72-76	1/213	71-75	96-102
1/7-70	62-70	„ 84-95	1/2-20	83-93	113-126
9/16-12	68-75	_ 82-902	9/16-12	90-100	122-136
9/1618	80-88	109119	9/1618	107-117	146-159
5/8-11	103-110	140-149	5/8-11	137-147	186-200
5/8-18	126-134	171-181	5/8-18	168-178	228-242
3/4-10	180-188	244-254	3/4-10	240-250	325-339
3/4-16	218-225	295-305	3/4-16	290-300	393-407
7/8-9	308-315	417-427	7/8-9	410-420	556-569
7/8-14	356-364	483-494	7/8-14	475-485	644-657
1-8	435-443	590-600	1-8	580-590	786-800
1-14	514-521	697-705	1-14	685-695	928-942

Grade identification markings are normally stamped on the heads of the bolts. To aid identification of the various bolts used in Detroit Diesel engines, refer to the following chart.

□ -- Grade Identification Marking on Bolt Head	GM Number	SAE Grade Designation	Nominal Size Diameter (inch)	Tensile Strength Min. (psi)
None	GM 255-M	1	No. 6 thru 1 1/2	60,000
None	GM 260-M	2	No. 6 thru 3/4 over 3/4 to 1 1/2	74.000 60.000
<J Bolts and Screws	GM 280-M	5	No. 6 thru 1 over 1 to 1 1/2	120,000 105,000
— Hex Head Sems Only	GM 275-M	5.1	No. 6 thru 3/8	120,000
Bol ts and Screws	GM 290-M	7	1/4 thru 1 1/2	133,000
Bolts and Screws	GM 300-M	8	1/4 thru 1 1/2	150,000
—* Bolts and Screws	GM 455-M	None	No. 6 thru 1 1/2	55,000

BOLT IDENTIFICATION CHART

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD	(lb-ft)	(N.m)
Camshaft coupling bolt (early 12 V only)	5/16-24	20-24	27-33
Exhaust valve bridge adjusting screw nut	5/16-24	20-25	27-34
Camshaft coupling bolt (early 12 V only)	3/8-24	45-50	61-68
Exhaust valve adjusting screw nut	3/8-24	30-35	41-47
Fuel pump drive coupling disc bolt	3/8-24	50-55	68-75
Camshaft coupling bolt (current)	7/16-20	57-61	77-83
♦Crankshaft coupling bolts (2-piece crankshaft)	7/16-20	70-80	95-108
Injector fuel pipe nut (large)	7/16-20	18-22	' 24-30
Injector fuel pipe nut (small)	7/16-24	18-22	24-30
♦Block attaching bolts	1/2-13	75-85	102-115
Camshaft bearing cap bolts	1/2-13	90-100	122-136
Fuel pipe connector nut	1/2-13	35-40	47-54
Idler gear hub retaining bolt	1/2-13	80-90	108-122
Rocker arm shaft bolt	1/2-13	90-100	122-136
♦Block attaching bolts	, 1/2-20	85-95	115-129
♦Connecting rod-to-piston pin bolt	1/2-20	35[A]45 + 60 -80°	47-61.+60°-80°
♦Crankshaft coupling bolts (2-piece crankshaft)	1/2-20	100-110	136-150
Exhaust manifold to block stud nuts	1/2-20	50-55	68-75
Bearing cap nut (oil pan removed)	9/16-18	45-55 +130°-150°	61-75 +130-150°
Bearing cap nut (oil pan installed)	9/16-18	125-135	170-183
♦Connecting rod cap nut (oil pan installed)	9/16-18	130-140	177-190
• * Connecting rod cap nut (oil pan removed)	9/16-18	45-55+ 130°-150°	61-75 +130-150°
♦Cylinder head bolt	9/16-18	140-150	190-204
♦Block attaching bolts	" 5/8-11	160-175	217-238
♦Flywheel bolt (see Sect. 1.4)	5/8-18		
Vibration damper hub to crankshaft bolt	5/8-18	180-190	244-258
♦Block attaching bolts [A]	’ 3/4-10	270-290	366-393
♦Main bearing cap bolt	3/4-10	280-290	379-393
Accessory drive pulley nut	3/4-16	120-140	163-190
Crankshaft pulley bolt '	1 1/4-7	;450-500	610-678
Front PTO hub nut	1 1/4-12	‘ 325-350	441—475
Blower drive support nut	1 7/16-16	50-60	68-81
Accessory gear locknuts	2 1/2-18	280-300	379-407
Idler gear locknuts (spanner, standard hex)	2.548-18	280-300	379-407
• Idler gear Locknut (hex w/locking lip) •	2.548-18	300-320	407-434
Camshaft gear locknut (spanner, standard hex)	3.137-12	280-300	379-407
• Camshaft gear locknut (hex w/locking lip)	3.137-12	300-320	407-434

♦Lubricate threads with International Compound No. 2, or equivalent (refer to Parts Catalog or Microfiche, Section 12.8000A).

 © Detroit Diesel Corporation

STANDARD PIPE PLUG TORQUE SPECIFICATIONS

NPTF SIZE THREAD	TORQUE (lb-ft)	N*m	NPTF SIZE THREAD	TORQUE (lb-ft)	N»m
1/8	10-19	14-16	1	79-89	102-115
1/4	14-10	19-22	1-1/10	89-Q9	115-129
9/8 *	18—99	24-30	1-1/4	os-ins	129-143
1/9	99-97	31-37	1-1/9	110-190	150-177
3/4.....	33-37	45-50			

SPECIAL PLUG TORQUE SPECIFICATIONS

APPLICATION	(lb-in)	(N*m)
Core hole plugs	150-180	204-244
♦Water core hole plug—-1 3/4a-16 special	150-20(r	204-271
# Water core hole plug--2 l/2a-16 special	220-250	298-339

♦Lubricate threads and washer face with International Compound No. 2, or equivalent (refer to Parts Cata Section. -12 8000A).
#Coat the threads and washer face with a good grade of coolant resistant sealant.

STUD TORQUE SPECIFICATIONS

----------->|- *f* ft

APPLICATION	STUD	(lb-in)	(N.m)
Exhaust manifold stud 4----------	1/2-13	35-40	47-54

SERVICE TOOLS

TOOL NAME	TOOL NO.
CYLINDER BLOCK	
Core hole plug remover and installer	J23019
Cylinder block bore aligning tool	J 22486
Cylinder block bore aligning tool (.020” oversize)	J 24542
Cylinder block bore aligning tool (.040” oversize)	J 24543
Dial bore gage	J 5347-B
Dial bore gage master setting fixture	J 23059-01
• Deck checker	PT-5075-B
• Conversion kit (for 149 block)	PT-5071
Pressure testing set	J 24051-B
|Sled gage	J 22273-01
Torque wrench adaptor	J 24533
Water ljole sleeve installer	J 24233-01
• Litter Iflange seat resurfacing tool	PT-2600
CYLINDER HEAD	
Broken valve bridge guide remover	J 7453
Cylinder head guide stud set	J28511-A
Cylinder head holding fixture	J 23741-A
Cylinder head remover	J24232
Feeler gage stock (.0015”)	J23185
Fuel line wrench set	J26617
Fuel line socket 9/16”	J21545
Sled gage	J 22273-01
Slide hammer < ” ■	J 2619-01
Spring tester	J 22738-02
Valve bridge guide installer	J 22487
Valve bridge guide remover	J 7091-01
Valve bridge holding fixture	J21772
Valve seat grinding set	J 4627-02
Valve guide cleaner	J 5585
Valve guide installer	J 22082-01
Valve guide remover	J 23458-A
Valve seal installer	J 25251
• Valve seat grinder (model V.I.P.)*	J 7040-A
— Grinder	, J 8165-1A
— Dial gage	J 8165-2
Valve seat insert installer	J22711
• Valve seat insert remover	J 23479-49
Valve spring checking gage	J 22738-02
Valve spring compressor (cyl. head installed) • *	J 22693-01
Valve spring compressor (cyl. head removed)	J 8062

•Consists of Single Dash (-) Items Below

 © Detroit Diesel Corporation

TOOL NAME	TOOL NO.
CRANKSHAFT AND BEARINGS	
Crankshaft front oil seal installer	J22518
Crankshaft rear oil seal expander	J 22605
Crankshaft rear oil seal expander (oversize seal)	J 22766
Crankshaft rear oil seal expander adaptor	J 23341
Crankshaft rear oil seal installer	J 22604-B
Crankshaft rear oil seal sleeve installer	J 22767
Cup plug tester	J 34728
Hand vacuum pump	J 23738-A
Engine barring tool	J 22582
Main bearing bolt torquing device	J 35371
Micrometer ball attachment	J 4757
Torque wrench adaptor set	J 22897
FLYWHEEL HOUSING	
Flywheel housing runout gage	J 9737-C
Pilot plate locating tool	NDD-4875
PISTON - CYLINDER LINER	
Cylinder bore gage	J 5347-B
Cylinder hone and glaze breaker set	J 5902-01
Cylinder liner installer	J 22641-A
Cylinder liner remover	J 22431-A
Dial bore gage master setting fixture	J 23059-01
Feeler gage set	J 5438-01
Spring scale	J 8129
Master ring gage (cylinder liner)	J22613
Piston crown identification gage	J 25397-A
Piston pin retainer installer	J 24274-B
Piston pin retainer leak detector	J 23738-A
Piston Pin retainer leak detector adaptor cup	J 24629
Piston ring compressor	J 22387
Piston ring remover and installer	J 22405-02
Piston seal ring compressor	J 24421
GEAR TRAIN	
Socket (accessory and blower drive hub nut)	J 23641
Spanner wrench set (cam and idler gear nut)	J 22556
Spring scale	J 8129
CAMSHAFTS AND BEARINGS	
Cam/idler gear retaining nut socket set	J 29744
Torque wrench adaptor - coupling bolt	J 28462

SECTION 2

FUEL SYSTEM AND GOVERNORS

CONTENTS

Fuel System.....2

Fuel Injector.....2.1.1
Fuel Injector Tube.....2.1.4

Fuel Pump.....2.2

Fuel Strainer andFuel Filter.....2.3

Fuel Manifolds.....2.4

Mechanical Governors.....2.7
Limiting Speed Mechanical Governor.....2.1
Variable Speed Mechanical Governor.....2.S[A']
Mechanical Output Shaft Governor.....2.7a

Hydraulic Governors.....2.8
SG Hydraulic Governor (Variable Speed).....2.8.1
PSG Hydraulic Governor.....2.8.2
Hydraulic Governor Drive and Operating Linkage.....2.8.3
Hydraulic Governor Synchronizing Motor.....2.8.4

Fuel Injector Control Tube.....2.9

Shop Notes - Trouble Shooting - Specifications - Service Tools.....2.0

FUEL SYSTEM

The fuel system (Fig. 1) includes the fuel injectors, fuel pipes (inlet and outlet), fuel manifolds, fuel pump, fuel strainer, fuel filter, junction block and fuel lines.

Fuel is drawn from the supply tank through the fuel strainer and enters the fuel pump at the inlet side. Leaving the pump under pressure, the fuel is forced through the fuel filter or secondary filter. From the secondary filter, the fuel is directed to a junction block where it is then routed to the inlet fuel manifolds for each injector bank. From the fuel manifolds, fuel reaches the fuel injector by means of a fuel inlet pipe. Surplus fuel returns from the outlet side of the injectors through the fuel outlet pipes to the fuel return manifold. The return fuel then passes through the fuel junction block and back to the fuel tank. All engines are equipped with a restrictive fitting in the fuel outlet manifold to maintain the fuel system pressure. Refer to Sections 2.4 and 13.2 for the size fitting required.

A check valve is installed in the fuel junction block on the outlet (spill) side to prevent fuel from draining from a high mounted fuel tank back into the injectors when the engine is not running (refer to Section 2.4).

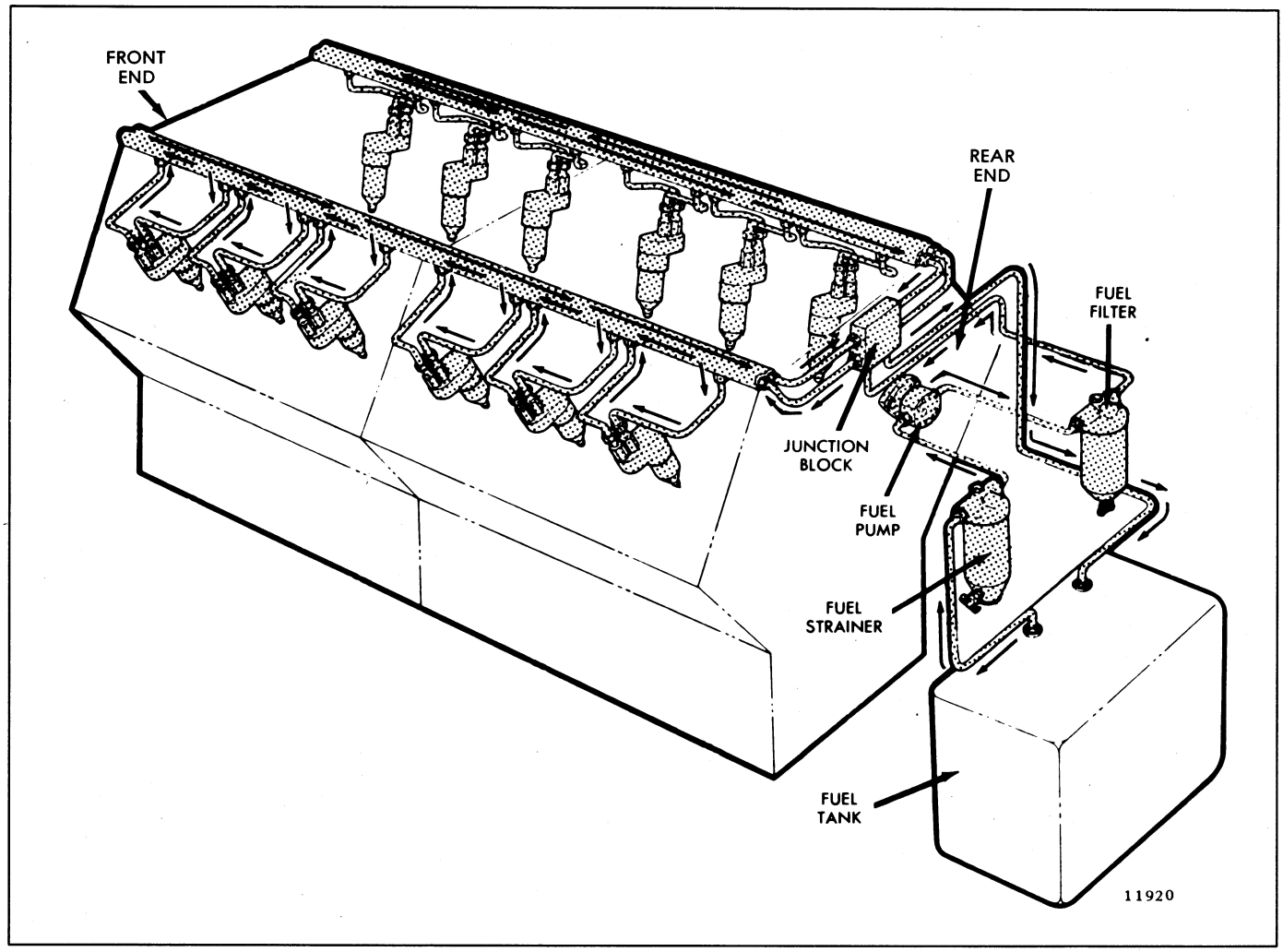


Fig. 1 – Schematic Diagram of Fuel System

 © Detroit Diesel Corporation

FUEL INJECTOR
MECHANICAL UNIT INJECTOR (MUI)
NEEDLE VALVE

The fuel injector (Figs. 1 and 2) is a lightweight compact unit which enables quick, easy starting directly on diesel fuel and permits the use of a simple open type combustion chamber. The simplicity of design and operation provides for simplified controls and easy adjustment. No high pressure fuel lines or complicated air-fuel mixing or vaporizing devices are required.

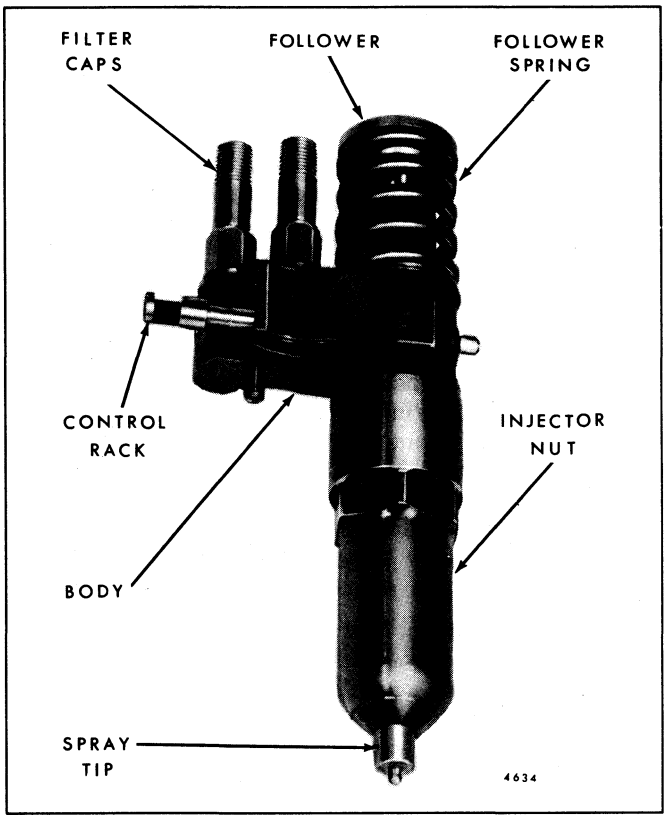


Fig. 1 - Fuel Injector Assembly

The fuel injector performs four functions (Times - Atomizes - Meters - Pressurizes):

1. Accurately times the moment of fuel injection.
2. Atomizes the fuel for vaporization and mixing with the air in the combustion chamber.
3. Meters and injects the correct amount of fuel required to maintain engine speed and to handle the load.
4. Creates the high pressure required for proper fuel injection.

Combustion required for satisfactory engine operation is obtained by injecting, under pressure, a small quantity of accurately timed, metered and finely atomized fuel oil into the combustion chamber.

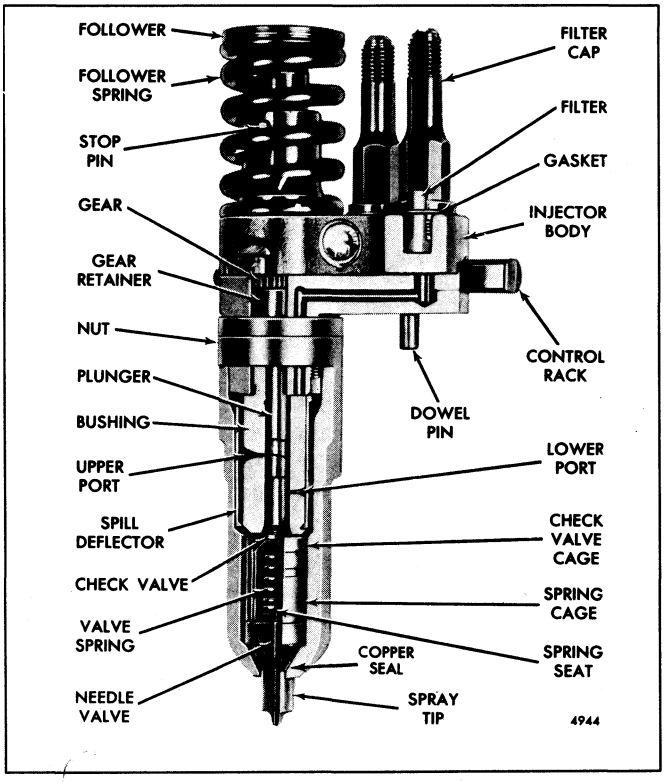


Fig. 2 – Cutaway View of Fuel Injector

Metering and timing during fuel injection is accomplished by an upper and lower helix machined in the lower end of the injector plunger. Fig. 3 illustrates the fuel metering from no load to full load by rotation of the plunger in the bushing.

Fig. 4 illustrates the phases of injector operation by the vertical travel of the injector plunger.

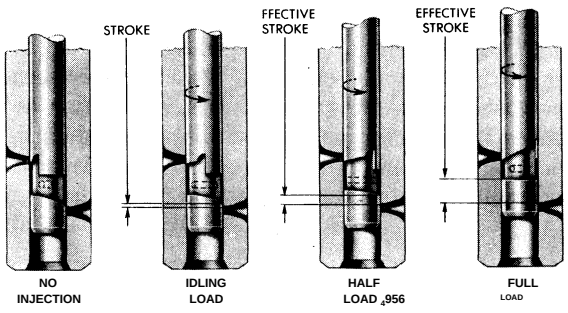


Fig. 3 - Fuel Metering from No Load to Full Load

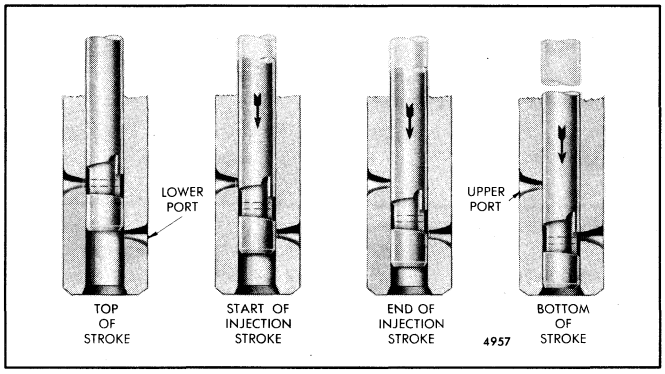


Fig. 4 - Phases of Injector Operation Through Vertical Travel of Plunger

The continuous fuel flow through the injector serves, in addition to preventing air pockets in the fuel system, as a coolant for those injector parts subjected to high combustion temperatures.

To vary the power output of the engine, injectors having different fuel output capacities are used. The fuel output of the various injectors is governed by the effective stroke of the plunger and the flow rate of the spray tip.

Since the helix angle and the plunger design determines the operating characteristics of a particular injector, it is imperative that the specified injectors are used for each engine. If injectors of different types are mixed in an engine, erratic operation will result and may cause serious damage to the engine or to the equipment which it powers.

Each fuel injector has a circular disc pressed into a recess at the front side of the injector body for identification purposes (Fig. 1).

Each injector control rack (Fig. 2) is actuated by a lever on the injector control tube which, in turn, is connected to the governor by means of a fuel rod. These levers can be adjusted independently on the control tube, thus permitting a uniform setting or fine tuning of all injector racks.

The fuel injector combines in a single unit all of the parts necessary to provide complete and independent fuel injection at each cylinder.

Operation

Fuel, under low pressure, enters the injector at the inlet side through a filter cap and filter positioned over the racks (Fig. 2). From the filter, the fuel passes through a drilled passage into the supply chamber, that area between the plunger bushing and the spill deflector, in addition to that area under the injector plunger within the bushing. The plunger operates up and down in the bushing, and is supplied fuel through the two funnel-shaped ports in the bushing wall.

The motion of the injector rocker arm is transmitted to the plunger by the follower which bears against the follower spring (Fig. 5). In addition to the reciprocating motion, the plunger cap be rotated around its axis by the gear which

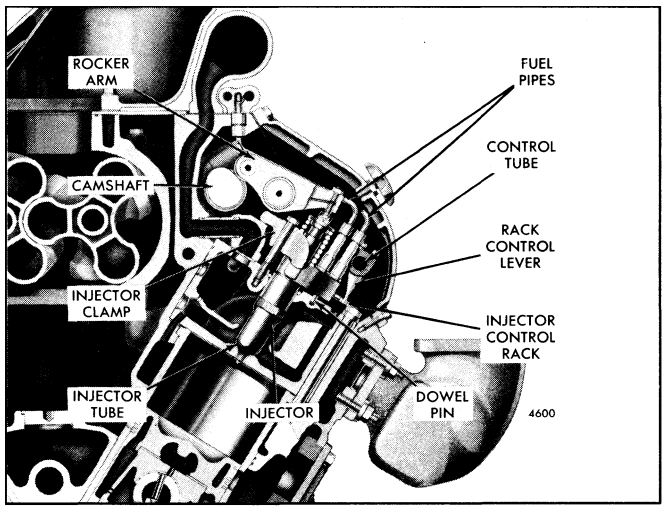


Fig. 5 - Fuel Injector Mounting

meshes with the control rack. To accomplish fuel metering, an upper helix and a lower helix are machined in the lower part of the plunger. The helix relationship to the ports changes with the rotation of the plunger.

As the plunger moves downward, under pressure of the injector rocker arm, some of the fuel under the plunger moves into the supply chamber through the lower port until the port is covered by the lower end of the plunger. The fuel below the plunger continues to move up through a central passage in the plunger into the fuel metering recess and into the supply chamber through the upper port until that port is covered by the upper helix of the plunger. With the upper and lower ports both covered, the remaining fuel trapped under the plunger is subjected to increased pressure by the continued downward movement of the plunger.

When sufficient pressure is built up, it opens the flat check valve. The fuel in the check valve cage, spring cage, tip passages and tip fuel cavity is compressed until the pressure force acting upward on the needle valve is sufficient to open the valve against the downward force of the valve spring. As soon as the needle valve lifts off of its seat, the fuel is forced through the small orifices in the spray tip and atomized into the combustion chamber.

When the lower land of the plunger uncovers the lower port in the bushing, the fuel pressure below the plunger is relieved and the valve spring closes the needle valve, ending injection.

A pressure relief passage has been provided in the spring cage to permit bleed-off of fuel leaking past the needle pilot in the tip assembly.

A check valve, directly below the bushing, prevents leakage from the combustion chamber into the fuel injector in case the valve is accidentally held open by a small particle of dirt. The injector plunger is then returned to its *original* position by the injector follower spring. Fig. 4 shows the various phases of injector operation by the vertical travel of the injector plunger.

 © Detroit Diesel Corporation

On the return upward movement of the plunger, the high pressure cylinder within the bushing is again filled with fuel oil through the ports. The constant circulation of fresh cool fuel through the injector renews the fuel supply in the chamber, helps cool the injector and also effectively removes all traces of air which might otherwise accumulate in the system and interfere with accurate metering of the fuel.

The fuel injector outlet opening, through which the excess fuel oil returns to the fuel return manifold and then back to the fuel tank, is directly adjacent to the inlet opening.

Changing the position of the helices, by rotating the plunger, retards or advances the closing of the ports and the beginning and ending of the injection period. At the same time, it increases or decreases the amount of fuel injected into the cylinder. Fig. 3 shows the various plunger positions from no load to full load. With the control rack pulled out all the way (no injection), the upper port is not closed by the helix until after the lower port is uncovered. Consequently, with the rack in this position, all of the fuel is forced back into the supply chamber and no injection of fuel takes place. With the control rack pushed all the way in (full injection), the upper port is closed shortly after the lower port has been covered, thus producing a maximum effective stroke and maximum injection. From this *no injection* position to *full injection* position (full rack movement), the contour of the upper helix advances the closing of the ports and the beginning of injection.

General Instructions For Injector Care And Overhaul

The fuel injector is one of the most important and precisely built parts f the engine. The injection of the correct amount of fuel into the combustion chamber at exactly the right time depends upon this unit. Because the injector operates against high compression pressure in the combustion chamber, efficient operation demands that the injector assembly is maintained in first-class condition at all times. Proper maintenance of the fuel system and the use of the recommended type fuel filters and clean water-free fuel are the keys to trouble-free operation of the injectors.

Due to the close tolerances of various injector parts, extreme cleanliness and strict adherence to service instructions is required.

Perform all injector repairs in a clean, well lighted room with a dust free atmosphere. An ideal injector room is slightly pressurized by means of an electric fan which draws air into the room through a filter. This pressure prevents particles of dirt and dust from entering the room through the doors and windows. A suitable air outlet will remove solvent fumes along with the outgoing air.

Provide the injector repair room with a supply of filtered, moisture-proof compressed air for drying the injector parts after they have been cleaned. Use wash pans of rust-proof material and deep enough to permit all of the injector parts to be completely covered by the cleaning solvent, when submerged in wire baskets of 16 mesh wire screen. Use baskets which will support the parts so as to avoid contact with the dirt which settles at the bottom of the pans.

Rags should never be used for cleaning injector parts since lint or other particles will clog parts of the injector when it is assembled. A lint-free paper tissue is a suitable material for wiping injector parts.

When servicing an injector, follow the general instructions outlined below:

1. Whenever the fuel pipes are removed from an injector, cover the filter caps with shipping caps to keep dirt out of the injectors and prevent damage. Also, protect the fuel pipes and fuel connectors from damage and the entry of dirt or other foreign material.
2. After an injector has been operated in an engine, do not remove the filter caps or filters while the injector is in the engine. Replace the filters only at the time of complete disassembly and overhaul of an injector.
3. Whenever an injector has been removed and reinstalled or replaced in an engine, make the following adjustments as outlined in Section 14:
   a. Time the injector.
   b. Position the injector control rack.
4. Whenever an engine is to be out of service for an extended period, purge the fuel system, then fill it with a good grade of rust preventive (refer to Section 15.3).
5. When a reconditioned injector is to be placed in stock, fill it with injector test oil J 26400. *Do not use fuel oil.* Install shipping caps on both filter caps immediately after filling. Store the injector in an *upright* position to prevent test oil leakage.

NOTICE: Make sure that new filters have been installed in a reconditioned injector which is to be placed in stock. This precaution will prevent dirt particles from entering the injector due to a possible reversal of fuel flow when installing the injector in an engine other than the original unit.

Remove Injector

1. Clean and remove the valve rocker cover. Discard the gasket.
2. Remove the fuel pipes from both the injector and the fuel connectors (Fig. 6), as follows:
   a. Disconnect the fuel pipe at the injector.
   b. Move the nut back on the pipe and slide a 3/8" I.D. hose over the open end of the pipe, being careful to avoid fuel spillage.

NOTICE: It will be necessary to loosen the fuel pipe nut at the fuel manifold a few turns to permit the fuel pipe to swing away from the injector.

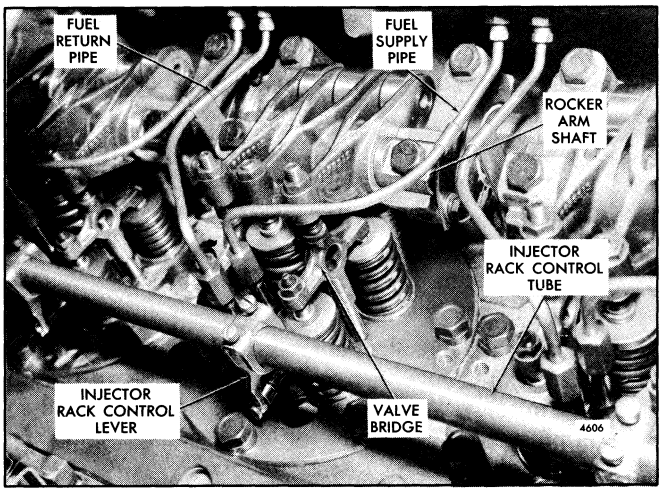


Fig. 6 - Location of Fuel Pipes and Connectors

c. Drain the fuel into a container. This will prevent the fuel in the manifold from draining onto the cylinder head. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings.

d. Immediately after removal of the fuel pipes from an injector, cover the filter caps with shipping caps to prevent dirt from entering the injector. Also, protect the fuel pipes and fuel connectors from entry of dirt or foreign material.

3. Remove the two bolts securing the rocker arm shaft to the camshaft bearing caps and remove the shaft and the valve and injector operating mechanism.

4. Remove the two exhaust valve bridges from the exhaust valve bridge guides.

5. Remove the injector clamp bolt, special washer and clamp (Fig. 7).

6. Loosen the inner and outer adjusting screws or adjusting screw and locknut on the injector rack control lever and slide the lever away from the injector.

7. Lift the injector from its seat in the cylinder (pot) head.

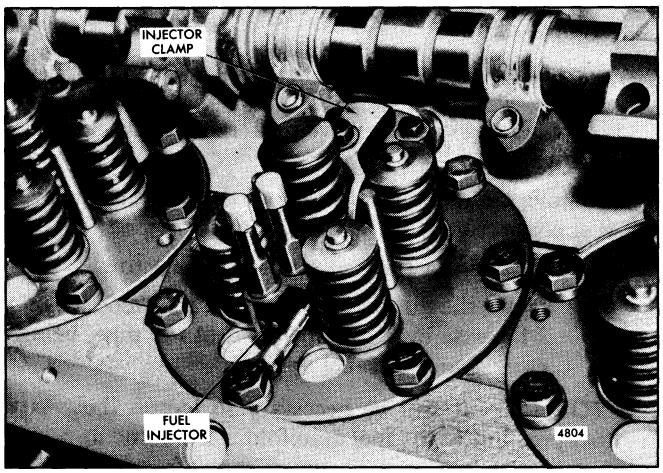


Fig. 7 - Fuel Injector and Clamp

8. Cover the injector hole in the cylinder head to keep foreign material out.

9. Clean the exterior of the injector with clean solvent and dry it with compressed air.

Inspect And Test Prior To Reuse

This inspection and test process is necessary if the injector is being considered for reuse rather than complete overhaul. Submerge the injector in clean solvent to wash it. Blow dry the injector.

CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

1. Inspect the following injector parts for external wear, rust and corrosion.

   Follower spring
   Injector body
   Body nut
   Spray tip
   Injector rack
   Filter caps

2. Inspect the following parts for wear or abrasion deterioration.

   Top of the follower
   Follower spring
   Injector body
   Spray tip orifices

3. Check the rack for freeness and the plunger movement in Tester J 22396.

With the injector control rack held in the *no-fuel* position, operate the handle to depress the follower to the bottom of its stroke. Then, very slowly release the pressure on the handle while moving the control rack up and down until the follower reaches the top of its travel (Fig. 8). If the rack falls freely, the injector passes the test. If the injector fails the rack freeness test, either the plunger is scored or there is a misalignment of the body, bushing or nut due to irregular or dirty parts.

4. Check the injector for leaks using Tester J 23010-A as outlined in Section 2.0 - Shop Notes.

5. Check the spray pattern, atomization and valve opening pressure using Tester J 23010-A as outlined in Section 2.0 - Shop Notes.

6. Perform injector fuel output test using Calibrator J 22410-A as outlined in Section 2.0 - Shop Notes.

If the injector passes the above tests, it can be reused.

If the results of the above tests reveal marginal performance, removal of the plunger may assist with further diagnosis of internal injector problems. Plungers that reveal scratches, score marks, abnormal wear, helix chipping or other obvious damage would indicate that the injector should not be reused.

 © Detroit Diesel Corporation

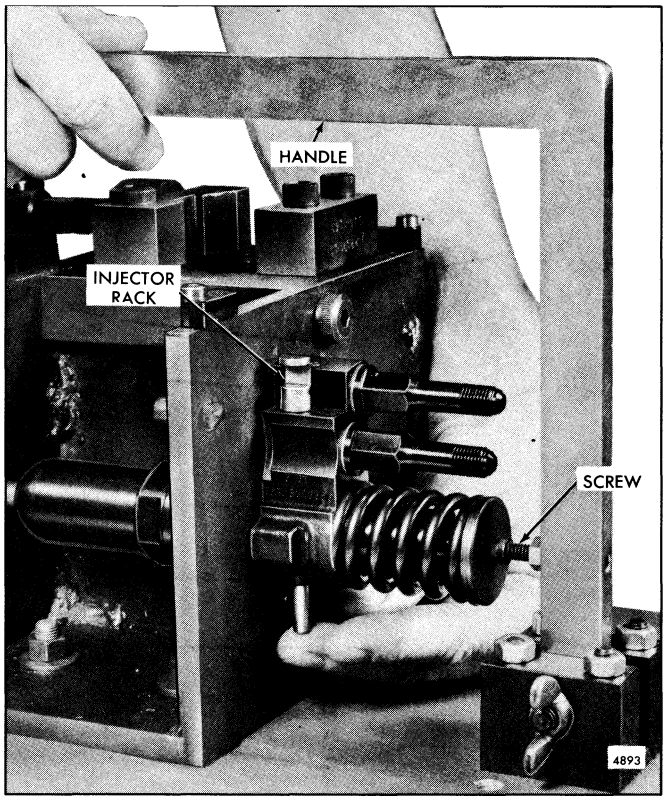


Fig. 8 - Checking Rack for Freeness in Tester J 22396

Disassemble Injector

1. Support the injector upright in injector holding fixture J 22396 (Fig. 9) and remove the filter caps, gaskets and filter.
2. Whenever a fuel injector is disassembled, discard the filter and gaskets and replace with a new filter and new gaskets. In the offset injector, a filter is used in the inlet side only. No filter is required in the outlet side (Fig. 10).
3. Compress the follower spring. Then, using a screw driver, press in on the stop pin to release the follower and remove the injector follower, plunger and spring from the injector body.
4. Rotate the injector in the injector assembly fixture and loosen the nut on the injector body, using injector nut socket J 22799 (Fig. 11).
5. Lift the injector nut straight up, being careful not to dislodge the spray tip and valve parts. Remove the spray tip and valve parts from the bushing and place them in a clean receptacle until ready for assembly. On a current injector remove the copper seal from the injector nut. Discard the copper seal.

   When an injector has been in use for some time, the spray tip, even though clean on the outside, may not be pushed readily from the nut with the fingers. In this event, support the nut on a wood block and drive the tip down through the nut, using tool J 1291-02 (Fig. 12).

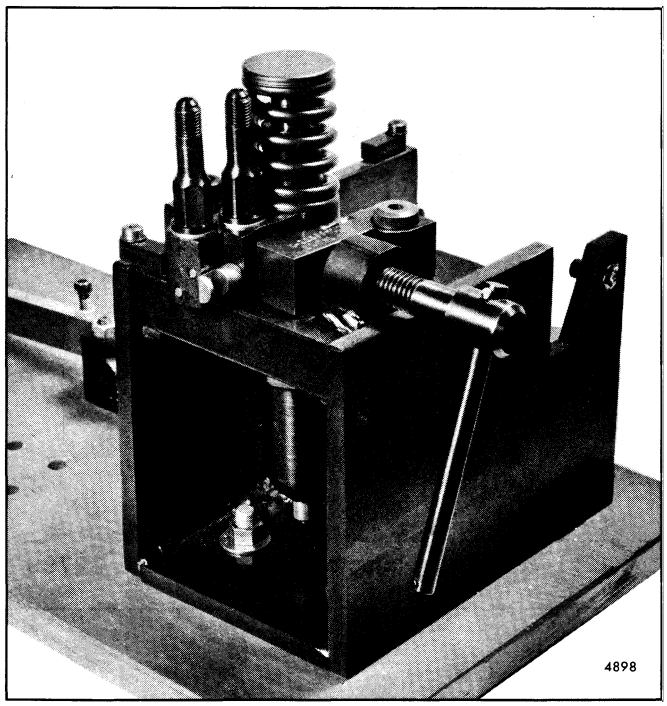


Fig. 9 - Removing Filter Cap

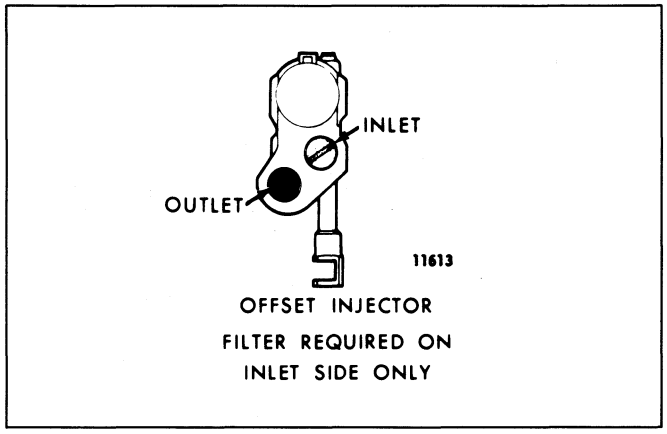


Fig. 10 – Location of Filter in Injector Body

6. Refer to Fig. 13 and remove the spill deflector. Then, lift the bushing straight out of the injector body.
7. Remove the injector body from the holding fixture. Turn the body upside down and catch the gear retainer and gear in your hand as they fall out of the body.
8. Withdraw the injector control rack from the injector body. Also, remove the seal ring from the body.

Clean Injector Parts

Since most injector problems are the result of dirt particles, it is essential that a clean area be provided on which to place the injector parts after cleaning and inspection.

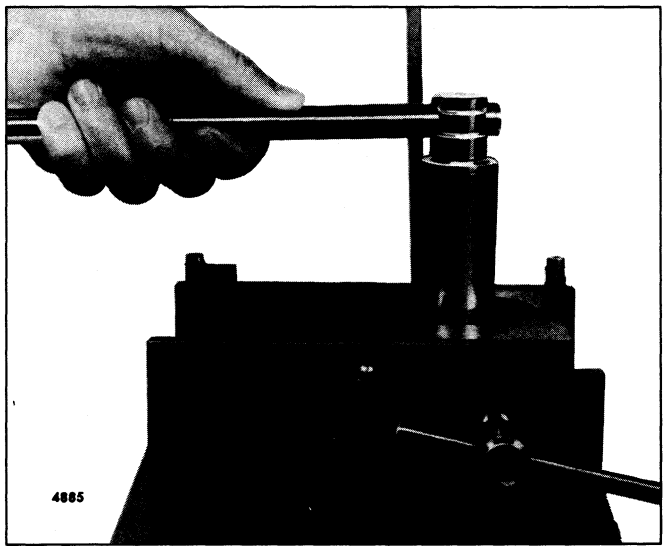


Fig. 11 - Removing Injector Nut using Tool J 22799

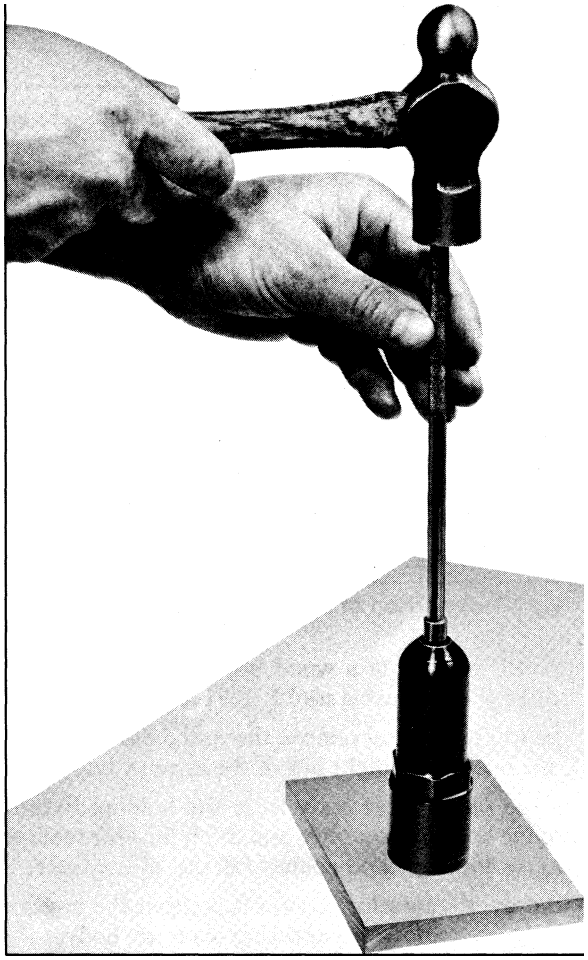


Fig. 1 2 - Removing Spray Tip from Injector Nut using Tool J 1291-02

Wash all of the parts with a suitable cleaning solvent and dry them with clean, filtered compressed air. Use lint free towels to wipe off the parts. Clean out the passages, drilled holes and slots in all of the injector parts.

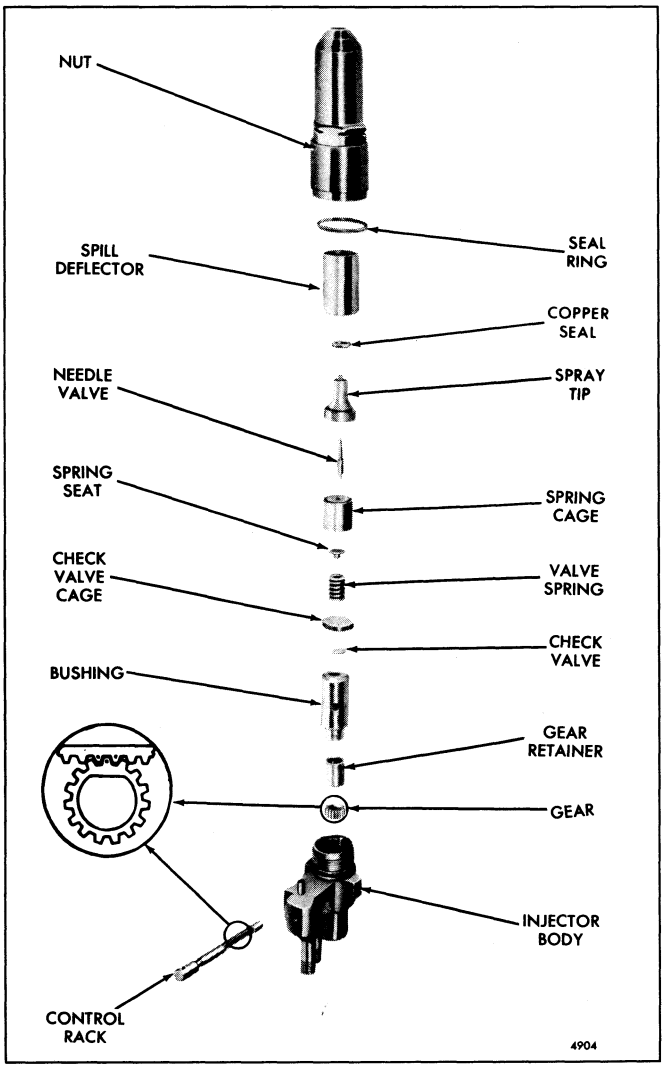


Fig. 13 – Injector Rack, Gear, Spray Tip and Valve Assembly Details and Relative Location of Parts

Carbon on the inside of the spray tip may be loosened for easy removal by soaking for approximately fifteen (15) minutes in a suitable solution prior to the external cleaning and buffing operation.

Clean the spray tip with tool J 22800-01 (Fig. 14).

NOTICE: Care must be exercised when inserting the carbon remover J 22800-01 in the spray tip to avoid contacting the needle valve seat in the tip.

Wash the tip in solvent and dry it with compressed air. Clean the spray tip orifices with pin vise J 4298-1 and a .009” cleaning wire J 22995 (Fig. 15).

Before using the wire, hone the end until it is smooth and free of burrs and taper the end a distance of 1/16” with stone J 8170. Allow the wire to extend 1/8” from tool J 4298-1. Ultra sonic cleaning is also an acceptable method.

 © Detroit Diesel Corporation

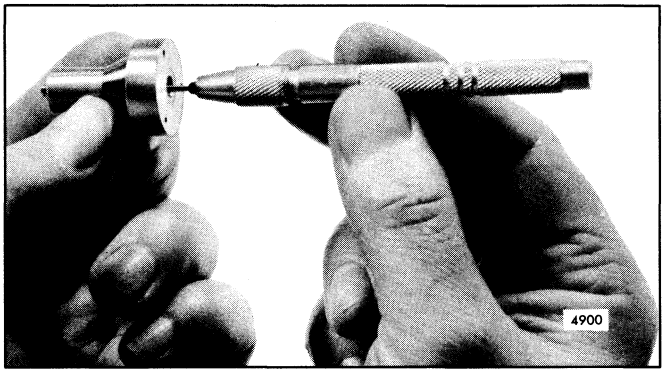


Fig. 14 - Cleaning Injector Spray Tip with Tool J 22800-01

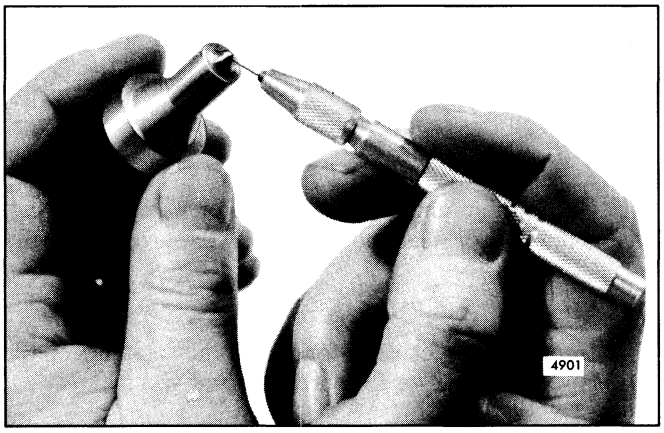


Fig. 15 - Cleaning Spray Tip Orifices with Tool J 4298-1

The exterior surface of an injector spray tip may be cleaned by using a brass wire buffing wheel, tool J 7944. To obtain a good polishing effect and longer brush life, the buffing wheel should be installed on a motor that turns the wheel at approximately 3000 rpm. A convenient method of holding the spray tip while cleaning and polishing is to place the tip over the drill end of the spray tip cleaner tool J 24838 and hold the body of the tip against the buffing wheel. In this way, the spray tip is rotated while being buffed.

NOTICE: Do not buff the spray tip area excessively. *Do not use a steel wire buffing wheel or the spray tip holes may be distorted.*

When the body of the spray tip is clean, lightly buff the tip end in the same manner to clean the spray tip orifice area.

Wash the spray tip in clean solvent and dry it with compressed air.

Clean and brush all of the passages in the injector body, using fuel hole cleaning brush J 8152 and rack hole cleaning brush J 8150. Blow out the passages and dry them with compressed air.

Carefully, insert carbon remover tool J 22096-1 in the injector nut. Turn it in a clockwise direction to remove the carbon deposits on the flat spray tip seat. Remove the carbon deposits from the lower end of the injector nut with carbon remover J 22096-2 (Fig. 16) in the same manner.

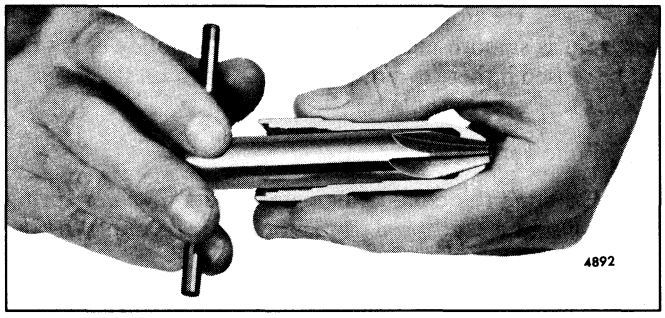


Fig. 16 - Cleaning Injector Nut Lower End with Tool J 22096-2

Wash the injector nut in clean solvent and dry it with compressed air. Carbon deposits on the spray tip seating surfaces of the injector nut will result in poor sealing and consequent fuel leakage around the spray tip.

When handling the injector plunger, do not touch the finished plunger surfaces with your fingers. Wash the plunger and bushing with clean solvent and dry them with compressed air. Be sure the high pressure bleed hole in the side of the bushing is not plugged. If this hole is plugged, fuel leakage will occur at the upper end of the bushing where it will drain out of the injector body vent and rack holes, during engine operation, causing a serious oil dilution problem. *Keep the plunger/bushing together as they are matched parts.*

After washing, submerge the parts in a clean receptable containing clean test oil. *Keep the parts of each injector assembly together.*

Inspect Injector Parts (Visual And Dimensional)

• **NOTICE:** Effective with 1988-build engines, the valve nuts, bodies, and filter caps on series 149 injectors are no longer blued. Bluing has no effect on a part's performance or service life.

1. Follower

   Measure between the top of the follower and the slot. This dimension must be 1.728 ± .002" (Fig. 17).

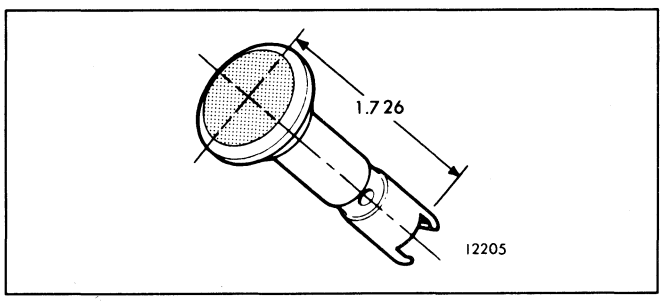


Fig. 17 – Injector Follower

Check the stop pin groove in the side of the follower to be sure it is smooth and not damaged. The follower should not be reused if there is more than .002" wear on the top or if there is any other visible damage or wear.

2. Follower Spring:

   Examine the outside diameter of the follower spring coils for wear caused by the rocker arms contacting the coils. If worn, do not reuse.

   Also, inspect for damage from rust pitting, nicks or notches in the coils, broken coils, broken coil ends and notches under the coil ends. If damaged, do not reuse.

   Check the follower spring tension with spring Tester J 22738-02.

   The current injector follower spring (.237"-.241" diameter wire) has a free length of approximately 2.200" and should be replaced when a load of less than 267 lbs. (current spring) or 290 lbs. (former spring) will compress it to 1.605".

   It is recommended that at the time of overhaul, all injectors in an engine be converted to incorporate the current spring (.237"-.241" diameter wire). However, in the event that one or two injectors are changed, the remaining injectors need not be reworked to incorporate the current spring.

3. Injector Body:

   Inspect the injector body threads, the bushing seating surface and the filter cap gasket sealing surfaces for damage. Then, inspect the rack hole, body seal ring sealing surface, clamp radius and dowel pin.

4. Filter Cap:

   Check the condition of the jumper line sealing surfaces on the filter caps, the copper gasket sealing surfaces, the threads and the fuel passage.

5. Control Rack

   Check the injector control rack for straightness, the teeth for wear and the width of the notch in the clevis. Also, check the rack for nicks, burrs, rust and hardness.

   The notch in the clevis should be .3125" to .3145". A .250" inside diameter bushing may be used to check the rack for straightness. A slightly bent rack will not pass freely back and forth through the bore of the bushing.

6. Gear and Gear Retainer

   Inspect the gear and the gear retainer for nicks, burrs or rust and the gear teeth for wear.

7. Bushing

   Check the bushing lapped sealing surface for scratches, the bushing internal diameter for scoring,

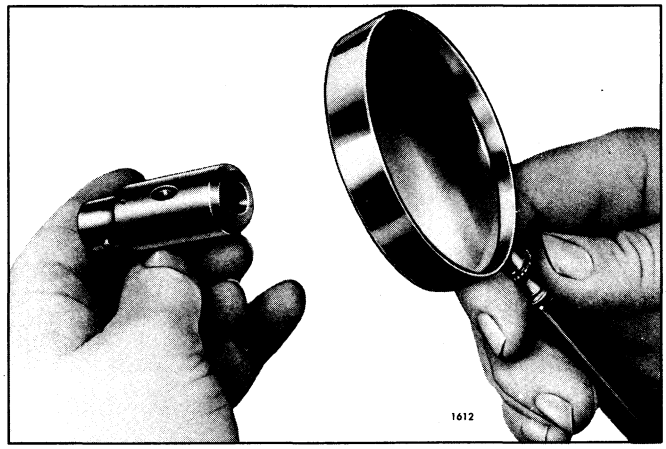


Fig. 18 - Examining Sealing Surface with a Magnifying Glass

the condition of the dowell pin and check for corrosion or varnish (Fig. 18).

8. Plunger:

   Check the plunger for corrosion or varnish, scoring, scratching or wear and chips along the edge of the helix (Fig. 19).

9. Check Valve:

   Inspect the check valve for cracks and scratches on the lapped surfaces or for corrosion and varnish.

10. Check Valve Cage:

    Inspect the check valve cage for cracks and scratches on the lapped surfaces or for corrosion, varnish and wear.

2085

Advanced stage of erosion caused by foreign matter in fuel due to improper fi ltration.

Chipped at lower helix. The above condition can be caused by either lack of fuel at high speeds or water in fuel.

Fig. 19 - Unusable Injector Plungers

 © Detroit Diesel Corporation

11. Valve Spring:

Check the injector valve spring for wear on the coil ends, broken coil ends and notches under the coil ends. Then, check for corrosion, nicks and cavitation erosion on the inside at approximately 1-1/2 coils from the end.

12. Spring Seat:

Check the surfaces for wear.

13. Spring Cage:

Inspect for cracks, corrosion or varnish and scratches on the lapped sealing surfaces. Also, inspect the spring seat surface and the needle valve seating surface for wear.

14. Spray Tip:

Check for cracks, enlarged spray holes, corrosion on the outside diameter taper and oxide scale on the spray hole end. Then, check the nut-to-tip sealing surface and the lapped sealing surface for scratches. Do not reuse if there is scale, cracks or enlarged spray holes.

15. Needle Valve:

Check the spray tip needle valve for erosion at the seat shoulder, scratches and overheating (discolored).

16. Nut:

Check the nut for damaged threads, the condition of the seal ring seating area, the condition of spray tip seating area and the spray tip hole for being corroded irregularly.

Current fuel injectors include a copper seal and a revised injector nut to prevent corrosion of the injector spray tip to nut seat. The angle of the injector nut surface below the spray tip seat has been changed to allow clearance in the injector nut for the installation of the copper seal (Fig. 20).

The new injectors are identified by a notch on the hex corners of the nut.

NOTICE: Do not use a former injector nut with the new copper seal. *Never reuse a copper seal.*

17. Spill Deflector:

Inspect both ends of the spill deflector for sharp edges or burrs.

18. Part Thickness:

Check the minimum thickness of the parts (see Table 1).

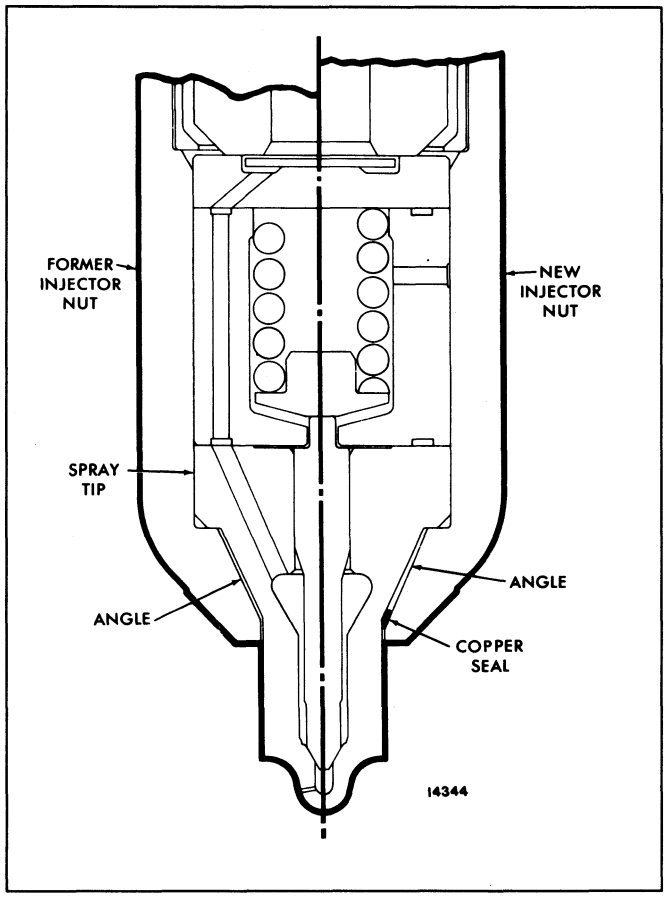


Fig. 20 - Location of Copper Seal in Injector Nut

Part Name	Minimum Thickness
Spray Tip (Shoulder)	.296"
Cage, Valve Spring	.861"
Cage, Check Valve	.186"
Valve, Check	.027"

TABLE 1 - MINIMUM THICKNESS (Used Parts)

19. Needle Valve Lift:

Measure the needle valve lift, using tool J 9462-02 (Fig. 21) as follows:

a. Zero the indicator by placing the bottom surface of the plunger assembly on a flat surface and zero the indicator dial.

b. Place the spray tip and needle valve assembly tight against the bottom of the gage with the quill of the needle valve in the hole in the plunger.

c. While holding the spray tip and needle valve assembly tight against the gage, read the needle valve lift on the indicator. The lift should be

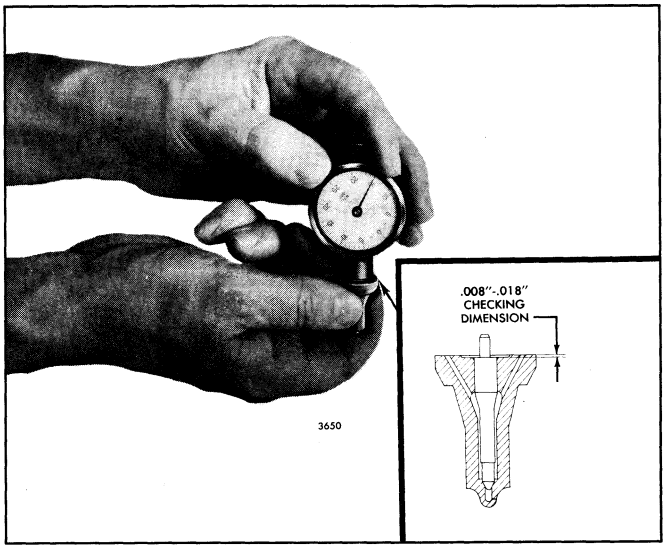


Fig. 21 - Checking Needle Valve Lift with Tool J 9462-02

.008" to .018". If it exceeds .018", that tip assembly must be replaced. If it is less than .008", inspect for foreign material between the needle valve and the tip seat.

d. If the needle valve lift is within limits, install a new needle valve spring and recheck the valve opening pressure and valve action. Low valve opening pressure or poor atomization with a new spring and seat indicates the spray tip and needle valve assembly should be replaced.

20. Classify Spray Tip:

Match the plunger/bushing assembly with the proper spray tip using Flow Gage J 25600-A (see Section 2.0).

Recondition Injector

If any of the injector parts listed below cannot be reconditioned satisfactorily, use new parts. A1 parts must be cleaned to be free of rust, varnish and carbon before reuse.

1. Follower:

■Resurface or replace if worn beyond dimensional limits.

2. Follower Spring:

■Reuse unless damaged, worn or won't meet test specifications.

3. Body:

■Lap bushing seat.

■Reblue.

■Repair damaged threads.

■Replace body if the clamp radius is badly worn or if the threads are less than 90% good.

4. Filter Caps:

■Recondition tapered seat.

■Clean and deburr hole.

■Reblue.

■ Replace if the threads or sealing surfaces are damaged.

5. Control Rack:

■Deburr teeth - check for straightness.

■Replace if the teeth show significant wear.

6. Gear and Gear Retainer:

■Deburr.

■Replace if cracked or significantly worn.

7. Bushing:

■Replace if scored, cracked or if residue cannot be removed.

■Lap the check valve seat (sealing) surface.

8. Plunger:

■ Clean - remove varnish.

■Replace if scored, chipped or scratched.

9. Check Valve:

■Lap both flat (sealing) surfaces.

■Replace if scratched, cracked or badly worn.

10. Check Valve Cage:

■Lap both flat sealing surfaces.

■Replace if cracked or too thin (see Table 1).

11. Valve Spring:

■Replace. Do not reuse unless there is absolutely no wear or damage.

12. Spring Seat:

■Replace if there is a hole worn in the rounded end where the needle quill touches.

13. Spring Cage:

■Lap both flat (sealing) surfaces.

■Replace if cracked or too thin (see Table 1) or if the needle has worn a pocket around the small hole.

14. Spray Tip:

■Regrind seat.

■Lap flat sealing surface.

■Regrind the needle conicol seat.

■ Replace if beyond flow limits i.e., erroded spray holes.

15. Nut:

■Remove carbon from the seat and tapered I.D.

■Reblue.

■Replace if the threads are damaged more than 10% or if the small I.D. is badly erroded.

 © Detroit Diesel Corporation

16. Spill Deflector:

■Remove burrs.

■Reuse if the ends are smooth and even and the deflector is not cracked.

Normally, new parts do not require lapping prior to use. Wash the service parts in clean solvent to remove the solitified preservative. However, if new parts become nicked or burred during handling, then lapping will be necessary to provide adequate sealing between the flat parts.

Lapping Injector Parts

If necessary, lap the sealing surfaces indicated in Fig. 22 as follows:

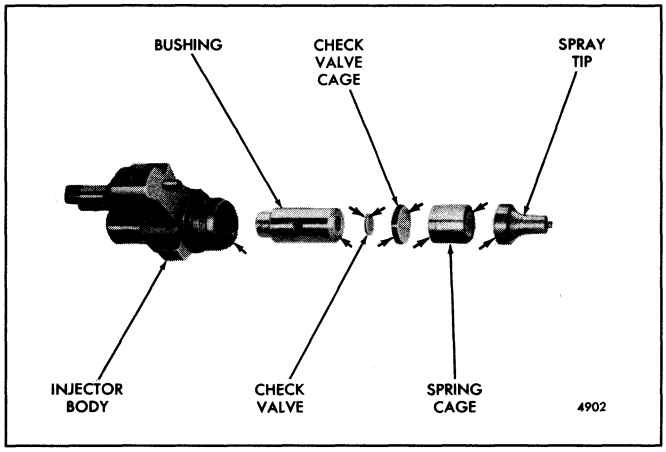


Fig. 22 - Sealing Surfaces which may Require Lapping

1. Clean the lapping blocks (J 22090) with compressed air. Do not use a cloth or any other material for this purpose.
2. Spread a good quality 600 grit dry lapping powder on one of the lapping blocks.
3. Place the part to be lapped flat on the block and, using a figure eight motion, move it back and forth across the block. Do not press on the part, but use just enough pressure to keep the part flat on the block. It is important that the part be kept flat on the block at all times.
4. After each four or five passes, clean the lapping powder from the part by drawing it across a clean piece of tissue placed on a flat surface and inspect the part. *Do not lap excessively.*
5. When the part is flat, wash it in cleaning solvent and dry it with compressed air.
6. Place the dry part on the second block. After applying lapping powder, move the part lightly across the block in a figure eight motion several times to give it a smooth finish. *Do not lap excessively.* Again wash the part in cleaning solvent and dry it with compressed air.
7. Place the dry part on the third block. Do not use lapping powder on this block. Keep the part flat and move it across the block several times, using the figure eight motion. Lapping the dry part in this manner gives it the "mirror" finish required for perfect sealing.
8. Wash all of the lapped parts in clean solvent and dry them with compressed air.

Assemble Injector

1. Secure the body in vise J 22396-1.
2. Insert new filter(s), dimple end down, slotted end up, in the top of the body (Fig. 23).

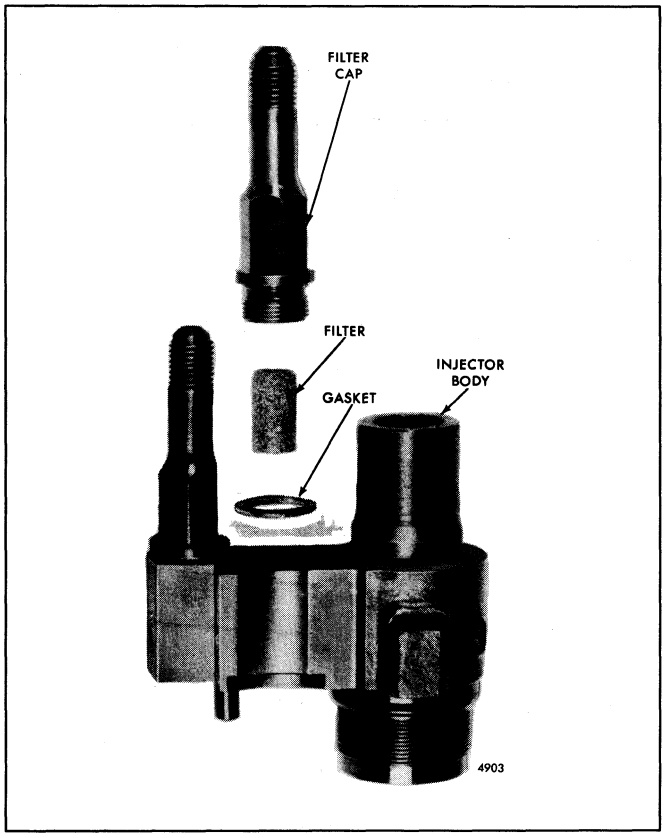


Fig. 23 - Details of Injector Filters and Caps and Their Relative Location

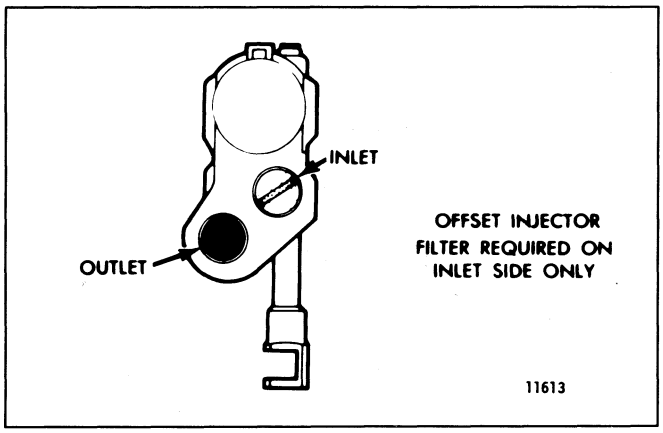


Fig. 24 - Location of Filter in Injector Body

Insert a new filter in the inlet side (located over the injector rack) in an offset injector. No filter is required at the outlet side (Fig. 24).

• 3. Place a new gasket on each filter cap. Lubricate the threads and install the filter caps. Tighten filter caps as follows:

Blued cap on blued body.....
.....70 lb-ft (95 Nem) torque

Non-blued cap on non-blued body or mixed (blued with non-blued part).....
.....62 lb-ft (84 Nem) torque

4. Install clean shipping caps to protect the sealing surfaces and to prevent dirt from entering the injector.
5. Remove the injector from the vise and hold the injector body, bottom end up.
6. Slide the control rack into the injector body.

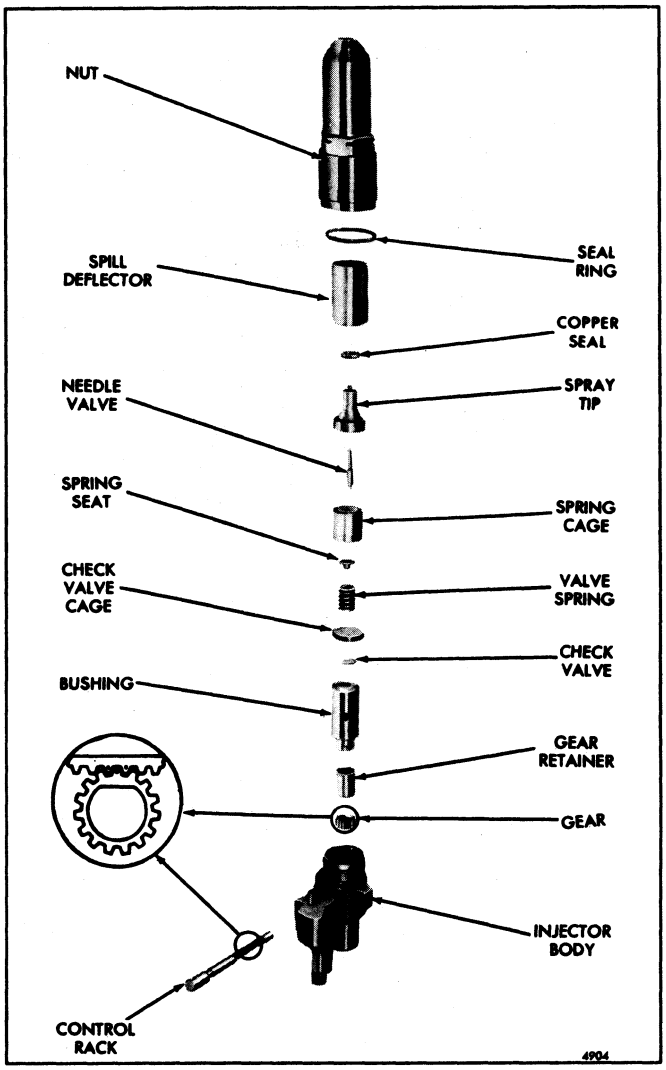


Fig. 25 - Injector Rack, Gear, Spray Tip and Valve Assembly Details and Relative Location of Parts

7. Refer to Fig. 25 and note the marked teeth on the control rack and gear. Then, look into the body bore and move the rack until you can see the drill marks. Hold the rack in this position.
8. Place the gear in the injector body so that the marked tooth is engaged between the two marked teeth on the rack (Fig. 25)
9. Place the gear retainer on top of the gear. Install a new seal ring wetted with test oil.

NOTICE: Wet the seal ring with test oil and install the ring all the way down past the threads and onto the shoulder of the injector body. This will prevent the seal from catching in the threads and becoming shredded.

10. Align the locating pin in the bushing with the slot in the injector body, then slide the end of the bushing into place.
11. Support the injector body, bottom end up, in injector vise J 22396-1.
12. Install the spill deflector over the barrel of the bushing.
13. Perform the spray tip test, as outlined in Section 2.0 using injector tip Tester J 22640-A before proceeding with the injector assembly.
14. Place the check valve centrally on the top of the bushing. Then, place the check valve cage over the check valve and against the bushing. The check valve cage must not rest on the check valve.
15. Insert the spring seat in the valve spring, then insert the assembly into the cage, spring seat first.
16. Place the spring cage, spring seat and valve spring assembly (valve spring down) on top of the check valve cage.
17. Put the needle, tapered end down, into the spray tip (Fig. 26). Then, place the spray tip assembly on top of the spring cage with the quill end of the needle valve in the hole in the spring cage.
18. Place a *new* copper seal (Fig. 20) over the spray tip (current injector nut only).
19. Lubricate the threads in the injector nut and carefully thread the nut on the injector body by hand. Rotate the spray tip between your thumb and first finger while threading the nut on the injector body. Tighten the nut as tight as possible by hand. At this point there should be sufficient force on the spray tip to make it impossible to turn with your fingers.

 © Detroit Diesel Corporation

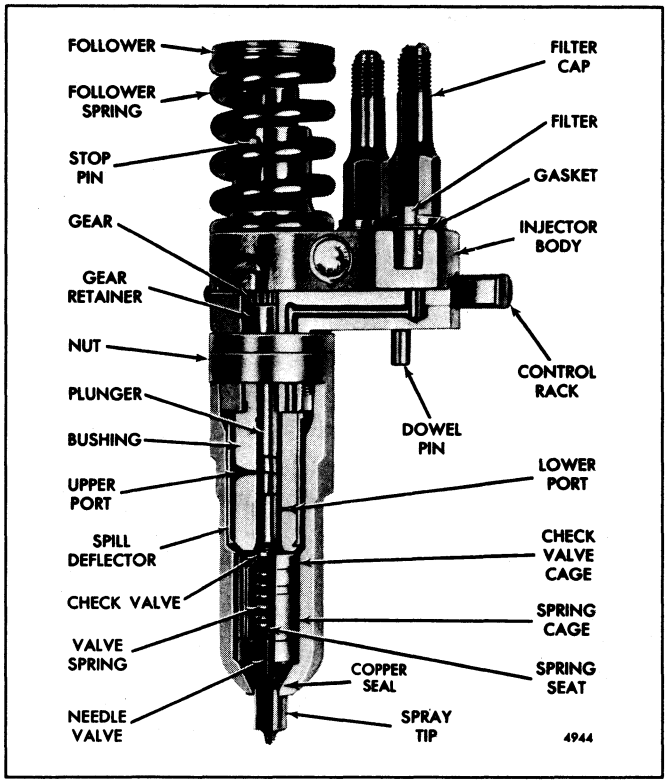


Fig. 26 – Cutaway View of Fuel Injector

• **20. Using socket J 22799 and a torque wrench, tighten injector nut as follows:**

Blued nut on Blued body..... ..... 130 lb-ft 177 N#m) torque

Non-blued nut on blued body..... ..... 85 lb-ft (115 N«n) torque

Mixed (blued with non-blued part)..... ..... 108 lb-ft 147 Nbm) torque

21. After assembling a fuel injector, always check the area between the nut and the body. If the seal is still visible after the nut is assembled, try another nut and a new seal which may allow assembly on the body without extruding the seal and forcing it out of the body-nut crevice.

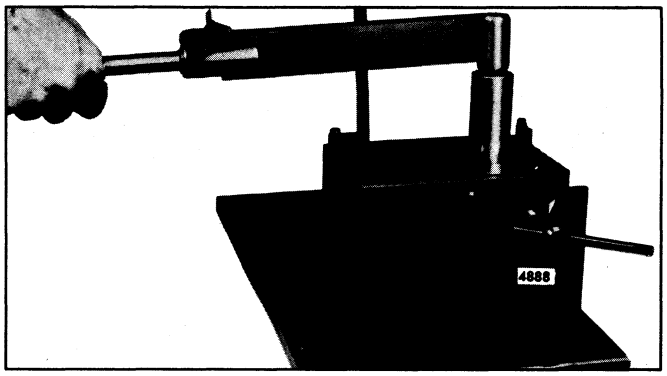


Fig. 27 - Tightening Injector Nut with Torque Wrench using Tool J 22799

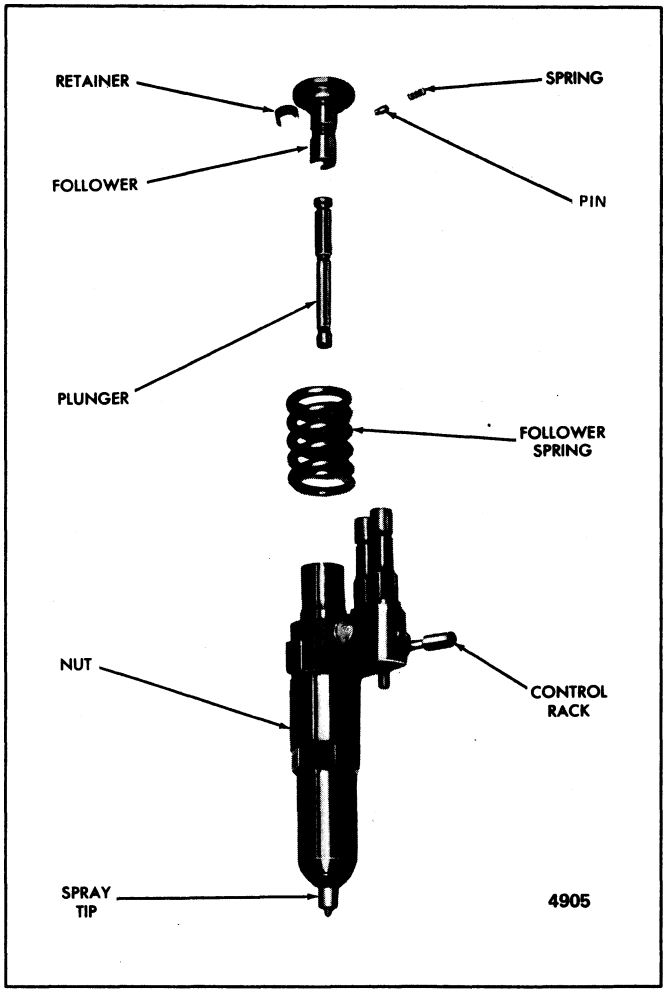


Fig. 28 - Injector Plunger, Follower and Relative Location of Parts

NOTICE: Do not exceed the specified torque. Otherwise, the nut may be stretched and result in improper sealing of the lapped surfaces in a subsequent injector overhaul.

22. Turn the injector over and push the rack all the way in.

23. Place the follower spring on the injector body.

24. Refer to Fig. 34 and place the stop pin on the injector body so that the follower spring rests on the narrow flange of the stop pin.

25. Refer to Fig. 28 and slide the head of the plunger into the follower.

26. Align the slot in the follower with the stop pin hole in the injector body.

27. Align the flat side of the plunger with the flat in the gear.

28. Insert the free end of the plunger in the injector body. Press down on the follower and at the same time press the stop pin into position. When in place, the spring will hold the stop pin in position.

Check Injector Output

Perform the injector fuel output test using Calibrator J 22410-A as outlined in Section 2.0 - Shop Notes.

Check Atomization And Spray Pattern

This test determines spray pattern uniformity and atomization.

1. Clamp the injector properly and purge the air from the system (Fig. 29).
2. Move lever 4 down.
3. Position the injector rack in the *full-fuel* position.
4. Place pump lever 1 in the *vertical* position.
5. Move lever 3 to the *forward detent* position.
6. The injector follower should be depressed rapidly using pump lever 1 (at 40 to 80 strokes per minute) to simulate operation in the engine. Observe the spray patten to see that all spray orifices are open and dispersing the test oil evenly. The beginning and ending of injection should be sharp and the test oil should be finely atomized with no drops of test oil forming on the end of the tip.

Check Pressure Holding And Test For Leaks

This test determines if the body-to-bushing mating surfaces in the injector are sealing properly and indicates proper plunger-to-bushing fit.

1. Clamp the injector properly in Tester J 23010-A and purge the air from the system (Fig. 29).
2. Close the Thru-Flow valve, but do not overtighten.
3. Move lever 2 to the rear, *horizontal* position.

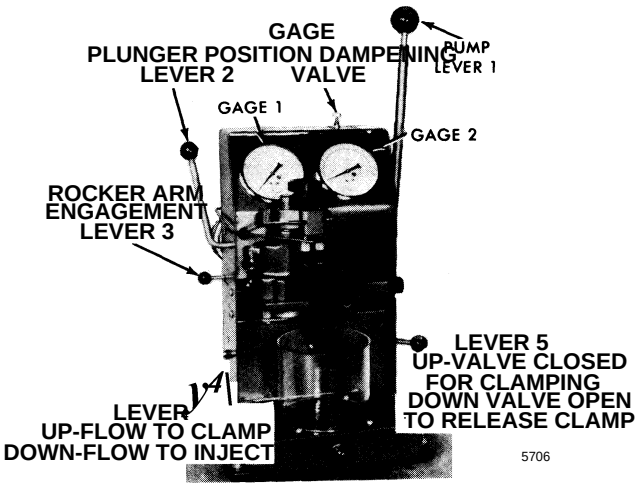


Fig. 29 - Injector in Position for Testing with Tester J 23010-A

4. Operate pump lever 1 until gage 1 slowly reaches 100-200 psi (689-1378 kPa), check for injector nut seal ring leaks. Then, increase the gage reading to 1500-2000 psi (10 335-13 780 kPa). Check for leaks at the filter cap gaskets and the body plugs. Note the time for the pressure to drop from 1500 psi to 1000 psi (10 335 kPa to 6890 kPa). This should not occur in less than 7 seconds. This test determines if the body-to-bushing mating surfaces in the injector are sealing properly.
5. Unclamp the injector.
6. Open the Thru-Flow valve to release pressure in the system.
7. Move lever 5 *down* to release the clamping pressure.
8. Swing out the adaptor plate and remove the injector after the nylon seals in the clamping head are free and clean of the injector filter caps.
9. Carefully, return lever 5 to the *up (horizontal)* position.

Check Rack Freeness And Spray Tip Concentricity

Place the injector in Tester J 29584 (Fig. 30) and check rack freeness.

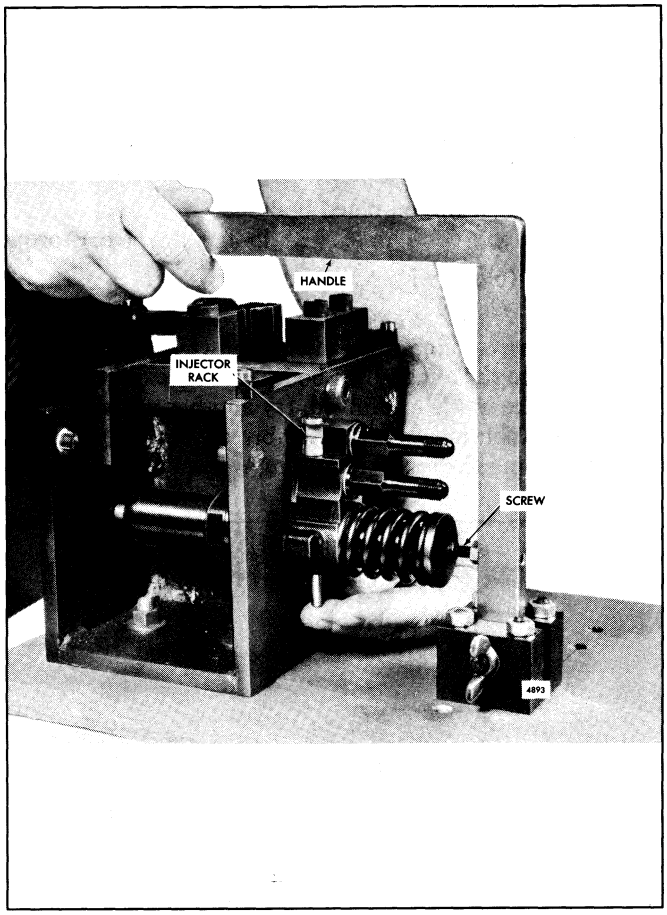


Fig. 30 - Checking Rack for Freeness in Tester J 29584

 © Detroit Diesel Corporation

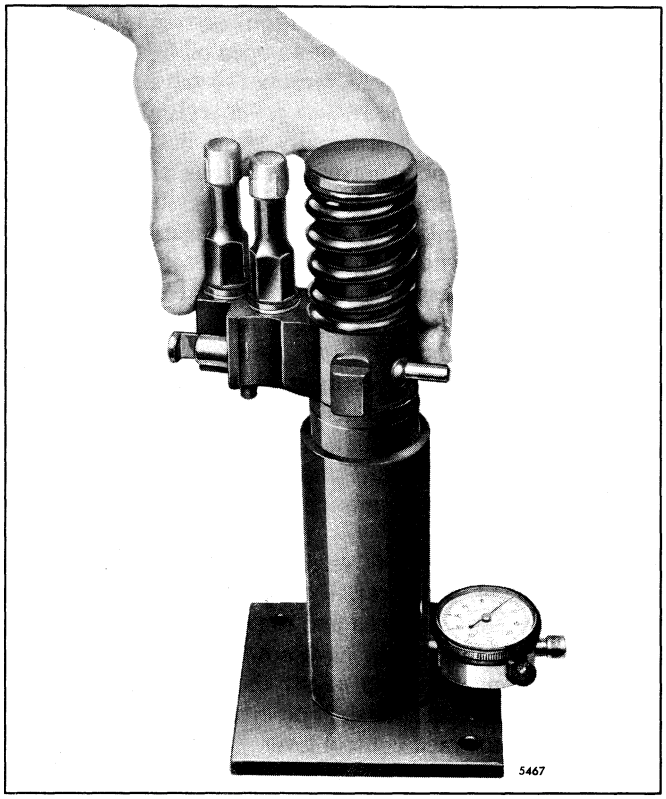


Fig. 31 - Checking Injector Spray Tip Concentricity using Tool J 23905

With the injector control rack held in the *no-fuel* position, operate the handle to depress the follower to the bottom of its stroke. Then, very slowly release the pressure on the handle while moving the control rack up and down until the follower reaches the top of its travel. If the rack falls freely the injector passes the test.

If the rack does not fall freely, loosen the injector nut, turn the tip, then retighten the nut. Loosen and retighten the nut a couple of times, if necessary. Generally, this will free the rack. Then, if the rack isn't free, change the injector nut. In some cases it may be necessary to disassemble the injector to eliminate the cause of the misaligned parts or to remove dirt.

To assure correct alignment, check the concentricity of the spray tip as follows:

1. Place the injector in Tester J 23905 (Fig. 31) and adjust the dial indicator to zero.
2. Rotate the injector 360° and note the total runout as indicated on the dial.
3. If the total runout exceeds .008", remove the injector from the gage. Loosen the injector nut, center the spray tip and tighten the nut to 120-140 lb—ft (163-190 NAm) torque. Recheck the spray tip concentricity. If, after several attempts, the spray tip cannot be positioned satisfactorily, replace the injector nut.

Box And Store Injector

If the reconditioned injector is to be placed in stock, fill it with injector test oil J 26400. *Do not use fuel oil.* Install shipping caps on both filter caps immediately after filling. Store the injector in an *upright* position to prevent test oil leakage.

Install Injector

Before installing an injector in an engine, remove the carbon deposits from the beveled seat of the injector tube in the cylinder head. This will assure correct alignment of the injector and prevent any undue stresses from being exerted against the spray tip.

Use injector tube bevel reamer J 22342-11 or a cylindrical wire brush, Section 2.1.4, to clean the carbon from the injector tube. Exercise care to remove ONLY the carbon so that the proper tip protrusion is maintained. Pack the flutes of the reamer with grease to retain the carbon removed from the tube.

Be sure the fuel injector is filled with fuel oil. If necessary, add clean fuel oil at the inlet filter cap until it ririiSv out of the outlet filter cap.

Install the injector in the engine as follows:

1. Refer to Fig. 5 and insert the injector into the injector tube with the dowel pin in the injector body registering with the locating hole in the cylinder head.
2. Slide the injector rack control lever over so that it registers with the injector rack.
3. Install the injector clamp, special washer (with curved side toward injector clamp) and bolt. Tighten the bolt to 46-50 lb—ft (62-68 N«m) torque. Make sure that the clamp does not interfere with the injector follower spring or the exhaust valve springs.

   NOTICE: Check the injector control rack for free movement. Excess torque can cause the control rack to stick or bind.
4. Install the two exhaust valve bridges.
5. Install the valve and injector operating mechanism. Tighten the two rocker arm shaft bolts to 90-100 lb—ft (122-136 N#m) torque.
6. Place the injector rack control tube assembly in position, with the control tube levers engaged with the injector racks, and secure it with four bolts and lock washers. Tighten to 13-17 lb—ft (18-23 N#m) torque.
7. Install the fuel supply and fuel return pipes. The current fuel pipe connector nuts are 9/16" diameter wrench hex at each end. The former connector nuts were 7/16" at the fuel manifold connector end and 9/16" at the injector filter cap end. The former and current fuel pipe assemblies are interchangeable on an engine.

   •**NOTICE:** DDC recommends that the original flared end fuel pipes not be reused. New flared end fuel pipes should be installed.

Use new wrench set J 26617 and tighten both nuts on each fuel pipe to 18-22 lb-ft (24-30 N#m) torque. Then, install the fuel line support clips.

The new handle J 26617-1 can be used to tighten or loosen the connector nuts without any resultant damage to the handle, providing 25 lb-ft (34 N«m) torque is not exceeded. The former tool J 23385 could fracture when tightening a damaged fuel line connector nut and therefore is no longer available and should not be used.

Also, with the use of the new wrench set J 26617 and the fact that the handle is preset to click at 20 lb-ft (27 N#m) torque, it will *no longer be necessary* to use the torque wrench reading procedure as outlined in Section 1.3 under *Assemble Crankshaft Halves.*

NOTICE: Do not bend the fuel pipes and do not exceed the specified torque. Excessive tightening will twist or fracture the flared end of the fuel line and result in leaks. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings (refer to *Fuel Jumper Line Maintenance and Reuse* Pressurize Fuel System - Check for Leaks in Section 2.0 - Shop Notes).

An indication of fuel leakage at the fittings of the fuel injector supply lines and connector nut seals could be either low lubricating oil pressure (dilution) or fuel odor coming from the crankcase breathers or an open oil filler cap. When any of the above are detected, remove the valve rocker cover. A close inspection of the rocker cover, cylinder head, fuel lines and connectors will usually show if there is a fuel leakage problem. Under normal conditions, there should be a coating of lubricating oil throughout the cylinder head area and puddles of oil where the fuel pipes contact the connectors and where the fuel connectors contact the cylinder head. If these areas do not have the normal coating of lubricating oil, it is likely that fuel oil is leaking and washing off the lubricating oil. Remove and replace the leaking fuel pipes and/or connectors. Use a new gasket and reinstall the rocker cover. Then, drain the lubricating oil and change the oil filter elements. Refer to Section 13.3 (Lubrication Specifications) and refill the crankcase to the proper level with the recommended grade of oil.

8. Perform a complete engine tune-up as outlined in Section 14. However, if only one injector has been removed and replaced and the other injectors and the governor adjustment have not been disturbed, it will only be necessary to adjust the valve clearance and time the injector for the one cylinder, and to position the injector rack control lever.

 © Detroit Diesel Corporation

FUEL INJECTOR TUBE

The bore in the cylinder head for the fuel injector is directly through the cylinder head water jacket as shown in Fig. 1. To prevent coolant from contacting the injector and still maintain maximum cooling of the injector, a tube is pressed into the injector bore. This tube is sealed at thetop with a neoprene ring and upset into a flare on the lowerside of the cylinder head to create water-tight joints at thetop and bottom.

Remove Injector Tube

When removal of an injector tube is required, use injector tube service tool set J 22342-01, as follows:

1. Remove, disassemble and clean the cylinder head, as outlined in Section 1.2.

2. Place the injector tube installer J 22342-1 in the injector tube. Insert the pilot J 22342-3 through the small opening of the injector tube and thread the pilot into the tapped hole in the end of the installer (Fig. 1).

3. Tap on the end of the pilot to loosen the injector tube. Then lift the injector tube, installer and pilot from the cylinder head.

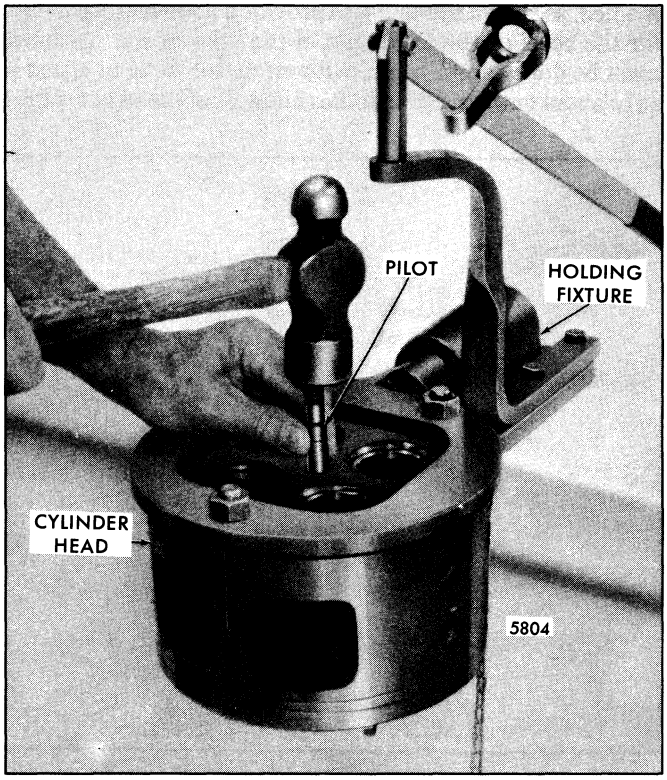


Fig. 1 - Removing Injector Tube

Install Injector Tube

Thoroughly clean the injector tube hole in the cylinder head to remove dirt, burrs or foreign material that may prevent the tube from seating at the lower end or sealing at the upper end. Then install the tube, as follows:

1. Place a new injector tube seal ring in the counterbore in the cylinder head.

2. Place the installer J 22342-1 in the injector tube. Then insert the pilot J 22342-3 through the small opening of the injector tube and thread it into the tapped end of the installer (Fig. 2).

3. Slip the injector tube and tool assembly in the injector bore and drive them in place (Fig. 2). The flange at the upper end of the tube will seat on the seal ring and into the counterbore of the cylinder head when the injector tube is properly positioned. Then remove the installer and pilot.

4. With the injector tube properly positioned in the cylinder head, assemble the swaging die and swage the lower end of the injector tube, as follows:

   a. Refer to Fig. 3 and thread stud J 22343-15 into body J 22342-4 until the stud head is approximately 1 1/2" above the top of the body. Place the seat and guide J 22342-12 into the lower end of the body.

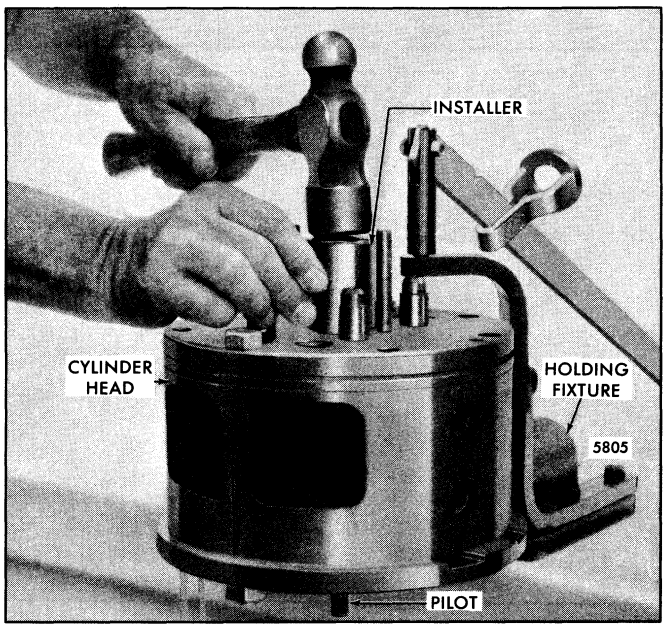


Fig. 2 - Installing Injector Tube

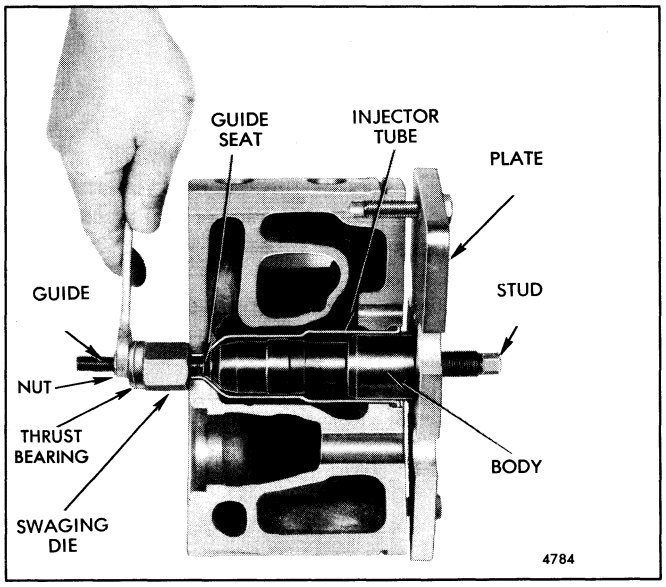


Fig. 3 - Swaging Injector Tube with Tool Set J 22342-01

b. Position the body assembly into the injector tube. Place plate J 22342-13 over the body and valve bridge guides, then secure the plate to the cylinder head with two bolts. Tighten the bolts to 5-7 lb—ft (7-10 N«m) torque.

NOTICE: The plate (J 22342-13) must be parallel to the cylinder head after the bo ts are torqued.

c. Turn the stud J 22342-15 until the guide seat makes contact with the lower end of the injector tube.

d. Slide swaging die J 22342-16 over seat and guide J 22342-12, with the arrow on the die pointing toward the cylinder head. This will place the flaring end of the swaging die against the injector tube.

e. Lubricate the thrust bearing, nut and flat washer with grease. Place thrust bearing J 22342-18 against the swaging die, then install the flat washer and nut J 22342-19.

f. Tighten the nut to 30-35 lb—ft (41-47 N«m) torque, turn the swaging die four full turns and retorque the nut to 30-35 lb—ft (41-47N#m) torque. Repeat this sequence until the injector tube is fully swaged.

NOTICE: Do not exceed the specified torque.

5. Disassemble and remove swaging tools.

Ream Injector Tube

After an injector tube has been installed in a cylinder head, it must be finished in three operations: First, *hand reamedas* shown in Fig. 4, to receive the injector body nut and spray tip; second, *spot-faced* to remove excess stock at the lower end of the injector tube (Fig. 5); and third, *hand reamed*, as shown in Fig. 6, to provide a good seating surface for the bevel or the lower end of the injector nut. Reaming must be done carefully and without undue force or speed so as to avoid cutting through the thin wall of the injector tube.

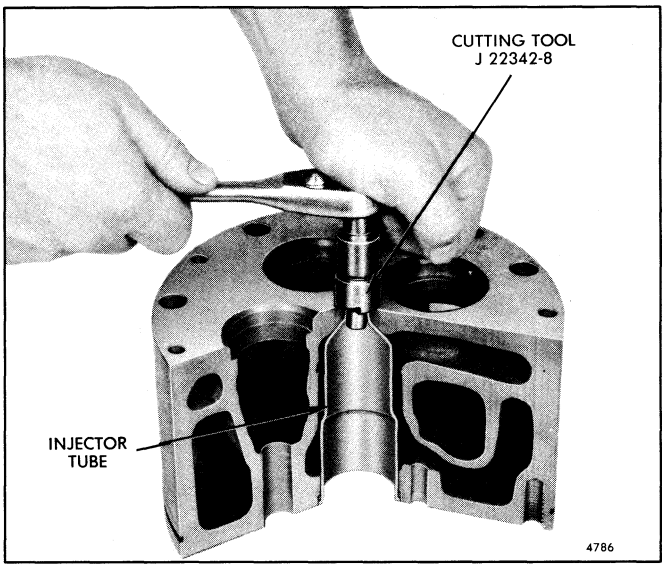


Fig. 4 - Reaming Injector Tube for Injector Body Nut and Spray Tip with Tool J 22342-5

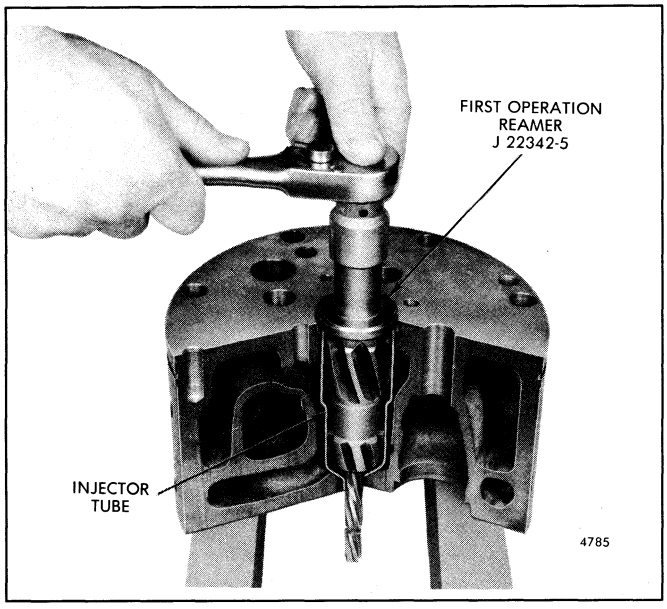


Fig. 5 - Removing Excess Stock from Lower End of Injector Tube with Tool J 22342-8

 © Detroit Diesel Corporation

NOTICE: The reamer should be turned in a *clockwise direction* only, both when inserting and when withdrawing the reamer, because movement in the opposite direction will dull the cutting edges of the flutes.

1. Ream the injector tube for the injector nut and spray tip. With the cylinder head right side up and the injector tube free from dirt, proceed with the first reaming operation, as follows:

   a. Place a few drops of light cutting oil on the reamer flutes, then carefully position the reamer J 22342-5 in the injector tube.

   b. Turn the reamer in a clockwise direction (withdrawing the reamer frequently for removal of chips) until the collar on the reamer contacts the injector tube (Fig. 4). Clean out all of the chips.

2. Remove excess stock.

   a. With the cylinder head bottom side up, insert the pilot of cutting tool J 22342-8 into the small hole of the injector tube.

   b. Place a few drops of cutting oil on the tool. Then, using a socket and speed handle (Fig. 5), remove the excess stock so that the lower end of the injector tube is from flush to .005” below the finished surface of the cylinder head.

3. Ream the bevel seat in the injector tube.

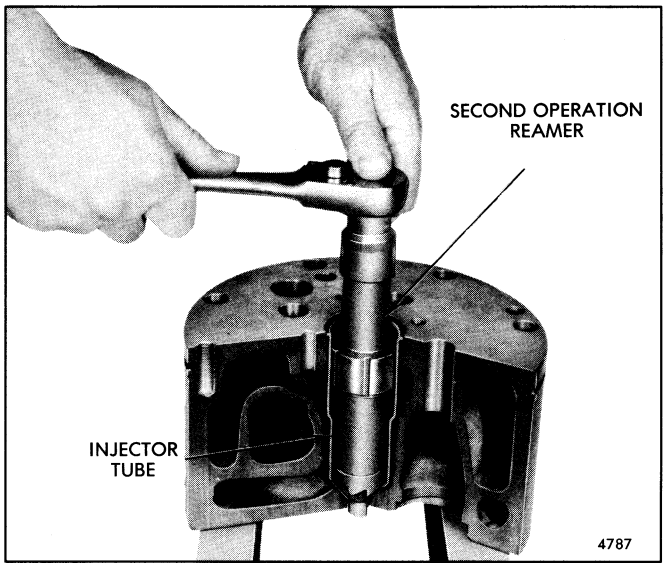


Fig. 6 - Reaming Injector Tube for Injector Nut with Tool J 22342-11

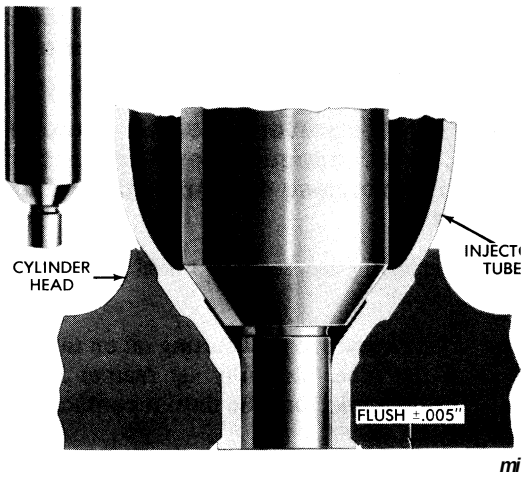


Fig. 7 - Injector Tube Bevel Seat to Cylinder Head Limits - Gage J 25561

The tapered lower end of the injector tube must provide a smooth and true seat for the loWer end of the injector nut to effectively seal the cylinder pressures and properly position the injector tip in the combustion chamber.

Therefore, to determine the amount of stock that must be reamed from the bevel seat of the tube, refer to Fig. 7.

Install gage J 25561. Zero the sled gage, with dial indicator J 22273-01, to the fire deck. The tool J 25561 should be flush to ± .005” with the fire deck of the cylinder head (Figs. 7 and 8).

NOTICE: Any fire deck resurfacing work must be done prior to final injector tube seat gaging. Refer to Section 1.2 for resurfacing instructions.

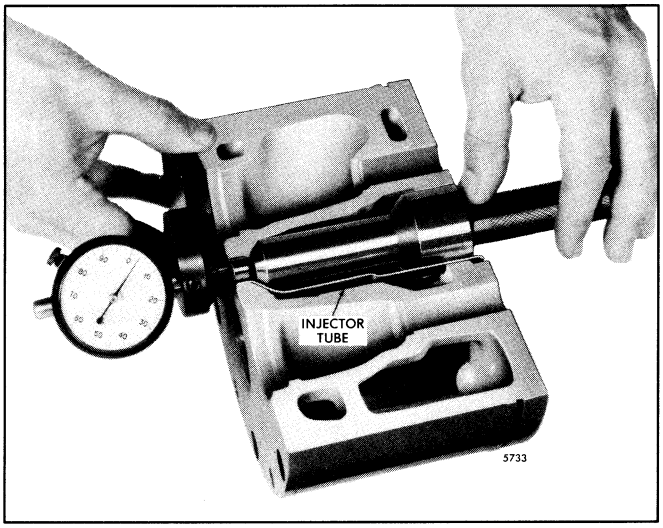


Fig. 8 - Checking Bevel Seat with Gage J 25561 and Dial J 22273

With the first reaming operation completed and the injector tube spot-faced, wash the interior of the injector tube with trichloroethylene or clean fuel oil and dry it with compressed air.

CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Then perform the second reaming operation, as follows:

a. Place a few drops of cutting oil on the bevel seat of the tube. Carefully set reamer J 22342-11 into the injeqtor tube until it contacts the bevel seat.

b. Make a trial cut by turning the reamer steadily without applying any downward force on the reamer. Remove the reamer, blow out the chips and look at the bevel seat to see what portion of the seat has been cut.

c. Proceed carefully with the reaming operation, withdrawing the reamer occasionally to observe the reaming progress.

d. Remove the chips from the injector tube and, using an injector as a gage, continue the reaming operation until the shoulder of the spray tip is within the limits (Fig. 7). Then wash the interior of the injector tube with trichloroethylene or clean fuel oil and dry it with compressed air.

CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

 © Detroit Diesel Corporation

FUEL PUMP

The positive displacement gear type fuel pump transfers fuel from the supply tank to the fuel injectors (Figs. 1, 8 and 9). The pump circulates an excess supply of fuel through the fuel injectors which purges the air from the system and cools the fuel injectors. The unused portion of fuel returns to the fuel tank by means of a fuel return manifold and fuel return line.

The fuel pump is mounted on an adaptor, attached to the flywheel housing, and is driven off the end of the blower drive gear by a drive coupling fork (Fig. 2). The drive coupling fork is attached to the end of the pump drive shaft and mates with a drive disc attached to the blower drive gear assembly. The fuel pump is a right-hand rotating pump. Regardless of engine rotation, the pump always rotates in a right-hand rotation.

The former fuel pump and drive fork was effective with engine serial numbers 12E-4192 (including 12E-4175,4181) and 16E-3421 (including 16E-3397). The former pump is identified by the number “11” stamped in the pump cover. The former pump (Fig. 4) differs from the early pump in that additional passages have been drilled in the cover, driven shaft and in the pump body to improve lubrication and increase the relief pressure capacity.

A new positive displacement fuel pump with 3/4” thick rotary gears is being used on all Series 149 engines (Fig. 9). The current pump differs from the former pump in that the drive and driven gears of the new are supported by precision anti-friction needle bearings. These bearings are lubricated through angle-drilled holes from the fuel pressure side of the pump. The drive and driven gears in the current pump body (stator) are a slip fit on the shafts. A Woodruff type key between the drive gear and drive shaft and a pin between the driven gear and idler (driven) shaft hold the gears in position. Snap rings on the ends of the gears prevent lateral movement.

The fuel pump cover and body are positioned by two dowels. The dowels aid in maintaining gear shaft alignment. The mating surface of the pump body and cover are perfectly flat ground surfaces. No gasket is used between the former cover and body since the pump clearances are set up on the basis of metal-to-metal contact. A very thin coat of sealant provides a seal against any minute irregularities in the mating surfaces. A plastic gasket is used to seal the gear housing (cover) and stator (body) and also maintain close gear end clearance for improved efficiency. Cavities in the pump cover accommodate the ends of the drive and driven shafts.

The fuel pump body is recessed to provide running space for the pump gears (Fig. 3). Recesses are also provided at the inlet and outlet positions of the gears. The small hole “A” (two holes current pump) permits the fuel oil in the inlet side of the pump to lubricate the relief valve at its outer end and to eliminate the possibility of a hydrostatic lock which would render the relief valve inoperative. Pressurized fuel contacts the relief valve through hole JIB” and provides for relief of excess discharge pressures. Fuel reenters the inlet side of the pump through hole “C” when the discharge pressure is great enough to move the relief valve back from its seat. Part of the relief valve may be seen through hole “C”. The cavity “D” provides escape for the fuel oil which is squeezed out of the gear teeth as they mesh together on the discharge side of the pump. Otherwise, fuel trapped at the root of the teeth would tend to force the gears apart, resulting in undue wear on the gears, shafts, body and cover.

Two oil seals are pressed into the bore in the flanged side of the pump body to retain the fuel oil in the pump and the lubricating oil in the flywheel housing (Fig. 5). The oil seals are installed with the lips of the seals facing toward the flanged end of the pump body. A small hole “E”(Fig. 3) serves as a vent passageway in the body, between the inner oil seal and the suction side of the pump, which prevents building up any fuel oil pressure around the shaft ahead of the inner seal.

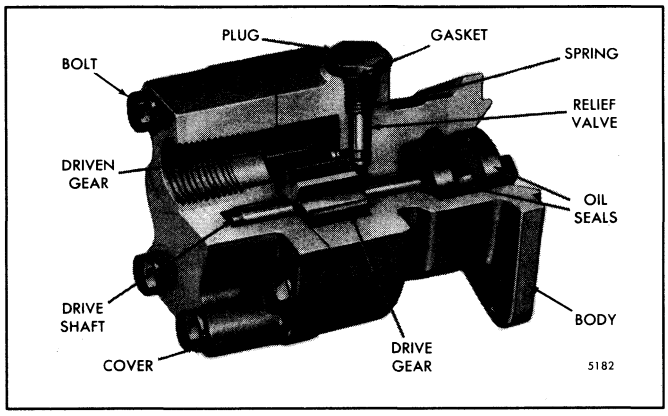


Fig. 1 - Early Fuel Pump Assembly

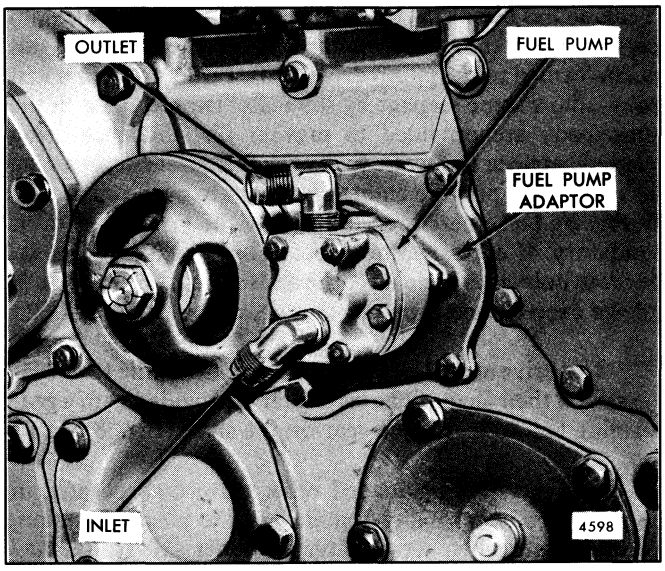


Fig. 2 - Fuel Pump Mounting

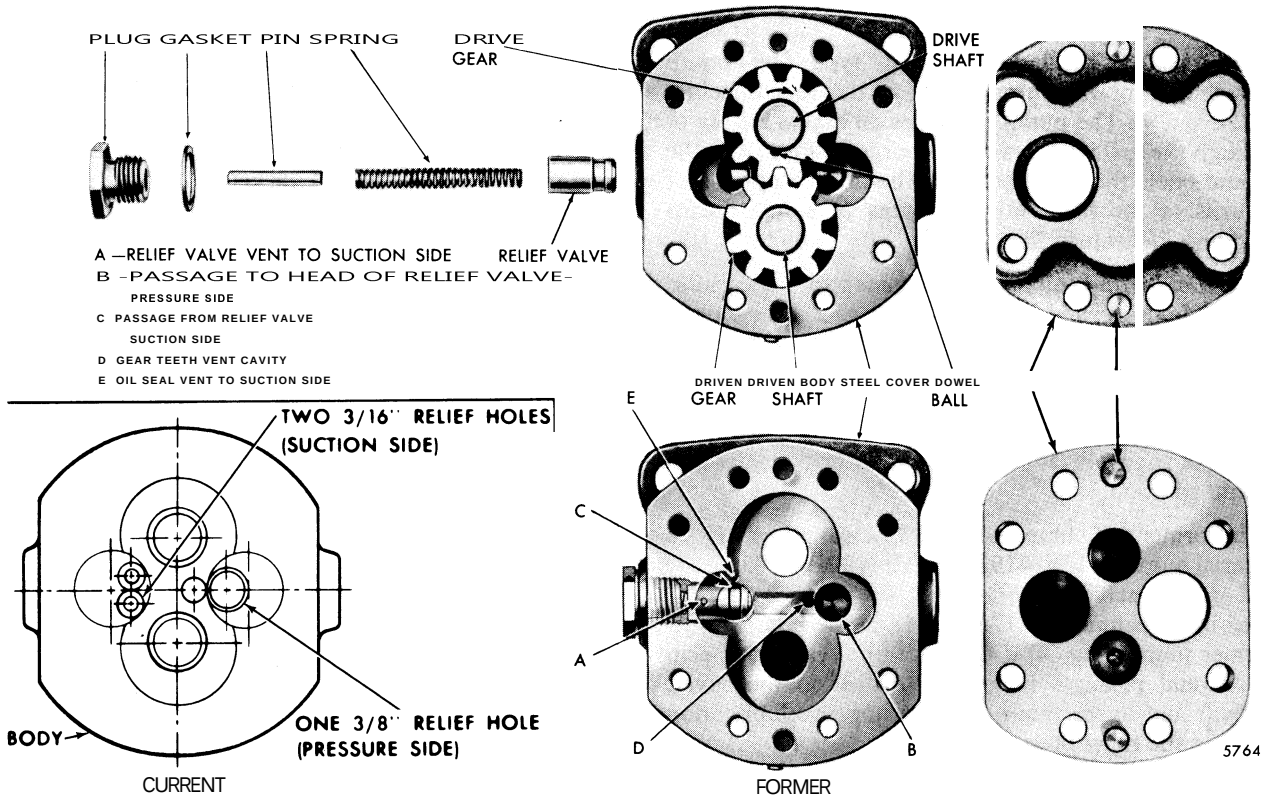


Fig. 3 - Typical Fuel Pump Valving and Rotation (Early and Former Pumps)

In addition to the above, the former fuel pump assembly was improved by the addition of the features illustrated in the inset of Fig. 3.

Some fuel oil seepage by the fuel pump seals can be expected, both with a running engine and immediately after an engine has been shut down. This is especially true with a new fuel pump and/or new pump seals, as the seals have not yet conformed to the pump drive shaft. Fuel pump seals will always allow some seepage by the seals. Tapped holes in the pump body are provided to prevent fuel oil from being retained between the seals. Excessive fuel retention between the seals could provide enough pressure to cause engine oil dilution by fuel, therefore, drainage of the excess fuel oil is mandatory. If excessive fuel leakage by the pump seals via the drain holes is experienced, the seals should be changed. If leakage exceeds one drop per minute, replace the seals.

The drive and driven gears are a line-to-line to a .001" press fit on their shafts. The drive gear is provided with a gear retaining ball to locate the gear on the shaft (Fig. 8 or 9).

The early spring-loaded relief valve incorporated in the pump body normally remains in the closed position, operating only when pressure on the outlet side (to the fuel filter) reaches approximately 70 psi (483 kPa).

The former relief valve spring (identified by an overall red Dykel dye) operates when the fuel pressure on the outlet side (to the fuel filter) reaches approximately 80 psi (552 kPa). The higher opening pressure relief valve spring ensures that the fuel pump relief valve will remain closed during normal engine operation. Since this spring resulted in higher fuel flow through the fuel injection system, a new larger spill orifice had to be used to maintain the same fuel inlet manifold pressure range.

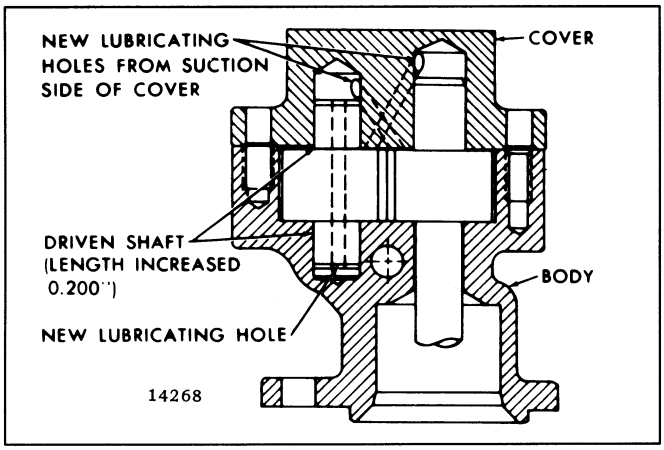


Fig. 4 – Former Fuel Pump

 © Detroit Diesel Corporation

When the former relief valve spring is used a new fuel pressure relief orifice plug, fuel junction block, and 1/4" tee fitting must also be used.

Operation

In operation, fuel enters the pump on the suction side and fills the space between the gear teeth which are exposed at that instant. The gear teeth then carry the fuel oil to the discharge side of the pump and, as the gear teeth mesh in the center of the pump, the fuel oil is forced out into the outlet cavity. Since this is a continuous cycle and fuel is continually being forced into the outlet cavity, the fuel flows from the outlet cavity into the fuel lines and through the engine fuel system under pressure.

The pressure relief valve relieves the discharge pressure by bypassing the fuel from the outlet side of the pump to the inlet side. This occurs when the discharge pressure reaches approximately 60-80 psi (414-552 kPa).

The fuel pump should maintain the fuel pressure at the fuel inlet manifold as shown in Section 13.2.

Remove Fuel Pump

1. Disconnect the fuel lines from the inlet and outlet openings of the fuel pump.
2. Disconnect the drain tube, if used, from the fuel pump.
3. Remove the three pump attaching bolts and withdraw the pump from the fuel pump adaptor.
4. If required, remove the fuel pump adaptor and discard the gasket.
5. Check the drive coupling fork and, if broken or worn, replace it with a new coupling.

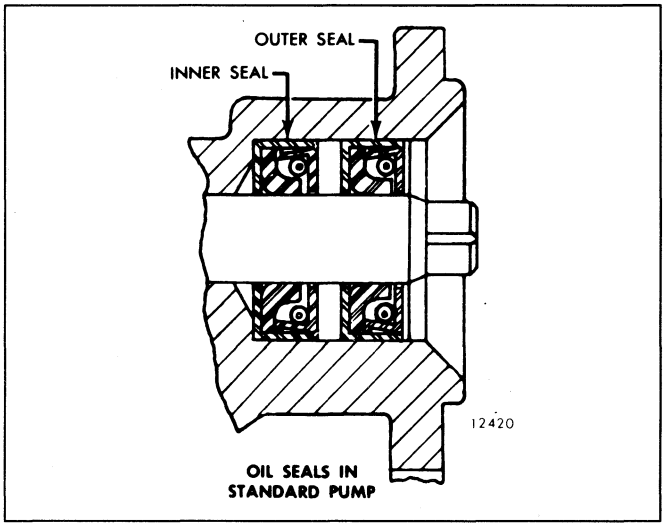
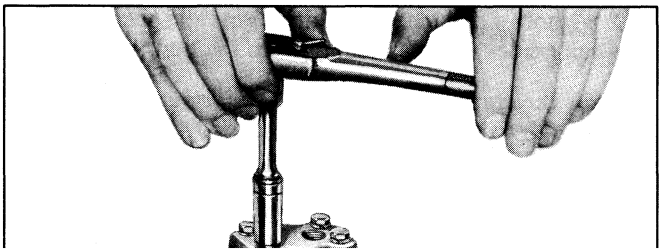


Fig. 5 – Fuel Pump Oil Seals



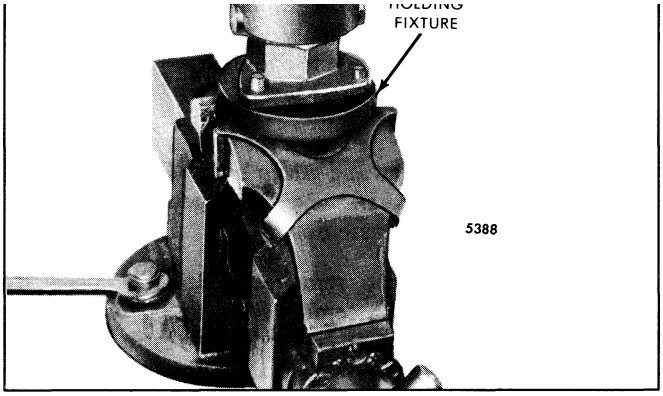


Fig. 6 - Removing Fuel Pump Cover using Holding Fixture J 1508-10

Disassemble Fuel Pump

With the fuel pump removed from the engine and mounted in holding fixture J 1508-10 (Fig. 6), refer to Figs. 1, 8 and 9 and disassemble the pump as follows:

1. Remove the eight cover bolts and withdraw the pump cover from the pump body. Use care not to damage the finished faces of the pump body and cover. Remove the thin plastic gasket from the current pump.

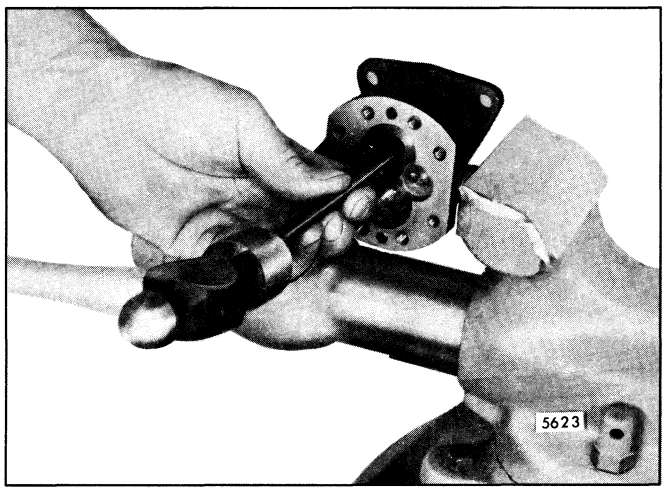


Fig. 7 - Removing Oil Seals from Fuel Pump Body using Tool J 1508-13

2. Withdraw the drive shaft, drive gear and gear retaining ball or key as an assembly from the pump body.

3. On the former pump, press the drive shaft just far enough to remove the steel locking ball. Then, invert the shaft and gear assembly and press the shaft from the gear. *Do not misplace the steel ball.* Do not press the squared end of the shaft through the gear as slight score marks will damage the oil seal contact surface.

On the current pump, remove the snap ring from the groove opposite the drive end of the shaft. Remove the gear and the key. The gear is a slip fit and does not require a pressing operation. Use caution to avoid scoring the seal area of the drive shaft.

4. On the former pump, remove the driven shaft and gear as an assembly from the pump body. *Do not remove the gear from the shaft* The driven gear and shaft are serviced only as an assembly.

On the current pump, remove the driven shaft, gear, pin and snap rings as an assembly from the stator (body). Remove the snap ring from either end of the shaft, then remove the gear and pin. The gear is a slip fit on the shaft and does not require a pressing operation.

5. Remove the relief valve plug and copper gasket.

6. Remove the valve spring, pin and relief valve from the valve cavity in the pump body.

7. If the oil seals need replacing, remove them with oil seal remover J 1508—13 (Fig. 7). Clamp the pump body in a vise and tap the end of the tool with a hammer to remove the inner and outer seals. Observe the position of the oil seal lips before removing the seals to permit installation of new seals in the same position.

8. If the needle bearings in the body and cover need replacing, insert bearing remover J 33853 into each needle bearing and tighten until the inside diameter of the bearing is securely gripped by the expanding end of the tool. Remove the bearings by using the slide hammer feature of the tool.

Inspection

Clean all of the parts in clean fuel oil and dry them with compressed air.

CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Fuel pumps stamped *2 *or 2D** on the cover have a matched pump body and cover. These pumps may be rebuilt the same as a standard pump, provided the body and cover are kept together and reused in the same pump. If either the body or cover of these pumps require replacement, a complete new fuel pump assembly must be installed.

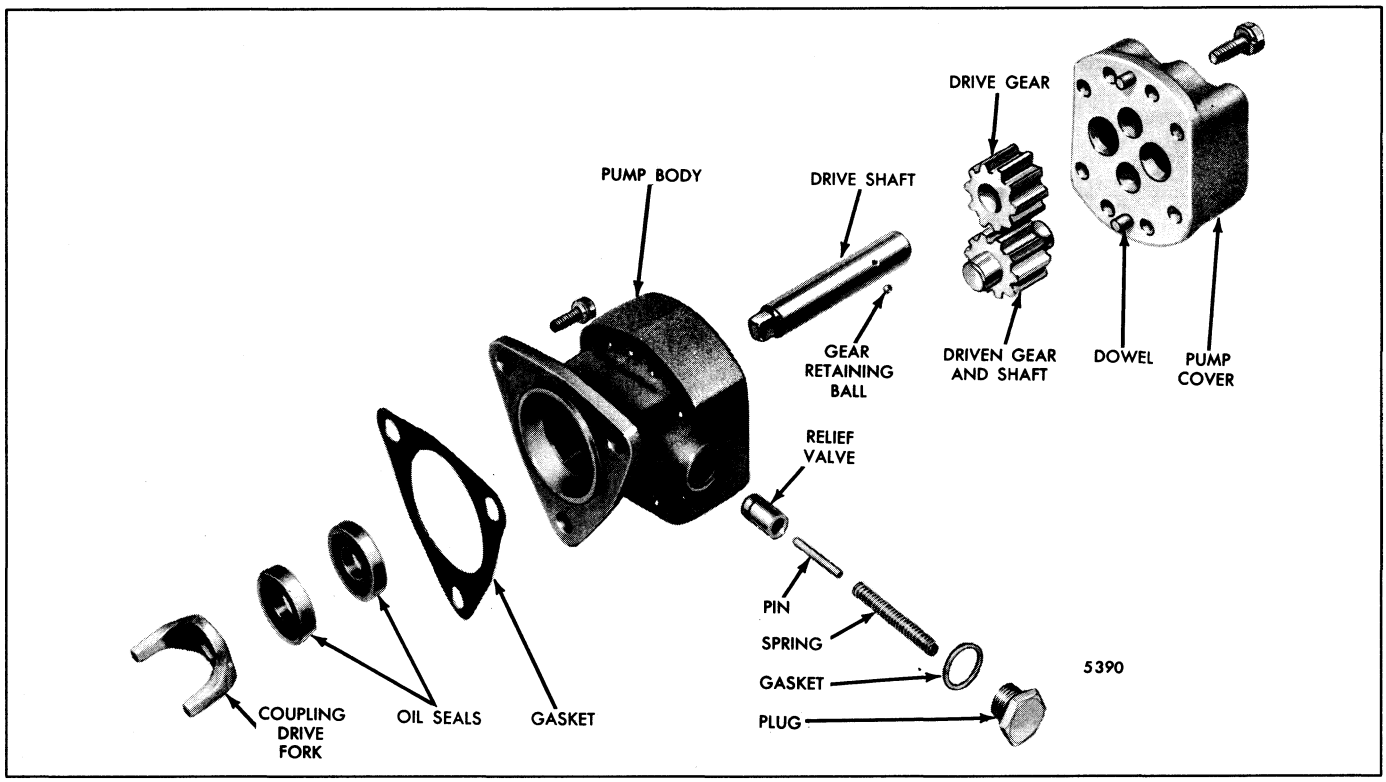


Fig. 8 - Former Fuel Pump Details and Relative Location of Parts

 © Detroit Diesel Corporation

Oil seals, once removed from the pump body, must be discarded and replaced with new seals. The lips of the oil seals must fit snug around the pump shaft and must be free of nicks or cracks.

Check the pump gear teeth for scoring, chipping or wear. Check the inside diameter of the gear for wear. If necessary, replace the gear.

Inspect the drive and driven shafts for scoring or wear. Replace the shafts, if necessary.

The mating faces of the pump body and cover must be flat and smooth and fit tightly together. Any scratches or slight damage may result in pressure leaks. Also, check for wear at areas contacted by the gears and shafts. Replace the pump cover or body, if necessary.

The relief valve must be free from score marks and burrs and fit its seat in the pump body. If the relief valve is scored and cannot be cleaned up with fine emery cloth or crocus cloth, it must be replaced.

Assemble Fuel Pump

Refer to Figs. 1, 3, 8 and 9 and assemble the pump as follows:

1. Lubricate the lips of the oil seals with a light coat of vegetable shortening, then install the oil seals in the pump body as follows:

   a. Place the inner oil seal on the pilot of the installer handle J 1508-8 so that the lip of the seal will face in the same direction as the original seal which was removed.

   b. With the pump body supported on wood blocks (Fig. 10), insert the pilot of the installer handle in the pump body so the seal starts straight into the pump flange. Then, drive the seal in until it bottoms.

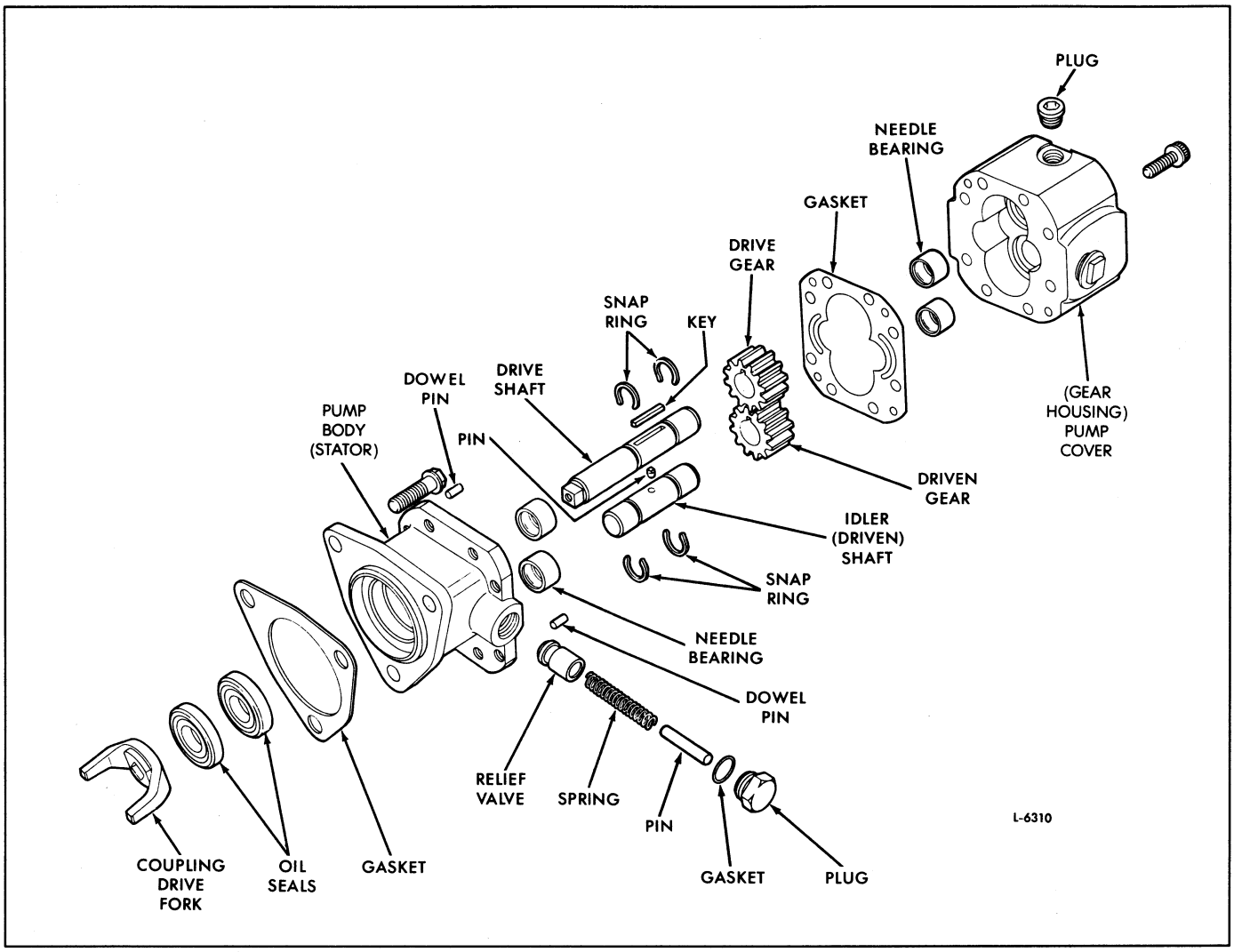


Fig. 9 – Current Fuel Pump Details and Relative Location of Parts

c. Place the shorter end of the adaptor J 1508-9 over the pilot and against the shoulder of the installer handle (Fig. 11). Place the outer oil seal on the pilot of the installer handle with the lip of the seal facing the adaptor. Then, insert the pilot of the installer handle into the pump body and drive the seal in until the shoulder of the adaptor contacts the pump body. Thus, the oil seals will be positioned so that the space between them will correspond with the drain holes located in the bottom of the pump body.

2. Clamp the pump body in a bench vise (equipped with soft jaws) with the valve cavity up. Lubricate the outside diameter of the valve and place it in the cavity with the hollow end up. Insert the spring inside of the valve and the pin inside of the spring. With a new copper gasket in place next to the head of the valve plug, place the plug over the spring and thread it into the pump body. Tighten the plug in the former pump to 18-22 lb—ft (24-30 N«m) torque. Tighten the plug in the current pump to 6-10 lb—ft (8-14 N«m) torque.

3. On the former fuel pump, install the fuel pump drive gear over the end of the drive shaft which is not squared (so the slot in the gear will face the plain end of the shaft). This operation is very important, otherwise fine score marks caused by pressing the gear into position from the square end of the shaft may cause rapid wear of the oil seals. Press the gear beyond the gear retaining ball detent. Then, place the ball in the detent and press the gear back until the end of the slot contacts the ball.

On the current pump, install one snap ring in the groove on the square end of the drive shaft by pressing it directly into the groove. *Do not slide the snap ring over the sealing area of the drive shaft* This operation is very important, otherwise fine score marks caused by sliding the snap ring into position from the square end of the shaft may cause rapid wear of the oil seals. Insert the long square key in the slot in the shaft. Slide the drive gear over the end of the shaft until the groove in the gear mates with the key in the slot. Install the second snap ring to hold the gear in place.

On the current pump, install one snap ring in the groove on the driven shaft and place the square-head pin in the hole in the shaft. Slide the driven gear onto the shaft until the groove in the gear mates with the pin. Install the second snap ring to hold the gear in place.

4. Lubricate the pump drive shaft and insert the square end of the shaft into the opening at the gear side of the pump body and through the oil seals (Fig. 12).

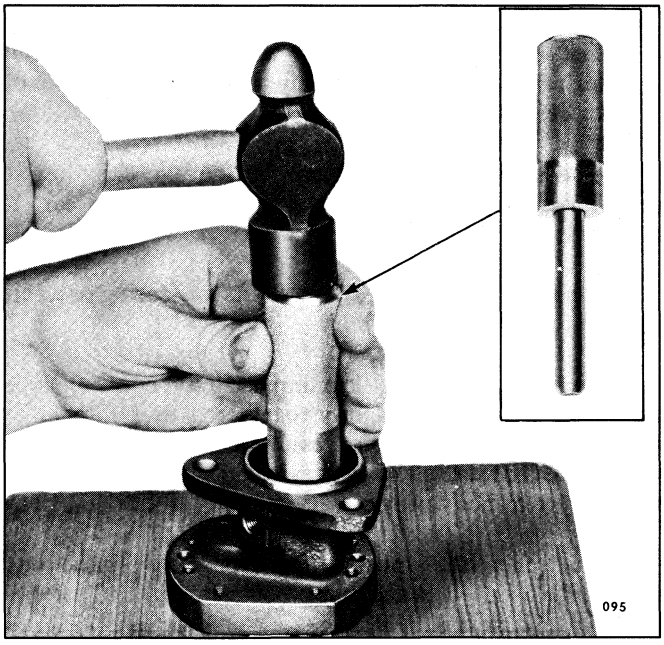


Fig. 10 - Installing Inner Oil Seal in Fuel Oil Pump Body with Tool J 1508-8

5. Place the driven shaft and gear assembly in the pump body.

6. Lubricate the gears and shafts with clean engine oil.

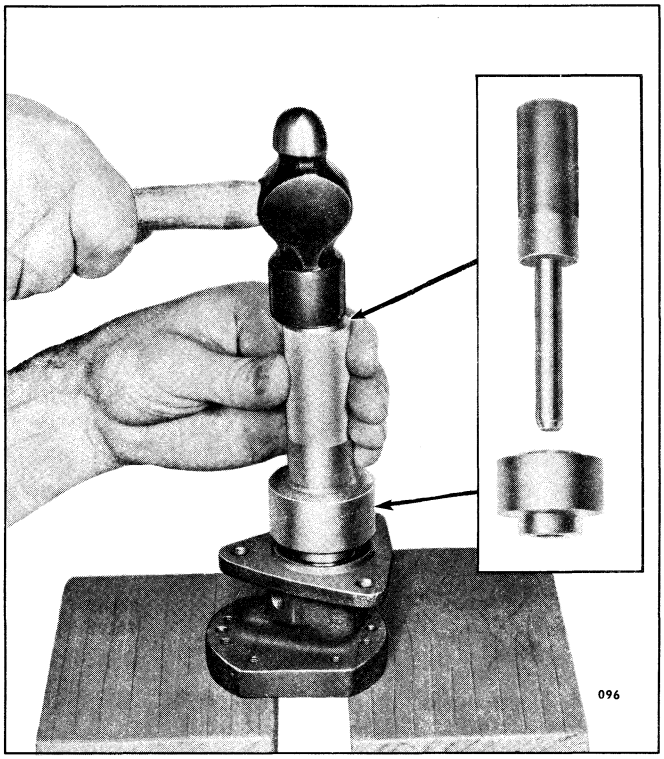


Fig. 1 1 - Installing Outer Oil Seal in Fuel Oil Pump Body with Tools J 1508-8 and J 1508-9

 © Detroit Diesel Corporation

7. On the former pump, apply a thin coat of quality sealant on the face of the pump cover outside of the gear pocket area. Then, place the cover against the pump body with the two dowel pins in the pump cover entering the holes in the pump. The cover can be installed in only one position over the two shafts.

NOTICE: The coating of sealant must be extremely thin since the pump clearances have been set up on the basis of metal-to-metal contact. Too much sealant could increase the clearances and affect the efficiency of the pump. Use care that sealant is not squeezed into the gear compartment, otherwise damage to the gears and shafts may result.

On the current pump, place a new thin plastic gasket on the body face. *Sealant is not required between the pump halves and should not be used.*

8. On the former pump, secure the cover in place with eight bolts and lock washers, tightening the bolts alternately and evenly.

On the current pump, *with the fuel inlet hole in the gear housing directly over the pressure relief valve in the body, lower the cover onto the shaft and gear assemblies until it rests on the body. Make sure that the dowel pins fit into the proper dowel holes. Using a No. E-8 Torx socket (J 25359-11), secure the housing in place with eight bolt/lock washer assemblies. Tighten the bolts alternately and evenly to a finish torque of 9-11 lb-ft (12-15 Nmm).*

9. After assembly, rotate the drive shaft by hand to make certain that the parts rotate freely. When the shaft does not rotate freely, attempt to free it by tapping a corner of the pump.

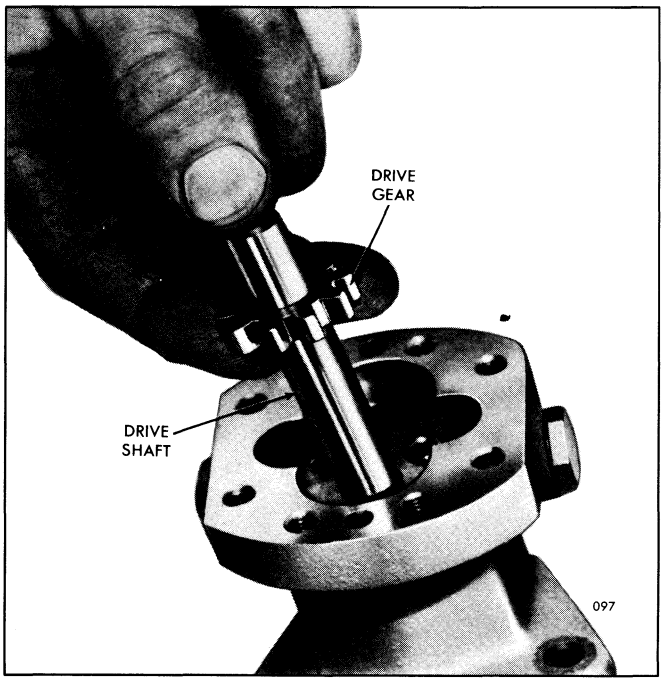


Fig. 12 - Installing Fuel Pump Drive Shaft

10. Install 1/8” pipe plugs in the upper unused openings.

11. If the pump is not to be used immediately, place plastic shipping plugs in the lower (drain) opening and the inlet and outlet openings to prevent dirt or other foreign material from entering the pump.

Install Fuel Pump

1. Affix a new gasket to the pump adaptor and install the adaptor on the flywheel housing with four 3/8”-16 x 1” bolts and lock washers. Tighten the bolts to 30-35 lb-ft (41-47 N#m) torque.

2. Affix a new gasket to the pump body mounting flange. Then, place the drive coupling fork on the square end of the drive shaft.

3. Place the fuel pump against the pump adaptor, being certain that the drive coupling fork registers with the slots in the drive coupling disc. Refer to Section 1.7.6 for installation of the drive coupling disc.

4. Secure the pump to the pump adaptor with three nylon patch bolts. To provide improved sealing against leakage, nylon patch bolts are used in place of the former bolt and seal assemblies. Tighten bolts to 30-35 lb-ft (41-47 N#m) torque.

• 5. If removed, install the inlet and outlet elbows in the pump cover. Before installing, coat the threads lightly with Gasoila, Permatex 2, or an equivalent non-hardening sealant. To prevent sealant from entering the fuel system, do not apply it to the first two (2) threads of the fittings. Tighten fittings to the low end of the torque. If necessary, continue tightening until alignment is achieved, but do not exceed maximum torque. Tighten 1/4” fittings to 14- 16 lb-ft (19 - 22 N#m), 3/8” fittings to 18 - 22 lb-ft (24 - 30 N#m), and 1/2” fittings to 20 - 25 lb-ft (27 - 34 N«m) torque.

NOTICE: Do not use Teflon tape or paste on fittings, since this can result in fuel pump cover damage (cracking) before the required torque is reached.

6. Connect the inlet and outlet fuel lines to the fuel pump elbows.

7. Connect the fuel pump drain tube, if used, to the pump body.

8. If the fuel pump is replaced or rebuilt, prime the fuel system with Tool J 5956 before starting the engine. This will prevent the possibility of pump seizure upon initial starting.

FUEL STRAINER AND FUEL FILTER

• A fuel strainer (primary) and fuel filter (secondary) are used to remove impurities from the fuel (Fig. 1). The fuel strainer is located between the fuel tank and the fuel pump. The replaceable density-type element is capable of filtering out particles of 30 microns (a micron is approximately .00004"). The fuel filter is installed between the fuel pump and the fuel inlet manifold. The replaceable paper-type element can remove particles as small as 10 microns. Fiber glass elements can remove particles as small as 5 microns.

NOTICE: A fuel tank of galvanized steel should never be used for fuel storage, as the fuel oil reacts chemically with the zinc coating to form powdery flakes which will quickly clog the fuel filter and cause damage to the fuel pump and the fuel injectors.

The bolt-on type fuel strainer and fuel filter (Figs. 1,2 and 3) are similar in construction and consist essentially of a shell, cover and a replaceable filtering element. The filtering element sets over the central stud, which is welded to the shell. The shell and element are attached to the cover by a nut or bolt that threads on or into the central stud. A shell gasket and cover bolt gasket seal the assembly against leakage.

• Spin-on type fuel strainer and filter assemblies are used on all current Series 149 engines, except certain marine and military models. The (primary) strainer assembly consists of a dual base adaptor (Fig. 4) and two (2) spin-on elements. The (secondary) filter assembly consists of a single base adaptor and spin-on element (Fig. 5). Spin-on elements include gaskets.

• Filter covers incorporate a threaded sleeve to accept the spin-on elements. The word "Primary" is cast into the fuel strainer cover, and the word "Secondary" is cast into the fuel filter cover.

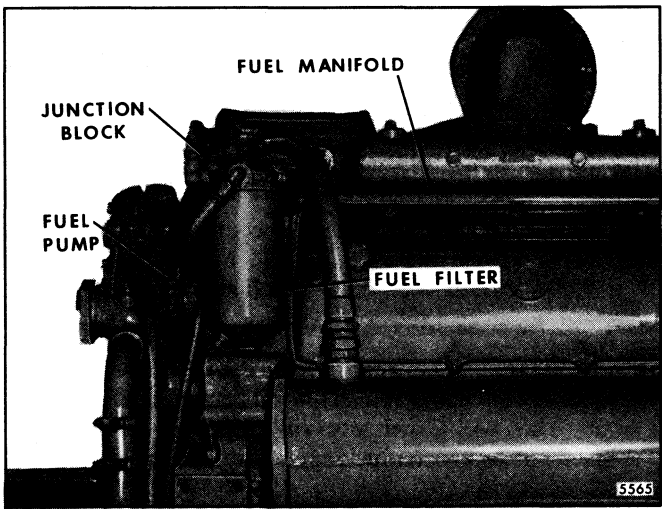


Fig. 1 - Fuel Filter Mounting (Early Engines)

• No drain cocks are provided on spin-on filters. Where water is a concern, a fuel/water separator should be installed. Otherwise, residue may be drained by removing and inverting the filter. Refill the filter with clean fuel oil before installing it.

Operation

Since the fuel strainer is between the fuel supply tank and the fuel pump, it functions under suction. The fuel filter,

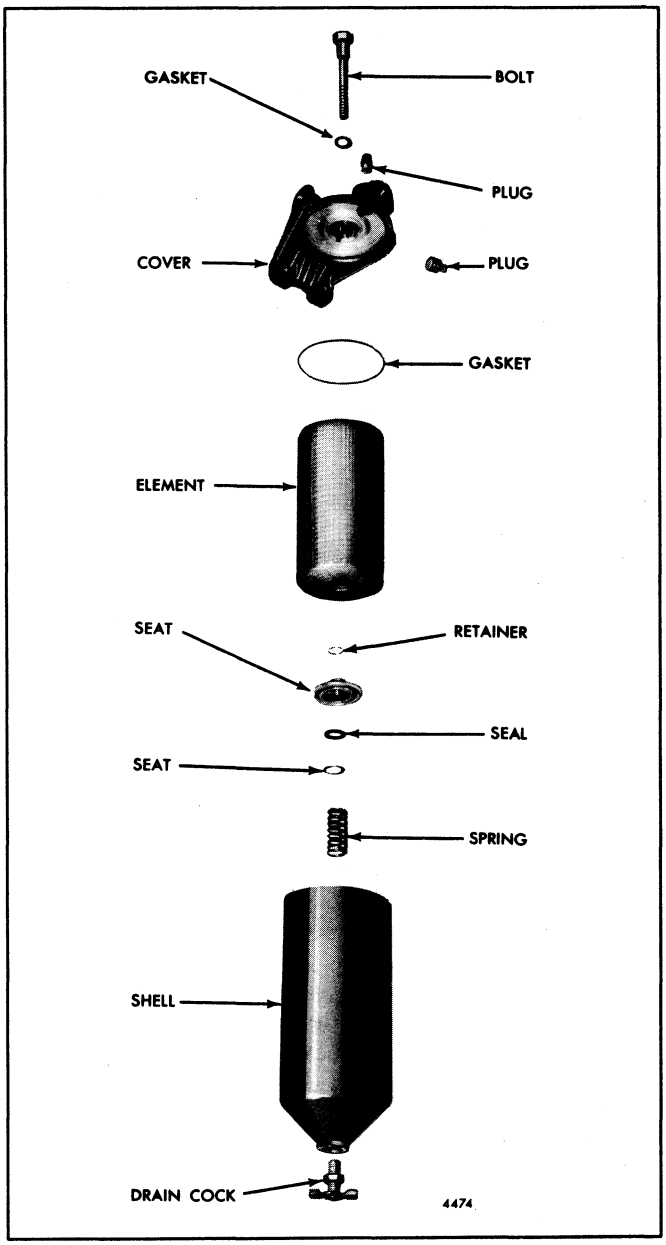


Fig. 2 - Fuel Strainer Details and Relative Location of Parts

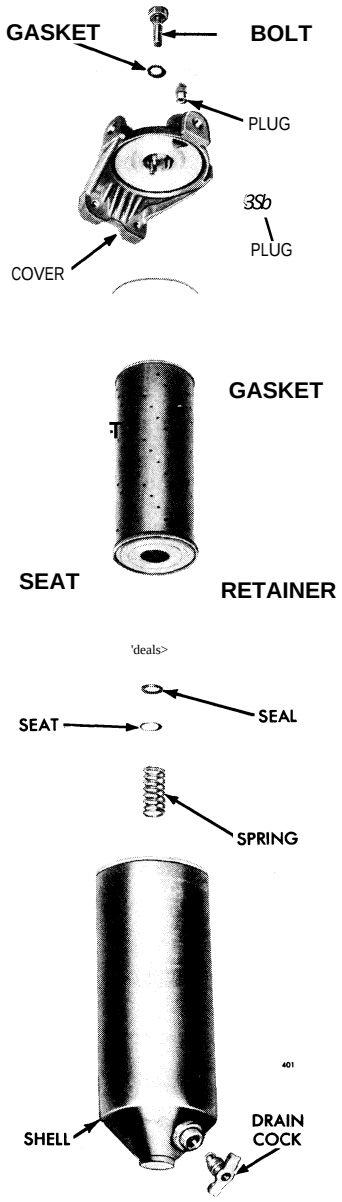


Fig. 3 - Fuel Filter Details and Relative Location of Parts

placed between the fuel pump and the fuel inlet manifold, operates under pressure. Fuel enters through the inlet passage in the cover and into the shell which surrounds the filter element. Pressure or suction created by the pump causes the fuel to flow through the filter element where any impurities are removed. The clean fuel flows to the interior of the filter element, up through the central passage in the cover and into the outlet passage.

If engine operation is erratic, indicating a shortage of fuel or flow obstructions, refer to *Trouble Shooting* in Section 15.2 for corrective measures.

Replace Fuel Strainer Or Filter Element Bolt-on Type

The procedure for replacing an element is the same for the fuel strainer or fuel filter. Refer to Figs. 2 and 3 and replace the element, as follows:

NOTICE: Only filter elements designed for fuel oil filtration should be used to filter the fuel.

1. With the engine stopped, place a container under the strainer or filter and open the drain cock. Loosen the cover nut or bolt just enough to allow the fuel oil to drain out freely. Then close the drain cock.

NOTICE: The wiring harness, starting motor or other electrical equipment must be shielded during the filter change, since fuel oil can permanently damage the electrical insulation.

2. While supporting the shell, unscrew the cover nut or bolt and remove the shell and element.

3. Remove and discard the filter element, shell gasket, and the cover nut or bolt gasket.

4. Wash the shell thoroughly with fuel oil and dry it with compressed air.

CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

5. Examine the element seat and the retaining ring to make sure they have not slipped out of place. Check the spring by pressing on the element seat. When released, the seat must return against the retaining ring.

NOTICE: The element seat, spring, washer and seal cannot be removed from the strainer shell. If necessary, the shell assembly must be replaced. However, the components of the filter shell are serviced. Examine the filter retainer seal for cracks or hardening. If necessary, replace the seal.

The current strainer and filter elements include the element, the cover gasket and cover bolt gasket.

6. Place a new element over the center stud and push it down against the element seat. Make sure the drain cock is closed, then fill the shell about two-thirds full with clean fuel oil.

NOTICE: Thoroughly soak the density-type *strainer* element in clean fuel oil before installing it. This will expel any air entrapped in the element and is conducive to a faster initial start.

7. Install a new shell gasket in the recess of the shell; also place a new gasket on the cover bolt.

 © Detroit Diesel Corporation

8. Place the shell and element in position under the cover. Then thread the cover bolt into the center stud.

9. With the shell and gasket properly positioned, tighten the cover bolt just enough to prevent fuel leakage.

10. Remove the pipe plug at the top of the cover and complete filling of the shell with fuel. Fuel system primer J 5956 may be used to prime the entire fuel system.

11. Start the engine and check the fuel system for leaks.

• Replace Fuel Strainer or Filter Element Spin-on Type

A 1" diameter twelve-point nut on the bottom of the filter is provided to facilitate removal and installation.

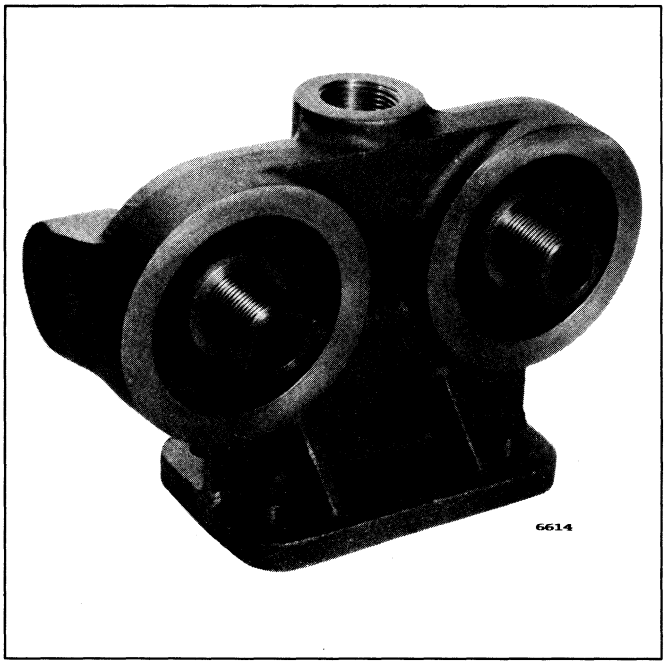


Fig. 4 Spin-on Fuel Strainer Adaptor

Replace the filter or strainer element as follows:

1. Unscrew the element and discard it.

2. Fill a new filter replacement element about two-thirds full with clean fuel oil. Coat the seal gasket lightly with clean fuel oil.

3. Install the new element and tighten it to one-half of a turn beyond gasket contact.

4. Start the engine and check for leaks.

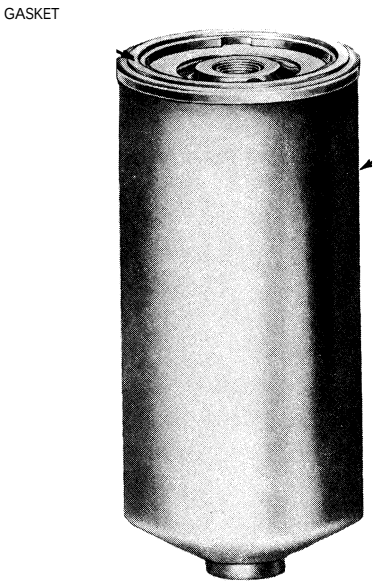


Fig. 5 Spin-on Filter Details

FUEL MANIFOLD

The fuel injectors are supplied with fuel oil through pipes connected to the fuel inlet manifold. Excess fuel oil is returned to the fuel tank from the fuel injectors through pipes connected to the fuel outlet manifold.

The fuel manifolds are attached to the top of the cylinder block on each bank of the engine (Fig. 1). Fuel connectors are installed in the bottom of the manifold and use copper washers to seal the connector to the manifolds. When assembling or replacing fuel connectors, tighten the connectors to 35-40 lb—ft (47-54 N«m) torque.

NOTICE: To permit more contact surface with the copper washer, the hex size of the fuel connector was increased from 5/8" to 11/16". The fuel manifold to cylinder block gasket was also revised to accept the new connector. The current gasket can be used with either the new or old connector.

When installing the fuel manifolds to the cylinder block, the fuel supply hole in the end of the fuel manifold will be in an outboard position on each injector bank (Fig. 2).

Remove Fuel Manifolds

If removal or replacement of a fuel manifold or manifolds is required, proceed as follows:

1. Drain the cooling system (Section 5).
2. Remove the water manifolds (Section 5.2).
3. Clean and remove the valve rocker covers.
4. Disconnect the fuel oil pipes from the injectors and the fuel connectors as follows:
   a. Disconnect the fuel pipe at the injector.
   b. Move the nut back on the pipe and slide a 3/8" I.D. hose over the open end of the pipe, being careful to avoid fuel spillage.

   NOTICE: It will be necessary to loosen the fuel pipe nut at the fuel manifold a few turns to permit the fuel pipe to swing away from the injector.

   c. Drain the fuel into a container. This will avoid the fuel in the manifold from draining onto the cylinder head. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings.
5. Disconnect the fuel supply and return hoses to the manifolds.
6. Remove the bolts and flat washers securing the manifolds to the cylinder block. Remove the manifolds from the engine and discard the gaskets.

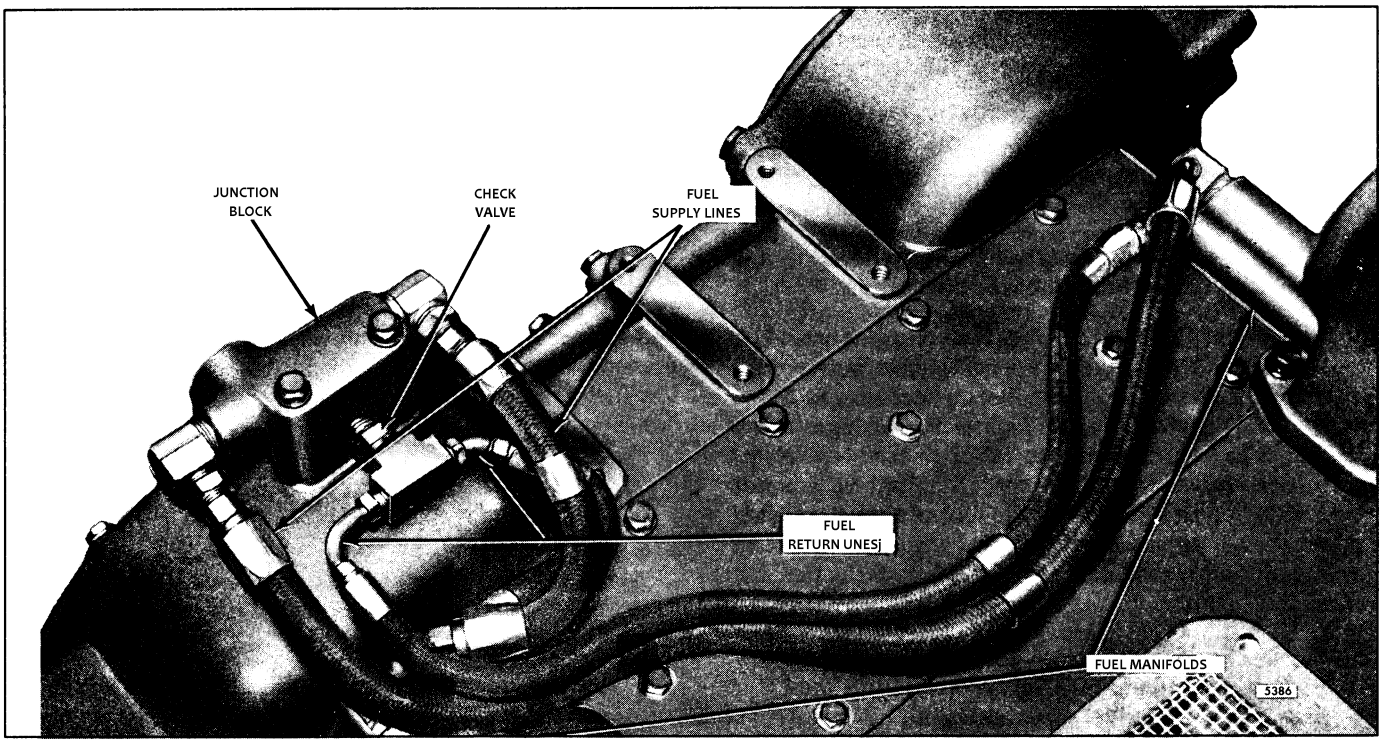


Fig. 1 - Fuel Manifolds and Piping (Early Engines)

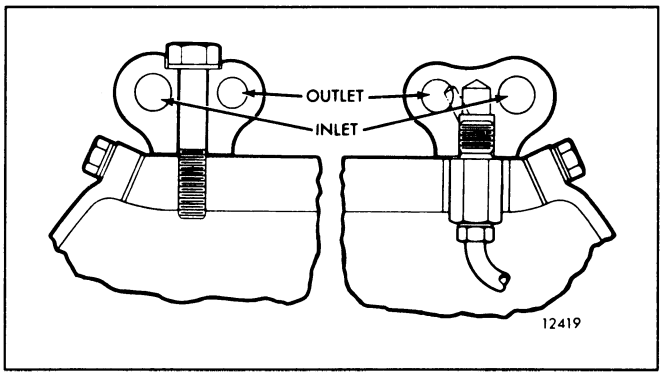


Fig. 2 - Location of Fuel Manifolds on Engine

Inspection

Inspect the gasket surface of the manifold for flatness.

When installing the manifold gaskets, a half-gasket is required on each end of the individual manifold (tear one of the gaskets at the perforation in the middle).

Install Fuel Manifolds

Prior to installing the fuel manifolds on the cyliner block, remove all of the old gasket material from the manifold and the cylinder block and proceed as follows:

1. If removed, install new copper gaskets on the fuel connectors and tighten the fuel connectors to 35-A0 lb—ft (47-54 N«m) torque.

2. Assemble both manifolds together at the center loosely for each cylinder bank on 12 or 16V-149 engines.

3. Affix new gaskets to the block and positioneach manifold assembly, as shown in Fig. 2, on the block. Install the 3/8”—16 x 2” bolts and flat washers and tighten the bolts to 30-35 lb—ft (41-47 N#m) torque.

4. Connect the fuel supply and return hoses to the manifolds and tighten all of the connections.

5. Install the fuel supply and fuel return pipes. Use adaptor J 21545 and an appropriate torque wrench and tighten the fuel pipe to fuel injector nuts to 18-22 lb—ft (24-30 N#m) torque. Tighten the fuel pipe to fuel manifold connector nuts to 18-22 lb—ft (24-3o N#m) torque. However, due to space limitations, adaptor J 23385 must be used and the torque wrench reading must be adjusted as outlined under ***Assemble Crankshaft Halves*** in Section 1.3. Install the fuel line support clips.

   NOTICE: Do not exceed the specified torque. Excessive tightening will twist or fracture the flared ends of the fuel pipes and result in leaks. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings.

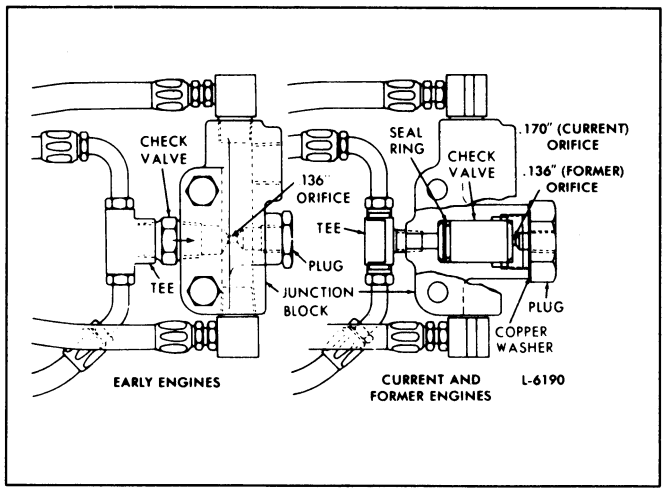


Fig. 3 – Location of Fuel Restriction Orifice

6. Install the water manifolds (Section 5.2).

7. Fill the cooling system (Section 5).

8. Prime the fuel system with tool J 5956 before starting the engine.

Fuel Lines

Flexible fuel lines are used to facilitate connections between the fuel junction block and the fuel manifolds attached to the cylinder block (Fig. 1). A restricted orifice (.170” current engines or .136” former engines) is drilled in the fuel pressure relief plug or in the junction block (early engines) to maintain pressure in the fuel system.

NOTICE: Do fittings anywhere else in the fuel system.

A check valve is installed in the fuel junction block of the fuel system to prevent fuel from draining back to the fuel tank when the engine is shut down.

All of the new parts for the fuel spill system must be used together. Components of the former and current systems are not functionally interchangeable. A new spring and former system will result in excessive fuel pump out pressure. A new system with the former spring will result in low fuel pump out pressure.

NOTICE: When the new relief spring is used the new fuel pressure relief orifice plug, fuel junction block and 1/4” tee fitting must also be used.

On engines prior to serial numbers 12E-2330 and 16E-2240, the check valve must be installed with the ***Arrow*** pointing towards the junction block.

On early engines (prior to 12E-317), the check valve is stamped ***Top*** on one of the hex flats and should be installed with the word ***Top*** up. The 1 1/16”-16 check valve plug is tightened to 80-90 lb—ft (108-122 N#m) torque.

 © Detroit Diesel Corporation

When installing flexible fuel lines, it is recommended that connections be tightened only sufficiently to prevent leakage of fuel; thus the flared ends of the fuel lines will not become twisted or fractured because of excessive tightening. After all of the lines are installed, ran the engine long enough to determine whether or not all of the connections are sufficiently tight. If any leaks occur, tighten the connections only enough to stop the leak.

MECHANICAL GOVERNORS

Horsepower requirements on an engine may vary due to fluctuating loads. Therefore, some method must be provided to control the amount of fuel required to hold the engine speed reasonably constant during load fluctuations. To accomplish this control, a governor is introduced in the linkage between the throttle control and the fuel injectors. The governor is mounted on the front end of the blower and is driven by one of the blower rotors. The following types of mechanical governors are used.

1. Limiting Speed Mechanical Governor.
2. Variable Speed Mechanical Governor.

Engines requiring a minimum and maximum speed control, together with manually controlled intermediate speeds, are equipped with a limiting speed mechanical governor.

Engines subjected to varying load conditions that require automatic fuel compensation to maintain a near constant engine speed, which may be changed manually by the operator, are equipped with a variable speed mechanical governor.

Each type of governor has an identification plate located on the control housing, containing the governor assembly part number, type, idle speed range and manufactured date. The maximum engine speed, not shown on the identification plate, is stamped on the option plate attached to one of the valve rocker covers.

Check Governor Operation

Governor difficulties are usually indicated by speed variations of the engine. However, it does not necessarily mean that all such speed fluctuations are caused by the governor. Therefore, when improper speed variations are speed varations present, check the engine as follows:

1. Make sure the speed changes are not the result of excessive load fluctuations.
2. Check the engine to be sure that all of the cylinders are firing properly (refer to Section 15.2). If any cylinder is not firing properly, remove the injector, test it and, if necessary, recondition it as outlined in Section 2.1.1.
3. Check for bind that may exist in the governor operating mechanism or in the linkage between the governor and the injector control tube.

With the fuel rod connected to the injector control tube lever, the mechanism should be free from bind throughout the entire travel of the injector racks. If friction exists in the mechanism, it may be located and corrected as follows:

1. If an injector rack sticks or moves too hard, it may be due to the injector hold-down clamp being too tight or improperly positioned. To correct this condition, loosen the injector clamp, reposition it and tighten the bolt to 46-50 lb—ft (62-68 N«m) torque.
2. An injector which is not functioning properly may have a defective plunger and bushing or a bent injector rack. Recondition a faulty injector as outlined in Section 2.1.1.
3. An injector rack may bind as the result of an improperly positioned rack control lever. Loosen the rack control lever adjusting screws. If this relieves the bind, relocate the lever on the control tube and position the rack as outlined in Section 14.
4. The injector control tube may bind in its support brackets, thus preventing free movement of the injector racks to their ***no-fuel*** position due to tension of the return spring. This condition may be corrected by loosening and realigning the control tube supporting brackets. If the control tube support brackets were loosened, realigned and tightened, the injector racks must be repositioned as outlined in Section 14.
5. A bent injector control tube return spring may cause friction in the operation of the injector control tube. If the spring has been bent or otherwise distorted, install a new spring.
6. Check for bind at the pin which connects the fuel rod to the injector control tube lever; replace the pin, if necessary.

If, after making these checks, the governor fails to control the engine properly, remove and recondition the governor.

LIMITING SPEED MECHANICAL GOVERNOR

The limiting speed mechanical governor (Fig. 1) performs the following two functions:

1. Controls the engine idling speed.
2. Limits the maximum operating speed of the engine.

The limiting speed governor used on the Series 149 engines is of the double-weight type. Each governor has an identification plate located on the governor housing containing the governor assembly number, type (D.W.-L.S.) and idle speed range (rpm).

The upper governor housing assembly is mounted on the air box cover plate at the front of the engine. The governor weight and drive mechanism, located underneath the air box cover plate, is driven by the left-hand helix blower rotor.

The governor drive and weight housing also serves as an end cover for the blower.

The governor assembly consists of two subassemblies.

1. Control Housing Assembly.
2. Weight Housing.

Operation

The governor holds the injector racks in the ***advanced fuel*** position for starting when the speed control lever is in the ***idle*** position. Immediately after starting, the governor moves the injector racks to that position required for idling.

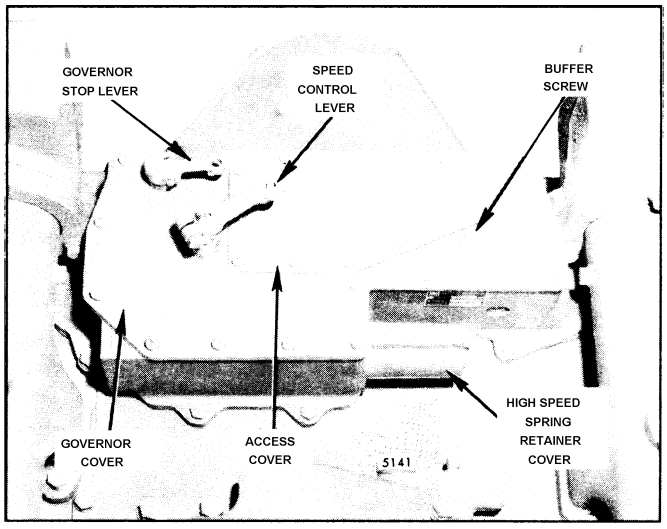


Fig. 1 - Governor Mounting

Current engines include a starting aid screw (62), Fig. 2, threaded into the governor gap adjusting screw. This limits fuel input during enginestart-up when the speed control lever is in its ***idle*** position. The current governor also includes lighter low-speed weights to permit an idle speed range of 550 to 750 rpm. Formerly, the idle speed range was 450 to 550 rpm.

To update a former limiting speed governor, remove the governor gap adjusting screw and nut. Install a service only bracket and the current gap adjusting screw and the starting aid screw (Fig. 2). The locknut is not required as both screws incorporate a nylon patch in lieu of the locknut. The former governor can also be reworked to increase the idle speed range by replacing the three low-speed weights with the current lighter low-speed weights. No other changes are necessary.

The centrifugal force of the revolving governor low and high-speed weights (Fig. 2) is converted into linear motion which is transmitted through the riser and operating shaft to the operating shaft lever. One end of this lever operates against the high and low-speed springs through the spring cap, while the other end provides a moving fulcrum on which the differential lever pivots.

When the centrifugal force of the revolving governor weights balances out the tension on the high or low-speed spring (depending on the speed range), the governor stabilizes the engine speed for a given setting of the speed control lever.

In the low-speed range, the centrifugal force of the low and high-speed weights together operate against the low-speed spring. As the engine speed increases, the centrifugal force of the low and high-speed weights together compress the low-speed spring until the low-speed weights are against their stops, thus limiting their travel, at which time the low-speed spring is fully compressed and the low-speed spring cap is within .0015” of the high-speed plunger.

Throughout the intermediate speed range, the operator has complete control of the engine because both the low-speed spring and the low-speed weights are against their stops and the high-speed weights are not exerting enough force to overcome the high-speed spring.

As the speed continues to increase, the centrifugal force of the high-speed weights increases until it overcomes the high-speed spring allowing the governor to again take control of the engine, limiting the maximum engine speed.

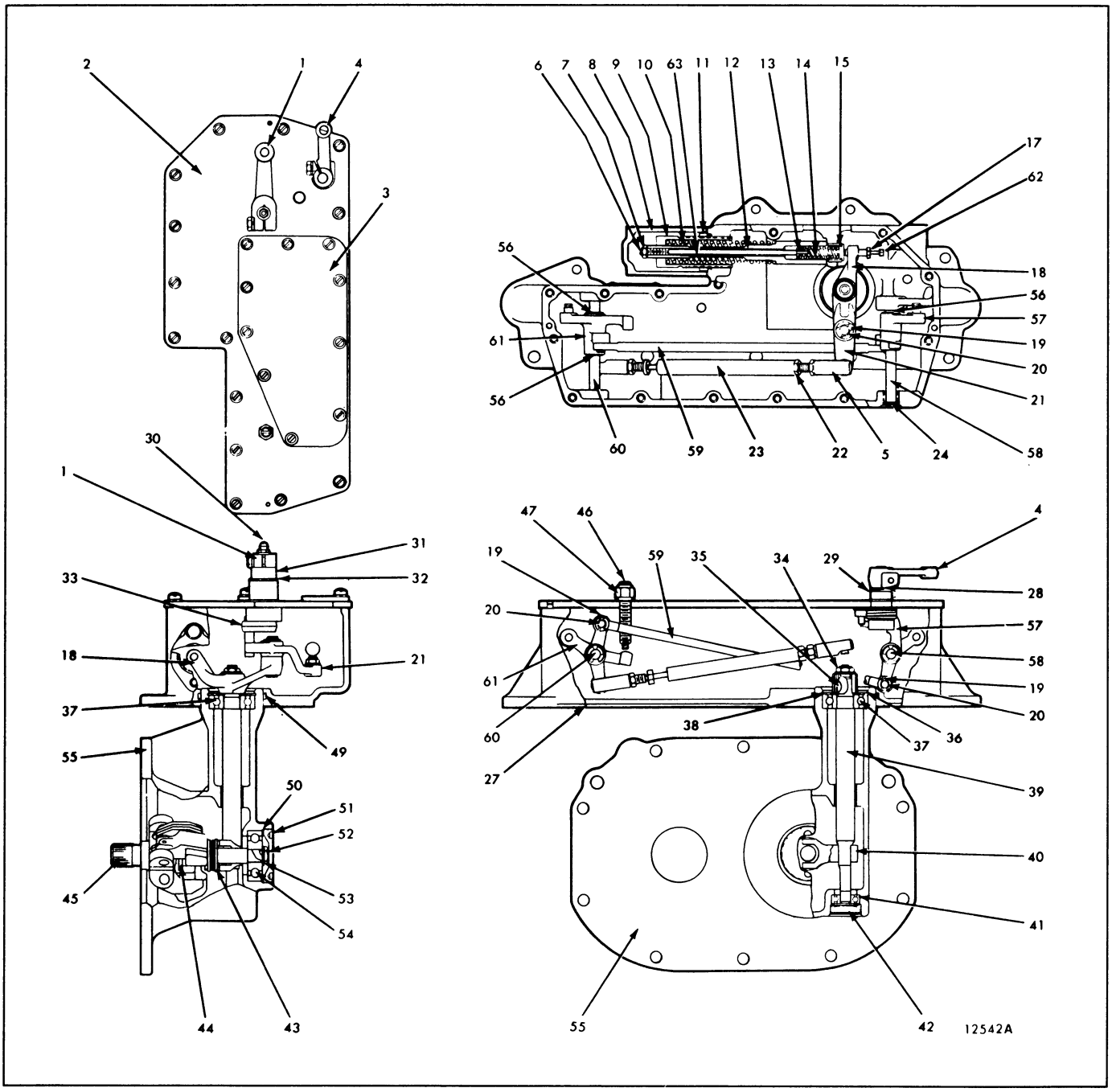


Fig. 2 - Cross Sections of Limiting Speed Governor (Current)

The engine idle speed is determined by the force exerted from the governor low-speed spring. When the governor speed control lever is placed in the *idle* position, the engine will operate at a speed where the force exerted by the governor low-speed weights will equal the force exerted by the governor low-speed spring. Adjustment of the engine idle speed is accomplished by changing the force on the low-speed spring by means of the idle adjusting screw (former governor) or the set screw and adjusting pin (current governors).

 © Detroit Diesel Corporation

1. Lever—Speed Control
2. Cover—Governor
3. Cover—Access
4. Lever—Stop
5. Ball Joint Assembly
6. Set Screw—Idle Speed Adjusting
7. Locknut
8. Housing—Spring
9. Retainer—Spring, High-Speed
10. Spring—High-Speed
11. Locknut—Retainer
12. Plunger—Spring, High-Speed
13. Seat—Spring, Low-Speed
14. Spring—Low-Speed
15. Cap—Spring, Low-Speed
17. Screw—Adjusting, Gap
18. Lever—Shaft, Operating
19. Retainer—Spring
20. Washer—Plain
21. Lever—Differential
22. Locknut
23. Rod—Differential Lever Connecting
24. Bearing—Enclosed
27. Housing—Control
28. Spacer
29. Ring—Snap
30. Fitting—Lubrication
31. Spacer
32. Washer—Plain
33. Shaft—Speed Control Lever
34. Nut—Retaining Operating Shaft Lever
35. Woodruff Key
36. Spacer
37. Bearing—Upper, Operating Shaft
38. Ring—Snap
39. Shaft—Operating
40. Fork—Operating
41. Bearing—Lower, Operating Shaft
42. Plug—Cup
43. Bearing—Thrust, Riser
44. Riser
45. Shaft—Weight
46. Screw—Buffer
47. Locknut—Buffer Screw
49. Ring—Seal
50. Gasket—Housing Plug
51. Plug—Housing
52. Bolt—Retaining, Bearing
53. Washer—Lock
54. Bearing—Weight Shaft
55. Housing—Weight
56. Ring—Retaining
57. Lever—Operating Control Link (Left Bank)
58. Shaft—Operating Control Link Lever (Left Bank)
59. Link—Connecting
60. Shaft-Operating Control Link Lever (Right Bank)
61. Lever—Operating Control Link (Right Bank)
62. Screw—Starting Aid
63. Pin—Idle Speed Adjusting

Fig. 2 - Cross Sections of Limiting Speed Governor (Current)

The engine maximum no-load speed is determined by the force exerted by the high-speed spring. When the governor speed control lever is placed in the *maximum speed* position, the engine will operate at a speed where the force exerted by the governor high-speed weights will equal the force exerted by the governor high-speed spring. Adjustment of the maximum no-load speed is accomplished by the high-speed spring retainer. Movement of the high-speed spring retainer will increase or decrease the tension on the high-speed spring.

For adjustment of the limiting speed governor, refer to Section 14.3.

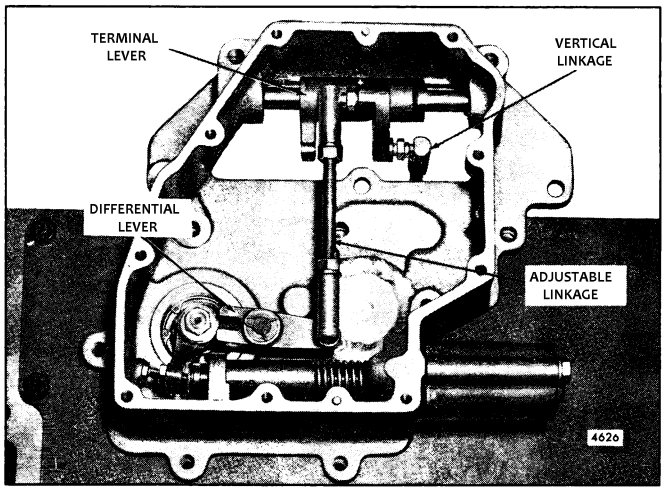


Fig. 3 - Governor Operating Linkage (Former)

Lubrication

The governor is lubricated by a spray of oil from two drilled orifices (holes) in the governor weight housing which direct oil to the governor drive shaft splines and to the bearing thrust riser. Formerly this was done with a spray nozzle located in the blower end plate. The governor weights distribute this oil to all parts of the governor assembly requiring lubrication.

Oil returning from the governor is directed through passages in the blower end plate and cylinder block to the engine oil pan.

Remove Governor

1. Disconnect the speed control rod from the speed control lever and the control linkage from the stop lever (Fig. 1).
2. Remove the screw and lock washer assemblies securing the cover assembly to the governor housing and remove the cover assembly and gasket.
3. On current governors, disconnect the right and left bank fuel rods from the governor control link operating levers and from the injector control tubes. Then, remove the fuel rods.
4. On former governors, disconnect the vertical linkage from the terminal shaft lever (Fig. 3).
5. Remove the operating shaft lever retaining nut (34), Figs. 2 and 5, and washer and remove the operating shaft lever from the operating shaft.

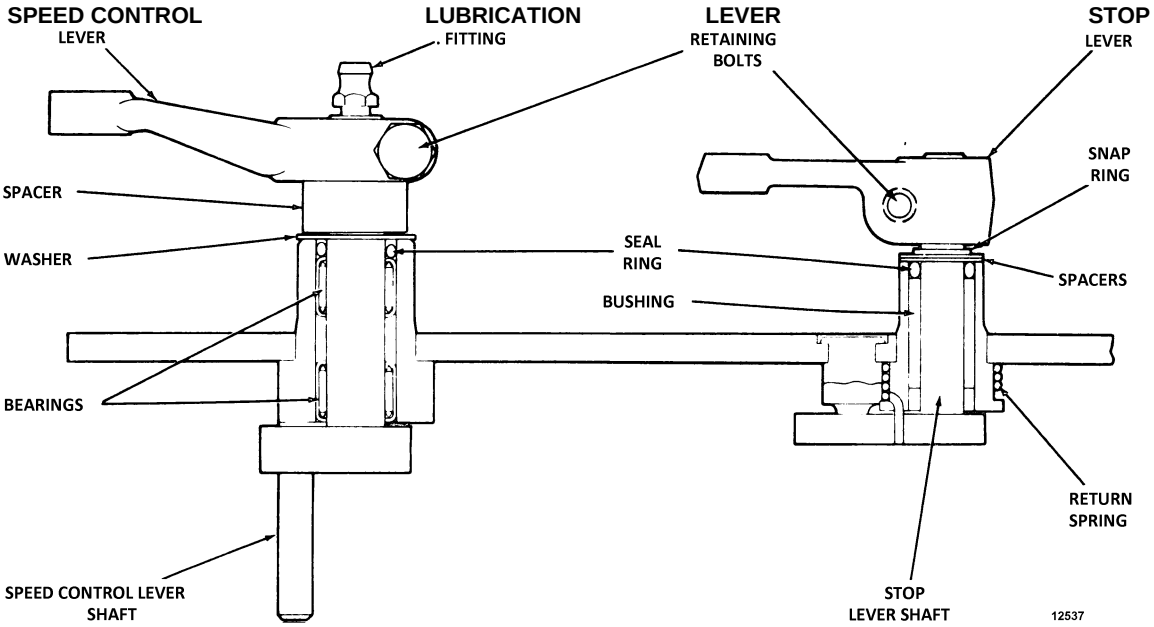


Fig. 4 - Cross Section of Governor Cover

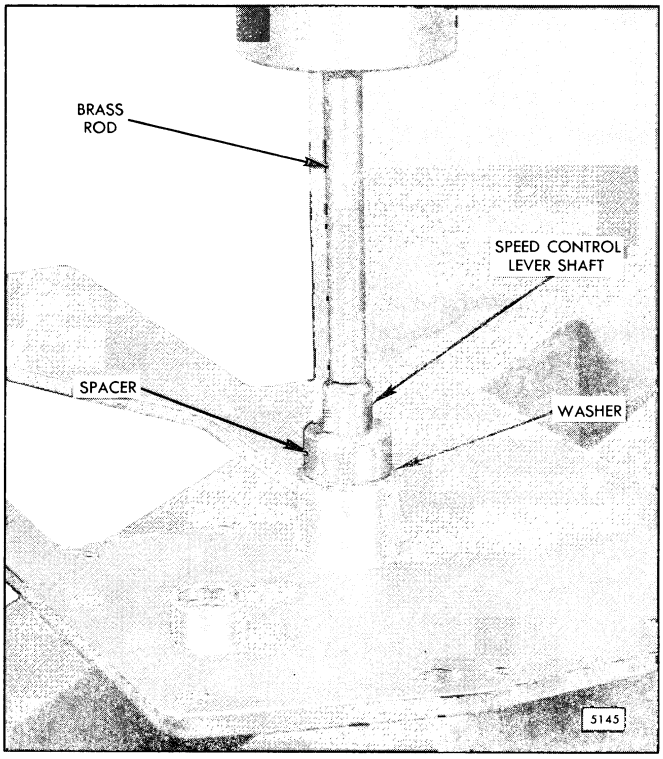


Fig. 5 - Removing Speed Control Lever Shaft From Cover

6. Remove the bolts and washers securing the governor housing assembly to the air box cover plate and remove the governor housing assembly and gasket. Remove starting aid screw stop bracket (service only), if used.

7. Remove the seal ring (49) from the control housing.

8. Remove the air inlet housing, water manifolds and any other accessories to gain access to the air box cover plate.

9. Remove the air box cover plate.

10. Remove the blower and governor drive assembly (refer to Section 3.4).

11. Remove the nine bolts and lock washers and one nut securing the governor weight housing assembly to the blower and remove the governor weight housing.

Disassemble Governor

Before removing any parts from the governor, wash the entire unit in clean fuel oil, dry it with compressed air and inspect for worn or damaged parts which may be repaired or replaced without complete disassembly.

1. Disassemble the governor cover assembly (Fig. 4) as follows:

   a. Remove the screw and lock washer assemblies securing the governor access cover to the governor cover and remove the access cover and gasket.

   b. On current governors, remove the buffer screw from the governor cover. On former governors, remove the buffer screw from the access cover.

   c. Remove the lubrication fitting from the top of the speed control lever shaft. Then, loosen the retaining bolt securing the speed control lever to the speed control shaft and remove the lever.

 © Detroit Diesel Corporation

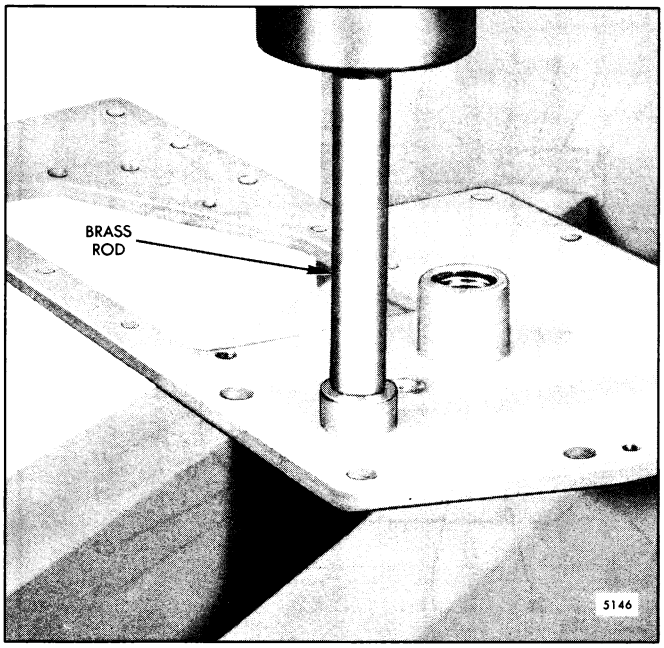


Fig. 6 - Removing Bushing From Stop Lever Shaft Opening In Cover

d. Place the cover assembly on the bed of an arbor press with the speed control lever shaft parallel and directly under the ram of the press. Use a suitable brass rod and press the shaft down through the spacer (Fig. 5) and remove the shaft, spacer and washer from the cover assembly.

e. Remove and discard the speed control lever shaft seal ring.

f. Loosen the retaining bolt securing the stop lever to the stop lever shaft and remove the lever.

g. Remove the snap ring and two spacers securing the stop lever shaft in the cover assembly and withdraw the shaft and return spring from the cover.

h. Remove and discard the stop lever shaft seal ring.

i. Wash the cover assembly thoroughly in clean fuel oil and inspect theneedle bearings and bushing for wear or damage. If the bearings or bushing are satisfactory for further use, removal is unnecessary.

j. Place the cover in an arbor press and, using a brass rod, remove the bushing from the stop lever shaft opening (Fig. 6).

k. With the cover in the arbor press, press the two bearings from the speed control lever shaft.

2. Refer to Figs. 2 and 7 and disassemble the spring housing as follows:

a. Place the governor in a vice equipped with soft jaws.

b. Remove the two bolts and copper washers securing the spring housing (8) to the governor control housing (27) and remove the spring housing.

c. Loosen the high-speed spring retainer locknut (11) Remove the spring retainer (9), high-speed spring (10) and related parts as an assembly.

d. Loosen the locknut (7) on the former idle speed adjusting screw and remove the adjusting screw and high-speed spring (10) from the high-speed spring plunger (12). Loosen the locknut (7) on the current idle speed adjusting set screw (6) and remove the set screw adjusting pin (63) and high-speed spring (10) from the high-speed spring plunger (12).

e. Remove the low-speed spring cap (15), low-speed spring (14) and low-speed spring seat (13) from the high-speed spring plunger (12).

3. Disassemble the governor control housing (Figs. 2 and 7) as follows:

a. Remove the differential lever (21) from the differential lever connecting rod (23).

b. Remove the spring retainer (19) and plain washer (20), securing the differential lever (21) to the operating shaft lever (18), and remove the differential lever and operating shaft lever.

c. On a current governor, remove the gap adjusting screw (17) and starting aid screw (62) from the operating shaft lever (18). On a former governor, remove the gap adjusting screw (17) and locknut (16) from the shaft lever (18).

d. On current governors, remove the differential lever connecting rod (23) from the operating control link lever (61).

e. On former governors, remove the differential lever connecting rod (23) from the terminal lever (25).

f. On current governors, remove the spring retainers (19) and washers (20) securing the connecting link (59) to the operating control link levers (57 and 61) and remove the connecting link.

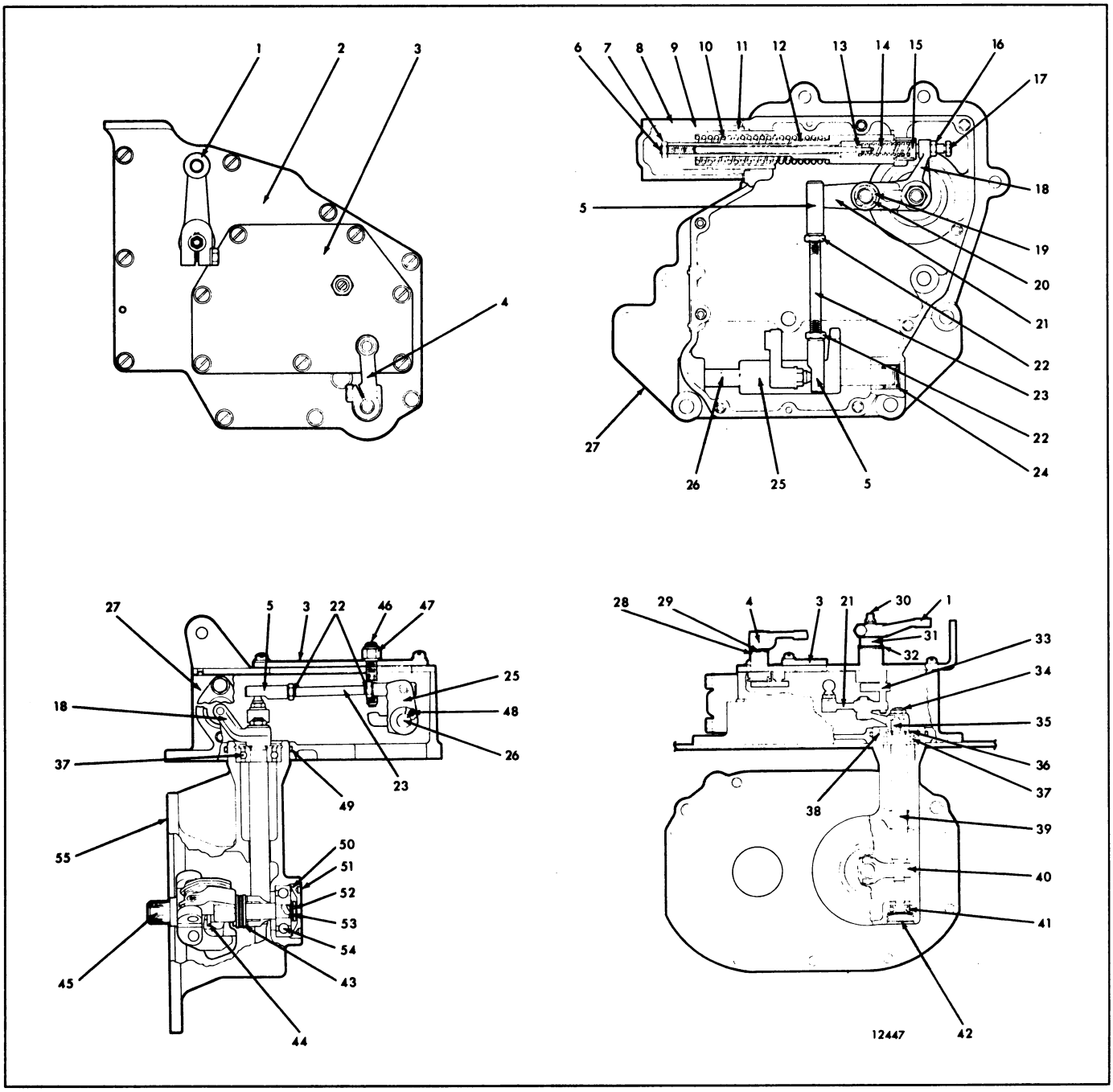


Fig. 7 - Cross Sections of Limiting Speed Governor (Former)

g. On current governors, remove the four retaining rings (56) positioning the operating control link levers (57 and 61) on the operating lever shafts.

h. On former governors, loosen the set screw (48) securing the terminal shaft lever (25) in position on the terminal shaft (26).

i. Place the control housing (27) in an arbor press with one of the operating shafts (58 and 60, current governors) or the terminal lever shaft (27, former governors) parallel and directly under the ram of the press. Place a brass rod between the ram and the front end of the shafts (Fig. 8).

 © Detroit Diesel Corporation

1. Lever—Speed Control
2. Cover—Governor
3. Cover—Access
4. Lever—Stop
5. Ball Joint Assembly
6. Screw—Idle Speed Adjusting
7. Locknut
8. Housing—Spring
9. Retainer—Spring, High-Speed
10. Spring—High-Speed
11. Locknut—Retainer
12. Plunger—Spring, High-Speed
13. Seat—Spring, Low-Speed
14. Spring—Low-Speed
15. Low-Speed
16. Screw
17.
18.
19.
20.
21.
22.
23. Connecting
24.
25.
26.
27.
28.
29. Ring—Snap
30. Fitting—Lubrication
31. Spacer
32. Washer—Plain
33. Shaft—Speed Control Lever
34. Nut—Retaining Operating Shaft Lever
35. Woodruff Key
36. Spacer
37. Bearing—Upper, Operating Shaft
38. Ring—Snap
39. Shaft—Operating
40. Fork—Operating
41. Bearing—Lower, Operating Shaft
42. Plug—Cup
43. Bearing—Thrust, Riser
44. Riser
45. Shaft—Weight
46. Screw—Buffer
47. Locknut—Buffer Screw
48. Screw—Set, Terminal Lever
49. Ring—Seal
50. Gasket—Housing Plug
51. Plug—Housing
52. Bolt—Retaining, Bearing
53. Washer—Lock
54. Bearing—Weight Shaft
55. Housing—Weight

Fig. 7 - Cross Sections of Limiting Speed Governor (Former)

j. Press the shafts straight through and remove the enclosed bearing assemblies (24) from each end of the shafts. Withdraw the operating shafts, operating levers and needle bearings (current governors) or the terminal lever, terminal lever shaft and needle bearings (former governors).

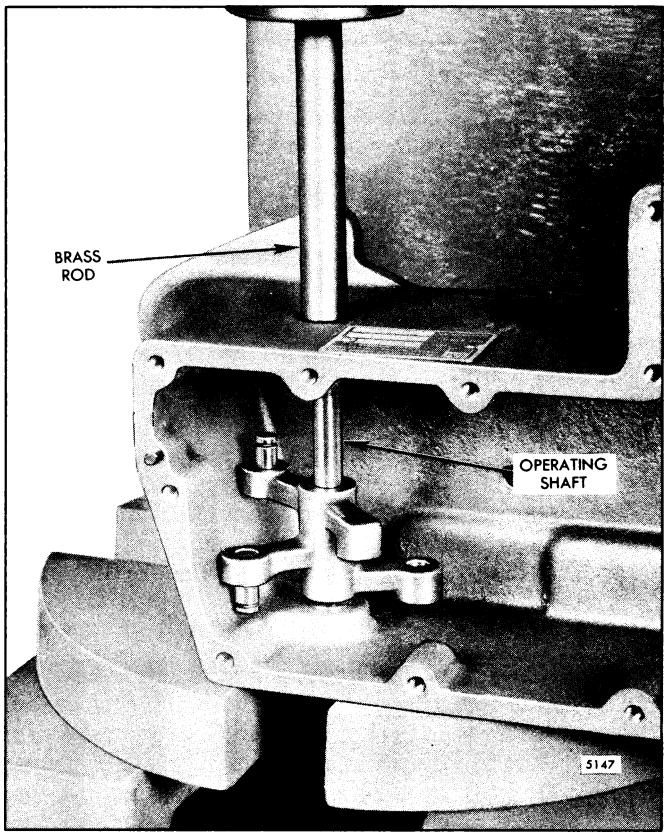


Fig. 8 - Removing Operating Lever Shaft and Enclosed Bearing Assembly

4. Remove the governor weight and shaft assembly as follows (refer to Figs. 2 and 7, unless otherwise indicated):

a. Remove the governor weight housing plug (51) and gasket (50) with socket J 23176.

b. Straighten the tang of the lock washer (53) and remove the bearing retainer bolt(52), washer and lock washer.

c. Thread a 5/16”-24 bolt into the tapped hole in the end of the weight shaft and remove the governor weight and shaft assembly, using an arbor press (Fig. 9).

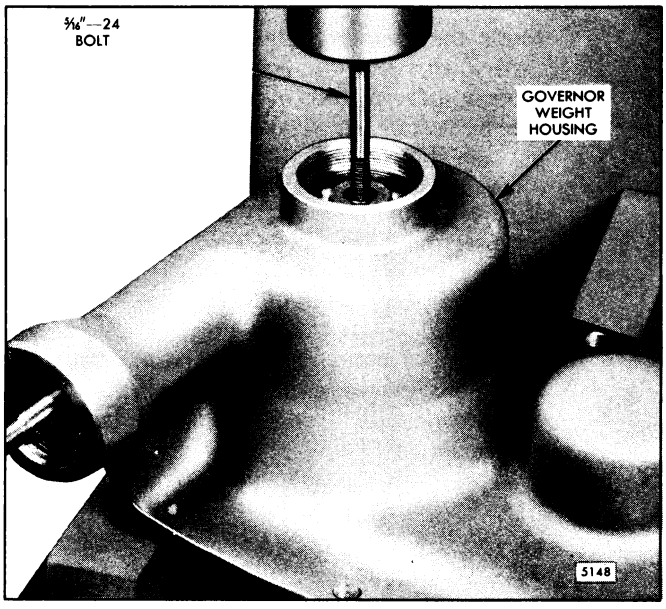


Fig. 9 - Removing Governor Weight and Shaft Assembly

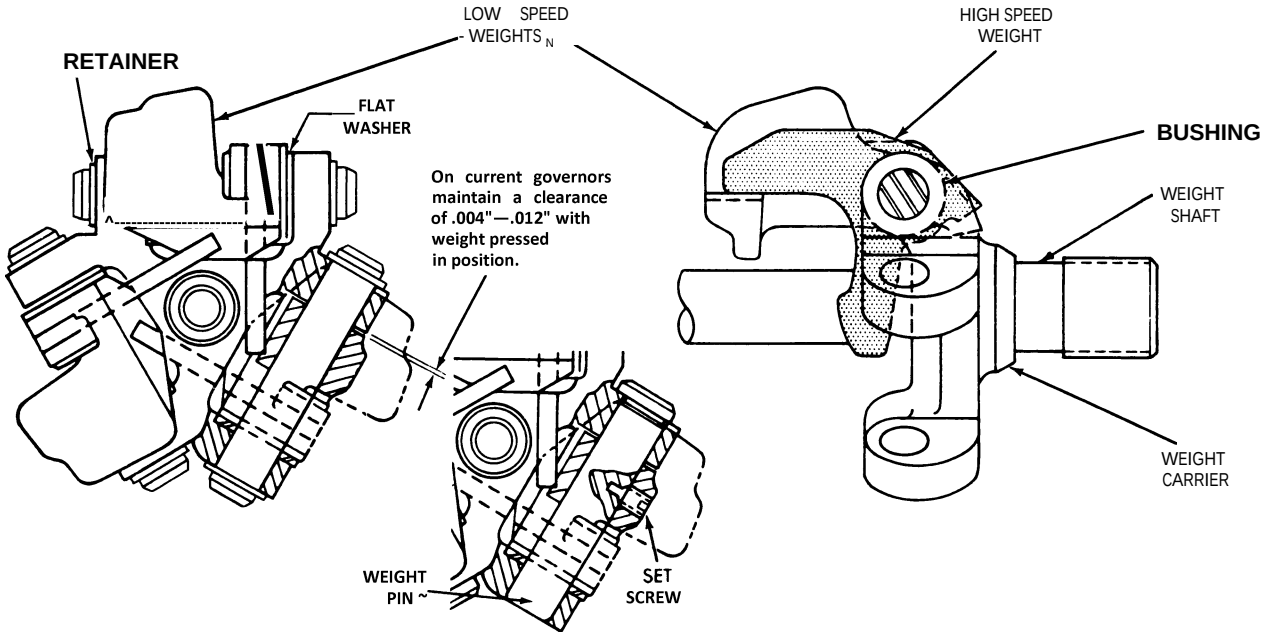


Fig. 10 - Cross Section of Governor Weight Assemblies

d. Slide the riser thrust bearing (43) and riser (44) from the shaft.

e. Remove the weight shaft bearing (54) from the governor housing.

5. Disassemble the governor weight and shaft assembly as follows:

a. Mark the low and high-speed weights and carrier with a center punch for identification. Also, note the position of the flat washers so that the parts can be replaced in their original position (Fig. 10).

b. If removal of the weights from the carrier is necessary on current governors, refer to Fig. 10 and remove the retainers from the weight pin. Press the pin from the low-speed weight. The high-speed weight is not a press fit. On former governors, remove the set screw from the low-speed weight with a 3/32" Allen wrench. Then, remove the weight pin and weight from the carrier.

c. Remove the second and third pair of weights from the carrier in the same manner as above.

d. Thread a 5/16"-24 bolt into the tapped hole in the end of the weight shaft and press the weight carrier from the weight shaft (Fig. 11).

e. Position the high-speed governor weight on the bed of an arbor press and press the bushing from the weight, using a suitable brass rod (Fig. 12).

6. Remove the operating shaft (Fig. 2) from the governor weight housing as follows:

a. Remove the Woodruff key (35) from the operating shaft (39).

b. Remove the two spacers (36) and snap ring (38) from the operating shaft.

c. Position the weight housing assembly in an arbor press (Fig. 13). Press down on the operating shaft (39) to remove the cup plug (42) from the bottom of the housing and the shaft from the upper bearing (37). Remove the upper bearing from the housing.

d. Turn the weight housing over and press down on the operating shaft to remove the shaft from the lower bearing (Fig. 15). Continue to press down on the shaft, with the operating fork (40) against the flat shoulder of the housing, to remove the operating fork (40) from the shaft. Remove the shaft, operating fork and lower bearing from the weight housing.

 © Detroit Diesel Corporation

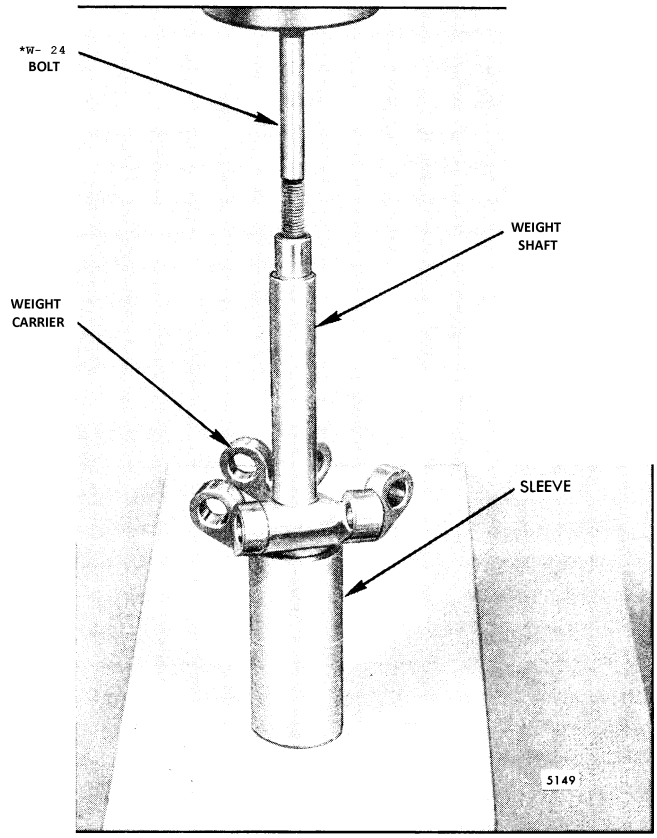


Fig. 1 1 - Removing Weight Carrier From Shaft

Inspect Governor Parts

Wash all of the parts in clean fuel oil and dry them with compressed air prior to inspection.

CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

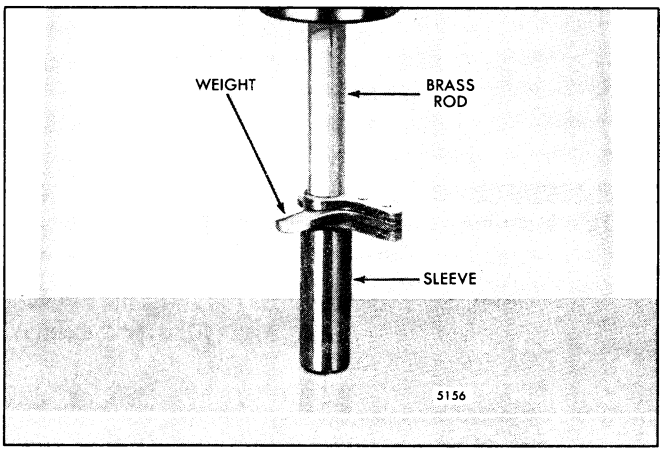


Fig. 1 2 - Removing High-Speed Weight Bushing

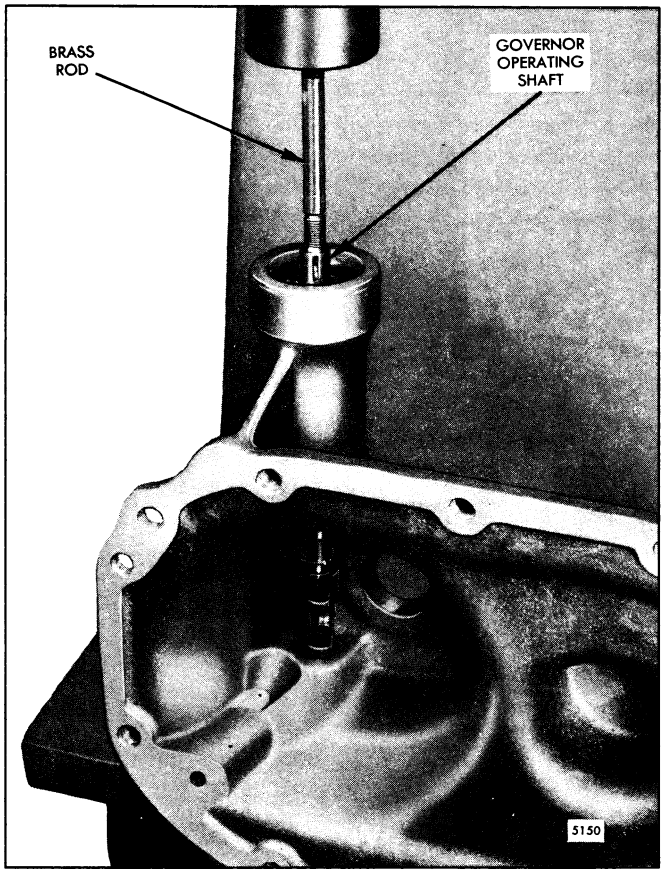


Fig. 13 - Removing Operating Shaft From Weight Housing Upper Bearing

Revolve the operating shaft bearings and the governor weight shaft bearing ***slowly*** by hand. Replace the bearings if rough or tight spots are detected.

Examine the riser thrust bearing for excessive wear, flat spots or corrosion. If any of these conditions exist, install a new thrust bearing assembly.

Inspect thegovernor stop lever shaft and bushingfor excessive wear or flat spots. If one or both conditions exist, install a new shaft and bushing.

Inspect the speed control lever shaft and bearingsfor excessive wear or flat spots at the bearing surface. If one or both conditions exist, install a new shaft and bearings.

Examine the weight carrier pins and weight bushings for excessive wear and flat spots. If either of the conditions exist, install new parts.

Current low-speed governor weights are secured to the weight shaft by a press fit. The former low-speed weights were secured by a set screw. Since the new weights have a smaller diameter bore, a new governor weight pin is required. Also, two retaining rings are required to secure the new weight pin in the weight carrier.

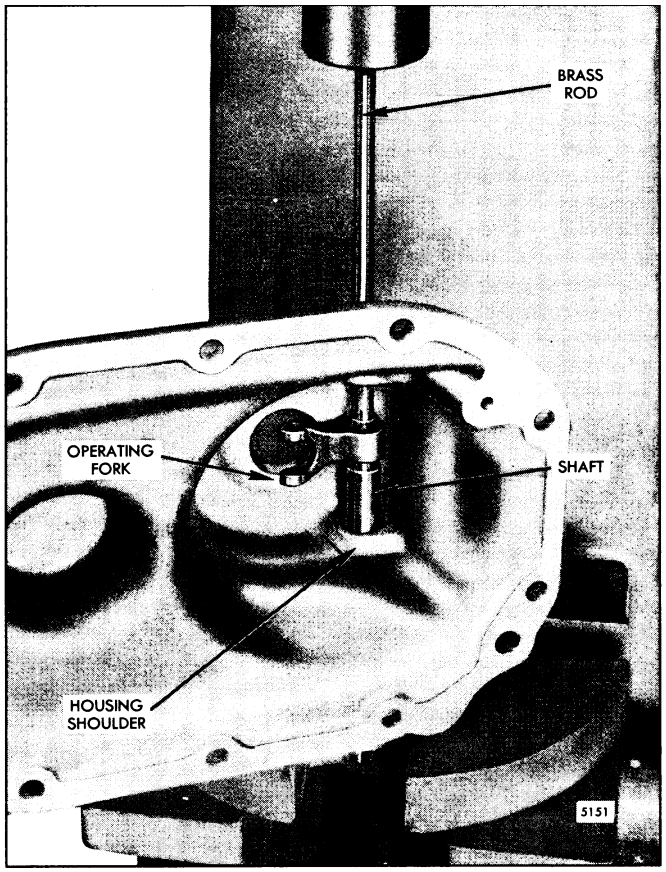


Fig. 14 - Removing Operating Shaft and Fork From Weight Housing

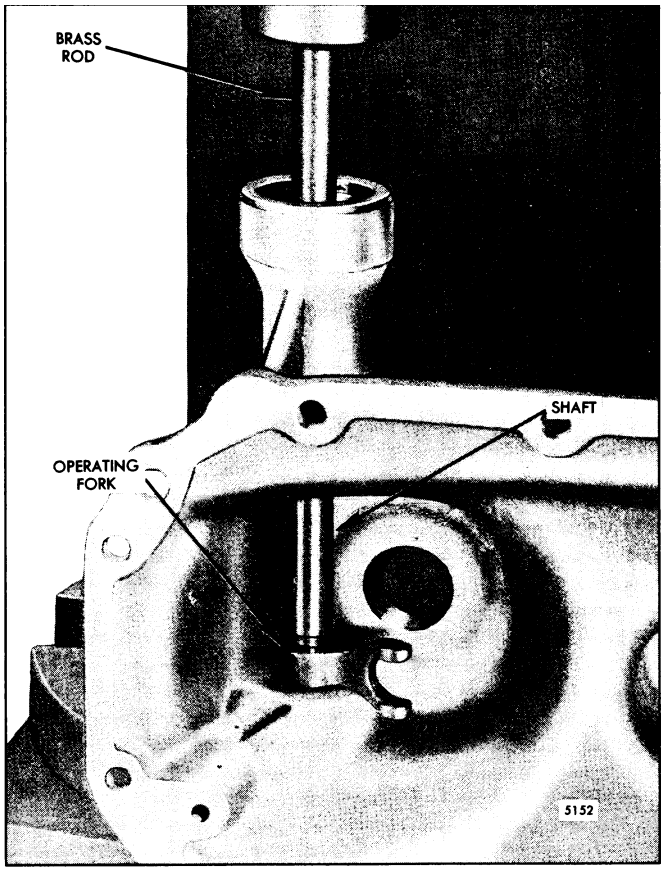


Fig. 15 - Installing Operating Shaft and Fork in Weight Housing

The current high-speed governor weight (without needle bearings) has a slip-fit bushing; the former weight had a press-fit bushing. The high-speed weight assembly which incorporates a needle bearing is not affected by the above changes and will continue to be used with the new low-speed weights where required.

When one set of weights requires replacement, it is recommended that both sets be replaced.

If the governor weight housing or the complete governor assembly is replaced on an early engine (prior to engine 12E-296), it will be necessary to remove the spray nozzle (used to lubricate the governor) from the blower front end plate and include a new governor-to-blower gasket. The current governor weight housing includes lubricating oil passages and the spray nozzle in the blower end plate is no longer required.

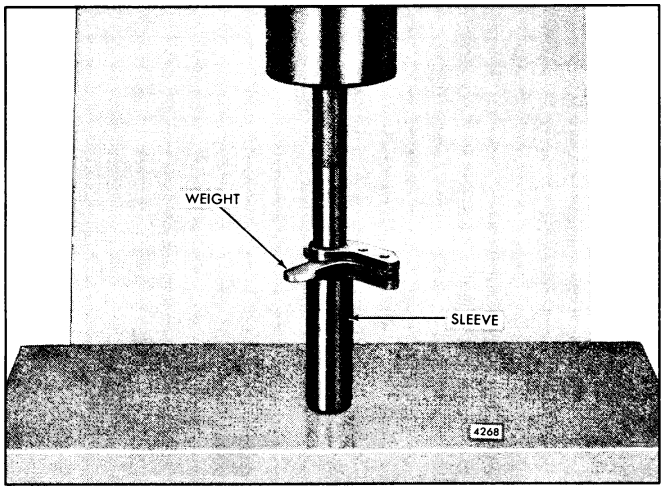


Fig. 1 6 - Installing Bushing In High-Speed Weight using Tool J 8985

Assemble Governor

During assembly, lubricate all needle bearing assemblies with Shell Alvania No. 2 grease, or equivalent.

1. Install the operating shaft in the governor weight housing as follows (Figs. 2 and 7):

   a. Insert the operating shaft (39) into the housing and slide the operating fork (40) over the end of the operating shaft.

   b. Place the weight housing (55) upright on the bed of an arbor press with the operating shaft parallel and directly under the ram of the press.

 © Detroit Diesel Corporation

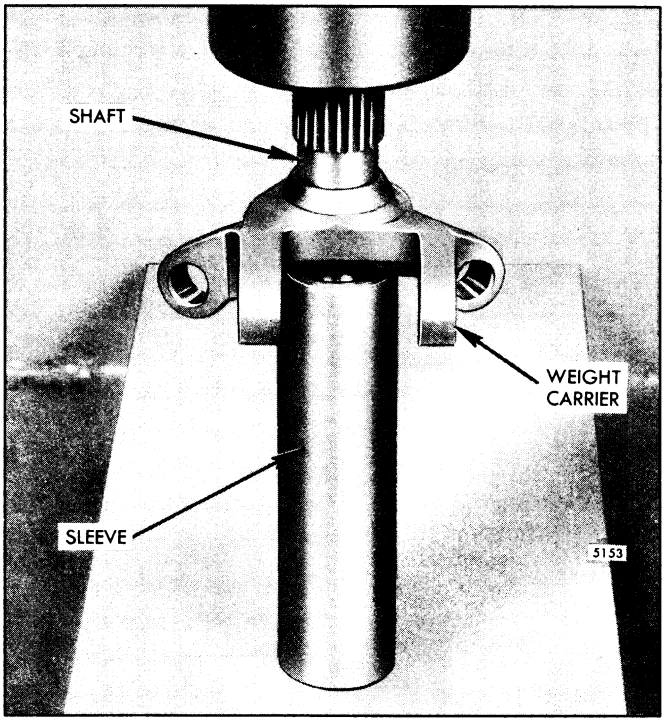


Fig. 1 7 - Installing Shaft In Weight Carrier

c. Start the operating fork (40) over its seating shoulder on the operating shaft (39).

d. Lower the operating shaft and fork until the fork is against the housing lower boss and, using a brass rod, press the operating shaft into the fork until the fork bottoms against the shoulder on the shaft (Fig. 15).

e. Turn the housing over and, with the operating shaft suitably supported, press the lower bearing assembly (41) over the lower end of the operating shaft. Install the bearing with the shielded side facing in.

f. Turn the housing back upright again and, using the same method, install the upper bearing (37) with the numbered side facing out. Make sure that the lower bearing assembly is in place in the housing lower bearing bore.

g. Rotate the shaft to make sure that the bearings are installed correctly.

h. Place the two spacers (36) over the top of the operating shaft and install the Woodruff key (35) and snap ring (38).

i. Apply a good quality sealant around the cup plug (42). Tap the plug into position in the weight housing operating shaft lower bearing bore.

2. Assemble the governor weight and shaft assembly as follows:

a. Place the governor high-speed weight on the bed of an arbor press (Fig. 16). Position the bushing in the bore of the weight and, using a suitable sleeve and replacer J 8985, press the bushing into the weight.

b. Slide the weight carrier over the end of the weight shaft. Place the weight carrier and weight shaft on the bed of an arbor press (Fig. 17).

c. Press the weight shaft into the weight carrier until the shaft bottoms against the shoulder of the carrier.

d. With current governors, refer to Fig. 10 and install a retainer on either end of the weight pin. Note the matchmarks placed on the weight carrier and weights at the time of disassembly. Then slide the weight pin through the carrier, flat washer and high-speed weight and its bushing. Place the low-speed weight in position. Then, press the weight pin through the low-speed weight and carrier until the retainer bottoms against the carrier. Maintain a clearance of .004"-.012" with the weight pressed in position. To maintain this clearance, insert a .004"-.012" shim between the low-speed weight and carrier while pressing the pin in position.

Remove the shim and install the second weightpin retainer. Install the second and third pair of weights inthe same manner.

e. With former governors, refer to Fig. 10 and install the governor weights, flat washers, weight pin and set screws. Stake the set screws at two places. Use Locktite sealant grade C or CV or equivalent, and tighten the set screw to 20 **lb-in** (2.26 N«m) torque.

3. Install the governor weight and shaft assembly (Figs. 2 and 7) as follows:

a. Slide the riser (44) over the weight shaft (45) and up against the finished surfaces of the governor weights.

b. Position the riser thrust bearing (43) over the weight shaft with the bearing race having the smaller inside diameter against the thrust riser.

c. Position the weight carrier and shaft assembly in the governor housing with the riser thrust bearing (43) up against the finished surfaces of the operating fork (40).

d. Support the splined end of the weight shaft on the bed of an arbor press. Start the weight shaft bearing (54) into the governor housing and over the end of the weight shaft.

e. Press the weight shaft bearing into the governor housing and over the weight shaft until it bottoms against the shoulder on the weight shaft.

f. Place the lock washer (53) on the bearing retaining bolt (52). Thread the retaining bolt into the tapped hole in the end of the weight shaft. Tighten the bolt and bend the tang of the lock washer against the head of the retaining bolt.

g. Place a gasket (50) against the weight shaft bearing. Apply a sealant such as Loctite grade H, HV or HVW to the threads of the governor housing and the plug (51) and thread the plug into the housing. Tighten the plug to 50-60 lb—ft (68-81 N#m) torque.

Rotate the governor weight assembly to make sure that there is no bind. If a bind exists, remove the housing plug and check to see if the weight shaft bearing is fully seated in the governor housing.

4. Assemble the governor control housing (Figs. 2 and 7) as follows:

a. Press a new enclosed bearing (24) flush with the counter bore in each shaft opening on the outside of the housing (current governors) or in one end of the terminal lever shaft bore (former governors).

b. On current governors, slide the operating levers (57 and 61) over the operating shafts (58 and 60) and place the shafts in the control housing, with one end of each shaft inserted into the enclosed bearings. Refer to Fig. 2 for proper orientation of the operating control link levers. Then, press a new enclosed bearing assembly (24) in each housing bore at the opposite ends of the shafts until there is .040" maximum end play and install four new retaining rings, positioning the operating levers on the operating shafts.

c. On former governors, slide the terminal lever (25) on the terminal shaft (26) and position one end of the shaft and lever assembly into the installed bearing assembly. Then, press a new enclosed bearing assembly (24) in the bore at the opposite end of the terminal shaft and over the terminal shaft end. Tighten the set screw (48) securing the terminal shaft lever to the terminal shaft.

d. On current governors, install the connecting link (59) to the operating levers (57 and 61), using a washer (20) and new spring retainer (19) at each end of the connecting link.

e. On former governors, connect thedifferential lever connecting rod (23) to the terminal lever (25).

f. On current governors, install thedifferential lever connecting rod (23) to the operating lever (61).

g. Connect the differential lever (21) to the differential lever connecting rod (23).

h. Secure the differential lever (21) to the operating shaft lever (18), using a plain washer (20) and spring retainer (19).

i. On current governors, install thestarting aid screw (62) in the gap adjusting screw (17) and thread the assembly into the operating shaft lever (18). On a former governor, thread the locknut (16) on the gap adjusting screw (17) and thread the assembly into the operating shaft lever (18).

j. Install the fuel rods.

5. Refer to Figs. 2 and 7 and assemble the spring housing as follows:

a. Place the low-speed spring seat (13), low-speed spring (14) and low-speed spring cap (15) in the high-speed spring plunger (12).

b. Position the high-speed spring (10) over the high-speed spring plunger (12) and place the high-speed spring retainer (9) over the spring. Place the current idle speed adjusting pin in the spring plunger. Thread the current set screw into the spring plunger (12) and secure the assembly together with the locknut (7). Thread the former idle speed adjusting screw into the spring plunger (12) and secure the assembly with the adjusting screw locknut (7).

c. Thread the spring retainer locknut (11) and position the gasket over the spring retainer (9) and install the assembly in the governor control housing (27).

d. Place the spring housing (8) over the assembly and up against the gasket and governor control housing. Secure it in place with two bolts and copper washers.

6. Assemble the governor cover (Fig. 4) as follows:

Lubricate the O.D. of the bearings with clean engine oil before pressing them in place.

a. Place the governor cover on the bed of an arbor press. Start the upper bearing straight into the bearing bore of the cover with the numbered side of the bearing up. Press the bearing into the cover using installer J 21068 (Fig. 18).

 © Detroit Diesel Corporation

b. Reverse the governor cover in the press. Start the second bearing into the bore with the numbered side of the bearing up. Press the bearing down into the cover until the bearing is flush with the boss surface on the cover.

c. Lubricate the speed control shaft needle bearings with Shell Alvania No. 2 grease, or equivalent.

d. Press the bushing into the stop lever shaft bore using installer J 21068. Press the bushing down into the bore 1/8" below the surface to allow room for the seal ring.

e. Insert the speed control shaft through the bearings in the cover assembly.

f. Slide a new seal ring over the shaft and into the bearing bore.

g. Slide the washer over the shaft and up against the cover boss.

h. Place the cover assembly on the bed of an arbor press.

i. Start the spacer over the end of the speed control shaft and, using a suitable sleeve, press the spacer on the shaft until there is approximately .008" to .012" end play when the shaft is moved within the cover assembly.

j. Position the speed control lever on the speed control lever shaft and tighten the clamping bolt.

k. Install the lubrication fitting at the top of the speed control lever shaft.

l. Insert the stop lever shaft, with the return spring in position (Fig. 4), through the bushing in the cover assembly.

m. Slide a new seal ring over the stop lever shaft and into the bushing bore.

n. Slide the two spacers over the shaft and up against the stop lever shaft boss.

o. Secure the stop lever in the cover assembly with the snap ring.

p. Position the stop lever on the stop lever shaft and tighten the stop lever bolt.

q. On current governors, install the buffer screw in the cover. On former governors, install the buffer screw in the access cover.

r. Assemble the access cover, using a new gasket, to the governor cover.

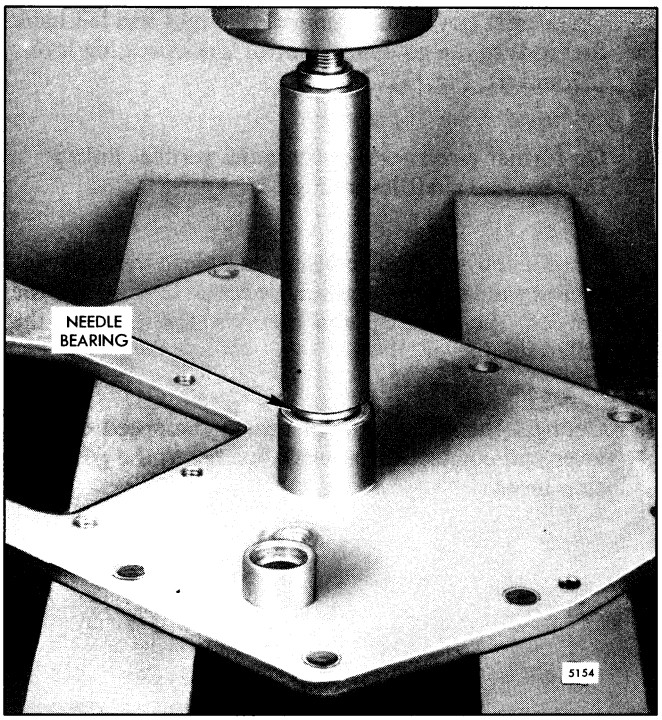


Fig. 18 - Installing Needle Bearings In Governor Cover using Tool J 21068

Install Governor

1. Install the governor-to-blower gasket on the blower and slide the weight housing assembly straight on the dowels in the blower housing. Align the splines of the weight shaft with the splines in the blower rotor. The tab on the gasket is to ensure the gasket is in place.

2. Secure the weight housing assembly to the blower using nine 3/8"—16 x 3-1/4" bolts and one 3/8"-24 nut. Tighten the bolts to 30-35 lb—ft (41-47 N#m) torque and the nut to 35-39 lb—ft (47-53 N«m) torque.

3. Install the blower and the governor drive and weight housing assembly in the engine (refer to Section 3.4).

4. Install the air box cover plate.

5. Install the water manifolds, air inlet housing and any other accessories removed under ***Remove Governor.***

Place a new seal ring (49) in the control housing (Figs. 2 and 7) and position the governor control housing over the drive mechanism and on the air box cover plate. Install and tighten the control housing to air box cover plate hold down bolts and washers. On the former governor, install the starting aid screw stop bracket (if used).

7. Refer to Figs. 2 and 7 and connect the operating shaft lever (18) to the operating shaft (39), using a retaining nut (34) and washer. Tighten the nut to 35-39 lb—ft (47-53 N#m) torque.

8. On current governors, connect the right and left bank fuel rods to the governor control link operating levers (57 and 61, Fig. 2).

9. On former governors, connect the vertical linkage to the terminal shaft lever (Fig. 3).

10. Place a new governor housing gasket on the governor housing and install the governor cover. Be sure that the pin on the throttle shaft enters the slot of the differential lever.

11. Connect the speed control rod to the speed control lever and connect the control linkage to the governor 12. stop lever.

CAUTION: Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assembly, the technician must determine that the injector racks move to the *no-fuel* position when the governor stop lever is placed in the *stop* position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever. An overspeeding engine can result in engine damage which could cause personal injury.

Perform an engine tune-up as outlined in Section 14.3.

 © Detroit Diesel Corporation

VARIABLE SPEED MECHANICAL GOVERNOR

The variable speed mechanical governor (Fig. 1) performs the following three functions:

1. Controls the engine idle speed.
2. Limits the maximum no-load speed.
3. Holds the engine at any constant speed, between idle and maximum, as desired by the operator.

The variable speed governor is of the single-weight type. Each governor has an identification plate located on the governor housing. It contains the governor assembly part number, type (S.W.V.S.) and idle speed range (RPM).

The upper governor housing assembly is mounted on the air box cover plate at the front of the engine. The governor weight and drive mechanism is located underneath the air box cover plate where it is driven by the left-hand helix blower rotor. The governor drive and weight housing also serves as an end cover for the blower.

The governor assembly consists of two subassemblies:

1. Control Housing Assembly
2. Weight Housing

Operation

Two manual controls are provided on the variable speed governor; a stop lever for starting and stopping and a speed control lever. For starting, the stop lever is moved to the *run* position which moves the injector control racks to the *full-fuel* position. Upon starting, the governor moves the injector racks out to that position required for idling. The engine speed is then controlled manually by movement of the speed control lever.

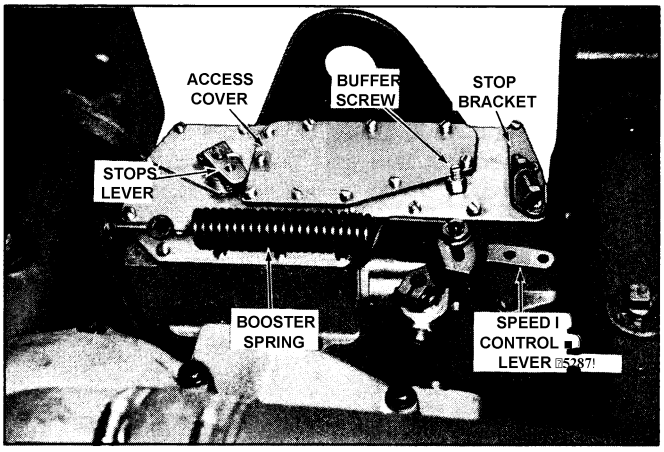


Fig. 1 - Governor Mounting

The centrifugal force of the revolving governor weights is converted into linear motion which is transmitted through the riser and operating shaft to the operating shaft lever (Fig. 2). One end of the operating shaft lever bears against the variable speed spring plunger while the other end provides a changing fulcrum on which the differential lever pivots.

The centrifugal force of the governor weights is opposed by the variable speed spring. Load changes or movement of the speed control lever create an unbalanced force between the revolving governor weights and the tension on the variable speed spring. When the two forces are equal, the engine speed stabilizes for a setting of the speed control lever.

The engine idle speed is determined by the centrifugal force required to balance out the tension on the variable speed spring in the low speed range.

Adjustment of the engine idle speed is accomplished by changing the tension on the variable speed spring by means of the idle speed adjusting screw.

Adjustment of the maximum no-load speed is accomplished by varying the tension on the variable speed spring by the installation or removal of stops (Fig. 2) and shims, as required.

For adjustment of the variable speed governor, refer to Section 14.4.

Lubrication

The governor is lubricated by a spray of oil from two drilled orifices (holes) in the governor weight housing, which directs oil to the governor drive shaft splines and to the riser thrust bearing. Formerly this was done with a spray nozzle located in the blower end plate. The governor weights distribute this oil to all parts of the governor assembly requiring lubrication.

Oil returning from the governor is directed through passages in the blower end plate and the cylinder block to the engine oil pan.

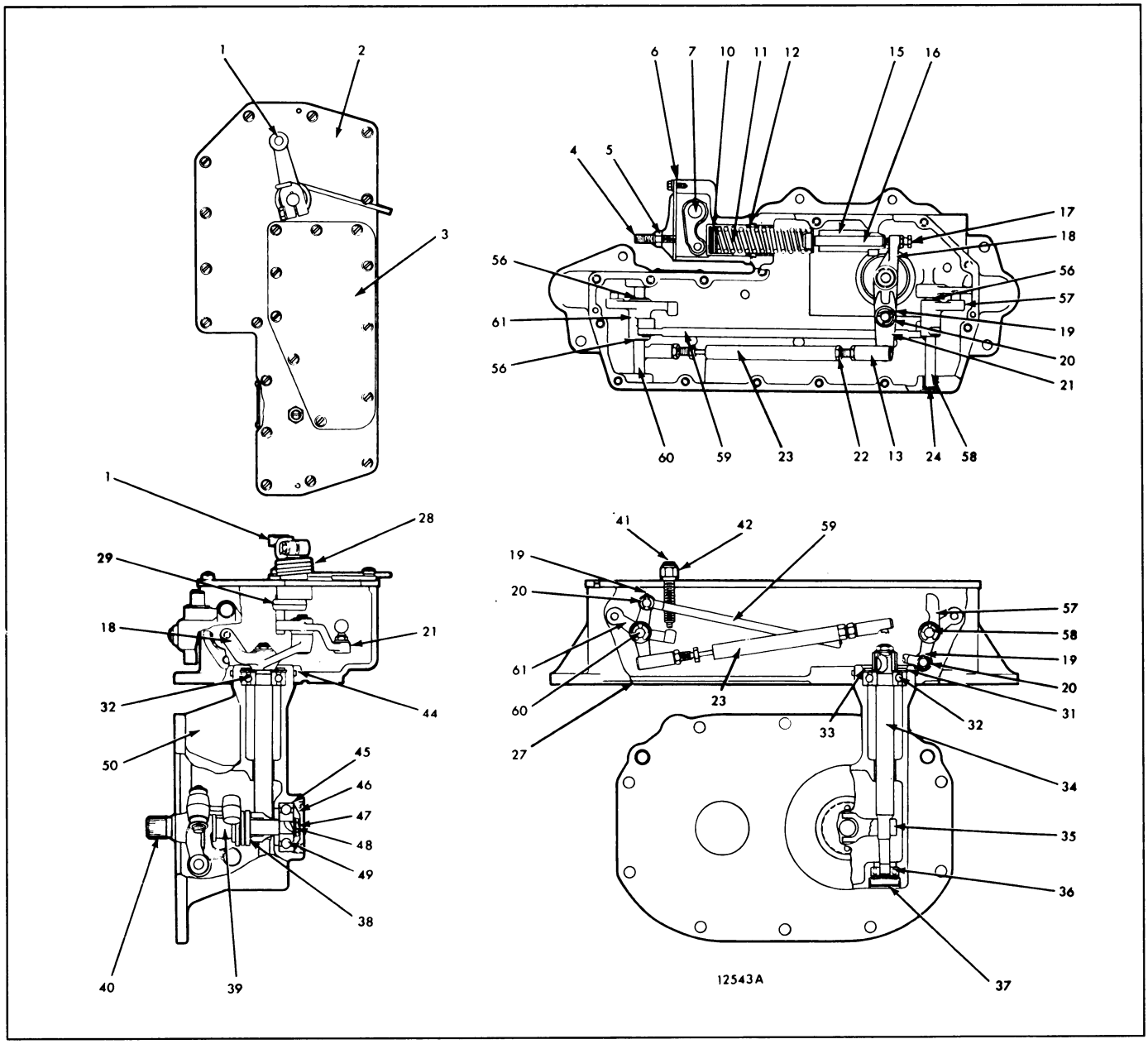


Fig. 2 - Cross Section of Variable Speed Governor (Current)

Remove Governor

1. Remove the starting aid system (refer to Section 14.14) air cylinder and shutdown solenoid (if used) from the governor cover.

2. Disconnect the speed control rod from the speed control lever and disconnect the booster spring from the speed control lever (Fig. 1).

3. Remove the screw and lock washer assemblies and lift the stop bracket (current engines), cover and gasket from the governor housing.

A speed control lever stop bracket with a 3/8"—16 x 1 3/4" adjustment bolt and locknut and a new speed control lever and booster spring hanger are now used effective with engine serial number 12E-359.

4. On current governors, disconnect the right and left bank fuel rods from the governor control link operating levers and from the injector control tubes. Remove the fuel rods.

5. On former governors, disconnect the vertical linkage from the terminal shaft lever (Fig. 3).

 © Detroit Diesel Corporation

1. Lever—Stop
2. Cover—Governor
3. Cover—Access
4. Screw—Idle Speed Adjusting
5. Locknut, Idle Speed Adjusting
6. Housing—Spring
7 Shaft—Speed Control Lever
10. Shim—Governor
11. Spring—Variable Speed
12. Stop—Governor
13. Ball Joint Assembly
15. Guide—Plunger
16. Plunger—V ariable Speed Spring
17. Screw—Gap Adjusting
18. Lever—Operating Shaft
19. Retainer—Spring
20. Washer—Plain
21. Lever—Differential
22. Locknut
23. Rod—Differential Lever-Connecting
24. Bearing—Enclosed
27. Housing—Control
28. Spring—Torsion Retraction
29. Shaft—Speed Control Lever
31. Spacer
32. Bearing—Upper, Operating Shaft
33. Ring—Snap
34. Shaft—Operating
35. Fork—Operating
36. Bearing—Lower, Operating Shaft
37. Plug—Cup
38. Bearing—Thrust, Riser
39. Riser
40. Shaft—Weight
41. Screw—Buffer
42. Locknut, Buffer Screw
44. Ring—Seal
45. Gasket—Housing Plug
46. Plug—Housing
47. Bolt—Retaining, Bearing
48. Washer—Lock
49. Bearing—Weight Shaft
50. Housing—Weight
56. Ring—Retaining
57. Lever—Operating Control Link (Left Bank)
5 8. Shaft—Operating Control Link Lever (Left Bank)
59. Link—Connecting
60. Shaft—Operating Control Link Lever (Right Bank)
61. Lever—Operating Control Link (Right Bank)
62. Gasket—Spring Housing Cover
63. Cover—Spring Housing

Fig. 2 - Cross Section of Variable Speed Governor (Current)

6. Remove the operating shaft lever retaining nut and washer and remove the operating shaft lever (18) from the operating shaft (Figs. 2 and 5).

7. Remove the bolts and washers securing the governor housing assembly to the air box cover plate and remove the governor housing assembly and gasket.

8. Remove the air inlet housing, water manifolds and any other accessories to gain access to the air box cover plate.

9. Remove the air box cover plate.

10. Remove the blower and governor drive assembly (refer to Section 3.4).

11. Remove the nine bolts and lock washers and one nut securing the governor weight housing assembly to the blower and remove the governor weight housing.

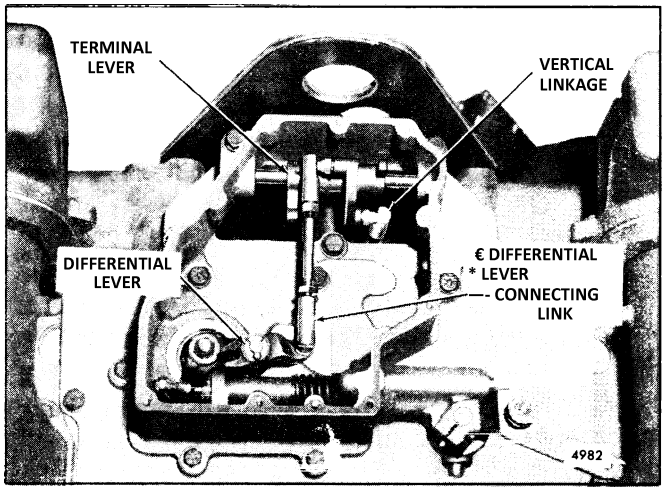


Fig. 3 - Governor Operating Linkage (Former)

Disassemble Governor

Before removing any parts from the governor, wash the entire unit in clean fuel oil, dry it with compressed air and inspect for worn or damaged parts which may be repaired or replaced without complete disassembly.

1. Disassemble the governor cover assembly as follows (Fig. 4):

   a. Remove the screw and lock washer assemblies securing the governor access cover to the governor cover and remove the access cover and gasket.

   b. On current governors, remove the buffer screw from the cover (Fig. 2). On former governors, remove the buffer screw from the access cover (Fig. 5).

   c. Loosen the stop lever retaining bolt and remove the stop lever and torsion retraction spring from the stop lever shaft.

   d. Remove the snap ring and two spacers securing the stop lever shaft in the cover assembly.

   e. Withdraw the stop lever shaft from the cover assembly.

   f. Wash the cover assembly thoroughly in clean fuel oil and inspect the bushings for wear or damage. If the bushings are satisfactory for further use, removal is unnecessary.

   Place the cover assembly (right side up) in an arbor press. Place remover J 21967-01 on top of the bushing and press the bushing out of the cover.

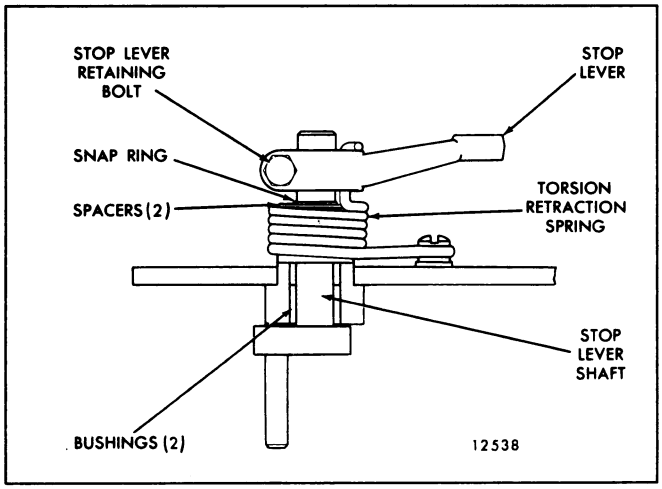


Fig. 4 – Cross Section of Governor Cover

2. Remove the variable speed spring housing from the governor housing (refer to Figs. 2 and 6 unless otherwise indicated):

   a. Place the governor housing (27) in a vise equipped with soft jaws.

   b. Remove the two bolts and lock washers securing the variable speed spring housing (6) to the governor housing and withdraw the variable speed spring housing and gasket. Remove the governor stops (12), variable speed spring (11) and variable speed spring plunger (16).

   c. Remove the governor shims (10) and spring retainer (9) from the variable speed spring housing.

   d. Drive the plunger guide (15) out of the housing with a brass rod.

3. Disassemble the governor variable speed spring housing (refer to Figs. 6 and 7):

   a. Loosen the bolt securing the speed control lever to the speed control shaft and pull the lever from the shaft.

   b. Remove the Woodruff key (65) and flat washer (66) from the speed control shaft (7).

   c. On current governors, remove one screw and lock washer and remove the spring housing cover and gasket. Then, remove the set screw from the spring lever.

On former governors, remove the pipe plug from the housing and, working through the opening, remove the set screw from the spring lever.

   d. Place a 3/4" inside diameter sleeve (approximately 1-1/2" long) on the bed of an arbor press. Support the spring housing assembly on top of the sleeve with the cup plug (71) in the side of the housing over the opening of the sleeve.

   e. Place a small brass rod on the end of the shaft and press the plug and bearing out of the spring housing.

   f. Remove the spring lever (8) from the spring housing (6) and the bearing (68) from the speed control shaft (7). If necessary, remove the Woodruff key from the shaft.

NOTICE: Due to the key in the speed control shaft, the inner end of the needle bearing will be damaged when pressing the bearing and cup plug out of the spring housing. Do not attempt to reuse the bearing.

   g. At this stage of disassembly, wash the spring housing (containing the remaining bearing) thoroughly in clean fuel oil and inspect the needle bearing for wear and damage. If the bearing is satisfactory for further use, removal is unnecessary.

   h. If removal of the needle bearing is necessary, support the spring housing, bearing side down, on top of the 3/4" inside diameter sleeve on the bed of the arbor press. Insert the bearing remover J 21967-01 through the housing and rest it on top of the bearing. Then, press the bearing out of the housing.

4. Disassemble the governor control housing as follows (Figs. 2 and 5):

   a. Remove the differential lever (21) from the differential lever connecting link (23).

   b. Remove the spring retainer (19) and plain washer (20) securing the differential lever (21) to the operating shaft lever (18) and remove both levers.

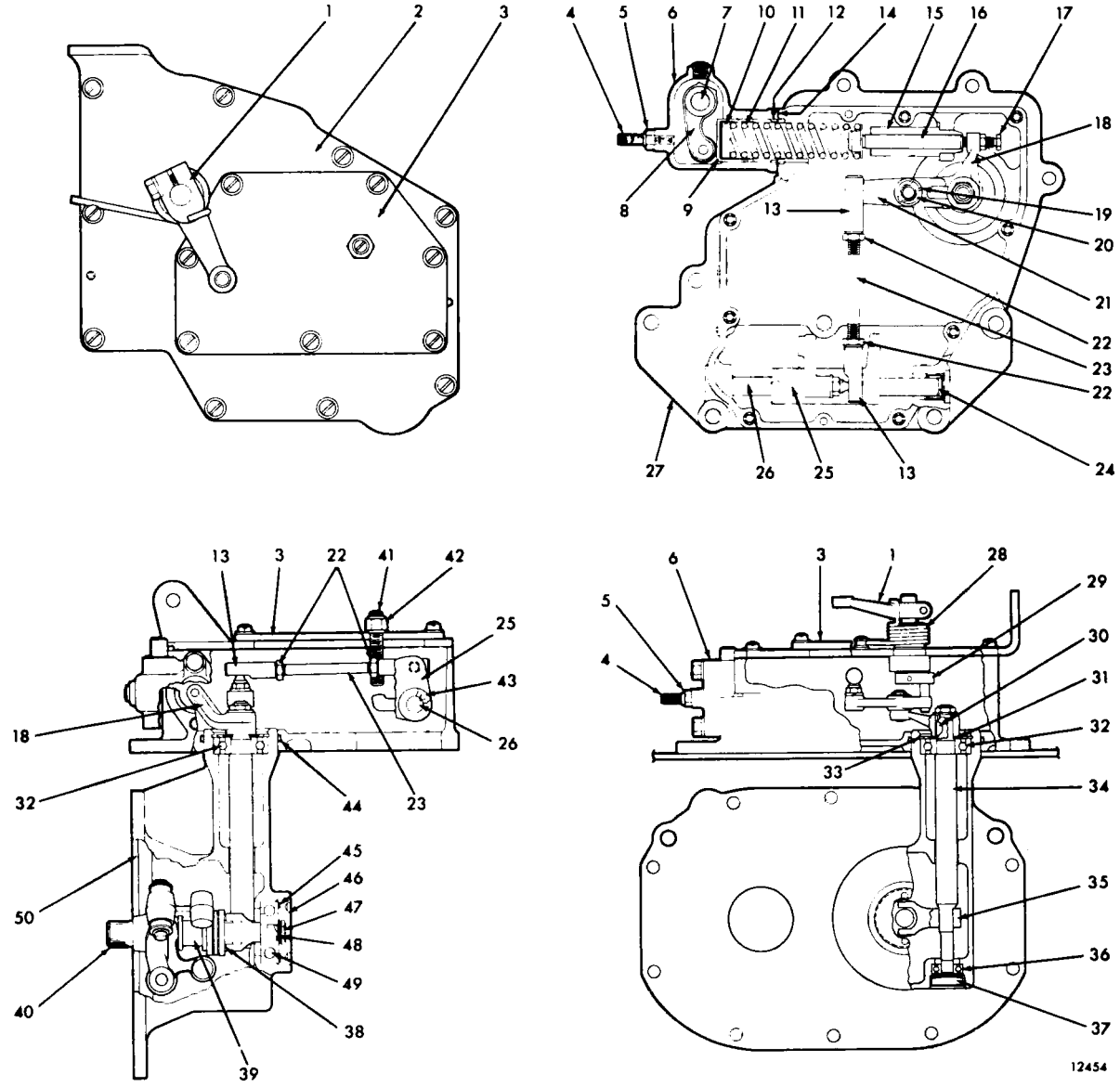
   c. On current governors, remove the differential lever connecting rod (23) from the operating control link lever (61).

   d. On former governors, remove the differential lever connecting rod (23) from the terminal lever (25).

   e. On current governors, remove the spring retainers (19) and washers (20) securing the connecting rod (59) to the operating controllink levers (57 and 61) and remove the connecting rod.

   f. On current governors, remove the four retaining rings (56) positioning the operating controllink levers (57 and 61) on the operating controllink lever shafts.

 © Detroit Diesel Corporation



1. Lever—Stop
2. Cover—Governor
3. Cover—Access
4. Screw—Idle Speed Adjusting
5. Locknut
6. Housing—Spring
7. Shaft—Speed Control Lever
8. Lever—Spring
9. Retainer—Spring
10. Shim
11. Spring—Variable Speed
12. Stop—Governor
13. Ball Joint Assy.
14. Gasket
15. Guide—Plunger
16. Plunger—Spring
17. Screw—Gap Adjusting
18. Lever—Operating Shaft
19. Retainer—Spring
20. Washer—Plain
21. Lever—Differential
22. Locknut
23. Link—Differential Lever Connecting
24. Bearing—Enclosed
25. Leve—Terminal
26. Shaft—Terminal Lever
27. Housing—Control
28. Spring—Torsion Retraction
29. Shaft—Speed Control Lever
30. Woodruff Key
31. Spacer
32. Bearing—Upper, Operating Shaft
33. Ring—Snap
34. Shaft—Operating
35. Fork—Operating
36. Bearing—Lower, Operating Shaft
37. Plug—Cup
38. Bearing—Thrust, Riser
39. Riser
40. Shaft—Weight
41. Screw—Buffer
42. Lock—nut
44. Ring—Seal
45. Gasket—Housing Plug
46. Plug—Housing
47. Bolt—Retaining, Bearing
48. Washer—Lock
49. Bearing—Weight Shaft
50. Housing—Weight

Fig. 5 - Cross Section of Variable Speed Governor (Former)

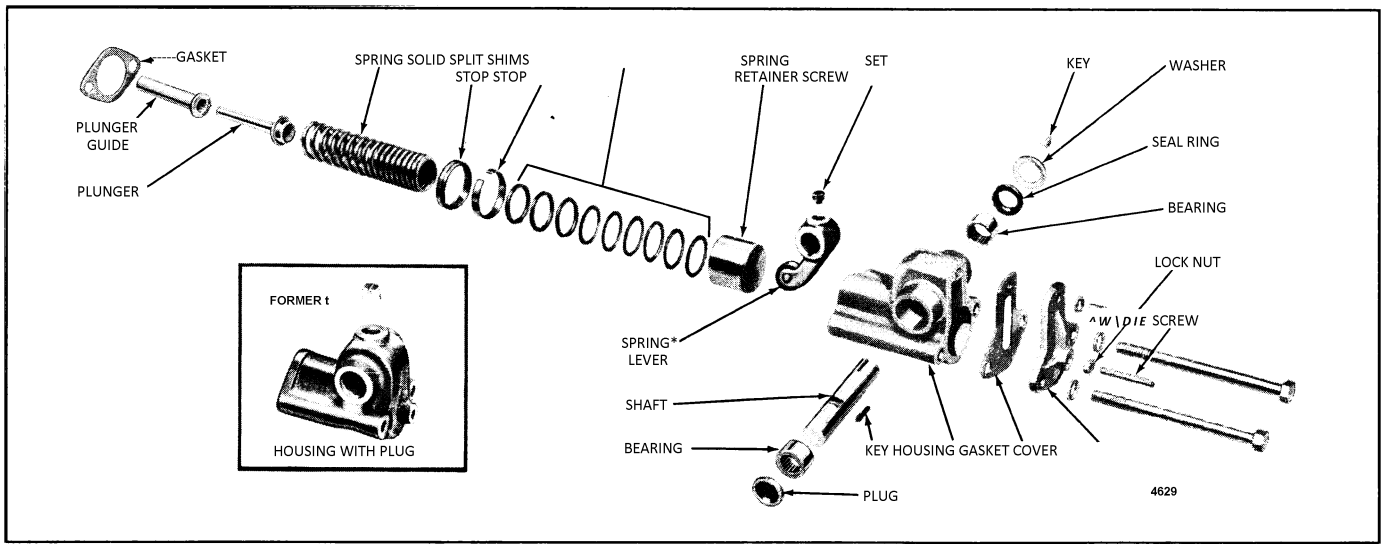


Fig. 6 - Variable Speed Spring Housing and Relative Location of Parts

g. On former governors, loosen the set screw (48) securing the terminal shaft lever (25) in position on the terminal shaft (26).

h. Place the control housing (27) in an arbor press with one of the operating shafts (58 and 60, current governors) or the terminal lever shaft (27, former governors) parallel and directly under the ram of the press. Place a brass rod between the ram and either end of the shafts (Fig. 8). Press the shafts straight through and remove the enclosed bearing assemblies (24) from each end of the shafts. Withdraw the operating shafts, operating levers and needle bearings (current governors) or the terminal lever, terminal lever shaft and needle bearings (former governors).

5. Remove the governor weight and shaft assembly (refer to Fig. 2 unless otherwise indicated):

a. Remove the housing plug (46) and gasket (45) from the end of the weight shaft (40).

b. Straighten the tang of the lock washer (48) and remove the bearing retainer bolt (47) and lock washer.

c. Thread a 5/16”-24 bolt into the tapped hole in the end of the weight shaft and remove the governor weight and shaft assembly, using an arbor press (Fig. 9).

d. Slide the riser thrust bearing (38) and riser (39) from the shaft.

e. Remove the weight shaft bearing (49) from the governor housing.

6. Disassemble the governor weight and shaft assembly:

a. Remove one lock ring from each weight pin. Withdraw the pins, flat washers and governor weights (Fig. 10).

b. Place the weight carrier and shaft assembly on the bed of an arbor press. Thread a 5/16”-24 bolt into the end of the weight shaft and, using a suitable sleeve, press the weight carrier from the shaft.

c. Place the governor weight on the bed of an arbor press (Fig. 11). Press the weight bearing from the governor weight with a suitable sleeve and replacer J 8985.

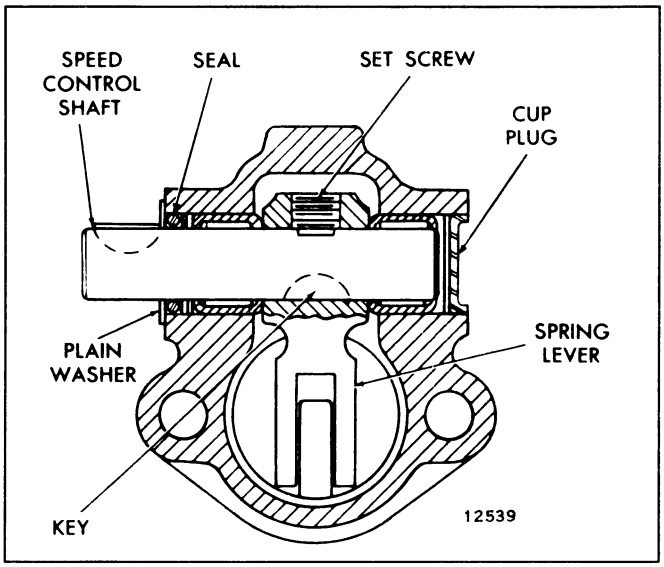


Fig. 7 - Governor Variable Speed Spring Housing

 © Detroit Diesel Corporation

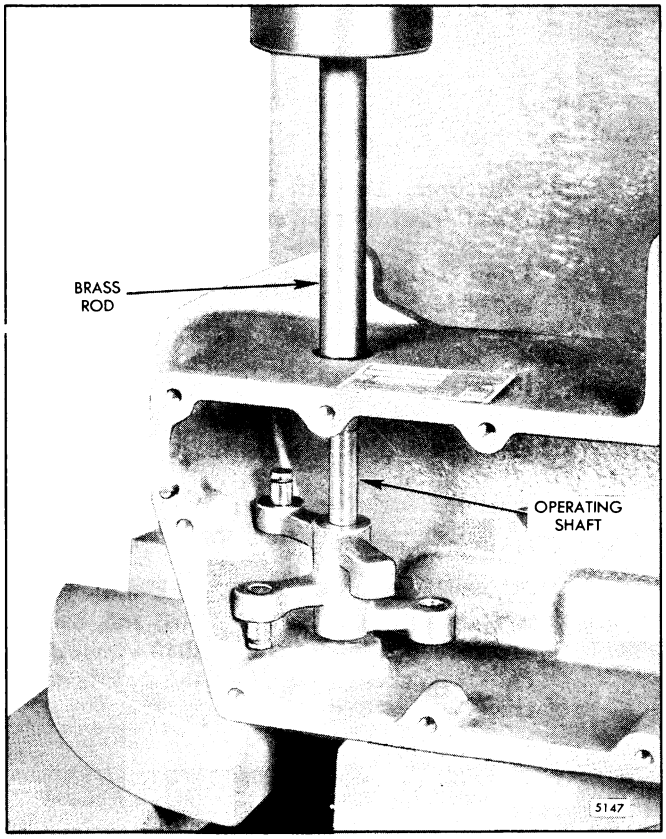


Fig. 8 - Removing Operating Lever Shafts and Enclosed Bearing Assemblies

7. Remove the operating shaft from the governor weight housing as follows (Fig. 2):

   a. Remove the Woodruff key (30) from the operating shaft (34).

   b. Remove the two spacers (31) and snap ring (33) from the operating shaft,

   c. Position the weight housing assembly (50) in an arbor press. Press down on the operating shaft (34) to remove the cup plug (37) from the bottom of the housing and to remove the upper bearing (32) from the shaft (Fig. 12).

   d. Turn the weight housing over and press down on the operating shaft (34) to remove the shaft from the lower bearing (36). Continue pressing down on the shaft, with the operating fork (35) against the flat shoulder of the housing, to remove the operating fork (35) from the shaft (Fig. 13).

   e. Withdraw the operating shaft from the weight housing.

   f. Remove the upper and lower bearings from the housing.

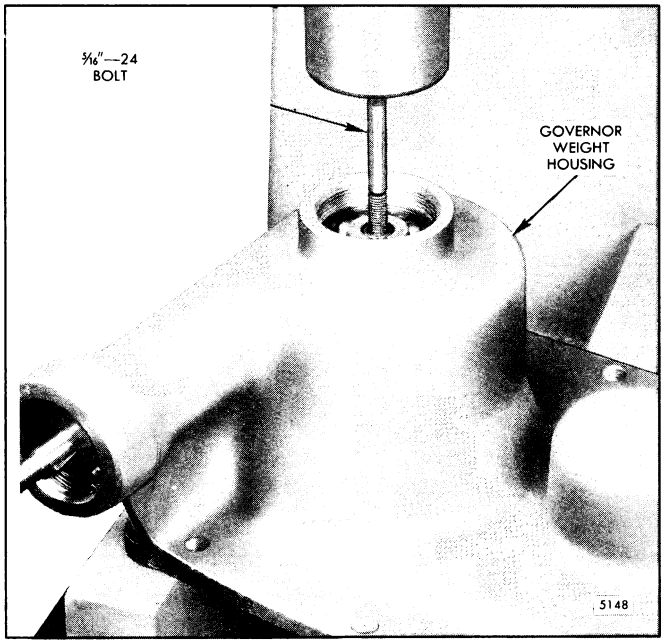


Fig. 9 - Removing Governor Weight and Shaft Assembly

Inspect Governor Parts

Wash all of the parts in clean fuel oil and dry them with compressed air.

CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Revolve the operating shaft bearings and the governor weight shaft bearing *slowly* by hand. Replace the bearings if rough or tight spots are detected.

Examine the riser thrust bearing for excessive wear, flat spots or corrosion. If any of these conditions exist, install a new thrust bearing assembly.

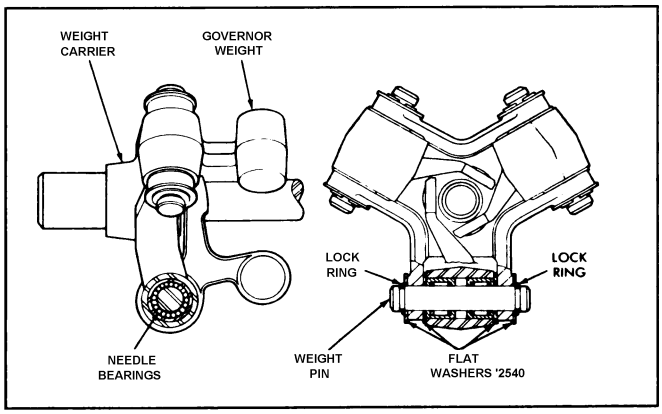


Fig. 10 - Cross Section of Governor Weight Assemblies

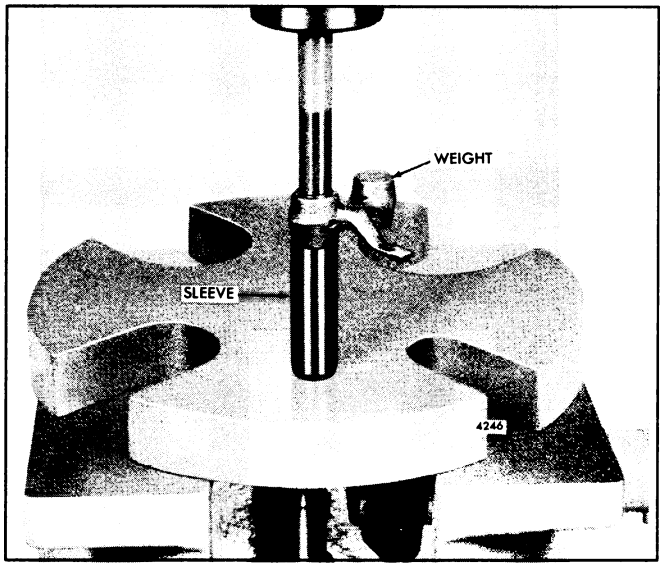


Fig. 11 - Removing or Installing Governor Weight Bearings using Tool J 8985

Inspect the governor stop lever shaft and bushing for excessive wear or flat spots. If one or both conditions exist, install a new shaft and bushing.

Inspect the speed control lever shaft and bearings for excessive wear or flat spots at the bearing surface. If one or both conditions exist, install a new shaft and bearings.

Examine the governor weights at the riser contact area for excessive wear. If worn, install a new governor weight.

When replacing the governor weights or riser, the current weight (.280" wide cam) and the current riser (1.31" diameter) must be used together to prevent interference between the weight arm and the riser. The current riser, if used with the narrow weight (.140" wide cam), could hang-up on the weight arm before making contact with the cam and result in erratic governor operation. The current governor weight also incorporates a stop to prevent the possibility of the weight hitting the weight housing at extreme overspeed.

Examine the weight carrier pins and weight bushings for excessive wear and flat spots. If either of these conditions exist, install new parts.

If the governor weight housing or the complete governor assembly is replaced on an early engine (prior to engine 12E-296), it will be necessary to remove the spray nozzle (used to lubricate the governor) from the blower front end plate and include a new governor-to-blower gasket. The current governor weight housing includes lubricating oil passages and the spray nozzle is no longer required.

Assemble Governor

During assembly, lubricate all needle bearing assemblies with Shell Alvania No. 2 grease, or equivalent.

1. Install the operating shaft in the governor weight housing as follows (Figs. 2 and 5):

   a. Insert the operating shaft (34) into the housing and slide the operating fork (35) over the end of the operating shaft.

   b. Place the weight housing (50) upright on the bed of an arbor press with the operating shaft parallel and directly under the ram of the press.

   c. Start the operating fork (35) over its seating shoulder on the operating shaft (34).

   d. Lower the operating shaft and fork until the fork is against the housing lower boss and, using a brass rod, press the operating shaft into the fork until the fork bottoms against the shaft shoulder (Fig. 14).

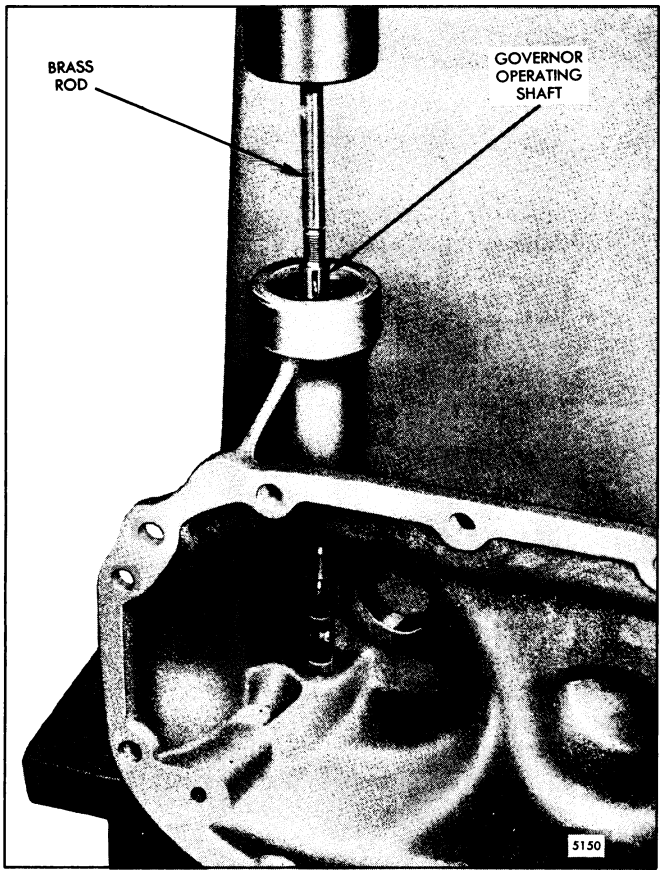


Fig. 12 - Removing Operating Shaft from Weight Housing Upper Bearing

 © Detroit Diesel Corporation

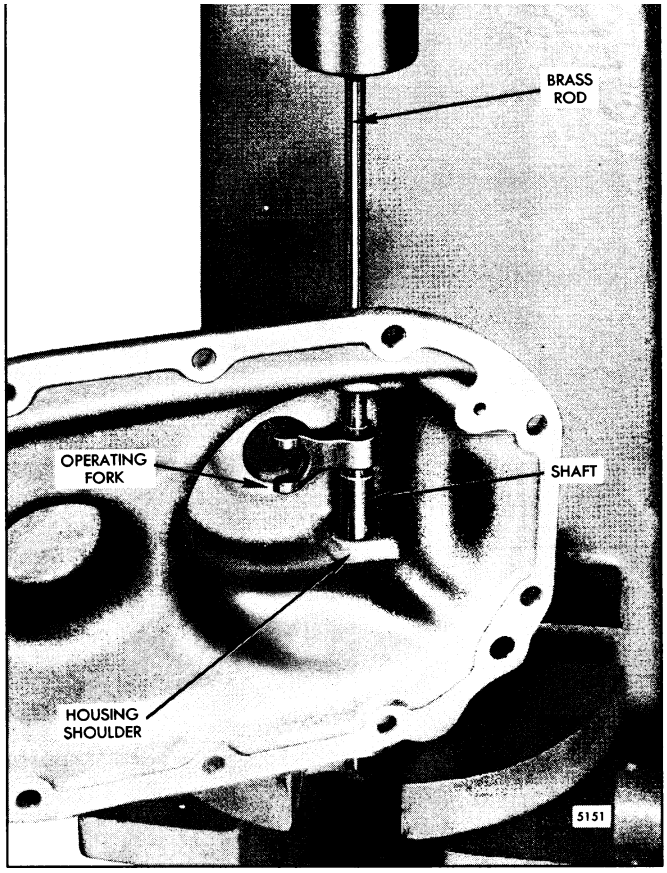


Fig. 13 - Removing Shaft From Lower Bearing and Operating Fork

e. Turn the housing over and, with the operating shaft suitably supported, press the lower bearing assembly (36), shielded side in, over the lower end of the operating shaft.

f. Turn the housing back upright again and, using the same method, install the upper bearing (32), numbered side out. Make sure that the lower bearing assembly is in place in the housing lower bearing bore.

g. Rotate the shaft to make sure that the bearings are installed correctly.

h. Place the two spacers (31) over the top of the operating shaft and install the Woodruff key (30) and snap ring (33).

i. Apply a good quality sealant around the cup plug (37). Tap the plug into position in the weight housing operating shaft lower bearing bore.

2. Assemble the governor weight and shaft assembly as follows:

a. Place the governor weight on the bed of an arbor press (Fig. 11).

b. Position the bearing in the bore of the weight and, using a suitable sleeve and replacer J 8985, press the bearing into the weight.

c. Slide the weight carrier over the end of the weight shaft. Place the weight carrier and weight shaft on the bed of an arbor press. Press the weight shaft into the weight carrier until the shaft bottoms against the shoulder of the carrier.

d. Refer to Fig. 10 and install the governor weights, flat washers, weight pin and lock rings.

3. Install the governor weight and shaft assembly (Figs. 2 and 5) as follows:

a. Slide the riser (39) over the weight shaft (40) and up against the finished surfaces of the governor weights.

b. Position the riser thrust bearing (38) over the weight shaft with the bearing race having the smaller inside diameter against the thrust riser.

c. Position the weight carrier and shaft assembly in the governor housing with the riser thrust bearing (38) up against the finished surfaces of the operating fork (35).

d. Support the splined end of the weight shaft on the bed of an arbor press. Start the weight shaft bearing (49) into the governor housing and over the end of the weight shaft. Press the weight shaft bearing into the governor housing and over the weight shaft until it bottoms against the shoulder on the weight shaft.

e. Place the lock washer (48) on the bearing retaining bolt (47). Thread the retaining bolt into the tapped hole in the end of the weight shaft. Tighten the bolt and bend the tang of the lock washer against the head of the retaining bolt.

f. Place a gasket (45) against the weight shaft bearing. Apply sealant such as Loctite H, HV or HVW to the threads of the governor housing and plug (46) and thread the plug into the housing. Tighten the plug to 50-60 lb—ft (68—81 N»m) torque.

Rotate the governor weight assembly to check for bind. If bind exists, remove the housing plug and check to see if the weight shaft bearing is fully seated in the governor housing.

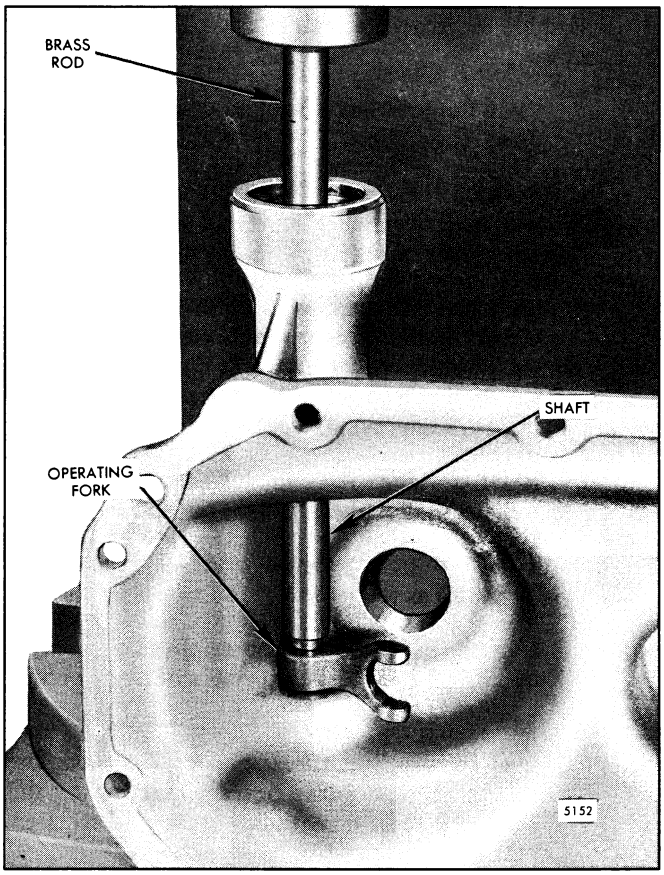


Fig. 14 - Installing Operating Fork and Shaft in Weight Housing

4. Assemble the governor control housing as follows (Figs. 2 and 5):

   a. Press a new enclosed bearing (24) flush with the counterbore in each shaft opening on the outside of the housing (current governors) or in one end of the terminal lever shaft bore (former governors).

   b. On current governors, slide the operating levers (57 and 61) over the operating shafts (58 and 60) and place the shafts into the control housing with one end of each shaft inserted into the enclosed bearings. Refer to Fig. 2 for proper orientation of the operating control link levers. Then, press a new enclosed bearing assembly (24) in each housing bore at the opposite ends of the shafts until there is .040" maximum end play and install four new retaining rings, positioning the operating levers on the operating shafts.

   c. On former governors, slide the terminal lever (25) on the terminal lever shaft (26) and position one end of the shaft and lever assembly in the installed bearing assembly. Then, press a new enclosed bearing assembly (24) in the bore at the opposite end of the terminal shaft and over the terminal shaft end. Tighten the set screw (43) securing the terminal shaft lever to the terminal shaft.

   d. On current governors, install the connecting rod (59) to the operating control link levers (57and 61) using a washer (20) and new spring retainer (19) at each end of the connecting rod.

   e. On former governors, connect the differential lever connecting rod (23) to the terminal lever (25).

   f. On current governors, install the differential lever connecting rod (23) to the operating control link levers (61).

   g. Connect the differential lever (21) to the differential lever connecting rod (23).

   h. Secure the differential lever (21) to the operating shaft lever (18) using a plain washer (20)and spring retainer (19).

   i. Install the fuel rods.

5. Assemble the governor variable speed spring housing (Figs. 6 and 7):

   a. Place the Woodruff Key (65) in the center key way of the speed control lever shaft (7). Start the set screw (63) in the spring lever (8).

   b. Lubricate the speed control lever shaft bearings with Shell Alvania No. 2 grease, or equivalent. Then, start one of the bearings, numbered end up, straight in the bearing bore in the right hand side of the spring housing as viewed in Fig. 7.

   c. Install the needle bearing pilot rod J 9196-2 in the installer body J 9196—1 and secure it in place with the retaining screw (Fig. 15).

   d. Place the pilot rod end of the bearing installer assembly in the bearing. Support the spring housing, bearing and installer on a short sleeve on the bed of an arbor press. Then, press the bearing in the housing. When the shoulder on the installer body contacts the housing, the bearing will be properly positioned in the housing.

   e. Install the current roller type bearing and pin in the spring lever. Press the pin below the surface of the lever and stake it at three places on both sides of the lever. The former ball type bearing (with two washers) is swaged at both ends to retain the bearing in the spring lever.

 © Detroit Diesel Corporation

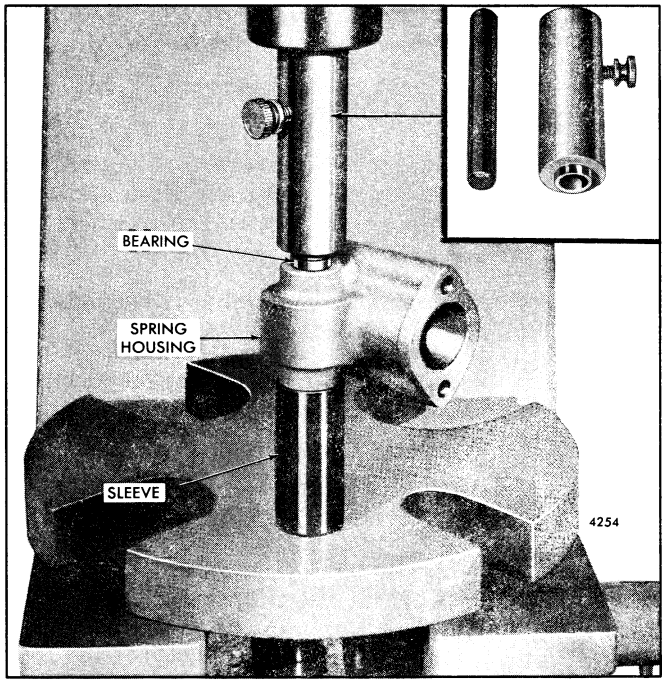


Fig. 15 - Installing Speed Control Shaft Bearings using Tool J 9196

f. Place the spring lever (8) between the bearing bores in the spring housing. Align the key in the shaft with the keyway in the spring lever. Push the shaft through the lever until the flat on the shaft is directly opposite the set screw.

g. With the lever centered between the bearing bores, tighten the set screw to 5-7 lb—ft (7-10 N«m) torque and stake the lever to the set screw. Install the plug in the spring housing on former governors.

h. On current governors, use a new gasket and attach the spring housing cover to the spring housing with a screw and lock washer.

i. Place the second speed control lever shaft needle bearing, numbered end up, over the protruding end of the shaft and start it straight in the bore of the housing.

j. Remove the bearing pilot rod J 9196-2 from the installer body J 9196-1 and place the installer body over the end of the shaft and against the bearing. Support the spring housing, bearings and installer on a short sleeve on the bed of an arbor press (Fig. 15). Then, press the bearing in the housing until the shoulder on the installer contacts the housing.

k. Apply some good quality sealant around the cup plug (71). Tap the plug in the shaft opening.

l. Place the seal (67) over the end of the shaft and into the counterbore of the spring housing. Place the plain washer (66) over the end of the shaft and insert the key (65) in the key way of the shaft.

m. Place the speed control lever on the control shaft and secure it with the retaining bolt.

n. Thread the locknut on the idle screw and thread the idle screw in the tapped hole of the spring housing cover (current governors) or the spring housing (former governors).

6. Install the variable speed spring housing on the governor housing (Fig. 2).

a. Drive the plunger guide (15) into the governor housing.

b. Lubricate the small end of the variable speed spring plunger (16) with Cindol 1705 and insert it into the plunger guide.

c. Lubricate the outer diameter of the spring retainer (9) and the inner contact area of the spring housing (6) with Cindol 1705 and place the spring retainer in the spring housing and against the spring lever (8). Insert the shims (10) in the spring retainer. Insert the stops (12) in the spring housing and against the spring retainer.

d. Position the variable speed spring (11) in the spring housing (6) with the tightly wound end of the spring against the shims.

e. On current governors, insert two bolts (with copper washers) through the spring housing cover and spring housing and place a new gasket over the bolts and against the spring housing. On former governors, insert the two bolts through the spring housing (with lock washers).

f. Position the variable speed spring housing (6) and a new gasket (14) against the governor housing (27) with the spring plunger (16) engaged in the end of the variable speed spring (11).

g. Tighten the attaching bolts to 13-17 lb—ft (18—23 N#m) torque.

7. Assemble the governor cover as follows (Fig. 4):

a. Place the governor cover on the bed of an arbor press. Start the bushing straight into the bushing bore of the cover. Press the bushing into the cover using installer J 4649. Press the bushing down into the bore 1/8” below the surface to allow room for the seal ring.

b. Insert the stop lever shaft through the bushing in the cover assembly.

c. Slide a new seal ring over the stop lever shaft and into the bushing bore.

d. Slide the two spacers over the shaft and up against the stop lever shaft boss.

e. Secure the stop lever shaft in the cover assembly with the snap ring.

f. Position the stop lever with the torsion retraction spring on the stop lever shaft and tighten the stop lever bolt.

Install Governor

1. Install the govemor-to-blower gasket on the blower and slide the weight housing assembly straight on the dowels in the blower end plate. The tab on the gasket is to ensure the gasket is in place. Align the splines of the weight shaft with the splines in the blower rotor.

2. Secure the weight housing assembly to the blower with nine 3/8"-16 x 3-1/4" bolts and one 3/8"-24 nut. Tighten the bolts to 30-35 lb—ft (41-47 N»m) torque and the nut to 35-39 lb—ft (47-53 NAm) torque.

3. Install the blower and the governor drive and weight housing assembly on the engine (refer to Section 3.4).

4. Install the blower cover plate.

5. Install the water manifolds, air inlet housing and any other accessories removed under ***Remove Governor.***

6. Place a new seal ring (44) in the control housing (Fig. 2) and position the governor control housing over the drive mechanism and on the air box cover plate.

7. On current governors, connect the right and left bank 13. fuel rods to the governor control link operating levers (Fig. 2). Then, install the operating shaft lever (18) and secure it with a washer and retaining nut.

8. On former governors, connect the vertical linkage to the terminal shaft lever (Fig. 3).

9. Place a new governor housing gasket on the governor housing and install the governor cover. Be sure that the pin on the governor shutdown lever shaft enters the slot of the differential lever.

10. Install the governor speed control lever stop bracket with three of the cover screws.

11. Connect the speed control rod to the speed control lever and connect the control linkage to the governor stop lever.

12. Install the starting aid system (refer to Section 14.14) air cylinder and shutdown solenoid (if used) on the governor cover.

CAUTION: Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assembly, the technician must determine that the injector racks move to the *no-fuel* position when the governor stop lever is placed in the *stop* position. Engine overspeed will result if the injector racks cannotbe positioned at no fuel with the governor stop lever. An overspeeding engine can result in engine damage which could cause personal injury.

Perform an engine tune-up as outlined in Section 14.4.

 © Detroit Diesel Corporation

MECHANICAL OUTPUT SHAFT GOVERNOR

The Pierce mechanical output shaft governor is used on certain engines, equipped with a torque converter, to regulate the speed of the output shaft. The output shaft governor (Fig. 1) is mounted on the engine governor and is driven by a flexible shaft from the torque converter output shaft and is connected, through linkage, to the engine governor. The mechanical limiting speed governor on the engine regulates the maximum and idle speeds of the engine while the output shaft governor has control of the engine speed in the intermediate speed range, between maximum and idle engine speed.

The flyweights (Fig. 2) on the output shaft governor are driven through the operating spider and shaft assembly by the governor drive adaptor. A shoulder on the flyweights bears against theriser that transmits the motion of the flyweights, through the riser thrust bearing, to the operating fork. The operating fork is attached to the rocker shaft that rides in the inner and outer ball bearings. Pinned to the rocker shaft are the spring lever and the rocker shaft lever. Connected to the spring lever is the speed adjusting spring that is, in turn, connected through the eyebolt to the speed adjusting spring lever. The speed adjusting spring lever is mounted on the speed adjusting shaft and is controlled by the engine operator when establishing the desired engine speed.

A minimum and a maximum output shaft speed adjusting bolt limits the travel of the speed adjusting shaft and thus the minimum and maximum output shaft speed settings. The linkage that operates the engine governor throttle is connected to the rocker shaft lever. The movement of the rocker shaft lever increases or decreases the speed of the engine.

Lubrication

The output shaft governor is lubricated by engine oil that is contained within the governor housing. The movement of the governor weights throws the oil to all parts in the governor requiring lubrication.

With the output shaft stopped, fill the governor sump through the hinged cap oiler until the oil begins to drip out of the oil level hole. When the sump is full, the oil will drip from the oil level hole. A plug should be installed in the oil level hole and tightened sufficiently to prevent oil leakage. The oil level should be checked every 8 service hours and changed every 500 hours.

NOTICE: Care should be taken to remove all dirt or foreign material from the governor openings before filling or checking the oil level.

The bearing surfaces of the speed adjusting shaft should be lubricated by a hand oiler with engine oil. Rod end ball joints are sealed assemblies and do not require lubrication. The throttle control lever and the levers surrounding its shaft should be lubricated with all purpose grease through the grease fitting.

Disassembly

After removing the governor and before removing any parts from the governor, wash the entire unit with clean fuel oil and dry it with compressed air. Then inspect for worn or damaged parts that can be repaired or replaced without complete disassembly. The output shaft governor may be disassembled by referring to Fig. 2 and proceeding as follows:

1. Remove the two socket head screws and lock washers that secure the speed adjusting shaft bracket to the governor body. Unhook the speed adjusting spring from the speed adjusting spring lever and the spring lever while removing the bracket.

2. With snap ring pliers J 4880, remove the speed adjusting shaft bracket retaining snap ring from the speed adjusting shaft. Remove the washer and slide the bracket from the shaft.

3. Note the position of the speed adjusting spring lever on the speed adjusting shaft. Then, using a small punch, drive out and discard the 5/32" roll pin that retains the lever to the speed adjusting shaft. After removing the roll pin, tap the end of the shaft with a soft hammer to remove the lever. The minimum and maximum speed adjusting bolts may be removed from the speed adjusting spring lever, if desired.

4. Remove the four socket head screws and lock washers that secure the governor flange to the body. Remove and discard the body to flange gasket. Remove the riser and thrust bearing from the governor operating spider and shaft assembly.

5. Remove the two screws and lock washers that secure the operating fork to the rocker shaft.

6. Remove and discard the oil seals from the governor body.

7. Remove the bearing retaining snap rings from the rocker shaft.

8. Tap the end of the rocker shaft gently and withdraw the shaft from the governor body.

   NOTICE: If the governor body is placed in a vise, care must be taken not to overtighten the vise as this could distort the aluminum body.

9. Remove the rocker shaft inner and outer ball bearings. The bearings may have to be tapped lightly to free them from the governor body.

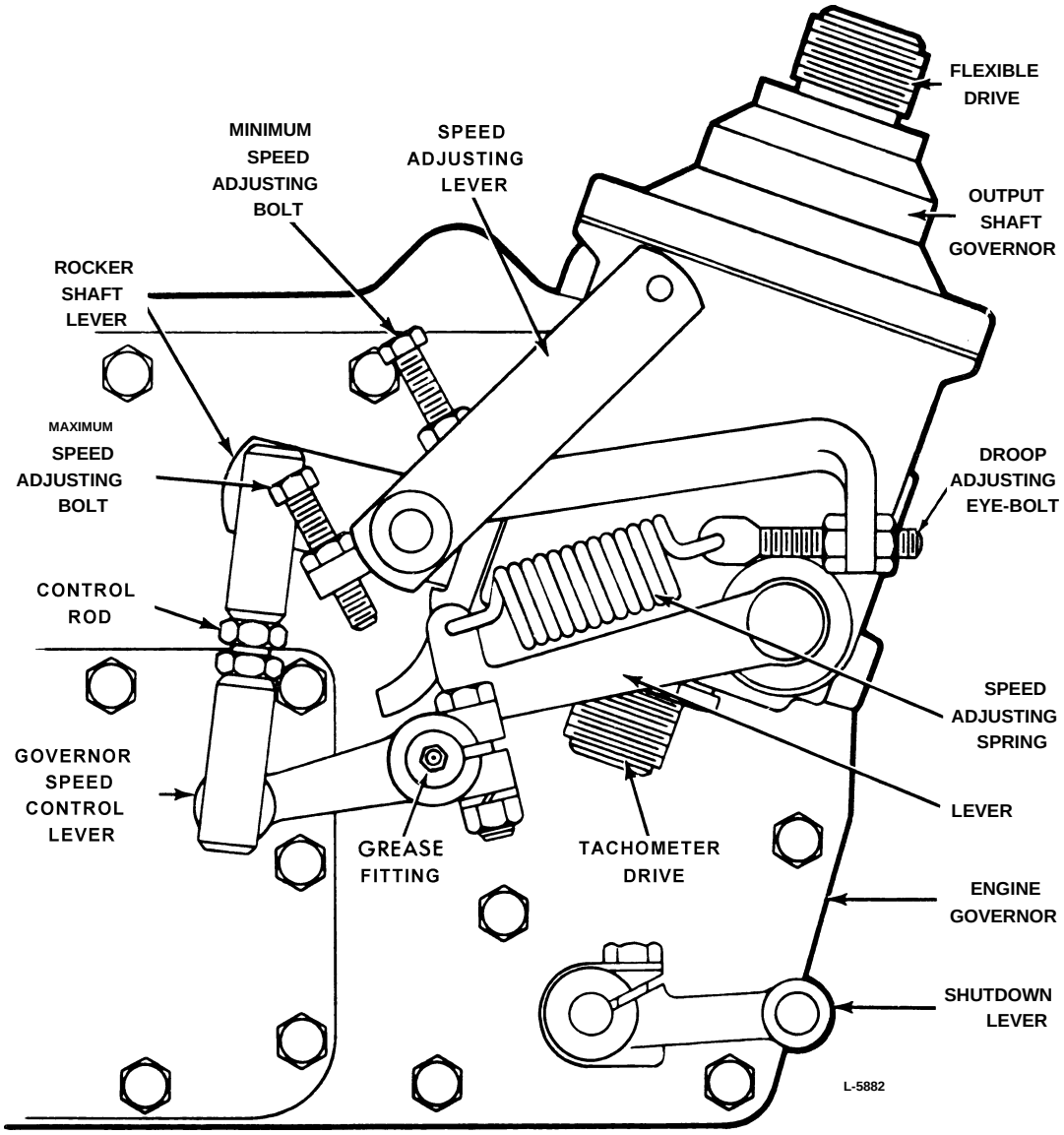


Fig. 1 - Mechanical Cable-Driven Output Shaft Governor and Linkage

10. Use a small punch to drive out the 5/32" roll pins that secure the spring lever and rocker shaft lever to the rocker shaft, after noting the relationship of the levers on the shaft. Then tap the end of the rocker shaft with a soft hammer to remove the levers from the shaft.

11. Secure the governor flange in a vise and, using tool J 4880, remove the lower bearing retaining snap ring.

12. Tap the splined end of the operating spider and shaft assembly lightly to loosen the shaft from the bearing. Remove the operating spider and shaft assembly.

13. Invert the governor base in the vise and remove the internal snap ring retaining the upper bearing.

14. Gently press the bearing out of the counterbore in the governor base.

15. Remove the eight hair pin clips that secure the weights on their supporting pins. Then, using a 5/32" punch, gently tap out the four flyweight supporting pins.

16. Carefully support the lower side of the riser thrust bearing in an arbor press. Then, using a 7/16" rod, gently press the riser from the inner race of the bearing. Use extreme care to prevent damage to the bearing shoulder of the riser.

17. Remove the nut and washer from the tachometer drive connection and remove the connection from inside the governor body.

 © Detroit Diesel Corporation

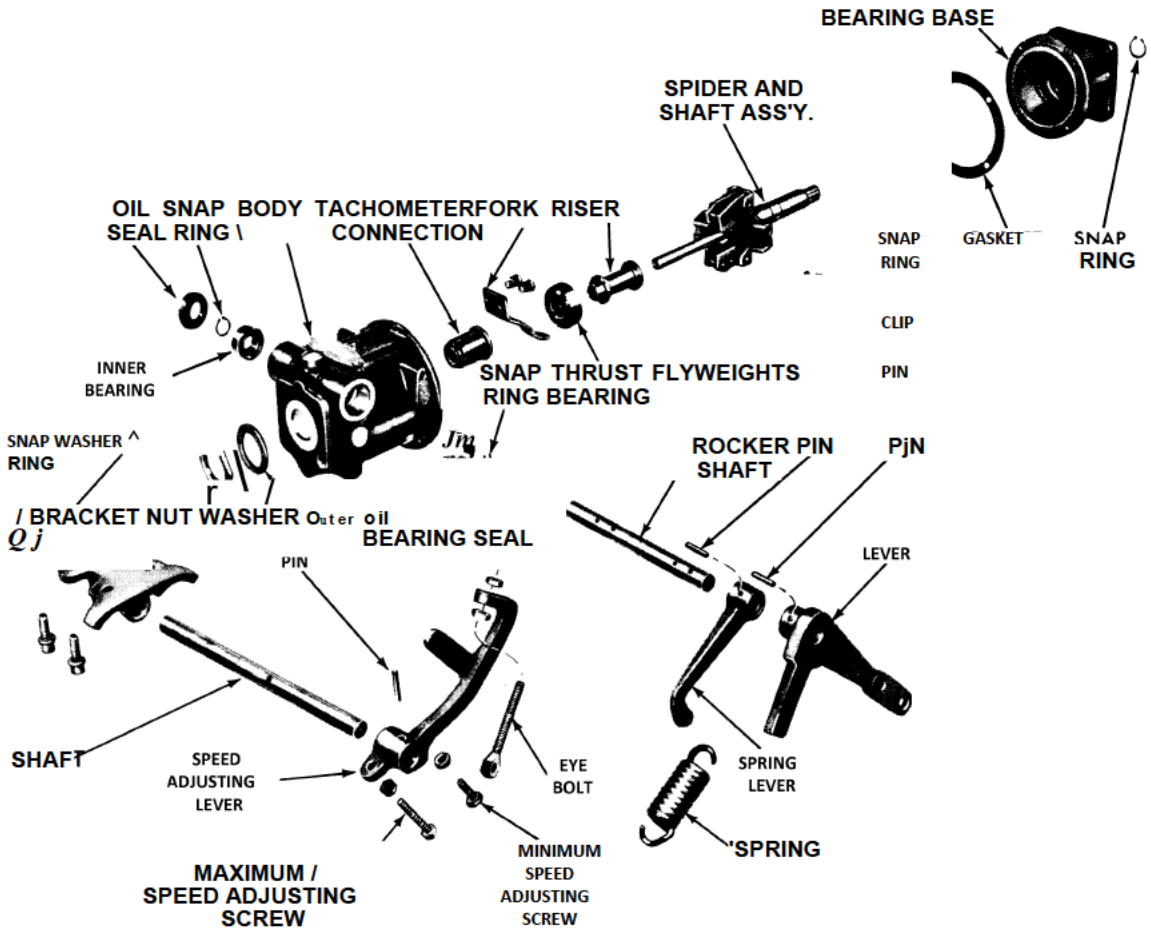


Fig. 2 - Output Shaft Governor Details and Relative Location of Parts

Inspection

After the governor assembly has been disassembled, thoroughly clean each piece in fuel oil and dry it with compressed air.

CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Inspect the rocker shaft bearings for excessive wear. Replace them if necessary.

Inspect the operating shaft bearing for excessive wear.

Replace the rubber oil seal on the governor rocker shaft. The slightest wear on this part can cause oil leakage. It is recommended that when overhauling a governor, a new oil seal be installed.

Inspect the tachometer drive connection for wear to either the bushing or oil seal. If either part appears worn or damaged excessively, replace the entire connecting assembly.

Inspect all of the retaining snap rings to determine if they have been damaged at the time of disassembly. Replace them if necessary.

Inspect the riser bearing surface of the flyweights for excessive wear or a flat spot. If either condition exists, new weights must be installed. The flyweights must work freely on their supporting pins for satisfactory governor operation.

Inspect the governor operating fork for excessive wear or distortion. If either condition exists, install a new fork.

Inspect the governor body for distortion or damage to the bearing seating surfaces and replace it, if necessary.

Assembly

After all of the parts have been cleaned and inspected, refer to Fig. 2 and assemble the governor as follows:

1. Place the governor base on a bench, bottom side down, and press the bearing into the base with the stamped side of the bearing inner race facing downward.
2. Install the upper bearing retainer internal snap ring into the base.
3. Replace the flyweights by positioning the operating shaft and spider assembly in a vertical position and install the supporting pins from left to right through the spider and weights. Retain the supporting pins with the hair pin clips at each end.
4. Lubricate the governor spider and operating shaft assembly lightly at the bearing end and, using an arbor press, force the shaft gently until it seats on the inner race of the bearing.
5. Install the lower bearing retainer snap ring.
6. Insert the tachometer drive connection into the governor body and retain it securely with the washer and nut.
7. Slide the spring lever and the rocker shaft lever on the rocker shaft, if removed, and pin the levers to the shaft with new 5/32" roll pins.
8. Place a new rubber oil seal (lip facing in) on the governor rocker shaft. Install the outer bearing retainer snap ring on the governor rocker shaft, taking precaution against damaging the bearing surface.
9. Place the outer rocker shaft bearing on the rocker shaft with the stamped side of the bearing facing (outward) the snap ring.
10. Place the governor body on a bench, with the name plate up and the body to base gasket surface facing the serviceman. Then insert the rocker shaft into the governor body from the left side until the bearing seats in the bore of the body.
11. Press the new rubber oil seal into the governor body.
12. Place the inner rocker shaft bearing in place on the shaft and gently press it into the governor body with its stamped side outward.
13. Install the inner bearing retainer snap ring on the rocker shaft. Then install a new rubber oil seal, pressing it firmly into the governor body.
14. Place the governor operating fork in the governor body on the flat section of the rocker shaft and securely tighten the retaining bolts.
15. Slide the speed adjusting spring lever, if removed, on the speed adjusting shaft and pin it securely, using a new 5/32" roll pin. Install the minimum and maximum speed adjusting bolts, if removed.
16. Slide the speed adjusting shaft through the speed adjusting shaft bracket and install the washer and snap ring.
17. Support the riser in a vertical position on an arbor press and place the thrust riser bearing in position on the riser, with the protruding race of the bearing facing upward. Then carefully press the bearing down until it is seated on the shoulder of the riser.
18. Install the riser on the operating spider and shaft assembly (Fig. 2).
19. Install a new body to base gasket and assemble the governor base to the body, using four socket head screws, with the oil drain hole boss in the governor base on the lever side of the governor.
20. Place the governor on a bench with the name plate downward. Hook the speed adjusting spring to the adjusting spring speed lever and rocker shaft spring lever.
21. Install the two socket head screws in the two lower holes of the speed adjusting shaft bracket and fasten them securely to the governor body.
22. Install the governor.
23. Refer to Section 14.10 for adjustment of the governor.

 © Detroit Diesel Corporation

HYDRAULIC GOVERNORS

Horsepower requirements on an engine may vary due to fluctuating loads. Therefore, some method must be provided to control the amount of fuel required to hold the engine speed reasonably constant during load fluctuations. To accomplish this control, a governor is introduced in the linkage between the throttle control and the fuel injectors.

Engines, subjected to varying load conditions that require an automatic fuel compensation to maintain more nearly constant engine speedwith a minimum speed droop, are equipped with a hydraulic governor.

In the hydraulic governor, the fuel is decreased by the action of the governor throttle control terminal lever retracting spring and increased by the opposing action of the power piston. A pilot valve controls the admission of oil flow to the power piston and the movement of the pilot valve in turn is controlled by the governor flyweights. The centrifugal force of these flyweights is opposed by the speeder spring compression which may be varied and yet accurately set and held at any speed between idle and maximum speed. The speed droop, which is the difference between no-load speed and full-load speed, is adjustable to within a very small percentage at maximum speed.

Check Governor Operation

Governor difficulties are usually indicated by speed variations of the engine. However, it does not necessarily mean that all such speed fluctuations are caused by the governor. Therefore, when improper speed variations appear, check the unit as follows:

1. Make sure the speed changes are not the result of excessive load fluctuations.

2. Check the engine to be sure that all of the cylinders are firing properly (refer to Section 15.2). If any cylinder is not firing properly, remove and test the injector and, if necessary, replace or recondition it.

3. Check for bind that may exist in the governor operating mechanism or in the linkage between the governor and the injector control tube. With the fuel rods connected to the injector control tube levers, the mechanism must be free from bind throughout the entire travel of the injector racks. If friction exists in the mechanism, locate and correct it as follows:

   a. If an injector rack sticks or moves too hard, check the injector hold-down clamp. If it is too tight or improperly positioned, loosen the clamp bolt, reposition the clamp and retighten the bolt to 46-50 lb-ft (62-68 N#m) torque.

   b. An internal dirt accumulation, a defective plunger and bushing or a bent injector control rack can result in bind. To correct this condition, remove the injector, then recondition and test it.

   c. An improperly positioned control rack lever will result in a binding injector rack. To relieve the bind, loosen the control rack lever adjusting screws. Then relocate the lever on the control tube and position it as outlined in Section 14.

   d. If the injector control tube binds in its support brackets, it will prevent free movement of the injector control racks to their no-fuel position. Loosen andre-align the control tube supporting brackets, then tighten the bolts to correct this condition. Reposition the injector racks after re-aligning the support brackets.

   e. Replace an injector control tube return spring which has been bent or otherwise distorted. When the injector control tube and the injector racks are free from bind, the control tube will return to the no-fuel position by action of the return spring.

NOTICE: Never stretch or tamper with an injector control tube return spring to change its tension. Use a new spring.

   f. Check for bind in the pins which connect the fuel rods to the injector control tube levers. If necessary, remove the pins and polish them with fine emery cloth.

4. If neither load, engine irregularities or bind are found to be the cause of the speed variations, the trouble is probably in the governor or governor drive. Check as follows:

   a. If the speed changes noted are in rapid oscillation (governor hunting), adjust the speed droop of the governor as outlined in Section 14. This applies only if the governor is overhauled or where the speed droop has been changed from the original factory setting.

   b. Worn blower rotor bearings or rubbing of the rotors on the housing will cause the load on the blower drive coupling (between the gear train and the blower) to vary erratically. This variation in load will be transmitted as a speed change to the governor. The governor will act to compensate for the change by moving the fuel rods. If this condition exists, inspect the blower.

c. If the speed variations are small in magnitude, check the governor drive. Excessive or insufficient clearance between the bevel drive gears can cause this condition.

d. If the speed variations are large and erratic and unaffected (except, perhaps, in magnitude) by changes in the speed droop adjustment, or if the governor fails to control the speed at all, replace or overhaul the governor.

If, after making these checks, the governor fails to control the engine properly, remove and recondition the governor.

To be certain whether the governor or engine is at fault, install a new governor (with the same part number) and check the performance of the engine.

 © Detroit Diesel Corporation

SG HYDRAULIC GOVERNOR

(VARIABLE SPEED)

The governor is located at the front of the engine (Fig. 1). It is mounted on a control housing (current engines) or an adaptor plate (former engines) which sets over the governor drive housing.

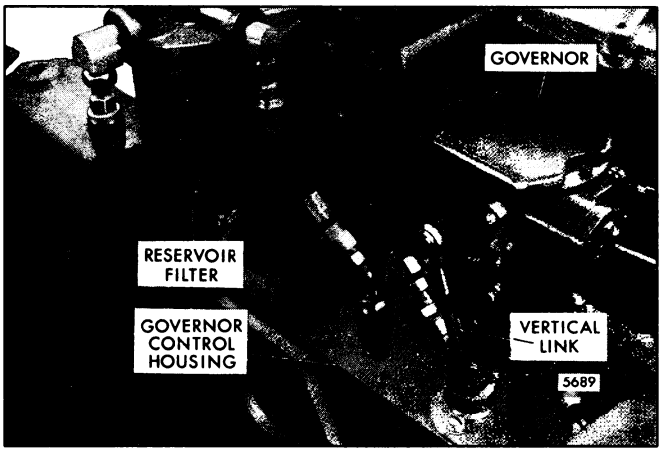


Fig. 1 - Hydraulic Governor Mounting

The governor, driven by one of the blower rotors through a bevel gear and shaft arrangement, actuates the injector control tubes through a linkage (refer to Section 2.8.3).

The governor is a hydraulic type with a speed droop stabilization mechanism (Fig. 2). Hydraulic action is transmitted by oil admitted under pressure from the engine lubricating system to an auxiliary oil pump in the governor. The auxiliary pump then develops the oil pressure necessary to actuate the governor mechanism.

To stabilize the governor, a speed droop adjustment is incorporated in the governor mechanism. The speed droop is regulated by a droop adjusting bracket attached to the side of the terminal lever. Movement of the droop adjusting bracket IN toward the center of the governor decreases the speed droop while movement in the opposite direction increases the speed droop.

The governor operates in such a manner that the amount of fuel supplied to the injectors is increased by the hydraulically operated servo-motor piston and decreased by action of the terminal lever return spring.

When starting a cold engine, time is required to develop sufficient oil pressure to operate the governor and thus move the injector control racks to the ***full-fuel*** position so the engine can start. Since this delay is undesirable, the starting time can be shortened by moving the governor operating lever to the ***full-fuel*** position to take control of the injector racks away from the governor.

An oil reservoir is provided to supply the governor with sufficient oil to overcome the delay in governor operation upon starting the engine. The engine can be stopped, regardless of the governor, by moving the governor operating lever to the ***no-fuel*** position.

In addition to its function of regulating the engine speed under varying load conditions, the hydraulic governor acts as an automatic shutdown device in the event of a loss of engine lubricating oil pressure. Should the engine fail to supply oil to the governor, the servo-motor piston will drop, thus allowing the governor operating lever to return to the ***no-fuel*** position.

Operation

• An oil pickup tube is installed in the top inlet hole of the cover on the oil reservoir assembly and extends down into the reservoir (Fig. 3). An oil supply line is connected between the fitting on the pickup tube and the hydraulic governor oil pump inlet (Fig. 4). A restricted fitting is screwed into one of the “OUT” openings on the cover (the other “OUT” opening is plugged). A line is connected between this restricted fitting and a fitting on the governor control housing. An oil return line runs from the governor oil pump outlet to a solenoid shutdown valve. Another line is connected between the shutdown valve outlet and a fitting on the governor control housing.

• When the engine is cranked, the shutdown solenoid valve closes and the governor oil pump immediately begins drawing oil through the pickup tube in the reservoir to pressurize its hydraulic circuit. This allows the governor to rapidly move the injector racks to the ***full-fuel*** position, permitting start-up with minimum delay.

• After start-up, the shutdown solenoid valve stays closed to maintain system oil pressure. Overflow oil from the filled reservoir is dumped into the governor control housing and returned to the oil pan. When the engine is shut down, the shutdown solenoid valve opens to relieve system oil pressure.

With the engine operating, oil from the engine lubrication system is admitted to the space around the oil pump gears. The gears raise the oil pressure to a value determined by the spring in the relief valve which opposes the relief valve plunger. The oil pressure is maintained in the annular space between the undercut portion of the pilot valve plunger and the bore in the ball head (Fig. 5).

For any given throttle setting, the speeder spring has a definite compressional force which is opposed by the centrifugal force of the revolving flyweights. When the two forces are equal, the land on the pilot valve plunger covers the lower opening in the ball head producing a constant speed condition (Fig. 5).

When the load on an engine is increased, the engine speed will drop momentarily and the governor weights will be forced inward by the speeder spring permitting the pilot valve plunger to uncover the lower port in the ball head. With this port uncovered, oil, under pressure of the governor pump, will be admitted to the cavity at the lower end of the power piston and force the piston and floating pin upward (Fig. 6). The upward motion of the piston is transmitted through the terminal lever and fuel rod to the injector control tube, causing the fuel setting of the engine to be increased.

As the power piston and terminal lever rise, the compressional load on the speeder spring is reduced, allowing the flyweights to again move out to their normal *vertical* position. With the governor weights in a *vertical* position, the land on the pilot valve plunger will again cover the ports in the ball head, trapping the regulating oil under the power piston. With the power piston held in its new position by the trapped regulating oil, the engine will carry the increased load at a slightly reduced speed.

Fig. 7 illustrates the governor reaction as the load on the engine is decreased and the engine speed increases.

•NOTICE: Because of its importance to engine starting, technicians servicing or rebuilding this system should always make sure that the oil pickup tube is placed in the reservoir and that oil supply and return lines are properly routed (Fig. 4). ***Under no circumstances should a filter element be installed in the reservoir.*** The oil reservoir/shutdown valve system should be tight and free of leaks to avoid the entrance of air or the possibility of siphon action depleting the reservoir oil supply. All electrical connections on the shutdown solenoid valve should be properly wired and securely fastened.

Lubrication

Oil seeping past the power piston and pilot valve plunger is vaporized by the revolving governor flyweights, providing lubrication for the moving parts in the governor housing. The governor pump, pilot valve plunger and power piston are all exposed to pressurized oil. The current pilot valve plunger has two oil holes to provide additional lubricating oil to the thrust bearing. Oil which collects on the floor of the governor housing passes through a drilled passage into the governor drive housing, providing lubrication for the governor drive and driven beveled gears and their bearings. In addition, current governors have a cast passage with a drilled orifice in the governor drive housing which sprays oil on the drive splines. On former governors, a spray nozzle pressed into the blower end plate directed oil to the drive splines.

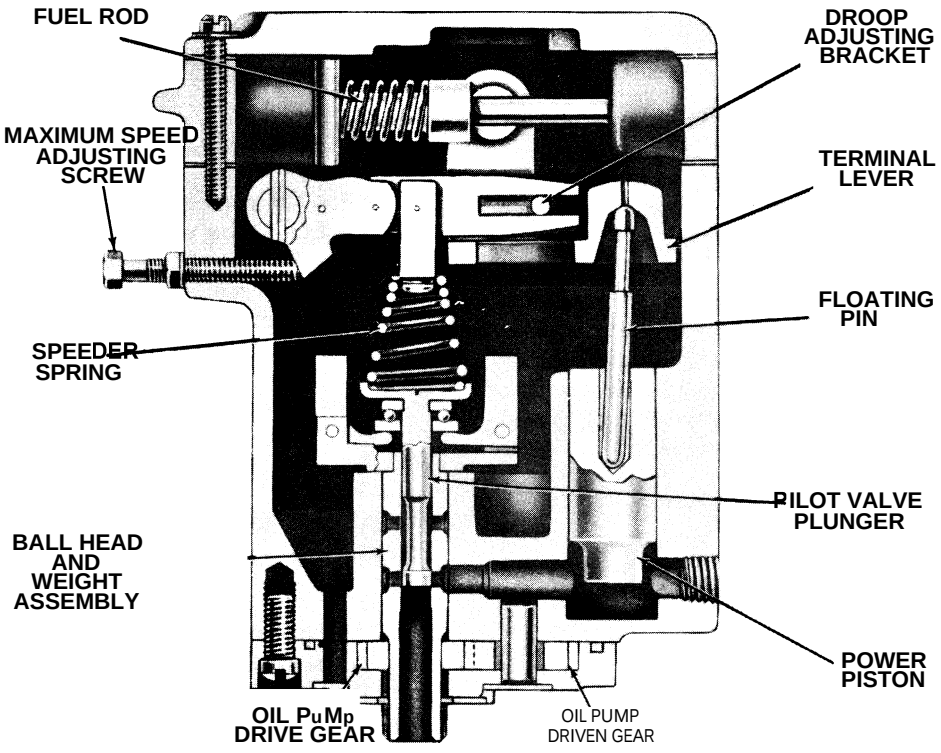
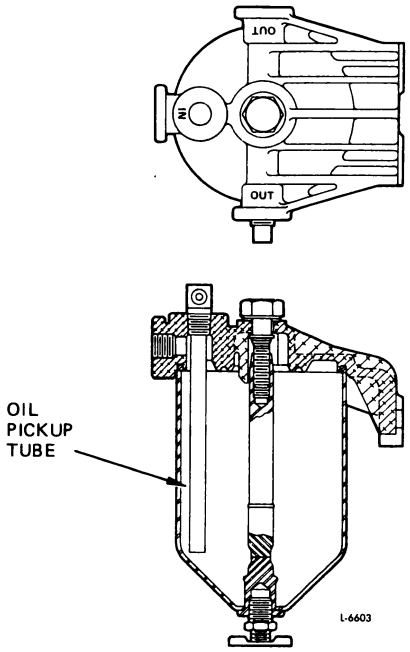


Fig. 2 - SG Hydraulic Governor Assembly

 © Detroit Diesel Corporation



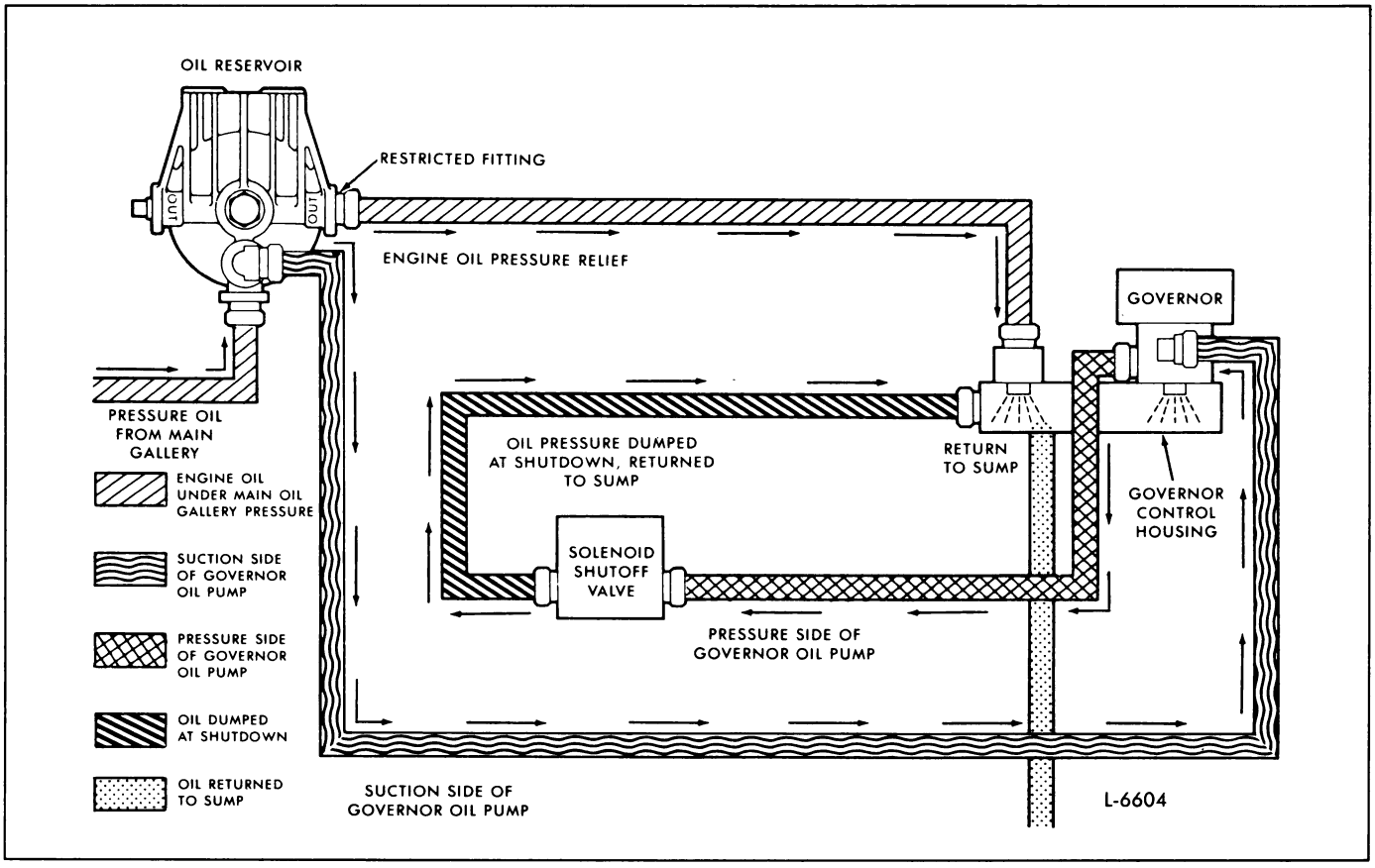
' Fig. 3 - Oil Reservoir Assembly with Pick-up Tube

The surplus oil returns to the engine crankcase through a passage in the bottom of the drive housing and into the gear housing and to the engine crankcase.

Remove Governor

Refer to Fig. 1 and remove the governor as follows:

1. Disconnect any linkage which may be attached to the governor speed control lever.
2. Drain the oil reservoir, if one is used.
3. Disconnect the vertical link assembly from the governor operating lever.
4. Disconnect the oil supply tube at the governor. Also, disconnect the oil return line, if one is used.
5. Disconnect the wires to the synchronizing motor, if used. Tag the wires to facilitate reassembly.
6. Remove the four (4) nuts or bolts and lock washers which attach the governor to the governor control housing cover (or the adaptor plate on former engines). Lift the governor away from the drive housing. Remove the gasket.



• Fig. 4 – Oil Flow Schematic – SG Hydraulic Governors

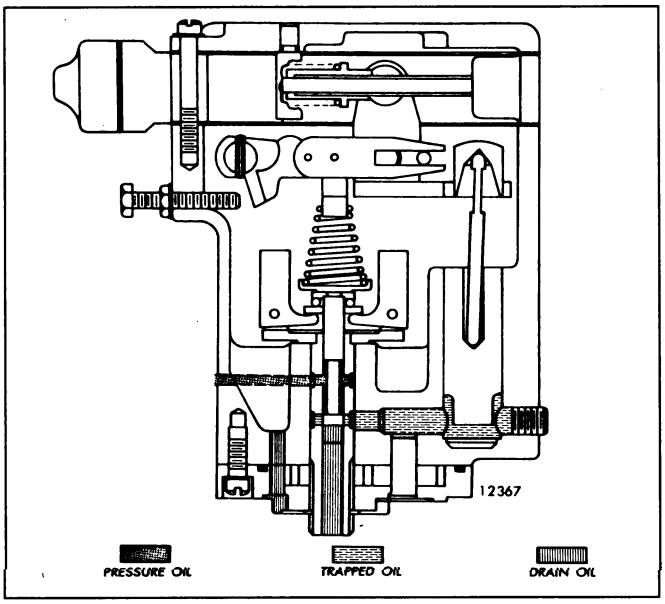


Fig. 5 - Position of Governor Mechanism when Load is Constant

Before a Barber-Coleman electronic governor is installed on a Series 149 engine previously equipped with a hydraulic governor, the vertical driven and horizontal drive shafts and bearings must be removed from the governor drive housing.

The shafts serve no useful purpose when the hydraulic governor is replaced by the electronic governor and will cause severe engine damage if not removed. Because the horizontal drive shaft is splined to the blower rotor shaft, both governor shafts will continue to rotate when the engine is operated. However, with the hydraulic governor removed, the horizontal and vertical shafts and bearings will no longer receive adequate support or lubrication and will quickly wear out.

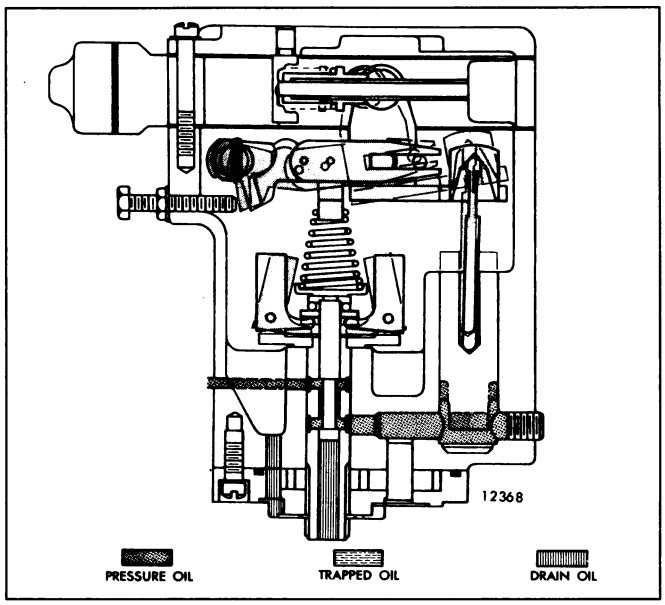


Fig. 6 - Position of Governor Mechanism as Load Increases and Engine Speed tends to Decrease

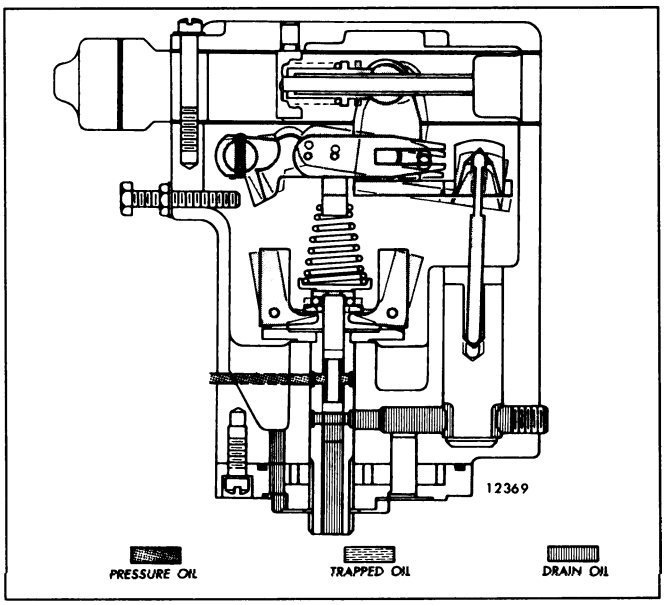


Fig. 7 - Position of Governor Mechanism as Load Decreases and Engine Speed tends to Increase

NOTICE: Do not remove only the vertical shaft and bearing. If the horizontal shaft and bearing assembly is left in the governor drive housing, the shaft will move freely back and forth during engine operation. This is due to the absence of load on the bevel gear which would normally keep the horizontal shaft in position. The rapid rotation and back-and-forth movement of the horizontal shaft can cause severe damage to the governor drive housing.

Use the following procedure to remove the vertical and horizontal shafts from the hydraulic governor housing before a Barber-Coleman electronic governor is installed:

1. Remove the governor and the upper governor control housing as outlined in Sections 2.8.1, 2.8.2 or 2.8.3.
2. Remove the air inlet shutdown systems as outlined in Section 3.3.
3. Remove the intercooler assembly, if necessary, as outlined in Section 3.5.2.
4. Remove the front blower as outlined in Section 3.4.
5. Remove the governor drive housing assembly from the front blower as outlined in Section 3.4.
6. Remove the snap ring and vertical and horizontal shafts from the governor drive housing as outlined in SEction 2.8.3.

 © Detroit Diesel Corporation

7. Install the governor drive housing on the blower using a new gasket.

8. Install the front blower and cover as outlined in Section 3.4.

9. Install all remaining parts and assemblies. Install the Barber-Coleman governor per the manufacturer's instruction, and perform the tune-up as outlined in Section 14.

Disassemble Governor

Before removing any of the parts from the governor, wash it thoroughly in clean fuel oil and dry it with compressed air. Then, inspect the governor for worn or damaged parts which can be repaired or replace without completely disassembling it. Disassemble the governor only as far as necessary to correct those difficulties which interfere with proper governor operation.

1. Loosen the governor operating lever clamping bolt and remove the lever.

2. Loosen the governor speed control lever clamping bolt and remove the lever.

3. Refer to Fig. 8 and remove the three (3) cover bolts and lock washers which attach the governor cover to the subcap. Remove the cover and gasket.

4. Refer to Fig. 8 and remove the two screws and lock washers which attach the governor subcap to the governor housing. Lift the subcap assembly off of the housing and remove the gasket.

5. Disassemble the subcap as follows (Figs. 8 and 9):

   a. Remove the two (2) screws and lock washers from the spring pad cover. Remove the cover and gasket.

   b. Withdraw the terminal lever return spring, the spring guide rod and the spring guide rod seat from the subcap.

   c. Loosen the locknut and remove the load limit screw and the copper washer.

6. Remove the screw, copper washer and lock washer from the terminal lever and remove the droop adjusting bracket. Refer to Figs. 8 and 10.

7. Remove the maximum speed adjusting screw and locknut from the governor housing.

8. Use a punch and drive the roll pin out of the speed adjusting lever and shaft (Fig. 11).

9. Drive the speed adjusting shaft and cup plug from the governor housing with a brass rod (Fig. 12). Remove the speed shaft oil seal - (Fig. 8).

10. Refer to Fig. 13 and remove the speed adjusting lever, floating lever, spring fork, speeder spring and pilot valve plunger as an assembly.

11. Refer to Figs. 8 and 10 and remove the two (2) cotter pins securing the terminal lever to the terminal lever shafts.

12. Remove the terminal lever shafts and cup plugs, using a brass rod (Fig. 14). Remove the terminal lever.

13. Remove the thrust bearing, floating pin and power piston from the governor housing (Fig. 8).

14. Refer to Fig. 8 and unscrew the plunger and spring seat from the speeder spring. Unscrew the speeder spring from the spring fork.

15. Straighten the ends of the lock wire and remove the lock wire separating the speed adjusting lever, spring fork and floating lever.

16. Remove the dummy hole plug and gasket from the governor housing.

17. Remove the oil inlet plug, gasket, sleeve retaining spring, relief valve spring, relief valve and relief valve sleeve.

18. Refer to Fig. 8 and remove the lock ring securing the weight assembly shaft to the governor housing and remove the weight assembly.

19. Remove the three (3) screws securing the governor base to the governor housing and remove the base and seal ring. Since the base is doweled to the governor housing, it may be necessary to tap the base lightly with a soft hammer to facilitate removal.

20. Refer to Fig. 8 and remove the oil pump drive and driven gears.

Inspection

After the governor assembly has been disassembled, each piece should be thoroughly cleaned in fuel oil, dried with compressed air and inspected.

CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Inspect the fuel rod bushing and seal for excessive wear and replace, if necessary.

Inspect the finished radius of the flyweights for excessive wear or flat spots. If either of these conditions exist, new flyweights must be installed. The flyweights should work freely on their supporting pins for satisfactory governor operation.

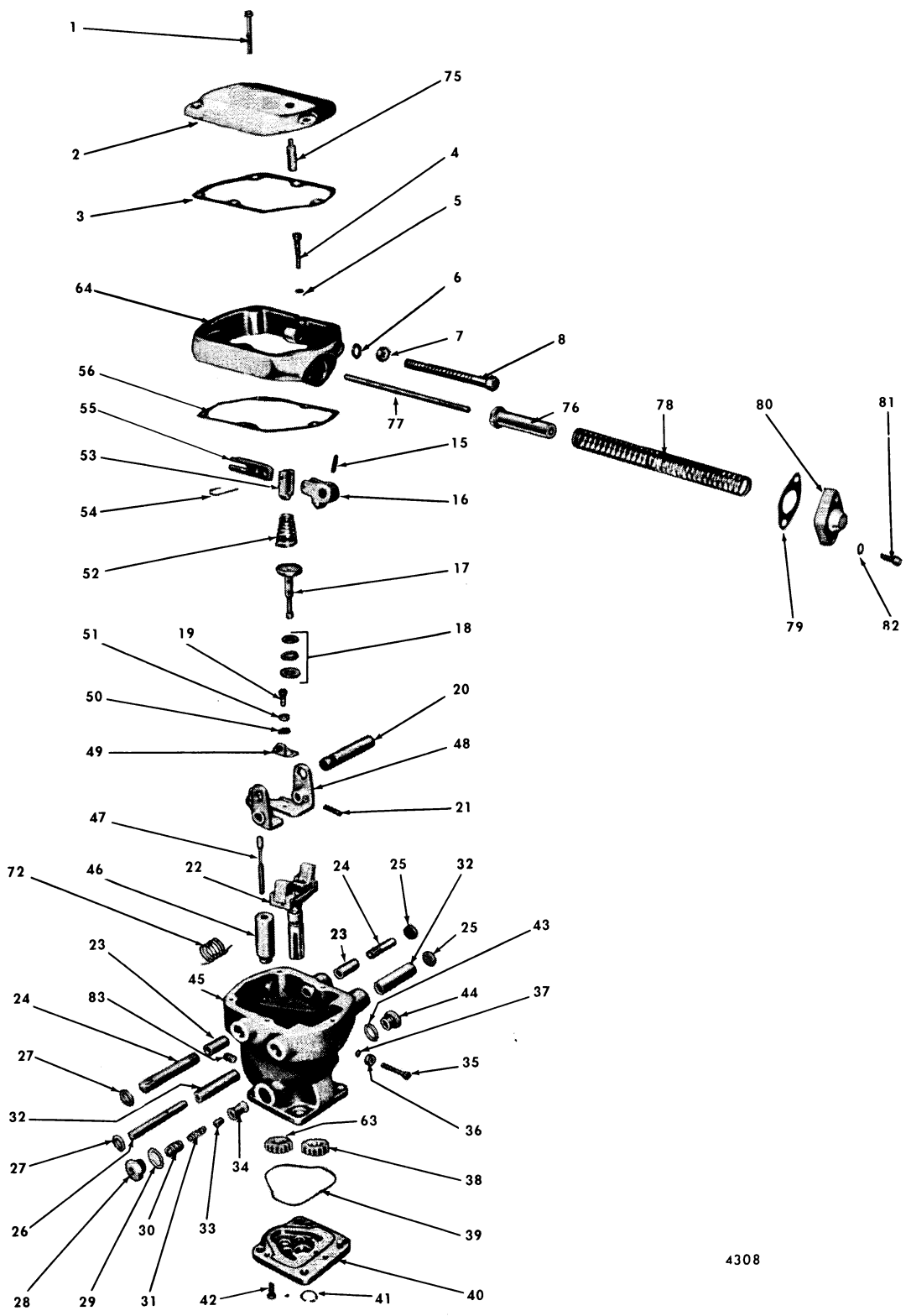


Fig. 8 - Hydraulic Governor Details and Relative Location of Parts

 © Detroit Diesel Corporation

1. Screw - Governor Cover
2. Cover — Governor
3. Gasket — Governor Cover
4. Screw — Subcap-to-Housing
5. Lock Washer
6. Washer — Copper
7. Lock Nut
8. Screw — Load Limit Adjusting
15. Pin —Roll
16. Lever - Speed Adjusting
17. Plunger - Pilot Valve
18. Bearing — Pilot Valve Plunger Thrust
19. Screw — Droop Adjusting Bracket
20. Pin — Terminal Lever Cross
21. Cotter Pin
22. Weight Assembly
23. Bushing — Terminal Lever
24. Shaft — Terminal Lever
25. Plug — Cap
26. Shaft — Speed Adjusting lever
27. Oil Seal
28. Plug — Governor Oil Inlet
29. Gasket - Relief Valve
30. Spring — Sleeve Retaining
31. Spring - Relief V alve
32. Bushing - Speed Adjusting Lever Shaft
33. Valve —Relief
34. Sleeve — Relief Valve
35. S crew — M aximum Speed Adjusting
36. Lock Nut
37. Washer — Copper
38. Gear — Oil Pump Drive
39. Ring — Housing-to-Base Seal
40. Base — Governor
41. Lock Ring
42. Screw — Governor Base
43. Gasket — Spacer Cap
44. Plug — Dummy Hole
45. Housing — Governor
46. Piston — Power
47. Pin — Floating
48. Lever — Terminal
49. Bracket — Speed Drop Adjusting
50. Plain Washer
51. Lock Washer
52. Spring — Speeder
53. Fork — Adjusting Linkage Spring
54. Pin — Spring Fork
55. Lever — Speed Adjusting Floating
56. Gasket — Subcap-to-Housing
63. Gear — Oil Pump Driven
64. Subcap — Governor
69. Bushing — Terminal Shaft
72. Spring — Torsion (Syn. Motors Only)
75. Screw — Low Speed Stop
76. Seat — Guide Rod Spring
77. Rod — Spring Guide
7 8. Spring — Terminal Lever Return
79. Gasket
80. Cover — Spring Pad
81. Screw — Spring Pad
82. Washer — Internal Lock
83. Plug — Housing

Fig. 8 - Hydraulic Governor Details and Relative Location of Parts

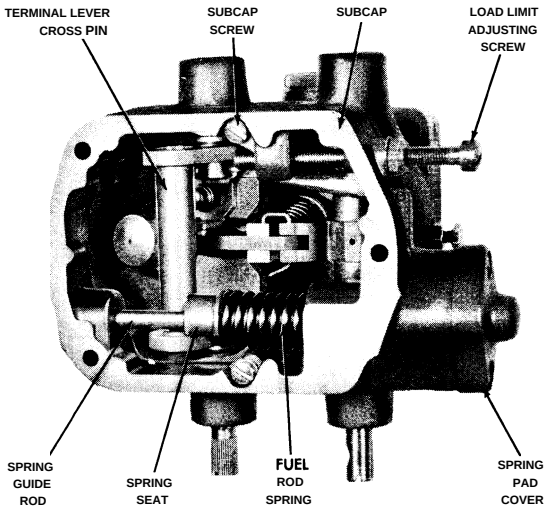


Fig. 9 - Top View of Governor

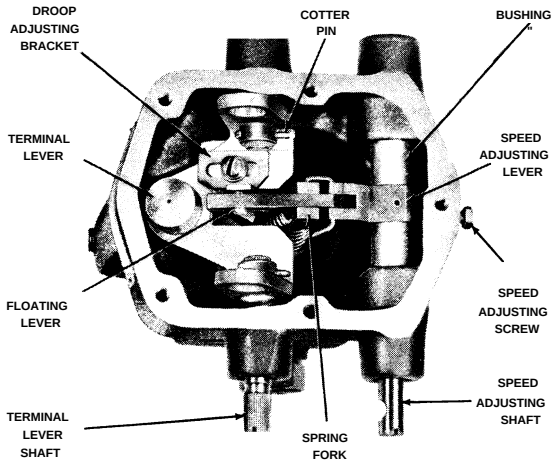


Fig. 10 - Top View of Governor with Subcap Removed

Inspect the pilot valve plunger for scratches or burrs. The plunger must work freely in the ball head assembly. Defective areas on the plunger may be dressed with a fine india stone, using extreme care to prevent rounding off the edges of the plunger.

Inspect the pilot valve bearing for excessive wear or flat spots. If either of these conditions exist, a new bearing must be installed.

Inspect the power piston for scratches or burrs. Defective areas may be dressed with a fine india stone, using extreme care to prevent rounding off the edges of the piston.

Inspect the governor ball head for free rotation in the governor housing and base.

Inspect the oil pump gears and driven gear bushing for excessive wear or damage. If either of these conditions exist, install new gears.

Inspect the terminal lever shaft and speed adjusting shaft bushings for scoring or excessive wear. Install new bushings if wear is excessive (Fig. 15).

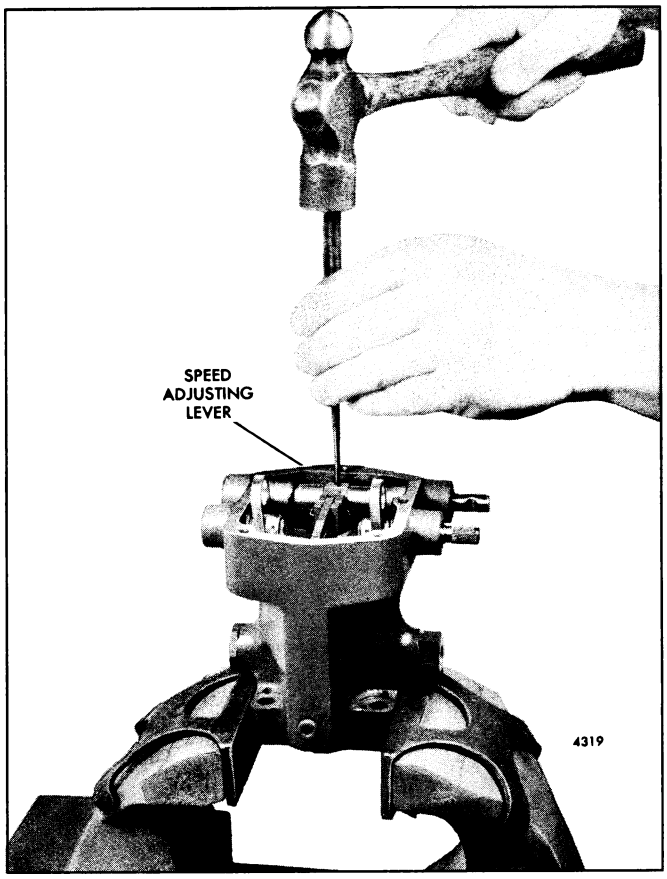


Fig. 11 - Removing Speed Adjusting Lever Roll Pin

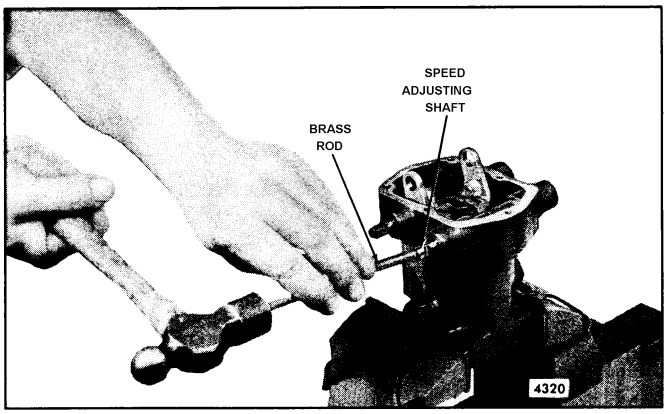


Fig. 1 2 - Removing Speed Adjusting Lever Shaft Cup Plug from Governor Housing

Assembly

After all of the parts have been cleaned and inspected, assemble the governor as follows:

1. Lubricate the two oil pump gears (Fig. 8) and place the gears in their respective positions in the governor base.
2. Place a new seal ring in the groove of the governor base, with the wide side of the seal down in the groove.

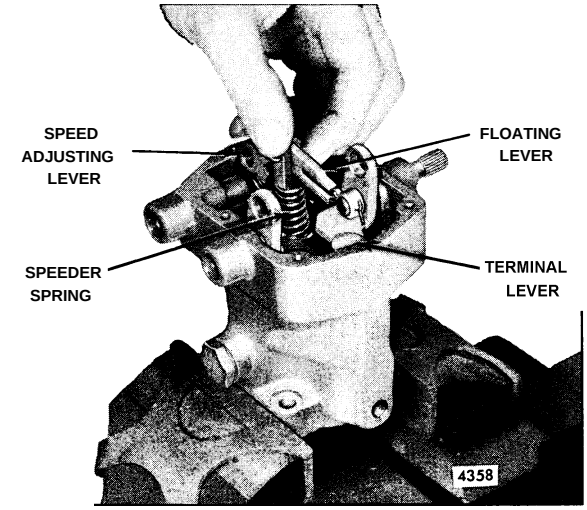


Fig. 13 - Removing or Installing Speed Adjusting Lever, Spring Fork, Speeder Spring and Pilot Valve Plunger Assembly

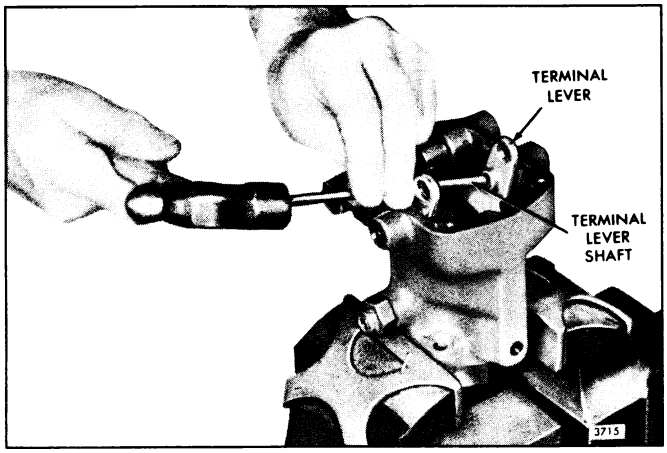


Fig. 14 - Removing Terminal Lever Shaft Cup Plug from Governor Housing

3. Set the governor housing on the base with the dowels in the base registering with the holes in the housing and the idler gear stud in the housing registering with the hole in the idler gear. Press the housing down against the base seal ring.
4. Lubricate the shaft of the weight assembly (22) and insert the shaft end of the assembly down through the bore of the housing, drive gear and base.
5. Install the three screws and secure the base to the housing. Revolve the weight assembly to be sure that it is free of bind. If bind exists, loosen the three screws, tap the sides of the base lightly with a plastic hammer and tighten the screws again. Revolve the weight assembly again and check for bind. Repeat, if necessary, until all parts rotate freely.

 © Detroit Diesel Corporation

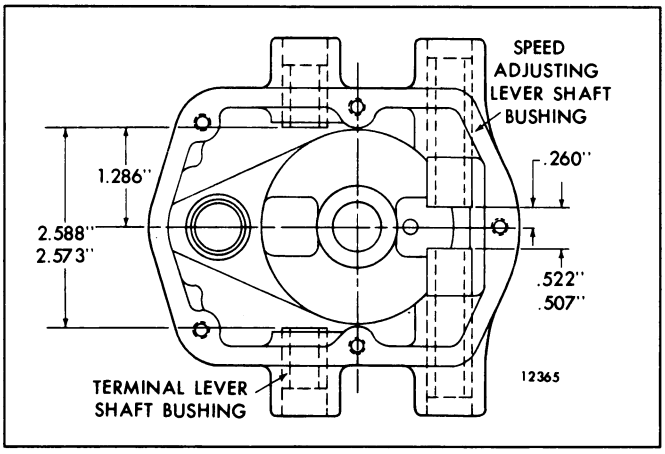


Fig. 1 5 - Location of Speed Adjusting Lever and Terminal Lever Shaft Bushing in Governor Housing

6. Install the lock ring in the groove at the lower end of the shaft.

7. Install the relief valve sleeve, relief valve, relief valve spring, sleeve retaining spring, gasket and oil inlet plug.

8. Install the dummy hole plug and gasket.

9. Install a new spring fork pin into the speed adjusting lever, spring fork and floating lever.

10. Thread the small end of the spring fork into the small end of the speeder spring, then thread the large end of the spring into the pilot valve plunger spring seat.

11. Place the plunger (thrust) bearing over the lower end of pilot valve plunger with the bearing washer having the smaller outside diameter against the spring seat.

12. Guide the pilot valve plunger in the opening of the weight assembly, being careful not to apply undue force on the plunger.

13. Install the power piston in the governor housing. Place the floating pin in the power piston on current design governors.

14. Install the terminal lever shafts and terminal lever. Align the holes in the lever shaft with the holes in the terminal lever and install the cotter pins - (Fig. 16).

15. Refer to Fig. 13 and install the speed adjusting lever, floating lever, spring fork, speeder spring and pilot valve plunger as an assembly.

16. Position the speed shaft oil seal into the governor housing. Refer to Fig. 17 and install the speed adjusting lever shaft in the governor housing and adjusting lever.

17. Drive a new roll pin through the roll pin holes and secure the speed adjusting lever to the speed adjusting shaft.

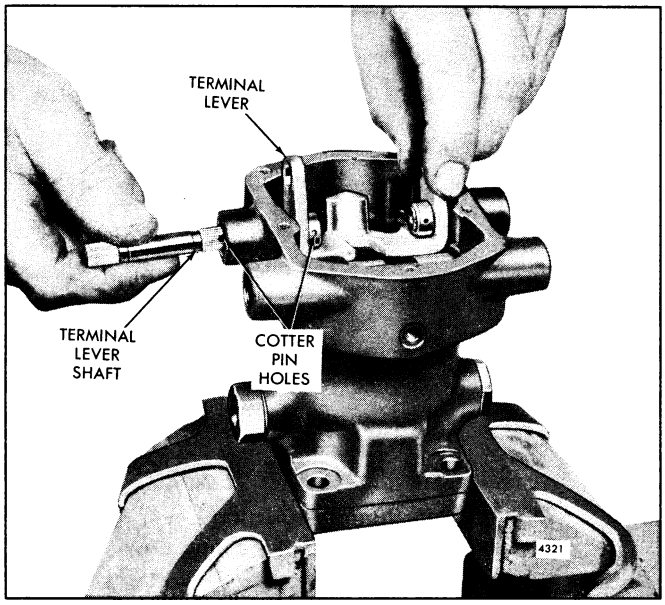


Fig. 16 - Installing Terminal Lever Shaft in Governor Housing and Terminal Lever

18. Install the maximum speed adjusting screw and locknut.

19. Press the plugs into the governor housing.

20. Install the droop adjusting bracket, using bolt, washer and lock washer.

21. Install the governor speed control and operating levers.

22. Attach a new subcap gasket to the top of the governor housing.

23. Place the subcap on the governor housing, with the spring pad on the same side as the governor maximum speed adjusting screw. Secure the subcap to the governor housing with two socket head screws and lock washers.

24. Install the terminal lever spring guide rod seat, spring guide rod, spring, spring pad cover and load limit screw in the subcap as follows:

    a. Place the spring guide rod seat in the subcap with the large diameter of the seat facing the terminal lever.

    b. Lubricate the spring guide rod with engine oil. Then, insert the rod through the spring pad opening, through the guide rod seat and into the boss at the opposite end of the subcap.

    c. Insert the spring over the guide rod and the small end of the guide rod spring seat.

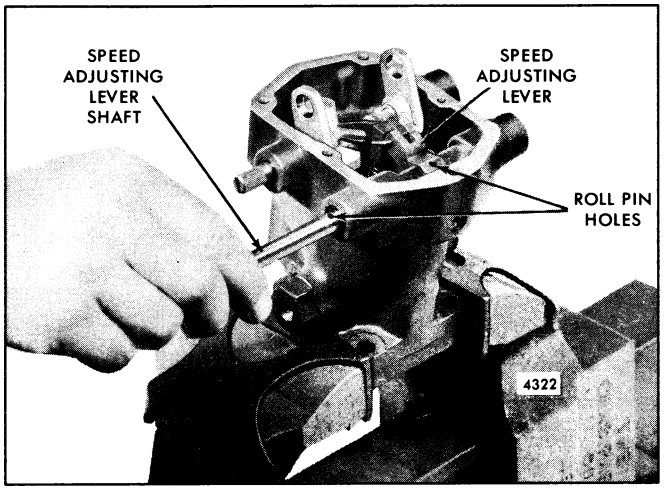


Fig. 1 7 - Installing Speed Adjusting Lever Shaft in Governor Housing and Adjusting Lever

d. Attach a new gasket to the spring pad cover. Then, place the cover against the spring. Push the cover to compress the spring and, at the same time, enter the spring guide rod in the hole in the cover. Secure the cover to the subcap with two screws and lock washers.

e. Thread a locknut on the load limit adjusting screw. Then, place a copper washer over the screw and thread the screw into the subcap until it almost contacts the terminal lever.

Install Governor

1. Place a new gasket on the governor control housing (current governors) or on the adaptor plate (former governors).

2. Place the governor on the governor control housing or adaptor plate. Turn the governor slightly, if necessary, to align the splines of the ball head shaft with the splines in the driven shaft sleeve. Then, secure the governor with four (4) nuts or bolts and lock washers. Tighten the bolts or nuts uniformly.

3. Install the oil supply tube (and oil return tube, if used).

4. Pour approximately one (1) pint of engine oil in the governor to provide initial lubrication. Refill the oil reservoir, if used, with engine oil. Under no circumstances should a filter element be installed in the reservoir.

5. Refer to Fig. 8 and attach a new governor cover gasket to the subcap.

6. If previouslyremoved, install the low-speed stop screw on the underside of the governor cover. Secure the stop to the cover with a stop nut and copper washer.

7. Before installing the governor cover or connecting the governor linkage, perform a complete engine tune-up as outlined in Section 14.7.2.

 © Detroit Diesel Corporation

PSG HYDRAULIC GOVERNOR

The governor is located at the front of the engine and is mounted on a control housing which sets over the governor drive housing (Fig. 1). It is driven by one of the blower rotors through a bevel gear and shaft arrangement and actuates the injector control tubes through a linkage (Section 2.8.3).

The governor is an isochronous hydraulic type with a speed droop stabilization mechanism. Hydraulic action is transmitted by filtered oil admitted under pressure from the engine lubricating system to an auxiliary oil pump in the governor. The auxiliary pump then develops the oil pressure necessary to actuate the governor mechanism.

The isochronous feature of this governor is its ability, at zero droop, to hold the engine at a constant speed regardless of the load, provided the load is within the capacity of the unit.

The governor operates in such a manner that the amount of fuel supplied to the injectors is increased by the hydraulically operated servo-motor piston and decreased by action of the terminal lever return spring.

• When starting a cold engine, time is required to develop sufficient oil pressure to operate the governor and thus move the injector control racks to the ***full-fuel*** position so the engine can start. Since this delay is undesirable, the starting time can be shortened by moving the governor operating lever towards the ***full-fuel*** position while cranking

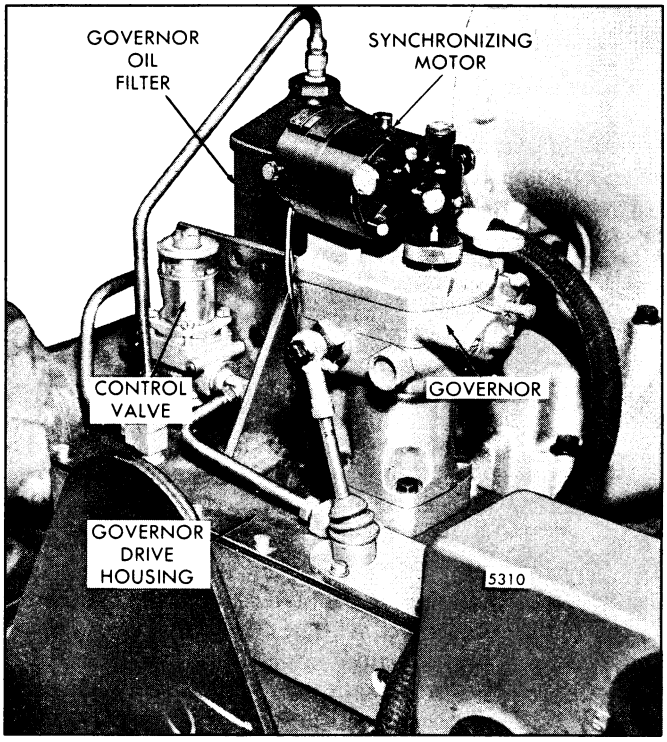
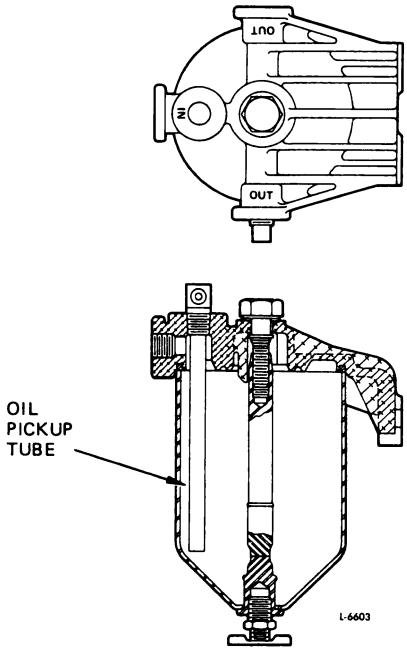


Fig. 1 - Governor Mounting



• Fig. 2 - Oil Reservoir Assembly with Pick-up Tube

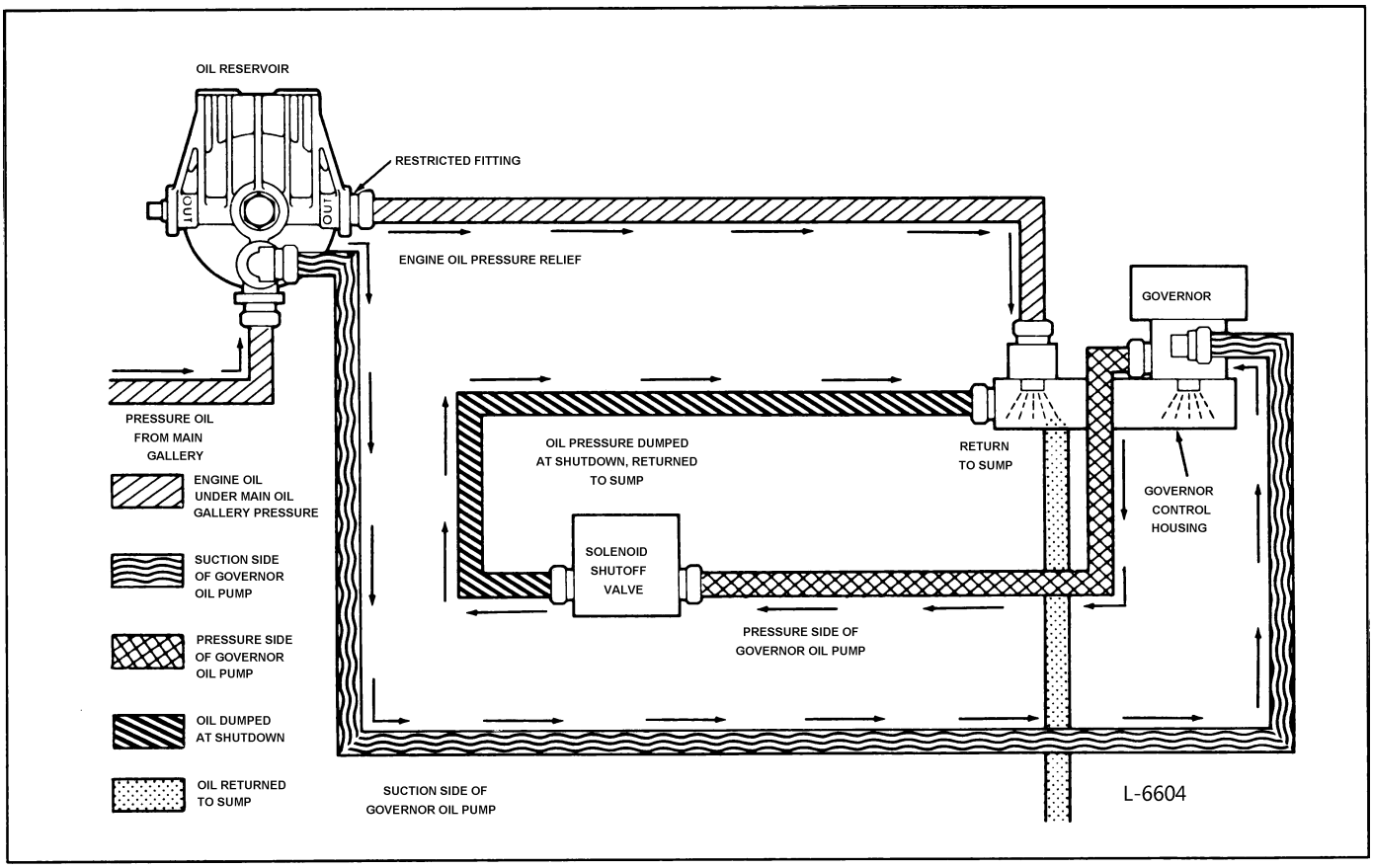
the engine. This takes control of the injector racks away from the governor. On certain installations, such as units equipped with automatic starting, an oil reservoir is provided to supply the governor with sufficient oil to overcome the delay in governor operation upon starting the engine. The engine can be stopped by moving the governor operating lever to the ***no-fuel*** position.

In addition to its function of holding theengine speed constant under varying load conditions, the hydraulic governor acts as an automatic shutdown device in the event of a loss of engine lubricating oil pressure. Should the engine fail to supply oil to the governor, the servo-motor piston will drop, thus allowing the governor operating lever to return to the ***no-fuel*** position.

Operation

• On units equipped with oil reservoirs, an oil pickup tube is installed in the top inlet hole of the cover on the oil reservoir assembly and extends down into the reservoir (Fig. 2). An oil supply line is connected between the fitting on the pickup tube and the hydraulic governor oil pump inlet (Fig. 3). A restricted fitting is screwed into one of the "OUT" openings on the cover (the other "OUT" opening is plugged). A line is connected between this restricted fitting and a fitting on the governor control housing. An oil return line runs from the governor oil pump outlet to a solenoid shutdown valve. Another line is connected between the shutdown valve outlet and a fitting on the governor control housing.

© Detroit Diesel Corporation



• Fig. 3 - Oil Flow Schematic - SG Hydraulic Governors

• When the engine is cranked, the shutdown solenoid valve closes (normally open valve) and the governor oil pump immediately begins drawing oil through the pickup tube in the reservoir to pressurize its hydraulic circuit. This allows the governor to rapidly move the injector racks to the *full-fuel* position, permitting start-up with minimum delay.

• After start-up, the shutdown solenoid valve stays closed to maintain system oil pressure. Overflow oil from the filled reservoir is dumped into the governor control housing and returned to the oil pan. When the engine is shut down, the shutdown solenoid valve opens to relieve system oil pressure.

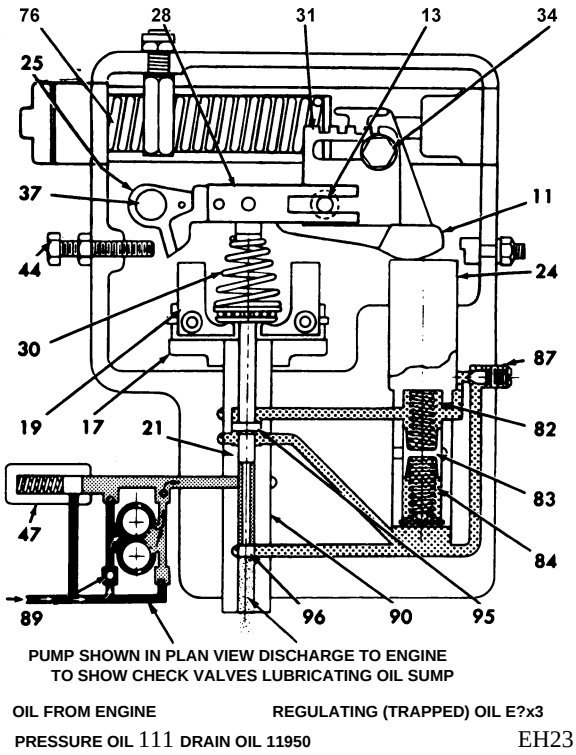
•NOTICE: Because of its importance to engine starting, technicians servicing or rebuilding this system should always make sure that the oil pickup tube is placed in the reservoir and that oil supply and return lines are properly routed (Fig. 3). ***Under no circumstances should a filter element be installed in the reservoir.*** The oil reservoir/shutdown valve system should be tight and free of leaks to avoid the entrance of air or the possibility of siphon action depleting the reservoir oil supply. All electrical connections on the shutdown solenoid valve should be properly wired and securely fastened.

With the engine operating, oil from the engine lubricating system is admitted to the space around the governor pump gears. The pump gears raise the oil pressure to a value determined by the spring in the relief valve which opposes the relief valve plunger. The oil pressure is maintained in the annular space between the undercut portion of the pilot valve plunger and the bore in the pilot valve bushing (Fig. 4).

For any given throttle setting, the speeder spring exerts a definite force which is opposed by the centrifugal force of the revolving flyweights. When the two forces are equal, the control land on the pilot valve plunger covers the lower ports in the pilot valve bushing.

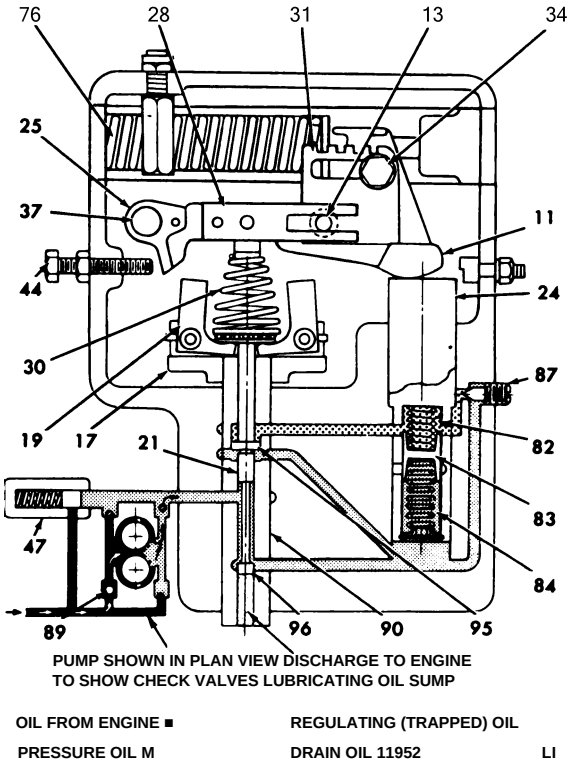
Under these conditions, equal oil pressure is maintained on both sides of the buffer piston and tension on the two buffer springs is equal. The oil pressure is also equal on both sides of the receiving compensating land of the pilot valve plunger, due to oil passing through the compensating needle valve. Thus, the hydraulic system is in balance and the engine speed remains constant.

 © Detroit Diesel Corporation



11. Lever—Terminal
13. Shaft—Terminal (long)
17. Ball Head Assy.
19. Flyweight
21. Plunger—Pilot V alve
24. Piston—Servo-Motor
25. Lever—Speed Adjusting
28. Lever—Floating
30. Spring—Speeder
31. Bracket—Droop Adjusting
34. Bolt—Droop Adjusting
37. Shaft—Speed Adjusting
44. Screw—Maximum Speed Adjusting
47. Valve—Relief
76. Spring—Terminal Lever Return
82. Spring—Buffer (upper)
83. Piston—Buffer
84. Spring—Buffer (lower)
87. Valve—Compensating Needle
89. Valve—Check
90. Bushing—Pilot Valve
95. Land—Receiving Compensating
96. Land—Pilot Valve Control

Fig. 4 - Stable Position of Governor When Load on Engine is Constant



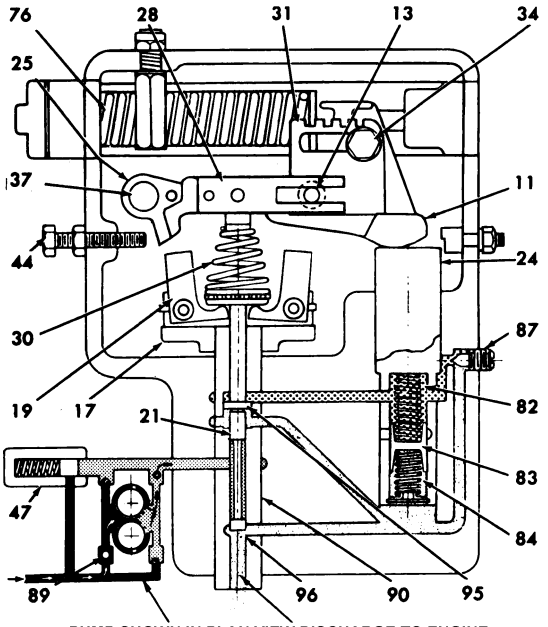
11. Lever—Terminal
13. Shaft—Terminal (long)
17. Ball Head Assy.
19. Flyweight
21. Plunger—Pilot Valve
24. Piston—Servo-Motor
25. Lever—Speed Adjusting
28. Lever—Floating
30. Spring—Speeder
31. Bracket—Droop Adjusting
34. Bolt—Droop Adjusting
37. Shaft—Speed Adjusting
44. Screw—Maximum Speed Adjusting
47. Valve—Relief
76. Spring—Terminal Lever Return
82. Spring—Buffer (upper)
83. Piston—Buffer
84. Spring—Buffer (lower)
87. Valve—Compensating Needle
89. Valve—Check
90. Bushing—Pilot Valve
95. Land—Receiving Compensating
96. Land—Pilot Valve Control

Fig. 5 - Position of Governor Mechanism as Load Increases and Engine Speed Tends to Decrease

Refer to Fig. 5 and assume that a load increase is applied to the engine. The engine speed will momentarily drop and the governor flyweights will be forced inward, thus lowering the pilot valve plunger. Oil under pressure will be admitted under the servo-motor piston causing it to rise. This upward motion of the servo-motor piston will be transmitted through the terminal lever and the linkage to the injector control tubes, causing the fuel setting of the engine to be increased.

The oil which forces the servo-motor piston upward also forces the buffer piston upward because the oil pressure at each side of the buffer piston is unequal. This upward motion of the piston compresses the upper buffer spring and relieves the pressure on the lower buffer spring.

The oil cavities above and below the buffer piston (Fig. 5) are common to the receiving compensating land on the pilot valve plunger. Since the higher pressure is below the compensating land, the pilot valve plunger is forced upward, re-centering the flyweights and causing the control land of the pilot valve to close off the regulating port. Thus the upward movement of the servo-motor piston stops when it has moved far enough to make the necessary fuel correction.



11. Lever—Terminal
13. Shaft—Terminal (long)
17. Ball Head Assy.
19. Flyweight
21. Plunger—Pilot Valve
24. Piston—Servo-Motor
25. Lever—Speed Adjusting
28. Lever—Floating
30. Spring—Speeder
31. Bracket—Droop Adjusting
34. Bolt—Droop Adjusting
37. Shaft—Speed Adjusting
44. Screw—Maximum Speed Adjusting
47. Valve—Relief
76. Spring—Terminal Lever Return
82. Spring—Buffer (upper)
83. Piston—Buffer
84. Spring—Buffer (lower)
87. Valve—Compensating Needle
89. Valve—Check
90. Bushing—Pilot Valve
9 5. Land—Receiving Compensating
96. Land—Pilot Valve Control

Fig. 6 - Position of Governor Mechanism as Load Decreases and Engine Speed Tends to Increase

Oil passing through the compensating needle valve equalizes the pressure above and below the buffer piston, thus allowing the piston to return to its center position which, in turn, equalizes the pressure above and below the receiving compensating land. The pilot valve plunger then moves to its central position and the engine speed returns to its original setting because there is no longer any excessive outward force on the flyweights.

Figure 6 illustrates the governor reaction as the load on the engine is decreased and the engine speed returns to normal. With a decrease in the load, the engine speed will momentarily increase and the flyweights will move outward, thus raising the pilot valve plunger.

This allows the oil below the buffer piston (and below the receiving compensating land) to flow to the drain passage, thus reducing the pressure on the lower side of the buffer piston and on the lower side of the receiving compensating land. This allows a downward movement of the servo-motor piston which is transmitted through the terminal lever and linkage to the injector control tubes, causing the fuel setting of the engine to be decreased.

The compensating mechanism produces stable engine operation by permitting the governor to move instantaneously in response to a load change and to make the necessary fuel adjustment to maintain the initial engine speed.

The speed changes previously described were the result of load changes. Similar governor movements occur through movement of the governor speed control lever. Movement of the speed control lever (through the vernier control and connecting linkage) changes the tension on the speeder spring, thus causing the pilot valve plunger to raise or lower.

Lubrication

Oil passes up through a drilled passage in the pilot valve plunger and is directed at the thrust bearing from where it is thrown onto the moving parts in the governor housing by the revolving flyweights. The governor pump gears, pilot valve plunger, servo-motor piston and buffer piston are all exposed to pressurized oil. Oil which collects on the floor of the governor housing passes through a drilled passage into the governor drive housing, thus lubricating the governor drive and driven gears and shafts and their bearings. Surplus oil returns to the engine crankcase through connecting drilled passages in the blower end plate and cylinder block.

Remove Governor

Refer to Fig. 1 and remove the governor as follows:

1. Disconnect any linkage which may be attached to the governor speed control lever.
2. Drain the governor oil filter.
3. Disconnect the oil supply tube between the governor and the filter.
4. Remove the oil filter element and clean the filter housing. Install a new filter element.
5. Disconnect the vertical link assembly from the governor operating lever.
6. Disconnect the wires to the synchronizing motor, if used. Tag the wires to facilitate reassembly.

 © Detroit Diesel Corporation

7. Remove the four bolts and lock washers that attach the governor to the control housing. Lift the governor away from the control housing. Remove the gasket.

Install Governor

1. Place a new gasket on the governor control housing.
2. Place the governor on the governor control housing. Turn the ball head slightly, if necessary, to align the splines on the pilot valve bushing with the splines in the driven shaft sleeve. Then secure the governor to the control housing with four bolts and lock washers. Tighten the bolts uniformly.
3. Install the oil supply tube.
4. Pour approximately one pint of engine oil in the governor to provide initial lubrication.
5. Attach a new governor cover gasket to the subcap.
6. If previously removed, install the speed adjusting lever stop on the underside of the governor cover. Secure the lever stop to the cover with a lock nut and copper washer.
7. Before installing the governor cover or connecting the governor linkage, perform a complete engine tune-up as outlined in Section 14.

HYDRAULIC GOVERNOR DRIVE AND GOVERNOR OPERATING LINKAGE

The governor is driven by one of the blower rotors through a horizontal drive shaft and bevel gear and an integral vertical shaft and bevel gear (Fig. 1). Each gear is mounted on a ball bearing and is contained in a drive housing that also serves as the blower front cover.

Splines on the horizontal drive shaft engage the splines in the blower rotor shaft that provides the drive. Splines on the lower end of the governor ball head register with the splines in the upper end of a sleeve that is pressed on the vertical driven shaft and gear.

On current engines, the fuel rods from each injector control tube are connected to operating levers in the governor control housing and the vertical link connects the governor operating lever with the left bank operating lever (Fig. 2).

On former engines, the fuel rods are connected to a bell crank attached to the front end of the cylinder block. The governor is connected to the bell crank by a vertical linkage attached to the governor operating lever (Fig. 3).

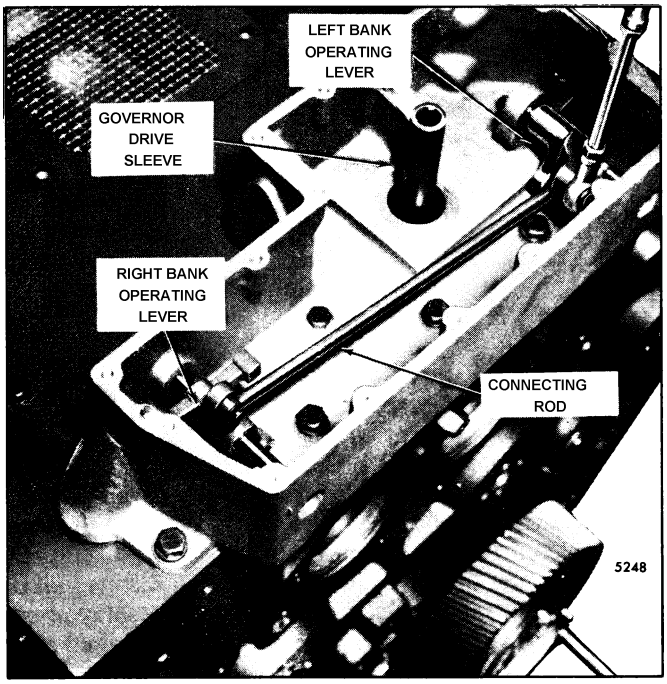


Fig. 2 - Governor Operating Linkage (Current)

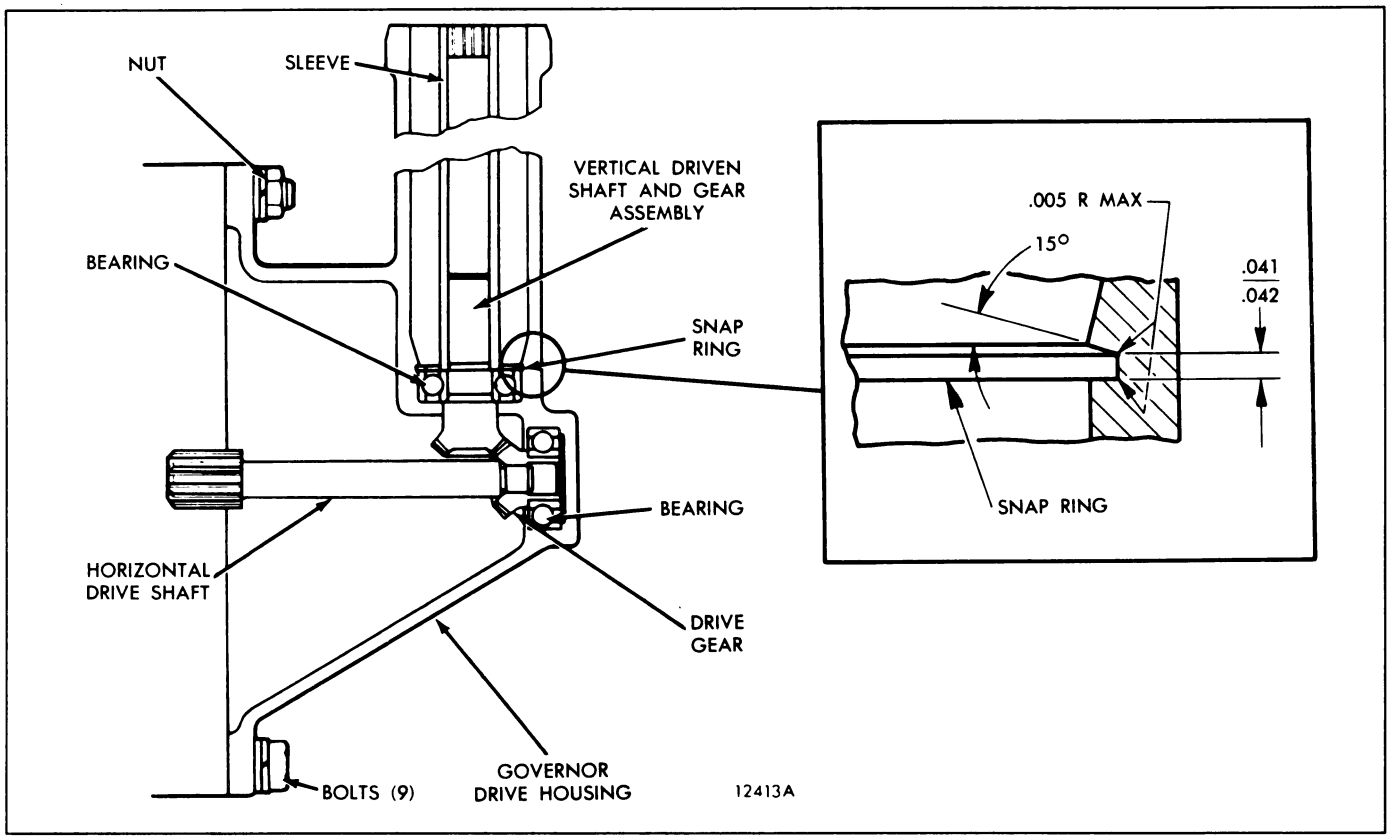


Fig. 1 – Governor Drive Assembly

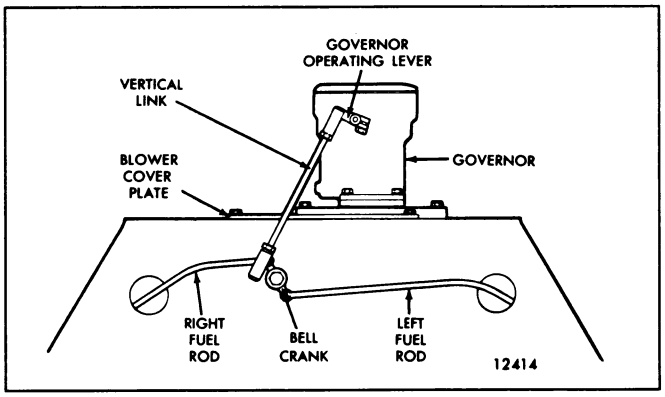


Fig. 3 - Governor Operating Linkage (Former)

Lubrication

The gears and bearings in the governor drive assembly are lubricated by surplus oil from the governor which spills over from the moving parts. On current engines, two drilled orifices in the oil passages in the governor drive housing direct a spray of lubricating oil on the drive shaft splines and the beveled drive and driven gears and their bearings. On former engines, there was one orifice which directed oil on the drive shaft spline only. On early engines, a spray nozzle pressed into the blower end plate directed lubricating oil to the drive shaft splines. The oil returns to the crankcase through drilled passages in the blower end plate and the cylinder block.

The rod end bearings of the vertical link assembly are lubricated with grease through fittings provided.

Disassemble Governor Linkage

If the governor is slow to react to load changes, the problem may be in the governor linkage. Check for bind in the linkage or for bent or damaged fuel rods. If necessary, disassemble the linkage, a§ follows:

CURRENT LINKAGE

1. Remove the governor (refer to Section 2.8.1).
2. Remove the valve rocker covers and disconnect the fuel rods from the injector control tube levers.
3. Remove the governor control housing cover.
4. Remove the spring retainers and washers securing the connecting rod to the right and left bank operating levers (Fig. 2).
5. Disconnect the fuel rods from the operating levers.
6. Remove the bolts securing the governor control housing to the engine. Remove the control housing.

FORMER LINKAGE

1. Remove the governor (refer to Section 2.8.1).
2. Remove the plate from the top of the engine front cover to expose the governor operating linkage.
3. Remove the valve rocker covers and disconnect the fuel rods from the injector control tube levers.
4. Disconnect the vertical link from the bell crank (Fig. 3).
5. Disconnect the fuel rods from the bell crank.
6. Remove the shoulder bolt securing the bell crank to the cylinder block. Remove the bell crank.

Remove Governor Drive

If the governor fails tocontrol the engine speed properly, the fault may lie in the governor drive. To function properly, there must be .001” to .003” clearancebetween the governor drive and driven gears.

With the governor and linkage removed, the governor drive assembly may be removed as follows:

1. Remove the air inlet housing, and any other accessories, to gain access to the blower cover plate.
2. Remove the blower and governor drive assembly from the engine (refer to Section 3.4).
3. Remove the nine (9) bolts and one nut (and lock washers) securing the governor drive assembly to the blower. Remove the governor drive assembly.

   NOTICE: Do not pry the housing off of the dowels as this will damage the finished surface.

4. Remove the drive housing gasket.

Before a Barber-Coleman electronic governor is installed on a Series 149 engine previously equipped with a hydraulic governor, the vertical driven and horizontal drive shafts and bearings must be removed from the governor drive housing (Fig. 1).

Disassemble Governor Drive

Refer to Fig. 1 and disassemble the governor drive, as follows:

1. Remove the snap ring securing the driven gear bearing in the drive housing.
2. Pull the driven gear, bearing and sleeve assembly from the housing.
3. Place the split bearing remover J 4685 between the driven gear and the bearing, with the beveled side of the remover facing the gear.
4. Support the gear and bearing assembly on an arbor press. Place a brass rod inside of the sleeve and press the gear from the sleeve and bearing (Fig. 4).

 © Detroit Diesel Corporation

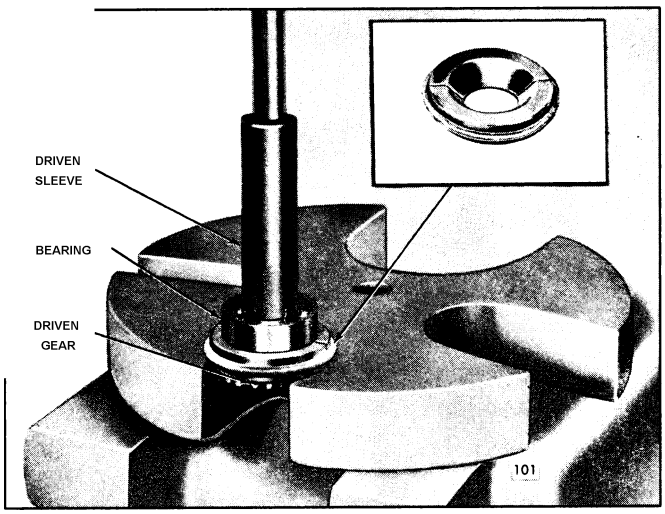


Fig. 4 - Removing Sleeve and Bearing from Driven Gear with Tool J 4685

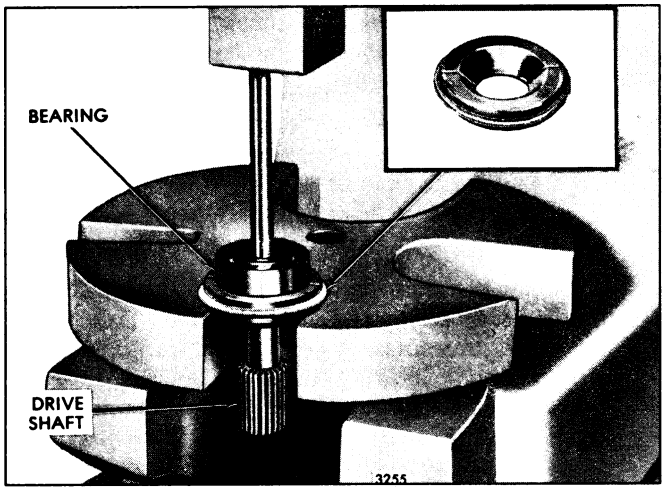


Fig. 5 - Removing Bearing from Drive Gear with Tool J 4685

5. Pull the governor drive gear, shaft and bearing assembly out of the housing.

6. Place the split bearing remover J 4685 between the drive gear and the bearing, with the beveled side of the remover facing the gear.

7. Support the gear and bearing assembly on an arbor press. Place a brass rod on the end of the shaft and press the gear and shaft from the bearing (Fig. 5).

8. Place two brass plates beneath the teeth of the drive gear and support the assembly on an arbor press (Fig. 6). Then, place a brass rod on the end of the drive shaft and press the shaft from the gear.

Inspection

Wash all of the parts in clean fuel oil and dry them with compressed air.

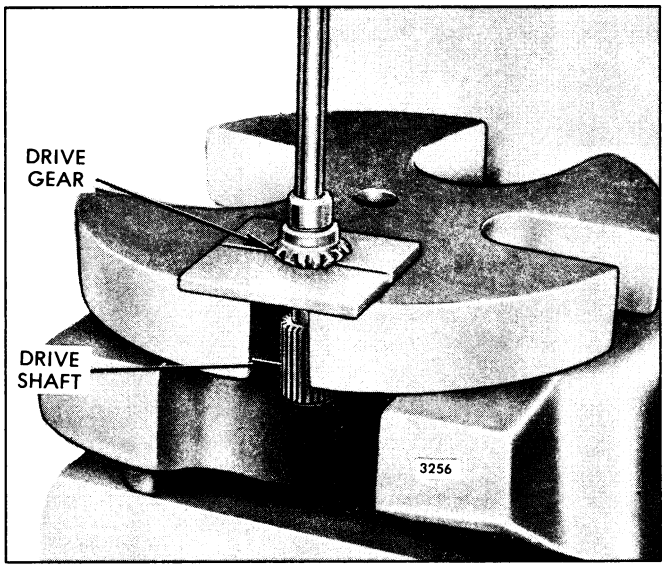


Fig. 6 - Removing Gear from Drive Shaft

CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Inspect the gears for worn, scored or chipped teeth. Replace the gears, if necessary.

Examine the splines on the drive shaft, driven sleeve and the mating parts for wear.

On current engines, the governor drive coupling (part ofthe EGB and LSG hydraulic governor assemblies) has been eliminated and the governor drive driven shaft sleeve lengthened 1.29” to offset the drive coupling.

The drive coupling must be removed from the governor when replacing the former governor drive sleeve with the current governor drive sleeve.

Check each ball bearing for indications of corrosion or pitting. Lubricate the bearing with light engine oil. Then, while holding the inner race, revolve the outer race slowly by hand. Any rough spot in the bearing is sufficient cause for rejection.

Inspect the needle bearings and spherical rod end bearings for wear and free movement. If a new bearing is required in the bell crank, press it in flush with the flat side of the bell crank.

Replace worn or damaged parts.

If the former governor drive assembly or housing is replaced by the current type, remove and discard the drive shaft oil slinger and the spray nozzle from the blower end plate.

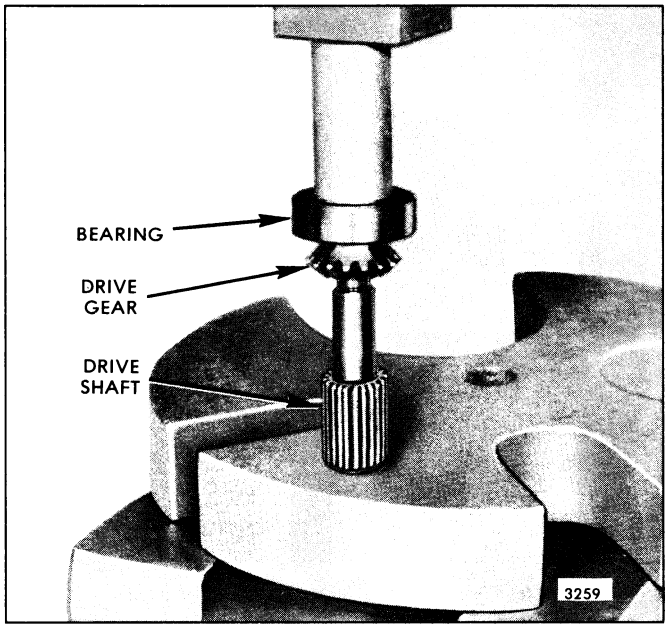


Fig. 7 - Installing Gear and Bearing on Governor Drive Shaft

Assemble Governor Drive

Refer to Fig. 1 and assemble the governor drive, as follows:

1. Install the bearing and gear on the governor drive shaft, as follows:
   a. Lubricate the bearing with engine oil. Then, start the bearing, numbered side up, straight on the end of the drive gear.
   b. Place the beveled end of the drive gear on an arbor press. Then, place a sleeve on the inner race and press the bearing tight against the shoulder on the drive gear.
   c. Lubricate the small end of the drive shaft with engine oil. Then, start the drive gear straight on the shaft with the gear teeth facing the splined end of the shaft.
   d. Place the shaft, gear and bearing assembly on an arbor press with the gear end up. Place a sleeve or brass bar on the inner race of the bearing and press the gear tight against the shoulder on the shaft (Fig. 7).
2. Lubricate the bearing with engine oil. Then, insert the drive shaft, gear and bearing assembly in the governor drive housing.
3. Install the bearing and sleeve on the driven gear, as follows:
   a. Lubricate the bearing with engine oil and start it, numbered end up, straight on the driven gear.

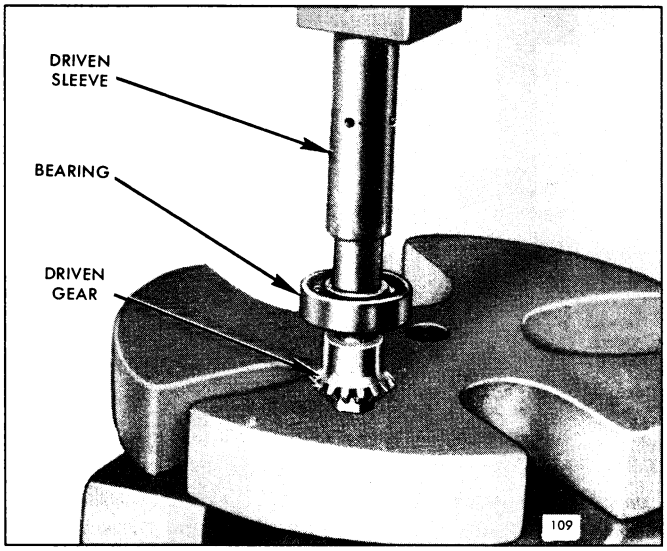


Fig. 8 - Installing Bearing and Sleeve on Driven Gear

   b. Lubricate the inner diameter of the sleeve with engine oil. Then, start the sleeve, splined end up, straight on the end of the driven gear.
   c. Place the driven gear, bearing and sleeve assembly on an arbor press, with a spacer under the gear to support the gear teeth above the bed of the press (Fig. 8). Then, press the sleeve and bearing tight against the shoulder on the gear.
4. Lubricate the bearing with engine oil. Then, insert the driven gear, bearing and sleeve assembly through the top of the governor drive housing and start the bearing straight into the bearing bore in the housing. Push the gear assembly down until the teeth of the drive and driven gears mesh (if necessary, rotate one of the gears slightly to align the gear teeth) and the bearing rests on the shoulder in the housing.
5. Install the snap ring in the groove in the housing next to the bearing. When installing the snap ring in its tapered groove in the hydraulic governor drive housing, be sure that the taper on the snap ring mates with the groove taper in the housing (Fig. 1).

   NOTICE: If the snap ring is not properly positioned in the groove, the bearing can work the snap ring and itself out of the drive assembly.
6. Rotate the drive and driven gears to check for freeness. The clearance between the gear teeth should be .001" to .003".

Install Governor Drive

1. Place a new gasket against the blower end plate. Then, with the splines of the governor drive shaft and the blower rotor shaft in alignment, insert the drive shaft into the rotor shaft and slide the governor drive housing on the dowels and against the blower end plate.

 © Detroit Diesel Corporation

2. Install the nine (9) attaching bolts and one nut, with ten (10) plain washers and ten (10) lock washers, to secure the drive housing to the blower end plate. Tighten the bolts and nut to 30-35 lb—ft (41-47 N#m) torque.

3. Install the blower and governor drive assembly on the engine (refer to Section 3.4).

4. Install the blower cover plate and air inlet housing.

Assemble Governor Linkage

CURRENT LINKAGE

1. Install the governor control housing on the blower cover plate, using a new gasket.

2. Connect the right and left bank fuel rods to the governor control operating levers (Fig. 2).

3. Connect the fuel rods to the injector control tube levers.

4. Install the connecting rod to the operating levers.

5. Install the vertical link to the left bank operating lever. Lubricate the end bearings with grease through the grease fittings.

6. Use a new gasket and install the control housing cover.

7. Install the governor (refer to Section 2.8.1).

FORMER LINKAGE

1. Attach the bell crank to the cylinder block with the shoulder bolt.

2. Connect the right and left bank fuel rods to the bell crank.

3. Connect the fuel rods to the injector control tube levers.

4. Connect the vertical link to the bell crank. Lubricate the end bearings with grease through the grease fittings.

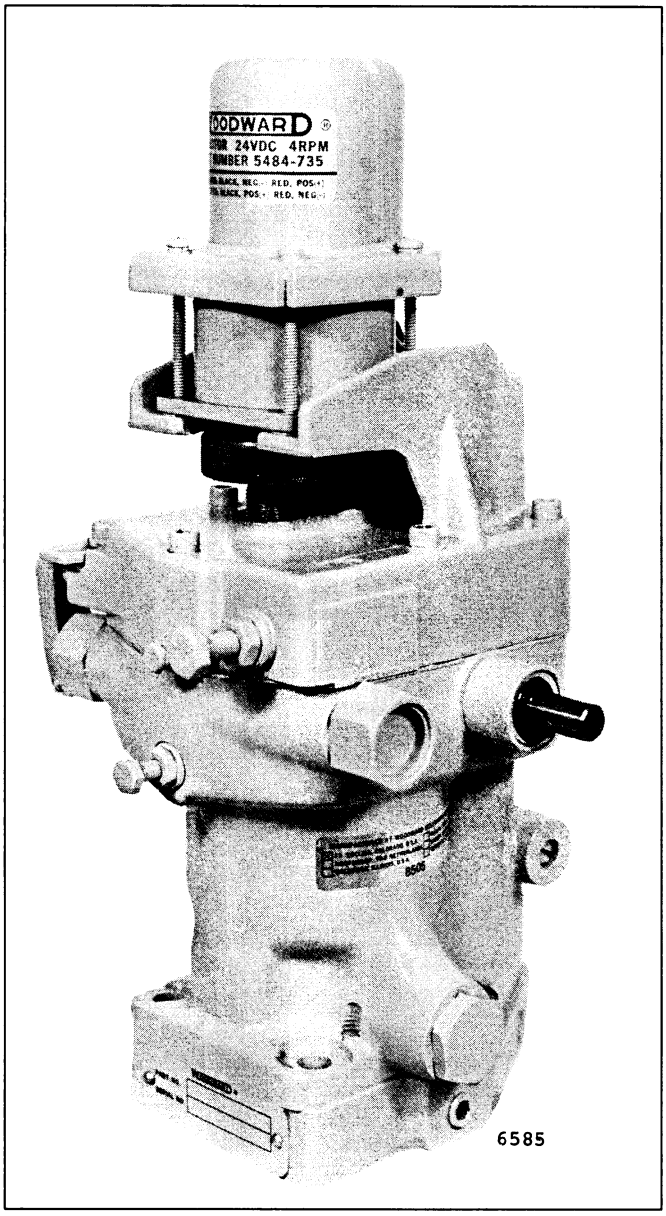
5. Position the adaptor plate, with a new gasket, on top of the engine front cover.

6. Slide the rubber boot over the vertical link and on the sleeve in the plate.

7. Install the governor (refer to Section 2.8.1).

Connect the throttle control linkage to the governor speed control lever. Refill the cooling system, if previously drained. Perform an engine tune-up as outlined in Section 14.7.2.

HYDRAULIC GOVERNOR SYNCHRONIZING MOTOR



• Fig. 1 - Woodward Synchronizing Motor Mounting

Some hydraulic governors are equipped with a reversible electric synchronizing motor mounted on the governor cover (Fig. 1). This motor, used in place of a vernier control knob, permits close adjustment of the engine speed from a remote control point. This feature is especially valuable when synchronizing two generators from a central control panel.

• Bodine motors (Fig. 2) are mounted horizontally on the governor covers and use a 90 degree offset drive connected through a reduction gear on the motor and a friction drive.

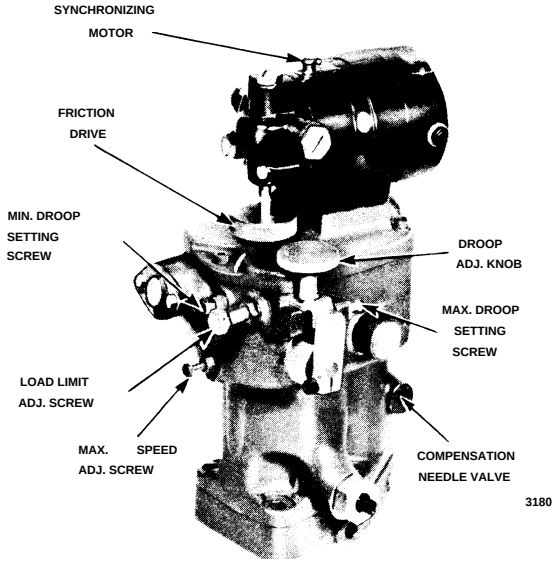


Fig. 2 - Bodine Synchronizing Motor Mounting

• Woodward motors (Fig. 1) are mounted vertically on the governor covers and connected to the governor speed adjusting shaft through a short gear train.

• A double pole, double throw switch is used to change the motor speed setting. Connect the switch to current motors as shown in Fig. 3.

Operation

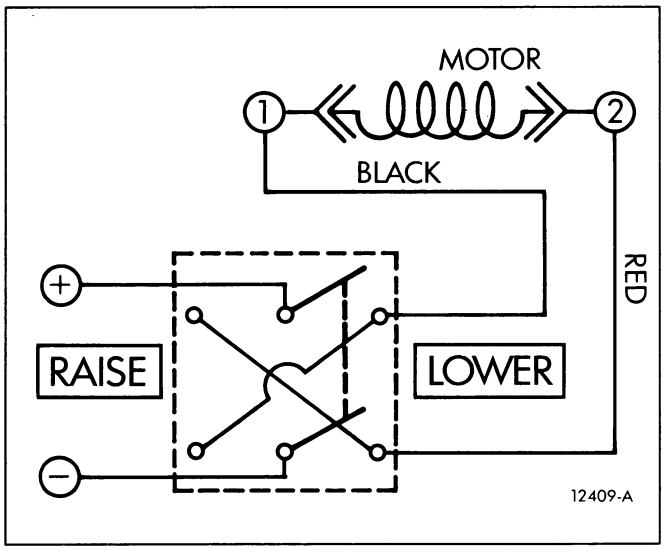
The synchronizing motor is used to change the engine speed when the unit is running alone, or to adjust the load when the unit is operating in parallel with other units. When the two-way control switch on the control panel is closed, the motor shaft turns the governor speed adjusting shaft by means of the reduction gear and friction drive. The direction of rotation (clockwise or counterclockwise) is dependent upon the position of the switch. When the desired engine speed is indicated on a tachometer or frequency meter on the control panel, the switch is returned to the ***off*** position by the operator.

If the switch is held in the ***lower*** speed position too long, the synchronizing motor will continue to lower the engine speed until it ultimately shuts the engine down. If the switch is held too long in the ***raise*** speed position, the motor will turn the governor speed adjusting shaft until it strikes the maximum speed adjusting screw, after which the friction drive will slip and the motor will continue to run at a slightly reduced speed without further effect.

Service

The synchronizing motor is constructed to render long satisfactory service. However, if the motor is damaged or fails to operate, replace the entire motor as an assembly.

The spring washer of the friction drive on the motor must be strong enough to permit the motor to carry the speed adjusting lever up against the maximum speed adjusting screw without slipping, yet it must be loose enough to slip after the lever contacts the screw.



• Fig. 3 – Synchronizing Motor Wiring Diagram

 © Detroit Diesel Corporation

FUEL INJECTOR **CONTROL** TUBE

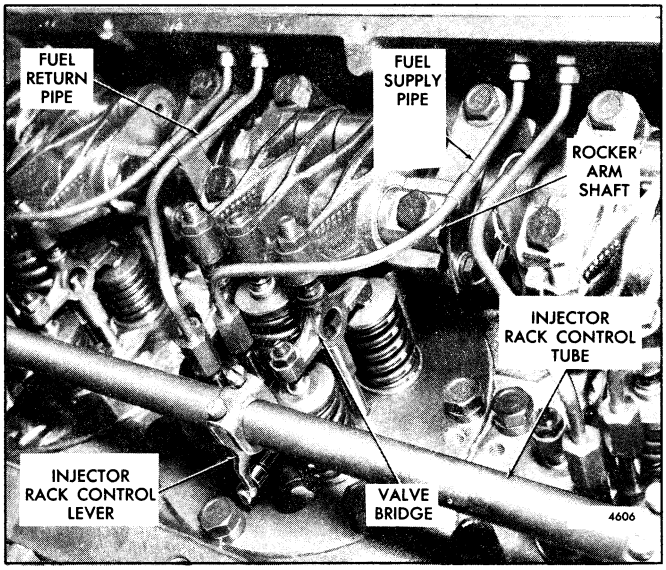


Fig. 1 - Injector Control Tube Mounting

The fuel injector control tube assemblies (Fig. 1) are mounted on the left and right bank of the cylinder block of the engine and consist of a control tube, injector rack control levers, a return spring and injector control tube lever mounted in two bracket and bearing assemblies attached to each bank of the cylinder block.

• The injector rack control levers connect with the fuel injector control racks and are held in position on the control tube with one adjusting screw (current engines) or two adjusting screws (early engines). The lever return spring enables the rack levers to return to the *no-fuel* position. Two separate control tubes on each bank are connected through a connecting link and control lever and operate as one unit. Engines with hydraulic or electronic governors use white and red-colored control tube return springs. Engines with mechanical governors use yellow and green control tube return springs. The injector control tube lever is pinned to the end of the control tube and connects with the fuel rod which connects with the engine governor. Refer to Section 14 for positioning of the injector rack control levers.

Current engines use spring-loaded injector control tube assemblies (Fig. 2) and they have a yield spring at each injector rack control lever and only one screw and locknut to keep each injector rack properly positioned. This enables an engine to be brought to a lesser or no-fuel position if there is an inoperative fuel injector rack whereas with the non-spring loaded two screw injector control tube (early engines) this could not be done. The above also permits the use of an air inlet housing with no emergency air shutoff valve as is required in some applications.

NOTICE: Do not replace the spring-loaded fuel injector control tube and lever assembly with the two screw design control tube assembly without including an air inlet housing that incorporates an emergency air shutoff valve. However, when the spring-loaded fuel injector control tube and lever assembly is installed on an engine and the emergency shutdown mechanism is removed from the air inlet housing, the shaft holes at each end of the housing must be plugged. Ream the shaft holes to .6290" and install a 5/8" cup plug at each end of the housing.

Engine shut down (normal or emergency) is accomplished on the spring-loaded fuel injector control tube (one screw design) by pulling the governor stop lever to the stop position. With the two screw design injector control tube and lever assembly, emergency engine shutdown is accomplished by tripping the air shutoff valve in the air inlet housing. Normal shut down is accomplished by pulling the governor stop lever to the stop position. Adjustment of the single screw and locknut on each injector rack control lever and the two screw design rack control lever are outlined in Section 14.

Remove Injector Control Tube

1. Remove the cotter pin and clevis pin connecting the fuel rod to the injector tube control lever.
2. Remove the two attaching bolts and lock washers at each bracket. Disengage the rack levers from the injector control racks and lift each control tube assembly from the cylinder block.

Disassemble And Assemble Injector Control Tube

The injector control tube assemblies are available as service assemblies. When any part of these assemblies need replacing, it is recommended the complete service assembly be replaced. Therefore, the disassembly and assembly procedure for the injector control tube assemblies are not included.

Install Injector Control Tubes

• 1. Install injector rack guard screens on 12V and 16V-149 engines.

NOTICE: Injector rack guard screens (Fig. 3) are used in place of cylinder block drain screens on all current 12V-149 and 16V-149 engines. Guard screens protect the injector control tube linkage passing through the front and rear block halves by preventing debris from wedging between the block and the injector control tube lever, jamming the racks. If racks are jammed at full-fuel, an overspeed condition and serious engine damage may result. ***Guard screens must be replaced if removed.***

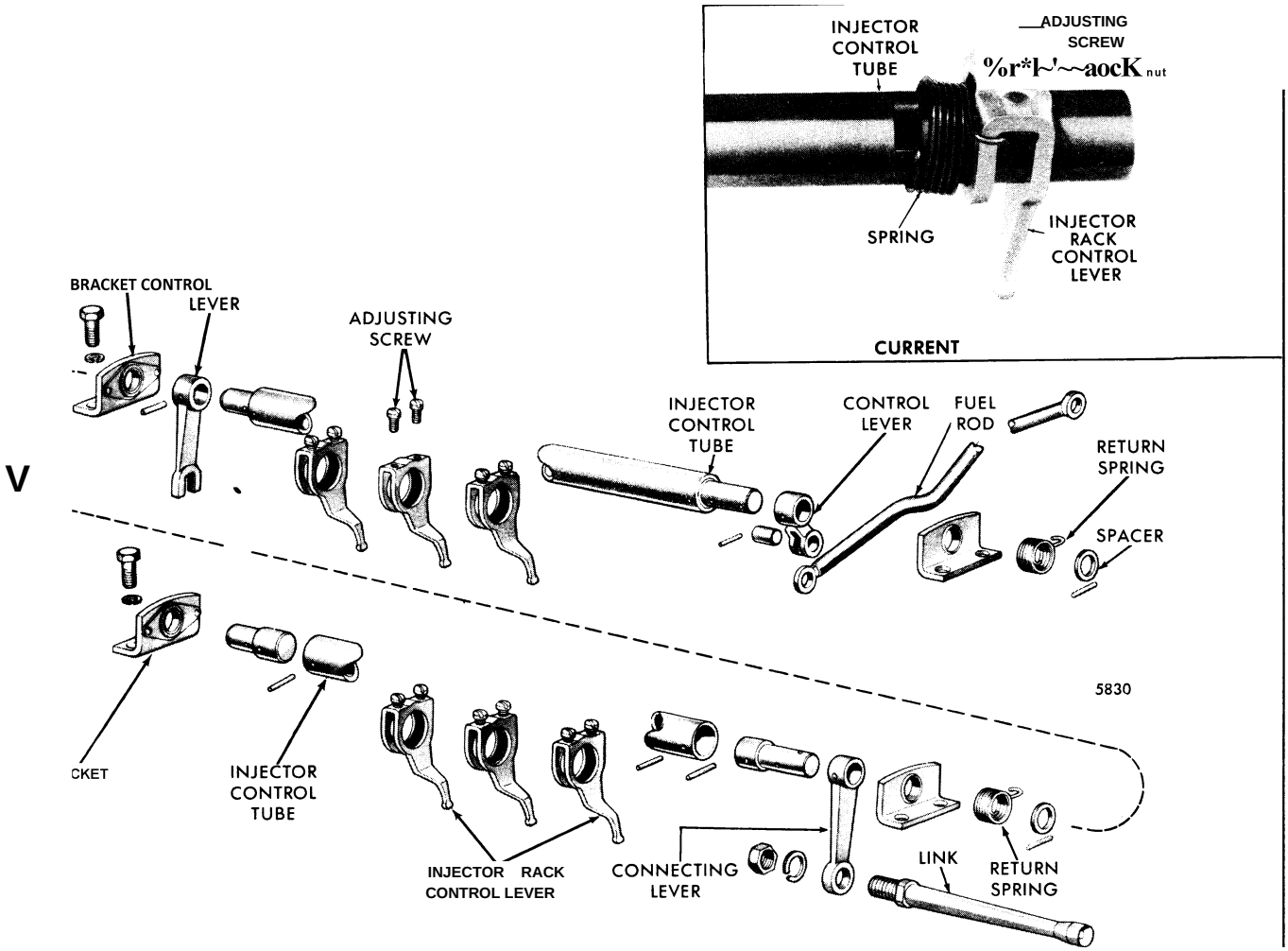


Fig. 2 - Injector Control Tube Details and Relative Location of Parts

2. Engage the injector rack control levers of the rear control tube assembly with the injector control racks and place the brackets over the mounting holes on the cylinder block.

3. Engage the injector rack control levers of the front control tube assembly with the injector control racks and the control lever engaging the connecting link in the rear control tube assembly and place the brackets over the mounting holes in the cylinder block.

4. Install the two 5/16”-18 x 3/4” bolts and lock washers at each bracket to attach the injector control tube assemblies to the cylinder block. Tighten the bolts to 13-17 lb—ft (18-23 N#m) torque.

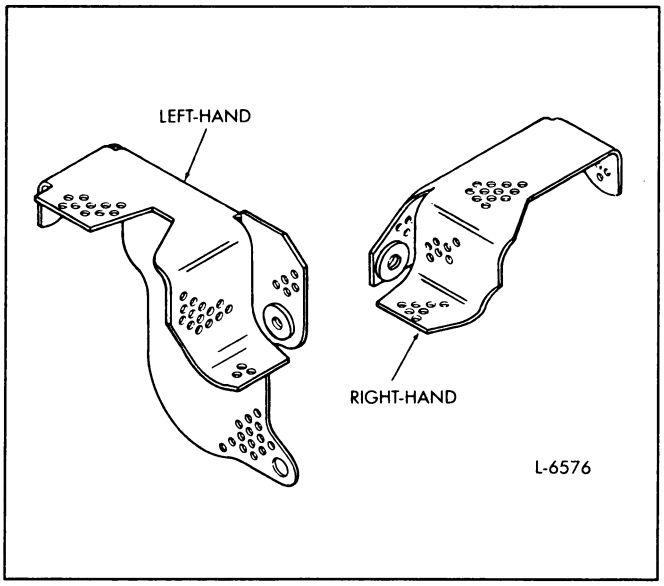
5. Check the control tubes to be sure they are free in the brackets. Tap the control tubes lightly to align the bearings in the brackets, if necessary.

6. Connect the fuel rod to the injector tube control lever with a clevis pin and a new cotter pin.

7. Refer to Section 14 and position the injector rack control levers. Be sure the injector rack control levers can be placed in a no-fuel position before restarting the engine.

CAUTION: Loss of shutdown control could result in a runaway engine which could cause personal injury.

 © Detroit Diesel Corporation



• Fig. 3 – Injector Rack Guard Screens

SHOP NOTES - TROUBLESHOOTING SPECIFICATIONS - SERVICE TOOLS

SHOP NOTES

INJECTOR TESTER J 23010-A

CAUTION: The fuel spray from an injector can penetrate the skin. Fuel oil which enters the blood stream can cause a serious infection. Therefore, follow instructions and use the proper equipment to test an injector.

Use injector test oil J 26400 in the injector tester.

Installing Fuel Injector In Tester

1. Select the proper clamping head (Fig. 1). Position it on the clamping post and tighten the thumb screw into the lower detent position (Fig. 2).

2. Connect the test oil delivery piping into the clamping head.

3. Connect the test oil clear discharge tubing onto the pipe on the clamping head.

4. Locate the adaptor plate on top of the support bracket by positioning the 3/8" diameter hole at the far right of the adaptor plate onto the 3/8" diameter dowel pin. This allows the adaptor plate to swing out for mounting the fuel injector.

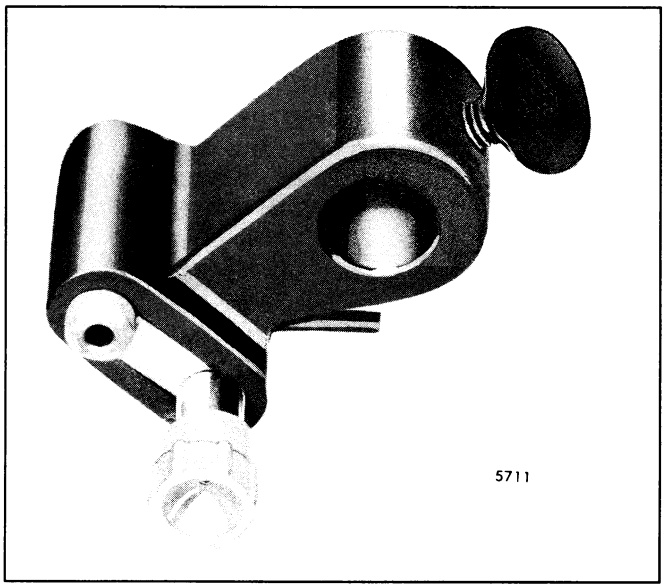


Fig. 1 - Injector Tester J 23010-A Clamping Head (J 23010-169)

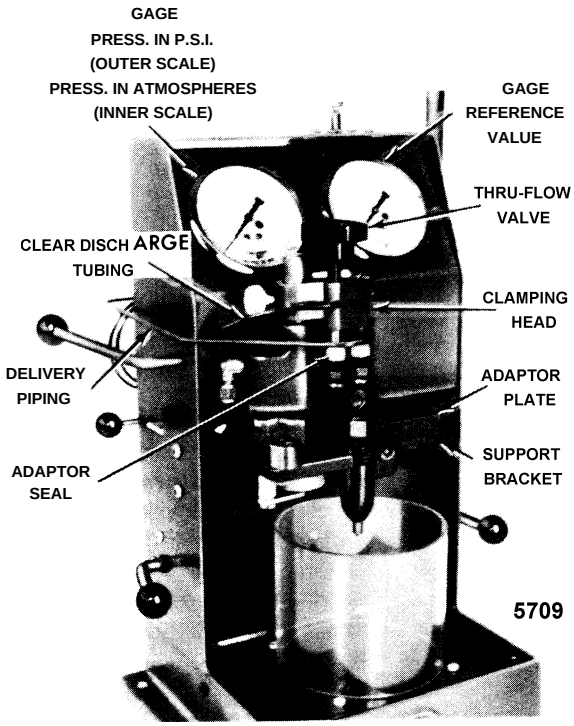


Fig. 2 - Injector Installed in Tester J 23010-A with Clamping Head

5. Mount the injector through the large hole and insert the injector pin in the proper locating pin hole (Fig. 1).

6. Swing the mounted injector and adaptor plate inward until they contact the stop pin at the rear of the support bracket.

Clamping The Fuel Injector

1. Refer to Fig. 3 and position the injector tester levers as follows:

   Lever 2 up and to the rear

   Lever 3 in the rear detent

   Lever 4 up (horizontal)

   Lever 5 up (horizontal)

2. Align the clamping head seals over the injector filter caps (Fig. 2).

3. Back off the Thru-Flow valve about half-way to allow the self-aligning fuel connector adaptors to seat properly during the clamping operation.

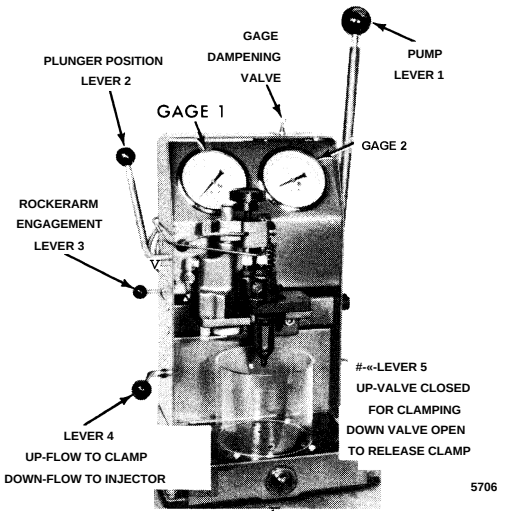


Fig. 3 - Injector in Position for Testing with J 23010-A

4. Hold the clamping head in position over the filter caps and, with the left hand, operate pump lever 1 evenly to move the clamping head *down* to seal the filter caps. The Thru-Flow valve should still turn freely. If it dows not, turn the valve counterclockwise until it rotates freely and reapply clamping pressure.

NOTICE: Excessive force on lever 1 during clamping can damage the seals in the valves operated by levers 4 and 5.

Purging Air From The System

Move lever 4 down and operate pump lever 1 to produce a test oil flow through the injector. When air bubbles no longer pass through the clear discharge tubing, the system is free of air and is now ready for testing.

Check the injector for leaks as follows:

1. Operate pump lever 1 until gage 1 slowly reaches 100-200 psi (689-1378 kPa). Check for injector nut seal ring leaks. Then, increase gage reading to 1500-2000 psi (10 335-13 780 kPa). Check for leaks at the filter cap gaskets and the body plugs.

2. Note the time for the pressure to drop from 1500 psi to 1000 psi (10 335 kPa to 6890 kPa). This should not occur in less than 7 seconds. This test determines if the body-to-bushing mating surfaces in the injector are sealing properly.

Injector Valve Opening Atomization And Spray Pattern Test

This test determines spray pattern uniformity and the relative pressure at which the valve opens and injection begins.

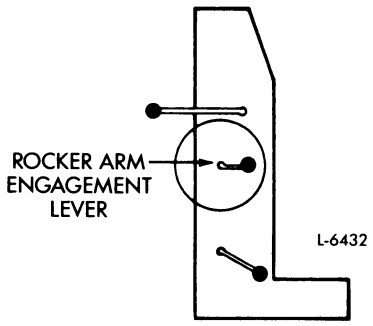


Fig. 4 - Position of Rocker Arm Engagement Lever

1. Position the injector rack in the *full-fuel* position.

2. Place pump lever in the *vertical* position.

3. Move the rocker arm engagement lever to the forward detent (Fig. 4).

4. Turn the gage damping valve knob (Fig. 3) clockwise to the *closed* position, then open the vlave slightly to control the rate of return of the gage hand. This valve is deleted on the current testers.

5. Operate the pump lever uniformly and observe the spray pattern produced.

Some experimentation may be necessary to determine the most effective rate at which the injector should be stroked. The correct rate is the one that produces the highest gage reading, too fast or too slow will give low readings.

The highest pressure indication will be reached just before injection ends. Use the following reference values to determine the relative acceptability of the injector (245 Min. - 265 Max.).

The reference values obtained when pop testing the needle valve injectors is to be used as a troubleshooting and diagnosis aid. This allows comparative testing of injectors without disassembly. Exact valve opening pressure values can only be determined by the needle valve tip test using the J 23010-A tester and tip tester adaptor on the J 22640 auxiliary tester.

Unclamping The Injector

1. Open the Thru-Flow valve to release pressure in the system.

2. Move lever 5 *down* to release the clamping pressure.

3. Swing out the adaptor plate and remove the injector after the nylon seals in the clamping head are free and clear of the injector filter caps.

4. Carefully, return lever 5 to the *up (horizontal)* position.

 © Detroit Diesel Corporation

CHECKING INJECTOR TESTER J 23010-A

The injector tester J 23010-A should be checked monthly to be sure that it is operating properly. The following check can be made very quickly using a test block.

Fill the supply tank in the injector tester with clean injector test oil J 26400. Open the valve in the fuel supply line. Place the test block on the injector locating plate and secure the block in place with the fuel inlet connector clamp. Operate the pump handle until all of the air is out of the test block, then clamp the fuel outlet connector onto the test block. Break the connection at the gage and operate the pump handle until all of the air bubbles in the fuel system disappear. Tighten the connection at the gage. Operate the pump handle to pressurize the tester fuel system to 2400-2500 psi (16 536-17 225 kPa.) Close the valve on the fuel supply line. After a slight initial drop, the pressure should remain steady. This indicates that the injector tester is operating properly. Open the fuel valve and remove the test block.

If there is a leak in the tester fuel system, it will be indicated by a drop in pressure. The leak must be located, corrected and the tester rechecked before checking an injector.

Occasionally, dirt will get into the pump check valve in the tester, resulting in internal pump valve leakage and the inability to build up pressure in the tester fuel system. Pump valve leakage must be corrected before an injector can be properly tested.

When the above occurs, loosen the fuel inlet connector clamp and operate the tester pump handle in an attempt to purge the dirt from the pump check valve. A few quick strokes of the pump handle will usually correct a dirt condition. The pump check valve in J 23010-A must be replaced.

If an injector tester supply or gage line is damaged or broken, install a new replacement line (available from the tester manufacturer). Do not shorten the old lines or the volume of test oil will be altered sufficiently to give an inaccurate valve holding pressure test.

If it is suspected that the lines have been altered, i.e. by shortening or replacing with a longer line, check the accuracy of the tester with a master injector on which the pressure holding time is known. If the pressure holding time does not agree with that recorded for the master injector, replace the lines.

INJECTOR SPRAY TIP TESTER (J 22640-A)

Valve Opening, Spray Pattern and Atomization.

1. Operate the pump handle until a clear flow of test oil is obtained at the tip mounting pedestal.
2. Place the tip assembly, valve spring with cage and check valve cage on top of the pedestal. Tighten the injector nut (Fig. 5).

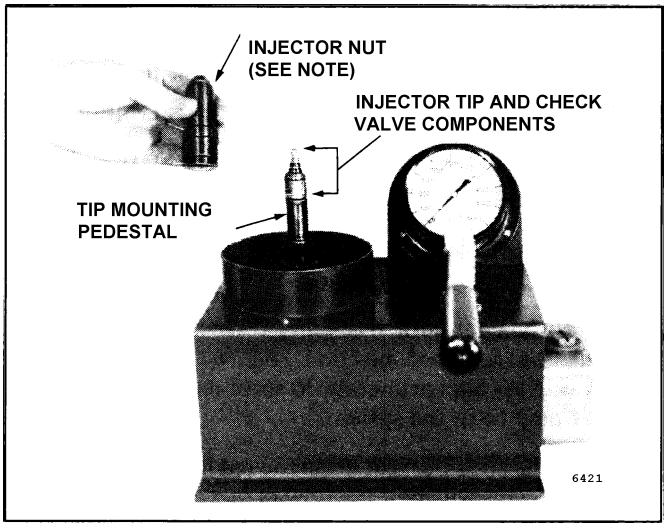


Fig. 5 - Installing Injector Nut

3. Place the shield on the tester and operate the pump handle until the needle valve has opened several times to purge air from the system (Fig. 6).

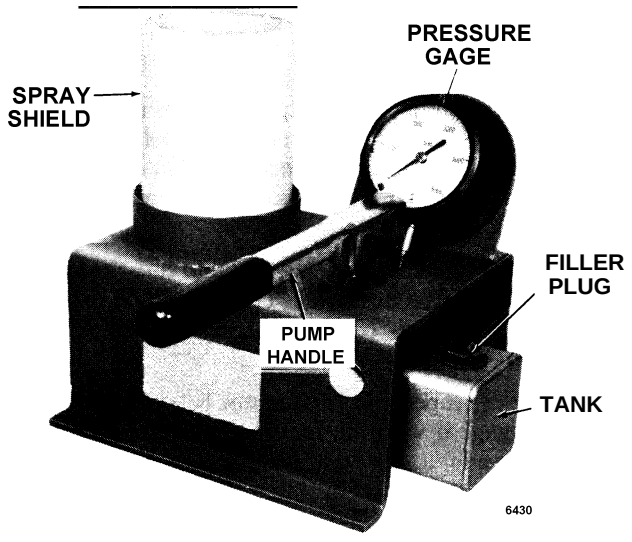


Fig. 6 - Tester J 22640-A with Shield Installed

CAUTION: Do not operate the tester without the shield. The fuel spray can penetrate the skin. Fuel oil which enters the blood stream can cause a serious infection. Therefore, follow instructions and use the proper equipment to test an injector.

4. Operate the pump lever rapidly with smooth even strokes (40 strokes per minute) simulating the action of the tip functioning in the engine. Note the pressure at which the test oil delivery occurs. Test oil delivery should occur between 2200 and 3300 psi (15 158 and 22 737 kPa). When using the high V.O.P. spring, the oil delivery will occur at 2900-3900 psi (19 981-26 871 kPa). The beginning and ending of delivery should be sharp and the test oil should be a finely atomized spray.

If the valve opening pressure is below the minimum specified limits or atomization is poor, the cause is usually a weak valve spring or poor needle valve seat.

If the valve opening pressure is within specified limits, proceed to check for spray tip leakage as follows:

When testing for spray tip leakage, be sure to use the proper spring for the valve tip being tested.

a. Actuate the pump lever several times and hold the pressure at 1500 psi (10 335 kPa) for 15 seconds.

b. Inspect the spray tip for leakage. There should be no fuel droplets, although a slight wetting at the spray tip is permissable.

Field Modification Kit (J 22640-51) consists of a pump and reservoir with hardware which is used to convert auxiliary tester J 22640 to J 22640-A. Tester J 22640 was previously connected to the pump of the pop stand.

INJECTOR SPRAY TIPS

Due to a slight variation in the size of the small orifices in the end of each spray tip, the fuel output of an injector may be varied by replacing the spray tip.

Flow gage J 25600 may be used to select a spray tip that will increase or decrease fuel injector output for a particular injector after it has been rebuilt and tested on the calibrator.

Field Modification Kit (J 25600-103) upgrades plunger and bushing/tip flow gage J 25600 to J 25600-A. A newly designed spray tip receiver/holder is included with the kit along with instruction decals to be applied to the tester. This kit greatly upgrades the function of J 25600 by improving operation and repeatability.

CHECK INJECTOR OUTPUT

Perform the injector fuel output test in calibrator J 22410-A (Fig. 7).

1. Before testing injector output, be sure calibrator test oil is supplied to the injector fitting located over the rack. To change the flow from the calibrator, exchange the positions of the braided and the clear fuel lines (Fig. 8).

2. Place the cam shaft index wheel and fuel flow lever in their respective positions. Turn on the test fuel oil heater switch to preheat the test oil to 95-105°F (35-40°C).

3. Place the proper injector adaptor between the tie rods and engage it with the fuel block locating pin. Then, slide the adaptor forward and up against the fuel block face.

4. Place the injector seat J 22410-226 into the permanent seat (cradle handle in the ***vertical*** position). Clamp the injector into position by operating the injector clamp-up valve.

Set the counter (Fig. 9) at the appropriate number of strokes, 500 or 1,000. If for any reason this setting has been altered, reset the counter for the correct number of strokes. Calibrators with Serial No. 1175 or lower were manufactured as 1,000 stroke machines, but may have been converted to 500 stroke machines with a conversion kit (J 22410-516). Refer to the calibrator instruction manual for information on setting the counter and any additional information required.

5. Pull the injector rack out to the ***no-fuel*** position.

6. Turn on the main power control circuit (vial light) switch. Then, start the calibrator by turning on the motor starter switch. The low oil pressure warning buzzer will sound briefly until the lubricating oil reaches the proper pressure.

7. After the calibrator has started, set the injector rack into the ***full-fuel*** position. Allow the injector to operate for approximately 30 seconds to purge the air that may be in the system.

8. After the air is purged, press the red button on the test switch. This will start the flow of fuel into the vial. The fuel flow to the vial will automatically stop after the correct number of preset strokes are counted.

 © Detroit Diesel Corporation

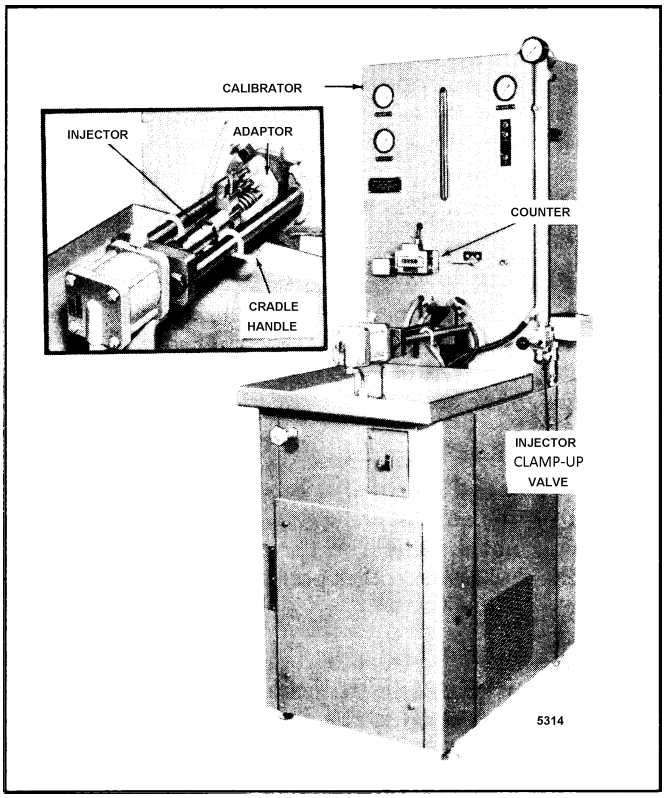


Fig. 7 - Injector in Calibrator J 22410-A

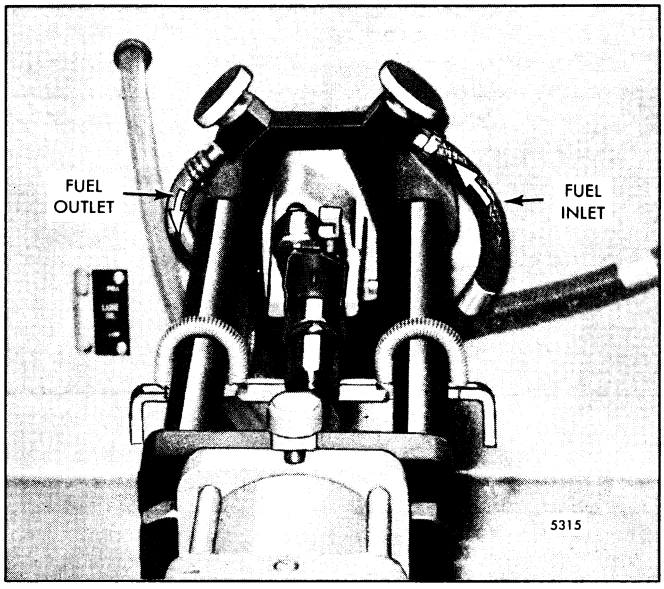


Fig. 8 - Position of Calibrator Fuel Flow Pipes

9. Shut the calibrator off when two consecutive tests show the same output. Usually, 3 tests are sufficient.

10. Observe the vial readings and refer to Table 1 to determine whether the injector fuel output falls within the specified limits. If the quantity of fuel in the vial does not fall within the specified limits, refer to

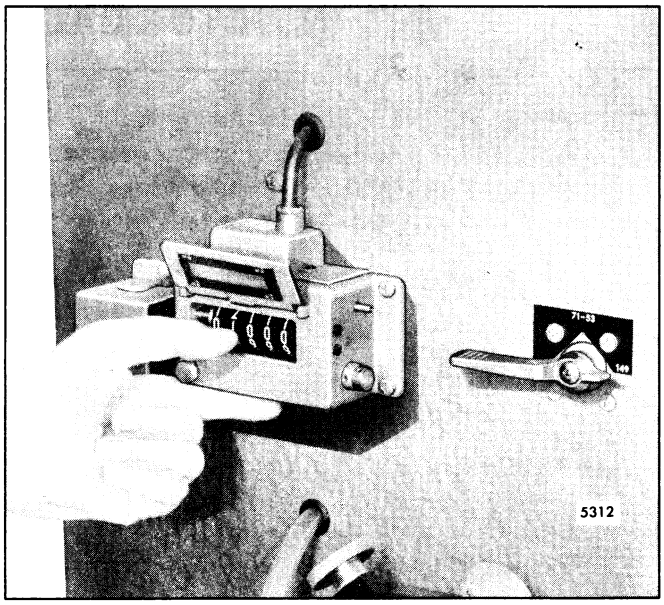


Fig. 9 - Setting Calibrator Stroke Counter

INJECTOR	FUEL OUTPUT MIN.	MAX.
120	118	126
130	138	146
140	150	158
145#	166	174
150	168	176
155	173	181
160	184	188
165	184	192
170	187	197
180	195	205
185	202	212
190*	210	217
195	222	234
230	219	233
240	230	242
270	262	268
6810	282	296
7110*	210	224

 # Rack Stamped 145A
*** Do not mix 190 and 7110 injectors in the same engine.**

• TABLE 1

Troubleshooting Chart 6 for the cause and remed;
See *Injector Calibrator Readings* for different facto
that may affect the injector calibrator output readin

The calibrator may be used to check and select a set injectors which will inject the same amount of fuel in ea< cylinder at a given throttle setting, thus resulting in a smoo running, well balanced engine.

An injector which passes all of the above tests may put back into service. However, an injector which fails pass one or more of the tests must be rebuilt and checked the calibrator.

Any injector which is disassembled and rebuilt must tested again before being placed in service.

MASTER INJECTOR CALIBRATING KIT

Use Master Injector Calibrating Kit J 26298 or J 34998 to determine the accuracy of the injector calibrator.

With the test fluid temperature at 100°F ± 1°F (38°C + 1°C) and each injector warm after several test cycles, run the three injectors contained in the kit. Several readings should be taken with each injector to check for accuracy and repeatability. If the output readings are within two (2) of the values assigned to the calibrated masters, the calibrator can be considered accurate. Injector testing can be carried out now without any adjustment of figures. However, when testing new injectors for output, any difference between the calibrator and the masters should be used to compute new injector calibration. If more than a 2 cm variation from the masters is noted, consult the calibrator manufacturer for possible causes.

The calibrated masters should only be used to qualify injector output calibration test equipment.

PLUNGER/BUSHING AND TIP FLOW GAGE

The injector fuel output is largely dependent upon the combined output of its plunger/bushing and spray tip assemblies. To assist in the rebuilding of fuel injectors that will calibrate within specified limits, it is desirable to preselect and match plunger/bushings and tips according to their output prior to assembly into the injector.

The J 25600-A Plunger/Bushing and Tip Flow Tester, using low pressure air, has the capabilities to measure the output of plunger/ bushing and spray tip assemblies. The flow (output) of the spray tip can be correlated to high pressure fuel flow during calibration however, used spray tips because of the worn condition of their spray holes will often flow higher then indicated on a low pressure air tester.

Records should be maintained which indicate the output values of both plunger/bushing and spray tip assemblies being matched with resultent calibration in order to develop a useful matching chart.

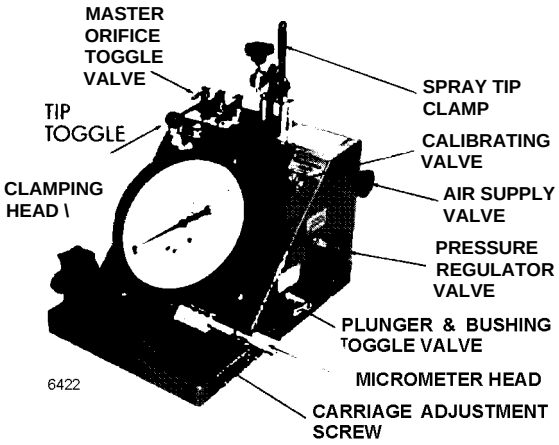


Fig. 12 - Plunger/Bushing and Tip Flow Gage J 25600-A

Installation

Place the flow gage unit in a clean well lighted area that has an air supply of 40 psi (276 kPa), but not more not more than 100 psi (1034 kPa). Turn off the air supply valve (on the rear of the flow

gage) and connect your air line. Familiarize yourself with the various components on the unit (Fig. 12).

Regulated Pressure Adjustment

1. Set all toggle valves in the *closed* position (Fig. 12).
2. Open the calibrating valve approximately 4 turns.

   NOTICE: DO NOT use this valve as an air shutoff. Tight closing of this valve may result in valve seat damage.

3. Turn the pressure regulator knob in a counterclockwise direction until it spins freely.
4. Open the air supply valve approximately 3 turns. The pressure regulator is a constant bleed type (.04 cubic feet per minute), the air supply valve is provided as a convenient shutoff to avoid compressed air waste when the flow gage is not in use.
5. Adjust the pressure regulator by rotating the knob in a clockwise direction until the gage needle is aligned exactly on the regulated pressure mark.

Calibration To Master Orifice

When no air is leaking through a master orifice, injector tip or plunger/bushing, the gage needle will go to the regulated pressure mark. The master orifices (A, B and C) are provided as controlled air leak passages. Flow tests are conducted comparing an injector tip or a plunger/bushing, to an air leak through a master orifice.

1. Be sure all toggle valves are in the off position. The gage needle will be at the regulated pressure mark.
2. Open master orifice valve C. The gage needle will move away from the regulated pressure mark.
3. Adjust the calibrating valve, so that the gage needle is exactly at the “set line” (Fig. 13).

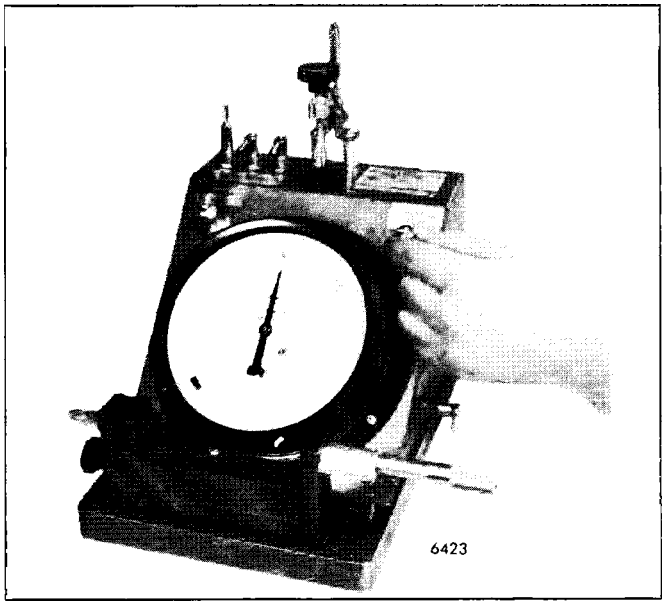


Fig. 13 - Adjusting the Calibrating Valve

4. Close the master orifice toggle valve (needle will return to the regulated pressure mark).
5. You are now ready to perform a flow measurement.

Measuring Spray Tip Flow

1. Clean all spray tips thoroughly (correct flow rate is dependent on a clean spray tip).
2. Observe the number and size of the spray tip holes marked on the narrow end of the spray tip and calibrate to orifice C. Refer to the Chart for the flow values.

TIP STAMP	NOMINAL VALUE FLOW	MASTER ORIFICE CALIBRATION
6-.012	85	
7-.0095	50	C
7-.010	50	

3. Remove the needle valve, if installed, and clamp the spray tip on the unit (Fig. 14).
4. Open the tip toggle valve and observe the gage reading.
5. The tip can now be compared to the specification sheet and sorted into groups; high, low, mean, etc.

Plunger/Bushing Effective Stroke Measurement

The objective of flowing plunger/bushing assemblies is to measure the effective stroke (port closing to opening), in thousandths of an inch. To find the closing and opening

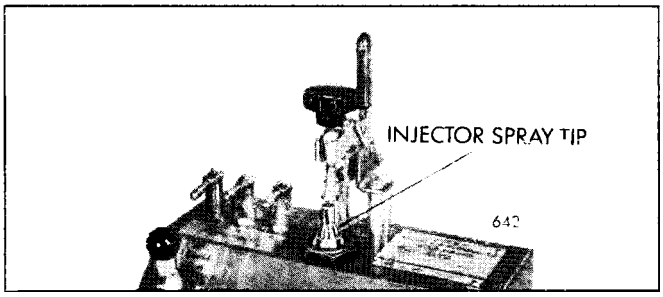


Fig. 14 - Spray Tip Installed in Tester

points a controlled air leak is required (‘.‘C” master orifice is used as reference). When the plunger is moved close to the port *closed* position, the gage needle will be at the set line. At this position, the air leaking out the bushing port matches the air that would leak out the “C” orifice.

As the plunger is moved inward, the leak stops and the gage needle goes to the regulated pressure mark. When the plunger is moved further, air begins to leak again. The gage needle moves away from the regulated pressure mark and moves toward the set line. When the plunger is moved far enough to read the effective stroke, the gage needle will be at the set line again. The distance the plunger has moved as indicated on the micrometer, is the effective stroke. This stroke is measured while the plunger/ bushing is held in the *full-fuel* position.

1. Select the proper cradle for the plunger/bushing to be tested and mount on the fixture (Fig. 15).
2. Calibrate to the “C” orifice, see “Calibration to Master Orifice”. All plunger/bushing tests use the “C” orifice as reference.
3. Close all toggle valves, gage needle will be at the regulated pressure mark.
4. Adjust the micrometer to zero reading (all zeros).
5. Place the plunger/bushing in the cradle. Be sure the plunger flat and locating pin or slot is properly positioned (Fig. 15). To check in *full-fuel* position, rotate bushing until the bushing pin contacts the rear locating surface.

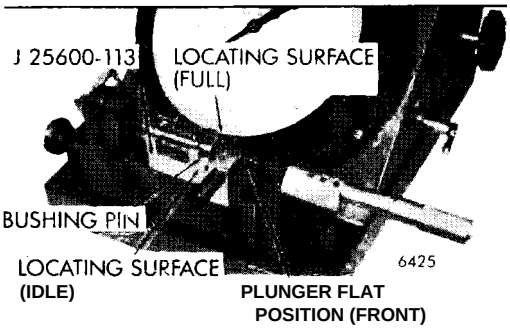


Fig. 15 Cradle Mounted on Fixture

 © Detroit Diesel Corporation

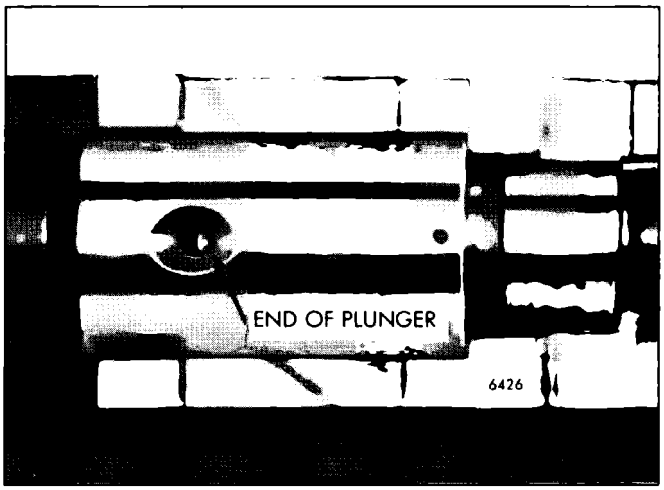


Fig. 1 6 - End of Plunger Shown in Port

6. Adjust spring loaded buttom until enough force is exerted on the plunger flat to hold the plunger steady, but not enough to restrict sliding movement when air pressure is applied.

7. Hold the plunger against the micrometer and rotate the carriage adjustment screw until the plunger almost closes the port (Fig. 16).

8. Open the plunger and bushing toggle valve.

9. If the plunger has not closed the port far enough, an air leak will be heard and the gage needle will be left of the set line. If it has closed the port too far, it will be to the right of the set line, toward or at the regulated pressure mark.

10. Turn the carriage adjustment screw until the gage needle is at approximately 20.

11. Turn the carriage adjustment screw clockwise very slowly until the gage needle is exactly at the set line. Always adjust in this manner, with the needle moving from approximately 20 to the set line.

12. Turn the micrometer thimble clockwise. The gage needle will move toward, and go to the regulated pressure mark. Very little air will be heard leaking.

13. Continue turning clockwise until the gage needle begins to move away from the regulated pressure mark (air from the bushing will again be heard leaking). Turn very slowly until the gage needle reaches the set line.

14. Observe and record the micrometer reading. The number shown is the effective stroke in thousandths of an inch.

15. Turn the micrometer back to zero. Gage needle should return to or very near the set line.

16. Turn off the plunger /bushing test toggle valve.

17. Loosen the clamping knob and remove the plunger /bushing.

18. Only minor carriage adjustment will be required for other plunger/bushing of the same type.

19. Chart the stroke readings and compare to the specifications. Sort into groups, high strokes, low strokes and mean strokes.

REFINISH LAPPING BLOCKS

As the continued use of the lapping blocks will cause worn or low spots to develop in their lapping surfaces, they should be refmished from time to time.

It is good practice, where considerable lapping work is done, to devote some time each day to refinishing the blocks. The quality of the finished work depends to a great degree on the condition of the lapping surfaces of the blocks.

To refinish the blocks, spread some 600 grit lapping powder of good quality on one of the blocks. Place another block on top of this one and work the blocks together (Fig. 17). Alternate the blocks from time to time. For example, assuming the blocks are numbered 1,2 and 3, work 1 and 2 together, then 1 and 3, and finish by working 2 and 3 together. Continue this procedure until all of the blocks are perfectly flat and free of imperfections.

Imperfections are evident when the blocks are clean and held under a strong light. The blocks are satisfactory



Fig. 1 7 - Refinishing Lapping Blocks

when the entire surface is a solid dark grey. Bright or exceptionally dark spots indicate defects and additional lapping is required.

After the surfaces have been finished, remove the powder by rinsing the lapping blocks in trichloroethylene and scrubbing with a bristle brush.

When not in use, protect the lapping blocks against damage and dust by storing them in a close fitting wooden container.

EFFECT OF PREIGNIT N ON FUEL INJECTOR

Preignition is due to ignition of fuel or lubricating oil in the combustion chamber before the normal injection period. The piston compresses the burning mixture to excessive temperatures and pressures and may eventually cause burning of the injector spray tip and lead to failure of the injectors in other cylinders.

When preignition occurs, remove all of the injectors and check for burned spray tips or enlarged spray tip orifices.

Before replacing the injectors, check the engine for the cause of preignition to avoid recurrence of the problem. Check for oil pull-over from the oil bath air cleaner, damaged blower housing gasket, defective blower oil seals, high crankcase pressure, plugged air box drains, ineffective oil control rings or dilution of the lubricating oil.

INJECTOR TIMING

If it is suspected that a fuel injector is “out of time”, the injector rack-to-gear timing may be checked without disassembling the injector.

A hole located in the injector body, on the side opposite the identification tag, may be used to visually determine whether or not the injector rack and gear are correctly timed. When the rack is all the way in *(full-fuel* position), the flat side of the plunger will be visible in the hole, indicating that the injector is “in time”. If the flat side of the plunger does not come into full view (Fig. 18) and appears in the “advanced” or “retarded” position, disassemble the injector and correct the rack-to-gear timing.

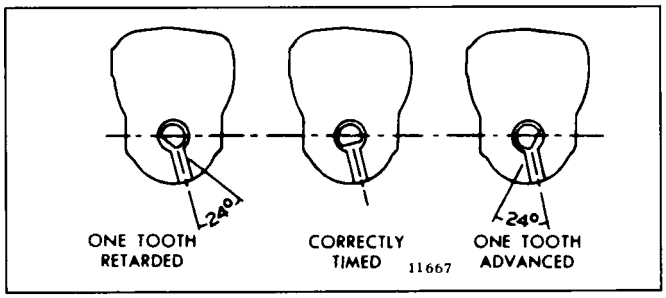


Fig. 18 – Injector Rack–to–Gear Timing

FUEL LINES

Flexible fuel lines are used to facilitate connection of lines leading to and from the fuel tank, and to minimize the effects of any vibration in the installation.

Be sure a restricted fitting of the proper size is used to connect the fuel return line to the fuel return manifold. Do not use restricted fittings anywhere else in the fuel system.

When installing fuel lines, it is recommended that connections be tightened only sufficiently to prevent leakage of fuel; thus, flared ends of the fuel lines will not become twisted or fractured because of excessive tightening. After all fuel lines are installed, run the engine long enough to determine whether or not all connections are sufficiently tight. If any leaks occur, tighten the connections only enough to stop the leak. Also, check the filter cover bolts for tightness.

LOCATING AIR LEAKS IN FUEL LINES

Air drawn into the fuel system may result in uneven running of the engine, stalling when idling, or a loss of power. Poor engine operation is particularly noticeable at the lower engine speeds. An opening in the fuel suction lines may be too small for fuel to pass through but may allow appreciable quantities of air to enter.

Check for loose or faulty connections. Also, check for improper fuel line connections such as a fuel pump suction line connected to the short fuel return line in the fuel tank which would cause the pump to draw air.

Presence of an air leak may be detected by observing the fuel filter contents after the filter is bled and the engine is operated for fifteen (15) to twenty (20) minutes at a fairly high speed. No leak is indicated if the filter shell is full when loosened from its cover. If the filter shell is only partly full, an air leak is indicated.

 © Detroit Diesel Corporation

PRESSURIZE FUEL SYSTEM - CHECK FOR LEAKS

Always, check the fuel system for leaks after injector or fuel pipe replacement and any time the fuel connections under the rocker cover are suspected of leaking. Failure to correct a serious fuel leak in this area can lead to dilution of the lube oil and bearing and/or cylinder kit damage.

Prime And Purge

Prime and/or purge the engine fuel system before starting the fuel leak check. *Prime* the system by blocking or disconnecting the line from the fuel pump, then apply fuel under pressure (60-80 psi or 413-552 kPa) to the inlet of the secondary filter. If the system is to be *purged* of air as well, allow the fuel to flow freely from the fuel return line until a solid stream without air bubbles is observed.

Check For Leaks

Use one of the following methods to check for leaks.

Method 1. Use when the engine has been operating 20-30 minutes.

After operating the engine, shut it off and remove the rocker covers. Inspect the lube oil puddles that normally form where the fuel connectors join the cylinder head and where the fuel pipes join the fuel pipe nuts.

If there is any leakage at these connections, the lube oil puddles will be smaller or thinner than the puddles on the connectors that are not leaking. Disassemble, inspect and correct or replace the suspect part (connector washer, connector, injector or jumper line). Test and reinspect.

Method 2. Use when the engine is not operating, such as during or after repairs.

Remove the rocker covers. Pour lube oil over all fuel pipes and connectors which would normally be splashed with oil during engine operation. This will cause oil puddles to form at the joining surfaces as mentioned in Method 1. Block off the fuel return line and disconnect the fuel pump supply line at the secondary filter. Install a pressure gage in the filter adaptor, then apply 60-80 psi (413-552 kPa)fuel to the outlet side of the secondary filter with the inlets plugged. Severe leaks will show up immediately. Minor leaks caused by nicks or burrs on sealing surfaces will take longer to appear. After maintaining 40-80 psi (276-552 kPa) for 20 to 30 minutes, a careful puddle inspection should reveal any suspect connectors. Inspect and repair or replace connectors as necessary. Test and reinspect.

Method 3. Use while the engine is operating at 400-600 rpm.

Apply an outside fuel source capable of 60-80 psi (413-552 kPa) to the outlet side of the secondary filter. Pour lube oil over jumper lines and connectors so that oil puddles form where lines and connectors meet. Install a valve and a pressure gage in the fuel return line. With the engine idling, close the valve enough to raise the engine fuel pressure to 70 psi (483 kPa). After ten to twenty minutes inspect the oil puddles to see if any have become smaller or run off completely. The undiluted oil will hang the same as when the oil was poured on. Repair and retest.

> **NOTICE:** With the engine at rest, as in Method 2 all injectors will leak to some extent when pressurized. The leakage occurs because there is no place else for the pressurized fuel to go. When the low and high pressure cavities in the injector are subjected to the high test pressure, fuel is forced past the plunger into the rack and gear cavity. Result: Droplets of fuel form at the rack and drip off.

Slightly worn plungers may leak more under these conditions. This leakage will not occur while the engine is running because of the dynamic and pressure conditions that exists.

If injectors are suspected of leaking and contributing to dilution of the lube oil, they should not be tested by pressurizing the fuel system as in Method 2. Injectors should be removed from the engine and tested for pressure-holding capability (see Section 2).

Points To Remember

Lube oil puddle inspection is the key to pressure testing the fuel system for internal leaks. This test can be performed any time the rocker covers are removed, after the fuel pipes and connectors have been splashed with oil and there is normal fuel pressure in the system. The weak or missing puddles show where the leaks are.

All leakage or spilage of fuel during leak detection testing further dilutes the lube oil, so the final step in maintenance of this type should include lube oil and lube oil filter changes.

DETECTING INTERNAL FUEL LEAKS

Used lube oil analysis often identifies a potential source of engine trouble before it occurs. One of the most serious conditions this test can uncover is the presence of excessive fuel in the lubricating oil. Inadequate bearing surface lubrication caused by lube oil dilution is a potential cause of engine malfunction and damage.

While used lube oil analysis can indicate the presence of fuel in engine lubricating oil, other methods must be used to determine its source. Two particularly effective methods involve the use of dye additives.

Red LTO 1140 Dye

The use of Red LTO 1140 dye (a product of Chemserve Corporation, 9505 Copland Ave., Detroit, MI 48209) is effective when bench pressure-testing complete cylinder head assemblies or when pressure testing head assemblies on new or newly overhauled *operating* engines which have *new, clean lubricating oil.* The red dye is most visible when clean lube oil is used. Prepare the dye as follows:

Mix two (2) ounces (59 ml) of Red LTO 1140 dye with fine (5) gallons (18.93 liters) of clean No. 1 or No. 2 diesel fuel in a clean container. The container should be marked "Test Fuel" to prevent accidental use and be resealable to prevent contamination when not in use.

Bench Testing

1. To bench test a complete cylinder head assembly, fill a fuel system priming pump (J 5956 or equivalent) with the red dye/fuel mixture.

2. Connect the outlet hose of the priming pump to the fuel inlet manifold. Connect a drain hose from the fuel outlet back to the test fuel container. Make sure that the required restricted fitting is installed in the fuel outlet. This will allow sufficient fluid pressure to build up.

3. Prime the cylinder head fuel system and check for leaks. The test fuel will show up as bright red.

4. Eliminate the cause of any leaks discovered. Wipe off the head components and retest until no further leaks occur.

Running Test

1. To pressure test the cylinder head on a new or newly overhauled engine, isolate the fuel system so that the fuel supply and return lines are connected only to the test container.

2. Start and run the engine on the test fuel at maximum no-load speed for approximately five minutes to bring it to operating temperature. Periodically check the level in the test fuel container to ensure an adequate supply. If necessary, replenish the test fuel by adding one ounce (30 ml) of Red LTO 1140 dye to each 2.5 gallons (9.463 liters) of make-up fuel. Three to five engines can normally be tested before replenishing the fuel.

3. Stop the engine and remove the rocker covers. Check the cylinder head and all fuel connections for any sign of fuel leakage. The test fuel will show up as bright red.

4. If any leaks are discovered, eliminate their cause. Wipe all head surfaces and fuel connections clean, then start the engine and retest.

5. When all leaks have been eliminated, replace the rocker covers, reinstall the original fuel lines and connect the engine to its normal fuel source. It is not necessary to change the fuel filter or strainer. Start and run the engine to purge any air from the system.

J 28431 Fluorescent Dye

The use of J 28431 fluorescent dye and a "black light" (ultraviolet light) is preferable when testing an engine that has been in service and has dark lubricating oil (from engine operation). Use the following procedure:

1. Mix four (4) ounces (11 ml) of fluorescent dye additive J 28431 with four (4) gallons (15.14 liters) of clean No. 1 or No. 2 diesel fuel in a clean container. The container should be marked "Test Fuel" to prevent its accidental usage and be resealable to prevent contamination when not in use.

2. Isolate the engine fuel system so that the supply and return lines are connected only to the test fuel container.

3. Start and run the engine on the test fuel at maximum no-load speed for approximately five minutes to bring it to operating temperature. Periodically, check the level in the test fuel container to ensure an adequate supply. If necessary, replenish the test fuel by adding one ounce (30 ml) of fluorescent dye for each gallon (3.79 liters) of make-up diesel fuel. Normally, three to five units can be tested before replenishing the fuel.

4. With the engine idling and the rocker covers removed, shine the "black light" over the head assembly. Lube oil will show up as a dull blue. A fuel leak will glow a bright yellow. This type of test is best conducted in a darkened or shadowed area. The darker the area surrounding the unit being tested, the easier it is to see the fluorescent dye.

 © Detroit Diesel Corporation

5. If bright yellow dye is detected, determine the cause of the fuel leak and eliminate it. Wipe the cylinder head and fuel connections clean, start and idle the engine and reckeck the head area.

6. When all leaks have been eliminated, install the fuel lines and connect the engine to its normal fuel source.

•NOTICE: DDC Recommends that the original flared end fuel pipes not be reused. New flared end fuel pipes should be installed.

It is not necessary to change the fuel filter or strainer. Start and run the engine to purge any air from the fuel system.

Normal Fuel Weepage

Some fuel weepage may normally be encountered from the follower and/or rack on DDC injectors while performing this test. Special consideration must be given to this weepage and the fact that it should not be allowed to exceed the DDC guidlines for pressure holding test (see Section 2.1.1) and the specification for lube oil dilution (2.5).

Since all leakage or spillage of fuel during leak detection testing dilutes the lube oil, the final step in maintenance of this type should include lube oil and lube oil filter changes.

FUEL JUMPER LINE MAINTENANCE

Maintenance and service personnel should be aware that severe engine damage could result from fuel oil leakage into the lubricating oil and should therefore, follow proper procedures when removing, handling and installing fuel jumper lines (fuel pipes).

The fuel jumper lines which carry fuel to and from the fuel injectors must be handled and installed very carefully to prevent line damage that can result in severe engine damage.

NOTICE: Severe fuel leakage, if not detected, can also result in an over-filled crankcase (oil pan) which can cause an abnormal amount of fuel and lubricating oil vapor to escape from the engine and crankcase breathers. An abnormal concentration of fuel and lube oil vapors is flammable and could ignite in a closed engine compartment.

The following are some of the conditions that can result in fuel jumper line leakage:

1. Improper handling and storage of jumper lines when servicing the engine can result in physical damage and contamination.

2. Careless use of special tool (socket) J 21545 during removal or installation can cause a jumper line to bend and be permanently distorted.

3. Excessive tightening of the jumper line nut will distort and fracture the flared end of the jumper line, resulting in a fuel leak.

4. Damaged threads and flare seats on the injector and cylinder head jumper line connectors can also result in fuel leakage.

5. Leaks can also occur at injector filter nut gaskets and/or cylinder head connector washers due to distortion, damage or incorrect torque.

Fuel jumper lines are pre-formed to facilitate easy installation on the injector and cylinder head jumper line connectors. Do not attempt to straighten distorted or bent jumper lines for reuse because the straightening process may cause the jumper line to weaken or fracture and result in fuel leakage.

The following troubleshooting procedure is recommended after installation of fuel jumper lines and/or connectors to determine if fuel leakage is present.

Checking For Fuel Leaks

Always check the fuel system for leaks after injector or fuel jumper line replacement and any time the fuel connections under the rocker cover are suspected of leaking.

NOTICE: Failure to correct a fuel leak in this area can lead to dilution of the lube oil.

Use one of the following methods to check for leaks.

METHOD A

Use when the engine has been operating 20-30 minutes. After operating the engine, shut it off and remove the rocker cover(s). Discard the gasket(s). Inspect the lube oil puddles that normally form where the fuel connectors join the cylinder head and where the fuel jumper lines join the fuel line nuts.

If there is any leakage at these connections, the lube oil puddles will be smaller or thinner than the puddles on the connectors that are not leaking. Disassemble, inspect and correct or replace the suspect part (connector washer, connector, injector or jumper line). Test and reinspect.

METHOD B

Use when the engine is not operating such as during or after repairs. Remove the rocker cover(s). Discard the gasket(s). Pour clean lube oil over the fuel jumper lines and connectors which would normally be splashed with oil during engine operation. This will cause oil puddles to form

at the joining surfaces as mentioned in Method A. Plug the fuel return line at a convenient location (cylinder head or fuel tank, for example). Disconnect the fuel pump supply line at the inlet of the secondary filter. Connect an external source of pressurized fuel (60-80 psi or 414—552 kPa) to the inlet of the secondary filter cover. Install a pressure gage (0-100 psi or 0-689 kPa) at the outlet of the filter cover. Gage installation can be accomplished by installing a “T” fitting between the filter cover and outlet line or by removing the pipe plug at the outlet in the cover. Use of a gage will allow ready reference to the fuel pressure being maintained for this test. Severe leaks are immediately visible and minor leaks take longer to appear. It may be necessary to maintain fuel pressure for a period of 20 to 30 minutes in order to find minor leaks. Leaks may be repaired by replacing damaged parts or determining if the part is loose and below torque specifications. Test and reinspect.

If injectors are suspected of leaking and contributing to dilution of the lube oil, they should not be tested by pressurizing the fuel system as in Method B. Injectors should be removed from the engine and high pressure tested as outlined in Section 2.1 or 2.1.1.

METHOD C

Use while the engine is operating at 400-600 rpm.

Apply an outside fuel source capable of 60-80 psi (414-552 kPa) to the outlet side of the secondary filter. Pour lube oil over the fuel jumper lines and connectors so that oil puddles form where jumper lines and connectors meet. Install a valve and a pressure gage in the fuel return line. With the engine idling, close the valve enough to raise the engine fuel pressure to 60-80 psi (414-552 kPa). After 10-20 minutes, inspect the oil puddles to see if any have become smaller or run off completely. The undiluted oil will hang the same as when the oil was poured on. Repair and retest.

Slightly worn injector plungers may leak more under these conditions. This leakage will not occur while the engine is running because of the dynamic and pressure conditions that exist.

METHOD D

Fluorescent dye fuel leak testing. When testing an engine that has been in service, it will be preferable to use the fluorescent dye and black light method of testing. Proceed as follows:

1. Mix 4 oz. of fluorescent additive J 28431 with 4 gallons (15 liters) of clean diesel fuel **(1 or 2) in a clean container. The container should be marked "Test Fuel" and be resealable so that it won't be contaminated when not being used.**
2. Isolate the engine fuel system so that the supply and return fuel lines are connected only to the test fuel container. It will be necessary to intermittently check the fuel level to maintain an adequate supply.
3. Warm up the engine by operating it at maximum no-load speed for approximately 15 minutes.
4. With the engine idling and the rocker cover removed, shine the black light over the head assembly. The lube oil will show a dull blue. If a fuel leak is present, the fuel with the fluorescent dye will glow a bright yellow.
5. After the cause of the fuel leak has been determined and corrected, wipe the area and fuel connections clean and recheck with the black light. When no leaks are present, reassemble the unit with the original fuel lines and normal fuel source. It is not necessary to change the fuel filters. Run the engine to purge the air from the fuel system.

With the engine at rest, all injectors will leak to some extent when pressurized. The leakage occurs because there is no other place for the pressurized fuel to go. When the low and high pressure cavities in the injector are subjected to the high test pressure, fuel is forced past the plunger into the rack and gear cavity. Result: Droplets of fuel form at the rack and drip off. Special consideration must be given to this weepage. If considered to be excessive, the injector should be removed and tested for pressure holding capabilities.

NOTICE: Since all leakage or spillage of fuel during leak detection testing dilutes the lube oil, the final step in maintenance of this type should include lube oil and lube oil filter changes.

Use new gasket(s) and reinatall the valve rocker cover(s).

POINTS TO REMEMBER

1. Lube oil puddle inspection is one method of testing the fuel system for internal leaks. The missing puddles show where the leaks are. This test can be performed any time the rocker covers are removed, after the fuel jumper lines and connectors have been splashed with clean lube oil and there is normal fuel pressure in the system.
2. All leakage or spillage of fuel during leak detection testing further dilutes the lube oil.
3. The final step in maintenance of this type should include lube oil filter changes if a fuel leak is detected.
4. Oil level above the dipstick “full” mark or a decrease in lube oil consumption may indicate internal fuel leaks.
5. Improper storage, handling or installation of jumper lines can cause fuel leakage, resulting in lube oil dilution and severe engine damage.

 © Detroit Diesel Corporation

TROUBLESHOOTING

FUEL PUMP

The fuel pump is so constructed as to be inherently trouble free. By using clean, water-free fuel and maintaining the fuel filters in good condition, the fuel pump will provide long satisfactory service and require very little maintenance.

However, if the fuel pump fails to function satisfactorily, first check the level in the fuel tank, then make sure the fuel supply valve is open. Also, check for external fuel leaks at the fuel line connections and filter gaskets. Make certain that all fuel lines are connected in their proper order.

Next, check for a broken pump drive shaft or drive coupling. Insert the end of a wire through the pump flange drain hole, then crank the engine momentarily and note whether the wire vibrates. Vibration will be felt if the pump shaft rotates.

All fuel pump failures result in no fuel or insufficient fuel being delivered to the fuel injectors and may be indicated by uneven running of the engine, excessive vibration, stalling at idling speeds or a loss of power.

The most common reason for failure of a fuel pump to function properly is a sticking relief valve. The relief valve, due to its close fit in the valve bore, may become stuck in a fully open or partially open position due to a small amount of grit or foreign material lodged between the valve and its bore or seat. This permits the fuel to circulate within the pump rather than being forced through the fuel system.

Therefore, if the fuel pump is not functioning properly, remove the relief valve plug, spring and pin and check the movement of the valve within the valve bore. If the valve sticks, recondition it by using fine emery cloth to remove any scuff marks. Otherwise, replace the valve. Clean the valve bore and the valve components. Then, lubricate the valve and check it for free movement throughout the entire length of its travel. Reinstall the valve.

After the relief valve has been checked, start the engine and check the fuel flow at some point between the restricted fitting in the fuel return manifold at the cylinder head and the fuel tank.

CHECKING FUEL FLOW

1. Disconnect the fuel return hose from the fitting at the fuel tank and hold the open end in a convenient receptacle.

2. Start and run the engine at 1,800 rpm and measure the fuel flow. Refer to Section 13.2 for the specified quantity per minute.

3. Immerse the end of the fuel hose in the fuel in the container. Air bubbles rising to the surface of the fuel will indicate air being drawn into the fuel system on the suction side of the pump. If air is present, tighten all fuel line connections between the fuel tank and the fuel pump.

4. If the fuel flow is insufficient for satisfactory engine performance, then:

    a. Replace the element in the fuel strainer. Then, start the engine and run it at 1,800 rpm to check the fuel flow. If the flow is still unsatisfactory, perform Step “b” below:

    b. Replace the element in the fuel filter. If the flow is still unsatisfactory, do as instructed in Step “c”.

    c. Substitute another fuel pump that is known to be in good condition and again check the fuel flow. When changing a fuel pump, clean all of the fuel lines with compressed air and be sure all fuel line connections are tight. Check the fuel lines for restrictions due to bends or other damage.

If the engine still does not perform satisfactorily, one or more fuel injectors may be at fault.

Check to see that the injectors are receiving fuel as follows:

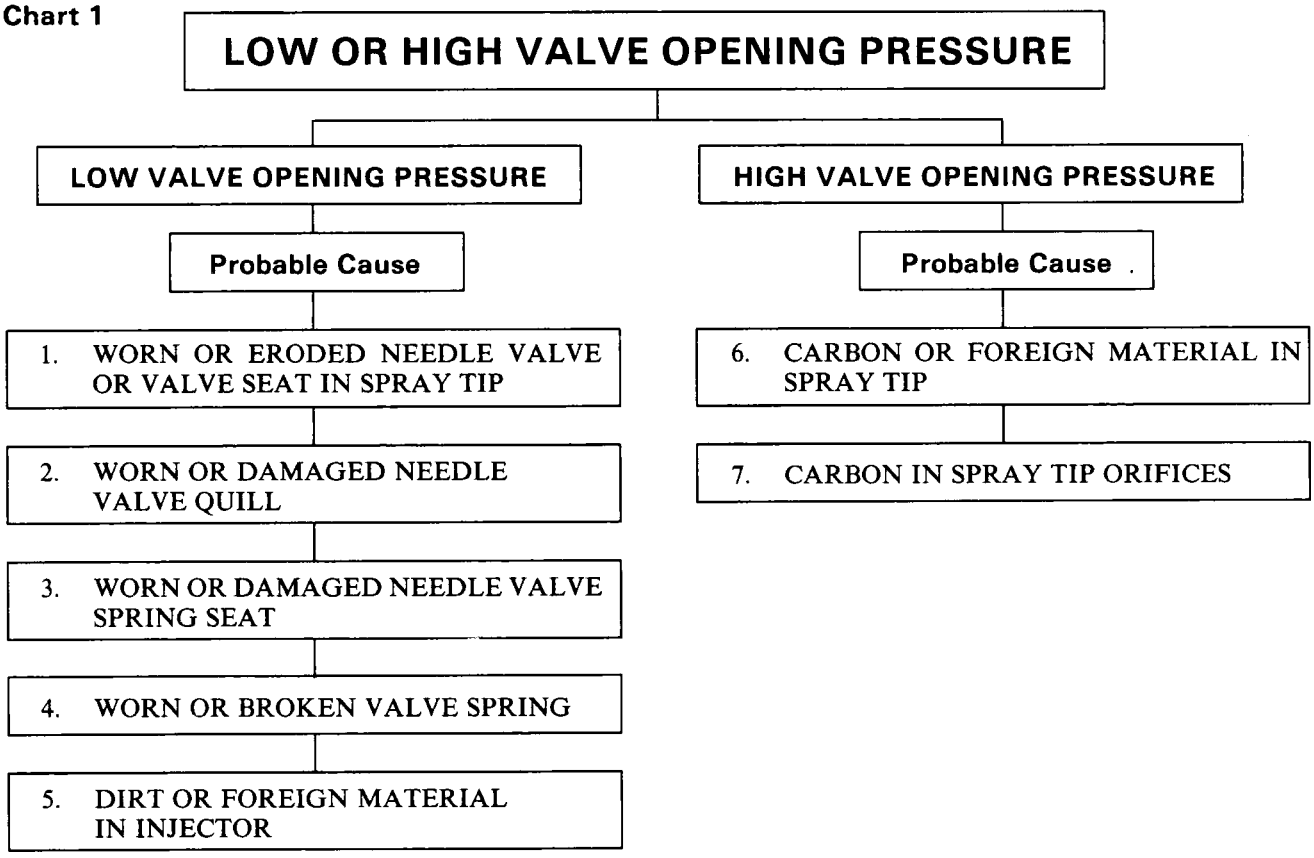
1. Stop the engine and remove the fuel pipe between the fuel return manifold and the injector.

2. Hold a finger over the injector fuel outlet and crank the engine with the starter. A gush of fuel while turning the engine indicates an ample fuel supply; otherwise, the injector filters are clogged and the injector must be removed for service.

© Detroit Diesel Corporation

NEEDLE VALVE INJECTORS

Chart 1



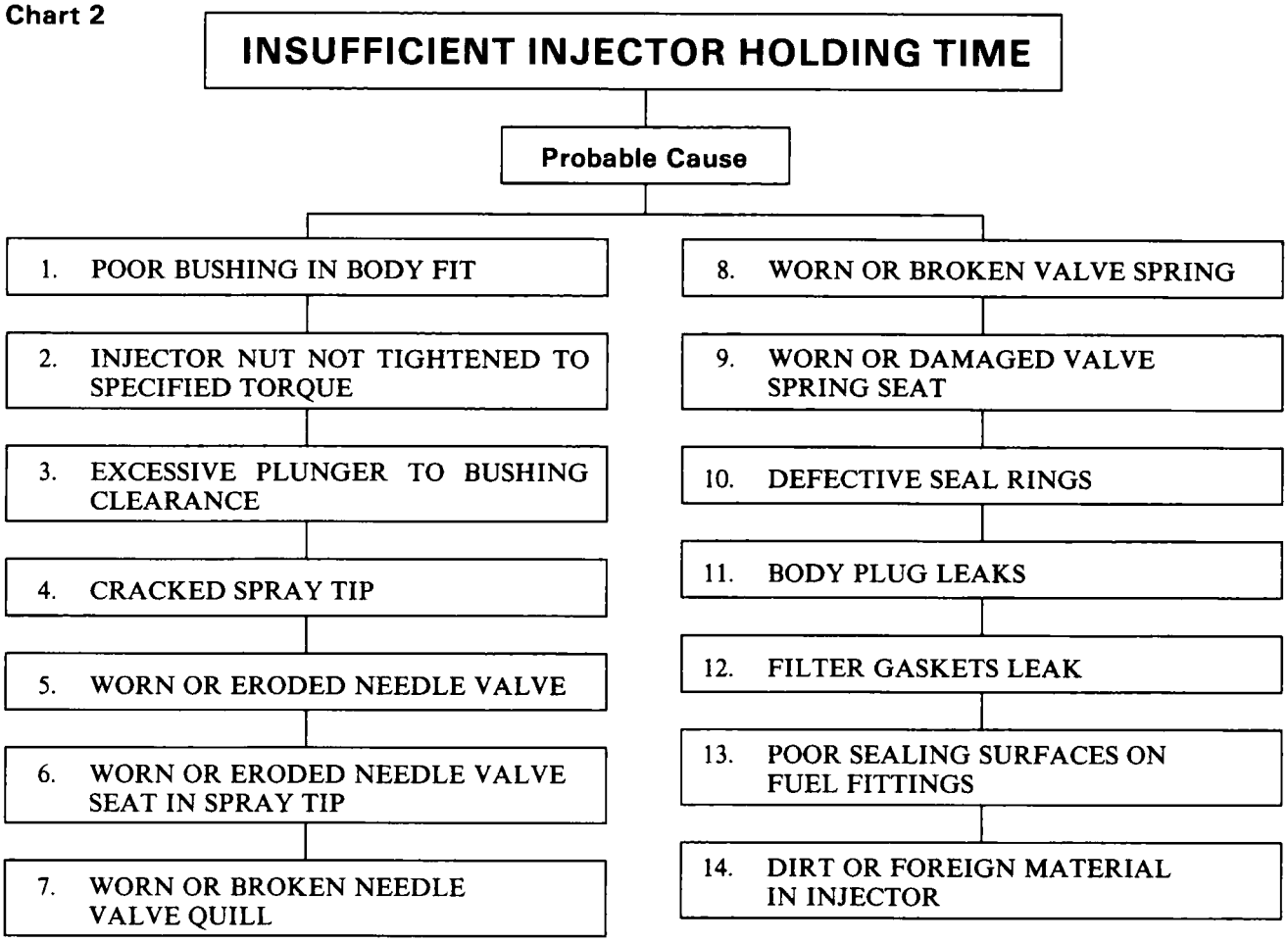
SUGGESTED REMEDY

1. Replace the needle valve andspray tip assembly.
2. Replace the needle valve andspray tip assembly.
3. Replace the spring seat.
4. Replace the valve spring.
5. Disassemble the injector and clean all of the parts.
6. Remove the carbon in the spray tip with tool J 22800-01 which is especially designed and ground for this purpose.
7. Check the size of the spray tip orifices. Then, using tool J 4298-1 with the proper size wire, clean the orifices.

 © Detroit Diesel Corporation

NEEDLE VALVE INJECTORS

Chart 2



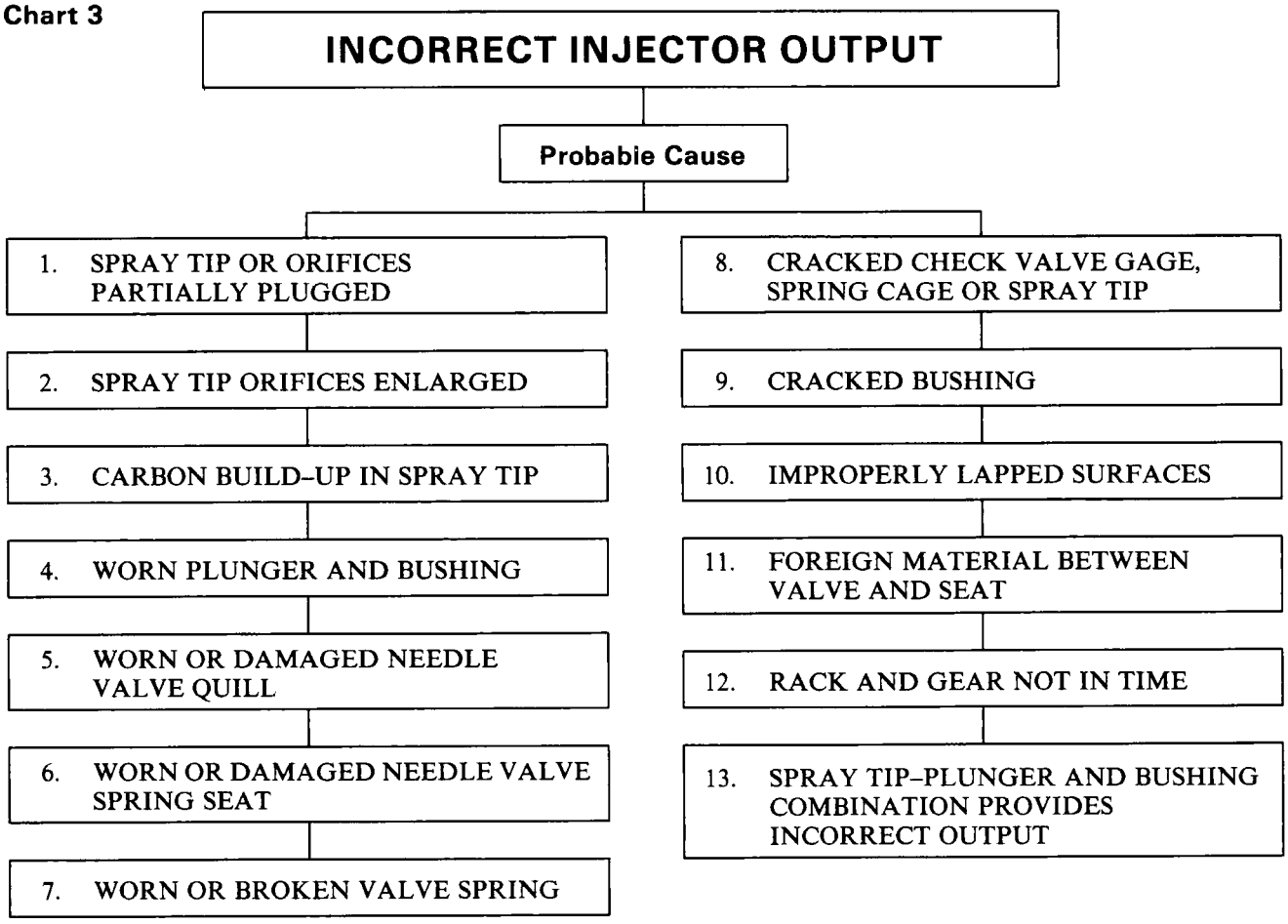
SUGGESTED REMEDY

1. Lap the injector body.
2. Tighten the injector nut to 120-140 lb—ft (163-190 N*m) torque. Do not exceed the specified torque.
3. Replace the plunger and bushing.
4, 5, 6 and 7. Replace the needle valve and spray tip assembly.
8. Replace the valve spring.
9. Replace the valve spring seat.
10. Replace the seal rings.
11. Install new body plugs.
12. Replace the filter cap gaskets and tighten the filter caps to 65-75 lb—ft (88-102 N*m) torque.
13. Clean up the sealing surfaces or replace the filter caps, if necessary. Replace the filter if a cap is replaced.
14. Disassemble the injector and clean all of the parts.

© Detroit Diesel Corporation

NEEDLE VALVE INJECTORS

Chart 3



SUGGESTED REMEDY

1. Clean the spray tip as outlined under *Clean Injector Parts.*
2. Replace the needle valve and spray tip assembly.
3. Clean the spray tip.
4. After the possibility of an incorrect or faulty spray tip has been eliminated and the injector output still does not fall within its specific limits, replace the plunger and bushing with a new assembly.

The fuel output of an injector varies with the use of different spray tips of the same size due to manufacturing tolerances in drilling the tips. If the fuel output does not fall within the specified limits of the *Fuel Output Check Chart,* try changing the spray tip. However, use only a tip specified for the injector being tested.

5. Replace the needle valve and spray tip assembly.
6. Replace the spring seat.
7. Replace the valve spring.
8. Replace the cracked parts.
9. Replace the plunger and bushing assembly.
10. Lap the sealing surfaces.
11. Disassemble the injector and clean all of the parts.
12. Assemble the gear with the drill spot mark on the tooth engaged between the two marked teeth on the rack.
13. Replace the spray tip and the plunger and bushing assembly to provide the correct output.

 © Detroit Diesel Corporation

SPECIFICATIONS

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	260M BOLTS TORQUE (lb-ft)	Nam	THREAD SIZE	280M OR BETTER TORQUE (lb-ft)	Nam
1/4-20	5-7	7-9	1/4-20	7-9	10-12
1/4-28	6-8	8-11	1/4-28	8-10	11-14
5/16-18	10-13	14-18	5/16-18	13-17	18-23
5/16-24	11-14	15-19	5/16-24	15-19	20-26
3/8-16	23-26	31-35	3/8-16	30-35	41-47
3/8-24	26-29	35-40	3/8-24	35-39	47-53
7/16-14	35-38	47-51	7/16-14	46-50	62-68
7/16-20	43-46	58-62	7/16-20	57-61	77-83
1/2-13	53-56	72-76	1/2—13	71-75	96-102
1/2-20	62-70	84-95	1/2-20	83-93	113-126
9/16-12	68-75	92-102	9/16-12	90-100	122-136
9/16-18	80-88	109-119	9/16-18	107-117	146-159
5/8-11	103-110	140-149	5/8-11	137-147	186-200
5/8-18	126-134	171-181	5/8-18	168-178	228-242
3/4-10	180-188	244-254	3/4-10	240-250	325-339
3/4-16	218-225	295-305	3/4-16	290-300	393-407
7/8-9	308-315	417-427	7/8-9	410-420	556-569
7/8-14	356-364	483-494	7/8-14	475-485	644-657
1-8	435-443	590-600	1-8	580-590	786-800
1-14	514-521	697-705	1-14	685-695	928-942

Grade identification markings are normally stamped on the heads of the bolts. To aid identification of the various bolts used in Detroit Diesel engines, refer to the following chart.

Grade Identification Marking on Bolt Head	GM Number	SAE Grade Designation	Nominal Size Diameter (inch)	Tensile Strength Min. (psi)
None	GM 255-M	1	No. 6 thru 1 1/2	60,000
None	GM 260-M	2	No. 6 thru 3/4 over 3/4 to 1 1/2	74.000 60.000
Bolts and Screws	GM 280-M	5	No. 6 thru 1 over 1 to 1 1/2	120,000 105,000
— Hex Head Sems Only	GM 275-M	5.1	No. 6 thru 3/8	120,000
' Bolts and Screws	GM 290-M	7	1/4 thru 1 1/2	133,000
5,C Bolts and Screws	GM 300-M	8	1/4 thru 1 1/2	150,000
- Bolts and Screws	GM 455-M	None	No. 6 thru 1 1/2	55,000

BOLT IDENTIFICATION CHART

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD	(lb-ft)	(N«m)
Fuel pump drive coupling disc bolt	3/8-24	50-55	68-75
Fuel jumper line nut to injector	7/16-20	18-22	24-30
Fuel jumper line nut to fuel manifold connector	7/16-24	18-22	24-30
Fuel manifold connector nut	1/2-13	35-40	47-54
.Injector filter cap			
Blued cap on blued body		70	95
Non-blue cap on non-blued body or mixed (blue with non-blued part)		62	84
•Injector body nut			
Blued nut on blued body		130	177
Non-blue nut on non-blued body		85	115
Mixed (blued with non-blued part)		108	147

STANDARD PIPE PLUG TORQUE SPECIFICATIONS

NPTF SIZE THREAD	TORQUE (lb-ft)	N»m	NPTF SIZE THREAD	TORQUE (lb-ft)	N*m
1/8	10-12	14-16	1	75-85	102-115
1/4	14-16	19-22	1-1/16	85-95	115-129
3/8	18-22	24-30	1-1/4	95-105	129-143
1/2	23-27	31-37	1-1/2	110-130	150-177
3/4.....	33-37	45-50			

SPECIAL PLUG TORQUE SPECIFICATIONS

APPLICATION	THREAD	(lb-ft)	(N*m)
Fuel pump valve plug	1/2-20	18-24	24-33
Fuel junction block check valve plug	1-1/16-16	80-90	108-122
Governor housing plug	1-15/16-16	50-60	68-81

 © Detroit Diesel Corporation

SERVICE TOOLS

TOOL NAME	TOOL NO.
INJECTOR	
Auxiliary injector tester	J 22640-A
Field modification kit	J 22640-51
Fuel hole brush	J 8152
Fuel line torquing set	J 26617
Injector fuel line nut socket	J 21545
Fuel system primer	J 5956
Injector calibrator	J 22410
Injector nut carbon remover set	J 22096-02
Injector nut socket	J 22799
Injector spray tip driver	J 1291-02
Injector test oil (5, 15, 30 or 55 gal.)	J 26400-(-5,-l 5,-30-55)
Injector tester	J 23010-B
Injector tester modification package (J 23010-A)	J 23010-195
Injector tip concentricity gage	J 23905
Injector vise and rack freeness tester	J 22396
Injector wire sharpening stone	J 8170
Lapping block set	J 22090-A
Master injector (149 Injector Only)	J 34998
Pin vise	J 4298-1
Polishing compound	J 23038
Rack hole brush	J 8150
Reamer (part of J 22342-01 set)	J 22342-11A
Spray hole wire (.009")	J 22885
Spray tip carbon remover	J 22800-01
Spray tip gage (needle lift)	J 9462-02
Spring tester	J 22738-02
Wire brush (brass)	J 7944
INJECTOR TUBE	
Dial Indicator	J 22273-01
Injector tip protrusion gage	J 25561
Injector tube reconditioning set	J 22342-C
FUEL PUMP	
Fuel pump tool kit	J 34607
Fuel pump tool set	J 1508-E
Fuel pump wrench	J 4242
Fuel system primer	J 5956

TOOL NAME	TOOL NO.
MECHANICAL GOVERNOR	
Control link bearing remover/installer	J 8985
Hydraulic governor drive gear and sleeve remover	J 4685
Governor cover bearing installer	J21068
Governor cover and spring housing bearing remover	J 21967-01
Governor weight housing plug remover/installer	J23176
Governor weight shaft retaining ring installer	J 36840
HYDRAULIC GOVERNOR	
Governor drive gear and sleeve remover	J 4685

© Detroit Diesel Corporation

SECTION 3

AIR INTAKE SYSTEM

CONTENTS

Air Intake System..... 3
Air Cleaner 3.1
Air Shutdown Housing..... 3.3
Blower..... 3.4
Blower Bypass Valve..... 3.4.2
Turbocharger 3.5
Turbocharger Intercoolers 3.5.2
Troubleshooting - Specifications - Service Tools..... 3.0

AIR INTAKE SYSTEM

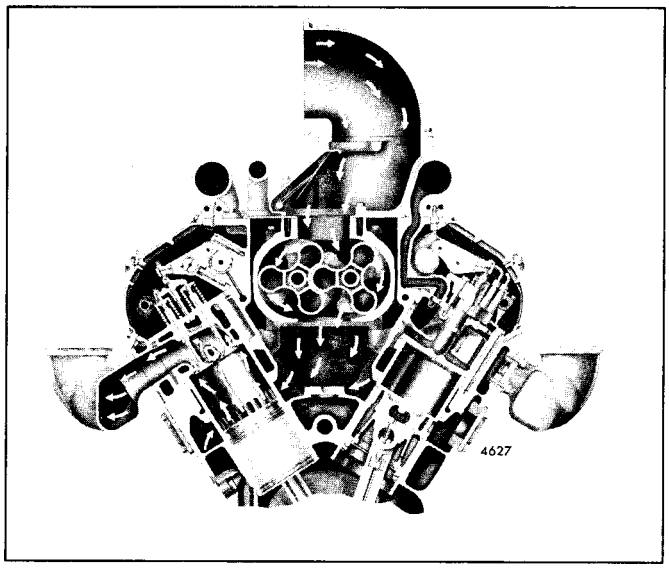


Fig. 1 - Air Flow Through Blower and Engine

In the scavenging process employed in the Series 149 engines, a charge of air is forced into the cylinders by the blower and thoroughly sweeps out all of the burned gases through the exhaust valve ports. This air also helps to cool the internal engine parts, particularly the exhaust valves. At the beginning of the compression stroke, therefore, each cylinder is filled with fresh, clean air which provides for efficient combustion.

The air, entering the blower from the air cleaner or air silencer, is picked up by the blower rotor lobes and carried to the discharge side of the blower as indicated by the arrows in Fig. 1. The continuous discharge of fresh air from the blower enters the air chamber of the cylinder block and sweeps through the intake ports of the cylinder liners.

The angle of the ports in the cylinder liners creates a uniform swirling motion to the intake air as it enters the cylinders. This motion persists throughout the compression stroke and facilitates scavenging and combustion.

Effective with engine serial numbers 12E-8157 and 16E-7668, turbocharged-intercooled engines were equipped with a blower bypass valve. This valve was located in a chamber between the intercooler and the blower (Fig. 2).

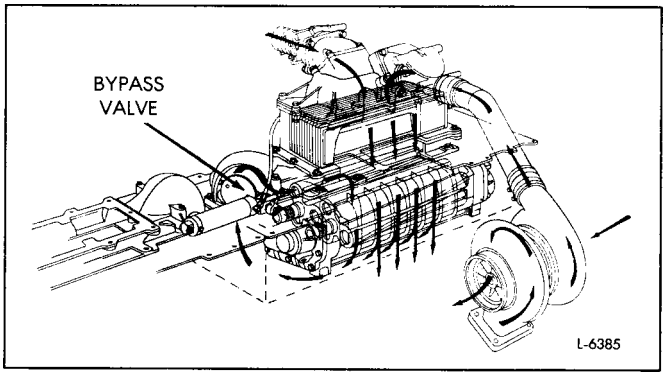


Fig. 2 - Air Flow Schematic - Former Flapper Style Blower Bypass Valve-Equipped Engine

© Detroit Diesel Corporation

• Effective with unit serial numbers 8E02594, 12E08925, and 16E08960, this “flapper” style blower bypass valve system was replaced by the piston style blower bypass valve system (Fig. 3).

During high rpm or high load engine operation the blower bypass valve opens, equalizing air pressure on the inlet and outlet sides of the blower and virtually eliminating its pumping horsepower requirement. Driven by the engine gear train, the blower continues to turn, but it does not compress the incoming air. Instead, the exhaust gas-driven turbocharger does the compressing. The blower requires little horsepower to operate in this manner, and it is this reduced horsepower need that helps improve fuel economy.

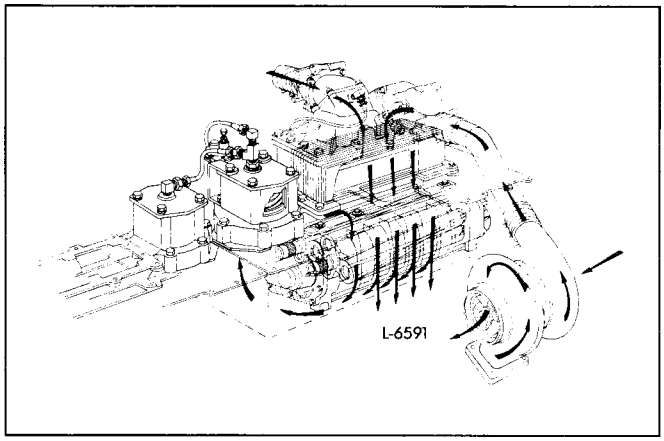


Fig. 3 - Air Flow Schematic — Current Piston Style Blower Bypass Valve-Equipped Engine

 © Detroit Diesel Corporation

AIR CLEANER

Both heavy duty and light duty oil bath type air cleaners and a multistage dry type air cleaner are used on the Series 149 engines, depending on the application and/or operating conditions.

The air cleaners are designed to remove dust and foreign material from the air, pass the required volume of air for efficient combustion and scavenging, and maintain their efficiency for a reasonable period of time before requiring service.

The importance of keeping dust and grit-laden air out of an engine cannot be overemphasized, since clean air is so essential to satisfactory engine operation and long engine life. The air cleaner must be able to remove fine materials such as dust and blown sand as well as coarse material like chaff, sawdust or lint from the air. It must also have a capacity large enough to retain the material separated from the air to permit operation for a reasonable period before cleaning is required.

Dust and dirt entering an engine will cause rapid wear of piston rings, cylinder liners, pistons and the exhaust valve mechanism with a resultant loss of power and high lubricating oil consumption. Also dust and dirt which is allowed to buildup in the air cleaner passages will eventually restrict the air supply to the engine and result in heavy carbon deposits on the pistons and valves due to incomplete combustion.

No hard fast rule for servicing an air cleaner can be given since it depends upon the type of air cleaner, air conditions and the type of application. A cleaner operating in severe dust conditions will require more frequent service than one operating in relatively clean air. The most satisfactory service period should be determined by inspecting the cleaners frequently, under normal operation, then setting the service period to best suit the requirements of the application.

A service indicator may be attached near the outlet side of some air cleaners to provide a visual means of determining when the cleaner requires service.

Air Cleaner Maintenance

Although air cleaners are highly efficient, the efficiency may be offset by leaks in the duct work, loose hose connections or damaged gaskets which permit dustladen air to completely bypass the cleaner and enter the engine directly.

The following maintenance procedure will assure efficient air cleaner operation:

1. Keep the air cleaner tight on the air intake to the engine.
2. Keep the air cleaner properly assembled so that the joints are strictly oil and air tight.
3. If the air cleaner, intake or connections are damaged, repair them at once.
4. In dusty areas, inspect the air cleaner frequently. Clean the oil cup often enough to prevent the oil from becoming excessively thick with sludge.
5. After servicing the air cleaner, remove the air inlet housing and clean accumulated dirt deposits from the blower screen and the air inlet housing. Make sure all air intake passages and the air box are kept clean.

DRY TYPE AIR CLEANER

The heavy duty dry type air cleaner is designed to provide highly efficient air filtration under all operating conditions and is not affected by engine speed (Fig. 1). The cleaner assembly consists of a centrifugal air cleaner in series with a replaceable impregnated paper filter element. Dust and dirt removed by the first stage centrifugal cleaner can be collected in a dust chamber or automatically removed by the use of vacuator valves. The centrifugal cleaner and replaceable filter element are held together in a steel housing. Positive sealing between the two elements and the housing is provided by rubber gaskets. The steel housing incorporates filter fasteners, mounting flanges and an outlet for the filtered air.

Operation

As air is drawn through the perforated sections of the steel housing, vanes in the tubes of the centrifugal stage of the cleaner impart a swirling motion to the air entering the cleaner and centrifuge the dust particles against the walls of the tubes. The dust particles are then carried to the dust chambers by a small portion of the air and either automatically removed by vacuator valves or stored for later removal. The remainder of the air then reverses direction in the tubes and spirals back along the tubes again centrifuging the air. The filtered air flow direction is again reversed and the air enters the replaceable filter element through the center of the tubes. The air is filtered once more as it passes through the paper element before entering the engine.

© Detroit Diesel Corporation

Service

Service and replace the air cleaner elements according to the manufacturer's recommendations. See Section 15.1 for element change intervals.

Under no engine operating conditions should the maximum allowable air intake restriction shown in Section 13.2 of the service manual be exceeded. Check restriction with a water manometer using the procedure outlined under "final RUN-IN" in Section 13.2.1. In addition, inlet restriction should be adjusted for high altitude conditions (see TABLE 1). A clogged air cleaner element will cause excessive intake restriction, reduce air supply to the engine, poor performance and higher valve and cylinder temperatures.

The filter manufacturer has no control over the field cleaning method or procedure. Therefore, it is the responsibility of the person or shop cleaning the element to assure the reliability of the filter after cleaning. It is also the responsibility of the installer to assure proper sealing of the gaskets.

Clean the air cleaner elements as follows:

1. Clean the tubes, dust bin and paper element with compressed air.

INTAKE DEPRESSION DERATING FOR ALTITUDE ALL ENGINES FOR ALL SPEEDS

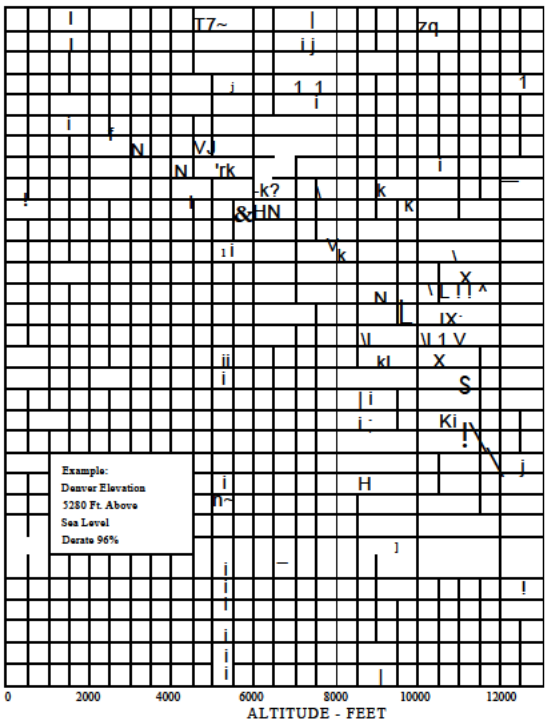


TABLE 1

NOTICE: When cleaning the paper element, direct the air jet against the inside of the element. Do not attempt to clean the element by beating or rapping it.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

2. If compressed air is not available, run water through the element. Use a gentle stream of water (less than 40 psi or 276 kPa).

   a. Clean the elements from the inside only.

   b. If mechanical dryers are used, the air must be circulated and must not exceed 180°F (82°C).

3. If the element is clogged with soot, carbon, lint and oil, use water and Donaldson filter cleaner compound or a non-sudsing equivalent.

   a. If compressed air is available, remove the loose dust by blowing from the inside of the element out. *Use less than 100 psi (689 kPa).* If compressed air is not available, use a stream of water (less than 40 psi or 276 kPa) to wash from the inside out.

   b. Soak the element in a solution of water and Donaldson filter cleaning compound or a non-sudsing equivalent.

NOTICE: Do not use fuel oil, gasoline or other volatile solvents.

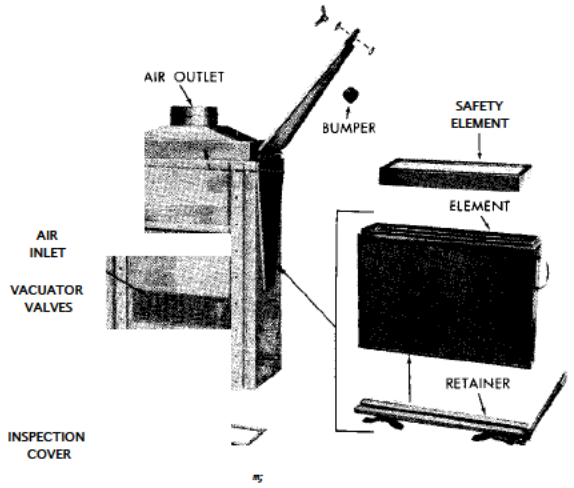


Fig. 1 - Heavy Duty Dry Type Air Cleaner

 © Detroit Diesel Corporation

BDC for Manuals - specs - Bolt torques
https://barringtondieselclub.co.za/

c. Gently swirl the element in the solution to loosen the dirt.

4. If plugged, clean the tubes with a stiff fiber brush or compressed air. Do not exceed 40 psi (276 kPa) air pressure.

5. Replace the safety element when the restriction (measured with a new or cleaned element) is one-third of the way from initial to maximum allowable restriction.

If a specific air cleaner has an initial restriction of 12 inches (2.99 kPa) of water (with a new vee pac and safety elements) and a maximum allowable restriction of 30 inches (7.47 kPa) of water, the safety element should be replaced when the restriction reaches 18 inches (4.48 kPa) or more (with a new or cleaned element).

Do not attempt to clean or reuse the safety element. Replace with a new element.

NOTICE: The safety element in early Donaldson SEG type air cleaners did not provide sufficient air flow when used on turbocharged engines and it was recommended that the element be removed and discarded. However, a new safety element, with increased filtering area and filter paper treated to resist the effects of exhaust soot, has replaced the former element for service. The new safety element can be used in SEG air cleaners on both turbocharged and non-turbocharged engines.
The SRG and STG type air cleaners, different in size and shape from the SEG type, have a safety element which flows sufficient air for all engine applications.

Inspection

After cleaning the air cleaner elements and before installation, inspect them.

Check the paper element with a bright light by holding the light on one side and checking for bright spots on the other side, which would indicate a rupture.

Inspect the gasket inside of the housing.

Check with a light to make sure that the tubes are clean and not plugged.

Install the elements.

Element Life

The recommended product life (shelf life plus service life) of Donaldson dry type air cleaner elements is three years. Consequently, Donaldson elements should be put into service no later than two years from the date of manufacture. Farr air cleaner elements should be put into service within one year from the date of manufacture.

OIL BATH TYPE AIR CLEANER

Heavy-Duty (Fig. 2): In this type of air cleaner, the air is drawn into the cleaner through the inlet opening at the top. The air passes over the oil and is then directed upwards by baffles and then passes through a removable screen assembly. During this change in direction of flow, the larger particles of foreign matter are removed from the air by the oil and the screen assembly and settle in the oil cup sump. The air continues upward through a metal-wool element where the finer particles and the entrained oil are removed. The clean air is then discharged through a side outlet near the top of the cleaner body and flows through the air inlet housing to the intake side of the blower assembly.

Light-Duty (Fig. 3): In this type of air cleaner, the air is drawn into the cleaner through a series of slots around the perimeter of the cleaner body just above the oil cup assembly. The air passes over the oil and is then directed upwards by baffles and then passes through a removable screen assembly (Fig. 4). During this change in the direction of flow, the larger particles of foreign matter such as lint, chaff, leaves, etc., are removed from the air by the oil and the screen assembly and settles in the oil cup sump. The air continues upward through a metal-wool element where finer particles such as dust and the entrained oil are removed. The clean air is then discharged through a side outlet near the top of the cleaner body and flows through the air inlet housing to the intake side of the blower assembly.

Air Cleaner Service

Loosen the clamp and remove the oil cup from the air cleaner. Then take the removable element or screen from the cup. Empty the oil from the cups. Remove the inner cup and clean the sludge from both cups with fuel oil.

Clean the separator screen or removable element by washing in a solvent and drying it with compressed air. An even pattern of light should be visible through the screen when held up to a light. If the screen or element cannot be cleaned, replace it.

Clean the air cleaner inlet center tube by running a solvent soaked swab completely through it.

Reassemble the oil cups and fill them to the indicated oil level with clean engine oil of the same viscosity and grade as used in the engine. Install the removable element or screen and install the cup assembly on the air cleaner. Make sure the oil cup is securely fastened to the air cleaner body.

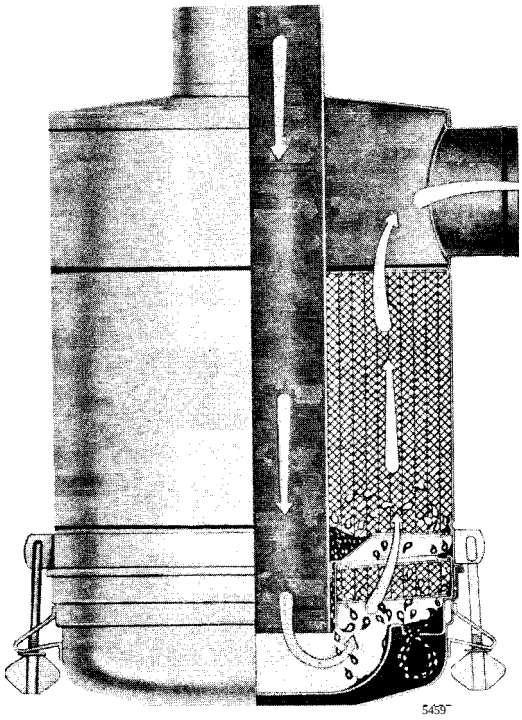


Fig. 2 - Air Flow Through Heavy Duty Oil Bath Type Air Cleaner

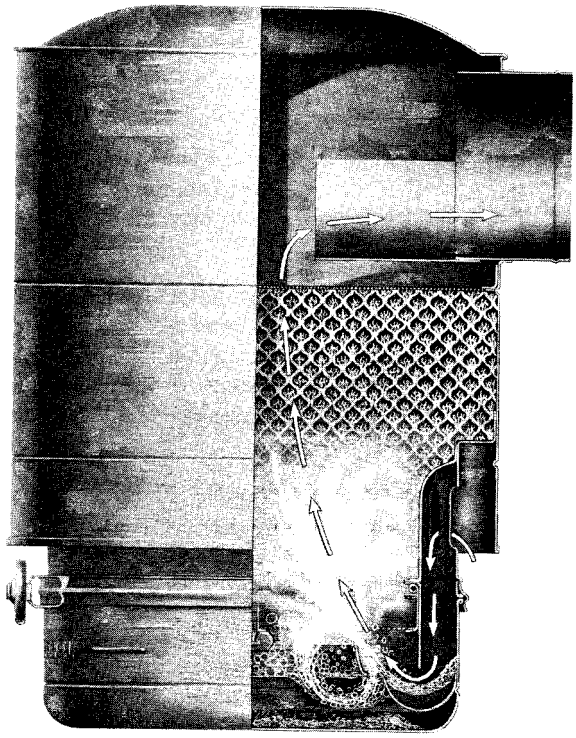


Fig. 3 - Air Flow Through Light Duty Oil Bath Type Air Cleaner

NOTICE: Do not overfill the oil cup. If too much oil is used, it may be pulled through the air cleaner and into the engine, carrying dirt into the cylinders and also result in excessive engine speed. Insufficient oil will decrease efficiency of the air cleaner.

Make sure all gaskets and joints are tight. Check all connections from the air cleaner to the engine for air leaks to prevent any air bypassing the air cleaner.

At some regular period of engine service, or when there is an indication of contaminant buildup or plugging, remove the entire air cleaner from the engine and clean the fixed element.

NOTICE: Do not remove the fixed element from the air cleaner body. If the element cannot be cleaned, the air cleaner should be replaced.

With the oil cup removed, pump solvent through the air outlet with sufficient force and volume to produce a hard even stream out the bottom of the air cleaner body. Continue reverse flushing until all foreign material is removed. If a recirculating system is used, it should be large enough to allow contaminants to settle out before the solvent is recirculated.

NOTICE: Do not use gasoline and never try to burn off lint or chaff. This heat will make the element brittle and will melt soldered joints.

When clean, allow the fixed element to dry thoroughly before installing the air cleaner on the engine. Clean out the center tube.

Reinstall the air cleaner body. Install new rubber seal rings, if used. Tighten the retaining device evenly and securely. Use a new gasket if the air cleaner is flange mounted. Service the oil cup and removable element and assemble it to the air cleaner.

If the fixed element requires too frequent cleaning, it is advisable to relocate the air intake to provide a cleaner air supply.

 © Detroit Diesel Corporation

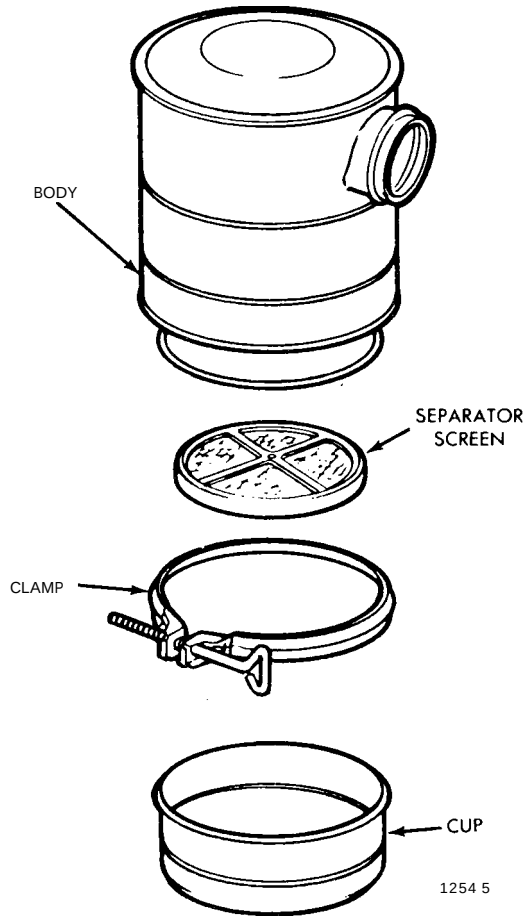


Fig. 4 - Light-Duty Air Cleaner Details and Relative Location of Parts

AIR SHUTDOWN HOUSING

TURBOCHARGED ENGINES

After passing through the air cleaners, and turbochargers, if used, the engine scavenging and combustion air supply flows through the air inlet housing, air shutdown housing, the blower and then into the engine air box and cylinders (Fig. 1).

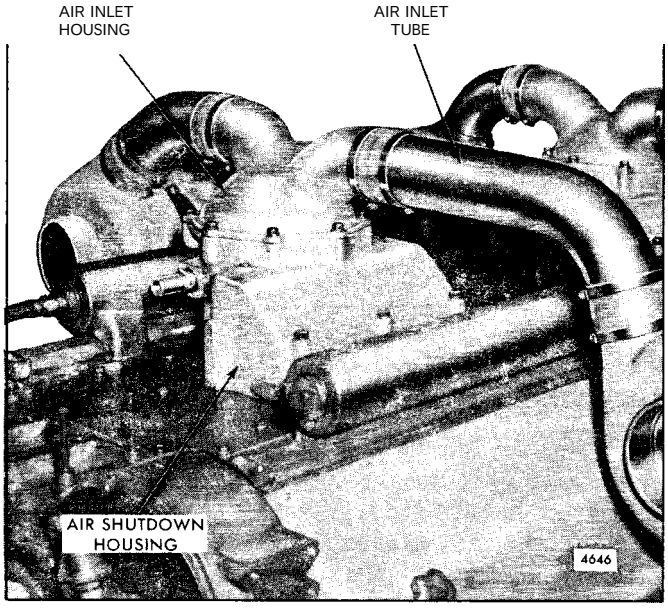


Fig. 1 - Typical Air Shutdown Housing Mounting

The air shutdown housing contains two air shutoff valves that shut off the air supply and reduce the speed of the engine whenever abnormal engine operating conditions require an emergency shut down.

The 12V and 16V naturally aspirated and turbocharged engines are equipped with two air shutdown housings connected together by a shaft and coupling arrangement (Fig. 2).

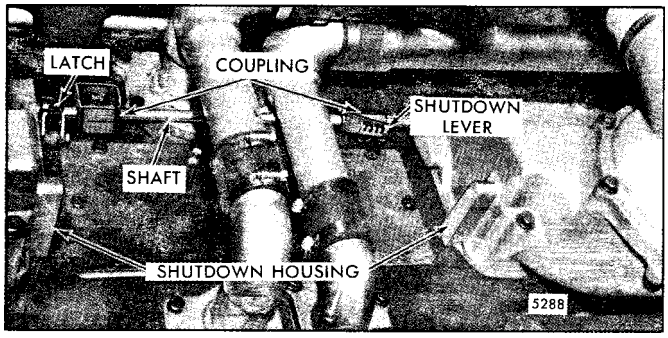


Fig. 2 - Air Shutdown Shaft and Coupling Arrangement

Remove Air Shutdown Housing

1. Disconnect and remove the air ducts between the air cleaner and the air shutdown housing. On turbocharged engines, loosen the hose clamps and slide the hose back over the air inlet tubes.
2. Disconnect the shutdown mechanism from the air shutdown latch. Then, remove the crossover shaft between the two air shutdown housings (12V and 16V) by removing the cotter pins in the couplings, loosening the bolts and sliding the couplings toward the shutdown housings.
3. Remove the eight bolts and washers which attach the air inlet housing to the air shutdown housing. Remove the air inlet housing and gasket.
4. Remove the bolts, lock washers and washers which attach the air shutdown housing to the blower. Then, remove the housing, blower screen, striker plate and gasket (current engines). Cover the blower opening to prevent dirt or foreign material from entering the blower.

Disassemble Air Shutdown Housing

1. Refer to Fig. 3 and remove the pin from the end of the shutdown shaft. Then, remove the spacer (current engines) or washer from the shaft and the seal rings from the housing.
2. Remove the pins which secure the air shutoff valves to the shaft.
3. Remove the bolt, lock washer and plain washer which attach the latch to the housing. Then, remove the latch, latch spring and bushing.
4. Note the position of the air shutoff valve; spring and valves. Then, withdraw the shaft from the housing to release the valves and spring.
5. If the shaft is to be replaced, remove the cam pin and the cam from the shaft.

Inspection

Clean all of the parts thoroughly, including the blower screen, with fuel oil and dry them with compressed air.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

© Detroit Diesel Corporation

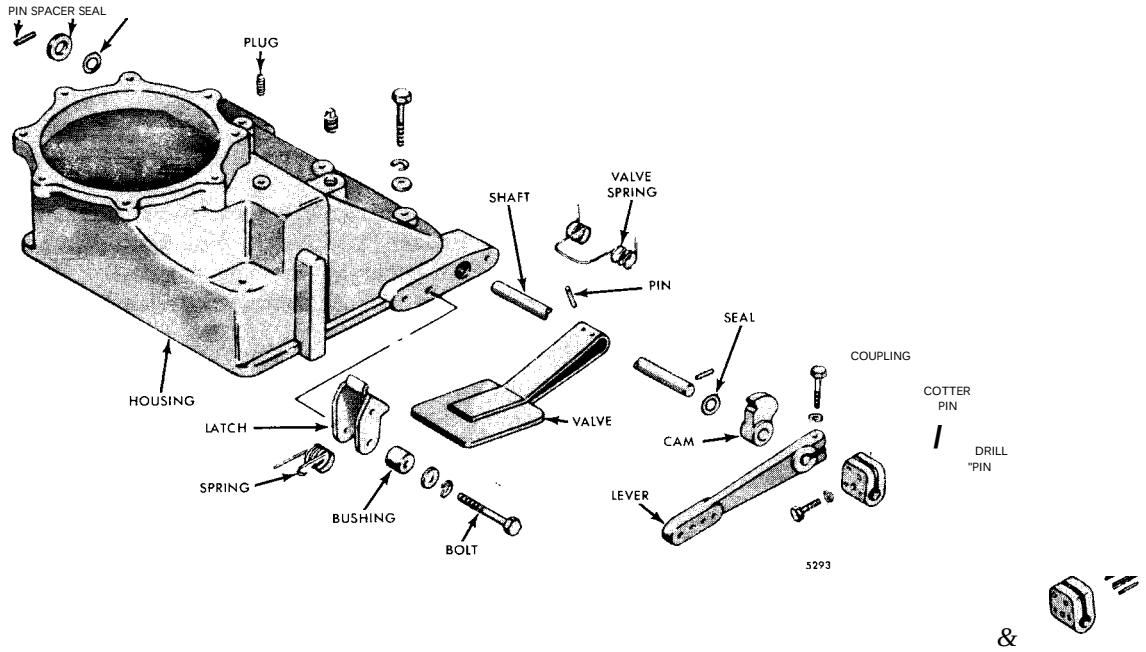


Fig. 3 - Air Shutdown Housing Details and Relative Location of Parts

Inspect the parts for wear or damage. The faces of the air shutoff valves must be perfectly flat to ensure a tight seal when they are in the *closed* position. Bend the valves *slightly*, if necessary.

Before replacing a turbocharger that has experienced compressor or turbine wheel damage, always inspect the air induction systems for damage and debris. Check air inlet ducting from the turbocharger compressor inlet pipe to the air cleaner assembly. Look for cracks or signs of air leakage and remove any dirt or debris. Check turbocharger discharge-to-blower piping for leaks or debris.

• A 3.75" long X 3.25" diameter hose and thick (.035") band stainless steel T-bolt clamp are currently used between the turbochargers, air outlet tubes, and air inlet housings of Series 149 engines. The former 3.25" long X 3.50" diameter hose and T-bolt clamp (.025" thick band) should be replaced with the new at time of normal engine overhaul, or earlier if sealing or clamping concerns are experienced.

Check the exhaust system from the cylinder head exhaust ports to the exhaust outlet piping on the turbine side of the turbocharger and the inside of the exhaust manifold(s). Remove any debris left over from the damaged turbocharger. Repair or replace any other damaged or defective components in the air induction systems.

Failure to remove contaminants or debris from these systems can result in damage to the replacement turbocharger. On engines equipped with mechanical emergency shutdown, check for proper operation of *each* flapper valve.

Assemble Air Shutdown Housing

The holes for the cam and retaining pins must be drilled, using a 1/8" diameter drill, at the time a new service shaft or air shutoff valve is assembled (see Shop Notes in Section 3.0 for the procedure). The valves must be in the same plane within .030" when in the *stop* position (flush with the housing face).

1. Place the valves and spring in position in the housing and slip the shaft in place. The shaft must extend 1.80" from the side of the housing where the shutdown latch is assembled.

2. Install a new seal ring at each end of the shaft. Be sure the seal rings are seated in the counterbores of the housing.

3. Install the cam on the shaft. Then install the pin which retains the cam to the shaft.

4. Install a spacer (formerly a washer) and retaining pin at the other end of the shaft.

5. Assemble the eccentric (bushing), spring and latch to the shutdown housing with the l/4"-20 bolt, lock washer and plain washer.

   a. Align the notch on the bushing with the notch on the latch and lock the bushing in this position.

   b. Install the pins in the valves to retain them on the shaft, with the cam release latch set and the valves in the *run* position.

© Detroit Diesel Corporation

c. Level the valves in the *shutoff* position.

d. Adjust the bushing so that the valves contact the housing when the cam release latch is set.

Install Air Shutdown Housing

1. Place the striker plate and gasket, if used, on the blower cover plate.
2. Place a new gasket and screen assembly on the striker plate or the blower cover plate. Position the gasket and screen assembly on the blower cover plate or the striker plate with the screen side of the gasket against the cover plate or striker plate. Otherwise, a positive seal may not be obtained and the engine may continue to run after attempting a shut down.
3. Position the air shutdown housing on the gasket and screen assembly and secure it in place with 7/16"—14 bolts, lock washers and washers. Tighten the bolts to 46-50 lb-ft (62-68 N*m) torque.
4. Install the air inlet housing, using a new gasket on the air shutdown housing, with eight (8) 3/8"-16 bolts, washers and lock washers. Tighten the bolts to 30-35 lb-ft (41—47 N*m) torque.
5. Connect the air inlet tubes. Be sure all connections are air-tight.
6. When both air shutdown housings have been installed (12V or 16V engine), position the crossover shaft and manual shutdown lever between the housings. Before securing the couplings, close the valves in both of the shutdowns and center the couplings on both housing shafts with the aid of new cotter pins. Tighten the bolts in the coupling to 21-26 lb-ft (28-35 N*m) torque.
7. Reset the air shutdown to the *run* position.
8. Before starting the engine, check the mechanical operation of the air shutdown assembly. Then, test the shutdown assembly as follows:
   a. Start and run the engine at slow idle and no load.
   b. Increase the speed to 600 rpm no load.
   c. After the engine has stabilized at the specified speed in Step “b”, trip the air shutdown. The engine speed must be reduced to at least 300 rpm.
   d. If a reduction in speed to 300 rpm or less cannot be obtained, the air shutdown assembly must be removed and checked.
9. After this test has been satisfactorily performed, drill and pin the couplings and linkage to the shafts with two (2) roll pins for each coupling and link (ball coupling), using a 1/8" diameter drill.

TURBOCHARGED INTERCOOLED ENGINES

The engine scavenging and combustion air supply flows through the air shutdown housings and air shutdown housing adaptors after having passed through the air cleaners and the turbochargers. The air then passes through the intercoolers where the temperature of the air is reduced before entering the blowers and then into the engine air box and cylinders.

On 12V and 16V engines, four air shutdown housings, an end and intermediate housing are mounted on each air inlet housing adaptor which is mounted on each intercooler. These housings contain an air shutoff valve that shuts off the air supply and reduces the speed of the engine whenever abnormal engine operating conditions require an emergency shut down.

Each pair of air shutdown housings (end housings and intermediate housings) are connected together by a cross-shaft and coupling arrangement, which in turn are linked together and controlled by a solenoid mechanism (Fig. 4). An air shutdown reset lever is attached to the end air shutdown housing shaft.

Remove Air Shutdown Housing (End Or Intermediate Housing)

1. Loosen the hose clamps at the shutdown housing and slide the hose back on the air inlet tube. The steel straps used with the hose clamps at both ends of the air inlet tube have been eliminated. Remove and discard the straps from all 12V and 16V turbocharged-intercooled high efficiency engines.
2. Disconnect the solenoid from the air shutdown latch (end housing). Disconnect the linkage at the crossover shafts. Remove the cotter pins and loosen the bolts in the coupling. Slide the coupling toward the shutdown housing and disconnect the crossover shaft. Disconnect the crossover shaft at the other housings in the same manner, if necessary.
3. Remove the four (4) bolts, washers, lock washers and one (1) stud nut, lock washer and washer which attach an air shutdown housing to an air inlet housing adaptor.
4. Remove the air inlet housing gasket. Discard the gasket.

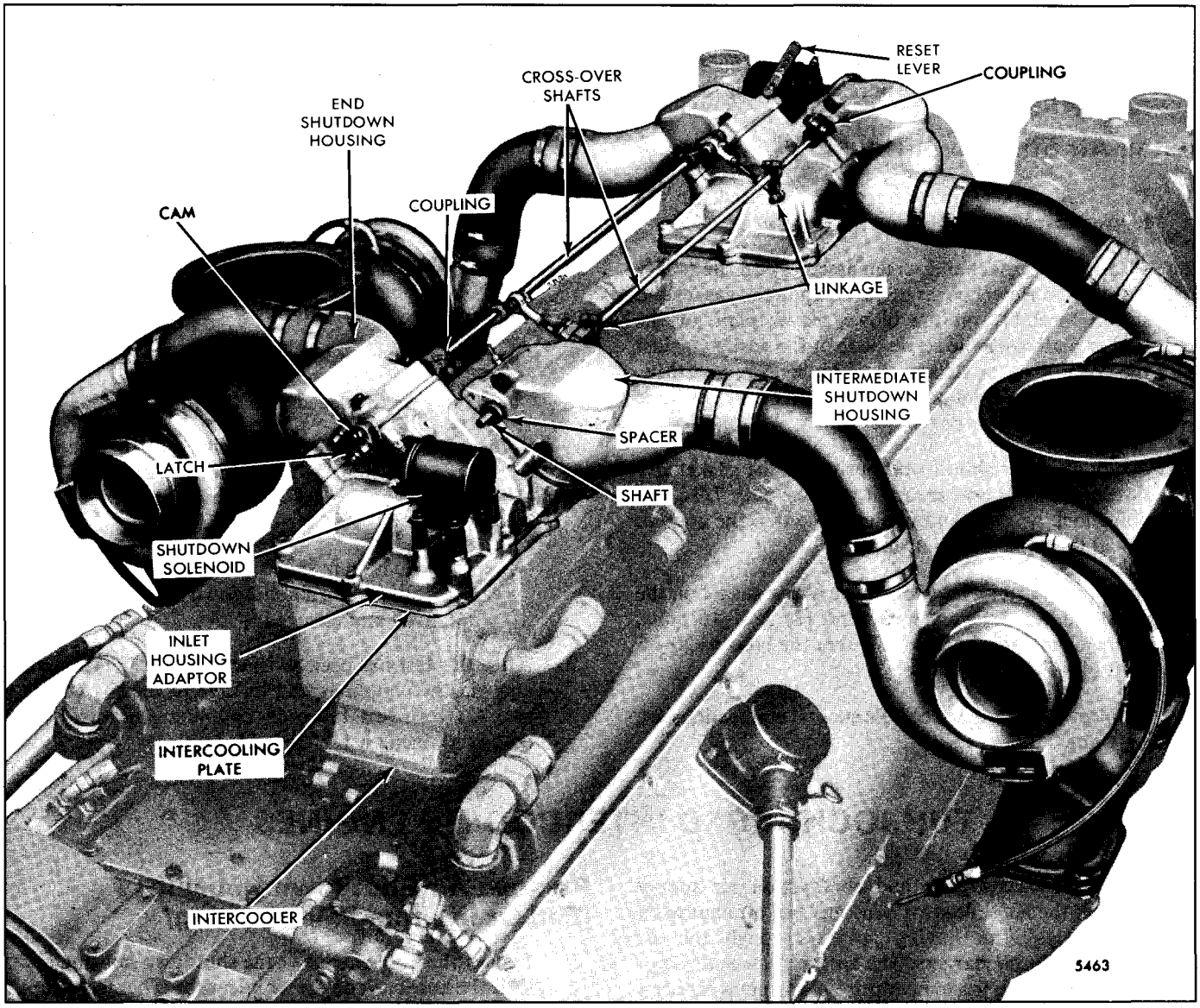


Fig. 4 - Intercooled Engine Air Shutdown Housing Mounting

NOTICE: Cover the air inlet housing adaptor opening to prevent dirt or foreign material from entering the intercooler.

Disassemble End Air Shutdown Housing

1. Refer to Fig. 5 and remove the retaining pin from the spacer and the shutdown shaft. Remove the spacer from the shaft and the seal ring from the housing. Discard the seal ring.

2. Remove the bolt and lock washer which attach the latch to the housing. Remove the latch, latch spring and bushing.

3. Remove the nut, washer and bolt that secures the valve to the valve lever.

4. Loosen the bolt that secures the valve lever to the shaft. Observe the position of the air shutoff valve spring and valve lever on the shaft.

5. Partially withdraw the shaft from the valve lever and remove the key. Withdraw the shaft from the housing to release the valve lever and spring. Remove the seal ring from the housing. Discard the seal ring.

6. Remove the cam pin and the cam from the shaft. Note the flat on the cam and its relationship to the key way of the shaft for reassembling.

 © Detroit Diesel Corporation

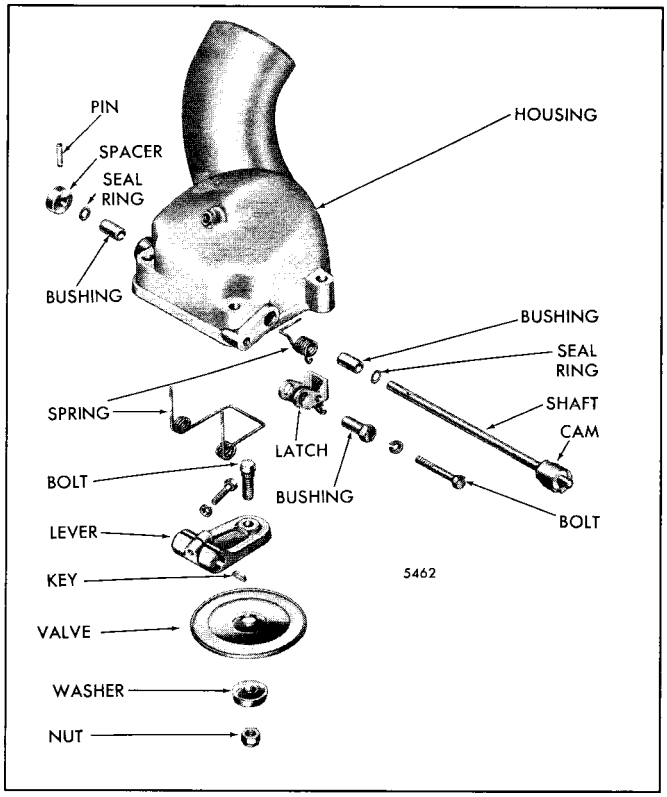


Fig. 5 - Intercooled Engine Air Shutdown Housing Assembly

Disassemble Intermediate Air Shutdown Housing

1. Refer to Fig. 5 and remove the retaining pin from the spacer at one end of the shutdown shaft. Remove the spacer from the shaft and the seal ring from the end of the housing. Discard the seal ring.
2. Remove the nut, washer and bolt that secures the valve to the valve lever.
3. Loosen the bolt that secures the valve lever to the shaft. Observe the position of the air shutoff valve spring and valve lever on the shaft.
4. Partially withdraw the shaft from the valve lever and remove the key. Withdraw the shaft from the housing to release the valve lever and spring. Remove the seal ring from the housing. Discard the seal ring.
5. If the shaft is to be replaced, remove the retaining pin and spacer.

Inspection

Clean all of the parts thoroughly with fuel oil and dry them with compressed air.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Inspect the parts for wear or damage. The face of the air shutoff valve must be perfectly flat to ensure a tight seal when it is in the *closed* position.

Before replacing a turbocharger that has experienced compressor or turbine wheel damage, always inspect the air induction and exhaust systems for damage and debris. Check air inlet ducting from the turbocharger compressor inlet pipe to the air cleaner assembly. Look for cracks or signs of air leakage and remove any dirt or debris. Check turbo discharge-to-blower piping for leaks or debris.

• A 3.75" long X 3.25" diameter hose and thick (.035") band stainless steel T-bolt clamp are currently used between the turbochargers, air outlet tubes, and air inlet housings of Series 149 engines. The former 3.25" long X 3.50" diameter hose and T-bolt clamp (.025" thick band) should be replaced with the new at time of normal engine overhaul, or earlier if sealing or clamping concerns are experienced.

Check the exhaust system from the cylinder head exhaust ports to the exhaust outlet piping on the turbine side of the turbocharger and the inside of the exhaust manifold(s). Remove any debris left over from the damaged turbocharger. Repair or replace any other damaged or defective components in the air induction or exhaust systems.

Failure to remove contaminants or debris from these systems can result in damage to the replacement turbocharger. On engines equipped with mechanical emergency shutdowns, check for proper operation of *each* flapper valve.

The bypass blower valve lever on certain early 8V engines may be capable of “going over center” (moving beyond its *center limit* position). If this occurs, the bypass blower valve may stick in the *open* position, causing inefficient engine operation and intermittent smoking, especially at low rpm. To eliminate the possibility of inefficent engine operation and smoking caused by a stuck-open bypass valve, Detroit Diesel recommends installing the bypass blower valve lever stop plate on early 8 V engines (see Shop Notes - Section 3.0).

Assemble End Air Shutdown Housing

The hole for the cam and spacer retaining pins must be drilled, using a 1/8" diameter drill, at the time the cam and spacer are assembled to a new service shaft (see Shop Notes in Section 3.0 for procedure).

1. Place the valve spring-and valve lever in position in the housing. Partially slide the shaft through the housing, valve spring and lever. Install the key in the shaft. Then, continue to slide and position the shaft through the valve lever, spring and shutdown housing.

© Detroit Diesel Corporation

2. Install a new seal ring at each end of the shaft. Be sure the seal rings are seated in the counterbores of the housing.

3. Install a spacer and retaining pin at the end of the shaft. Drill and pin the spacer to the shaft. To eliminate possible bind due to metal expansion, be sure to leave .020"-.025" end play between the spacer and the housing. Also apply a dry type anti-seize thread compound, such as Molykote "Z" or equivalent, to both ends of the shaft assembly.

4. Assemble the bushing (eccentric), spring and latch to the housing with the l/4"-20 bolt and lock washer. Align the notch on the bushing with the notch on the latch and lock the bushing in this position.

5. Install the cam on the shaft. Align the flat of the cam with the notch on the latch and hold the cam in this position. Drill the retaining pin hole through the cam and the shaft and install the retaining pin.

6. Install the valve to the valve lever with the 5/16"-18 bolt, washer and nut. Tighten the nut.

   a. With the cam release latch set, the valve spring in place and the valve in the *run* position, tighten the valve lever to shaft bolt.

   b. Level the valve in the *shutoff* position.

   c. Adjust the bushing (eccentric) so that the valve contacts the housing when the cam release latch is set.

7. Be sure the bolt hole in the center of the housing is sealed with the bolt and copper washer.

Assemble Intermediate Air Shutdown Housing

The hole for the spacer retaining pins must be drilled, using a 1/8" diameter drill, at the time the spacers are assemblied to a new service shaft (see Shop Notes in Section 3.0 for procedure).

1. Place the valve spring and valve lever in position in the housing. Partially slide the shaft through the housing, valve spring and valve lever. Install the key in the shaft. Then, continue to slide and position the shaft through the valve lever, spring and housing.

2. Install a new seal ring at each end of the shaft. Be sure the seal rings are seated in the counterbores of the housing.

3. Install a spacer and retaining pin at each end of the shaft. Drill the retaining pin hole through the spacers and shaft and install the retaining pins.

4. Install the valve to the valve lever with the 5/16"—18 bolt, washer and nut. Tighten the nut.

5. With the valve spring in place and the valve in the *run* position, tighten the valve lever to shaft bolt.

6. Level the valve in the *shutoff* position.

7. Be sure the bolt hole in the center of the housing is sealed with the bolt and copper washer.

Install Air Shutdown Housing (End Or Intermediate Housing)

1. Place a new gasket on the air inlet housing adaptor.

2. Place the air shutdown housing and stud assembly on the housing adaptor and secure it with the four (4) 3/8"—16 bolts, washers and lock washers and stud nut, lock washer and washer. Tighten the bolts and nut to 30-35 lb-ft (41-47 N«m) torque.

3. Slide the hose back over the air inlet tube, position and tighten the hose clamps. Be sure all connections are air tight.

4. Connect the end shutdown housing solenoid to the air shutdown latch.

5. On 12V and 16V engines, couple the crossover shaft to each air inlet housing shaft. Tighten the bolts to 21-26 lb-ft (28-35 N*m) torque. Install a new cotter pin in each coupling.

6. If removed, couple the other cross-over shaft to the air inlet housing shafts in the same manner and connect the linkage between the crossover shafts. Before securing the couplings, close the valves in all of the shutdown housings and center the couplings on all of the housing shafts with the aid of new cotter pins. Tighten the bolts in the coupling to 21-26 lb-ft (28—35 N*m) torque. Be sure the linkage operates freely.

7. Install the reset lever and tighten the attaching bolt.

8. Reset the air shutdowns to the *run* position.

9. Before starting the engine, check the mechanical operation of the air shutdown assembly. Then, test the shutdown assembly as follows:

   a. Start and run the engine at slow idle and no load.

   b. Increase the speed to 600 rpm no load.

   c. After the engine has stabilized at the specified speed in Step "b", trip the air shutdown. The engine speed must be reduced to at least 300 rpm.

   d. If a reduction in speed to 300 rpm or less cannot be obtained, the air shutdown assembly must be removed and checked.

10. After this test has been satisfactorily performed, drill and pin the couplings and linkage to the shafts with two (2)roll pins for each coupling and link (ball coupling), using a 1/8" diameter drill.

 © Detroit Diesel Corporation

BLOWER

The Series 149 engine blower, designed especially for efficient diesel operation, supplies the fresh air needed for combustion and scavenging. Its operation is similar to that of a gear-type oil pump. Two hollow three-lobe rotors revolve with very close clearances in a housing located within the cylinder block, between the two banks of cylinders. To provide continuous and uniform displacement of air, the rotor lobes are made with a helical (spiral) form.

• A single blower is used on 8V engines. Two blowers, coupled together (12V and 16V engines), are mounted in tandem in the air box (Fig. 1) of 12V and 16V engines. The basic parts for the 8V, 12V and 16V blowers are identical and interchangeable with the exception of the housing and rotors which differ in length.

Normal gear wear causes a decrease of rotor-to-rotor clearance between the leading edge of the right-hand helix (drive) rotor and the trailing edge of the left-hand helix (driven) rotor. Clearance between the opposite sides of the rotor lobes is increased correspondingly.

The blower rotors are timed by the two rotor gears at the rear end of the rotor shafts. This timing must be correct, otherwise the required clearance, obtained by the use of shims behind the gears, between the rotor lobes will not be maintained.

While the rotor-to-rotor lobe clearance may be corrected by adjustment, gear backlash cannot be corrected. When gears have worn to the point where the backlash exceeds .004", the gears should be replaced.

The right-hand helix rotor of the blower is driven at approximately twice engine speed by the blower drive shaft (refer to Section 1.7.6). The blower drive shaft is splined at one end to a flexible drive hub attached to the blower drive gear and at the other end to a flexible coupling attached to the right-hand helix blower timing gear. The mating left-hand helix timing gear drives the left-hand helix rotor.

A flexplate coupling, consisting of three spring plates, is used to take up misalignment between the blower and blower drive gear.

Metal ring-type oil seals are incorporated in the blower. Each oil seal consists of a carrier pressed on the rotor shaft, a collar pressed into the end plate and a seal ring contained in a groove in the carrier. The outside diameter of the seal ring seats against the collar and the sides of the seal ring seat against the groove in the carrier to prevent leakage of air or oil.

Each rotor is supported in the doweled end plates of the blower housing by a roller bearing at the front end and a two row pre-loaded radial and thrust ball bearing at the gear end.

Lubrication

The blower bearings, timing gears and governor drive assembly are pressure lubricated by means of oil passages which lead from the main oil galleries to an oil passage in each blower end plate.

A cup-shaped oil strainer has been incorporated in the vertical oil passage at the bottom of each blower end plate to remove any foreign material in the lubricating oil.

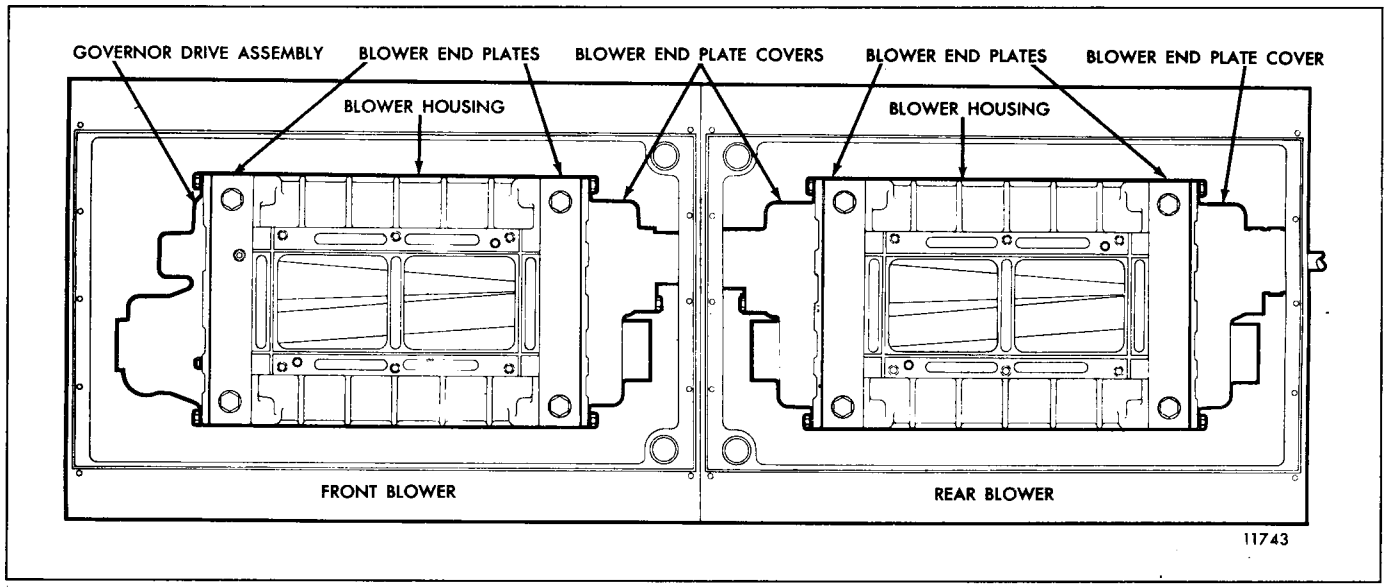


Fig. 1 – Tandem Blower Installation (12V–149)

© Detroit Diesel Corporation

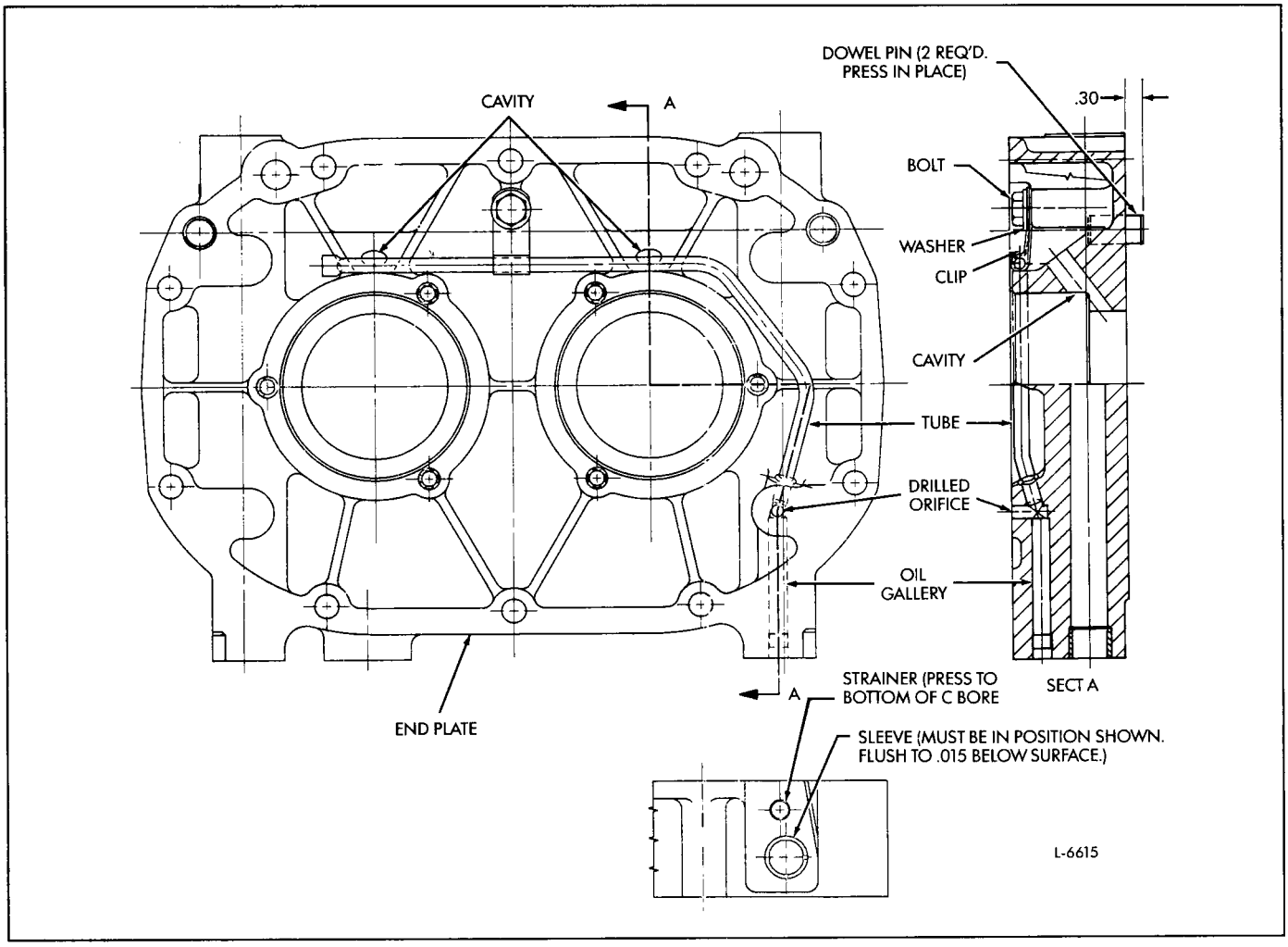


Fig. 2 – Blower Housing Rear End Plate

The oil flows upward through the end plate into the end plate cover and leaves through a small orifice spraying the splines on the drive couplings and drive shafts. It is then carried by splash to the bearings and timing gears. Oil which collects at the bottom of each end plate flows into a drain passage which leads back to the crankcase via oil passages in the cylinder block.

• Blowers on current Series 149 engines incorporate a rear end plate with a steel lubrication tube securred by a bolt, washer, and clip (Fig. 2). Oil diverted to the tube squirts out two discharge holes, filling the cavities above the bearing bores in the end plate. As oil drains from the cavities, it flows over the bearings, providing positive lubrication and cooling.

Two timing gears, located on the drive end of the rotor shafts, space the rotor lobes with a close tolerance. Therefore, as the lobes of the two rotors do not touch at any time, no lubrication is required.

The blower drive support bushings receive oil under pressure from an oil passage in the cylinder block to passages in the blower drive support. Excess oil drains back to the crankcase by way of the gear train.

Preliminary Inspection

The blower may be inspected without being removed from the engine. However, the air inlet housing and the air shutdown housing must be removed first.

Dirt or chips drawn through the blower will make deep scratches in the rotors and housing and throw up burrs around such abrasions. If burrs cause interference between the rotors or between the rotors and the housing, the blower should be removed from the engine and the parts dressed down to eliminate interference. The rotors should be replaced if they are too badly scored.

Oil radiating away from the oil seals in the blower end plates usually indicates worn oil seals. However, on turbocharged engines, once the turbocharger has cut in, worn oil seals will be detected by high crankcase pressure due to air leaking past the seals.

 © Detroit Diesel Corporation

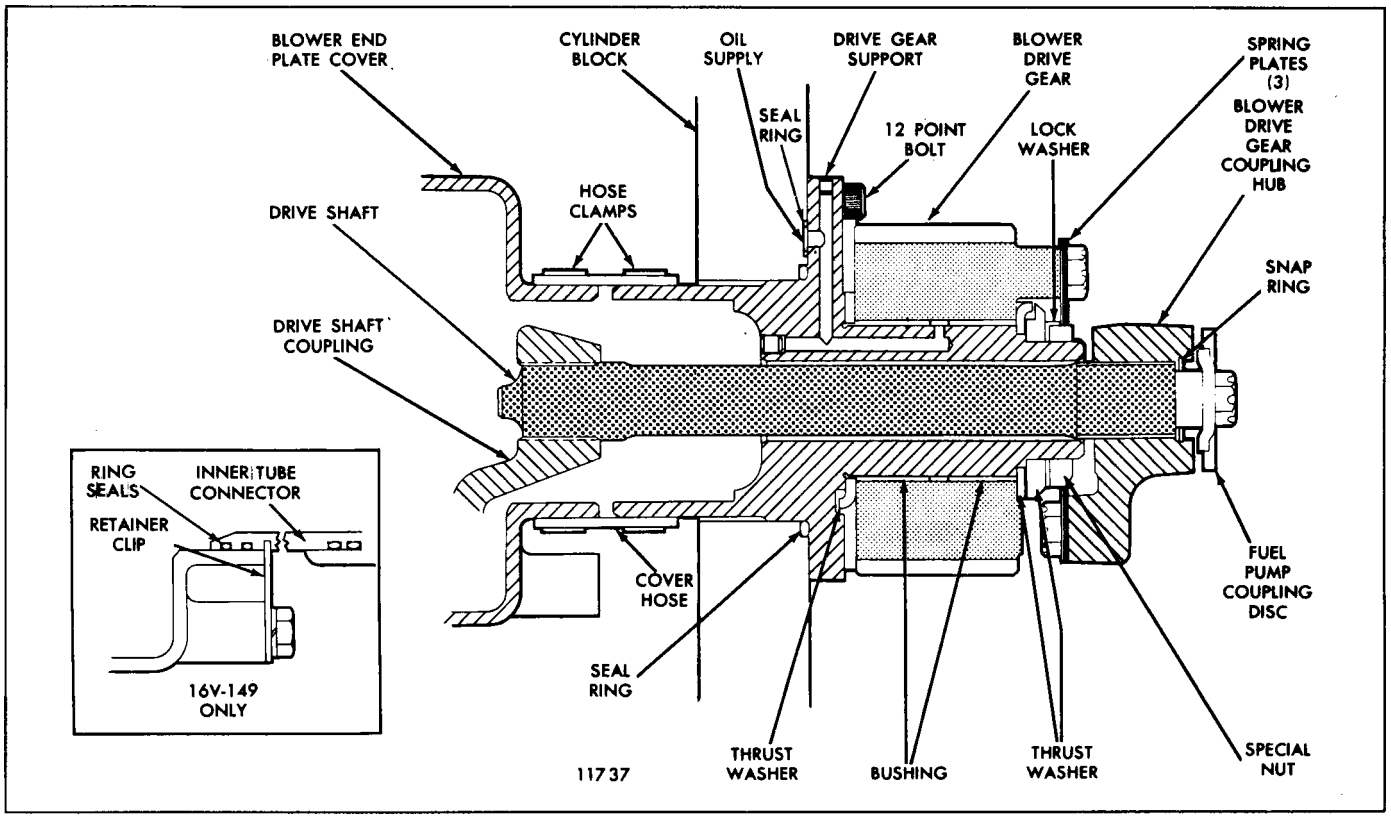


Fig. 3 – Blower Drive Hub and Gear Assembly (12V–149)

Loose rotor shafts or damaged bearings will cause rubbing and scoring between the crowns of the rotor lobes and the mating rotor roots, between the rotors and the end plates, or between the rotors and the housing. Generally a combination of these conditions exists. A loose shaft usually causes rubbing between the rotors and the end plates. Worn or damaged bearings will cause rubbing between mating rotor lobes at some point or perhaps allow the rotor assemblies to rub the blower housing. This condition will usually show up at the end where the bearings have failed.

Excessive backlash between the blower timing gears usually results in the rotor lobes rubbing throughout their entire length.

The blower inlet screen should be inspected periodically for an accumulation of dirt which, after prolonged operation, may affect the air flow. Servicing of the screen consists of throughly washing in fuel oil and cleaning with a stiff brush until the screen is free of all dirt deposits.

Remove Blower(s) From Engine

1. On non-turbocharged engines, loosen the hose clamps and slide the air inlet housing hoses back to disconnect the housing from the air cleaners. On engines equipped with turbochargers, disconnect and remove the air inlet and outlet tubes from the turbochargers.

2. Remove the eight (8) bolts, lock washers and plain washers securing the air inlet housing to the air shutdown housing. Remove the air inlet housing and gasket.

3. Disconnect the wire cable from the air shutoff cam pin handle.

4. On tandem blower installations, remove the shutdown linkage between the two air shutdown housings (Section 3.3).

5. Remove the engine ventilating system (Section 4.8).

• 6. Remove the 7/16" bolts, lock washers and plain washers securing air shutdown housings to the lower cover plate, then remove the air shutdown housings and gaskets.

7. Remove the governor control housing, blower cover plate and gaskets as outlined in the governor section of this manual.

8. Remove the fuel pump from the flywheel housing (Section 2.2).

9. Remove the blower drive shaft (Fig. 3) from the blower drive gear hub assembly (Section 1.7.6).

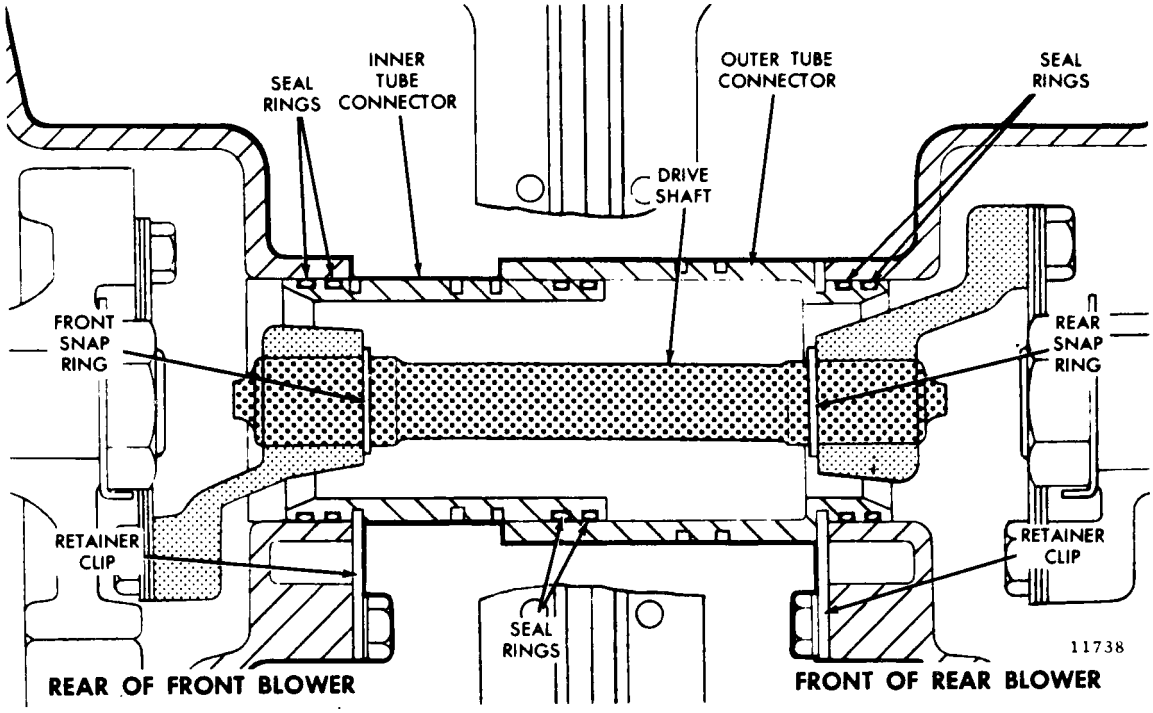


Fig. 4 - Tandem Blower Drive Shaft and CouplingInstallation

10. On 12V engines, loosen the two (2) hose clamps securing the cover hose to the blower end plate cover and the blower drive gear support (Fig. 3) and slide the hose back over the drive support. The 16V-149 engine uses a blower inner tube connector (inset, Fig. 3) in place of the hose and hose clamps. Remove the retainer clip and slide the inner tube connection back into the blower drive gear support.

11. Disconnect the center drive shaft and tube connections on 12V and 16V engine tandem blower applications as follows (Fig. 4):

    a. Remove the retainer bolts and clips securing the inner and outer tube connections in position.

    b. Slide the inner tube connector inside of the outer tube connector to expose the blower drive shaft front snap ring.

    c. Remove the front snap ring from its slot in the drive shaft and slide it toward the center of the shaft.

    d. Slide the drive shaft into the front blower coupling (toward the direction of the loosened snap ring) to disengage the drive shaft from the rear blower.

    e. Slide the outer tube connector out from the rear blower.

12. Remove the four (4) bolts and washers securing each blower to the block.

13. Attach a suitable rope to the webbing of the blower housing and, using a hoist, remove the blower or blowers from the cylinder block.

    NOTICE: On the 12V and 16V engines, remove the rear blower first, slide the center drive shaft and tube connector from the front blower and then remove the front blower.

14. Remove the oil seal rings in the cylinder block counterbores.

Remove Governor Drive Assembly, Blower End Plate Covers And Drive Components

After removing the blower(s) from the engine, remove the governor drive assembly, blower end plate covers and the drive components from the blowers as follows:

1. On 12V engines, remove the nine (9) 3/8”—16 x 3-1/4" bolts, one (1) nut, lock washers and plain washers securing the governor drive assembly to the front blower and remove the governor drive assembly and gasket. Place a clean cloth between the rotors and remove the 1 5/16"-18 retainer nut and spacer from the R.H. helix rotor.

 © Detroit Diesel Corporation

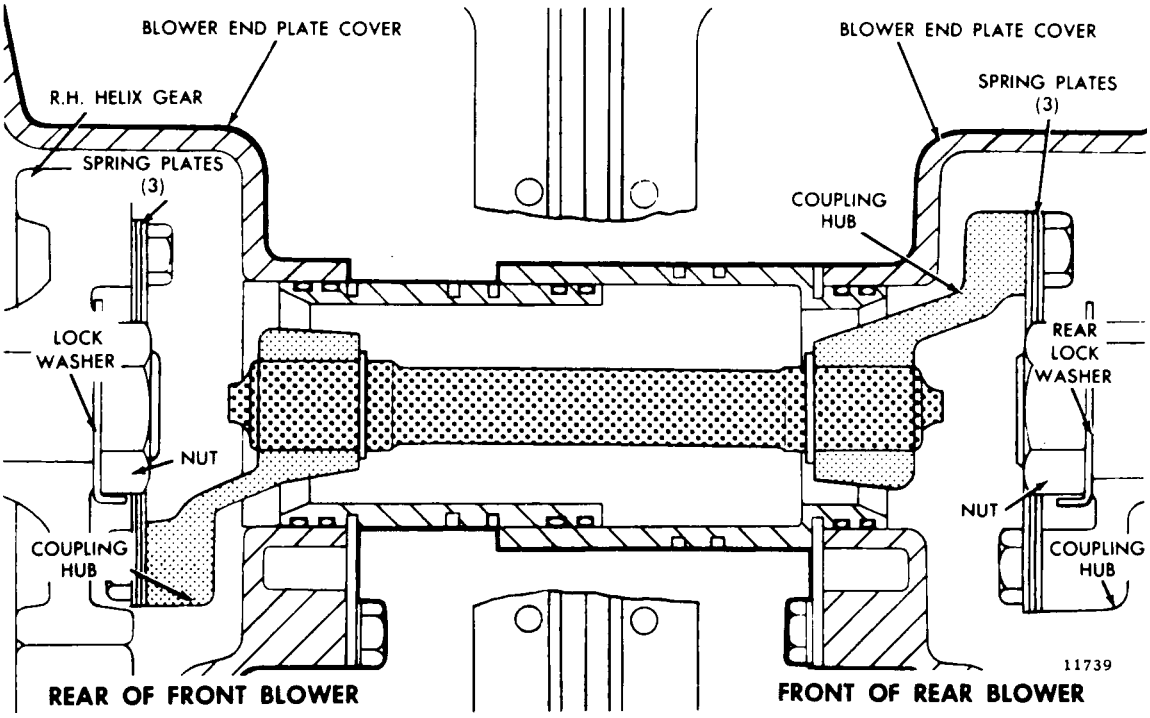


Fig. 5 - Tandem Blower Coupling Hubs

2. On 16V engines, remove the governor drive assembly and spacer, retaining nut and spacer as follows:

   a. Remove the nine (9) 3/8"-16 x 5" bolts, one (1) nut, lock washers and plain washers securing the governor drive assembly to the blower and remove the governor drive assembly and gasket.

   b. Remove the governor drive assembly spacer and gasket.

   NOTICE: Do not pry the housing or spacer from the dowels. If necessary, tap lightly with a plastic hammer.

   c. Place a clean cloth between the rotors and remove the 1-5/16" retaining nut and spacer on the front R.H. helix rotor (Fig. 13).

3. Remove the ten (10) 3/8"-16 x 3-1/4" bolts, lock washers and plain washers securing each of the blower end plate covers to the rear of the front blower and the front and rear of the rear blower. Remove the blower end plate covers and gaskets.

4. Remove the three (3) 7/16"-20 x 7/8" self-locking bolts securing each blower drive coupling hub to the R.H. helix timing gear of each blower (Figs. 4 and 5). Remove the hub and spring plate assemblies.

5. Remove the three (3) 7/16"-20 x 7/8" self-locking bolts securing the blower drive coupling hub to the front of the rear blower (Fig. 5). Remove the hub and spring plate assembly.

6. Place a clean cloth between the rotors and bend the tang of the lock washer back. Remove the 1—5/16”—18 retaining nut and lock washer securing the blower drive coupling hub to the front of the R.H. helix rotor on the rear blower.

7. Remove the blower drive coupling hub from the front R.H. helix rotor shaft of the rear blower with puller J 22706-16 (inset, Fig. 13).

   NOTICE: Place a clean cloth between the rotors when removing the hub.

Disassemble Blower

This disassembly procedure will apply to all blowers although disassembly of only one blower will be covered in the text.The difference, if any, will be noted in the text. Disassemble the blower as follows:

NOTICE: On tandem blowers, matchmark the blower components when disassembling the blowers.

1. Place a clean cloth between the rotors. Then, bend the tang of each of the lock washers open and remove the l-5/16"-18 retaining nuts securing the timing gears to the rotor shafts.

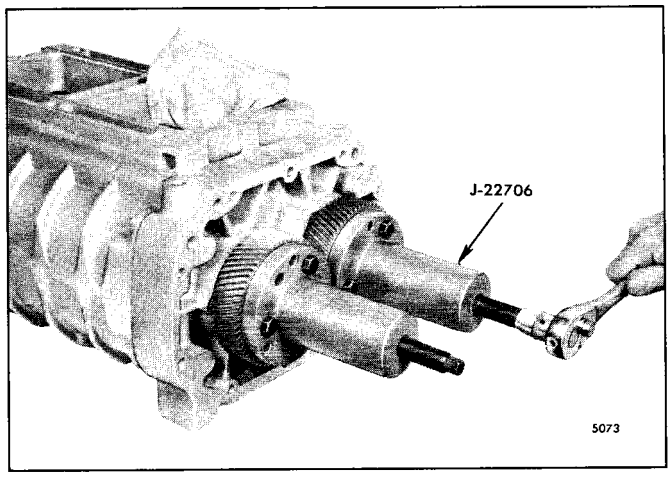


Fig. 6 – Removing Blower Gears using Tool J 22706–16

2. Remove the 1—5/16"—18 retainer nut from the front end of the L.H. rotor assembly.

3. Remove the self-locking bolts securing the rotor shaft bearing retainers to the front blower end plate. Remove the retainers and outer bearing spacers.

4. Remove the blower front end plate. Tap the end plate with a plastic hammer to loosen it from the housing.

NOTICE: The roller bearing inner races will remain on the shafts of the rotors.

5. Remove the timing gears with pullers J 22706-16 (Fig. 6). Both gears must be pulled at the same time as follows:

   a. Back out the center screws of both pullers and place the flanges against the gear faces, aligning the flange holes with the tapped holes in the gears. Secure the pullers to the gears with six (6) 7/16"-20 x 1—1/2" bolts (three on each gear).

   b. With a clean cloth placed between the rotors to prevent rotation, turn the two puller screws uniformly clockwise and withdraw the gears from the rotor shafts (Fig. 6).

v 6. Remove the shims from the rotor shafts and note the number and thickness of shims on each rotor shaft to ensure identical replacement when assembling the blower.

7. Remove the three (3) self-locking bolts securing each rotor shaft bearing retainer to the rear blower end plate. Remove the retainers.

8. Remove the rotors from the rear end plate and blower housing as follows:

   a. Install two (2) temporary hold down bolts through the rear blower end plate (Fig. 7).

   b. Back out the center screws of the pullers (J 22706-16) far enough to allow the flanges of the pullers to lay flat on the face of the rear end plate.

   c. Align the holes of the puller flanges with the tapped holes in the end plate. Secure the pullers to the end plate with six (6) 5/16"—18 x 1-1/4" bolts.

NOTICE: Be sure that the 5/16”—18 bolts are threaded all the way into the tapped holes in the end plate to provide maximum anchorage for the pullers and to eliminate possible damage to the end plate.

   d. Turn the puller screws in a clockwise direction to push the blower rotors out of the rear end plate (Fig. 7). Push the rotors out together.

   e. Remove the bolts securing the rear end plate to the housing and remove the rear end plate.

NOTICE: It may be necessary to tap the rear end plate lightly with a plastic hammer.

9. Remove the bearings and ring-type oil seals, carriers, roller bearing inner races and collars from the blower rotor shafts and end plates as follows:

   a. Clamp one lobe of the rotor in a bench vise equipped with soft jaws (Fig. 8). Tighten the vise just enough to hold the rotor stationary.

   b. Remove the oil seal ring from the seal ring carrier on each blower rotor shaft with a pair of snap ring pliers (Fig. 8).

   c. Refer to Fig. 9 and place the seal ring carrier remover adaptor J 22706-7 over the carrier. Make sure the adaptor is seated in the groove of the carrier.

   d. Back out the center screw of puller J 22706-16 far enough to permit the puller flange to lay flat against the adaptor J 22706-7.

   e. Place the puller over the end of the rotor shaft and against the adaptor on the oil seal ring carrier. Align the holes in the puller flange with the tapped holes in the adaptor, then secure the puller to the adaptor with two (2) bolts.

   f. Turn the puller screw clockwise and pull the oil seal ring carrier and roller bearing inner race (front end of blower rotors only) from the rotor shaft (Fig. 9).

   g. Remove the remaining oil seal ring carriers from the rotor shafts in the same manner.

© Detroit Diesel Corporation

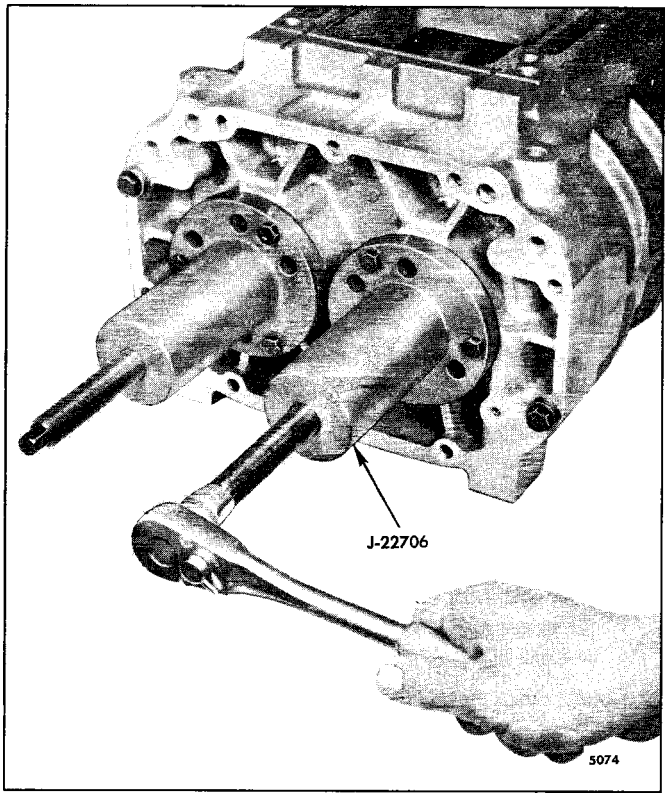


Fig. 7 - Removing Blower Rotors from Housing and Rear End Plate using Tool J 22706-16

• h. Remove the bolt, washer, and clip securing the oil supply tube to the rear end plate. Pull the tube out of the end plate.

i. Refer to Fig. 10 and support the outer face of the blower end plate on wood blocks on the bed of an arbor press.

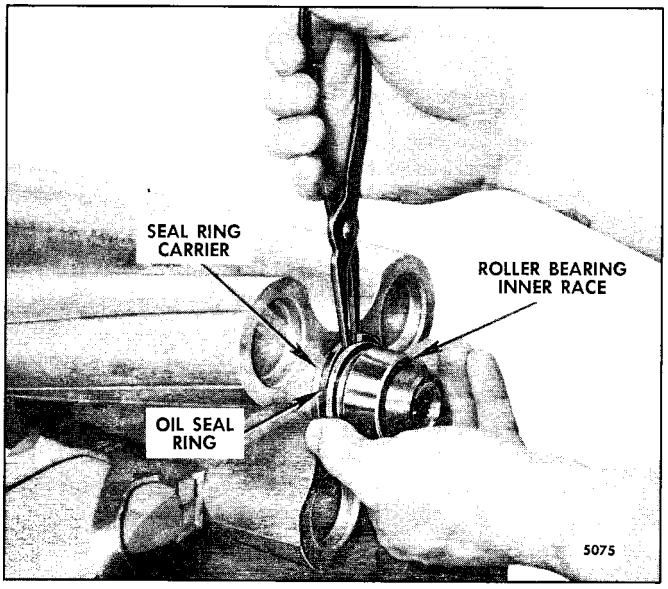


Fig. 8 - Removing or installing Oil Seal Ring

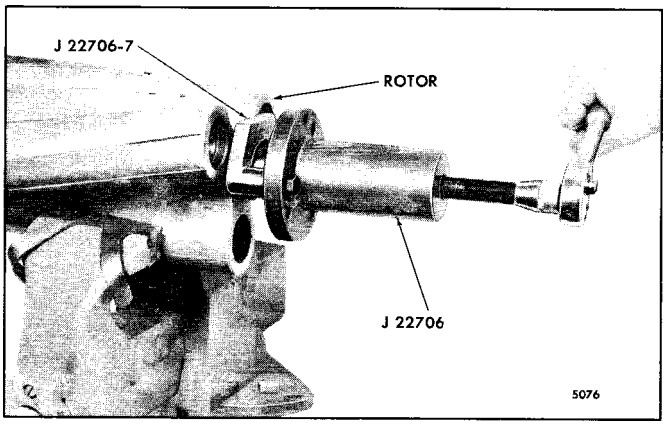


Fig. 9 - Removing Oil Seal Ring Carrier from Blower Rotor Shaft

j. Place the long end of the oil seal remover and installer J 22706-3 down through the oil seal ring collar and into the bearing, with the opposite end of the remover under the ram of the press (Fig. 10). Then, press the bearing and oil seal ring collar out of the end plate.

k. Remove the remaining bearings and oil seal ring collars from the end plates in the same manner. Keep each roller bearing inner race with its mating outer race.

Inspection

Wash all of the blower parts in clean fuel oil and dry them with compressed air.

CAUTIONiTo prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Examine the ball bearings for any indications of corrosion or pitting. Lubricate each bearing with light engine oil. Then, while holding the bearing inner race from turning, revolve the outer race slowly by hand and check for rough spots. The double-row ball bearings are pre-loaded and have no end play. A new double-row bearing will seem to have considerable resistance to motion when revolved by hand.

Check the oil seal rings, carriers and collars for wear and scoring. If worn excessively, replace them.

Inspect the blower rotor lobes, especially the sealing ribs, for burrs and scoring. Rotors must be smooth for efficient operation of the blower. If the rotors are slighly scored or burred, they may be cleaned up with emery cloth.

Examine the rotor shaft serrations for wear, burrs or peening.

© Detroit Diesel Corporation

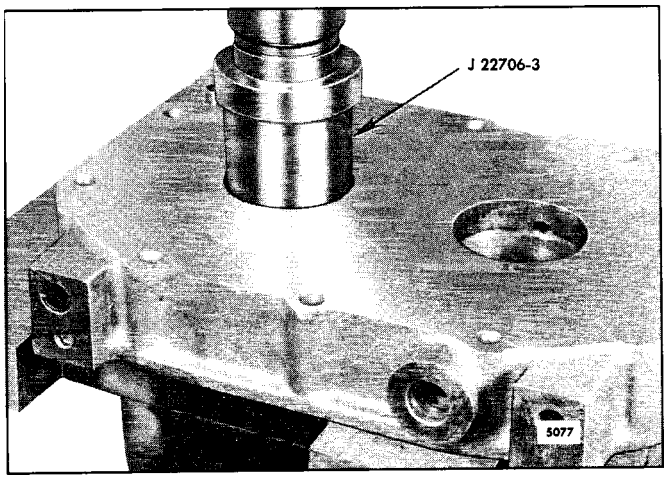


Fig. 10 - Removing Oil Seal Ring Collar and Bearing from End Plate using Tool J 22706-3

Inspect the inside surface of the blower housing for burrs and scoring. The inside surface must be smooth for efficient operation of the blower. If the inside surface of the housing is slightly scored or burred, it may be cleaned up with emery cloth.

Check the finished ends of the blower housing for flatness and burrs. The end plates must set flat against the blower housing.

The finished inside face of each end plate must be smooth and flat. If the finished face is slightly scored or burred, it may be cleaned up with emery cloth.

The bottom surface of each blower end plate must be smooth and flat. A service blower shim is available for use when the blower end plates show signs of fretting corrosion and can not be cleaned up with emery cloth (see Shop Notes in Section 3.0).

• Blowers on current Series 149 engines incorporate a rear end plate with a steel lubrication tube securred by a bolt, washer, and clip (Fig. 2). Make sure oil discharge holes and drain cavities are open.

> **NOTICE:** Do not mix a salvaged end plate and a new end plate on the same blower. The service shim must be used in pairs (one under each end plate.)

Examine the serrations in the blower timing gears for wear and peening; also check the teeth for wear, chipping or damage. If the gears are worn to the point where the backlash between the gear teeth exceeds .004", or are damaged sufficiently to require replacement, both gears must be replaced as a set.

Check the blower drive shaft serrations for wear or peening. Replace the shaft if it is bent.

Inspect the blower drive couplings, hub and spring plates for wear.

> **NOTICE:** Effective with engine serial numbers 12E-5700 and 16E-5276 new ductile iron hubs (drive gear, drive coupling and rotor coupling) identified by the part number on the casting are being used. Former and new hubs are interchangable. When one or more hubs require replacement all of the hubs should be replaced.

Replace all worn or excessively damaged blower parts.

• Check the rear end plate oil supply tube for damage or plugging. Clean or replace as required.

Clean the oil strainer in the vertical oil passage at the bottom of each blower end plate and blow out all oil passages with compressed air.

> **CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.**

Clean the orifice plug in the oil passages of the blower end plate cover with compressed air (Fig. 12).

> **CAUTION-.To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.**

Replace the plugs, if necessary. Press the orifice plugs flush to .020" below the surface of the cover and stake them securely.

> **NOTICE:** Current engines use a four hole orifice plug to lubricate the blower drive coupling. Prior to engines 12E-2100 and 16E-2072, a two hole orifice was used. However, only the four hole plug is serviced.

On the former 12V-149 front blower (prior to engine 12E-387), install the spray nozzle in the front end plate of the front blower as follows:

1. Position the spray nozzle so that when the shank end of a No. 60 drill is inserted in the hole in the side of the nozzle a sighted line along the drill will pass within 1/8" of the center of the rotor stub shaft (Fig. 11).
2. When the nozzle is properly positioned, press it into the blower front end plate.

• On certain early 8V-149 engines equipped with a flapper style blower bypass valve, the bypass valve lever may be capable of “going over center” (moving beyond its center limit position). If this occurs, the bypass valve may stick in the *open* position, causing inefficient engine operation and intermittent smoking, especially at low rpm. To eliminate the possibility of inefficient engine operation caused by a stuck-open bypass valve, DDC recommends installing the blower bypass valve lever stop plate on early 8 V-149 engines. Refer to Shop Notes, section 3.0.

© Detroit Diesel Corporation

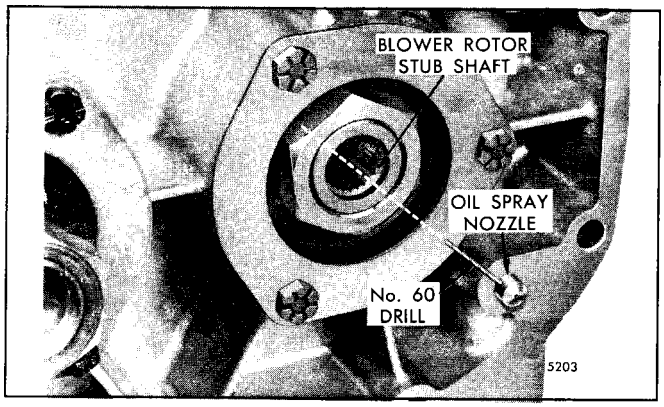


Fig. 11 - Positioning Blower Spray Nozzle (Former)

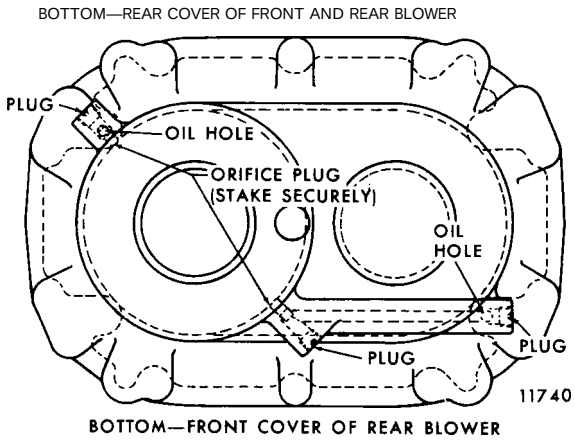


Fig. 1 2 - Location of Orifice Plugs in Blower End Plate Cover

• See section 3.4.2 for blower bypass valve description, disassembly, and assembly procedures. See section 3.0 for troubleshooting blower bypass valve performance. See section 15.1 for preventive maintenance.

Assemble Blower

Several precautions are given below to assure the proper assembly of the rotors and gears for correct blower timing.

1. The lobes on the *driving* blower rotor and the teeth on its gear form a right-hand helix while the lobes and teeth of the *driven* rotor and gear form a left-hand helix. A rotor with right-hand helix lobes must be used with a gear having right-hand helix teeth.

2. One serration is omitted on the drive end of each blower rotor shaft and a corresponding serration is omitted in each gear. Assemble the gears on the rotor shafts with the serrations in alignment (Fig. 22).

NOTICE: The blower rotor timing gears are a press fit on the rotor shafts. With the splines of the *rear* rotor shafts coated with light engine oil, the torque required to move the gears down the shaft should fall within a range of 30-130 lb—ft (41-177 N*m) torque (corresponds to .0015"-.0045" press fit).

If the installation torque does not fall within the 30-130 lb—ft (41-177 N*m) range, the timing gears or rotor assemblies must be replaced. A minimum and maximum torque is not required on the *front* rotor shaft splines. A loose spline fit can result in a major blower failure.

3. The rotors must be assembled in the blower housing with the omitted serrations in the rotor shafts aligned (Fig. 22).

4. The rotors are stamped GEAR END on one of the rotor lobes of each rotor.

With these precautions in mind, proceed with assembly of the blower.

1. Install the ring type oil seals, carriers, collars and roller bearing inner races on the rotor shafts and in the end plates as follows:

   a. Support one of the rotor assemblies on wood blocks on the bed of an arbor press (Fig. 14).

   b. Lubricate the inside diameter of the oil seal ring carrier with engine oil, then start the carrier straight over the end of the rotor shaft with the chamfered inside diameter end facing the rotor.

   c. Place the oil seal ring carrier installer J 22706-4 and adaptor J 22706-9 over the end of the rotor shaft and against the carrier with the end of the installer under the ram of the press. Then, press the carrier down tight against the rotor.

   d. Install the remaining oil seal ring carriers on the rotor shafts in the same manner.

   e. Position the roller bearing inner race, numbered side up, over the front end of the rotor shaft and press the race on the shaft with tool J 22706-4 until the bearing race contacts the shoulder on the shaft.

   f. Install the bearing inner race on the front end of the other rotor in the same manner.

   g. Install an oil seal ring in the ring groove of each carrier with a pair of snap ring pliers in the same manner as shown in Fig. 8.

NOTICE: To avoid breaking the oil seal rings, do not spread them any more than necessary to place them over the end of the carrier. Do not twist the rings or possible distortion may result in loss of side contact area.

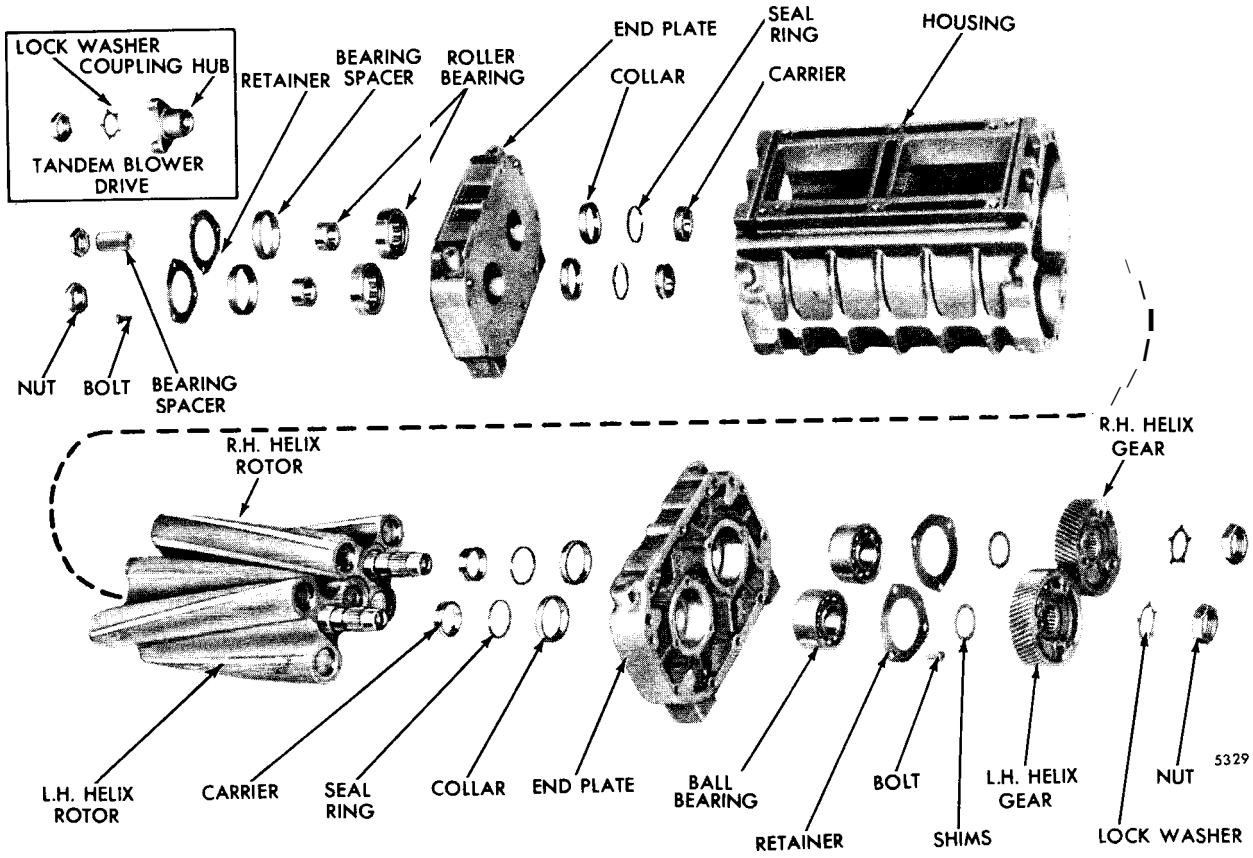


Fig. 13 - Blower Components

h. Support one of the blower end plates, inner face up, on wood blocks on the bed of an arbor press (Fig. 15).

i. Lubricate the outside diameter of a seal ring collar with engine oil, then start the chamfered outside diameter end of the collar straight into the bore in the end plate.

j. Place the oil seal ring collar installer J 22706-3 on top of the seal ring collar and under the ram of the press (Fig. 15). Then, press the collar into the end plate until the shoulder on the installer contacts the end plate. The collar must be flush to .010" below the surface of the end plate.

k. Install the remaining oil seal ring collars in the end plates in the same manner.

Assemble Rotors And End Plates

1. Install the blower front end plate on the blower rotors as follows:

r

a. Check the dowel pins. The dowel pins must project .300" from the flat inner face of the front end plate to assure proper alignment of the end plate with the housing.

b. Support the front end plate on two wood blocks approximately 4" high, with the inner face of the end plate facing up and the TOP side of the plate away from the technician and the bottom toward the technician (Fig. 16).

c. Lubricate the oil seal ring in the carrier on the front end of the right-hand helix rotor shaft with engine oil.

d. Hold the right-hand helix rotor in a *vertical* position (with end stamped GEAR END up). Position the seal ring in the carrier so the ring protrudes from its groove the same amount on each side.

e. Start the end of the rotor shaft straight into the right-hand shaft opening in the end plate (Fig. 16). Continue to lower the rotor until the oil seal ring contacts the seal ring collar in the end plate. Then, carefully work the oil seal ring into the collar until the rotor contacts the end plate.

 © Detroit Diesel Corporation

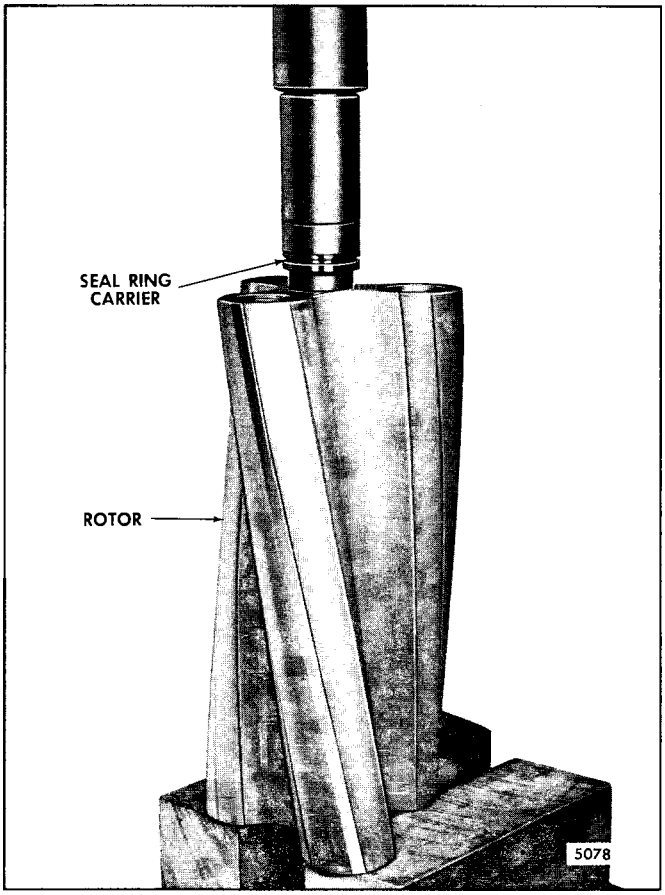


Fig. 1 4 - Installing Oil Seal Ring Carrier on Blower Rotor Shaft

NOTICE: Position the rotor so that the missing serration is facing toward the left (Fig. 22).

f. Perform Steps “c” and “d” on the left-hand helix rotor.

g. Position the rotors so the lobes are in mesh and the omitted serrations in the splines of both rotor shafts are facing toward the left side of the end plate (Fig. 22). Then, start the end of the rotor shaft straight into the left-hand opening in the end plate. Continue to lower the rotor until the oil seal ring contacts the seal ring collar in the end plate. Then, carefully work the oil seal ring into the collar until the rotor contacts the end plate.

2. Install the blower housing over the rotors and attach it to the front end plate as follows:

   a. Position the blower housing over the top of the rotors. Then lower the housing over the rotors until it contacts the dowel pins in the end plate.

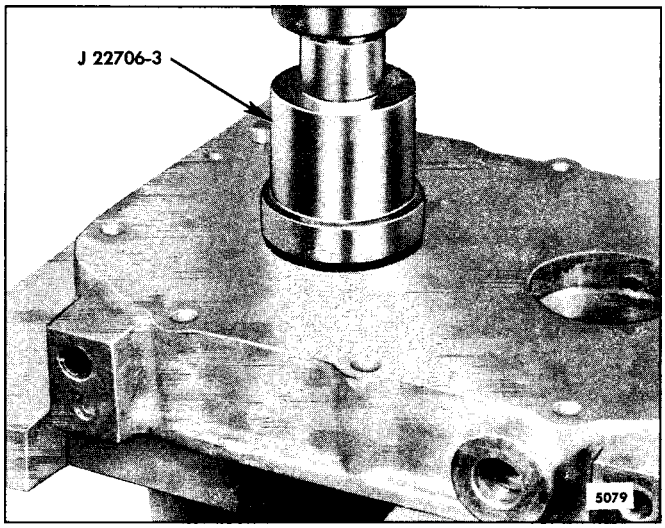


Fig. 1 5 - Installing Oil Seal Ring Collar in End Plate using Tool J 22706-3

   b. Align the dowel pin holes in the housing with the dowel pins in the end plate and push the housing tight against the end plate. If necessary, tap the housing lightly with a plastic hammer.

   c. Temporarily insert four (4) 3/8"-16 x 2-1/2" bolts with washers through the front end plate and thread them into the housing. Tighten the bolts securely.

3. Install the blower rear end plate on the rotor shafts and housing as follows:

   a. Check the dowel pins. The dowel pins must project .300" from the flat inner face of the rear end plate to assure proper alignment of the end plate with the housing.

   b. Lubricate the oil seal rings in the carriers on the rotor shaft with engine oil. Position the seal ring on each carrier so the ring protrudes from its groove the same amount on each side.

   c. Position the rear end plate over the top of the rotor shafts with the inner face of the end plate facing the rotors.

   d. Lower the end plate straight over the rotor shafts until the dowel pins in the end plate contact the blower housing (Fig. 17). Then, carefully work the dowel pins into the dowel pin holes in the housing and the oil seal rings into the collars. Push the end plate tight against the housing. If necessary, tap the end plate lightly with a plastic hammer.

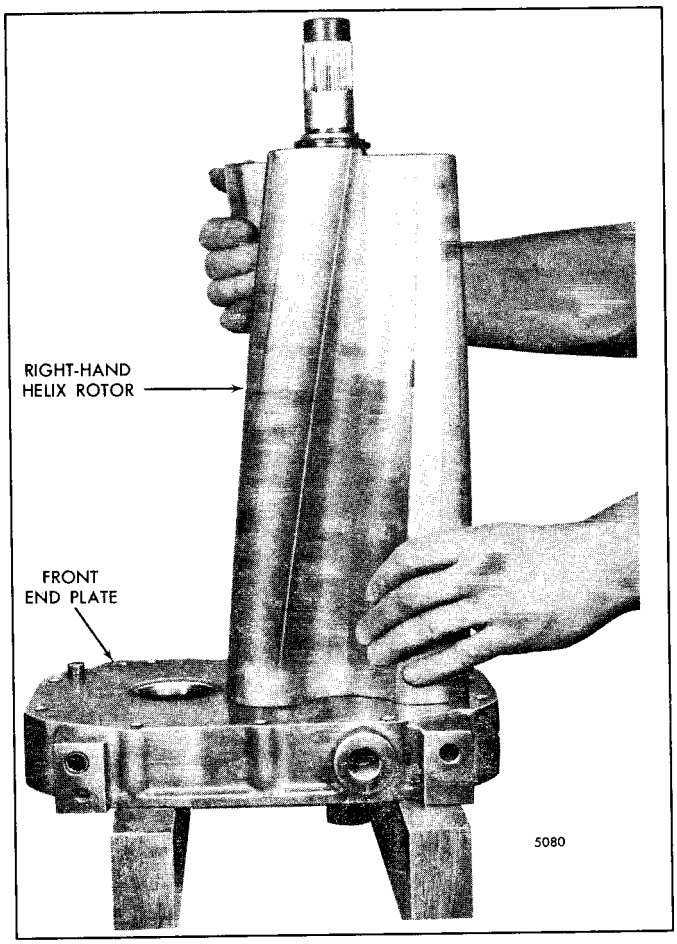


Fig. 16 – Installing Blower Rotor in Front End Plate

e. Temporarily insert four (4) 3/8"—16 x 2-1/2" bolts with washers through the rear end plate and thread them into the housing. On former 12V blowers, the front end plate of the front blower must have the oil nozzle positioned so the oil flow is directed toward the governor drive (Fig. 11). Tighten the bolts securely.

If the governor weight housing or the complete governor assembly is replaced on an early engine (prior to engine 12E-387), it will be necessary to remove the spray nozzle from the blower end plate and include a new governor-to-blower gasket. The tab on the gasket is to assure the gasket is in place.

Install Blower Rotor Shaft Bearings And Gears

1. With the blower housing, rotors and end plates still supported in a vertical position on the two wood blocks, install the ball bearings on the rotor shafts and in the rear end plate as follows:

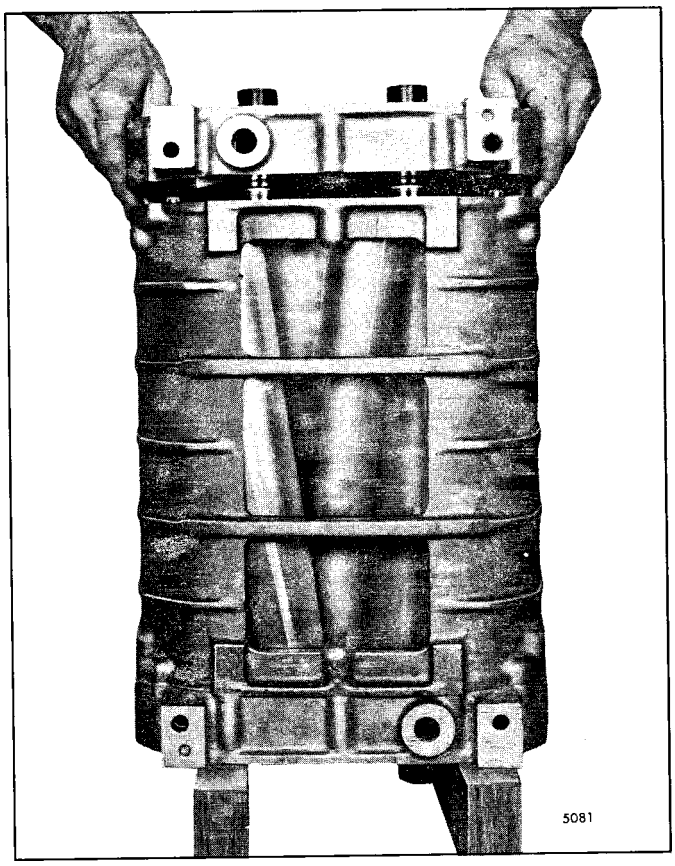


Fig. 17 - Installing Rear End Plate on Blower Rotors and Housing

a. Lubricate one of the ball bearings with light engine oil. Start the bearing, numbered end up, straight on one of the rotor shafts.

b. Place installer J 22706-5 on top of the bearing and tap the bearing straight on the shaft and into the rear end plate (Fig. 18).

c. Install the second ball bearing on the remaining rotor shaft in the same manner.

d. Place the bearing retainers on top of the bearings and the end plate. Then, install three self-locking retainer bolts in each retainer. Tighten the bolts to 13-17 lb-ft (18-23 N*m) torque.

2. Install the roller bearing outer race assemblies in the front end plate as follows:

a. Reverse the position of the blower housing on the two wood blocks (Fig. 19).

b. Lubricate one of the roller bearings with light engine oil. Start the bearing over the rotor shaft and bearing inner race and into the end plate.

© Detroit Diesel Corporation

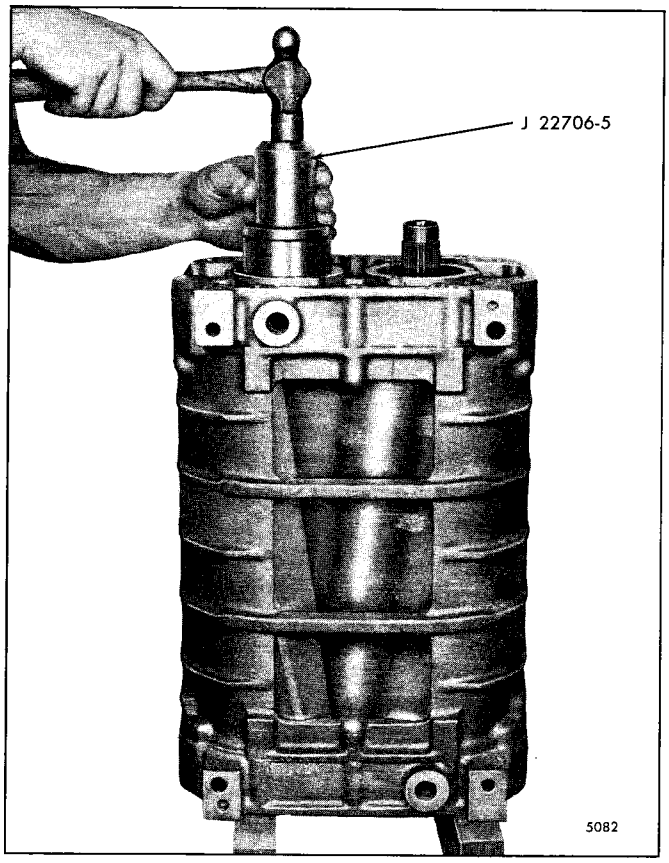


Fig. 18 - Installing Ball Bearings on Rotor Shafts and in Rear End Plate using Tool J 22706-5

c. Place installer J 22706-5 on top of the bearing and tap the bearing straight on the inner race and into the front end plate (Fig. 19).

d. Install the second roller bearing on the remaining rotor shaft in the same manner.

e. Install bearing spacers over the outer races of the roller bearings (Fig. 13).

f. Place the bearing retainers on top of the bearings and the end plate. Then, install three self-locking retainer bolts in each retainer. Tighten the bolts to 13-17 lb-ft (18-23 N*m) torque.

• g. Insert the steel lube oil supply tube into the drilled oil passage of the rear end plate. Secure in place with bolt, washer, and clip.

3. Before installing the blower rotor timing gears on the rotor shafts, observe precautions “2” and “3” relative to the rotor shaft and timing gear alignment under *Assemble Blower.*

The stamped “O” mark in the end of each gear at the omitted serration will assist in aligning the gears on the shafts.

If shims were removed from the back side of the gears (between the inner race of the bearing and the gear), replace them in their *original* positions before installing the gears.

4. Install the blower timing gears as follows:

a. Place the blower assembly on the bench, with the top of the housing up and the rear end (ball bearing end) of the blower facing the outside of the bench.

b. Rotate the rotors to bring the omitted serrations on the shafts in alignment and facing to the left.

c. Install the same number and thickness of shims on the rotor shafts that were removed at the time of disassembly.

d. Lubricate the serrations of the rotor shafts with light engine oil.

e. Place the teeth of the rotor gears in mesh so that the omitted serrations inside the gears are in alignment and facing the same direction as the omitted serrations on the shafts.

f. Start both rotor gears straight on the rotor shafts with the right-hand helix gear on the right-hand helix rotor and the left-hand helix gear on the left-hand helix rotor, with the omitted serrations in the gears in line with the omitted serrations on the rotor shafts (Fig. 22).

g. Place a clean folded cloth between the lobes of the rotors to prevent the gears from turning.

h. Press the gears on the rotor shafts with gear installers J 22706^1 and J 22706-10. The torque required to move the gears down the shafts should fall within a range of 30-130 lb-ft (41-177 N*m) torque. The gears must be pressed on simultaneously. One gear will move freely for only a short distance down the shaft before it binds with the mating gear.

NOTICE: The 30-130 lb-ft (41-177 N«n) torque corresponds to .0015"-.0045" press fit. The 30 lb-ft (41 N*m) minimum torque ensures a interference fit between each timing gear and rotor shaft. This is required to prevent working between the gear and the shaft at the spline. The 130 lb-ft (177 N«m) maximum torque prevents excessive interference fit between each timing gear and rotor shaft. Higher interference may prevent the gear from sliding back on the shaft to secure the inner bearing race.

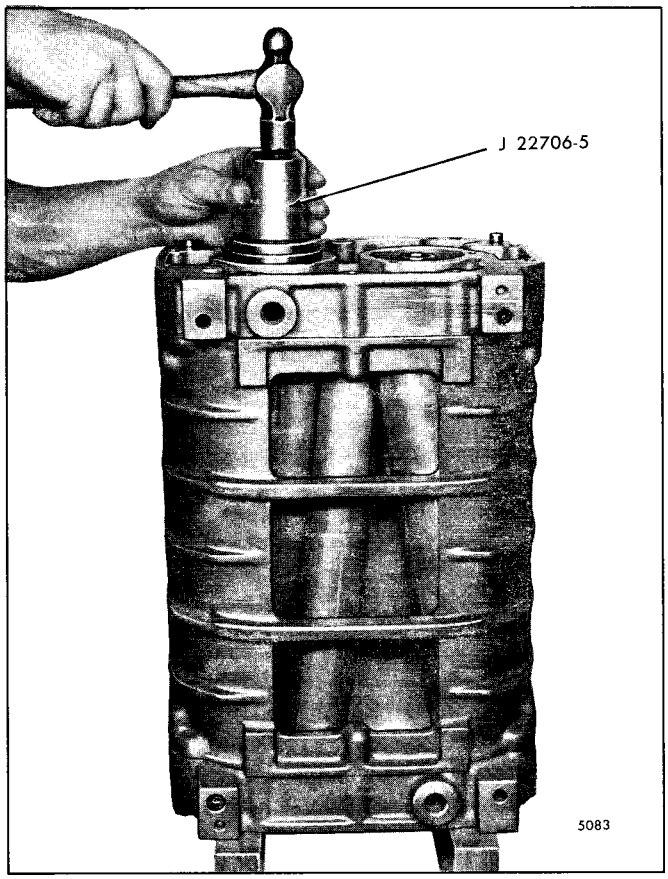


Fig. 19 - Installing Roller Bearings on Rotor Shafts and in Front End Plates using Tool J 22706-5

If the installation torque does not fall within the 30-130 lb-ft (41-177 N»m) torque, the timing gear or rotor assembly must be replaced.

i. Place a lock washer over each end of the rotor shaft, with the tang of the lock washer positioned in the hole in the gear.

NOTICE: The inner face of the locking washer (tang type) must be clean and dry to prevent it from turning.

j. Apply a small quantity of International Compound No. 2, or equivalent, on the threads of the rear rotor shafts and the contact face of the gear retaining nuts and start the nuts on the shafts. *Do not* use International Compound on the shaft splines. After the timing gears have been worked down the shafts and begin to bottom, continue to tighten the 1—5/16"—18 retaining nuts alternately to 200-250 lb-ft (271-339 N«m) torque (Fig. 13). Bend one or more of the tangs on each lock washer against the side of its retaining nut.

k. Apply a small quantity of International Compound No. 2, or equivalent, on the threads of the front L.H. helix rotor shaft and the contact face of the retaining nut and start the nut on the shaft. Tighten the 1-5/16" retaining nuts to 200-250 lb-ft (271-339 N«m) torque.

• 1. Apply a small quantity of International Compound No. 2, or equivalent, to the threads on the front of the front blower right-hand rotor stub shaft and the contact face of the 1-5/16 retaining nut. Install the 1.70" tube spacer and start the nut on the shaft. Tighten the retaining nut to 200 - 250 lb-ft (271 - 399 N»m) torque.

NOTICE: A minimum and maximum torque is not required on the front rotor shaft spline.

Hold the blower firmly on the work bench and keep the rotors from turning so that the correct torque can be obtained when tightening the retaining nuts. A suggested fixture to hold the blower firmly on the work bench would be a “C” clamp with the ball swivel pad removed. The ball portion of the “C” clamp should be inserted into the blower end plate mounting hole and clamped finger tight to the work bench. Torque can then be applied to the rotor nuts without the blower moving on the work bench.

Timing Blower Rotors

After the blower rotors and timing gears are installed, make a preliminary check of the rotor-to-end plate and rotor-to-rotor clearances with a feeler gage (Figs. 20 and 23). Refer to Fig. 21 for minimum blower clearances. The blower rotors, when properly positioned in the housing, run with a slight clearance between the lobes. This clearance may be varied by moving one of the helical gears in or out on the shaft relative to the other gear.

If the right-hand helix gear is moved out, the right-hand helix rotor will turn counterclockwise when viewed from the gear end. If the left-hand helix gear is moved out, the left-hand helix rotor will turn clockwise when viewed from the gear end. This positioning of the gear, to obtain the proper clearance between the rotor lobes, is known as blower timing.

Moving the gears OUT or IN on the rotor shafts is accomplished by adding or removing shims between the gears and the bearings.

The clearance between the rotor lobes may be checked with 1/2" wide feeler gages in the manner shown in Fig. 20. A specially designed feeler gage set, J 1698-02, for the blower clearance operation is available.

It is preferable to measure the clearance with a feeler gage comprised of two or more feelers since a combination is more flexible than one single feeler gage. When measuring clearances of more than .005", use gages made up of .002", .003" or .005" feeler stock to obtain accurate readings.

 © Detroit Diesel Corporation

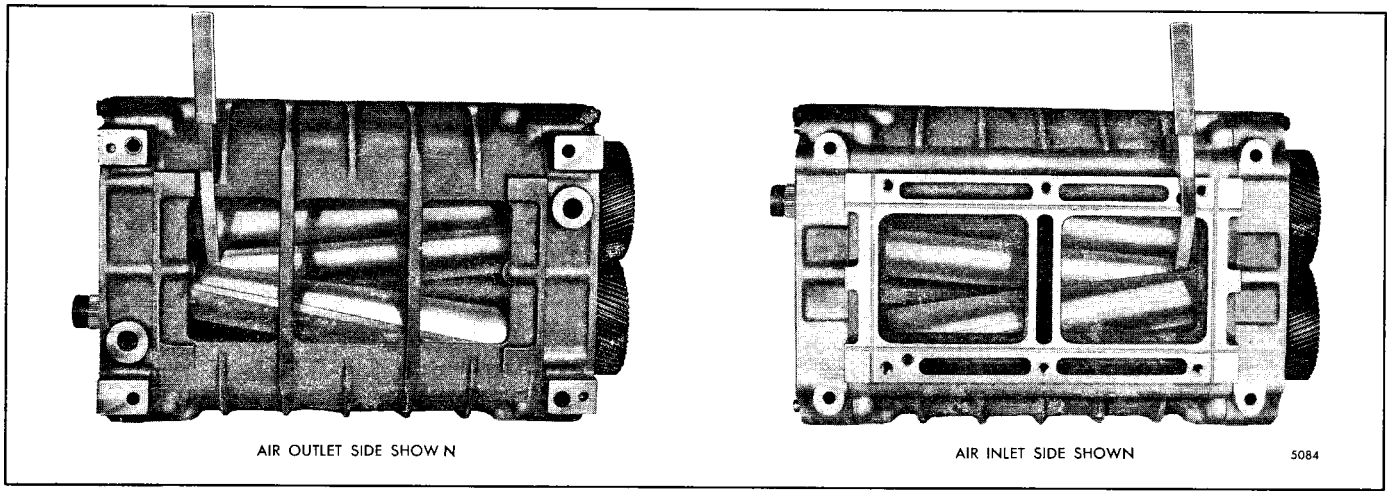


Fig. 20 - Measuring "CC" and "C" Clearance BetweenBlower Rotor Lobes

Time the rotors as follows:

1. Time the rotors to have a minimum clearance of .014" between the *trailing* edge of the right-hand helix rotor and the *leading* edge of the left-hand helix rotor ("CC" clearance) measured from both the inlet and outlet sides (Figs. 20 and 21). Check the clearance between the *leading* edge of the right-hand helix rotor and the *trailing* edge of the left-hand helix rotor ("C" clearance) for the minimum clearance of .024". Rotor-to-rotor measurements should be taken 1" from each end, and at the center of the blower.

2. After determining the amount one rotor must be revolved to obtain the proper clearance, add shims back of the proper gear to produce the desired result (Fig. 22). When more or less shims are required, both gears must be removed from the rotors. Placing a .003" shim in back of a rotor gear will revolve the rotor .001",

3. Install the required thickness of shims back of the proper gear and next to the bearing inner race and reinstall both gears. Recheck the clearances between the rotor lobes.

4. Determine the minimum clearances at points "A" and "B" (Fig. 21). Insert the feeler gages, (Fig. 23), between the end plates and the ends of the rotors. This operation must be performed at the ends of each lobe, making 12 measurements in all. Refer to Fig. 21 for the minimum clearances.

5. Check the clearance between each rotor lobe and the blower housing at both the inlet and outlet side — 12 measurements in all. Refer to Fig. 21 for the minimum clearances.

After the blower rotors are timed, complete the assembly of the blower as outlined below:

1. Remove the temporary hold down bolts from the blower end plates (front and rear of both blowers).

2. If removed, attach three (3) spring plates to the blower drive coupling hub with three (3) 7/16"-30 x 7/8" self-locking bolts. Tighten the bolts to 57-61 lb-ft (77-83 N*m) torque.

3. Attach the hub and spring plate assembly to the R.H. helix timing gear of the rear blower with three (3) 7/16"-20 x 7/8" self-locking bolts. Tighten the bolts to 57-61 lb-ft (77-83 N«m) torque.

4. Install the blower end plate cover gasket and blower end plate cover over the gear end of the rear blower (Fig. 13). Install ten (10) 3/8"-16 x 3-1/4" bolts, lock washers and plain washers.

   NOTICE: Be sure the lubrication hole in the gasket is aligned with the oil supply hole in the blower end plate. Tighten the bolts to 30-35 lb-ft (41-47 N#m) torque.

5. Place a cloth between the rotors when installing the coupling hub. Install the blower rotor coupling hub on the front of the R.H. helix rotor of the rear blower with gear installer J 22706^1 and installer set J 22706-10 (inset, Fig. 13).

Place a cloth between the rotors when installing the coupling hub.

NOTICE: Be sure the coupling hub is seated against the inner race of the front roller bearing.

6. Apply a small quantity of International Compound No. 2, or equivalent, on the threads of the front R.H. helix rotor shaft and the contact face of the retaining nut. Install the lock washer with the tang positioned in the slot provided in the coupling hub and start the nut on the shaft. Tighten the 1—5/16"—18 retaining nut to 200-250 lb—ft (271-339 Nem) torque.

7. Bend one or more of the tangs on the lock washers against the side of the nut to lock the nut in position.

8. If removed, install three spring plates to each of the inner blower rotor coupling hubs with three (3) 7/16"—20 x 7/8" self-locking bolts (Fig. 5). Tighten the bolts to 57-61 lb—ft (77-83 Nem) torque.

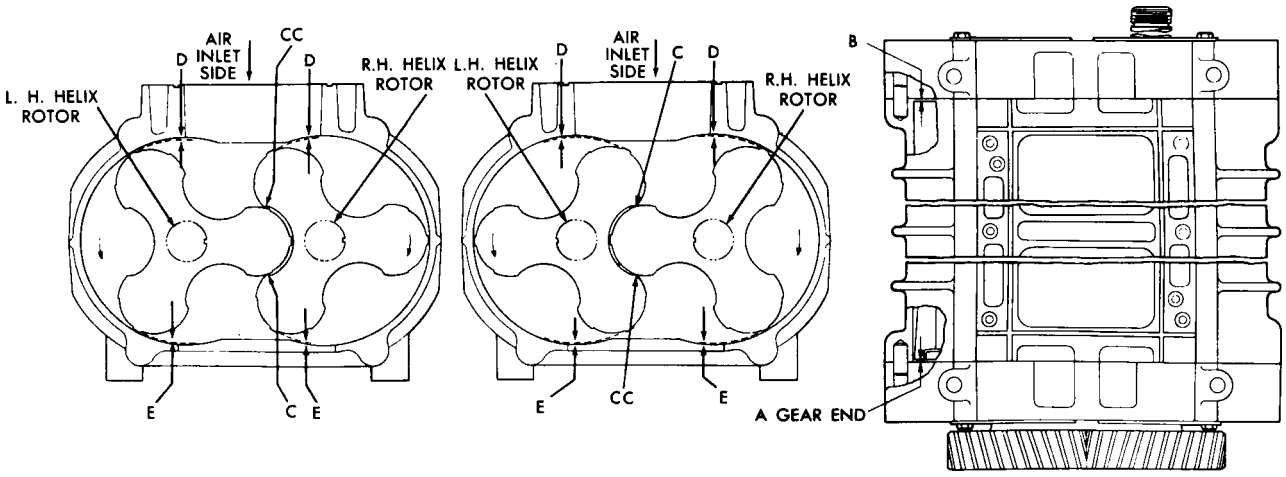
9. Attach one hub and spring plate assembly to the front blower rotor coupling hub on the front of the rear blower with three (3) 7/16"-20 x 7/8" self-locking bolts. Tighten the bolts to 57-61 lb-ft (77-83 Nem) torque.

10. Use a new gasket and install the blower end plate cover on the front of the rear blower (Fig. 13). Install ten (10) 3/8"-16 x 3-1/4" bolts, lock washers and plain washers. Tighten the bolts to 30-35 lb-ft (41-47 Nem) torque.

NOTICE: Be sure the lubrication hole in the gasket is aligned with the oil supply hole in the blower end plate. The tab on the gasket is to assure the gasket is in place.

11. Attach the other hub and spring plate assembly to the rear of the front blower R.H. helix timing gear with three (3) 7/16"-20 x 7/8" self-locking bolts. Tighten the bolts to 57-61 lb-ft (77-83 Nem) torque.

12. Use a new gasket and install the blower end plate cover on the gear end of the front blower (Fig. 13). Install ten (10) 3/8"-16 x 3-1/4" bolts, lock washers and plain washers. Tighten the bolts to 30-35 lb-ft (41-47 Nem torque.



VIEWS FROM GEAR END OF BLOWER NEW PARTS

VIEW	A	B	C	CC	D	E
MIN. 12 V-149 MAX.	.007" TO .013"	.013" TO .030"	.024" MIN.	.014" MIN.	.021" MIN.	.007" MIN.
MIN. 8V, 16 V-149 MAX.	.007" TO .013"	.021" TO .038"	.024" MIN.	.014" MIN.	.021" MIN.	.007" MIN.

VIEWS FROM GEAR END OF BLOWER USED PARTS

VIEW	A	B	C	CC	D	E
MIN. 12V-149 MAX.	.007" TO .013"	.013" TO .050"	.024" MIN.	.014" MIN.	.021" MIN.	.007" MIN.
MIN. 8V, 16 V-149 MAX.	.007" TO .013"	.021" TO .058"	.024" MIN.	.014" MIN.	.021" MIN.	.007" MIN.

NOTE: Time rotors to dimensions on chart for clearance between trailing side of R.H. Helix Rotor and leading side of L.H. Helix Rotor (cc) from both inlet and outlet side of blower.

Fig. 21 - Chart of Minimum Blower Clearances

 © Detroit Diesel Corporation

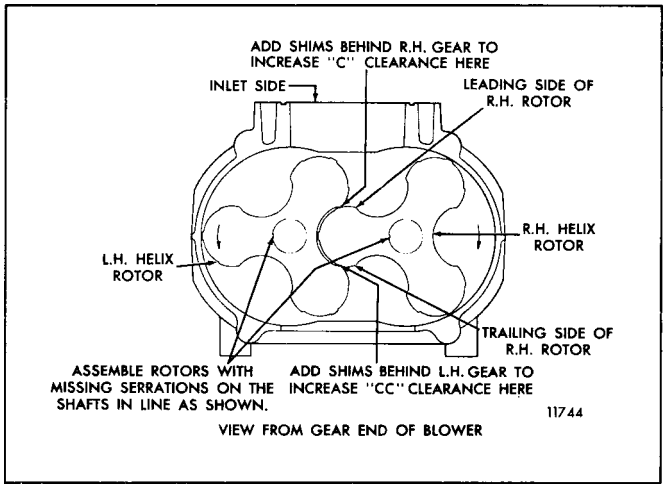


Fig. 22 - Diagram Showing Proper Location of Shims for Correct Rotor Lobe Clearances

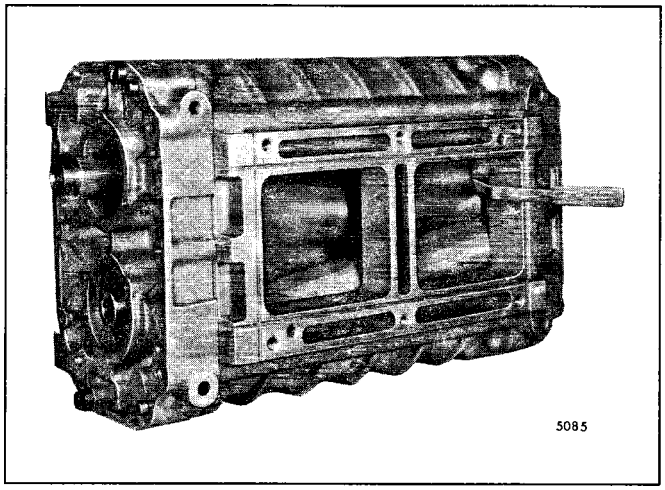


Fig. 23 - Measuring End Clearance Between Blower Rotors and End Plate

13. If removed, press two (2) 1/2" x 15/16" dowel pins .300" above the end surface of the front blower end plate on a 12V front blower (Fig. 24).

NOTICE: Be sure the lubrication hole in the gasket is aligned with the oil supply hole in the blower end plate. The tab on the gasket is to assure the gasket is in place.

14. On a 16V front blower, tap the 1/2" x 2-3/4" dowel pins in the blower end plate. They must extend 2.100" from the end surface of the end plate.

15. Use a new gasket and install the governor drive assembly over the dowel pins and against the front end plate on a 12V front blower.

NOTICE: Be sure the lubrication hole in the gasket is aligned with the oil supply hole in the blower end plate. The tab on the gasket is to assure the gasket is in place.

It may be necessary to rotate the drive shaft slightly to align the splines of the drive shaft and the blower rotor shaft.

16. Install nine (9) 3/8"-16 x 3-1/4" bolts, one nut, washers and plain washers. Tighten the bolts and nut to 30-35 lb-ft (41-47 N*m) torque.

17. Install the governor drive assembly on a 16V front blower as follows:

a. Use a new gasket and install the governor drive housing spacer over the two (2) dowel pins and up against the blower end plate. If necessary, tap the spacer lightly with a plastic hammer.

NOTICE: Be sure the lubrication hole in the spacer and gasket is aligned with the oil supply hole in the blower end plate.

b. Use a new gasket (refer to note above)and install the governor drive assembly over the dowel pins and up against the spacer.

It may be necessary to rotate the drive shaft slightly to align thesplines of the drive shaft and the blower rotor shaft.

c. Install nine (9) 3/8"-16 x 5" bolts, one nut, lock washers and plain washers. Tighten the bolts and nut to 3CU35 lb-ft (41-47 N»m) torque.

Install Blower(s) In Engine

The current engines use 9/16"-12 x 10" blower hold-down bolts in place of the 7/16"—14 x 10" bolts formerly used. The blower end plates and cylinder blocks were revised to accommodate the larger bolts. J 23459 fixture should be used when reworking former cylinder blocks to accept the larger blower hold down bolts. Install the blower(s) as follows:

1. Install new oil seal rings in the cylinder block.

2. Before positioning the blower in the block, install the blower drive cover hose on the blower drive gear hub (12V engine only — Fig. 3) or install four new seals on the inner tube connector and slide the tube connector into the blower drive gear hub on 16V applications (inset, Fig. 3).

NOTICE: The inner tube connector used on the 16V engines has a bevel at the inner diameter at one end only. Install the beveled end towards the blower end plate cover (inset, Fig. 3).

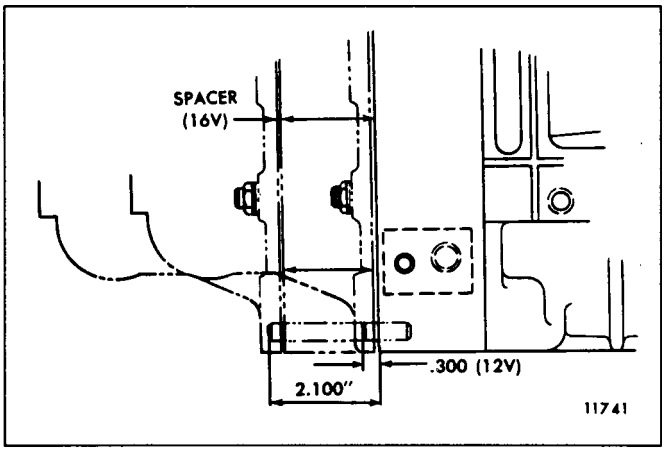


Fig. 24 – Governor Drive Assembly

3. Carefully lower the blower into the cylinder block, using a hoist, so as not to dislodge the oil seals in the cylinder block.

NOTICE: Alignment studs should be used when lowering the blower into the block to facilitate proper installation. Alignment studs can be fabricated by cutting the heads off of two (2) 9/16"-12 x 10" or two (2) 7/16"-14 x 10" bolts.

When installing the rear blower on a 12V engine, it will be necessary to jockey the blower into position to clear the block center joint bolt and also to install the blower drive cover hose (Fig. 3).

4. On 12V and 16V engines, install the front blower first and then proceed as follows:

   a. Position both snap rings over the blower center drive shaft with the front snap ring loose on the shaft (Fig. 4).

   b. Insert the drive shaft in the drive shaft coupling hub on the front blower.

   c. Place four new seal rings in position on the inner tube connector and slide the inner tube connector into the outer tube connector (Fig. 4).

NOTICE: The inner and outer tube connectors each have a bevel on the inner diameter at one end only (Fig. 4). The beveled end must be installed towards the blower end plate covers.

   d. Place two (2) new seal rings in position on the outer tube connector and slide the tube connector assembly into the rear of the front blower (Fig. 4).

   e. Place the rear blower on a hoist and lower it into position in the air box.

NOTICE: Use extreme care when seating the blower over the spring pins in the block. The pins could gouge the aluminum blower end plates, allowing oil to be forced into the air box.

5. Apply engine oil only to the threads and the underside of the bolt heads. Then, install four (4) blower hold-down bolt and *special washers* in each blower. Tighten the 9/16"—12 bolts to 75-85 lb—ft (102-115 N*m) torque or the 7/16"-14 bolts to 50-55 lb—ft (68-75 N*m) torque.

NOTICE: Do not over-torque the blower hold-down bolts. International Compound No. 2 should *NOT* be used.

6. Connect the center blower drive shaft on the tandem blowers and the blower drive shaft as follows:

   a. With the rear snap ring in position on the blower drive shaft, slide the shaft into position against the rear blower drive coupling hub (Fig. 4).

   b. Slide the inner and outer connector tube assembly toward the rear blower to expose the front end of the drive shaft. Install the front snap ring in the groove on the shaft.

   c. Position the inner and outer tube connectors in the blower end plate covers and secure them in place with retainer clips.

   d. On 12V engines, slide the cover hose, located on the blower drive gear support, over the blower end plate cover with two (2) hose clamps.

   e. On the 16V engine, slide the inner tube connector into the blower end plate cover and secure it in place with a retainer clip (inset, Fig. 3).

   f. Install the blower drive shaft as outlined in Section 1.7.6.

• A new double-shaft drive system has been released to provide direct (shaft) drives to the rotor of both blowers used in Series 149 hydrofracturing units (see Section 1.7.6).

7. Install the fuel pump (Section 2.2).

8. Install the blower cover plates and access covers on the 12V and 16V engines as follows:

   a. Install a new blower to cover plate seal ring in the groove of the blower housing on each blower.

   b. Install a new cylinder block to cover plate seal ring in the groove of each cylinder block.

 © Detroit Diesel Corporation

NOTICE: The seal rings must lay flat in the grooves and must not be twisted.

c. Install four (4) new "0"-rings (two per block) in the counterbores at the breather passages near the center of the blocks.

d. Install the cover plates and tighten the bolts.

9. Install the governor and control linkage as outlined in the governor section of this manual.

10. Install the air shutdown housing (or housings) and linkage (Section 3.3).

11. Install the air inlet housing or housings (Section 3.3).

Install the turbochargers, if removed (Section 3.5).

Install the engine breather (Section 4.8).

Install any other accessories on the engine that were removed.

Check the cooling system (Section 5).

Check the lubrication system (Section 4).

Perform the governor and injector rack control adjustment as outlined in Section 14.

Check for and correct any water or oil leaks after the engine has been run.

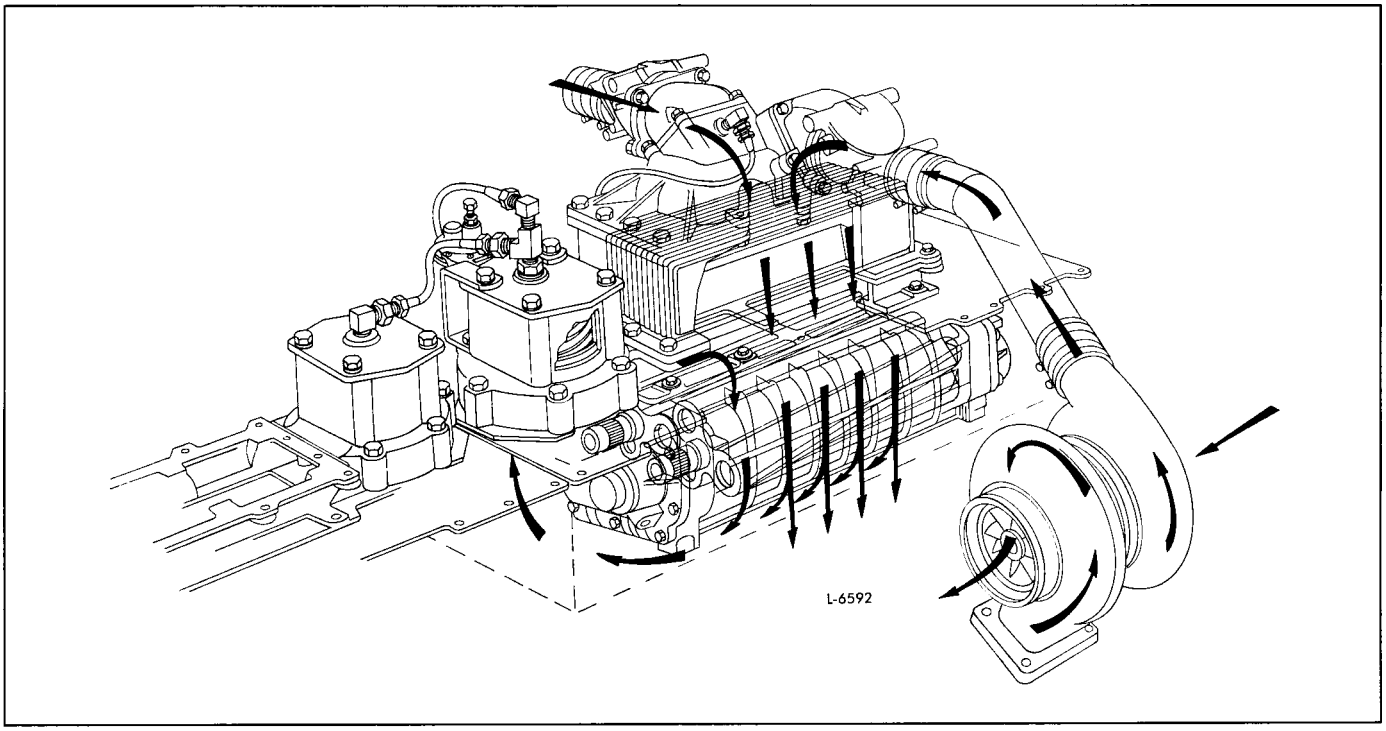


Fig. 2 – Air Flow Schematic – Series 149 Blower Bypass Valve Equipped Engine (Current Piston Style Valve System)

As engine rpm increases, airbox pressure rises until it reaches a point at which it can overcome valve spring tension and effect a bypass. The valve then is moved off its seat, allowing air from the turbocharger to bypass the blower and flow directly into the airbox.

Former and new bypass valves are interchangeable on a system-for-system basis, but not part for part. Components of the former flapper valve style system will be serviced, except for the valve housing. When this requires replacement, the former system must be removed and replaced with the new system.

RECOMMENDATION: Because of the improved combustion efficiency that results, DDC recommends replacing the former system with the new system when the former system requires repair or at time of engine overhaul.

The following disassembly, assembly, and adjusting procedures apply to the current piston style blower bypass valve system.

Disassemble Current Blower Bypass Valve

This procedure can be performed on the engine or on the bench.

CAUTION: The bypass valve cover is under spring tension. To prevent the possibility of personal injury, Kent-Moore tool J 37466 and the following procedure must be used to remove it for service and/or cleaning of the piston valve.

ToolJ 37466 (Fig. 4) consists of a threaded rod with a handle on the end and a special retaining collar attached to a hex nut which moves up and down the threaded rod. This tool is inserted through the air supply lines hole in the cover to aid in the disassembly and assembly of the bypass valve.

1. Remove the air line and associated fittings to expose the hole in the cover of the piston valve housing (Fig. 5).
2. Insert the threaded end of tool J 37466 through the hole and screw it into the tapped hole in the piston.
3. Tighten the nut until the retaining collar is seated firmly against the top of the cover.
4. Remove the four (4) cap screws that secure the cover to the housing. Tool J 37466 will hold the cover and spring in place.
5. Move the retaining collar by slowly turning the nut up the threaded shaft. This will release spring tension.
6. When the spring is relaxed, pull the piston, spring, and cover from the valve housing and complete the disassembly of the piston.

 © Detroit Diesel Corporation

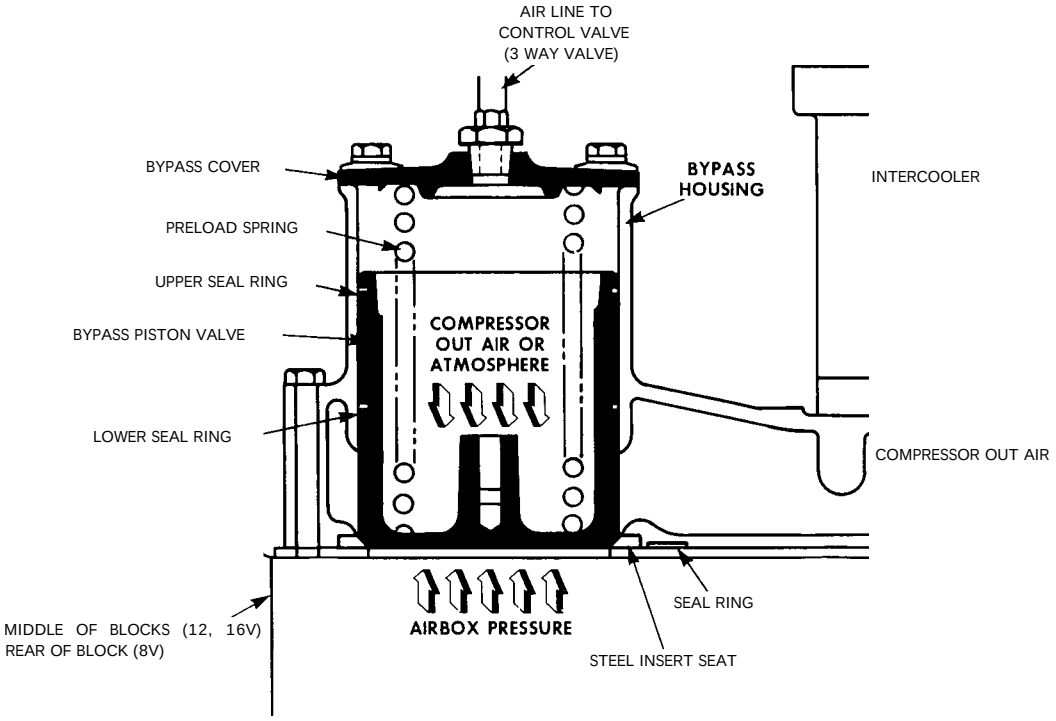


Fig. 3 - Piston Style Blower Bypass Valve Assembly

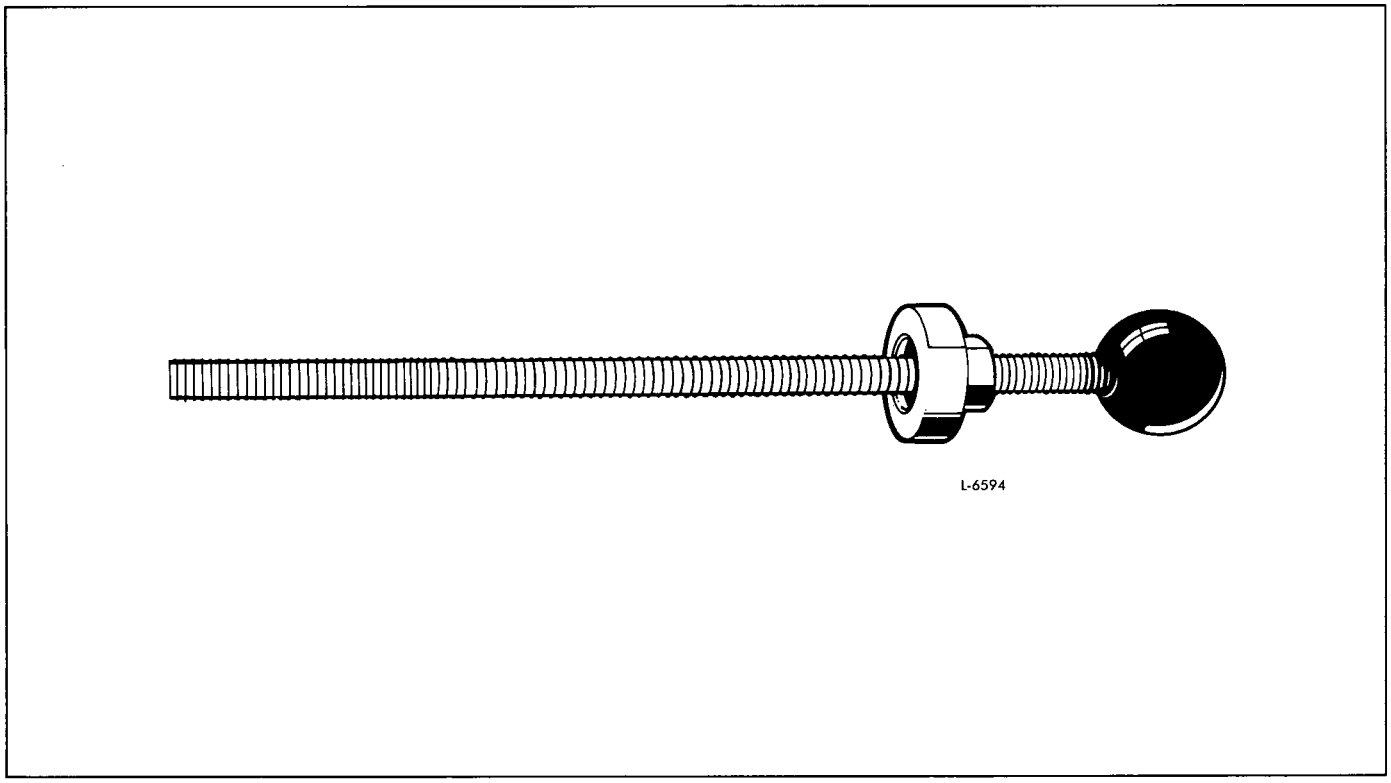


Fig. 4 – Bypass Valve Assembly/Disassembly Tool J–37466

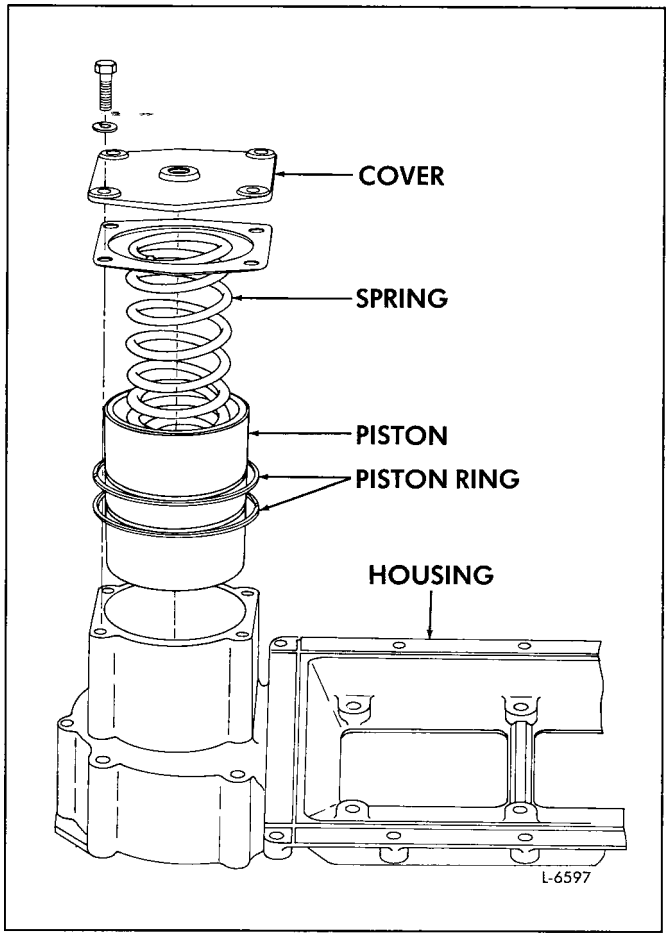


Fig. 5 – Blower Bypass Valve Assembly

Assemble Blower Bypass Valve

This procedure can be completed on the engine or on the bench. To assemble the blower bypass valve, refer to Fig. 5 and proceed as follows:

1. Load the piston assembly using Kent-Moore tool J 8037 or an equivalent piston ring compressor.
2. Place the spring in the housing, locating it correctly on the spring seat in the piston.
3. With the retaining collar and nut at the top of tool J 37466, insert the threaded end through the center hole in the cover and position the cover with the tool in place over the bypass housing. The piston should be in the bottom of the bore and the spring in place.
4. Screw the threaded end securely into the piston.
5. Turn the retaining collar nut until the cover is in place.
6. Install the four cap screws into the cover and tighten to 30 lb-ft (41 N*m) torque.
7. Unscrew the threaded rod from the piston and remove the tool.

CAUTION: To alert serving personnel to a potential hazard and avoid possible personal injury from improper disassembly /assembly, always replace the *CAUTION* label (Fig. 6) on the cover after servicing the bypass valve.

****CAUTION****
COVER UNDER LOAD
TO AVOID PERSONAL INJURY
DO NOT REMOVE CAP SCREWS
BEFORE CONSULTING ^
SERVICE MANUAL ^

L-6596

Fig. 6 - Caution Label

Remove Bypass Valve Housing From Engine

Instructions in steps 1, 2, 3 and 4 apply to all bypass housings. Step 3 applies to 12V-149 engines with small intercooler systems only.

1. Remove the intercooler per instructions in section 3.5.2 of the service manual (or the air inlet housing for non-turbocharged engines) to expose the bypass valve housing.
2. Remove the following bolts, lockwashers, and plain washers that attach the housing to the engine:

BOLTS PER HOUSING	SIZE	HOUSING STYLE	ENGINE
8	7/16"— 14 x 2-1/4"	Lg. Intrclr	8V, 16V
6	7/16"— 14 x 2-1/4"	Lg. Intrclr	12V
8	7/16" — 14 x 1-5/8"	Sml. Intrclr	8V, 16V
2	7/16"— 14 x 1-1/4"	Sml. Intrclr	12V

In addition, five (5) 3/8" -16x3 3/4" bolts per housing must be removed from the piston valve end of all bypass housing systems.

3. On 12V-149 engines with small intercoolers *only,* four (4) 7/16" - 14 x 4 1/4" bolts are also used to interconnect the intercooler and the bypass housing through the top airbox plate into the blower. These may have been removed per instructions in step one. If not, they must be removed now.
4. Lift the bypass valve housing from the engine and discard the two (2) seal rings.

© Detroit Diesel Corporation

Install Bypass Valve Housing On Engine

1. Clean the seal ring grooves in the bottom of the valve housing.

2. Lubricate two (2) new seal rings and the grooves in the bottom of the housing with Lubricone, or equivalent, and install the seal rings.

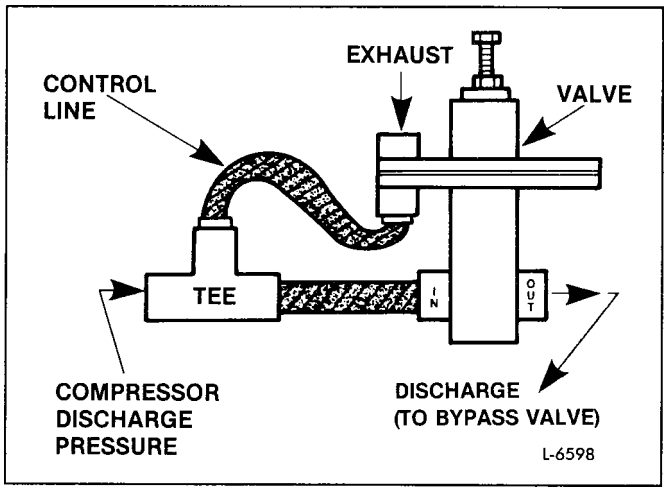
3. Position the housing on the cover plate and install the correct number of properly sized bolts as outlined in the previous section. Install lockwashers and flatwashers under each bolt. To prevent air box leakage, use Loctite 271 sealant, or equivalent, or the five (5) 3/8" - 16 x 3 3/4" bolts on the piston end of all bypass valve housings). Tighten 7/16" bolts to 46 - 50 lb—ft (62 - 68 N«m) torque. Tighten 3/8" bolts to 30-50 lb—ft (41-47 N*m) torque.

Bypass Valve Adjustment

A special three-way valve controls air pressure to the bypass assembly. An adjusting screw on the control valve is used to regulate air pressure. Maximum air delivery should be set to occur between 6 and 9 psi (41.4 and 62.1 kPa). This will automatically set the valve to cut off air between 9 and 14 psi (62.1 and 97 kPa).

Proper adjustment of the control valve is critical to engine operation. Adjustment is *best* completed with the valve disconnected from the engine. If this is impractical, an on-the-engine adjustment may be made until an appropriate bench adjustment can be performed. Control valve settings should be checked every 5000 hours and reset, if necessary.

The control valve is connected according to the following schematic:



Compressor discharge pressure is “teed” to the *inlet* and *control* ports of the valve. The *discharge* (out) port of the valve is plumbed to the bypass valve housings. This insures seating of the piston valve during light load operation.

Control Valve Adjustment (on Bench)

This procedure requires the use of two 0-40 psi (0 - 276 kPa) gages, a 0 - 100 psi (0 - 689 kPa) air pressure regulator, and shop air of approximately 100 psi (689 kPa) pressure. Refer to Fig. 7.

1. Attach one pressure gage to the *discharge* port of the control valve with a “tee.” The open end of the “tee” should be plugged so that there is no airflow beyond the gage.

2. Connect the second pressure gage between the regulator and a “tee” fitting. Connect a hose from the tee to the *control* port of the valve. Connect another hose from the tee to the *inlet* port.

3. Connect shop air pressure to the regulator valve. **Important:** The control hose should be in place when the valve is adjusted.

4. Loosen and back out the adjusting screw on the three-way valve.

5. Adjust the air pressure regulator valve to obtain a supply side pressure of 10 psi (69 kPa).

6. Adjust the three-way valve screw until the gage on the discharge side just reaches the maximum value and stops moving. Back off the adjusting screw until the discharge pressure just starts to drop. Then *slowly* readjust back to the maximum value and stop adjustment immediately when this point is reached.

7. Tighten the adjusting screw locknut.

8. *Slowly* increase supply air pressure with the air pressure regulator until 14 - 18 psi (97 - 124 kPa) is reached. *Discharge* pressure should read zero.

9. Readjust as needed to obtain the required calibration.

© Detroit Diesel Corporation

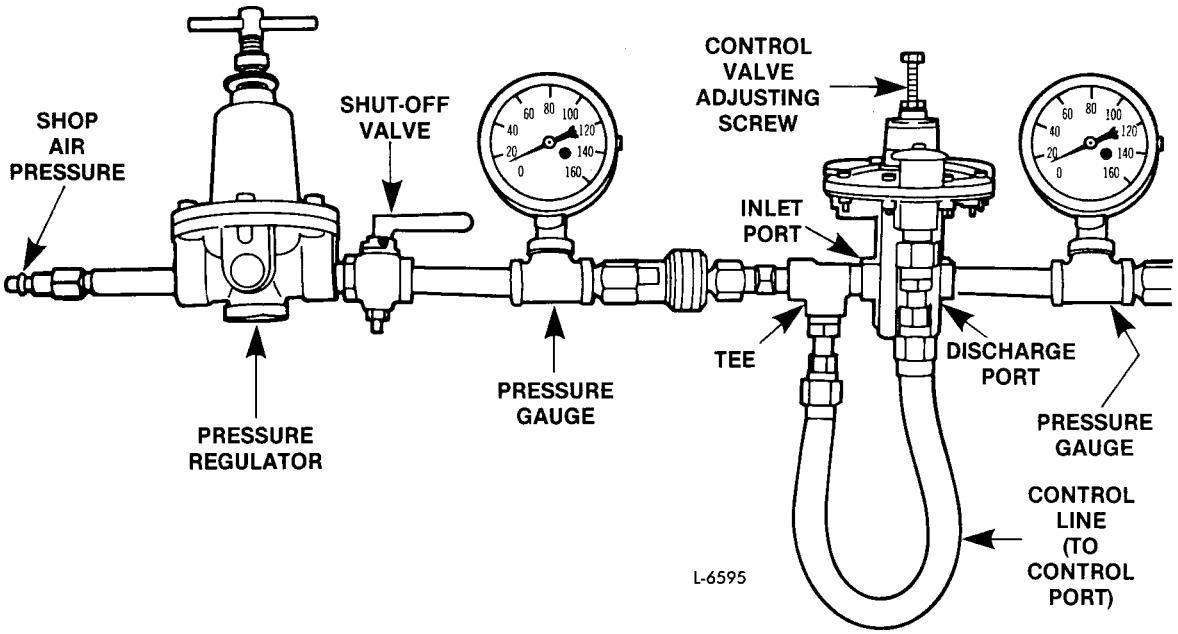


Fig. 7 - Control Valve Adjustment Set-up (Bench)

Control Valve Adjustment (on Engine)

The control valve can be calibrated on the engine, although not as accurately as on the bench. After the piston style blower bypass valve system has been installed, adjust the control valve as follows:

1. Install pressure gages to read airbox pressure and turbocharger compressor discharge pressure in inches of mercury (0 - 100 Hg gages).
2. Back out the adjusting screw on the control valve.
3. Start the engine and run it at a speed and load that will provide approximately 30 in. Hg airbox pressure.
4. *Slowly* adjust the screw on the 3-way valve until the smallest differential between airbox pressure and turbocharger compressor discharge pressure is obtained.
5. Tighten the adjusting screw locknut.

This procedure will adjust the valve close enough until an appropriate bench calibration can be performed.

© Detroit Diesel Corporation

TURBOCHARGER (AIRESEARCH)

T18 A40, TV7101 AND TV8115 TURBOCHARGERS

The turbocharger (Fig. 1) is designed to increase the overall efficiency of the engine. Power to drive the turbocharger is extracted from the waste energy in the engine exhaust gas.

The turbocharger consists of a radial inward flow turbine wheel and shaft, a centrifugal compressor wheel and a center housing which serves to support the rotating assembly, bearings, seals, turbine housing and compressor housing. The center housing has connections for oil inlet and oil outlet fittings.

The turbine wheel is located in the turbine housing and is mounted on one end of the turbine shaft. The compressor wheel is located in the compressor housing and is mounted on the opposite end of the turbine wheel shaft to form an integral rotating assembly.

The rotating assembly consists of a turbine wheel and shaft assembly, piston ring(s), thrust spacer, compressor wheel and wheel retaining nut. The rotating assembly is supported on two pressure lubricated bearings which are retained in the center housing by snap rings. Internal oil passages are drilled in the center housing to provide lubrication to the turbine wheel shaft bearings, thrust washer, thrust collar and thrust spacer.

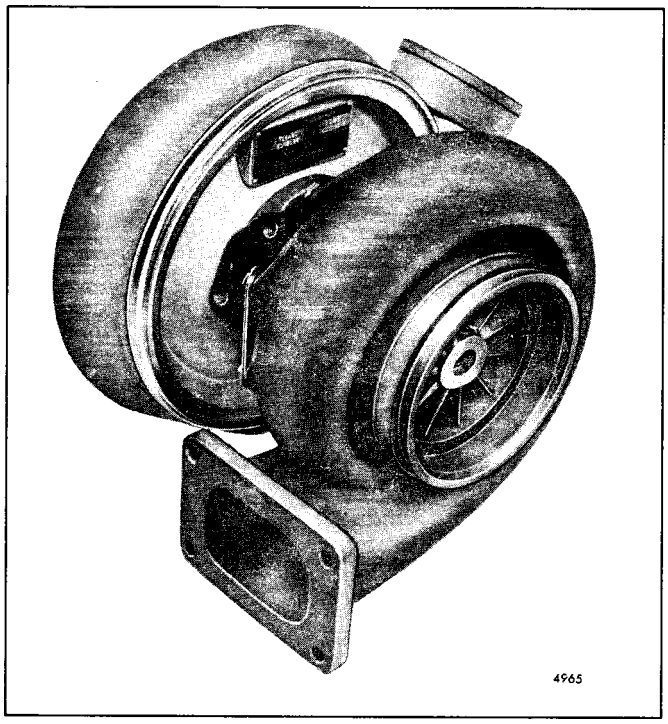


Fig. 1 - Turbocharger Assembly

The turbine housing is a heat resistant alloy casting which encloses the turbine wheel and provides a flanged engine exhaust gas inlet and an axially-located turbocharger exhaust gas outlet. The T18A40 turbine housing is bolted to the turbine end of the center housing and the TV7101 and TV8115 turbine housings are secured with a “V” band coupling, thus providing a compact and vibration free assembly.

The compressor housing which encloses the compressor wheel provides an ambient air inlet and a compressed air discharge outlet. The compressor housing is secured to the compressor end of the center housing backplate assembly with a “V” band coupling.

Operation

The turbocharger is mounted on the exhaust outlet flange of the engine exhaust manifold. After the engine is started, the exhaust gases flowing from the engine and through the turbine housing cause the turbine wheel and shaft to rotate (Fig. 2). The gases are discharged into the atmosphere after passing through the turbine housing.

The compressor wheel, which is mounted on the opposite end of the turbine wheel shaft, rotates with the turbine wheel. The compressor wheel draws in fresh air, compresses it and delivers high pressure air through the engine blower to the engine cylinders.

During operation, the turbocharger responds to the engine load demands by reacting to the flow of the engine exhaust gases. As the engine power output increases or decreases, the turbocharger responds to the engine’s demand to deliver the required amount of air under all conditions.

Certain engines are equipped with intercoolers to reduce the temperature of the discharge air from the turbocharger before it enters the engine blower (refer to Section 3.5.2).

Lubrication

Lubricating oil for the turbocharger is supplied under pressure through an external oil line extending from the engine cylinder block to the top of the center housing. From the oil inlet in the center housing, the oil flows through the drilled oil passages in the housing to the shaft bearings, thrust ring, thrust bearing and backplate or thrust plate (Fig. 3). The oil returns by gravity to the engine oil pan through an external oil line extending from the bottom of the turbocharger center housing to the oil pan (current engines) or the side of the cylinder block (former engines).

© Detroit Diesel Corporation

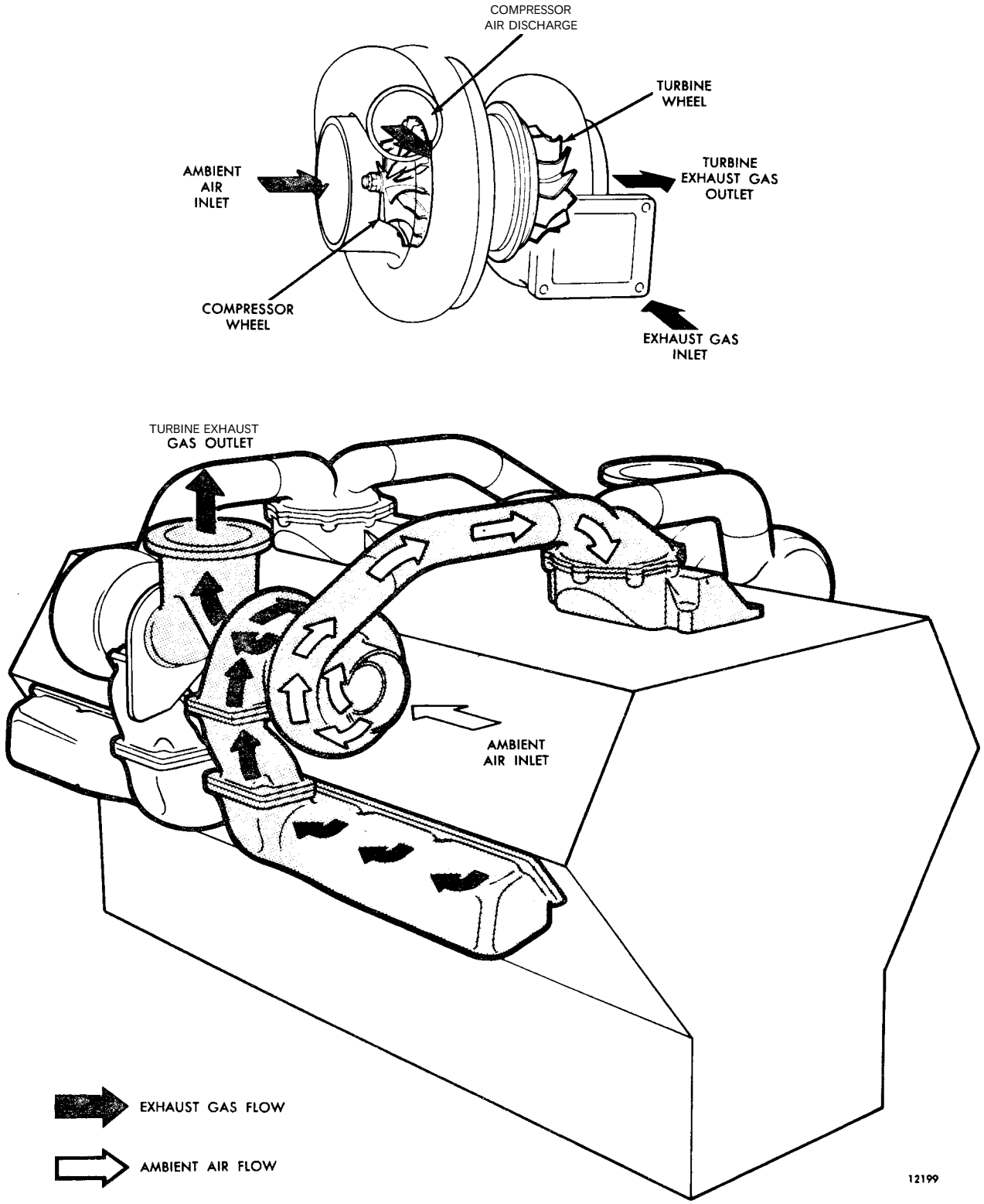


Fig. 2 - Schematic Air Flow Diagram

 © Detroit Diesel Corporation

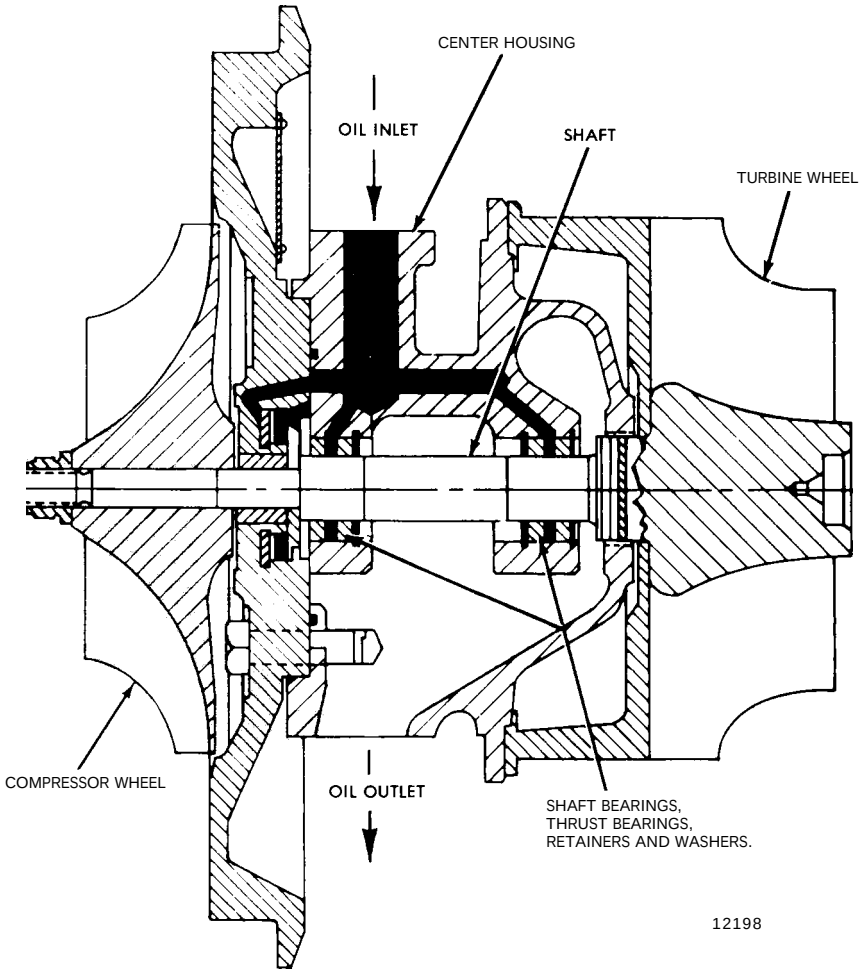


Fig. 3 -Turbocharger Oil Flow Diagram

Before the initial engine start, when a new or overhauled turbocharger is installed, the turbocharger must be pre-lubricated as outlined under *Install Turbocharger.*

NOTICE: Failure to perform the prelubrication procedure may result in premature bearing failure due to *oil lag* or lack of lubrication.

■ **NOTICE:** DO NOT permit "drafting" of the turbocharger without an adequate flow of oil to the bearings. "Drafting" refers to wheel shaft rotation caused by strong outside air currents passing over the compressor or turbine wheels while the engine is stopped. Wheel shaft rotation without adequate lubrication can lead to serious turbocharger bearing damage. Drafting can occur if strong air currents enter the turbo while the engine is in transit (on the bed of a moving truck, for example). It can also result from air currents entering an open exhaust manifold while the engine is stationary (during set-up on a dynamometer, for example). A cover on the turbocharger inlet can protect against drafting.

Periodic Inspection

NOTICE: A turbocharger compressor inlet shield, (Fig. 4) J 26554—A, is available for use anytime the engine is operated with the air inlet piping removed. The shield helps to prevent foreign objects entering the turbocharger and prevents a service technician from touching the moving impeller. The use of this shield *does not* preclude any other safety practices contained in this manual.

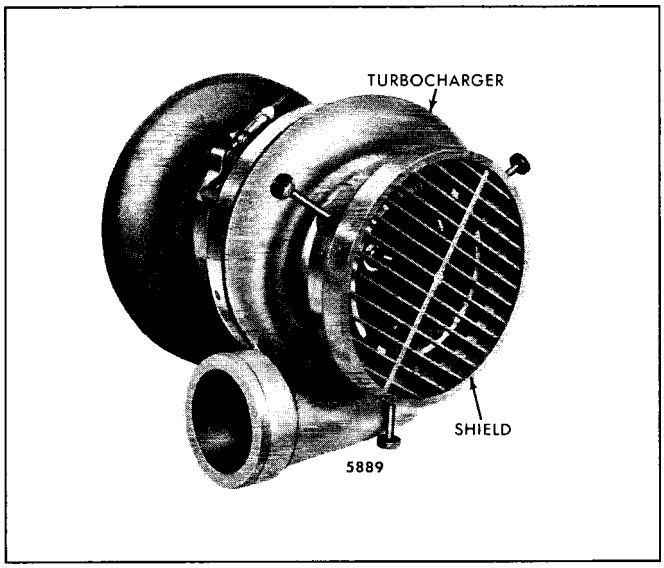


Fig. 4 - Inlet Shield (J 26554-A)

Inadequate air filtering and excessive restrictions to air and exhaust flows will adversely affect turbocharger life and performance. Do not permit restriction levels to exceed the specified limits (refer to Section 13.2).

A periodic inspection of the turbocharger should be made along with an engine inspection.

Inspect the turbocharger mountings and check all of the air ducting and connections for leaks. Make the inspection with the engine running and with it shutdown. Check for leaks at the manifold connection, the turbine inlet and exhaust manifold gasket.

NOTICE: Do not operate the engine if leaks are found in the turbocharger ducting or if the air cleaner is not filtering efficiently. Dust leaking into the air ducting can damage the turbocharger and the engine.

Remove the inlet duct to the turbocharger compressor housing and check for carbon or dirt build up on the impeller or in the housing. Excessive accumulations indicate either a leak in the ducting or a faulty air filtering system. Remove all such accumulations and determine and correct the cause. Refer to *Trouble Shooting Charts* (Fig. 5). Uneven deposits left on the compressor wheel can affect the balance and cause premature bearing failure.

NOTICE: Do not attempt to remove carbon or dirt build up on the compressor or turbine wheels without removing the turbocharger from the engine. The blades on the wheels must be thoroughly cleaned. If chunks of carbon are left on the blades, an unbalanced condition would exist and subsequent failure of the bearings would result if the turbocharger is operated. However, it is not necessary to disassemble the turbocharger to remove dirt and dust buildup.

For proper operation, the turbocharger rotating assembly must turn free. Whenever the exhaust ducting is removed, spin the turbine wheel by hand. If it does not spin freely, refer to Chart 1 of Fig. 5. Inspect the compressor and turbine wheels for nicks or loss of material. Both wheels are precision balanced. A broken or bent blade can throw the rotating assembly out of balance and shorten the life of the turbocharger.

Inspect the oil inlet and oil return lines to make certain all of the connections are tight and that the lines are not dented or looped so that oil flow to and from the center housing is restricted. Looping the oil return lines disrupts gravity flow of the oil back to the engine.

NOTICE: Be sure the oil inlet lines are filled with oil and that they are clear of the turbine housings.

Check for signs of oil leaking from the turbocharger housings.

Lubricant applied under pressure to the center housing while the shaft is not turning may allow oil to enter the turbine and compressor housings. However, after the turbocharger has been operated for a time under load conditions and with the inlet restriction at normal, oil in these sections should disappear. If the oil does not disappear, refer to Chart 2 of Fig. 5.

Oil pull-over from an oil bath type air cleaner can also cause oil to enter the compressor housing. Check for a dirty air cleaner element or for too low viscosity oil in the air cleaner. Also, too small an air cleaner could create excessive air flow velocity and result in oil pull-over.

Evidence of oil in the inlet or outlet ducts or dripping from either housing indicates a seal problem that will require overhaul of the turbocharger. Refer to Chart 3 of Fig. 5.

Tests show there are three conditions that contribute to oil seal leakage at the internal turbocharger oil seal.

1. A worn or defective oil seal, which must be replaced.
2. High air inlet restriction (above specified limits). This will cause oil to be pulled past the oil seal.
3. Long periods of operation where the engine is being motored (using the engine as a braking device when going down a long hill). This can also cause oil to pass by the oil seal.

 © Detroit Diesel Corporation

TROUBLE SHOOTING CHARTS

CHART1

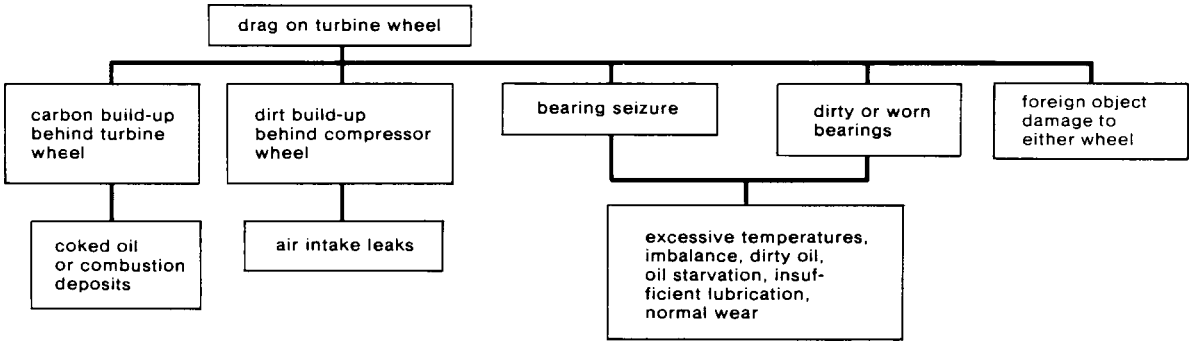


CHART 2

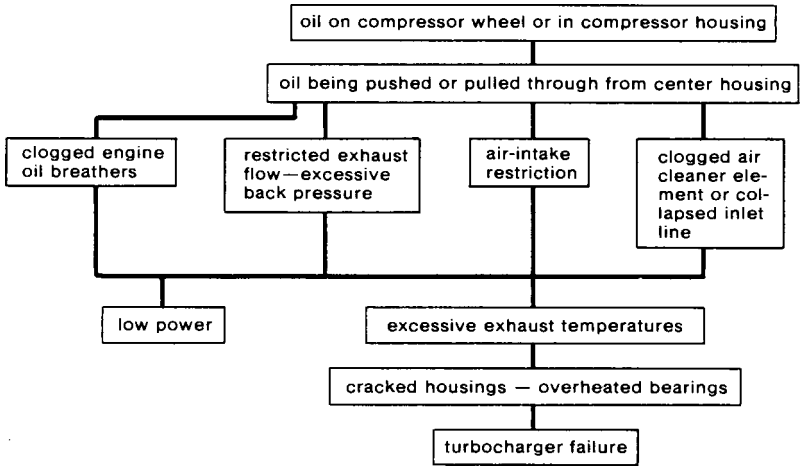


CHART 3

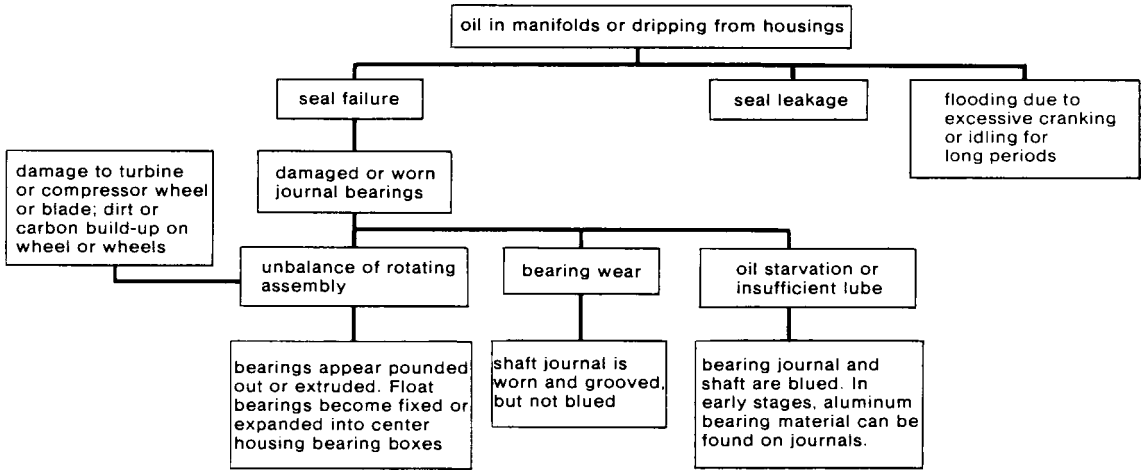


Fig. 5 - Inspection Checks for Turbocharger

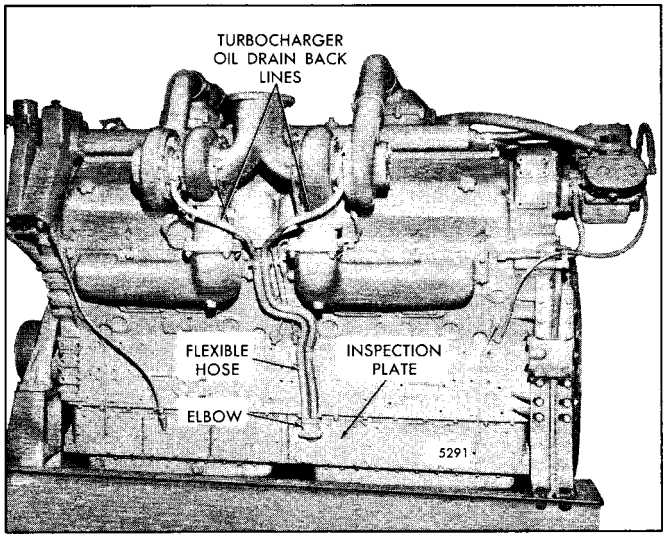


Fig. 6 - Turbocharger Oil Drain and Oil Supply Line Connections (Former Engines)

To confirm oil leakage from one or more of these conditions, remove the compressor housing and inspect the backplate. If the surface is wet with oil, it indicates leakage.

If this test does not show leakage patterns, the oil seal assembly is good for normal operation. This simple test will allow some positive testing on each engine in all cases.

Turbocharger compressor end shaft oil seal effectiveness can be determined by the following procedure:

1. Determine that air inlet restriction is within the Detroit Diesel maximum limit. Refer to Section 13.2.

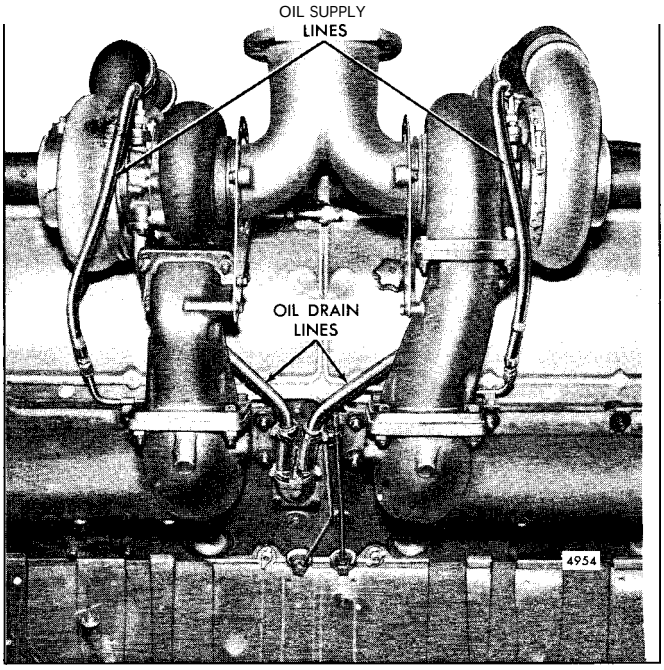


Fig. 7 -Turbocharger Oil Drain and Oil Supply Line Connections (Former Engines)

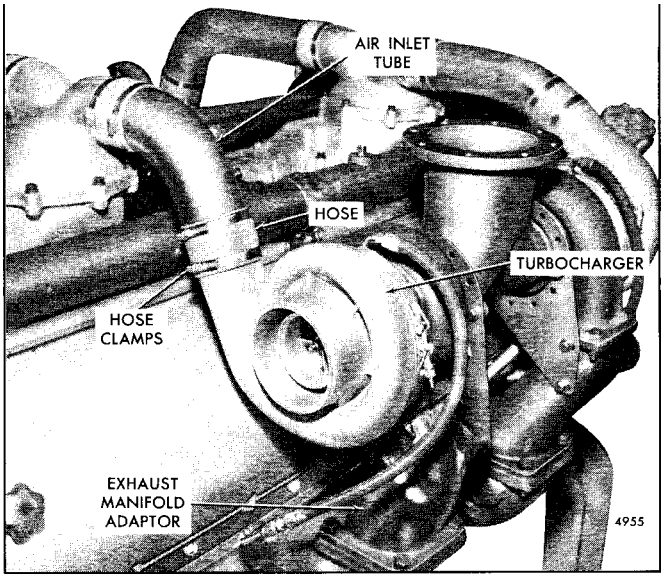


Fig. 8 - Turbocharger-to-Air Inlet Tube Connection

2. Be certain that the turbocharger oil drain line is unrestricted.

3. Be certain that the turbocharger has not obviously been damaged and in need of major repair.

4. Remove air intake ducting. Inspect inside of ducting for evidence of oil. If oil is found in the intake system, determine the source before proceeding with the compressor seal test and also thoroughly remove oil from the intake. Some external sources of oil are oil bath air cleaners, air compressor line, or a leak near an oil source such as an engine breather, etc.

5. Remove the compressor housing from the turbocharger.

6. Thoroughly clean the internal surfaces of the compressor housing, impeller cavity behind the impeller, and the backplate annulus with suitable solvent spray and then dry completely with shop air.

7. Spray the backplate annulus with a light coating of “Spot-Check” developer type SKD-MF, or equivalent.

8. Install the compressor housing on the turbocharger and reconnect the inlet and outlet connections.

9. Warm up the engine to normal operating temperature.

10. Operate the engine at no load at the governor limited high speed for approximately five minutes.

11. Return the engine to low idle and then stop it.

 © Detroit Diesel Corporation

12. Remove the intake duct and outlet hose and then remove the compressor housing. Evidence of compressor end shaft seal oil leakage will be observed as oil streaks in the "Spot-Check" developer on the backplate annulus. This surface should be completely free of oil streaks after the test.

13. If leakage is detected, and oil is positively not entering through the intake duct, then the turbocharger may be removed from the engine and inspected for damaged components.

Remove Turbocharger

1. Disconnect the oil supply line and the oil drain line from the turbocharger (Figs. 6 and 7).

2. Cover the end of each oil inlet and outlet line and the air inlet and exhaust outlet openings on the engine to prevent the entrance of foreign material.

3. Loosen the two hose clamps securing the hose to the turbocharger and the air inlet tube and slide the hose up over the inlet tube (Fig. 8).

   NOTICE: The steel straps used with the hose clamps at both ends of the air inlet tube have been eliminated. Remove and discard the straps from all 12 V-149 and 16 V-149 turbocharged-intercooled high efficiency engines.

4. Remove the four bolts, nuts and washers securing the turbocharger to the exhaust manifold adaptor and remove the turbocharger and gasket.

Disassemble Turbocharger

Clean the exterior of the turbocharger with a non-caustic cleaning solvent before disassembly and proceed as follows:

NOTICE: Mark related positions of the compressor housing, center housing and turbine housing with a punch or scribe prior to disassembly to assure reassembly in the same relative position.

1. Refer to Figs. 9 and 10 and loosen the "V" band coupling (1) securing the compressor housing (2) to the backplate assembly (14) and remove the compressor housing and "V" band.

   NOTICE: Exercise care when removing the compressor housing and turbine housing to prevent damage to the compressor and turbine wheels.

2. With the T18A40 turbocharger bend down the ends of the lockplates (4) and remove the eight bolts (3) securing the four lockplates and turbine housing clamps (5) to the center housing (27) and turbine housing (6). With the TV7101 and TV8115 turbochargers loosen the "V" band coupling (28) securing the turbine housing (6) to the center housing (27). Remove the turbine housing from the center housing.

   NOTICE: Tap the housing with a soft hammer if force is needed for removal.

3. Position the turbine wheel (9) of the center housing assembly in a suitable holding fixture (Fig. 11). Remove the wheel nut (7) from the shaft. To prevent the possibility of bending the turbine wheel shaft, remove the compressor wheel nut from the shaft with a double universal socket and tee handle.

   NOTICE: If a holding fixture is not available, clamp a suitable socket or box end wrench in a vise and place the extended hub on the shaft in the socket or wrench. Hold the center housing upright and remove the wheel nut from the shaft.

4. Press the compressor wheel (8) from the wheel shaft assembly (9).

5. Withdraw the wheel shaft assembly (9) from the center housing. The wheel shroud (10), which is not retained, will fall free when the wheel shaft is removed.

6. With the TV7101 and TV8115 turbochargers remove and discard the turbine piston ring (11) from the wheel shaft.

7. Bend down the lock tabs and remove the four bolts (12) and lockplates (13) securing the backplate assembly (14) to the center housing (27) and remove the backplate assembly.

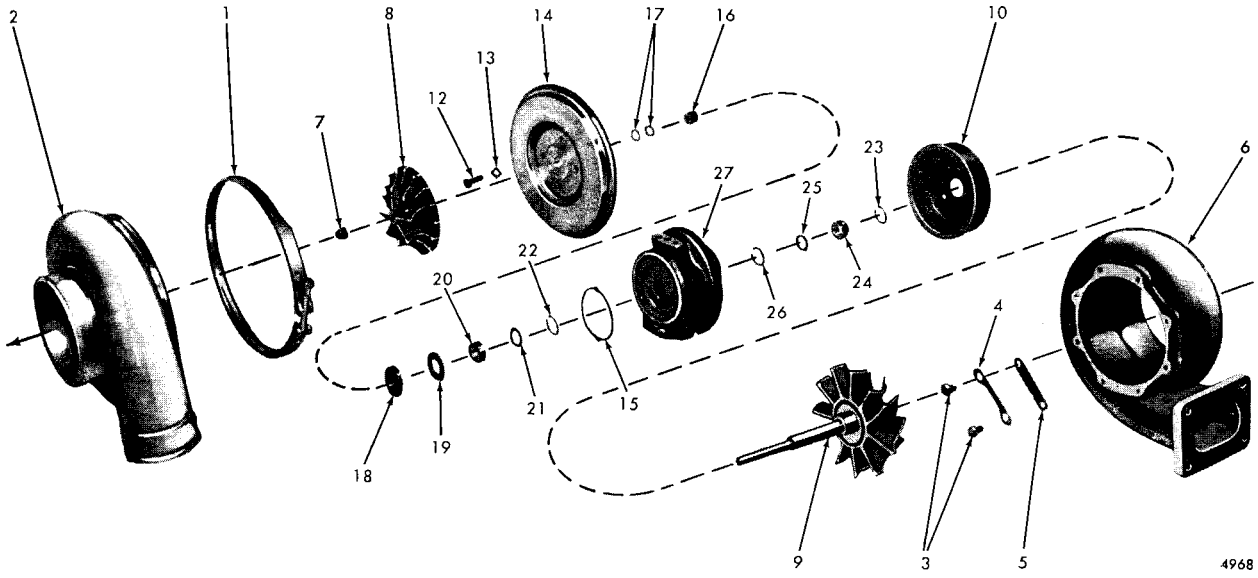
   NOTICE: Tap the backplate lightly to remove it from the center housing recess.

8. Remove and discard the seal ring (15) from the groove in the center housing.

9. Remove the thrust spacer (16) and piston ring(s) (17) from the backplate assembly. Discard the piston ring(s).

10. Remove the thrust collar (18), inboard thrust washer (19), bearing (20), bearing washer (21) and snap ring (22) from the center housing. Discard the thrust washer, bearing, washer and snap ring.

11. Remove the snap ring (23), bearing (24), bearing washers (25) and snap ring (26) from the opposite end of the center housing. Discard the snap rings, bearing and washers.



1.	Coupling—"V" Band	8.	Wheel—Compressor	15.	Ring—Seal	21.	Washer—Bearing
2.	Housing—Compressor	9.	Shaft—Turbine Wheel Assembly	16.	Spacer—Thrust	22.	Ring—Snap
3.	Bolt	10.	Shroud—Turbine Wheel	17.	Ring—Piston	23.	Ring—Snap
4.	Lockplate	12.	Bolt	18.	Collar—Thrust	24.	Bearing
5.	Clamp—T urbine Housing	13.	Lockplate	19.	Washer—Inboard Thrust	25.	Washer—Bearing
6.	Housing—T urbine	14.	Backplate Assembly	20.	Bearing	26.	Ring—Snap
7.	Nut—Self-Locking					27.	Housing—Center

Fig. 9 - T18A40 Turbocharger Details and Relative Location of Parts

Cleaning

Before cleaning, inspect the parts for signs of burning, rubbing or other damage which might not be evident after cleaning.

Soak all parts in a non-caustic cleaning solvent for about 25 minutes. After soaking, use a stiff bristle brush and remove all dirt particles. Dry all of the parts thoroughly.

CAUTION: Never use a caustic cleaning solution for cleaning as this will damage certain parts. Use the cleaning solution in an open or well ventilated area. Avoid breathing the fumes. Keep away from open flames. Do not use a wire brush or a steel blade scraper to clean the parts.

Make sure that both wheel blades are thoroughly clean. Deposits left on the blades will affect the balance of the rotating assembly.

Clean all of the internal cavities and oil passages in the center housing thoroughly with dry compressed air.

CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Clean the oil passage in the center housing thrust plate with dry compressed air.

Remove the oil inlet and outlet lines from the engine and thoroughly clean the oil lines inside and out. An oil line that is dented or crimped enough to restrict the flow of oil must be replaced.

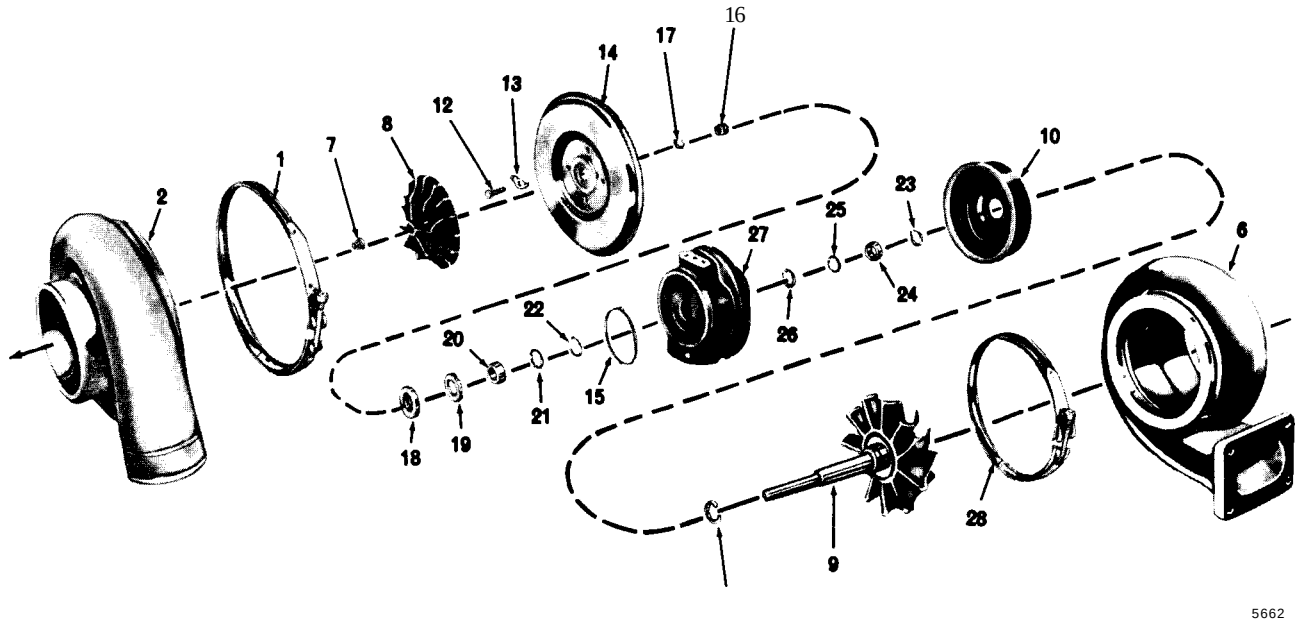
Inspection

Inspect all of the parts for signs of damage, corrosion or deterioration. Check for nicked, crossed or stripped threads.

Visually check the turbine wheel for signs of rubbing or wear. For shaft bearing journal dimensions and wear limits, refer to Section 3.0.

Inspect the shaft for signs of scoring, scratches or bearing seizure.

 © Detroit Diesel Corporation



1.	Coupling—"V" Band	10.	Shroud—T urbine Wheel	16.	Spacer—Thrust	22.	Ring—Snap
2	Housing—Compressor	11.	Ring—Turbine Piston	17.	Ring—Piston	23.	Ring—Snap
6	Housing—T urbine	12.	Bolt	18.	Collar—Thrust	24.	Bearing
7	Nut—Self-Locking	13.	Lockplate	19.	W asher—Inboard Thrust	25.	W asher—Bearing
8	Wheel—Compressor	14.	Backplate Assembly	20.	Bearing	26.	Ring—Snap
9.	Shaft—Turbine Wheel Assembly	15.	Ring—Seal	21.	Washer—Bearing	27.	Housing—Center
						28.	Coupling—"V" Band

Fig. 10 - TV7101 and TV8115 Turbocharger Details and Relative Location of Parts

Check the compressor wheel for signs of rubbing or damage from foreign material. Check to see that the wheel bore is not galled. The wheel must be free of dirt and other foreign material.

Inspect the seal parts for signs of rubbing or scoring of the running faces.

Approximately November, 1976, the turbine wheel shaft assembly in the T18A40 turbocharger was revised in that the new turbine wheel has fillets between the blade roots to strengthen the blades (Fig. 12).

Inspect the backplate for wear or damaged bore (piston ring groove).

Inspect the housing for contact with the rotating parts. The oil and air passages must be clean and free of obstructions.

Minor surface damage may be burnished or polished. Use a Silicone Carbide abrasive cloth for aluminum parts or a crocus abrasive cloth for steel parts.

It is recommended that the piston ring(s), thrust washers, bearings, bearing washers and snap rings be replaced at time of disassembly.

Inspect the exhaust outlet elbow seal ring for signs of wear or breakage.

Assemble Turbocharger

Check each part prior to installation to ensure cleanliness. As the parts are assembled, cover the openings to prevent entry of dirt or other foreign material.

Refer to Figs. 9 and 10 for parts orientation and proceed as follows:

1. Lubricate the new bearings (20 and 24) with clean engine oil.

2. Install a new snap ring (26), bearing washer (25), bearing (24) and snap ring (23) in the turbine end of the center housing (27).

3. Install a new snap ring (22), bearing washer (21) and bearing (20) in the compressor end of the center housing.

NOTICE: Install the current inboard thrust bearing (three oil grooves) with the smooth side against the center housing.

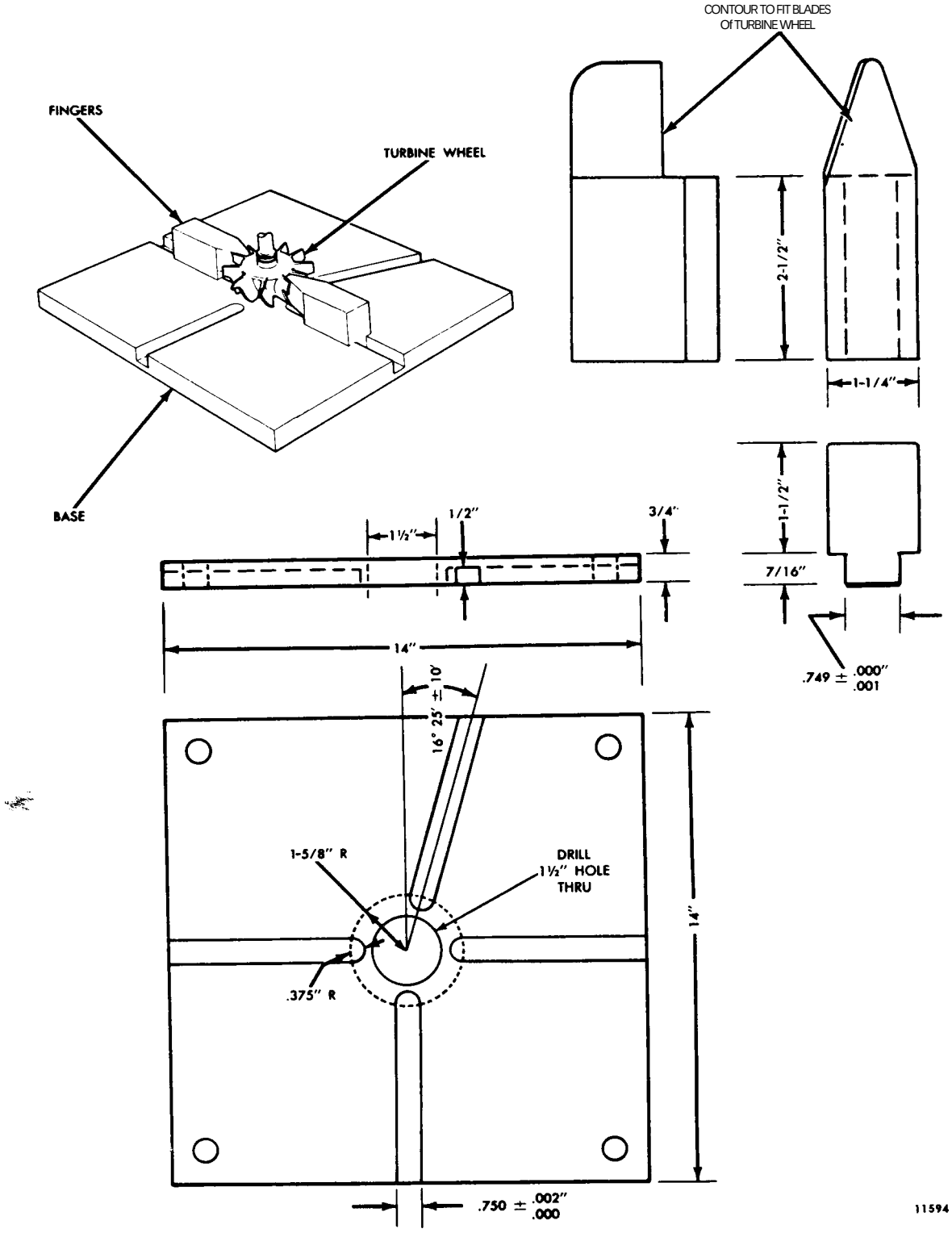


Fig. 1 1 - Turbocharger Holding Fixture

 © Detroit Diesel Corporation

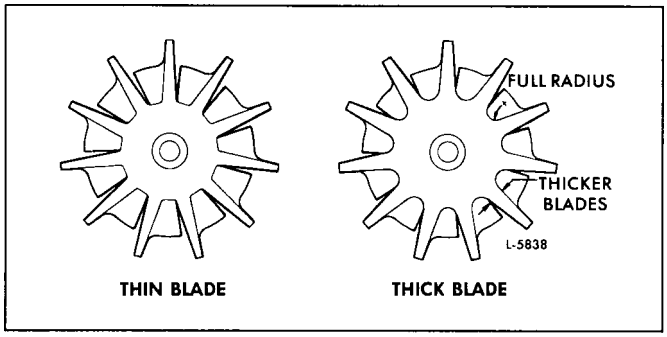


Fig. 12 - Comparison of Former and Current Turbine Wheels

4. Install a new piston ring(s) (17) on the thrust spacer (16) and gently insert the spacer into the backplate assembly (14). The current thrust spacer has two grooves. When replacing the former one groove spacer with the two groove spacer, be sure and include two piston rings. Do not force the piston rings into place.

   NOTICE: Make sure the *current* small diameter thrust spacer (.672"-.673") is used with the current thrust collar (Fig. 13). The former spacer was .677"-.678" in diameter.

5. Make sure the compressor bearing is in place, then position the new inboard thrust washer (19) flat against the center housing with the hole and cutout in the thrust washer in alignment with the pins in the center housing.

6. Install the thrust collar (18) snugly against the thrust washer. Lubricate the thrust collar and thrust washer with clean engine oil.

7. Install a new seal ring (15) in the groove at the compressor end of the center housing.

8. Align the oil feed holes in the center housing (27) and the backplate assembly (14) and attach the backplate to the center housing with four bolts (12) and new lockplates (13). Tighten the T18A40 bolts to 90-110 lb-in (10-12 N*m) torque or the TV7101 and TV8115 bolts to 80-100 lb-in (9-11 N*m) torque and bend the lockplate tangs up against the side of the bolt heads.

   NOTICE: If a new backplate with a warning plate is inadvertently installed, *the warning plate must be removed and the three drive screw holes plugged to prevent air leakage.*

9. On TV7101 and TV8115 turbochargers, install a new turbine piston ring (11) on the wheel shaft assembly.

   NOTICE: Before installing the piston ring, fill the piston ring groove with Dow Corning High Vacuum Silicone grease, or equivalent.

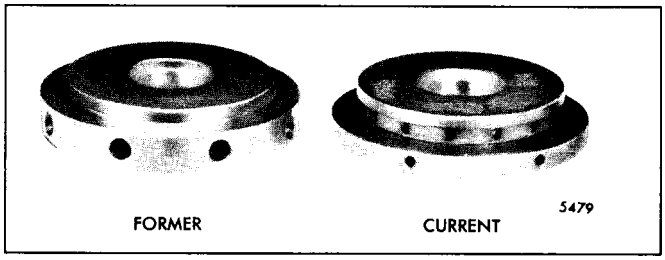


Fig. 1 3 - Former and Current Thrust Collar

10. Position the wheel shroud (10) against the center housing (27) and insert the wheel shaft assembly (9) through the wheel shroud and into the center housing.

    NOTICE: Be careful not to scuff or scratch the bearings when installing the shaft.

11. Place the turbine wheel shaft assembly, shroud, center housing and backplate upright in a suitable holding fixture (Fig. 11).

    NOTICE: If a holding fixture is not available, clamp a suitable socket or box wrench in a vise and place the extended hub on the shaft in the socket or wrench.

12. With the compressor wheel at room temperature, position it over the shaft.

13. Lightly lubricate the shaft threads and wheel face that will be under the nut with engine oil and install the retaining nut. Tighten the nut to 125-150 lb-in (14—17 N«m) torque to seat the compressor wheel against the thrust spacer.

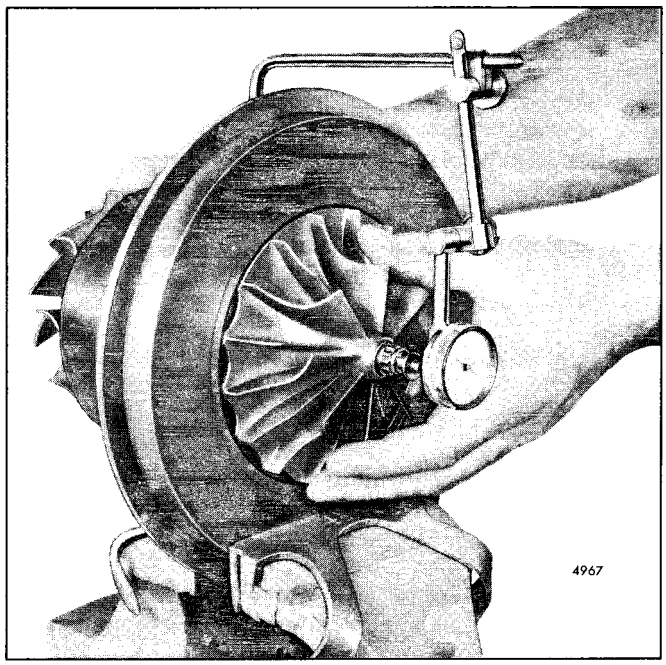


Fig. 14 – Checking Bearing Axial End Play

14. Loosen the nut and inspect the nut face and front face of the compressor wheel to be sure they are smooth and clean.

15. Retighten the nut to 35-55 lb-in (4-6 N*m) torque.

16. Continue to tighten the retaining nut until the shaft increases in length ,007"-.008" (T18A40) or ,009"-.010" (TV7101 and TV8115). Tighten the nut in such a manner as not to impose bending loads on the shaft.

NOTICE: If equipment is not available to measure the shaft stretch, tighten the wheel retaining nut to 35-55 lb-in (4-6 N«m) torque. Then, continue to tighten the nut through an angle of 100-110° turn for the T18A40 turbocharger or 120-130° turn for the TV7101 and TV8115 turbochargers (90° = 1/4 turn).

17. Check the bearing axial end play:

a. Clamp the center housing assembly in a bench vise equipped with soft jaws (Fig. 14).

b. Fasten the dial indicator and magnetic base (J 7872-2) to the center housing so that the indicator tip rests on the end of the rotating shaft on the compressor side (Fig. 14).

c. Move the shaft axially back and forth by hand. The total indicator reading (thrust float) should be between .004" and .009" (TT18A40) or .003" and .010" (TV7101 andTV8115). If the total dial indicator readings do not fall within the specified limits, repair or replace the rotating assembly.

18. Position the turbine housing (6), as marked at disassembly, against the center housing (27) and secure it in place.

a. Secure the T18A40 turbine with four clamps (5), four new lockplates (4) and eight bolts(3). Tighten the bolts to 100-130 lb-in (11-15 N*m) torque.

b. Secure the TV7101 and TV8115 turbine housing with the "V" band coupling (28). Position the V-band so the "T" bolt end does not interfere with the turbine housing (Fig. 10). Failure to properly orient the "T" bolt end of the clamp can result in an exhaust leak and/or turbine wheel damage. Tighten the toggle nut as follows:

1. Lubricate the toggle bolt threads with a high temperature anti-seize compound, such as Jet Lube (Mil Spec A-907D), or equivalent.

2. Tighten the nut on the "V" band toggle bolt to approximately 160 lb-in (18 N*m) torque.

NOTICE: Do not pull a misaligned turbine housing into alignment with the "V" band coupling. The parts must be aligned and seated first.

3. Loosen the "V" band coupling nut to approximately 50 lb-in (6 N*m) torque, then retorque the nut to 152-168 lb-in (17-19 N*m) torque.

19. Position the compressor housing (2), as marked at disassembly, against the backplate (14) and secure it in place with the "V" band coupling (1). Lightly lubricate the threads of the toggle bolt with engine oil and tighten the nut to 110-130 lb-in (12-15 N*m) torque.

20. Check the shaft radial movement:

a. Position the magnetic base J 7872-2 with the swivel adaptor J 7872-3 on the flat surface of the turbine housing inlet flange (Fig. 15).

b. Fasten the dial indicator extension rod J 7872-1 to the dial indicator J 8001-3 and attach the dial indicator to the swivel adaptor.

c. Insert the extension rod J 7872-1 into the oil drain tube mounting pad opening so that the rod is against the wheel shaft and is perpendicular to the shaft.

NOTICE: Make sure the extension rod does not make contact with the sides of the center housing, otherwise it will be impossible to obtain an accurate reading.

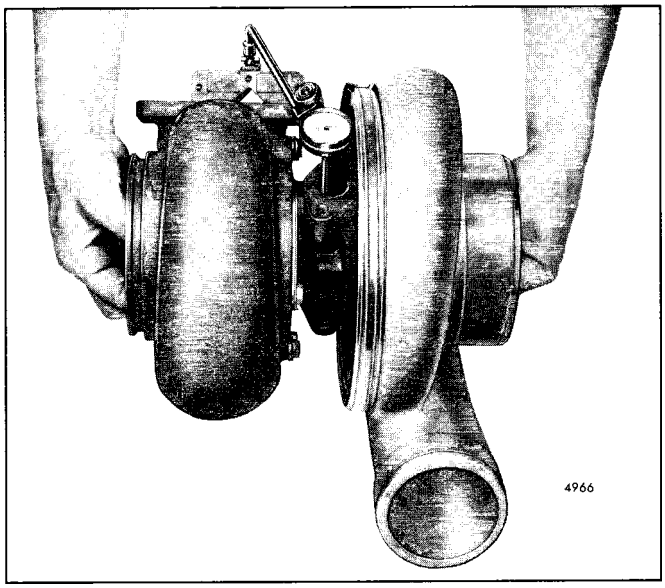


Fig. 1 5 - Checking Shaft Radial Movement

 © Detroit Diesel Corporation

d. Grasp each end of the rotating assembly and, applying equal pressure at each end, move the rotating shaft first toward and then away from the dial indicator, creating a transverse movement in the shaft (Fig. 15). The dial indicator displacement should be between .003" and .007". If the displacement does not fall within these limits, disassemble and repair or replace the rotating assembly.

21. If it is to be stored, lubricate the unit internally and install protective covers on all openings.

22. Stamp the letter "R" in the lower left-hand corner of the name plate to identify that the turbocharger has been reworked.

Install Turbocharger

• To improve engine breathing and to keep oil from blowing out the breather tube, the turbocharger oil drain back flexible hoses have been relocated from the center inspection plate on the upper oil pan to the center of the block (Fig. 7).

• When replacing the former front or rear cylinder block with the current front or rear blocks, it is recommended that the turbocharger oil drain back flexible hoses be relocated using the current parts. Also, the oil drain back hole in the upper oil pan center inspection plate must be plugged.

• A 3.75” L x 3.25" diameter hose and thick band (.035") stainless steel T-bolt clamp are currently used between the trubochargers, air outlet tubes, and air inlet housings of Series 149 engines. The former 3.25" L x 3.50" diameter hose and T-bolt clamp (.025" thick band) should be replaced with the new at time of normal engine overhaul, or earlier if sealing or clamping concerns are experienced.

Before replacing a turbocharger that has experienced compressor or turbine wheel damage, always inspect the air induction and exhaust systems for damage and debris. Check air inlet ducting from the turbocharger compressor inlet pipe to the air cleaner assembly. Look for cracks or signs of air leakage and remove any dirt or debris. Check turbo discharge-to-blower piping for leaks of debris.

Check the exhaust system from the cylinder head exhaust ports to the exhaust outlet piping on the turbine side of the turbocharger and the inside of the exhaust manifold(s). Remove any debris left over from the damaged turbocharger. Repair or replace any other damage or defective components in the air induction or exhaust systems.

NOTICE: Failure to remove contaminants or debris from these systems can result in damage to the replacement turbocharger. On engines equipped with mechanical emergency shutdowns, check for proper operation of *each* flapper valve.

1. Install the seal ring on the exhaust outlet elbow.

2. Position the turbocharger on the exhaust manifold adaptor and into the exhaust outlet elbow. Use a new mounting gasket and secure the turbocharger in place with four bolts, washers and nuts (Figs. 6 and 7).

   NOTICE: When attaching the exhaust manifold adaptor to the turbine housing, be sure the inner diameter of the adaptor is the same as the turbine housing inner diameter. The turbine opening in the T18A40 turbocharger is 3.850", the TV7101 turbocharger is 3.480" and the TV8115 turbocharger is 3.892".

3. Slide the hose over the end of the turbocharger air outlet opening with the “T” bolt positioned away from the parting line of the tube (Fig. 8).

   Tighten the two hose clamps so a .017" feeler gage will pass freely between the coils. Do not collapse the clamp spring completely. A collapsed spring may cause clamp breakage.

4. Install the oil drain line between the opening in the bottom side of the center housing and the cylinder block (Figs. 6 and 7).

5. Attach the oil inlet line at the cylinder block.

6. After installing a rebuilt or new turbocharger, it is very important that all moving parts of the turbocharger center housing be lubricated as follows:

   a. Clean the area and disconnect the oil inlet (supply) line at the bearing (center) housing (Fig. 3).

   b. Fill the bearing housing cavity with clean engine oil. Turn the rotating assembly by hand to coat all of the internal surfaces with oil.

   c. Add additional clean engine oil to completely fill the bearing housing cavity and reinstall the oil line. Clean off any spilled oil.

   d. Start and run the engine at idle until oil pressure and supply has reached all of the turbocharger moving parts. A good indicator that all of the moving parts are getting lubrication is when the oil pressure gage registers pressure (10 psig or 69 kPa at idle speed).

© Detroit Diesel Corporation

CAUTION: Do not hold the compressor wheel, for any reason, while the engine is running. This could result in personal injury.

The free floating bearings in the turbocharger center housing require positive lubrication. This is provided by the above procedure *before the turbocharger reaches its maximum operating speed* which is produced by high engine speed. Starting any turbocharged engine and accelerating to any speed above idle before engine oil supply and pressure has reached the free floating bearings can cause severe damage to the shaft and bearings of the turbocharger.

7. Check all connections, ducts and gaskets for leaks.
8. Operate the engine at rated output and listen for sounds of metallic contact from the turbocharger. If any such noise is apparent, stop the engine immediately and correct the cause.

NOTICE: After the turbocharger has been operating long enough to permit the unit and the oil to warm up, the rotating assembly should coast freely to a stop after the engine is stopped. If the rotating assembly jerks to a sudden stop, the cause should be immediately determined and eliminated.

© Detroit Diesel Corporation

TURBOCHARGER INTERCOOLER

On 12V-149 and 16V-149 engines, two intercoolers (Fig. 1) are mounted on the top of the engine between the air discharge end of the turbochargers and the air inlet side of the blowers. One intercooler is used on 8V engines.

Cooling of the air is accomplished by circulating engine coolant from the engine water inlet tube through the cells of each intercooler core and out to the water manifolds. The compressed air enters the intercooler via individual air inlet housings mounted on the top of each intercooler and circulates past the cooler cores.

• The coolant circulated through the intercoolers on a turbocharged-intercooler engine is protected by a water strainer. Current engines use a bracket-mounted basket-type strainer assembly (Fig. 3) located on top of the engine. One strainer is used on 8V engines, while two are used on 12V and 16V engines. This basket-type strainer filters the coolant going into the intercooler(s). It is in the system to prevent plugging of the water side of the intercooler core, which would result in excessive cylinder temperatures. Former engines used a 20 mesh cone-shaped screen located at the water connection in the water pump-to-engine oil cooler tube (“S tube”).

Remove Intercooler(s)

1. Drain the engine cooling system (Section 5) and each intercooler at the draincock provided at the outlet connector.

2. Disconnect each turbocharger air inlet tube at the air shutdown housing.

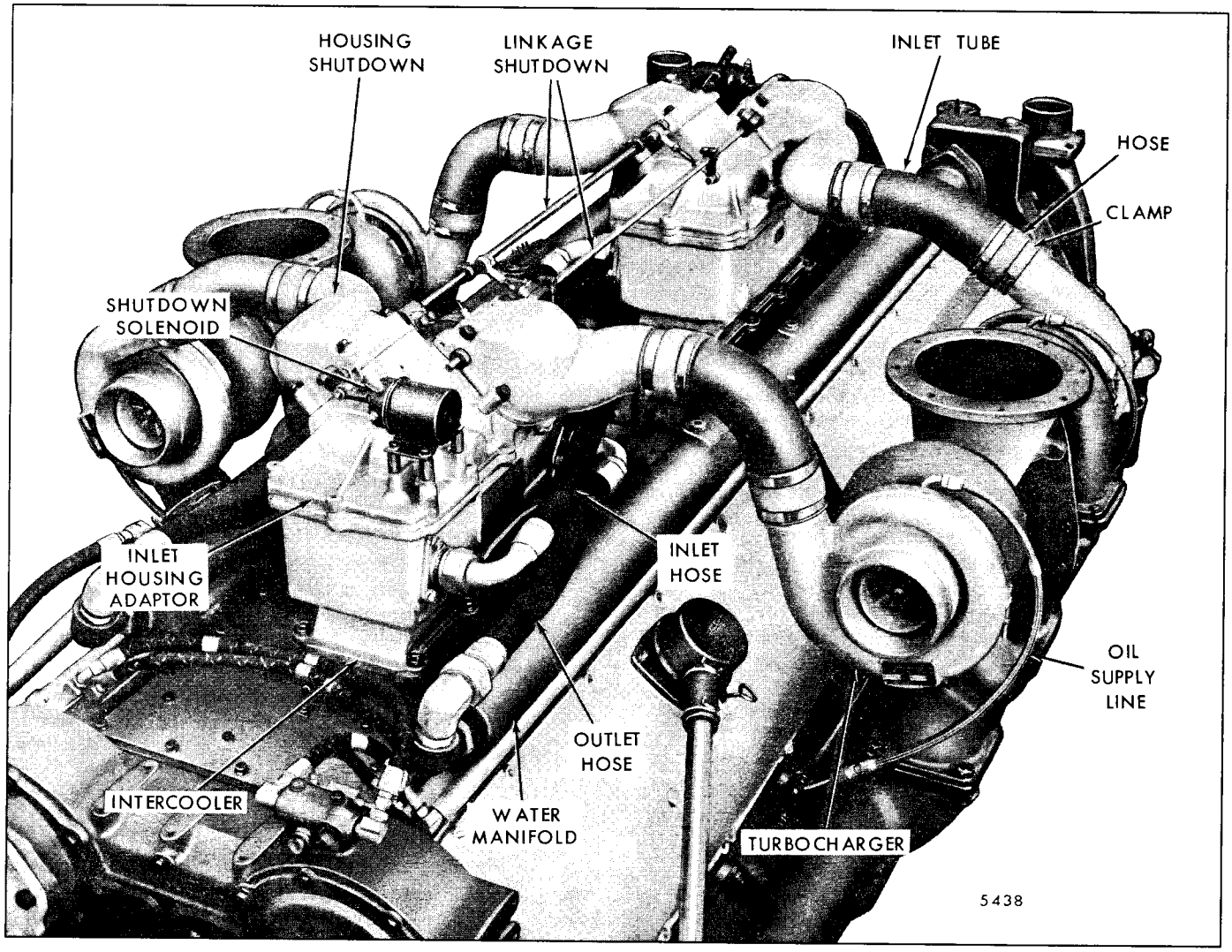


Fig. 1 - Typical Intercooler Mounting

© Detroit Diesel Corporation

NOTICE: The steel straps used with the hose clamps at both ends of the air inlet tube have been eliminated. Remove and discard the straps from all 12V-149 and 16V-149 turbocharged-intercooled high efficiency engines.

3. Disconnect the water hoses at the inlet and outlet connectors from each intercooler.

4. Disconnect each shutdown solenoid from the shutdown linkage.

5. Disconnect and remove the shutdown linkage from the shutdown housing (Section 3.3).

6. Remove the air shutdown housing and the air inlet housing adaptor (Section 3.3).

7. Remove six 7/16"—14 x 1 3/4" bolts, lock washers and washers from each intercooler on 12V-149 engines or eight bolts, lock washers and washers on 8V-149 and 16V-149 engines. Then, remove the intercoolers and seal rings. Discard the seal rings.

Disassemble Intercooler

1. Remove the two bolts and lock washers and withdraw the drain adaptor with the draincock from the drain hole below the intercooler outlet connector (Fig. 2).

2. Remove three bolts and lock washers from each connector and withdraw the inlet and outlet connectors straight out from the intercooler. Remove and discard the gaskets.

3. Remove the drain, inlet and outlet tubes and seal rings from the water openings in the intercooler. Remove and discard the two seal rings on each tube.

4. Remove the four cross head screws from the intercooler adaptor plate, then remove the plate and discard the seal ring.

5. Remove the top one-piece aramid fiber pad and two smaller pads.

6. Lift the intercooler core straight up and out of the housing. Do not use sharp or prying tools.

7. Remove the four upright aramid fiber pads.

Inspection

Clean all of the parts thoroughly and dry them with compressed air.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Clean the intercooler core by immersing it in a scale solvent consisting of 1/2 pound of oxalic acid to each 2-1/2 gallons of a solution composed of 1/3 muriatic acid and 2/3 water. The cleaning action is evident by the bubbling and foaming. Carefully observe the process and remove the intercooler core from the solution when the bubbling stops (this generally takes from 30 to 60 seconds). Then thoroughly flush the intercooler core with clean hot water under pressure.

CAUTION: To avoid possible personal injury, wear adequate eye protection and avoid breathing the fumes or direct contact of the acid with your skin.

• The strainer should be removed and inspected for damage or clogging when the cooling system is cleaned. If badly clogged or damaged, replace the strainer. *Do not operate an intercooled engine without the strainer in place.*

Solid contaminants in the engine coolant which is allowed to bypass a missing or damaged water filter screen, can not be effectively removed from the core. Contaminated cores must be replaced.

Pressure Check Intercooler Core

1. Make a suitable adaptor to which an air hose can be attached and fasten it to the inlet pipe of the cooler core. Use a suitable piece of hose, a plug and clamp to seal the outlet pipe.

2. Attach an air hose and supply approximately 30 psi (207 kPa) air pressure. Then, submerge the cooler core in a tank of water. Any leaks will be indicated by air bubbles in the water.

CAUTION: When making this pressure test, be sure that personnel are adequately protected against any stream of pressurized water from a leak or rupture of a fitting, hose or the intercooler core.

3. After the pressure test is completed, remove the air hose, clamp, plug, hose and adaptor and dry the cooler core with compressed air. Replace the cooler core if leaks were indicated.

Assemble Intercooler

1. Fix the four upright and two horizontal (bottom) aramid fiber pads in place in the intercooler housing using Silastic 732 RTV, or equivalent. Air dry for twenty-four (24) hours to cure the Silastic or heat in an oven at 250-300°F (121-149°C) for four hours.

 © Detroit Diesel Corporation

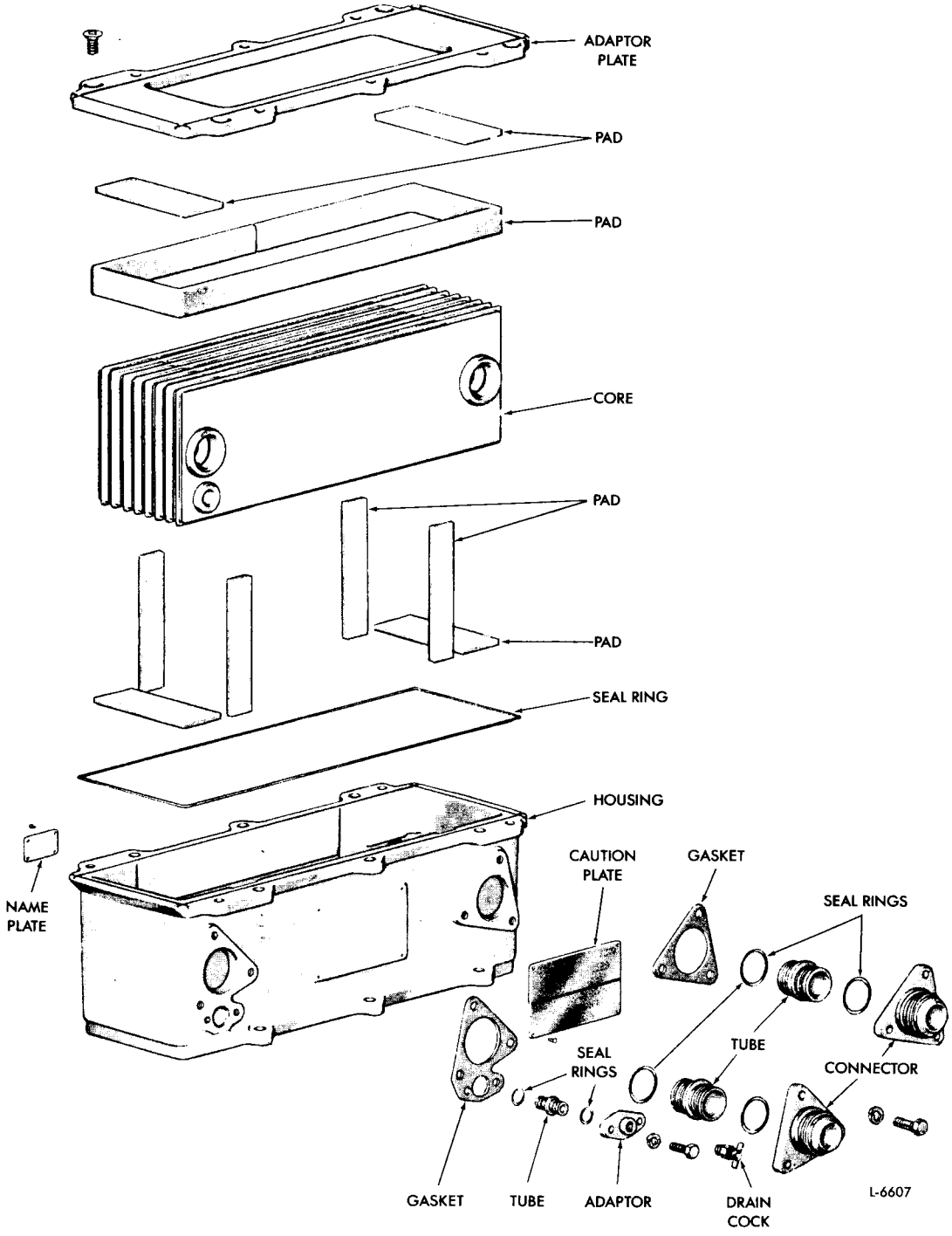
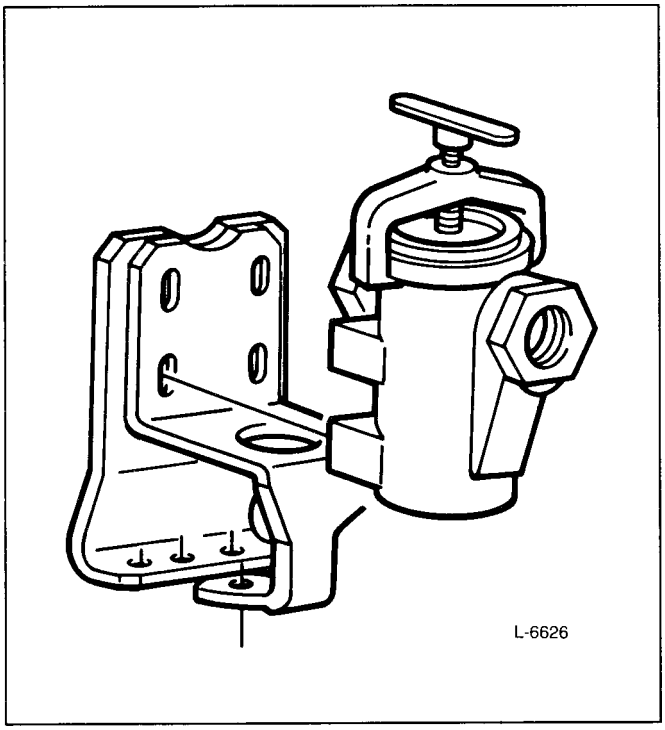


Fig. 2 - Intercooler Details and Relative Location of Parts



• Fig. 3 Water Strainer Assembly

2. Place the intercooler core straight down into the housing. Some spray lubricant may be required on the vertical side pads to allow the core to slide into place. Check the clearance of the core to the case wall. End clearance and side clearance (nipple side) is minimum .150 to maximum .230".

3. Fix the one-piece aramid fiber pad around the top side of the housing. It should butt together at the center of the housing and must not overlap. Bond the pads on the top of the core.

4. Lubricate a *new* seal ring and the groove in the adaptor plate with lubricone and install the seal ring in the plate. Place the adaptor plate on the intercooler housing and thread the four 3/8”—16 x .75" screws into the housing. Tighten the screws to 250-300 **lb-in** (28-34 N*m) torque.

5. Spray the core collars with GM silicone spray or equivalent.

6. Lubricate new seal rings and the two grooves on each water tube with GM silicone spray or an equivalent spray. Then, place the seal rings on the tubes.

7. Position the tubes in the water openings in the side of the housing, and insert the tubes with a *downward twisting motion.* This helps prevent seal distortion and rollout.

8. Use new gaskets and install the water inlet and outlet connectors on the housing with three each 3/8"-16 x 1" bolts and lock washers. Tighten the bolts to 240 **lb-in** (27 N*m) torque.

   NOTICE: The gasket with the drain hole is used at the outlet opening.

9. Install the drain adaptor and drain cock with two 5/16"—18 x .88" bolts and lock washers. Tighten the bolts to 120 **lb-in** (14 N*m) torque.

Test For Leaks

1. With the drain cock closed, install a cap on one nipple and connect a regulated air cource with a shutoff valve to the other nipple. Install a 50 psi (345 kPa) gage between the shutoff valve and the nipple.

2. Pressurize the assembled core to 30 psi (207 kPa) and close the shutoff valve.

3. Observe the pressure after five minutes. A pressure loss of more than 0.5 psi (3.5 kPa) indicates leaking “O” ring seals. Replace leaking “O” ring seals.

Install The Intercooler

1. Lubricate *new* seal rings and the groove in the bottom of the intercooler housings with lubricone and install a seal ring in each housing.

2. Install the intercooler on the blower cover plate with six 7/16"—14 x 1 3/4" bolts (12V-149 engines) or eight 7/16"-14 x 1 3/4" bolts (8V-149 and 16V-149 engines), lock washers and washers. Tighten the bolts to 46-50 lb—ft (62-68 N*m) torque.

3. Install the air inlet adaptors and air shutdown housing assemblies (Section 3.3).

4. Install the shutdown solenoids and shutdown linkage (Section 3.3).

5. Connect the water hoses at the inlet and outlet connectors for each intercooler.

6. Connect each turbocharger air inlet tube at the air shutdown housing.

7. Fill the intercooler and engine cooling system with coolant (Section 5).

 © Detroit Diesel Corporation

SHOP NOTES - TROUBLESHOOTING SPECIFICATIONS - SERVICE TOOLS

SHOP NOTES

REWORKING BLOWER END PLATE

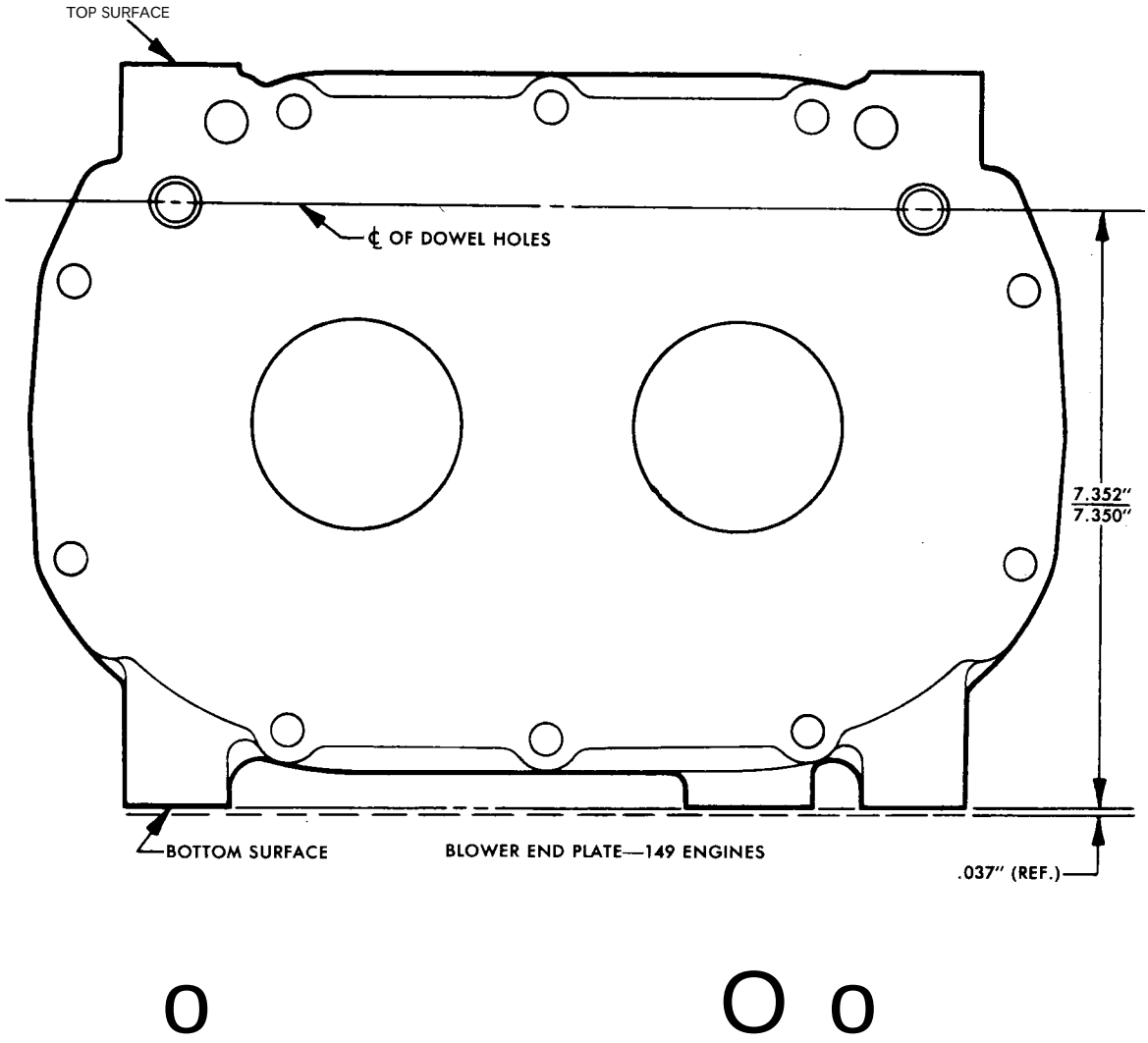


Fig. 1 - Blower End Plate

The bottom surface of each blower end plate must be smooth and flat. To reuse a blower that has end plates that show signs of fretting corrosion and cannot be cleaned up with emery cloth, a service blowor shim is provided. The shim is .048"-.042" thick with a controlled thickness of .037" after the blower (end plate) has been installed in the cylinder block.

When it becomes necessary to rework a blower end plate, mill off material from the bottom of the end plate to achieve the 7.352"-7.350" height (Fig. 1). Then, for future identification stamp “RW” on the top left side of the case portion of the reworked blower end plate. Do not remove more or less material than the referenced .037".

The new shim will position the reworked blower to the required height necessary to achieve alignment of both blowers in the cylinder block. Position the shim such that all holes are open to allow oil flow to the blower and oil drainage is not affected. Do not mix a salvaged end plate and a new end plate on the same blower. The service shim must be used in pairs (one under each end plate).

© Detroit Diesel Corporation

DRILLING PROCEDURE FOR AIR SHUTDOWN REPLACEMENT SHAFT

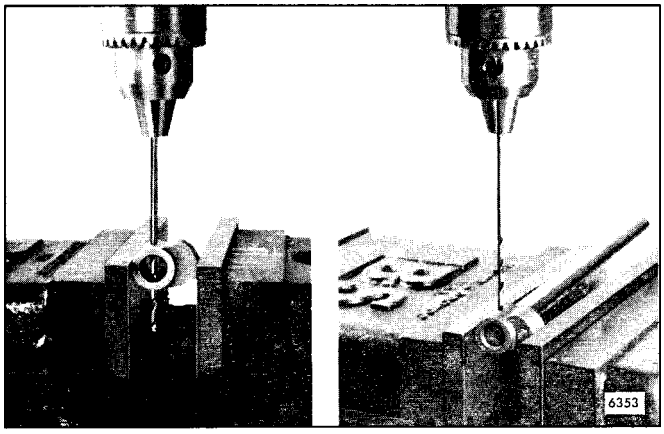


Fig. 2 - Aligning Drill Bit and Drilling Shaft

Whenever a replacement air shutdown valve shaft is installed on a Series 149 engine, the shaft must be match-drilled to the cam and the flapper valve in order to ensure positive air shutdown operation. Failure to properly index the shaft can result in improper flapper valve operation and engine run-on at shutdown. Use the following procedure to drill the air shutdown valve shaft:

1. Install a 1/8" drill bit in the chuck of a drill press, then locate and align the bit through the existing hole in the shutdown cam (Fig. 2). Lock the cam in the holding fixture on the drill press, and withdraw the bit.
2. Insert the replacement shaft into the cam until the end of the shaft is recessed 1/8" from the end of the cam. Start the drill and bore a hole through the shaft (Fig. 2). Withdraw the drill bit, install the pin handle through the hole and remove the shaft from the drill press.
3. Insert the shaft into the shutdown housing bore and install the spacer on the end of the shaft. Place a .015" feeler gage between the housing and spacer and mark the shaft with a center punch inserted into the existing hole in the spacer (Fig. 3).
4. Remove the shaft from the housing. Locate and align the 1/8" drill bit through the hole in the spacer and lock the spacer in the holding fixture on the drill press. Withdraw the drill bit.

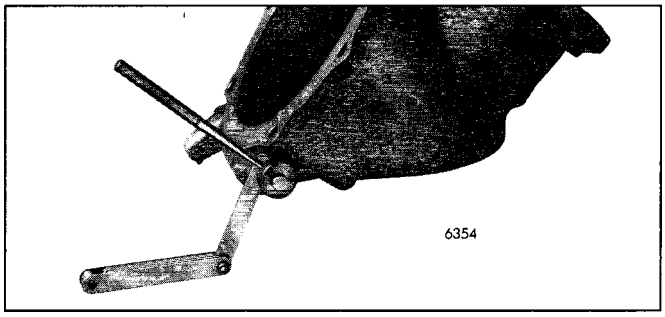


Fig. 3 - Center Punch Shaft thru Spacer Hole

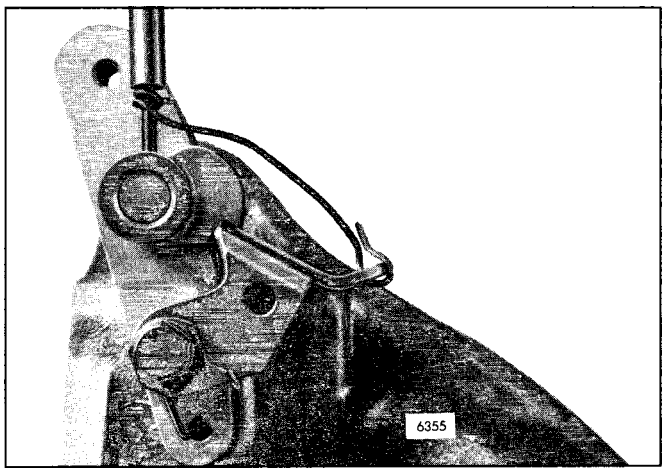


Fig. 4 - Cam and Latch Wired to Prevent Movement

5. Insert the shaft through the spacer, locate the center punched mark and drill a hole through the shaft. Remove the shaft and spacer from the drill press.
6. Assemble the shaft, seal rings spring, flapper valve and spacer in the housing (see Section 3.3). If using a new valve, center punch for holes in approximately the same position as on the old valve. If reusing the old valve, center punch for holes just inside the existing holes.
7. Align the notch on the cam with the latch and hold in this position with a piece of stiff wire (Fig. 4).
8. Place the housing on the drill press. With the valve held in the wide open *run* position, align the 1/8" drill bit with the marks center punched on the valve in Step 6. Then, drill through the valve and shaft (Fig. 5). Install the retaining pins to hold the valve to the shaft.
9. Clean the air shutdown assembly thoroughly and check for proper operation before installing it on the engine.

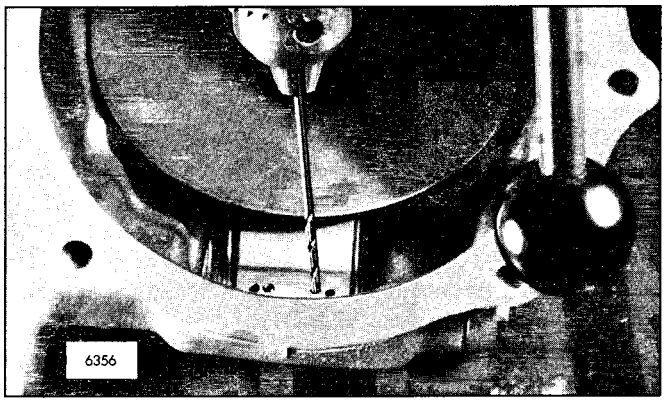


Fig. 5 - Drilling Valve-to-Shaft Holes

 © Detroit Diesel Corporation

INSTALL BYPASS BLOWER VALVE LEVER STOP PLATE

• Effective with unit serial number 8E2524, a lever stop plate (Fig. 6) was installed on the blower cover plate below the bypass valve lever of all 8V-149 engines. Use of this plate was discontinued when the flapper style bypass valve was replaced by the piston style valve (unit serial number 8E2594).

To accommodate the additional stop plate thickness, two (2) 7/8" bolts formerly used to hold the cover plate to the block were replaced by two (2) 1-1/4" bolts with anaerobic (RTV) sealant applied to the threads.

To eliminate the possibility of inefficient engine operation and smoking caused by a stuck-open bypass valve, Detroit Diesel recommends installing the bypass blower valve lever stop plate on 8V engines built prior to serial number 8E-2524 (Fig. 7). This is a very simple operation and can be done whenever practical. If the bypass blower valve lever stop plate is not readily available, an acceptable substitute can be manufactured from any 3/8" thick low carbon steel (Fig. 8).

NOTICE: When installing the blower cover plate and lever stop plate, RTV sealant must be used on the bolt threads to ensure the proper air seal between the blower cover plate and engine air box. Failure to coat the bolt threads before installation can result in air leakage around the bolts, lowered airbox pressure and inefficient engine operation.

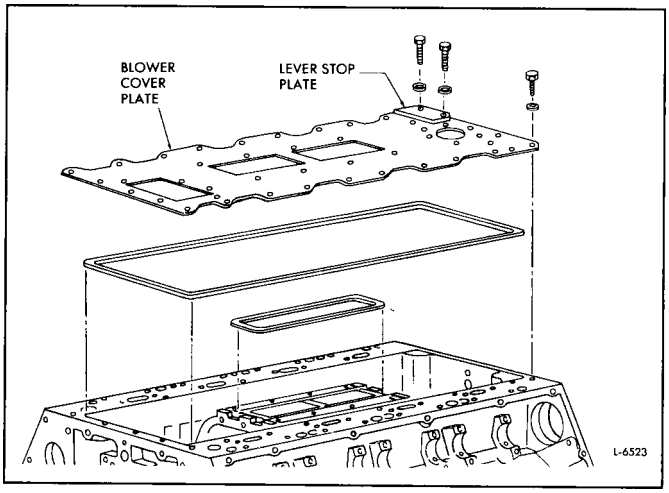


Fig. 6 - Bypass Blower Valve Lever Stop Plate Location

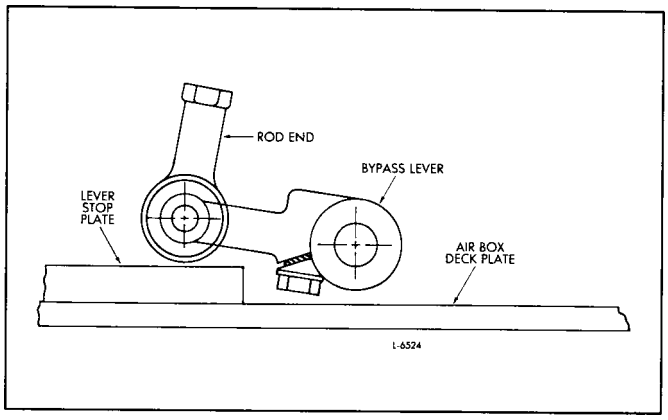


Fig. 7 - Bypass Blower Valve Lever/Lever Stop Plate Schematic

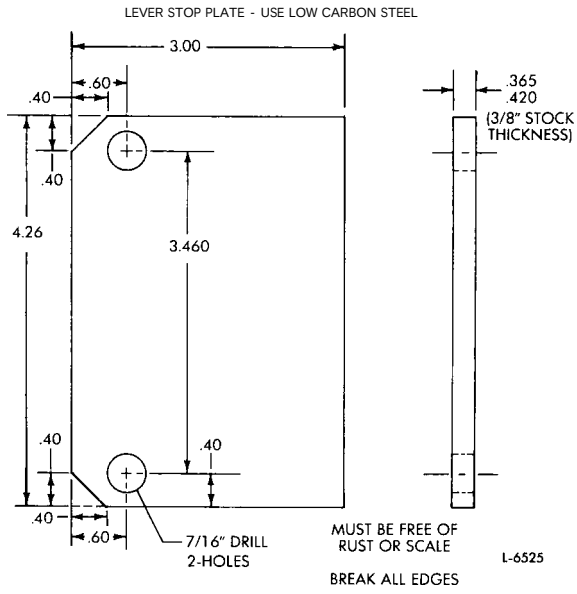


Fig. 8 - Lever Stop Plate Dimensions

TROUBLESHOOTING
BLOWER BYPASS VALVE

Beginning early in 1984, a bypass valve-equipped air induction system has been used on all turbocharged and turbocharged-intercooled engines. Ths system increases fuel efficiency by reducing the amount of engine power required to operate the blowers.

The bypass valve is located in an adaptor on the top deck of the engine. Each air inlet housing has its own individual bypass valve and mechanism. At engine start-up and during light-load operation the valve is closed. As load and engine speed increase, turbocharger boost pressure also increases, raising the pressure in the line from the air inlet housing to the air cylinder which activates the bypass valve mechanism. At 7 psi (48 kPa) the charge of air overcomes the force of the spring within the cylinder, causing the valve to open. The valve is fully open at 10 psi (69 kPa). Opening the valve allows air pressure on the inlet and outlet sides of the blower to equalize, eliminating most of the pumping load of the blower.

A bypass valve stuck in the *open* position will cause the engine to black smoke heavily during acceleration. If stuck in the *closed* position, the benefits of improved fuel ecomony may not be fully realized.

Refer to Section 15.1, Item 49, for the bypass valve preventive maintenance procedure.

TURBOCHARGER

CONDITION	PROBABLE CAUSE	SUGGESTED REMEDY
NOISY OPERATION OR VIBRATION	**WHEEL SHAFT BEARINGS ARE NOT BEING LUBRICATED**	Locate cause of loss of oil pressure and repair. Remove, dis-assemble and inspect turbocharger for bearing damage.
	IMPROPER CLEARANCE BETWEEN TURBINE WHEEL AND HOUSING	Remove, disassemble, and inspect turbocharger.
	LEAK IN ENGINE AIR INTAKE OR EXHAUST MANIFOLD	Tighten all loose connections or replace exhaust manifo'd gaskets as necessary.
ENGINE WILL NOT DELIVER RATED POWER	**CLOGGED AIR INTAKE SYSTEM**	Check air cleaner and clean air intake ducts.
	FOREIGN MATERIAL LODGED IN COMPRESSOR OR TURBINE WHEELS	Remove, disassemble and clean turbocharger.
	EXCESSIVE DIRT BUILD-UP IN COMPRESSOR	Thoroughly clean compressor assembly. Clean air cleaner arid check for leaks.
	LEAK IN ENGINE AIR INTAKE OR EXHAUST MANIFOLD	Tighten all loose connections or replace exhaust manifold gaskets as necessary.
	ROTATING ASSEMBLY BEARING SEIZURE	Remove and overhaul turbocharger.

© Detroit Diesel Corporation

SPECIFICATIONS

Specifications, clearances and wear limits are listed satisfactory performance. It should be emphasized that the below. It should be specifically noted that the clearances figures given as “Limits” must be qualified by the judgement apply only when all new parts are used at the point where the of personnel responsible for installing new parts. These wear various specifications apply. This also applies to references limits are, in general, listed only for the parts more frequently within the text of the manual. The column entitled “Limits” replaced in engine overhaul work. For additional in this chart lists the amount of wear or increase in clearance information, refer to the text,
which can be tolerated in used engine parts and still ensure

TABLE OF SPECIFICATIONS, NEW CLEARANCES AND WEAR LIMITS

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
BLOWER			
Backlash—timing gears	.0005”	.0025"	.0040"
Clearances:			
Rotor to end plate (gear end)	.0070"	.0130"	
Rotor to end plate (front end - 12V)	.0130"	.0230"	
Rotor to end plate (front end - 16V2)	.0210"	.0310"	
Rotor to housing (inlet side)	.0210"		
Rotor to housing (outlet side)	.0070"		
Trailing edge of right-hand helix rotor to leading edge of left-hand helix rotor	.0140"		
Leading edge of right-hand helix rotor to leading edge of left-hand helix rotor	.0240"		
TURBOCHARGER			
End play — rotating shaft (T18A40 and TV8115)	.0040"	.0090"	
End play — rotating shaft (TV71 and TV81)	.0030"	.0100"	
Radial movement — rotating shaft	.0030"	.0070"	
Turbine wheel shaft journal bearing:			
Inside diameter	.6268"	.6272"	
Outside diameter	.9780"	.9785"	
Journal diameter — turbine wheel shaft	.6247”	.6250”	
Bearing bore — center housing (inside diameter)	.9830"	.9835"	
Backplate Seal Bore:			
Inside diameter	.6875"	.6885"	.6895"
Thrust Collar:			
Thickness	.2990"	.3000"	.2970"
Bore - Inside Diameter	.3754"	.3758"	.3778"
Thrust Spacer:			
Outside diameter	.6715"	.6725"	.6705"
Ring groove width	.0685”	.0695"	.0715"
Thrust Washer, Inboard:			
Thickness	.0900"	.0920"	
Compressor Wheel Bore:			
Inside diameter	.3736"	.3739"	.3749"

© Detroit Diesel Corporation

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	260M BOLTS TORQUE (lb—ft)	Nam	THREAD SIZE	280M OR BETTER TORQUE (lb-ft)	Nam
1/4-20	5-7	7-9	1/4-20	7-9	10-12
1/4-28	6-8	8-11	1/4-28	8-10	11-14
5/16-18	10-13	14-18	5/16-18	13-17	18-23
5/16-24	11-14	15-19	5/16-24	15-19	20-26
3/8-16	23-26	31-35	3/8-16	30-35	41-47
3/8-24	26-29	35-40	3/8-24	35-39	47-53
7/16-14	35-38	47-51	7/16-14	46-50	62-68
7/16-20	43-46	58-62	7/16-20	57-61	77-83
1/2-13	53-56	72-76	1/2-13	71-75	96-102
1/2-20	62-70	84-95	1/2-20	83-93	113-126
9/16-12	68-75	92-102	9/16-12	90-100	122-136
9/16-18	80-88	109-119	9/16-18	107-117	146-159
5/8-11	103-110	140-149	5/8-11	137-147	186-200
5/8-18	126-134	171-181	5/8-18	168-178	228-242
3/4-10	180-188	244-254	3/4-10	240-250	325-339
3/4-16	218-225	295-305	3/4-16	290-300	393-407
7/8-9	308-315	417-427	7/8-9	410-420	556-569
7/8-14	356-364	483-494	7/8-14	475-485	644-657
1-8	435-443	590-600	1-8	580-590	786-800
1-14	514-521	697-705	1-14	685-695	928-942

Grade identification markings are normally stamped on the heads of the bolts. To aid identification of the various bolts used in Detroit Diesel engines, refer to the following chart.

Grade Identification Marking on Bolt Head	GM Number	SAE Grade Designation	Nominal Size Diameter (inch)	Tensile Strength Min. (psi)
None	GM 255-M	1	No. 6 thru 1 1/2	60,000
None	GM 260-M	2	No. 6 thru 3/4 over 3/4 to 1 1/2	74.000 60.000
Bolts and Screws	GM 280-M	5	No. 6 thru 1 over 1 to 1 1/2	120,000 105,000
— Hex Head Sems Only	GM 275-M	5.1	No. 6 thru 3/8	120,000
Bolts and Screws	GM 290-M	7	1/4 thru 1 1/2	133,000
Bolts and Screws	GM 300-M	8	1/4 thru 1 1/2	150,000
—* Bolts and Screws	GM 455-M	None	No. 6 thru 1 1/2	55,000

BOLT IDENTIFICATION CHART

 © Detroit Diesel Corporation

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD	(lb-ft)	(N*m)
Fuel pump coupling disc bolt	3/8-24	50-55	68-75
* Blower hold-down bolt	7/16-14	50-55	68-75
* Blower hold-down bolt	9/16-12	78-85	102-115
# Blower timing gear and bearing retaining nuts	1 5/16-18	200-250	271-339

* Threads and under head of bolt to be lubricated with engine oil.
#Threads lubricated with International Compound No. 2, or equivalent (refer to Parts Catalog or Microfiche, Section 12.8000A).

SERVICE TOOLS

TOOL NAME	TOOL NO.
BLOWER	
Blower-to-block drilling and tapping fixture	J 23459
Blower service tool set	J 22706-02
Feeler gage (blower timing)	J 1698-02
. BLOWER BYPASS VALVE	
Blower bypass valve assembly/disassembly tool	J 37466
TURBOCHARGER	
Dial indicator set (magnetic base)	J 7872
Turbocharger inlet shield	J 26554-A

SECTION 4

LUBRICATION SYSTEM

CONTENTS

Lubrication System 4
Lubricating Oil Pump 4.1
Lubricating Oil Pressure Regulator and Relief Valves 4.1.1
Lubricating Oil Filters.....4.2
Lubricating Oil Cooler.....4.4
Oil Level Dipstick 4.6
Oil Pan.....4.7
Ventilating System 4.8
Shop Notes - Specifications - Service Tools.....4.0

LUBRICATION SYSTEM

Fig. 1 schematically illustrates the flow of oil through a typical Series 149 engine lubrication system including the various components such as the oil pump, oil filter, oil cooler, pressure regulator and bypass valve.

The gear type oil pump is mounted on the main bearing caps and is gear driven from the rear end of the crankshaft. The oil pump accommodates a tandem installation of a scavenging pump section whereas oil is picked up from the front of the engine and dumped in the rear near the oil pump intake.

Oil is drawn by suction from the oil pan through the intake screen and pipes to the oil pump where it is pressurized. The oil then passes from the pump into a short gallery in the cylinder block to the oil filter adaptor and into the oil filter. At the same time, oil from the pump is directed to a spring-loaded pressure relief valve mounted on the oil pump. This valve discharges excess oil when the pump pressure exceeds 100 psi (689 kPa) with the former valve, 130 psi +10 psi (896 + 69 kPa) with the current valve. The former valve should be replaced with the current valve at time of engine overhaul.

From the oil filter, the oil passes back to the cylinder block where a short longitudinally drilled passage carries the oil to the oil cooler. The oil is then directed from the oil cooler to a vertically-drilled passage in the cylinder block to the main oil gallery.

Stabilized lubricating oil pressure is maintained within the engine at all speeds, regardless of the oil temperature, by two pressure regulator valves located at the ends of the vertical oil galleries connected to the main oil gallery. When the oil pressure at the valve exceeds 70 psi (483 kPa) (current and high output engines) or 50 psi (345 kPa) (former engines), the regulator valve opens, discharging the excess oil back into the sump.

From the main oil gallery, the pressurized oil flows through a drilled passage to each main bearing and through a drilled passage in the crankshaft to adjacent connecting rod bearings. By use of grooves in the unloaded halves of the rod bearings, the oil is directed to the rifle drilled passages in the rod to the piston pin and through the piston pin and carrier, spraying the underside of the piston dome. The drain oil from the piston dome is “sloshed” back and forth between the piston skirt and the carrier wall, with a portion of the oil draining through two holes drilled near the bottom of the carrier back to the crankcase.

Lubrication is supplied under pressure from the main oil gallery through drilled passages in the cylinder block to each camshaft bearing. Oil is then picked up by diagonal holes in the camshaft and directed through the rifle drilled longitudinal passage of the camshaft to lubricate the couplings and drive shafts at the rear ends of each camshaft.

The valve and injector operating mechanism is lubricated from the camshaft bearing caps where the lubricating oil is picked up from the grooves in the camshaft bearings. The lubricating oil enters the rocker arm shaft through drilled passages in the bearing caps. From there the oil follows the drilled shaft to each rocker arm where it enters a drilled passage leading to the valve adjusting screw. Lubricating oil is then directed through another drilled passage in the valve adjusting screw, where it lubricates the frictional surfaces between the base of the adjusting screw and the valve button.

The contact surface between the camshaft lobes and the rocker arm rollers is lubricated by jets machined in the bearing caps which spray oil on the rollers.

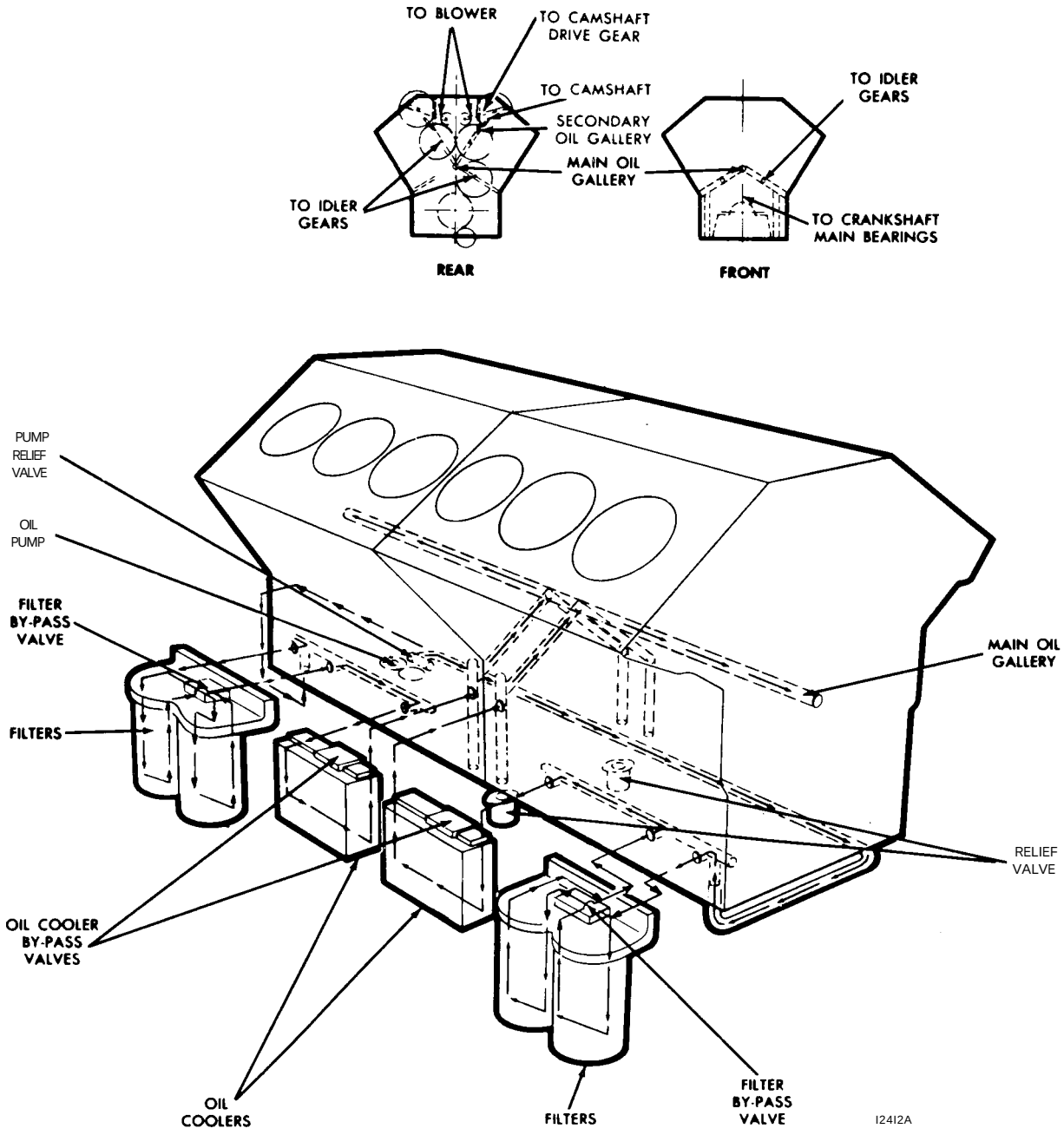


Fig. 1 - Typical 149 Lubrication System

Excess oil from the rocker arms lubricates the exhaust valve stems.

The gear train is lubricated by oil from the longitudinally drilled passages in the camshaft hubs, idler gear center retaining bolts and by oil splash from the oil pan. A certain amount of oil also spills into the gear train compartment from the blower drive bearing and the idler gear bearings. The idler gear bearings are lubricated by oil directly from the cylinder block oil gallery.

The camshaft gears and the idler gears (front and rear gear train) are pressure lubricated by oil from the cylinder block oil gallery. Oil enters a longitudinal drilled passage in the hub center retaining bolt on both the front and rear gear train idler gears. A hole is drilled in the side of the center bolt allowing oil to flow through a transverse drilled passage in the idler hubs where it is circulated around the roller bearings in the rear gear train and the bushings in the front gear train.

© Detroit Diesel Corporation

Lubrication System Maintenance

Use the proper viscosity grade and type of *heavy duty* oil as outlined in the *Lubrication Specifications* in Section 13.3. Change the oil and replace the oil filter elements at the periods recommended to ensure trouble-free lubrication and longer engine life (refer to *Pressurize Fuel System - Check for Leaks* in Section 2.0).

The oil level should never be allowed to drop below the *low* mark on the dipstick. Overfilling the crankcase may contribute to abnormal oil consumption, high oil temperatures, and also result in oil leaking past the crankshaft rear oil seal.

To obtain the true oil level, the engine should be stopped and sufficient time (approximately twenty minutes) allowed for the oil to drain back from the various parts of the engine. If more oil is required, add only enough to bring it to the proper level on the dipstick.

Cleaning Lubrication System

Thorough flushing of the lubrication system is required at times. Should the engine lubrication system become contaminated by ethylene glycol antifreeze solution or other soluble material, refer to Section 5 for the recommended cleaning procedures.

Detection Of Lube Oil Leaks

Detroit Diesel Corporation uses red dye to detect lube oil system leaks during engine test. Customers receiving new engines may notice some residual dye remaining in their lube oil systems. This dye should be quickly dispersed after the first few hours of engine operation.

© Detroit Diesel Corporation

LUBRICATING OIL PUMP

The gear-type lubricating oil pump is mounted on the rear two main bearing caps and is driven by the crankshaft gear (Fig. 1).

Oil is drawn by suction from the oil pan through the oil pump inlet screen and elbow into the oil pump where it is pressurized and directed to the oil filters, oil coolers and the main oil gallery in the cylinder block.

The scavenging pump, mounted in tandem with the pressure pump, is used in conjunction with a deep oil pan which has a shallow reservoir at one end. Oil which flows to the shallow end of the oil pan, during inclined operation of the engine, is transferred to the deep end, or sump, by the scavenging pump and is then picked up by the pressure pump for distribution throughout the engine.

Remove Oil Pump

Refer to Figs. 1 and 2.

1. Remove the oil drain plug from the lower oil pan and drain the oil from the engine.
2. Remove the lower oil pan, gasket and as many upper oil pan inspection hole covers, as necessary, to allow removal of the oil pump and piping (refer to Section 4.7).

8V-149 Engines

Follow steps 3 thru 5 when removing oil pump from 8 V engine.

3. Remove the six bolts and lock washers which secure the oil pump outlet adaptor (Fig. 2) to the oil pump and the cylinder block. Remove the adaptor and pressure relief valve as an assembly. Discard the gasket and seal ring.
4. Remove the four bolts and lock washers which attach the oil pump inlet elbow to the pump. Remove the elbow and screen assembly and discard the gasket.
5. Remove the two bolts and two stud nuts which secure the oil pump to the main bearing caps. Remove the oil pump. Shims are used between the oil pump mounting flange and the rear main bearing cap. Save the shims for reinstallation of the oil pump.

12V and 16V Engines

Follow steps 3 thru 10 when removing oil pump from 12V or 16V engine.

3. Remove the scavenging pump inlet pipe supports.
4. Remove the four bolts and lock washers which secure the scavenging pump inlet pipe to the oil pump. Then, remove the pipe and screen assembly. Discard the seal ring and gasket.
5. Remove the support brackets and clips which secure the oil pump outlet pipe to the main bearing caps.
6. Remove the four bolts and lock washers which secure the oil pump outlet pipe to the cylinder block and the oil pump outlet adaptor. Remove the pipe and discard the gasket and seal ring.
7. Remove the six bolts and lock washers which secure the oil pump outlet adaptor (Fig. 4) to the oil pump and the cylinder block. Remove the adaptor and pressure relief valve as an assembly. Discard the gasket and seal ring.

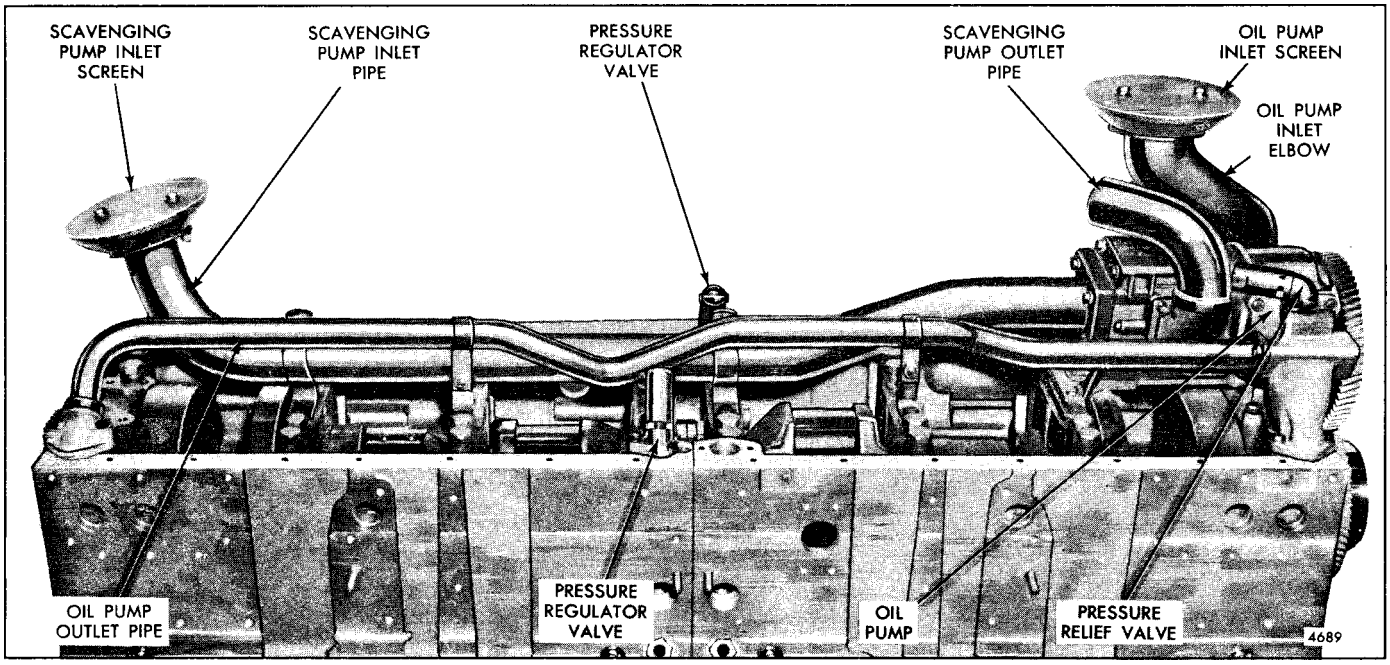


Fig. 1 - Typical Oil Pump Mounting (Rear Sump)

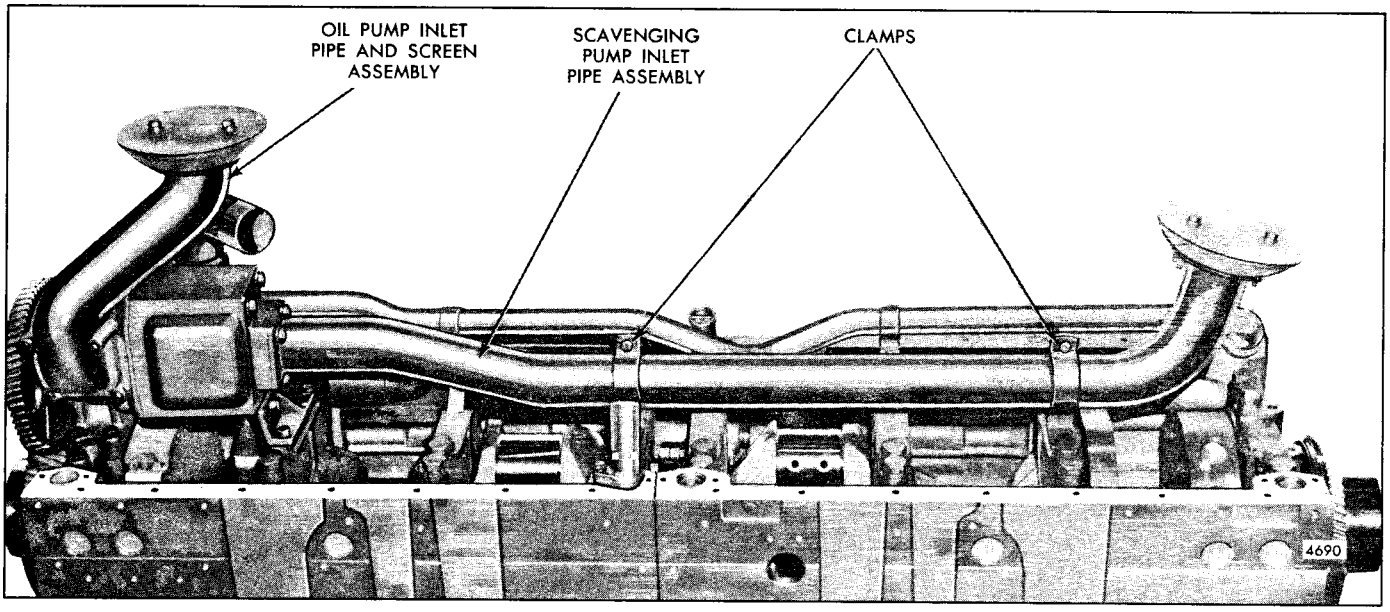


Fig. 2 - Typical Oil Pump Inlet Piping (Rear Sump)

8. Remove the four bolts and lock washers which secure the scavenging pump outlet pipe to the pump. Remove the pipe and discard the gasket.

9. Remove the four bolts and lock washers which attach the oil pump inlet elbow to the pump. Remove the elbow and screen assembly and discard the gasket.

10. Remove the four bolts and two stud nuts (six bolts on former engines) which secure the oil pump to the main bearing caps. Remove the oil pump. Shims are used between the oil pump mounting flange and the rear main bearing cap. Save the shims for reinstallation of the oil pump.

Disassemble Oil Pump (8V Engines)

Refer to Fig. 3.

1. Remove the bolts which secure the cover to the oil pump body.
2. Withdraw the oil pump drive and driven gears and remove the key from the drive shaft.
3. Remove the oil pump drive gear with a gear puller. Then, remove the key from the drive shaft.

   NOTICE: Place a washer between the end of the drive shaft and the puller screw to prevent damage to the drive shaft.
4. Remove the pin from the pump body and driven shaft and withdraw the shaft.

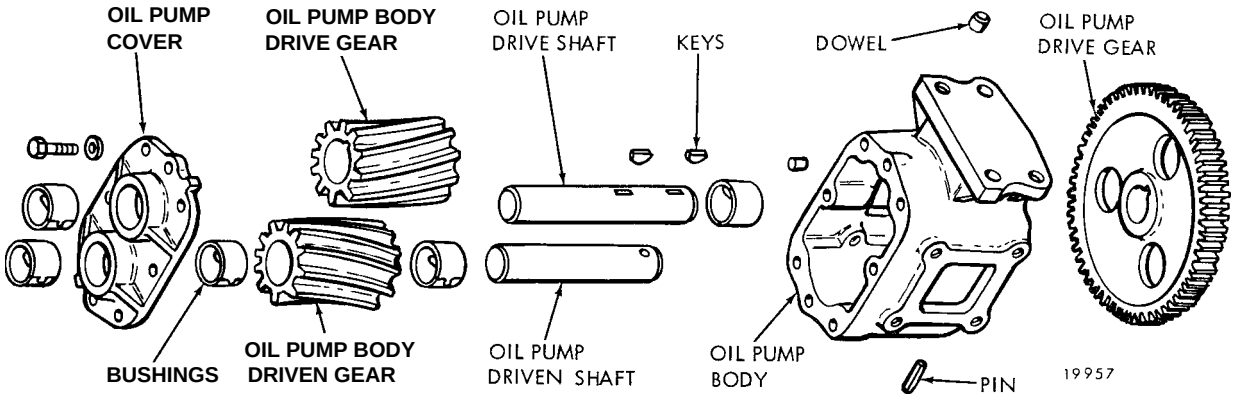


Fig. 3 - Oil Pump Details and Relative Location of Parts (8V Engines)

© Detroit Diesel Corporation

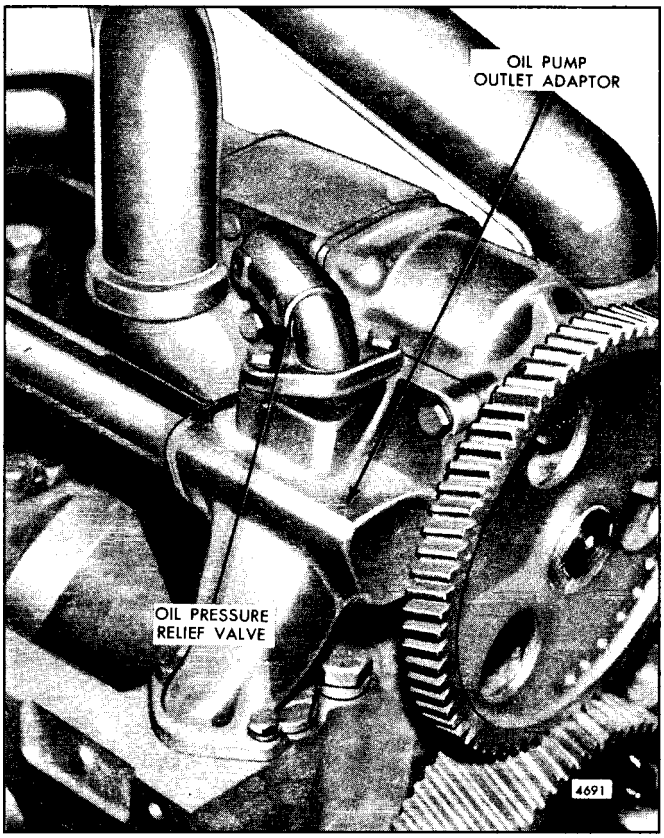


Fig. 4 - Oil Pump Outlet Adaptor (12V and 16V Engines)

Disassemble Oil Pump (12V and 16V Engines)

Refer to Fig. 5.

1. Remove the four bolts, washers and lock washers which secure the front pump support to the scavenging pump body, then remove the support.
2. Loosen and remove the four bolts which secure the scavenging pump section to the oil pump and withdraw the scavenging pump body.
3. Withdraw the scavenging pump drive and driven gears and remove the keys from the drive shaft.
4. Remove the spacer.
5. Remove the external pump drive gear with a gear puller. Then, remove the key from the drive shaft.

   NOTICE: Place a washer or nut between the end of the drive shaft and the puller screw to prevent damage to the drive shaft.

6. Withdraw the drive shaft and drive gear.
7. On current oil pumps, withdraw the driven gear. Then, remove the pin from the pump body and driven shaft and withdraw the shaft.

   On former pumps, the driven gear is keyed to the shaft and the shaft is not pinned to the pump body.

8. If necessary, press the drive gear from the shaft, then remove the key from the shaft. On former pumps, press the gear from the driven shaft and remove the key.

Inspection

Wash all of the parts with clean fuel oil and dry them with compressed air.

CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Inspect the pump and related parts (8V engines). Inspect the pump inlet and outlet pipes and related parts (12V and 16V engines). Replace any damaged parts.

Examine the oil pump body for indications of excessive wear or scoring in the gear cavities (8V engines). Examine the oil pump and scavenging pump bodies for indications of excessive wear or scoring in the gear cavities (12V and 16V engines). Check the bushings for excessive wear. The shaft-to-bushing clearance with new parts is .0015" to .0032". The inside diameter of a new bushing is 1.5015" to 1.5027" and the diameter of a new drive or driven (former 12V and 16V engines) shaft is 1.4995" to 1.5000".

Check the pump spacer and the pump shafts for excessive wear or scoring. Also, check the keyways in the shafts for damage.

Inspect the pump gears for scoring or excessive wear. The helix gears should have a free-running fit, without looseness, within the pump body. Excessively worn helix gears can result in low oil pressure which could cause serious damage to the engine.

Inspect the bushings in the driven gears, used in current pump assemblies, for excessive wear or scoring. The shaft-to-gear bushing clearance with new parts is .0015" to .0032". The inside diameter of a new bushing is 1.5025" to 1.5037" and the diameter of a new (pinned), driven shaft is 1.5005" to 1.5010".

Replace excessively worn or damaged parts.

Service (8V Engines)

Refer to Fig. 7.

1. Clean the pump components with fuel oil and dry them with compressed air.

   CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

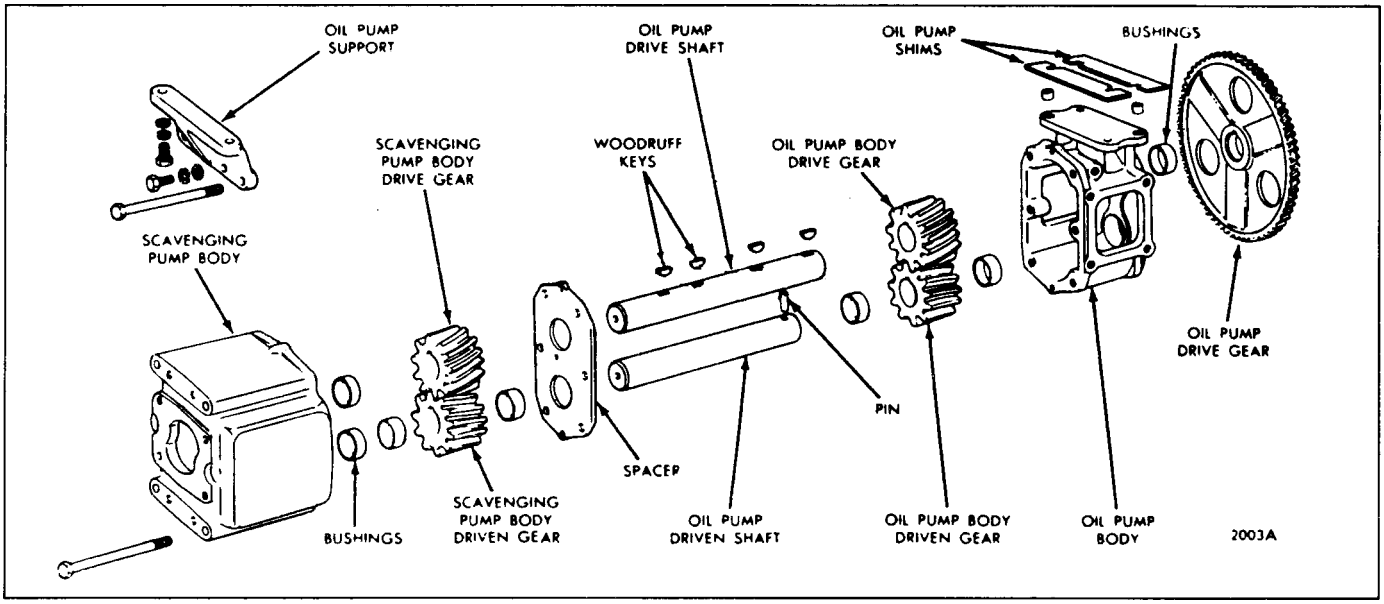


Fig. 5 - Oil Pump Details and Relative Location of Parts (12V and 16V Engines)

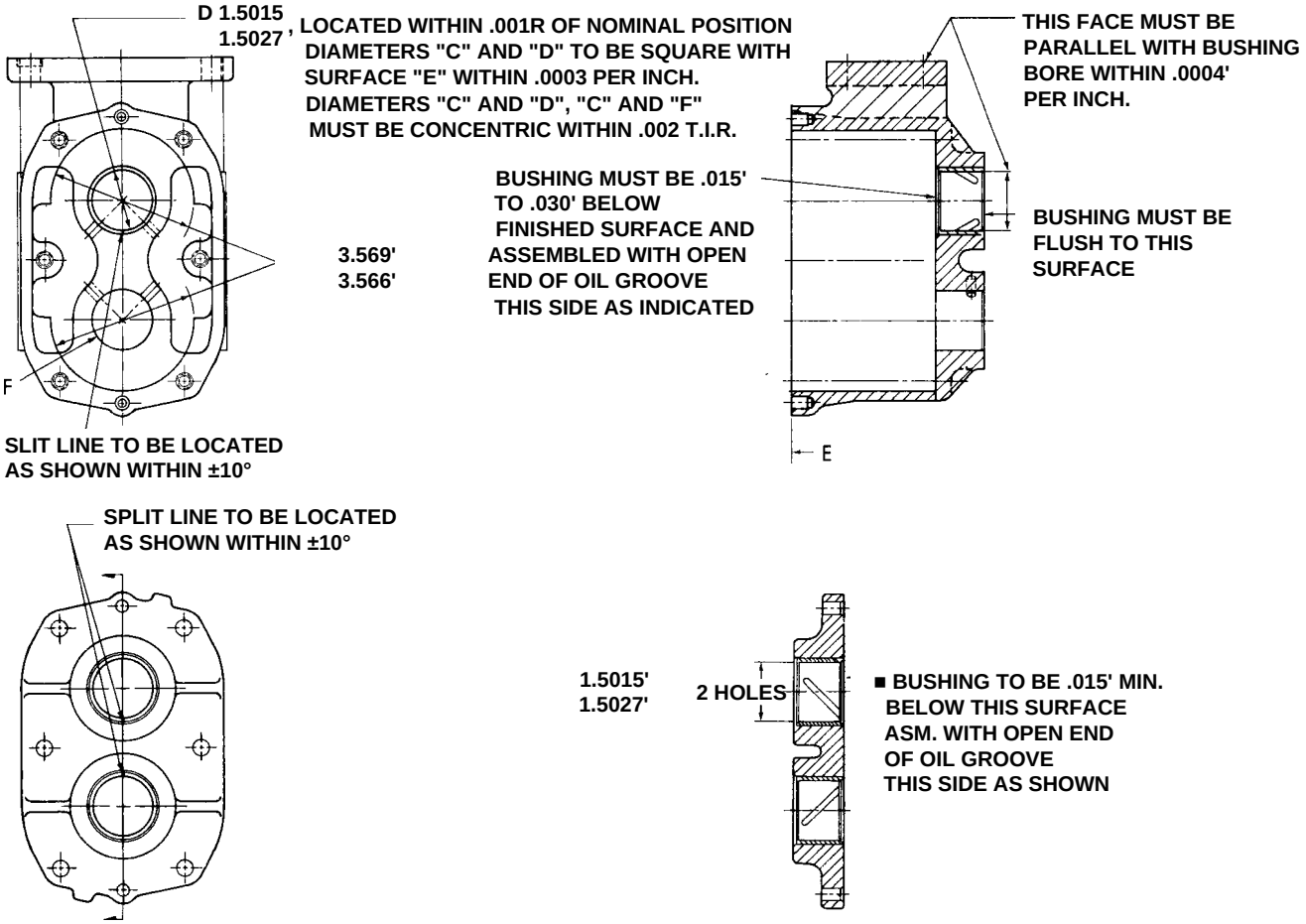


Fig. 6 - Location and Position of Oil Pump Bushing (8V Engines)

 © Detroit Diesel Corporation

Clean the new bushings and mating parts with a suitable degreaser or chlorinated solvent.

CAUTION: The chlorinated solvent must be used in a properly ventilated area with all safety precautions.

2. After the parts are completely dry, apply a continuous fdm of Loctite 75 retaining compound completely around the bushing bore (just inside the entry lip of the bore) in the pump body. It is not desirable to coat the entire width of the bore.
3. Press the bushing in place and remove the excess compound with a clean, dry cloth. *Do not use solvent.*

Loctite 75 develops fixturing strength in approximately fifteen minutes; full cure takes approximately four hours.

After installing, each bushing must withstand a load of 4,000 pounds without moving.

When installing new bushings in the driven helix gear, press each bushing in .030" below the face of the gear and with the open end of the oil groove facing toward the center of the gear.

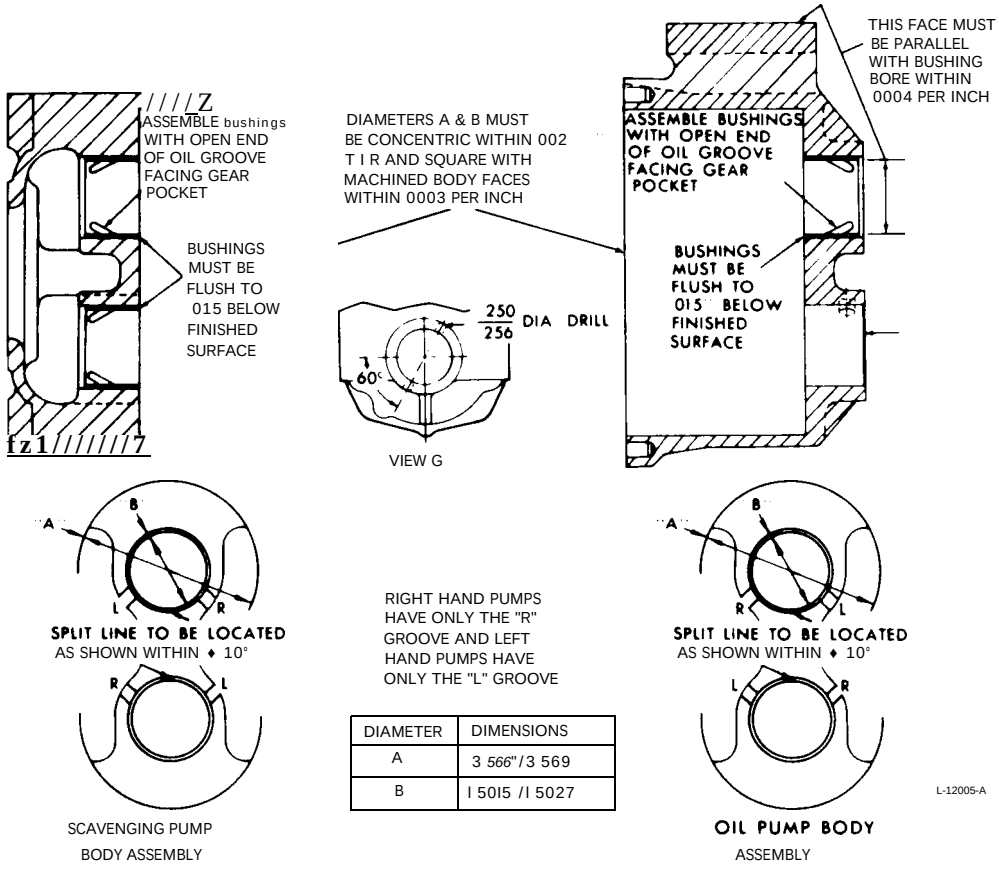
If the bushing in the oil pump body is worn excessively, replace the pump body unless suitable boring equipment is available for finishing the new bushing.

When installing new bushings, replace all of the bushings in both the pump body and the pump cover. The bushings must be located and positioned as shown in Fig. 6. Ream the bushings to 1.5015" to 1.5027.

Service (12V and 16V Engines)

Effective with engines 12E-762 and 16E-037 (approximate serial numbers), new oil pump assemblies replaced the old. The pump bodies in the new pumps have thicker walls and increased bearing bores (1.6865" to 1.6880") to accomodate bushings with a larger outside diameter (.100/. 104" thick wall) to give greater holding capability. The bearing bores in the former pump bodies were 1.6245" to 1.6260". The old pump assemblies and their components are not serviced. Worn components must be replaced by a current pump assembly.

The oil pump assemblies were further revised by adding bushings to both of the *driven* helix gears and pinning the drive gear end of the driven shaft so that the gears rotate



DIAMETER	DIMENSIONS
A	3 566"/3 569
B	I 5015 /I 5027

Fig. 7 - Location and Position of Oil Pump Bushings (1 2V and 1 6V Engines)

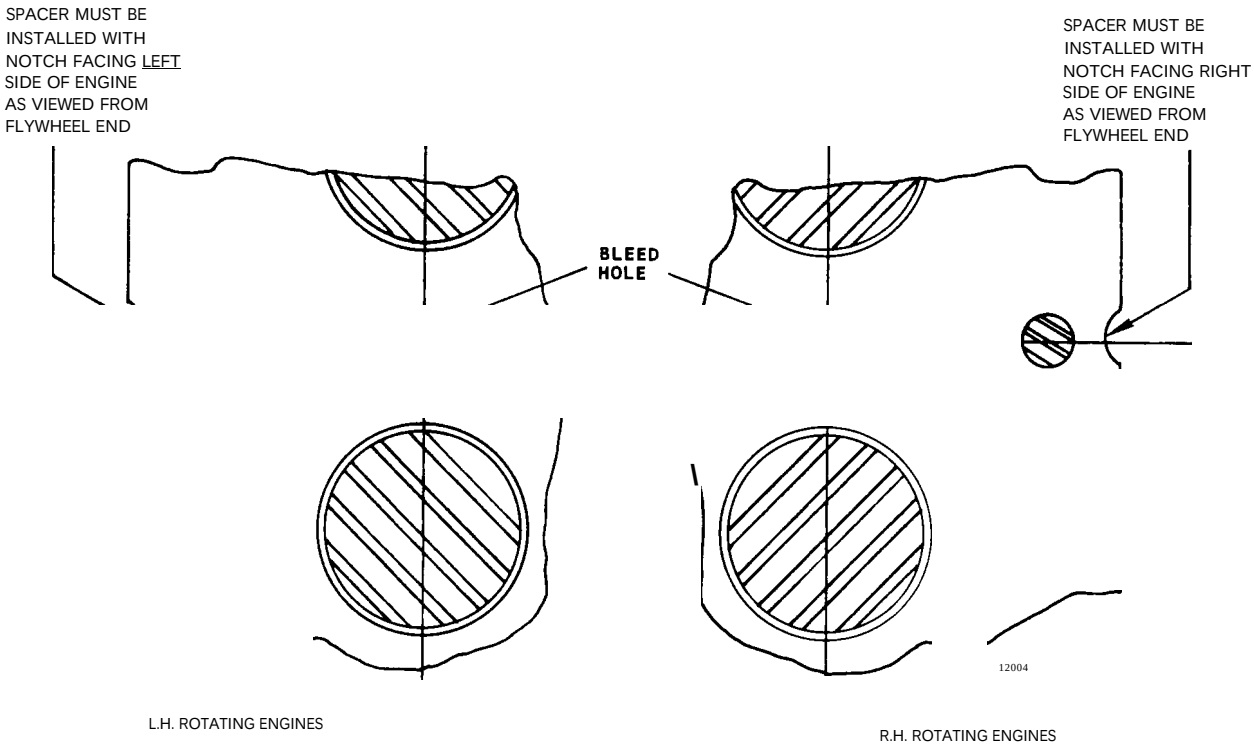


Fig. 8 - Orientation of Oil Pump Spacer Bleed Hole

on the shaft. The former pump assemblies (incorporating the larger bushings) can be reworked by drilling a hole in the pressure pump body (Fig. 7) to receive a 1/4" x 2 1/2" long slotted spring pin and replacing the driven shaft and driven gears with the current parts. Only the drilled shaft and the current gear and bushing assemblies are available for service.

The outside diameter of the current drive and driven gears is approximately .005" smaller.

Effective with engines 12E-5002 and 16E-4207 (approximate serial numbers), new oil pump assemblies featuring a new body, body spacer, drive shaft and a driven gear bushing replace the former pumps.

The new pump body differs from the former in that it provides oil grooves to improve bushing lubrication. These grooves are positioned to agree with pump rotation and the body is stamped "LH" or "RH" for identification.

Oil grooves have also been provided in a new body spacer (center plate) for improved lubrication to a new inner driven gear bushing. The new bushing has an oil groove across the entire width. In addition, the new spacer has a pump assembly rotation identification notch in the upper left-hand corner for a right-hand rotation pump as viewed from the scavenging end. The opposite notch location applies for a left-hand rotation pump assembly.

The new pump drive shaft is hardened at the center portion and at both ends to provide increased strength. Only the ends of the former shaft were hardened.

Only the new pump assemblies will be available for service.

Current oil pump assemblies have Loctite 75 retaining compound applied to the bushings in the driven helix gears and the pump pressure and scavenging bodies. When new bushings are installed, apply Loctite 75, or equivalent, as follows:

1. Clean the pump components with fuel oil and dry them with compressed air.

   CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

   Clean the new bushings and mating parts with a suitable de-greaser or chlorinated solvent.

   CAUTION: The chlorinated solvent must be used in a properly ventilated area with all safety precautions.

2. After the parts are completely dry, apply a continuous film of Loctite 75 retaining compound completely around the bushing bore (just inside the entry lip of the bore) in the pump body. It is not desirable to coat the entire width of the bore.

3. Press the bushing in place and remove the excess compound with a clean dry cloth. *Do not use solvent.*

© Detroit Diesel Corporation

Loctite 75 develops fixturing strength in approximately fifteen minutes; full cure takes approximately four hours.

To replace the bushings in the driven helix gears, press each new bushing in .030" below the face of the gear and with the open end of the oil groove facing toward the center of the gear. After installation, each bushing must withstand a load of 2,500 pounds without moving. Ream the bushings to 1.5025" to 1.5037" diameter.

If the bushings in the pump bodies are worn excessively, replace the pump bodies unless suitable boring equipment is available for finishing the new bushings.

When installing new bushings, replace all of the bushings in both the pressure pump body and the scavenging pump body. The bushings must be located and positioned as shown in Fig. 7. The gear bore and bushing bore in both pump bodies must be concentric within .002" total indicator reading. The bushing bores must be square with the machined faces of the pump bodies within .0003" per inch and parallel with the pump body mounting flange within .0004" per inch. The bushings must withstand a load of 2,500 pounds without moving. Ream the bushings to 1.5015" to 1.5027" diameter.

Assemble Oil Pump (8V Engines)

Refer to Fig. 3.

1. Lubricate the driven shaft with engine oil and insert the drilled end in the pump body. Align the drilled holes in the shaft and body and install a new pin to secure the shaft.
2. Install a key in the second keyway from the drive gear end of the drive shaft. Lubricate the shaft with engine oil. Then, align the slot in the drive gear with the key and press the gear on the shaft. Position the gear 2.22" from the drive gear end of the shaft.
3. Lubricate the end of the drive shaft with engine oil and slip the gear and shaft assembly through the bushing in the pump body. Install a key in the shaft.
4. Start the oil pump drive gear on the drive shaft with the ribbed side facing away from the pump and the slot in the gear aligned with the key. Then, press the gear on the shaft to give .020" maximum clearance when the internal gear is against the pump body and .006" minimum when the internal gear is against the pump cover.
5. Lubricate the driven shaft with engine oil and slide the driven gear on the driven shaft.
6. Attach the cover to the body with six 3/8"—16 x 1 1/2" bolts and lock washers. Tighten the bolts to 30-35 lb—ft (41—47 N*m) torque.

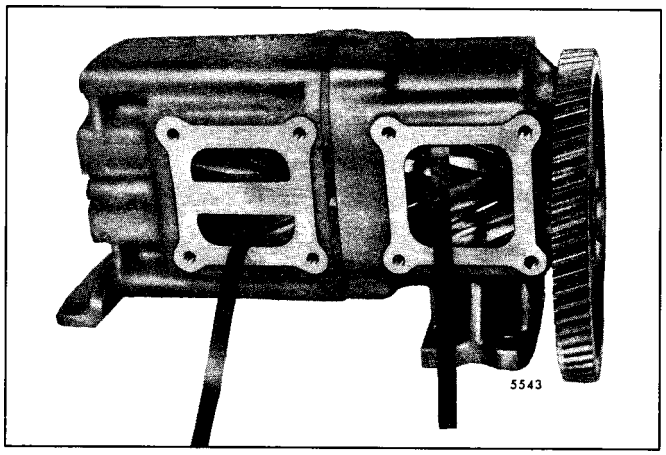


Fig. 9 - Checking Minimum Clearance Between Oil Pump Gear and Body

Assemble Oil Pump (12V and 16V Engines)

Refer to Fig. 5.

1. Lubricate the driven shaft with engine oil and insert the drilled end in the lower bushing in the pump body. The shaft should be a slip fit in the pump body. Align the drilled holes in the shaft and body and install a new pin to secure the shaft.
2. Install a key in the second keyway from the drive gear end of the drive shaft. Lubricate the shaft with engine oil. Then, align the slot in the pump body drive gear with the key and press the gear on the shaft. Position the gear 2.22" from the drive gear end of the shaft.
3. Lubricate the end of the shaft with engine oil and slip the gear and shaft assembly through the upper bushing in the pump body. Install a key in the shaft.
4. Start the external pump drive gear on the shaft with the ribbed side facing away from the pump and the slot in the gear aligned with the key. Then press the gear on the shaft to give .020" maximum clearance when the internal gear is against the pump body and .006" minimum when the internal gear is against the pump spacer. A left-hand helix external drive gear is used for a right-hand rotation engine and a right-hand helix external gear is used for a left-hand rotation engine.

   The clearance between the drive gear and the pump body on early pumps (with the small diameter bushings) was .006"-.012".
5. Slide the driven gear on the driven shaft. On former pumps, the driven gear was keyed to the shaft and positioned 1.28" from the drive gear end of the driven shaft.
6. Install the spacer. When installing the spacer between the pump bodies, be sure the bleed hole is located on the discharge side of the oil pump assembly (refer to Fig. 8).

© Detroit Diesel Corporation

7. Lubricate the drive shaft with engine oil and install two keys in the remaining keyways. Then, align the slot in the scavenging pump drive gear with the keys and press the gear on the shaft.

8. Lubricate the driven shaft with engine oil and slide the scavenging pump driven gear on the shaft.

9. Install the scavenging pump body over the gears and shafts. Then, install four 3/8"—16 x 7 1/2" bolts in the lower four bolt holes to secure the scavenging pump body to the oil pump body. Before final tightening of the bolts, center the two pump bodies to provide equal clearance at all places between each gear and its pump body. The minimum clearance at any point between a gear and its pump body should be .003" (Fig. 9). Then, tighten the bolts to 30-35 lb—ft (41-47 N*m) torque.

10. Attach the oil pump support to the scavenging pump body with two 3/8"-16 x 1 1/8" bolts and lock washers and two 3/8"—16 x 7 1/2" bolts. *Do not tighten the bolts at this time.* Turn the oil pump drive gear by hand to ensure that the shafts turn freely.

Install Oil Pump

Refer to Figs. 1 and 2

1. If removed, install the two hollow dowel pins in the oil pump mounting flange.

2. Position the pump over the mounting studs on the rear main bearing cap so that the oil pump drive gear meshes with the crankshaft gear. Install the same number and thickness of shims that were removed at time of disassembly. Then, install two 1/2"—13 x 1 1/2" bolts with lock washers and two stud nuts and lock washers to secure the pump in place. Tighten the bolts and nuts to 71-75 lb-ft (96-102 N«m) torque.

   On earlier 12V and 16V engines, four bolts were used to attach the pump to the rear main bearing cap. To facilitate installation when replacing an oil pump, install two l/2"-13 x 2.24" studs, in the positions opposite the pump locating dowel counterbores, in the bearing cap to replace two of the pump attaching bolts.

3. With the engine in the normal running position, check the clearance (backlash) between the oil pump drive gear and the crankshaft gear with a feeler gage or dial indicator. The clearance should be .006" to .012". Shims of .003" and .005" thickness are available for adjusting this clearance. Each .005" shim will change the clearance .0035".

8V Engines

Follow steps 4 thru 10 below when installing oil pump on 8V Engine.

4. Use a new gasket and attach the oil pump inlet elbow and screen assembly to the oil pump with two 3/8"—16 x 3 1/2" bolts and lock washers and two 3/8"—16 x 1 3/8" bolts and lock washers. Tighten the bolts to 30-35 lb-ft (41-47 N*m) torque.

5. Install the oil pump outlet adaptor (Fig. 3) to the oil pump and the cylinder block as follows:

   a. Use a new gasket and a new seal ring and position the adaptor against the oil pump and cylinder block.

   b. Attach the adaptor to the pump with four 3/8"-16 x 1 1/8" bolts and lock washers. *Do not tighten the bolts.*

   c. Attach the adaptor to the cylinder block pan rail with two 3/8"-16 x 1 1/8" bolts and lock washers. *Do not tighten the bolts.*

   d. To avoid breakage of the adaptor, tighten the attaching bolts in the following sequence.

      1) First snug down the two flange bolts at the block pan rail so that there is a slight metal-to-metal contact. This will keep the adaptor positioned against the block and also enable it to slide when attaching the other end to the oil pump.

      2) Snug down the four adaptor-to-pump bolts.

      3) Tighten the four adaptor-to-pump bolts to 30-35 lb-ft (41—47 N*m) torque, thus compressing the gasket the full amount.

      4) Tighten the two adaptor-to-block bolts to 30-35 lb-ft (41—47 N.m) torque.

6. If removed, install the pressure relief valve on the oil pump outlet adaptor (Section 4.1.1).

7. Use a new gasket and attach the cover to the oil pump adaptor with two 3/8"—16 x 1 1/8" bolts and lock washers. Tighten the bolts to 30-35 lb-ft (41-47 N«m) torque.

8. Use new gaskets and install the upper oil pan inspection hole covers.

9. Use a new gasket and attach the lower oil pan to the upper oil pan.

10. Fill the oil pan to the proper level with the oil recommended in the “Lubrication Specifications” in Section 13.3.

12V and 16V Engines

Follow steps 4 thru 15 below when installing oil pump on 12V and 16V engines.

4. After the gear clearance has been adjusted, install the two l/2"-13 x 1 1/2" bolts, lock washers and flat washers which attach the front oil pump support to the main bearing cap. Tighten these bolts to 71-75 lb-ft (96-102 N*m) torque *first* to prevent binding of the

 © Detroit Diesel Corporation

pump shafts. This will allow the support to shift and align itself within the support-to-pump bolt holes clearance limits. Then, tighten the four 3/8"—16 support-to-pump bolts (previously installed but not tightened) to 30-35 lb—ft (41-47 N«m) torque.

5. Use a new gasket and attach the scavenging pump outlet pipe to the scavenging pump body with four 3/8"—16 x 1" bolts and lock washers. Tighten the bolts to 30-35 lb—ft (41-47 N*m) torque.
6. Install the oil pump outlet adaptor (Fig. 4) to the oil pump and the cylinder block, as follows:
   a. Use a new gasket and a new seal ring and position the adaptor against the oil pump and cylinder block.
   b. Attach the adaptor to the pump with four 3/8"-16 x 1 1/8" bolts and lock washers. *Do not tighten the bolts.*
   c. Attach the adaptor to the cylinder block pan rail with two 3/8"—16 x 1 1/8" bolts and lock washers. *Do not tighten the bolts.*
   d. To avoid breakage of the adaptor, tighten the attaching bolts in the following sequence:
      1) First snug down the two flange bolts at the block pan rail so that there is a slight metal-to-metal contact. This will keep the adaptor positioned against the block and also enable it to slide when attaching the other end to the oil pump.
      2) Snug down the four adaptor-to-pump bolts.
      3) Tighten the four adaptor-to-pump bolts to 30-35 lb—ft (41-47 N*m) torque, thus compressing the gasket the full amount.
      4) Tighten the two adaptor-to-block bolts to 30-35 lb-ft (41-47 N*m) torque.
7. Use a new seal ring and a new gasket and install the oil pump outlet pipe. Attach the front end of the pipe to the cylinder block with two 3/8"-16 x 1 3/4" bolts and lock washers. Attach the other end to the oil pump adaptor with two 3/8”—16 x 1 1/8" bolts and lock washers. Tighten the bolts to 30-35 lb-ft (41-47 N*m) torque.
8. Secure the oil pump outlet pipe to the main bearing caps with two support brackets and two clips. Fasten the clips to the brackets with two 3/8"-24 x 1" bolts, four washers and two nuts. Attach the brackets to the main bearing caps with two l/2"-13 x 1" bolts and lock washers.
9. If removed, install the pressure relief valve on the oil pump outlet adaptor (Section 4.1.1).
10. Use a new gasket and attach the oil pump inlet elbow and screen assembly to the oil pump with two 3/8"-16 x 3 1/2" bolts and lock washers and two 3/8"-16 x 1 1/8" bolts and lock washers. Tighten the bolts to 30-35 lb-ft (41-47 N*m) torque.
11. Slide the flange and a new seal ring over the scavenging pump inlet pipe and screen assembly. Then, place the pump inlet adaptor on the end of the pipe and, using a new adaptor-to-pump gasket, attach the inlet pipe assembly to the scavenging pump body with four 3/8"—16 x 1 5/8" bolts and lock washers. Tighten the bolts to 30-35 lb-ft (41-47 N*m) torque.
12. Position the four supports (in pairs) on the scavenging pump inlet pipe. Fasten each pair together with a 3/8"-24 x 1 1/8" bolt, lock washer and nut. Fasten the supports to the main bearing caps with four l/2"-13 x 1" bolts and lock washers.
13. Use new gaskets and install the upper oil pan inspection hole covers.
14. Use a new gasket and attach the lower oil pan to the upper oil pan.
15. Fill the oil pan to the proper level with the oil recommended in Section 13.3.

LUBRICATING OIL PRESSURE REGULATOR AND RELIEF VALVES

REGULATOR VALVE

Stabilized lubricating oil pressure is maintained within the engine at all speeds, regardless of oil temperature, by means of pressure regulator valve(s) (Fig. 1). The 8V engines are equipped with one valve. On the 12V and 16V engines, two valves are located at the end of vertical oil galleries near the center of the cylinder block.

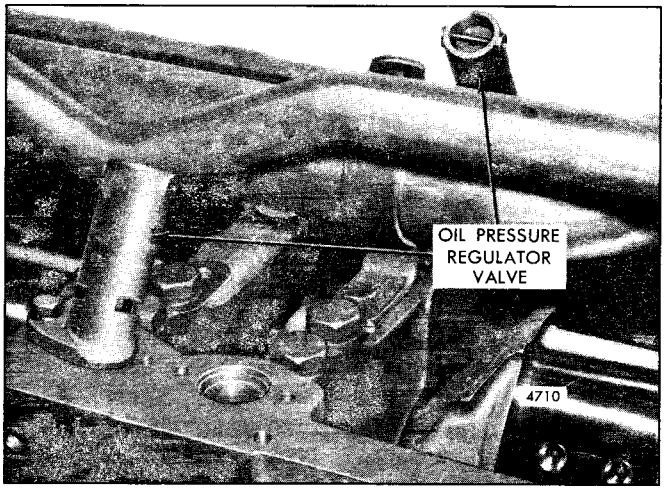


Fig. 1 - Oil Pressure Regulator Valve Mounting

The oil pressure regulator consists of a valve body, a hollow piston-type valve, a spring, a spring seat and a pin to retain the valve assembly within the valve body (Fig. 2).

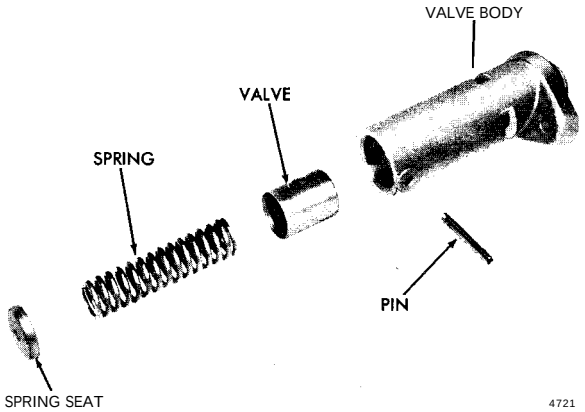


Fig. 2 - Oil Pressure Regulator Valve Details and Relative Location of Parts

The valve is held on its seat by the spring, which is compressed by the pin in back of the spring seat. The entire assembly is bolted to the lower flange of the cylinder block and sealed against leaks by a seal ring between the block and the valve housing. When conditions are such that the oil pressure at the valve exceeds the valve setting, the valve is forced from its seat and oil from the engine gallery is bypassed to the engine oil pan. Thus, stabilized lubricating oil pressure is maintained at all times.

Under normal conditions, the oil pressure regulator should require very little attention. If sludge has been allowed to accumulate in the lubricating system, the valve may not work freely, thereby remaining open or failing to open at the normal operating pressure.

Whenever the lubricating oil pump is removed for inspection, remove the regulator valve and spring and thoroughly clean and inspect them.

Remove Regulator Valves

Remove each pressure regulator assembly from the cylinder block, as follows:

1. Remove the regulator-to-cyUnder block attaching bolt and lock washer.
2. Tap the regulator body lightly to loosen it from the cylinder block. Remove the regulator and discard the seal ring.

The former regulator valve should be replaced with the current regulator valve at time of engine overhaul.

Disassemble Regulator Valve

Disassemble the regulator valve, as follows:

1. Clamp the regulator assembly in a bench vise equipped with soft jaws and remove the spring seat retaining pin from the regulator body.

   • CAUTION: Always depress spring seat and hold securely while removing pin. Release spring tension slowly when pin is removed. Failure to observe this precaution could allow the spring seat and spring to leave the valve body with force during pin removal, possibly causing personal injury.

2. Remove the spring seat, spring and valve from the regulator body.

Inspection

Clean all of the regulator components in fuel oil and dry them with compressed air.

© Detroit Diesel Corporation

CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

The regulator valve must move freely in the valve body. If the valve or the valve body is scored and cannot be cleaned up with crocus cloth, replace them. Replace a pitted or fractured spring.

Effective with engine 12E-784, the relief slots have been relocated, 90° from their *original* position, to direct the oil away from the ventilation passages at the joint surface of the cylinder block.

• Effective with unit serial numbers 8E02537, 12E08778, and 16E08567, a new 70 psi (483 kPa) lube oil pressure regulator valve replaced the former 50 psi (345 kPa) valve in the following engines:

— All 8V, 16V tube and shell-equipped engines

— Model 9123-7301 when used in hydrofrac applications

— Models 9123-7311, 9163-7311, 9163-7316

Concurrent with this change, the former 50 psi (345 kPa) valve was also replaced by a new 50 psi valve on all other Series 149 engines.

Both new valve assemblies consist of identical components, including a valve body with two sets of valve spring seat retaining pin holes (Fig. 3). The 70 psi (483 kPa) valve has the pin installed in the holes identified by a cast, raised number “70.” On the 50 psi (345 kPa) valve, the pin is installed in the holes identified by a cast, raised number “50.” The former 50 psi valve assembly (Fig. 2) had one set of valve spring seat retaining pin holes.

Because of the improved lubrication provided to tube and shell oil cooler-equipped engines by the higher pressure valve, DDC recommends replacing the former 50 psi (345 kPa) valve with the 70 psi (483 kPa) valve at time of major engine repair or normal engine overhaul.

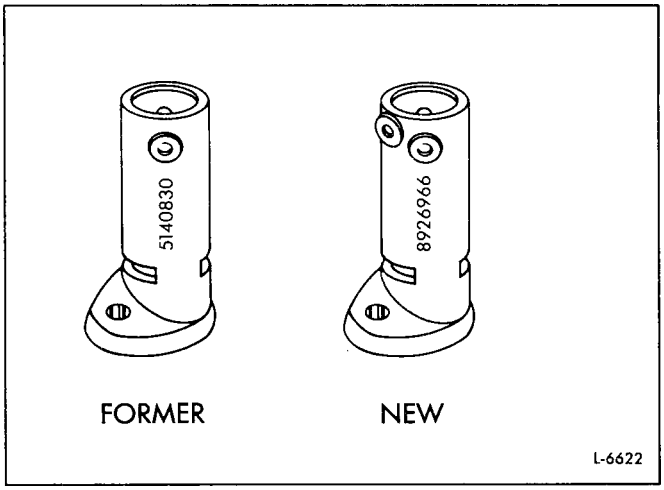


Fig. 3 - Former and New Lube Oil Pressure Regulator Valve Bodies

Assemble Regulator Valve

After the parts have been cleaned and inspected, refer to Figs. 1 and 2 and assemble the regulator, as follows:

1. Apply clean engine oil to the outer face of the valve and slide it into the regulator body, closed end first.
2. Insert the spring in the valve and install the spring seat. While compressing the spring, install the retaining pin behind the spring seat. Press the pin flush to .010" below the surface of the valve body.

Install Regulator Valves

Install each regulator assembly to the cylinder block, as follows:

1. Clean the regulator counterbores in the cylinder block.
2. Install a new seal ring and secure the regulator assembly to the cylinder block with one bolt and lock washer. Tighten the bolt.

RELIEF VALVE

Oil leaving the pump under pressure passes by a pressure relief valve (Fig. 4). The former spring-loaded valve opens when the pressure exceeds approximately 100 psi (689 kPa) or 130+10 psi (896+69 kPa) for current engines and directs the excess oil to the oil pan. The pressure relief valve is located on the oil pump outlet adaptor attached to the oil pump body.

The pressure relief valve consists of a valve body, a hollow piston-type valve, a spring, spring seat and a pin to retain the valve assembly within the valve body (Fig. 5).

The current high output pressure relief valve consists of a valve body, hollow piston-type valve, innerspring, two innerspring seats, outer spring, spring seat and a pin to retain the valve assembly within the valve body (Fig. 6).

Remove Relief Valve

1. Remove the two relief valve-to-adaptor attaching bolts and lock washers.
2. Tap the relief valve body lightly to loosen it from the gasket and the oil pump outlet adaptor. Remove the relief valve and gasket.

The former valve should be replaced with the current valve at time of engine overhaul.

 © Detroit Diesel Corporation

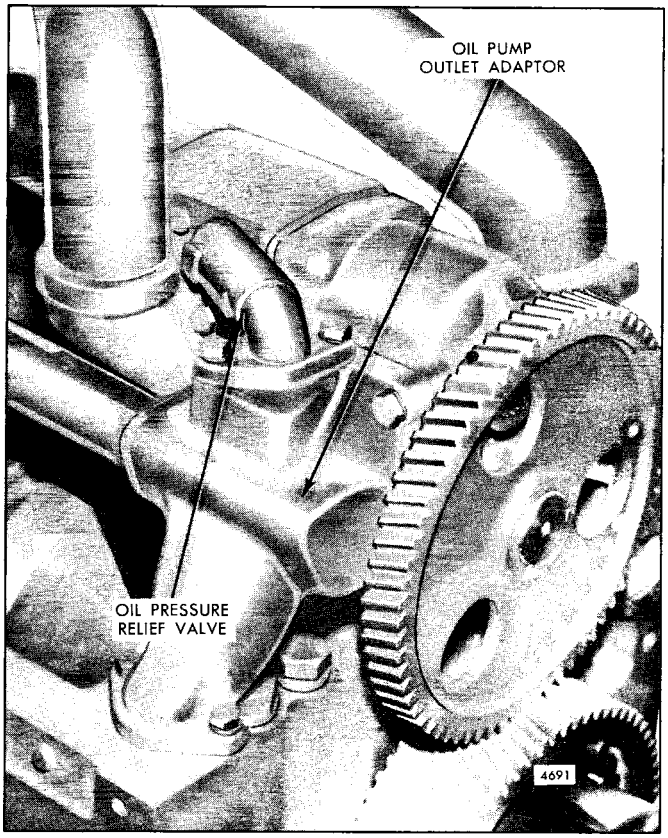


Fig. 4 - Oil Pressure Relief Valve Mounting

Disassemble Relief Valve

1. Clamp the oil pressure relief valve in a bench vise equipped with soft jaws and remove the spring seat retaining pin from the valve body.

   • CAUTIOI\I:Always depress spring seat and hold securely while removing pin. Release spring tension slowly when pin is removed. Failure to observe this precaution could allow the spring seat and spring to leave the valve body with force during pin removal, possibly causing personal injury.

2. Remove the spring seats, springs and valve from the valve body.

Inspection

1. Remove all traces of old gasket material from the oil pressure relief valve and oil pump outlet adaptor.

Clean all of the pressure relief valve components in fuel oil and dry them with compressed air.

CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

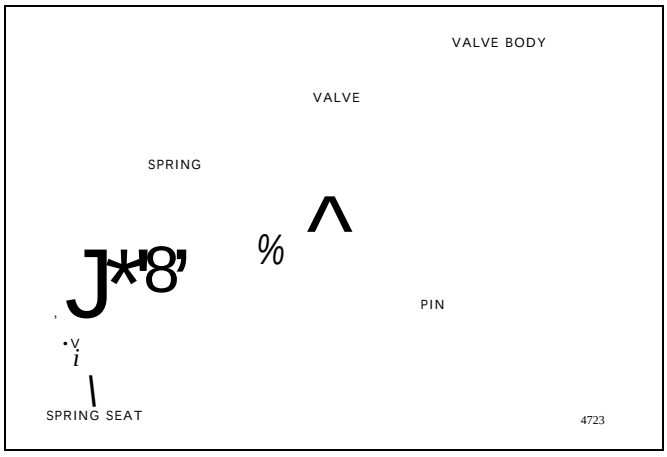


Fig. 5 - Former Oil Pressure Relief Valve Details and Relative Location of Parts

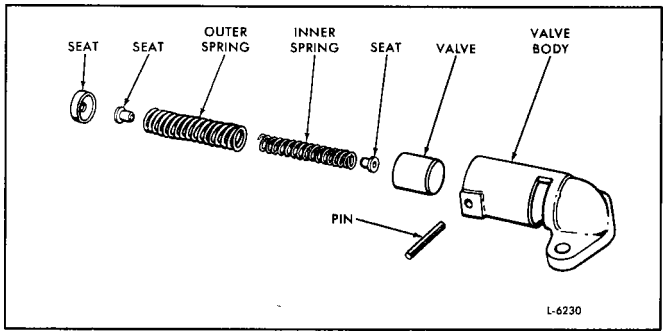


Fig. 6 - Current Oil Pressure Relief Valve Details and Relative Location of Parts

Check the relief valve to see that it moves freely in the valve body. If the valve is scored and cannot be cleaned up with crocus cloth, replace the valve. Replace a pitted or fractured spring.

Assemble Relief Valve

• 8V Engines

Refer to Fig. 5 or 6 and assemble the oil pressure relief valve as follows:

1. Apply clean engine oil to the outer face of the valve and slide it into the relief valve body (closed end first).
2. Insert the spring in the valve and install the spring seat. If the current high output valve assembly is used, insert the inner spring inside the outer spring with an inner spring seat on each end of the inner spring. Insert one end of this assembly into the valve and install the spring seat (Fig. 6).
3. While compressing the spring, install the retaining pin behind the spring seat. Press the pin flush to .010" below the surface of the valve body.

© Detroit Diesel Corporation

• 12V and 16V Engines

Refer to Figs. 5 or 6 and assemble the oil pressure relief valve as follows:

1. Apply clean engine oil to the outer face of the valve and slide it into the relief valve body (closed end first).
2. Insert the spring in the valve and install the spring seat. If the current high output valve assembly is used, insert the innerspring inside the outer spring with an innerspring seat on each end of the innerspring. Insert one end of this assembly into the valve and install the spring seat (Fig. 6).
3. While compressing the spring, install the retaining pin behind the spring seat. Press the pin flush to .010" below the surface of the valve body.

Install Relief Valve >

1. Place a new gasket on the oil pressure relief valve body.
2. Secure a relief valve assembly with a cast iron body to the oil pump outlet adaptor with two bolts and lockwashers. When installing a relief valve assembly with an aluminum body, use two 3/8" plain washers and two 3/8"-16 x 7/8" bolts.

 © Detroit Diesel Corporation

LUBRICATING OIL FILTERS

Each engine is equipped with full flow type lubricating oil filters which are attached to the base of the cylinder block or are remotely mounted (Fig. 1). The 12V and 16V engines use four filters (two at the front and two at the rear of the cylinder block). An oil filter adaptor provides a support and a cover for each pair of oil filters.

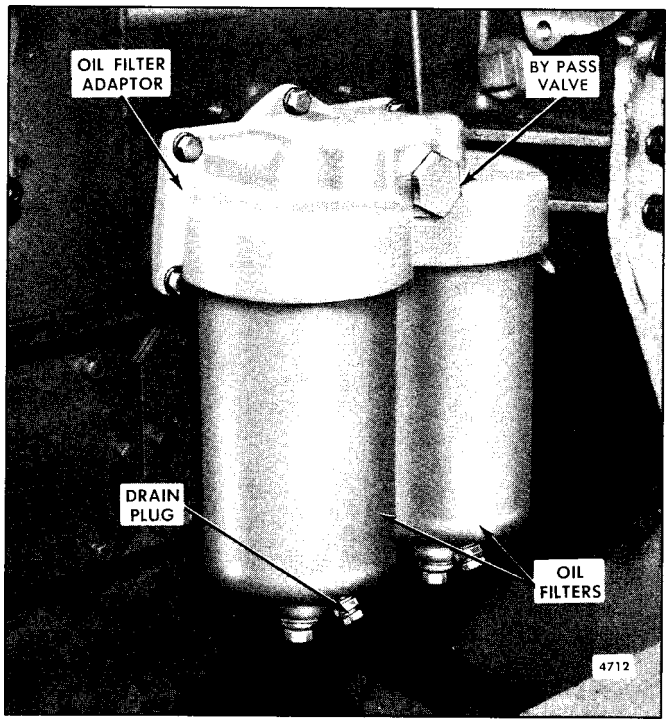


Fig. 1 - Oil Filter Mounting (Canister)

• Multi-pack oil filter adaptors with spin-on filters are used on engines with tube and shell oil coolers. The adaptor on 8V engines requires three (3) filters, the adaptor on 12V engines requires four (4) filters, and the adaptor on 16V engines (Fig. 2) requires six (6) filters.

All of the oil supplied to the engine by the oil pump passes through the filter before reaching the various moving parts of the engine. The oil is forced by pump pressure through a passage in the filter adaptor to the space surrounding the filter element. Impurities are filtered out as the oil is forced through the element to a central passage surrounding the center stud and out through another passage in the filter adaptor to the oil cooler.

A valve, which opens at approximately 23-28 psi (159-193 kPa), is located in each oil filter adaptor and will bypass the oil directly to the oil cooler should the filter become clogged.

• Depending on the engine, multi-pack oil filter adaptors used with tube and shell oil coolers have two (8V), three (12V), or four (16V) filter bypass valves.

If the engine is equipped with a remote mounted bypass type oil filter, a *.156" diameter orifice must be installed on the discharge side of the filter.* This will regulate the oil flow through the filter and aid in maintaining the proper oil pressure. If a multiple bypass oil filter arrangement is used, *all of the oil discharging from the filters must pass through a single .156' orifice.*

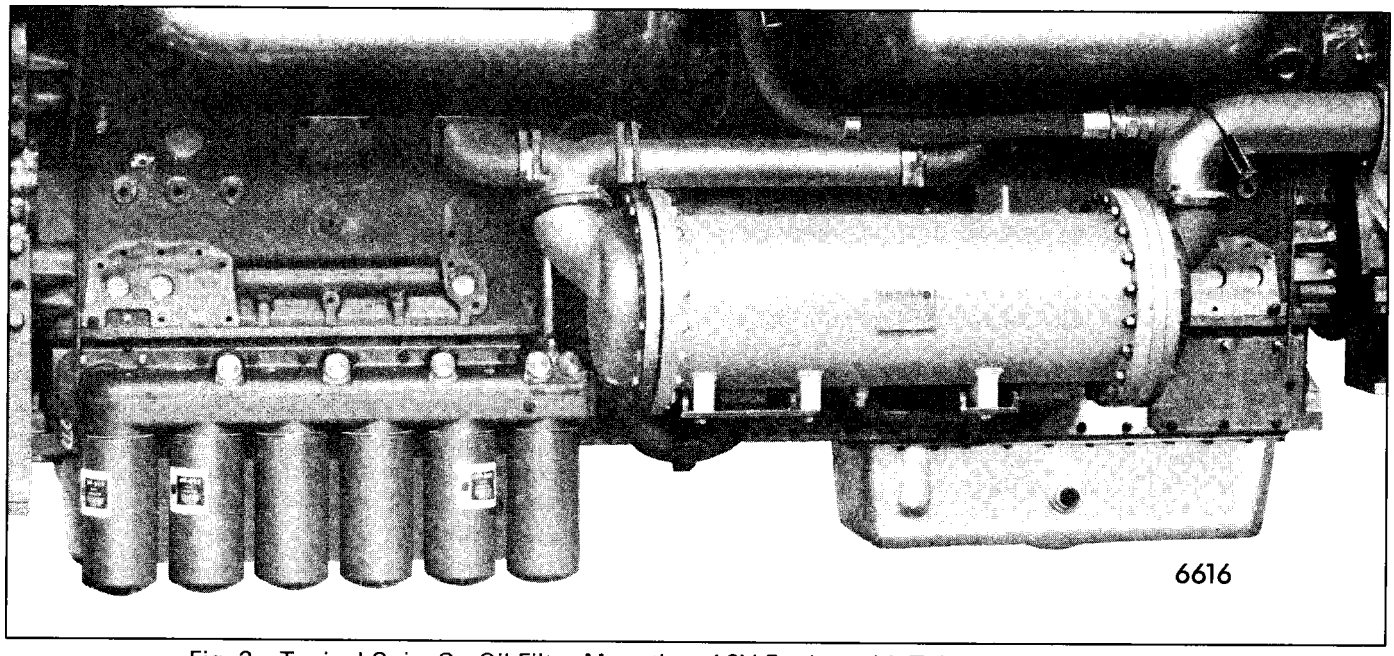


Fig. 2 – Typical Spin–On Oil Filter Mounting–16V Engine with Tube and Shell Oil Cooler

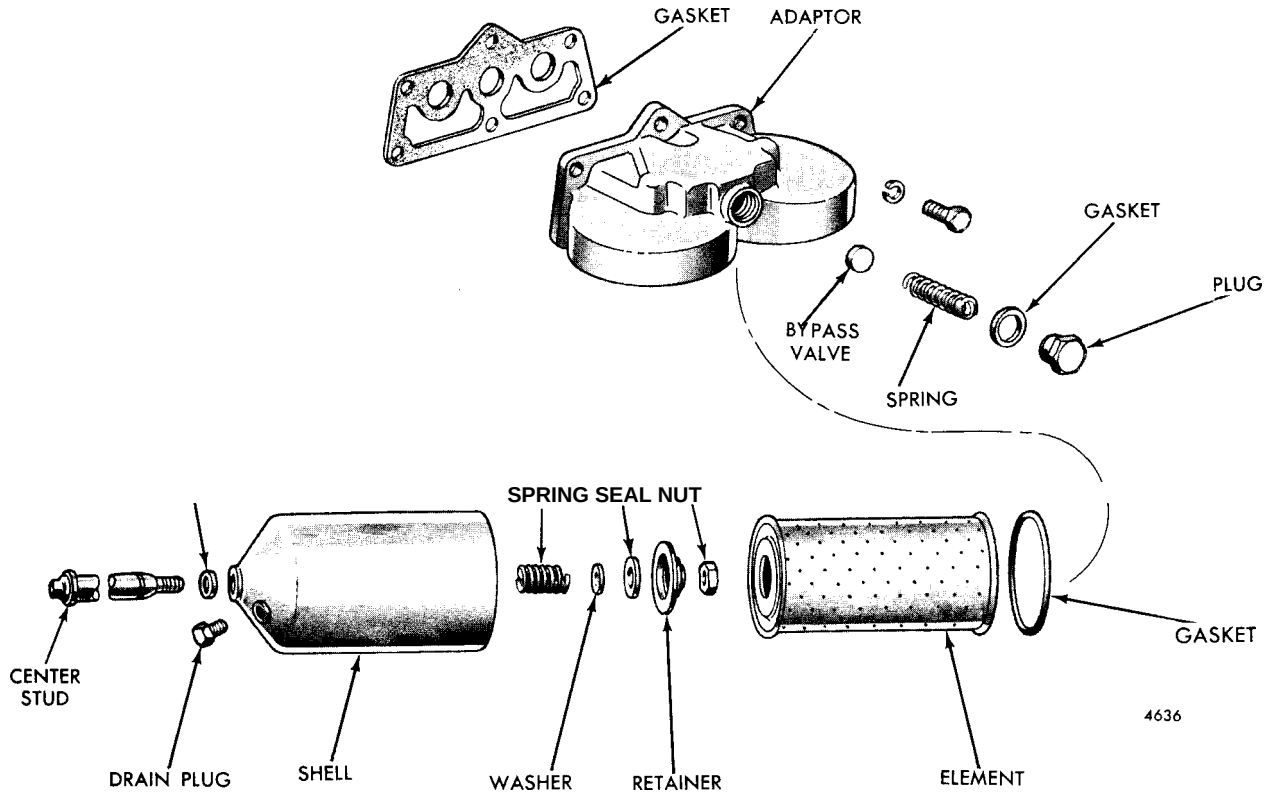


Fig. 3 - Oil Filter Details and Relative Location of Parts (Canister)

The former canister-type filter assembly consists of a replaceable element enclosed within a shell which is mounted in an adaptor or base (Fig. 3). When the filter shell is in place, the element is restrained from movement by a coil spring. The current spin-on filter consists of a shell, element and gasket combined into a unitized assembly (Fig. 4).

A new spin-on oil filter adaptor assembly now used on 12V and 16V-149 engines replaces the canister-type adaptor assembly formerly used on 16V engines. This new adaptor assembly also replaces the spin-on adaptor assembly formerly used on 12V engines. The new spin-on filter adaptor assembly can be distinguished from the former by the different contours on the top of the adaptor body (Fig. 5). •

• An optional AC service filter is available which has a synthetic (fiberglass), rather than an organic (cellulose) filtering medium. The filter is available in spin-on or canister style and is otherwise identical to the current production filter. The new filter traps particles as small as 12 microns (at 98% efficiency per AC test procedures), compared to 45 microns for the production filter. Because of its increased filtering capability, DDC recommends using it on new, rebuilt, or newly overhauled engines being placed in service.

NOTICE: The new service filter will improve oil filtration on a properly maintained and operated engine. It will not prevent wear or malfunctions caused by poor maintenance or improper engine operation.

Oil Filter Maintenance

With the use of detergent lubricating oils, the color of the lubricant has lost value as an indicator of oil cleanliness or proper filter action. Due to the ability of the detergent compounds to hold minute carbon particles in suspension, heavy duty oils will always appear dark-colored on the oil level dipstick.

Heavy sludge deposits found on the oil filter elements at the time of an oil change must be taken as an indication that the detergency of the oil has been exhausted. When this occurs, the oil drain interval should be shortened. The removal of abrasive dust, metal particles and carbon must be ensured by replacement of the oil filter elements at the time the engine oil is changed.

Selection of a reliable oil supplier, strict observation of his oil change period recommendations and proper filter maintenance will ensure trouble-free lubrication and longer engine life.

 © Detroit Diesel Corporation

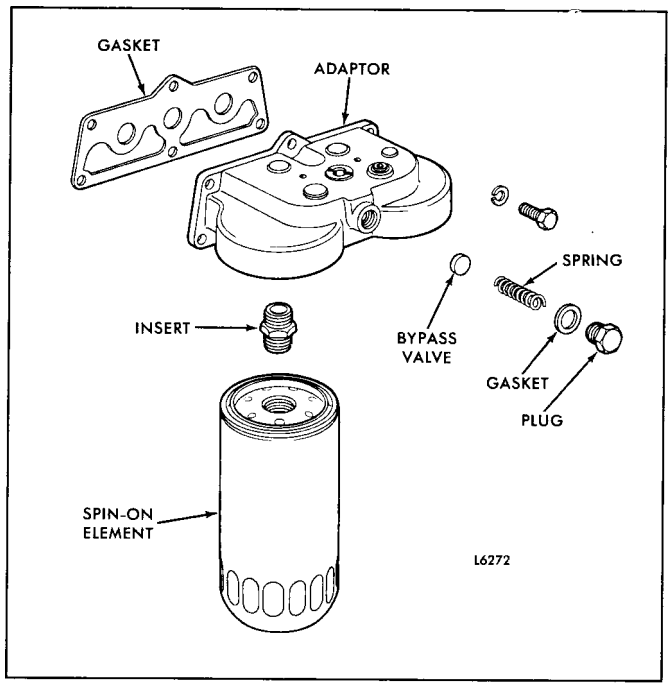


Fig. 4 – Spin–On Oil Filter Details and Relative Location of Parts

Replace Oil Filter Element (Canister Type)

Replace the oil filter element (Fig. 3) as follows:

1. Remove the drain plug from the filter shell and drain the oil.
2. Back out the center stud and withdraw the shell, element and stud as an assembly. Discard the element and the shell gasket.
3. Remove the center stud and gasket. Retain the gasket unless it is damaged and oil leaks occurred.
4. Remove the nut on the center stud.
5. Remove and discard the element retainer seal (Fig. 3). Install a new seal.
6. Clean the filter shell and the adaptor.
7. Assemble the spring, washer, seal and retainer on the stud. Use a new gasket and slide the stud through the filter shell.
8. Install a new shell gasket in the filter adaptor.

   NOTICE: Before installing the filter shell gasket, be sure all of the old gasket material is removed from the filter shell and the adaptor. Also make sure the gasket surfaces of the shell and the adaptor have no nicks, burrs or other damage.

9. Position the new filter element carefully over the center stud and within the shell. Then place the shell, element and stud assembly in position on the filter adaptor and tighten the stud to 50-60 lb—ft (68-81 N-m) torque.
10. Install the drain plug.
11. Start and run the engine for a short period and check for oil leaks. After any oil leaks have been corrected, and the engine has been stopped long enough (approximately twenty minutes) for the oil from various parts of the engine to drain back to the crankcase, add sufficient oil to bring it to the proper level on the dipstick.

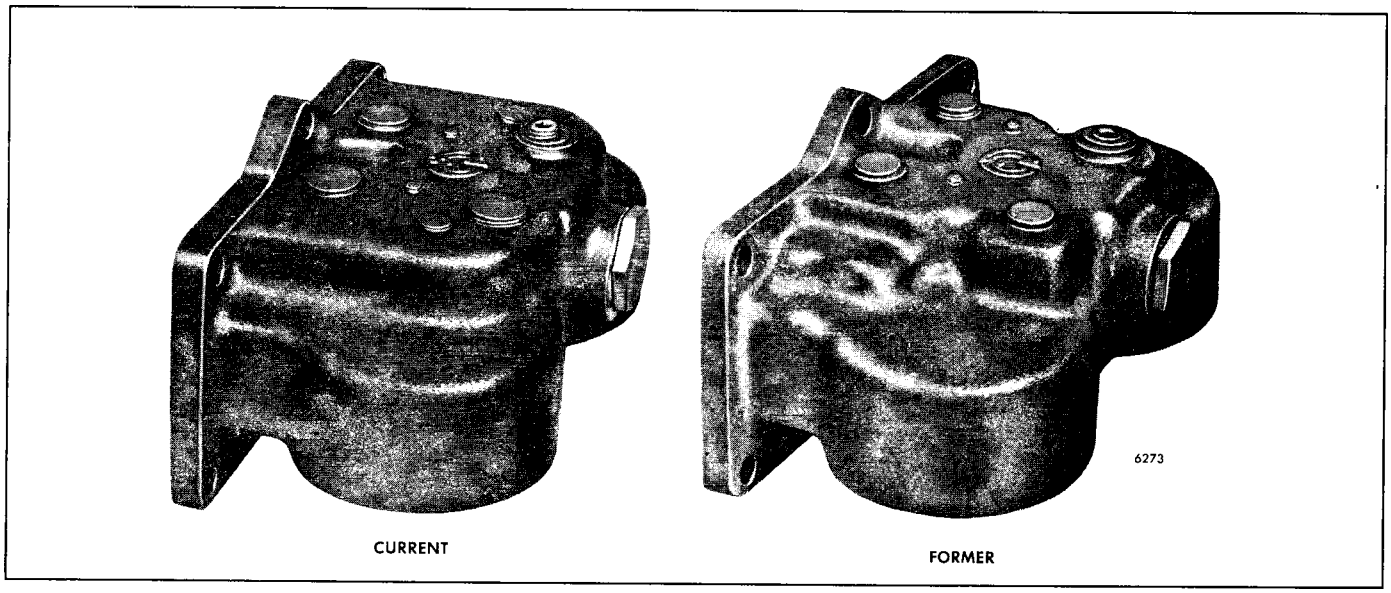


Fig. 5 - Spin-On Lube Oil Filter Adaptor Assembly

Replace Spin-On Filter

1. Remove the spin-on oil filter (Fig. 4) using strap wrench tool J 29917 which must be used with a 1/2" drive socket wrench and extension.
2. Discard the used oil filter.
3. Clean the filter adaptor with a clean, lint-free cloth.

   •**NOTICE:** Do not clean multi-pack lube oil filter adaptors by "hot tanking." Multi-pack oil filter adaptors used with tube and shell oil coolers are impregnated with a special compound to seal any porosity in the cast iron. *This compound can be removed by hot tanking.* Clean adaptors by immersing in pure mineral spirits or clean fuel oil.
4. Lightly coat the oil filter gasket (seal) with clean engine oil.
5. Start the new filter on the adaptor and *tighten by hand* until the gasket touches the mounting adaptor head. Tighten an additional two-thirds turn.

   NOTICE: Mechanical tightening will distort or crack the filter adaptor.
6. Start and run the engine for a short period and check for oil leaks. After any oil leaks have been corrected and the engine has been stopped long enough for oil from the various parts of the engine to drain back to the crankcase (approximately 20 minutes), add sufficient oil to raise the oil level to the proper mark on the dipstick.

Remove And Install Bypass Valve

1. Remove the plug and gasket and withdraw the spring and bypass valve (Figs. 3 and 4).
2. Wash all of the parts in clean fuel oil and dry them with compressed air.

   CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.
3. Inspect the parts for wear. If necessary, install new parts.
4. Reassemble and install the bypass valve. Tighten the l-l/4"-16 bypass valve plug to 95-105 lb—ft (129-143 N‘m) or the 1—1/2"—6 plug to 110-130 lb—ft (150-177 N • m) torque.

 © Detroit Diesel Corporation

LUBRICATING OIL COOLER

To perform its functions satisfactorily, the lubricating oil must be kept within the proper temperature limits. If the oil is too cold, it will not flow freely. If the oil is too hot, it cannot support the bearing loads, it cannot carry away enough heat and it may result in too great an oil flow. As a consequence oil pressure may drop below acceptable limits and oil consumption may become excessive.

In performing its lubricating and cooling functions, the oil absorbs a considerable amount of heat and this heat must be dissipated by an oil cooler(s).

PLATE TYPE OIL COOLER

• Two oil coolers are used on the 12V and 16V engines and are centrally located on the right side of the cylinder block (Fig. 1). A new, increased-capacity, 30 plate lube oil cooler core has been released for 12V and 16V engines. The new oil cooler core is completely interchangeable with the 26-plate oil cooler core formerly used, and only the new 30-plate core should be installed on 12V and 16V engines. Current high strength, 30-plate cores are made of stainless steel and have regularly spaced, rounded rises (bumps) on their plate surfaces.

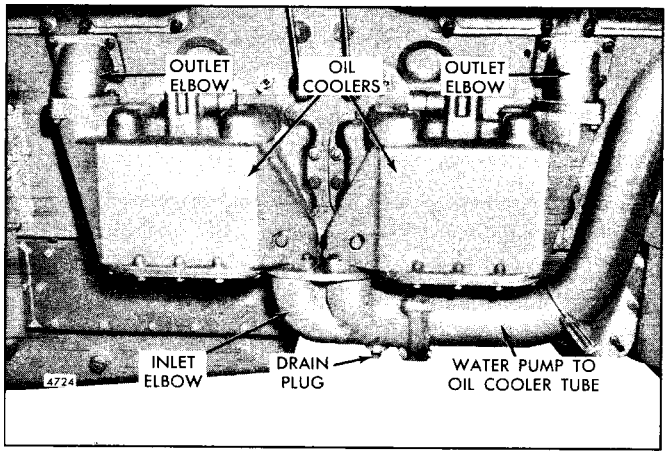


Fig. 1 - Oil Cooler Mounting

To cool the lubricating oil used in a Torqmatic converter or a marine gear, a separate oil cooler core is mounted on the opposite side of the engine (Fig. 2).

Oil from the lubricating oil pump flows through a passage in the oil filter adaptor to the oil filter, then through the oil cooler and finally through the outlet passage in the cooler adaptor which leads to the cylinder block oil galleries. The engine coolant is pumped through the oil cooler and completely surrounds the oil cooler core.

To ensure continuing engine lubrication should the oil cooler become plugged, a bypass valve is installed in the oil cooler adaptor (Fig. 3).

Remove Oil Cooler Assembly

1. Remove the oil drain plug from the oil pan and drain the lubricating oil system.

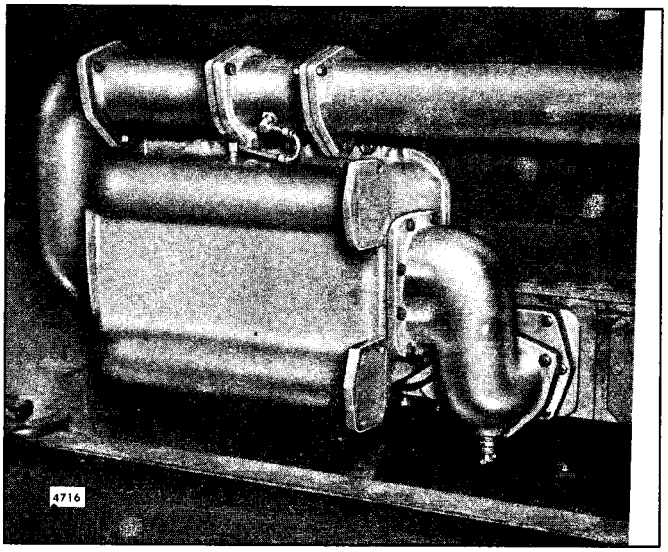


Fig. 2 - Torqmatic Converter Oil Cooler

2. Drain the cooling system by removing the drain plug located at the bottom of the oil cooler. On units where the oil cooler water inlet elbow is located at the bottom of the oil coolers, remove the drain plug from the elbow (Fig. 3).
3. Remove the three bolts and lock washers securing the oil cooler inlet elbow to the water pump-to-oil cooler tube.
4. Remove the six bolts and lock washers securing the oil cooler inlet elbow to the oil coolers and remove the inlet elbow, seal ring and gaskets.
5. Remove the three bolts and lock washers securing the oil cooler outlet elbow to the cylinder block and remove the outlet elbow and gaskets. On units equipped with a Torqmatic converter, remove the outlet elbow located at the bottom of the oil coolers (Fig. 2).
6. Remove the six bolts and lock washers securing the oil cooler to the cylinder block. Then, suitably support the oil cooler and remove the two remaining nuts and lock washers securing the oil cooler and remove the oil cooler and gasket from the cylinder block.
7. Clean all traces of gasket material from the cylinder block and the oil cooler components.

© Detroit Diesel Corporation

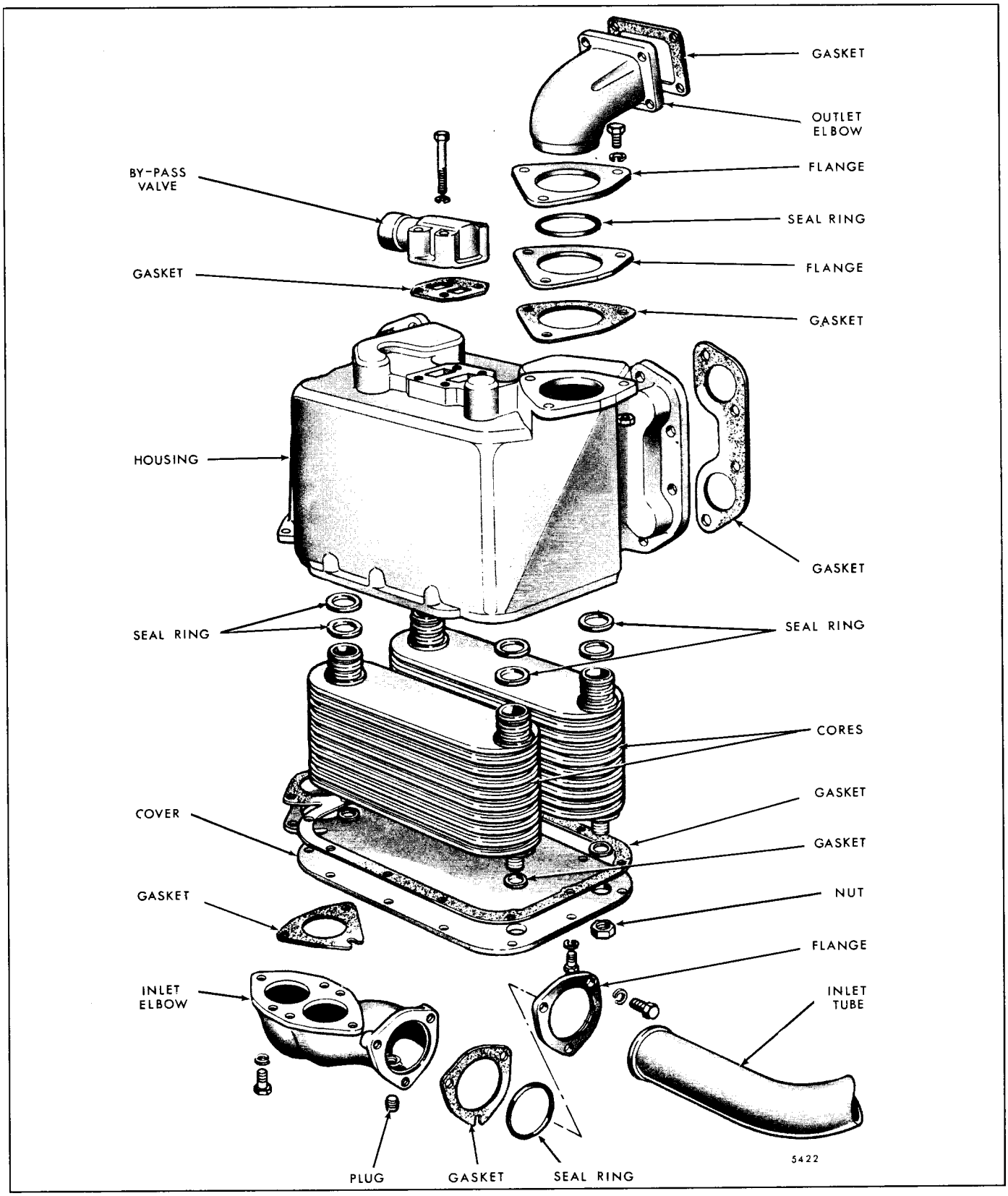


Fig. 3 - Lubricating Oil Cooler and Relative Location of Parts

 © Detroit Diesel Corporation

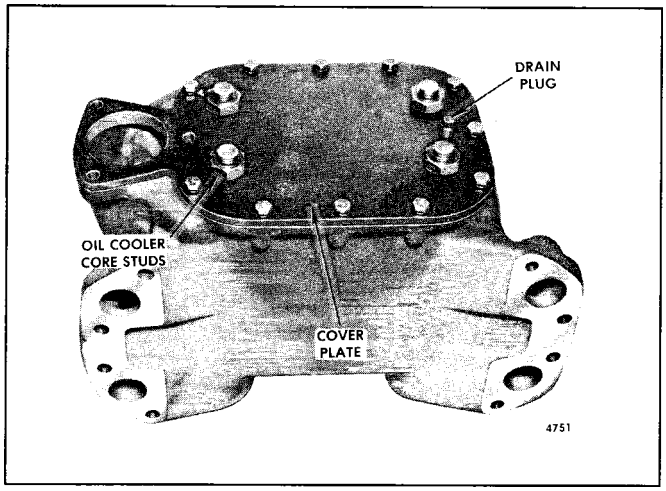


Fig. 4 - Oil Cooler Cover Plate Mounting

Disassemble Oil Cooler

1. Refer to Fig. 4 and remove the four nuts securing the oil cooler cores to the oil cooler base plate.
2. Refer to Fig. 3 and remove the eleven bolts and lock washers securing the cover plate to the oil cooler housing and remove the cover plate and gasket.
3. Slide the two oil cooler cores out from the oil cooler housing and remove the oil seal rings from the cores.
4. Remove the four bolts and lock washers securing the oil cooler bypass valve to the top of the oil cooler and remove the bypass valve and gasket. Refer to *Lubricating Oil Cooler Bypass Valve* in this section for maintenance on the bypass valve.

Clean Oil Cooler Core

1. Clean the oil passages in the oil cooler core by circulating a solution of 1,1,1 -tricholorethane through the passages with a force pump.

CAUTION: To avoid personal injury, perform this operation in the open or in a well ventilated area. Avoid breathing the fumes or direct contact of the chemicals with your skin. Use recommended safety equipment, as required.

Clean the oil cooler core before the sludge hardens. If the oil passages are badly clogged, circulate a cleaning solution through the oil cooler core and flush it thoroughly with clean, hot water.

NOTICE: Do not attempt to clean an oil cooler core when an engine failure occurs in which metal particles from worn or broken parts are released into the lubricating oil. In this instance, replace the oil cooler core.

2. After cleaning the oil passages, clean the water side of the oil cooler core by immersing it in a solution made as follows: add 1/2 pound of oxalic acid to each 2-1/2 gallons of a solution composed of 1/3 muriatic acid and 2/3 water. The cleaning action is evident by the bubbling and foaming. Carefully observe the process and remove the oil cooler cover from the solution when the bubbling stops (this usually takes from 30 to 60 seconds). Then, thoroughly flush the oil cooler core with clean, hot water. After cleaning, dip the oil cooler core in light oil.

CAUTION: Protect your eyes and avoid breathing the fumes or direct contact of the acid with your skin.

Pressure Check Oil Cooler Core

1. Make a suitable adaptor to which an air hose can be attached and fasten it to the inlet pipe of the cooler core. Use a suitable piece of hose, a plug and clamp to seal the outlet pipe.
2. Attach an air hose and apply approximately 75-150 psi (517-1034 kPa) air pressure. Then, submerge the cooler core in a tank of water. Any leaks will be indicated by air bubbles in the water.

CAUTION: When making this pressure test, be sure that personnel are adequately protected against any stream of pressurized water from a leak or rupture of a fitting, hose or the oil cooler core.

3. After the pressure test is completed, remove the air hose, clamp, plug, hose and adaptor and dry the cooler core with compressed air. Replace the cooler core if leaks were indicated.

NOTICE: In cases where a leaking oil cooler core has caused contamination of the engine, the engine must be flushed immediately to prevent serious damage (refer to Section 5).

Inspection

Check the bores in the oil cooler housing for corrosion, pitting and wear. The bores must be clean and smooth to prevent leaks and damage to the oil seals. Repair worn seal bores as outlined in Section 4.0.

Assemble Oil Cooler

1. Refer to Fig. 3 and install the oil cooler bypass valve and a new gasket on the oil cooler using four 5/16"-l 8 bolts and lock washers. Tighten the bolts to 13-17 lb—ft (18-23 N*m) torque.
2. Place new oil seal rings on the oil cooler core inlet and outlet tubes.
3. Insert the oil cooler cores into the oil cooler housing, making sure not to dislodge the oil seal rings on the inlet and outlet tubes. The inlet and outlet openings in

the oil cooler core are marked IN and OUT. Make sure the oil cooler core is reinstalled in its *original* position, otherwise the oil flow will be reversed and could result in foreign particles that may not have been removed to be loosened and circulated through the engine. If the openings are unidentified, it is suggested that they be marked before installing the oil cooler core.

4. Position the oil cooler cover plate, with a new gasket, against the bottom of the oil cooler housing with the oil cooler core studs aligned through the four holes in the cover plate. Insert one 3/8"-16 alignment bolt through the inner hole of the oil cooler water inlet to maintain the gasket in position. To insure proper installation of the cover plate, one side is stamped “inside”.
5. Secure the cover plate to the housing with eleven 5/16"—18 bolts and lock washers. Tighten the bolts to 13-17 lb-ft (18-23 N«m) torque. Remove the aligning bolt.
6. Thread the four nuts over the core studs and tighten them to 70-80 lb-ft (95-108 N*m) torque.

Install Oil Cooler

Refer to Fig. 1 and install the engine oil coolers, as follows:

1. Use a new gasket and position the oil cooler over the two studs and up against the cylinder block. Thread the two stud nuts and lock washers over the studs and draw the nuts up finger tight only. On the 12V and 16V engines, position both oil coolers before proceeding with the installation of the remaining bolts.
2. Install the water inlet elbow and gasket and tighten the bolts finger tight only.
3. Install the water outlet elbows, spacers and gaskets. Center the elbow flanges on the cooler flanges, then install and tighten all of the bolts finger tight only.
4. Install the inlet tube between the water pump and the oil cooler inlet elbow, leaving the bolts loose. Position the tube brackets.
5. With coolers, elbows and tube in position (Fig. 1), proceed to tighten the bolts, as follows:
   a. Tighten the bolts on the water inlet elbow. Start with one of the four top bolts and alternately tighten the bolts to 30-35 lb-ft (41-47 N»m) torque.
   b. Tighten the cooler to block bolts and nuts. Start at the center and work toward the outside. Tighten the stud nuts to 83-93 lb-ft (113-126 N*m) torque and the bolts to 71-75 lb-ft (96-102 N«m) torque.
   c. With the flanges centered, tighten the water outlet elbow bolts (elbow to block bolts first). Then, gradually and alternately tighten the elbow to cooler bolts to avoid cracking the flange.
   d. Alternately tighten the water inlet tube to water inlet elbow bolts. Then alternately tighten the water inlet tube to water pump flange bolts. Tighten the bolts to 30-35 lb-ft (41-47 N«m) torque.
   e. Tighten the water inlet tube bracket bolts.
   f. If removed, install the drain plug in the water inlet elbow or the bottom of the oil cooler. On engines equipped with a Torqmatic converter, install the outlet elbow at the bottom of the oil cooler, between the oil cooler and the water crossover tube.
6. Install the oil pan drain plug and fill the oil pan to the proper level on the dipstick with the lubricating oil recommended in *Lubrication Specification* (Section 13.3).
7. Start and run the engine for a short period and check for oil and water leaks. Stop the engine and, after approximately twenty (20) minutes, recheck the oil level on the dipstick.

LUBRICATING OIL C< ILER BYPASS VALVE

To ensure engine lubrication should the oil cooler become plugged, a bypass valve (Fig. 5) is installed in the oil inlet passage of the oil cooler housing. The valve opens and allows oil to bypass the oil cooler when the pressure at the inlet side exceeds the pressure at the outlet side by 26.5 psi (179 kPa).

The bypass valve assembly consists of a housing, valve, spring, retaining plug and gasket. The bypass valve should be removed, cleaned, inspected and reassembled whenever the oil cooler core is cleaned or replaced. However, the bypass valve can be disassembled without removing the oil cooler.

Remove Oil Cooler Bypass Valve

1. Remove the four bolts and lock washers securing the bypass valve housing to the oil cooler and remove the housing and gasket.
2. Remove the retaining plug and gasket from the housing and withdraw the spring and valve.

Inspection

Clean the housing and bypass valve components with fuel oil and dry them with compressed air.

 © Detroit Diesel Corporation

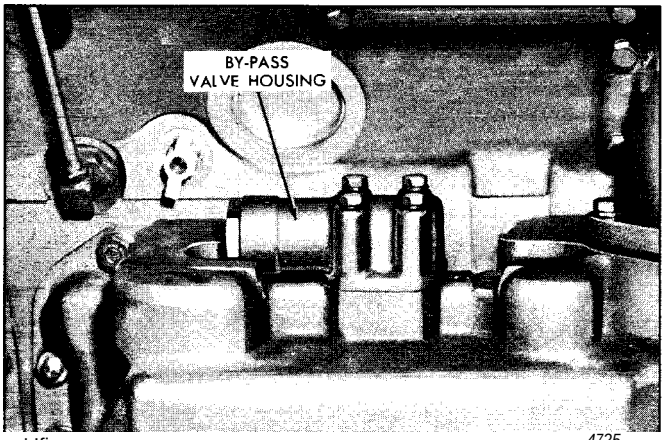


Fig. 5 - Oil Cooler Bypass Valve Mounting

CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Inspect the valve and spring for wear or damage and replace them, if necessary. The bypass valve spring has an approximate free length of 2.73". Use spring tester J 22738-02 to check the spring load. When a force of 39.25 pounds or less will compress the spring to a length of 2.201", replace the spring.

Install Oil Cooler Bypass Valve

1. Apply clean engine oil to the outside surface of the bypass valve and place it in the bypass valve housing. Be sure to place the closed end of the valve toward the back of the housing cavity.
2. Insert the spring inside the bypass housing and into the valve cup.
3. Place a new gasket on the retaining plug and install the retaining plug. Tighten the 1—1/16"—16 plug to 80-90 lb—ft (108-122 N«m) torque.
4. Place a new gasket on the oil cooler bypass valve housing mounting surface and install the housing on the oil cooler using four 5/16"-18 bolts and lock washers. Tighten the bolts to 13-17 lb-ft (18-23 N#m) torque.

TUBE TYPE OIL COOLER

TURBOCHARGED INTERCOOLED ENGINES

• Tube type oil cooler assemblies (Fig. 6) are installed on certain 8 V, 12V, and 16V-149 turbocharged-intercooled engines.

The original water inlet housing and seal (Fig. 7) used on tube type oil coolers were replaced approximately April, 1985. The new water inlet housing is similar to the former, except that the seal gland lead-in chamfer is wider. The new seal is slightly thinner than the former seal and has a different profile (Fig. 7), which allows it to be compressed more easily. This design insures direct metal-to-metal contact between the water inlet housing, the weep ring, and the tube bundle shell. Without metal-to-metal contact, the fasteners holding these parts together can lose torque and loosen, resulting in a coolant leak.

The former seal and housing are not longer available. When seal replacement is required on assemblies with the former housing, the former housing *must* be reworked to permit installation of the new seal. See rework instructions (section 4.0).

NOTICE: Before disassembling a tube and shell oil cooler assembly, match marks should be scribed on oil cooler end covers and housing and the locations of nuts and bolts should be noted.

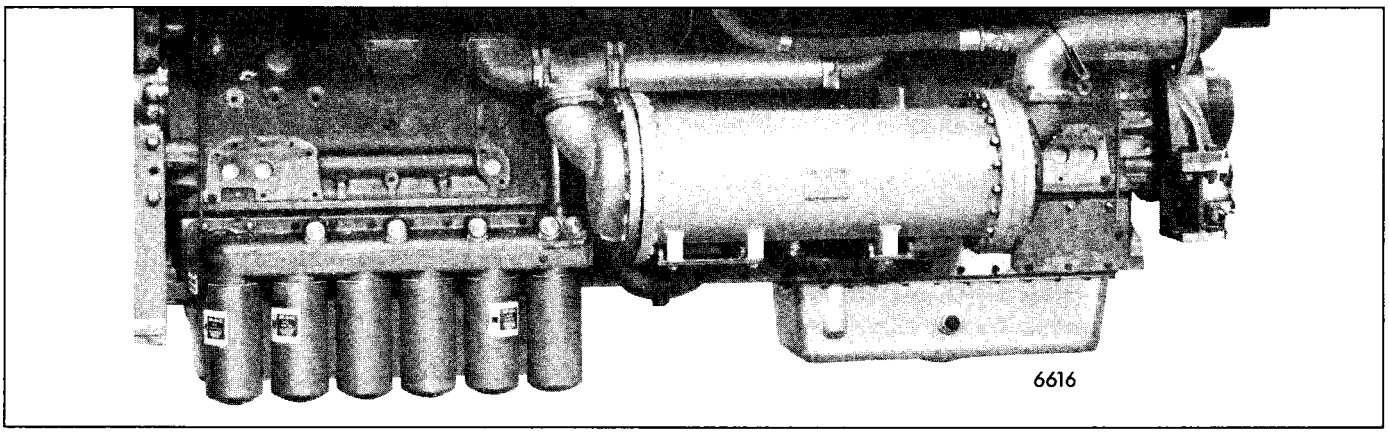


Fig. 6 – Tube and Shell Oil Cooler Mounting (16V–149 Engine Shown)

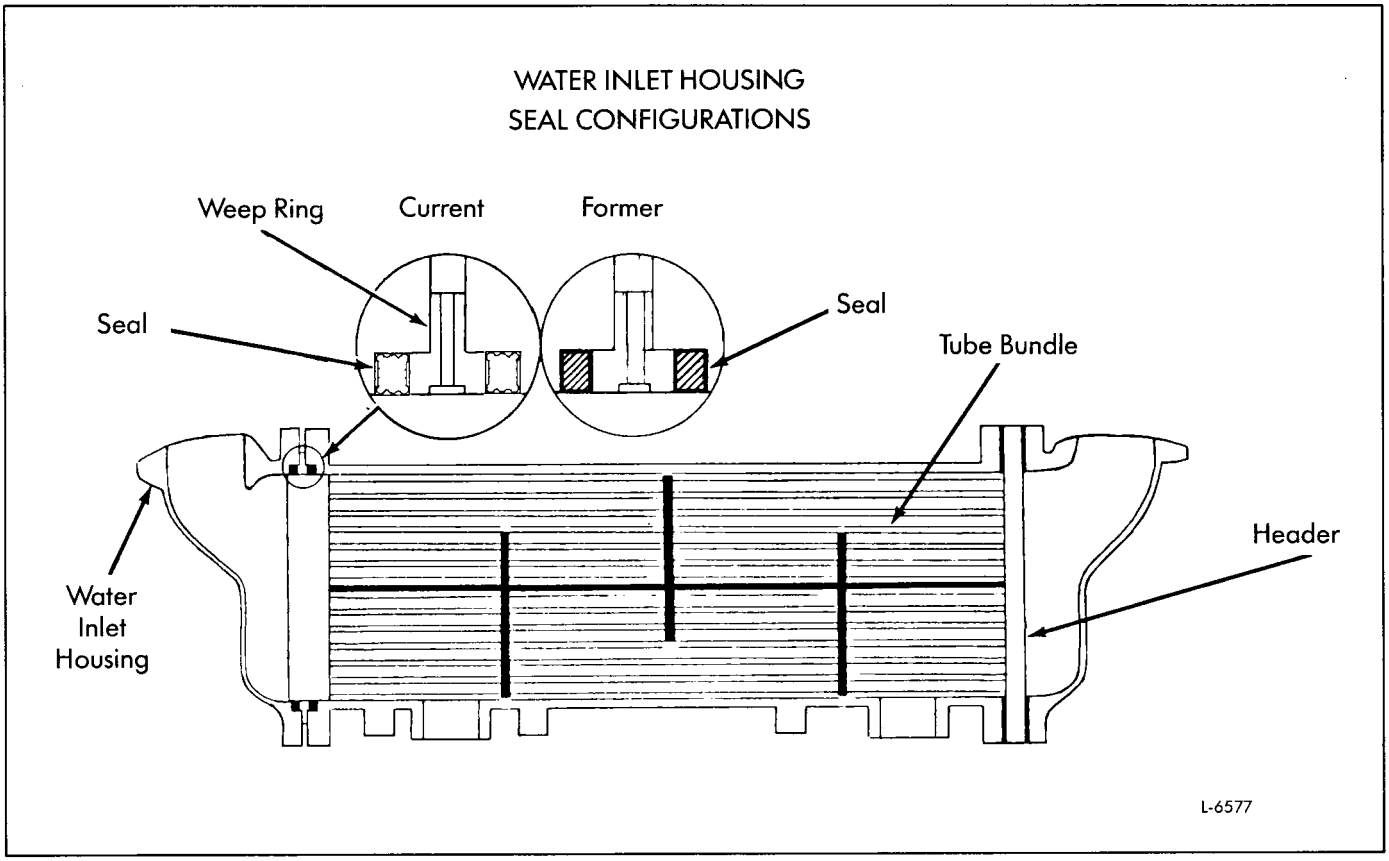


Fig. 7 – Tube and Shell Oil Cooler

Remove Oil Cooler

1. Drain the cooling system.
2. Remove the water pump to oil cooler tube.
3. Remove the oil cooler to cylinder block tube.
4. Remove the two elbows attached to the bottom of the oil cooler.
5. Remove the bolts and lockwashers which secure the oil cooler assembly to the support brackets. Remove the oil cooler.
6. Drain the oil from the oil cooler.
7. Clean the exterior surface of the oil cooler with fuel oil.
8. Remove the tube bundle from the shell.

Clean Oil Cooler

CAUTION: To avoid personal injury, perform this operation in the open or in a well ventilated area. Avoid breathing the fumes or direct contact of the chemicals with your skin. Use recommended safety equipment, as required.

NOTICE: Do not attempt to clean an oil cooler core when an engine failure occurs in which metal particles from worn or broken parts are released into the lubricating oil. In this instance, replace the oil cooler core.

Clean the tubes by circulating a cleaning solvent (Stoddard Solvent or equivalent) through the tubes. Then, run a brush through the tubes. After the brushing is completed, rinse the tubes with clean hot water.

NOTICE: Precautions must be taken so the cleaning agents do not corrode the tubes. If an acid solution is used, the residue must be neutralized.

Assemble Oil Cooler

1. Place the shell in a *vertical* position on the floor and place a gasket on the end of the shell.
2. Insert the tube bundle into the shell. Align match marks.
3. Place the oil cooler water inlet cover gasket on the end of the shell.
4. Align and bolt the water inlet housing (cover) on the fixed end of the oil cooler assembly with seventeen (17) bolts, lockwashers and nuts, and three bolts with

 © Detroit Diesel Corporation

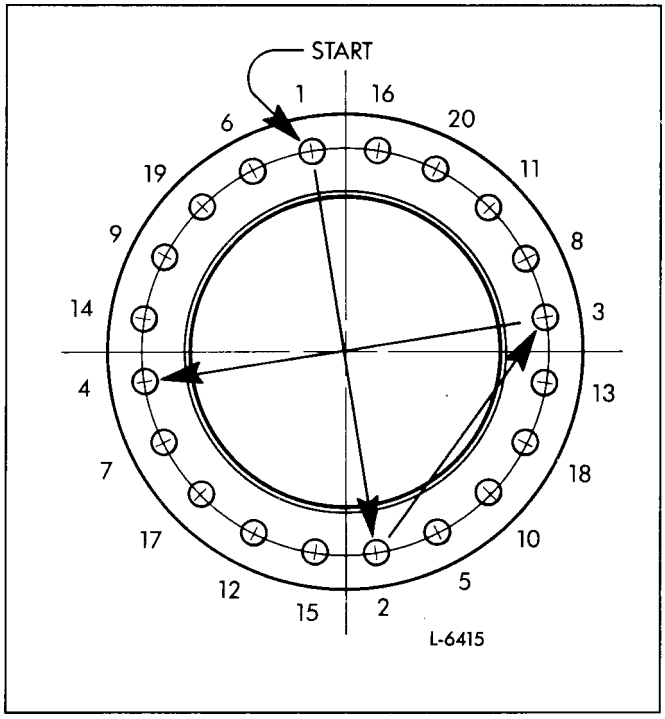


Fig. 8 - Bolt Tightening Sequence

lockwashers in the threaded holes at the top of the flange. Tighten the bolts to 30 lb—ft (41 N*m) torque using the sequence outlined in Fig. 8.

5. Place the metal weep ring on the end of the shell.
6. Place a seal (packing ring) in the water outlet housing (cover).
7. Align and bolt the water outlet housing (cover) to the floating end of the oil cooler assembly with seventeen (17) bolts, lockwashers and nuts, and three (3) bolts with lockwashers in the threaded holes at the top of the flange. This cover is not to be mounted flush to the shell flange. A gap must be maintained for the weep ring. Tighten the bolts to 35 lb—ft (47 N*m) torque using the sequence outlined in Fig. 8.
8. Apply sealant to the oil drain plug and install the plug in the bottom of the oil cooler.
9. Apply sealant to the drain plug and install the plug in the water inlet housing (cover) on the front end of the oil cooler.
10. Apply sealant to the drain plug and install the plug in the water outlet housing (cover) on the opposite end of the oil cooler.

.Install Tube And Shell Oil Cooler — 8V-149 Engine

Refer To Fig. 9

1. Using a new gasket, attach oil filter outlet elbow (A) to oil filter adaptor (B) with three (3) l/2"-13 x 1 3/8" bolts, one (1) l/2"-13 x 1.25" bolt, one (1) l/2"-20 nut, and four (4) 1/2" lockwashers. Tighten to 71-75 lb—ft (96-102 N*m) torque.
2. Using a new gasket, attach oil inlet elbow (C) to block with two (2) 1/2"—13 x 1 1/2" bolts and lockwashers. Tighten to 71-75 lb-ft (96-102 N«m) torque.
3. Attach front and rear oil cooler mounting brackets to block with six (6) 1/2"—13 x 1 3/8" bolts and lockwashers (front and rear brackets) and two (2) 7/16”—14 x 1 1/4" bolts and lockwashers (rear bracket). Using fabricated mounting bracket alignment tool (refer to Shop Notes, Section 4.0), align mounting brackets and tighten bolts. Tighten l/2"-13 bolts to 71-75 lb-ft (96-102 N*m) torque. Tighten 7/16"-14 bolts to 46-50 lb-ft (62-68 N#m) torque.
4. Install 90° hydraulic fluid elbow (D) into oil cooler oil outlet elbow (E). Elbow must face inboard. Install 1" connector into elbow (D). Install oil bypass hose assembly to connector.
5. Using a new gasket, install oil cooler oil outlet elbow (E)-with bypass hose attached onto front of oil cooler with four (4) 1/2"—13 x 1.50"L bolts and lockwashers. Tighten to 71-75 lb-ft (96-102 N*m) torque.
6. Using a new gasket and seal, attach flange, plate, and oil cooler water inlet elbow (F) to rear of oil cooler housing with three (3) 3/8"—16 x 1.75"L bolts and lockwashers. Install loose. Do not tighten at this time.
7. Using a suitable support, move the oil cooler to the engine. The bypass hose must be positioned between the oil cooler and block. Attach oil cooler to mounting brackets with four (4) 1/2"—13 x 1 3/8" bolts and lockwashers (front and rear brackets). Tighten bolts to 71-75 lb-ft (96-102 N»m) torque.
8. Using a new gasket, attach rear water inlet elbow (F) to block with four (4) 3/8"-16 x 1.135" flange hex head bolts. Tighten to 30-35 lb-ft (41-47 N«m) torque.
9. Using a new seal and gasket, attach oil cooler oil outlet elbow (E) to oil inlet-to-block elbow (C) with flange, plate, and three (3) 3/8" - 16 x 1.75"L bolts and lockwashers. Tighten to 30-35 lb-ft (41-47 N«m) torque.
10. Using new seals, attach water pump outlet tube (G) to front of oil cooler housing with flange and three (3) 3/8" - 16 x 1 3/8"L bolts and lockwashers. Slip flange and new seal onto opposite end of water pump outlet tube and install to water pump with three (3) 3/8"-16 x 1 3/8"L bolts and lockwashers. Install breather pipe clip under top, left flange bolt. Tighten all bolts to 30-35 lb-ft (41-47 N*m) torque.
11. Install 1 5/16"-12 flared tube connector into oil cooler oil inlet/bypass elbow assembly (H). Then secure a new oil cooler housing gasket to the top of the oil inlet/bypass elbow assembly.

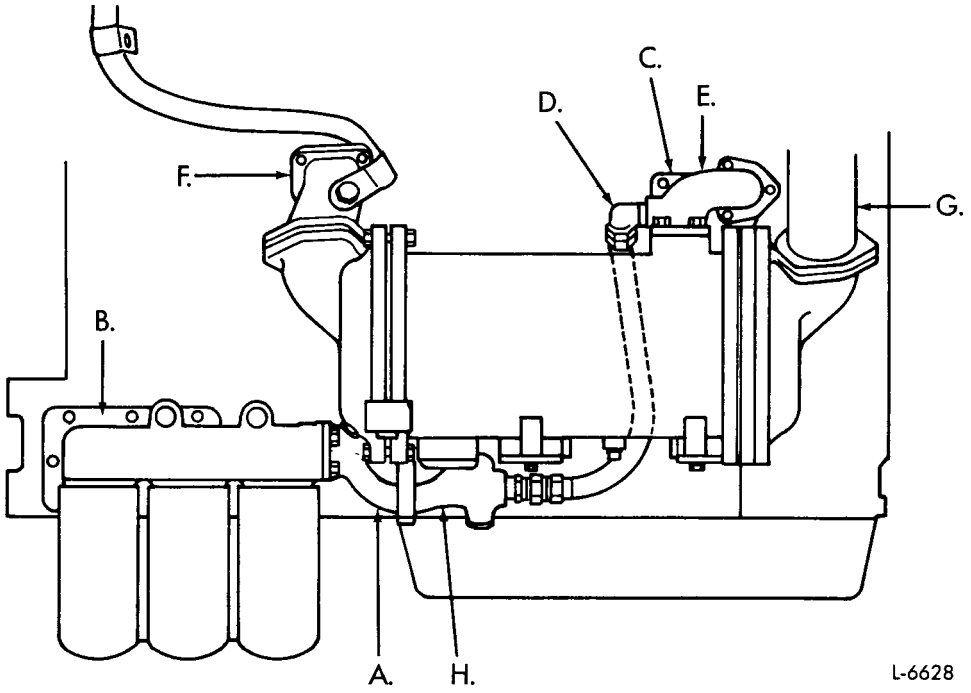


Fig. 9 - 8V-149 Oil Cooler Installation

12. Using a new seal, attach oil inlet/bypass elbow assembly (H) to oil filter outlet elbow (A) with flange, two (2) 3/8"—16 x 1 3/8"L bolts, one (1) 3/8"—16 x 1 5/8" L bolt and one 3 / 8 1 6 nut (bottom, outboard), and lockwashers. Install loose. Do not tighten at this time.
13. Attach oil inlet/bypass elbow assembly (H) to bottom rear of oil cooler housing with four (4) 1/2"—13 x 1 1/2"L bolts and lockwashers. Tighten to 71-75 lb—ft (96-102 N*m) torque.
14. Tighten the 3/8"—16 bolts holding oil inlet/bypass elbow assembly (H) to oil filter outlet elbow (A) to 30-35 lb—ft (41-47 N»m) torque.
15. Install end of oil bypass hose assembly into connector in oil inlet/bypass elbow assembly (H).

•Install Tube And Shell Oil Cooler — 12V, 16V-149 Engines

Refer To Fig. 10

1. Using a new gasket, attach oil cooler outlet (A) to oil filter adaptor (B) with three (3) l/2"-13 x 1.50" bolts, one (1) 1/2"—13 x 1 1/4" bolt (left, upper outer hole), and lockwashers. Tighten bolts to 71-75 lb—ft (96-102 N«m) torque.
2. Attach front and rear oil cooler mounting brackets loosely to side of block with eight (8) l/2"-13 x 1 3/8" bolts and lockwashers, and two (2) 7/16"-14 x 1 1/4" bolts and lockwashers (front bracket only). Do not tighten at this time.
3. Using a new gasket, attach oil cooler outlet tube assembly (C) to block with four (4) 1/2"—13 x 3.00" bolts and lockwashers. Mount loosely. Do not tighten at this time.
4. Slip two (2) flanges and new seals onto oil filter bypass tube (D). Slip open end of bypass tube into oil cooler outlet tube assembly (C). Using a new gasket and two (2) 3/8"—16 x 1.135" bolts and lockwashers, install bypass tube onto oil filter adaptor (B). Tighten bolts to 3CU35 lb-ft (41—47 N*m) torque.
5. Secure bypass tube bracket to block with one (1) 7/16"-14 x 3/8" bolt and lockwasher. Tighten to 46-50 lb-ft (62-68 N*m) torque.
6. Using fabricated oil cooler mounting bracket alignment tool (refer to Shop Notes, Section 4.0), align oil cooler mounting brackets and tighten attaching bolts. Tighten 1/2"—13 bolts to 71-75 lb-ft (96-102 N*m) torque. Tighten 7/16"—14 bolts to 46-50 lb-ft (62-68 N»m) torque.

© Detroit Diesel Corporation

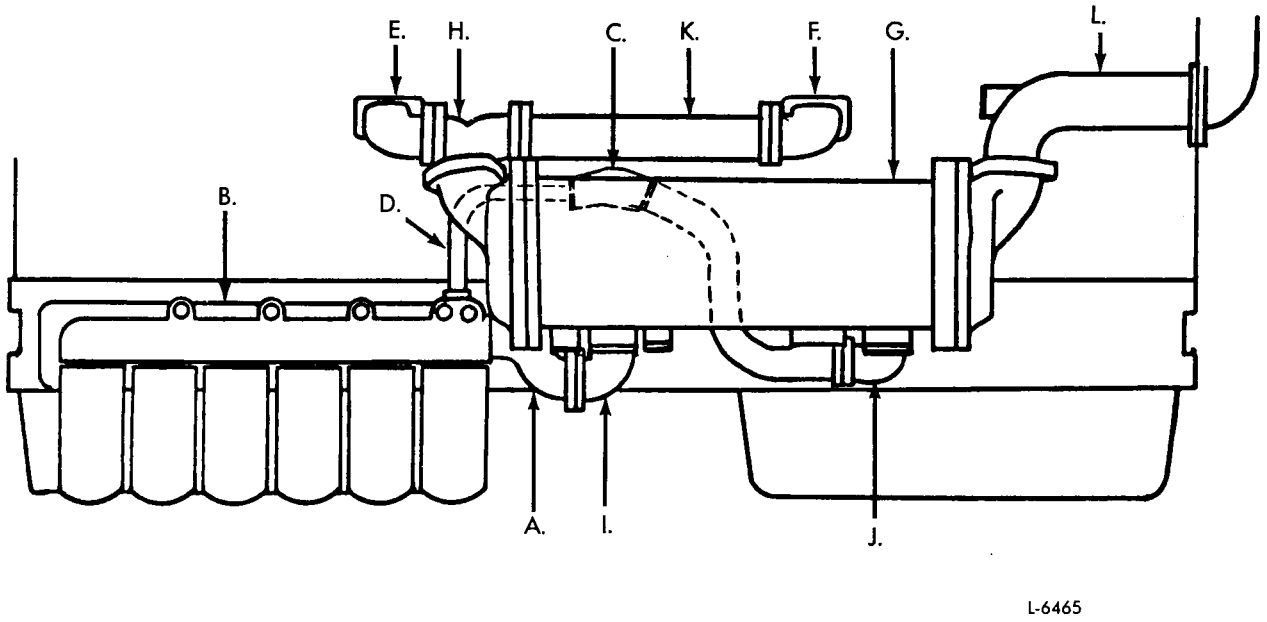


Fig. 10 - Tube and Shell Oil Cooler Mounting 16V-149 Engine Mounting Shown

7. Attach rear water elbow (E) and front water elbow (F) to block using new gaskets and eight (8) 3/8"-16 x 1.25" bolts and lockwashers. Tighten front elbow mounting bolts to 30-35 lb—ft (41^-7 N*m) torque. Do not tighten rear elbow at this time.

8. Apply Formagasket to left outlet flange of oil cooler (G), place new gasket on flange, and install water outlet tee (H) using three (3) 3/8"—16 x 1.38 bolts. Tighten to 30-35 lb—ft (41—47 N»m) torque.

9. Using a hoist or other suitable means, properly support the oil cooler assembly and move to the engine. Two 1/2" dowels may be installed in the right and center cooler bases to aid in aligning cooler base bolt holes with brackets. When the oil cooler is in position, remove the two dowels and install six (6) 1/2-13 x 1 1/4" mounting bolts. Tighten to 71-75 lb—ft (96-102 N*m) torque.

10. Slip flange and seal ring onto open end of oil filter outlet elbow (A). Insert open end into oil cooler inlet elbow (I). Then, using a new gasket and four (4) l/2"-13 x 1 1/2" bolts and lockwashers, install oil cooler inlet elbow to bottom left of oil cooler. Using two (2) 3/8"-16 x 1 3/8" bolts, one 3/8"-16 x 1.62" bolt, one 3/8" nut, and lockwashers, attach oil cooler inlet elbow (I) to oil filter outlet elbow (A). Install the 1.62" long bolt, the nut, and a lockwasher in the bottom bolt hole. Tighten the four 1/2" mounting bolts to 71-75 lb—ft (96-102 N«m) torque. Then tighten the 3/8" bolts to 30-35 lb—ft (4-1—47 N*m) torque.

11. Tighten the four l/2"-13 bolts holding the tube assembly (C) to the block to 71-75 lb—ft (96-102 N.*m) torque.

12. Slip flange and seal ring onto open end of tube assembly (C). Slip end of tube assembly into oil cooler outlet elbow (J). Using a new gasket, four (4) l/2"-13 x 1 1/2" bolts and lockwashers, attach outlet elbow to bottom right of oil cooler. Do not tighten at this time.

13. Using three (3) 3/8"-16 x 1" bolts and lockwashers, attach oil cooler outlet elbow (J) to flange on end of tube assembly. Install loose. After lining up elbow and tube assembly, tighten the four 1/2" elbow-to-cooler bolts to 71-75 lb—ft (96-102 N*m) torque. Then tighten the three 3/8" elbow-to-tube assembly flange bolts to 30-35 lb—ft (41-47 N*m) torque.

14. Tighten the two 3/8"—16 flange bolts holding the end of the bypass tube (D) to the oil cooler outlet tube assembly (C) to 30-35 lb—ft (41-47 N«m) torque.

15. Using flange, plate, a new gasket and seal ring, and three (3) 3/8"—16 x 1.62" bolts and lockwashers, attach oil cooler water outlet tee (H) to the rear water elbow (E). Snug all bolts. Then tighten the four rear elbow mounting bolts to 30-35 lb—ft (41—47 N*m) torque.

© Detroit Diesel Corporation

Tighten the three tee-to-elbow bolts to 30-35 lb—ft (41-47 N*m) torque.

16. Install tube assembly (K) between the tee and front water elbow. On left side install with flange, seal, plate, new gasket, and three (3) 3/8"—16 xl.62 bolts and lockwashers. On right side install with flange (w/tapped holes), gasket, plate, seal, flange (no tapped holes), three 3/8"—16 x 1.62" bolts and lockwashers. Tighten all bolts to 30-35 lb—ft (41-47 N*m) torque.

17. After installing water pump, install water pump outlet tube (L) to oil cooler using new gasket and three (3) 3/8"-16 x 1.38 bolts and lockwashers. Tighten to 30-35 lb—ft (41-47 N*m) torque.

.TUBE AND SHELL OIL)OLER BYPASS VALVE

To ensure lubrication if the tube and shell oil cooler should become plugged, a bypass valve is installed in the oil inlet/bypass elbow assembly on 8V engines and in the oil filter adaptor on 12V and 16V engines. The valve opens and allows the oil to bypass the oil cooler when the pressure at the inlet side exceeds the pressure at the outlet side by 26.5 psi (179 kPa).

Besides the valve housings which are machined into the elbow or adaptor, bypass valve components consist of a valve, spring, retaining plug, and gasket. Bypass valves should be disassembled, cleaned, inspected, and reassembled whenever the tube and shell oil cooler is removed from the engine.

Disassemble Oil Cooler Bypass Valve

1. Loosen and *slowly* remove the bypass valve retaining plug.

CAUTION: The valve plug is under spring pressure. To avoid possible personal injury, hold the plug securely while removing.

2. Remove the plug gasket and withdraw the spring and valve.

After Installing Oil Cooler

After installing the oil cooler on an 8V, 12V, or 16V-149 engine, proceed as follows:

1. Fill the cooling system to the proper level.
2. Add sufficient oil to bring the oil level to the proper mark on the dipstick.
3. Start and run the engine for a short period and check for oil or coolant leaks. After leaks have been corrected and the engine has been stopped long enough for the oil from various parts of the engine to drain back to the crankcase (approximately 20 minutes), bring the oil level up to the proper mark in the dipstick. Allow the engine to cool and add coolant as required to bring coolant to the proper level.

Inspection

Clean bypass valve components with fuel oil and dry with compressed air.

CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Inspect the valve and spring for wear or damage and replace them, if necessary. The bypass valve spring has an approximate free length of 2.73". Use spring tester J 22738-02 to check the spring load. When a force of 39.25 pounds or less will compress the spring to a length of 2.201", replace the spring.

Install Oil Cooler Bypass Valve

1. Apply clean engine oil to the outside surface of the bypass valve and place it in the bypass valve housing. Place the closed end of the valve toward the back of the housing cavity.
2. Insert the spring inside the housing and into the valve cup.
3. Place a new gasket on the retaining plug and install the retaining plug. Tighten the 1 1/16”—16 plug to 80-90 lb-ft (108-122 N*m) torque.

 © Detroit Diesel Corporation

OIL LEVEL DIPSTICK

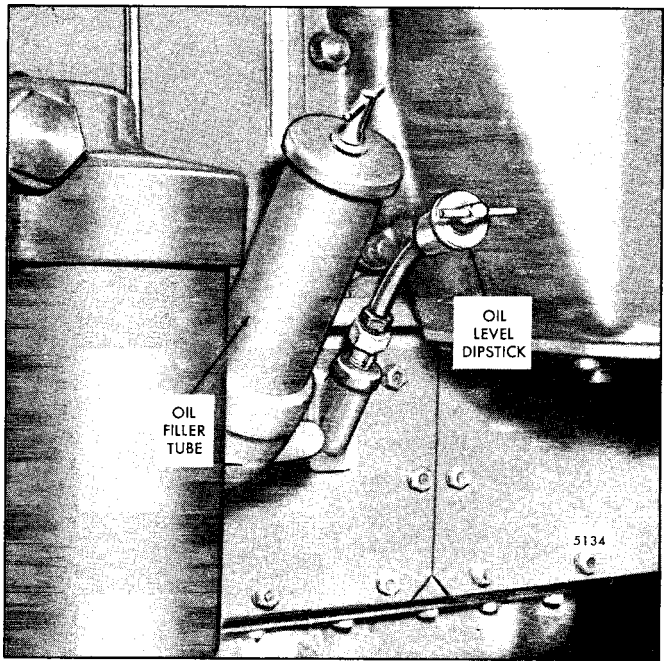


Fig. 1 - Typical Dipstick Mounting

A steel ribbon type oil level dipstick is used to check the quantity of oil in the engine oil pan. The dipstick is located in the side of the cylinder block or the oil pan (Fig. 1). The current engines include a 3/4" long rubber oil seal which prevents the escape of vapors carrying oil from the dipstick tube.

Maintain the oil level between the full and low marks on the dipstick and never allow it to drop below the *low* mark. No advantage is gained by having the oil level above the *full* mark. Overfilling will cause the oil to be churned by the crankshaft throws causing foaming or aereation of the oil. Operation below the low mark will expose the pump pick-up causing aereation and/or loss of pressure.

Check the oil level after the engine has been stopped for a minimum of twenty minutes to permit oil in the various parts of the engine to drain back into the oil pan.

NOTICE: Check the oil level at the start of each (8 hour) shift or before starting the engine.

Dipsticks are normally marked for use only when the equipment the engine powers is on a level surface. Improper oil levels can result if the oil level is checked with the equipment on a grade.

Fill the crankcase with oil as follows:

1. Fill the oil pan to the full mark on the dipstick.
2. Start and run the engine for approximately ten minutes.
3. Stop the engine and wait a minimum of twenty minutes. Then add the required amount of oil to reach the *full* mark on the dipstick. Each engine oil filter will require approximately two additional quarts (1.9 liters) of oil.

Marine Engines

Dipsticks in marine engines are located and marked to provide the proper oil level at any angle within the recommended maximum installation angle applicable to the specific boat.

In a properly filled crankcase, the oil level must be *below* the crankshaft rear oil seal when the boat is at rest.

© Detroit Diesel Corporation

OIL PAN

The engine incorporates two oil pans: an upper oil pan and a lower oil pan (Fig. 1).

The upper oil pan is a one-piece iron casting on the 8V-149 engine and a two-piece iron casting on the 12 and 16V-149 engines, with a series of hand hole plates located along each side. These plates provide access to the connecting rod bearing caps, oil pressure regulator and relief valves, and oil pump.

The lower oil pan is a one-piece stamping which bolts to the upper oil pan and houses the main body of lubricating oil.

A baffle between the lower and upper oil pans ensures sufficient oil in the lower pan at all times (Fig. 2). Positive seal between the upper oil pan and the cylinder block is accomplished by a seal ring located in a machined groove around the top of the oil pan frame. Preformed gaskets provide a seal for the upper oil pan hand hole plates and between the upper and lower oil pan.

Remove Oil Pan

1. Remove the drain plug located in the bottom of the oil pan and drain the lubricating oil.
2. Remove the bolts and lock washers securing the lower oil pan to the upper oil pan and remove the lower oil pan, baffle and gaskets.
3. Remove the oil level dipstick and shroud assembly from the upper oil pan frame.
4. When the engine is equipped with the current turbocharger drain back hoses, loosen the bolts and remove the drain back elbow from the oil pan hand hole plate on each side of the upper oil pan.
5. On units equipped with a Torqmatic converter oil cooler, disconnect and remove the water outlet elbows located on each side of the engine at the upper oil pan hand hole plates (Section 4.4).
6. Remove the four 5/8"-11 bolts and shims securing the upper oil pan to the flywheel housing.
7. Remove the remaining bolts, nuts and lock washers holding the upper oil pan to the cylinder block and remove the oil pan and seal ring.

Inspection

Clean all of the parts with fuel oil and dry them with compressed air.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Inspect the lower oil pan for cracks or other damage.

Remove the hand hole plates from the upper oil pan and check the frame for cracks. Check the seal ring groove in the top of the upper oil pan for burrs or foreign material. Scrape all of the old gasket material from the oil pan and hand hole plates.

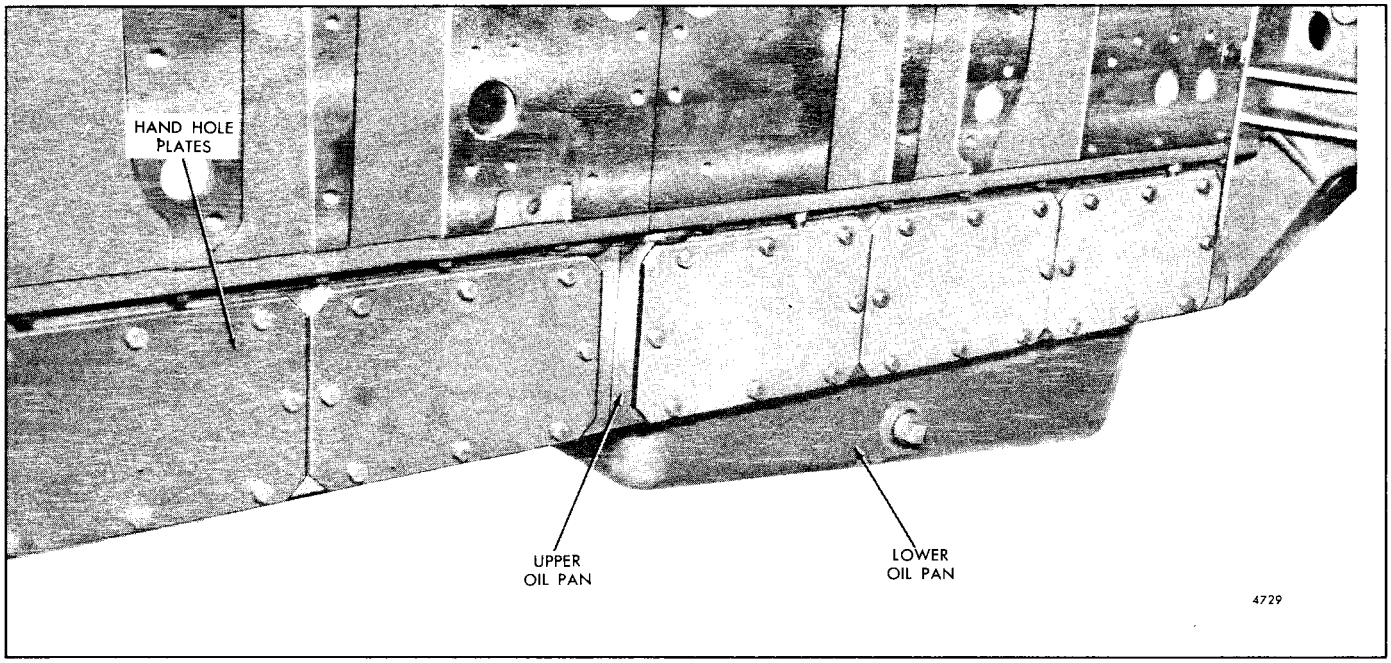


Fig. 1 – Oil Pan Installed on 12V–149 Engine

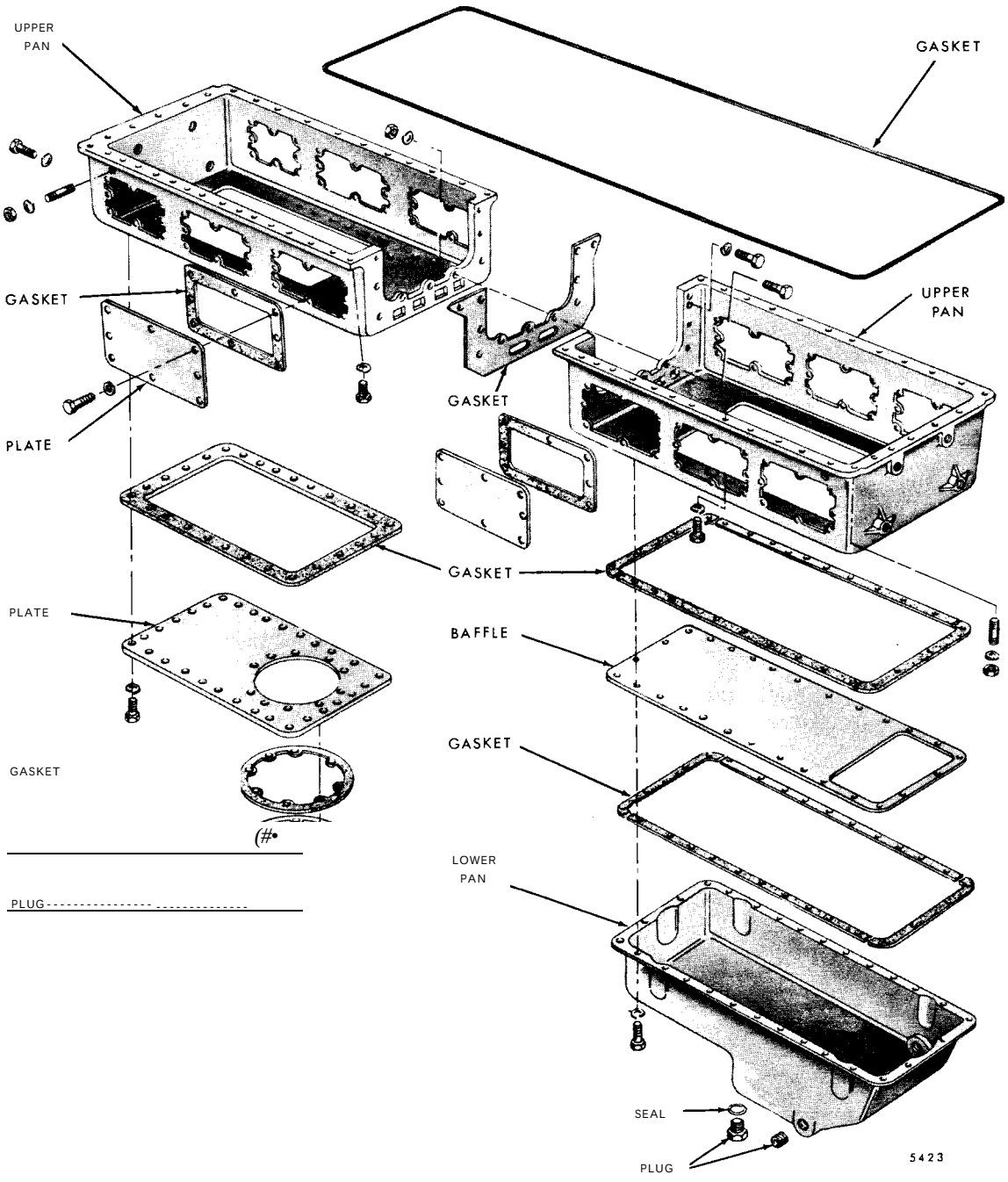


Fig. 2 - Typical Oil Pan and Relative Location of Parts

© Detroit Diesel Corporation

Assemble Oil Pan (Upper)

1. Refer to Fig. 2 and place a new gasket between the two oil pan halves. Install the seven l/2"-20 bolts, nuts and lock washers and the two 1/2"—13 bolts and lock washers. Tighten the l/2"-20 bolts to 83-93 lb—ft (113-126 N • m) torque and the 1 /2" -13 bolts to 71-75 lb-ft (96-102 N-m) torque. *Trim the excess gasket material flush on the sides and bottom of the seal ring groove to allow installation of the seal ring.*
2. Move a dial indicator across the top surfaces of the upper oil pans at the joint between the two pan halves. The mismatch, if any, between the top surfaces of the pans must not exceed .005" on either side.

Install Oil Pan

- 1. Apply a thin coat of 3M EC-1300 Rubber Adhesive, or equivalent, in the seal ring groove at the top of the upper oil pan and install a new seal ring. *The seal ring must lay flat in the groove and must not be twisted.*
- 2. Check to make sure mating surfaces of the block and upper oil pan are clean and free of nicks and burrs.
- 3. Position the upper oil pan against the cylinder block and secure it in place with bolts, nuts and lock washers. Tighten the bolts and nuts to 45-50 lb-ft (61-68 N • m) torque, except the 4 bolts on the bottom of the flywheel housing. Seclect shims to fill in the space between the flywheel housing and upper pan. Shims available are .010", .003" and .005" in thickness. Install the shims and tighten the bolts to 137-147 lb-ft (186-200 N*m) torque.

  NOTICE: Install the new scavenging oil pump inlet tube, if used, before installing the upper oil pan.

- 4. Install the upper oil pan hand hole plates, using new gaskets. Coat each side of gaskets with Permatex 3D Sealer, or equivalent, before installing. Secure each plate with bolts, nuts and lock washers as required. Tighten the bolts and nuts to 30-35 lb-ft (41-47 N • m) torque.
- 5. Apply Permatex Spray Adhesive to contact surfaces and place a new gasket around both the top of the lower oil pan and the baffle. Install the lower oil pan and baffle against the upper oil pan with twenty-eight 3/8"-16 bolts and lock washers. Tighten the bolts to 30-35 lb-ft (41-47 N-m) torque. Current oil pan attaching bolts are coated with a locking material. To reactivate the locking ability of the used bolts, apply a drop or two of Loctite J 26558-242, or equivalent, at reassembly.

6. On units equipped with a Torqmatic converter oil cooler, install the water outlet elbows (Section 4.4).
7. When the engine is equipped with the current turbocharger drain back hoses, install the drain back elbow, using a new gasket on the oil pan hand hole plate on each side of the upper oil pan. Tighten the bolts.
8. Install the oil level dipstick and shroud assembly on the upper oil pan.
9. Install the drain plug in the lower oil pan and tighten it to 25-35 lb-ft (34—47 N*m) torque. Fill the lubricating oil system to its proper level. Refer to Section 13.3 for the recommended grade of oil.
10. Run the engine for a short period and check for oil leaks. Then stop the engine and, after a minimum of twenty minutes, check the oil level. Add oil if necessary.

© Detroit Diesel Corporation

VENTILATING SYSTEM

Harmful vapors which may be formed within the engine are removed from the crankcase, gear train and valve compartment by a continuous pressurized ventilating system.

Effective with engine serial numbers 12E-5672 and 16E-5308 breathing is through a cast breather body, element, screens and retainers mounted on the valve rocker cover (Fig. 1), as well as through passages in the joint face of the cylinder blocks. The cast body is mounted on the left bank front and right bank rear rocker covers for naturally aspirated engines and is mounted on all the rocker covers except the right bank front cover for turbocharged engines.

Certain engines have an additional steel breather assembly mounted on the flywheel housing.

On former turbocharged engines a steel breather and oil separator assembly are mounted on two of the four valve rocker covers (Fig. 2).

On early naturally aspirated and turbocharged engines breathing is through the passages in the joint face of the blocks and through elbows and piping mounted on the air box cover plate of the rear cylinder block (Figs. 3 and 4).

The breather pipes and elbows should be kept clean for efficient breathing and inspected periodically for damage that would restrict breathing.

Both the early, former and new breather systems will be serviced. When installing the new cast breather assembly on former or early engines, new rocker covers are required because of breather and turbocharged interferences. The new rocker covers are the same as the former covers, except that the 19.36" dimension locating the breather mounting pad is now 10.08". Both the former and new rocker covers are serviced. Also new cylinder block air box cover plates are required. This is due to the elimination of the two 1.56" diameter breather system holes. Both the former and new cover plates are serviced.

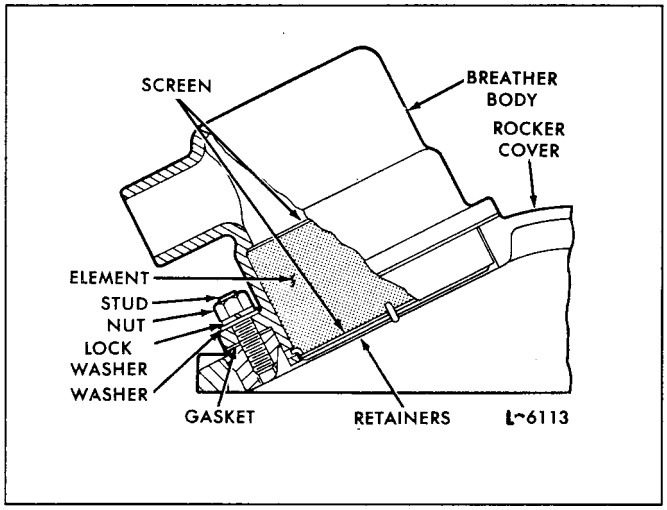


Fig. 1 - Engine Breather Mounting (Current Engines)

SERVICE

If for any reason a new cast breather housing and rocker cover are installed on a former naturally aspirated engine, it will be necessary to replace the air box cover plate or seal off the vent holes in the former plate and cylinder block. Refer to Shop Note “Breather Hole Plugs in Cylinder Block” in Section 1.0. The new breather housing cannot be mounted on the former rocker covers of turbocharged engines due to turbocharger interference.

Remove Early Breather Tubing

1. Remove the bolts, flat washers and lock washers securing the breather pipe assembly to the air box cover plate.

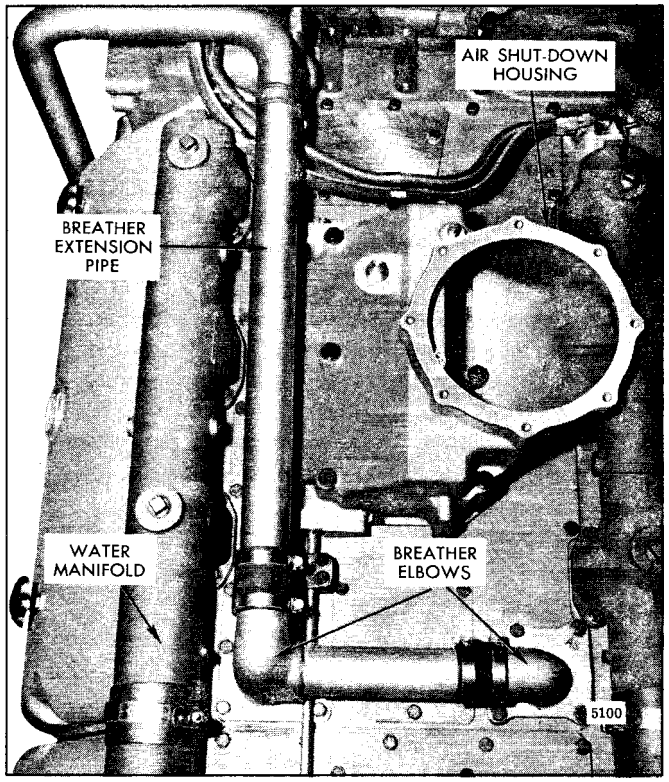


Fig. 2 - Engine Breather Mounting (Former Naturally Aspirated Engines)

2. Remove the bracket holding the breather pipe extension to the cylinder block.
3. Loosen the hose clamps and separate the breather pipes.
4. Remove the breather elbows and gaskets from the engine.

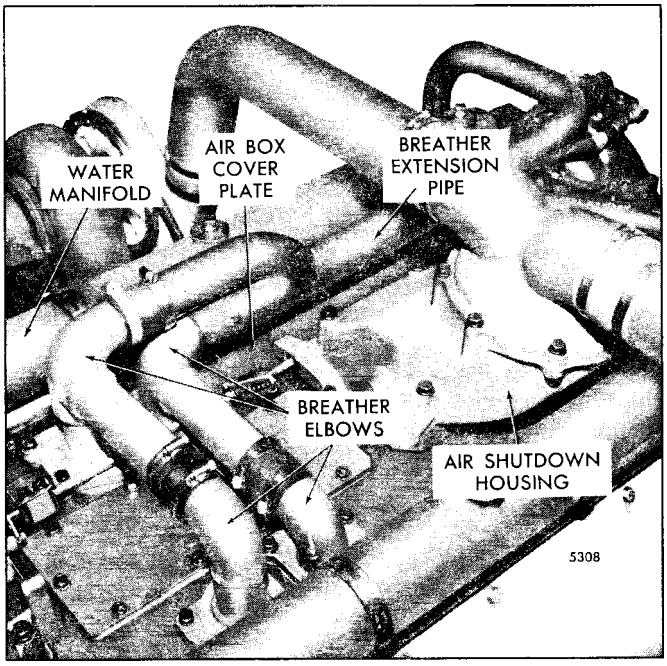


Fig. 3 - Engine Breather Mounting (Early Turbocharged Engines)

Inspection

Clean the breather assembly and inspect the former and early breather pipes and elbows for any damage that would restrict engine breathing.

The current cast breather housing assembly can be removed for cleaning without removing the rocker cover. This is not the case with the steel breather assembly.

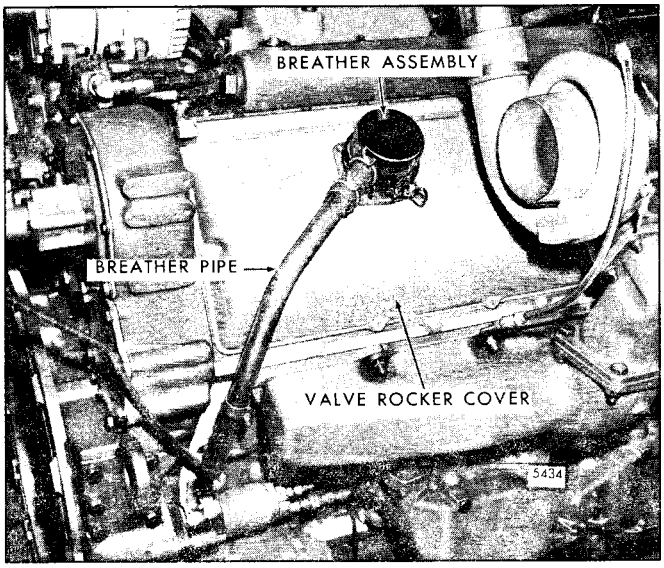


Fig. 4 - Engine Breather Mounted on Valve Rocker Cover (Former Turbocharged Engines)

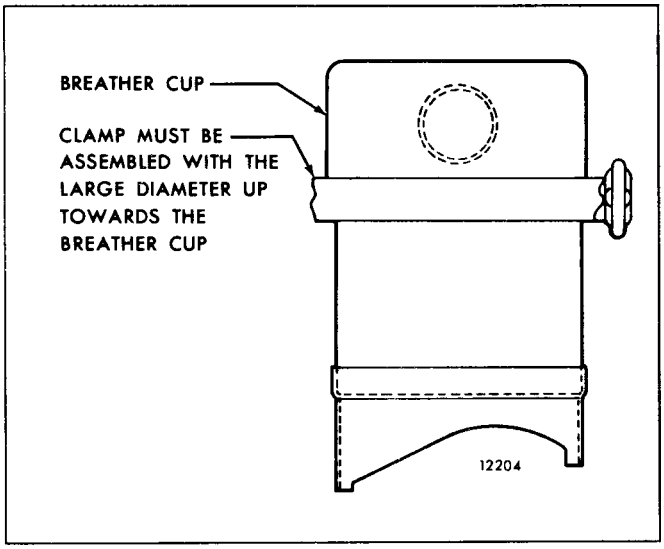


Fig. 5 - Correct Installation of Breather Clamp

The cylinder block breather system formerly used on naturally aspirated engines has been eliminated, however, the various tubes will continue to be serviced. When adding the valve rocker cover breather system (Fig. 1) to a naturally aspirated or a turbocharged engine it is necessary to remove the former breather tubing and seal the air box openings on the top of the cylinder block with covers and gaskets.

Install Early Breather Tubing

1. Use new gaskets and install the breather elbows. Tighten the 3/8"-16 bolts to 30-35 lb-ft (41-47 N m) torque. There are different gaskets for the right and left bank breather elbows.
2. Install the breather pipe extension and tighten the hose clamps.
3. Connect the breather pipe extension to the bracket with a 3/8" bolt, nut and lock washer.

Service

The breather assembly mounted on the flywheel housing, or the valve rocker cover on former turbocharger engines (Fig. 4), consists of a wire mesh pad, a steel shell and a breather body. The pad filters out any oil which may be present in the crankcase vapors. A slot in the shell permits the oil to drain back to the crankcase. Clean the breather pad with fuel oil and dry it with compressed air.

CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

NOTICE: Be sure the pad covers the slot in the shell.

The element in the breather assembly mounted on the valve rocker cover should be cleaned if excessive crankcase pressure occurs. Also clean the breather pipe.

© Detroit Diesel Corporation

BDC for Manuals - specs - Bolt torques

NOTICE: Dirt can collect around the breather clamp. Clean out the dirt thoroughly before disassembling the breather.

Wash the element in fuel oil and dry it with compressed air.

CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

When reassembling the breather, *be sure the clamp is installed with the large (open) diameter facing up* as illustrated in Fig. 5. If the clamp is improperly installed, it could eventually loosen.

© Detroit Diesel Corporation

BDC for Manuals - specs - Bolt torques

SHOP NOTES - SPECIFICATIONS - SERVICE TOOLS

SHOP NOTES

REPAIRING OIL COOLER HOUSINGS WITH WORN SEAL BORES

Engine oil cooler housings with worn oil cooler core inlet and outlet O-ring seal bores (Fig. 1) can be restored to serviceable condition if the bores are machined oversize and sleeved. Use the following procedure.

1. Rework the housing by reaming all four seal bore holes to 1.618" + .002" diameter. Break top of hole edges .010" maximum (Fig. 2).
2. Cut four .88" long sleeves from SAE 1010-1020 mild steel tube stock having a finished outside diameter that will provide a sleeve-to-bore press fit of .0005" to .0015" (Fig. 3). Outside surfaces of the sleeves must be smooth and free from burrs. Chamfer (break) the outside edge on one end of each sleeve 15° - 20° for lead into housing.
3. Wash all cuttings from the housing and sleeves with clean mineral spirits and dry with compressed air.

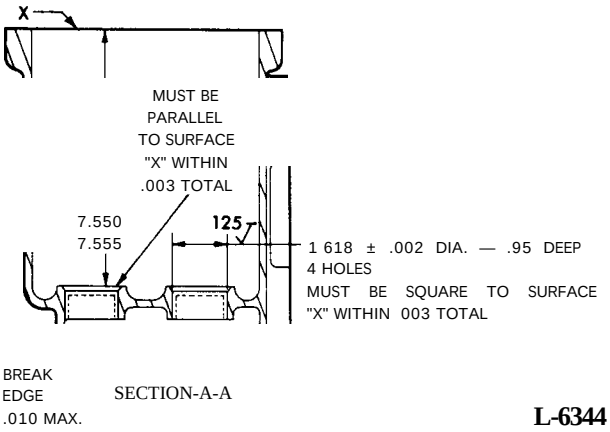


Fig. 2 - Initial Machining of Used Housing

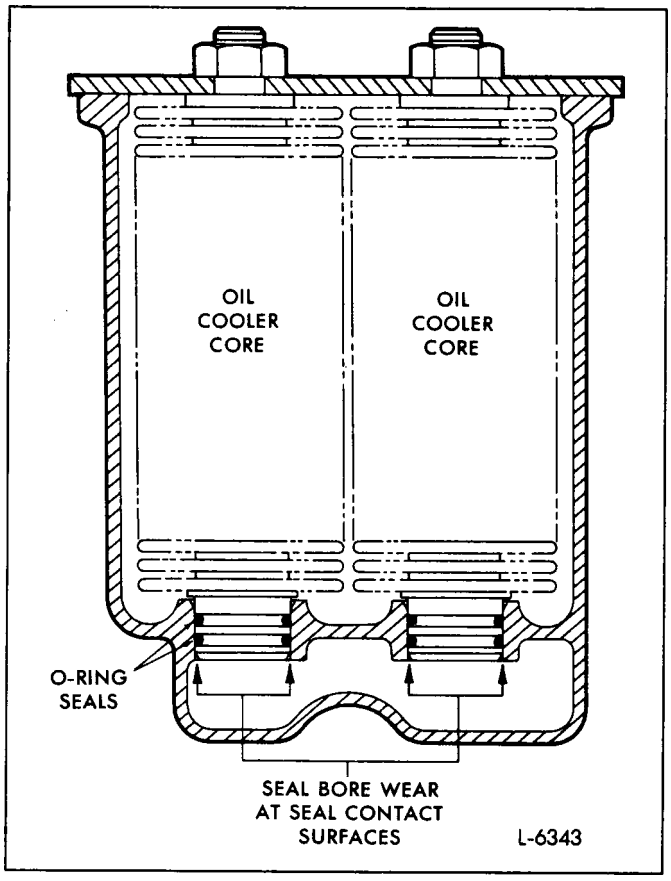


Fig. 1 - Oil Cooler Housing with Seal Bore Wear Area

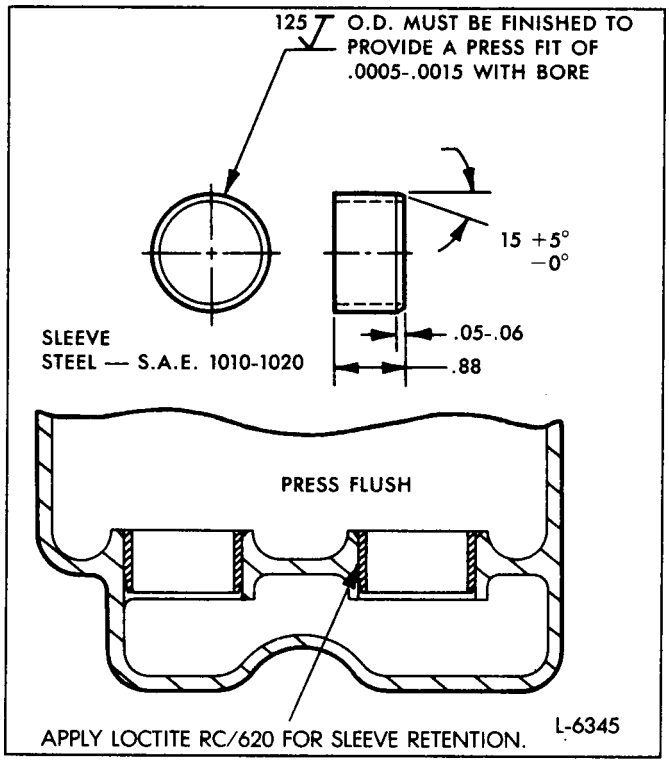


Fig. 3 – Machined Sleeve Pressed into Housing

© Detroit Diesel Corporation

BDC for Manuals - specs - Bolt torques

CAUTION: Do not exceed 20 psi (138 kPa) air pressure. Wear adequate eye protection and provide proper ventilation to avoid personal injury.

4. The sleeve and all mating part surfaces must be free of oil, grease or other contaminants. Use a chlorinated solvent or suitable degreaser on a clean, dry rag to wipe parts clean. Allow to dry completely after cleaning.

CAUTION: To avoid personal injury, clean parts in a properly ventilated area, wear adequate safety equipment (face guard, gloves, etc.), and observe safety precautions recommended by the cleaning product manufacturer.

5. Coat the inside of the housing bores and the outside of the sleeves with a continuous film of Loctite RC/620 retaining compound, or equivalent (Fig. 3).

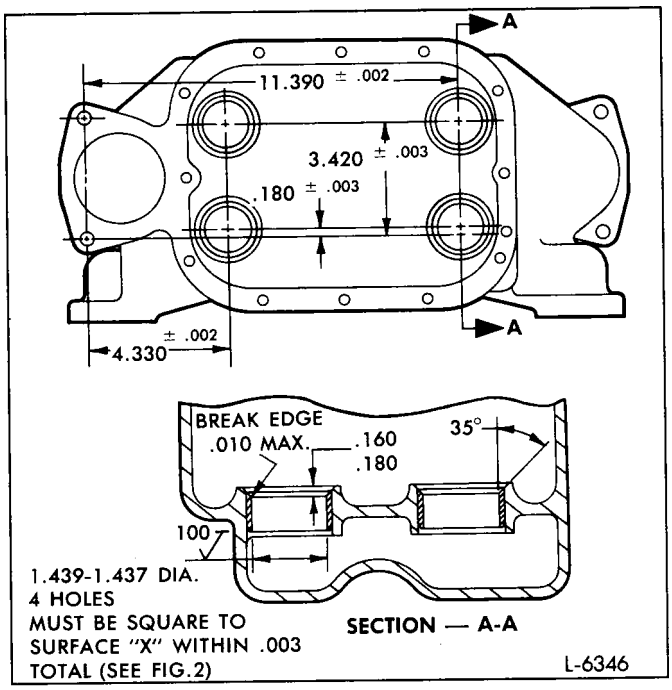


Fig. 4 – Final Machining of Housing

6. Start the sleeves into the housing bores chamfered ends first and press the sleeves in until flush with the top of the casting (Fig. 3).

7. Remove excess compound with a clean dry cloth. *Do not use solvent.* Loctite RC/620 develops fixturing strength in approximately 15 minutes. Full cure takes approximately 4 hours.

8. Ream the sleeves to provide an inside diameter of 1.437" to 1.439". After reaming, machine a 35° chamfer into the top end of the sleeves and housing to a depth of .160" to 180" (Fig. 4).

9. Wash all cuttings from the housing. After cleaning, inspect the housing carefully. The beveled openings and inside of the sleeves must be free from burrs and sharp edges to avoid damaging the oil cooler core seal rings at assembly.

© Detroit Diesel Corporation

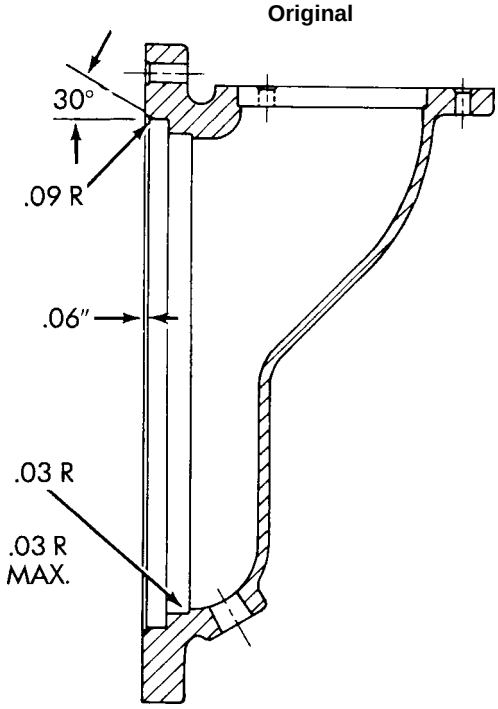
BDC for Manuals - specs - Bolt torques

.REWORK INSTRUCTIONS

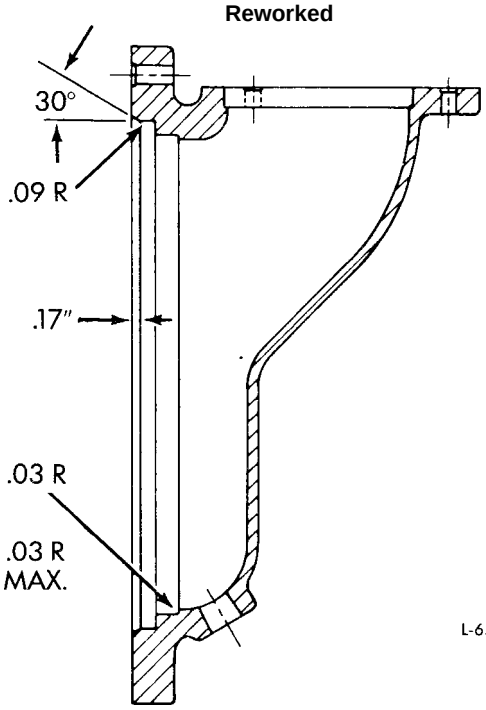
TUBE AND SHELL OIL COOLER WATER INLET HOUSING

Before installing new seals in a cooler assembly having the former water inlet housing, the lead-in chamfer must be machined to a depth of .17" by a reliable machine shop. The original and reworked housings are shown below.

Original



Reworked

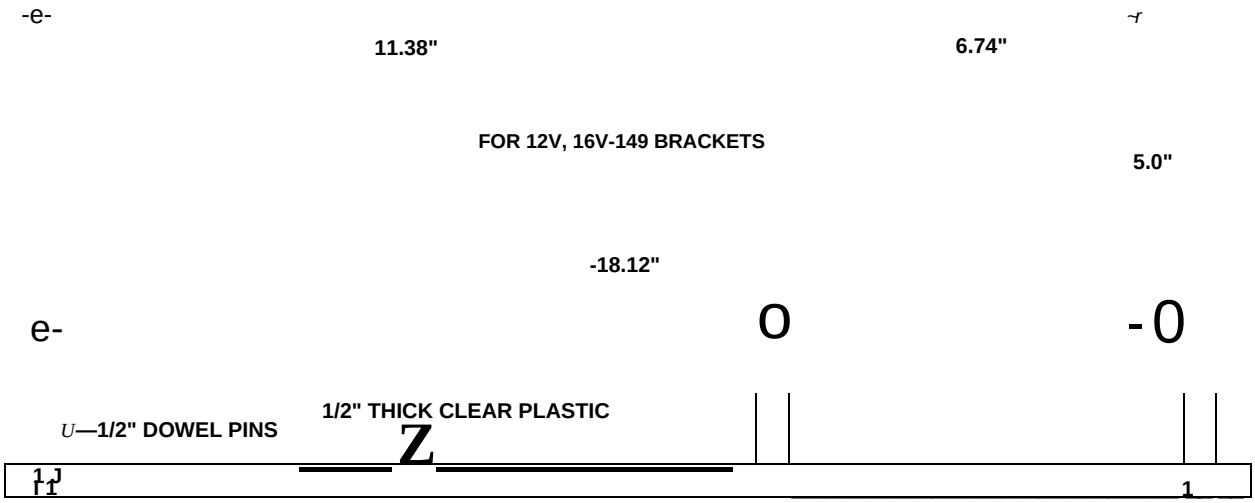


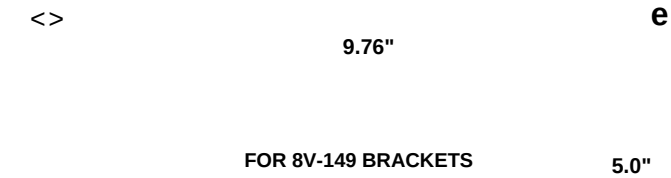
L-6578

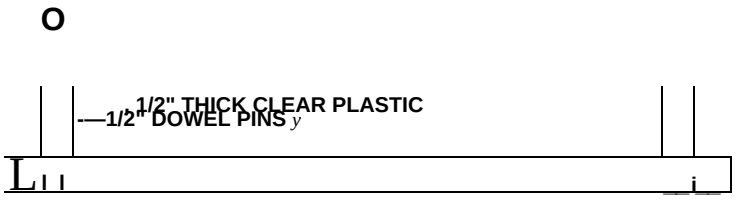
NOTE: The angle and radius of the counterbone remain the same.

BDC for Manuals - specs - Bolt torques

TUBE AND SHELL OIL COOLER MOUNTING BRACKET ALIGNMENT TOOL







NOTE: DIMENSIONS SHOWN ARE HOLE CENTER TO HOLE CENTER

 © Detroit Diesel Corporation

BDC for Manuals - specs - Bolt torques

SPECIFICATIONS

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	260M BOLTS TORQUE (lb—ft)	N»m	THREAD SIZE	280M OR BETTER TORQUE (lb-ft)	l\Um
1/4-20	5-7	7-9	1/4-20	7-9	10-12
1/4-28	6-8	8-11	1/4-28	8-10	11-14
5/16-18	10-13	14-18	5/16-18	13-17	18-23
5/16-24	11-14	15-19	5/16-24	15-19	20-26
3/8-16	23-26	31-35	3/8-16	30-35	41-47
3/8-24	26-29	35^40	3/8-24	35-39	47-53
7/16-14	35-38	47-51	7/16-14	46-50	62-68
7/16-20	43-46	58-62	7/16-20	57-61	77-83
1/2-13	53-56	72-76	1/2-13	71-75	96-102
1/2-20	62-70	84-95	1/2-20	83-93	113-126
9/16-12	68-75	92-102	9/16-12	90-100	122-136
9/16-18	80-88	109-119	9/16-18	107-117	146-159
5/8-11	103-110	140-149	5/8-11	137-147	186-200
5/8-18	126-134	171-181	5/8-18	168-178	228-242
3/4-10	180-188	244-254	3/4-10	240-250	325-339
3/4-16	218-225	295-305	3/4-16	290-300	393^407
7/8-9	308-315	417^427	7/8-9	410-420	556-569
7/8-14	356-364	483-494	7/8-14	475-485	644-657
1-8	435-443	590-600	1-8	580-590	786-800
1-14	514-521	697-705	1-14	685-695	928-942

Grade identification markings are normally stamped on the heads of the bolts. To aid identification of the various bolts used in Detroit Diesel engines, refer to the following chart.

Grade Idenlification Marking on Boll Head	GM Number	SAE Grade Designation	Nominal Size Diameter (inch)	Tensile Strength Min. (psi)
None	GM 255-M	1	No. 6 thru 1 1/2	60,000
None	GM 260-M	2	No. 6 thru 3/4 over 3/4 to 1 1/2	74.000 60.000
/'>. Bolts and Screws	GM 280-M	5	No. 6 thru 1 over 1 to 1 1/2	120,000 105,000
— H e x Head Sems Only	GM 275-M	5.1	No. 6 thru 3/8	120,000
Bolts and Screws	GM 290-M	7	1/4 thru 1 1/2	133,000
Bolts and Screws	GM 300-M	8	1/4 thru 1 1/2	150,000
~ Bolts and Screws	GM 455-M	None	No. 6 thru 1 1/2	55,000

BOLT IDENTIFICATION CHART

© Detroit Diesel Corporation

BDC for Manuals - specs - Bolt torques

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD	TORQUE (lb—ft)	TORQUE (N*m)
Lubricating oil filter center stud	5/8-18	50-60	68-81
Oil cooler bypass retaining plug	1 1/16-16	80-90	108-122
Oil cooler core stud nuts	3/4-10	70-80	95-108
Oil filter bypass valve plug	1 1/4-16	95-105	129-143
Oil filter bypass valve plug	1 1/2-6	110-130	150-177
Oil pan drain plug (nylon washer)	18MM	25-35	34—47

SERVICE TOOLS

TOOL NAME	TOOL NO.
Spring checking gage	J 22738-02
Strap wrench (spin-on filter)	J 24783

© Detroit Diesel Corporation

BDC for Manuals - specs - Bolt torques

SECTION 5

COOLING SYSTEM

CONTENTS

Cooling System 5
Water Pump 5.1
Water Manifold 5.2
Thermostat 5.2.1
Radiator 5.3
Coolant Pressure Control Cap 5.3.1
Engine Cooling Fan 5.4
Heat Exchanger 5.5
Raw Water Pump (Jabsco) 5.6
Coolant Filter and Conditioner 5.7
Shop Notes - Troubleshooting - Specifications
Service Tools 5.0

COOLING SYSTEM

To effectively dissipate the heat generated by the engine, one of three different types of cooling systems is used on the Series 149 engines; radiator and fan, heat exchanger and raw water pump, or keel cooling. Each system is provided with a centrifugal type water pump that circulates the engine coolant. Each system incorporates thermostats to maintain a normal engine operating temperature (refer to Section 13.2).

© Detroit Diesel Corporation

BDC for Manuals - specs - Bolt torques

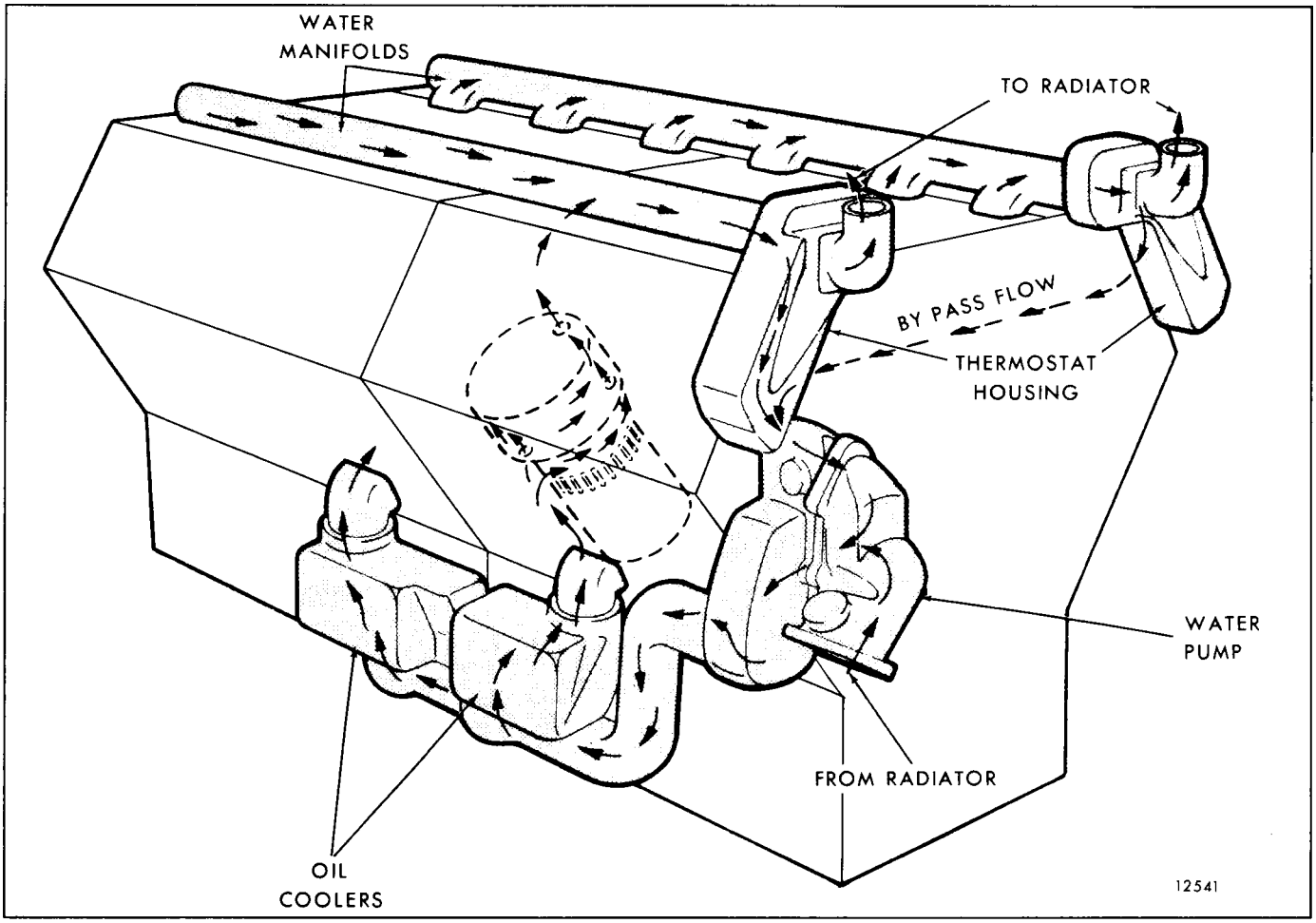


Fig. 1 – Schematic Diagram of Typical Engine Cooling System

RADIATOR COOLING SYSTEM

Coolant is drawn from the lower portion of the radiator by the water pump and is forced through the oil cooler housing and into the cylinder block (Fig. 1).

From the cylinder block, the coolant passes up through the cylinder heads into the water manifold and, when the engine is at normal operating temperature, through the thermostats into the upper portion of the radiator. The coolant passes down a series of tubes where its temperature is lowered by the air stream created by the revolving fan.

Upon starting a cold engine or when the coolant is below operating temperature, the coolant is restricted at the thermostats and a bypass provides water circulation within the engine during the warm-up period.

HEAT EXCHANGER COOLING SYSTEM

In the heat exchanger cooling system, the coolant is drawn by the engine water pump from the heat exchanger and is forced through the engine oil cooler, cylinder block, cylinder heads, exhaust manifolds and water manifolds to the thermostat housings. A bypass from the thermostat housings to the inlet side of the water pump permits circulation of coolant through the engine when the thermostats are closed. When the thermostats are open, the coolant flows through the heat exchanger where it is cooled.

Engine driven raw water pumps circulate raw water (sea water) through the heat exchanger to lower the temperature of the engine coolant.

 © Detroit Diesel Corporation

BDC for Manuals - specs - Bolt torques

KEEL COOLING SYSTEM

In the keel cooling system, the coolant is drawn by the engine water pump from the keel cooler and is forced through the engine oil cooler, cylinder block, cylinder heads and exhaust manifolds and to the thermostat housings. A bypass from the thermostat housings to the inlet side of the water pump permits circulation of coolant through the engine when the thermostats are closed. When the thermostats are open, the coolant flows through the keel cooling coils to be cooled.

The heat of the engine coolant is transferred through the coils of the keel cooler to the surrounding sea water.

THESE OPTIONS ARE PROPOSED TO PREVENT BLEED-OFF OF THE MAIN AIR SUPPLY AND TO PREVENT COOLING SYSTEM PRESSURIZATION WHEN THE ENGINE IS NOT IN OPERATION

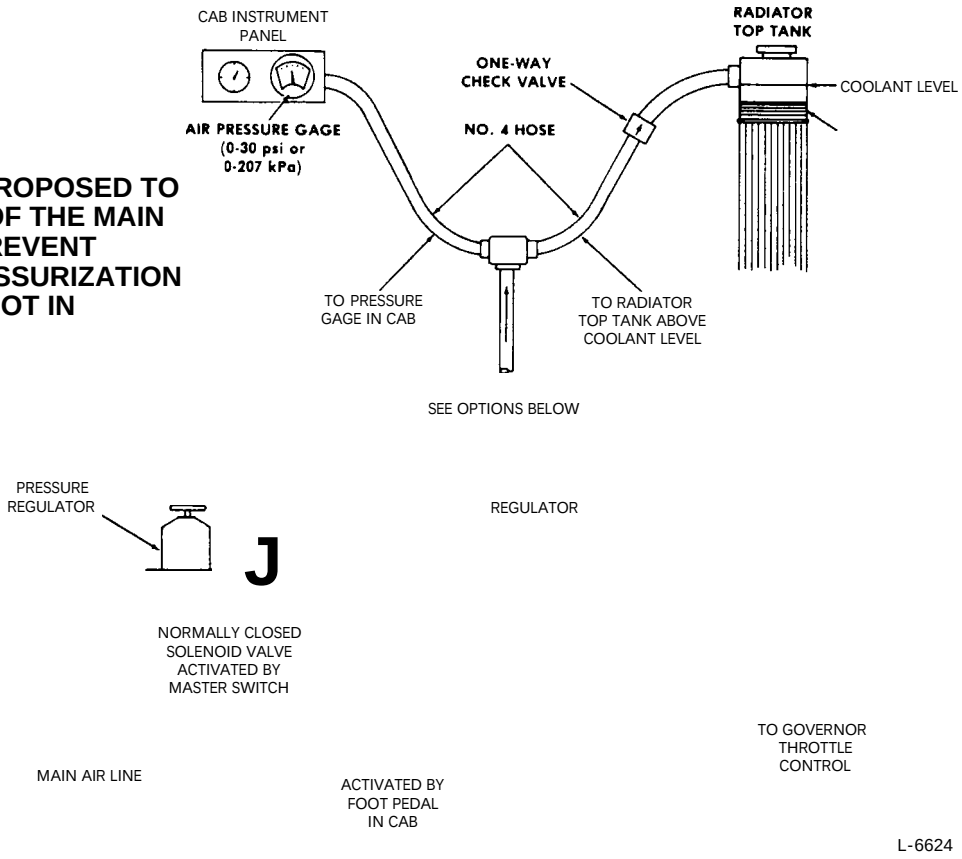


Fig. 2 - Pressurized Top Tank Installation

COOLING SYSTEM REQUIREMENTS FOR DIRECT RADIATOR-COOLED ENGINES

Pressurized Cooling System

The cooling system must be pressurized to operate properly. Pressure in the cooling system prevents cavitation, suction leaks and localized boiling.

System pressure is produced by the expansion of the coolant as it is heated. Checking the coolant level while coolant temperature is hot will result in a loss of this pressure. This pressure may not be completely restored until the system is allowed to cool and then heated again. To avoid this situation an auxiliary air supply is required to maintain system pressure (see Fig. 2). The pressure from this air supply should be regulated to 7-10 psi (48.3-68.9 kPa).

© Detroit Diesel Corporation

BDC for Manuals - specs - Bolt torques

MAXIMUM ENGINE COOLANT TEMPERATURE

The heat dissipating capacity of the Series 149 engine cooling system and related components must be sufficient to prevent the engine coolant-out temperature from rising above 200°F (93.3°C). This temperature must not be exceeded under any engine operating condition, regardless of altitude, type of coolant used, or cooling system condition.

When the cooling system is sized properly, the engine will operate under thermostat control so that the coolant-out temperature is between 170°F and 187°F (76.7°C-86°C) the majority of the time. Maximum engine life will be obtained when the engine is operating under thermostat control. Coolant temperatures above 187°F (86°C) are out of thermostatic control and will rise on a 1 to 1 basis with an increase in the ambient air temperature.

Site Conditions:	
Operating site altitude	**8000 Feet**
Maximum recorded temperature at nearest official temperature recording station	**IOf F (38.36°C)**
Site temperature difference compared to nearest temperature recording station	**+ 4° F (2.22°C)**
Special site conditions	**2° F (1.11° C)**
Type of coolant (Ethylene Glycol/Water)	**50/50 Mix**
Calculations:	
Maximum allowed coolant-out temperature	**200° F (93°C)**
Altitude compensation (2° F/1000 Ft) 8000 Ft/1000 +2° F	**-16° F (-8.89° C)**
Maximum recorded temperature	**-101° F (-56.16° C)**
Temperature difference, operating site to official weather station	**—4° F (-2.22° C)**
Recirculation effects	**—2° F (-1.11° C)**
Coolant compensation	**—6° F** *(-3.33C)*
Cooling index requirement (ATW) Corrected to sea level	**71° F (21.7° C)**
Conclusions:	
The measured cooling index (ATW) for this application must be 71° F (21.7° C) or less to qualify at this operating site.	

Fig. 3 - Sample Calculation for Determining Required Cooling Index

COOLING INDEX

The cooling index is a measurement that represents differences between the stabilized coolant-out temperature and the true ambient air temperature while the engine is operating under full load conditions at rated speed with the thermostats fully open. This temperature difference is referred to as "ATW" (air-to-water) and indicates the performance of the cooling system. The cooling index is corrected to sea level so that it can be compared to cooling index requirements for specific operating sites. Smaller ATW values have greater cooling capability than larger ATW values.

A *new measured cooling index must be determined if changes are made to the application that influence engine cooling. These changes include increasing the horsepower, altering fan pitch, fan size, shrouding or baffles around the radiator, any site condition or operating location changes.*

COOLING INDEX REQUIREMENT

The *cooling index requirement* is a calculated number representing the maximum allowable cooling index (ATW) that will provide adequate engine cooling. This number is based on the requirement that the engine coolant-out temperature must not exceed 200°F (93.3°C) during the most severe ambient conditions for a specific operating site. The number is calculated by applying correction factors for altitude, maximum operating temperature, and type of coolant from the maximum engine coolant-out temperature. A brief description of these parameters follows (see Fig. 3 for sample calculation):

ALTITUDE

Increasing altitude reduces air density and the ability of the cooling system to dissipate engine heat to the air. Higher altitudes will increase the cooling index by 2°F (1.1°C) per 1000 feet (305m). Altitude corrections to sea level are applied to the cooling index and the

© Detroit Diesel Corporation

BDC for Manuals - specs - Bolt torques

cooling index requirement for comparative purposes. Minimum cap pressure at all altitudes is 14 psi (96.6 kPa).

MAXIMUM OPERATING SITE TEMPERATURE

When calculating the cooling index requirements, the maximum ambient temperature for the operating location must be determined. To establish this temperature, the nearest official weather recording station must be consulted to determine the highest ambient temperature ever recorded at that station. Once this is established, the difference between that station and the operating site must be determined. For example, a characteristic of deep pit mines is that the pit tempertaure can be as much as 30°F (16.7°C) higher than the ambient temperature recorded in the nearest official temperature recording station. Combining the maximum weather station recorded temperature with the difference of the operating site and weather station temperatures, will extablish the maximum ambient temperature design criteria for the cooling system. Furthermore, additional variations in ambient temperature can occur on the same haul road due to tail winds causing recirculation of air around the radiator, pit wall radiated heat, etc. *Actual tests should be conducted to establish the highest ambient temperature encountered during a haul cycle, including the effect of winds and radiated heat.*

ENGINE COOLANT

The use of ethylene glycol antifreeze reduces the ability of the cooling system to dissipate heat. For example, a 50/50 mixture of water and ethylene glycol (the maximum concentration of antifreeze recommended by DDC) will increase the measured cooling index by 6°F (3.3°C). Water is generally used for the coolant when the cooling test is performed. Therefore, *the cooling index requirement must be reduced by* 6°F *(3.3°C) if antifreeze is to be used in the application.*

SHORT DURATION FULL LOAD OPERATION

In cases where *full-fuel* operation is less than 8 minutes and the duty cycle *will not* increase, test data has shown that the cooling index requirement can be increased. *Written concurrence by DDC's Engineering Department is necessary to exceed the cooling index requirement.*

ENGINE COOLING SYSTEM MAINTENANCE

The function of the engine coolant is to absorb the heat, developed as a result of the combustion process in the cylinders, from components such as exhaust valves, pistons and cylinder liners which are surrounded by water jackets. In addition, heat absorbed by the oil is also removed by the engine coolant in the oil-to-water oil cooler. When operating within the proper temperature range and not exceeding the recommended horsepower output of the unit, all engine parts will be within their design operating temperature range and at their proper operating clearances. Coolant must be properly selected and maintained (refer to Section 13.3 for *Coolant Specifications).*

A pressurized cooling system, which normally operates at temperatures higher than a non-pressurized system, is used. It is essential that the cooling system is kept clean and leakproof, that the filler cap and pressure relief mechanism be correctly installed and that the coolant level be properly maintained.

CAUTION: Use extreme care when removing a coolant pressure control cap. The sudden release of pressure from a heated cooling system can result in loss of coolant and possible personal injury (scalding) from the hot liquid.

Cooling System Capacity

The capacity of the basic engine cooling system (cylinder block, cylinder heads, water manifolds, thermostat housings and oil cooler housing) is shown in Table 1. These quantities do not include the capacity of the radiator, hoses or related parts.

BASIC ENGINE COOLANT CAPACITY

BASIC ENGINE	QUARTS	LITERS
8V-149TI (Standard)	91	86.1
8V-149TI (Large)	95	89.9
12V-149	142	134.4
12V-149T	142	134.4
12V-149TI (Standard)	148	140.1
12V-149TI (Standard, T&S)	147	139.1
12V-149TI (Large, T&S)	151	142.9
16V-149	175	165.6
16V-149T	175	165.6
16V-149TI (Standard)	182	172.2
16V-149TI (Standard, T&S)	181	171.3
16V-149TI (Large, T&S)	187	177.0

"Standard" and "Large" Indicate Size of Intercoolers.
"T&S" Means Tube and Shell Oil Cooler.

TABLE 1

Fill Cooling System

To permit proper filling of the cooling system, it is necessary that an air bleed hose be installed between the top

BDC for Manuals - specs - Bolt torques

of each thermostat housing and the radiator top tank (Section 5.3), or the top of the expansion tank (Section 5.5).

Before starting the engine, close all of the drain cocks and fill the cooling system with coolant (refer to Section 13.3). If the unit has a raw water pump, it should be primed, since operation without water may cause impeller failure. Start the engine and, after the normal operating temperature has been reached, check the coolant level. The coolant level should be within two inches of the top of the filler neck.

CAUTION: Use extreme care when removing a coolant pressure control cap. The sudden release of pressure from a heated cooling system can result in loss of coolant and possible personal injury (scalding) from the hot liquid.

Should a daily loss of coolant be observed, and there are no apparent leaks, there is a possibility that gases are leaking past the cylinder head water seal rings into the cooling system. The presence of air or gases in the cooling system may be detected by connecting a rubber tube between the overflow pipe and a container of water. Bubbling of the water in the container during engine operation will indicate leakage. Another method for observing air in the cooling system is by inserting a transparent tube in the engine coolant outlet line.

Drain Cooling System

To ensure that all of the coolant is drained completely from a unit, all cooling system drains should be opened. Should any entrapped water in the cylinder block or radiator freeze, it will expand and may cause damage. When freezing weather is expected, drain all units not adequately protected by antifreeze. Leave all drain cocks open until refilling the cooling system.

The engine coolant is drained by opening the drain cocks and removing the cooling system filler cap. Removal of the filler cap permits air to enter the cooling passages and the coolant to drain completely from the system.

Drain cocks are located on each side of the cylinder block at both the front and rear of the engine. The drain cocks are below the exhaust manifold.

In addition to the cylinder block drains, the oil cooler housing has a drain cock at the extreme bottom. Radiators are drained by opening a drain cock in the bottom of the tank.

Marine engine exhaust manifolds are cooled by the same coolant used in the engine. Whenever the engine cooling system is drained, open the exhaust manifold drain cocks.

Raw water pumps are drained by loosening the cover attaching screws and tapping the cover gently to loosen it. After the water has drained, tighten the screws.

An engine equipped with intercoolers has a cone shaped water filter (screen) at the water connection in the water pump to the engine oil cooler tube. Refer to Section 15.1 for service and preventive maintenance.

Flushing

If a coolant filter or corrosion inhibitor supplement is used and properly maintained, the cooling system need not be flushed. However, if the cooling system was not properly protected, drain and flush the cooling system each fall. Examine the cooling system for contamination and, if necessary, chemically clean it. Perform the flushing operation as follows:

1. Drain the coolant from the engine.
2. Refill with soft clean water.

   NOTICE: If the engine is hot, fill *slowly* to prevent rapid cooling and distortion of the engine castings.
3. Start the engine and operate it for fifteen minutes to thoroughly circulate the water.
4. Drain the engine completely.
5. Refill with the solution required (refer to Section 13.3).

Cooling System Cleaners

If the engine overheats, and the fan belt tension and water level have been found to be satisfactory, it may be necessary to clean and flush the entire cooling system. Remove scale formation by using a reputable and safe descaling solvent. Immediately after using the descaling solvent, neutralize the system with the neutralizer. It is important that the directions printed on the container of the descaler be thoroughly read and followed.

After the solvent and neutralizer have been used, completely drain the engine and radiator and reverse flush, as outlined below, before filling the system.

Reverse Flushing

After the engine and radiator have been thoroughly cleaned, they should be reverse flushed. The water pump should be removed and the radiator and engine reverse flushed separately to prevent dirt and scale deposits clogging the radiator tubes or being forced through the pump. Reverse flushing is accomplished by hot water, under air pressure, being forced through the cooling system in a direction opposite to the normal flow of coolant, loosening and forcing scale deposits out.

The radiator is reverse flushed as follows:

1. Remove the radiator inlet and outlet hoses and replace the radiator cap.
2. Attach a hose at the top of the radiator to lead water away from the unit.

 © Detroit Diesel Corporation

BDC for Manuals - specs - Bolt torques

3. Attach a hose to the bottom of the radiator and insert a flushing gun in the hose.
4. Connect the water hose of the gun to the water outlet and the air hose to the compressed air outlet.
5. Turn on the water and, when the radiator is full, turn on the air in short blasts, allowing the radiator to fill between air blasts.

NOTICE: Apply air gradually. Do not exert more than 30 psi (207 kPa) air pressure. Too great a pressure may rupture a radiator tube.

6. Continue flushing until only clean water is expelled from the radiator.

The cylinder block and cylinder head water passages are reverse flushed as follows:

1. Remove the thermostats and the water pump.
2. Attach a hose to the water inlet of the cylinder block or cylinder head to drain the water away from the engine.
3. Attach a hose to the water outlet at the top of the cylinder block or cylinder head and insert the flushing gun in the hose.
4. Turn on the water and, when the water jackets are filled, turn on the air in short blasts, allowing the block or head to fill with water between air blasts.
5. Continue flushing until the water from the engine runs clean.

If scale deposits in the radiator cannot be removed by chemical cleaners or reverse flushing as outlined above, it may be necessary to remove the upper tank and rod out the individual radiator tubes with flat steel rods. Circulate water through the radiator core from the bottom to the top during this operation.

Miscellaneous Cooling System Checks

In addition to the above cleaning procedures, the other components of the cooling system should be checked periodically to keep the engine operating at peak efficiency. The cooling system hoses, thermostats and radiator pressure cap should be checked and replaced if found to be defective.

When water connection seals and hoses are installed, be sure the connecting parts are properly aligned and the seal or hose is in its proper position before tightening the clamps.

All external leaks should be corrected as soon as detected.

The fan belt must be checked and adjusted, if necessary, to provide the proper tension. The fan shroud must be tight against the radiator core to prevent recirculation of air which may lower the cooling efficiency.

Contaminated Engines

When the engine cooling or lubricating system becomes contaminated, it should be flushed thoroughly to remove the contaminants before the engine is seriously damaged. One possible cause of such contamination is a cracked oil cooler core. With a cracked oil cooler core, oil will be forced into the cooling system while the engine is operating, and when it is stopped, coolant will leak into the lubricating system.

Coolant contamination of the lubricating system is especially harmful to engines when the cooling system is filled with an ethylene glycol antifreeze solution. If mixed with the oil in the crankcase, this antifreeze forms a varnish which can cause the engine to seize or result in severe bearing wear.

Make certain that the cause of the internal coolant leak has been corrected before flushing the contaminated systems.

Contaminants may be flushed from the engine systems as follows:

COOLING SYSTEM

If the engine has had a failure resulting in the contamination of the cooling system with lubricating oil, the following procedure is recommended.

1. Prepare a mixture of Calgon, or equivalent, and water at the rate of two ounces (dry measure) to one gallon of water.
2. Remove the engine thermostats to permit the Calgon and water mixture to circulate through the engine and the radiator or heat exchanger.
3. Fill the cooling system with the Calgon solution.
4. Run the engine for five minutes.
5. Drain the cooling system.
6. Repeat Steps 1 through 5.
7. Fill the cooling system with clean water.
8. Let the engine run five minutes.
9. Drain the cooling system completely.
10. Install the engine thermostats.
11. Close all of the drains and refill the cooling system with fresh coolant (refer to Section 13.3).

LUBRICATION SYSTEM

• When the engine lubricating system has been contaminated by an ethylene glycol antifreeze solution or other water soluble material, the following cleaning procedure, using DPM (Dipropylene Glycol Methyl Ether), or equivalent, is recommended.

CAUTION: Use extreme care in the handling of these chemicals to prevent serious injury to the person or damage to finished surfaces. Wash off spilled fluid immediately with clean water.

BDC for Manuals - specs - Bolt torques

1. Drain all of the lubricating oil.
2. Remove and discard the oil filter elements. Clean and dry the filter shells and replace the elements.
3. Mix two parts of DPM, or equivalent, with one part SAE 10 engine oil. Fill the engine crankcase to the proper operating level with the mixture.
4. Start and run the engine at a fast idle (1,000 to 1,200 rpm) for thirty minutes to one hour. Check the oil pressure frequently.
5. After the specified time, stop the engine and immediately drain the crankcase and the filters. *Sufficient time (approximately twenty minutes) must be allowed to drain all of the fluid.*
6. Replace the drain plugs and refill the crankcase with SAE 10 oil and run the engine at the same fast idle for ten or fifteen minutes and again drain the oil thoroughly.
7. Remove and discard the oil filter elements, clean the filter shells and install new elements.
8. Replace the drains and fill the crankcase to the proper level with the oil recommended for normal engine operation.
9. To test the effectiveness of the cleaning procedure, it is recommended that the engine be started and run at a fast idle (1,000 to 1,200 rpm) for approximately thirty minutes. Then, stop and immediately restart the engine. There is a possibility that the engine is not entirely free of contaminant deposits if the starting speed is slow.
10. If the procedure for cleaning the lubricating oil system was not successful, it will be necessary to disassemble the engine and to clean the affected parts thoroughly.

Make certain that the cause of the internal coolant leak has been corrected before returning the engine to service.

MAXIMUM ENGINE COOLANT TEMPERATURE

The heat-dissipating capacity of Series 149 engine cooling systems and related components must be sufficient to prevent the coolant temperature from rising above 200°F (93°C). This temperature must not be exceeded under any engine operating condition, regardless of altitude, type of coolant used, or cooling system condition. Exceeding this limit can result in malfunction or serious engine damage.

TEMPERATURE CONTROL COMPONENTS

These engines are designed to operate with 160°F (71°C) or 170°F (77°C) thermostats which, combined with a radiator or heat exchanger, regulate coolant temperature within a range of 160°F - 177°F (71°C - 81°C) or 170°F - 187°F (77°C - 86°C). Many engines also use radiator shutters, clutch fans or combinations of both to help control coolant temperature. These “add on” cooling system components must operate in proper sequence to prevent coolant temperature instability and/or engine overheating.

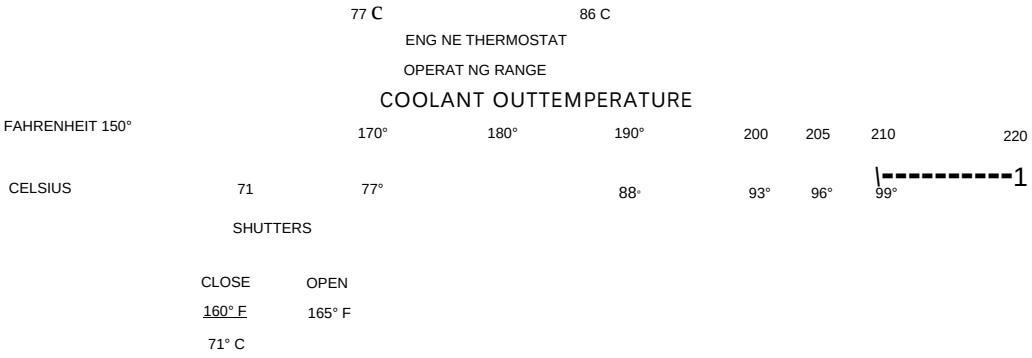
A badly adjusted operating sequence can also have a detrimental effect on the life of the “add on” components as well.

The following chart gives the recommended temperature settings for various coolant temperature control devices. These settings should not be exceeded, since this will unnecessarily increase the engine coolant and lubricating oil temperature, possibly resulting in serious engine damage.

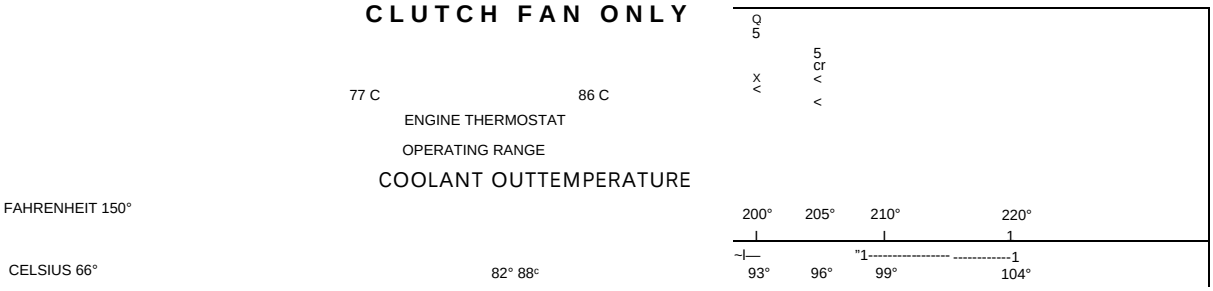
© Detroit Diesel Corporation

BDC for Manuals - specs - Bolt torques

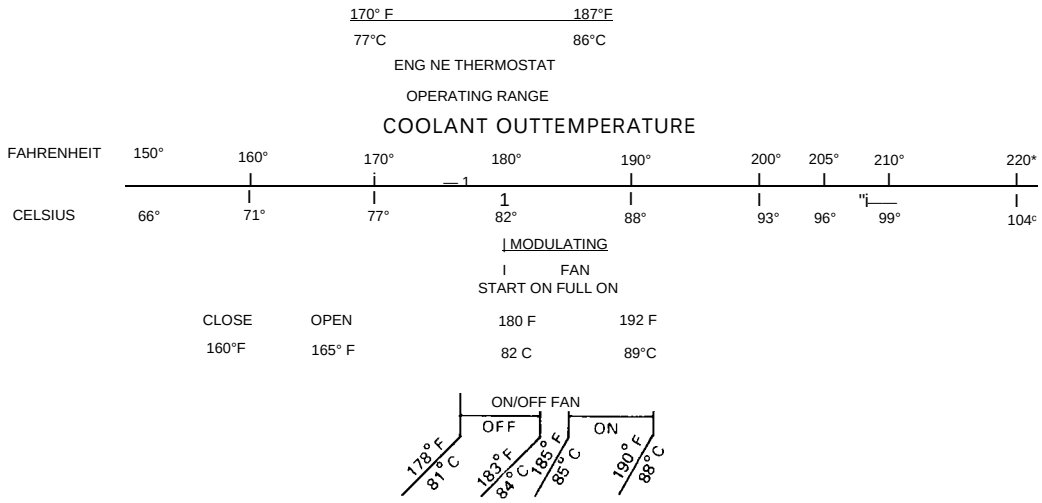
SHUTTERS ONLY



CLUTCH FAN ONLY



CLUTCH FAN AND SHUTTER COMBINATION



NOTE: For engines with 160 F thermostats, reduce shutter and clutch fan operating temperatures by 10°F; reduce Celsius temperatures by 6°C. Maximum and alarm temperatures remain at 200°F (93°C) and 205°F (96°C), respectively.

CHART - 170°F Thermostat

© Detroit Diesel Corporation

BDC for Manuals - specs - Bolt torques

WATER PUMP

The centrifugal-type water pump (Fig. 1) circulates engine coolant through the oil coolers, cylinder block, cylinder heads and radiator.

The pump is mounted on the engine front cover and is driven by the front crankshaft gear through two idler gears.

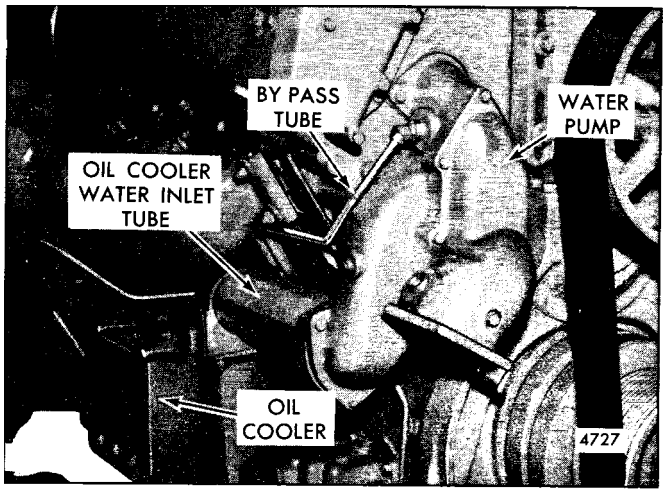


Fig. 1 - Water Pump Mounting

A bronze impeller is secured to one end of a stainless steel shaft by a locknut. A drive gear is pressed on the opposite end of the shaft. Two ball bearings are used to carry the shaft. The larger bearing is used at the drive gear end of the shaft to accommodate the thrust load.

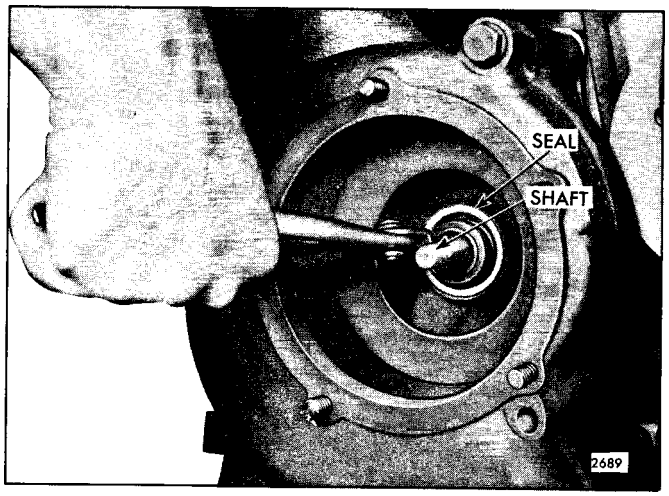


Fig. 2 - Removing Water Seal from Pump

An oil seal is located in front of the smaller bearing and a spring-loaded face-type water seal is used behind the impeller.

Refer to *Troubleshooting* in Section 5.0 for combustion gas leakage into the cooling system.

To prevent water pump weep hole plugging on engines working in a dirty environment, periodically push a piece of wire into the weep hole and pull out any dirt that may be in there. The hole must remain open, draining any coolant that may leak past the water seal and preventing it from accumulating and possibly contaminating the bearings or engine oil with coolant.

Lubrication

The pump bearings are lubricated with oil splashed by the water pump gear.

Replace Water Seal

The water seal can be replaced without removing the pump if the radiator, fan and fan shroud have been removed.

1. Remove the pump cover and gasket (Fig. 3).
2. Remove the locknut and washer and withdraw the impeller with puller J 24420-A.
3. Grasp the water seal assembly with suitable pliers and pull the seal out of the retainer (Fig. 2).
4. To prevent possible coolant leakage, apply a light coat of non-hardening sealant to the outside diameter of a new water seal. Then, tap the seal into the seal cavity with a suitable sleeve which has an inside diameter large enough to fit around the seal and rest on the brass cartridge lip.

•5. Inspect the water pump impeller for wear (erosion) and reuse or replace, as required. If the impeller is reused, the ceramic impeller insert *must* be replaced. Use a new ceramic insert on the impeller and bond it to the impeller, as follows:

   a. Bake the insert and impeller assembly at 500°F (260°C) for 90 minutes. The insert can be removed easily while the adhesive is hot. After removing the insert, clean the insert area on the impeller with sandpaper, wire brush or a buffing wheel to remove the old adhesive, oxide, scale, etc.

   b. Wet a clean cloth with suitable solvent such as alcohol and thoroughly clean the impeller insert area and the grooved side of a new ceramic insert. Then, wipe the parts with a clean, dry cloth.

   c. Place the adhesive washers (2) in the impeller bond area with the ceramic insert on top. The polished face of the ceramic insert should be visible to the assembler.

© Detroit Diesel Corporation

BDC for Manuals - specs - Bolt torques

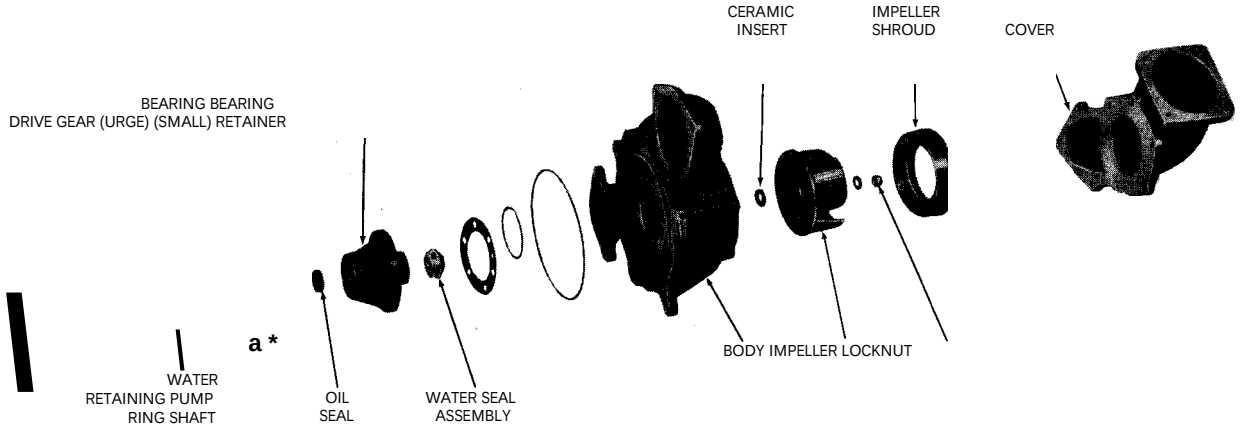


Fig. 3 - Water Pump Details and Relative Location of Parts (8V, 12V-149 Pump Shown)

Clamp the ceramic insert and impeller together with a 3/8" bolt and nut and two *smooth* .125" thick washers. Tighten the bolt to 10 lb—ft (14 Nam) torque.

NOTICE: Do not mar the polished surface of the ceramic insert.

d. Place the impeller assembly in a level position, with the ceramic insert up, in an oven preheated to 350°F (17TC) for one hour. The face of the ceramic insert must be square with the axis of the tapered bore within .004". The pump shaft may be used as a mandrel for this inspection.

e. Remove the impeller from the oven and, after it has cooled to room temperature, install it in the pump. Do not loosen and remove the clamping bolt and washers until the assembly cools.

6. Make sure the mating surfaces of the water seal and the ceramic insert are free of dirt, metal particles and oil film.

7. Apply a small quantity of International Compound No. 2, or equivalent, to the threads of the pump shaft.

8. Place the impeller and washer on the shaft and start a new lock washer on the shaft. Hold the pump gear securely while drawing the impeller down on the shaft with the locknut. Tighten the nut to 35-40 lb—ft (47-54 N«n) torque.

9. Use a new gasket and install the water pump cover. Tighten the nuts securely.

Remove Pump

1. Drain the engine cooling system. Refer to Section 5.

2. If necessary, remove the radiator, fan shroud and fan.

3. Remove the three bolts, two nuts and lock washers securing the water pump to the oil cooler inlet tube.

4. Remove the four bolts, nuts and lock washers securing the water pump to the radiator or heat exchanger outlet tube.

5. Remove the nut and lock washer at the back side of the water pump.

6. Remove the seven bolts and lock washers securing the water pump to the front cover and remove the water pump. Be careful not to damage the gear teeth while removing the water pump.

When removing the water pump on engines built prior to engine 12E-215, be sure to remove the bolt located inside the water pump cover. The bolt may be reached by using a socket and rachet and working through the inlet opening.

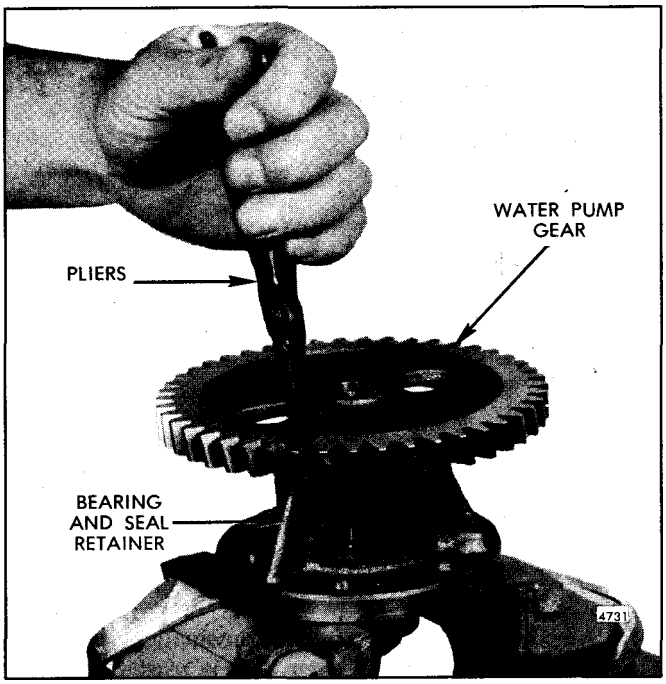


Fig. 4 - **Removing Retaining Ring with Pliers** J 4646

 © Detroit Diesel Corporation

BDC for Manuals - specs - Bolt torques

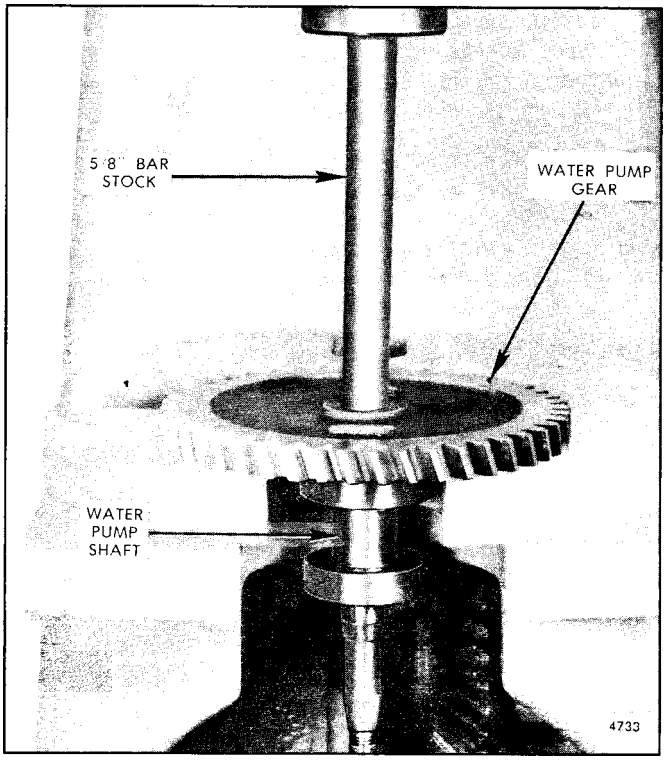


Fig. 5 - Pressing Shaft Out of Gear

7. Remove the two water seal rings from the back side of the water pump.

Disassemble Pump

NOTICE: Refer to Fig. 3 unless otherwise indicated.

1. Remove the pump cover and gasket.
2. With a suitable puller, remove the impeller shroud from the pump body (12V-149 engines only).
3. Remove the locknut and washer and withdraw the impeller with puller J 24420-A.
4. Remove the six nuts and lock washers securing the bearing retainer to the water pump and remove the bearing retainer from the pump body.
5. Turn the pump gear so the slot is over the ends of the bearing retaining ring, insert pliers J 4646 into the slot and, with the aid of a small screw driver, remove the ring from the groove (Fig. 4).
6. While supporting the bearing and seal retainer, tap the threaded end of the shaft lightly with a soft hammer to separate the shaft and bearing assembly from the retainer.
7. Place the gear on the bed of an arbor press with the shaft extending downward. Then, place a short piece of .6250" diameter bar stock between the shaft and the ram of the press and press the shaft out of the gear as shown in Fig. 5.
8. Support the shaft assembly on the inner race of the large bearing with the threaded end down. Place a flat plate between the ram of the press and the shaft and press the pump shaft out of the large bearing.
9. Invert the shaft, support it on the inner race of the small bearing and repeat the process described in Step 8.
10. Pry the water seal out of the bearing retainer with a screw driver, if necessary.
11. Push the oil seal out of the retainer.

NOTICE: The water and oil seals must not be reused if they are removed. A new ceramic impeller insert must be used if the seals were removed.

Inspection

Wash all of the pump parts in clean fuel oil, dry them with compressed air.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Inspect parts for cracks, wear or other damage. Replace damaged or worn parts. A new ceramic insert must be used. Refer to *Replace Water Seal.*

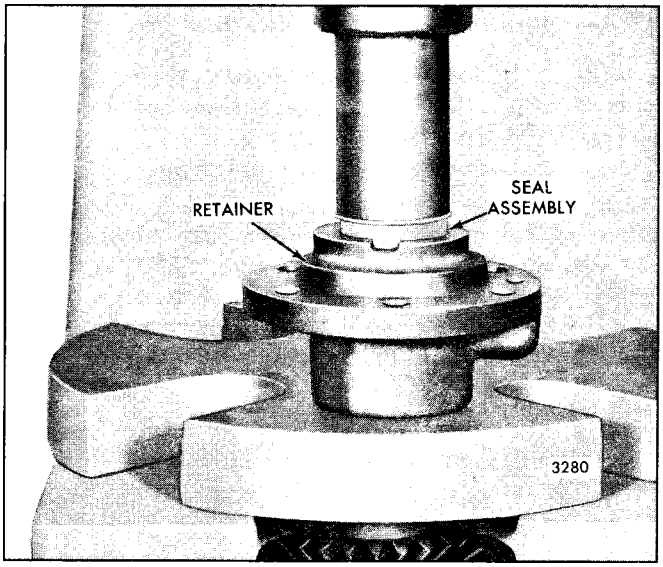


Fig. 6 - Installing Water Seal Assembly

• Inspect impeller and shaft taper area. If either the shaft taper or the impeller taper shows evidence of wear, circular score lines, scratches or abrasion, the worn part must be replaced. If a new shaft is used, make sure it has an “H” marked on the gear end.

Examine the bearings for corrosion, pitting, wear and freedom of movement. Apply engine oil to the bearings; hold the inner race and slowly revolve the outer race to check for roughness. Replace the bearings, if necessary.

© Detroit Diesel Corporation

BDC for Manuals - specs - Bolt torques

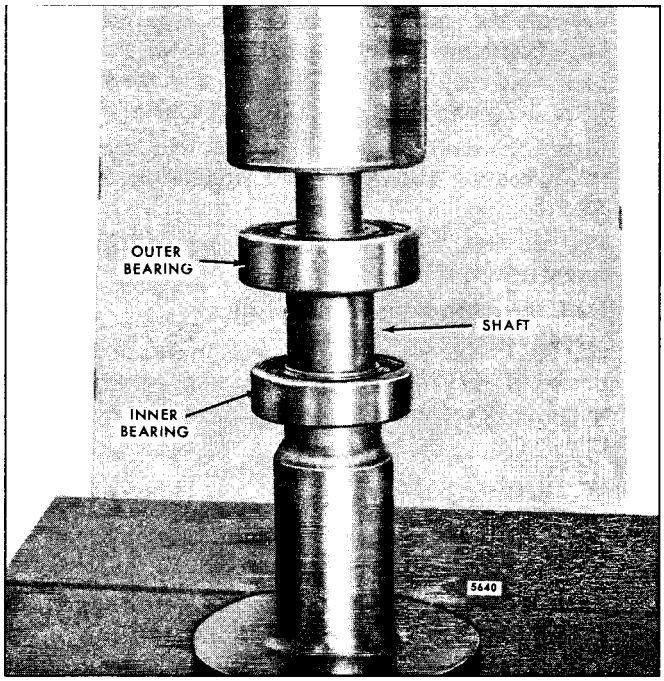


Fig. 7 - Pressing Bearing on Pump Shaft using Tool J 25257

NOTICE: When replacing an inner or outer bearing, always replace the other bearing.

Check the studs in the water pump body for damage. Apply a sealant to the threads of new studs and drive them in to 20-30 lb—ft (27-41 N«m) torque.

The current water pump used on 16V engines (except marine) has a strengthened pump body. All other pump components remain the same. However, the water inlet bolt circle diameter has been increased from 6.250" to 6.390" requiring a new water inlet elbow and gasket. When a new service pump or body assembly is used, the new elbow and gasket must be included to ensure interchangability.

Assemble Pump

Assemble the water pump, as follows:

1. Lubricate the bearing bores and shaft bearing surfaces. Use bearing and gear installer J 25257 and press the ball bearings against the shoulders on the shaft (Fig. 7).
2. Support the bearing retainer on the bed of an arbor press, water seal end down, and press the shaft and bearing assembly into the retainer. Make sure shaft is marked with “H” on gear end.

   NOTICE: Apply pressure to the outer race of the large bearing only when installing the shaft and bearing assembly in the retainer.

3. Install the bearing retainer ring.
4. With gear installer J 25257 positioned on the impeller end of the shaft, place the water pump on the bed of an arbor press. Press the gear on the shaft so it is flush with the end of the shaft.
5. Affix a new gasket and install the bearing retainer on the pump body with six lock washers and nuts. Tighten the nuts.
6. Apply a film of engine oil to the circumference of the oil seal and place it on installer J 8501 with the lip of the seal away from the tool.
7. Use a suitable sleeve and tap the seal into place until the edge of the seal is flush with the edge of the seal cavity on the bearing side.
8. To reduce possible coolant leakage, apply a light coat of suitable non-hardening sealant on the outside diameter of a new water seal. Then, press the seal assembly in place with a suitable sleeve, with an inside diameter large enough to fit around the seal and resting on the brass cartridge lip.
9. Make sure the mating surfaces of the water seal and the ceramic insert are clean and free of dirt, metal particles, grease or oil film.

   NOTICE: The gear and impeller on the shaft must withstand a torque of 80 lb—ft (108 N*m) without slipping.

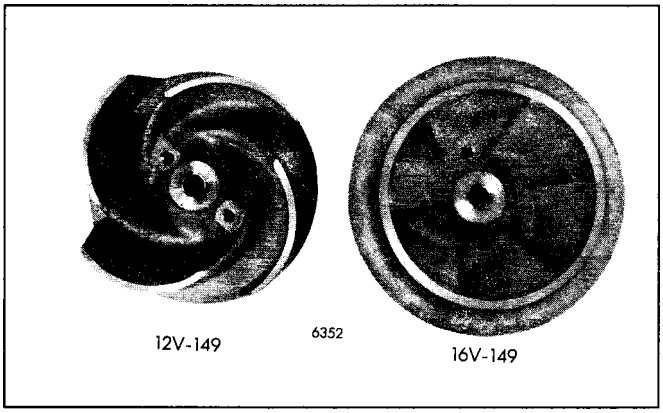


Fig. 8 - Water Pump Impeller Identification

Always install the proper impeller when overhauling a Series 149 engine fresh water pump. The 12V-149 engine fresh water pump is smaller than the 16V-149 engine pump and uses an impeller with a separate impeller shroud. The 16V-149 pump uses an impeller with a cast-in shroud (Fig. 8).

Though a 12V-149 pump impeller will fit into the larger 16V-149 pump housing, it is not functionally interchangeable and should not be installed in the 16V-149 pump. Failure to install the correct impeller can result in pump cavitation, insufficient coolant flow and serious engine damage.

© Detroit Diesel Corporation

BDC for Manuals - specs - Bolt torques

NOTICE: Never attempt to reuse the impeller ceramic insert, regardless of its apparent condition. During water pump operation, the seal contacts the surface of the ceramic insert and takes on a wear pattern that may not be easily detected. If a new seal with a new surface is installed against the old insert, the wear pattern on the ceramic may not provide proper contact with the seal face, causing a leak between the two surfaces. To avoid this possibility, always replace the ceramic insert or the impeller assembly with insert at the time of overhaul.

*10. With the water pump assembly sitting squarely on the table of an arbor press, place a 1" x 5/8" piece of bar stock under the pump shaft at the drive gear end. *This is necessary to prevent damaging the shaft bearings, breaking the retaining ring, or moving the large water pump shaft bearing off its seat during impeller installation.*

11. Place a 4" x 5/8" brass sleeve over the threaded end of the shaft. This will protect the threads during impeller installation.

12. Position the water pump impeller over the end of the shaft so the ceramic insert faces the gear end of the pump and mates with the water seal surface. With a force of 400 lbs. (1779 Newtons) min. to 600 lbs. (2669 Newtons) max., press the impeller onto the shaft until firmly seated.

13. Lubricate the threads of the shaft with a small quantity of International Compound No. 2. Install a new flat washer and lock nut.

14. Hold the pump body and gear securely in fixture J-34034 and tighten the impeller-to-shaft lock nut to 40—45 lb/ft. (54—61 N«m) torque.

15. Check the water pump impeller and gear slip torque as follows:

    a. Attach Kent-Moore tool J-34034-2 to the end of a torque wrench and place it over the impeller. Hold pump and gear in fixture J-34034.

    b. Apply 80 lb/ft. (108 N*m) of torque to the impeller in the direction opposite to the arrow on the impeller. *The impeller and gear must withstand this torque without slipping.*

    c. If the impeller slips, remove impeller, clean shaft and impeller tapers with solvent and assemble again. Recheck slip torque. If the impeller rubs on the body of the pump, check for pump or impeller irregularities, such as casting flash. Repair as required. Install a new impeller, if necessary, using the torquing method stated above.

Install Pump

1. Lubricate the new large and small water seal rings with grease and position them in the pump body.
2. Position the pump against the front cover, making sure the pump gear teeth are engaged correctly with the idler gear teeth.
3. Install the six pump body-to-front cover bolts and lock washers.
4. Install the nut and lock washer at the back side of the water pump.
5. Tighten the bolts to 30-35 lb—ft (41-47 N*m) torque and the nut to 25-30 lb—ft (34—41 N«m) torque.
6. To check the gear backlash (clearance) between the water pump gear and the idler gear, set the dial indicator pointer against one of the impeller vanes, and while keeping the idler gear stationary, rock the impeller. The gear backlash setting should be .004" to .008".

The current engine front cover has a 1/4" access hole located in line with the right front idler gear to permit holding the idler gear in a loaded position while checking the gear backlash. The idler gear must be held stationary in the loaded position to eliminate the possibility of including the idler gear to idler gear backlash in the idler gear to water pump gear backlash readings. For engines without the access hole, see Section 5.0. A 1/4” pipe plug is used to seal the opening after the gear lash check is completed.

When the specified gear backlash cannot be obtained, loosen the pump attaching bolts and nut and move the pump up as required to obtain the correct gear backlash. Retighten the bolts and nut, as noted in Step 5.

7. Position the impeller shroud in the pump body (8V and 12V-149 engines only).
8. Install the pump cover and a new gasket.
9. Connect the outlet tube from the radiator or heat exchanger.
10. Connect the oil cooler inlet tube to the pump.
11. Install the fan, radiator and fan shroud, if removed.
12. Refill the cooling system as required for warm or cold weather operation. Refer to Section 5.

© Detroit Diesel Corporation

BDC for Manuals - specs - Bolt torques

WATER MANIFOLD

The water manifolds (Fig. 1) are attached to the cylinder block at each water opening with two bolts and lock washers. A separate gasket is used at each attaching flange. The front right and left bank manifolds are also attached to their respective thermostat housings with a flange, seal, plate, gasket and three bolts and lock washers. The front and rear manifolds on each cylinder bank are joined and sealed together with seals and clamps.

Coolant passes through the water jacket in the cylinder head and enters each water opening in the manifold, then flows into the thermostat housing.

Refer to *Troubleshooting* in Section 5.0 for combustion gas leakage into the cooling system.

Remove Water Manifolds

1. Open the drain cock or remove the plug at the bottom of each thermostat housing and drain the cooling system to the proper level.
2. Disconnect any water lines attached to the water manifolds.

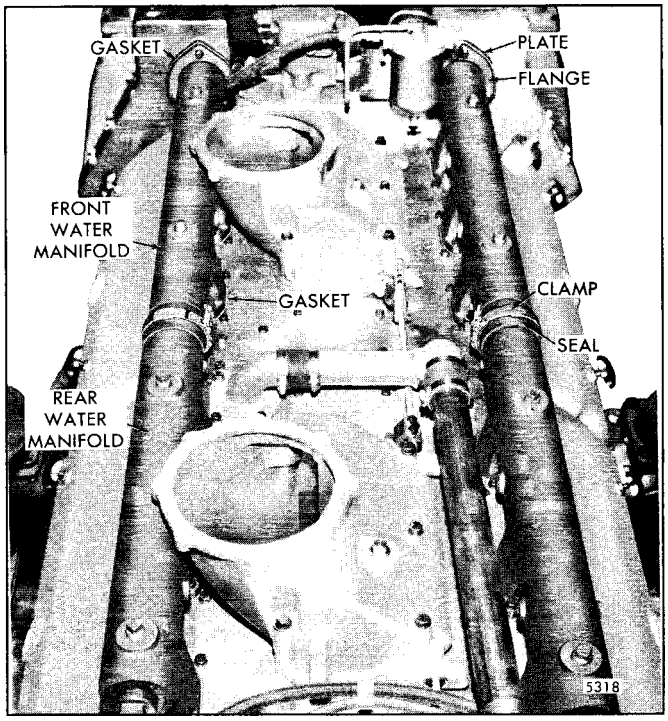


Fig. 1 - Typical Water Manifold Mounting

3. On 12V and 16V engines, loosen the seal and clamp between each front and rear manifold. Discard the seals.
4. Remove the three manifold flange attaching bolts and lock washers from each thermostat housing. Then, slide each flange, seal and plate back on the manifolds. Discard the seals and gaskets.
5. Remove the bolts and lock washers which attach the manifolds to the cylinder block. Then, remove the manifolds from the cylinder block.
6. Remove and discard the gaskets.

Install Water Manifolds

1. Attach a new gasket at each water opening in the cylinder block.
2. Install a new seal in the flange of each front manifold.
3. Place one of the front manifolds in position on the cylinder block and, using a new gasket, install the plate and three flange-to-thermostat housing bolts and lock washers. Do not tighten the bolts at this time.
4. Install the manifold-to-block bolts and lock washers. Do not tighten the bolts at this time.
5. 12V and 16V engines only:
   a. Place a new seal and a clamp on the rear manifold.
   b. Place the rear manifold on the cylinder block and install the manifold-to-block bolts and lock washers. Do not tighten the bolts at this time.
   c. Align the front and rear manifolds, position the seal and tighten the clamp.
6. Tighten the 3/8"—16 manifold-to-block and manifold-to-thermostat housing bolts to 30-35 lb—ft (47—47 N*m) torque.
7. Install the manifolds on the opposite cylinder bank in the same manner.
8. Install and connect any water lines previously removed.
9. Close the drain cock or install the drain plug in each thermostat housing.
10. Fill the cooling system to the proper level.

© Detroit Diesel Corporation

BDC for Manuals - specs - Bolt torques

THERMOSTAT

The temperature of the coolant is automatically controlled by six blocking type thermostats (Figs. 1 and 2) which are located in the two thermostat housing covers (three in each cover) at the front of the engine.

•Construction

Thermostats used in Detroit Diesel engines consist of a brass cup filled with a heat-expansive wax-like material. The wax compound is retained within the cup by an elastomeric seal. The valve of the thermostat is attached to a piston which is held on the elastomer by a spring.

•Thermostat Operation

Two thermostat heat motor (power element) designs are shown (Fig. 3). The basic principle (expansive wax) remains the same for all thermostats. The valve is in the closed position when the thermostat is cold (wax solid). When the wax-filled brass cup is heated by engine coolant, the wax-like material expands. As the coolant temperature in the engine reaches the calibrated "start-to-open" thermostat setting, the force of the expanding wax on the piston exceeds the closing force of the spring and the valve begins to open. As the coolant temperature continues to increase, the wax-like material continues to expand and the valve opens further until it reaches its maximum design travel.

When the temperature of the engine coolant drops, the wax cools and contracts. This reduces the pressure on the piston and allows the spring to draw the valve back toward its seat (closed thermostat).

Operation In The Engine

At water temperatures below the start-to-open setting, the thermostat valves remain closed, blocking the flow of coolant through the radiator or heat exchanger core. The coolant then bypasses the radiator or heat exchanger and flows back through the water pump to the oil cooler, cylinder block, cylinder heads and back up through the thermostat housings. As the coolant temperature continues to rise, the thermostat valves start to open, allowing some of the coolant to pass down through the radiator or heat exchanger where the coolant is cooled and then circulated through the water pump to the engine. As the temperature rises, more coolant is allowed to pass through the thermostat. When the thermostat valves are fully open, most of the coolant is circulated through the radiator or heat exchanger, thereby regulating the coolant temperature.

•Type

Full blocking type thermostats (Fig. 4) are used in Series 149 engines. The full blocking type thermostat simultaneously controls the flow of coolant to the radiator and bypass circuit. During the engine warm-up, all engine coolant flows through the bypass circuit. As the thermostat opens, increasing amounts of coolant flow to the radiator and the bypass flow is correspondingly reduced. At approximately 17° - 20°F above the opening temperature of the thermostat, the bypass opening is fully blocked and the total flow of coolant is directed into the radiator. Series 149 thermostats are non-vented due to the rapid warm-up cooling system.

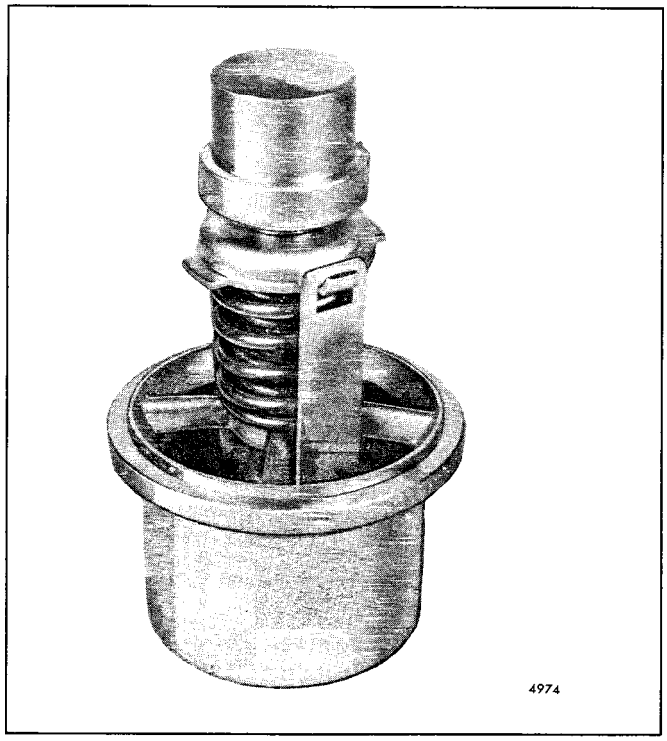


Fig. 1 – Blocking Type Thermostat (Former)

•The Bypass Circuit

The bypass circuit (Fig. 4) provides a route for coolant circulation before the thermostat opens. Coolant from the top of the engine flows back to the water pump without passing through the radiator or other heat exchanger. This flow of bypass coolant permits the engine to warm up to operating temperature while preventing "hot spots" which might damage the engine during this period of operation.

•Running Without A Thermostat

Operating an engine without a thermostat is not recommended. Removing the thermostat can permit the engine to run too cool or too hot. If engines run too cool, condensation of water from the combustion process can mix with lubricating oil and other products of combustion to form corrosive acids and sludge. These, in turn, can restrict the flow of oil and accelerate engine wear. Low combustion

© Detroit Diesel Corporation

chamber temperatures can also lead to rough idling and increased amounts of pollutants and white smoke.

Running without a thermostat can cause overheating, since the bypass systems using full blocking thermostats will remain open. This may prevent an adequate flow of coolant to the radiator core.

Preventive Maintenance

Check thermostat calibration and the condition of thermostat seals after 5,000 hours of operation or once per year, whichever comes first. Replace as required. Always replace thermostats and seals at time of engine overhaul, regardless of condition.

> **NOTICE:** Attempting to reuse defective thermostats and/or seals can result in inefficient engine operation and/or damage.

Properly operating thermostats are essential for efficient operation of the engine. If the engine operating temperature deviates from the normal range (refer to Section 13.2) the thermostats must be removed and checked.

When comments of low operating temperatures are reported, check for the following *before* considering thermostat replacement.

1. Inaccurate temperature gauge.
2. Casting interference restricting thermostat valve movement.
3. Thermostat cocking or misalignment.
4. System contamination-sand or debris holding the thermostat open.
5. Malfunctioning rapid warm-up system.

Many cold complaints actually relate to lack of cab heat rather than engine temperature. When this is the case, look for such causes as a plugged heater core or restricted heater core hoses, improperly routed heater hoses, blocked heater ducts, inadequate heater coolant flow, etc.

Remove Thermostats

1. Open the drain cock located at the bottom of each thermostat housing and drain the cooling system to that level (Fig. 5).
2. Loosen the hose clamps securing the radiator or heat exchanger hoses to the thermostat housing covers and remove the hoses from the thermostat housing covers.

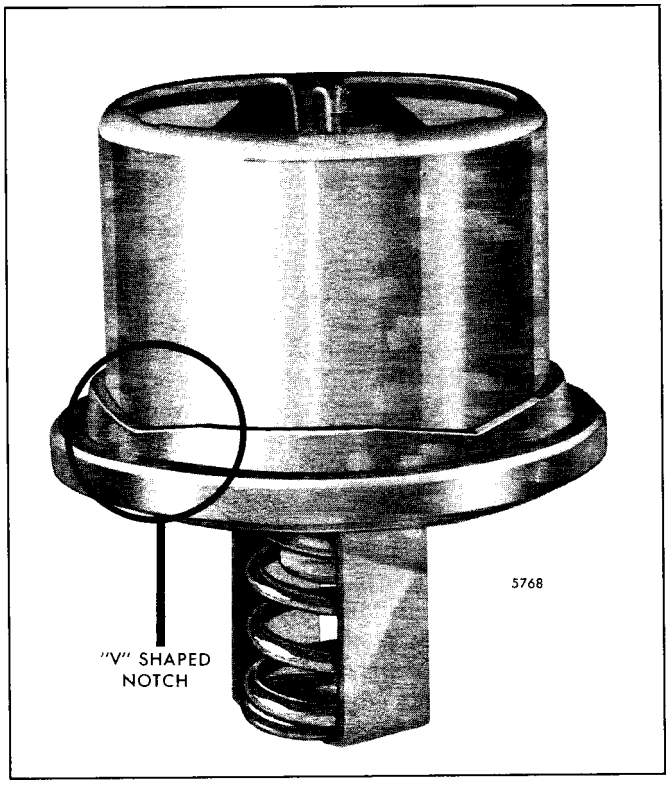
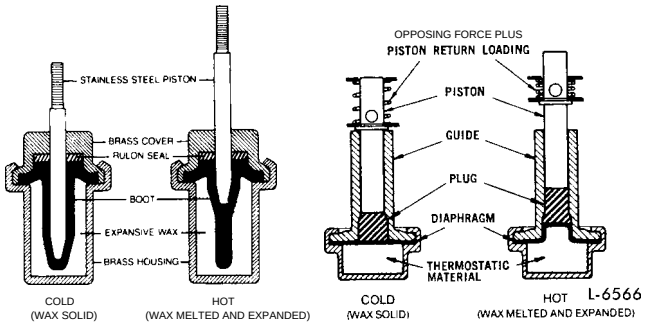


Fig. 2 - Weir Type Thermostat (Current)

3. Remove the bolts and lock washers securing the covers to the thermostat housings. Then remove the thermostat housing covers and gaskets.
4. Remove the thermostats from the covers.
5. Clean the thermostat seating surfaces in the thermostat housing covers.
6. Remove the seals from the thermostat housing covers and discard the seals.

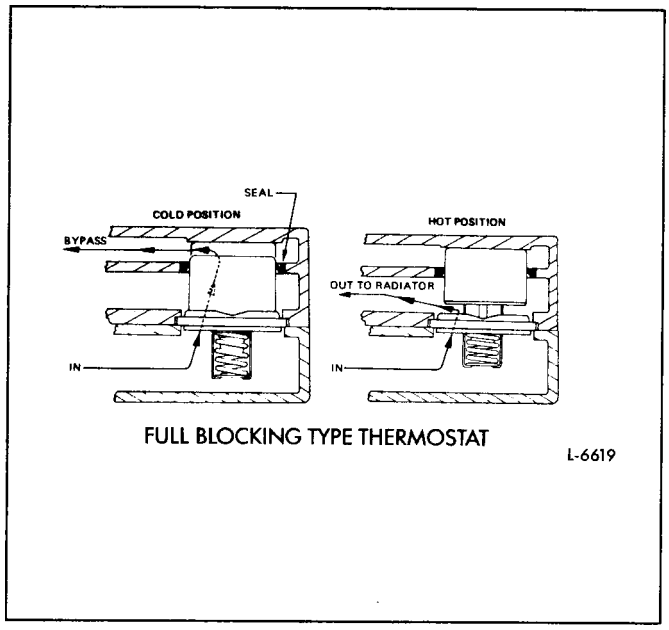
Inspection

1. Check the thermostats.



.Fig. 3 - Thermostat Heat Motors

© Detroit Diesel Corporation



•Fig. 4 - Full Blocking Type Thermostat

A defective thermostat which remains closed, or only partially open, will restrict the flow of coolant and cause the engine to overheat. A thermostat which is stuck in a full open position may not permit the engine to reach its normal operating temperature. The incomplete combustion of fuel due to cold engine operation will result in excessive carbon deposits on the pistons, rings and valves. To check the operation of thermostats, refer to Section 5.0.

• 2. Check the thermostat flange counterbore in the housing. Make sure it is clean and free from any obstructions that could prevent full seating of the flange.

• 3. Check the thermostat housing cover bypass cast seal ring. Check for wear and proper alignment of thermostat. Replace the cover if the thermostat will not properly block off the bypass cavity during full-open thermostat operation.

Install Thermostats

1. Always install a new seal when replacing a thermostat. Install new seals in the thermostat housing covers with installer J 8550 and driver handle J 7079-2. Position the seals so that the lips of the seals face up (away from the thermostats) when the cover is installed on the thermostat housing. The seal installing tool assures that the seal is positioned the correct distance from the bottom face of the cover and parallel with the cover face.

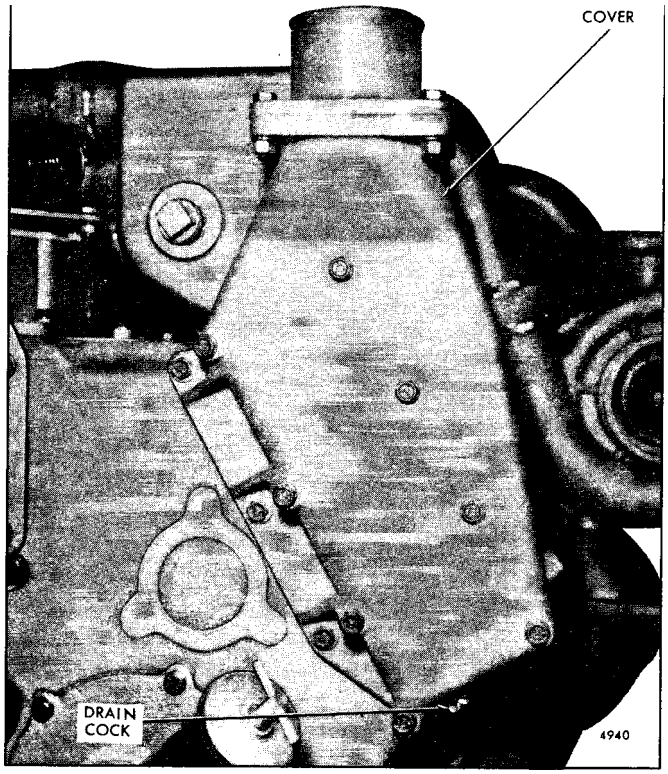


Fig. 5 - Thermostat Housing Mounting

2. Install the thermostats in the thermostat housing covers.
3. Place new gaskets on the thermostat housings.
4. Attach the covers to the thermostat housings. Tighten the bolts to 30-35 lb—ft (41—47 N«m) torque.
5. Slide the radiator or heat exchanger-to-thermostat housing hoses over the thermostat housing covers and secure them in place with hose clamps.
6. Close the thermostat housing drain cocks and fill the cooling system to the proper level. Refer to Section 5.
7. Start the engine and check for leaks.

RADIATOR

On some engines the temperature of the coolant circulating through the engine is lowered by the action of the radiator and the fan. The radiator is mounted in front of the engine so that the fan will draw air through it, thereby lowering and maintaining the coolant temperature to the degree necessary for efficient engine operation.

The life of the radiator will be considerably prolonged if the coolants used are limited to either clean, soft water and a corrosion inhibitor or a mixture of water and a permanent type antifreeze (refer to Section 13.3). The use of any other type antifreeze is not recommended.

To increase the cooling efficiency of the radiator, a metal shroud is placed around the fan (Fig. 1). The fan shroud must be fitted airtight against the radiator to prevent recirculation of the hot air drawn through the radiator. Hot

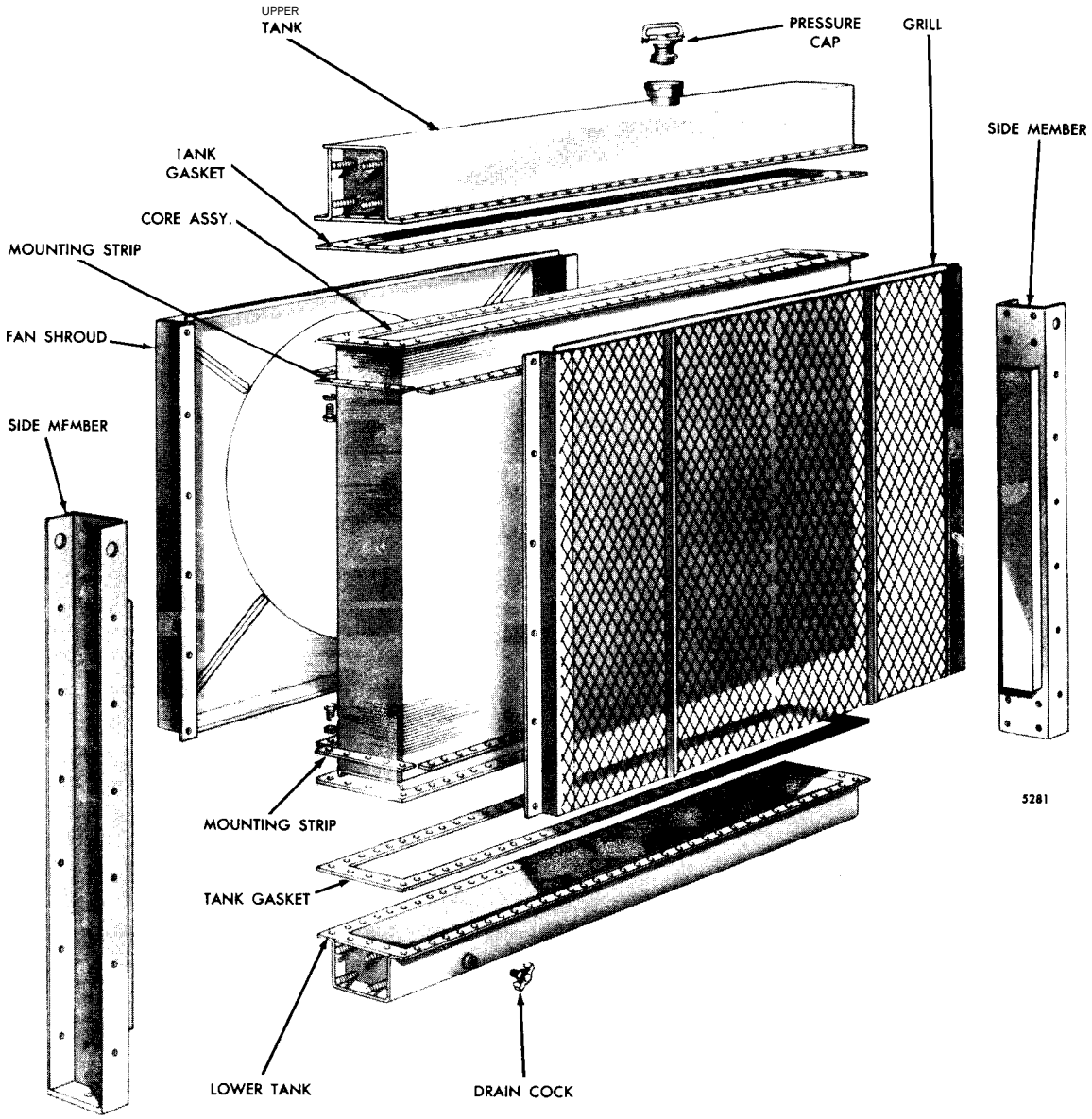


Fig. 1 - Radiator Details and Relative Location of Parts

air which is permitted to pass around the sides or bottom of the radiator and is again drawn through the radiator will cause overheating of the engine.

Another cause of overheating is slippage of the fan drive belts which is caused by incorrect belt tension, worn belts or worn fan belt pulley grooves, or the use of fan belts of unequal length when two or more belts are used. The belt tension and condition of the belts should be checked periodically as outlined in Section 15.1.

A radiator that has a dirty, obstructed core or is leaking, a leak in the cooling system, or an inoperative thermostat will also cause the engine to overheat. The radiator must be cleaned, the leaks eliminated and defective thermostats replaced immediately to prevent serious damage from overheating.

The external cleanliness of the radiator should be checked if the engine overheats and no other causes are apparent. To permit proper filling of the radiator, it is necessary that an air bleed hose be installed between the top of each thermostat housing and the radiator top tank. When a unit is not equipped with air bleed hoses, they can be installed as follows:

NOTICE: The thermostat housings do not have internal air bleed holes.

Remove the 3/8" pipe plug in the top of each thermostat housing. Install a 3/8" I.D. constant rise air bleed hose (with no bends) to each top side of the radiator.

NOTICE: Tapped holes are provided in the top of the radiator supplied by Detroit Diesel.

Cleaning Radiator

CAUTION: To avoid being burned by the hot liquid, allow the engine to cool before draining the coolant from the radiator.

The radiator should be cleaned whenever the foreign deposits are sufficient to hinder the flow of air or the transfer of heat to the air. In a hot, dusty area, periodic cleaning of the radiator will prevent a decrease in efficiency and add life to the engine.

The fan shroud and grille should be removed, if possible, to facilitate the cleaning of the radiator core.

An air hose with a suitable nozzle is often sufficient to remove loose dust from the radiator core. Occasionally, however, oil may be present requiring the use of a solvent, such as mineral spirits, to loosen the dirt. *The* use *of gasoline, kerosene, or fuel oil is not recommended as a solvent.* A spray gun is an effective means of applying the solvent to the radiator core. Use air to remove the remaining dirt. Repeat this process as many times as necessary, then rinse the radiator with clean water and dry it with air.

CAUTION:To prevent possible personal injury, wear adequate personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

NOTICE: Provide adequate ventilation of the working area to avoid possible toxic effects of the cleaning spray.

Another method of cleaning the radiator is the use of steam or a steam cleaning device, if available. If the foreign deposits are hardened, it may be necessary to apply solvents.

CAUTION: To avoid possible personal injury when working with steam or chemical solvents, wear adequate protective clothing (face shield, rubber apron, gloves, boots, etc.) and work in a well ventilated area.

The scale deposit inside the radiator is a result of using hard, high mineral content water in the cooling system. The effect of heat on the minerals in the water causes the formation of scale, or hard coating, on metal surfaces within the radiator, thereby reducing the transfer of heat. Some hard water, instead of forming scale, will produce a silt-like deposit which restricts the flow of water. This must be flushed out at least twice a year -— more often if necessary.

To remove the hardened scale, a direct chemical action is necessary. A flushing compound such as sal-ammoniac, at the specified rate of 1/4 pound per each gallon of radiator capacity, should be added to the coolant water in the form of a dissolved solution while the engine is running. Operate the engine for at least 15 minutes, then drain and flush the system with clean water.

Other flushing compounds are commercially available and should be procured from a reliable source. Most compounds attack metals and should not remain in the engine for more than a few minutes. A neutralizer should be used in the cooling system immediately after a de-scaling solvent is used.

For extremely hard, stubborn coatings such as lime scale, it may be necessary to use a stronger solution. The corrosive action of a stronger solution will affect the thin metals of the radiator, thereby reducing its operating life. A complete flushing and rinsing is mandatory and must be accomplished skillfully.

After the solvent and neutralizer have been used and the cooling system is flushed, completely drain the entire system again and fill it with coolant (refer to *Engine Coolant* in Section 13.3). After filling the cooling system, inspect the radiator and engine for water leaks. »

NOTICE: When draining or filling, the cooling system must be vented.

After the radiator core has been thoroughly cleaned and dried, reinstall the fan shroud and grille, if removed.

 © Detroit Diesel Corporation

Remove Radiator

1. Remove the radiator filler cap and open the drain cock to drain the cooling system. Also open the drain cock on the oil cooler and the engine block.
2. Remove the bolts, lock washers and nuts which attach the fan guards to the fan shroud.
3. Loosen the hose clamps at the radiator inlet hose and remove the hose.
4. Loosen the hose clamps at the radiator outlet hose and remove the hose.
5. Use a chain hoist and a suitable lifting device (through the filler neck or otherwise) and draw the hoisting chain taut to steady the radiator.
6. Remove the bolts, lock washers, plain washers, nuts and bevel washers (if used) which attach the radiator shell to the engine base.

   NOTICE: Since the shroud is very close to the tips of the fan blades, to prevent damage to these parts great care must be exercised whenever the radiator is removed.
7. Lift the radiator enough to clear the engine base and move it directly away from the engine.
8. Remove the fan shroud and the radiator core by removing the bolts securing them in place.

Inspection

Clean all radiator parts thoroughly, removing dirt, scale and other deposits. Examine the radiator for cracks or other damage. The core fins should be straight and evenly spaced to permit a full flow of cooling air. The core tubes should be clean inside and outside and have no leaks.

If repainting the raidator core becomes necessary, it is recommended that a thin coat of dull black radiator paint or another high quality flat black paint can be used. Ordinary oil paints have an undesirable glossy finish and do not transmit heat as well.

Check all radiator hoses and clamps. Replace cracked and deteriorated hoses and damaged clamps.

Install Radiator

Assemble the radiator, grill and shroud. Then mount the assembly on the engine base by reversing the procedure given for removal.

Check for clearance between the tips of the fan blades and radiator shroud after the radiator is in place. There must be sufficient clearance or damage to the fan and shroud will result when the engine is started. Use shims between the radiator and base, if necessary, to obtain the proper clearance.

© Detroit Diesel Corporation

COOLANT PRESSURE CONTROL CAP

• The radiator (or expansion tank) has a pressure control cap with a normally closed valve. The cap, with a number 7 or 14 stamped on its top, is designed to permit a pressure of approximately 7 psi (48.3 kPa) or 14 psi (96.6 kPa) in the system before the valve opens. A 7psi (48.3 kPa) pressure cap is used at altitudes below 5000 ft (1525 m). At altitudes above 5000 ft (1525 m), a 14 psi (96.6 kPa) cap is required. This pressure raises the boiling point of the cooling liquid and permits somewhat higher engine operating temperatures without loss of any coolant from boiling. To prevent the collapse of hoses and other parts which are not internally supported, a second valve in the cap opens under vacuum when the system cools. *Refer to "Pressurized Cooling System " (Section 5) for Information on Pressurized Top Tank Installation.*

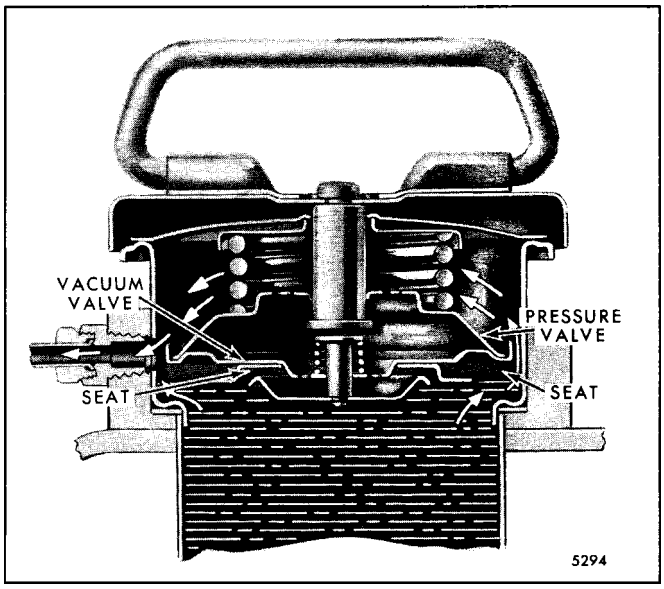


Fig. 1 - Pressure Control Cap (Pressure Valve Open)

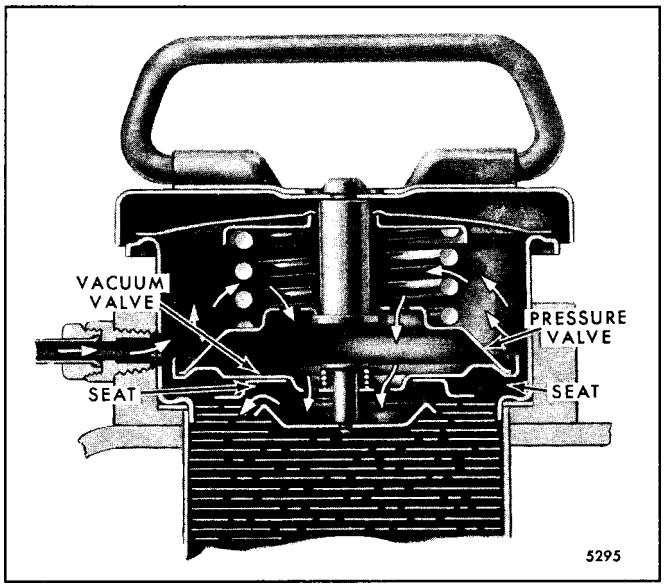


Fig. 2 - Pressure Control Cap (Vacuum Valve Open)

CAUTION: Use extreme care when removing the coolant pressure control cap. Remove the cap *slowly* after the engine has cooled. The sudden release of pressure from a heated cooling system can result in loss of coolant and possible personal injury (scalding) from the hot liquid.

To ensure against possible damage to the cooling system from either excessive pressure or vacuum, check both valves periodically for proper opening and closing pressures. If the pressure valve does not open between 6.25 psi (43.1 kPa) and 7.5 psi (51.7 kPa) or the vacuum valve does not open at .625 psi (4.3 kPa) (maximum), replace the pressure control cap.

© Detroit Diesel Corporation

ENGINE COOLING FAN

The fan used for cooling radiator equipped engines is belt driven from the crankshaft pulley.

The fan is bolted to a hub and pulley which are carried on two tapered roller bearings. The fan bracket and shaft are an integral unit which is mounted to the engine front cover by four bolts, lock washers and special flat washers (Fig. 1). Fan height is adjusted by means of an adjusting screw and adjusting bracket.

Poly-V belts are used on all Series 149 engines. Poly-V is the name given to a type of drive belt which has a drive surface of longitudinal V-shaped ribs formed on a common base.

Lubrication

The tapered roller bearings are pressure lubricated before being installed in the hub. A cap and seal retain a supply of grease in the cavity between the bearings. Refer to Section 15.1 for the maintenance schedule.

Fan Belt Adjustment

Adjust the fan belt periodically as outlined in Section 15.1.

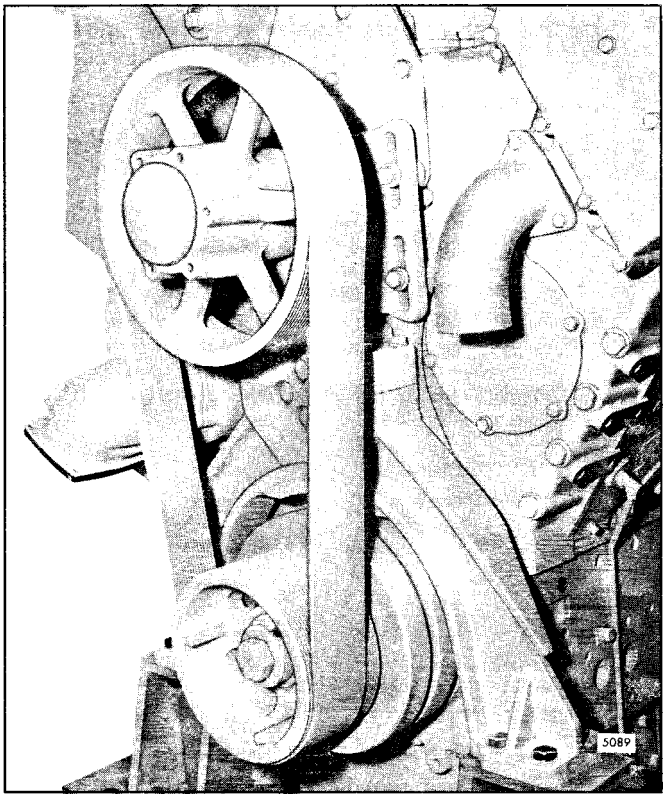


Fig. 1 - Typical Fan Drive Mounting

Remove And Install Fan Blade Assembly

Remove the fan blades from the hub by removing the six bolts and lock washers, providing enough clearance exists between the fan blades and the inner face of the radiator core with the belt guard and fan guard removed. If the fan blades cannot be removed in this manner, the fan, hub and bracket may be removed as an assembly from the support on the engine front cover, and then the fan blades removed from the hub. See *Remove Fan, Hub and Bracket* below.

The fan blades may be installed by reversing the procedure used for removal.

Remove Fan, Hub And Adjusting Bracket

The fan blades must rotate in a vertical plane parallel with and a sufficient distance from the radiator core. Bent fan blades reduce the efficiency of the cooling system, may throw the fan out of balance, and are apt to damage the radiator core. Before removing the fan, check the blades for alignment. Do not rotate the fan by pulling on the fan blades.

1. Remove the belt and fan guards.
2. Remove the six attaching bolts and lock washers, then remove the fan and spacer (if used).

NOTICE: If insufficient clearance exists between the fan and radiator, remove the fan, hub and adjusting bracket as an assembly.

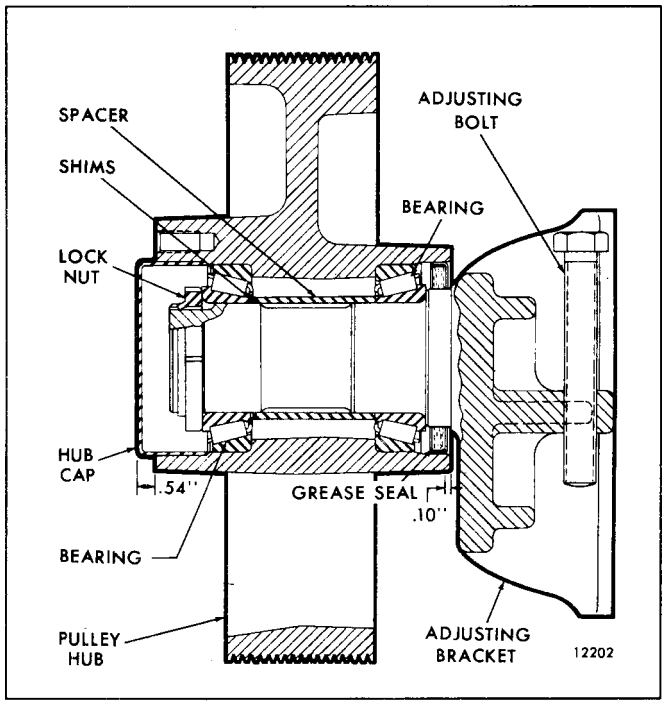


Fig. 2 – Fan Drive and Support Assembly

3. Loosen the four adjusting bolts and lower the fan shaft bracket by turning the adjusting screw on the adjusting bracket. Then remove the fan drive belt.
4. Remove the four adjusting bolts, lock washers and special flat washers. Remove the fan, hub and bracket as an assembly from the engine.

NOTICE: Early engines required two spacers between the fan hub bracket and the front engine lifter bracket.

Disassemble Fan, Hub And Bracket

Disassemble the fan, hub and bracket as follows:

NOTICE: Whenever tapered roller bearings are removed, all parts must be matchmarked and kept as a set to be reassembled in their original position.

1. Remove the six bolts and lock washers securing the fan and spacer to the pulley. Remove the fan blades and spacer.
2. Remove and discard the hub cap. Then pry out that part of the lock nut staked into the shaft and remove the nut.
3. Support the pulley hub, front face up, on wood blocks high enough to allow the adjusting bracket to be removed. Tap the shaft with a plastic hammer to free the bracket assembly from the bearings in the pulley hub.
4. Support the pulley hub, front face up, on wood blocks spaced far enough apart to permit removal of the felt grease seal and bearing from the hub.
5. Remove and discard the felt grease seal in the rear of the hub. Then remove the rear roller bearing cone, spacer and shims.

NOTICE: Record the number of shims removed to insure identical replacement when assembling the fan hub.

6. Remove the rear roller bearing cup from the hub by tapping alternately around the rear face of the cup with a small brass rod and hammer.
7. Reverse the pulley hub on the wood blocks and remove the front roller bearing from the hub in the same manner as described in Steps 5 and 6.

Inspection

Wash the fan and fan drive components with fuel oil and dry them with compressed air.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Inspect the bearing rollers and cups for wear or damage.

Check the fan blades for cracks. Replace the fan if the blades are badly bent, since straightening may weaken the blades, particularly in the hub area.

Remove any rust or rough spots in the grooves of the fan pulley and the crankshaft pulley. If grooves are damaged or severely worn, replace the pulleys.

Assemble Fan, Hub And Bracket

1. Before assembling the tapered roller bearings into the pulley hub, pressure lubricate the bearings. Use Texaco Premium RB or an equivalent Lithium base multi-purpose grease.
2. Install the rear roller bearing in the pulley hub, numbered side out, as follows:
   a. Press the cup into the pulley hub.
   b. Place the cone in the bearing cup.
3. Press a new felt grease seal, numbered side out, in 3/32" (.100") from the end of the pulley hub (Fig. 2).
4. Place the adjusting bracket on wood blocks on the bed of an arbor press. Then press the pulley hub on the fan shaft.
5. Fill the pulley hub cavity 20-30% full of grease.
6. Install the spacer and necessary shims on the fan shaft.
7. Install the front roller bearing, numbered side out, in the pulley hub and on the fan shaft as follows:
   a. Press the cup into the pulley hub.
   b. Press the cone on the fan shaft and against the shims.
8. Install the lock nut and tighten it to 195-205 lb-ft (265-278 N*m) torque while rotating the pulley hub.
9. Check the end play. It must be .001" to .006". If necessary, remove the lock nut and front bearing and add or remove shims as required.

NOTICE: The pulley must rotate freely after assembly.

10. After the specified end pla; obtained, stake the lock nut to the fan shaft.
11. Fill the cap 70-80% full of grease and install it in the pulley hub.

Install Fan, Hub And Bracket

1. Secure the fan and spacer to the pulley hub with six bolts. Tighten the bolts to 71-75 lb-ft (92-102 N*m) torque.

2. Attach the fan, hub and bracket assembly to the engine front cover with four 1/2"—13 bolts, lock washers and special flat washers. Leave the bolts loose.

 © Detroit Diesel Corporation

NOTICE: Early engines required two spacers between the fan hub bracket and the engine front lifter bracket.

3. Install the drive belt.

NOTICE: Before a Poly-V belt is installed, it is very important that the crankshaft pulley and the fan drive pulley are in alignment.

Misalignment between the pulleys cannot be more than .009" per inch of center line distance. A straight line can be determined by placing a straight edge on the rims of the pulleys.

4. Adjust the bracket to provide the proper belt tension (Section 15.1). Tighten the bolts to 71-75 lb—ft (96-102 N*m) torque.

© Detroit Diesel Corporation

HEAT EXCHANGER

The heat exchanger system incorporates two cooler cores located in separate heat exchanger tanks which are mounted on each side of a large expansion tank (Fig. 1).

The heat exchanger core consists of a series of cells with a header at one end and a water inlet at the opposite end. The core is mounted inside of the heat exchanger tank with the header or outlet end bolted to the tank at the top and the inlet end sealed inside a retainer. A gasket between the tank and the flange of the core, another gasket between the flange of the core and the outlet cover, and seals surrounding the circular inlet end prevent the coolant from mixing with the raw cooling water on its course between the cells of the cooling core.

In this sytem of engine cooling, the hot coolant leaving the thermostat housing passes into the heat exchanger tank, then through the cells of the cooling core. After leaving the heat exchanger, the engine coolant is picked up by the fresh water pump and circulated through the engine. The raw water is forced between the cells of the core and serves to lower the temperature of the coolant as it passes through the cells.

To protect the heat exchanger core from the electrolytic action of the raw water, zinc electrodes are located in the heat exchanger inlet and outlet connections and in the raw water pump inlet elbow.

The expansion tank provides a means of filling the engine cooling system, as well as space for expansion of the coolant as its temperature rises. An overflow pipe, near the top of the tank, provides a vent to the atmosphere. To permit proper filling of the heat exchanger cooling system, it is necessary that an air bleed hose be installed between the top of each thermostat housing and the top of the expansion tank. When a unit is not equipped with air bleed hoses, they can be installed as follows:

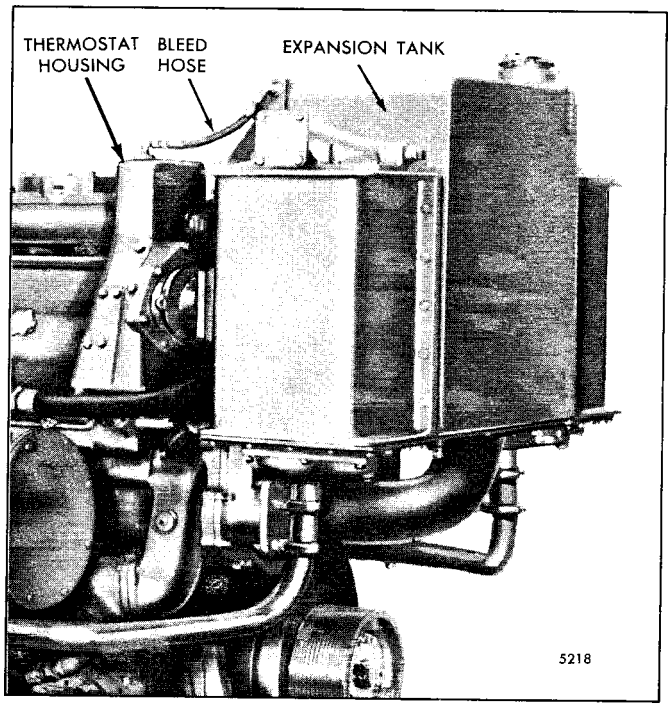


Fig. 1 – Heat Exchanger Mounting

NOTICE: The thermostat housings do not have internal air bleed holes.

Remove the 3/8" pipe plug in the top of each thermostat housing. Install a 3/8" I.D. constant rise air bleed hose (with no bends) to each top side of the expansion tank (Fig. 1).

NOTICE: Tapped holes are provided in the top of the expansion tank supplied by Detroit Diesel.

The length of time a heat exchanger will function satisfactorily before cleaning will be governed largely by the kind of coolant used in the engine and the kind of raw water used. Soft water, plus a good grade of rust inhibitor or antifreeze, should be used as the engine coolant. The coolant level should be maintained near the top of the expansion tank.

If the heat exchanger fails to cool the engine properly, the core assembly should be examined for foreign deposits.

Remove Heat Exchanger Core

1. Drain the fresh and raw water systems by opening the drain cocks.

2. Remove the bolts that hold the outlet cover and the heat exchanger core to the tank. Remove the cover and the gasket.

3. Remove the bolts that hold the seal retainer to the inlet cover. Remove the retainer and gasket.

4. Remove the seals and the seal gland from the tank.

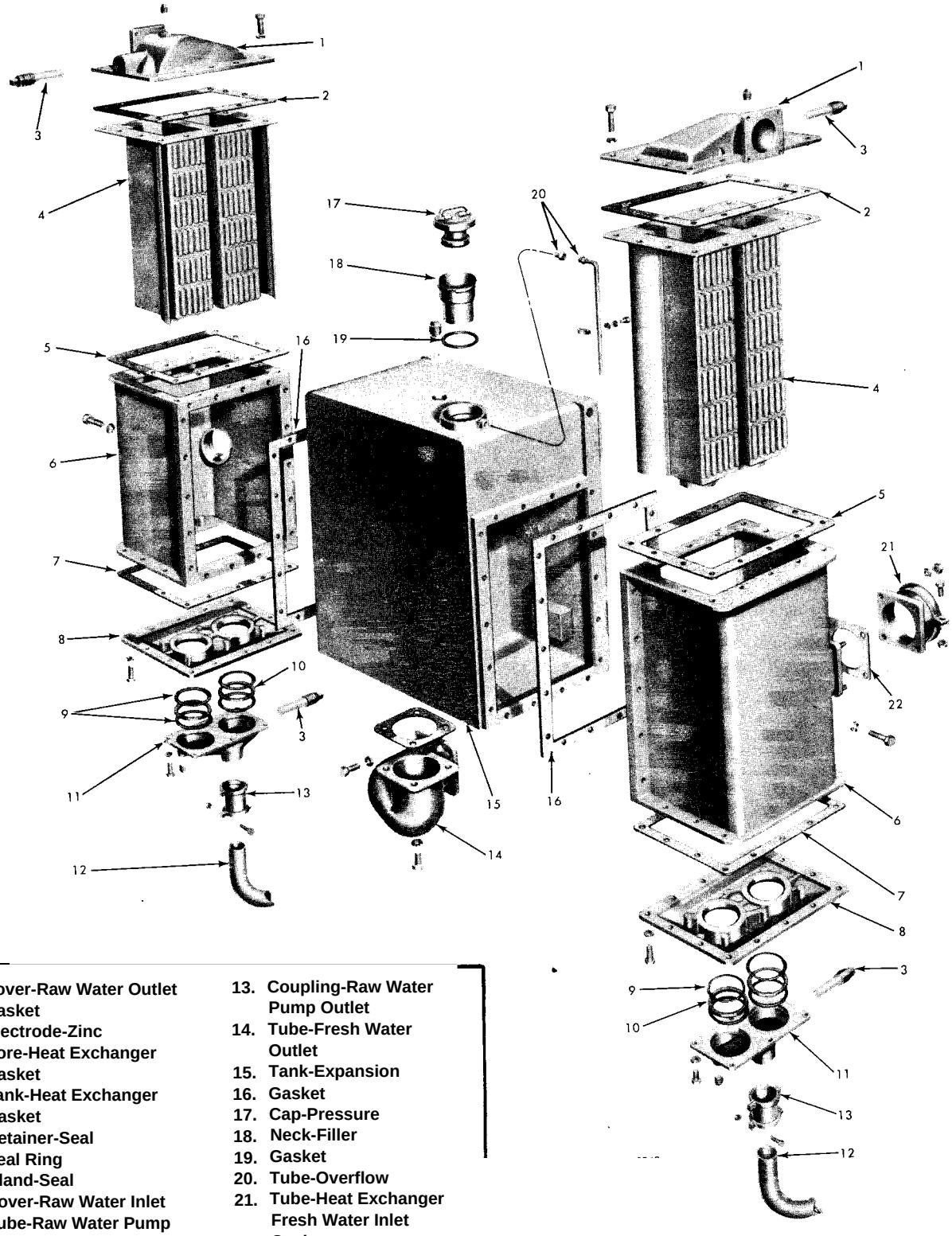
5. Withdraw the heat exchanger core and gasket from the top of the heat exchanger tank.

Clean Heat Exchanger Core

When foreign deposits accumulate in the heat exchanger to the extent that cooling efficiency is impaired, remove the heat exchanger core and clean it as follows:

Immerse the heat exchanger core in a scale solvent consisting of one-third (1/3) muriatic acid and two-thirds (2/3) water to which one-half (1/2) pound of oxalic acid has been added to each two and one-half (2-1/2) gallons of solution. Remove the core when foaming and bubbling stops. This usually takes from thirty to sixty seconds. Flush the core thoroughly with clean hot water under pressure.

© Detroit Diesel Corporation



1. Cover-Raw Water Outlet
2. Gasket
3. Electrode-Zinc
4. Core-Heat Exchanger
5. Gasket
6. Tank-Heat Exchanger
7. Gasket
8. Retainer-Seal
9. Seal Ring
10. Gland-Seal
11. Cover-Raw Water Inlet
12. Tube-Raw Water Pump Outlet
13. Coupling-Raw Water Pump Outlet
14. Tube-Fresh Water Outlet
15. Tank-Expansion
16. Gasket
17. Cap-Pressure
18. Neck-Filler
19. Gasket
20. Tube-Overflow
21. Tube-Heat Exchanger Fresh Water Inlet
22. Gasket

Fig. 2 - Heat Exchanger Details and Relative Location of Parts

© Detroit Diesel Corporation

CAUTION: To avoid possible personal injury when working with chemicals, steam and/or hot water, wear adequate protective clothing (face shield, rubber apron, gloves, boots, etc.), work in a well ventilated area, and exercise caution.

To prevent drying and hardening of accumulated foreign substances, the heat exchanger core must be cleaned as soon as possible after removing it from service.

Inspect Zinc Electrodes

Remove the zinc electrodes from the inlet side of the raw water pump and the heat exchanger. Clean the electrodes with a wire brush or, if worn excessively, replace with new electrodes. To determine the condition of a used electrode, strike it sharply against a hard surface; a weakened electrode will break.

Install Heat Exchanger Core

After the heat exchanger core has been cleaned and inspected, refer to Fig. 2 and install it by reversing the sequence of operations given for removal, using new gaskets and seals.

NOTICE: To minimize electrolytic action of the raw water, brass pipe plugs are used in the raw water system components wherever pipe plugs are required. Replace any steel plugs that may be found.

Refill the fresh and raw water systems and check for leaks.

© Detroit Diesel Corporation

ENGINE COOLING RAW WATER PUMP (JABSCO)

Raw water for lowering the temperature of the engine coolant is circulated through the heat exchangers by two positive displacement pumps (Fig. 1). The pumps are attached to adaptors which are bolted to the flywheel housing and are driven through couplings attached to the rear idler gears (Fig. 2).

The drive from the idler gear is to the pump drive shaft which is carried on a double-row ball bearing located in the flange end of the pump housing.

An impeller, splined to the end of the drive shaft, is self-lubricated by the water pumped and should not be run dry for longer than normally required for the pump to prime itself.

• Two types of raw water pump are used on Series 149 engines. In the first type, the impeller rotates against a bronze cam in the impeller housing. A single wear plate is installed between the impeller and the housing end to prevent wear of the pump housing. A slot machined in the outer periphery of the plate registers with a dowel pin in the pump housing, thus preventing it from rotating with the impeller.

In the second type of raw water pump, the impeller rotates against a polyurethane cam/liner inside the pump body (housing). Two wear plates — one at each end of the impeller — are used to prevent wear of the pump housing and the cover gasket. Slots in these plates register with dowel pins in the pump housing, cam/liner, and cover, thus preventing the plates from rotating with the impeller.

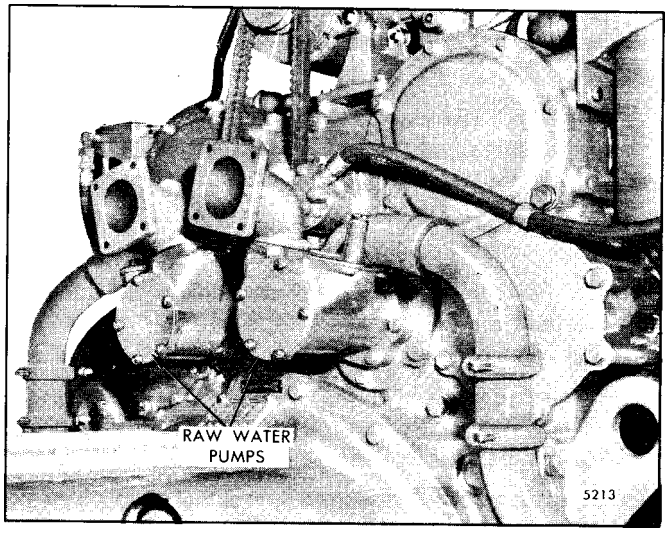
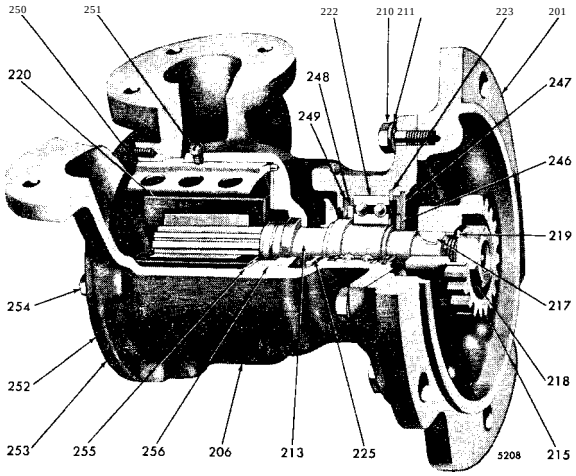


Fig. 2 - Raw Water Pump Mounting

Wear plates on both types of pumps can be reversed if wear on the plates becomes excessive. A rotary type seal assembly seals against leakage along the shaft.



201. Adaptor—Pump
206. Housing—Pump
210. Bolt—Housing to Adaptor
211. Lock Washer
213. Shaft—Drive
215. Gear—Drive
217. Key—Woodruff
218. Nut—Gear Retaining
219. Lock Washer
220. Impeller
222. Ball Bearing
223. Retainer—Bearing
225. Oil Slinger—Shaft
246. Washer—Felt
247. Seal—Bearing
248. Washer—Felt
249. Seal—Bearing
250. Cam—Offset
251. Bolt—Cam
252. Cover
253. Gasket—Cover
254. Bolt—Cover
255. Wear Plate
256. Seal Assy.

Fig. 1 - Raw Water Pump Assembly

Operation

The pump can be operated in a clockwise or counterclockwise direction. Raw water is drawn into the pump through the outlet opening, both openings being located at the top of the pump housing.

> •**NOTICE:** Always prime the raw water pump before starting the engine. Since water acts as a lubricant for the impeller, failure to prime the pump (or at least wet the impeller vanes to induce a self-priming suction) can result in severe impeller damage when the engine is started. Insufficient raw water flow into the heat exchanger caused by a damaged impeller can lead to overheating and subsequent engine damage. To prime the pump: a) remove the pipe plug from the water inlet elbow; b) pour in at least a pint of water; c) replace the plug.

Lubrication

The shielded type double-row ball bearing is filled with lubricant when assembled. No further lubrication is required.

Raw Water Pump (With Bronze Cam)

The following service procedures apply to raw water pumps with bronze cams (Fig. 1, 3).

© Detroit Diesel Corporation

Replace Pump Seal

Seal parts may be removed and replaced with new parts by removing the impeller, but without removing the pump from the engine.

NOTICE: Use care not to scratch or burr the lapped surface of the seal seat or that portion of the shaft which the seal contacts.

1. Remove the cover screws and lift the cover and gasket from the housing (Fig. 3).
2. Use pliers to grasp a blade at each side of the impeller and pull the impeller from the shaft. The spline plug will come out with the impeller.
3. Insert two wires, each with a hook at one end, between the housing and the seal, with the hook over the edge of the carbon seal. Pull the seal assembly from the shaft.
4. The seal seat and gasket may be removed in the same manner.
5. If removed, place the gasket and the seal seat over the shaft and press them into position in the seal cavity.
6. Assemble the carbon seal, seal ring and washer in their correct relative positions and slide them over the shaft and against the seal seat. Care must be used to assure that the seal ring is contained snugly within the ferrule, thereby gripping the shaft.
7. Install the Marcel washer next to the flat washer.
8. Compress the impeller blades to clear the off-set cam and press the impeller onto the splined shaft. Install the spline plug.
9. Turn the impeller several turns, in that direction in which it will normally operate, to position the blade properly.
10. Install the cover on the housing, using a new gasket.

Remove Pump From Engine

If complete disassembly or replacement of the pump becomes necessary, refer to Fig. 2 and proceed as follows:

1. Drain the raw water system.
2. Loosen the hose clamps at the outlet elbow and intermediate tube and slide the hose along the tube.
3. Loosen the hose clamps at the inlet elbow and the inlet tube and slide the hose along the tube.
4. Remove the bolts and lock washers holding the inlet and outlet elbows to the pump and lift the elbows from the pump. Remove the gaskets.
5. Remove the adaptor to flywheel housing bolts and lock washers.
6. Loosen the pump from the flywheel housing by tapping on the edge of the adaptor with a soft hammer.
7. Withdraw the pump straight out from the flywheel housing, disengaging the drive gear from the coupling. Cover the pump opening in the flywheel housing with a clean cloth to prevent the entrance of foreign matter.

Disassemble Pump

Refer to Fig. 3 and disassemble the pump as follows:

1. Remove the seal assembly as previously outlined.
2. Mark the housing and the adaptor for reference when reassembling, then remove the bolts and lock washers and separate the adaptor from the housing.
3. Clamp the drive gear in a vise equipped with soft jaws and remove the retaining nut and lock washer from the shaft.
4. Take the gear from the vise and, using a suitable puller, pull the gear from the shaft. Remove the Woodruff key from the shaft.
5. Remove the bearing retainer from the groove in the housing.
6. Support the pump housing in an arbor press, with the mounting flange resting on the bed of the press and the splined end of the shaft under the ram of the press. Use a brass rod between the shaft and the ram and press the shaft and ball bearing from the housing.
7. Remove the slinger from the housing.
8. Pull the bearing seal from the pump housing.
9. Use an arbor press and a suitable sleeve to press the shaft from the bearing.
10. Remove the bolt and lift the cam from the housing.
11. Lift the wear plate off of the dowel.

Inspect Pump Parts

After disassembly, clean all of the parts thoroughly, except the bearing. *The shielded bearing must not be washed; dirt may be washed in and the cleaning fluid could not be entirely removed from the bearing.* Wipe the bearing clean on the outside and then inspect it. Hold the inner race and revolve the outer race slowly to detect possible wear or rough spots. Replace the bearing if it is worn or does not roll freely.

Examine the components of the seal assembly and discard any parts that have been worn or otherwise damaged.

Inspect the oil seal contact surfaces of the shaft for scratches or grooves. If scratched, smooth the surface with crocus cloth wet with fuel oil.

Inspect the impeller to make sure the bond between the neoprene and the metal is good. If the impeller blades have a permanent set, use a new impeller.

Remove burrs from the wear plate. If wear on the plate is excessive, it may be reversed when the pump is assembled.

© Detroit Diesel Corporation

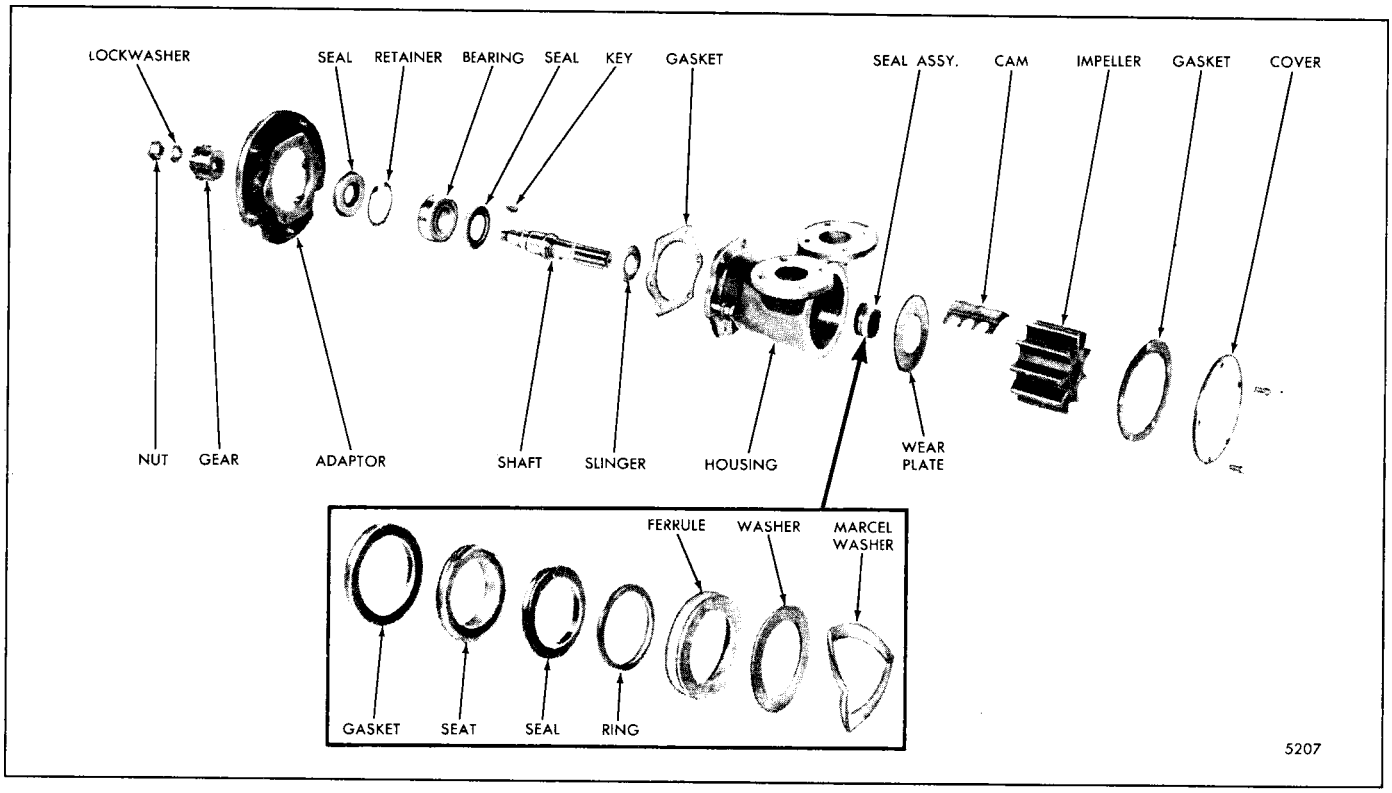


Fig. 3 – Raw Water Pump Details and Relative Location of Parts (Bronze Cam Design)

Assemble Pump

Use new parts where required and assemble the pump as follows:

1. Install the wear plate in the pump housing, with the locating hole in the plate over the dowel in the housing.
2. Place the cam in the housing so the end of the cam is flush with the end of the housing and install the bolt.
3. Support the splined end of the shaft on a wood block on the bed of the arbor press. Start the bearing straight on the shaft and, using a sleeve between the ram of the press and the inner race of the bearing, press the bearing tight against the shoulder on the shaft.
4. Install the bearing seal in the housing with the lip facing toward the bearing.
5. Place the slinger in position and then press the shaft and bearing into the counterbore in the housing.
6. Install the bearing retainer in the groove in the housing.
7. Install a Woodruff key in the shaft and start the gear straight on the shaft over the key.
8. Place the housing in an arbor press, with the splined end of the shaft supported on a wood block, and press the gear tight against the shoulder on the shaft.
9. Clamp the gear in a vise equipped with soft jaws. Install the lock washer and retaining nut. Tighten the nut to 25-30 lb—ft (34—41 N*m) torque. Do not exceed the specified torque, otherwise shaft fracture and consequent early pump failure may result.
10. Position the adaptor on the housing by aligning the marks made when disassembling and install the six lock washers and bolts.

Raw Water Pump (With Polyurethane Cam/Liner)

The following service procedures apply to raw water pumps with polyurethane cam/liners (Fig. 4).

Remove Pump From Engine

If complete disassembly on replacement of the pump becomes necessary, refer to Fig. 2 and proceed as follows:

1. Drain the raw water system.
2. Loosen the hose clamps at the outlet elbow and intermediate tube and slide the hose along the tube.
3. Loosen the hose clamps at the inlet elbow and the inlet tube and slide the hose along the tube.
4. Remove the bolts and lock washers holding the inlet and outlet elbows to the pump and lift the elbows from the pump. Remove the gaskets.

© Detroit Diesel Corporation

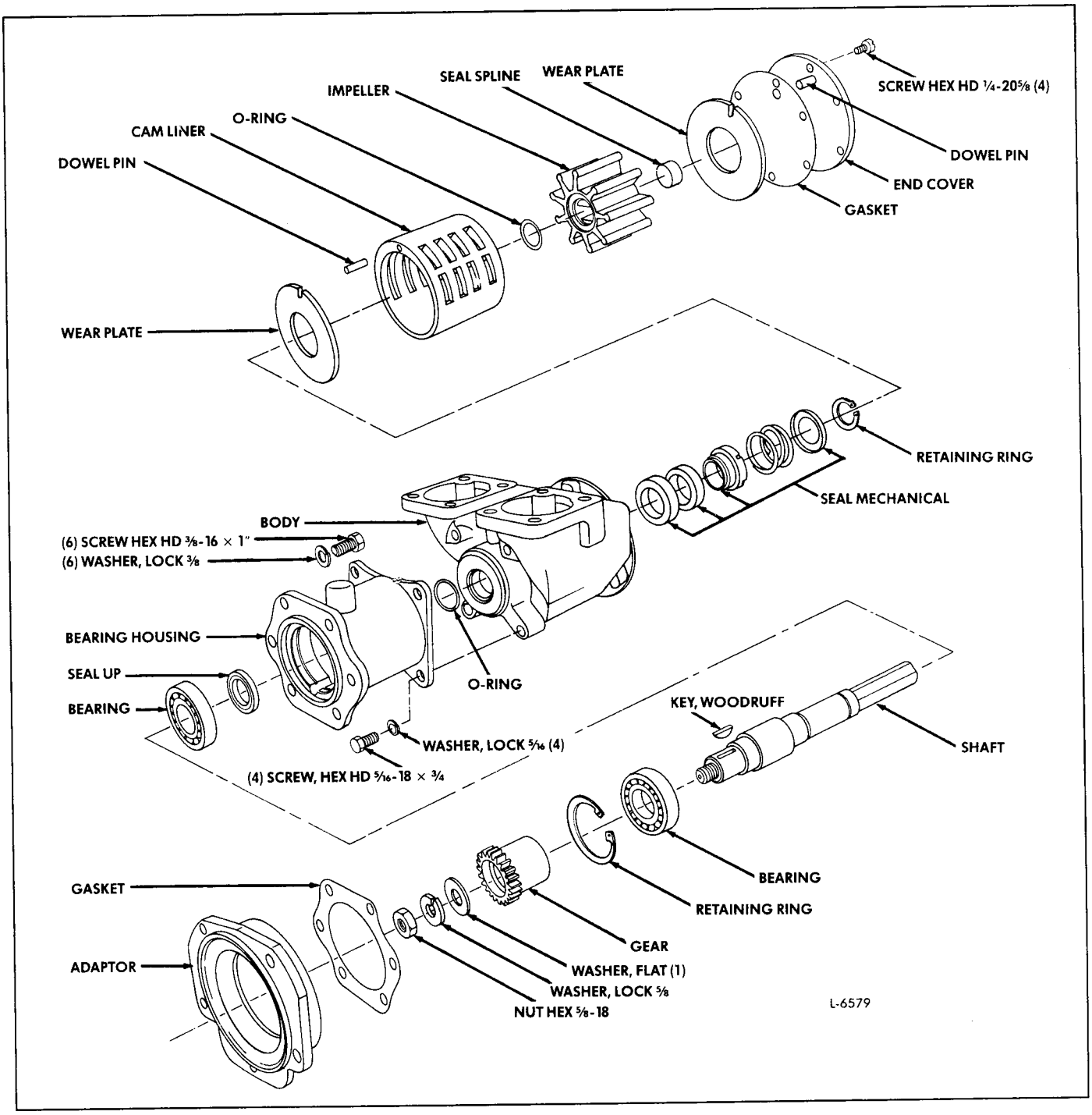


Fig. 4 Raw Water Pump Details and Relative Location of Parts (Polyurethane Cam/Liner Design)

5. Remove the adaptor to flywheel housing bolts and lock washers.
6. Loosen the pump from the flywheel housing by tapping on the edge of the adaptor with a soft hammer.
7. Withdraw the pump straight out from the flywheel housing, disengaging the drive gear from the coupling.

Cover the pump opening in the flywheel housing with a clean cloth to prevent the entrance of foreign matter.

Disassemble Pump Body

1. Remove end cover screws and end cover. Remove gasket and outer wear plate.

© Detroit Diesel Corporation

2. Grasp hub of impeller with pliers and remove from impeller bore. If impeller O-ring remains on shaft, remove it.
3. Remove cam/liner from pump body.
4. Remove inner wear plate.
5. Remove seal retaining ring, taking care not to scratch shaft. Remove carbon portion of mechanical seal with tensioning spring attached.
6. Remove bolts securing adaptors to pump inlet and outlet ports. With pump body held securely to keep it from falling, remove four (4) 5/16" screws and lockwashers holding pump body to bearing housing.
7. Remove pump body from bearing housing and shaft sub-assembly. Remove anty remaining gasket material from port adaptors.
8. Remove slinger O-ring from shaft.
9. From drive end of pump body, press out remaining portions of mechanical seal (boot and ceramic seat).
10. Clean and inspect all parts for wear. Worn wear plate(s) should be reversed, if reusable, or replaced. If cam/liner thickness is 3/8" or less at its thickest section, it should be replaced.

Assemble Pump Body

1. Install new slinger O-ring on shaft near bearing housing.
2. Install mechanical seal components. *Do not allow seal components to become soiled during assembly.* Lubricate ceramic seal seat boot with *water* only and press into seal bore of pump body. Install ceramic seal seat. Exposed ceramic surface should face toward impeller bore.
3. Slide pump body over shaft, taking care not to dislodge seal seat as body is moved toward (and aligned with) bearing housing. Attach pump body to bearing housing with four (4) 5/16" screws and lockwashers. Tighten to 14 - 15 lb-ft (19-22 N*m) torque.
4. Install carbon portion of mechanical seal with tensioning spring and spring washer over shaft, and locate in seal bore with carbon face against ceramic seal seat. Slide seal retaining ring over shaft against seal thrust ring and locate in retaining ring groove.
5. Install inner wear plate in pump body, aligning notch in wear plate with pin in body.
6. Lubricate bore of body with film of water pump grease. Align hole in top of cam/liner with pin in pump body and push cam/liner into body. Cam liner should be recessed about 1/8" from end cover surface to permit installation of wear plate.
7. Liberally coat inside of cam/liner with water pump grease.
8. Insert impeller O-ring in groove in impeller recess. With O-ring end of impeller facing pump housing, rotate impeller in direction of pump rotation to bend vanes under cam and push into bore until impeller insert flats align with shaft flats. Then push impeller all the way into impeller bore. End of impeller should be approximately even with cam/liner. Install rubber spline plug into end of impeller.
9. Install outer wear plate (align notch in wear plate with hole in top of cam/liner) and place end cover gasket over pin in end cover.
10. Install end cover, aligning pin with hole in cam/liner. Install six (6) 1/4" fillister head screws in end plate cover. Tighten to 72 - 78 lb-in (8.13 - 8.81 N«m) torque. *Do not overtorque.*

Disassemble Pump Bearing Housing

1. Follow disassembly steps 1 through 10 of minor service instructions.
2. With housing held securely to keep it from falling, remove the six (6) 3/8" screws and lockwashers in housing flange and remove bearing housing and shaft sub-assembly from adaptor.
3. Prevent shaft from rotating by holding it with a wrench on shaft flats on impeller end. Then remove drive gear retaining nut, lock washer, and retaining flat washer.
4. Remove drive gear from shaft. A punch and small mallet may be used to gently tap the underside of the drive gear teeth to loosen gear from shaft. Remove woodruff key.
5. Remove retaining ring securing bearing in bearing housing.
6. Press against impeller end of shaft to remove shaft and bearing sub-assembly from bearing housing.
7. Support inner race of bearing and press shaft out of bearing. Repeat procedure on second bearing.
8. From pump end of bearing housing, push oil seal out of bearing housing. Discard seal.

Inspect Pump Parts

After disassembly, clean all parts thoroughly, except the bearing, and replace as required. The shielded bearing must not be cleaned. Dirt may be washed in and the cleaning fluid may not be entirely removed from the bearing. Wipe the bearing clean on the outside and then inspect it. Hold the inner race and revolve the outer race slowly to detect possible wear or rough spots. Replace the bearing if it is worn or does not roll freely. Clean any remaining gasket material from face of adaptor flange on engine.

Assemble Pump Bearing Housing

1. Lightly coat the outside diameter of a new oil seal with clean engine oil. From drive end of bearing housing, press new oil seal into seal bore. Seal lip must point to drive end of housing.

© Detroit Diesel Corporation

2. With pressure applied to *inner* race of bearings, press bearings onto shaft.
3. With pressure applied to *outer* race of outer bearing, install bearing and shaft sub-assembly into bearing housing.
4. Install bearing retaining ring in bearing housing, insuring it is securely seated in ring groove.
5. Insert woodruff key into groove on end of shaft. Install drive gear onto shaft by gently tapping it with a small plastic-face mallet.
6. Install flat washer, lock washer, and retaining nut onto shaft. Prevent shaft from rotating by holding it with a wrench on shaft flats at impeller end, and tighten retaining nut to 24 - 30 lb—ft (33 - 41 N*m) torque.
7. Follow steps 1 through 10 of minor assembly instructions to install pump body and components.
8. Install new adaptor flange gasket, and secure pump assembly to adaptor with six (6) 3/8" screws, flat washers, and lock washers. Tighten to 13 - 15 lb—ft (18 - 20 N*m) torque.
9. Using new gaskets, attach raw water pump inlet and outlet adaptors.

Install Pump On Engine

The pump may be installed by reversing the procedure used for removal.

Note that the end cover is marked to show the outlet port for RH rotation and the outlet port for LH rotation.

Follow these markings when installing the raw water pump to avoid any difficulty regarding direction of flow. Also, when installing the inlet elbow or the outlet elbow, be sure to use two flat washers on the bolt being installed in the blind hole in the pump housing.

© Detroit Diesel Corporation

COOLANT FILTER AND CONDITIONER

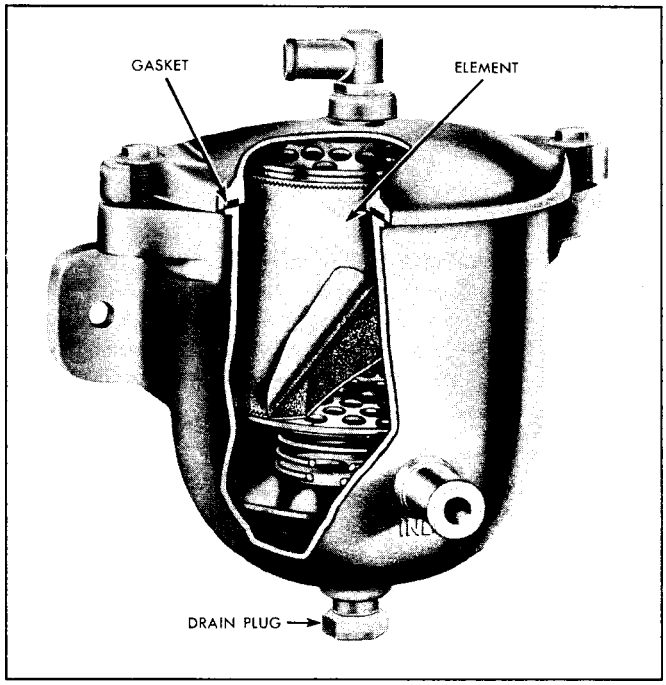


Fig. 1 - Coolant Filter and Conditioner (Canister Type)

The engine cooling system filter and conditioner is a compact by-pass type unit with a replaceable canister type element (Fig. 1), a spin-on type element (Fig. 2) or a clamp-on type element (Fig. 3).

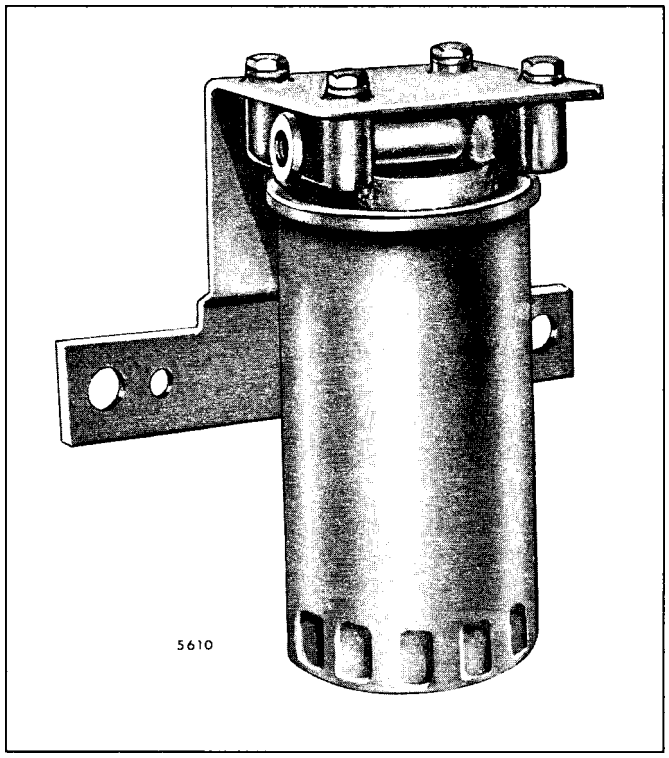


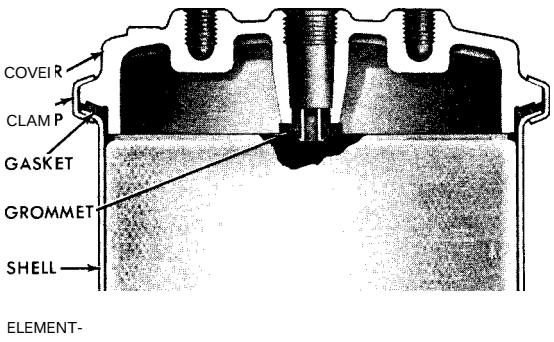
Fig. 2 - Coolant Filter and Conditioner (Spin-On Type)

The current type filter assembly includes one filter element while the former filter assembly included two filter elements. Two coolant filters connected in parallel are used on the Series 149 engine (Fig. 4).

A correctly installed and properly maintained coolant filter and conditioner provides a cleaner engine cooling system, greater heat dissipation, increased engine efficiency through improved heat conductivity and contributes to longer life of engine parts.

The filter provides mechanical filtration by means of a closely packed filter element through which the coolant passes. Any impurities such as sand and rust particles suspended in the cooling system will be removed by the straining action of the element. The removal of these impurities will contribute to longer water pump life and proper operation of the thermostat.

The filter also serves to condition the coolant by softening the water to minimize scale deposits, maintain an acid-free condition and acts as a rust preventive. Corrosion inhibitors are placed in the element and dissolve into the coolant, forming a protective rustproof film on all of the metal surfaces of the cooling system (refer to Section 13.3).



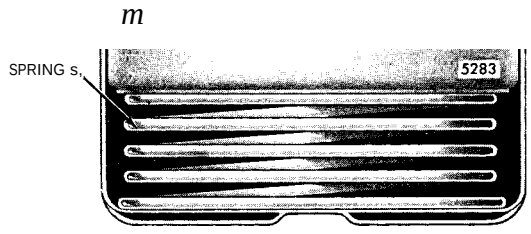


Fig. 3 - Coolant Filter and Conditioner (Clamp-On Type)

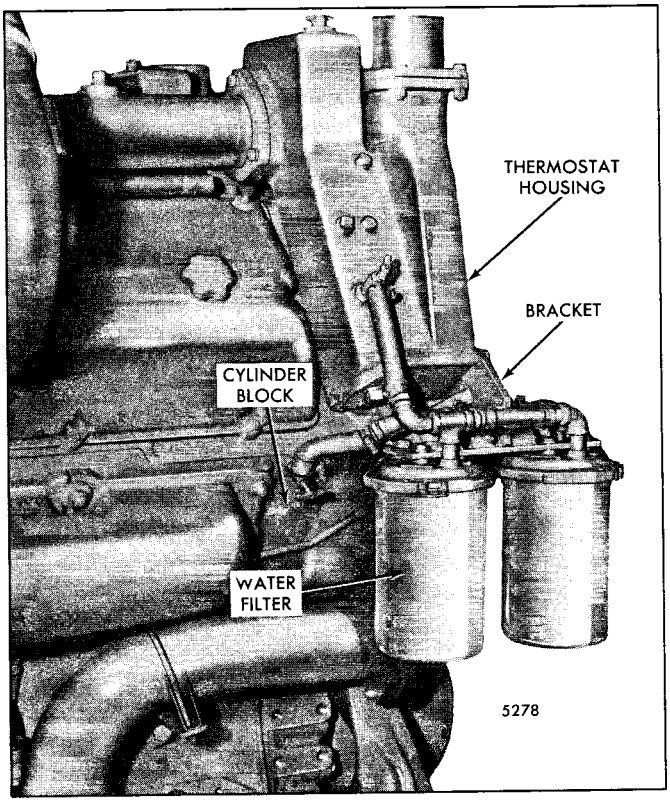


Fig. 4 - Typical Coolant Filter Mounting

The other components of the element perform the function of cleaning and preparing the cooling passages while the corrosion inhibitors protect them.

Filter Installation

If a coolant filter and conditioner is to be installed on an engine which has been in service, drain and flush the cooling system prior to installation of the filter.

Filter Maintenance

Replace the chemically activated element, following the manufacturer's recommended change periods (refer to Section 15.1). The lower corrosion resistor plate (if used) must be buffed each time (discard the plate if excessive metal loss or pitting is evident) to ensure effective protection of the cooling system.

If the filter is installed on an engine which has previously been in service, it may be necessary to change the filter element two or three times at intervals of approximately 200 hours or 6,000 miles, or less, to clean up accumulations of scale and rust in the cooling system. It is advisable to drain and flush the system during these initial change intervals.

Make-up water up to 40% of the total capacity of the cooling system may safely be added before a filter element change is required.

NOTICE: Sea water must never be used for make-up water in a marine engine, except under emergency conditions. If it is necessary to use sea water, the cooling system must be completely drained and flushed with fresh water upon reaching port. The filter element must be changed. Filters with resistor plates must be inspected for pitting. *Presence of salt in the coolant results in rapid pitting of the resistor plates.*

If it is necessary for any reason to drain the cooling system before an element change, the treated water should be saved and reused. If the treated water is discarded, a new filter element must be installed since the protective agents in the used filter will have been partially consumed in treating the discarded water.

Service

The coolant filter may be grounded at the option of the user.

The current coolant filter includes a non-chromate type element. This element can be used in place of either of the former filter elements (permanent type antifreeze or plain water type) and thus provides year around cooling system protection. The current and the former filter elements are completely interchangeable in the former filter can (refer to Section 13.3).

Replace the element and service the filter and conditioner as follows:

1. Close the filter inlet and outlet shut-off valves. If shut-off valves are not provided, vise grip pliers can be used to clamp each hose closed during the filter change. Use caution to avoid damaging the hoses with the vise grip pliers.
2. Canister Type Element:
   a. Remove the drain plug in the bottom of the filter body and let drain.
   b. Remove the filter cover-to-filter body bolts.
   c. Remove and discard the element.
   d. Remove and discard the corrosion resistor plates, if used.
   e. Remove the sludge and sediment and wash the filter body. Dry it thoroughly with compressed air.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

   f. Replace the drain plug in the bottom of the filter.
   g. Insert the new element.
   h. Use a new filter cover gasket and install the filter cover and tighten the bolts evenly.

© Detroit Diesel Corporation

3. Spin-On Type Element:
   a. Remove and discard the element.
   b. Clean the gasket seal on the filter cover.
   c. Remove the sludge and sediment and wash the filter body. Dry it thoroughly with compressed air.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

   d. Apply clean engine oil to the filter element gasket and install the new element. A 1/2 to 3/4 turn after gasket contact assures a positive leakproof seal.
4. Clamp-On Type Element:
   a. Remove the retaining clamp.
   b. Remove and discard the element.
   c. Remove the sludge and sediment and wash the filter body. Dry it thoroughly with compressed air.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

   d. Insert the new element.
   e. Secure the filter body in place with the clamp.
5. Open the inlet and outlet lines byopening the shut-off valves or removing the vise grip plier clamps.
6. Operate the engine and check for leaks. The top of the filter and the outlet line should feel warm to the touch with the rise in coolant temperature. If not, disconnect the filter outlet line at the end opposite the filter connection to bleed the air from the system and reconnect the line. Use caution to minimize coolant loss.

© Detroit Diesel Corporation

SHOP NOTES - TROUBLESHOOTING SPECIFICATIONS - SERVICE TOOLS

SHOP NOTES

DRAINING JABSCO RAW WATER PUMP

Although the engine is provided with draincocks for the purpose of draining the cooling system, a small amount of coolant may remain in the impeller housing of the raw water pump.

Under normal circumstances there would be no need in completely draining the impeller housing of a raw water pump, therefore, no drain plug has been incorporated at this location. However, certain models employ a raw water pump in conjunction with a fresh water cooling system.

In the event the engine is to be stored in below freezing temperatures, it is suggested that, in addition to draining the cooling system of the engine, the impeller housing of the raw water pump be completely drained. This may easily be accomplished by loosening the five (5) fillister head screws which attach the end cover to the pump housing, at the impeller end of the pump, then pulling the end cover away from the pump body, while being careful to avoid damage to the gasket. The screws need only be loosened sufficiently to allow complete draining of the impeller housing, then retightened.

RAW WATER PUMP IMPELLERS

The Jabsco raw water pump is equipped with synthetic rubber impellers. Since the synthetic rubber begins to lose its elasticity at low temperatures, impellers made of natural rubber may be installed when it is necessary to pump raw water that has a temperature below 40°F (4°C). However, the standard impellers must be used when the pump operates in warmer water.

New service impellers of natural rubber are identified by a stripe of green paint.

BACKLASH BETWEEN WATER PUMP GEAR AND IDLER GEAR (ACCESS HOLE)

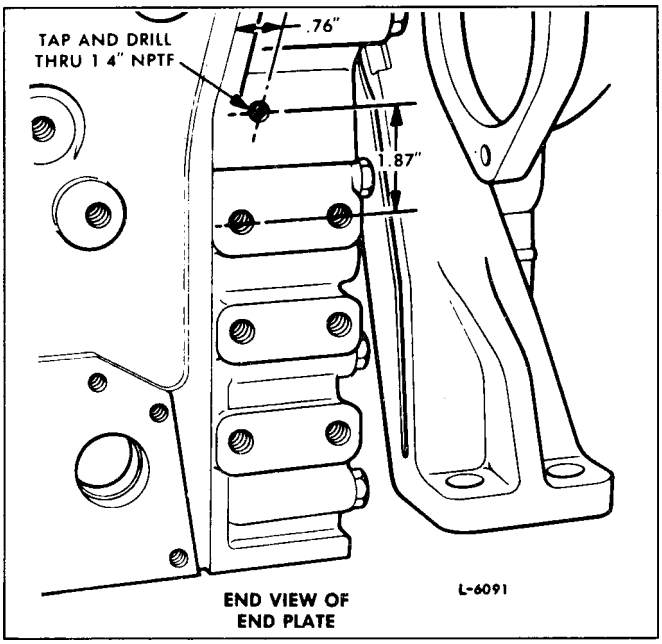


Fig. 1 - Location of Access Hole

If the engine front cover is the former style and does not contain an access hole, it is advisable that one be machined at the time of overhaul (Fig. 1).

Use 1/4 inch pipe plug to seal the opening after the hole is machined and the gear lash check is complete.

TROUBLESHOOTING

COMBUSTION GAS LEAKAGE INTO THE COOLING SYSTEM

Determining the area from which combustion gas is leaking into the cooling system can be both troublesome and time consuming. If a visual inspection of the cylinder kits through the air box (see Section 1.6) or a pressure check of the cooling system does not reveal the source of the leakage, the following procedure may be used:

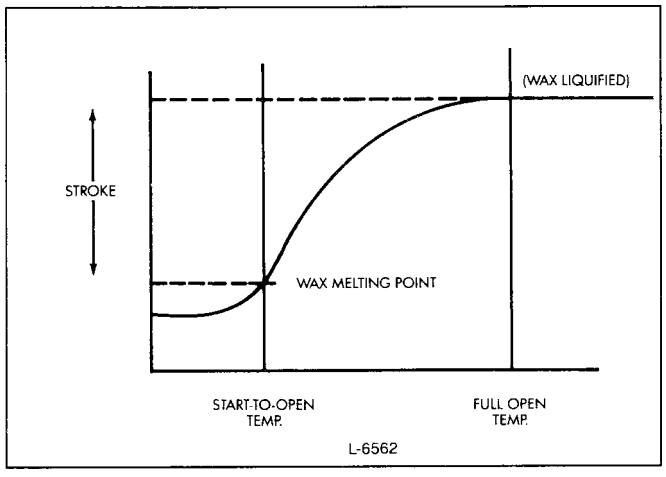
1. Drain the coolant from the engine.
2. Refer to Section 5.1:
   a. Remove the water pump cover and gasket.
   b. Remove the locknut and washer and withdraw the impeller using puller J 24420-A.
   c. Remove the vanes from an impeller. A vaneless impeller is required to render the pump inoperative while maintaining an effective pump seal. Make sure the ceramic insert remains in the impeller counterbore. Place this impeller and a washer on the shaft and start the locknut on the shaft. Hold the pump gear securely while drawing the impeller down with the locknut. Tighten the nut to 35-40 lb—ft (47-54 N*m) torque.
   d. Install the water pump cover and gasket. Tighten the nuts securely.
3. Refer to Section 5.2:
   a. Disconnect any water lines attached to the water manifolds.
   b. Loosen the seal and clamp between each front and rear manifold. Discard the seals.
   c. Remove the three manifold flange attaching bolts and lock washers from each thermostat housing. Slide each flange, seal and plate back on the manifolds. Discard the seals and gaskets.
   d. Remove the bolts and lock washers which attach the manifolds to the cylinder block, then remove the manifolds from the cylinder block. Remove and discard the gaskets.
4. Refill the cooling system so that the coolant level rises to the open water manifold outlet holes in the block. Do not overfill the cooling system.
5. To locate the faulty cylinder, start the engine and visually check for combustion gas bubbles forming at the water manifold outlet holes. Because coolant will not circulate through the engine with the impeller vanes removed, care must be taken not to allow the engine to exceed normal operating temperatures.
6. Replace the vaneless water pump impeller with a serviceable one (refer to Section 5.1).
7. Install the water manifolds (refer to Section 5.2).
8. Refill and properly inhibit the engine cooling system (refer to *Coolant Specifications (Section 13.3) or Coolant for Detroit Diesel Engines - Form 7SE298).*

.THERMOSTAT FUNCTION TESTING

Thermostat print specifications normally call for three specific operating conditions: namely, start-to-open temperature, full-open temperature, and full-open dimension. The most important of these is the *start-to-open* temperature. This is the temperature at which the motor mechanism (wax compound) experiences a change from a solid to a liquid, expanding and opening the thermostat to allow coolant flow. At full-open temperature, the liquid wax is fully expanded and the full-open dimension is reached, ensuring proper coolant flow to the radiator. The start-to-open temperature is normally stamped or printed on the thermostat.

A definite relationship exists between the start-to-open temperature and operating stroke (full-open travel) of the thermostat. This relationship may be seen in the illustration below. The normal tolerance for the start-to-open temperature is +2°F or -3°F (+1.11°C or -1.67°C).

To ensure that sufficiant coolant flows through the radiator to control engine temperature, the start-to-open temperature and the full-open dimension of the thermostat should be checked. Series 149 thermostats are designed so that at 3/4 of their stroke coolant flow is not substantially affected so as to cause coolant temperature concerns. Thermostats may be tested on the simple fixture shown (Fig. 4). This fixture can be made from readily available materials.



 © Detroit Diesel Corporation

Materials

1 Stainless steel or non-ferrous metal vessel approximately 8" diameter by 6" deep

1 2000 watt immersion-type heating element

1 Thermostatic control having a 60°F to 230°F (15.6° to 110°C) temperature range and a capillary tube sensing device

1 12" length of 1/4" copper tubing

1 3/8" drain valve

1 7 1/2" diameter piece of 12-gauge galvanized sheet steel or 1/8" aluminum (for bed plate)

1 Bulkhead fitting

1 Air control valve

1 Laboratory thermometer with a 60°F to 230°F (15.6°C to 110°C) range

1 Dial indicator having a one inch travel with a 3/8" gauge holding rod and swivel post lock screw

The thermostat test fixture consists of the test vessel with control (Fig. 3) and the test plate assembly (Fig. 2).

Making The Test Fixture

1. Drill a 1/8" hole in the side of the vessel and braze a bulkhead fitting to the vessel to accept an air control valve. Shop air will be used to agitate the water and relieve temperature stratification within the vessel.
2. Manufacture an aeration line from a 12" length of 1/4" copper tubing by drilling four equally spaced 1/8" holes in the tube and crimping or blocking one end. Attach the open end of the tube to the air valve and bend the tube to the inside contour of the vessel.
3. Install a 3/8" drain valve in the lower portion of the vessel.
4. Fabricate the bed plate from 12-gauge galvanized steel or 1/8" aluminum sheet stock. The bed plate is used to suspend the thermostat at a mid-point in the vessel. This component must fit squarely in the vessel and have legs of sufficient length to ensure that stats won't contact the heating element and aeration line.

   Bore 1 9/16", 2", and 2 3/4" holes in the plate spaced 120° from each other to facilitate the installation of the variety of stats normally encountered. Drill three 7/16" holes at 60° from each thermostat mounting bore for conveniently locating a thermometer during testing.

   Install a 3/8" x 8" upright base post in the center of the plate to provide the mounting for a dial indicator.
5. Attach the dial indicator gauge to the upright center post of the plate to permit accurate thermostat travel measurement. The bed plate and dial indicator shown have components added to raise the indicator vertically above the gauge holding rod; however, the extra items are not required.

Thermostat Testing Procedure

NOTICE: This procedure will take time to do properly. Refer to Fig. 4.

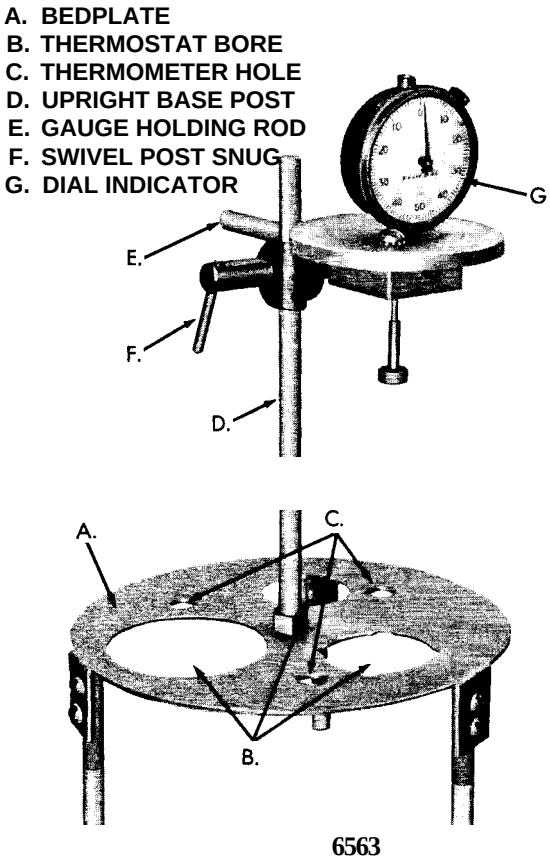


Fig. 2 - Test Plate Assembly

Place the vessel on a level surface and lower the bed plate into position, being careful to avoid contact with the heating element.

Fully submerge the thermostat in warm water and place a laboratory thermometer in one of the 7/16" holes on the bed plate. Position the dial indicator over the thermostat, centering the contact point on the motor mechanism. Zero the dial. To ensure accurate test results, allow the thermostat to warm up to water temperature before testing. Then, turn on the heating element (if necessary) and bring water temperature to a few degrees below the start-to-open temperature of the thermostat being tested. Hold at this temperature for 2-3 minutes.

With the heating element on, adjust the air valve to sufficiently agitate the water for equal heat distribution. Bring bath temperature up to the maximum specified

© Detroit Diesel Corporation

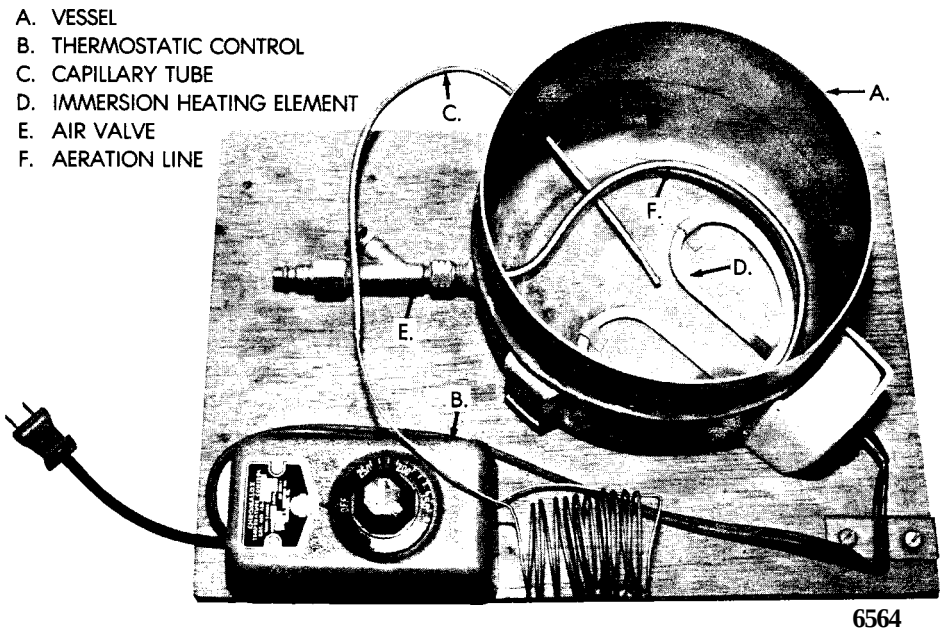


Fig. 3 - Test Vessel and Control

start-to-open temperature of the thermostat. Observe the dial indicator and note the temperature at which the needle just begins to move. This if referred to as the *start-to-open temperature.* The total indicator travel, from start-to-open to full-open is referred to as the *full open travel.*

For full-open temperature and travel, raise bath temperature a few degrees above the specified full-open temperature and hold at that temperature for 2 to 3 minutes.

To efficiently test a number of thermostats, simply add cold water to the vessel. This will reduce the water temperature to a level below the next thermostat opening temperature, thus saving time. Turn the heating element off after completing the tests.

Conducting Cooling Tests

When conducting cooling tests on an engine, it is essential that maximum radiator/heat exchanger coolant flow be achieved. Coolant flow and, subsequently, the accuracy of cooling system test results depend to a large extent on the condition of the thermostat installation. If maximum flow does not occur, check for these causes.

1. Thermostat(s) not blocked open to correct dimension.
2. Thermostat housing seal(s) missing.
3. Thermostat housing seal(s) worn.
4. Thermostat housing cover bypass cavity sealing surface(s) not centered and/or worn.

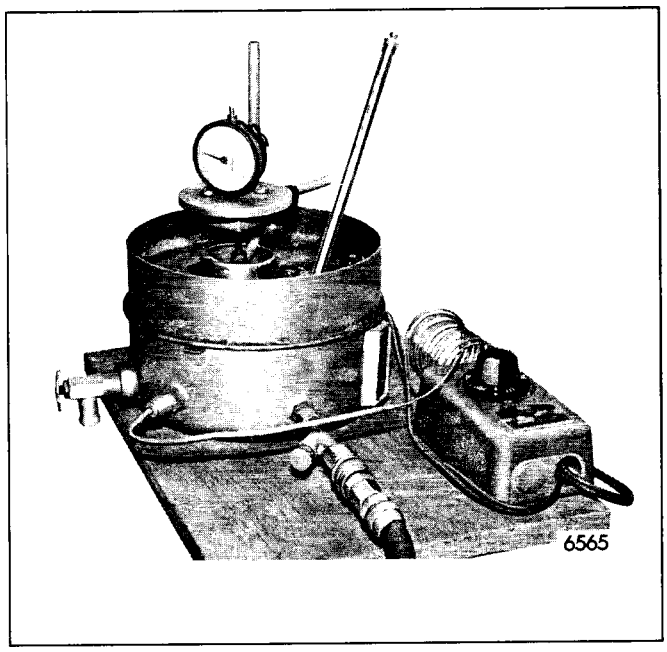


Fig. 4 - Testing a Thermostat in the Test Fixture

 © Detroit Diesel Corporation

.FIND COOLANT LEAKS WITH FLUORESCENT DYE, BLACK LIGHT

Finding the source of an engine coolant leak is often a time-consuming affair. To speed the process, a fluorescent dye such as *15174 Uranine**, or equivalent, may be added to the coolant. Under an ultraviolet (black) light, the *Uranine* dye-treated coolant turns a highly visible, bright *yellow-green* color, making the leak path easy to trace.

* Available from:

CHEMCENTRAL CORPORATION
7050 West 71st Street
Chicago, Illinois 60638

© Detroit Diesel Corporation

SPECIFICATIONS

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	260M BOLTS TORQUE (lb-ft)	INUm	THREAD SIZE	280M OR BETTER TORQUE (lb-ft)	INUm
1/4-20	5-7	7-9	1/4-20	7-9	10-12
1/4-28	6-8	8-11	1/4-28	8-10	11-14
5/16-18	10-13	14-18	5/16-18	13-17	18-23
5/16-24	11-14	15-19	5/16-24	15-19	20-26
3/8-16	23-26	31-35	3/8-16	30-35	41—47
3/8-24	26-29	35-40	3/8-24	35-39	47-53
7/16-14	35-38	47-51	7/16-14	46-50	62-68
7/16-20	43-46	58-62	7/16-20	57-61	77-83
1/2-13	53-56	72-76	1/2-13	71-75	96-102
1/2-20	62-70	84-95	1/2-20	83-93	113-126
9/16-12	68-75	92-102	9/16-12	90-100	122-136
9/16-18	80-88	109-119	9/16-18	107-117	146-159
5/8-11	103-110	140-149	5/8-11	137-147	186-200
5/8-18	126-134	171-181	5/8-18	168-178	228-242
3/4-10	180-188	244-254	3/4-10	240-250	325-339
3/4-16	218-225	295-305	3/4-16	290-300	393-407
7/8-9	308-315	417—427	7/8-9	410-420	556-569
7/8-14	356-364	483^494	7/8-14	475—485	644-657
1-8	435-443	590-600	1-8	580-590	786-800
1-14	514-521	697-705	1-14	685-695	928-942

Grade identification markings are normally stamped on the heads of the bolts. To aid identification of the various bolts used in Detroit Diesel engines, refer to the following chart.

Grade Identification Marking on Bolt Head	GM Number	SAE Grade Designation	Nominal Size Diameter (inch)	Tensile Strength Min. (psi)
None	GM 255-M	i	No. 6 thru 1 1/2	60,000
None	GM 260-M	2	No. 6 thru 3/4 over 3/4 to 1 1/2	74.000 60.000
Bolts and Screws	GM 280-M	5	No. 6 thru 1 over 1 to 1 1/2	120,000 105,000
Hex Head Sems Only	GM 275-M	5.1	No. 6 thru 3/8	120,000
'yC Bolts and Screws	GM 290-M	7	1/4 thru 1 1/2	133,000
Bolts and Screws	GM 300-M	8	1/4 thru 1 1/2	150,000
Bolts and Screws	GM 455-M	None	No. 6 thru 1 1/2	55,000

BOLT IDENTIFICATION CHART

 © Detroit Diesel Corporation

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD	lb-ft	N«m
Fresh water pump shaft locknut	7/16-20	40-45	54-61
Fan shaft locknut		195-205	265-278
Raw water pump drive gear locknut	5/8-18	25-30	34-41

STUD TORQUE SPECIFICATIONS

APPLICATION	STUD	lb-ft	N*m
Water pump body stud	3/8-16	20-30	27—41

SERVICE TOOLS

TOOL NAME	TOOL NO.
Belt gage (10 or 18 ribs, L section)	J 33889
Belt gage (8 rib, K section - 10 rib, L section)	J 23586-B
Driver handle	J 7079-2
Impeller slip checking fixture	J 34034
Installer—water pump oil seal	J 8501
Puller—universal	J 24420-B
Seal installer	J 8550
Snap ring pliers	J 4646
Water pump drive gear installer	J 25257

© Detroit Diesel Corporation

SECTION 6

EXHAUST SYSTEM

CONTENTS

Exhaust System 6
Exhaust Manifold (Air-Cooled) 6.1
Exhaust Manifold (Water-Cooled)..... 6.1.1

EXHAUST SYSTEM

Fan and radiator cooled engines are equipped with an air-cooled exhaust manifold. A water-cooled exhaust manifold is provided for engines incorporating a heat exchanger or keel cooling system.

The outlet flange may be located at the end or at the mid-section of the exhaust manifold, depending upon the installation requirements. A flexible exhaust connection or a muffler may be attached to the outlet flange.

The exhaust manifold is attached to the cylinder block by studs, special washers, clamps and nuts.

© Detroit Diesel Corporation

EXHAUST MANIFOLD (AIR COOLED)

• A two-piece exhaust manifold with metal seal ring and expander (Fig. 1) is used on each side of 8V-engines. Two one-piece exhaust manifolds (Fig. 2) are used on each side of 12V engines. Two one-piece manifolds (Fig. 3) were formerly used on each side of 16V engines. These were replaced by new two-piece manifolds with seals, expanders, and clamps (Fig. 1), effective with unit serial number 16E08115.

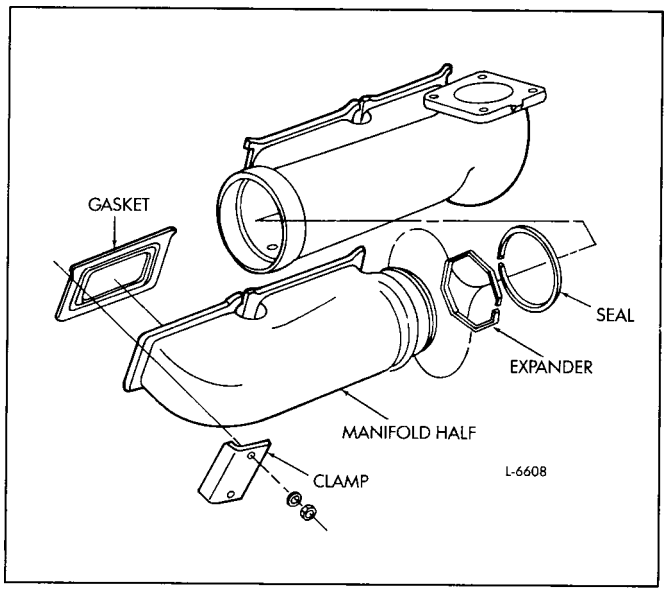


Fig. 1 Typical Two–Piece Exhaust Manifold Mounting

A single " Y" shaped adaptor connects the manifolds to the exhaust piping for each bank on a naturally aspirated engine (Fig. 2). Turbocharged engines utilize an adaptor on each manifold which connects the exhaust manifolds to the turbochargers. •

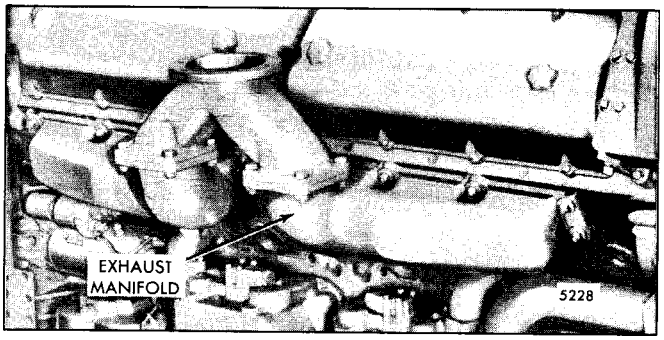


Fig. 2 - Typical One-Piece Exhaust Manifold Mounting

• In 1982, drain holes (Fig. 3) were added to all Series 149 non-marine exhaust manifolds in order to visually detect a *coolant leak and prevent the buildup* of potentially damaging *coolant inside the manifolds.* Effective with engine serial numbers 12E08857 and 16E08747, a new drain plug is factory-installed in the exhaust manifolds of all mine haul engines and is provided as a ship loose item (at 1 per manifold) with all other industrial models. DDC recommends installing these drain plugs in all engine applications (including 8V-149) that can tolerate open exhaust drains.

Remove Exhaust Manifold

1. Disconnect the exhaust pipe or adaptor from the exhaust manifold flange.
2. Loosen and remove the nuts, clamps and special washers which secure the exhaust manifold to the cylinder block. It is suggested that, as a safeguard, one nut and washer be loosened and left on one of the center studs of each manifold or manifold half until all of the other nuts and washers have been removed.
3. Support the manifold(s) and remove the nut(s) and washer(s) from the center stud(s).
4. Lift the manifold(s) away from the cylinder block.
5. Remove the gasket(s).

Inspection

Remove the loose scale and carbon that may have accumulated on the internal walls of the exhaust manifold. It is especially important to clean the manifold used on a turbocharged engine to eliminate the possibility of loose scale entering and damaging the turbocharger.

Before replacing a turbocharger that has experienced compressor turbine wheel damage, always inspect for and remove any debris that may have accumulated in the exhaust manifold. Failure to remove debris can result in damage to the replacement turbocharger.

Check the 1 /8" drain holes (if used) in the manifolds to be sure they are open.

Because some engine applications cannot tolerate open exhaust drains, all drain openings are plugged at the factory. Anyone wishing to utilize the drain hole feature must remove the solid pipe plugs from the manifolds and install a special service only plug which incorporates a 1/8" drilled hole. Through engine testing, the Engineering Department has determined that a 1/8" drilled hole has no significant effect on engine performance.

NOTICE: A drain hole larger than the 1/8" drilled hole may affect engine performance.

Those wishing to add this preventive maintenance feature to engines currently in service may modify their one-piece exhaust manifolds by drilling 1/8" holes in the locations shown in Fig. 3. Position the holes in the approximate center of the manifold in the logitudinal direction and at the lowest point in the transverse direction. Thread holes with 1/8" NPSF tap and install service-only exhaust manifold drain plugs which incorporate a 1/8" drilled hole.

© Detroit Diesel Corporation

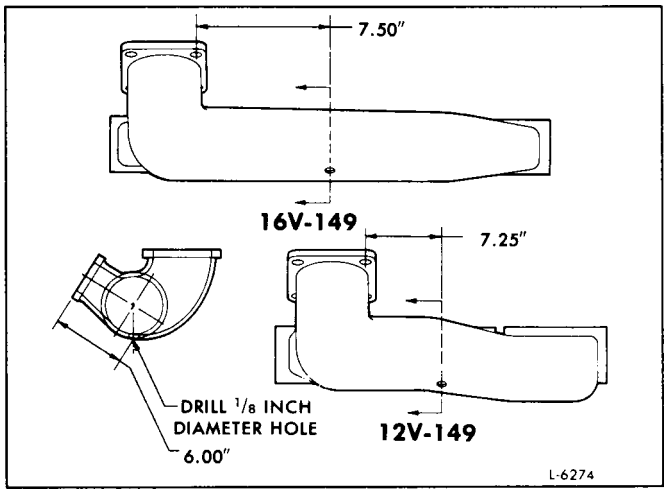


Fig. 3 - Exhaust Manifold Drain Hole Location

The exhaust manifolds and turbocharger exhaust inlet adaptors have been revised to provide a centrally located exhaust outlet connection. The exhaust manifold gasket and manifold attaching clamp have also been revised to improve sealing.

Check the flatness of each manifold. Flatness must be held at .005" to ensure proper sealing at the mating surface to the cylinder block. If the flange faces require milling, remove only the minimum amount of material necessary. To maintain sufficient end clamping, the height of the end clamp support legs should be reduced by an amount equal to that removed from the flange faces.

When replacing an exhaust manifold on a naturally aspirated engine, the current front and rear manifolds on the same cylinder bank must be used together with the revised gasket and clamp.

When replacing an exhaust manifold or an exhaust inlet adaptor on a turbocharged engine, both the current adaptor and manifold must be used together with the revised gasket and clamp.



Fig. 4 - Former and Current Exhaust Manifold Gaskets

Install Exhaust Manifold

- 1. Place a new, all-metal gasket over the studs (Fig. 4). When the current all-metal gasket is used, all studs will be the same length. Omit the beveled washer on the end studs when the new end clamp (Fig. 5) is used.
2. On 8V and 16V engines equipped with two-piece exhaust manifolds, install the expander and seal ring in the groove in the manifold, then assemble the two halves.
3. Position the exhaust manifold over the studs and up against the gasket.
4. Install the special washers so that the outer diameter will rest on the manifold and the crown is toward the nut. Then, install the two end clamps and attaching nuts on the studs. When an all-metal gasket is used on a 16V engine equipped with a one-piece exhaust manifold, use new end clamps or former clamps that have been reworked (Fig. 5).
5. Draw the manifold against the gasket, starting with the center nut. Tighten the nuts with stud nut wrench J 26816 to 50-55 lb—ft (68-75 N'm) torque.
6. Connect the exhaust pipe or adaptor to the exhaust manifold flange. Tighten the 5/8"—18 outlet flange nuts to 103-110 lb—ft (140-149 N-m) torque. Do not allow exhaust piping to impose excessive loads on the turbocharger.
7. Inspect exhaust outlet piping for dents, holes and potential sources of water infiltration such as loose clamps or deteriorated seals. Repair or replace, if necessary.

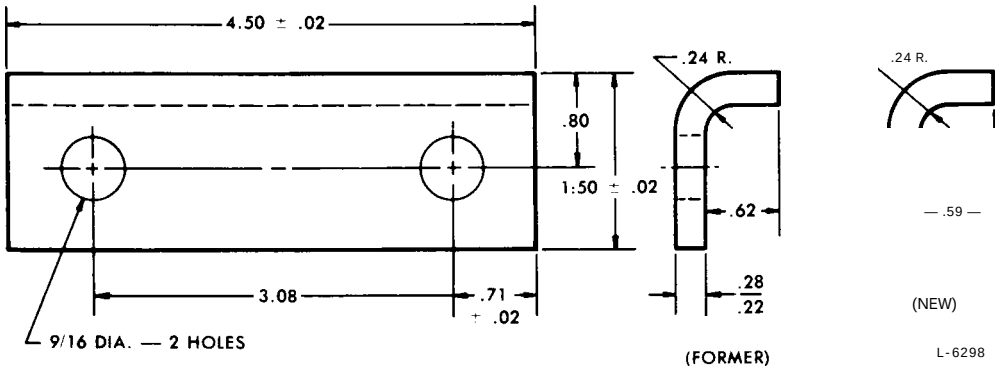


Fig. 5 - Former and Current End Clamps Used on One-Piece Exhaust Manifold

 © Detroit Diesel Corporation

EXHAUST MANIFOLD (WATER COOLED)

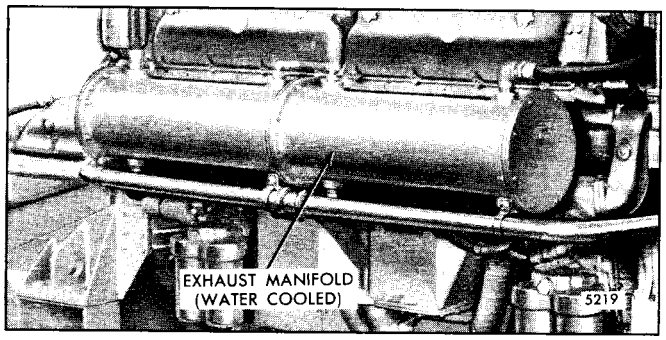


Fig. 1 - Water Cooled Exhaust Manifold Mounting (Naturally Aspirted Engines)

Water cooled exhaust manifolds are generally used on marine units, and some enclosed stationary installations, where the temperature of the engine room would raise the engine operating temperature above acceptable limits.

• The two-piece bolt-together water cooled exhaust manifold (Fig. 1) is designed with an integral water jacket surrounding the exhaust chamber. A portion of the engine coolant is bypassed from the rear of the water manifold into the rear exhaust manifold and is discharged from the front of the rear manifold into the rear of the front manifold. Coolant exits from the front of this manifold to different locations, depending on the application. A drain cock is installed in the bottom of each manifold for draining the water jacket. Manifolds may also have a center drain cock to check the exhaust path for the presence of water.

• One-piece water-cooled exhaust manifolds (Fig. 2) have a cast-in water jacket surrounding the exhaust chamber. A drain cock is normally installed in the bottom of the manifold(s) for draining the water jacket. On engines using one-piece water-cooled manifolds, the coolant flow is as follows:

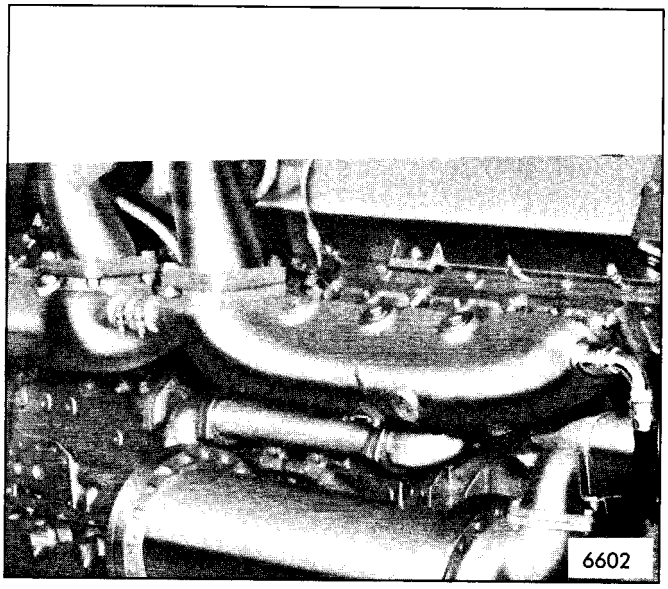


Fig. 2 - Water Cooled Exhaust Manifold Mounting (Turbocharged Engines)

8V Engines

Coolant flows from hoses on each side of the block into water inlet elbows at the front of the manifolds. After passing through the exhaust manifolds, the coolant exits through hoses routed to the water manifolds, then flows from the water manifolds through the thermostat housings and into the heat exchanger.

12V Engines

Left bank: Coolant flows from the heat exchanger into the left-bank thermostat housing and then into the left-bank water manifold. Coolant exits through a hose at the rear of the water manifold and enters the rear of the left-bank exhaust manifold. From here it passes through a connector into the front manifold and exits out a hose routed back to the heat exchanger.

Right bank: Coolant flows from a hose on the side of the block into the front of the right-bank exhaust manifold, passes through a connector into the rear exhaust manifold, and exits through a hose routed to the rear of the water manifold. After flowing through the water manifold, it enters the thermostat housing and returns to the heat exchanger.

16V Engines

Coolant flows from hoses on each side of the block into water inlet elbows in the front manifold. Coolant from each front manifold flows through connecting hoses into each rear manifold. The coolant exits through hoses routed to the rear of the water manifolds, then flows through the thermostat housings and into the heat exchanger.

Refer to *Troubleshooting* in Section 5.0 for combustion gas leakage into the cooling system.

Remove Exhaust Manifold

Because of the weight of the water cooled exhaust manifold, care should be taken to provide adequate support and means of removing and installing the manifolds on the engine.

Two-Piece Bolt Together Manifolds

1. Drain the cooling system.
2. Disconnect the water inlet and the water outlet tubes from the exhaust manifolds.
3. Disconnect the tubes or hoses connecting the manifolds.
4. Loosen and remove the nuts, two clamps and special washers which secure the exhaust manifold to the cylinder block. It is suggested that, as a safeguard, one

© Detroit Diesel Corporation

nut and washer be loosened and left on one of the center studs until all other nuts and washers have been removed.

5. Support the manifold and remove the nut and washer from the center stud.
6. Lift the manifold off the studs and away from the cylinder block.
7. Remove the manifold gaskets.

Inspection

Remove the loose scale and carbon that may have accumulated on the internal walls of the exhaust manifold. It is especially important to clean the manifold used on a turbocharged engine to eliminate the possibility of loose scale entering and damaging the turbocharger.

Before replacing a turbocharger that has experienced compressor turbine wheel damage, always inspect for and remove any debris that may have accumulated in the exhaust manifold. Failure to remove debris can result in damage to the replacement turbocharger.

Install Exhaust Manifold

1. On all engines, place a new, all-metal gasket over the studs (Fig. 3).



Fig. 3 - Former and Current Exhaust Manifold Gaskets

2. Position one of the exhaust manifolds over the studs and up against the gasket.
3. Install the special washers so that the outer diameter will rest on the manifold and the crown is toward the nut. Then, install the nuts on the studs.

NOTICE: When an all-metal gasket is used on an engine, use new end clamps or former clamps that have been reworked (Fig. 4).

.4. Draw the manifold against the gasket, starting with the center nut. *When installing'two-piece, bolt-together manifolds,* tighten the nuts with stud nut wrench J 26816 to 50-55 lb—ft (68-75 N*m) torque.

When installing one-piece cast manifold, tighten the 5/8"-18 center stud nut and the 5/8"—11 bolts to 103-110 lb—ft (140-149 N*m) torque.

5. Install a new center gasket and attach the remaining manifold, if removed.
6. If the exhaust flange was removed from the manifold, install the flange, using a new gasket.
7. Connect the exhaust pipe to the flange. Tighten the 5/8"—11 outlet flange nuts to 103-110 lb-ft (140-149 N*m) torque.
8. Connect the water inlet and outlet tubes to the manifold.

NOTICE: Do not allow exhaust piping to impose excessive loads on the turbocharger.

9. Inspect exhaust outlet piping for dents, holes and potential sources of water infiltration such as loose clamps or deteriotated seals. Repair or replace, if necessary.
10. Fill the cooling system and check for leaks.

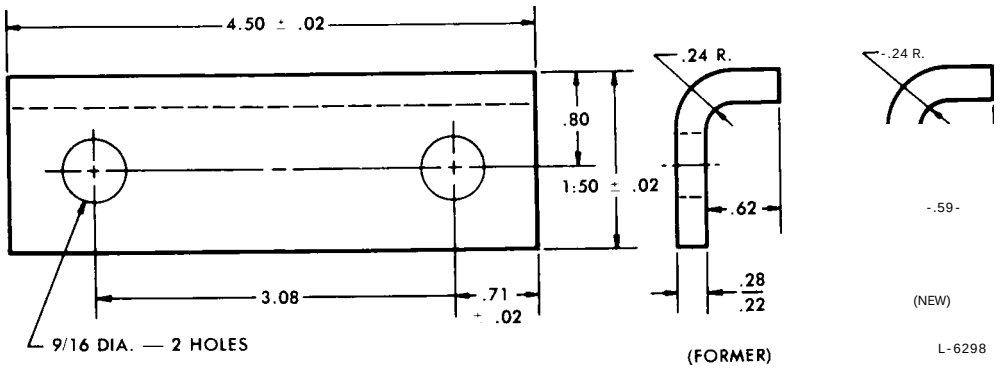


Fig. 4 - Former and Current Exhaust Manifold End Clamps

© Detroit Diesel Corporation

SECTION 7

ELECTRICAL EQUIPMENT, INSTRUMENTS AND PROTECTIVE SYSTEMS

CONTENTS

Electrical System 7

Battery-Charging Alternator..... 7.1

Storage Battery..... 7.2

Starting Motor..... 7.3

Instruments and Tachometer Drive 7.4
Engine Protective Systems..... 7.4.1
Alarm System..... 7.4.2
Overspeed Governors 7.4.3

Power Generator..... 7.5

Shop Notes - Trouble Shooting - Specifications..... 7.0

ELECTRICAL SYSTEM

A typical engine electrical system generally consists of the starting motor(s), a battery-charging alternator, storage batteries and the necessary wiring. Additional equipment such as an engine protective system may also be included.

Detailed information on maintenance and repair of the specific types of electrical equipment can be found in the service manuals and bulletins issued by the equipment manufacturer. Information regarding equipment manufactured by the Delco-Remy Division of General Motors Corporation may be obtained from their electrical equipment operation and service manuals. The manuals may be obtained from AC-Delco service outlets, or from the Technical Literature Section, Delco-Remy Division of General Motors Corporation, Anderson, Indiana.

In most instances, repairs and overhaul work on electrical equipment should be referred to an authorized repair station of the manufacturer of the equipment. Replacement parts for electrical equipment should be ordered through the equipment manufacturer's outlets, since these parts are not normally stocked by Detroit Diesel Corporation. For electrical equipment manufactured by Delco-Remy Division, repair service and parts are available through AC-Delco branches and repair stations.

© Detroit Diesel Corporation

BATTERY-CHARGING ALTERNATOR

The battery-charging circuit consists of an alternator, battery (Section 7.2), and the wiring. The battery-charging alternator (Fig. 1) is introduced into the electrical system to provide a source of electrical current for maintaining the storage battery in a charged condition and to supply sufficient current to carry any other electrical load requirements up to the rated capacity of the alternator.

HINGE-MOUNTED ALTERNATOR (BELT-DRIVEN)

The hinge-mounted alternating current self-rectifying alternator, mounted at the rear of the engine, is belt-driven. The alternator drive pulley is keyed to a shaft which is coupled to the blower drive gear.

An adequate alternator drive ratio is necessary for an engine equipped with extra electrical accessories and one that has to operate for extended periods at idle speeds. Diodes, built into the slip ring end frame, rectify the three phase A.C. voltage to provide D.C. voltage at the battery terminal of the alternator, thereby eliminating the need for an external rectifier. The alternator is also available in various sizes and types, depending upon the specific application.

The SI series alternators have replaced the DN series alternator. With the new alternators, the need for a separately mounted voltage regulator is eliminated.

The 32 volt, 50 ampere 25SI alternator has been replaced by the 30SI alternator, rated at 60 amperes, for marine applications. When installing the 30SI alternator, a wire running from the alternator to the battery (insulated ground vs negative ground) must be installed.

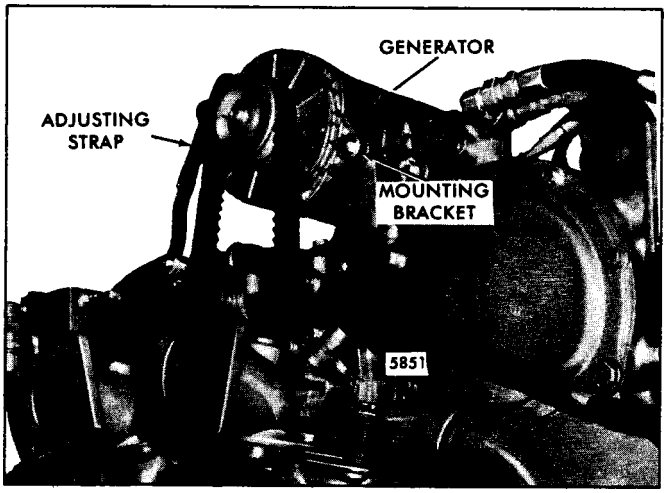


Fig. 1 - Typical Hinge-Mounted Alternator

The access hole permitting the external adjustment of the voltage regulator has been eliminated on current alternators. To adjust the voltage setting on the current alternators, remove the rectifier end plate. The voltage regulator adjustment is located on the voltage regulator circuit board. Refer to the pertinent Delco Service Bulletin for complete adjustment procedure.

The proper selection of an alternator which will meet the needs of the battery-charging circuit on the particular engine is mandatory. This, together with adherence to the recommended maintenance procedures will reduce alternator troubles to a minimum. Since most alternators adhere to the same basic design, the maintenance, removal and installation procedures for all are similar.

Alternator Maintenance

1. Maintain the proper drive belt tension. Replace worn or frayed belts. Belts should be replaced as a set when there is more than one belt on the alternator drive.

2. When installing or adjusting the drive belt, be sure the bolt at the pivot point is properly tightened, as well as the bolt in the adjusting slot.

3. Alternator bearings are permanently lubricated. There are no external oiler fittings.

Remove Alternator

1. Disconnect the cables at the battery supply. Disconnect all other leads from the alternator and tag each one to ensure correct reinstallation.

2. Loosen the mounting bolts and the adjusting strap bolt. Then remove the drive belts.

3. While supporting the alternator, remove the adjusting strap bolt and washers. Then remove the mounting bolts, washers and nuts. Remove the alternator carefully and protect it from costly physical damage.

4. Remove the pulley assembly if the alternator is to be replaced (Fig. 2).

© Detroit Diesel Corporation

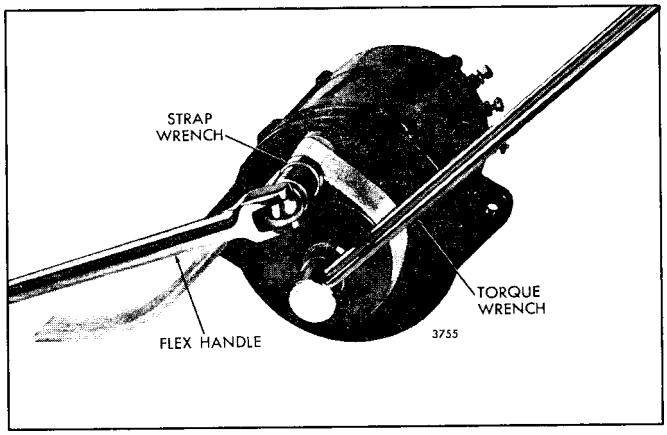


Fig. 2 - Tightening Alternator Pulley Retaining Nut

Alternator Service

Repairs and overhaul work on alternators should be referred to an authorized repair station of the manufacturer of this equipment. Replacement parts for alternators should be ordered through the equipment manufacturer's outlets. For alternators manufactured by Delco-Remy Division, repair service and parts are available through AC Delco branches and repair stations.

Install Alternator

1. Install the drive pulley, if it was removed. Tighten the 5/8" - 18 pulley retaining nut to 70-80 lb—ft (95-108 N*m) torque (Fig. 2).

   NOTICE'.If the pulley was not removed, check the retaining nut for proper torque.

2. Position the alternator on the mounting brackets and start the bolts, with washers in place, through the bolt holes in the end frames. If nuts are used, insert the bolts through the bolt holes in the mounting bracket and end frame. Make sure that the washers and nuts are in their proper locations.

3. Align the threaded hole in the adjusting lug of the drive end frame with the slot in the adjusting strap. Start the bolt, with the washers, through the slot of the adjusting strap and into the threaded hole in the end frame.

4. Place the drive belts in the grooves of the pulleys.

5. Adjust the belt tension as outlined in Section 15.1. After the belt tightening is complete, tighten the 7/16"-14 mounting bolts to 46-50 lb—ft (62-68 N*m) torque and the 1/2"-13 mounting bolts to 60-70 lb—ft (81-95 N*m) torque.

6. Attach the wires and cables. Be sure that each one is correctly installed in accordance with its previous location on the alternator. Keep all connections clean and tight.

ALTERNATOR PRECAUTIONS

Precautions must be taken when working on or around alternators. The diodes and transistors in the alternator circuit are very sensitive and can be easily destroyed.

Avoid grounding or shorting the output wires or the field wires between the alternator and the regulator. Never run an alternator on an open circuit.

Grounding an alternator's output wire or terminals, which are always "hot" regardless of whether or not the engine is running, or accidental reversing of the battery polarity will destroy the diodes. Grounding the field circuit will also result in the destruction of the diodes. Some voltage regulators provide protection against some of these circumstances. However, it is recommended that extreme caution be used.

Accidentally reversing the battery connections must be avoided.

Never disconnect the battery while an alternator is in operation. Disconnecting the battery will result in damage to the diodes due to the momentary high voltage and current generated by the rapid collapse of the magnetic field surrounding the field windings.

In marine applications which have two sets of batteries, switching from one set of batteries to the other while the engine is running will momentarily disconnect the batteries and result in damage to the alternator diodes.

If a booster battery is to be used, the batteries must be connected correctly (negative to negative and positive to positive).

Never use a fast charger with the battery connected or as a booster for battery output.

Never attempt to polarize the alternator.

The alternator diodes are also sensitive to heat and care must be exercised to prevent damage to them from soldering irons, etc.

If faulty operation of an alternator occurs on an engine equipped with an insulated starting motor, check to be sure that a ground strap is present and is correctly installed.

© Detroit Diesel Corporation

STORAGE BATTERY

• The battery is a device for storing electrical energy and converting chemical energy into electrical energy.

• The three basic types of batteries currently being marketed are:

Filler Cap Batteries

These are lead-acid batteries with a high degree of antimony in the grid alloy. They require frequent servicing, especially the need for adding water, as well as cleaning salts from the terminal posts.

Semi-Maintenance Free Batteries

These are conventional filler cap batteries with reduced amounts of antimony in the grid alloy and, consequently, servicing is somewhat reduced. Water must still be periodically added. Terminal posts tend to accumulate salts.

Maintenance-Free Batteries

These batteries use lead-calcium grid construction without antimony. They never need water, nor are provisions provided for adding water. As these batteries have no filler caps to leak acid fumes, terminal posts have less tendency to accumulate salts, and as a result require less frequent cable inspection and cleaning.

The chart below gives the minimum battery capacity recommended for acceptable engine cranking.

Function Of Battery

The battery has three major functions:

1. It provides a source of current for starting the engine.
2. It acts as a stabilizer to the voltage in the electrical system.
3. It can, for a limited time, furnish current when the electrical demands exceed the output of the generator or alternator.

NOTICE: In the selection of a replacement battery, it is always good practice to select one of an "electrical size" at least equal to the battery originally engineered for the particular equipment by the manufacturer.

Install Battery

While the battery is built to satisfactorily withstand the conditions under which it will normally operate, excessive mechanical abuse leads to early failure.

Install the battery as follows:

1. Be sure the battery carrier is clean and that the battery rests level when installed.
2. Tighten the hold-down clamps evenly until snug. However, do not draw them down too tight or the battery case will become distorted or will crack.
3. Attach the cable clamps after making sure the cables and terminal clamps are clean and in good condition. To make the cable connections as corrosion resistant as possible, place a felt washer at the base of each terminal, beneath the cable clamp. Coat the entire connection with a heavy general purpose grease. Be sure the ground cable is clean and tight at the engine block or frame.
4. Check the polarity to be sure the battery is not reversed with respect to the generating system.
5. Connect the *grounded* terminal of the battery last to avoid short circuits which will damage the battery.

Servicing The Battery

A battery is a perishable item which requires periodic servicing. Only when the battery is properly cared for as described below can long and trouble-free service be expected.

1. On filler cap batteries or semi-maintenance free batteries, check the level of the electrolyte regularly. Add water if necessary, but do not overfill. Overfilling can cause poor performance or early failure.
2. Keep the terminal end of the battery clean. When necessary, wash with a baking soda solution and rinse with fresh water. Do not allow the soda solution to enter the cells.

ENGINE MODEL	SYSTEM VOLTAGE	MINIMUM BATTERY RATINGS	
		SAE COLD CRANKING AMPS (CCA) @ 0°F (-17.8°C)	
		ABOVE 32°F (0"C)	BELOW 32°F (0°C)
8V-149 12V-149, 16V-149	24V, 32V 24V#, 32V#	950	1250

#Two cranking motors. Battery recommendation is for each motor.

• Fig. 1 - General Battery Recommendations

© Detroit Diesel Corporation

3. Inspect the cables, clamps and hold-down bracket regularly. Clean and reapply a coat of grease when needed. Replace corroded or damaged parts.

4. Use the standard battery test (below) as the regular service test to check the condition of the battery.

5. Check the electrical system if the battery becomes discharged repeatedly.

Many electrical troubles caused by battery failures can be prevented by systematic battery service.

• Testing Batteries

CAUTION: Battery electrolyte is a solution of sulfuric acid. Avoid contact with clothing, skin, and eyes.

CAUTION: When batteries are being charged and tested, an explosive gas forms inside the battery. Some of this gas escapes through the holes in the vent plugs or vents in the battery cover and may form an explosive atmosphere around the battery itself if ventilation is poor. Sparks or flame can ignite this gas, causing an explosion which can shatter the battery. Flying pieces of the battery structure and splash of electrolyte can cause personal injury.

To avoid personal injury, observe these precautions before charging and/or testing a battery:

1. Wear face and eye protection.

2. Have a clean water supply available (to wash off any splashed electrolyte).

3. Provide proper ventilation.

4. Do not test near fire or flame.

• Testing Maintenance-Free (Freedom) Batteries

Test each battery separately as follows:

1. Disconnect both terminals of each battery.

2. If battery has threaded stud terminals, use terminal adapters (AC-Delco # ST 1201) when testing or charging.

3. Check each battery visually.

4. Examine the hydrometer “eye” (if no eye, proceed to Step 5).

   - Eye shows green - continue test.

     Eye shows dark - recharge, then continue.

   - Eye shows yellow - replace battery.

5. Apply a 300 amp load for 15 seconds. Turn off load. Wait one minute.

6. If no hydrometer eye, measure terminal voltage (Fig- 2)

   If 12.4 volts or more - continue.

   - If less than 12.4 volts - recharge, then repeat Steps 5 and 6.

7. Apply a test load of 1/2 CCA rating (in amps). After 15 seconds, with load still applied, measure the terminal voltage. Turn the load off.

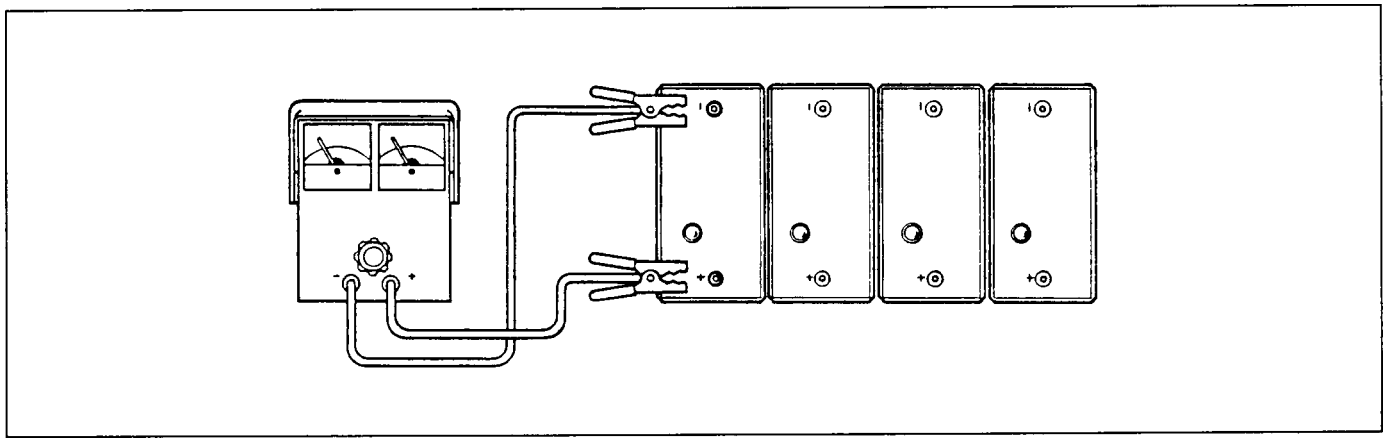


Fig. 2 - Battery Testing

 © Detroit Diesel Corporation

8. Estimate the temperature of the battery. If measured voltage does not meet or exceed the values shown below, replace the battery.

TEMPERATURE	MIN. VOLTS
70°F (2 1.1°C)	9.6
50°F (10.0°C)	9.4
30°F (1.1 1°C)	9.1
1 5°F (-9.44°C)	8.8
0°F (-1 7.8°C)	8.5

9. Clean all cable ends and terminals of the battery with a wire brush.

10. Tighten the hold-down to specification.

.Testing Filler Cap And Semi-Maintenance-Free Batteries

Test each battery separately as follows:

1. Disconnect both terminals of each battery.

2. If battery has threaded stud terminals, use terminal adapters (AC-Delco # ST 1201) when testing or charging.

3. Check each battery visually.

4. Check electrolyte level.

   If fluid is above the top of the plates in all cells, proceed to Step 5.

   - If not, add water, replace vent caps, and charge battery for 15 minutes at 15 to 25 amps to mix electrolyte. Proceed to Step 5.

5. Check specific gravity. If hydrometer readings for all cells are 1.230 or above and show less than 0.050 between high and low at electrolyte temperature of 80°F, proceed to Step 6.

   - If the readings show more than 0.050 difference - replace battery.

   If the readings show less than 0.050 difference, but some cells read less than 1.230 - recharge battery.

   If charging won't bring up the specific gravity - replace battery.

6. Remove vent caps and connect 300 amp load for 15 seconds.

   - If a blue haze or smoke is seen in any cell - replace battery.

   If not, proceed to Step 7.

7. Measure electrolyte temperature and replace vent caps.

   - Connect voltmeter (Fig. 2) and a specific load of one-half the battery's rated CCA.

   - Read voltage after 15 seconds while load is still connected.

   - Disconnect load.

   - Compare voltage reading with the chart below.

   If voltage is less than the chart, replace battery.

   - If voltage is equal or greater than the chart - the battery is good.

ELECTROLYTE TEMPERATURE	VOLTAGE
70°F (21.1°C)	9.6
60°F (1 5.6°C)	9.5
50°F (10.0°C)	9.4
40°F (4.44°C)	9.3
30°F (1.1 1°C)	9.1
20°F (-6.67°C)	8.9
10°F (-1 2.2°C)	8.7
0°F (-1 7.8°C)	8.5

8. Clean all cable ends and terminals of the battery with a wire brush.

9. Tighten the hold-down to specification.

© Detroit Diesel Corporation

STARTING MOTOR

• Starting motors are mounted on the flywheel housing (Fig. 1). One starting motor is used on 8V engines, and two motors are used on 12V and 16V engines. When the starting circuit is closed, a small drive pinion on the armature shaft of each starter engages with the teeth on the engine flywheel ring gear to crank the engine. When the engine starts, it is necessary to disengage the drive pinions to prevent the armatures from overspeeding and damaging the starting motors. To accomplish this, the starting motors are equipped with heavy-duty overrunning clutches.

See Section 7.0 for the mounting of a Delco-Remy starter auxiliary magnetic switch.

A solenoid switch, mounted on the starting motor housing, operates the overrunning clutch drive by linkage and a shift lever (Fig. 2). When the starting switch is engaged, the solenoid is energized and shifts the starting motor pinion into mesh with the flywheel ring gear and closes the main contacts within the solenoid. Once engaged, the clutch will not disengage during intermittent engine firing. To protect the armature from excessive speed when the engine starts, the clutch "overruns", or turns faster than the armature, which permits the pinion to disengage itself from the flywheel ring gear.

The solenoid plunger and shift lever on this type of starting motor are totally enclosed to protect them from dirt, water and other foreign material.

An oil seal, between the shaft and the lever housing, and a linkage seal prevents the entry of transmission oil into the main frame of the starting motor and solenoid case, allowing the motor to be used on wet clutch applications.

The nose housing on the starting motor can be rotated to obtain a number of different solenoid positions with respect to the mounting flange. The nose housing, on starters equipped with the heavy-duty clutch, is attached to the lever housing by six bolts located around the outside of the housing. When repositioning of the solenoid is required on a service replacement starting motor, proceed as follows:

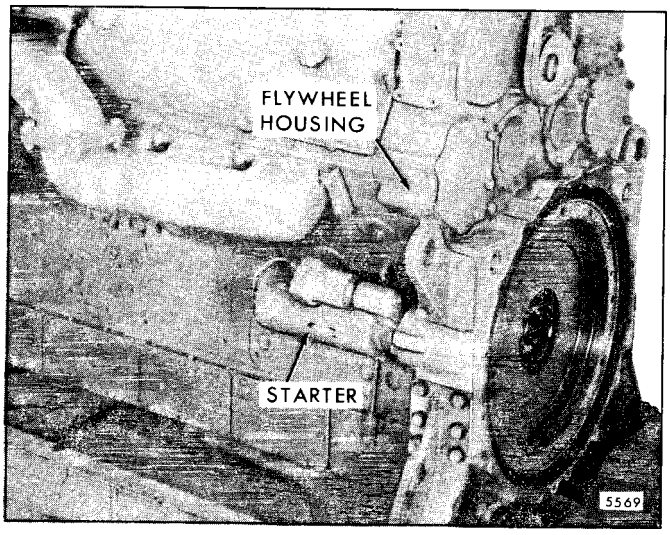


Fig. 1 - Starting Motor Mounting

1. Remove the six socket head screws (1 short and 5 long).

2. Turn the nose housing to the required position.

   NOTICE: The solenoid must never be located below the centerline of the starter or dust, oil, moisture and foreign material can collect and cause solenoid failures.

3. Install the six socket head screws, with the short screw in the shallow hole nearest the solenoid.

4. Tighten the screws to 13-17 lb—ft (18-23 N*m) torque.

Lubrication

• Starting motors are permanently lubricated at time of manufacture, and no further lubrication is required.

Remove Starting Motor

Failure of a starting motor to crank the engine at normal cranking speed may be due to a defective battery, worn battery cables, poor connections in the cranking circuit, defective engine starting switch, low temperature, condition of the engine or a defective starting motor.

If the engine, battery and cranking circuit are in good condition, remove the starting motor as follows:

1. Remove the ground strap or cable from the battery or the cable from the starting motor solenoid. Tape the end of the cable to prevent discharging the battery from a direct short.

2. Disconnect the starting motor cables and solenoid wiring.

   NOTICE: Tag each lead to ensure correct connections when the starting motor is reinstalled.

3. Support the motor and remove the three bolts and lock washers which secure it to the flywheel housing. Then, pull the motor forward to remove it from the flywheel housing.

4. Check the starting motor in accordance with the Delco-Remy "Cranking Circuit" maintenance handbook.

© Detroit Diesel Corporation

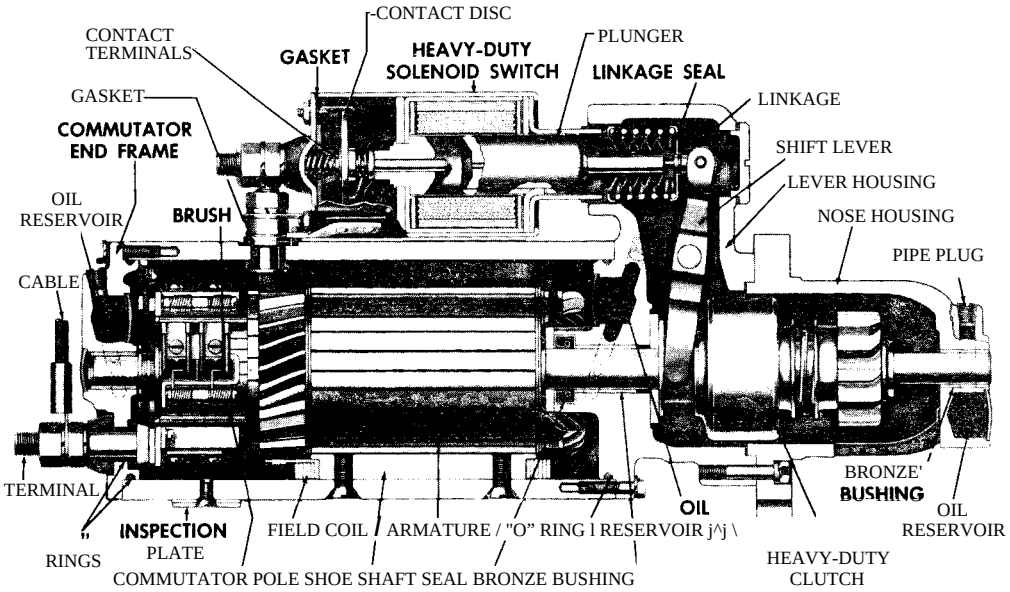


Fig. 2 - Cross-Section of Starting Motor with Heavy-Duty Drive

Install Starting Motor

To install the starting motor, reverse the procedure outlined for removal. Tighten the 5/8"—11 starter attaching bolts to 137-147 lb—ft (186-200 N«m) torque.

Keep all of the electrical connections clean and tight. When installing wiring terminal leads to the starting motor and the solenoid switch, tighten the No. 10-32 connections to 16-30 lb-in (2-3 N*m) torque and the 1/2"-13 connections to 20-25 lb—ft (27-34 N*m) torque.

© Detroit Diesel Corporation

INSTRUMENTS AND TACHOMETER DRIVE

INSTRUMENTS

The instruments generally required in the operation of a diesel engine consist of an oil pressure gage, water temperature gage, an ammeter and a mechanical tachometer. Also, closely related and usually installed in the general vicinity of these instruments are certain controls consisting of an engine starting switch, engine stop knob and an emergency stop knob.

The instruments, throttle control and engine starting and stopping controls are mounted in various locations, depending upon the particular use of the engine.

Marine propulsion engines are provided with an instrument panel which usually includes an engine oil pressure gage, reverse gear oil pressure gage, water temperature gage, ammeter and a tachometer. The instrument panels are generally mounted some distance from the engine.

Anti-Vibration Instrument Mountings

Anti-vibration mountings are used in many places to absorb engine vibration in the mounting of instruments, drop relays, tachometers, etc. When it may become necessary to service a part secured by rubber mounts, care should be taken during removal and installation of the part to avoid twisting the rubber diaphragm. At the time the part is removed from the engine for service, the mounts should be inspected for damage and replaced, if necessary.

The attaching screw, through the center of the mount, must be held from turning during final tightening of the nut. Support the screw and tighten the nut only. If this screw turns, it will pre-load the rubber diaphragm in torsion and considerably shorten the life of the mount.

Oil Pressure Gage

The oil pressure gage registers the pressure of the lubricating oil in the engine. As soon as the engine is started, the oil pressure gage should start to register. If the oil pressure gage does not register at least the minimum pressure listed in the *Operating Conditions* in Section 13.2, the engine should be stopped and the cause of the low oil pressure determined and corrected before the engine is started again.

Current oil pressure gages have male threads and require female fittings. When replacing a former gage with female threads, a new mounting clamp and connector must be used.

Water Temperature Gage

The engine coolant temperature is registered on the water temperature gage.

Incorrect water temperature readings will be registered if the gage assembly is incorrectly installed or the capillary tube is damaged.

To prevent damage to the gage assembly from vibration, the capillary tube must be securely fastened to the engine the full length with suitable clips at intervals of ten inches or less. Sharp bends in the tube must be avoided, particularly at the gage or bulb connection areas. Where the tube must be bent around any object, the bend must not be less than one inch radius.

Any extra length can be taken up by coiling, the diameter of which should not be less than two inches. The coils must be located so that they may be securely fastened to prevent vibration.

Ammeter

An ammeter is wired into the electrical circuit to show the current flow to and from the battery. After starting the engine, the ammeter should register a high charge rate at rated engine speed. This is the rate of charge received by the battery to replenish the current used to start the engine. As the engine continues to operate, the ammeter should show a decline in the charge rate to the battery. The ammeter will not show zero charge rate since the regulator voltage is set higher than the battery voltage. The small current registered prevents rapid brush wear in the battery-charging generator or alternator. If lights or other electrical equipment are connected into the circuit, then the ammeter will show discharge when these items are operating and the engine speed is reduced.

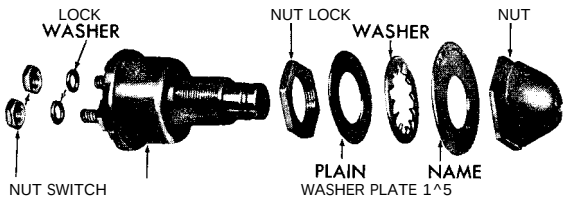


Fig. 1 - Typical Starting Switch Assembly

© Detroit Diesel Corporation

Tachometer

The tachometer, driven by the engine, registers the speed of the engine in revolutions per minute (rpm).

Throttle Control

The engine throttle is connected to the governor speed control shaft through linkage. Movement of the speed control shaft changes the speed setting of the governor and thus the engine speed.

Engine Starting Switch

To start the engine, a switch is used to energize the starting motor (Fig. 1). Starting switches may vary in design and their contacts must be rated sufficiently to carry the starter solenoid current.

> **NOTICE:** Tighten the 5/8”-32 starting switch mounting nut to 36-48 lb-in (4-5.5 N*m) torque.

Engine Stop Knob

A stop knob is used to shut down the engine. When stopping an engine, the engine speed should be reduced to idle and the engine allowed to operate at idle for a few minutes to permit the coolant to reduce the temperature of the engine’s moving parts. Then, pull the stop knob and hold it until the engine stops.

> **NOTICE:** When an emergency shutdown is necessary on a current engine with the spring loaded fuel injector control tube (one adjustment screw) the stop knob should be pulled **immediately** and held until the engine stops. Pulling on the stop knob manually places the injector racks in the *no-fuel* position. Return the stop knob to its *original* position after the engine stops.

Emergency Stop Knob (Engines With Air Shutoff Valve)

In an emergency, or if the engine continues to operate after pulling the stop knob, the emergency stop knob may be used to stop the engine. When the emergency stop knob is pulled, the air shutoff valve, located between the air intake and the blower, will trip and shut off the air supply to the engine. Lack of air to the engine will prevent further combustion of the fuel and stop the engine.

The emergency stop knob must be pushed back in after the engine is stopped, and the air shutoff valve must be reset manually. The cause of the malfunction should be determined before the engine is started again.

.CRANKCASE PRESSURE MONITOR

Effective with engines built approximately March 1 of 1984, a new crankcase pressure monitor is used on all Series 149 engines. The new monitor (Fig. 2) is larger than the former monitor and is mounted on the engine front cover.

The crankcase pressure monitor is used to detect excessive crankcase pressure which may be caused by internal engine malfunction. Early detection of an internal malfunction may prevent catastrophic engine damage.

The monitor senses excessive crankcase pressure by means of a diaphragm connected to a microswitch (see Fig. 3). There are three contacts in the microswitch: *common, normally open, and normally closed.* Depending on the application, these contacts may be used as required to activate an alarm system or a shutdown device and/or remove the load from the engine (for example, inhibit electric drive propulsion) when excessive crankcase pressure is detected. Detroit Diesel Corporation has determined that reducing or eliminating load from the engine will reduce the possibility of catastrophic engine damage until engine shutdown can be accomplished.

The microswitch in the monitor is activated when crankcase pressure exceeds 4.5 + .5 inches of water (1.0 to 1.2 kPa) and remains activated even when pressure is reduced. The monitor is reset by removing the safety cover and pushing in the reset button.

> **CAUTION: The crankcase pressure monitor is mounted on the engine front cover and is near the engine cooling fan and belt drives. To avoid personal injury, the engine must be shut down before resetting the monitor.**

Overhaul Procedure

Detroit Diesel Corporation recommends overhauling the current monitor at normal engine overhaul intervals or if a malfunction (failure to reset, for example) should occur.

> **CAUTION: To avoid personal injury and/or engine damage caused by accidental start-up, disconnect the battery cables or the air starter system before removing or installing the crankcase pressure monitor.**

 © Detroit Diesel Corporation

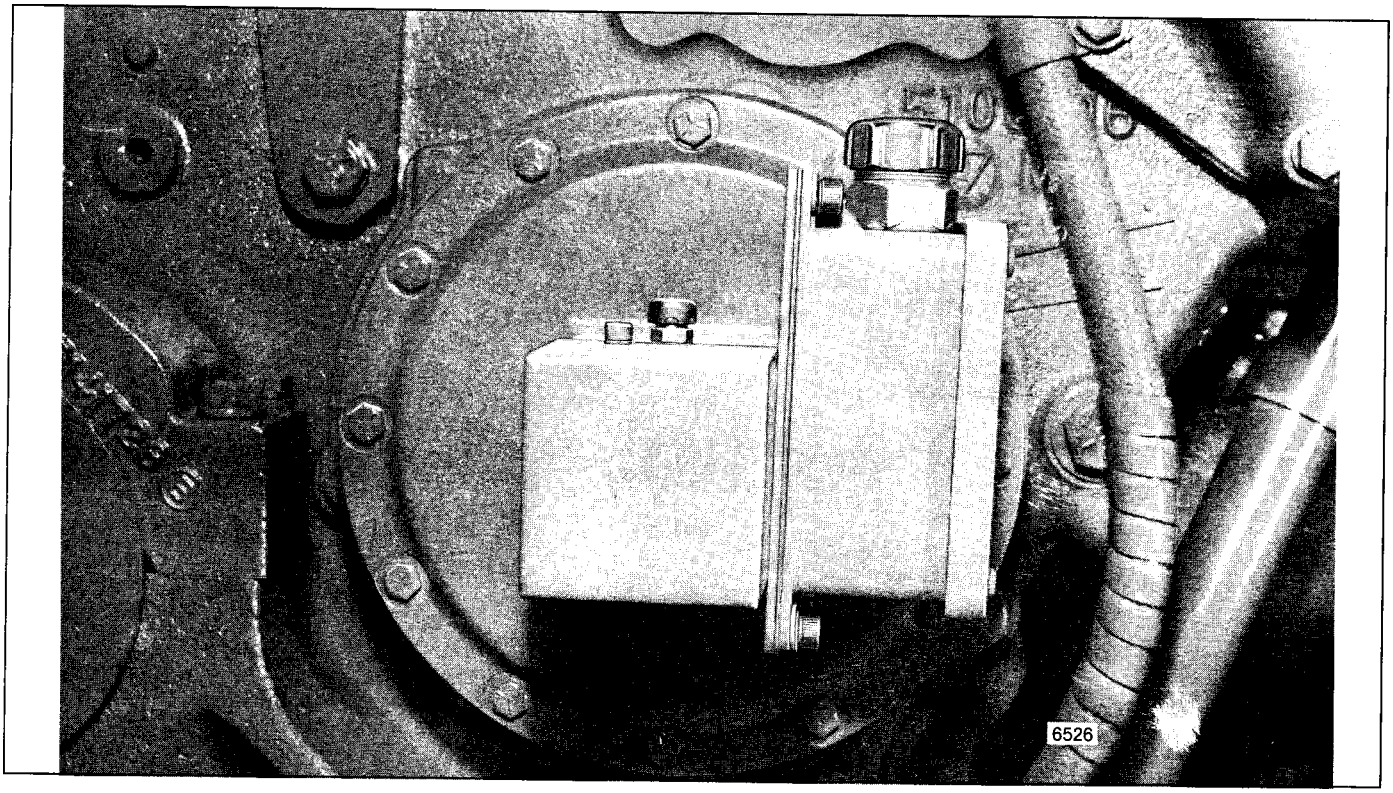


Fig. 2 - Crankcase Pressure Monitor Installed on Front Cover

1. Detach the wiring and remove crankcase pressure monitor from engine. Plug conduit connector hole, and clean all exterior surfaces with solvent or suitable engine degreaser.

2. Wipe or blow dry and place unit, large flange down, on flat, clean surface.

3. Refer to Fig. 4 and remove button cover (17) and terminal box cover (34). Discard screws (1), washers (2), and cover (17).

4. Remove four screws and washers (33 & 32). Remove terminal box (45).

5. Remove two screws and washers (28 & 27), and remove switch plate assembly (26).

6. Remove two screws (18) and withdraw stem assembly (4). Set crankcase tag (3) aside.

7. Remove screw (43) in center of button (42). Remove button and spring (41). Remove stem (38) from guide flange (40). Remove old O-ring (39) and discard. Clean all parts, install new O-ring (39) and reassemble, putting Loctite 271 (or equivalent) on screw (43), and greased O-ring (39) on stem.

8. Remove two #6-32 nuts (30) and washers (29, 36) from screws (22). Remove and discard microswitch assembly (35) and spring (24).

9. Drive out lever retaining pin (25). Discard lever (23) and pin (25).

10. Install new lever (23) and pin (25), with flat side facing up, away from switch.

11. Install new microswitch assembly (35) using screws (22) and washers (29, 36) and nuts (30). Make sure spring (24) is between switch body and lever, over stem of switch. Letter-marked side of switch should face out (be visible).

12. Remove four socket head 1/4" - 20 screws (5) and hold housing assemblies (6 & 7) to upper cover (11).

13. Remove housing assembly (7) and keep the 3 balls (8) for ball retainer (21) removal.

14. Remove ball retainer (21) using tool J 35352-2. With the balls in place, install the tool to engage the balls in the slots of the tool. Turn counterclockwise to remove. Discard the balls.

15. Remove O-ring (20) from ball retainer (21) and replace with new O-ring (20), lightly greased.

© Detroit Diesel Corporation

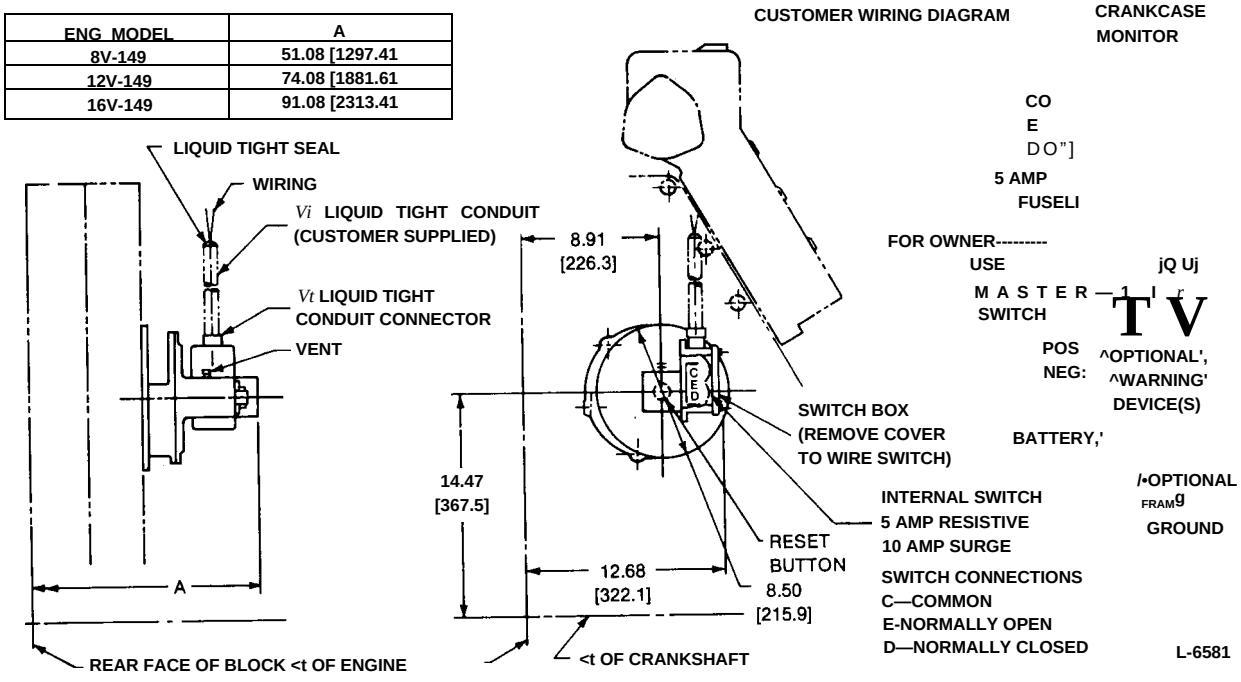


Fig. 3 - Crankcase Pressure Monitor Installation Schematic

16. Place ball retainer (21) into housing (19) by the reverse of step 14, tighten firmly and lock thread joint with punch mark.

17. Place new balls (8) into ball retainer (21) with grease.

18. Remove spring (10) from base of unit and discard.

19. Remove 12 screws (9) from base and separate the two halves (11, 16).

20. Remove diaphragm assembly (14) with gaskets (13) and ball cage (12) attached.

21. Remove 3 small screws (15) from underside of plate to release ball cage (12) from diaphragm. Discard diaphragm.

22. Clean ball cage (12) and install with 3 screws onto new diaphragm assembly (14).

23. Install new gaskets (13) to both sides of diaphragm assembly (14) and place on base. Align holes.

24. Place upper cover (11) on diaphragm assembly (14) and base (16), aligning all gasket and component holes.

25. *Start* 12 screws (9) into base (16) through cover (11), gasket (13) and diaphragm (14).

26. Insert alignment tool J 35352-1 through the cover into the diaphragm-ball cage assembly (12 and 13).

27. Tighten 12 screws (9) and remove the tool.

28. Place new spring (10) into base, around ball cage (12).

29. Place housing assemblies (6 & 7) onto base, being careful not to displace balls (8). Note correct orientation and drop 4 screws (5) into place.

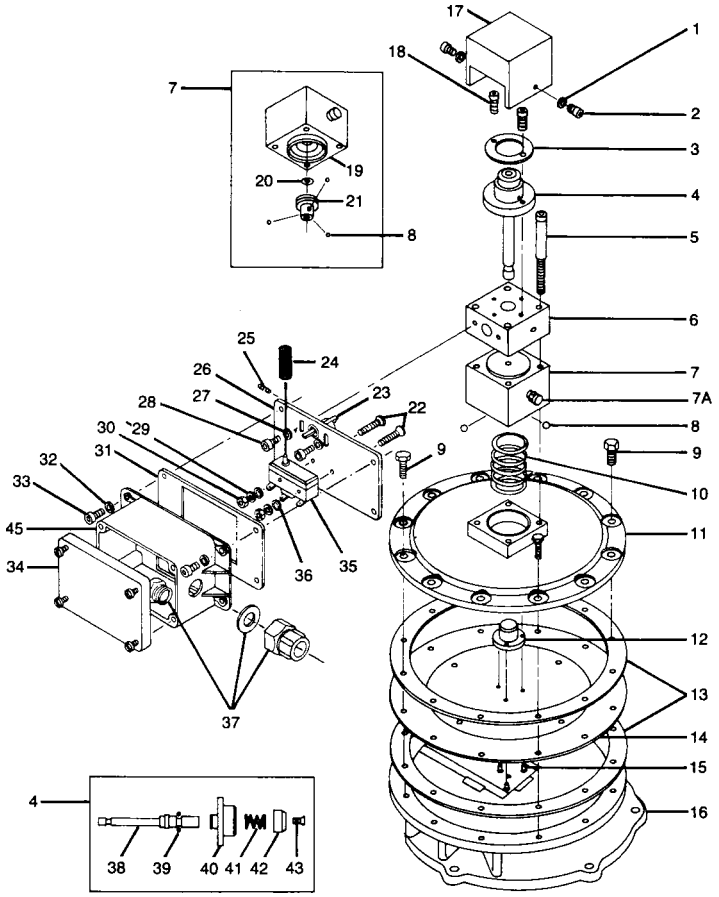
30. Install alignment tool J 35352-3 through center of housing assembly (6). Insert any slender rod (3/16 dia. or smaller) through hole in bottom of base (16) and press lightly until alignment tool seats fully. Tighten 4 screws (5) securely.

31. Depress slender rod again (from step 30). Insert stem assembly (4), install crankcase tag (3) over top of stem assembly (4), and fasten all to housing assembly (6) with two screws (18).

32. Place screws (28) through switch plate (26), noting orientation shown in Fig. 4 and being careful to place end of lever (23 - opposite switch) above collar on stem (38). This may require movement of stem assembly. Press button (42) in slightly.

33. Test the monitor for proper operation.

© Detroit Diesel Corporation



L-6528

LEGEND

1. Washer Lock (2 req)*	11. Upper Cover (half)	23. Lever*	35. Micro-Switch Assy.*
2. ScrewSockethead(2req)*	12. Ball Cage	24. Compression Spring*	36. Washer (2 req)
3. Crankcase Tag	13. Gasket (2 req)*	25. Lever Retaining Pin*	37. Conduit Connector
4. Stem Assy	14. Diaphram Assembly*	26. Switch Plate	38. Stem
5. Sockethead Screws 1/4x20 (4 req)	15. Screw (3 req)	27. Washer (2 req)	39. "0"Ring*
6. Housing Assy (block)	16. Base (half) (mounting)	28. Screw (2 req)	40. Guide Flange
7. Housing Assy	17. Button Cover*	29. Washer (2 req)	41. Spring
7A. Vent*	18. Screw (2 req)*	30. Nut 6x32 (2 req)	42. Button
8. Ball (3 req)*	19. Housing	31. Gasket, Terminal Box	43. Screw (1 req)
9. Screw (12 req)	20. "O" Ring*	32. Washer (4 req)	44. Spring
10. Spring*	21. Ball Retainer	33. Screw (4 req)	45. Terminal Box
	22. Screw (2 req)	34. Terminal Box Cover	

'THESE COMPONENTS ARE INCLUDED IN MONITOR OVERHAUL KIT 8928694.

Fig. 4 - Crankcase Pressure Monitor Exploded View

Test Procedure (Bench)

Mechanical Test

A. With button (42) out (visible red band), switch (35) circuit should be closed across terminals "C" and "E" (see Fig. 3).

B. Push button in to latch (may have to hold in to permit full latching). When latched, normally opened contacts of switch, "C" and "E", should be open.

C. To trip device on bench, insert slender rod (3/16" dia. or smaller) through hole in bottom center of base (16) and lightly depress until device trips (switch should operate). Reset by pushing button (42) until it latches again.

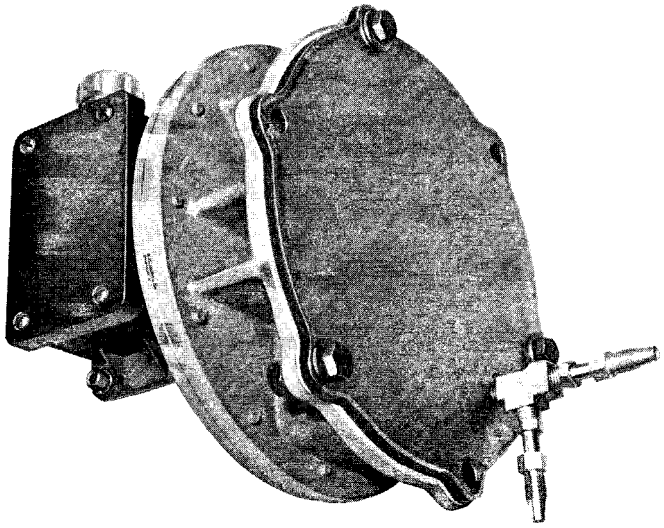


Fig. 5 - Cover Plate, Gasket, Bolts, and "T" Fitting Installed on Monitor

Pressure Test

A. Bolt cover plate (part no. 5139582) and gasket (part no. 5139583) onto mounting flange and thread a “Y” or “T” fitting into the 1/8" NPT hole in plate (Fig. 4). Attach two tight-fitting hoses to each leg of the “Y” or “T” fitting. Connect one hose to a water manometer capable of measuring 10 inches of H_20.

B. To test, connect the other hose to a low air pressure source (0 - 1 0 inches water). Slowly increase pressure until the manometer reaches a pressure that trips the latch. Button (42) will pop out showing the red band. The pressure increase will cause the water in the manometer to go up in one tube and go down in the other tube. Add the numbers at the water level (Meniscus) in each tube to obtain the number of inches of water (pressure). As the pressure increases to the specified trip pressure (4.0 to 5.0 inches), the diaphragm in the crankcase monitor will start to move. As it moves, the pressure in the manometer will drop off a little. When the button pops out, the pressure will drop off to zero. The diaphragm should start to move at 4.0 to 5.0 inches of water. If the manometer pressure builds up to 4.0 to 5.0 inches of water, then drops off until the button pops out, the crankcase monitor is operating correctly.

34. Attach new button cover (17) to housing (16), with screws (2) and washers (1).

35. Attach terminal box (45) to plate (26) with 4 screws and washers (32 & 33). Make sure terminal box gasket (31) is in place.

36. If the screws holding the terminal box cover (34) are tight, overhaul of the monitor is complete.

Test Procedure (On The Engine)

To ensure efficient crankcase pressure monitor operation, Detroit Diesel Corporation recommends testing it every 500 hours in its particular application on the engine. Use this procedure:

1. Block off one rocker cover breather.

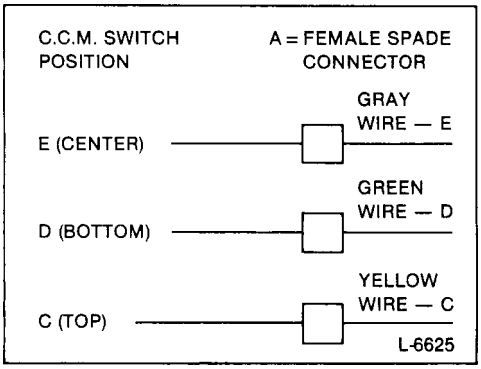
2. Connect one end of a hose to a water manometer and the other end to either of the two remaining rocker cover breathers.

3. Attach a hose with a shut-off valve to the one remaining breather.

4. Start the engine and, after bringing it up to no-load speed, begin closing the shut-off valve. As crankcase pressure increases, the diaphragm in the crankcase monitor will start to move. When crankcase pressure builds up to the specified trip pressure (4.0 - 6.0 inches of water on the manometer), the crankcase monitor should activate.

NOTICE: Due to variations in measuring devices, level of engine condition, and rate of pressure buildup, 4.0 - 6.0 inches of water is acceptable for monitor trip point when checking monitors in the field.

 © Detroit Diesel Corporation



NOTE: IMPROPER INSTALLATION OF WIRES CAN LOG THE FOLLOWING FAULT CODES:

81 VOLTAGE LOW
82 VOLTAGE HIGH
84 MONITOR TRIPPED (HIGH CRANKCASE PRESSURE)

Fig. 6 - Monitor Wiring Schematic - DDC II Equipped Engines

When the monitor is activated on mechanical unit injector-equipped engines, there will be a momentary decrease in crankcase pressure. The reset button on the crankcase monitor should also pop out and an electrical signal should be generated by the crankcase monitor micro-switch, activating the alarm system and/or shutdown system. (The micro-switch lead wires may be wired either normally open or normally closed, depending on application requirements).

When the monitor is activated on DDC II-equipped engines, there will be a momentary decrease in crankcase pressure. The reset button should also pop out, the "Check Engine" and "Stop Engine" lights should be illuminated, and active *Code 84* should be logged.

NOTICE: Improper installation of wires will log fault codes. Refer to Fig. 6 for proper wiring.

Any crankcase pressure monitor that fails to activate should be repaired or replaced.

The crankcase pressure monitor must be reset after completing the test. To reset the monitor, remove the safety cover and push in the reset button. Hold the button in for 3 to 5 seconds to ensure proper reset. The button will remain in the depressed position when properly reset (the red band will not show).

NOTICE: On DDC II-equipped engines, clear all codes from the historical codes with the DDR (Diagnostic Data Reader) tool J 36500.

CAUTION: Because the crankcase pressure monitor is mounted on the engine front cover and is near the engine fan and drive belts, *the engine must be shut down before resetting the monitor.* Failure to observe this precaution may result in personal injury.

TACHOMETER DRIVE

A tachometer drive is attached to the right bank camshaft gear drive flange or the right bank idler gear and extends through an adaptor attached to the flywheel housing cover (tachometer drive cover), Figs. 7 and 8.

When required, a tachometer drive cable adaptor is used to change speed or to change direction of rotation, depending upon the location of the tachometer drive. A special key is used to connect the drive shaft to the tachometer drive cable adaptor.

The cable connection at the current tachometer head is a 5/8" threaded connection in place of the former 7/8" connection. To eliminate possible misalignment, the current tachometer angle drive has a short flexible cable and incorporates an integral oil seal. The output shaft key size has been increased from 5/32" to SAE 3/16". New flexible drive cables are also required with the current tachometers and angle drives.

Remove Tachometer Drive

1. Disconnect the tachometer drive cable from the tachometer drive cable adaptor.
2. Loosen the "A" clamp or the two attaching bolts and remove the tachometer drive cable adaptor and shaft assembly.
3. Remove the tachometer drive cover and gasket from the flywheel housing.
4. Remove the two attaching bolts and the driven tachometer adaptor from the camshaft gear drive flange or the idler gear.

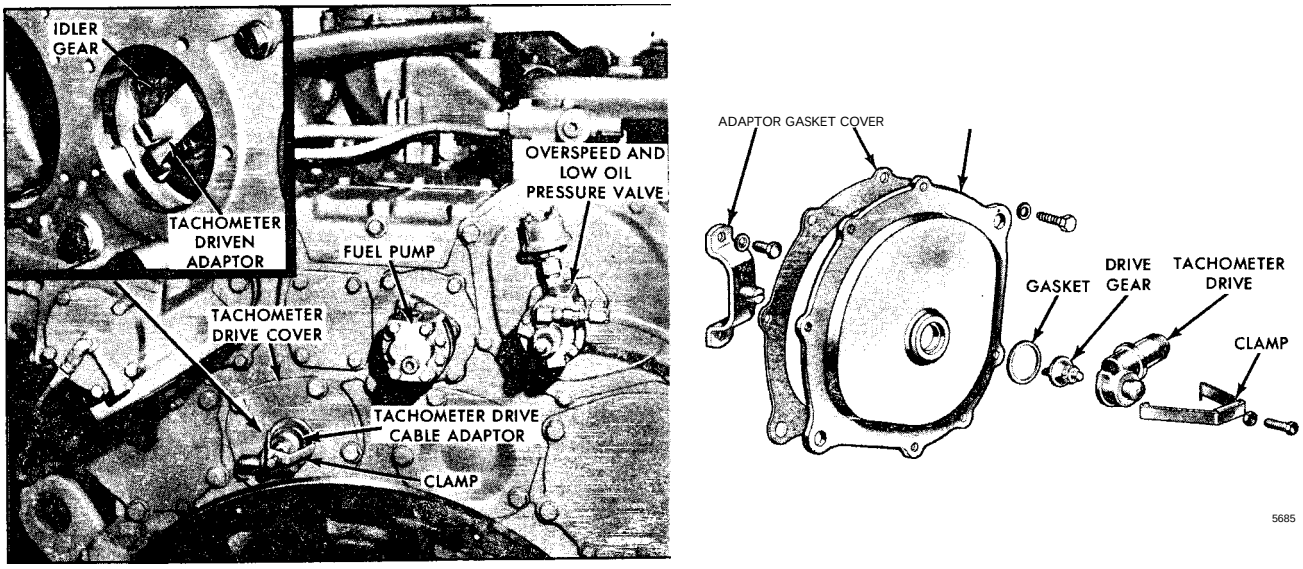


Fig. 7 - Tachometer Drive (Single Outlet)

Install Tachometer Drive

1. Attach the driven tachometer adaptor with two attaching bolts to the camshaft gear drive flange or the idler gear. Tighten the bolts.
2. Use a new gasket and install the tachometer drive cover and attaching bolts. Tighten the bolts.
3. Install the tachometer drive cable adaptor and shaft assembly. Install the “A” clamp or two attaching bolts and tighten the clamp nut or bolts.
4. Attach the tachometer drive cable.

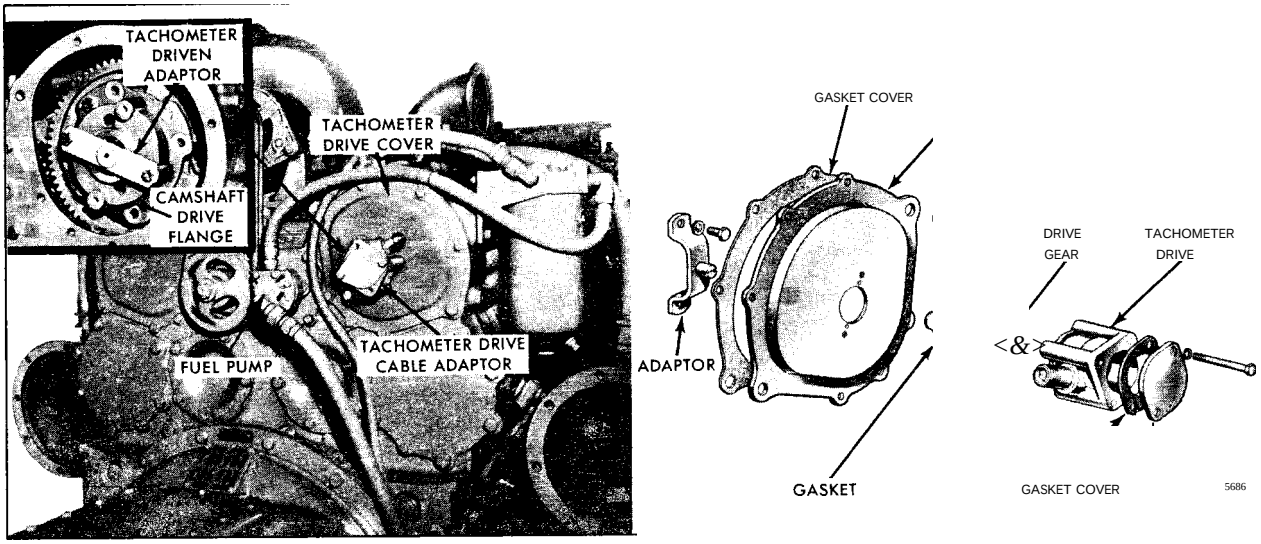


Fig. 8 - Tachometer Drive (Double Outlet)

© Detroit Diesel Corporation

ENGINE PROTECTIVE SYSTEMS

MANUAL SHUTDOWN SYSTEM

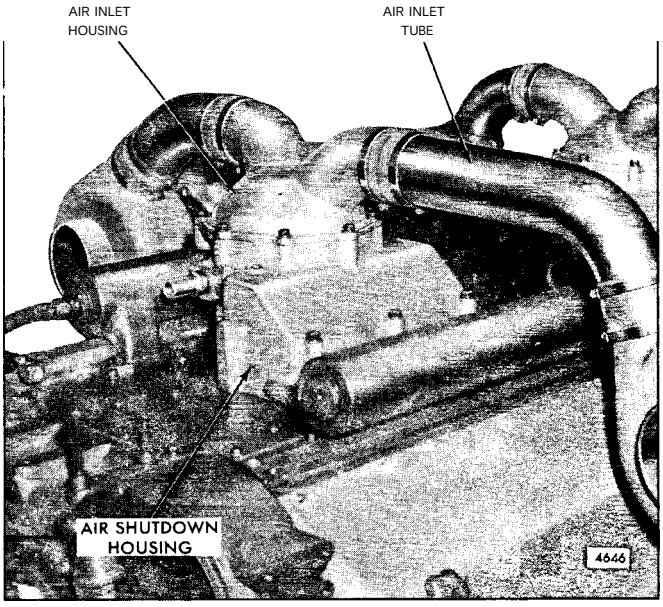


Fig. 1 - Typical Air Shutdown Housing Mounting

A manually operated emergency engine shutdown system, consisting of air shut-off valves mounted in the air shutdown housing and a suitable operating mechanism, enables the engine operator to stop the engine in the event an abnormal condition should arise. If the engine continues to run after the engine throttle is placed in the no-fuel position, or if combustible liquids or gases are accidentally introduced into the combustion chamber, causing the engine to overspeed, use of the shutdown will prevent damage to the engine by cutting off the air supply and thus stopping the engine.

The air shutdown housing(s) is mounted over the blower(s) on the air box cover (Fig. 1).

The air shut-off valves are retained in the open position by a latch. A cable assembly or solenoid is used to trip the latch. Pulling the emergency shutdown knob all the way out will stop the engine. After the engine stops, the operator must push the emergency shutdown knob all the way in and manually reset the air shut-off valves before the engine can be started again.

When service of the shutdown system is required, refer to Section 3.3.

AUTOMATIC ELECTRICAL SHUTDOWN SYSTEM

The automatic electrical shutdown system shown in Fig. 2 protects the engine against a loss of coolant, overheating of the coolant, loss of oil pressure or overspeeding. In the event one of the foregoing conditions arises, a switch will close the electrical circuit and energize the solenoid switch, causing the shutdown solenoid to release the air shutdown latch and stop the engine.

Operation

The electrical circuit is de-energized under normal operating conditions. When the engine is started, one oil pressure switch opens when the oil pressure reaches approximately 10 psi (69 kPa) and the fuel oil pressure switch closes at approximately 20 psi (138 kPa) fuel pressure.

If the oil pressure drops below 10 psi (69 kPa), the oil pressure switch will close the circuit and energize the shutdown solenoid. This will activate the shutdown mechanism and stop the engine.

A loss of coolant or an increase in coolant temperature in the cylinder block to approximately 203°F (96°C) will close the contacts in the water temperature switch, thus closing the electrical circuit and activating the shutdown mechanism.

The water temperature switch consists of a temperature-sensing element and a micro-switch. The element contacts a copper plug (heat probe) which extends into the exhaust manifold outlet. Engine coolant is directed over the temperature sensing element of the switch and should the coolant temperature in the cylinder block exceed approximately 203°F (96°C), the element will close the contacts in the micro-switch and energize the shutdown circuit. If a loss of coolant occurs, the heat of the exhaust gases will be transmitted through the copper plug to the temperature-sensing element and cause the shutdown circuit to be activated.

In the event of an automatic shut down, the cause of the abnormal conditions must then be determined and corrected before the engine is started again. Also, the air shut-off valve must be manually reset in the open position before the engine can be started.

© Detroit Diesel Corporation

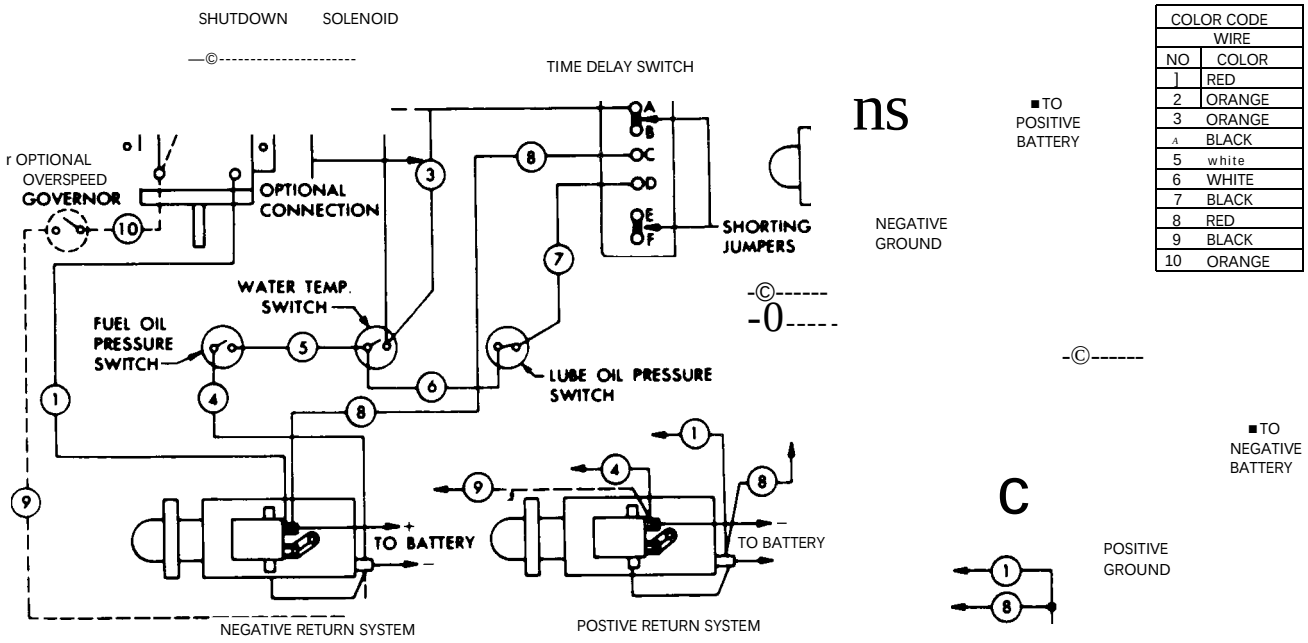


Fig. 2 - Typical Automatic Electrical Shutdown System Diagram

When the engine is shut down, the decrease in oil and fuel pressures will close the oil pressure switches and open the fuel pressure switch, thus de-energizing the circuit.

Some engines are equipped with an electrically operated automatic shutdown system which incorporates a solid state time delay switch (Fig. 2).

Since the fuel pressure builds up rapidly, the fuel oil pressure switch could close before the lubricating oil pressure switch opens, thereby stopping the engine. The time delay switch, however, delays operation of the solenoid for three to ten seconds to enable the lubricating oil pressure to build up and open the oil pressure switch contacts.

When the lubricating oil pressure falls below 10 + 2 psi (69 ± 14 kPa), the contacts in the oil pressure switch used in this system will close and current will flow to the time delay switch. The few seconds required to heat the time delay switch provides sufficient delay to avoid stopping the engine when low oil pressure is caused by a temporary condition such as an air bubble or a temporary overlap in the operation of the oil pressure switch and the fuel oil pressure switch when starting or stopping the engine.

Solid State Time Delay Switch

A bench test procedure for the solid state time delay switch is as follows:

1. Refer to Fig. 2 and remove the time delay switch from the engine.
2. Refer to Fig. 3 and install the jumper straps on terminals A to B and E to F.
3. Install a positive battery lead to terminal A.
4. Install a negative battery lead to one side of a 12 volt light.
5. Install a lead from the opposite side of the light to terminal D. A switch may be used in this lead, if desired.
6. After the negative lead is connected to terminal D or the switch is closed, the lamp should light in 8 to 10 seconds. If not, the time delay switch must be replaced.

 © Detroit Diesel Corporation

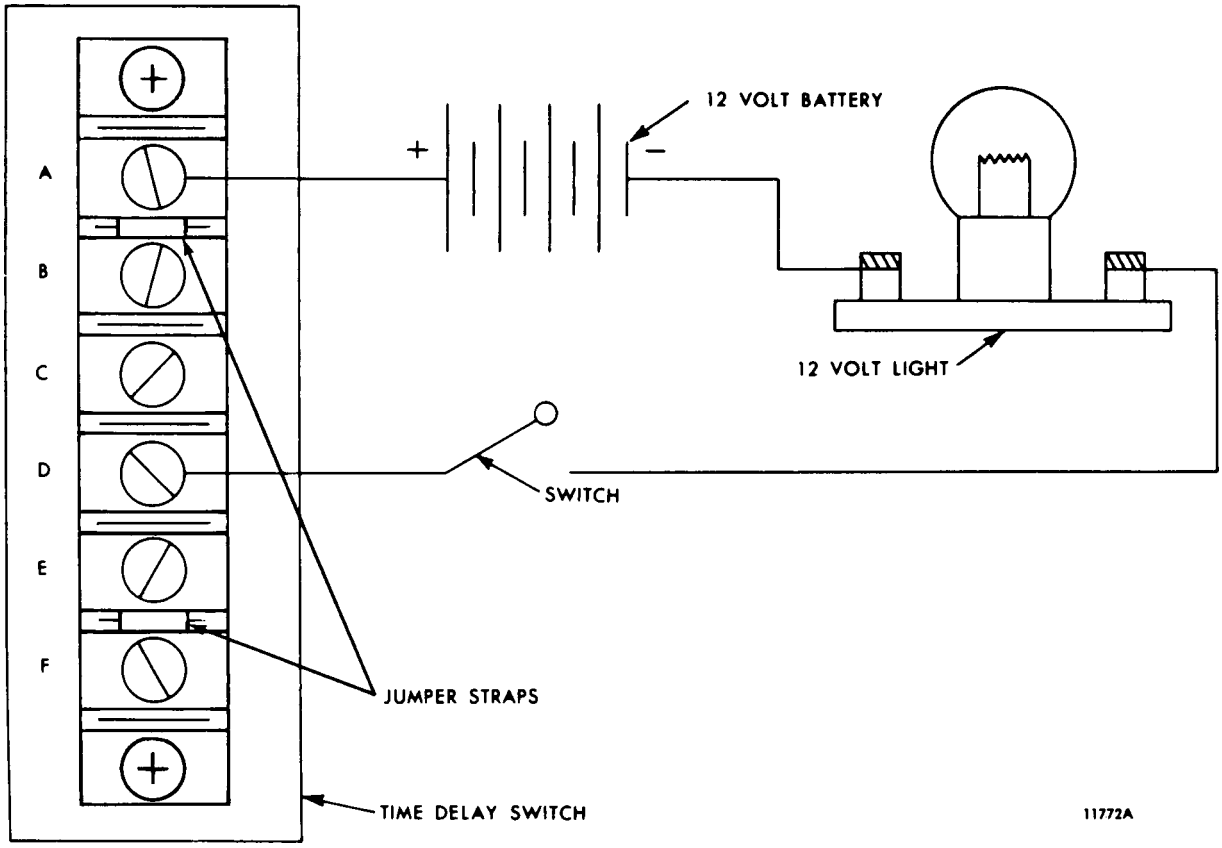


Fig. 3 - Solid State Time Delay Switch Testing Diagram

ALARM SYSTEMS

Electrical alarm systems (Figs. 1 and 2) are used to warn the operator of abnormal operating conditions such as low oil pressure, high water temperature, or a loss of either water or oil.

A typical system consists of a fuel oil pressure switch, a temperature switch and adaptor assembly mounted on the exhaust manifold, a low oil pressure and overspeed valve, a lubricating oil pressure switch, an alarm, and sometimes a relay.

Operation

The fuel oil pressure switch automatically turns the alarm system on and off. When it is open, the alarm is off. The switch is open when the fuel pressure is less than the switch setting which is stamped on the switch cover.

Coolant protection is obtained with an exhaust probe and adaptor assembly and a temperature switch. In this system, the engine coolant is circulated around the switch power element to prevent the switch from being activated by the heat transfer from the exhaust probe. Therefore, an alarm will occur under load if coolant flow through the adaptor is interrupted for any reason. The switch will also operate when the engine coolant discharge temperature exceeds 200-205°F (93-96°C).

The oil pressure switch, mounted in the low oil pressure and overspeed valve, will close to sound the alarm when the engine oil pressure drops below the safe operating pressure. The switch can also detect engine overspeed. Engine oil is supplied to the valve. Should the engine oil pressure drop below a safe operating value, above 1200 rpm, the valve will operate, dropping the oil pressure at the switch which completes the circuit and sounds the alarm. Below 1200 rpm, the oil pressure switch will close whenever the oil pressure is less than the switch setting. Engine overspeed is detected by the operation of the valve, which results in the oil switch closing. The travel of the piston in the valve, which is adjustable, controls the overspeed setting. The relay is used to prevent damage to the pressure and temperature switches should the current to operate the alarm device be too high. Should the alarm be activated for any reason, stop the engine immediately and check the cause before starting the engine again.

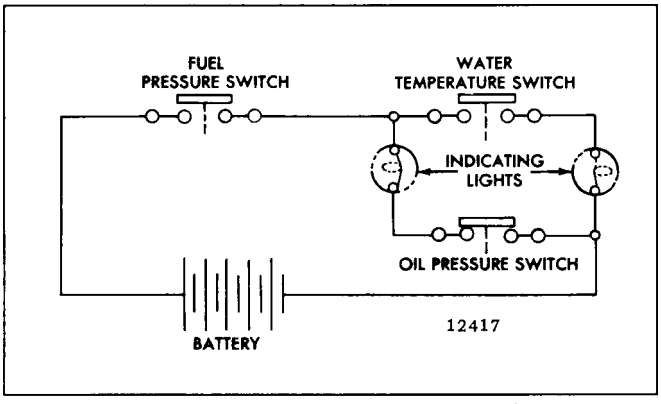


Fig. 1 – Typical Alarm Wiring Diagram

TESTING PROTECTION DEVICES

In a properly maintained installation, the protection devices seldom have cause to operate. Therefore, it is advisable to check to be sure that they will function when needed. It is important that the engine be thoroughly warmed up when checking any device on the engine. Prior to checking the protection devices, the alarm device and wiring should be checked. This is done by placing a jumper wire across the oil pressure switch terminals and operating the engine at rated speed. Failure to obtain an alarm is an indication of a faulty alarm, faulty wiring or inoperative fuel oil pressure switch.

Checking Pressure Switches

A calibrated 0-100 psi (0-689 kPa) pressure gage and a continuity checker are required to check the pressure switches. The pressure switches can be checked on the engine. However, if a regulated air supply is available, it is recommended that they be checked off the engine. Whether checking the switches on or off the engine, the concept of testing is the same. Use the continuity checker to observe when the switch operates and use the pressure gage to determine the pressure at the switch when it operates.

NOTICE: The pressure setting and type of switch ("make" or "break") are stamped on the switch cover.

"Make" switches close with increasing pressure and "break" switches open with increasing pressure. The switches should operate at the pressure setting stamped on the switch. Normal tolerances for the switches are ± 1 psi (+ 6.9 kPa) for switches stamped up to and including 5 psi (34.5 kPa) and+ 2 psi (± 13.8 kPa) from 7-30 psi (48.3-207 kPa). The switches have been adjusted and sealed at the factory; therefore, it is recommended that faulty switches be replaced.

© Detroit Diesel Corporation

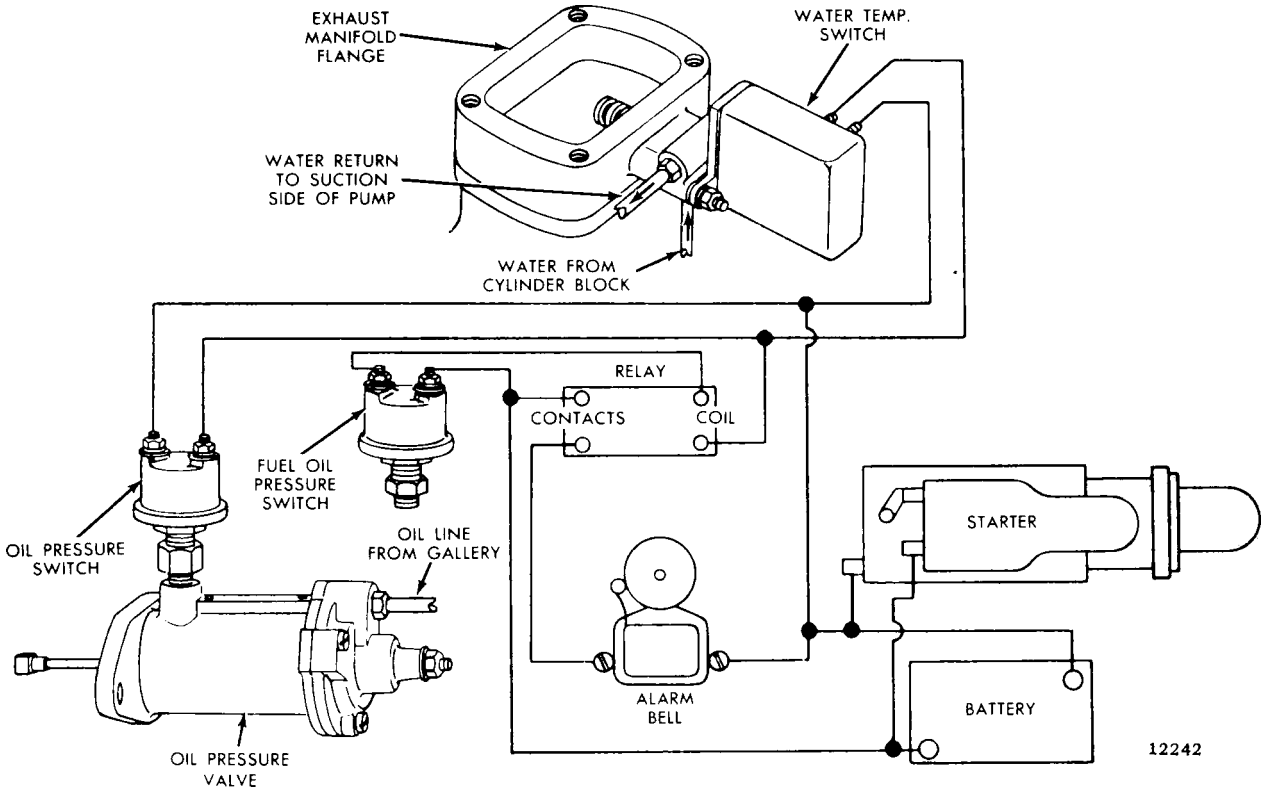


Fig. 2 - Schematic Drawing of Typical Alarm System

Checking Operation Of Temperature Switch

There are several methods for checking the performance of the temperature switch (Fig. 3). The method selected will be determined by the circumstances. Approved methods for checking the operation of the temperature switch are as follows:

1. Remove the temperature switch and immerse the switch sensing element to the switch mounting base in a container of water or ethylene glycol that is agitated and heated. Operation of the switch can be noted with a continuity checker and an accurate thermometer. The switch should operate at 203° + 2°F (95°+ 1°C).

   NOTICE: The temperature of the fluid in the container should be increased slowly after the temperature reaches about 190°F (88°C). Increasing the temperature too rapidly will indicate a false high reading for the switch because the switch will have insufficient time to reach the fluid temperature.

2. Stop coolant flow to the switch and operate the engine at rated speed and no-load. The switch should operate in about one to three minutes and can be noted by operation of the alarm.

   NOTICE: Restore normal coolant circulation to the switch after completing this test. Operation of the switch without coolant and high exhaust temperatures over a period of time will destroy it.

3. In some applications, it may be practical to reduce the effectiveness of the cooling system so that, with the engine operated at rated speed and no-load or a light

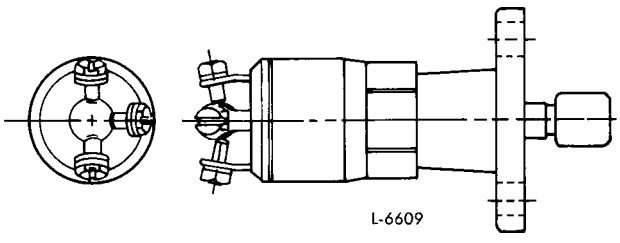


Fig. 3 - Water Temperature Switch

 © Detroit Diesel Corporation

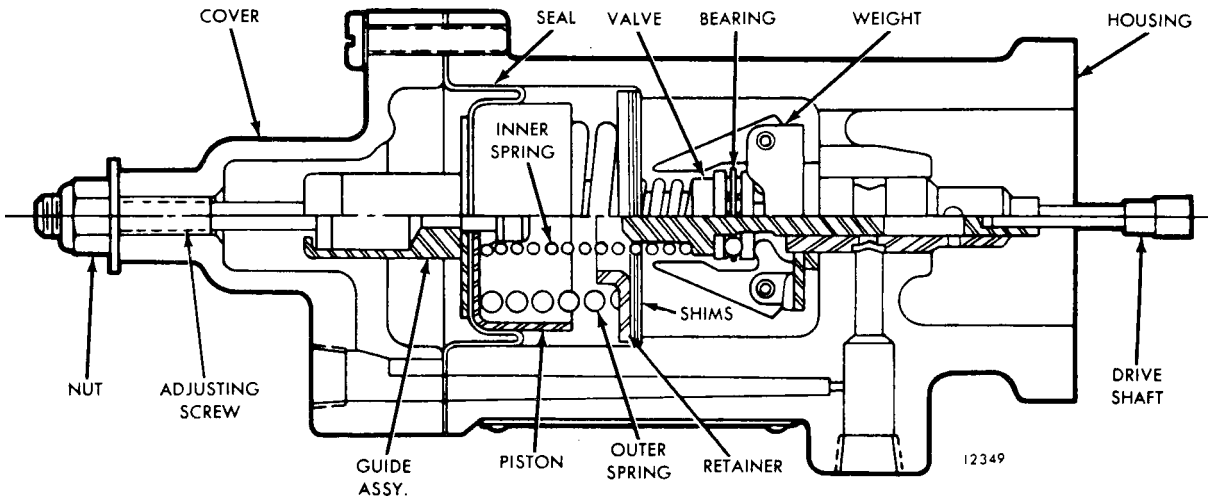


Fig. 4 - Low Oil Pressure and Overspeed Valve

load, the engine coolant temperature can be increased to 208°F (97°C). For example, the air circulation to the radiator on units with suction fans can be stopped by placing sheets of cardboard over the radiator, or on units with blower fans, the fan belts can be loosened so that the fan does not operate.

After reducing the coolant system effectiveness, remove the radiator cap and insert an accurate steel jacketed thermometer. Then operate the engine at rated speed and enough load to gradually increase the temperature until the switch operates.

NOTICE: Do not exceed 210°F (99°C) when performing this test. The switch should operate at 204°F±4° (95.2°C± 2.2°). This procedure will not work for units using water as a coolant at altitudes above 1000 feet (305 metres). This is because the water will boil below the switch setting at the higher altitudes. For these circumstances, the radiator pressure cap must be maintained.

The engine temperature gage, if it is determined to be accurate, can be used in this test. After completion of the test, immediately restore the engine cooling system to normal and operate the engine at rated speed and no-load until normal engine operating temperature is reached.

Temperature Switch Adjustment

The temperature switch setting can be changed by turning the element into or out of the mounting base. Turning the element into the base lowers the setting and turning the element out raises the setting. Total range of adjustment is about 10°F (5.56°C).

NOTICE: Torque should only be applied to the element at the wrench flats provided on the element. Failure to do this can result in the switch becoming inoperative due to damage to the element. After completing the switch adjustment, torque the element lock nut to 40-50 in-lbs (5-6 N.m).

Exhaust Probe And Adaptor Assembly, Plunger And Spring

These parts should normally require no maintenance. Flowever, when installing a new switch or a readjusted switch, check to make sure the plunger is free. It is possible that deposits from the cooling system can build up and freeze the plunger. If this has happened, replace the probe and adaptor assembly, spring and plunger. A frozen plunger can either interfere with the element or there can be a gap between it and the element, both of which can destroy the effectiveness of the switch.

Checking Low Oil Pressure And Overspeed Valve

The only adjustment that can be made for the low oil pressure and overspeed valve is the overspeed setting (Fig. 4). The overspeed setting is normally set 15% above rated speed, and is adjusted by loosening the speed adjusting screw lock nut and turning it in to increase the setting or out to lower the setting. The operation of the valve can be easily checked by first noting the projection of the speed adjusting screw beyond the cover and then lowering the overspeed setting. The speed adjusting screw can be backed out 3/4 inch. An alarm should be obtained with the screw backed out when the engine is operated at rated speed. Failure to obtain an alarm is an indication of a faulty valve. Return the speed adjusting screw to its original position after completing this test.

OVERSPEED GOVERNORS

Certain engines are equipped with an electric overspeed governor to prevent excessive engine speeds. The governor is adjustable in the full-load engine speed range. The electric overspeed governor is mounted on the flywheel housing and is driven by the engine camshaft or the accessory drive gear. The governor is connected electrically to a solenoid which actuates the shutdown mechanism on the air inlet housing or actuates a warning device.

ELECTRIC OVERSPEED GOVERNOR (Two Switch)

The series GY-2 Synchro-Start overspeed governor (Fig. 1) contains two separate snap action switches with single-pole double-throw contacts which operate at two different speeds. The governor is adjusted by the manufacturer to trip at the speeds required as indicated on the name plate. Unless otherwise specified, the name plate indicates trip points on increasing speed. The contacts will return to normal when the speed is decreased approximately 100 rpm below the trip speed, except on the high-speed switch of those models having a manual reset button. The letter “M” after any model number indicates the high-speed switch must be reset manually.

Service

1. The snap action switches may be replaced as follows:

   a. Mark the position of the dust cover and remove both hold-down screws.

   b. Observe the position of the switches. Usually they are positioned with 1/64" clearance between the switch button and the lifters. If the lifters are replaced, make certain that the long lifter is placed beneath the low-speed switch and the short lifter is placed beneath the high-speed switch.

   c. Install the new switches by reversing the above procedure.

   NOTICE: When replacing the dust cover on a governor with a manual reset, make certain the switch wiring does not interfere with the reset mechanism.

   d. Adjust the speed as outlined under *Speed Adjustment.*

2. Remove the governor cap as follows:

   a. Observe the marking on the cap and the body and remove the three holding screws.

   b. Remove the cap assembly, being careful not to damage the seal ring.

   c. Replace any internal parts as required and reassemble and return the cap to the original position. A light coat of grease will facilitate assembly of the seal ring to the body.

   NOTICE: The position of the cap is very critical on governors in which the difference in trip points between the two switches is more than 1000 rpm and the trip point of the high-speed switch is above 2100 rpm. These governors use elongated loop flyweight springs. If, after assembly, the No. 1 switch trips at a far higher point than normal, lower the cap position slightly. If the No. 2 switch trips at a very low speed, raise the cap position slightly. If difficulty arises, refer to Step 5 below.

   d. Adjust the speed as outlined under *Speed Adjustment.*

3. Replace the speed adjusting springs as follows:

   a. Hold the speed adjusting stud with a 5/16" open end wrench and loosen the adjusting stud nut with a 3/8" open end wrench.

   b. After the above nut is removed, the adjusting spring and related parts may be removed and replaced as necessary. Exercise care to prevent particles of dirt from accumulating on the parts.

4. Replace the flexible drive shaft as follows:

   a. Insert a sharp pointed instrument in the loop of the spring clip and pull it from the shaft as far as possible and remove the shaft assembly.

   b. Upon reassembly, first install the spring clip in the groove of the fitting on the end of the governor shaft.

   c. Push the shaft assembly into the square end of the governor shaft and the spring clip will snap in place.

   NOTICE: Check the position of the spring clip. If the clip has sprung out of position, use a small screw driver to push it into place.

© Detroit Diesel Corporation

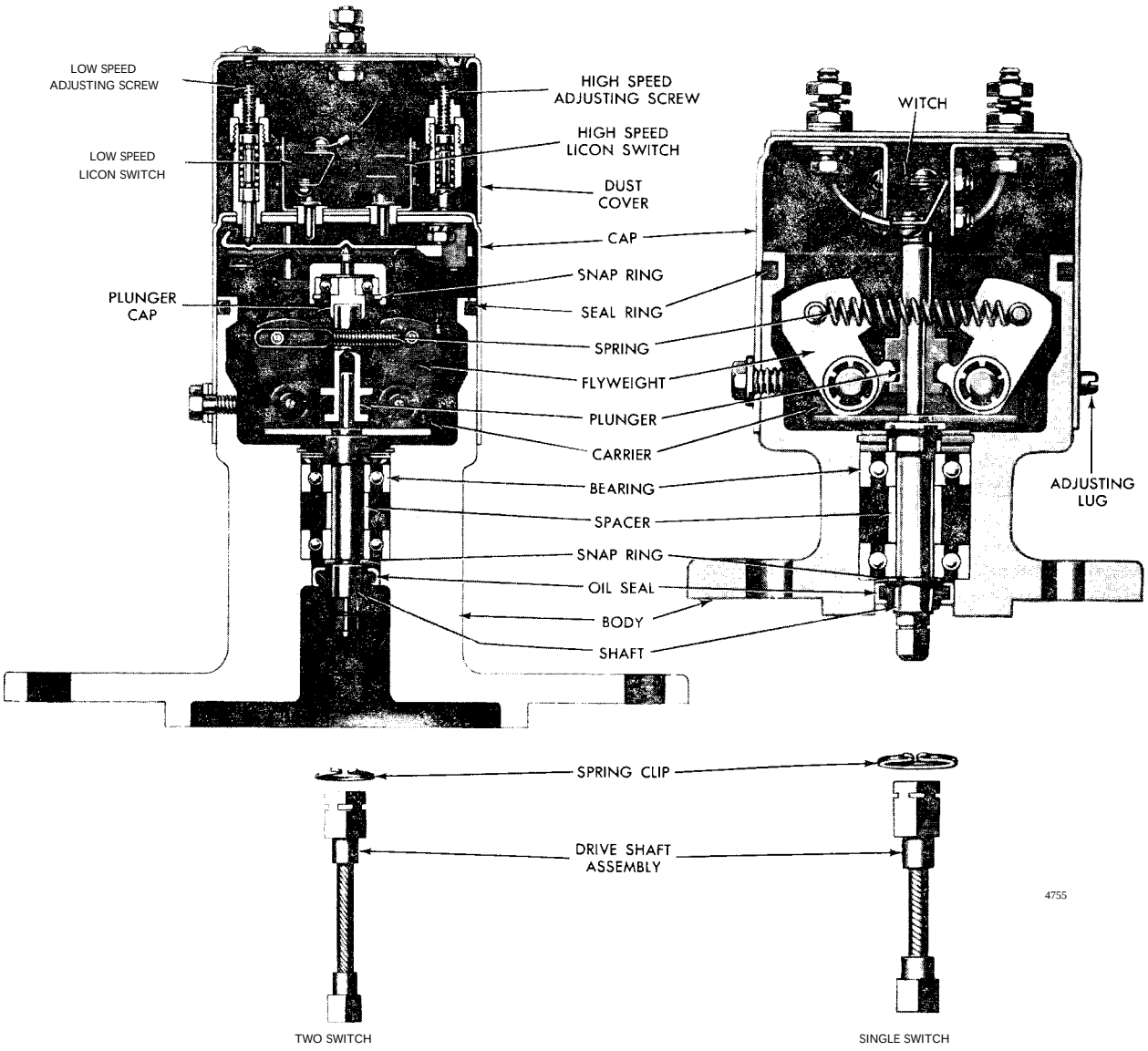


Fig. 1 - Electric Overspeed Governors

5. Adjust the governor cap (with the dust cover in place):
   a. Turn the low-speed adjusting screw out for minimum speed adjustment. In this position, the top of the adjusting screw is approximately 1/8" from the top of the dust cover.
   b. Turn the high-speed adjusting screw in for almost maximum speed adjustment. In this position, the top of the adjusting screw is approximately 5/16" from the top of the dust cover.
   c. With partial tension on the cap holding screws, turn the governor cap to the maximum extended position.
   d. Operate the governor at 200 rpm above the trip point of the low speed switch.
   e. Rotate the cap slowly in a clockwise direction until the low-speed switch trips, mark the cap position and stop the engine. Then turn the cap another 1/16" and lock the holding screws securely.
   f. Complete the operation as outlined under *Speed Adjustment.* Generally, the trip point of the low-speed switch will have to be increased and the high-speed switch decreased.

 © Detroit Diesel Corporation

Maintenance

Grease the governor shaft ball bearings every 10,000 hours (every 5,000 hours if the governor speed is above 2500 rpm) as follows:

1. Remove the governor cap.
2. Remove the flexible drive shaft.
3. Remove the retaining ring from the groove in the housing. Then remove the weight and shaft assembly.
4. Inspect the oil seal and, if necessary, replace it as follows:
   a. Place the governor body in an arbor press, with the mounting flange toward the bottom, and use a 9/16" diameter rod to press the oil seal out.
   b. Press a new oil seal in place 3/64" from the bottom of the bearing cavity.
5. Fill the grease reservoir between the bearings *only 3/4 full* with Texaco "Unitemp" grease, or equivalent.
6. Reassemble the governor by reversing the procedure for disassembly and adjust the trip speeds as outlined below.

Speed Adjustment

Both switches may be individually adjusted. The dust cover screw marked "1" covers the low-speed adjuster; the screw marked "2" covers the high-speed adjuster. Proceed as follows:

1. Remove the appropriate dust cover screw. Then insert a 1/16" Allen wrench into the adjusting screw.
2. Turn the screw clockwise to increase the trip speed, or counterclockwise to decrease the speed.

NOTICE: If the adjusting screws are turned in too far, the switch will no longer operate. Do not attempt to use the slots in the cap for normal speed adjustments. This position is set and marked by the manufacturer for operation in the speed range required.

ELECTRIC OVERSPEED GOVERNOR (SINGLE SWITCH)

The Series GYA Synchro-Start overspeed governor (Fig. 1) is calibrated by the manufacturer to open or close the switch contacts at the particular speed required. The switch contacts will reset automatically when the speed is reduced approximately 100 rpm below the trip speed.

Service

Grease the governor shaft ball bearings every 10,000 hours (every 5,000 hours if the governor speed is above 2500 rpm) as follows:

1. Remove the adjusting screw and the adjusting stud. Then remove the governor cap.
2. Insert a sharp pointed instrument in the loop of the spring clip and pull the clip from the flexible shaft as far as possible. Then remove the shaft assembly.
3. Remove the retaining ring from the groove in the housing.
4. Remove the weight and shaft assembly.
5. Inspect the oil seal and, if necessary, replace the seal as follows:
   a. Place the governor body in an arbor press, with the mounting flange facing down, and use a 9/16" diameter rod to press the oil seal out of the body.
   b. Press the new oil seal in place 3/64" from the bottom of the bearing cavity.
6. Fill the grease reservoir between the bearings *only 3/4 full* with Texaco "Unitemp" grease, or equivalent.
7. Reassemble the governor by reversing the procedure for disassembly and adjust the trip speed as outlined below.

Speed Adjustment

Loosen the cap adjusting lock screw and turn the cap until the desired trip speed is reached. Clockwise rotation of the cap lowers the trip speed, and counterclockwise rotation increases the trip speed. The total range of adjustment of the particular governor is indicated on the governor name plate. The governor should not be adjusted to trip below 100 rpm above the normal running speed of the governor. Make sure the governor cap locking screw is tightened after the adjustment has been completed.

NOTICE: Under no circumstances should the governor switch be by-passed to prevent engine shut down in the event of overspeed, otherwise serious damage, to not only the engine but also to the governor, may be incurred since the governor is not designed to operate above its tripping speed.

POWER GENERATOR

Detailed information on the maintenance and repair of power generators, control cabinets and component assemblies such as voltage regulators can be found in the service manuals and bulletins issued by the equipment manufacturers.

In many instances, repairs and overhaul work on electrical equipment may be referred to an authorized repair station of the manufacturer of the equipment.

Replacement parts for electrical equipment should be ordered through the equipment manufacturers outlets since these parts are not normally stocked by Detroit DieselCorporation.

POWER GENERATOR FOR STATIONARY APPLICATIONS

Remove Power Generator

1. Attach a crane or hoist to support the generator.
2. Remove the engine starting motor(s).
3. Install engine barring tool J 22582 in place of the starting motor.
4. Remove the flywheel housing plugs adjacent to the starting motor opening on each side of the housing.
5. Rotate the crankshaft until one of the dowels is visible through the plug hole. Mark this area for ease of alignment upon reinstallation. A can of spray paint can be used for this purpose. Rotate the crankshaft to gain access to the coupling attaching bolts and remove them through the openings in the flywheel housing.

. 6. Remove the bolts and lock washers or stud nuts which attach the generator frame to the flywheel housing adaptor. Remove bolts attaching the generator to the base. Then back the generator away from the engine, using pry bars or jack screws if necessary.

NOTICE: The drive coupling assembly used between the engine crankshaft and the generator armature has been doweled, machined and balanced as a complete assembly and no attempt should be made to interchange parts with those of another assembly.

Install Power Generator

Check the engine crankshaft for distortion at the rear connecting rod journal counterweights **before** and **after** installing the power generator. Refer to Section 1.3 for the procedure.

1. If not previously removed, remove the plugs adjacent to the starting motor on each side of the flywheel housing.
2. Install the crankshaft portion of the drive coupling assembly on the crankshaft. Special attention should be paid to the position of the staggered locating dowels. Each dowel must be in the same position as removed (refer to Item 5 under *Remove Power Generator).*

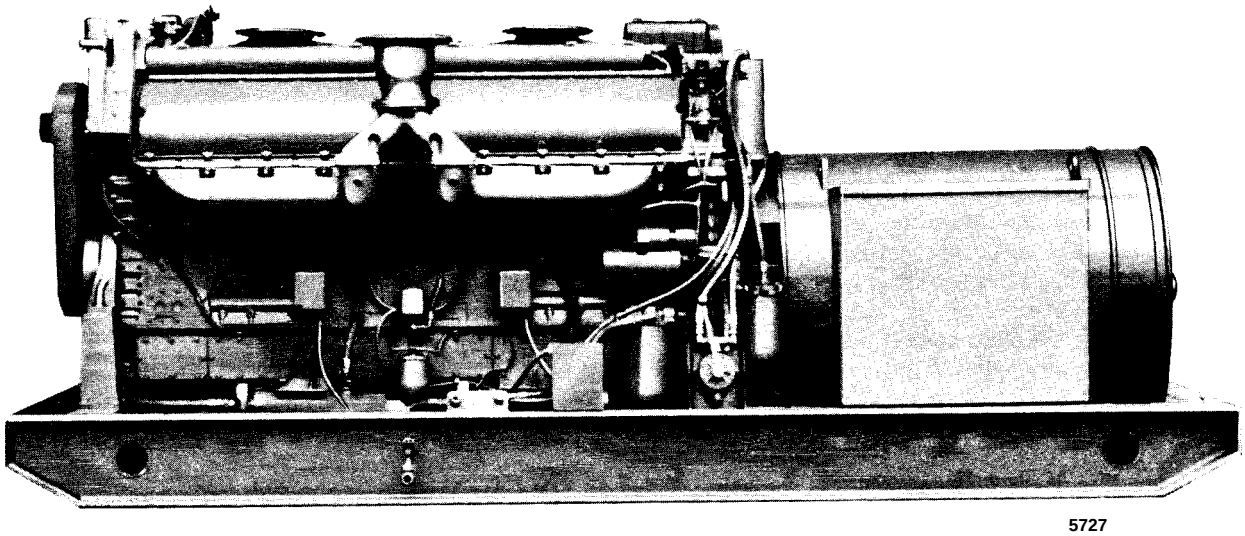


Fig. 1 - Typical Power Generator Mounting

© Detroit Diesel Corporation

NOTICE: If the dowels are not in the same position as removed, severe damage to the coupling can result when the coupling is assembled.

3. If the generator coupling has been removed from the engine, apply a small amount of International Compound No. 2, or equivalent, to the bolt threads and install the 5/8"-18 x 4" self-locking coupling bolts, being sure to install the scuff plate between the coupling and the bolt heads. Tighten the bolts to 180-190 lb-ft (244-258 N«m) torque.

4. Install the generator portion of the coupling to the generator armature, again paying special attention to the position of the staggered dowel holes and making certain that the holes are in the same position as the dowels on the crankshaft portion of the coupling.

NOTICE: Be sure to follow any special installation instructions of the generator manufacturer.

5. Apply a small amount of International Compound No. 2, or equivalent, to the threads and install the 5/8"-18 x 2 1/2" self-locking bolts and hardened washers. Tighten the bolts to 180-190 lb-ft (244—258 N«m) torque.

6. Apply a small amount of International Compound No. 2, or equivalent, to the threads of the 5/8"-11 x 1 7/8" studs and assemble them in the generator frame. Position three studs on each side to match with the spot faced holes in the flywheel housing adaptor.

7. Tighten the studs to 137-148 lb-ft (186-200 N*m) torque. Check the stud extension above the generator frame. The studs should not extend beyond 7/8".

8. Use a crane or hoist to raise the generator so that the centerline of the armature is slightly above the center line of the crankshaft.

   a. Move the generator toward the engine until the chamfer on the armature coupling begins to engage the chamfer on the crankshaft portion of the coupling, at approximately the 12 o'clock position. Align each of the dowels in the crankshaft coupling so that they will engage in their respective dowel holes in the generator adaptor.

   b. Continue moving the generator towards the engine until full engagement of the dowels is attained. It may be necessary to raise or lower the generator slightly to engage the generator to the flywheel housing attaching studs, which will start to engage shortly after the dowels engage. It may also be necessary to rotate the crankshaft so that the dowel holes are properly aligned.

9. Install the stud nuts as the studs begin to extend beyond the flywheel housing adaptor. With the generator in position against the engine, check the flywheel housing plug hole to make certain the dowel pin has not been pushed through the crankshaft coupling (this could result in a broken casting) during generator installation. Use a depth gage to check the position of the dowel relative to the rear face of the crankshaft coupling. If the dowel pin does not extend at least 1/2" below the rear of the crankshaft coupling, the generator armature coupling may not be properly supported. Both dowel pins should be checked for proper engagement.

10. Apply a small amount of International Compound No. 2, or equivalent, to the threads and install the 5/8"-ll x 1 7/8" bolts through the flywheel housing adaptor to the generator and tighten them and the six stud nuts to 137-147 lb-ft (186-200 N*m) torque.

11. Apply a small amount of International Compound No. 2, or equivalent, on the threads and install the 5/8"—11 x 2 1/2" self-locking bolts and hardened washers to attach the crankshaft coupling to the armature adaptor.

NOTICE: Do not install the bolts part way, but snug them up to prevent lockup when the crankshaft is rotated.

12. After all of the bolts are assembled, tighten them progressively to 137-147 lb-ft (186-200 N*m) torque.

13. Rotate the crankshaft one full revolution and inspect the coupling and adaptor through the flywheel housing openings for proper assembly. A mirror inserted into the flywheel housing openings will facilitate this inspection.

14. Remove the barring tool and install the starter(s) and the flywheel housing plugs.

© Detroit Diesel Corporation

TRACTION GENERATOR FOR ELECTRIC DRIVE VEHICLES

Remove Generator

1. Attach a crane or hoist to support the generator.
2. Remove the engine starting motor(s).
3. Install engine barring tool J 22582 in place of the starting motor.
4. Remove the flywheel housing plugs adjacent to the starting motor opening on each side of the housing.
5. Rotate the crankshaft until one of the dowels is visible through the plug hole. Mark this area for ease of alignment upon reinstallation. A can of spray paint can be used for this purpose. Rotate the crankshaft to gain access to the twelve coupling attaching bolts and remove them through the openings in the flywheel housing.
6. Remove the ten 5/8"—11 bolts and lock washers and the six stud nuts which attach the generator frame to the flywheel housing adaptor. Remove the six nuts while backing the generator away from the engine, using pry bars or jack screws if necessary.

NOTICE: The drive coupling a'.?,embly used between the engine crankshaft and the generator armature has been doweled, machined and balanced as a complete assembly and no attempt should be made to interchange parts with those of another assembly.

Install Generator

Before and after installing the generator in an electric drive vehicle, it is essential that the axial end play and axial alignment of the crankshaft and generator be maintained within limits. This will prevent possible thrust washer damage due to insufficient crankshaft end play and assure generator-to-engine alignment to avoid overloading and subsequent damage to the rear main bearings and outboard support bearing.

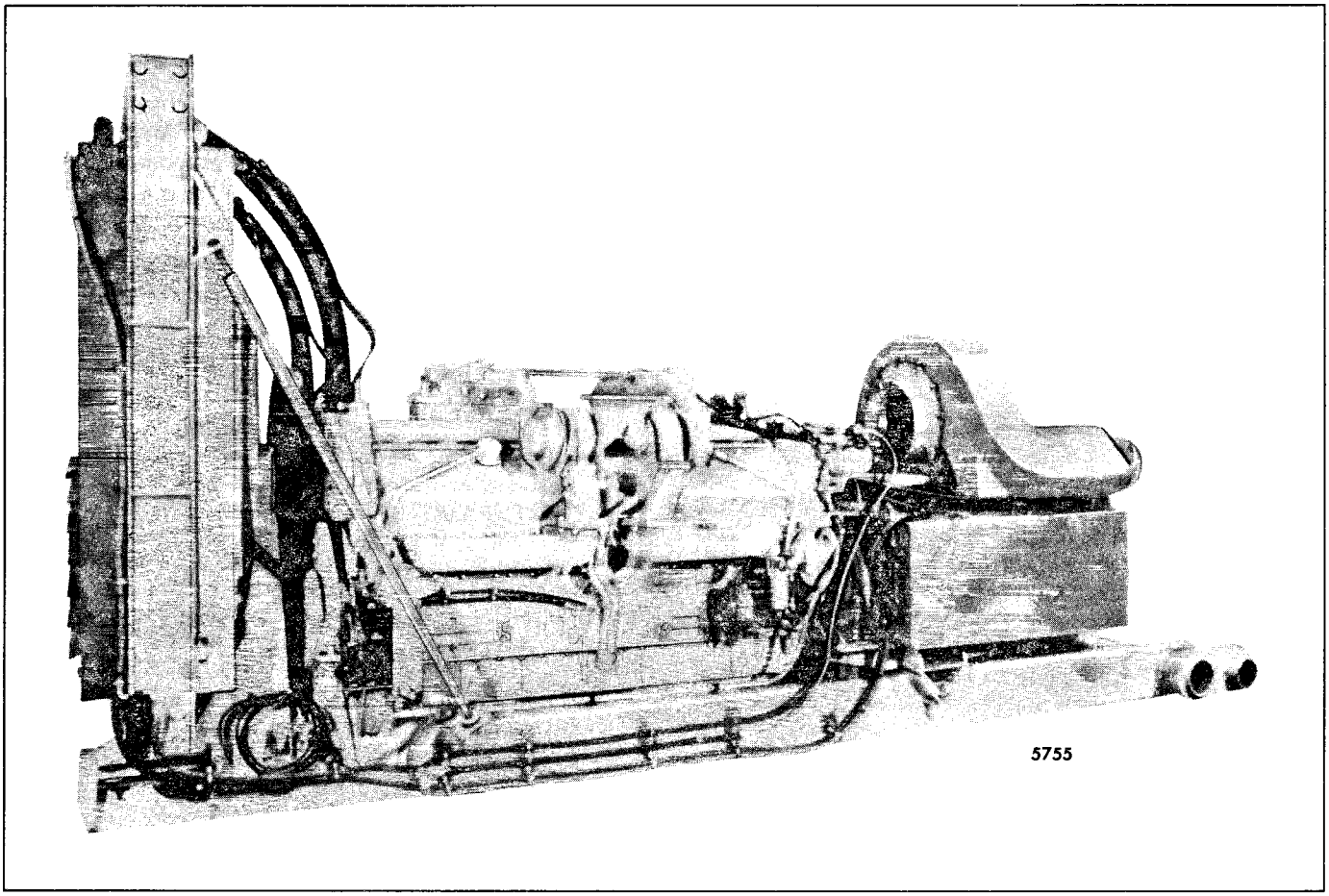


Fig. 2 – Typical Mounting of Traction Generator

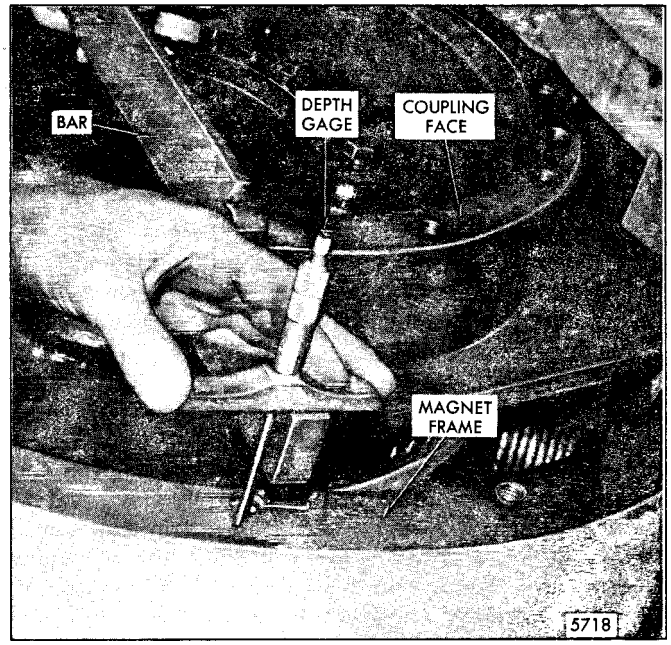


Fig. 3 - Measuring Distance from Generator Coupling Face to Magnet Face

The following procedure ensures that crankshaft and generator end play will be within specifications and that the generator armature and magnet frame will be in alignment with the crankshaft.

Check Engine

1. Check and record the crankshaft end play (refer to Section 1.3). The specified end play is ,004"-.014" with new parts or a maximum of .018" with used parts.

2. Position the rear outboard bearing support in the flywheel housing (refer to Section 1.3.5.2).

3. Check the coupling assembly runout (refer to Section 1.4). The maximum allowable runout is .011" when measured using a dial indicator between the coupling-to-generator bolt holes and the outside diameter of the coupling assembly.

4. Check the flywheel housing face and bore runout (refer to Section 1.5). The maximum total indicator reading must not exceed .013" for either the housing face or the bore runout.

5. Check the flywheel housing adaptor face and bore runout (refer to Section 1.5.1). Maximum total indicator reading must not exceed .026" for either the adaptor face or the bore. This check need not be performed on Terex/Titan vehicles because the Delco generator does not utilize the adaptor ring.

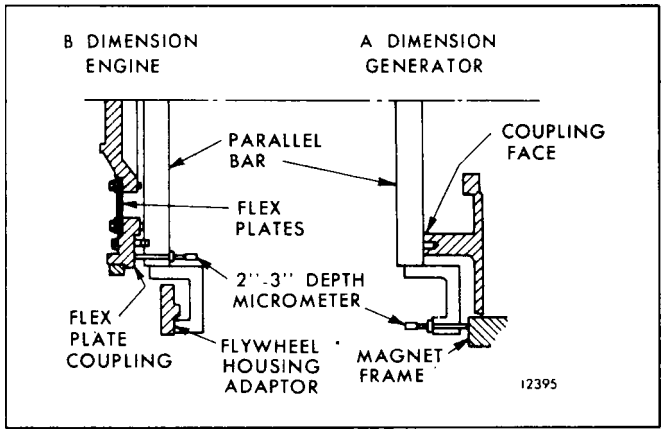


Fig. 4 - Determining Shims Required Between Engine and Generator

Clean Mating Faces

Thoroughly clean the generator magnet face, the generator coupling face, the engine flywheel housing adaptor face and the flexible drive coupling face. Any nicks or burrs should be stoned smooth.

Shimming Generator To Engine Coupling (G.E. Generator)

This check need not be performed on Terex/Titan applications. The Delco generator used on Terex/Titan applications does not require the use of generator-to-engine shims.

Consult the generator manufacturer's specifications for normal end play tolerances and the method of measurement. In the absence of the manufacturer's method, proceed as follows:

1. Support the generator with a crane or hoist and sling. Then hang the generator in a vertical position with the rear end down. Be sure the generator is centered by shimming the four flange radius corners for equal clearance at all four locations.

2. Attach a magnetic base dial indicator to the generator magnet frame and set the pointer on the coupling adaptor surface. Adjust the dial indicator to read zero. Pull the generator armature straight upward and record the end play observed on the dial indicator.

3. Lower the armature toward the commutator end as far as the rear bearing will permit. Place a parallel steel bar across the generator coupling face and measure the distance between the coupling face and the magnet frame face with a depth gage (Fig. 3). Take four readings 90° apart and record the average of the readings. To center the ball bearings in the race seat, it is necessary to add one-half of the end play measured to the total distance determined. Record the average adjusted measurement (dimension "A" on Fig. 4).

 © Detroit Diesel Corporation

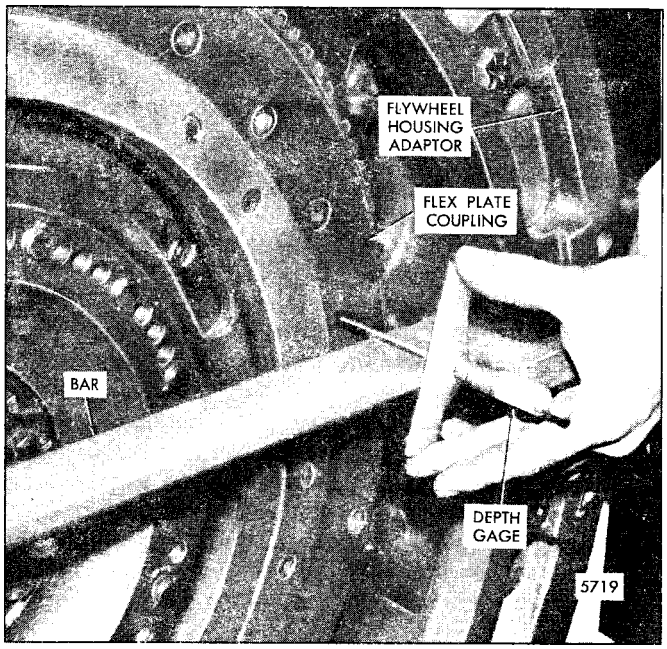


Fig. 5 - Measuring Distance from Flywheel Housing Adaptor to Engine Flex Plate Coupling

4. Center the crankshaft end play and measure from the flywheel housing adaptor to the engine flexible plate coupling mating face using a parallel bar and depth gage (Fig. 5). Obtain four readings 90° apart and record the average measurement (dimension "B" on Fig. 4).

Truck Manufacturer	Housing (16 Bolt)	Rotor/Flywheel (12 Bolt)
	Thickness	Thickness
Unit Rig	.005 .010 .020 .040 .060	.005 .010 .020
Wabco	.004 .007	.004 .007
Euclid	.003 .011/.009 .022/.018	.003 .011/.009 .022/.018

Shims are available from the truck manufacturer

TABLE 1 - G.E. A-1 5 Generator

5. If the generator measurement "A" exceeds engine measurement "B", shim between the generator magnet frame face and the flywheel housing adaptor face by the difference between these dimensions, with an allowable .002" tolerance (Fig. 6).

6. If the engine measurement "B" is greater than the generator measurement "A", shim between the generator adaptor face and the engine flexible coupling plate face by the difference between these dimensions, with an allowable .002" tolerance (Fig. 7). See Table 1 for required shims.

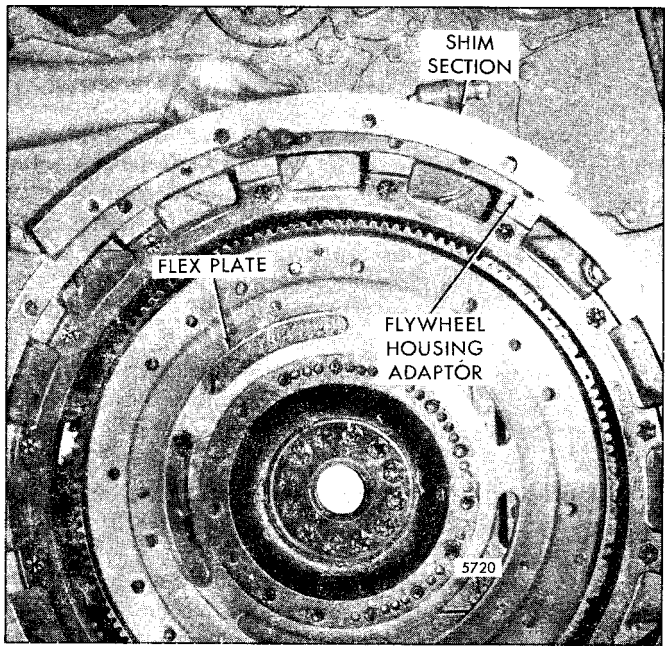


Fig. 6 - Installing Engine Flywheel Housing Adaptor Shim Section

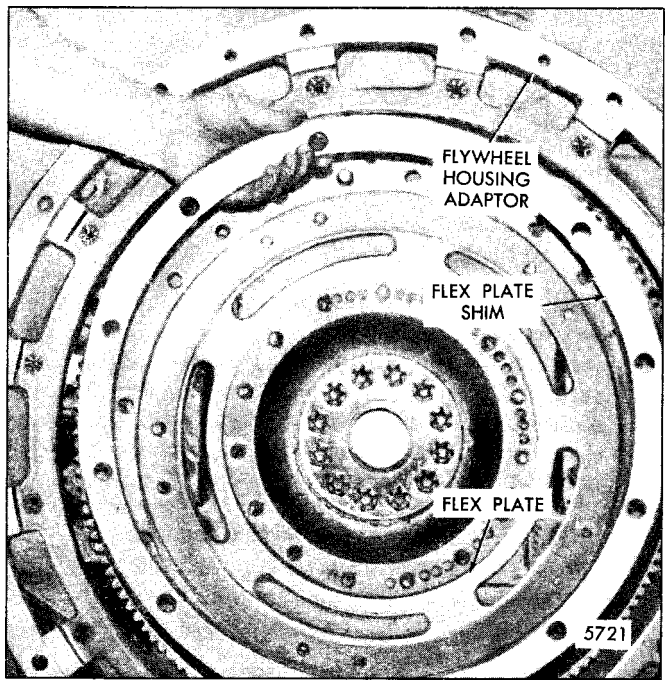


Fig. 7 - Installing Engine Flex Coupling Shim

Shimming Generator Or Engine Mount

Various types of generator-to-engine mount systems are used by the various OEM's and some may require shimming under the engine or generator supports to maintain the correct crankshaft-to-generator relationship. Correct alignment is required to prevent placing excessive loads on the crankshaft main bearings and the rear outboard support bearing.

THREE-POINT (CRADLE) MOUNT

The cradle mount system incorporates a support bracket attached to each side of the engine and generator as a unit. When assembled properly, this system generally does not require shimming to maintain engine-to-generator alignment because it effectively supports the entire rear of the engine and generator as a single unit.

FIVE POINT MOUNT

The five point mount system with separate mounts attached to both rear engine flywheel housing supports and both of the generator mounts at each side will usually require shimming to maintain generator to engine alignment. Shims may be necessary either at the generator mount or the engine mount.

Attach Generator To Engine

The generator must be attached with the module frame out of the vehicle chassis and the engine sitting horizontal in the module. The clamp joint achieved by the mating parts maintains generator alignment during vehicle operation.

EUCLID

1. Install the right and left side arms to the module frame at the six-bolt horizontal flange, but do not fully tighten the bolts.

2. With the engine installed into the module frame and secured at the front engine trunnion mount, temporarily support the rear of the engine with suitable floor jacks from below or a chain hoist from above so that the side arm-to-flywheel housing bolts can be installed. Attach side arms to the flywheel housing, but do not fully tighten the bolts.

   NOTICE: Do not remove support from the rear of the engine. The engine must remain supported until the generator has been fully coupled to the engine and secured to the module.

3. Using the 3 lifter brackets provided, lift the generator into position. The top front lifter bracket should be equipped with an adjustable member such as a come-along and the side lifting members should be of equal length to ensure that the generator is evenly balanced and can be adjusted squarely to the flywheel housing.

   NOTICE: The generator should be supported by a stable overhead crane or hoist. Wheeled lifting devices or equipment are not recommended.

4. Carefully move the generator horizontally into place and engage the coupling assembly dowel pins into the generator drive ring. Install the engine adaptor ring-to-generator outer case bolts, but do not tighten fully. Allow a slight clearance between the generator and engine adaptor ring. Insert a feeler gage between the engine adaptor ring and generator to ensure equal clearance 360° around the adaptor ring. Adjust the generator position with the lifting equipment to obtain an equal clearance 360° around the adaptor ring.

   NOTICE: Once equal clearance has been achieved, do not disturb the engine or generator support until the entire alignment procedure has been completed.

5. Torque the adaptor ring-to-generator outer case bolts alternately in a criss-cross pattern. Install side arm-to-generator bolts, but do not tighten fully.

   NOTICE: If side arm-to-generator bolts will not engage with the generator, reposition the module frame. Under no circumstances should the engine or generator support be moved.

6. Move the right and left side arms in tight against the generator and flywheel housing pads. Properly tighten and torque the side arm-to-generator and side arm-to-flywheel housing pad bolts. Properly tighten and torque the side arm-to-module frame bolts. Install and properly tighten and torque engine coupling-to-generator drive ring bolts. Refer to the necessary Euclid service manuals for the applicable torque values.

7. Lift the rear of the module frame to support the engine/generator assembly and remove the equipment used for alignment purposes.

   NOTICE: An improper unloading sequence can result in generator-to-engine misalignment.

8. Use care when handling the completed module. Never lift it by the engine/generator lifter brackets, since engine/generator misalignment may result. The completed module should always be lifted by the module frame only.

© Detroit Diesel Corporation

9. Check the crankshaft end play with a magnetic base dial indicator at the front of the crankshaft damper. Engine crankshaft end play should be a minimum of .004" and will not normally change from the original reading in Step 1 under *Check Engine.*

   NOTICE: Do not pry against the damper(s) because dents will render it ineffective and cause subsequent crankshaft damage.

10. If end play cannot be obtained, repeat Steps 2 through 7. The generator may not be aligned correctly and maybe restricting the movement of the crankshaft.

11. If end play still cannot be obtained, the generator to engine coupling may have been shimmed incorrectly and this procedure must be repeated.

12. Rotate the crankshaft one full revolution and listen for any unusual noises caused by moving components contacting stationary parts. The crankshaft and armature should rotate without excessive effort.

13. Operate the engine and attached generator on the module and check for excessive vibration.

UNIT RIG

1. Perform Steps 1 thru 5 under *Check Engine* and Clean Mating Faces.

2. With the engine installed into the module frame and secured at the front engine trunnion mount, temporarily support the rear of the engine with suitable jacks from below or a chain hoist from above. Install and properly tighten and torque the engine flywheel housing-to-module frame bolts.

3. Using the 3 lifter brackets provided, lift the generator into position. The top front lifter brackets should be equipped with an adjustable member such as a come-along and the side members should be of equal length to ensure that the generator is evenly balanced and can be adjusted squarely to the flywheel housing.

   NOTICE: The generator should be supported by a stable overhead crane or hoist. Wheeled lifting devices or equipment are not recommended.

4. Carefully move the generator horizontally into place and engage the coupling assembly dowel pins into the generator drive ring. Install the engine adaptor ring-to-generator outer case bolts, but do not fully tighten. Allow a slight clearance between the generator and engine adaptor ring. Insert a feeler gage between the engine adaptor ring and generator to ensure equal clearance 360° around the adaptor ring. Adjust the generator position with the lifting equipment to obtain an equal clearance 360° around the adaptor ring.

   NOTICE: Once equal clearance has been achieved, do not disturb the engine or generator support until the entire alignment procedure has been completed.

5. Torque the adaptor ring-to-generator outer case bolts alternately in a criss-cross pattern. Install side arm-to-engine and generator bolts and properly tighten and torque.

6. Install and properly tighten and torque the engine coupling-to-generator drive ring bolts. Refer to the necessary Unit Rig service manuals for the applicable torque values.

7. Support the engine/generator assembly by lifting the rear of the module frame by the cradle arms at the points which suspend the module in the vehicle. Remove the equipment used for alignment purposes.

   NOTICE: An improper unloading sequence can result in generator-to-engine misalignment.

8. Use care when handling the completed module. Never lift it by the engine/generator lifter brackets, since engine/generator misalignment may result. The completed module should always be lifted by the module frame only.

9. Check the crankshaft end play with a magnetic base dial indicator at the front of the crankshaft damper. Engine crankshaft end play should be a minimum of .004" and will not normally change from the original reading in Step 1 under *Check Engine.*

   NOTICE: Do not pry against the damper(s) because dents will render it ineffective and cause subsequent crankshaft damage.

10. If end play cannot be obtained, repeat Steps 2 through 7. The generator may not be aligned correctly and may be restricting the movement of the crankshaft.

11. If end play still cannot be obtained, the generator-to-engine coupling may have been shimmed incorrectly, and the shimming procedure must be repeated.

12. Rotate the crankshaft one full revolution and listen for any unusual noises caused by moving components contacting stationary parts. The crankshaft and armature should rotate without excessive effort.

13. Operate the engine and attached generator on the module and check for excessive vibration.

WABCO (THREE-POINT MOUNT)

1. Perform Steps 1 thru 5 under *Check engine* and *Clean Mating Faces.*

2. With the engine installed into the module frame and secured at the front engine trunnion mount, temporarily support the rear of the engine with suitable floor jacks from below or with a chain hoist from above.

   NOTICE: Do not remove the support from the rear of the engine. The engine must remain supported until the generator has been fully coupled to the engine and secured to the module.

3. Using the 3 lifter brackets provided, lift the generator into position. The top front lifter bracket should be equipped with an adjustable member such as a come-along and the side lifting members should be of equal length to ensure that the generator is evenly balanced and can be adjusted squarely to the flywheel housing.

   NOTICE: The generator should be supported by a stable overhead crane or hoist. Wheeled lifting devices or equipment are not recommended.

4. Carefully move the generator horizontally into place and engage the coupling assembly dowel pins into the generator drive ring. Install the adaptor ring-to-generator outer case bolts, but do not tighten fully. Allow a slight clearance between the generator and engine adaptor ring. Insert a feeler gage between the engine adaptor ring and generator to ensure equal clearance 360° around the adaptor ring. Adjust the generator position with the lifting equipment to obtain an equal clearance 360° around the adaptor ring.

   NOTICE: Once equal clearance has been achieved, do not disturb engine or generator support until the entire alignment procedure has been completed.

5. Torque the adaptor ring-to-engine and generator outer case bolts alternately in a criss-cross patern.

6. Install and properly tighten and torque engine coupling-to-generator drive ring bolts. Refer to the necessary Wabco service manuals for the applicable torque values.

7. Install and properly tighten the cradle arms-to-module connecting bolts. Lift the rear of the module frame to support the engine/generator assembly and remove the equipment used for alignment purposes.

   NOTICE: An improper unloading sequence can result in generator-to-engine misalignment.

8. Use care when handling the completed module. Never lift it by the engine/generator lifter brackets, since engine/generator misalignment may result. The completed module should always be lifted by the module frame only.

9. Check the crankshaft end play with a magnetic base dial indicator at the front of the crankshaft damper. Engine crankshaft end play should be a minimum of .004" and will not normally change from the original reading in Step 1 under *Check Engine.*

   NOTICE: Do not pry against the damper(s), because dents will render it ineffective and cause subsequent crankshaft damage.

10. If end play cannot be obtained, repeat Steps 2 through 7. The generator may not be aligned correctly and may be restricting the movement of the crankshaft.

11. If end play still cannot be obtained, the generator-to-engine coupling may have been shimmed incorrectly and the shimming procedure must be repeated.

12. Rotate the crankshaft one full revolution and listen for any unusual noises caused by moving components contacting stationary parts. The crankshaft and armature should rotate without excessive effort.

13. Operate the engine and attached generator on the module and check for excessive vibration.

WABCO (FIVE-POINT MOUNT)

1. Perform Steps 1 thru 5 under *Check Engine* and *Clean Mating Faces.*

2. Support the module frame with suitable blocks at the front and rear module-to-truck support points.

3. Install the engine into the module frame and properly tighten and torque the front engine trunnion mount-to-front module engine bracket bolts and module frame support bracket-to-flywheel housing bolts.

4. Using the 3 lifter brackets provided, lift the generator into position. The top front lifter bracket should be equipped with an adjustable member such as a come-along and the side lifting members should be of equal length to ensure that the generator is evenly balanced and can be adjusted squarely to the flywheel housing.

   NOTICE: The generator should be supported by a stable overhead crane or hoist. Wheeled lifting devices or equiipment are not recommended.

 © Detroit Diesel Corporation

5. Carefully move the generator horizontally into place and engage the coupling assembly dowel pins into the generator drive ring. Install the engine adaptor ring-to-generator outer case bolts, but do not tighten fully. Allow a slight clearance between the generator and engine adaptor ring. Insert a feeler gage between the engine adaptor ring and generator to ensure equal clearance 360° around the adaptor ring. Adjust the generator position with the lifting equipment to obtain an equal clearance 360° around the adaptor ring.

   NOTICE: Once equal clearance has been achieved, do not disturb engine or generator support until the entire alignment procedure has been completed.

6. Torque the adaptor ring-to-generator outer case bolts alternately in a criss-cross pattern. Place shims under generator mounting pad. Install and properly tighten and torque engine coupling-to-generator drive ring bolts. Refer to the necessary Wabco service manuals for applicable torque values.

   NOTICE: If the generator brackets cannot be installed, shims will have to be placed under the flywheel housing-to-module frame support brackets. To accomplish this, the generator must be uncoupled from the engine and then reattached, repeating Steps 2 through 5.

7. Use care when handling the completed module. Never lift it by the engine/generator lifter brackets, since engine/generator misalignment may result. The completed module should always be lifted by the module frame only.

8. Check the crankshaft end play with a magnetic dial indicator at the front of the crankshaft damper. Engine crankshaft end play should be a minimum of .004" and will not normally change from the original reading in Step 1 under *Check Engine*.

   NOTICE: Do not pry against the damper(s), because dents will render it ineffective and cause subsequent crankshaft damage.

9. If end play cannot be obtained, repeat Steps 2 thru 6. The generator may not be aligned correctly and may be restricting the movement of the crankshaft.

10. If end play still cannot be obtained, the generator-to-engine coupling may have been shimmed incorrectly, and the shimming procedure must be repeated.

11. Rotate the crankshaft one full revolution and listen for any unusual noise caused by rotating components contacting stationary parts. The crankshaft and armature should rotate without excessive effort.

12. Operate the engine and attached generator on the module and check for excessive vibration.

TITAN/TEREX 33-15

This procedure requires the use of alignment studs which are available from Delco Products. The use of these studs will improve alignment of the generator drive disc in the pilot of the engine flywheel.

1. Perform Steps 1 thru 4 under *Check Engine* and *Clean Mating Faces.*

2. With the engine installed into the module frame and secured at the front engine trunnion mount, temporarily support the rear of the engine with suitable floor jacks from below or with a chain hoist from above so that a clearance of l/4"-3/8" exists between the rear engine mounting brackets and the engine/generator support brackets.

3. Position the generator coupling and engine flywheel so that the holes, indicated by an “X” on Figure 8, are horizontal.

4. Screw the two alignment studs into the flywheel at locations “X-X” until the polished section of the stud is within 1/16" of the flywheel face.

   NOTICE: The holes indicated by “X-X” must be horizontal.

5. Using the lifter brackets provided, lift the generator into position. The top front lifter bracket should be equipped with an adjustable member such as a come-along and the side members should be of equal length to ensure that the generator is evenly balanced and can be adjusted squarely to the flywheel housing.

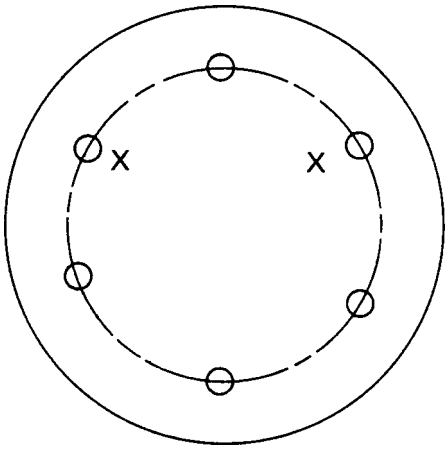


Fig. 8 - Location of Alignment - Stud Holes

NOTICE: The generator must be supported by a stable overhead crane or hoist. Wheeled lifting devices or equipment are not recommended.

6. Carefully move the generator horizontally into place and engage the flywheel studs into the generator driving discs. Install the flywheel housing-to-generator frame bolts, but do not tighten fully. Allow a slight clearance between the generator frame and flywheel housing. Insert a feeler gage between the flywheel housing and generator frame to ensure equal clearance 360° around the flywheel housing.

NOTICE: Once equal clearance has been achieved, do not distrub engine or generator support until the entire alignment procedure has been completed.

7. Torque the flywheel housing-to-generator frame bolts alternately in a criss-cross pattern.

8. Loosen the bolts between the engine/generator support brackets and the module frame, allowing the support brackets to be raised to contact the generator mounting feet.

9. Measure the gap between the rear engine mounting bracket and the engine generator support bracket adjacent to each of the mounting bolts. Install the appropriate shim pack per bolt, insert the bracket bolts and properly tighten and torque.

10. Lift the rear of the module frame to support the engine/generator assembly and remove the equipment used for alignment purposes.

NOTICE: An improper unloading sequence can result in generator-to-engine misalignment.

11. Install the flywheel bolts through the generator coupling and into the flywheel. Properly tighten and torque. Remove the two alignment studs and install and torque the two remaining bolts.

12. Use care when handling the completed module. Never lift it by the engine/generator lifter brackets, since engine/generator misalignment may result. The completed module should always be lifted by the module frame only.

13. Check the crankshaft end play with a magnetic base dial indicator at the front of the crankshaft damper. Engine crankshaft end play should be a minimum of .004" and will not normally change from the original reading in Step 1 under *Check Engine.*

NOTICE: Do not pry against the damper(s), because dents will render it ineffective and cause subsequent crankshaft damage.

14. If end play cannot be obtained, repeat Steps 2 thru 11. The generator may not be aligned correctly and may be restricting the movement of the crankshaft.

15. If end play still cannot be obtained, the generator-to-engine coupling may have been shimmed incorrectly, and the shimming procedure must be repeated.

16. Rotate the crankshaft one full revolution and listen for any unusual noises caused by rotating components contacting stationary parts. The crankshaft and armature should rotate without excessive effort.

17. Operate the engine and attached generator on the module and check for excessive vibration.

 © Detroit Diesel Corporation

SHOP NOTES - TROUBLESHOOTING - SPECIFICATIONS

SHOP NOTES

PROPER OPERATION OF THE SWITCHES OR ALARM SYSTEM FOR TESTING THE ELECTRICAL SHUTDOWN

The protective system is activated whenever low lubricating oil pressure, high coolant temperature, engine overspeed or any other abnormal condition develops that could damage the engine.

In a properly maintained installation, the shutdown system seldom has cause to function. Therefore, it is advisable to check the system periodically to be sure that it will function when needed.

Check each component of the shutdown system as outlined below. It is important to thoroughly warm-up the engine before any component of the shutdown system is checked.

Overspeed Governor

1. Remove the valve rocker cover.
2. Start the engine and move the speed control lever to the full-speed position.
3. While watching a tachometer, manually move the control tube slowly towards the increased fuel position until the air shutoff valve closes, stopping the engine.

   NOTICE: Do not exceed the engine no-load operating speed by more than 10%.

4. Note the speed at which the engine stops and adjust the overspeed governor, if necessary, as outlined in Section 7.4.3.
5. Replace the valve rocker cover.

Water Temperature Switch

The terminals of the water temperature switch are connected into the shutdown system and when the engine water temperature reaches 200°-210°F (93°-99°C), the switch closes and completes the circuit in the shutdown or alarm system.

1. Cover the radiator with a sheet of cardboard to prevent circulation of air.
2. Remove the radiator cap, if the engine is operating near sea level, and insert a steel jacketed thermometer.

   NOTICE: The boiling point of water lowers approximately 2° for each 1,000 foot rise in altitude. As an example, water boils at approximately 203°F (95°C) at 5,000 feet and at 195°F (91°C) at 9,000 feet altitude. It is necessary to retain the radiator pressure cap on engines which operate in excess of 1,000 feet altitude to prevent the coolant from boiling while performing this test. The engine temperature gage, if it is found to be accurate, may be used when performing this test.

   Do not exceed 210°F (99°C) when performing this test.

3. Start and run the engine at rated speed and with enough load to raise the water temperature gradually until the air shutoff valve closes. The water temperature switch will usually be set at 200°-210°F (93°-99°C).
4. Note the temperature at which the air shutoff valve closed.
5. Remove the radiator cover and start the engine without load immediately after the engine stops. This will permit the engine to cool down to normal operating temperature.

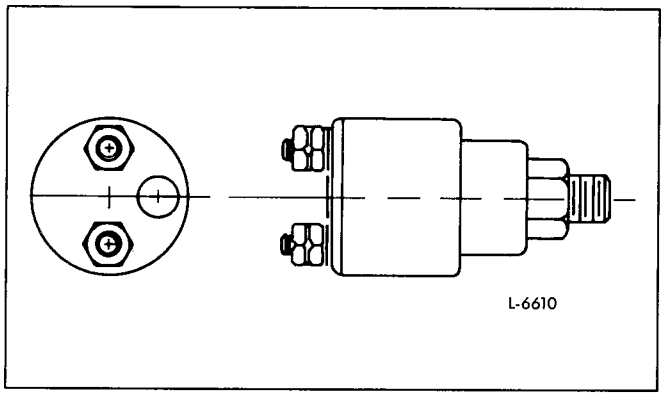


Fig. 1 – Fuel Oil Pressure Switch

© Detroit Diesel Corporation

Fuel Oil Pressure Switch

The fuel oil pressure switch is set to make contact at an increasing fuel pressure of 20 psi (138 kPa), and the phrase "20-MAKE" is stamped on the switch cover.

As the fuel pressure increases upon starting the engine, a diaphragm in the switch body expands and forces the plunger upwards (Fig. 1). Since the bottom of the adjusting screw bears against this plunger, the adjusting screw and the lower breaker point are also forced upwards. When the fuel pressure reaches 20 psi (138 kPa), the breaker points close and current flows to the terminals of the lubricating oil pressure switch and the water temperature switch.

When the engine is stopped, the fuel pressure decreases and the diaphragm in the switch body contracts. This action causes the plunger to lower and, when the fuel pressure decreases to 20 psi (138 kPa), permits the lower breaker point arm to lower and break the electrical circuit. The bracket to which the lower breaker point arm and the adjusting screw are attached is spring-loaded, which provides for positive breaking of the connection when the fuel pressure decreases sufficiently.

1. Insert a pressure gage on the discharge side of the fuel strainer.
2. Remove one of the leads from the lubricating oil pressure switch while this test is being performed, to prevent the engine from being shut down.
3. Start and run the engine at idle speed.
4. Slow the engine down by moving the speed control lever towards the *no-fuel* position until the fuel pressure is approximately 15 psi (103 kPa), with the engine barely turning over.
5. Place a jumper wire across the water temperature switch terminals.
6. Raise the engine speed slowly and watch the fuel oil pressure gage until the air shutoff valve closes.
7. Note the fuel pressure at which the air shutoff valve closed and, if necessary, replace the switch.
8. Remove the jumper wire from the water temperature switch and reconnect the lubricating oil pressure switch.

Lubricating Oil Pressure Switch

The construction of the lubricating oil pressure switch is very similar to that of the fuel oil pressure switch, except that the lubricating oil pressure switch is calibrated to break contact when the lubricating oil pressure increases to 10 psi (69 kPa). The phrase "10 BREAK" is stamped on the switch cover.

A 20 psi (138 kPa) break switch is used on some engines whose predominant operation is constant speed.

As the lubricating oil pressure increases upon starting, the diaphragm in the switch body expands and forces the plunger upwards (Fig. 2). Since the bottom of the adjusting screw bears against the plunger, and the adjusting screw is attached to the bracket which controls the upper breaker point arm, the arm is also forced upwards. When the lubricating oil pressure increases to 10 psi (69 kPa), the points separate. Current flows to the lubricating oil pressure switch only after the fuel oil pressure switch closes, at which time the points of the lubricating oil switch are open. Should the lubricating oil pressure decrease to 10 psi (69 kPa) during operation, the breaker point will close and either the alarm bell or shutdown solenoid will be energized.

1. Start and run the engine at idle speed.
2. Place a jumper wire on the hot wire relay between the "1" and "S" terminals.
3. Place a jumper wire across the fuel oil pressure switch terminals.
4. Reduce the engine speed by moving the control lever towards the *no-fuel* position while watching the lubricating oil pressure gage.
5. Note the oil pressure at which the switch stops the engine and, if necessary, replace the switch.

6. Remove the jumper wire.

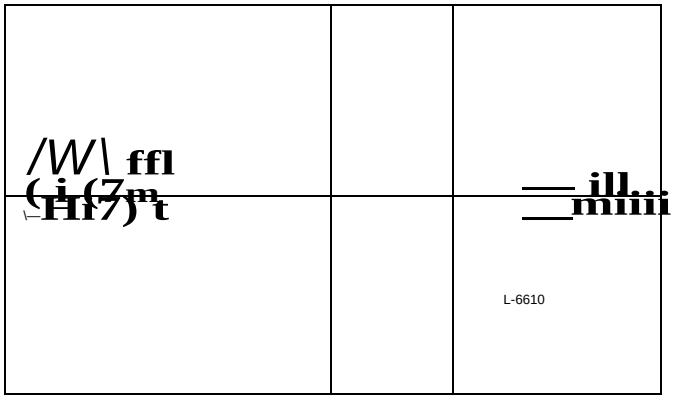


Fig. 2 - Lubricating Oil Pressure Switch

© Detroit Diesel Corporation

Hot Wire Relay

1. Start and operate the engine at idle speed.
2. Place the jumper wire across the terminals of the lubricating oil pressure switch while watching a second hand of a clock.
3. Not more than three (3) to ten (10) seconds should elapse between the time the jumper wire is placed across the terminals of the lubricating oil pressure switch and the air shutoff valve closes.

The above procedures completely test the normally open electrical shutdown system on an engine.

NOTICE: When the engine is operating at idle speed or above, the air shutoff valve will completely close off the air from the engine, causing it to stop. However, when the engine is operating at the very low speeds that are necessary when performing the test on the fuel shutdown switch and the lubricating oil shutdown switch, the air damper solenoid will close the air shutoff valve, but the engine may continue to run very slowly. This may be due to insufficient force exerted by the low air flow on the back of the shutoff valve to completely close it.

Solid State Time Delay Switch

A solid state time delay switch is used on current engines in place of the former hot wire relay.

A bench test procedure for the solid state time delay switch (Fig. 3) is as follows:

1. Remove the time delay switch from the engine.
- 2. Install the jumper straps on terminals “A” to “B” and “E” to “F”, if they have been removed. Normally, jumper straps are on the time delay switches as supplied.
3. Install a positive battery lead to terminal “A”.
4. Install a negative battery lead to one side of a 12 volt light which is a “known good test lamp”.
5. Install a lead from the opposite side of the light to terminal “D”. A switch may be used in this lead, if desired.
6. After the negative lead is connected to “D” or the switch is closed, the lamp should light in 8 to 10 seconds. If not, the time delay switch must be replaced.

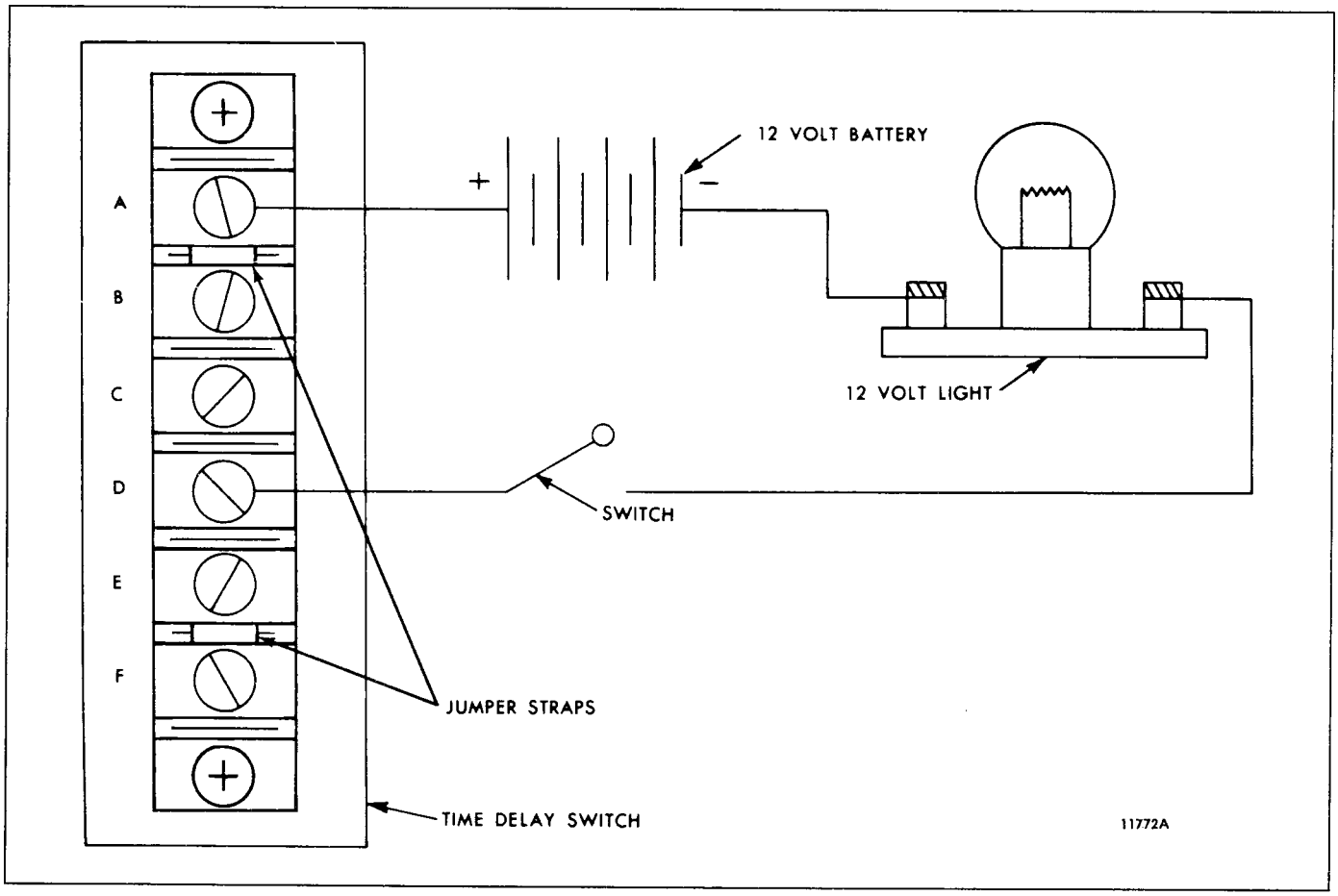


Fig. 3 – Time Delay Switch Testing Diagram

MOUNTING THE STARTER AUXILIARY MAGNETIC SWITCH

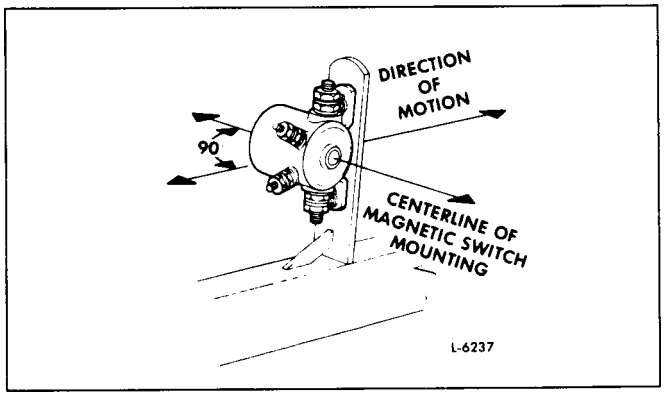


Fig. 4 - Starter Auxiliary Magnetic Switch Mounting

On certain locomotives and off-highway haul trucks equipped with Detroit Diesel engines and Delco-Remy starter auxiliary magnetic switches, a no-start condition may result from damage to the starter auxiliary magnetic switch caused by vibration. The vibration may result from improper mounting of the auxiliary magnetic switch.

The following guidelines should be followed when mounting a Delco-Remy starter auxiliary magnetic switch (Fig. 4):

1. Do not mount the switch on the engine.
2. Position the mounting pads of the switch vertically (one above the other).
3. Mount the switch on a rigid bracket, base rail or fire wall.
4. Mount the switch on a surface perpendicular (90°) to the forward motion of the vehicle so that contact disc movement is not in line with gravity or vehicle movement.

© Detroit Diesel Corporation

TROUBLESHOOTING

CHECKING ENGINE ELECTRICAL GENERATING SYSTEM

Whenever trouble is indicated in the electrical generating system, the following quick checks can be made to assist in localizing the cause.

A *fully charged battery and low charging rate* indicates normal alternator-regulator operation.

Alow battery and high charging rate indicates normal alternator-regulator operation.

A *fully charged battery and high charging rate* condition usually indicates the voltage regulator is set too high or is not limiting the alternator output. A high charging rate to a fully charged battery will damage the battery and other electrical components.

A *low battery and low or no charging rate* condition could be caused by: Loose connections or damaged wiring, defective battery or alternator and defective regulator or improper regulator setting.

© Detroit Diesel Corporation

SPECIFICATIONS

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	260M BOLTS TORQUE (lb—ft)	N*m	THREAD SIZE	280M OR BETTER TORQUE (lb—ft)	N*m
l/4_20	5-7	7-9	1/4-20	7-9	10-12
1/4-28	6-8	8-11	1/4-28	8-10	11-14
5/16-18	10-13	14-18	5/16-18	13-17	18-23
5/16-24	11-14	15-19	5/16-24	15-19	20-26
3/8-16	23-26	31-35	3/8-16	30-35	41-47
3/8-24	26-29	35-40	3/8-24	35-39	47-53
7/16-14	35-38	47-51	7/16-14	46-50	62-68
7/16-20	43-46	58-62	7/16-20	57-61	77-83
1/2-13	53-56	72-76	1/2-13	71-75	96-102
1/2-20	62-70	84-95	1/2-20	83-93	113-126
9/16-12	68-75	92-102	9/16-12	90-100	122-136
9/16-18	80-88	109-119	9/16-18	107-117	146-159
5/8-11	103-110	140-149	5/8-11	137-147	186-200
5/8-18	126-134	171-181	5/8-18	168-178	228-242
3/4-10	180-188	244-254	3/4-10	240-250	325-339
3/4-16	218-225	295-305	3/4-16	290-300	393—407
7/8-9	308-315	417-427	7/8-9	410-420	556-569
7/8-14	356-364	483-494	7/8-14	475-485	644-657
1-8	435-443	590-600	1-8	580-590	786-800
1-14	514-521	697-705	1-14	685-695	928-942

Grade identification markings are normally stamped on the heads of the bolts. To aid identification of the various bolts used in Detroit Diesel engines, refer to the following chart.

Grade Identification Marking on Bolt Head	GM Number	SAE Grade Designation	Nominal Size Diameter (inch)	Tensile Strength Min. (psi)
None	GM 255-M	1	No. 6 thru 1 1/2	60,000
None	GM 260-M	2	No. 6 thru 3/4 over 3/4 to 1 1/2	74.000 60.000
Bolts and Screws	GM 280-M	5	No. 6 thru 1 over 1 to 1 1/2	120,000 105,000
—'— Hex Head Sems Only	GM 275-M	5.1	No. 6 thru 3/8	120,000
''s' Bolts and Screws	GM 290-M	7	1/4 thru 1 1/2	133,000
jjC Bolts and Screws	GM 300-M	8	1/4 thru 1 1/2	150,000
—[1] Bolts and Screws	GM 455-M	None	No. 6 thru 1 1/2	55,000

BOLT IDENTIFICATION CHART

© Detroit Diesel Corporation

SECTION 8

POWER TAKE-OFF

CONTENTS

Power Take-Off - - Hydraulic (Rear Mounted)..... 8.1

POWER TAKE-OFF - HYDRAULIC (REAR MOUNTED)

The hydraulic power take-off (PTA-0101-H) is a self-contained unit with an integral lubricating oil pump, independent oil supply and 10.5" eight-plate half pack hydraulic clutch (Fig. 1). The oil pump is gear driven from the input hub and supplies oil under pressure through a control valve to the clutch. The input hub in coupled to the engine through flexible discs bolted directly to the flywheel.

Oil flow is from the sump through the full flow filter screen to the oil pump, then to the valve assembly. The valve assembly is preset and regulates pressure and channels oil to the supply pressure line, the lubricating oil line, or back to the sump as the position of the regulator valve dictates. Shaft bearings are oiled internally, therefore this unit requires no external lubrication other than periodic oil changes based on hours of operation.

NOTICE: This unit is not recommended for use in side load applications.

Operation

Run the engine a short time, allowing the oil pressure to stabilize, before engaging the clutch. Without sufficient oil flow, low oil pressure could cause extended clutch slippage to the disc pack. Extended clutch slippage should be avoided as it may generate extreme heat build-up which can cause plate warpage.

After the oil pressure is stabilized, clutch engagement is accomplished by moving the lever at the back of the valve body, which is mounted directly on top of the power take-off.

Full clutch actuation is possible in .6 of a second, but this may be extended by pulling the lever slowly to the over-center position.

The clutch may be engaged at any engine speed provided the driven load does not exceed the maximum torque rating of the power take-off. When the engine is stopped, the clutch will automatically release and the operating valve will return to the release position due to low oil pressure. *

The operating lever of the valve has three positions:

1. The clutch is engaged by pulling the lever back away from the valve body. The lever is held in this position by the supply oil pressure.

2. The release position is obtained when the operating handle is parallel with the back of the valve body. The supply pressure is shut off and only lubricating oil is permitted to flow, which cools the clutch and oils bearings that are still operating.

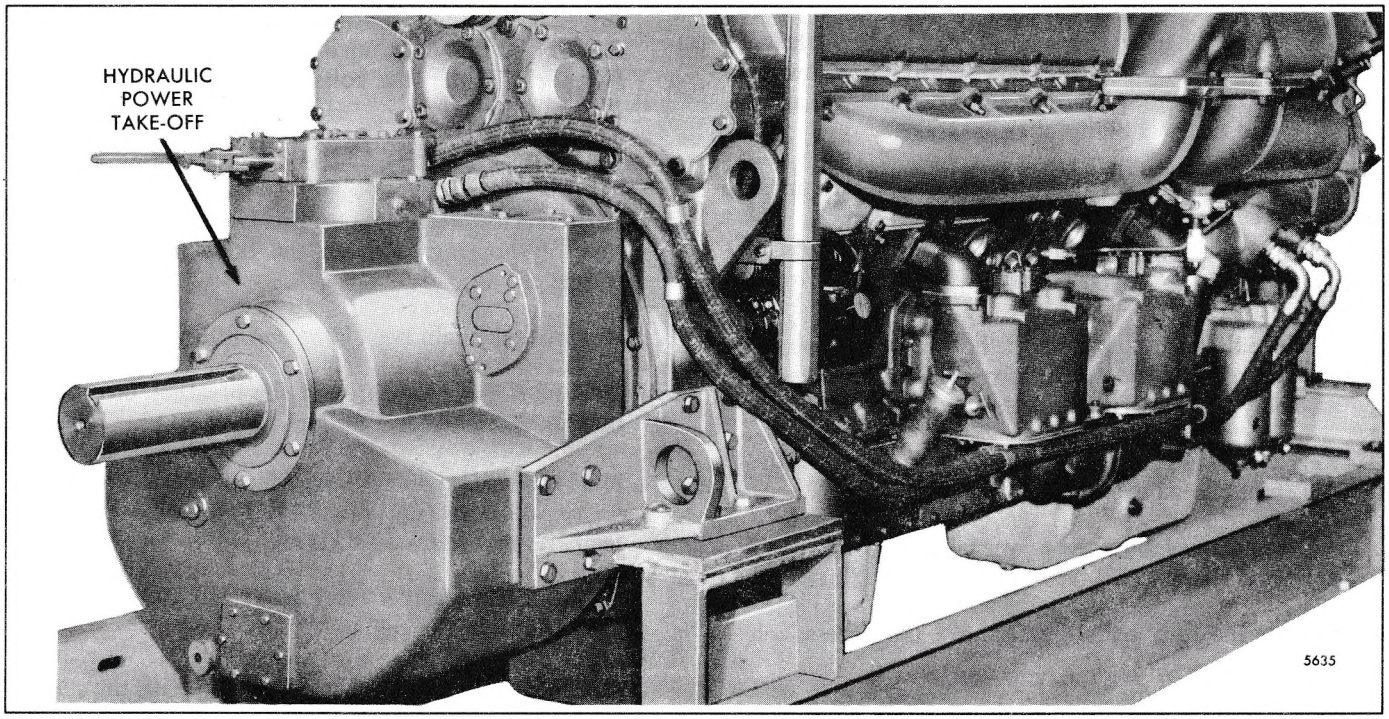


Fig. 1 - Hydraulic Power Take-Off Mounting

3. The third position is with the operating lever pushed forward toward the back of the valve body. This is used primarily to dump the lubricating oil pressure, reduce drag between clutch plates and to facilitate shifting when the power take-off is coupled to a gear box. As the operating lever is spring-loaded, it must be held in this position. When released, the lever automatically returns to the release position.

Oil System

Main or supply oil pressure is from 150 to 200 psi (1034—1378 kPa) and can be checked by removing the 1/8" pipe plug in the ditch plate under the valve assembly. Oil pressure is from 8 to 30 psi (55-207 kPa) and can be checked by removing the 3/8" pipe plug in the ditch plate.

Engine speed and oil temperature will cause variations in both lubricating oil and main pressures; but if the pressures are maintained within the given range, performance of the unit will not be affected.

The oil should be changed after each 1000 hours of operation. The oil capacity is 47 quarts (44.5 litres) (does not include heat exchanger). Along with each oil change, thoroughly clean the filter screen in the sump and the breather filter and dry them with compressed air.

CAUTION:To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

To remove the filter screen cover plate, remove the six bolts at the bottom of the power take-off directly below the output shaft. Discard the plate gasket and replace with a new gasket to avoid the possiblility of an oil leak.

Inspect a new power take-off the first few hours of operation to ensure that the unit is not leaking oil.

Remove Power Take-Off

1. Remove the pipe plug from the bottom of the housing and drain the lubricating oil from the power take-off assembly. Reinstall and tighten the pipe plug.

2. Remove the breather filter and install an eyebolt with a 3/4" pipe thread to lift the power take-off.

3. Support the weight of the power take-off with a chain hoist and sling.

4. Loosen the four bolts and remove the access hole cover.

5. Disconnect the six bolts holding the clutch drive discs to the flywheel.

6. Remove the four bolts holding each support bracket to the power take-off.

7. Remove the sixteen bolts and lock washers securing the power take-off to the engine flywheel housing.

8. Install two of the above bolts into the tapped holes provided in the bolting flange of the clutch housing and move the power take-off straight back away from the flywheel housing.

Disassemble And Assemble Power Take-Off

For service and overhaul procedures for the hydraulic power take-off (PTA-0101-H), refer to Borg Warner Corp., Rockford Clutch Division, Rockford, Illinois.

Install Power Take-Off

1. Support the power take-off assembly with a chain hoist and sling. Then position the power take-off square against the engine flywheel housing.

2. Enter the pilot of the clutch housing straight into the flywheel housing. Secure the power take-off in place with the sixteen 1/2"-13 x 1 1/2" bolts and lock washers (includes two bolts installed in tapped holes in the clutch housing for positioning power take-off). Tighten the bolts to 71-75 lb-ft (96—102 N*m) torque.

3. With the access cover removed, rotate the clutch driven discs and assemble (if removed) the six 5/8"-ll x 1 1/2" clutch drive attaching bolts into the flywheel. Tighten the bolts to 81-97 lb-ft (110-132 N*m) torque.

4. Secure the access hole cover with four bolts.

5. Align and install the support bracket bolts in the power take-off housing. Tighten the bolts to the proper torque.

6. Remove the chain hoist sling and lifting eye.

7. Add lubricating oil through the breather filter hole tube until the oil level reaches the check plug hcde.

   NOTICE: Use SAE 30W oil for temperatures above 32°F (0°C) or SAE 10W oil for temperatures below 32°F (0°C).

8. Reinstall the breather filter and check the hole plug before starting the engine.

   NOTICE: Before applying load and with the clutch released, rotate the shaft by hand to check for free turning.

 © Detroit Diesel Corporation

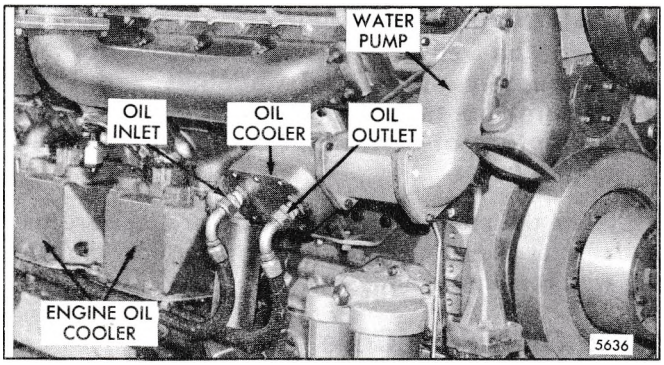


Fig. 2 - Power Take-Off Oil Cooler Mounting

Power Take-Off Oil Cooler

To provide cooling for the oil used in the hydraulic power take-off, a separate oil cooler (Fig. 2), similar to the engine lubricating oil cooler, is mounted on the side of the engine adjacent to the engine water pump. Thus sufficient cooling is provided to ensure that normal operating temperatures are maintained in the system under all conditions of speed and load.

The oil cooler core is contained in a single housing which is attached to the front of the cylinder block and is located between the fresh water pump discharge line and the engine oil cooler.

Oil is drawn from the oil sump through the oil strainer by the oil pump. The oil is then forced through the oil filter to the oil cooler.

The oil cooler core should be removed and cleaned periodically, or at the time of each engine or power take-off overhaul, to prevent overheating of the power take-off oil.

Remove Oil Cooler Core

The oil cooler core (Fig. 3) may be removed from the housing for cleaning and inspection as follows:

1. Drain the engine cooling system.
2. Matchmark the end of the cooler core and cooler housing with a punch or file so they can be installed in their same relative positions.
3. Disconnect the two power take-off oil tubes from the elbows in the oil cooler core.

   NOTICE: Tag the inlet and outlet oil tubes for future reference.
4. Remove the bolts and lock washers securing the core to the oil cooler housing.

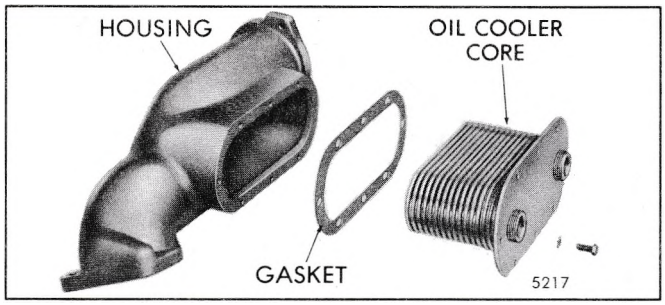


Fig. 3 - Power Take-Off Oil Cooler

5. Tap the edge of the core with a plastic hammer to loosen it.
6. Remove the oil cooler core from the oil cooler housing.
7. Remove the gasket from the oil cooler core or housing.

Clean Oil Cooler Core

1. *Clean the oil side of the core:* Circulate a solution of 1, 1, 1 trichloroethane through the core passages with a force pump to remove the carbon and sludge. Clean the core before the sludge hardens. If the oil passages are badly clogged, circulate an oakite or alkaline solution through the core and flush thoroughly with clean hot water.

   CAUTION: To avoid persona! injury, wear adequate protective clothing (face shield, rubber gloves, apron). This operation should be done in the open or in a well ventilated room when trichloroethane or other chemicals are used for cleaning.

2. *Clean the water side of the core:* After cleaning the oil side of the core, immerse it in the following solution: Add one-half pound of oxalic acid to each two and one-half gallons of solution composed of one-third muratic acid and two-thirds water. The cleaning action is evidenced by bubbling and foaming. Watch the process carefully and, when bubbling stops (this usually takes from 30 to 60 seconds), remove the core from the cleaning solution and thoroughly flush it with clean hot water. After cleaning, dip the core in light engine oil.

   NOTICE: Cleaning an oil cooler core is not recommended where the history of usage shows power take-off failure which has released metal particles from worn or broken parts into the lubricating oil. In this instance, replacement of the oil cooler core is strongly recommended.

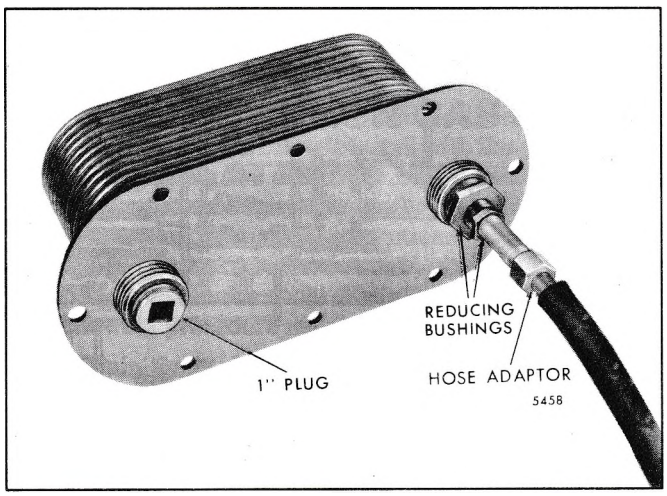


Fig. 4 - Oil Cooler Core Prepared for Pressure Test

Pressure Check

After the oil cooler has been cleaned, it may be checked for leaks as follows:

1. Install a 1" pipe plug in one of the core openings. In the other opening, install the necessary reducing bushings and a suitable air hose adaptor as shown in Fig. 4.
2. Attach an air hose and apply approximately 75-150 psi (517-1034 kPa) air pressure and submerge the core and plate assembly in a tank of water heated to 180°F (82°C). Any leaks will be indicated by air bubbles in the water. If leaks are indicated, replace the core.

CAUTION: When making this pressure test, be sure that personnel are adequately protected against any stream of pressurized water from a leak or rupture of a fitting, hose or the oil cooler core.

3. After the pressure check is completed, remove the adaptor and air hose from the core, then dry the core with compressed air.

Install Oil Cooler Core

1. Affix a new gasket to the oil cooler housing.
2. Align the matchmarks previously placed on the core and housing and install the oil cooler core in the oil cooler housing.
3. Install the bolts and lock washers. Tighten the bolts to 13-17 lb-ft (18-23 N*m) torque.
4. Connect the two oil tubes to the elbows in the oil cooler.

NOTICE: Be sure the inlet and outlet tubes are reinstalled in their original positions, otherwise the oil flow will be reversed and could result in loosening foreign particles that may not have been removed and circulating them through the power take-off.

5. Fill the engine cooling system.
6. Start the engine and check for oil and water leaks

%

f

 © Detroit Diesel Corporation

SECTION 9

TRANSMISSIONS

CONTENTS

Twin Disc Marine Gear
fMarine Gear Oil Cooler **9.5.5**

‘For service and overhaul procedures for the Twin Disc Marine Gear assembly, refer to the manufacturer:

Twin Disc, Inc.
1328 Racine Street
Racine, Wise. 53403

t **Current engines not equipped with marine gear oil cooler.**

MARINE GEAR OIL COOLER

To provide cooling for the oil used in the marine gear, a separate oil cooler, similar to the engine lubricating oil cooler, is mounted on the side of the engine adjacent to the engine water pump. Thus, sufficient cooling is provided to insure that normal operating temperatures are maintained in the marine gear oil system under all conditions of speed and load in both forward and reverse.

The oil cooler core is contained in a single housing which is attached to the front of the cylinder block and is located between the fresh water pump discharge line and the engine oil cooler (Fig. 1).

Oil is drawn from the marine gear oil sump through the oil strainer by the marine gear oil pump. The oil is then forced through the oil filter to the oil cooler and through the oil cooler to the selector control valve.

The oil cooler core should be removed and cleaned periodically, or at the time of each engine or marine gear overhaul, to prevent overheating of the marine gear oil.

Effective with approximate engine serial numbers 12E-5615 and 16E-5195, engines equipped with or for a Twin Disc marine gear will no longer be supplied with an engine mounted marine gear oil cooler.

NOTICE: Twin Disc now recommends oil temperatures lower than 185° F (85°C) for many applications. Since Detroit Diesel oil coolers use 180°F (82°C) engine coolant, it is not possible for our marine gear oil cooler to achieve the conditions recommended by Twin Disc using a practical oil cooler size.

Remove Oil Cooler Core

The oil cooler core may be removed from the housing for cleaning and inspection as follows:

1. Drain the engine cooling system.
2. Matchmark the end of the cooler core and cooler housing with a punch or file so they can be installed in their same relative positions.
3. Disconnect the two marine gear oil tubes from the elbows in the oil cooler core.

   NOTICE: Tag the inlet and outlet oil tubes for future reference.

4. Remove the bolts and lock washers securing the core to the oil cooler housing.
5. Tap the edge of the core with a plastic hammer to loosen it.

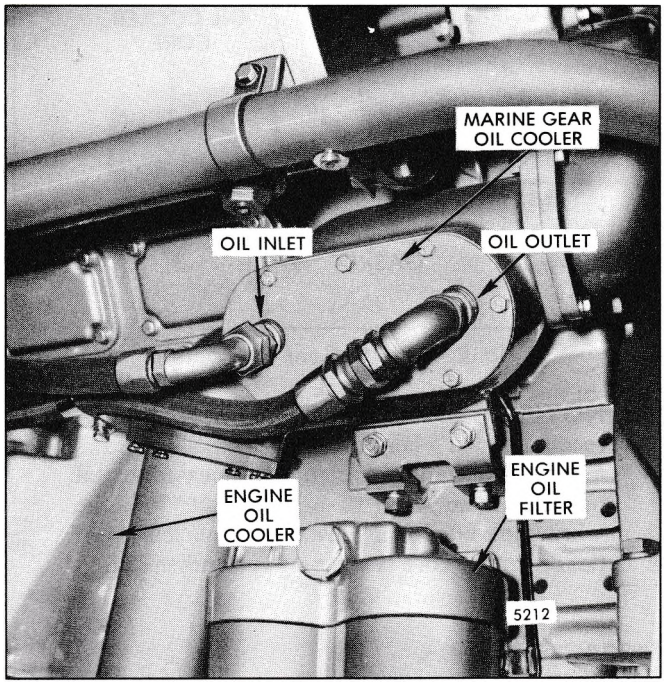


Fig. 1 - Marine Gear Oil Cooler Mounting

6. Remove the oil cooler core from the oil cooler housing.
7. Remove the gasket from the oil cooler core or housing.

Clean Oil Cooler Core

1. Clean the oil side of the core: Circulate a solution of 1,1,1-trichloroethane through the core passages with a force pump to remove the carbon and sludge. Clean the core before the sludge hardens. If the oil passages are badly clogged, circulate an oakite or alkaline solution through the core and flush thoroughly with clean hot water.

   CAUTION: To avoid personal injury, wear adequate protective clothing (face shield, gloves, apron, rubber boots) and work in the open or in a well ventilated area.

2. Clean the water side of the cover: After cleaning the oil side of the core, immerse it in the following solution: Add one-half pound of oxalic acid to each two and one-half gallons of solution composed of one-third muratic acid and two-thirds water. The cleaning action is evidenced by bubbling and foaming. Watch the process carefully and when bubbling stops (this usually takes from 30 to 60 seconds), remove the core from the cleaning solution and thoroughly flush it with clean hot water. After cleaning, dip the core in light engine oil.

© Detroit Diesel Corporation

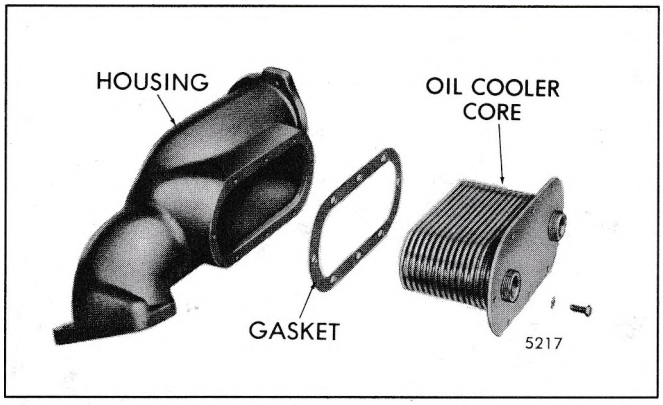


Fig. 2 – Marine Gear Oil Cooler

NOTICE: Cleaning an oil cooler core is not recommended where the history of usage shows marine gear failure which has released metal particles from worn or broken parts into the lubricating oil. In this instance, replacement of the oil cooler core is strongly recommended.

Pressure Check

After the oil cooler core has been cleaned, it may be checked for leaks as follows:

1. Install a 1" pipe plug in one of the core openings. In the other opening, install the necessary reducing bushings and a suitable air hose adaptor as shown in Fig. 3.

   CAUTION: When making a pressure test, be sure that personnel are adequately protected against any stream of pressurized water from a leak or rupture of a fitting, hose or the oil cooler core.

2. Attach an air hose and apply approximately 75-150 psi (517-1 034 kPa) air pressure and submerge the core and plate assembly in a tank of water heated to 180°F (82°C). Any leaks will be indicated by air bubbles in the water. If leaks are indicated, replace the core.

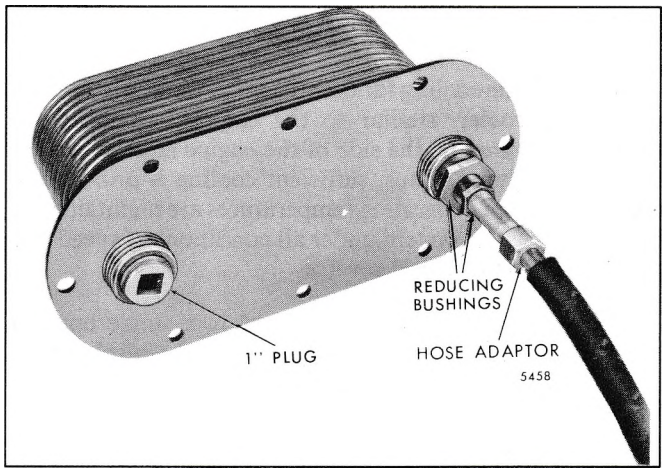


Fig. 3 - Oil Cooler Element Prepared for Pressure Test

3. After the pressure check is completed, remove the adaptor and air hose from the core, then dry the core with compressed air.

Install Oil Cooler Core

With the oil cooler core cleaned and inspected, it may be installed as follows:

1. Affix a new gasket to the oil cooler housing.
2. Align the matchmarks previously placed on the core and housing and install the oil cooler core in the oil cooler housing.
3. Install the bolts and lock washers. Tighten the bolts to 13-17 lb-ft (18-23 N*m) torque.
4. Connect the two oil tubes to the elbows in the oil cooler.

   NOTICE: Be sure the inlet and outlet tubes are reinstalled in their original positions, otherwise the oil flow will be reversed and could result in loosening foreign particles that may not have been removed and circulating them through the marine gear. ..

5. Fill the engine cooling system.
6. Start the engine and check for oil and water leajcs.

 © Detroit Diesel Corporation

SECTION 12

SPECIAL EQUIPMENT

CONTENTS

Air Compressor **12.4**

Cold Weather Starting..... **12.6**

Service Tools **12.0**

AIR COMPRESSOR

• The air compressor (Fig. 1) may be mounted on a bracket attached to the cylinder block of the engine and belt-driven from the crankshaft pulley, or it may be flange-mounted to the flywheel housing and gear-driven by means of an accessory drive attached to a camshaft. Series 149 engines currently use 12 CFM (inline configuration) or 24 CFM (vee configuration) air compressors.

The air compressor runs continuously while the engine is running. While the compressor is running, actual compression of air is controlled by the compressor governor which acts in conjunction with the unloading mechanism in the compressor cylinder block. The governor starts and stops the compression of air by loading or unloading the compressor when the air pressure in the system reaches the desired minimum or maximum pressure.

During the downstroke of each piston, a partial vacuum is created above the piston which unseats the inlet valve and then allows air drawn from the air box in the engine cylinder block or through an intake strainer to enter the cylinder above the piston. As the piston starts the upward stroke, the air pressure on top of the inlet valves, plus the inlet valve return spring force, closes the inlet valve. The air above the piston is further compressed until the pressure lifts the discharge valve and the compressed air is discharged through the discharge line into the reservoir.

As each piston starts its downstroke, the discharge valve above it returns to its seat, preventing the compressed air from returning to the cylinder; and the same cycle is repeated.

When the air pressure in the reservoir reaches the maximum setting of the governor, compressed air from the reservoir passes through the governor into the cavity below the unloading pistons in the compressor cylinder block. The air pressure lifts the unloading pistons which in turn lifts the inlet valves off their seats.

With the inlet valves held off their seats, the air during each upstroke of the piston is merely passed back through the air inlet cavity and to the other cylinder where the piston is on the downstroke. When the air pressure in the reservoir drops to the minimum setting of the governor, the governor releases the air pressure beneath the unloading pistons. The unloading piston return spring then forces the piston down and the inlet valve springs return the inlet valves to their seats and compression is resumed.

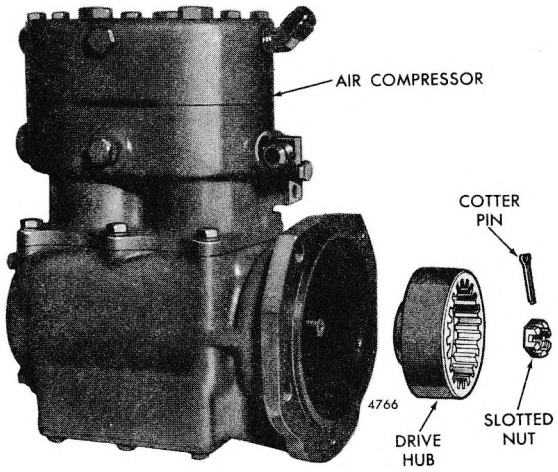


Fig. 2 - Typical Air Compressor With Drive Hub

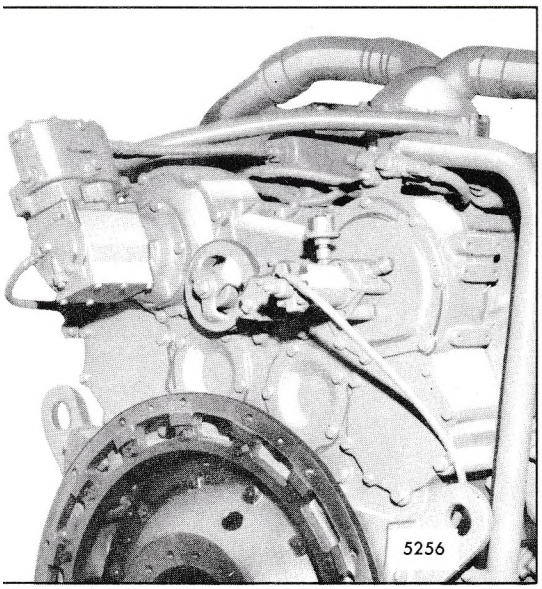
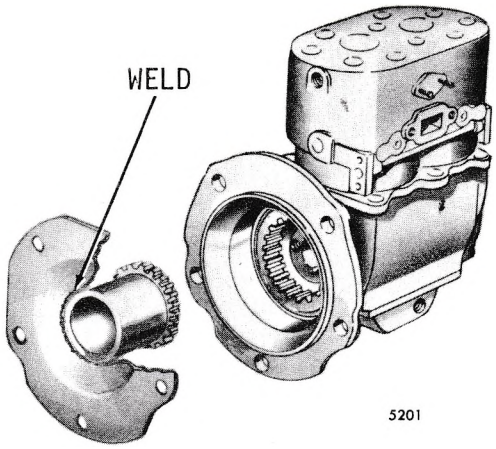


Fig. 1 - Air Compressor Mounting



Fig, 3 - Fixture For Holding Drive While Installing or Removing Slotted Nut

Service Note

When installing a pulley or a drive hub on a flange mounted air compressor (Fig. 2), it is important the 3/4"-16 drive shaft slotted nut be tightened to 100 lb-ft (136 N*m) torque minimum before installing the 3/32” x 1-1/4" cotter pin.

The air compressor drive shaft will turn during the torquing operation unless some provision is made to hold it. One way this can be done is to weld a modified drive coupling to a support or base which in turn can be anchored to the mounting flange of the compressor. An old flywheel housing cover that matches the flange of the compressor makes an ideal base for the modified coupling. With the exterior splines of the coupling in mesh with the internal splines of the drive hub and the entire assembly secured to the compressor housing, the hub and shaft are kept from rotating when the torque is applied. That part of the base within the inner diameter of the coupling must be removed to permit placement of the wrench socket on the nut. Two bolts will secure the base to the compressor during the torquing operation (Fig. 3).

• Air Compressor Service

For air compressor disassembly, assembly, or overhaul procedures, consult with an authorized service center for the manufacturer’s product.

 © Detroit Diesel Corporation

COLD WEATHER STARTING

When starting an internal combustion engine in cold weather, a large part of the energy of combustion is absorbed by the pistons, cylinder walls, coolant and in overcoming friction.

Under extremely low outside temperatures, the cold oil in the bearings and between the pistons and cylinder walls creates very high friction and the effort required to crank the engine is much greater than when the engine is warm.

In a diesel engine, the normal means of igniting the fuel sprayed into the combustion chamber is by the heat of the air compressed in the cylinder. This temperature is high enough under ordinary operating conditions, but at extremely low outside temperatures may not be sufficiently high enough to ignite the fuel injected.

To assist in starting an engine under low temperature conditions, cold weather starting devices are available.

NOTICE: Starting aids are not intended to correct deficiencies such as low battery, heavy oil, etc. They are for use when other conditions are normal but the air temperature is too low for the heat of compression to ignite the fuel-air mixture.

CAUTION: Starting fluid used in capsules is highly inflammable, toxic and possesses sleep inducing properties.

PRESSURIZED CYLINDER STARTING AID

Operation

Start the engine during cold weather, using the "Quick Start" starting aid system (Fig. 1) as follows:

1. Press the engine starter button.
2. Pull out the "Quick Start" knob for one or two seconds, then release it.
3. Repeat the procedure if the engine does not start on the first attempt.

NOTICE:. Do not crank the engine more than 30 seconds at a time when using an electric starting motor. Always allow one minute intervals between cranking attempts to allow the starting motor to cool.

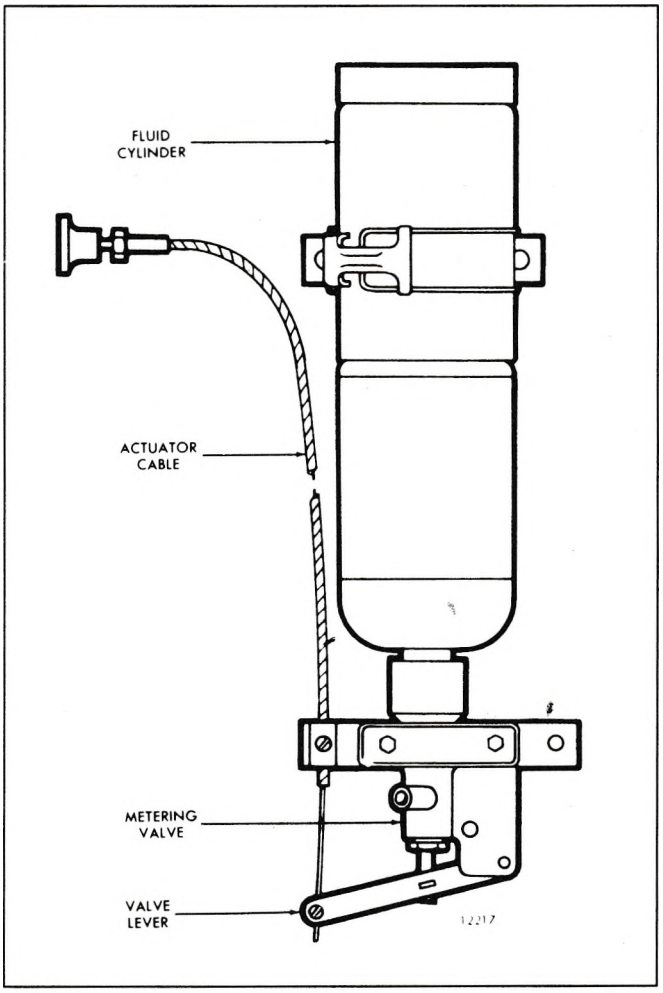


Fig. 1 – "Quick Start" Assembly

Service

Periodically perform the following service items to assure good performance:

1. Remove the fluid cylinder and lubricate the valve around the pusher pin under the gasket with a few drops of oil.
2. Lubricate the actuator cable.
3. Actuate the valve with the cable to distribute the oil on the cable and allow the oil to run down through the valve.
4. Remove any dirt from the orifice by removing the air inlet housing fitting, the orifice block and the screen. Then blow air through the orifice end only.

5. Assemble and tighten the air inlet housing fitting to the actuator valve and tube.

6. Check for leakage of fluid (fogging) on the outside of the engine air inlet housing by actuating the starting aid while the engine is stopped. If fogging occurs, disassemble and retighten the air inlet housing fitting to the housing.

NOTICE: Do not actuate the starting aid more than once with the engine stopped. *Over-loading the engine air box with this highly volatile fluid could result in a minor explosion and serious engine damage.*

7. Check the fluid cylinder for hand tightness.

%

*

 © Detroit Diesel Corporation

SERVICE TOOLS

TOOL NAME	TOOL NO.
Air Compressor Hub Remover	J 36309
Air Compressor Hub Installer	J 36311

ENGINE OPERATING INSTRUCTIONS

PREPARATION FOR STARTING ENGINE FIRST TIME

Before starting an engine for the first time, carefully read and follow the instructions in Sections 13 and 14 of this manual. Attempting to run the engine before studying these instructions may result in serious damage to the engine.

> **NOTICE:** When preparing to start a new or overhauled engine or an engine which has been in storage, perform all of the operations listed below. Before a routine start (at each shift), see *Daily Operations* in the *Lubrication and Preventive Maintenance Chart,* Section 15.1.

Cooling System

Install all of the drain cocks in the cooling system (drain cocks are removed for shipping).

• Open the cooling system vents, *if* the engine is so equipped. The majority of Series 149 engines use a rapid warm-up cooling system which is self-venting.

• Remove the radiator or heat exchanger pressure control cap and fill the cooling system with clean, soft properly inhibited water or an ethylene glycol base antifreeze, if the engine will be exposed to freezing temperatures (refer to Section 13.3). Fill to the filler neck.

Close the vents, *if used,* after filling the cooling system.

On marine installations, prime the raw water cooling system and open any sea cocks in the raw water pump intake line. Prime the raw water pump by removing the pipe plug or electrode provided in the pump outlet elbow and pour water in the pump.

> **NOTICE:** Failure to prime the raw water pump may result in damage to the pump impeller.

Lubrication System

The lubricating oil film on the rotating parts and bearings of a new or overhauled engine, or one which has been in storage, may be insufficient for proper lubrication when the engine is started for the first time.

To ensure an immediate flow of oil to all bearing surfaces at initial engine start-up, DDC recommends that the engine lubrication system be charged with a commercially available pressure prelubricator. Use the following procedure:

1. Remove the pipe plug from the engine main oil gallery and attach the prelubricator hose.

• 2. Remove the valve rocker cover and gasket and, using a positive displacement pump set at 25-35 psi (172-241 kPa), pump in the recommended grade of engine lubricating oil until it is observed flowing from the rocker arms. Refer to section 13.3 for *Lubricating Oil Recommendations.*

• 3. If the engine is turbocharged, disconnect the oil supply lines at the turbocharger bearing (center) housings and fill the bearing housing cavities with approximately one (1) pint of the recommended grade of clean engine oil. Remove air inlet duct and turn the rotating assemblies by hand to coat all internal surfaces with oil and reinstall the turbocharger oil supply lines (refer to Section 3.5). Refer to Section 13.3 for lubricating oil recommendations.

4. After twenty (20) minutes, check the crankcase oil level. Add enough oil to bring the level to the “full” mark on the dipstick. *Do not overfill.*

5. Disconnect the prelubricator hose, plug the main oil gallery hole and replace all components and gaskets previously removed.

6. Before initial engine start-up, DDC also recommends cranking the engine with the governor in the *no-fuel* position until oil pressure registers on the gage.

• If a pressure prelubricator is not available, fill the crankcase to the proper level with *heavy duty* lubricating oil as specified in Section 13.3. Then prelubricate the upper engine parts by removing the valve rocker covers and pouring lubricating oil, of the same grade and viscosity as used in the crankcase, over the rocker arms. Using new gasket, reinstall the valve rocker covers.

Turbocharger

> **CAUTION: Do not hold the compressor wheel, for any reason, while the engine is running. This could result in personal* injury.**

• After installing a rebuilt or new turbocharger, it is very important that all the moving parts of the turbocharger center housing be lubricated as follows:

1. Clean the area and disconnect the oil inlet line at the bearing housing.

• 2. Fill the bearing housing cavity with clean engine oil. Remove air inlet duct and turn the rotating assembly by hand to coat all of the internal surfaces with oil.

3. Add additional engine oil to completely fill the bearing housing cavity and reinstall the oil line. Clean off any spilled oil.

Air Cleaner

If the engine is equipped with oil bath air cleaners, fill the air cleaner oil cups to the proper level with clean engine oil. *Do not overfill.*

Transmission

Fill the transmission case, marine gear or torque converter supply tank to the proper level with the lubricant recommended by the gear manufacturer.

• Fuel System

Fill the tank with the fuel specified under *Fuel Recommendations* (Section 13.3).

If the unit is equipped with a fuel supply shutoff valve, it must be opened. Special note should be taken of the direction of flow through any check valves used in the system to be sure of their proper installation.

To ensure prompt starting and even running, the fuel system must be purged of air and full of fuel from the supply tank to the restricted fitting at the fuel return line. To accomplish this, a manual priming pump, such as J 5956 or an electrical type priming pump can be adapted easily to the fittings provided on the primary or secondary filter is preferred. The system should be primed until no air is present in the fuel flow from the return line. Pressure should not exceed 15 psi (103 kPa) for ease of handling and safety reasons.

Pressurization of the fuel tank, although not recommended, can be used with controlled air pressure and a modified filler cap (do not exceed 15 psi or 103 kPa). If this system is used, be sure the return line from the head is disconnected to bleed the system or no flow will occur. Reverse flow through the return line should be avoided to prevent reverse flushing of filters and flushing residue from the fuel tank into the injectors. Special provisions may have to be made on dual tanks to prevent loss of pressure from the vent on the tank opposite the tank being pressurized.

Priming is not always necessary if the filter elements are filled with fuel when installed and the manifolds in the head are not drained of fuel. Prolonged use of the starter motor and engine fuel pump to prime the system can result in damage to the starter, fuel pump, injectors and erratic running of the engine, due to the amount of air in the lines and filters from the supply tank to the cylinder head.

Engines equipped with starting devices dependent on compressed air or gas reservoirs should always be primed prior to initial start-up, otherwise reserve pressure can be exhausted. Injectors can be damaged from lack of lubrication and cooling.

NOTICE: Under no circumstances should a starting aid such as ether be used to run the engine until the fuel system is primed. Injector damage will occur if this method is used. The heat generated by the external fuel source will cause the tips to be damaged when the fuel cools them. The plunger and bushing can be scored from running without lubrication.

Lubrication Fittings

Fill all grease cups and lubricate at all fittings with an all purpose grease. Apply lubricating oil to the throttle linkage and other moving parts and fill the hinged cap oilers with a hand oiler.

Drive Belts

Adjust all drive belts as recommended under *Lubrication and Preventive Maintenance* in Section 15.1.

Storage Battery

• Check the battery. The top should be clean and dry, the terminals tight and protected with a coat of petroleum jelly. Check the “Eye” of maintenance-free batteries for charge. Check standard lead-acid and semi-maintenance free batteries, when necessary, with a hydrometer; the reading should be 1.265 or higher. However, hydrometer readings should always be corrected for the temperature of the electrolyte.

Generator Set

Where applicable, fill the generator end bearing housing with the same lubricating oil as used in the engine.

A generator set should be connected and grounded in accordance with the applicable local electrical codes.

NOTICE: The base of a generator set must be grounded. *

Clutch

Disengage the clutch, if the unit is so equipped.

STARTING

Before starting the engine for the first time, perform the operations listed under *Preparation For Starting Engine First Time.*

Before a routine start, see *Daily Operations* in the *Lubrication and Preventive Maintenance Chart*, Section 15.1.

 © Detroit Diesel Corporation

If a manual or an automatic shutdown system is incorporated in the unit, the control must be set in the *open* position before starting the engine. A blower will be seriously damaged if operated with the air shutoff valve in the *closed* position.

NOTICE: On engines with dual air shutdown housings, both air shutoff valves must be in the *open* position before starting the engine.

Starting

Set the speed control lever at part throttle, then bring it back to the desired no-load speed. In addition, on mechanical governors, make sure the stop lever on the governor cover is in the *run* position.

• If the unit is located in a closed room, start the room ventilating fan or open the windows, as weather conditions permit, so ample air is available for the engine.

• The engine may require the use of a cold weather starting aid if the ambient temperature is below 40°F (4°C).

• CAUTION: Starting fluid used in capsules is highly flammable, toxic, and possesses sleep-inducing properties.

• Initial Engine Start (Electric)

Start an engine equipped with an electric starting motor as follows:

1. Set the speed control lever at part throttle, then bring it back to the desired no-load speed. In addition, make sure the stop lever on the cover of mechanical governors is in the run position. On hydraulic governors, make sure the stop knob is pushed all the way in.
2. Press the starter switch firmly.

   NOTICE: To prevent serious starting motor damage, do not press the starter switch again after the engine has started.

3. If the engine fails to start within 30 seconds, release the starter switch and allow the starting motor to cool a few minutes before trying again. If the engine fails to start after four attempts, an inspection should be made to determine the cause.

• Initial Engine Start (Air Starter)

Because of the limited volume of most storage tanks and the relatively short duration of the cranking cycle, it is important to make sure the engine is ready to start before activating the air starter. Start an engine equipped with an air starter as follows:

1. Set the speed control lever at part throttle, then bring it back to the desired no-load speed. In addition, make sure the stop lever on the cover of mechanical governors is in the run position. On hydraulic governors, make sure the stop knob is pushed all the way in.
2. Check the pressure in the air storage tank. If necessary, add air to bring the pressure up to at least the recommended minimum for starting.
3. Press the starter button firmly and hold until the engine starts.

• Initial Start (Hydrostarter)

Start an engine equipped with a hydrostarter as follows:

1. Set the speed control lever at part throttle, then bring it back to the desired no-load speed. In addition, make sure the stop lever on the cover of mechanical governors is in the run position. On hydraulic governors, make sure the stop knob is pushed all the say in.
2. Use the priming pump to make sure the fuel filter, fuel lines and injectors are full of fuel before attempting to start the engine.
3. Raise the hydrostarter accumulator pressure with the hand pump until the gage reads as indicated in Table 1.
4. Set the engine controls for starting with the throttle at least half open.

   NOTICE: During cold weather, add starting fluid at the same time the hydrostarter motor lever is moved. Do not wait to add the fluid after the engine is turning over.

5. Push the hydrostarter control lever to simultaneously engage the starter pinion with the flywheel ring gear and to open the control valve. i
6. Close the valve as soon as the engine starts to conserve the accumulator pressure and to avoid excessive over-running of the starter drive clutch assembly.

Ambient Temperature	Pressure Gage Reading	
	psi	kPa
Above 40° F (4.4° C)	1500	10 342
40 - 0° F (4.4 to -18° C)	2500	17 237
Below 0° F (-18° C)	3300	22 753

TABLE 1

RUNNING

Oil Pressure

• Observe the oil pressure gage immediately after starting the engine. A good indicator that all of the moving parts are getting lubrication is when the oil pressure gage registers pressure (5 psi - 34.5 kPa at idle speed). If there is no oil pressure indicated within 10 to 15 seconds, stop the engine and check the lubricating system. The pressure should not fall below 50 psi (345 kPa) at 1800 rpm, and normal operating pressure should be higher.

Warm-Up

Run the engine at part throttle and no load for approximately five (5) minutes, allowing it to warm up before applying a load.

Operating Oil Pressure at 180° F (82° C)*				
Marine Gear	Position	t Test rpm	Test Pressure	
			psi	kPa
MG-527	Neutral	600	45-85	310-586
	Neutral	1800	65-100	448-689
	Engaged	600	180-215	1241-1481
	Engaged	1800	188-220	1296-1516
	Cruising	min.	165	1137 i
MG-540 SAE #0	Neutral	600	50-75	345-517
	Neutral	1800	78-95	538-655
	Engaged	600	226-251	1557-1730
	Engaged	1800	239-265	1647-1826
	Cruising	Min.	220	1516

* Sump or heot exchanger inlet 210° F (99° C) maximum.
Normal operating range desired 140-180° F (60-82° C) minimum.

t Sump or heat exchanger inlet 225° F (107° C) maximum
intermittent permissable in pleasure craft.

TABLE 2 - Twin Disc Marine Gear Operating Conditions

If the unit is operating in a closed room, start the room ventilating fan or open the windows, as weather conditions permit, so ample air is available for the engine.

Inspection

While the engine is running at operating temperature, check for water, fuel or lubricating oil leaks. Tighten the line connections where necessary to stop leaks.

Temperature

Normal engine coolant temperature is 160°-185°F (71°-85°C).

Crankcase

If the engine crankcase was refilled, stop the engine after normal operating temperature has been reached, allow the oil to drain (approximately twenty (20) minutes) back into the crankcase and check the oil level. Add oil, if necessary, to bring it to the proper level on the dipstick

Use only the *heavy duty* lubricating oil as specified under *Lubrication Recommendations* in Section 13.3

> • **NOTICE:** If the oil level is constantly above normal and excess lube oil has not been added to the crankcase, consult with a DDC distributor for the cause. Fuel or coolant dilution of lube oil can result in serious engine damage.

Cooling System

Check coolant level after the engine has operated approximately two minutes to determine if the fill system has trapped air or a false fill condition. Remove the radiator or heat exchanger tank cap *slowly* after the engine has reached normal operating temperature and check the engine coolant level. The coolant level should be near the top of the opening. If necessary, add clean soft water with a corrosion inhibitor or an ethylene glycol base antifreeze.

Transmission

Check the marine gear oil pressure (refer to Table 1). Check and, if necessary, replenish the oil supply in the transmission.

Turbocharger

> • **CAUTION: Do not hold the compressor wheel, for any reason, while the engine is running. This could result in personal injury.**

• The free floating bearings in the turbocharger center housing require positive lubrication. This is provided by the above procedure *before the turbocharger reaches its maximum operating speed* which is produced by high engine speeds. Starting any turbocharged engine and accelerating to any speed above idle before engine oil supply and pressure has reached the free floating bearings can cause severe damage to the shaft and bearings of the turbocharger.

Make a visual inspection of the turbochargers for leaks and excessive vibration. Stop the engine immediately if there is an unusual noise in the turbocharger.

Avoid Unnecessary Engine Idling

During long engine idling periods, the engine coolant temperature will fall below the normal operating range. The incomplete combustion of fuel in a cold engine will cause crankcase dilution, formation of lacquer or gummy deposits on the valves, pistons and rings and rapid accumulation of sludge in the engine.

> **NOTICE:** When prolonged engine idling is necessary, maintain at least 800 to 1000 rpm. Do not operate between 1100-1300 rpm for prolonged periods.

 © Detroit Diesel Corporation

STOPPING

Normal Stopping

1. Release the load and decrease the engine speed.
2. Allow the engine to run at half speed or slower with no load for four (4) or five (5) minutes, then move the stop lever to the *stop* position to shut down the engine.

Emergency Stopping

If the engine is equipped with the two-screw design injector control tube (Section 2.9) and does not stop after using the normal stopping procedure, pull the "Emergency Stop" knob all the way out. This control cuts off the air to the engine. Do not try to restart again until the cause for the malfunction has been found and corrected.

> **NOTICE:** The emergency shutdown system should never be used except in an emergency. Use of the emergency shutdown can cause oil to be sucked past the oil seals and into the blower housing.

The air shutoff valves, located on the blower air inlet housings, must be reset by hand and the "Emergency Stop" knob pushed in before the engine is ready to start again.

Fuel System

If the unit is equipped with a fuel valve, close it. Fill the fuel tank; a full tank minimizes condensation.

Exhaust System

Drain the condensation from the exhaust line or silencer.

Cooling System

Drain the cooling system if it is not protected with antifreeze and freezing temperatures are expected. Leave the drains open. Open the raw water drains of a heat exchanger cooling system.

Crankcase

• Check the oil level in the crankcase (about 20 minutes after stopping). Add oil, if necessary, to bring it to the proper level on the dipstick.

Transmission

Check and, if necessary, replenish the oil supply in the transmission.

Clean Engine

Clean and check the engine thoroughly to make certain it will be ready for the next run.

Refer to *Lubrication and Preventive Maintenance* and perform all of the daily maintenance operations. Also, perform the operations required for the number of hours or miles the engine has been in operation.

Make the necessary adjustments and minor repairs to correct difficulties which became apparent to the operator during the last run.

*

i

ENGINE OPERATING CONDITIONS

The engine operating charts are included as an aid for engine operation and trouble shooting. Any variations from the conditions as listed may indicate an abnormal situation in need of correction. Make sure that the readings represent true values, and that instruments are accurate, before attempting to make corrections to the engine.

12V AND 16V-149 ENGINES (NON-TURBOCHARGED)

120 and 130 Injectors	1500 rpm	1800 rpm	1900 rpm
Lubrication System			
Lubricating oil pressure (psi) - normal	35-65	40-70	45-75
f Lubricating oil temperature (deg. **F)** - max	225	225	225
Air System			
Air Box Pressure (Inches Mercury) - Min. Full Load:			
At zero exhaust back pressure	3.5	4.6	5.0
At max. exhaust back pressure	5.4	7.3	8.0
# Air inlet restriction (inches water) - max. full load:			
Dirty air cleaner - oil bath and dry (heavy duty)	20.0	25.0	25.0
Clean air cleaner - oil bath and dry (heavy duty	12.0	14.2	14.2
Crankcase pressure (inches water) - max	0.5	0.7	0.8
Exhaust back pressure (inches mercury) - max.:			
Full load	2.5	3.6	4.0
No load	1.5	2.3	2.6
Fuel System			
Fuel pressure at inlet manifold (psi) - normal:			
With 0.136" restriction	50-80	60-80	60-80
Fuel spill (gpm) - min. at no load:			
With 0.136" restriction	2.0	2.0	2.0
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) - normal	160-185	160-185	160-185
Compression			*
Compression pressure (psi at sea level):			
Average - new engine at 600 rpm 500			
Minimum at 600 rpm 450			*t*

+ The lubricating oil temperature range is based on the temperature measurement in the oil pan **at the oil pump inlet.** When measuring the oil temperature at the cylinder block oil gallery, **it** will be **approximately 10° lower** than the **oil** pan temperature.

Measured in duct 2" from hose or flange connection at engine.

12V-149T ENGINE INDUSTRIAL AND MARINE

140 and 150 Injectors	1500 rpm	1800 rpm	1900 rpn
Lubrication System			
Lubricating oil pressure (psi) - normal.....	35-65	40-70	45-75
fLubricating oil temperature (deg. F) - max.....	225	230	230
Air System			
Air box pressure (inches mercury) - min. full load:			
At zero exhaust back pressure:			
140 Injector.....	17.3	22.0	26.0
150 Injector.....	19.2	24.0	27.0
At max. exhaust back pressure:			
140 Injector.....	15.4	20.5	24.3
150 Injector.....	17.3	22.5	25.3
+ Air inlet restriction (inches water):			
Max. full load:			
Dirty air cleaner - dry type (heavy duty)	13.0	17.5	20.0
Clean air cleaner - dry type (heavy duty.....	7.5	10.5	12.0
Max. no load:			
Dirty air cleaner - dry type (heavy duty)	7.5	10.4	12.0
Clean air cleaner - dry type (heavy duty).....	4.5	6.3	7.0
§ Crankcase pressure (inches water) - max.:			
140 Injector	1.7	1.9	2.0
150 Injector	1.7	2.1	2.2
Exhaust back pressure (inches mercury) - max.:			
Full load.....	1.5	2.2	2.5
No load	1.1	1.6	1.8
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal with 0.136" restriction	50-80	60-80	60-80
Fuel spill (gpm) - min. no load:			
With 0.136" restrictions	2.0	2.0	2.0
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) - normal.....	160-185	160-185	160-185
Compression			
Compression pressure (psi at sea level):			
Average - new engine at 600 rpm..... 500			
Minimum at 600 rpm 450			

f The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

+ Includes air cleaner and duct measured 6" to 8" before the turbocharger compressor inlet.

§ Leakage from the breather must not exceed 12 drops of oil per minute.

 © Detroit Diesel Corporation

12V-149T ENGINE (WITH TV7101 TURBOCHARGERS) (1.39 A/R* * Turbine Housing) INDUSTRIAL AND MARINE

140 and 150 Injectors	1500 rpm	1800 rpm	1900 rpir
Lubrication System			
Lubricating oil pressure (psi) - normal.....	35-65	40-70	45-75
■(Lubricating oil temperature (deg. F) - max.....	225	230	230
Air System			
Air box pressure (inches mercury) - min. full load:			
At zero exhaust back pressure:			
140 Injector.....	16.4	25.0	29.0
150 Injector.....	18.0	27.5	30.0
At max. exhaust back pressure:			
140 Injector.....	15.3	23.3	27.1
150 Injector.....	16.9	25.9	28.1
+ Air inlet restriction (inches water):			
Max. full load:			
Dirty air cleaner - dry type (heavy duty)	13.0	17.5	20.0
Clean air cleaner - dry type (heavy duty).....	7.5	10.5	12.0
§ Crankcase pressure (inches water) - max.:			
140 Injector	1.7	1.9	2.0
150 Injector	1.7	2.1	2.2
Exhaust back pressure (inches mercury) - max.:			
Full load.....	1.5	2.2	2.5
No load.....	1.1	1.6	1.8
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal with 0.136" restriction	40-70	60-80	60-80
Fuel spill (gpm) - min. no load:			
With 0.136" restriction.....	2.0	2.0	2.0
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system.....	12.0	12.0	12.0
			*
Cooling System			
Coolant temperature (deg. F) - normal.....	160-185	160-185	160-185

Compression

Compression pressure (psi at sea level):

Average - new engine - at 600 rpm.....500

Minimum at 600 rpm 450

+ The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

* Turbine Housing Designation.

-f Includes air cleaner and duct measured 6" to 8" before the turbocharger compressor inlet.

§ Leakage from the breather must not exceed 12 drops of oil per minute.

12V AND 16V-149T ENGINES (WITH T18A40 TURBOCHARGERS) GENERATOR SET

165 and 180 Injectors	1500 rpm 12V	1500 rpm 16V	1800 rpm 12V	1800 rpm 16V
Lubrication System				
Lubricating oil pressure (psi) - normal	35-65	35-65	40-70	40-70
(•Lubricating oil temperature (deg. F) - max	230	230	230	230
Air System				
Air box pressure (inches mercury) - min. full load:				
At zero exhaust back pressure:				
165 Injector	19.0	23.0	28.0	30.0
180 Injector	21.5	25.0	30.0	34.0
At max. exhaust back pressure:				
165 Injector	17.9	21.9	26.4	28.4
180 Injector	20.4	23.9	28.4	32.4
+ Air inlet restriction (inches water):				
Max. full load:				
Dirty air cleaner - dry type (heavy duty	13.0	13.0	20.0	20.0
Clean air cleaner - dry type (heavy duty)	7.5	7.5	12.0	12.0
Max. no load:				
Dirty air cleaner - dry type (heavy duty)	7.5	7.5	12.0	12.0
Clean air cleaner - dry type (heavy duty)	5.0	5.0	7.0	7.0
§ Crankcase pressure (inches water) - max	1.5	1.5	2.2	2.2
Exhaust back pressure (inches mercury) - max.:				
Full load	1.5	1.5	2.2	2.2
No load	1.1	1.1	1.6	1.6
Fuel System				
Fuel pressure at inlet manifold (psi):				
Normal with 0.136" restriction	50-80	50-80	60-80	60-80
Fuel spill (gpm) - minimum at no load:				
With 0.136" restriction	2.0	2.0	2.0	2.0
Pump suction at inlet (inches mercury) - max.:				
Clean system	6.0	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0	12.0
				V
Cooling System				
Coolant temperature (deg. F) - normal	160-185	160-185	160-185	160-185

Compression

Compression pressure (psi at sea level):

Average - new engine at 600 rpm 500

Minimum at 600 rpm 450

fThe lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

+ Includes air cleaner and duct measured 6" to 8" before the turbocharger compressor inlet.

§ Leakage from the breather must not exceed 12 drops of oil per minute.

 © Detroit Diesel Corporation

12V-149T ENGINE (WITH TV7101 TURBOCHARGERS)
(1.39 A/R* Turbine Housing)
GENERATOR SET

170 Injectors	1500 rpm	1800 rpm
Lubrication System		
Lubricating oil pressure (psi) - normal	35-65	40-70
■(Lubricating oil temperature (deg. F) - max.	225	230
Air System		
Air box pressure (inches mercury) - min. full load:		
At zero exhaust back pressure	22.3	32.0
At max. exhaust back pressure	21.2	30.4
+ Air inlet restriction (inches water):		
Max. full load:		
Dirty air cleaner - dry type (heavy duty)	13.0	20.0
Clean air cleaner - dry type (heavy duty)	7.5	12.0
§ Crankcase pressure (inches water) - max.:	1.8	**2.2**
Exhaust back pressure (inches mercury) - max.:		
Full load	1.5	**2.2**
No load	1.1	1.6
Fuel System		
Fuel pressure at inlet manifold (psi):		
Normal with 0.136" restriction	40-70	60-80
Fuel spill (gpm) - min. no load:		
With 0.136" restriction	2.0	2.0
Pump section at inlet (inches mercury) - max.:		
Clean system	6.0	6.0
Dirty system	12.0	12.0
Cooling System		
Coolant temperature (deg. F) - normal	160-185	160-185
Compression		
Compression pressure (psi at sea level):		
Average - new engine - at 600 rpm	500	*
Minimum - at 600 rpm	450	

t The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

* Turbine Housing Designation.

+ Includes air cleaner and duct measured 6" to 8" before the turbocharger compressor inlet.

§ Leakage from the breather must not exceed 12 drops of oil per minute.

12V-149TI ENGINE (WITH TV7101 TURBOCHARGERS) (1.39 A/R* Turbine Housing) TURBO-INTERCOOLED

165 and 170 Injectors		1500 rpm	1800 rpm	1900 rpm
Lubrication System				
Lubricating oil pressure (psi) - normal.....		35-65	40-70	45-75
tLubricating oil temperature (deg. F) - max.....		225	230	230
Air System				
Air box pressure (inches mercury) - min. full load:				
At zero exhaust back pressure:				
165 Injector.....		23.5	34.5	38.0
170 Injector.....		25.0	36.0	39.0
At max. exhaust back pressure:				
165 Injector.....		22.4	32.9	36.1
170 Injector.....		23.9	34.4	37.1
+ Air inlet restriction (inches water):				
Max. full load:				
Dirty air cleaner - dry type (heavy duty) ...		13.0	17.5	20.0
Clean air cleaner - dry type (heavy duty) ...		7.5	10.5	12.0
§ Crankcase pressure (inches water) - max.:				
165 Injector		2.1	2.3	2.4
170 Injector		2.1	2.4	2.5
Exhaust back pressure (inches mercury) - max.:				
Full load.....		1.5	2.2	2.5
No load.....		1.1	1.6	1.8
Turbocharger				
Compressor outlet pressure (inches mercury):				
Full load max. exhaust back pressure:				
165 Injector.....		23.0-27.0	29.4-33.4	30.0-34.C
170 Injector.....		25.0-29.0	30.4-34.4	32.0-36.C
Fuel System				
Fuel pressure at inlet manifold (psi):				
Normal with 0.136" restriction.....		40-70	60-80	60-80
Fuel spill (gpm) - min. at no load:				
With 0.136" restriction.....		2.0	2.0	2.0
Pump suction at inlet (inches mercury) - max.:				
Clean system		6.0	6.0	6.0
Dirty System		12.0	12.0	sl2.0
Cooling System				
Coolant temperature (deg. F) - normal.....		160-185	160-185	160-185
Compression				
Compression pressure (psi at sea level):				
Average - new engine at 600 rpm.....	420			
Minimum - at 600 rpm	370			

fThe lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

‘Turbine Housing Designation.

+ Includes air cleaner and duct measured 6" to 8" before the turbocharger compressor inlet.

§ Leakage from the breather must not exceed 12 drops of oil per minute.

 © Detroit Diesel Corporation

12V-149TI ENGINE (WITH TV7101 TURBOCHARGERS) (1.39 A/R* * Turbine Housing) - TURBO-INTERCOOLED

195 Injectors	1500 rpm	1800 rpm	1900 rpm
Lubrication System			
Lubricating oil pressure (psi) - normal	35-65	40-70	45-75
•(Lubricating oil temperature (deg. F) - max	225	230	230
Air System			
Air box pressure (inches mercury - min. full load):			
At zero exhaust back pressure	28.7	43.4	44.6
At max. exhaust back pressure	27.5	41.1	42.7
+ Air inlet restriction (inches water):			
Max. full load:			
Dirty air cleaner - dry type (heavy duty)	10.9	17.5	20.0
Clean air cleaner - dry type (heavy duty)	6.5	10.5	12.0
Max. no load:			
Dirty air cleaner - dry type (heavy duty)	6.4	10.2	12.0
Clean air cleaner - dry type (heavy duty)	4.0	6.4	7.3
§ Crankcase pressure (inches water) - max	2.3	2.7	2.8
Exhaust back pressure (inches mercury) - max.:			
Full load	1.5	2.3	2.5
No load	1.1	1.6	1.8
Turbocharger			
Compressor outlet Pressure (inches mercury):			
Full load max. exhaust back pressure	28.0-34.0	34.0-40.0	35.0-41.0
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal with 0.136" restriction	40-70	60-80	60-80
Fuel spill (gpm) - min. at no load:			
With 0.136" restriction	2.0	2.0	2.0
Pump suction at inlet (inches mercury) max.			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (Deg. F) normal	160-185	160-185	160-185
Compression			
Compression pressure (psi at sea level):			
Average - new engine - at 600 rpm	420		
Minimum - at 600 rpm	370		

t The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

* Turbine Flousing Designation.

+ Includes air cleaner and duct measured 6" to 8" before the turbocharger compressor inlet.

§ Leakage from the breather must not exceed 12 drops of oil per minute.

12V-149TI ENGINE (WITH T18A40 TURBOCHARGERS) TURBO-INTERCOOLED GENERATOR SET

165 and 180 Injectors	1500 rpm	1800 rpm	1900 rpm
Lubrication System			
Lubricating oil pressure (psi) - normal	35-65	40-70	45-75
•(Lubricating oil temperature (deg. F) - max	230	230	230
Air System			
Air box pressure (inches mercury - min. full load):			
At zero exhaust back pressure:			
165 Injector	24.5	33.0	36.5
180 Injector	27.0	39.0	42.0
At max. exhaust back pressure:			
165 Injector	22.9	31.4	34.6
180 Injector	25.9	37.4	40.1
+ Air inlet restriction (inches water):			
Max. full load:			
Dirty air cleaner - dry type (heavy duty)	13.0	20.0	20.0
Clean air cleaner - dry type (heavy duty)	7.5	12.0	12.0
Max. no load:			
Dirty air cleaner - dry type (heavy duty)	7.5	12.0	12.0
Clean air cleaner - dry type (heavy duty)	5.0	7.0	7.0
§ Crankcase pressure (inches water) - max.:			
165 injector	1.5	2.4	2.5
180 injector	1.5	2.4	2.5
Exhaust back pressure (inches mercury) - max.:			
Full load	1.5	2.2	2.5
No load	1.1	1.6	1.8
Turbocharger			
Compressor outlet pressure (inches mercury):			
Full load max. exhaust back pressure:			
165 Injector	21.0-25.0	26.0-30.0	28.0-32.0
180 Injector	23.0-27.0	30.0-34.0	32.0-36.0
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal with 0.136" restriction	50-80	60-80	60-80
Fuel spill (gpm) - min. at no load:			
With 0.136" restriction	2.0	2.0	2.0
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty System	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) - normal	160-185	160-185	160-185

Compression

Compression pressure (psi at sea level):

Average - new engine at 600 rpm 420

Minimum at 600 rpm 370

fThe lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

+ Includes air cleaner and duct measured 6" to 8" before the turbocharger compressor inlet.

§ Leakage from the breather must not exceed 12 drops of oil per minute.

 © Detroit Diesel Corporation

12V-149TI ENGINE (WITH TV7511 TURBOCHARGERS) (1.08 A/R* Turbine Housing) TURBO INTERCOOLED

240 Injectors	1500 rpm	1800 rpm	1900 rpir
Lubrication System			
Lubricating oil pressure (psi) - normal	55-65	65-75	65-80
■(Lubricating oil temperature (deg. F) - max.	225	230	230
Air System			
Air box pressure (inches mercury - min. full load):			
At zero exhaust back pressure:			
240 Injector	41.0	49.0	51.0
At max. exhaust back pressure:			
240 Injector	39.9	47.9	49.9
+ Air inlet restriction (inches water):			
Max. full load:			
Dirty air cleaner - dry type (heavy duty	10.9	17.5	20.0
Clean air cleaner - dry type (heavy duty)	6.5	10.5	12.0
§ Crankcase pressure (inches water) - max.:			
240 Injector	1.8	2.2	2.5
Exhaust back pressure (inches mercury) - max.:			
Full load (new)	1.0	1.3	1.5
No load	0.6	0.9	1.0
Full load (dirty)	1.2	1.8	2.0
Turbocharger			
Compressor outlet pressure (inches mercury):			
Full load max. exhaust back pressure:			
240 Injector	35.9	43.9	45.9
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal with 0.136" restriction	40-70	60-80	60-80
Fuel spill (gpm) - min. at no load:			
With 0.136" restriction	2.0	2.0	2.0
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) - normal	160-185	160-185	160-185

Compression

Compression pressure (psi at sea level):

Average - new engine - at 600 rpm 500

Minimum at 600 rpm ..... 450 *

fThe lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

* Turbine Housing Designation.

+ Includes air cleaner and duct measured 6" to 8" before the turbocharger compressor inlet.

§ Leakage from the breather must not exceed 12 drops of oil per minute.

16V-149T ENGINE
INDUSTRIAL AND MARINE

140 and 150 Injectors	1500 rpm	1800 rpm	1900 rpm
Lubrication System			
Lubricating oil pressure (psi) - normal	35-65	40-70	45-75
•(Lubricating oil temperature (deg. F) - max.	225	230	230
Air System			
Air box pressure (inches mercury - min. full load):			
At zero exhaust back pressure:			
140 Injector	18.4	25.0	28.0
150 Injector	20.0	27.0	30.5
At max. exhaust back pressure:			
140 Injector	16.5	23.3	26.3
150 Injector	18.1	25.3	28.8
+ Air inlet restriction (inches water):			
Max. full load:			
Dirty air cleaner - dry type (heavy duty)	13.0	17.5	20.0
Clean air cleaner - dry type (heavy duty)	7.5	10.5	12.0
Max. no load:			
Dirty air cleaner - dry type (heavv duty)	7.5	10.4	12.0
Clean air cleaner - dry type (heavy duty)	4.5	6.3	7.0
§ Crankcase pressure (inches water) - max.:			
140 Injector	1.7	1.9	2.0
150 Injector	1.7	2.1	2.2
Exhaust back pressure (inches mercury) - max.:			
Full load	1.5	2.2	2.5
No load	1.1	1.6	1.8
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal with 0.136" restriction	50-80	60-80	60-80
Fuel spill (gpm) - min. no load:			
With 0.136" restriction	2.0	2.0	2.0
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (dee. F) - normal	160-185	160-185	160-185
Compression			
Compression pressure (psi at sea level):			
Average - new engine at 600 rpm	500		
Minimum at 600 rpm	450		

$

tThe lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

-f Includes air cleaner and duct measured 6" to 8" before the turbocharger compressor inlet.

§ Leakage from the breather must not exceed 12 drops of oil per minute.

 © Detroit Diesel Corporation

12V-149TI ENGINE (WITH TV7511 TURBOCHARGERS) (1.08 A/R* Turbine Housing) TURBO INTERCOOLED

240 Injectors	1500 rpm	1800 rpm	1900 rpm
Lubrication System			
Lubricating oil pressure (psi) - normal	55-65	65-75	65-80
•(Lubricating oil temperature (deg. F) - max.	225	230	230
Air System			
Air box pressure (inches mercury - min. full load):			
At zero exhaust back pressure:			
240 Injector	41.0	49.0	51.0
At max. exhaust back pressure:			
240 Injector	39.9	47.9	49.9
+ Air inlet restriction (inches water):			
Max. full load:			
Dirty air cleaner - dry type (heavy duty	10.9	17.5	20.0
Clean air cleaner - dry type (heavy duty)	6.5	10.5	12.0
§ Crankcase pressure (inches water) - max.:			
240 Injector	1.8	2.2	2.5
Exhaust back pressure (inches mercury) - max.:			
Full load (new)	1.0	1.3	1.5
No load	0.6	0.9	1.0
Full load (dirty)	1.2	1.8	2.0
Turbocharger			
Compressor outlet pressure (inches mercury):			
Full load max. exhaust back pressure:			
240 Injector	35.9	43.9	45.9
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal with 0.136” restriction	40-70	60-80	60-80
Fuel spill (gpm) - min. at no load:			
With 0.136" restriction	2.0	2.0	2.0
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) - normal	160-185	160-185	160-185 *i*
Compression			
Compression pressure (psi at sea level):			
Average - new engine - at 600 rpm	500		
Minimum at 600 rpm	450		

f The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

* Turbine Housing Designation.

+ Includes air cleaner and duct measured 6" to 8" before the turbocharger compressor inlet.

§ Leakage from the breather must not exceed 12 drops of oil per minute.

16V-149TI ENGINE (WITH TV8115 TURBOCHARGERS) (1.60 A/R* Turbine Housing) - TURBO-INTERCOOLED

195 Injectors	1500 rpm	1800 rpm	1900 rpm
Lubrication System			
Lubricating oil pressure (psi) - normal	35-65	40-70	45-75
■(Lubricating oil temperature (deg. F) - max.	225	230	230
Air System			
Air box pressure (inches mercury - min. full load):			
At zero exhaust back pressure	28.4	40.8	45.1
At max. exhaust back pressure	27.3	39.1	43.2
+ Air inlet restriction (inches water):			
Max. full load:			
Dirty air cleaner - dry type (heavy duty)	10.9	17.5	20.0
Clean air cleaner - dry type (heavy duty)	6.5	10.5	12.0
Max. no load:			
Dirty air cleaner - dry type (heavy duty)	6.4	10.2	12.0
Clean air cleaner - dry type (heavy duty)	4.0	6.4	7.3
§ Crankcase pressure (inches water) - max.	2.3	2.7	2.8
Exhaust back pressure (inches mercury) - max.:			
Full load	2.8	3.5	4.0
No load	1.1	1.6	1.8
Turbocharger			
Compressor outlet pressure (inches mercury):			
Full load max. exhaust back pressure	25.0-31.0	32.0-38.0	34.0-40.0
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal with 0.136" restriction	40-70	60-80	60-80
Fuel spill (gpm) - min. at no load:			
With 0.136" restriction	2.0	2.0	2.0
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
		**	
Cooling System			
Coolant temperature (deg. F) - normal	160-185	160-185	160-185
			$
Compression			
Compression pressure (psi at sea level):			
Average - new engine - at 600 rpm	420		
Minimum - at 600 rpm	370		

tThe lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

* Turbine Housing Designation.

+ Includes air cleaner and duct measured 6" to 8" before the turbocharger compressor inlet.

§ Leakage from the breather must not exceed 12 drops of oil per minute.

 © Detroit Diesel Corporation

16V-149TI ENGINE (WITH T18A40 TURBOCHARGERS) TURBO-INTERCOOLED GENERATOR SET

165 and 180 Injectors	1500 rpm	1800 rpm	1900 rpm
Lubrication System			
Lubricating oil pressure (psi) - normal	35-65	40-70	45-75
fLubricating oil temperature (deg. **F)** - max.	230	230	230
Air System			
Air box pressure (inches mercury - min. full load):			
At zero exhaust back pressure:			
165 Injector	24.0	31.5	35.5
180 Injector	27.0	35.0	40.0
At max. exhaust back pressure:			
165 Injector	22.9	29.9	33.6
180 Injector	25.9	33.4	38.1
+ Air inlet restriction (inches water):			
Max. full load:			
Dirty air cleaner - dry type (heavy duty)	13.0	20.0	20.0
Clean air cleaner - dry type (heavy duty)	7.5	12.0	12.0
Max. no load:			
Dirty air cleaner - dry type (heavy duty)	7.5	12.0	12.0
Clean air cleaner - dry type (heavy duty)	5.0	7.0	7.0
§ Crankcase pressure (inches water) - max.:			
165 Injector	1.5	2.4	2.5
180 Injector	1.5	2.4	2.5
Exhaust back pressure (inches mercury) - max.:			
Full load	1.5	2.2	2.5
No load	1.1	1.6	1.8
Turbocharger			
Compressor outlet pressure (inches mercury):			
Full load max. exhaust back pressure:			
165 Injector	21.0-25.0	26.0-30.0	28.0-32.0
180 Injector	24.0-28.0	30.0-34.0	32.0-36.0
Fuel System			
Fuel Pressure at inlet manifold (psi):			
Normal with 0.136" restriction	50-80	60-80	60-80
Fuel spill (gpm) - min. at no load:			
With 0.136" restriction	2.0	2.0	2.0
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			*$*
Coolant temperature (deg. F) - normal	160-185	160-185	160-185
Compression			
Compression pressure (psi at sea level):			
Average - new engine at 600 rpm	420		
Minimum - at 600 rpm	370		

t The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

+ Includes air cleaner and duct measured 6" to 8" before the turbocharger compressor inlet.

§ Leakage from the breather must not exceed 12 drops of oil per minute.

16V-149TI ENGINE (WITH TV8402 TURBOCHARGERS) (1.23 A/R* TURBINE HOUSING) TURBO-INTERCOOLED

240 Injectors	1500 rpm	1800 rpm	1900 rpir
Lubrication System			
Lubricating oil pressure (psi) - normal.....	55-65	65-75	65-80
fLubricating oil temperature (deg. F) - max.....	225	230	230
Air System			
Air box pressure (inches mercury - min. full load):			
At zero exhaust back pressure:			
240 Injector.....	42.0	50.0	52.0
At max. exhaust back pressure:			
240 Injector.....	40.9	48.9	50.9
+ Air inlet restriction (inches water):			
Max. full load:			
Dirty air cleaner - dry type (heavy duty)	10.9	17.5	20.0
Clean air cleaner - dry type (heavy duty).....	6.5	10.5	12.0
§ Crankcase pressure (inches water) - max.:			
240 Injector	1.8	2.2	2.5
Exhaust back pressure (inches mercury) - max.:			
Full load (new)	1.0	1.3	1.5
No load.....	0.6	0.9	1.0
Full load (dirty)	1.2	1.8	2.0
Turbocharger			
Compressor outlet pressure (inches mercury):			
Full load max. exhaust back pressure (min.):			
240 Injector.....	36.9	44.9	46.9
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal with 0.136" restriction.....	40-70	60-80	60-80
Fuel spill (gpm) - min. at no load:			
With 0.136" restriction.....	2.0	2.0	2.0
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system.....	12.0	12.0	.12.0
Cooling System			
Coolant temperature (deg. F) - normal.....	160-185	160-185	160-185
Compression			
Compression pressure (psi at sea level):			
Average - new engine - at 600 rpm	 420		
Minimum at 600 rpm	 370		

t The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

* Turbine Housing Designation.

+ Includes air cleaner and duct measured 6" to 8" before the turbocharger compressor inlet.

§ Leakage from the breather must not exceed 12 drops of oil per minute.

 © Detroit Diesel Corporation

• COOLING SYSTEM REQUIREMENTS SERIES 149 DIRECT RADIATOR-COOLED ENGINES

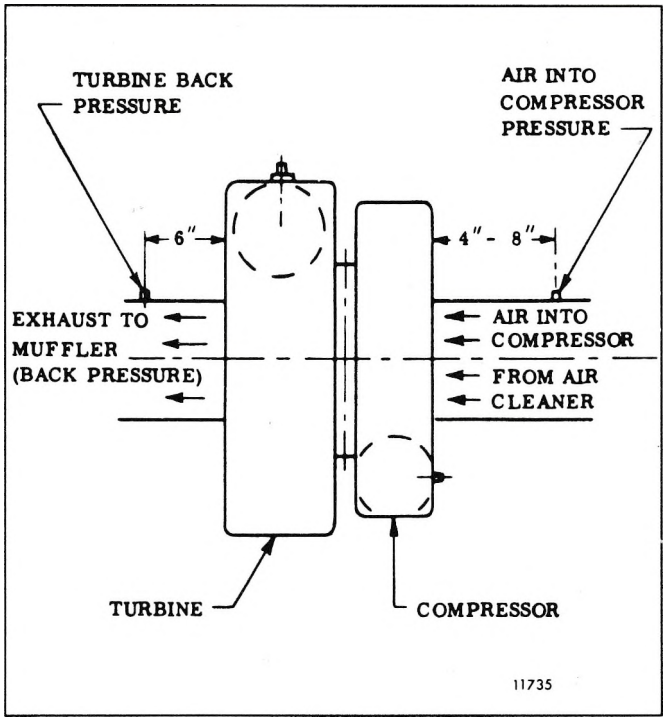


Fig. 1 - Points at which to Measure Air Inlet Restrictions and Exhaust Restriction (8V-149 Only)

'On 1 2V and 1 6V engines take reading 6" from outlet flange.

This section is intended to emphasize the basic cooling system requirements' of Series 149 engines. Although these requirements apply to all direct radiator-cooled engine applications, including off-highway haul truck, industrial, marine, generator sets and military, recommendations are *primarily intended for mine haul trucks and loaders. For more detailed information, refer to Engineering Bulletin No. 28, "Cooling of Off-Highway Industrial Engines" (Form 18SA202), available from DDC Distributors.*

The engine coolant and cooling system components control internal engine temperature by dissipating heat generated from combustion and friction. Anything that interferes with this heat transfer can result in serious engine damage and reduce engine life.

PRESSURIZED COOLING SYSTEM

The cooling system must be pressurized to operate properly. Pressure in the cooling system prevents cavitation, suction leaks and localized boiling.

System pressure is produced by the expansion of the coolant as it is heated. Checking the coolant level while coolant temperature is hot will result in a loss of this pressure. This pressure may not be completely restored until the system is allowed to cool and then heated again. To avoid this situation an auxiliary air supply is required to maintain system pressure (see Fig. 2). The pressure from this air supply should be regulated to 7-10 psi (48.3-68.9 kPa).

MAXIMUM ENGINE COOLANT TEMPERATURE

The heat dissipating capacity of the Series 149 engine cooling system and related components must be sufficient to prevent the engine coolant-out temperature from rising above 200°F (93.3°C). This temperature must not be exceeded under any engine operating condition, regardless of altitude, type of coolant used, or cooling system condition. When the cooling system is sized properly, the engine will operate under thermostat control so that the coolant-out temperature is between 170°F and 187°F (76.7°C - 86°C) the majority of the time. Maximum engine life will be obtained when the engine is operating under thermostat control. Coolant temperatures above 187°F (86°C) are out of thermostatic control and will rise on a 1 to 1 basis with an increase in the ambient air temperature.

COOLING INDEX

The cooling index is a measurement that represents differences between the stabilized coolant-out temperature and the true ambient air temperature while the engine is operating under full load conditions at rated speed with the thermostats fully open. This temperature difference is referred to as "ATW" (air-to-water) and indicates the performance of the cooling system. The cooling index is corrected to sea level so that it can be compared to cooling index requirements for specific operating sites. Smaller ATW values have greater cooling capability than larger ATW values.

A new measured cooling index must be determined if changes are made to the applications that influence engine cooling. These changes include increasing the horsepower, altering fan pitch, fan size, shrouding or baffles around the radiator, any site condition or operating location changes.

COOLING INDEX REQUIREMENT

The *cooling index requirment* is a calculated number representing the maximum allowable cooling index (ATW) that will provide adequate engine cooling. This number is based on the requirement that the engine coolant-out temperature must not exceed 200°F (93.3°C) during the most severe ambient conditions for a specific operating site. The number is calculated by applying correction factors for altitude, maximum operating temperature, and type of coolant from the maximum engine coolant-out temperature. A brief description of these parameters follows (see Fig. 3 for sample calculation):

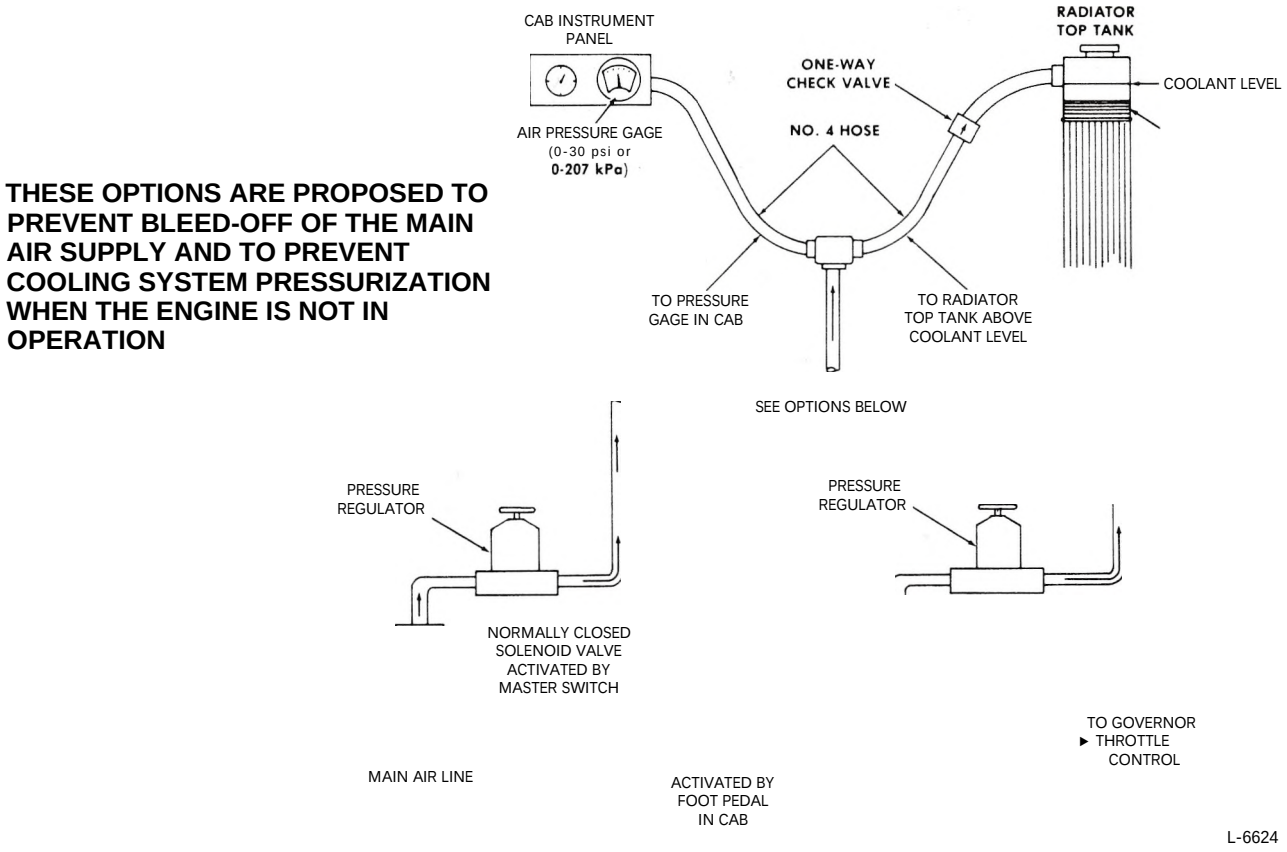


Fig. 2 - Pressurized Top Tank Installation

ALTITUDE

Increasing altitude reduces air density and the ability of the cooling system to dissipate engine heat to the air. Higher altitudes will increase the cooling index by 2°F (1.1°C) per 1000 feet (305m). Altitude corrections to sea level are applied to the cooling index and the cooling index requirement for comparative purposes.

MAXIMUM OPERATING SITE TEMPERATURE

When calculating the cooling index requirements, the maximum ambient temperature for the operating location must be determined. To establish this tempertaure, the nearest official weather recording station must be consulted to determine the highest ambient temperature ever recorded at that station. Once this is established, the difference between that station and the operating site must be determined. For example, a characteristic of deep pit mines is that the pit temperature can be as much as 30°F (16.7°C) higher than the ambient temperature recorded in the nearest official temperature recording station. Combining the maximum weather station recorded temperature with the difference of the operating site and weather station temperatures, will establish the maximum ambient temperature design criteria for the cooling system. Furthermore, additional variations in ambient temperature can occur on the same haul road due to tail winds causing recirculation of air around the radiator, pit wall radiated heat, etc. *Actual tests should be conducted to establish the highest ambient temperature encountered during a haul cycle, including the effect of winds and radiated heat.*

ENGINE COOLANT

The use of ethylene glycol antifreeze reduces the ability of the cooling system to dissipate heat. For example, a 50/50 mixture of water and ethylene glycol (the maximum concentration of antifreeze recommended by DDC) will increase the measured cooling index by 6°F (3.3°C). Water is generally used for the coolant when the cooling test is performed. Therefore, *the cooling index requirement must be reduced by 6°F (3.3°C) if antifreeze is to be used in the application.*

 © Detroit Diesel Corporation

Site Conditions:	
Operating site altitude	8000 Feet
Maximum recorded temperature at nearest official temperature recording station	10f F (38.36°C)
Site temperature difference compared to nearest temperature recording station	+ 4° F (2.22°C)
Special site conditions	2° F (1.11° C)
Type of coolant (Ethylene Glycol/Water)	50/50 Mix
Calculations:	
Maximum allowed coolant-out temperature	200°F (93°C)
Altitude compensation (2° F/1000 Ft) 8000 Ft/1000 +2° F	-16° F (-8.89° C)
Maximum recorded temperature	-101° F (—56.16° C)
Temperature difference, operating site to official weather sta ion	—4°F (-2.22°C)
Recirculation effects	—2°F (-1.11° C)
Coolant compensation	—6° F (-3.3T C)
Cooling index requirement (ATW) Corrected to sea level	71° F (21.7° C)
Conclusions:	
The measured cooling index (ATW) for this application must be 71° F (21.7° C) or less to qualify at this operating site.	

Fig. 3 - Sample Calculation for Determining Required Cooling Index

SHORT DURATION FULL LOAD OPERATION

In cases where full-fuel operation is less than 8 minutes and the duty cycle *will not* increase, test data has shown that the cooling index requirement can be increased. *Written concurrences by DDC's Engineering Department is necessary to exceed the cooling index requirement.*

The individual cooling system requirements for each Series 149 engine are shown on sheet 2 of the specific engine performance curve. Curves are contained in Sales Tech Data Book 18SA323, *Construction, Industrial Engines Performance Curves.* This information is available from Detroit Diesel Corporation Distributors. A broad general summary of Series 149 Engine Cooling System Requirements is shown below.

Maximum Coolant-Out Temperature .... 200°F (93.3°C)

Minimum Coolant Pump Inlet Pressure .... Not Less than Zero
(Fill Line Operating)

Maximum Coolant Pump Inlet Pressure..... .....-3.0 in. Hg (10.0 kPa)
(Fill Line Blocked)

Minimum Coolant Flow..... ..... 95% Rated (See Sheet 2 of the engine performance curves)

Minimum Fill Line Size..... ..... 1 3/8 in. (34.9mm) I.D.

Deaeration Line Size (Quantity of 2)
Minimum..... ..... 3/8 in. (9.5mm) I.D.
Maximum ....7/16 in. (1 1.1mm) I.D.

Series 149 Engine Cooling System Requirements (Cont'd)

Minimum Drawdown Capacity	See Chart in Engineering Bulletin No. 28, "Cooling of Off-Highway Industrial Engines" Form 18SA202.
Minimum Expansion Volume	6% of Total System Capacity
Top Tank Stand Pipe Size (Quantity of 2)	
Minimum	7/1 6 in. (1 1.1 mm) I.D.
Maximum	1/2 in. (12.7mm) I.D.
Minimum Deaeration Capability	1cfm (2.8 liters/min.) Per Cyl. (corrected)
Minimum System Pressure (Supplied by External Source)	7-10 psi (48.3-68.9 kPa)
Minimum Cap Pressure	14 psi (96.6 kPa)
Minimum Fill Rate (closed thermostats)	5 gpm (18.9 liters/min.)

v

i

 © Detroit Diesel Corporation

ENGINE RUN-IN INSTRUCTIONS

Following a complete overhaul or any major repair job involving the installation of piston rings, pistons, cylinder liners or bearings, the engine should be "Run-In" on a dynamometer prior to release for service.

The dynamometer is a device for applying specific loads to an engine. It permits the serviceman to physically and visually inspect and check the engine while it is operating. It is an excellent method of detecting improper tune-up, misfiring injectors, low compression and other malfunctions, and may save an engine from damage at a later date.

The operating temperature within the engine affects the operating clearances between the various moving parts of the engine and determines to a degree how the parts will wear. Normal coolant temperature (160-185°F or 71-85°C) should be maintained throughout the Run-In.

The rate of water circulation through the engine on a dynamometer should be sufficient to avoid having the engine outlet water temperature more than 10°F (6°C) higher than the water inlet temperature. Though a 10°F (6°C) rise across an engine is recommended, it has been found that a 15° F (8° C) temperature rise maximum can be permitted.

Thermostats are used in the engine to control the coolant flow. Therefore, be sure they are in place and fully operative or the engine will overheat during the Run-In. However, if the dynamometer has a water standpipe with a temperature control regulator, such as a Taylor valve or equivalent, the engine should be tested without the thermostats.

Because of the wet cylinder liners in the Series 149 engine, it is desirable that the engine Run-In be made on a closed (heat exchanger type) cooling system where the coolant can be treated with a rust inhibitor (refer to Section 13.3). Use of a good rust inhibitor in the coolant system during engine Run-In will prevent rusting of the outside diameter of the cylinder liners after the engine has been removed from the dynamometer test stand.

The *Basic Engine Run-In Schedule* is shown in Table 1. The *Final Engine Run-In Schedule* is shown in Table 2. The horsepower shown in the tables is at SAE conditions: dry air density .0705 lb/cu. ft. (1.129 Kg/cu m), air temperature of 85°F (29°C) and 500 ft. elevation.

DYNAMOMETER TEST AND RUN-IN PROCEDURES

The Basic Engine

The great number of engine applications make any attempt to establish comparisons for each individual model impractical. For this reason, each model has a basic engine rating for comparison purposes.

A basic engine includes only those items actually required to run the engine. The addition of any engine driven accessories will result in a brake horsepower figure less than the values shown in the *Basic Engine Run-In Schedule.* The following items are included on the basic engine: blower, fuel pump, water pump and governor. The fan and battery-charging alternator typify accessories not considered on the basic engine.

In situations where other than basic engine equipment is used during the test, proper record of this fact should be made on the *Engine Test Report.* The effects of this additional equipment on engine performance should then be considered when evaluating test results.

Dynamometer

The function of the dynamometer is to absorb and measure the engine output. Its basic components are a frame, engine mounts, the absorption unit, a heat exchanger, and a torque loading and measuring device.

The engine is connected through a universal coupling to the absorption unit. The load on the engine may be varied from zero to maximum by decreasing or increasing the resistance in the unit. The amount of power absorbed in a water brake type dynamometer, as an example, is governed by the volume of fluid within the working system. The fluid offers resistance to a rotating motion. By controlling the volume of water in the absorption unit, the load may be increased or decreased as required.

The power absorbed is generally measured in torque (lb-ft or N-m) on a suitable scale. This value for a given engine speed will show the brake horsepower developed in the engine by the following formula:

BHP = (T x RPM)/5250

Where:

BHP = brake horsepower

T = torque in lb-ft

RPM = revolutions per minute

Some dynamometers indicate direct brake horsepower readings. Therefore, the use of the formula is not required when using these units.

During the actual operation, all data taken should be recorded immediately on an *Engine Test Report* (see sample on page 4).

Instrumentation

Certain instrumentation is necessary so that data required to complete the *Engine Test Report* may be obtained. The following list contains both the minimum amount of instruments and the proper location of the fittings on the engine so that the readings represent a true evaluation of engine conditions.

a. Oil pressure gage installed in one of the engine main oil galleries.

b. Oil temperature gage installed in the oil pan, or thermometer installed in the dipstick hole in the oil pan.

c. Adaptor for connecting a pressure gage or mercury manometer to the engine air box.

The new steel hand hole cover used in production has no provision for checking the air box pressure. When checking air box pressure a service only hand hole cover with a tapped hole for attaching a gage is now available.

d. Water temperature gage installed in the thermostat housing.

e. Adaptor for connecting a pressure gage or water manometer to the crankcase.

f. Adaptor for connecting a pressure gage or mercury manometer to the exhaust manifold at the flange.

g. Adaptor for connecting a vacuum gage or water manometer to the blower inlet.

h. Adaptor for connecting a fuel pressure gage to the fuel manifold inlet passage.

i. Adaptors for connecting a pressure gage or mercury manometer to the turbocharger.

In some cases, gages reading in pounds per square inch are used for determining pressures while standard characteristics are given in inches of mercury or inches of water. It is extremely important that the scale of such a gage be of low range and finely divided if accuracy is desired. This is especially true of a gage reading in psi, the reading of which is to be converted to inches of water. The following conversion factors may be helpful.

Inches of water = psi x 27.7"
Inches of mercury = psi x 2.04"
Inches of water = kPa x 4.02"
Inches of mercury = kPa x 0.30"

Before starting the Run-In or starting the engine for any reason following an overhaul, it is of extreme importance to observe the instructions on *Preparation for Starting Engine First Time* in Section 13.1.

• Block Oil Filter Bypass Before Initial Start-Up And Dynamometer Test Of Rebuilt Engines

Cold engine start-up causes the lubricating oil filter bypass valve to open until oil temperature increases. When an engine is rebuilt and then dynamometer tested, this bypass condition may result in the circulation of abrasive (harmful) debris introduced into the engine during rebuild.

To prevent unnecessary circulation of debris through the lube oil system, DDC recommends plugging the filter bypass before start-up and during basic engine run-in. This allows all the lube oil to flow through the filter(s), trapping contaminants. To plug the bypass, proceed as follows:

Drill and tap a l/4"-20 hole in a filter bypass valve plug. Install a bolt long enough to contact the valve and keep it from opening and a nut to lock the bolt in position (Fig. 1). When the dynamometer test is completed, replace the modified plug with a standard plug and change the filter(s).

NOTICE: To avoid damaging the phenolic bypass valve, the bolt should be finger-tightened only and then secured in place with the lock nut. On filter adaptors with more than one bypass valve, install modified valve plugs in all valve openings before starting or dynamometer testing the engine.

DDC recommends bringing lube oil temperature up to at least 60°F (15.6°C) before starting the engine prior to testing. If the lube oil is too cold when the engine is started, the resistance to the flow of the heavier oil may cause filter gasket leakage or bearing surface damage from inadequate oil film.

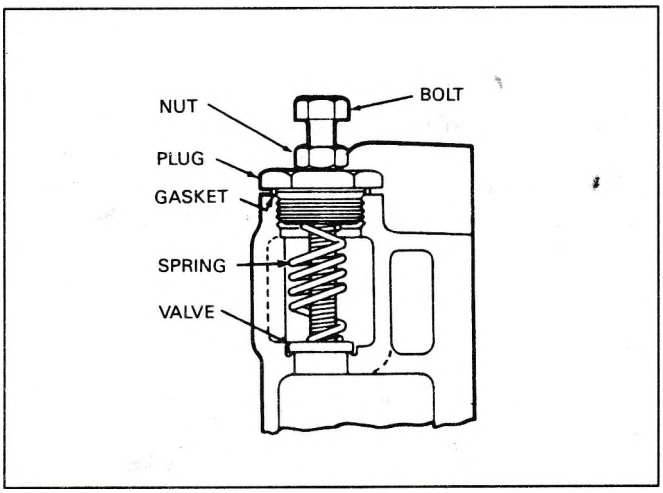


Fig. 1 - Bypass Valve with Modified Valve Plug Installed

 © Detroit Diesel Corporation

Run-In Procedure

The procedure outlined below will follow the order of the sample *Engine Test Report.*

A. PRE-STARTING

1. Fill the lubrication system as outlined under *Lubricating System — Preparation for Starting Engine First Time* in Section 13.1.

2. Prime the fuel system as outlined under *Fuel System — Preparation for Starting Engine First Time* in Section 13.1.

3. A preliminary valve clearance adjustment must be made before the engine is started. See *Valve Clearance Adjustment* in Section 14.1.

4. A preliminary injector timing check must be made before starting the engine. See *Fuel Injector Timing* in Section 14.2.

5. Preliminary governor adjustments must be made as outlined in Section 14.

6. Preliminary injector rack adjustment must be made (Section 14).

Prior to starting a turbocharged engine, remove the oil supply line at each turbocharger and add clean oil to the oil inlet to ensure pre-lubrication of the turbochargers. Reconnect the oil lines and idle the engine for at least one minute after starting and before increasing the speed.

B. BASIC ENGINE RUN-IN

The operator should be observant at all times so that any malfunction which may develop will be detected. Since the engine has just been reconditioned, this Run-In will be a test of the workmanship of the serviceman who performed the overhaul. Minor difficulties should be detected and corrected so that a major problem will not develop.

After performing the preliminary steps, be sure all water valves, fuel valves, etc. are open. Also inspect the exhaust system, air cleaner and air inlet piping to insure that it is properly connected to the engine. Always start the engine with minimum dynamometer resistance.

After the engine starts, if using a water brake type dynamometer, allow sufficient water, by means of the control loading valves, into the dynamometer absorption unit to show a reading of approximately 5 lb-ft (7 N • m) on the torque gage (or 10-15 H.P. on a horsepower gage). This is necessary, on some units, to lubricate the absorption unit seals and to protect them from damage.

See Engine Test Report, "Basic Engine Run-in" and "Final Run-in" (Sections B and E).

Point	Speed (RPM)	Load (% of rated hp)	Time (Minutes)
1	1200	20*	10
2	1500	25	15
3	1800	40	30
4	1900	75	30
Final	Rated rpm#	100	30

* But not more than 300 hp.

44 But not less than 1 800 rpm.

Table 1 - Basic Engine Run-in Schedule

Set the engine throttle at idle speed, check the lubricating oil pressure and check all connections to be sure there are no leaks.

Refer to the *Engine Test Report* sample, which establishes the sequence of events for the test and Run-In, and to the *Basic Engine Run-In Schedule* which indicates the speed (rpm), length of time and the brake horsepower required for each phase of the test. Also refer to the *Operating Conditions* in Section 13.2 which presents the engine operating characteristics. These characteristics will be a guide for tracing faulty operation or lack of power.

Engine governors in most cases must be reset at the maximum full-load speed designated for the Run-In. If a governor is encountered which cannot be adjusted to this speed, a stock governor should be installed for the Run-In.

After checking the engine performance at idle speed and being certain the engine and dynamometer are operating properly, increase the engine speed to half speed and apply the load indicated on the *Basic Engine Run-In Schedule.*

The engine should be run at this speed and load for 10 minutes to allow sufficient time for the coolant temperature to reach the normal operating range. Record length of time, speed, brake horsepower, coolant temperature and lubricating oil pressure on the *Engine Test Report.*

Run the engine at each speed and rating *t* for the length of time indicated in the *Basic Engine Run-In Schedule.* This is the Basic Run-In. During this time, engine performance will improve as new parts begin to “seat in”. Record all of the required data.

C. BASIC RUN-IN INSPECTION

While the engine is undergoing the Basic Run-In, check each item indicated in Section “C” of the *Engine Test Report.* Check for fuel oil or water leaks in the rocker arm compartment.

Injector Size	Engine Horsepower at 1800 RPM						
	8VTI	12V	12VT	12VTI	16V	16VT	16VTI
120							
130		770			1025		
140							
145			980			1315	
150							
160	780						
165			1155			1545	
170				1175			1580
180							
190/7110#	860			1290			1740
195							
230							
240							
270	1010			1515			2020
290/6810				1700			2275
300				1750			2350

#190 and 7 1 10 injectors should never be mixed in an engine.
* Within 5% of brake horsepower rating shown above at governor speed.

Size	Engine Horsepower at 1900 RPM						
	8VTI	12V	12VT	12VTI	16V	16VT	16VTI
120		727			970		
130		805	910		1070	1195	
140	635		940	980		1275	1325
145	740		1050	1100		1400	1480
150				1130			1515
160	800			1200			1600
170	825			1240			1650
180	850			1275			1700
190/7110#	900			1350			1800
195	950			1425			1900
230				1500			i 2000
240	1000						

190 and 7110 injectors should never be mixed in an engine.
* Within 5% of brake horsepower rating shown above at governor speed.

Table 2 - Rated Engine Horsepower at RPM/Injector Size

 © Detroit Diesel Corporation

ENGINE TEST REPORT

Date___ _____ **Unit Number**_____
Repair Order Number _____ **Model N umber** _

PRE-STARTING

PRIME LUBE ' OIL SYSTEM	PRIME FUEL ' SYSTEM	ADJUST VALVES AND BRIDGES	TIME 4- IN J.	, ADJ. ' GOV.	ADJUST INJ. 6' RACKS

B BASIC ENGINE RUN-IN

TIME AT SPEED	TIME START	TIME STOP	RPM	BHP	WATER TEMP.	LUBE OIL PRESS.

C BASIC RUN-IN INSPECTION

1. Check oil at rocker mechanism	
2. Inspect for lube oil leaks	
3. Inspect for fuel oil leaks	
4. Inspect for water leaks	
5. Check and tighten all external bolts	
6.	

INSPECTION AFTER BASIC RUN-IN

l. Tighten Rocker Shaft Bolts
2. Adjust Valves (Hot)
3. Time Injectors
4. Adjust Governor Gap
5. Adjust Injector Racks
6.

FINAL RUN-IN

TIME START	TIME STOP	TOP RPM NO LOAD	TOP RPM FULL LOAD	BHP	AIR BOX PRESSURE FULL LOAD	EXHAUST BACK PRESSURE FA	CRANKCASE PRESSURE FA

BLOWER INTAKE RES. - FA	FUEL OIL PRESSURE RET. MAN. FA	WATER TEMP. FULL LOAD	LUBE OIL TEMP. FA	LUBE OIL PRESSURE FULL LOAD IDLE	IDLE SPEED

INSPECTION AFTER FINAL RUN

l. Inspect Air Box, Pistons, Liners, Rings
2. Inspect Blower
3. Check Generator Charging Rote
4. Wash Oil Pan, Check Gasket
5. Clean Oil Pump Screen, Remove Cloth
6. Replace Lube Filter Elements
7. Tighten Flywheel Bolts
8. Rust Proof Cooling System
9.

REMARKS'

UL.

Final Run OK'd **Dynamometer** **Date**

NOTE; Operator must initial each check and sign this report.

During the final portion of the Basic Run-In, the engine should be inspected for fuel oil, lubricating oil and water leaks.

Upon completion of the Basic Run-In and Inspection, remove the load from the dynamometer and reduce the engine speed gradually to idle and then stop the engine.

D. INSPECTION AFTER BASIC RUN-IN

The primary purpose of this inspection is to provide a fine engine tune-up. Complete the applicable tune-up procedure. Refer to Section 14.

E. FINAL RUN-IN

After all of the tests have been made and the *Engine Test Report* is completed through Section "D", the engine is ready for final test. This portion of the test and Run-In procedure will assure the engine owner that his engine has been rebuilt to deliver factory rated performance at the same maximum speed and load which will be experienced in the installation.

If the engine has been shutdown for one hour or longer, it will be necessary to have a warm-up period of 10 minutes at the same speed and load used for warm-up in the Basic Run-In. If piston rings, pistons, cylinder liners or bearings have been replaced as a result of findings in the Basic Run-In, the entire Basic Run-In must be repeated as though the Run-In and test procedure were started anew.

All readings observed during the Final Run-In should fall within the range specified in the *Operating Conditions* in Section 13.2 and should be taken at full load unless otherwise specified. Following is a brief discussion of each condition to be observed.

The engine *water temperature* should be taken during the last portion of the Basic Run-In at full load. It should be recorded and should be within the specified range.

The *lubricating oil temperature* reading must be taken while the engine is operating at full load and after it has been operating long enough for the temperature to stabilize. This temperature should be recorded and should be within the specified range.

The *lubricating oil pressure* should be recorded in psi or kPa after being taken at engine speeds indicated in the *Operating Conditions,* Section 13.2.

The *fuel oil pressure* at the fuel manifold inlet passage should be recorded and should fall within the specified range. Fuel pressure should be recorded at maximum engine speed during the Final Run-In.

Check the *air box pressure* while the engine is operating at maximum speed and load. This check may be made by attaching a suitable gage (0-15 psi or 0-103 kPa) or manometer (15-0-15) to an air box drain or to a hand hole plate prepared for this purpose. If an air box drain is used as a source for this check, it must be clean. The air box pressure should be recorded in inches of mercury.

Check the *crankcase pressure* while the engine is operating at maximum Run-In speed. Attach a manometer, calibrated to read in inches of water, to the oil level dipstick opening. Normally, crankcase pressure should decrease during the Run-In, indicating that new rings are beginning to "seat-in".

Check the *air inlet restriction* with a water manometer connected to a fitting in the air inlet ducting located 2" above the air inlet housing. When practicability prevents the insertion of a fitting at this point, the manometer may be connected to a fitting installed in the 1/4" pipe tapped hole in the engine air inlet housing. If a hole is not provided, a stock housing should be drilled, tapped and kept on hand for future use.

The restriction at this point should be checked at a specific engine speed. Then the air cleaner and ducting should be removed from the air inlet housing and the engine again operated at the same speed while noting the manometer reading. The difference between the two readings, with and without the air cleaner and ducting, is the actual restriction caused by the air cleaner and ducting.

On turbocharged engines, measure the air inlet restriction, at each turbocharger, with a water manometer connected in the large diameter of the air duct just before it is reduced to enter the turbocharger compressor. There should not be more than 2" of water difference in the compressor inlet readings for the turbochargers being supplied from a common air cleaner(s).

Check the normal *air intake vacuum* at various speeds (at no-load) and compare the results with the *Engine Operating Conditions* in Section 13.2. Record these readings on the *Engine Test Report.*

Check the *exhaust back pressure* (except turbocharged engines) at the exhaust manifold companion flange or within one inch of this location. This check should be made with a mercury manometer through a tube adaptor installed at the tapped hole. If the exhaust manifold does not provide a 1/8" pipe tapped hole, such a hole can be incorporated by reworking the exhaust manifold. Install a fitting for a pressure gage or manometer in this hole. Care should be exercised so that the fitting does not protrude into the stack. On turbocharged engines, check the exhaust back pressure in the exhaust piping *6"* to 12" from the turbine outlet. The tapped hole must be in a comparatively straight area for an accurate measurement. The manometer check should produce a reading in inches that is below the *Maximum Exhaust Back Pressure* for the engine (refer to Section 13.2).

 © Detroit Diesel Corporation

ENGINE TEST REPORT

Date_____ **_____ Unit Number_____**
Repair Order Number **Model Number,**

PRE-STARTING

PRIME LUBE ' OIL SYSTEM	PRIME FUEL ' SYSTEM	ADJUST VALVES AND BRIDGES	TIME 4> INJ.	- ADJ. GOV.	ADJUST INJ. RACKS

B BASIC ENGINE RUN-IN

TIME i AT j---------- SPEED 1	TIME START	STOP	RPM	BHP	WATER TEMP.	LUBE OIL PRESS.

BASIC RUN-IN INSPECTION

1. Check oil at rocker mechanism
2. Inspect for lube oil leaks
3. Inspect for fuel oil leaks
4. Inspect for water leaks
5. Check and tighten all external bolts

INSPECTION AFTER BASIC RUN-IN

1. Tighten Rocker Shaft Bolts
2. Adjust Valves (Hot)
3. Time Injectors
4. Adjust Governor Gap
5. Adjust Injector Racks
6.

FINAL RUN-IN

TIME START	TIME STOP	TOP RPM NO LOAD	TOP RPM FULL LOAD	BHP	AIR BOX PRESSURE FULL LOAD	EXHAUST BACK PRESSURE FA	CRANKCASE PRESSURE FA

BLOWER INTAKE RES. - FA	FUEL OIL PRESSURE RET. MAN. FA	WATER TEMP. FULL LOAD	LUBE OIL TEMP. FA	LUBE OIL PRESSURE FULL LOAD IDLE	IDLE SPEED

INSPECTION AFTER FINAL RUN

1. Inspect Air Box, Pistons, Liners, Rings
2. Inspect Blower
3. Check Generator Charging Rate
4. Wash Oil Pan, Check Gasket
5. Clean Oil Pump Screen, Remove Cloth
6. Replace Lube Filter Elements
7. Tighten Flywheel Bolts
8. Rust Proof Cooling Systen
9.
10.

REMARKS:

Final Run OK'd **Dynamometer** **Date**

NOTE; Operator must initial each check and sign this report.

During the final portion of the Basic Run-In, the engine should be inspected for fuel oil, lubricating oil and water leaks.

Upon completion of the Basic Run-In and Inspection, remove the load from the dynamometer and reduce the engine speed gradually to idle and then stop the engine.

D. INSPECTION AFTER BASIC RUN-IN

The primary purpose of this inspection is to provide a fine engine tune-up. Complete the applicable tune-up procedure. Refer to Section 14.

E. FINAL RUN-IN

After all of the tests have been made and the *Engine Test Report* is completed through Section "D", the engine is ready for final test. This portion of the test and Run-In procedure will assure the engine owner that his engine has been rebuilt to deliver factory rated performance at the same maximum speed and load which will be experienced in the installation.

If the engine has been shutdown for one hour or longer, it will be necessary to have a warm-up period of 10 minutes at the same speed and load used for warm-up in the Basic Run-In. If piston rings, pistons, cylinder liners or bearings have been replaced as a result of findings in the Basic Run-In, the entire Basic Run-In must be repeated as though the Run-In and test procedure were started anew.

All readings observed during the Final Run-In should fall within the range specified in the *Operating Conditions* in Section 13.2 and should be taken at full load unless otherwise specified. Following is a brief discussion of each condition to be observed.

The engine *water temperature* should be taken during the last portion of the Basic Run-In at full load. It should be recorded and should be within the specified range.

The *lubricating oil temperature* reading must be taken while the engine is operating at full load and after it has been operating long enough for the temperature to stabilize. This temperature should be recorded and should be within the specified range.

The *lubricating oil pressure* should be recorded in psi or kPa after being taken at engine speeds indicated in the *Operating Conditions*, Section 13.2.

The *fuel oil pressure* at the fuel manifold inlet passage should be recorded and should fall within the specified range. Fuel pressure should be recorded at maximum engine speed during the Final Run-In.

Check the *air box pressure* while the engine is operating at maximum speed and load. This check may be made by attaching a suitable gage (0-15 psi or 0-103 kPa) or manometer (15-0-15) to an air box drain or to a hand hole plate prepared for this purpose. If an air box drain is used as a source for this check, it must be clean. The air box pressure should be recorded in inches of mercury.

Check the *crankcase pressure* while the engine is operating at maximum Run-In speed. Attach a manometer, calibrated to read in inches of water, to the oil level dipstick opening. Normally, crankcase pressure should decrease during the Run-In, indicating that new rings are beginning to "seat-in".

Check the *air inlet restriction* with a water manometer connected to a fitting in the air inlet ducting located 2" above the air inlet housing. When practicability prevents the insertion of a fitting at this point, the manometer may be connected to a fitting installed in the 1/4" pipe tapped hole in the engine air inlet housing. If a hole is not provided, a stock housing should be drilled, tapped and kept on hand for future use.

The restriction at this point should be checked at a specific engine speed. Then the air cleaner and ducting should be removed from the air inlet housing and the engine again operated at the same speed while noting the manometer reading. The difference between the two readings, with and without the air cleaner and ducting, is the actual restriction caused by the air cleaner and ducting.

On turbocharged engines, measure the air inlet restriction, at each turbocharger, with a water manometer connected in the large diameter of the air duct just before it is reduced to enter the turbocharger compressor. There should not be more than 2" of water difference in the compressor inlet readings for the turbochargers being supplied from a common air cleaner(s).

Check the normal *air intake vacuum* at various speeds (at no-load) and compare the results with the *Engine Operating Conditions* in Section 13.2. Record these readings on the *Engine Test Report.*

Check the *exhaust back pressure* (except turbocharged engines) at the exhaust manifold companion flange or within one inch of this location. This check should be made with a mercury manometer through a tube adaptor installed at the tapped hole. If the exhaust manifold does not provide a 1/8" pipe tapped hole, such a hole can be incorporated by reworking the exhaust manifold. Install a fitting for a pressure gage or manometer in this hole. Care should be exercised so that the fitting does not protrude into the stack. On turbocharged engines, check the exhaust back pressure in the exhaust piping 6" to 12" from the turbine outlet. The tapped hole must be in a comparatively straight area for an accurate measurement. The manometer check should produce a reading in inches that is below the *Maximum Exhaust Back Pressure* for the engine (refer to Section 13.2).

 © Detroit Diesel Corporation

Turbocharger compressor outlet and turbine inlet pressures are taken at full-load and no-load speeds.

Refer to the *Final Engine Run-In Schedule* and determine the maximum rated brake horsepower and the full-load speed to be used during the Final Run-In. Apply the load thus determined to the dynamometer.

If a hydraulic governor is used, the droop may be adjusted at this time by following the prescribed procedure.

The engine should be run at this speed and load for 1/2 hour. While making the Final Run-In, the engine should develop, within 5%, the maximum rated brake horsepower indicated for the speed at which it is operating. If this brake horsepower is not developed, the cause should be determined and corrections made.

When the above conditions have been met, adjust the maximum no-load speed to conform with that specified for the particular engine. This speed may be either higher or lower than the maximum speed used during the Basic Run-In. This will ordinarily require a governor adjustment.

All information required in Section "E", Final Run-In, of the *Engine Test Report* should be determined and filled in. After the prescibed time for the Final Run-In has elapsed, remove the load from the dynamometer and reduce the engine speed gradually to idle speed and then stop the engine. The Final Run-In is complete.

F. INSPECTION AFTER FINAL RUN-IN

After the Final Run-In and before the *Engine Test Report* is completed, a final inspection must be made. This inspection will provide final assurance that the engine is in proper working order. During this inspection, the engine is also made ready for any brief delay in delivery or installation which may occur. This is accomplished by rustproofing the fuel system as outlined in Section 15.3 and adding a rust inhibitor to the cooling system (refer to Section 13.3). The lubricating oil filters should also be changed.

NOTICE: A rust inhibitor in the coolant system is particularly important because of the wet cylinder liners. Omission of a rust inhibitor will cause rusting of the outside diameter of the liners and interference with liner heat transfer.

t

LUBRICATING OIL, FUEL OIL AND FILTER RECOMMENDATIONS

Selection of the proper quality of fuel and lubricating oil is important to achieve the long and trouble-free service for which Detroit Diesel engines are designed. Conversely, operation with improper fuels and lubricants can cause problems. The manufacturer's warranty applicable to Detroit Diesel engines provides, in part, that warranty shall not apply to any engine which has been subject to misuse, negligence or accident. Accordingly, malfunctions attributable to neglect or failure to follow manufacturer's fuel or lubricating recommendations may not be covered by the warranty.

A requirement of Detroit Diesel Corporation's extended warranty program (Power Protection Plan) is that the customer use the lubricants, fuels and filters recommended in this publication.

It is Detroit Diesel's policy to build engines which will operate satisfactorily with fuels and lubricants available in the commercial market. However, not all fuels and lubricants are adequate. Product selection should be made based on these recommendations and in consultation with a reliable supplier who understands the equipment and its application.

LUBRICATING OIL

Engine service life depends upon selecting the proper lubricating oil and maintaining proper oil drain and filter change intervals.

LUBRICANT SELECTION

There are hundreds of commercial oils marketed today, but labeling terminology differs among suppliers and can be confusing. Some marketers may claim that their lubricant is suitable for all makes of diesel engines and may list engine makes and types, including Detroit Diesel, on their containers. Such claims by themselves are insufficient as a method of lubricant selection for Detroit Diesel engines.

The proper lubricating oil for all Detroit Diesel engines is selected based on SAE Viscosity Grade and API (American Petroleum Institute) Service Designation. Both of these properties are displayed on oil containers in the API symbol. In addition, military specifications may be used for selecting engine lubricants. MU-L-2104D represents the most current military specification for diesel lubricants and the only one recommended for Detroit Diesel engines. For two-cycle Detroit Diesel engines, the proper lubricant must also possess a sulfated ash content below 1.0% mass. Refer to the following specific recommendations.

TWO-CYCLE ENGINES
Detroit Diesel Series 53, 71, 92, 149

LUBRICANT RECOMMENDATION

API Symbol:



SAE Viscosity Grade: 40
API Classification: CD-II
Military Spec.: Mil-L-2104D
Sulfated Ash: less than 1.0%

This is the only engine oil recommended for Detroit Diesel two-cycle engines. Lubricants meeting these criteria have provided maximum engine life when used in conjunction with recommended oil drain and filter maintenance schedules.

A more detailed description of each of these selection criteria may be found in a further section of this publication. Certain engine operating conditions may require exceptions to this recommendation. They are as follows:

1. For continuous high temperature operation (over 100°F ambient or 200°F Coolant Out) the use of an SAE grade 50 lubricant in all series two-cycle DDC engines is recommended.

2. At ambient temperatures below freezing where starting aids are not available or at very cold temperatures (0 to -25°F), the use of multiviscosity grade 15W-40 or monograde SAE 30 lubricants will improve startability. **Exception: Do not use these lubricants in two-cycle marine engines or DDC series 149 engines under any circumstances.**

3. The API category CD-II is relatively new and may not be fully in use at the time of this publication. API category CD may be used provided the recommended military specification is satisfied. Oils with API designation CE are not recommended in DDC two-cycle engines unless accompanied by CD-II.

4. When the use of high sulfur fuel is unavoidable, lubricants with a Total Base Number exceeding 10 are recommended. Such a lubricant may have a Sulfated Ash content above 1.0% mass. High sulfur fuels require modification to oil drain intervals. For further information refer to that section of this publication.

FOUR-CYCLE ENGINES
Detroit Diesel Series 60 and 8.2L

LUBRICANT RECOMMENDATION

API Symbol:



SAE Viscosity Grade: 15W-40
API Classification: CE
Military Spec.: Mil-L-2104D

This is the only engine oil recommended for Detroit Diesel Series 60 and 8.2L engines. Lubricants meeting these criteria have provided maximum engine life when used in conjunction with recommended oil drain and filter maintenance schedules.

When the use of high sulfur fuel is unavoidable, lubricants with a TBN exceeding 10 are recommended. High sulfur fuels require modification to oil drain intervals. For further information refer to that section of this publication.

LUBRICATING OIL SELECTION CRITERIA

SAE VISCOSITY GRADE

Viscosity is a measure of an oil's ability to flow at various temperatures. The SAE Viscosity Grade system is defined in SAE Standard J300 which designates a viscosity range with a grade number. Lubricants with two grade numbers separated by a "W" are classified as multigrade, while those with a single number are monograde. The higher the number the higher the viscosity.

API SERVICE CLASSIFICATION

The American Petroleum Institute has established a means of classifying lubricant performance suitable for different types of engines and types of service. The higher performance or quality API classifications for diesel engines include CD, CE (for four-cycle diesel engines) and CD-II (for two-cycle diesel engines). Detroit Diesel does not recommend the use of the older and lower performance classifications such as CC, CB and CA.

Multiple API Service Classifications such as "API SERVICE CD, CE" or "API SERVICE CE/CD-II" are frequently listed. Additional classifications not listed here may also be included. It is important that the DDC recommended classification be among those listed.

API SYMBOL

Lubricant marketers have adopted a uniform method of displaying the SAE viscosity grade and API service classification information on product containers and in product literature. The three segment "donut" contains the SAE grade number in the center, and the API service in the top segment. The lower segment is used to designate energy conserving status for gasoline engine use and has no significance for diesel engine use.

MILITARY SPECIFICATION

U.S. Military specifications are another means of classifying the performance of lubricants. As with the API system, lubricants must meet performance criteria before approval is given. The essential difference, however, is that lubricants meeting military specifications, particularly those possessing Qualified Products Listing (QPL) Numbers, have been reviewed by a committee consisting of engine manufacturers, including Detroit Diesel.

Military Specification Mil-L-2104D represents the current specification for heavy-duty diesel engines and the only one recommended by Detroit Diesel Corporation.

SULFATED ASH AND TOTAL BASE NUMBER

This is a lubricant property obtained by a laboratory test (ASTM D874) to determine potential for the formation of metallic ash. The ash residue is related to the oil's additive composition and is significant in predicting lubricants which may cause valve distress under certain operating conditions. Sulfated ash is related to Total Base Number (TBN), also a laboratory test (ASTM D2896) which measures an oil's ability to neutralize acids. As TBN increases, sulfated ash also increases to where lubricants with TBNs above 10 will likely have sulfated ash contents above 1.0% mass.

Total Base Number is important to deposit control in four-cycle diesel engines and to neutralize the effects of high sulfur fuel in all diesel engines. In general, Detroit Diesel recommends lubricants with sulfated ash contents below 1.0% mass and TBNs between 7 and 10 for all Series engines operating on low sulfur fuel.

UNIVERSAL OILS

Universal oils are designed for use in both gasoline and diesel engines and provide an operational convenience in mixed fuel engine fleets. These products are identified with combination API category designations such as SF/CD or SG/CE. Although such products can be used in Detroit Diesel engines (provided they satisfy all DDC requirements), their use is not as desirable as lubricants formulated specifically for diesel engines, and bearing only the API CD-II or CE designations.

 © Detroit Diesel Corporation

SYNTHETIC OILS

Synthetic oils may be used in Detroit Diesel engines provided they meet the viscosity, performance classification and chemical recommendations listed for non-synthetic lubricants. Product information about synthetic oils should be reviewed carefully since these lubricants are often claimed to be of monograde viscosity. Their use does not permit extension of recommended oil drain intervals.

MARINE LUBRICANTS, RAILROAD DIESEL LUBRICANTS

The petroleum industry markets specialty lubricants for use in diesel engines designed specifically for marine propulsion or railroad locomotive use. These lubricants take into consideration the unique environments and operational characteristics of this type of duty, and consequently, they are formulated quite differently from the types of lubricants recommended by Detroit Diesel. Although in some cases they may be suitable in Detroit Diesel engines, they should not be used without specific consultation with your Detroit Diesel distributor or regional office and the lubricant supplier.

USE OF SUPPLEMENTAL ADDITIVES

Lubricants meeting the Detroit Diesel recommendations outlined in this publication already contain a balanced additive treatment. The use of supplemental additives, such as break-in oils, top oils, graphitizers, and friction-reducing compounds, is generally unnecessary and can even be harmful. Never use a lubricant supplement to “fix” a mechanical problem, and be cautious of products purporting to prevent one. The best approach is to follow DDC’s lubricant recommendations.

EVIDENCE OF SATISFACTORY LUBRICANT PERFORMANCE

These recommendations are intended to provide a guideline for lubricating oil selection based on favorable service history in typical applications of Detroit Diesel engines. Specific situations may warrant consideration of a lubricant that does not fit these guidelines. Such a lubricant may perform satisfactorily in certain circumstances, and be inappropriate for others.

For such products, evidence of satisfactory performance should be obtained from the oil supplier on the specific lube oil blend being considered and compared with the performance of a DDC recommended lubricant as reference. Comparative performance evidence would include stationary engine tests and field testing in a similar application and severity.

The type of field test used by the oil supplier depends on the series engine in which the candidate oil will be used and the service application. The candidate test oil engines should all operate for the mileage/hours indicated in the table below. Any serious mechanical problems should be recorded. At the conclusion of the test, the engines should be disassembled and quantitatively compared with reference oil engines for:

- Ring conditions (broken, stuck and wear)
  Cylinder liner and piston skirt scuffing
- Exhaust valve face and seat deposits and distress
- Piston pin and slipper bushing wear
  Piston ring land deposits
  Overall valve train and bearing wear

Several stationary engine tests have been designed by and utilized by Detroit Diesel for evaluation of lubricants. These tests include:

100 Hour Series 92 Accelerated Engine Test
- evaluates liners, rings and slipper bushings

Series 71 Valve Guttering Test
- evaluates effects of high ash on valve distress

100 Hour Series 60 Truck Cycle Test
- evaluates deposit and ring sticking

240 Hour 6V53T Endurance Test (FTM 355)
- evaluates liner and ring wear (used for CD-II)

LUBRICATING OIL FIELD TESTING GUIDELINES

ENGINE SERIES	SERVICE APPLICATION	TEST DURATION	NO. ENGINES ON CANDIDATE TEST OIL	NO. ENGINES ON REFERENCE BASELINE OIL
53	Pickup & Delivery	50,000 Miles	5	5
60, 71, 92	Highway Truck, GVW 78,000 lbs	200,000 Miles	5	5
149	Off-Road 120 Ton Rear Dump	10,000 Hours	3	3

Although stationary engine testing provides important lubricant performance evaluation, it should be considered secondary to a properly conducted field test evaluation.

Upon completion of the field and stationary testing of products which meet or exceed the performance of lubricants recommended in this publication, Detroit Diesel will issue a written approval for their use in the application field tested. Such approval will be limited to the specific formulation (identical basestock and additive treatment) in which the testing was conducted.

OIL CHANGE INTERVALS

During use, engine lubricating oil undergoes deterioration from combustion by-products and contamination. For this reason, regular oil drain intervals are necessary. These intervals however, may vary in length depending upon engine operation, fuel quality, and lubricant quality. The oil drain interval may be established on recommendations of a Detroit Diesel Oil Analysis Program until the most practical oil change interval has been determined. Under no circumstances, however, should the drain intervals in the chart be exceeded. Refer to the "Used Lubricating Oil Analysis" section of this publication for more information. All engine oil filters should be changed when the lube oil is changed.

MAXIMUM RECOMMENDED OIL DRAIN INTERVALS (Normal Operation)

SERVICE APPLICATION	ENGINE SERIES	OIL DRAIN INTERVAL
Highway Truck	60,7 1 8.92	20,000 Miles (32,000 kM)
City Transit Coaches	53, 71 8. 92	6,000 Miles (9,600 kM)
Pick-up & Delivery, Stop & Go, Short Trip	53, 71, 92 8.2L	12,000 Miles (19,000 kM) 6,000 Miles (9,600 kM)
Industrial, Agricultural and Marine	149NA 1 49T	500 Hrs. or 1 Yr. 300 Hrs. or 1 Yr.
	53, 60, 71, 92 8. 8.2L	150 Hrs.
Stationary Units Full Time	53, 71,92 81 149	500 Hrs. or 1 Mo.
Standby	53, 71,92, 149 8. 8.2L	150 Hrs. or 1 Yr.

OIL CHANGE INTERVALS WHEN USING HIGH SULFUR FUEL

When the continuous use of high sulfur fuel (greater than 0.5%) is unavoidable, lubricant selection and oil drain interval must be modified. A lubricant with a Total Base Number (TBN per ASTM D 2896) above 10 is recommended. It is likely that such a lubricant will also exhibit a sulfated ash above 1.0%. The proper oil drain interval must be determined by oil analysis when operating on high sulfur fuel. A reduction in TBN (D 2896) to one third of the initial value provides a general drain interval guideline.

MAXIMUM RECOMMENDED OIL DRAIN INTERVALS

FUEL SULFUR 0.5% TO 1.0%
Use a lubricant with TBN (ASTM D 2896) 10 to 30

SERVICE APPLICATION	ENGINE SERIES	OIL DRAIN INTERVAL 10-19 TBN	20-30 TBN
Highway Truck	60, 71 & 92	15,000 Mi. (24,000 kM)	20,000 Mi. (32,000 kM)
City Transit Coaches	53, 71 & 92	4,000 Mi. (6,400 kM)	6,000 Mi. (9,600 kM)
Pick-up & Delivery Stop & Go, Short Trip	53, 71 & 92	8.000 Mi. (12,500 kM)	12,000 Mi. (20,000 kM)
	8.2L	4.000 Mi. (6,400 kM)	6,000 Mi. (9,600 kM)
Industrial, Agricultural and Marine	149NA	300 Hrs.	500 Hrs.
	149T	200 Hrs. (or 1 Yr. Maximum)	300 Hrs.
	53, 60, 71, 92 & 8.2L	100 Hrs.	1 50 Hrs.
Stationary Units Full Time	53, 71,92 & 149	300 Hrs. (or 1 Mo. Maximum)	500 Hrs.
Standby	53, 71, 92, 149 & 8.2L	100 Hrs. (or 1 Yr. Maximum)	150 Hrs.

MAXIMUM RECOMMENDED OIL DRAIN INTERVALS

FUEL SULFUR ABOVE 1.0%
Use a lubricant with TBN (ASTM D 2896) 10 to 30

SERVICE APPLICATION	ENGINE SERIES	OIL DRAIN INTERVAL 10-19 TBN	20-30 TBN
Highway Truck	60, 71 8. 92	7,500 Mi. (12,000 kM)	15,000 Mi. (24,000 kM)
City Transit Coaches	53, 71 & 92	2,000 Mi. (3,000 kM)	4,000 Mi. (6,400 kM)
Pick-up & Delivery Stop & Go, Short Trip	53,71 & 92	4.000 Mi. (6,500 kM)	8.000 Mi. (12,500 kM)
	8.2L	2.000 Mi. (3,000 kM)	4.000 Mi. (6,400 kM)
Industrial, Agricultural and Marine	149NA	150 Hrs.	300 Hrs.
	149T	100 Hrs. (or 6 Mos. Maximum)	200 Hrs.
	53, 60, 71, 92 8. 8.2L	50 Hrs.	100 Hrs.
Stationary Units Full Time	53, 71,92 & 149	150 Hrs.	300 Hrs.
Standby	53, 71,92, 149 8. 8.2L	50 Hrs. (or 6 Mos.	100 Hrs. Maximum)

 © Detroit Diesel Corporation

USED LUBRICATING OIL ANALYSIS

A used lubricating oil analysis program such as the Detroit Diesel Oil Analysis Program is recommended for the monitoring of crankcase oil in all engines. Since an oil analysis indicates the condition of the engine, not the lubricating oil, it should not be used to extend oil drain intervals. The oil should be changed immediately if any contamination is present in concentrations exceeding the warning limits shown in the table. It should not however, be concluded that the engine is worn out based on *a single* measurement that exceeds the warning level. Imminent engine wearout can only be determined through a *continuous* oil analysis program wherein the change in data or deviation from baseline data can be used to interpret condition of engine parts.

Characteristics relating to lubricating oil dilution should trigger corrective action to identify and fix the source(s).

Confirmation of the need for engine overhaul should be based on operational data (increasing oil consumption and crankcase pressure, for example) and physical inspection of parts.

USED LUBRICATING OIL ANALYSIS WARNING LIMITS

These values indicate the need for an immediate oil change, but do not necessarily indicate internal engine problems requiring engine teardown.

WARNING LIMITS

	ASTM Designation	Two Cycle		Four Cycle
		53, 71, 92	149	60, 8.2
Pentane Insolubles Mass % Max.	D 893	1.0	1.0	1.0
Carbon (Soot) Content, TGA Mass %Max.	E 1 131	0.8		1.5
Viscosity at 40°c St % Max. Increase % Max. Decrease	D 445 & D 2161	 40.0 15.0	 40.0 15.0	 40.0 15.0
Total Base Number (TBN) Min. Min.	 D 664 D 2986	 1.0 2.0	 1.0 2.0	 1.0 2 0
Water Content (dilution) Vol. % Max.	D 95	0.30	0.30	0.30
Flash Point °C Reduction Max.	D 92	40.0	40.0	40.0
Fuel Dilution Vol. % Max.	*	2.5	1.0	2.5
Glycol Dilution PPM Max.	D 2982	1000	1000	1000
Iron Content PPM Fe Max.	**	150	35	60=150 8.2=250
Copper Content PPM Cu Max.	* *	25	25	60 = 90 8.2 = 30
Sodium Content PPM Na Over Baseline Max.	* *	50	50	50
Boron Content PPM B Over Baseline Max.	* *	20	20	20

* No ASTM Designation

** Elemental Analysis are conducted using either emission or atomic absorption spectroscopy. Neither method has an ASTM designation.

$

FUELOIL

QUALITY AND SELECTION

The quality of fuel used is a very important factor in obtaining satisfactory engine performance, long engine life, and acceptable exhaust emission levels. DDC engines are designed to operate on most diesel fuels marketed today. In general, fuels meeting the properties of ASTM Designation D 975 (grades 1-D and 2-D) have provided satisfactory performance. The ASTM D 975 specification however does not in itself adequately define the fuel characteristics necessary for assurance of fuel quality. The properties listed in the Fuel Oil Selection Chart have provided optimum engine performance.

FUEL OIL SELECTION CHART

General Fuel Classification	ASTM Test	No. 1 ASTM 1-D	No. 2* ASTM 2-D
Gravity, "API #	D 287	40-44	33-37
Flash Point Min. °F fC)	D 93	100 (38)	125 (52)
Viscosity, Kinematic cST @ 100°F (40°C)	D 445	1.3-2.4	1.9-4.1
Cloud Point °F #	D 2500	See Note 1	See Note 1
Sulfur Content wt%. Max.	D 129	0.5	0.5
Carbon Residue on 10%, wt%, Max.	D 524	0.15	0.35
Accelerated Stability Total Insolubles mg/100 ml, Max. #	D 2274	1.5	1.5
Ash, wt%. Max.	D 482	0.01	0.01
Cetane Number, Min. +	D 613	45	45
Distillation Temperature, °F (°C) IBP, Typical # 10% Typical # 50% Typical # 90% + End Point #	D 86	350 (177) 385 (196) 425 (218) 500 (260) Max. 550 (288) Max.	375 (191) 430 (221) 510(256) 625 (329) Max. 675 (357) Max.
Water & Sediment %, Max.	D 1796	0.05	0.05

Not specified in ASTM D 975

+ Differs from ASTM D 975

* No. 1 diesel fuel is recommended for use in city coach engine models. No. 2 diesel fuel may be used in city coach engine models which have been certified to pass Federal and California emission standards.

Note 1: The cloud point should be 10°F (6°C) below the lowest expected fuel temperature to prevent clogging of fuel filters by wax crystals.

Note 2: When prolonged idling periods or cold weather conditions below 32°F (0°C) are encountered, the use of 1-D fuel is recommended. Number 1-D fuels should also be considered when operating continuously at altitudes above 5000 ft.

FUEL OIL SELECTION CRITERIA

DISTILLATION

The boiling range is a very important property in consideration of diesel fuel quality. The determination of boiling range is made using ASTM Test Method D 86. Many specifications contain a partial listing of the distillation results, ie., Distillation Temperature At 90% Recovered. Many diesel fuels are blended products which may contain constituents with boiling ranges much different than the majority of the fuel composition. The full boiling range as shown in the Fuel Oil Selection Chart should be used for proper selection.

FINAL BOILING POINT

Fuel can be burned in an engine only after it has been vaporized. The temperature at which fuel is completely vaporized is described as the End point Temperature in ASTM D 86 Distillation Test Method. This temperature must be low enough to permit complete vaporization at combustion chamber temperatures. The combustion chamber temperature depends on ambient temperature, engine speed and load. Poor vaporization is more apt to occur during severe cold weather, prolonged idling, and/or light load operation. Therefore engines operating under these conditions should utilize fuels with lower distillation end point temperatures.

COMPLETELY DISTILLED FLUID

Fuel selected should be completely distilled material. That is, the fuel should exhibit no less than 98% recovery when subjected to the ASTM D 86 Distillation Test Method.

CETANE NUMBER

Cetane Number is mistakenly used to indicate fuel quality. However, Cetane Number is most useful in predicting engine startup. A high Cetane Number should not be considered alone when evaluating fuel quality. Other properties such as end point distillation temperature and carbon residue should also be considered. Calculated Cetane Index is sometimes reported instead of Cetane Number. Cetane Index is an empirical property determined through the use of a mathematical equation whereas Cetane Number is determined through an engine test.

FUEL STABILITY

Diesel Fuel oxidizes in the presence of air and water, particularly if the fuel contains cracked products which are relatively unstable. The oxidation of fuel can result in the formation of undesirable gums and sediment. Such undesirable products can cause filter plugging, combustion chamber deposit formation and gumming or lacquering of injection system components with resultant sticking or wear.

 © Detroit Diesel Corporation

FUELOIL

QUALITY AND SELECTION

The quality of fuel used is a very important factor in obtaining satisfactory engine performance, long engine life, and acceptable exhaust emission levels. DDC engines are designed to operate on most diesel fuels marketed today. In general, fuels meeting the properties of ASTM Designation D 975 (grades 1-D and 2-D) have provided satisfactory performance. The ASTM D 975 specification however does not in itself adequately define the fuel characteristics necessary for assurance of fuel quality. The properties listed in the Fuel Oil Selection Chart have provided optimum engine performance.

FUEL OIL SELECTION CHART

General Fuel Classification	ASTM Test	No. 1 ASTM 1-D	No. 2* ASTM 2-D
Gravity, °API #	D 287	40-44	33-37
Flash Point Min. °F (°C)	D 93	100 (38)	125 (52)
Viscosity, Kinematic cST @ 100°F (40°C)	D 445	1.3-2.4	1.9-4.1
Cloud Point °F #	D 2500	See Note 1	See Note 1
Sulfur Content wt%, Max.	D 129	0.5	0.5
Carbon Residue on 10%, wt%, Max.	D 524	0.15	0.35
Accelerated Stability Total Insolubles mg/100 ml, Max. #	D 2274	1.5	1.5
Ash, wt%, Max.	D 482	0.01	0.01
Cetane Number, Min. -f-	D 613	45	45
Distillation Temperature, °F (°C)	D 86		
IBP, Typical #		350 (177)	375 (191)
10% Typical #		385 (196)	430 (221)
50% Typical #		425 (218)	510 (256)
90% +		500 (260) Max.	625 (329) Max.
End Point #		550(288) Max.	675 (357) Max.
Water & Sediment %, Max.	D 1796	0.05	0.05

Not specified in ASTM D 975

+ Differs from ASTM D 975

* No. 1 diesel fuel is recommended for use in city coach engine models. No. 2 diesel fuel may be used in city coach engine models which have been certified to pass Federal and California emission standards.

Note 1: The cloud point should be 10°F (6°C) below the lowest expected fuel temperature to prevent clogging of fuel filters by wax crystals.

Note 2: When prolonged idling periods or cold weather conditions below 32°F (0°C) are encountered, the use of 1-D fuel is recommended. Number 1-D fuels should also be considered when operating continuously at altitudes above 5000 ft.

FUEL OIL SELECTION CRITERIA

DISTILLATION

The boiling range is a very important property in consideration of diesel fuel quality. The determination of boiling range is made using ASTM Test Method D 86. Many specifications contain a partial listing of the distillation results, ie., Distillation Temperature At 90% Recovered. Many diesel fuels are blended products which may contain constituents with boiling ranges much different than the majority of the fuel composition. The full boiling range as shown in the Fuel Oil Selection Chart should be used for proper selection.

FINAL BOILING POINT

Fuel can be burned in an engine only after it has been vaporized. The temperature at which fuel is completely vaporized is described as the End point Temperature in ASTM D 86 Distillation Test Method. This temperature must be low enough to permit complete vaporization at combustion chamber temperatures. The combustion chamber temperature depends on ambient temperature, engine speed and load. Poor vaporization is more apt to occur during severe cold weather, prolonged idling, and/or light load operation. Therefore engines operating under these conditions should utilize fuels with lower distillation end point temperatures.

COMPLETELY DISTILLED FLUID

Fuel selected should be completely distilled material. That is, the fuel should exhibit no less than 98% recovery when subjected to the ASTM D 86 Distillation Test Method.

CETANE NUMBER

Cetane Number is mistakenly used to indicate fuel quality. However, Cetane Number is most useful in predicting engine startup. A high Cetane Number should not be considered alone when evaluating fuel quality. Other properties such as end point distillation temperature and carbon residue should also be considered. Calculated Cetane Index is sometimes reported instead of Cetane Number. Cetane Index is an empirical property determined through the use of a mathematical equation whereas Cetane dumber is determined through an engine test.

FUEL STABILITY

Diesel Fuel oxidizes in the presence of air and water, particularly if the fuel contains cracked products which are relatively unstable. The oxidation of fuel can result in the formation of undesirable gums and sediment. Such undesirable products can cause filter plugging, combustion chamber deposit formation and gumming or lacquering of injection system components with resultant sticking or wear.

 © Detroit Diesel Corporation

ASTM Test Method D 2274 measures diesel fuel oxidative stability. Although the results of the test may vary with actual field storage, it does measure characteristics which will effect fuel storage stability for periods up to 12 months.

FUEL SULFUR CONTENT

The sulfur content of the fuel should be as low as possible to avoid premature wear and excessive deposit formation. Fuel containing no more than 0.5% sulfur are recommended. If the use of fuels with sulfur contents above 0.5% are unavoidable, lube oil drain intervals and lubricant selection need to be changed. Detroit Diesel recommends that the Total Base Number (TBN D 2896) of the lubricant be monitored and the oil drain interval be reduced.

FUEL OPERATING TEMPERATURE AND VISCOSITY

Since Diesel Fuel provides cooling of the injection system, the temperature of the fuel may vary considerably due to the ambient temperature, engine operating temperature, and the amount of fuel remaining in the tank. As fuel temperature increases, the fuel viscosity and therfore the lubrication capabilities of the fuel diminish. Maintaining proper fuel temperatures in combination with selection of fuels with the viscosity ranges shown in the Fuel Oil Selection Chart will assure proper injection system functioning.

DIESEL FUEL STORAGE

Fuel oil should be clean and free of contamination. Storage tanks and stored fuel should be inspected regularly for dirt, water, and sludge; and cleaned if contaminated. Diesel fuel tanks can be made of aluminum, monel stainless steel, black iron, welded steel or reinforced (non-reactive) plastic.

NOTICE: Galvanized steel or sheet metal tanks and galvanized pipes or fittings should never be used in any diesel fuel storage, delivery or fuel system. The fuel oil will react chemically with the zinc coating, forming a compound which can clog the filters and can cause engine damage.

FUEL ADDITIVES

Detroit Diesel engines operate satisfactorily on a wide range of diesel fuels without the addition of supplemental additives. Such additives increase operating costs without providing benefit.

Fuel additives specifically NOT recommended include:

- Used Lubricating Oil
- Gasoline

Detroit Diesel does NOT recommend the use of drained lubricating oil or gasoline in diesel fuel. Furthermore Detroit Diesel Corporation will not be responsible for any detrimental effects which it determines resulted form this practice.

Some fuel additives provide temporary benefits but do not replace good fuel handling practices. Such additives are helpful when water contamination is suspected:

Isopropyl Alcohol—1 pint per 125 gallons of fuel for winter freeze up protection.

- Biocide—For treatment of microbe growth or black “slime”. Follow manufacturers’ instructions for treatment.

Other fuel additives are of questionable benefit. These include a variety of independently marketed products which claim to be:

- Cetane Improvers

Combustion Improvers

- Cold Weather Flow Improvers

These products should be accompanied with performance data supporting their merit. It is not the policy of Detroit Diesel Corporation to approve or endorse such products.

FILTER RECOMMENDATIONS

Filters make up an integral part of fuel and lubricating oil systems. Proper filter selection and maintenence are important to satisfactory engine operation and service life.

Filters should be utilized for maintaining a clean system, not for cleaning up a contaminated system,

FUEL FILTER RECOMMENDATION
Regular Service

Filter Type	Micron Rating	Beta Ratio	Manufacturer	Filter No.
Primary	30		AC Spark Plug Div. GM	T552 T553 T54 1 T632 T9 15 T936 T958
Secondary	12		AC Spark Plug Div. GM	TP509 TP540X TP624 TP916 TP928 TP959

FUEL FILTER RECOMMENDATION
Severe Duty Service

Filter Type	Micron Rating	Beta Ratio	Manufacturer	Filter No.
Primary	–	–	Racor	B32002
Secondary	3	200	Pall Corp.	Head HH7400AT2UPRBP Element HC7400SUP-4H
Secondary (Alternate)	5	–	AC Spark Plug	TP916L TP928L TP959L

 © Detroit Diesel Corporation

LUBRICATING OIL FILTER RECOMMENDATION
Series 53, 71, 92, 149

Filter Type	Micron Rating	Beta Ratio	Manufacturer	Filter No.
Full Flow	12	75	AC Spark Plug Div. GM	PF91 1 L P/N 25013192

LUBRICATING OIL FILTER RECOMMENDATION
Series 60

Filter Type	Micron Rating	Beta Ratio	Manufacturer	Filter No.
Full Flow	45	80	AC Spark Plug Div. GM	PF9 1 1 P/N 25010495
By-Pass	10	90	AC Spark Plug Div. GM	P-940 P/N 2501 1 188

LUBRICATING OIL FILTER RECOMMENDATION
Series 8.2L

Filter Type	Micron Rating	Beta Ratio	Manufacturer	Filter No.
Full Flow	25	88	AC Spark Plug Div. GM	PF35 P/N 6438384

COOLANT SPECIFICATIONS

The coolant provides a medium for heat transfer and controls the internal temperature of the engine during operation. In an engine having proper coolant flow, the heat of combustion is conveyed through the cylinder walls and the cylinder head into the coolant. Without adequate coolant, normal heat transfer cannot take place within the engine, and engine temperature rapidly rises. In general, water containing various materials in solution is used for this purpose.

COOLANT REQUIREMENTS

Coolant solutions used in Detroit Diesel engines must meet the following basic requirements:

1. Provide for adequate heat transfer.
2. Provide a corrosion-resistant environment within the cooling system.
3. Prevent formation of scale or sludge deposits in the cooling system.
4. Be compatible with the cooling system hose and seal materials.
5. Provide adequate freeze protection during cold weather operation and boil-over protection in hot weather.

The first four requirements are satisfied by combining a suitable water with reliable inhibitors. When freeze protection is required, a solution of suitable water and an antifreeze containing adequate inhibitors will provide a satisfactory coolant. Ethylene glycol-based antifreeze solutions are recommended for year-round use in Detroit Diesel engines.

WATER

Whether of drinking quality or not, any water will produce a corrosive environment in the cooling system, and the mineral content may permit scale deposits to form on internal cooling system surfaces. Therefore, water selected as a coolant must be properly treated with inhibitors to control corrosion and scale deposition.

To determine if a particular water is suitable for use as a coolant when properly inhibited, the following characteristics must be considered: the concentration of chlorides and sulfates, total hardness and dissolved solids.

Chlorides and/or sulfates tend to accelerate corrosion, while hardness (percentage of magnesium and calcium salts broadly classified as carbonates) causes deposits of scale. Total dissolved solids may cause scale deposits, sludge deposits, corrosion or a combination of these. Chlorides, sulfates, magnesium and calcium are among the materials which make up dissolved solids. Water within the limits specified in Table 1 is satisfactory as an engine coolant when proper inhibitors are added. The procedure for evaluating water intended for use in a coolant solution* is shown in Table 2.

	PARTS PER MILLION	GRAINS PER GALLON
Chlorides (Maximum)	40	2.5
Sulfates (Maximum)	100	5.8
Total Dissolved Solids (Maximum)	340	20
Total Hardness (Maximum)	170	10

TABLE 1

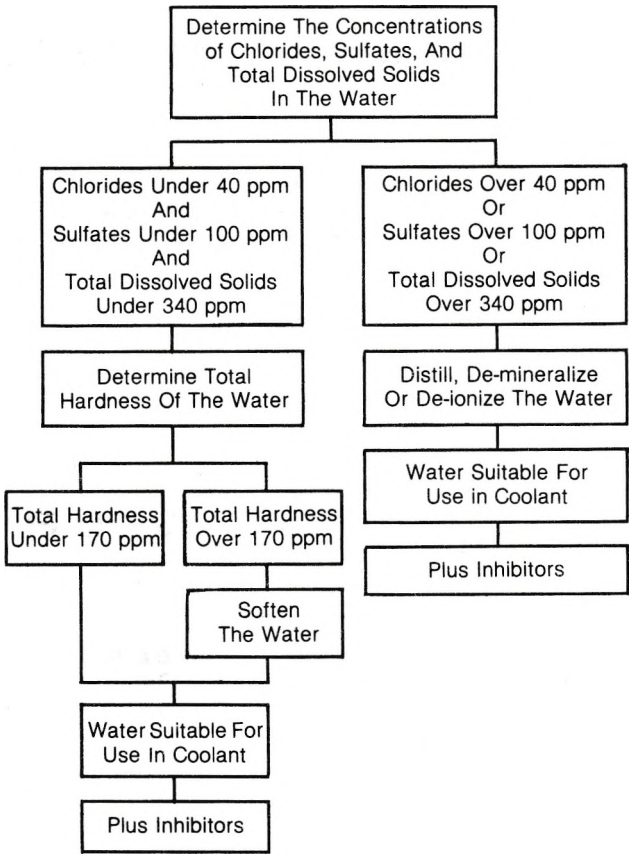


TABLE 2

CORROSION INHIBITORS VITAL

A corrosion inhibitor is a water-soluble chemical compound which protects the metallic surfaces of the cooling system against corrosive attack. Some of the more commonly used corrosion inhibitors are chromates, borates, nitrates, nitrites and soluble oil. (Soluble oil is not recommended as a corrosion inhibitor). Depletion of all types of inhibitors occurs through normal operation.

 © Detroit Diesel Corporation

Therefore, strength levels must be maintained by adding inhibitors as required after testing the coolant.

The importance of a properly inhibited coolant cannot be overstressed. A coolant which has insufficient inhibitors, the wrong inhibitors, or no inhibitors at all invites the formation of rust and scale deposits within the cooling system. Rust, scale, and mineral deposits can wear out water pump seals and coat the walls of the cylinder block water jackets and the outside walls of the cylinder liners. As these deposits build up, they insulate the metal and reduce the rate of heat transfer. For example, a 1/16" deposit of rust or scale on 1" of cast iron is equivalent to 4—1/4" of cast iron in heat transferability (Fig. 1).

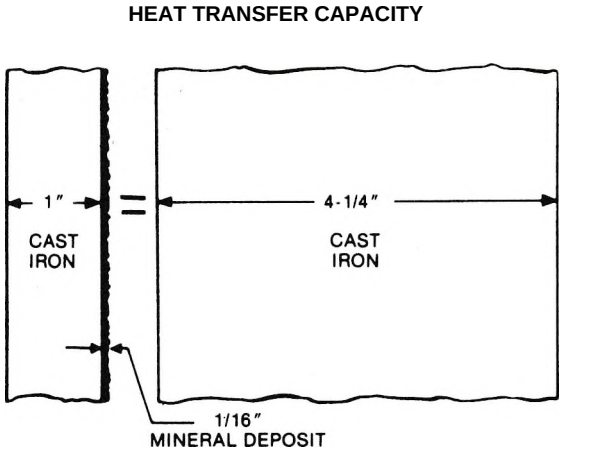


Fig. 1 - Heat Transfer Capacity

An engine affected in this manner overheats gradually over a period of weeks or months. Liner scuffing, scoring, piston seizure and cylinder head cracking are the inevitable results. An improperly inhibited coolant can also become corrosive enough to "eat away" coolant passages and seal ring grooves and cause coolant leaks to develop. If sufficient coolant accumulates on top of a piston, a hydrostatic lock can occur while the engine is being started. This, in turn, can result in a bent connecting rod.

An improperly inhibited coolant can also contribute to *cavitation erosion.* Cavitation erosion is caused by the collapse of bubbles (vapor pockets) formed at the coolant side of an engine component. The collapse results from a pressure differential in the liquid caused by the vibration of the engine part. As bubbles collapse, they form pin points of very high pressure. Over a period of time, the rapid succession of millions of tiny bursting bubbles can wear away (erode) internal engine surfaces.

Components such as fresh water pump impellers and cylinder liners are especially susceptible to cavitation erosion. In extreme cases their surfaces can become so deeply pitted that they appear to be spongy, and holes can develop completely through them.

Chromates

Sodium chromate and potassium dichromate are two of the best and most commonly used water system corrosion inhibitors. Care should be exercised in handling these materials due to their toxic nature.

Chromate inhibitors should *not* be used in antifreeze solutions. Chromium hydroxide, commonly called "green slime", can result from the use of chromate inhibitors with antifreeze. This material deposits on the cooling system passages, reducing the heat transfer rate (Fig. 1) and resulting in engine overheating. Engines which have operated with a chromate-inhibited water must be chemically cleaned before the addition of antifreeze. A commercial heavy-duty descaler should be used in accordance with the manufacturer's recommendation for this purpose.

Soluble Oil

Soluble oil has been used as a corrosion inhibitor for many years. It has, however, required very close attention relative to the concentration level due to adverse effects on heat transfer if the concentration exceeds 1 % by volume. For example: 1.25% of soluble oil in the cooling system increases fire deck temperatures 6% and a 2.50% concentration raises fire deck temperatures up to 15%. *Soluble oil is not recommended as a corrosion inhibitor.*

Non-Chromates

Non-chromate inhibitors (borates, nitrates, nitrites, etc.) provide corrosion protection in the cooling system with the basic advantage that they can be used with either water or a water-and-antifreeze solution.

INHIBITOR SYSTEMS

An inhibitor system is a combination of chemical compounds which provide corrosiom protection, pH control and water-softening ability. Corrosion protection is discussed under the heading *Corrosion Inhibitors Vital.* pH control is used to maintain an acid-free solution. The water-softening ability deters formation of mineral deposits. Inhibitor systems are available in various forms such as coolant filter elements, liquid and dry bulk inhibitor additives and as integral parts of antifreeze.

Coolant Filter Elements

Replaceable elements are available with various chemical inhibitor systems. Compatibility of the element with other ingredients of the coolant solution cannot always be taken for granted.

Problems have developed from the use of the magnesium lower support plate used by some manufacturers in their coolant filters. The magnesium plate will be attacked by solutions which will not be detrimental to other metals in the cooling system. The dissolved magnesium will be deposited in the hottest zones of the engine where heat transfer is most critical. The use of an aluminum or zinc support plate in preference to magnesium is recommended to eliminate the potential of this type of deposit.

High chloride coolants will have a detrimental effect on the water-softening capabilities of systems using ion-exchange resins. Accumulations of calcium and magnesium ions removed from the coolant and held captive by the zeolite resin can be released into the coolant by a regenerative process caused by high chloride-content solutions.

Inhibitor Additives

Commercially packaged inhibitor systems are available which can be added directly to the engine coolant. Both chromate and non-chromate systems are available and care should be taken regarding inhibitor compatibility with other coolant constituents.

Non-chromate inhibitor systems are recommended for use in Detroit Diesel engines. These systems can be used with either water or water-and-antifreeze solutions and provide corrosion protection, pH control and water softening. Most non-chromate inhibitor systems offer the additional advantage of a simple on-site test to determine protection level. Since they are added directly to the coolant, they require no additional hardware or plumbing.

All inhibitors become depleted through normal operation and additional inhibitor must be added to the coolant as required to maintain original strength levels.

NOTICE: Over-inhibiting antifreeze solutions can cause silicate dropout. Always follow the supplier's recommendations on inhibitor usage and handling.

TEST METHODS

Test kits and test strips are commercially available to check engine coolant for corrosion inhibitor strength level. Coolant should be tested to determine the need for corrosion inhibitor supplements and the amount required. Do not use one manufacturer's test to measure the inhibitor strength level of another manufacturer's product. Always follow the manufacturer's recommended test procedures.

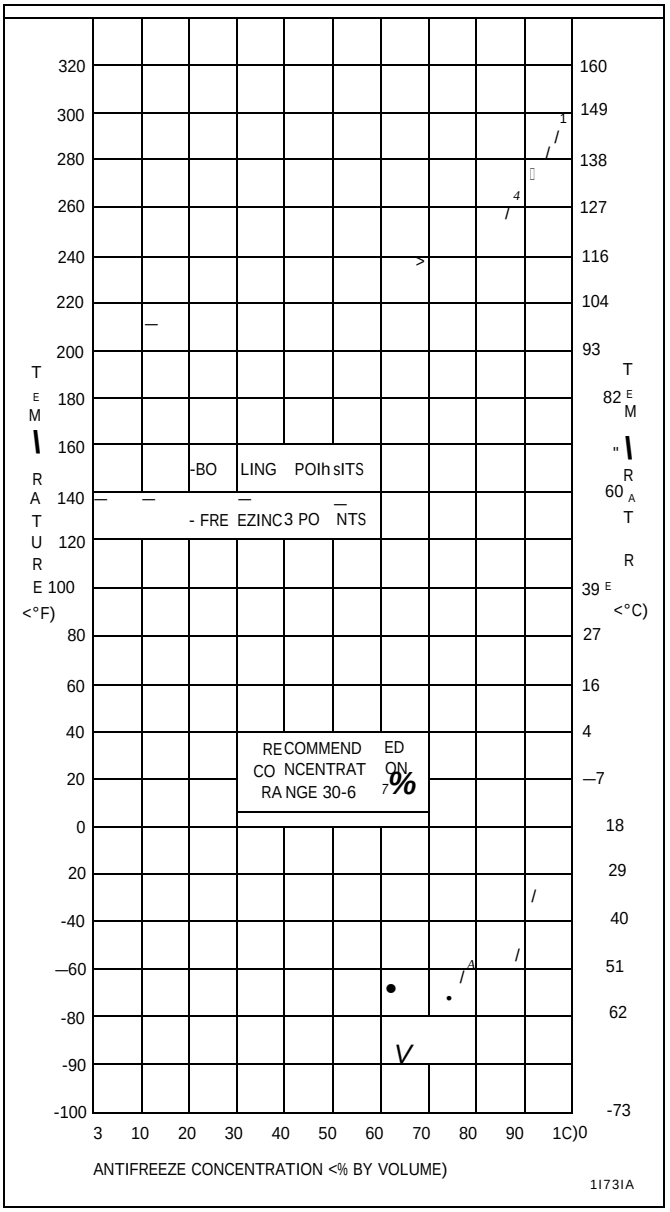


Fig. 2 - Coolant Freezing and Boiling Temperatures vs. Antifreeze Concentration (Sea Level)

ANTIFREEZE

When freeze protection is required, use an Antifreeze that meets the GM 603 8M formulation, which limits silicate to 0.15% maximum or an equivalent formulation meeting the 0.15% maximum silicate and GM 1899M performance requirements.

Solutions of less than 30% do not provide adequate corrosion protection. Concentrations over 67% adversely affect freeze protection, heat transfer rates and silicate stability. A 50% antifreeze solution is normally used as factory-fill.

 © Detroit Diesel Corporation

Ethylene glycol base antifreeze is recommended for use in all Detroit Diesel engines. Methyl alcohol base antifreeze is not recommended because of its effect on the non-metallic components of the cooling system and because of its low boiling point. Methoxy propanol base antifreeze is not recommended for use in Detroit Diesel engines due to the presence of fluoroelastomer seals in the cooling system.

Antifreeze solutions should be used year-round to provide freeze protection in the winter, boil-over protection in the summer and a stable environment for seals and hoses in the cooling system of the engine.

The inhibitors in antifreeze solutions should be replenished with a non-chromate corrosion inhibitor supplement when indicated by testing the coolant. Engine coolant should be checked at approximately 500 hour or 20,000 mile intervals.

• A cooling system properly maintained and protected with supplemental corrosion inhibitors can be operated up to two years, 200,000 miles, or 6000 hours, whichever comes first. At this interval the antifreeze should be drained and the cooling system cleaned thoroughly. The cooling system should then be replenished with an ethylene glycol-base antifreeze/water solution in the required concentration (see graph).

> **NOTICE:** Failure to maintain inhibitors at proper levels can result in damage to the cooling system and its related components. Conversely, *overinhibiting antifreeze solutions can cause silicate dropout.* Always follow the supplier's recommendations on inhibitor usage and handling.

SILICATE DROPOUT

Excessive amounts of chemicals in the engine coolant can cause silicate dropout, which creates a gel-type deposit that reduces heat transfer and coolant flow.

The gel takes on the color of the coolant solution in the wet state but appears as a white powdery deposit when dry. Although silica gel is non-abrasive, it can pick up solid particles in the coolant and become a gritty abrasive deposit that can cause excessive wear of water pump seals and other cooling system components. The wet gel can be removed by non-acid (alkali) type heavy-duty cleaners, while the dried silicate requires engine disassembly and caustic solution or mechanical cleaning of individual components.

The total amount of chemicals in the coolant can be minimized by using GM 603 8M formulation antifreeze at the required freeze protection level, corrosion inhibitor supplements as needed to maintain protection and water that meets Detroit Diesel requirements.

GENERAL RECOMMENDATIONS

All Detroit Diesel engines incorporate pressurized cooling systems which permit operation at temperatures higher than non-pressurized systems. It is essential that these systems be kept clean and leak-free, that filler caps and pressure relief mechanisms be correctly installed at all times and that coolant levels be maintained.

Always maintain engine coolant at the proper level. A low coolant level allows the water pump to mix air with the coolant. Air bubbles in the coolant can "insulate" the cylinder walls, preventing normal heat transfer. An abnormally low coolant level can cause the water pump to become "air-bound," a condition in which it works feverishly but pumps nothing. Without proper heat transfer, silicone elastomer head-to-block water hole seals can deteriorate and cylinder components can expand so that pistons rapidly cut through the lubricant on the liner walls. Scuffing and piston seizure may follow.

> **CAUTION: Use extreme care when removing a radiator pressure-control cap from an engine. The sudden release of pressure from a heated cooling system can result in a loss of coolant and possible personal injury (scalding) from the hot liquid.**

An engine may contain the correct amount of properly inhibited coolant, but still fail to adequately cool the engine. In cases where this occurs, other causes of low coolant flow, either engine or cooling system related, should be investigated.

1. Always use a properly inhibited coolant.
2. Do not use soluble oil.
3. Maintain the prescribed inhibitor strength level by adding inhibitors as needed after testing the coolant.
4. Always follow the manufacturer's recommendations on inhibitor usage and handling.
5. If freeze protection is required, use a solution of water and antifreeze that meets the GM 6038M formulation or an equivalent antifreeze with a 0.15% maximum silicate content that meets GM 1899M performance specifications.
6. Reinhibit antifreeze with a non-chromate inhibitor system.
7. Do not use a chromate inhibitor with antifreeze.
8. Do not use methoxy propanol base antifreeze.

9. Do not mix ethylene glycol base antifreeze with methoxy propanol base antifreeze in the cooling system.

10. Antifreeze makeup solutions should be mixed at the same concentration as the original coolant.

11. Do not use sealer additives or antifreeze containing sealer additives.

12. Do not use methyl alcohol base antifreeze.

13. Use extreme care when removing the radiator pressure-control cap.

14. Do not add inhibitor supplements to *new* antifreeze solutions, except for the *initial fill* to provide optimum cavitation protection.

15. Use an antifreeze solution year-round for freeze and boil-over protection. Seasonal changing of coolant from an antifreeze solution to an inhibitor-water solution is *not recommended.*

• 16. A cooling system properly maintained and protected with supplemental corrosion inhibitors can be operated up to two years, 200,000 miles, or 6000 hours, whichever comes first. At this interval the antifreeze should be drained and the cooling system cleaned thoroughly.

*

 © Detroit Diesel Corporation

SECTION 14

ENGINE TUNE-UP

CONTENTS

Engine Tune-Up Procedures 14

Exhaust Valve Clearance Adjustment..... 14.1

Fuel Injector Timing..... 14.2

Limiting Speed Mechanical Governor and Injector Rack Control Adjustment 14.3

Variable Speed Mechanical Governor and Injector Rack Control Adjustment 14.4

Hydraulic Governor and Injector Rack Control Adjustment 14.7.2
Hydraulic Governor (Pneumatically Operated Isochronous Type)..... 14.7.6

Mechanical Output Shaft Governor and Linkage Adjustment 14.10

Supplementary Governing Device Adjustment:
Throttle Delay Mechanism..... 14.14
Starting Aid System (Variable Speed Governor)..... 14.14
Governor Shutdown Solenoid 14.14
Starting Aid Screw (see Section 14.3)

ENGINE TUNE-UP PROCEDURES

There is no scheduled interval for performing an engine tune-up. As long as the engine performance is satisfactory, no tune-up should be needed. Minor adjustments in the valve and injector operating mechanism, governor, etc. should only be required periodically to compensate for normal wear on parts.

The type of governor used depends upon the engine application. Since each governor has different characteristics, the tune-up procedure varies accordingly. The following types of governors are used:

1. Limiting speed mechanical.
2. Variable speed mechanical.
3. Hydraulic.

The mechanical governors are identified by a name plate attached to the governor housing. The letters D.W.-L.S. stamped on the name plate denote a double-weight limiting speed governor. A single-weight variable speed governor name plate is stamped S.W.-V.S.

Normally, when performing a tune-up on an engine in service, it is only necessary to check the various adjustments for a possible change in the settings. However, if a cylinder head, the governor or injectors have been replaced or overhauled, then certain preliminary adjustments are required before the engine is started.

The preliminary adjustments consist of the first four items in the tune-up sequence. The procedures are the same except that the valve clearance is greater for a cold engine.

If a supplementary governing device, such as the throttle delay mechanism, is used, it must b! disconnected prior to the tune-up. After the governor and injector rack adjustments are completed, the supplementary governing device must be reconnected and adjusted.

To tune-up an engine completely, perform all of the adjustments in the applicable tune-up sequence given below after the engine has reached normal operating temperature. Since the adjustments are normally made while the engine is stopped, it may be necessary to run the engine between adjustments to maintain normal operating temperature.

t

*

EXHAUST VALVE CLEARANCE ADJUSTMENT

The correct exhaust valve clearance at normal engine operating temperature is important for smooth, efficient operation of the engine.

Insufficient valve clearance can result in loss of compression, misfiring cylinders and, eventually, burned valve seats and valve seat inserts. Excessive valve clearance will result in noisy operation, increased valve face wear and valve lock damage.

Whenever a cylinder head is overhauled, the exhaust valves are reconditioned or replaced, or the valve operating mechanism is replaced or disturbed in any way, the valve clearance must first be adjusted to the cold setting to allow for normal expansion of the engine parts during the engine warm-up period. This will ensure a valve setting that is close enough to the specified clearance to prevent damage to the valves when the engine is started.

The exhaust valve bridges must be adjusted and the adjustment screws locked securely at the time the cylinder head is installed on the engine. The necessary adjustment procedure is outlined in Section 1.2.2.

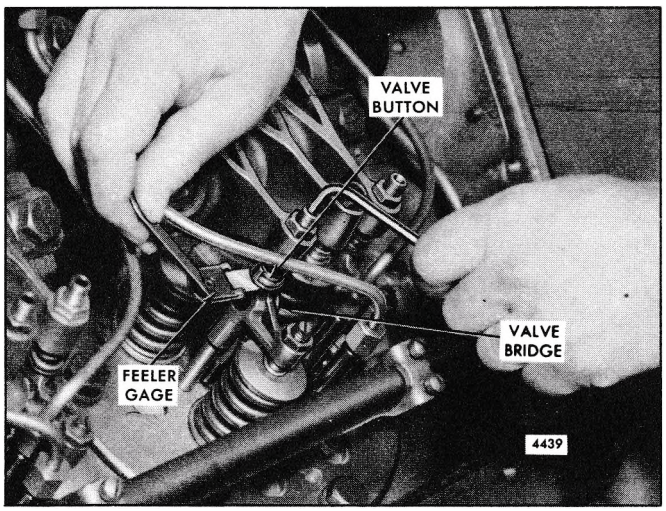


Fig. 1 - Adjusting Valve Clearance

The exhaust valve bridge balance should be checked when a general valve adjustment is performed. After the bridges are balanced, adjust the valve clearance. Do not disturb the exhaust valve bridge adjusting screw.

All of the exhaust valves may be adjusted in firing order sequence during one full revolution of the crankshaft. Refer to the *General Specifications* at the front of the manual for the engine firing order.

Valve Clearance Adjustment (Cold Engine)

1. Remove the loose dirt from the valve rocker covers and remove the covers. Discard the gaskets. Cover all drain cavities in the cylinder block to prevent foreign niaterial from entering*-

2. Place the governor speed control lever in the *idle* position. If a stop lever is provided, secure it in the *stop* position.

3. Rotate the crankshaft, by using either barring tool J 22582 or the starting motor, until the injector follower is fully depressed on the particular cylinder to be adjusted. If a wrench is used on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation or the bolt may loosen.

   CAUTION: To reduce the risk of persona! injury when barring over or "bumping" the starter while performing an engine tune-up, personnel should keep their hands and clothing away from the engine as there is a remote possibility the engine could start.

4. Loosen the exhaust valve adjusting screw locknut on the rocker arm.

5. Place a .016" feeler gage (J 9708-01) between the end of the valve button and the pallet of the valve bridge (Fig. 1). Adjust the valve adjusting screw to obtain a smooth pull on the feeler gage.

6. Remove the feeler gage and tighten the locknut to 30-35 lb-ft (41—-47 N-m) torque.

7. Recheck the clearance and adjust, if necessary.

8. Adjust and check the remaining exhaust valves in the same manner as above.

Valve Clearance Adjustment (Hot Engine)

Maintaining normal engine operating temperature is particularly important when making the fin^l exhaust valve clearance adjustment. If the engine is allowed to cool before setting any of the valves, the clearance when running at full load may become insufficient.

1. With the engine at normal operating temperature (see Section 13.2), recheck the exhaust valve clearance with feeler gage J 9708-01. At this time, if the valve clearance is correct, a .012" feeler gage will pass freely between the valve button and the valve bridge.

2. After the exhaust valve clearance has been adjusted, check the fuel injector timing (Section 14.2).

© Detroit Diesel Corporation

FUEL INJECTOR TIMING

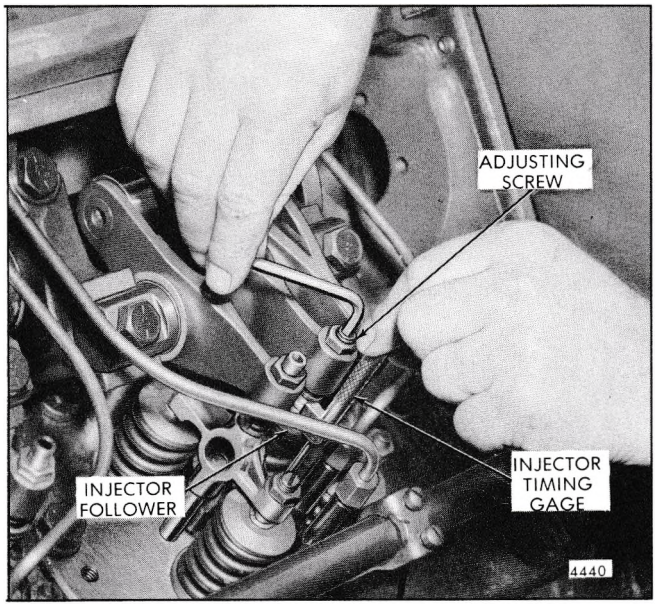


Fig. 1 - Timing Fuel Injector

All of the injectors can be timed in firing order sequence during one full revolution of the crankshaft. Refer to the *General Specifications* at the front of the manual for the firing order.

Time Fuel Injector

After the exhaust valve clearance has been adjusted (Section 14.1), time the fuel injectors as follows:

1. Place the governor speed control lever in the *idle speed* position. If a stop lever is provided, secure it in the *stop* position.

2. Rotate the crankshaft, with the starting motor or with engine barring tool J 22582 (refer to Section 1.2.2), until the exhaust valves are fully depressed on the particular cylinder to be timed.

   • CAUTION: To reduce the risk of personal injury when barring over or bumping the starter while performing an engine tune-up, personnel should keep their hands and clothing away from the engine as there is a remote possibility the engine could start.

Injector	Timing Gage Dimension	Timing Gage Tool No.	Camshaft Timing
120	2.1750"	J 22412	Std.
130	2.1750"	J 22412	Std.
140	2.1750"	J 22412	Std.
*140	2.2050"	J 24283	Std.
145	2.2050"	J 24283	Std.
150	2.1750"	J 22412	Std.
*150	2.2050"	J 24283	Std.
155	2.2050"	J 24283	Std.
*160	2.2050"	J 24283	Std.
165	2.1750"	J22412	Std.
*165	2.2050"	J 24283	Std.
170	2.1750"	J 22412	Std.
*170	2.2050"	J 24283	Std.
*180	2.2050"	J 24283	Std.
185	2.2050"	J 24283	Std.
*190	2.2050"	J 24283	Std.
*195	2.1850"	J 29116	Std.
230	2.1750"	J 22412	Std.
240	2.1850"	J 29116	Std.
270	2.1850"	J 29116	Std.
290	2.1750"	J 22412	Std.
315	2.1750"	J 22412	Std.
6810	2.1750"	J 22412	Std.
*7110	2.2050"	J 24283	Std.

*Used on turbocharged-intercooled engines.
Notice: Do not mix 190 and 7110 injectors in the same engine. L-6627

• TABLE 1 - INJECTOR TIMING

   NOTICE: If a wrench is used on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation because the bolt may be loosened.

3. Place the small end of the injector timing gage (refer to Table 1 for the correct timing gage) in the hole provided in the top of the injector body with the flat of the gage toward the injector follower (Fig. 1).

   Loosen the injector rocker arm adjusting screw locknut.

   Turn the adjusting screw to adjust the injector rocker arm until the extended part of the gage will just pass over the top of the injector follower.

   Hold the adjusting screw and tighten the locknut to 30-35 lb-ft (41-47 N-m) torquq. Check the adjustment and, if necessary, readjust the rocker arm.

   Time the remaining injectors in the same manner as outlined above.

8. If no further engine tune-up is required, install the valve rocker covers, using new gaskets.

LIMITING SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor and position the injector rack control levers (Fig. 1).

Before proceeding with the governor and injector rack adjustments, disconnect any supplementary governing device. After the adjustments are completed, reconnect and adjust the supplementary governing device as outlined in Section 14.14.

Adjust Governor Gap

With the engine stopped and at operating temperature, adjust the governor gap, as follows:

1. Back out the buffer screw until it extends approximately 5/8" from the locknut (Fig. 1).
2. Remove the high-speed spring retainer cover.
3. Start the engine.
4. Loosen the locknut and adjust the former idle speed adjusting screw or the current idle speed adjusting set screw to obtain the desired engine idle speed (Fig. 9).

The recommended engine idle speed is 550-750 rpm (current engines) or 450-550 rpm (former engines), but may vary with special engine applications.

5. Stop the engine. Clean and remove the governor cover and lever assembly and the valve rocker covers. Discard the gaskets.
6. Start and run the engine between 1,100 and 1,300 rpm by manual operation of the differential lever. Do not overspeed the engine.
7. Check the gap between the low-speed spring cap and the high-speed spring plunger with a feeler gage (Fig. 2). The gap should be .002"-.004". If the gap setting is incorrect, reset the gap adjusting screw.
8. On governors without the starting aid screw, hold the gap adjusting screw and tighten the locknut.
9. Recheck the gap with the engine operating between 1,100 and 1,300 rpm and readjust, if necessary.

Current governors include a starting aid screw threaded into the governor gap adjusting screw. A locknut is not required as both screws incorporate a nylon patch in lieu of locknuts.

10. Stop the engine.
11. If a starting aid screw is used, adjust it after the injector rack control levers are positioned.

Position Injector Rack Control Levers

The position of the injector racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

Properly positioned injector rack control levers (with the engine at full load) will result in the following:

1. Speed control lever at the *full-fuel* position.

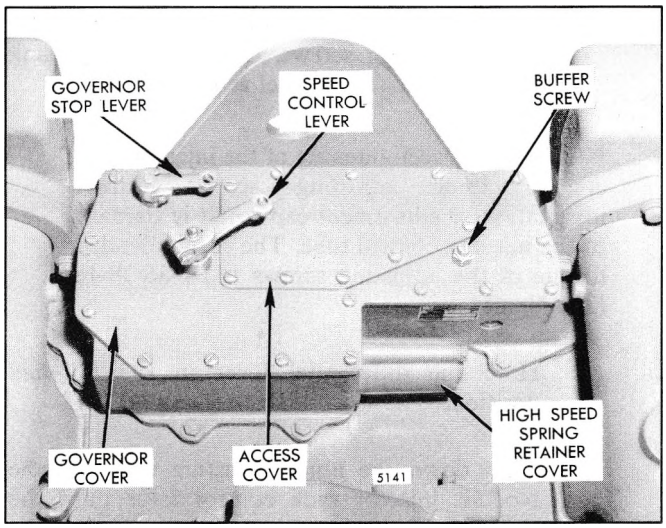


Fig. 1 - Limiting Speed Governor Mounting

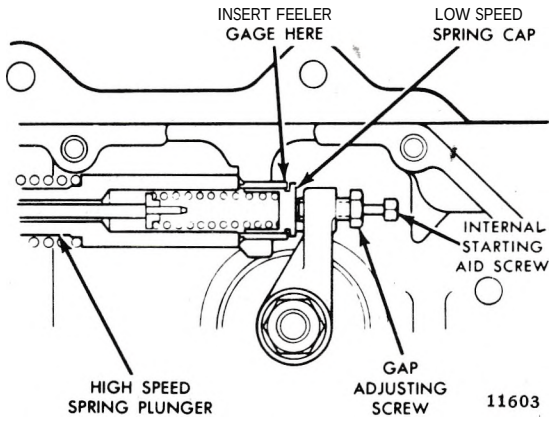


Fig. 2 - Governor Gap Adjustment

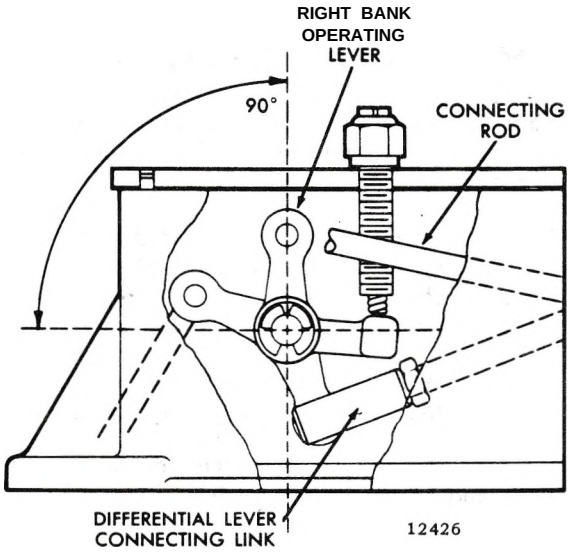


Fig. 3 - Operating Lever in Position (Current Governor)

2. Governor low-speed gap closed.

3. Fligh-speed spring plunger on the seat in the governor control housing.

4. Injector fuel control racks in the *full-fuel* position.

The letters “R” and “L” indicate the injector location in the right or left cylinder bank as viewed from the rear of the engine. The cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the No. 1L and No. 1R injector rack control levers first to establish a guide for adjusting the remaining injector rack control levers.

The injectors incorporate an “injector rack stop”. The stop limits the travel of the injector rack and has been preset at the factory. *Under no circumstances should the injector stop setting be altered.*

1. Adjust the current idle speed adjusting set screw or the former idle speed adjusting screw until 1/2" of the threads (12-14 threads) project from the locknut when the nut is against the high-speed spring plunger. A false full-fuel rack setting may result if the idle speed adjusting screw is not backed out, as noted above.

2. Clean and remove the valve rocker covers. Discard the gaskets.

3. Loosen all of the inner and outer injector rack control lever adjusting screws or adjusting screws and locknuts. Be sure all of the injector rack control levers are free on the injector control tubes.

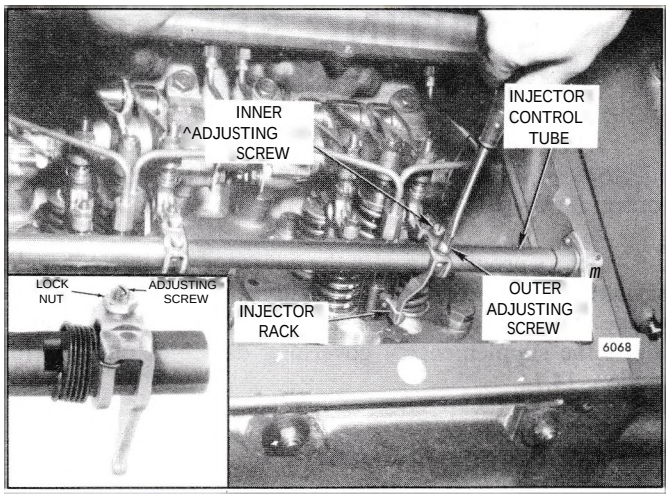


Fig. 4 - Positioning No. 1 Injector Rack Control Lever

4. **On current governors,** position the right bank operating lever (Fig. 3) with the arm that carries the connecting rod in the vertical position. Then, set the No. 1R and No. 1L injector rack control levers, as follows:

Two Screw Assembly (Former)

a. With the fuel rod on the left bank injector control tube disconnected and the fuel rod on the right bank injector control tube connected, turn down the outer adjusting screw (Fig. 4) of the No. 1R injector control lever until the ball-end of the lever is just snug against the injector rack (with the rack in the *no-fuel* position).

b. Turn down the inner adjusting screw until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screws. Connect the left bank injector control tube fuel rod.

s

NOTICE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24—36 **lb-in** (3-4 N-m).

c. Hold the differential lever in the *full-fuel* position.

d. Turn down the inner adjusting screw in the No. 1L injector rack control lever until the ball-end of the lever is just snug against the injector rack.

 © Detroit Diesel Corporation

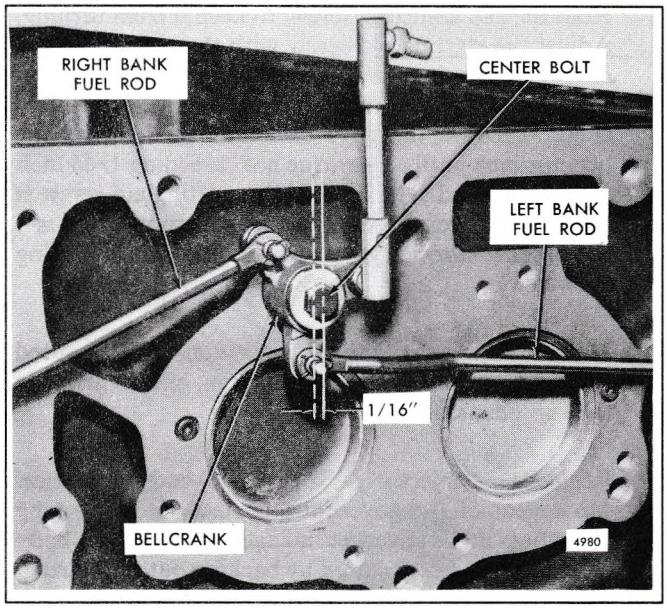


Fig. 5 - Bellcrank in Position (Former Governor)

e. Turn down the outer adjusting screw until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screws.

One Screw and Locknut Assembly (Current)

a. With the fuel rod on the left bank injector control tube disconnected and the fuel rod on the right bank injector control tube connected, tighten the adjusting screw (Fig. 4) of the No. 1R injector control lever until the ball-end of the lever is just snug against the injector rack (with the rack in the *no-fuel* position).

b. Securely lock the adjusting screw locknut. Connect the left bank injector control tube fuel rod.

NOTICE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24—36 **lb-in** (3-4 N-m).

c. Hold the differential lever in the *full-fuel* position.

d. Tighten the adjusting screw in the No. 1L injector rack control lever until the ball-end of the lever is just snug against the injector rack.

e. Securely lock the adjusting screw locknut.

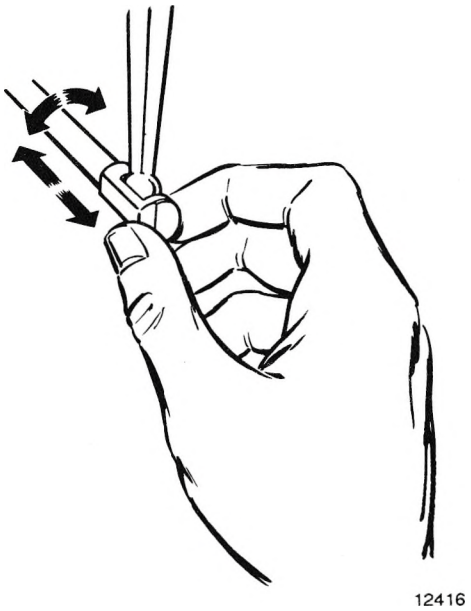


Fig. 6 - Checking Movement of Injector Control Rack

5. On former governors, position the elongated pin in the bellcrank — the pin which carries the left bank fuel rod — so that it lines up with the center bolt of the bellcrank from vertical to approximately 1/16" off center toward the right cylinder bank (Fig. 5).

a. With the fuel rod on the right bank injector control tube disconnected and the fuel rod on the left bank injector control tube connected, turn down the outer adjusting screw (Fig. 4) of the No. 1L injector control lever until the ball-end of the lever is just snug against the injector rack (with the rack in the *no-fuel* position).

b. Turn down the inner adjusting screw until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screws. Install the right bank fuel rod.

c. Hold the terminal lever in the *full-fuel* position. Refer to Section 2.7.1. *

d. Turn down the inner adjusting screw in the No. 1R injector control tube lever until the ball—and of the lever is just snug against the injector rack.

e. Turn down the outer adjusting screw until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screws to 24—36 **lb-in** (3-4 N • m) torque.

6. Balance the No. IRandNo. 1L injector control rack levers by grasping each rack (No. IRandNo. 1L — one at a time) with the thumb and index finger and, using a push-pull rotating motion (Fig. 6) , note the amount of movement of each injector control rack. If the movement is the same between the No. 1R and No. 1L injector control racks, the two levers are in adjustment. On former governors, if the movement is not the same between the two racks, loosen either the inner or outer adjusting screw of the No. 1R control rack lever and adjust the lever until the two racks are balanced. On current governors, loosen either the inner or outer adjusting screw (Two Screw Assembly) or turn the adjusting screw (One Screw and Locknut Assembly) of the No. 1L control rack lever and adjust the lever until the two racks are balanced.

Never alter the setting of the No. 1L injector rack control lever (former governors) or the No. 1R injector rack control lever (current governors) after they have been initially set.

7. Set the remaining control rack levers in the same manner as described in Steps “4d” or “5d”, using the No. 1R and No. 1L injector rack control levers as a guide for each respective bank. Use a spring of suitable length to fasten each control tube in the *full-fuel* position.

Once the No. 1 injector rack control lever on each bank has been set (either former or current governors), do not alter their settings. All further adjustments are made on the remaining injector control racks.

Adjust Starting Aid Screw

The starting aid screw (Figs. 2 and 7) is threaded into the governor gap adjusting screw. This screw is adjusted to position the injector racks at less than full fuel when the governor speed control lever is in the *idle* position.

The reduced fuel makes starting easier and reduces the amount of smoke on start-up.

The effectiveness of the starting aid screw will be eliminated if the speed control lever is advanced to wide open throttle during starting.

After the normal governor *running* gap of .0015" has been set and the injector racks positioned, adjust the starting aid screw, as follows:

1. Provide a cutaway cover to adjust the starting aid screw (Fig. 7).

2. With the engine *stopped*, place the governor stop lever in the *run* position and move the speed control lever to the *idle* position.

3. Hold the gap adjusting screw, to keep it from turning. Adjust the starting aid screw with the proper gage to obtain the required clearance between the shoulder on the No. 1L injector rack clevis and the injector body (Fig. 7). Move the gage back and forth along the injector rack until a clearance not exceeding 1/64 inch (.016") is noted. The head of the starting aid screw is against the governor wall (current governor) or against the bracket (former governor equipped with starting aid screw).

4. Move the stop lever to the *stop* position, with the speed control lever still in the *idle* position, and return it to the *run* position.

5. Recheck the injector rack clevis-to-body clearance. Movement of the governor stop lever is to take-up clearances in the governor linkage. The clevis-to-body clearance can be increased by backing out the starting aid screw or reduced by turning it farther into the gap adjusting screw.

CAUTION: Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assembly, the technician must determine that the injector racks move to the *no-fuel* position when the governor stop lever is placed in the *stop* position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever. An overspeeding engine can result in engine damage which could cause personal injury.

6. Start the engine and recheck the *running* gap (.0015") and, if necessary, reset it. Then, stop the engine.

Adjust Differential Lever Connecting Link

If necessary, pre-adjust the differential * lever connecting link by positioning the ball joints on the link to have 6 13/16" between the inside ends of the ball joints, thus obtaining an approximate link setting.

1. Remove cutaway governor cover.

2. Use a new gasket and install the governor cover (access cover removed).

3. Back off the idle speed adjusting screw.

 © Detroit Diesel Corporation

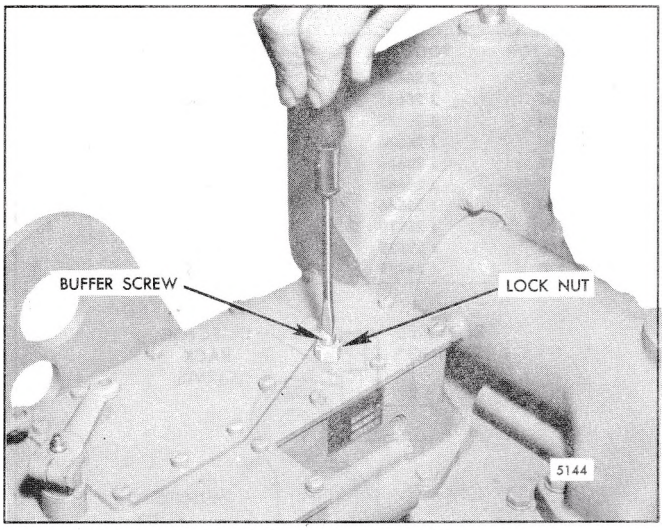


Fig. 10 – Adjusting Buffer Screw

Adjust Maximum No-Load Speed

All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced, and to ensure the engine speed will not exceed the recommended no-load speed as given on the engine option label, the maximum no-load speed may be set, as follows:

Be sure the buffer screw projects 5/8" from the locknut to prevent interference while adjusting the maximum no-load speed.

1. Loosen the spring retainer locknut (Fig. 8) and back off the high-speed spring retainer, if necessary, so that a minimum of 3/8" of the threads on the retainer extend beyond the locknut.
2. With the engine running at operating temperature and no load, place the speed control lever in the *maximum* speed position. Turn the high-speed spring retainer until the engine is operating at the recommended no-load speed.
3. Hold the high-speed spring retainer and tighten the locknut.

Adjust Idle Speed

Adjust the engine idle speed, as follows:

1. With the engine running at normal operating temperature and with the buffer screw backed out to avoid contact with the differential lever, turn the former idle speed adjusting screw (Fig. 9) or the current idle speed adjusting set screw until the engine is operating at approximately 15 rpm below the recommended idle speed. The recommended idle speed is 550-750 rpm (current engines) or 450-550 rpm (former engines), but may vary with special engine applications.

The increased idle speed of current engines results from the use of lighter low-speed governor weights in the current governor.

It may be necessary to use the buffer screw to eliminate engine roll. Back out the buffer screw, after the engine idle speed is established, to the previous setting (5/8").

2. Hold the current set screw or the former idle speed adjusting screw and tighten the locknut.
3. Install the high-speed spring retainer cover.

Adjust Buffer Screw

With the idle speed properly set, adjust the buffer screw, as follows:

1. With the engine running at normal operating temperature, *turn the buffer screw (Fig. 10) IN* so that it contacts the right bank operating lever as lightly as possible and still eliminates engine roll. Do not increase the engine idle speed more than 15 rpm with the buffer screw.
2. Recheck the maximum no-load speed. If it has increased more than 25 rpm, back off the buffer screw until the increase is less than 25 rpm.
3. Hold the buffer screw and tighten the locknut.

*

 © Detroit Diesel Corporation

VARIABLE SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor and position the injector rack control levers.

Before proceeding with the governor and injector rack adjustments, disconnect any supplementary governing device. After the adjustments are completed, reconnect and adjust the supplementary governing device, as outlined in Section 14.14.

Adjust Governor Gap

With the engine stopped and at normal operating temperature, set the governor gap, as follows:

1. Disconnect any linkage attached to the governor stop lever.
2. Back out the buffer screw until it extends approximately 5/8" from the locknut.
3. Clean and remove the governor cover (Fig. 1), including the stop lever bracket (current engines). Discard the gasket.
4. Place the speed control lever in the *maximum speed* position.
5. Insert a .006" feeler gage between the spring plunger and the plunger guide (Fig. 2). If required, loosen the locknut and turn the adjusting screw until a slight drag is noted on the feeler gage.
6. Hold the adjusting screw and tighten the locknut. Check the gap again and, if necessary, readjust.

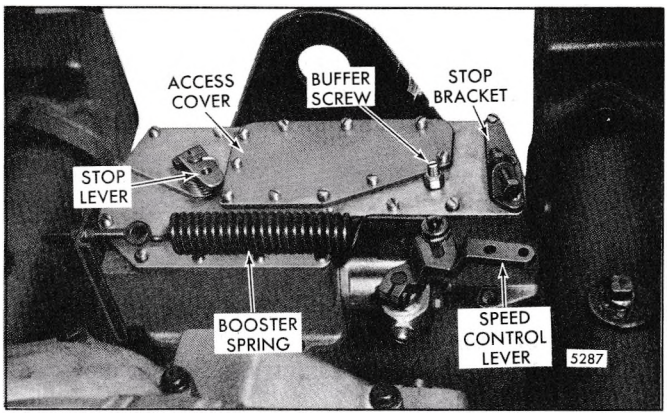


Fig. 1 - Variable Speed Governor Mounting

Position Injector Rack Control Levers

The position of the injector control rack levers must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

Properly positioned injector rack control levers, with the engine at full load, will result in the following:

1. Speed control lever at the *full-fuel* position.
2. Stop lever in the *run* position.
3. Variable speed spring plunger within .005" to .007" of its seat in the governor control housing.
4. Injector fuel control racks in the *full-fuel* position.

The letters “R” and “L” indicate the injector location in the right or left cylinder bank, viewed from the rear of the engine. The cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the No. 1L and No. 1R injector rack control levers first to establish a guide for adjusting the remaining control levers.

The injectors incorporate an “injector rack stop”. The stop limits the travel of the injector rack and has been preset at the factory. *Under no circumstances should the injector stop setting be altered.* Refer to Section 2.1,1.

1. Clean and remove the valve rocker covers and discard the gaskets.

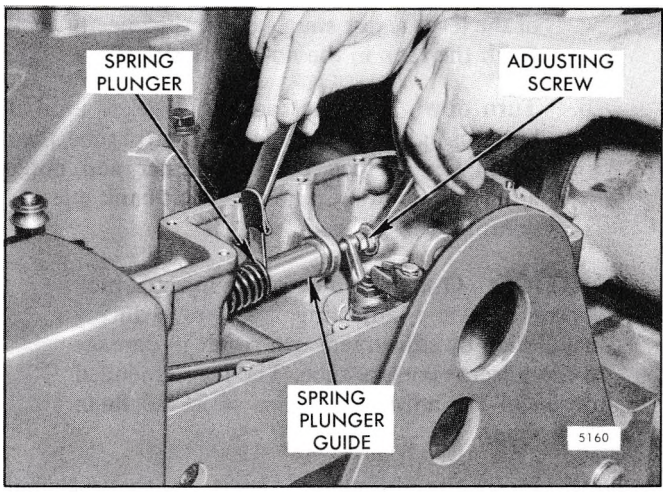


Fig. 2 – Adjusting Governor Gap

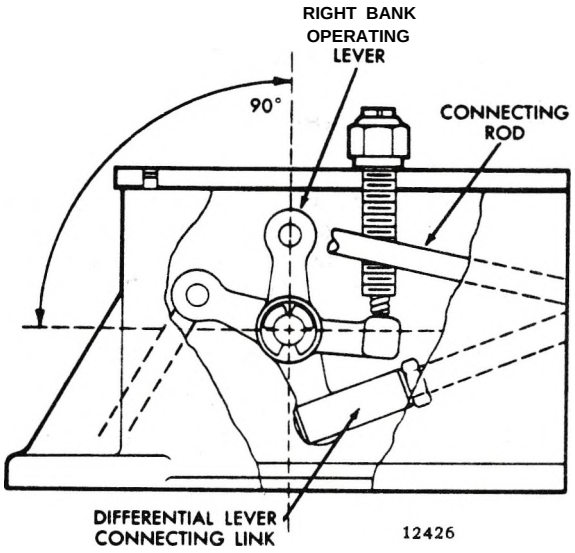


Fig. 3 - Operating Lever in Position (Current)

2. Loosen all of the inner and outer injector rack control lever adjusting screws or adjusting screws and locknuts. Be sure all of the injector rack control levers are free on the injector control tubes.

3. **On current governors,** with the governor cover removed, position the right bank operating lever (Fig. 3) with the arm that carries the connecting rod in the vertical position. Then set the No. 1R injector control lever in the *no-fuel* position, as follows:

Two Screw Assembly

a. With the fuel rod on the left bank injector control tube disconnected and the fuel rod on the right bank injector control tube connected, turn down the outer adjusting screw (Fig. 4) of the No. 1R injector control lever until the ball-end of the lever is just snug against the injector rack (with the rack in the *no-fuel* position).

b. Turn down the inner adjusting screw until it bottoms lightly on the injector control tube, then alternately tighten both the inner and outer adjusting screws. Connect the left bank injector control tube fuel rod.

NOTICE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 N-m).

c. Hold the differential lever in the *full-fuel* position.

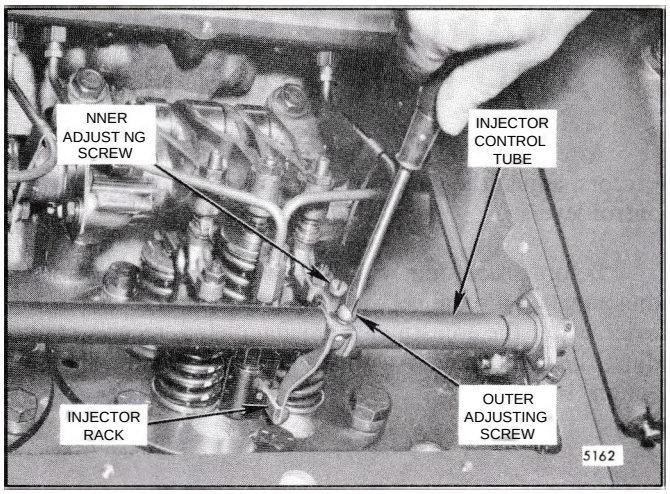


Fig. 4 - Positioning No. 1 Injector Rack Control Lever

d. Turn down the inner adjusting screw in the No. 1L injector control lever until the ball-end of the lever is just snug against the injector rack.

e. Turn down the outer adjusting screw until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screws.

One Screw and Locknut Assembly

a. With the fuel rod on the left bank injector control tube disconnected and the fuel rod on the right bank injector control tube connected, tighten the adjusting screw (Fig. 4) of the No. 1R injector control lever until the ball-end of the lever is just snug against the injector rack (with the rack in the *no-fuel* position).

b. Securely lock the adjusting screw locknut. Connect the left bank injector control tube fuel rod.

NOTICE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 N-m).

c. Hold the differential lever in the *full-fuel* position.

d. Tighten the adjusting screw in the No. 1L injector control lever until the ball-end of the lever is just snug against the injector rack.

e. Securely lock the adjusting screw locknut.

 © Detroit Diesei Corporation

4. On former governors, position the elongated pin in the bellcrank (the pin which carries the left bank fuel rod) so that it lines up with the center bolt of the bellcrank from vertical to approximately 1/16" off center toward the right cylinder bank (Fig. 5). Then, set the No. 1L injector in the *no-fuel* position, as follows (Fig. 4):

   a. With the fuel rod on the right bank injector control tube disconnected and the fuel rod on the left bank injector control tube connected, turn down the outer adjusting screw on the No. 1L injector control lever until the ball-end of the lever is just snug against the injector rack.

   b. Turn down the inner adjusting screw until it bottoms lightly on the injector control tube, then alternately tighten both the inner and outer adjusting screws. Connect the right bank fuel rod.

   c. Hold the terminal lever (Fig. 3, Section 2.7.2) in the *full-fuel* position.

   d. Turn down the inner adjusting screw in the No. 1R injector control lever until the ball-end of the lever is just snug against the injector rack.

   e. Turn down the outer adjusting screw until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screws to 24-36 lb-in (3-4 N • m) torque.

5. Balance the No. IRandNo. 1L injector rack control levers by grasping each rack (No. 1R and 1L — one at a time) with the thumb and index finger and, using a push-pull rotating motion (Fig. 6), note the amount of movement of each injector control rack. If the movement is the same between the No. 1R and No. 1L injector control racks, the two control levers are in adjustment. On former governors, if the movement is not the same between the two racks, loosen either the inner or outer adjusting screw of the No. 1R rack control lever and adjust the lever until the two racks are balanced. On current governors, loosen either the inner or outer adjusting screw (Two Screw Assembly) or turn the adjusting screw (One Screw and Locknut Assembly) of the No. 1L control rack lever and adjust the lever until the two racks are balanced. Never alter the setting of the No. 1L injector rack control lever (former governors) or the No. 1R injector rack control lever (current governors) after they have been initally set.

6. Set the remaining rack control levers in the same manner as described in Steps “3d” or “4d”, using the No. IRandNo. 1L injector rack control levers as a guide for each respective bank. Use a spring of suitable length and fasten each control tube in the *full-fuel* position.

Once the No. 1 injector rack control lever on each bank has been set (either former or current governors), do not alter their settings. All further adjustments are made on the remaining control racks.

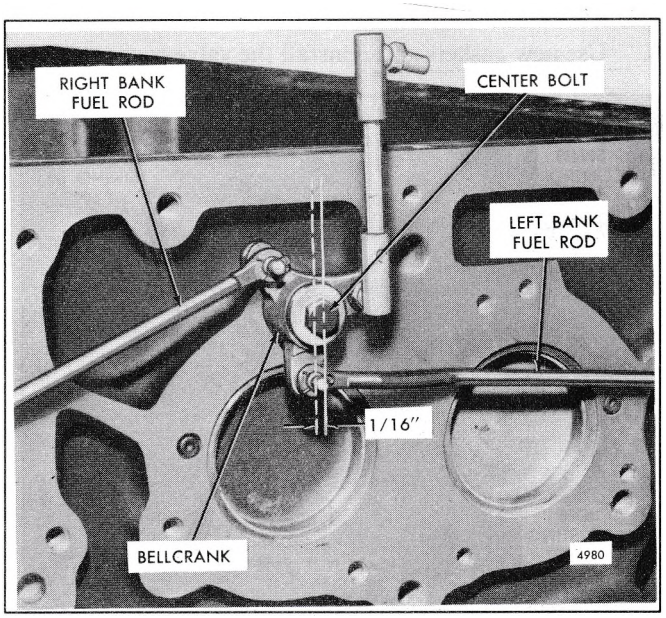


Fig. 5 - Bellcrank in Position (Former)

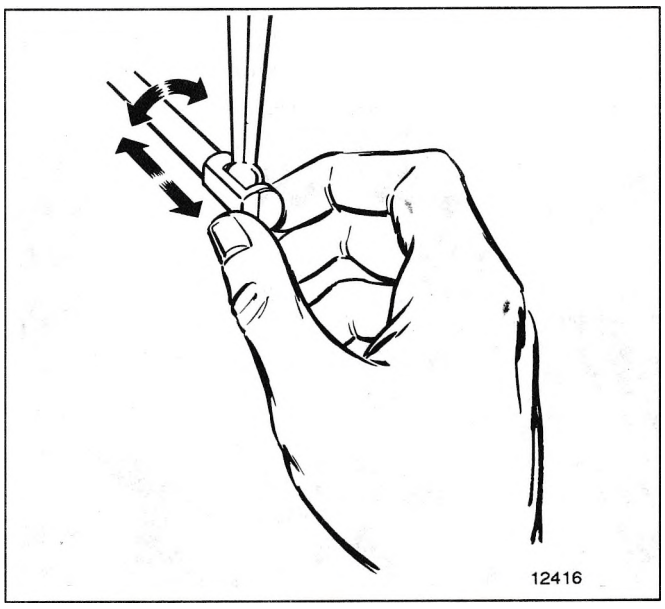


Fig. 6 - Checking Movement of Injector Control Rack

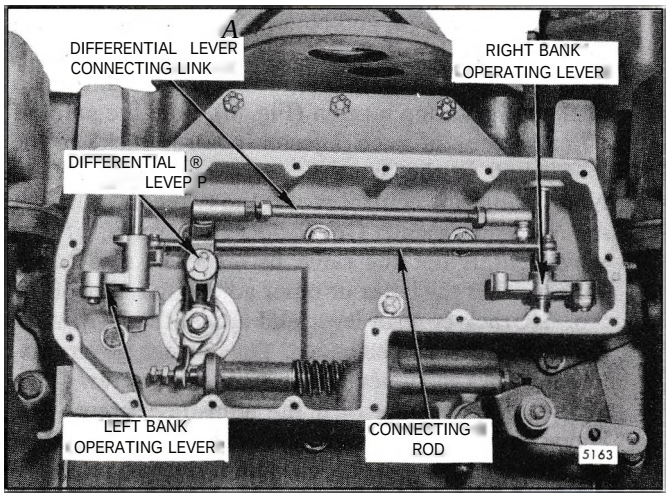


Fig. 7 - Variable Speed Governor with Cover Removed (Solid Connecting Link)

Adjust Differential Lever Connecting Link

If necessary, pre-adjust the differential lever connecting links by positioning the ball joints on the link to have 6 13/16" between the inner ends of the ball joints, thus obtaining an approximate link setting.

1. Use a new gasket and install the governor cover (access cover removed) and speed control stop bracket. Be sure the stop bolt is turned in far enough so that it will not interfere with the *full-speed* position of the speed control lever. The stop lever spring must be disconnected.

2. On governors with a connecting yield (spring) link (Fig. 8), hold the stop lever in its *run* position and move the speed control lever to full speed. Then, adjust the link until it just starts to compress. Lock the link in this position. On governors with a solid connecting link, hold the stop lever in the *run* position and adjust the differential lever connecting link (Fig. 7) until there is no step-up in effort when moving to the *run* position. Lock the link in this position.

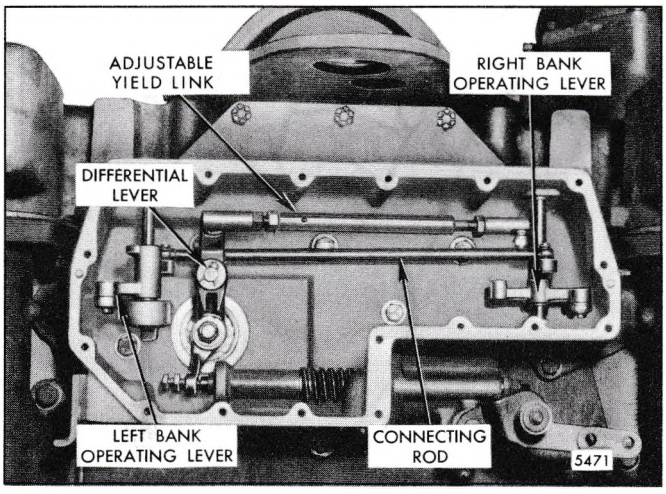


Fig. 8 - Variable Speed Governor with Cover Removed (Adjustable Yield Link)

A short yield link will cause a low power condition because the injector rack cannot reach the *full-speed* position. A long yeild link will result in not being able to reach the *no-speed* position with the stop lever.

3. Check the differential lever connecting link, to see that all governor and injector control linkage is tight, by moving the stop lever to the *run* position and noticing a very slight return of the stop lever when released.

4. Check for any bind in the governor-to-control tube linkage by moving the linkage through its full range of travel with one hand on the stop lever and the other hand on one of the control tube levers.

5. With the speed control lever at the *maximum speed* position and the stop lever in the *run* position, be sure that all of the injector rack control levers are in the *full-fuel* position.

CAUTION: Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assembly, the technician must determine that the injector racks move to the *no-fuel* position when the governor stop lever is placed in the *stop* position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever. An overspeeding engine can result in engine damage which could cause personal injury.

6. Use new gaskets and reinstall the valve rocker covers.

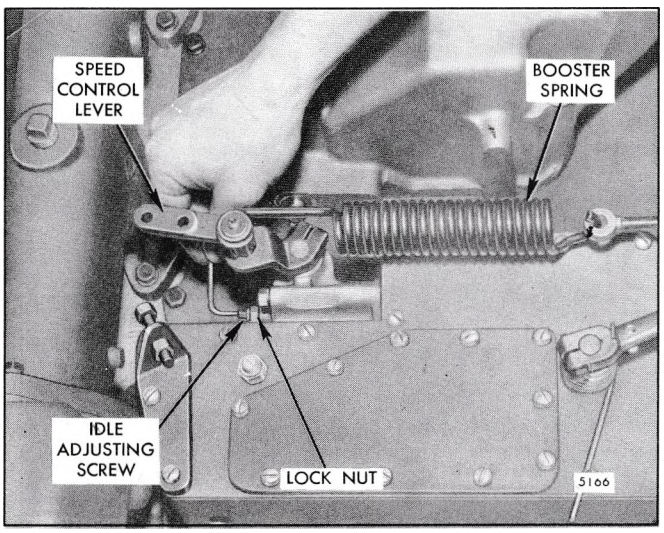


Fig. 9 - Adjusting Idle Speed

 © Detroit Diesel Corporation

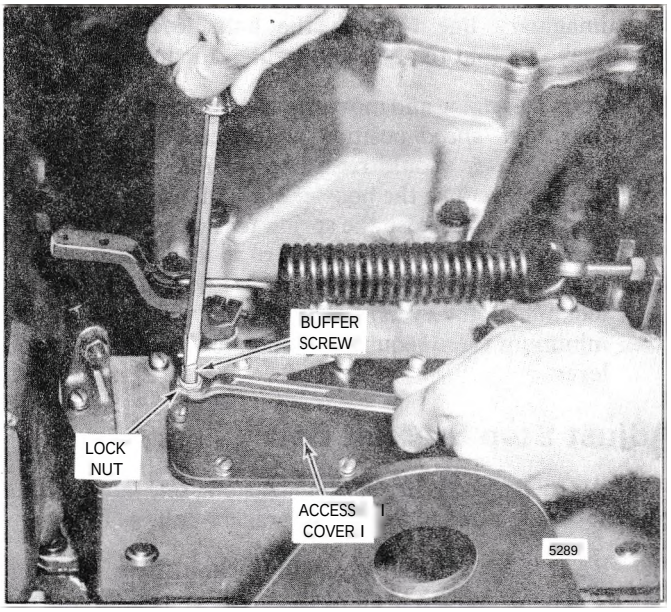


Fig. 10 - Adjusting Buffer Screw

Adjust Maximum No-Load Speed

Disconnect any linkage (throttle actuator) attached to the speed control lever.

All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced, and to ensure the engine speed will not exceed the recommended no-load speed as given on the engine option plate, the maximum no-load speed may be set, as follows:

Be sure the buffer screw projects 5/8" from the locknut to prevent interference while adjusting the maximum no-load speed.

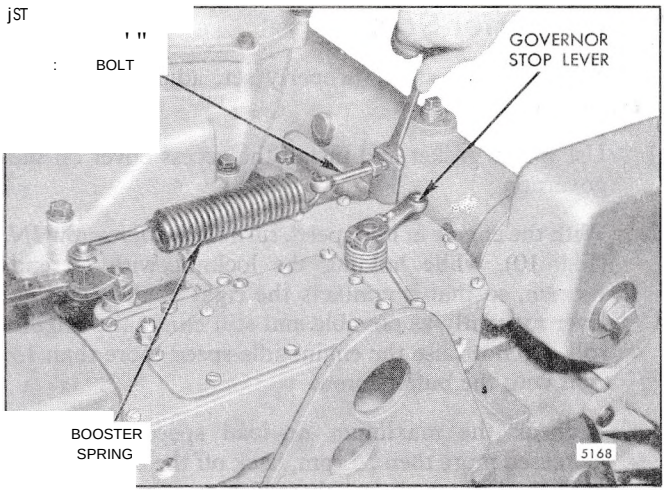
Use an accurate tachometer and determine the maximum no-load speed of the engine. Then, make the following adjustments, if required:

1. Disconnect the booster spring.

2. Remove the two bolts and withdraw the variable speed spring housing from the governor housing.

3. Set the recommended maximum no-load speed by adding or removing shims, as required.

4. Install the variable speed spring housing and recheck the maximum no-load speed.



S-ig. 1 1 - Adjusting Booster Spring

Adjust idle **Speed**

With the maximum no-load speed properly adjusted, adjust the idle speed, as follows:

1. Place the stop lever in the *run* position and the speed control lever in the *idle* position.

2. With the engine running at normal operating temperature, loosen the locknut and turn the idle speed adjusting screw (Fig. 9) until the engine is operating at approximately 15 rpm below the recommended idle speed. The recommended idle speed is 550 rpm, but may vary with special engine applications.

3. Hold the idle speed adjusting screw and tighten the locknut.

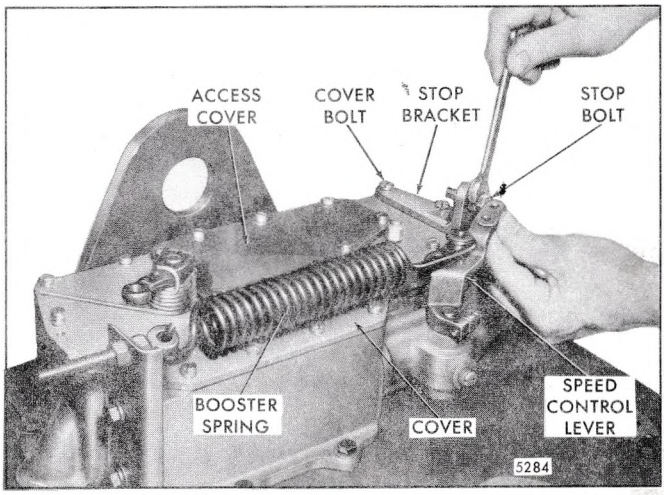


Fig. 1 2 - Adjusting Stop Bracket Bolt

Adjust Buffer Screw

With the idle speed properly set, adjust the buffer screw, as follows:

1. Use a new gasket and install the access cover on the governor.
2. With the engine at idle speed, *turn the buffer screw IN* (Fig. 10), while holding the locknut with an end wrench, so that it contacts the right bank operating lever as lightly as possible and still eliminates engine roll. Do not raise the engine idle speed more than 15 rpm with the buffer screw.
3. Recheck the maximum no-load speed. If it has increased more then 25 rpm, back off the buffer screw until the increase is less then 25 rpm.
4. Hold the buffer screw and tighten the locknut.

Adjust Booster Spring

With the engine idle speed set, adjust the booster spring, as follows:

1. Move the speed control lever to the *idle* speed position.
2. Refer to Fig. 11 and loosen the booster spring retaining nut on the speed control lever. Loosen the locknuts on the bolt at the opposite end of the spring.
3. Move the spring retaining bolt in the slot of the speed control lever until the center of the bolt is on or slightly over center (toward the *idle speed* position) of an imaginary line through the bolt, lever shaft and eyebolt. Hold the bolt and tighten the locknut.
4. Start the engine and move the speed control lever to the *maximum speed* position and release it. The speed control lever should return to the *idle* position. If it does not, reduce the booster spring tension; if it does, continue to increase the spring tension until the point is reached that it will not return to idle. Then, reduce the tension until it does return to idle and tighten the locknut on the eyebolt. This setting will result in the minimum force required to operate the speed control lever.

Adjust Stop Bracket Bolt

With the booster spring tension set, adjust the governor speed control lever stop bracket bolt, as follows:

1. Refer to Fig. 12 and loosen the locknut. Turn the stop bolt in far enough to allow the speed control lever to be held in its *full-speed* position.
2. Operate the engine at the maximum no-load speed.
3. Hold the speed control lever in the *full-speed* position. Set the stop bolt so that the head of the stop bolt moves the speed control lever towards idle until the no-load speed is reduced 5 to 10 rpm.
4. Tighten the locknut to hold the setting.

If the governor is equipped with a starting aid system, adjust the components as outlined in Section 14.14.

 © Detroit Diesel Corporation

HYDRAULIC GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT



Fig. 1 - Throttle Delay Yield Link Assembly

Adjust the governor and the injector rack control levers after adjusting the exhaust valve clearance and timing the injectors.

Effective with engines built April 1, 1980 a throttle delay yield link assembly (Fig. 1) replaces the vertical link assembly, for those applications where a throttle delay mechanism is used in conjunction with the hydraulic governor (refer to Section 14.14).

Adjust Governor Linkage And Position Injector Rack Control Levers

1. Clean and remove the valve rocker cover from each cylinder bank.
2. Loosen all of the inner and outer injector rack control lever adjusting screws or loosen all of the adjusting screws and locknuts. Be sure all of the control levers are free on the injector control tubes.
3. Disconnect the yield link assembly or vertical link assembly from the governor operating lever (Fig. 2).

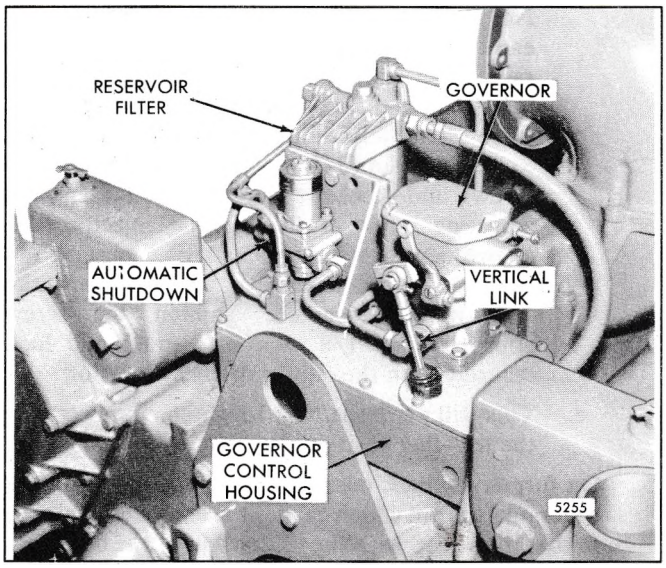


Fig. 2 - Hydraulic Governor Mounting and Linkage (Current with Vertical Link)

Do not remove the lever. On current engines, remove the small cover from the governor control housing and disconnect the yield link or vertical link from the left-bank operating lever (Fig. 3). On former engines, remove the small cover on top of the engine front cover and disconnect the vertical link from the bellcrank lever (Fig. 4).

The letters R and L indicate the injector location in the right or left cylinder bank, as viewed from the rear of the engine. The cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the No. 1L and No. 1R injector rack control levers first to establish a guide for adjusting the remaining levers.

The injectors incorporate an injector rack stop. The stop limits the travel of the injector rack and has been preset at the factory. *Under no circumstances should the injector stop setting be altered.*

4. **On current engines,** position the linkage setting gage J 23475-01 as shown in Fig. 5. This will place the left-bank operating lever in the correct *no-fuel* position.

The former gage J 23475 can only be used with current engines that have 120, 130, 140 or 150mm fuel injectors. Gage J 23475-01 can be used on engines equipped with any size fuel injector.

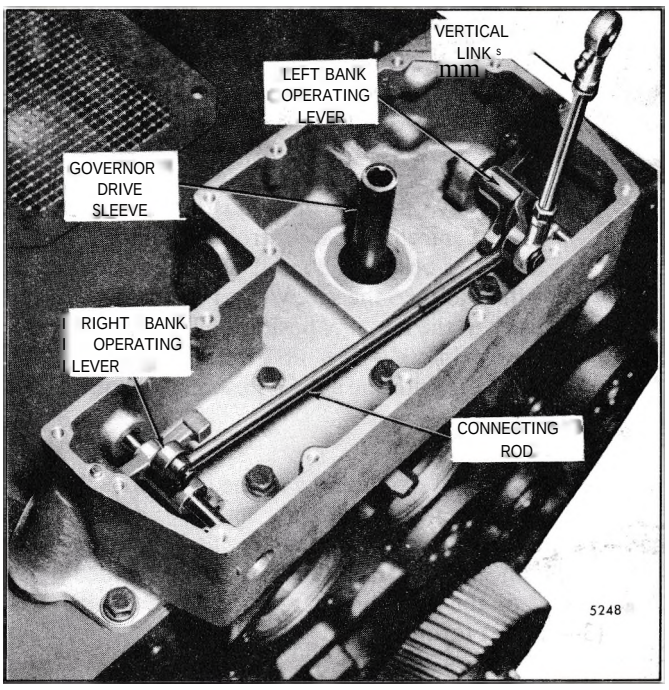


Fig. 3 - Governor Control Housing and Linkage (Current with Vertical Link)

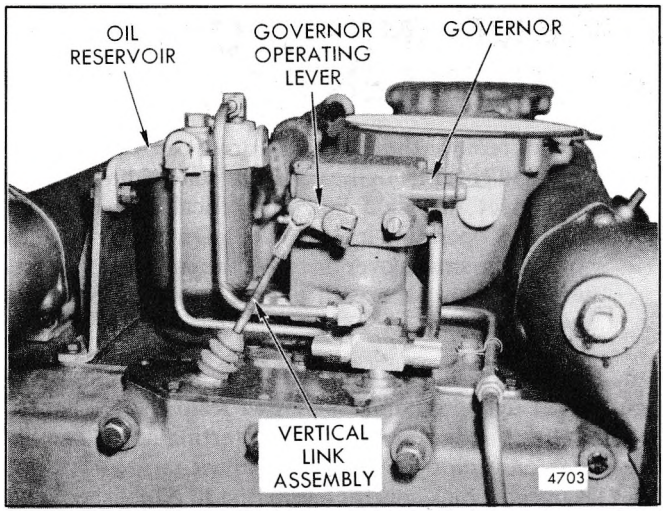


Fig. 4 - Hydraulic Governor Mounting and Linkage (Former with Vertical Link))

At the *no-fuel* position, the distance from the top of the main cover on the governor control housing to the center line of the bolt hole on the arm of the left-bank operating lever (which carries the yield link or vertical link) is 1.80".

Maintain the above dimension and set the No. 1L and No. 1R injector rack control levers, as follows:

a. With the fuel rod on the right-bank injector control tube removed and the fuel rod on the left-bank injector control tube installed, turn down the outer adjusting screw (two screw assembly) of the No. 1L injector rack control lever until the ball end of the lever is just snug against the injector rack (with the rack in the *no-fuel* position). Turn down the inner adjusting screw until it bottoms lightly on the injector control tube. Then alternately tighten both adjusting screws. On the one screw and locknut assembly, tighten the adjusting screw of the No. 1 injector rack control lever until the rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted (with the rack in the *no- fuel* position). Tighten the screw approximately 1/8 of a turn more and lock securely_with the adjusting screw locknut. Refer to Fig. 6,

NOTICE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24—36 **lb-in** (3—4 N-m) torque.

Remove the gage and install the right-banl{ injector control tube fuel rod.

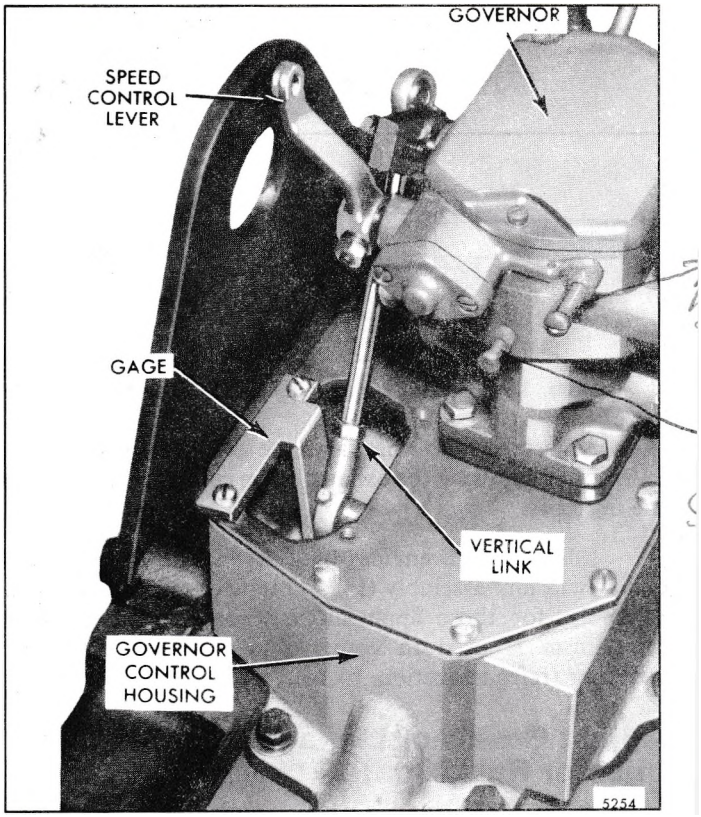


Fig. 5 Positioning of Current Governor Operating Link with Vertical Link (Gage J 23475-01)

c. Move the No. 1 left bank injector control lever to the full-fuel position by depressing the arm of the left-bank operating lever (which carries the yield link or vertical link).

Hold this position and turn dow-n the inner adjusting screw (two screw assembly) in the No. 1R injector rack control lever until the ball end of the lever is just snug against the injector rack. Turn down the outer adjusting screw until it bottoms lightly on the injector control tube. Then alternately tighten both adjusting screws to 24-36 **lb-in** (3—4 N-m) torque/On the one' screw and locknut assembly, ‘ tighten the adjusting screw of the No. 1R injector rack control lever until the rack clevis is observed to roll up or an increase in effort to {urn the screwdriver is noted. Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut.

e. This will place the No. 1 right-bank injector in the *full-fuel* position. '

5. **On former engines,** position the elongated pin in the bellcrank (the pin which carries the left-bank fuel rod) so that it lines up with the center bolt of the bellcrank ^ from vertical to approximately 1/16" off center toward the right cylinder bank (Fig. 7).

 © Detroit Diesel Corporation

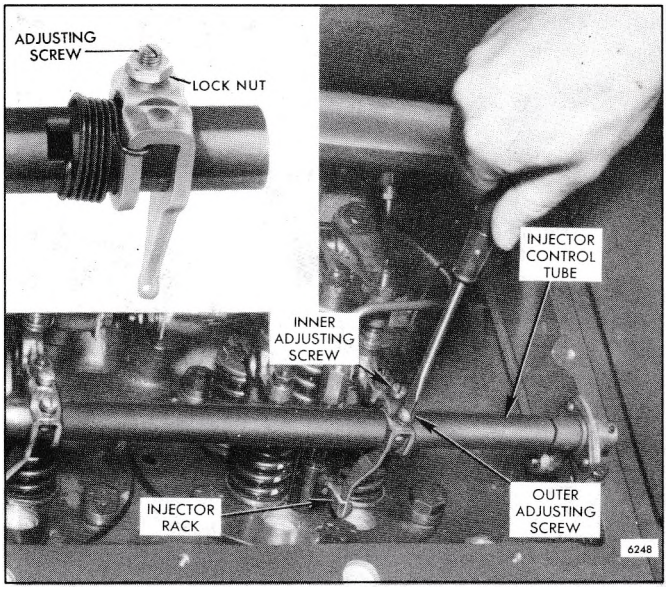


Fig. 6 - Positioning the No. 1 Injector Rack Control Lever

a. With the fuel rod on the right-bank injector control tube removed and the fuel rod on the left-bank injector control tube installed, turn down the outer adjusting screw of the No. 1L injector rack control lever until the ball end of the lever is just snug against the injector rack (with the rack in the no-fuel position). Refer to Fig- 5.

b. Turn down the inner adjusting screw until it bottoms lightly on the injector control tube. Then alternately tighten both adjusting screws. The recommended torque of the adjusting screws is 24-36 lb-in (3-4 N-m) torque.

c. Install the right-bank fuel rod.

d. Hold the bellcrank lever in the full-fuel position and turn down the inner adjusting screw in the No. 1R injector rack control lever until the ball end of the lever is just snug against the injector rack.

e. Turn down the outer adjusting screw until it bottoms lightly on the injector control tube. Then alternately tighten both adjusting screws to 24-36 lb-in (3^4 N-m) torque.

6. Check the adjustment of the No. 1L and No. 1R injector control racks in the full-fuel position by moving the left-bank operating lever (current) or the bellcrank (fofmer) and determine if the adjustment between the two injector control racks is equal.

   a. Grasp each injector control rack (one at a time) with the thumb and index finger and, using a push-pull rotating motion, note the amount of movement of each lever within the rack opening

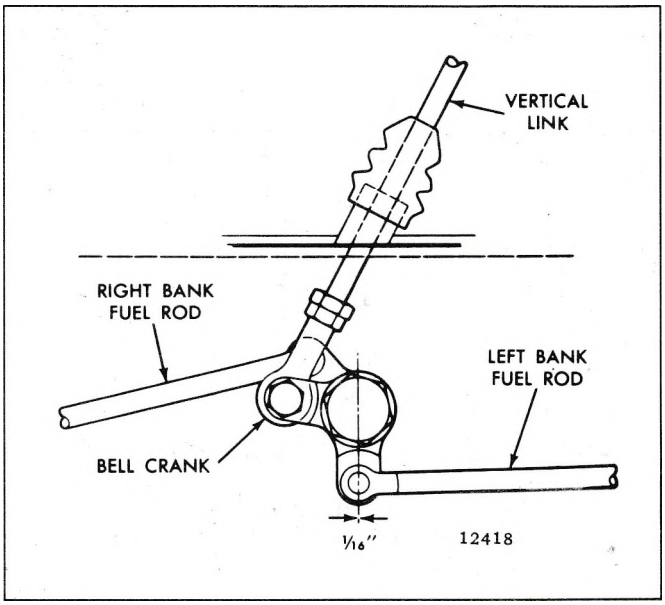
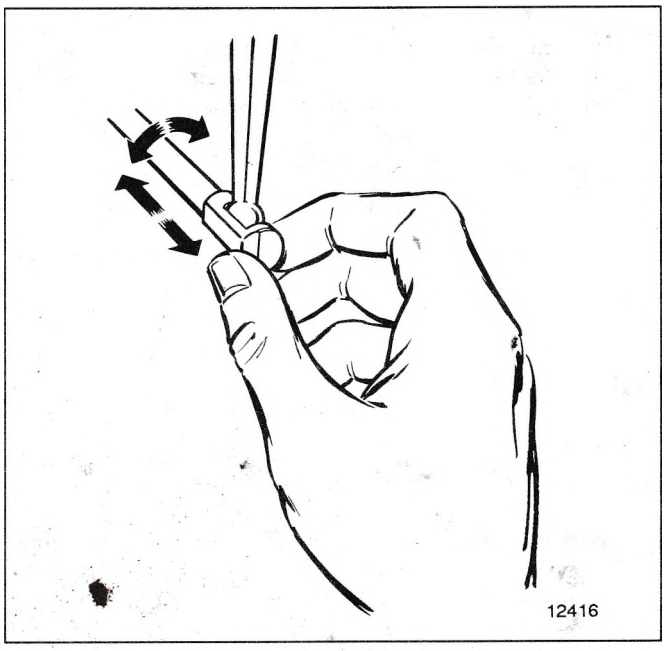


Fig. 7 - Positioning of the Bellcrank (Former Engines)

(Fig. 8). If the movement is the same for both, the two rack control levers are in adjustment. If the movement is not the same, loosen either the inner or outer adjusting screw (two screw assembly) of the No. 1R rack control lever and adjust the lever until both, the No. 1L and No. 1R levers are balanced, On the one screw and locknut assembly, loosen the locknut on the ; No. 1R rack control lever and turn the r adjusting screw clockwise or counterclockwise until both the No. 1L and No. 1R levers are balanced. Tighten the locknut securely.



8 – Checking Injector Rack Movement

Governor	Distance Between Center Lines of End Bearing Bolt Holes
SG (current)	7.00" (Approx.)
PSG	7.44" (Approx.)
SG (former)	8.88" (Approx.)

TABLE 1

Never alter the setting of the No. 1L injector rack control lever after it has once been set.

7. Set the remaining injector rack control levers, using he No. 1R and No. 1L control levers as a guide for each respective cylinder bank. Use a spring of suitable length to hold each injector control tube in the full-fuel position.

8. Remove the governor cover.

9. Adjust the load limit screw to obtain a distance of 2" from the outside face of the boss on the governor subcap to the end of the screw.

10. Position the governor operating lever on the shaft toward the left cylinder bank (on *current* engines) or toward the right cylinder bank (on *former* engines/so that the center of the bolt hole is approximately 5/16" above a horizontal line through the shaft (with the lever in the no-fuel position).

11. Refer to Table 1 and adjust the length of the yield link or vertical link so that the bolt holes of the levers and the rod end bearings are lined up with the governor lever and the injector racks are in the no-fuel position. Always install the throttle delay yield link of a Series 149 hydraulic governor with the yieldable end inside the governor control housing (Fig. 1). Positioned in this manner the yieldable end is protected from abrasives which can accelerate shaft wear.

12. Replace the two bolts in the levers and tighten the bolts.

Adjust Load Limit

With the injector rack control levers properly adjusted, set the load limit as follows:

1. With the governor cover removed and the load limit screw locknut loosened, move the governor operating lever toward the full-fuel position until the injector racks just reach the full-fuel position. Do not overstress the linkage.

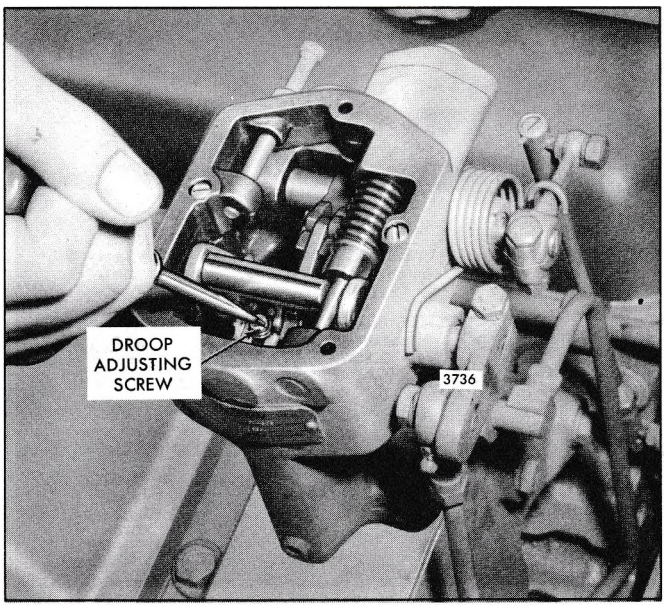


Fig. 9 - Adjusting Speed Droop

2. Turn the load limit adjusting screw inward until the injector racks just loosen on the ball ends of the control levers.

3. Release the governor operating lever and hold the load limit screw while tightening the locknut. Install the governor cover.

Adjust Governor Speed Droop

INTERNAL DROOP ADJUSTMENT

The purpose of adjusting the speed droop is to establish a definite engine speed at no load with a given speed at rated full load. The governor speed droop is set at the factory and further adjustment should be unnecessary.

However, if the governor has been overhauled, the speed droop must be readjusted.

If a full-rated load can be established on the engine, and the fuel rods, injector rack control levers and the load limit have been adjusted, set the speed droop as follows:*

1. Start the engine and run it at approximately one-half the rated no-load speed until the lubricating oil temperature stabilizes. When the engine lubricating oil is cold, the governor regulation may be erratic. Regulation will become increasingly stable as the temperature of the oil increases.

2. Stop the engine and remove the governor cover.

3. Loosen the locknut and back off the maximum speed adjusting screw approximately 5/8".

 © Detroit Diesel Corporation

4. Loosen the droop adjusting screw. Move the droop adjusting bracket so that the screw is midway between the ends of the slot in the bracket. Tighten the screw (Fig. 9).

5. With the throttle in the *run* position, adjust the engine speed until the engine is operating at 3% to 5% above the recommended full-load speed. Use an accurate tachometer to determine the engine speed.

6. Apply the full-rated load on the engine and readjust the engine speed to the correct full-load speed.

7. Remove the load and note the engine speed after the speed stabilizes under no load. If the speed droop is correct, the engine speed will be approximately 3% to *5%* higher than the full-load speed.

8. If the speed droop is too high, stop the engine, loosen the droop adjusting screw and move the adjusting bracket *in* toward the center of the governor. Tighten the adjusting screw. If the speed droop is too low, move the bracket *out*, away from the center of the governor.

The speed droop in governors which control engines driving generators in parallel must be identical, otherwise the electrical load will not be equally divided.

Adjust the speed droop bracket in each governor to obtain the desired variation between engine no-load and full-load speeds. The recommended speed droop for generator sets operating in parallel is 50 rpm (2-1/2 cycles) for units operating at 1000 or 1200 rpm and 75 rpm (2-1/2 cycles) for units operating at 1500 or 1800 rpm (Table 2).

However, this droop recommendation may be varied to suit the individual application.

EXTERNAL DROOP CONTROL

Some PSG type governors are equipped with an external adjustable droop control. This permits the speed droop to be adjusted without removing the governor cover. With this feature, a unit can be paralleled with another unit that is operating at constant frequency (zero droop). The incoming unit must have its droop bracket set in the maximum position while it is being paralleled and while operating in parallel. When it is desired to stop the unit operating at constant frequency, shift the load to the incoming unit and move the governor droop bracket to zero droop.

Fu 11 Load	No-Load
50 cycles 1000 rpm	52.5 cycles 1050 rpm
60 cycles 1200 rpm	62.5 cycles 1250 rpm
50 cycles 1500 rpm	52.5 cycles 1575 rpm
60 cycles 1800 rpm	62.5 cycles 1875 rpm

TABLE 2

Then, adjust the outgoing unit to maximum droop, remove it from the line and stop the engine. The incoming unit will now be carrying the load and operating at constant frequency (zero droop).

Adjust the governor speed droop as follows:

1. Start the engine and run it at approximately one-half of the rated full-load speed until the lubricating oil temperature stabilizes.

2. Remove the load from the engine.

3. Back off the compensation needle valve to release any air that may be trapped in the system. Turn the needle valve in slowly to reduce governor “hunting”. The correct needle valve setting will be between 1/8 and 1/2 turn open.

4. Back out the maximum droop setting screw.

5. Loosen the droop adjusting knob and move the slide all the way toward the minimum adjusting screw. Then tighten the knob.

6. Loosen the locknut on the maximum speed adjusting screw and turn the screw out until 5/8" of the threads are exposed.

7. With the engine operating at the recommended full-load speed, apply the full-rated load and recheck the engine speed If required, readjust the engine to full-load speed.

8. Remove the load and note the engine speech If the zero droop setting is correct, the engine speed will remain constant. If the engine speed is higher, loosen the droop adjusting knob and set the slider to a reduced droop position.

9. When the desired minimum droop setting is reached, turn the minimum droop setting screw inward until it contacts the droop linkage within the governor. This will be felt by a step-up of resistance while turning the adjusting screw. Lock the adjusting screw in this position.

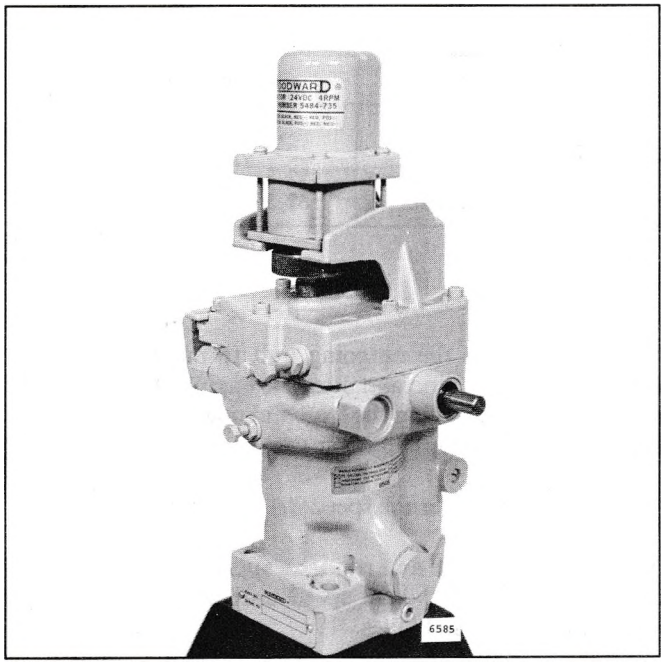


Fig. 10 - Typical Synchronizing Motor Mounting

10. Loosen the droop adjusting knob and slide the droop bracket in a direction to increase the droop. Perform Steps 7 and 8 to check the droop until the desired maximum speed droop is attained.

11. When the desired maximum droop setting is reached, loosen the locknut and turn the maximum droop setting screw inward until it contacts the droop slider arm. Lock the adjusting screw in this position.

12. Recheck the minimum and maximum droop setting as outlined in Steps 7 and 8 and adjust the adjustment screws, if necessary, until the correct settings are obtained.

Adjust Maximum No-Load Speed

With the speed droop properly adjusted, set the maximum no-load speed as follows:

1. With the engine operating.at no load, adjust the speed until the engine is operating at approximately 8% higher than the rated full-load speed.

2. Turn the maximum speed adjusting screw in until the screw contacts the throttle linkage internally, limiting the maximum speed of the engine at 8% above the rated full-load speed (Fig. 10).

3. Hold the screw and tighten the locknut.

Governors With Synchronizing Motor

Some hydraulic governors are equipped with a reversible electric synchronizing motor mounted on the governor cover (Fig. 10).

The adjustments are the same as on a governor without a motor. However, the governor cover and motor assembly must be removed when setting the engine speed droop (except on the PSG type governor equipped with an external droop adjustment). The cover and motor must be reinstalled to check the speed droop.

 © Detroit Diesel Corporation

HYDRAULIC **GOVERNOR**
(Pneumatically **Operated Isochronous Type)**

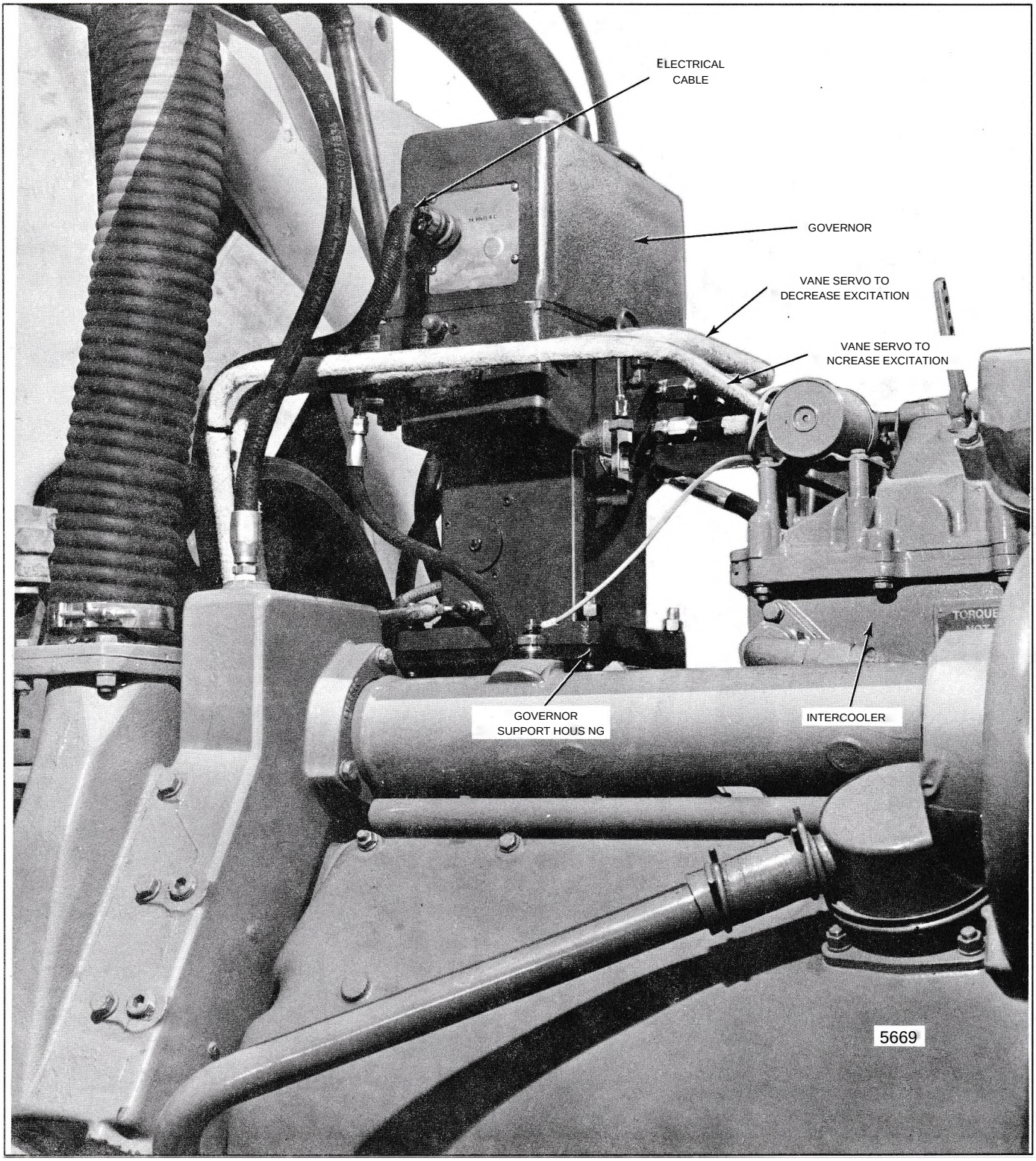


Fig. 1 - Hydraulic Governor Mounting

© Detroit Diesel Corporation

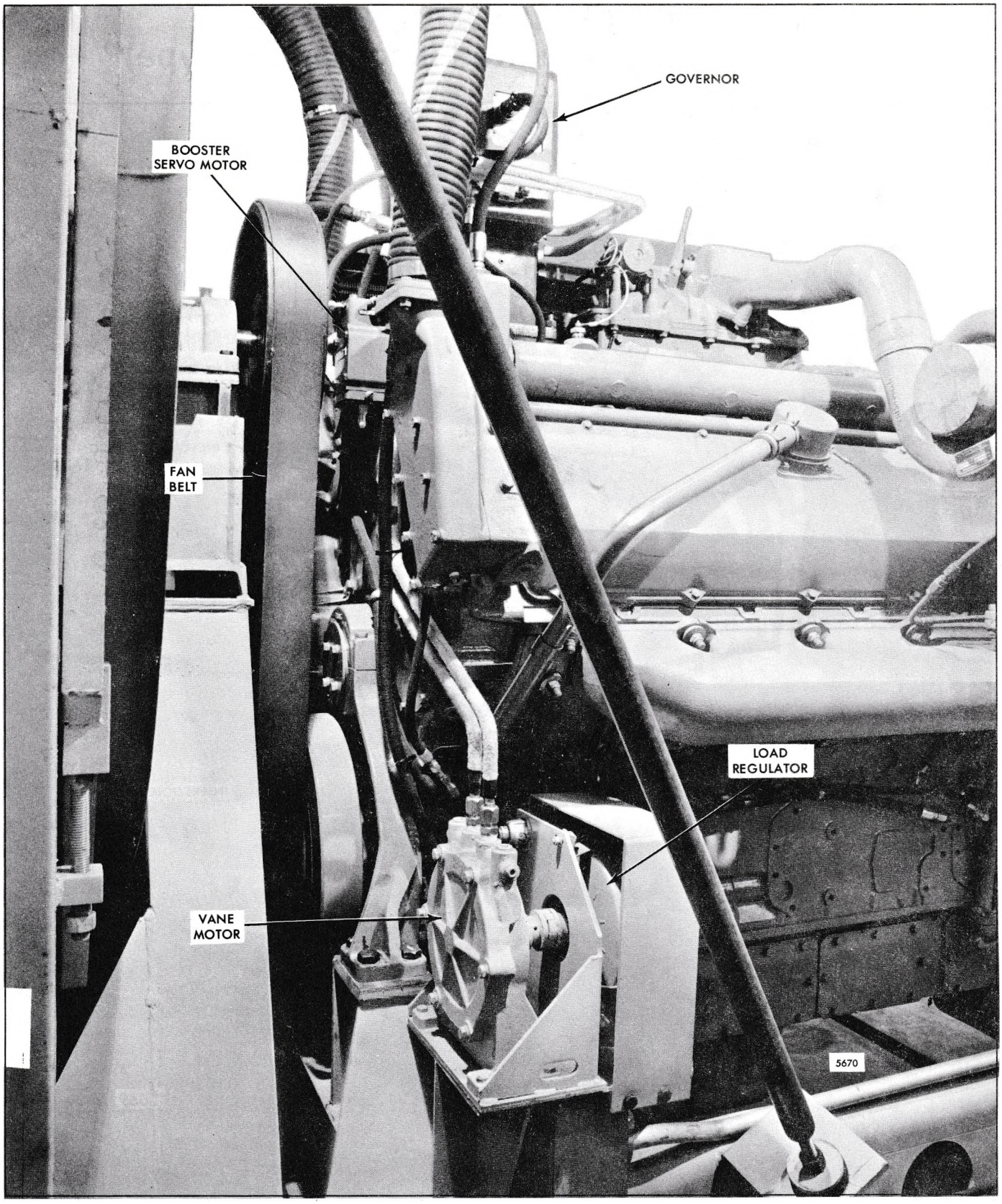


Fig. 2 - Location of Governor, Booster Servomotor, Vane Motor and Load Regulator

 © Detroit Diesel Corporation

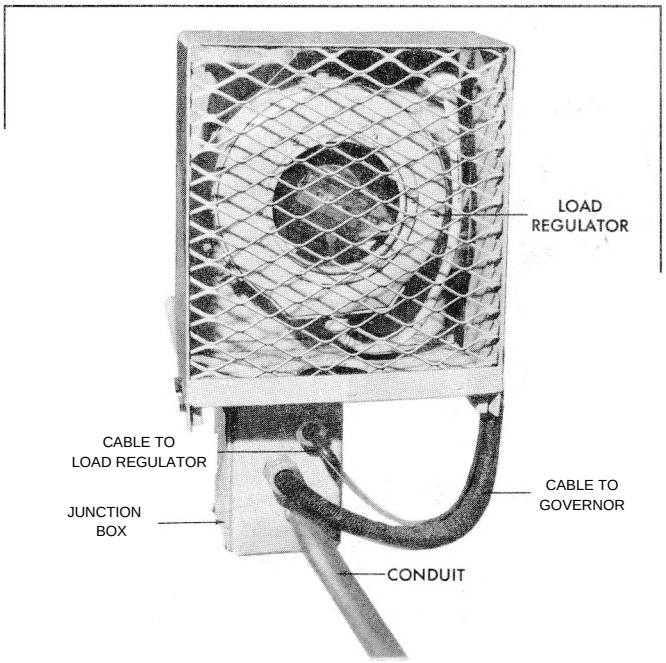


Fig. 3 - Load Regulator

The governor is located at the front of the engine and is mounted on a governor support housing (Fig. 1) which encloses the governor operating linkage. The governor is driven by one of the blower rotors through a bevel gear and shaft arrangement and actuates the injector control tubes through a linkage. For location of the governor, booster, vane motor and load regulator, refer to Fig. 2.

The governor is a pneumatically operated isochronous hydraulic type. The isochronous feature of the governor is its ability for any given speed setting to maintain a constant engine speed, regardless of changing load conditions on the engine. Speed change of the engine is accomplished by varying the air pressure to the governor, by means of the foot throttle in the operator's cab, from zero psi for an idle speed of 800 rpm to 60 psi (414 kPa) for a full governed engine speed of 1900 rpm.

Operation

With most governor applications, the primary purpose of the governor is to control fuel flow to the engine in sufficient amounts to maintain a certain set speed under varying load conditions. In this application, while the primary objective is still to maintain a desired engine speed, a secondary function is to maintain a constant horsepower output of the engine for each specific speed setting (throttle position).

Thus, for each setting of the throttle, not only is there a constant engine speed desired, but also a fixed pre-determined setting of fuel to the engine. To accurately

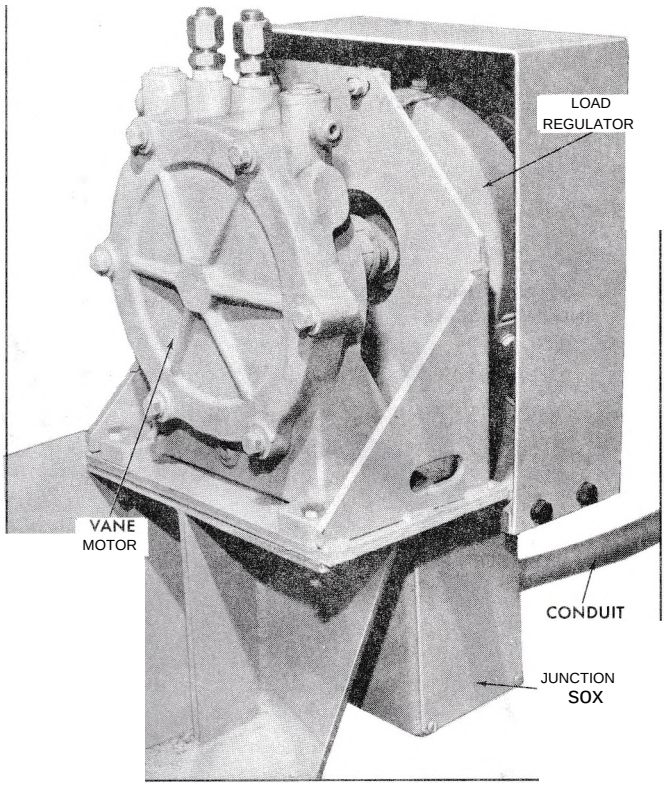


Fig. 4 - Hydrauiicaliy Operated Vane Motor

establish these conditions, it is necessary to control the load on the engine at a constant value for each throttle position.

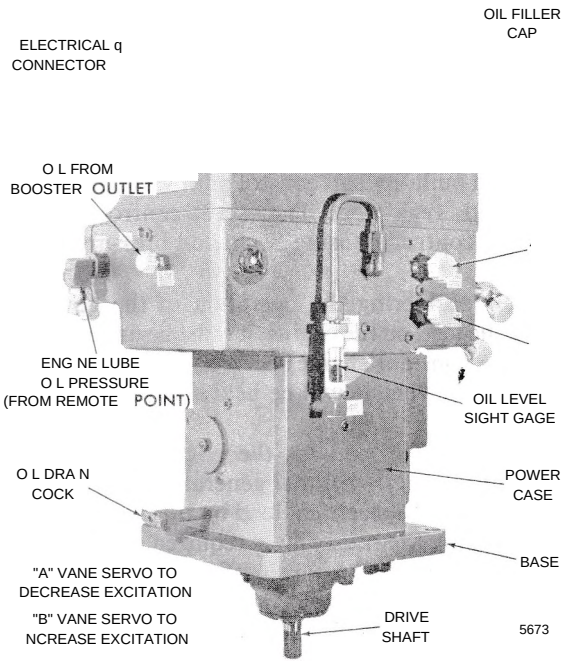


Fig. 5 - Pneumatic-Hydraulic Governor

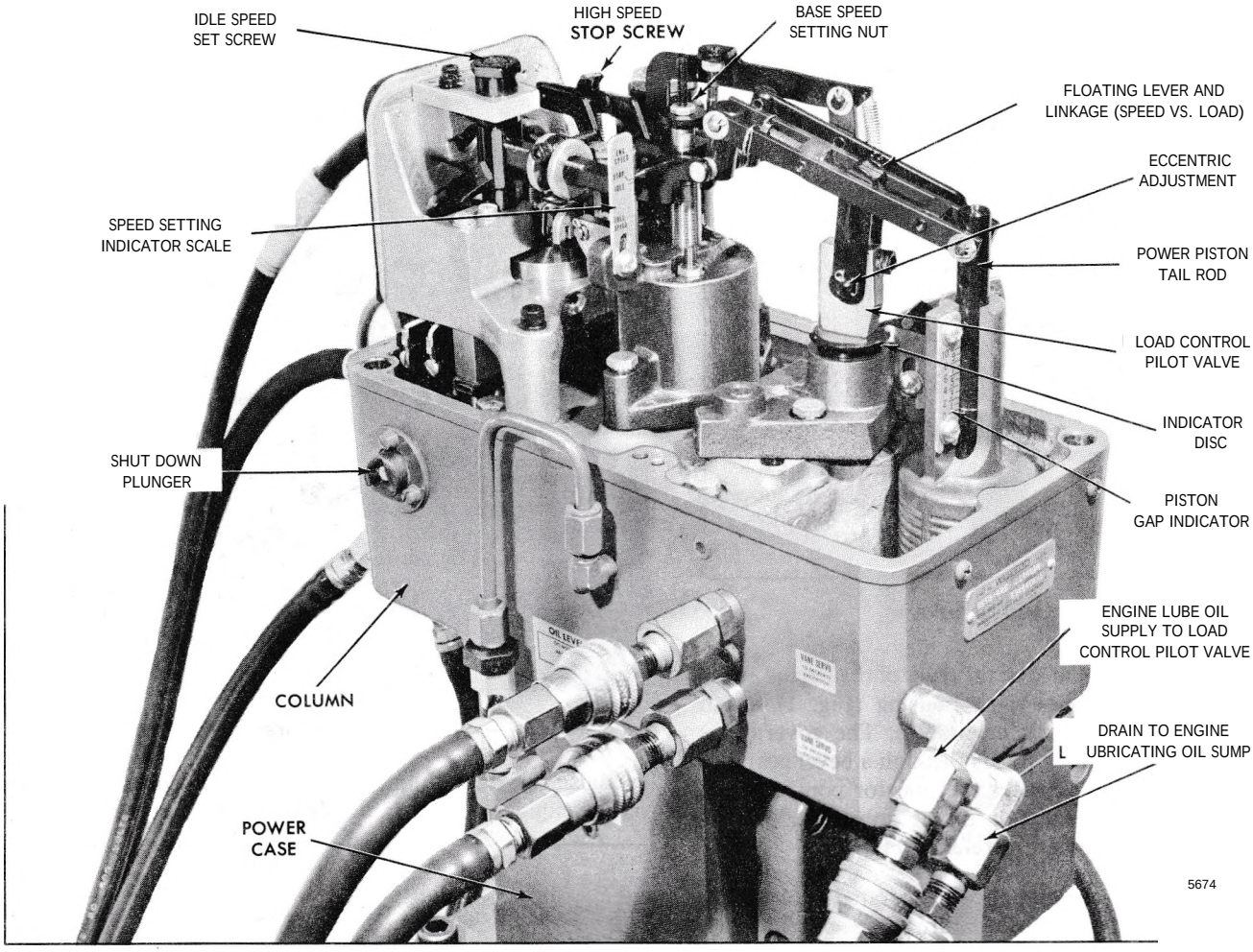


Fig. 6 - Governor Interior

This is achieved by means of a load control system consisting of a built-in load control pilot valve and a remote mounted load regulator. The load control system is hydraulically controlled using engine oil pressure (Fig. 3).

While considering the operation of the governor in controlling the load on the engine, it must be understood that maintaining a constant engine speed does not mean that the road speed of the vehicle will be held constant.

Control of the load on the engine is obtained by adjusting the strength of the generator field excitation current whenever the electrical load on the generator varies, and so controlling the horsepower required of the engine by the generator at a constant value for each specific speed setting. The excitation current of the generator is adjusted through the use of a variable resistance in the field excitation circuit, mounted in the load regulator assembly (Fig. 3), and actuated by means of the hydraulically operated vane motor (Fig. 4) which is controlled by the governor load control pilot valve.

The load control linkage in the governor is so arranged that for each speed setting there is only one fuel setting (or horsepower output) at which the load control pilot valve will be centered. A change in speed setting of the governor, or a change in horsepower requirements (load on the generator), will uncenter the load control pilot valve and permit» flow of oil to the vane motor. This in turn will move the vane motor clockwise or counterclockwise, depending upon the flow of oil, and adjust excitation.

The governor has a built-in provision for sensing low engine oil pressure, which is used to operate an alarm system.

A connection is made from a remote point of the engine lubricating system to a low oil pressure switch in the governor (Fig. 5).

 © Detroit Diesel Corporation

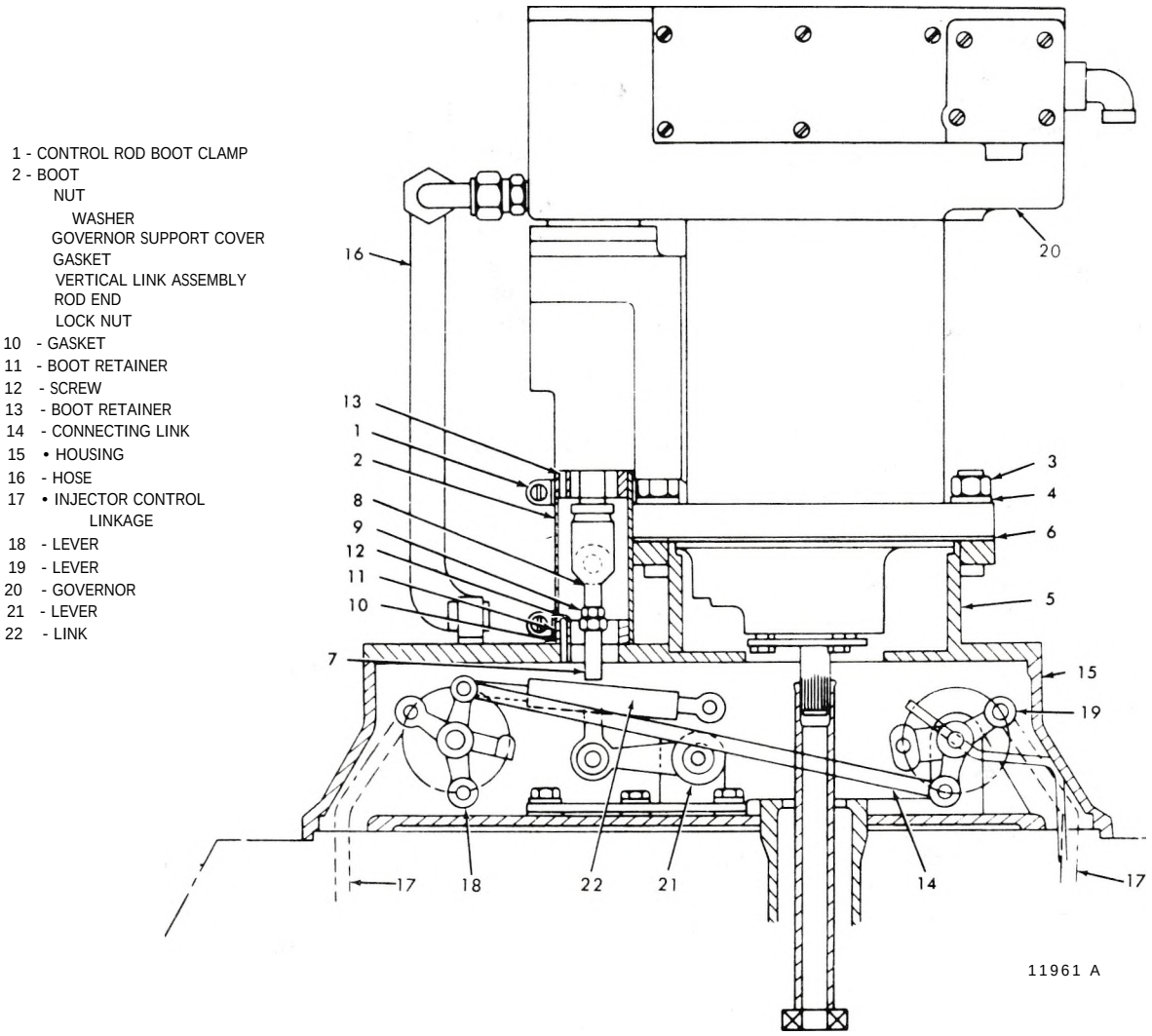


Fig. 7 - Governor Operating Linkage

There is a built-in delay period of 35-45 seconds to allow engine oil pressure to build-up upon initial start up of the engine. If, after this delay period or at any time when the engine is idling at 800 rpm, an oil pressure of 10+ 2 psi (69+ 14 kPa) is not achieved, the low oil pressure switch will close and operate an alarm bell and a warning light in the operator's cab. The same sequence of events will occur if the engine oil pressure at full governed engine speed of 1900 rpm drops below or does not obtain 4 0 + 2 psi (276 ± 14 kPa).

In both cases, upon restoration of oil pressure, the alarm circuit will reset automatically. The position of the low oil pressure switch can be checked externally by observing the governor. Low oil pressure is indicated when the low oil pressure switch plunger (Fig. 5) protrudes from the governor approximately 1/2" more than the normal operating position.

Normal shut down of the engine is effected by depressing the engine stop switch in the operator's cab. This electrically energizes a shutdown solenoid in the governor which moves the power piston to the no-fuel position and shuts the engine down.

If it is necessary to remove the governor from the engine in order to carry out repair work, proceed as explained in the following paragraph.

If the governor is removed from the engine due to a malfunction in the governor, it is strongly recommended that the governor be returned to the factory for overhaul or to the nearest governor repair shop which is equipped with a test stand and trained personnel. *Under no circumstances should untrained personnel be allowed to tamper with the governor.*

For a view of the interior of the governor, refer to Fig. 6.

General Oil Specifications

Use SAE 20 or 30 oil for ordinary temperature conditions. If governor operating conditions are extremely hot, use SAE 40 or 50; if extremely cold, use SAE 10. The oil must not contain additives, which are used to free up rings, remove carbon, etc., unless a non-foaming additive is also present.

The oil should not foam or sludge when agitated, or form gummy deposits when heated.

Use clean, new oil or filtered oil. All containers must be clean and should be rinsed with light grade fuel oil or kerosene before using.

Keep the governor oil level *between* the lines in the oil gage *while the engine is running.* The oil may be added to the governor through the oil filler cup in the top cover. Add oil slowly to avoid over-filling.

Oil level above or below the lines on the gage, when running, will cause aeration of the oil and result in a hunting condition.

Remove Governor

Numbers in parentheses refer to Fig. 7.

NOTICE: Before attempting to remove the governor, it is essential that the governor and the top of the engine in the vicinity of the governor be thoroughly clean and free from loose scale and debris which could find its way into the engine.

1. Disconnect the electrical cable to the governor by unscrewing the connector counterclockwise.
2. Drain the governor by means of the oil drain cock located on the power case of the governor.
3. Disconnect all air and oil lines at the governor and identify each line to its appropriate connector to facilitate installation. Cap all hoses and plug all connectors to prevent dirt from getting into the system.
4. Loosen the governor control rod boot clamp (1) at the bottom end of the boot (2) and ease the boot upwards until the control rod clevis pin is exposed.
5. Remove the split pin and the clevis pin from the control rod.
6. Remove the four 1/2"—13 UNC nuts (3) and lock washers (4) securing the governor (20) to the governor support cover (5).
7. Screw a 3/8"—16 UNC bolt into the top of the governor in the tapped hole provided and, using a suitable lifting tackle, carefully lift the governor clear of the support cover, taking care not to damage the stud threads.
8. Remove the governor from the unit and stand it vertically on a wooden base with holes provided to accept the governor gear box and power piston.
9. Remove and discard the gasket (6) and cover the governor and control rod openings in the governor support to prevent dirt and foreign matter from entering the engine.
10. Remove the gasket (10) and boot retainer (11).

Install Governor

Numbers in parentheses refer to Fig. 7.

Before installing a new or factory reconditioned governor, perform a complete engine tune-up.

1. Measure the center-to-center distance of the vertical link assembly (7) and set the center-to-center distance of the rod ends (8) to measure approximately 4.1875" by threading the rod ends on an equal amount. Leave the upper lock nut (9) loose at this stage.
2. Install the gasket (10) and boot retainer (11) and secure them to the governor power piston housing, using three 5"^10 x 3/4" long screws (12).
3. Apply the protective boot (2) and secure it to the boot retainer on the governor by means of the gear clamp **CD-**
4. Attach the gasket (6) to the governor support housing cover (5).
5. Lower the governor carefully over the mounting studs ensuring that the splined governor shaft is located in the splined governor drive sleeve and the vertical link rod (8) is located in the clevis of the power piston rod end.

   NOTICE: If the governor does not rest flat on the support housing (35), the cause should*be investigated. Do not seat the governor by means of the nuts, since if the governor is “hung up” on the drive shaft splines, the pre-load imposed by pulling the governor down will pre-load the drive shaft gear and bearing which could lead to a drive shaft failure, resulting in serious damage to the engine.

6. Install the lock washers (3) and nuts (4) on the mounting studs and torque the nuts to 58 lb-ft (79 N-m).

 © Detroit Diesel Corporation

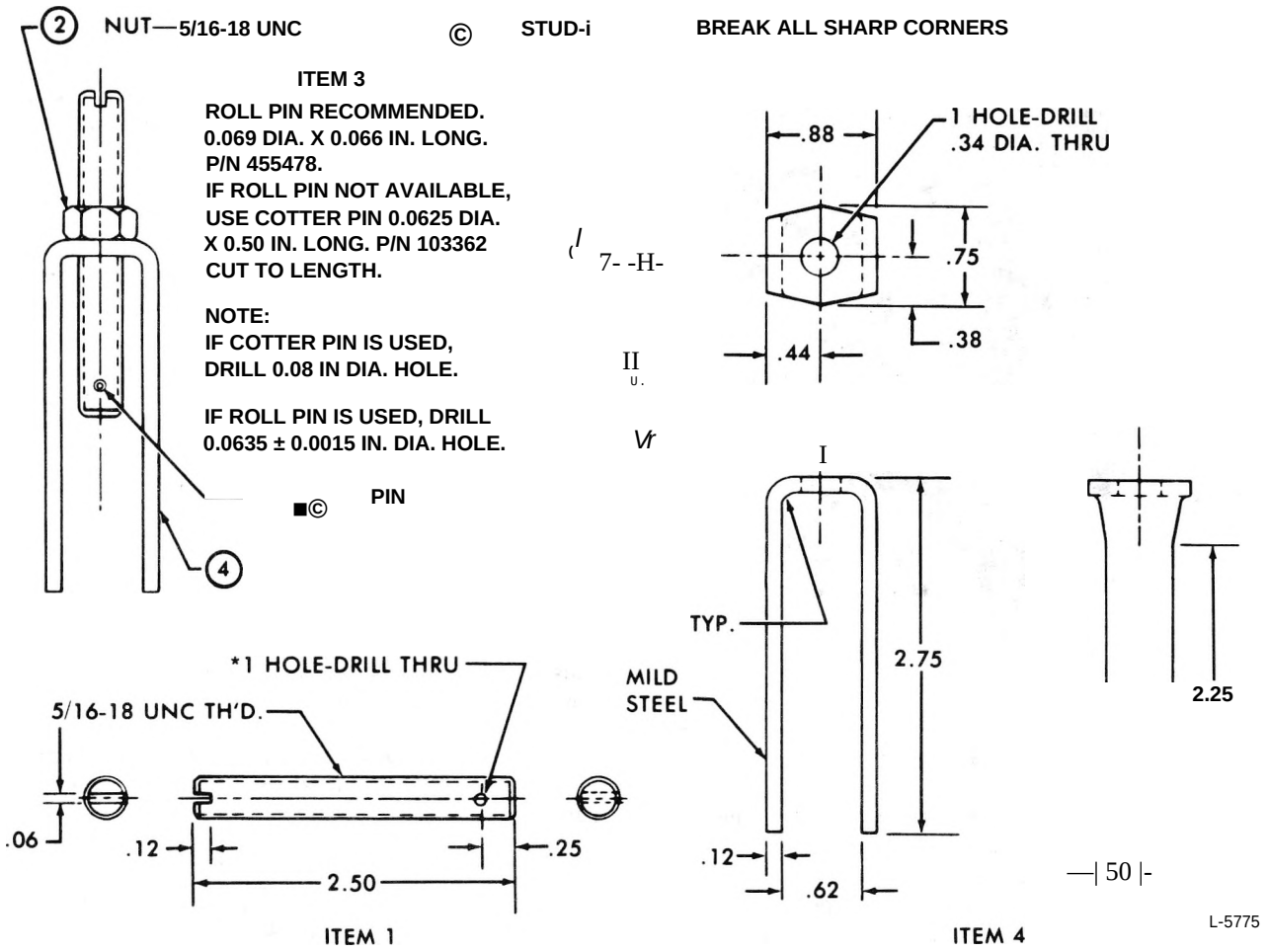


Fig. 8 - Governor Piston Rod Jack Fabrication

7. Check that the hole in the spherical bushing of the vertical link rod end (8) lines up with the hole in the power piston rod end.

   NOTICE: The power piston rod end is in the *no-fuel* position when the governor is disconnected or shut down. The vertical link (7) must be adjusted to this *no-fuel* position to within .010". When checking the line-up of the spherical bushing with the power piston rod end, exert moderate pressure in the downward direction on the vertical link rod end (8) to ensure that the injector racks are in the *no-fuel* position. Should it be found necessary to adjust the center-to-center distance of the vertical link assembly once the governor is in position, proceed as in Steps 8 through 9.

8. Remove the governor cover and, using a power piston jack, raise the governor power piston until the scribed line on the power piston tail rod lines up with the full load fuel scribe mark on the scale next to the tail rod.

   NOTICE: The power piston jack can be fabricated as shown in Figure 8.

9. Hold the injector racks in the *full-fuel* position, ease boot (2) upward and check that the hole in the spherical bushing of the vertical link rod end (8) lines up with the hole in the power piston rod clevis within ± .010". Should it be necessary to adjust the center-to-center distance of the vertical link assembly once the governor is in position, proceed as in Steps 13 and 14. *

10. Allow the fuel racks to return to the *no-fuel* position, thus lowering the rod end.

11. Rotate the rod end clockwise, or counterclockwise, whichever way is required to increase or decrease the center-to-center distance of the vertical link (7).

Return the fuel racks to the *full-fuel* position and check the line-up between the rod end hole and the power piston clevis hole. Repeat the procedure until the holes are in line.

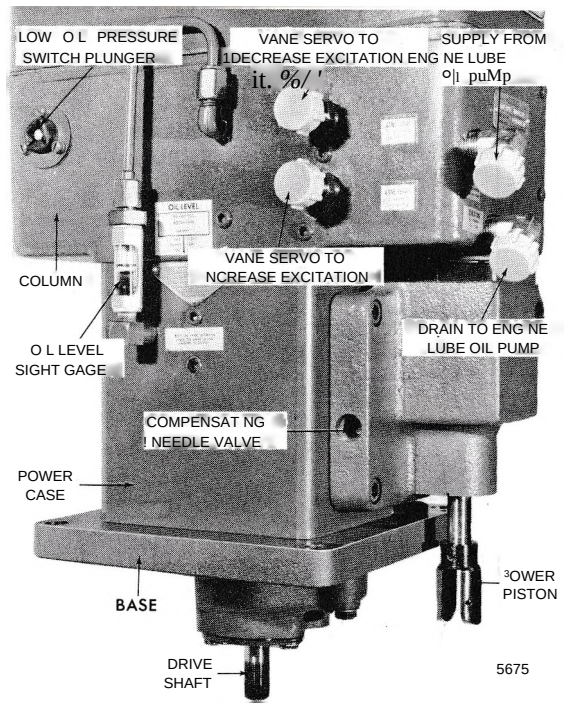


Fig. 9 - Governor

NOTICE: It is important that the center-to-center distance of the vertical link assembly was originally set at 4.1875" as outlined in Step 1. If this was not done, it is possible when adjusting the vertical link as explained in Step 14, to either run out of adjustment one way or unscrew the rod end completely the other.

If this situation occurs, or if it is felt that there is insufficient thread length securing the rod end to the vertical link, remove the governor and completely re-adjust the vertical link.

12. Once the line-up of the power piston rod end and the vertical link rod end (8) clevis pin hole has been achieved, install the clevis pin and retain it in position with a split pin. With the power piston in the *"full-fuel"* position, tighten the lock nut (9) to secure the vertical link rod end (8). Remove the tail rod jack and install the governor cover.

13. Slide the protective boot (2) over the boot retainer (13) on the governor support housing cover (5) and install the clamp (1).

14. Connect all air and oil lines to the governor ensuring that each line is connected to the appropriate connector.

15. Plug in the electrical cable and secure it by screwing the connector cap clockwise.

16. Fill the governor with oil to the prescribed level, as shown on the oil level gage, by removing the cap on on the governor cover and filling through the top cover. Add oil slowly to avoid over filling.

Installation Adjustments

On all new or factory rebuilt governors, the speed settings and other operating adjustments are made at the factory when the governor is tested before shipment, leaving only the compensating needle valve (Fig. 9) to be adjusted to suit the engine on which the governor is to be used.

Compensation Adjustment

When the engine is started for the first time, or after the governor has been drained and cleaned or if the governor has been removed and replaced for any reason, the governor must be filled with oil to the prescribed level and the governor oil system purged of trapped air.

To do this, loosen the air vent plug, shown in Fig. 10, far enough to establish a leak. Start the engine and allow it to run at *idle speed.*

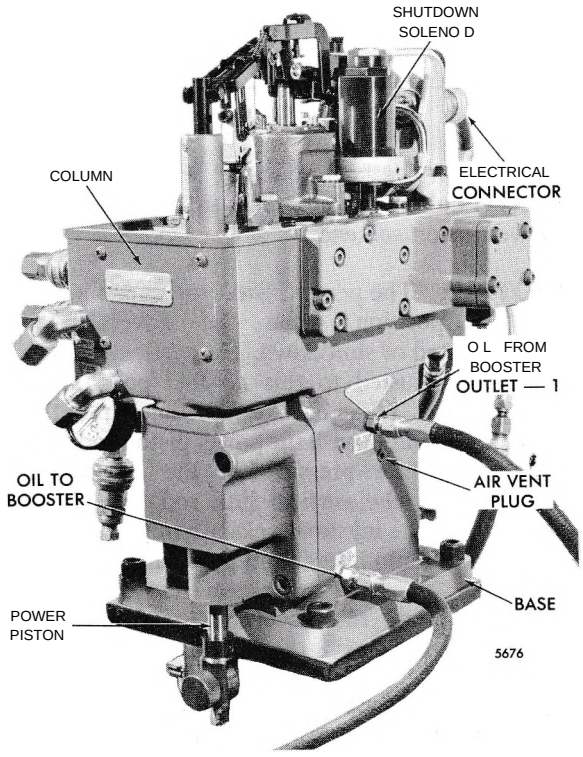


Fig. 10 - PG Governor

 © Detroit Diesel Corporation

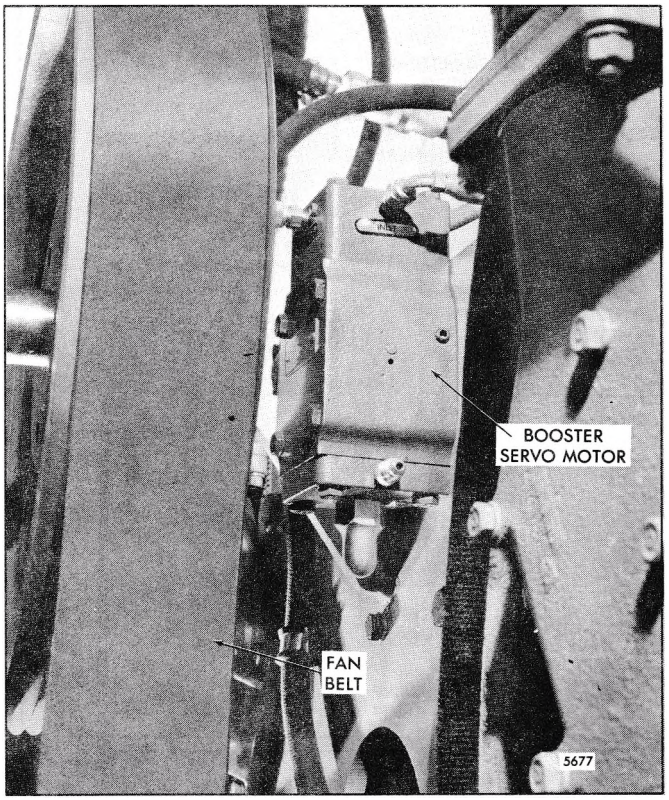


Fig. 1 1 - Location of Booster Servomotor

Open the compensating needle valve (Fig. 9) several turns. This should cause the engine to hunt, and the alternating movements of the governor parts will force all trapped air out of the governor oil passages and out of the governor at the vent plug.

Allow the engine to hunt at idle speed long enough to bleed all trapped air from the governor oil system. This will be evidenced by leakage of only oil at the vent screw. Tighten the vent screw and, if necessary, add oil to the governor to restore the correct level. Close the compensating needle valve slowly until the hunting condition is minimized, or eliminated, and allow the engine to run at idle speed until the engine and the governor reach normal operating temperature.

When operating temperature has been reached, open the compensating needle valve again several turns, enough to cause the engine to hunt, then close the needle valve slowly until the hunting is entirely eliminated. This will usually occur when the needle valve is open between one-quarter turn and three full turns. The correct setting will depend upon the characteristics of the engine. .

Test stability by disturbing the engine speed. If the engine returns to steady speed, the adjustment is satisfactory. But if the engine starts hunting, close the needle valve slightly and test again.

Keep the needle valve as far open as possible to prevent sluggishness and still obtain stability. Once it is correctly adjusted for the engine, it should not be necessary to change the setting of the needle valve except for a large permanent temperature change affecting the viscosity of the governor oil.

The needle valve setting will vary from 1/16 to 2 turns open. The needle valve must never be closed tight, as the governor can not operate satisfactorily when this condition exists.

Booster Servomotor

To facilitate a quick start and conserve starting air, a booster servomotor is used in conjunction with the governor. The booster servomotor is located on the front engine lifter bracket below the governor (Fig. 11) and is connected to the governor by flexible lines.

The booster servomotor's function is to supply oil under pressure to the governor at the instant starting air is supplied to the engine; this results in the governor moving the power piston into a fuel on position. The engine will then fire at once instead of after the time lag normally required for the rotary gear pump within the governor to build-up oil pressure to move the piston.

To ensure that the booster servomotor receives air at the instant starting air is supplied to the engine, the booster servomotor air supply is taken from the same solenoid-operated air start valve that operates the two main air starting valves mounted on the two starting air reservoirs.

See Fig. 12 for schematic operation of the booster servomotor.

The sequence of operation of the booster servomotor is as follows:

1. Compressed air is admitted to the air cylinder of the booster at the same time that the engine is started.
2. Air pressure moves the piston up, creating pressure in the oil cylinder and seating the inlet check valve.

   Refer to the direction arrows in Fig. 13.
3. Pressure oil passes through outlet checldvalve No. 1 to the governor pressure oil system.
4. Oil pressure moves the governor power piston in the direction to increase fuel.
5. For governors having speed setting servomotors, pressure oil also passes through outlet check valve No. 2 and forces the speed setting piston down. The piston loads the speeder spring which pushes the pilot valve plunger down so that the control land is below its centered position. Oil from the governor gear pump can then flow towards the governor power piston.

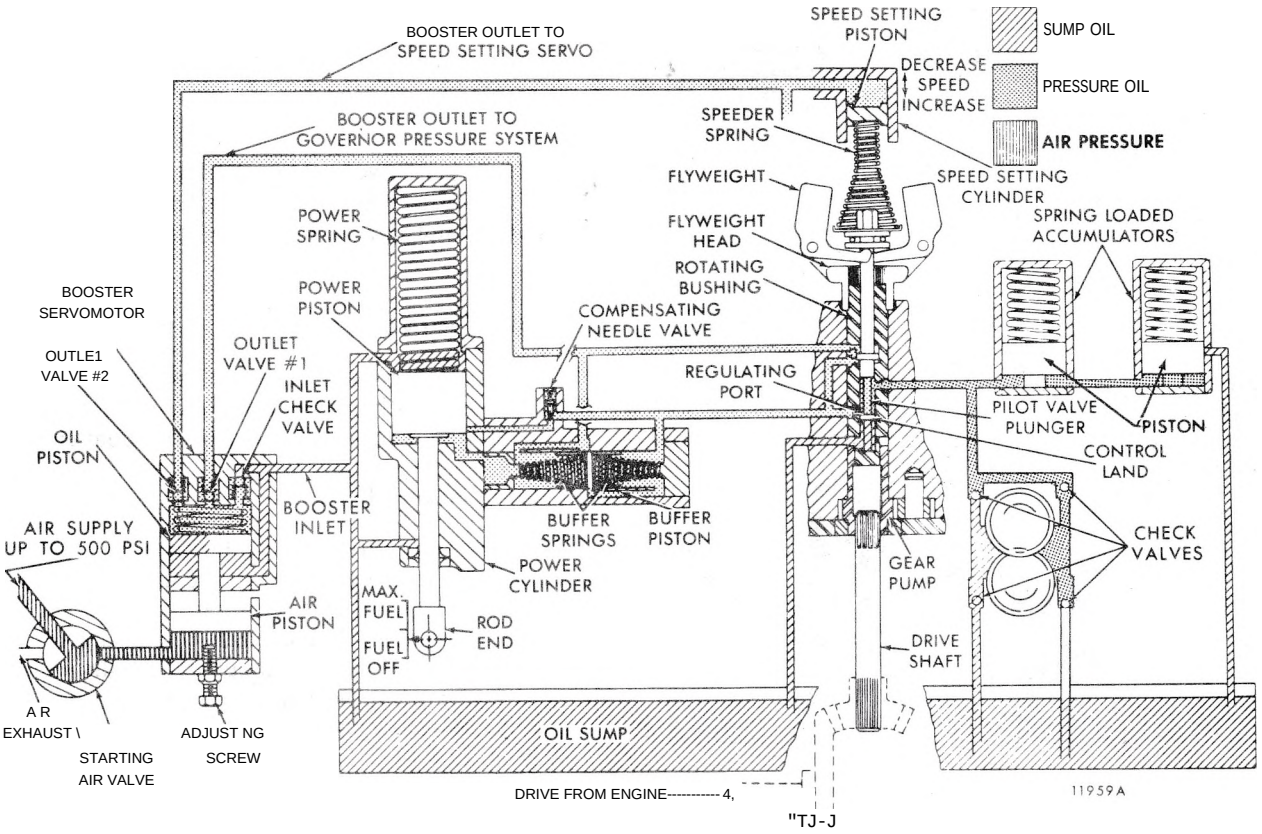


Fig. 1 2 - Schematic Diagram of Booster Servomotor

6. **As soon as the engine fires, the air cylinder of the booster is vented to the atmosphere.**

7. **After several revolutions, the governor** pump **builds up pressure, seating the outlet check valve.**

8. **Spring force returns the piston to its original position. Refer to the direction arrows in Fig. 14.**

9. **Oil flows from the sump into the oil cylinder of the booster.**

10. **The booster is then ready for another start.**

Troubleshooting

If the engine is slow to start or does not start at all due to lack of fuel, the booster servomotor should be checked for correct operation as follows:

1. **Ensure that the booster is receiving sufficient air pressure from the solenoid-operated air start valve by installing a *tee* fitting in the air line at the booster and connecting to a pressure gage. The pressure gage should indicate air start system pressure of between 100-200 psi (689-1378 kPa).**

2. **Check that all air has been purged from the oil lines between the booster and the governor (refer to *Adjustments)* and that there are no restrictions or blockages in the oil lines.**

3. **Adjust the limit screw on the booster as explained under *Adjustments.***

If all of the above checks have been mad^ and the booster still does not function, it should be removed and dismantled as covered under the appropriate headings.

Remove Booster Servomotor

1. **Drain the governor oil.**

2. **Identify and disconnect all oil and air lines at the booster servomotor and cap all lines and connectors securely to prevent the entry of dirt into the system.**

 © Detroit Diesel Corporation

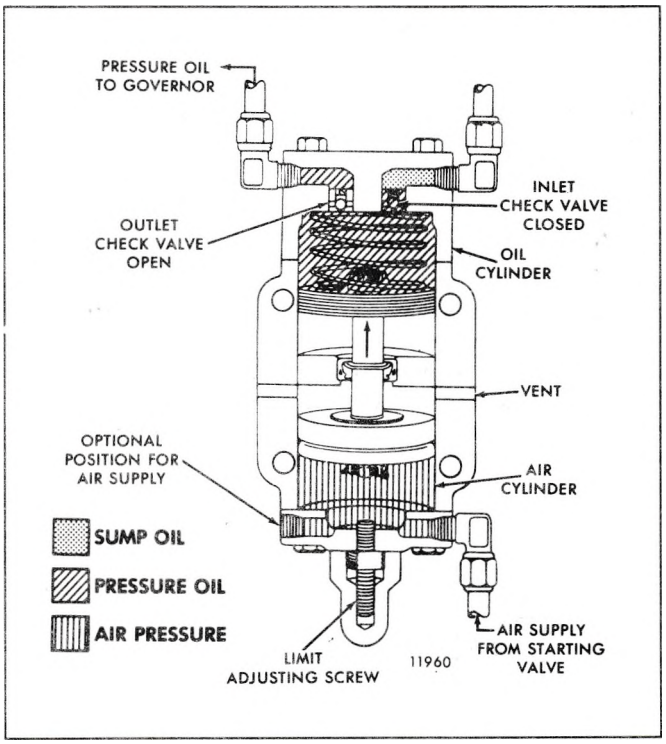


Fig. 13 - Oil Pressure Outlet Check Valve in Open Position

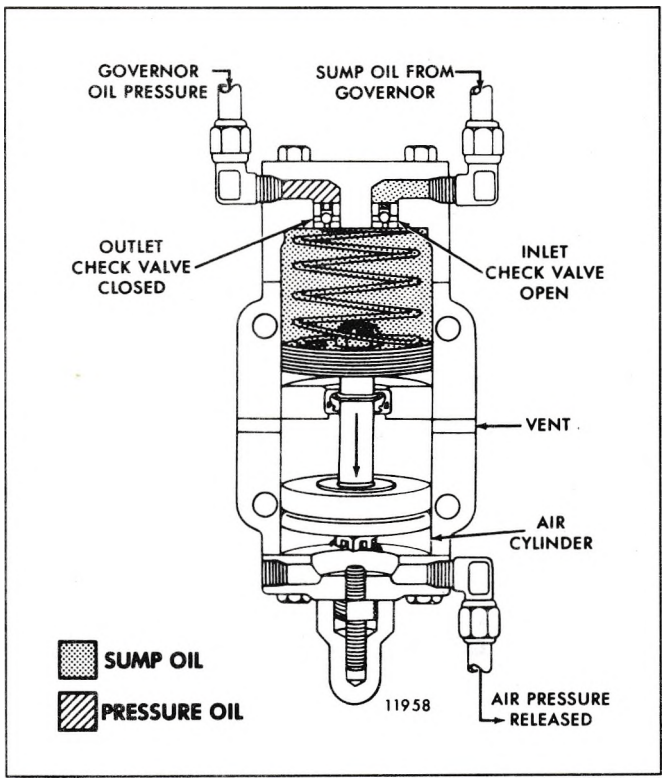


Fig. 1 4 - Oil Pressure Outlet Check Valve in Closed Position

NOTICE: It is possible to avoid draining the governor of oil by removing the oil lines one at a time and quickly capping the hose and its connector. If adopting this method, it is essential that the governor oil level be checked before putting the unit back into service in case any of the caps have been leaking oil.

3. Remove the four bolts, lock washers and nuts securing the booster servomotor to the front engine lifter bracket and remove the booster servomotor from the unit.

Disassembly

Numbers in parentheses refer to Fig. 15.

1. Thoroughly clean the exterior of the booster servomotor, using a suitable grease solvent, and dry with compressed air.

2. Remove the four cap screws (25) and lock washers (3) securing the cylinder head (7) at the oil end of the booster to the power cylinder (6). Remove the cylinder head (7), gasket (17) and spring (16).

3. Remove the four cap screws (24) and lock washers (3) securing the cylinder head (10) at the air end of the booster and remove the cylinder head (10) and gasket (17).

4. Remove the split pin (1) and castle nut (5) securing the washer (15), washer seal (12), piston (8) and washer (32) to the piston rod (18) and remove.

5. The piston rod (18) and oil piston (20) assembly can now be removed for further disassembly.

6. Press out the piston rod oil seal (14) from the air end of the power cylinder (6).

7. Thoroughly clean all components in a suitable solvent and dry. Clean the washer seal (12) and oil seal (14) in a non-petroleum based cleaner.

8. Inspect all components for signs of damage and wear and inspect the outlet and inlet check valve assemblies (21) for correct operation and seating. Replace all damaged or worn parts and gaskets.

t

Assembly

1. Lightly coat the inside of the power cylinder with governor oil and assemble in the reverse order of disassembly.

Install On Engine

1. Mount the booster servomotor on the front engine lifter bracket, with the oil cylinder head uppermost. Secure it with four 5/16"—18 UNC bolts, nuts and lock washers and torque the nuts to 13 lb-ft (18 N-m).

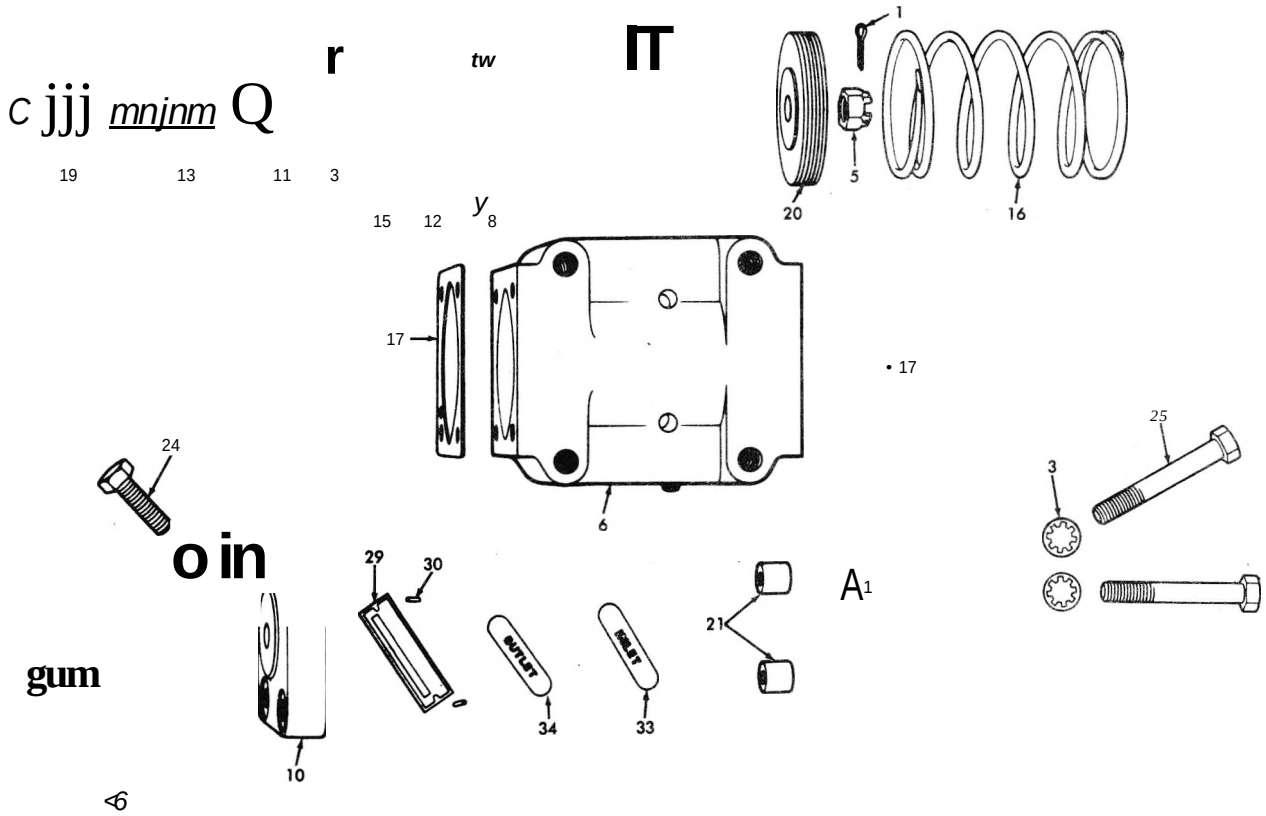
2. Reconnect the oil and air lines to the booster servomotor ensuring that each line is connected to the appropriate fitting.
3. Fill and check the oil level in the governor.
4. Purge the booster servomotor of air as explained under *Booster Servomotor Adjustments.*

NOTICE: If the governor hunts when the engine is started, purge the governor of air as covered under *Compensation Adjustment.*

Booster Servomotor Adjustments

Under normal circumstances, no adjustment is required to the booster servomotor. However, if the booster servomotor has been removed and overhauled, the oil lines from the booster servomotor to the governor will need to be purged of air. To do this, simply remove the air start lines at the air start motors and then operate the air start valve three or four times by actuating the engine start toggle switch in the cab.

After all of the air has been removed from the oil lines, the initial opening of the fuel racks can be adjusted to the desired stroke by adjusting the limit screw located on the end of the booster servomotor under the end nut. Turn counterclockwise to increase starting fuel and vice versa. This screw limits the intake stroke of the booster piston and thus the volume of oil supplied to the governor in one stroke of the booster piston.



1	Split Pin	11	Lock Nut	17	Gasket	25	Cap Screw
3	Lock Washer	12	Seal Washer	18	Piston Rod	29	Name Plate
5	Castle Nut	13	Adjusting Screw	19	End Nut	30	Pin
6	Power Cylinder	14	Oil Seal	20	Piston	32	Washer
7	Cylinder Head	15	Washer	21	Check Valve	33	Decal (Inlet)
8	Piston	16	Spring	24	Cap Screw	34	Decal (Outlet)
10	Cylinder Head						

Fig. 1 5 - Booster Servomotor Details and Relative Location of Parts

 © Detroit Diesei Corporation

MECHANICAL OUTPUT SHAFT GOVERNOR AND LINKAGE ADJUSTMENT

A Pierce mechanical governor is used to maintain a near constant output shaft speed on engines equipped with a torque converter. The governor (Fig. 1) is mounted on the engine governor and is driven by a flexible shaft from the converter output shaft and is connected, through linkage, to the engine governor.

The output shaft governor is lubricated by engine oil contained within the governor housing. The governor sump is filled through the hinged cap oiler until the oil begins to drip out of the oil level hole. After filling, a plug is installed in the oil level hole to prevent leakage. The oil level should be checked every 8 service hours and changed every 500 hours.

The output shaft governor is connected to the engine governor by a control rod and levers as illustrated in Fig. 1. The control rod end ball joints are sealed assemblies and do not require lubrication. However, the throttle control shaft bearings should be lubricated periodically with all purpose grease through the grease fitting. Other moving parts of the control linkage should be lubricated with engine oil.

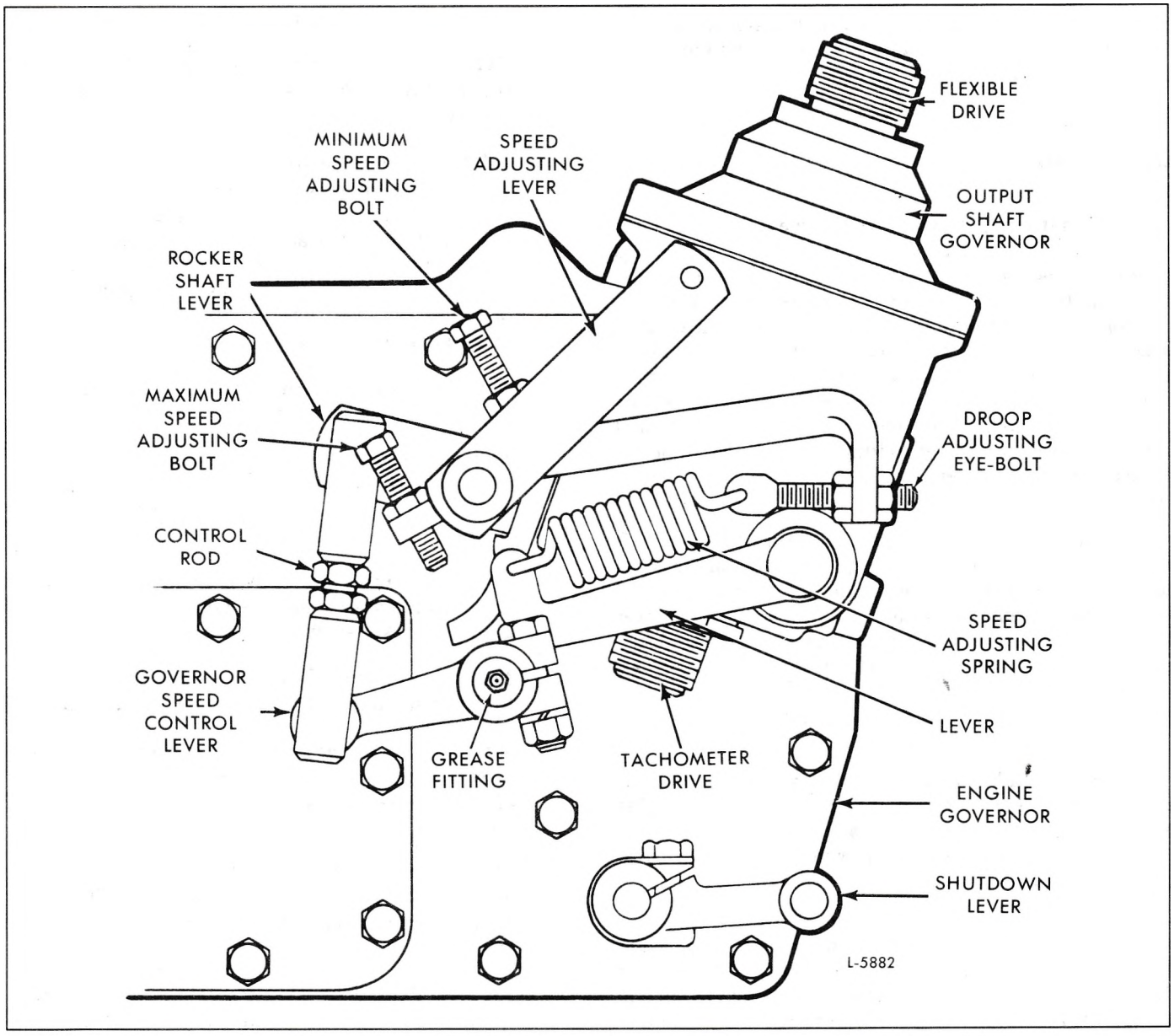


Fig. 1 – Mechanical Cable–Driven Output Shaft Governor and Linkage

The centrifugal force of the revolving output shaft governor flyweights is converted into linear motion which is transmitted through a riser, thrust bearing, operating fork and rocker shaft to an external speed adjusting spring. The speed of the torque converter output shaft is governed by the tension of the speed adjusting spring. This spring tension is established by the operator when he moves the output shaft governor speed adjusting lever to the desired speed setting.

Movement of the output shaft governor speed adjusting lever is limited by the maximum and minimum speed adjusting bolts.

The engine shutdown lever is connected through a shaft to another lever, under the governor cover, which bears against an arm of the left bank control link operating lever. To stop the engine, the shutdown lever is used to move the control link lever to the no-fuel position.

Operation

When the output shaft governor speed adjusting lever is advanced, the tension on the speed adjusting spring is increased. The force resulting from the increased spring tension is transmitted through the rocker shaft lever and control linkage to the engine governor speed control lever which advances the injector racks. Engine speed increases, as a result of the increased fuel, until the output shaft governor weight force is sufficient to balance the increased spring tension. The weights then move against the spring and reduce the injector rack fuel setting to an amount sufficient to maintain the higher engine speed setting.

Should the operator move the speed adjusting shaft lever to a decreased speed position, the tension on the speed adjusting spring will decrease and the governor weights will overcome the spring tension and move the rocker shaft lever to a decreased fuel position. The engine speed will be reduced until the force of the output shaft governor weights equals the tension of the speed adjusting spring. The engine will then operate at the desired reduced engine speed.

When a load is applied to the unit, the output shaft slows down and the force exerted by the governor flyweights is reduced, allowing the spring to move the rocker shaft lever to an increased fuel position to provide sufficient power to equal the new load.

When the load on the unit is removed, the output shaft speed will increase and the force exerted by the governor flyweights will increase, overcoming the spring tension and moving the rocker shaft lever to a decreased fuel position to reduce the power to match the reduced load.

Tune-Up

Adjust the exhaust valve clearance, time the injectors and adjust the engine and output shaft governors as follows:

1. Adjust the exhaust valve clearance and time the fuel injectors (Sections 14.1 and 14.2).

2. Disconnect the output shaft governor control rod. Then adjust the engine governor as outlined under *Limiting Speed Mechanical Governor and Injector Rack Control Adjustment* (Section 14.3).

   NOTICE: Set the no-load engine speed to that specified on the engine option plate. The no-load speed varies with the converter used and the maximum output shaft speed setting.

3. Reconnect the control rod linkage to the governor speed control lever only and check the total travel of the speed control lever.

   NOTICE: The speed control lever on the engine governor moves approximately 32 1/2 degrees from the idle speed to the full-fuel position. It should be adjusted so that when it is in the center of its travel, it is perpendicular to the engine center line. This will provide optimum linearity between the output shaft operating lever and engine speed control lever.

4. Move the engine governor speed control lever to the maximum speed position.

5. Move the output shaft governor rocker shaft lever to the maximum fuel position and retain it by moving the output shaft speed adjusting lever to the full-speed position.

6. Adjust the output shaft governor control rod length until it will just slide into the hole of the output shaft governor rocker shaft lever. Tighten the adjustment.

7. Move the output shaft governor speed adjusting lever to the minimum speed position and start the engine.

8. Advance the output shaft governor speed adjusting lever to the desired maximum output shaft spfeed and adjust the maximum speed adjusting bolt to retain the lever.

9. Move the output shaft governor speed adjusting shaft lever to the desired minimum speed position and adjust the minimum speed adjusting bolt to retain the lever.

10. Recheck the output shaft maximum and minimum speeds and readjust the position of the speed adjusting bolts, if necessary.

 © Detroit Diesel Corporation

11. To check the unit for stability as affected by governor speed droop, move the speed adjusting shaft lever, with the engine operating at no load, to the maximum speed position. Then move the output shaft governor rod to cause a speed decrease of several hundred rpm. Release the rod and check for hunting when the governor returns the engine to the maximum speed setting. If the engine stabilizes in less than three surges, the droop may be set too high; if the engine does not stabilize in five surges, the droop may be set too low. Set the speed droop as follows:

    a. If the engine hunts less than three surges, back . off the inner speed adjusting spring eye bolt nut one full turn and tighten the outer nut one turn to retain the adjustment. If the engine hunts more than five surges, back off the outer speed adjusting spring eye bolt nut one full turn and tighten the inner nut one turn to retain the adjustment.

NOTICE: The eye of the bolt must be in a horizontal plane to avoid twisting the spring.

    b. Reset the maximum engine no-load speed, if necessary, as outlined in Steps 8 and 9.

    c. Recheck the speed droop. The engine speed should be stable when the governor droop is 7-1/2% to 10% of the full-load speed. For example, at an output shaft speed setting of 1800 rpm full load, the output shaft speed droop should be 150 to 200 rpm. Therefore, the no-load output shaft speed should be set at 1950 to 2000 rpm.

SUPPLEMENTARY GOVERNING DEVICE ADJUSTMENT

THROTTLE DELAY MECHANISM

A throttle delay mechanism has been added to certain Series 149 turbocharged engines equipped with a mechanical governor or a hydraulic governor with a throttle delay yield link. This device reduces smoke emission by momentarily retarding full-fuel injection when the engine is accelerated.

The throttle delay mechanism is installed on the number one cylinder of the right-bank cylinder head (Fig. 1). It consists of a cylinder, piston, oil supply tube, ball check valve, orifice plug, lever and connecting link.

The throttle delay mechanism may be installed on former turbocharged engines. However, on engines prior to serial number 12E-139 with the original cylinder block and governor, it may be necessary to rework the throttle delay cylinder by grinding or filing the cylinder to eliminate possible interference with operation of the governor fuel rod (Fig. 2). On engines equipped with a hydraulic governor it will also be necessary to replace the vertical link with a throttle delay yield link (Section 14.7.2). Also, a different spring-loaded connecting link, oil supply tube and connector must be used on these engines. The oil supply tube used on current engines connects to an oil supply hole machined horizontally into the right-hand side of the cylinder block; on the early cylinder blocks, the oil hole was drilled vertically into the cylinder block.

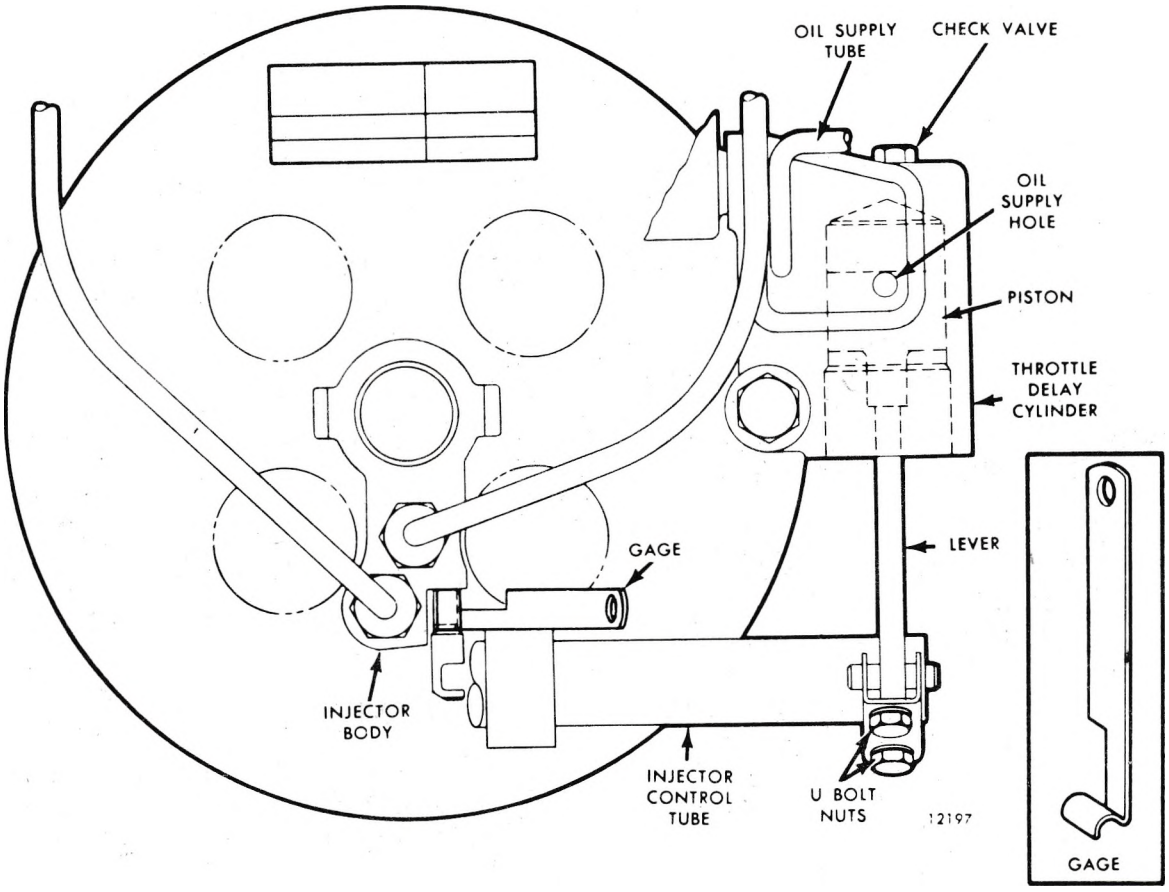


Fig. 1 - Throttle Delay Adjustment

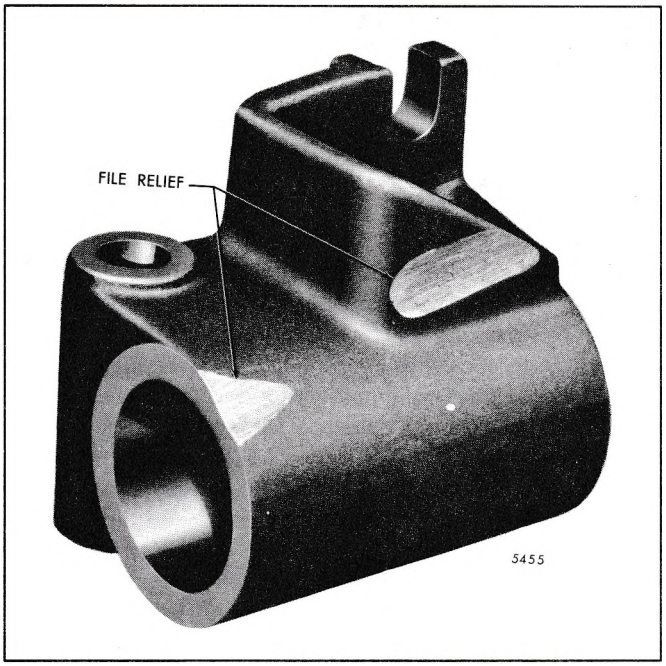


Fig. 2 - Reworked Throttle Delay Cylinder

Operation

Oil is supplied to a reservoir above the throttle delay cylinder through an oil supply tube from the cylinder block As the injector racks move toward the no-fuel position, free movement of the throttle delay piston is assured by air drawn into the cylinder through the ball check valve. Further movement of the piston uncovers an opening which permits oil from the reservoir to enter the cylinder and displace the air. When the engine is accelerated, movement of the injector racks toward the full-fuel position is momentarily retarded while the piston expels the oil from the cylinder through an orifice. To permit full throttle travel, regardless of the retarded position of the injector racks, the current limiting speed and variable speed mechanical governors have been revised by replacing the solid differential lever connecting link by a spring-loaded connecting link.

Adjustment

Whenever the injector rack control levers are adjusted, disconnect the throttle delay mechanism by loosening the U-bolt which clamps the lever to the injector control tube. After the injector rack control levers have been positioned, the throttle delay mechanism must be readjusted. With the engine stopped, proceed as follows:

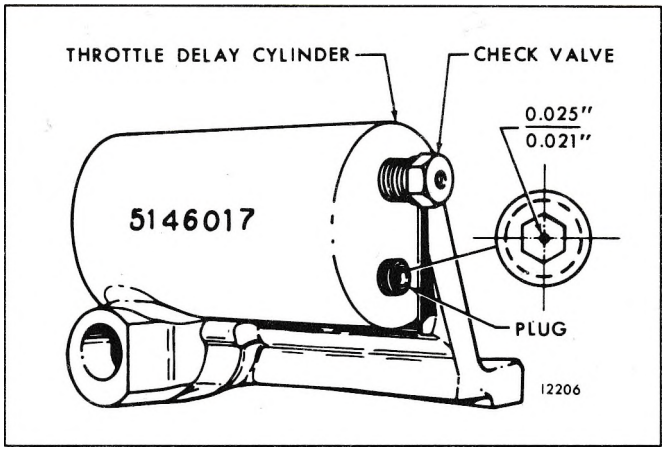


Fig. 3 - Throttle Delay Cylinder Plug Location

1. RefertoFig. landusegageJ 23190(.454" setting)or gage J 28779 (.365" setting) for 195 injector. Insert the gage between the injector body and the shoulder on the injector rack. Then exert a light pressure on the injector control tube in the direction of full fuel.
2. Align the throttle delay piston so that the leading edge of the piston just covers the oil fill hole.
3. Tighten the U-bolt on the injector control tube and remove the gage.
4. Move the injector rack from the no-fuel to the full-fuel position to make sure it does not bind.

Inspection

The diameter of the orifice in the throttle delay cylinder plug has been enlarged to improve engine response in electric drive off-highway trucks (Fig. 3).

If unsatisfactory engine response is experienced, install a current plug (.021 "-.025" orifice) or rework the former plug (.014"—.018" orifice) by enlarging the orifice with a No. 74 drill (.0225" diameter). Only the current plug is available for service.

STARTING AID SYSTEM

A starting aid system has been provided for turbocharged (including intercooled) engines equipped with variable speed mechanical governors (Fig. 4).

The starting aid limits the fuel during engine starting. This is accomplished by an air cylinder mounted on the governor. The air cylinder is connected to the starting air supply line (Fig. 4) or is activated by a throttle control (air solenoid) valve which is operated by the electric starting switch (Fig. 5). The air cylinder is controlled so that it is pressurized when the engine is being started. Pressurizing the air cylinder results in the air cylinder piston rod contacting and moving the governor stop lever from the run position. Thus the movement of the stop lever from the run position moves the injector racks from their full-fuel position.

 © Detroit Diesel Corporation

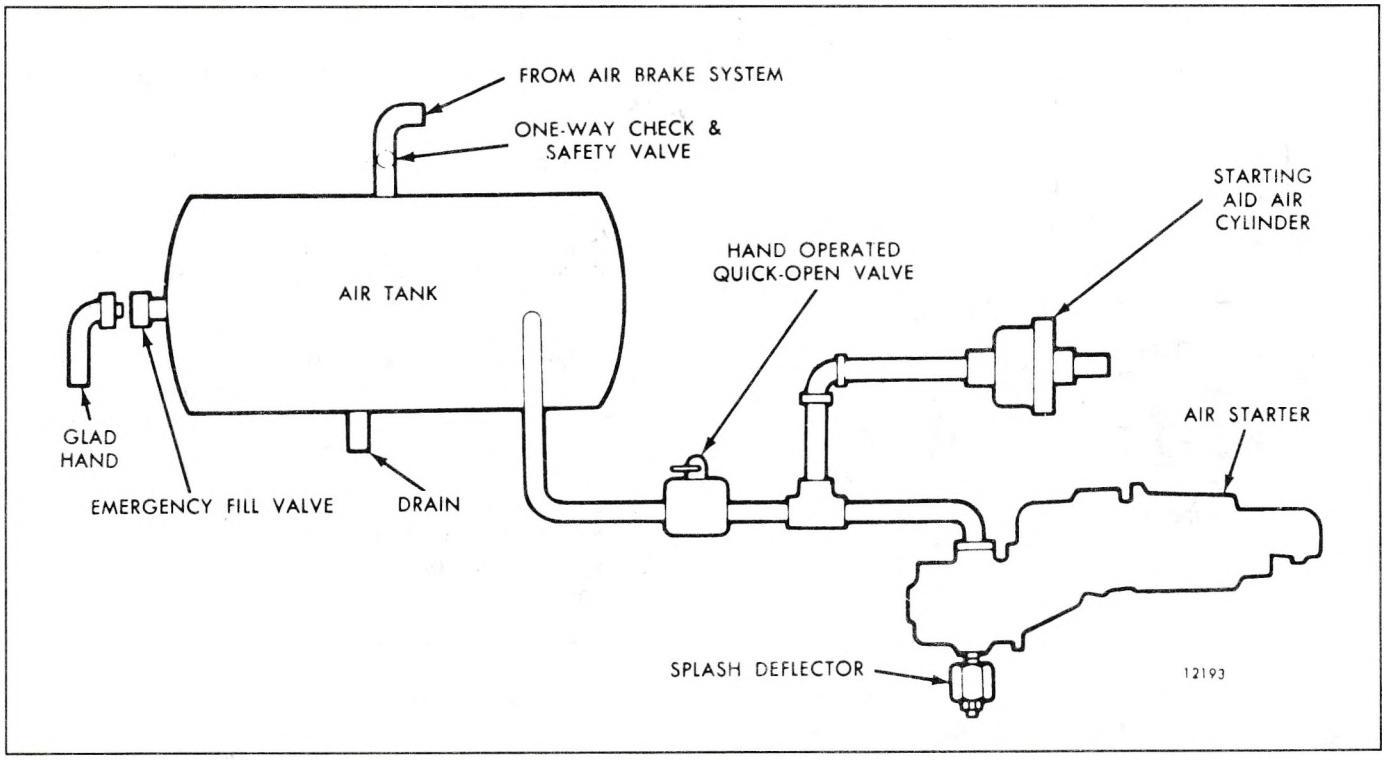


Fig. 4 – Typical Starting Aid System

The air cylinder is vented after starting, allowing the air cylinder piston rod to retract and the governor stop lever to return to the run position, thus permitting full fuel operation. The main components of the starting aid system are an air cylinder, an air cylinder mounting bracket and special stop lever plus customer furnished items such as the air supply hose and connections, air solenoid valve, etc. An electric shutdown solenoid or a wire cable can be used with the system.

Adjustment

Adjust the starting aid system by positioning the governor stop lever and the air cylinder to obtain the proper air cylinder to stop lever clearance as outlined below.

Position Solenoid Operated Stop Lever

Refer to Fig. 6 and position the solenoid operated governor stop lever as follows:

1. Remove the bolt connecting the solenoid plunger rod end eye to the stop lever.

2. Align and clamp the stop lever to the shutdown shaft so that, at its mid-travel position, it is perpendicular to the solenoid plunger. This will ensure that the linkage will travel as straight as possible. The solenoid plunger has available 1/2" of travel which is more than adequate to move the injector control racks from the full fuel to the no-fuel position and to accomplish shutdown prior to attaining full plunger travel.

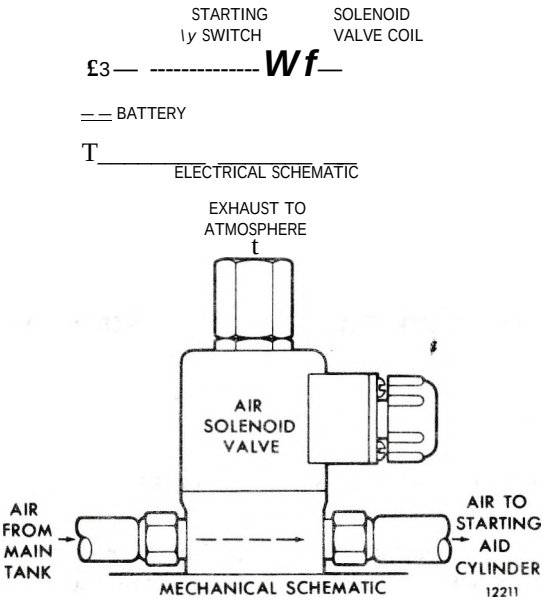


Fig. 5 - Starting Aid Schematic

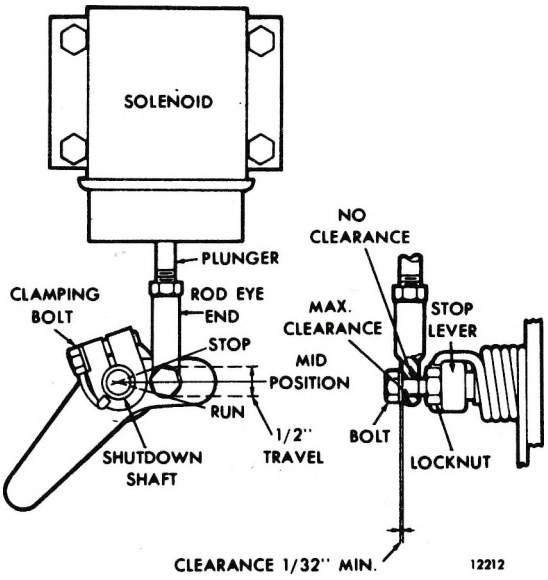


Fig. 6 - Positioning Solenoid Operated Stop Lever

3. With the stop lever in the *run* position, adjust the solenoid plunger rod end eye to position its slot to the bolt for minimum engagement when the connecting bolt is installed. The oversize hole in the rod will permit the solenoid to start closing the air gap, with a resultant buildup of pull in force prior to initiating stop lever movement.

4. Adjust the connecting bolt to a height which will allow approximately 1/32" clearance above and below the rod end eye and lock the bolt in place on the stop lever.

5. Move the lever to the *stop* position and check the solenoid plunger for possible bind. If necessary, loosen the mounting bolts and realign the solenoid to provide free plunger movement.

Position Manually Operated Stop Lever

Refer to Fig. 7 and position the manually operated governor stop lever as follows:

1. Place the stop lever in the *run* position.

2. Then loosen the stop lever and position it so that the centerline of the lever is 2 13/16" from the centerline of the cover screw as indicated in Fig. 7.

3. Tighten the stop lever clamping bolt.

Position Air Cylinder

Refer to Figs. 7 and 8 and position the starting aid air cylinder as follows:

1. Attach the air cylinder to its mounting bracket with two screws.

2. Install the mounting bracket, spacers and air cylinder on the governor cover with three screws.

•3. With the governor stop lever properly positioned as outlined above, observe the slots in the mounting bracket and position the air cylinder to provide the air cylinder piston-to-governor stop lever clearance indicated in Figs. 7 and 8.

4. After the air cylinder has been positioned and secured in place, connect the air supply line to the air cylinder. An air supply of not less than 40 psi (276 kPa) nor more than 200 psi (1378 kPa) is required.

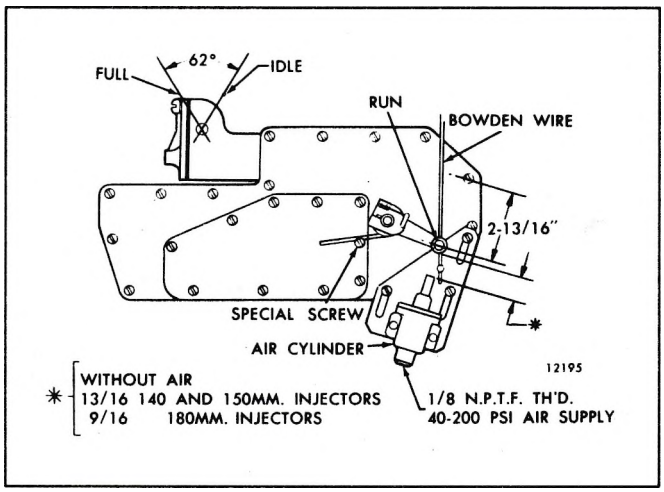


Fig. 7 - Positioning Manually Operated Stop Lever

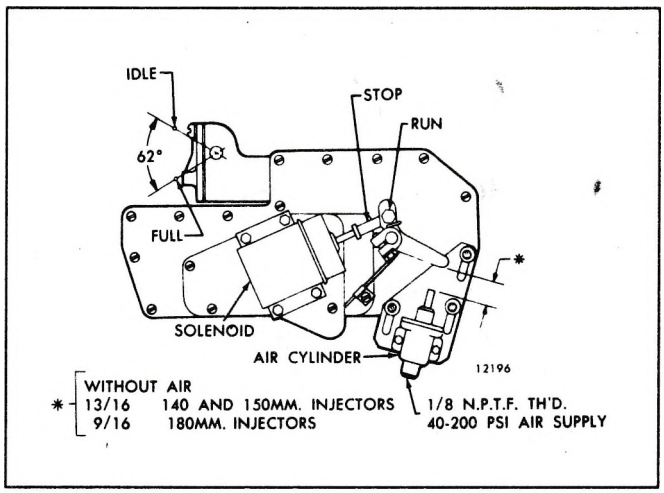


Fig. 8 – Positioning Air Cylinder

 © Detroit Diesel Corporation

ADJUSTMENT OF MECHANICAL GOVERNOR SHUTDOWN SOLENOID

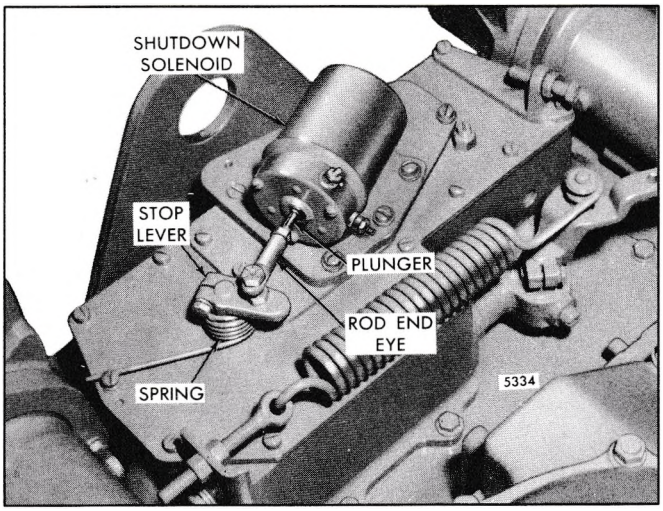


Fig. 9 - Typical Shutdown Solenoid Mounting

When a governor shutdown solenoid is used on an engine equipped with a mechanical governor, the Governor stop lever must be properly adjusted to match the shutdown solenoid plunger travel (Fig. 9).

The solenoid plunger can be properly aligned to the governor stop lever as follows:

1. Remove the bolt connecting the rod end eye (variable speed governor) or the right angle clip (limiting speed governor) to the stop lever (Figs. 10 and 11). Align and clamp the lever to the shutdown shaft in such a way that, at its mid travel position, it is perpendicular to the solenoid plunger. This assures that the linkage will travel as straight as possible. The solenoid plunger has available 1/2" travel which is more than adequate to move the injector control racks from the full-fuel to the complete no-fuel position and shutdown will occur prior to attaining complete travel.

2. With the stop lever in the *run* position, adjust the rod end eye or right angle clip for minimum engagement on the solenoid plunger when the connecting bolt is installed. The oversize hole in the eye or clip will thereby permit the solenoid to start closing the air gap, with a resultant buildup of pull in force prior to initiating stop lever movement.

3. The bolt through the rod end eye or the right angle clip should be locked to the stop lever and adjusted to a height that will permit the eye or clip to float vertically. The clearance above and below the eye or clip and the bolt head should be approximately 1/32" minimum. The lock nut can be either on top of or below the stop lever.

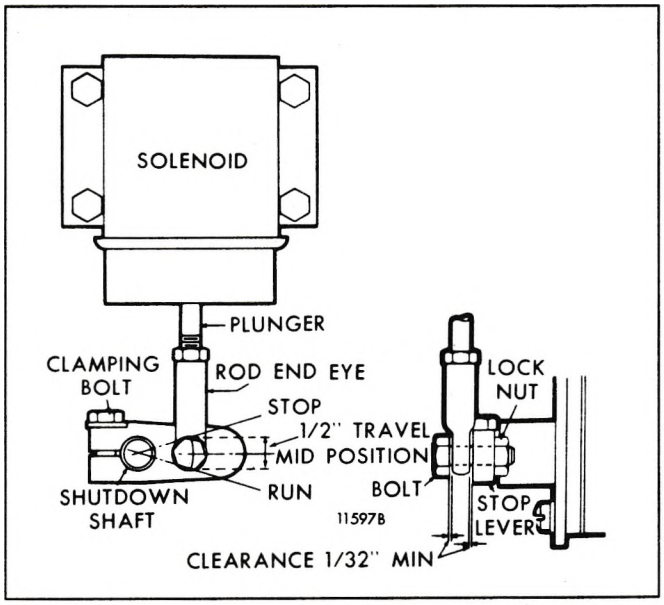


Fig. 10 – Typical Variable Speed Governor Lever Position

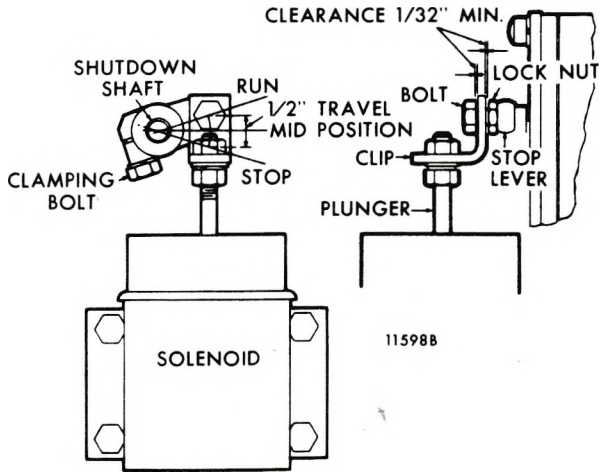


Fig. 11 - Typical Limiting Speed Governor Lever Position

4. Move the lever to the *stop* position and observe the plunger for any possible bind. If necessary, loosen the mounting bolts and realign the solenoid to provide free plunger motion.

SECTION 15

PREVENTIVE MAINTENANCE - TROUBLESHOOTING - STORAGE

CONTENTS

Lubrication and Preventive Maintenance 15.1
Troubleshooting .... r..... 15.2
Storage 15.3

LUBRICATION AND PREVENTIVE MAINTENANCE

The *Lubrication and Preventive Maintenance Schedule* is intended as a guide for establishing a preventive maintenance schedule. The suggestions and recommendations for preventive maintenance should be followed as closely as possible to obtain long life and best performance from a Detroit Diesel engine. The intervals indicated on the charts are time or miles (in thousands) of actual operation.

MAINTENANCE SCHEDULE EXPLANATION

The time or mileage increments shown apply only to the maintenance function described. These functions should be coordinated with other regularly scheduled maintenance.

The daily instructions pertain to routine or daily starting of an engine and not to a new engine or one that has not been operated for a considerable period of time. For new or stored engines, carry out the instructions given under *Preparation for Starting Engine First Time* under *Operating Instructions* in Section 13.1.

%

INDUSTRIAL	TIME INTERVALS					
HRS.	DLY.	EACH SHIFT 8	300	600	1,000	5,000
1. — Lubricating Oil		X	X			
2. — Fuel Tank		X		X		
3. — Fuel Lines and Flexible Hoses	X			X		
4. — Cooling System*		X		X		X
5. — Turbocharger	X					
6. — Battery			X			
7. — Tachometer Drive			X			
8. — Air Cleaners		X		X		
9. — Drive Belts		X	X			
10. — Air Compressor	X		X			X
11. — Throttle and Clutch Controls	X		X			
12. — Lubricating Oil Filter	X		X			
13. — Fuel Strainer and Filter			X			
14. — Coolant Filter				X		
15. — Starting Motor*						
16. — Air System	X		X			
17. — Exhaust System	X		X			
18. — Air Box Drain Tube					X	
19. — Emergency Shutdown	X		X			
21. — Radiator					X	
22. — Shutter Operation	X					
23. — Oil Pressure			X			
24. — Overspeed Governor				X		
26. — Throttle Delay*					X	X
27. — Battery-Charging Alternator*						
28. — Engine and Transmission Mounts					X	
29. — Crankcase Pressure					X	
31. — Fan Hub*						
32. — Thermostats and Seals						X
33, — Blower Screen					X	
34. — Crankcase Breather					X	
36. — Engine Tune-Up*						X
37. — Heat Exchanger*				X	x ,	
38. — Raw Water Pump*						
39. — Power Generator*						
40. — Power Take-Off*						1
41. — Marine Gear	X				X	
49. — Blower Bypass Valve* (Former)				X		
49. — Blower Bypass Valve* (Current)						X
50. — Crankcase Pressure Monitor				X		

*See Item

NOTICE; Certain preventive maintenance checks should be made on a daily basis or at the beginning of each (8 hour) shift. Intervals of 300 and 600 hours indicate preventive maintenance that should be performed every oil change or every other oil change. Intervals of 1000 and 5000 hours indicate long term preventive maintenance.

 © Detroit Diesel Corporation

Item 1 - Lubricating Oil

• Check the oil level at the beginning of each shift (every eight working hours) or before starting the engine. If the engine has just been stopped, wait approximately twenty (20) minutes to allow the oil to drain back to the oil pan. Add the proper grade oil as required to maintain the correct level on the dipstick (refer to Section 13.3).

NOTICE: Oil may be blown out through the crankcase breather if the crankcase is overfilled.

Make a visual check for oil leaks around the filters and the external oil lines.

• Change the lubricating oil at the intervals shown in the Chart. See Section 13.3 for drain intervals when using high sulfur fuel (above 0.50 mass percent).

ENGINE OIL CHANGE INTERVALS			
Service Application	Non-Turbo or Turbo	Max. Engine Oil Change Interval (Hours)	
		Diesel Fuel Sulfur Content % by Wt. Max.	
		0 to .50	
Industrial & Marine	Non-Turbo or Turbo	300 Hours or 1 Year	

When using high TBN/ash oils, a rule of thumb for oil change intervals is to drain the oil when the TBN drops to one-half of the new oil TBN. *Since lubricant composition varies from brand to brand, the time and rate of TBN reduction will vary.* These differences manifested by the various high TBN/ash oils will influence the drain interval.

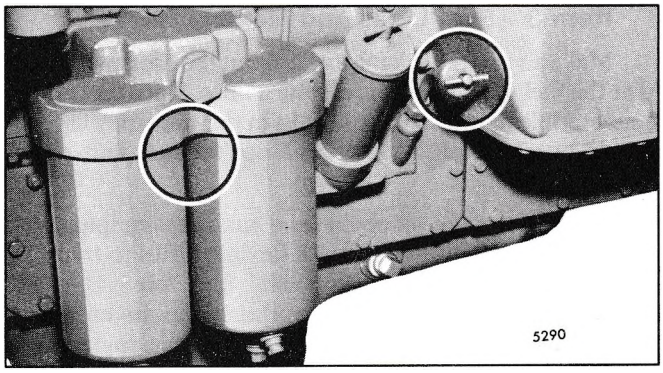
The drain interval may be established on the recommendations of an independent oil analysis laboratory or the oil supplier (based upon the used oil sample analysis) until the most practical oil change period has been determined.

If the lubricating oil is drained immediately after an engine has been run for some time, most of the sediment will be in suspension and will drain readily. Select the proper grade of oil in accordance with the instructions given in the *Lubricating Oil Recommentations* in Section 13.3.

Item 2 - Fuel Tanks

Check fuel level at the beginning of each shift. Keep the fuel tank filled to reduce condensation to a minimum. Select the proper grade of fuel in accordance with the *Fuel Recommendations* in Section 13.3.

• Open the drain at the bottom of the fuel tank every 600 hours or every other oil change to drain off any water and/or sediment. Tighten all fuel tank mountings and brackets at this *time. At the same time, check the seal in the fuel tank* cap, the breather hole in the cap and the condition of the crossover fuel line. Repair or replace the parts, as necessary.



Items 1 and 1 2

Diesel Fuel Contamination

The most common form of diesel fuel contamination is water. Water is harmful to the fuel system in itself, but it also promotes the growth of microbiological organisms (microbes). These microbes clog fuel filters with a “slime” and restrict fuel flow.

Water can be introduced into the fuel supply through poor maintenance (loose or open fuel tank caps), contaminated fuel supply or condensation.

Condensation is particularly prevalent on units which stand idle for extended periods of time, such as marine units. Ambient temperature changes cause condensation in partially filled fuel tanks.

Water accumulation can be controlled by mixing isopropyl alcohol (dry gas) into the fuel oil at a ratio of one pint (.5 liter) per 125 gallons (473 liters) fuel (or 0.10 by volume).

Marine units in storage are particularly susceptible to microbe growth. The microbes live in the fuel-water interface. They need both liquids to survive. These microbes find excellent growth conditions in the dark, quiet, non-turbulent nature of the fuel tank.

Microbe growth can be eliminated through the use of commericially available biocides. There are two basic types on the market.

%

1. The water soluble type treats *only the tank* where it is introduced. Microbe growth can start again if fuel is transferred from a treated to an untreated tank.
2. Diesel fuel soluble type, such as “Biobor” manufactured by U.S. Borax or equilvalent, treats *the fuel* itself and therefore the entire fuel system.

Marine units, or any other application, going into storage should be treated as follows: Add the biocide according to the manufacturer’s instructions. This operation is most effective when performed as the tank is being filled. Add dry gas in the correct proportions.

If the fuel tanks were previously filled, add the chemicals and stir with a clean rod.

Item 3 - Fuel Lines and Flexible Hoses

Make a visual check for fuel leaks at the crossover lines and at the fuel tank suction and return lines. Since fuel tanks are susceptible to road hazards, leaks in this area may best be detected by checking for accumulation of fuel under the tanks.

The performance of engine and auxiliary equipment is greatly dependent on the ability of flexible hoses to transfer lubricating oil, air, coolant and fuel oil. Diligent maintenance of hoses is an important step in ensuring efficient, economical and safe operation of the engine and related equipment.

Check hoses daily as part of the pre-start up inspection. Examine hoses for leaks and check all fittings, clamps and ties carefully. Make sure that hoses are not resting or touching shafts, couplings, heated surfaces including exhaust manifolds, any sharp edges or other obviously hazardous areas. Since all machinery vibrates and moves to a certain extent, clamps and ties can fatigue with age. To ensure continued proper support, inspect fasteners frequently and tighten or replace them, as necessary.

Leaks

Investigate leaks immediately to determine if fittings have looseded or cracked or if hoses have ruptured or worn through. Take corrective action immediately. Leaks are not only potentially detrimental to machine operation, but they also result in added expense caused by the need to replace lost fluids.

CAUTION: Personal injury and/or property damage may result from fire due to the leakage of flamable fluids such as fuel or lube oil.

Service Life

• A hose has a finite service life. The service life of a hose is determined by the temperature and pressure of the air or fluid within it, its time in service, its mounting, the ambient temperatures, amount of flexing and vibration it is subject to. With this in mind, all hoses should be thoroughly inspected at least every 600 operating hours, every other oil change, or annually, whichever comes first. Look for cover damage or indications of damaged twisted, worn, crimped, brittle, cracked or leaking lines. Hoses having the outer cover worn through or damaged metal reinforcement should be considered unfit for further service.

All hoses in or out of machinery should be replaced during major overhaul and/or after a maximum of five years service.

Item 4 - Cooling System

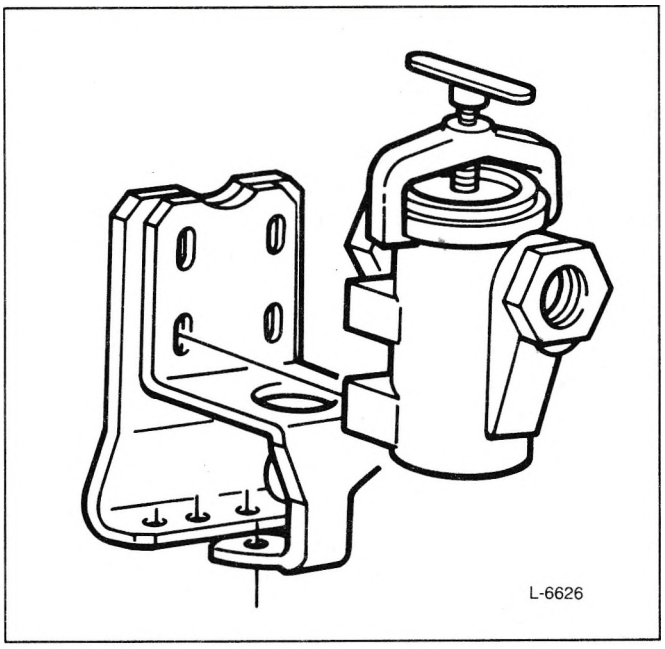
• **CAUTION: Do not remove the pressure control cap from the radiator or heat exchanger or attempt to drain the coolant until the engine has cooled. Once the engine has cooled, use extreme care when removing the cap. The sudden release of pressure from a heated cooling system can result in a loss of coolant and possible personal injury (scalding) from the hot liquid.**

Check the coolant level at the beginning of each shift and maintain it near the top of the heat exchanger tank or make sure it covers the radiator tubes. Add coolant, as necessary. *Do not overfill.*

Make a visual check for cooling system leaks. Check for an accumulation of coolant beneath the vehicle during periods when the engine is running and when the engine is stopped.

Clean the cooling system annually or every 5,000 hours using a good radiator cleaning compound in accordance with the instructions on the container. After the cleaning operation, rinse the cooling system thoroughly with fresh water. Then, fill the system with soft water, adding a good grade of rust inhibitor or an ethylene glycol base antifreeze solution (refer to *Coolant Specifications* in Section 13.3). With the use of a proper antifreeze or rust inhibitor, this interval may be lengthened until, normally, this cleaning is done only in the spring or fall. The length of this interval will, however, depend upon an inspection for rust or other deposits on the internal walls of the cooling system. When a thorough cleaning of the cooling system is required, it should be reverse flushed.

• The coolant circulated through the intercoolers on a turbocharged-intercooled engine is protected by a water strainer. Current engines use a bracket-mounted water strainer assembly located on top of the engine. This basket-type strainer filters the coolant going into the



● Item 4

 © Detroit Diesel Corporation

intercooler(s). Former engines used a 20 mesh cone-shaped screen located at the water connection in the water pump-to-engine oil cooler tube ("S-tube").

The strainer should be removed and inspected for damage or clogging when the cooling system is cleaned. If badly clogged or damaged, replace the strainer. *Do not operate an intercooled engine without the strainer in place.*

• Inspect all of the cooling system hoses at least once every 600 hours or every other oil change, whichever comes first. Make sure the clamps are tight and properly seated on the hoses, and check or signs of deterioration.

• Check inhibitor and antifreeze concentration every 600 hours or every other oil change to insure proper cooling system protection. Replace the hoses, if necessary.

Item 5 - Turbocharger

Inspect the mountings, intake and exhaust ducting and connections for leaks daily. Check the oil inlet and outlet lines for leaks and restriction to air flow. Check for unusual noise or vibration and, if excessive, remove the turbocharger and correct the cause.

• CAUTION: To eliminate the possibility of personal injury when air inlet piping is removed, do not operate an engine unless the turbo inlet shield (J 26554-A) is installed.

• Item 6 - Battery

Check the "eye" of maintenance-free batteries for charge. If lead-acid or low maintenance batteries are used, check the specific gravity of the electrolyte in each cell every 300 hours. In warm weather, however, it should be checked more frequently due to a more rapid loss of water from the electrolyte. The electrolyte level should be maintained in accordance with the battery manufacturer's recommendations.

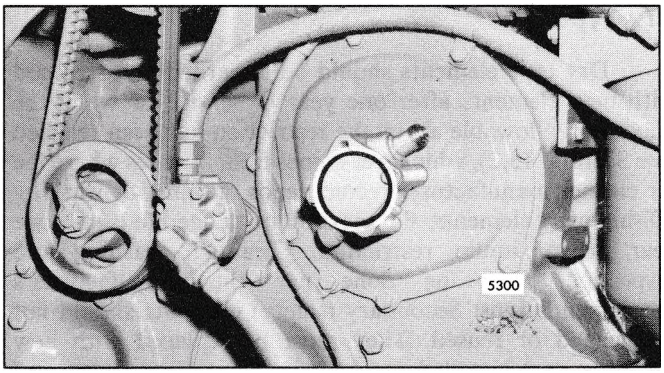
Item 7 - Tachometer Drive

• Lubricate the tachometer drive every 300 hours with an all purpose grease at the grease fitting. At temperatures above 30°F (-1°C), use a No. 2 grade grease. Use a No. 1 grade grease below this temperature.

Item 8 - Air Cleaner

Under no engine operating conditions should the air inlet restriction exceed 25 inches of water (6.2 kPa) for non-turbocharged engines or 20 inches of water (5.0 kPa) for turbocharged engines. A clogged air cleaner element will cause excessive intake restriction and a reduced air supply to the engine.

• Inspect air cleaner housing fasteners, clamps, and ducting for damage and tightness at the beginning of each shift.



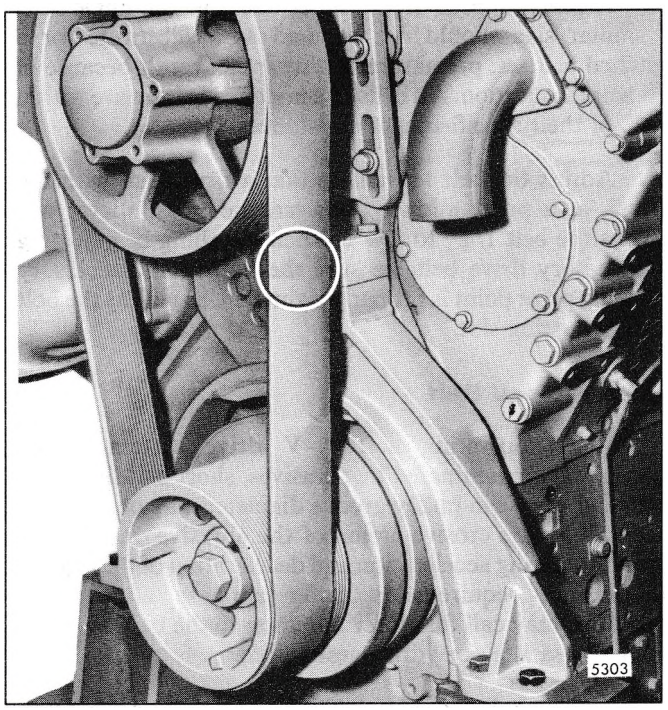
Item 7

Oil Bath

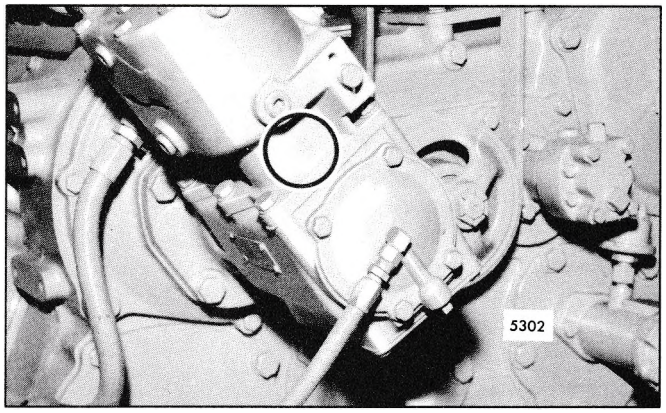
Remove the dirty oil and sludge from the oil bath type air cleaner cups and center tubes every 8 hours or less if operating conditions warrant. Wash the cups and elements in clean fuel oil and refill the cups to the level mark with the same grade and viscosity *heavy-duty* oil as used in the engine. The frequency of servicing may be varied to suit local dust conditions. If heavy rain or snow has been encountered, check the air cleaner for an accumulation of water.

Remove and steam clean the air cleaner element and baffle annually.

• It is recommended that the body and fixed element in the heavy-duty oil bath type air cleaner be serviced every 600 hours or as conditions warrant.



Item 9



Item 10

Item 10 - Air Compressor

• Inspect daily for loose fittings, damaged hoses, and coolant leaks.

• Remove and wash all of the polyurethane sponge strainer parts every 300 hours. The strainer element should be cleaned or replaced. If the element is cleaned, it should be washed in commercial solvent or a detergent and water solution. The element should be saturated in clean engine oil, then squeezed dry before replacing it in the strainer. Be sure to replace the air strainer gasket if the entire air strainer is removed from the compressor intake.

• For replacement of the air strainer element, contact the nearest Bendix or Midland air compressor dealer; replace with the polyurethane element, if available.

• Every 5000 hours tighten the air compressor mounting bolts. If the air compressor is belt driven, check the belts for proper tension.

Item 11 - Throttle and Clutch Controls

• Inspect daily for loose linkage and tighten as required.

• Every 300 hours lubricate the throttle control mechanism. Use an all purpose grease (No. 2 grade) at temperatures 30° F (-1° C) and above. At temperatures below this use a No. 1 grade grease.

Lubricate all other control mechanisms, as required, with engine oil.

Item 12 - Lubricating Oil Filter

• Install new oil filter elements (and gaskets on cartridge type filter assemblies) each time the engine oil is changed.

• Make a visual check of all lubricating oil lines for wear and chafing on a daily basis. If any indication of wear is evident, replace the oil lines and correct the cause.

When the engine is equipped with a turbocharger, pre-lubricate it as outlined under *Install Turbocharger* in Section 3.5.

Check for oil leaks after starting the engine.

Item 13 - Fuel Strainer and Filter

• Install new elements every 300 hours or when plugging is indicated.

• A method of determining when elements are plugged to the extent that they should be changed is based on the fuel pressure at the cylinder head fuel inlet manifold and the inlet restriction at the fuel pump. In a clean system, the maximum pump inlet restriction must not exceed 6 inches of mercury (20.3 kPa). With 16V non-turbocharged engine at normal operating speeds and with .170" restriction fittings (current engines) or .136" restriction fittings (former engines), the fuel pressure is 35-75 psi (241-517 kPa). With turbocharged engines, at normal operating speeds and with either .170" (current) or .136" (former) restriction fittings, the fuel pressure is 35-75 psi (241-517 kPa). Change the fuel filter elements whenever the inlet restriction at the fuel pump reaches 12 inches of mercury (41 kPa) at normal operating speeds and whenever the fuel pressure at the inlet manifold falls to the minimum fuel pressure shown above.

> • **NOTICE:** *To improve starting, have replacement filters filled with fuel and ready to install immediately after used filters are removed. This will prevent possible fuel siphoning, causing fuel system aeration. If the engine fails to start after replacement of the fuel filter element(s), the fuel system will require priming with tool J 5956, or equivalent.*

Item 14 - Coolant Filter

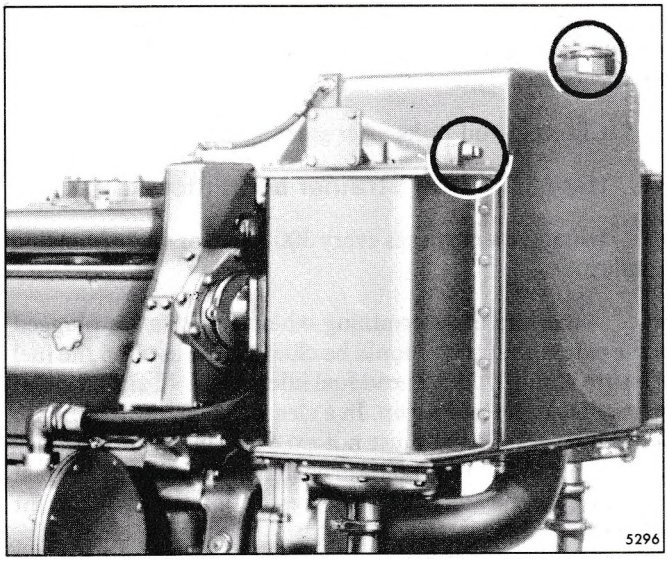
• If the cooling system is protected by a coolant filter and conditioner, the filter element should be changed every 600 hours. Select the proper coolant filter element in accordance with the instructions given under *Coolant recommendations* in Section 13.3. Use a new filter cover gasket when installing the filter element. After replacing the filter and cover gasket, start the engine and check for leaks.

Item 15 - Starting Motor

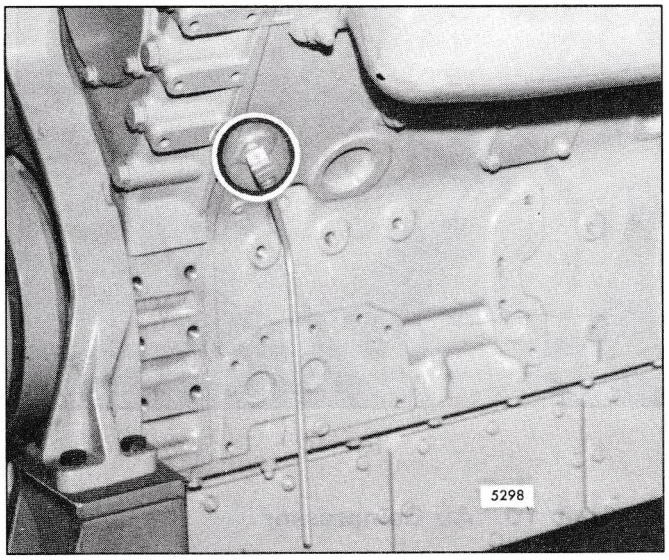
• The electrical starting motor is permanently lubricated at the time of manufacture. No further lubrication is required. Follow starter manufacturer's recommendations if disassembly or overhaul is required.

Item 16 - Air System

• Visually check all of the connections in the air system to be sure they are tight on a daily basis. Check all hoses for punctures or other damage and replace, if necessary. Retighten connections every 300 hours.



Items 1 4 and 37



Item 1 8

Item 17 - Exhaust System

• Visually check the exhaust manifold retaining nuts, exhaust flange clamp and other connections for tightness on a daily basis. Check for proper operation of the exhaust pipe rain cap, if one is used. Retighten connections every 300 hours.

Item 18 - Air Box Drain Tube

With the engine running, check for flow of air from the air box drain tubes every 1,000 hours. If the tubes are clogged, remove, clean and reinstall the tubes. The air box drain tubes should be cleaned periodically even though a clogged condition is not apparent.

If the engine is equipped with an air box drain tank, drain the sediment periodically.

Item 19 - Emergency Shutdown

• Visually inspect emergency shutdown linkage for proper setting, wear, damage, etc. on a daily basis. With the engine running at idle speed, check the operation of the emergency shutdown every 300 hours. Reset the air shutdown valve in the open position after the check has been made.

Item 21 - Radiator

• Inspect the exterior of the radiator core every 1000 hours and, if necessary, clean it with a quality grease solvent such as mineral spirits and dry it with compressed air.

• CAUTION: To avoid personal injury, wear adquate eye protection and do not exceed to psi (276 kPa) air pressure.

Do not use fuel oil, kerosene or gasoline. Clean the radiator more frequently if the engine is being operated in extremely dusty or dirty areas.

Item 22 - Shutter Operation

Check the operation of the shutters and clean the linkage and controls daily.

Item 23 - Oil Pressure

• Under normal operation, oil pressure is noted each time the engine is started. In the event the engine is equipped with warning lights rather than pressure indicators, the pressure should be checked and recorded every 300 hours.

Item 24 - Overspeed Governor

• Lubricate the overspeed governor, if it is equipped with a hinge-type cap oiler or oil cup, with 5 or 6 drops of engine oil every 600 hours. Avoid excessive lubrication and do not lubricate the governor while the engine is running.

Item 26 - Throttle Delay

• Inspect and adjust throttle delay every 5000 hours. Inspect spring-loaded yield link every 1000 hours for proper operation. Replace yield link after 5000 hours, or earlier if required.

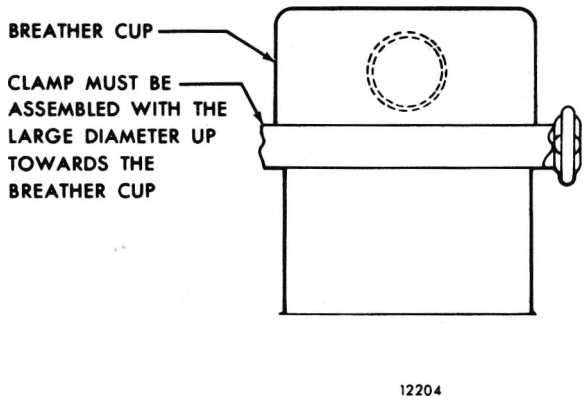
The throttle delay system limits the amount of fuel injected during acceleration by limiting the rate of injector rack movement with a hydraulic cylinder. The initial location of this cylinder must be set with the proper gage to achieve the appropriate time delay (Section 14.14).

Inspect the check valve by filling the throttle delay cylinder with diesel fuel and watching for valve leakage while moving the throttle from the idle to the *full-fuel* position.

Stem 27 - Battery-Charging Alternator

Inspect the terminals for corrosion and loose connections and the wiring for frayed insulation.

 © Detroit Diesel Corporation



Item 34

or, if worn excessively, replace with new electrodes. To determine the condition of a used electrode, strike it sharply against a hard surface; a weakened electrode will break.

Drain the cooling system, disconnect the raw water pipes at the outlet side of the heat exchanger and remove the retaining cover every 1,000 hours and inspect the heat exchanger core. If a considerable amount of scale or deposits are present, clean the core as outlined in Section 5.5.

Item 38 - Raw Water Pump

• Always prime the raw water pump before starting the engine. Since water acts as a lubricant for the impeller, failure to prime the pump (or at least wet the impeller vanes to induce a self-priming suction) can result in severe impeller damage when the engine is started. Insufficient raw water flow into the heat exchanger caused by a damaged impeller can lead to overheating and subsequent engine damage. To prime the pump: a) remove the pipe plug from the water inlet elbow; b) pour in at least a pint of water; c) replace the plug.

Item 39 - Power Generator

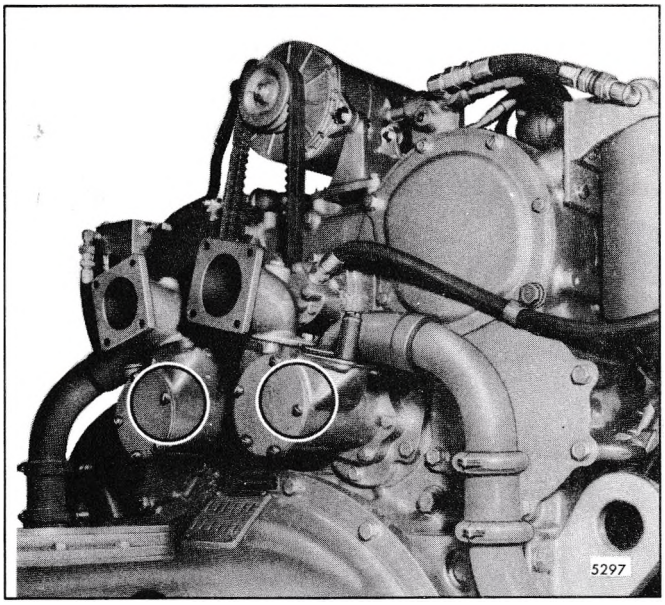
• Follow the power generator manufacturer's lubrication and preventive maintenance recommendations at his suggested intervals.

Item 40 - Power Takeoff

Follow the power take-off manufacturer's lubrication and preventive maintenance recommendations at his suggested intervals.

Item 41 - Marine Gear

Check the oil level daily in the Twin Disc Marine Gear. Check the oil level with the engine running for three to five minutes at low idle speed and the gear in neutral. Keep the oil up to the proper level on the dipstick. Use the same grade and viscosity *heavy-duty* oil as used in the engine.



Item 38

Change the oil and oil filter element every 1,000 hours. After draining the oil, thoroughly clean the removable oil screen and breather. Reinstall the breather and refill the marine gear with oil up to the full mark on the dipstick. Start the engine and, with the gear in neutral, run the engine at idle speed for three to five minutes and check the marine gear oil level. If necessary, add oil to bring it up to the full mark on the dipstick.

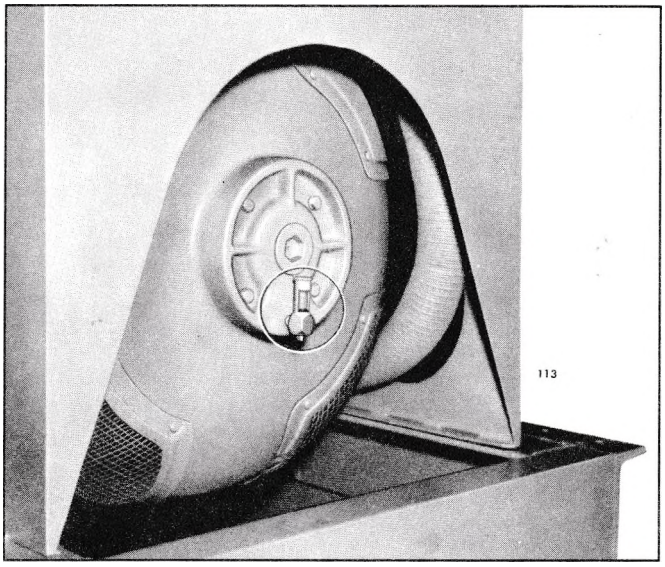
Item 49 - Bypass Blower Valve

Former System

• On engines with a former flapper-style bypass valve-equipped air induction system, make the following checks after every 600 hours of engine operation.

1. Visually inspect the entire bypass operating system, including air cylinders, lever and roll pin, operating shaft and ball joint connector for binding, misalignment or abnormal wear. Replace, if necessary.
2. With the engine stopped, disconnect the ball joint connector from the operating shaft lever. Rotate the lever through its arc of rotation to ensure that the shaft operates freely and that there is no excessive play. If excessive play is detected this could indicate a loose valve. Remove the housing and inspect the \jalve, the valve hold-down block and the shaft. Replace, if necessary.
3. Check the air cylinder for proper operation, using the following procedure:
   a. With the engine stopped and the air cylinder-to-valve linkage disconnected, detach the boost pressure line from the air inlet housing and install a tee fitting on the end of the hose. Attach a low pressure gage and an air supply line to the open ends of the tee fitting.

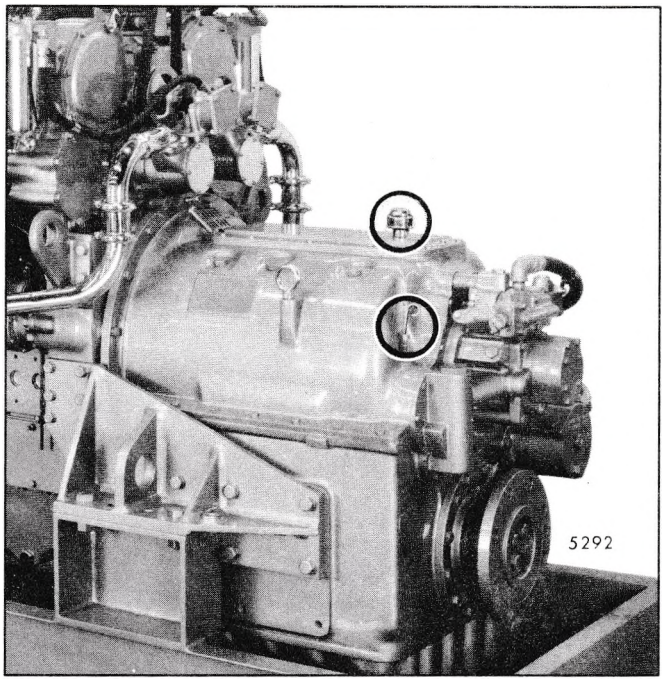
 © Detroit Diesel Corporation



Item 39

b. Using regulated shop air, slowly charge the cylinder and watch the rod on the end of the piston. The rod should start to move at 7 psi (48 kPa) and be fully extended at 10 psi (69 kPa). As pressure drops, the rod should be fully seated in the cylinder at 3 psi (21 kPa). If the air cylinder fails this test, check the breather filter element on the end and replace, if plugged. A plugged breather filter element will not allow the cylinder to exhaust and intake air during engine operation. In areas where severe plugging is experienced, a remote mounted, dry type air filter may be installed. If the air cylinder still does not function properly, replace the cylinder.

c. If the air cylinder operates properly during the test but the valve continues to malfunction when linkage is reconnected, check the linkage for binding and misalignment. If this fails to correct the malfunction, the valve should be replaced.



Item 41

d. Remove the tee fitting and pressure gage. Reconnect the turbocharger boost line to the air cylinder.

• Current System

On engines with current piston-style bypass valve-equipped air induction systems, verify the settings on the control valve every 5000 hours. Refer to section 3.4.2 for procedure.

Item 50 - Crankcase Pressure Monitor

Check the crankcase pressure monitor for proper operation every 600 hours. Repair or replace as required. Refer to section 7.4 for procedure.

i

TROUBLESHOOTING

Certain abnormal conditions which sometimes interfere with satisfactory engine operation, together with methods of determining the cause of such conditions, are covered on the following pages.

Satisfactory engine operation depends primarily on:

1. An adequate supply of air compressed to a sufficiently high compression pressure.
2. The injection of the proper amount of fuel at the right time.

Lack of power, uneven running, excessive vibration, stalling at idle speed and hard starting may be caused by either low compression, faulty injection in one or more cylinders, or lack of sufficient air.

Since proper compression, fuel injection and the proper amount of air are important to good engine performance, detailed procedures for their investigation are given below:

Checking Compression Pressure

To prevent excessive oil splash and/or loss of oil when performing a compression pressure check, a spare rocker cover should be modified as shown in Fig. 1. This rocker cover can then be used at any one of the cover locations.

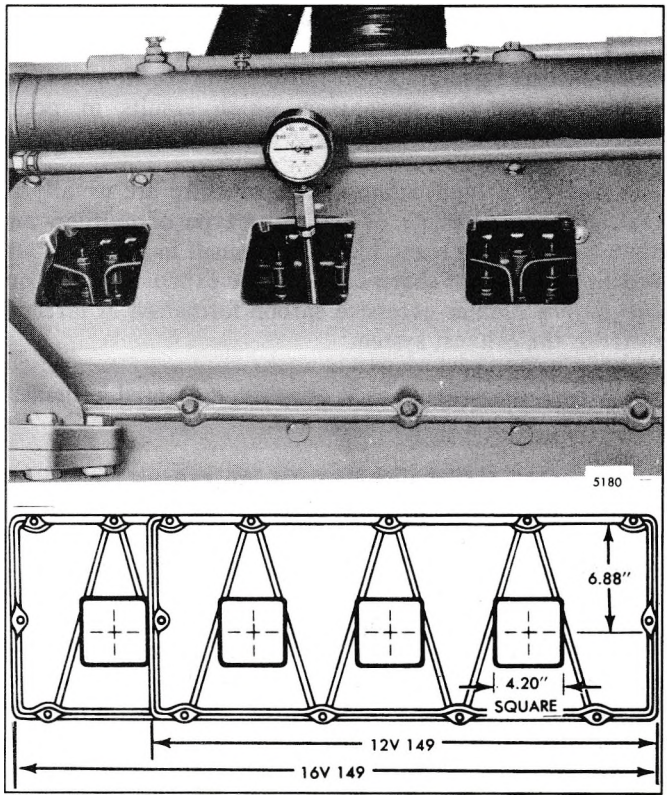


Fig. 1 - Instructions for Modifying the Rocker Cover for Compression Test

NOTICE: Be sure to reinstall each standard cover after performing the compression check with the modified cover.

Check the compression pressure as follows:

1. Start the engine and run it at approximately one-half rated load until normal operating temperature is reached.
2. Stop the engine and remove the fuel pipes from the injector and fuel connectors of the No. 1 cylinder.

• **NOTICE:** To avoid dilution of lube oil, use a clean rag to catch and absorb fuel spill from the fuel mainfold.

3. Remove the injector from the No. 1 cylinder and remove the injector rocker arm. Then install spacer J 22503-7 in place of the injector rocker arm and install pressure gage J 22503, using the injector hold-down clamp to retain the pressure gage.
4. Use a spare fuel pipe to fabricate a jumper connection between the fuel inlet and return manifold connectors. This will permit fuel from the inlet manifold to flow directly to the return manifold.

• To fabricate the jumper line connection, cut off the injector end of a spare fuel pipe and remove the injector nut. Slip a fuel manifold nut onto the pipe and flare the end of the tube. Bend the line to fit.

5. Start the engine and run it at 600 rpm. Observe and record the compression pressure indicated on the gage. *Do not crank the engine with the starting motor to obtain the compression pressure.*
6. Perform Steps 2 through 5 on each cylinder. The compression pressure in any one cylinder should not be less than shown in Table 1. In addition, the variation in compression pressures between cylinders must not exceed 25 psi (172 kPa) at 600 rpm.

Minimum Compression Pressure at 600 rpm				Altitude ^ above Sea Level		t Air Density
149 and 149T		149TI				
psi	kPa	psi	kPa	Feet	Meters	
450	3101	370	2550	0-500	0-152.4	.0715
415	2859	340	2343	2,500	762.0	.0663
385	2653	315	2170	5,000	1524.0	.0613
355	2446	290	1999	7,500	2285.0	.0567
330	2274	270	1861	10,000	3048.0	.0525

t Air density at 500 ft. altitude based on 85° F (29.4° C) and 29.38 in Hg (99.49 kPa) wet barometer.

TABLE 1

Low compression pressure may result from any one of several causes:

A. Piston rings may be stuck or broken. To determine the condition of the rings, remove the air box cover and inspect them by pressing on the rings with a blunt tool. A broken or stuck ring will not have a "spring-like" action.

B. Compression may be leaking past the cylinder head gasket, the valve seats, the injector tube or a hole in the piston.

Engine Out Of Fuel

The problem in restarting an engine after it has run out of fuel stems from the fact that after the fuel is exhausted from the fuel tank, fuel is then pumped from the primary fuel strainer and sometimes partially removed from the secondary fuel filter before the fuel supply becomes insufficient to sustain engine firing. Consequently, these components must be refilled with fuel and the fuel pipes rid of air in order for the system to provide adequate fuel for the injectors.

When an engine has run out of fuel, there is a definite procedure to follow for restarting it.

1. Fill the fuel tank with the recommended grade of fuel oil. If only partial filling of the tank is possible, add a minimum of 25 gallons (95 litres) of fuel.
2. Remove the fuel strainer shell and element from the strainer cover and fill the shell with fuel oil. Install the shell and element.
3. Remove and fill the fuel filter shell and element with fuel oil as in Step 2.
4. Start the engine. Check the filter and strainer for leaks.

NOTICE: In some instances, it may be necessary to remove a valve rocker cover and loosen a fuel pipe nut to bleed trapped air from the fuel system. Be sure the fuel pipe is retightened securely before replacing the rocker cover.

Primer J 5956 may be used to prime the entire fuel system. Remove the filler plug in the fuel filter cover and install the primer. Prime the system. Remove the primer and install the filler plug.

Fuel Flow Test

The proper flow of fuel is required for satisfactory engine operation. Check the condition of the fuel pump, fuel strainer and fuel filter as outlined in Section 2.0 under *Troubleshooting.*

Crankcase Pressure

The crankcase pressure indicates the amount of air passing between the oil control rings and the cylinder liners into the crankcase, most of which is clean air from the air box. A slight pressure in the crankcase is desirable to prevent the entrance of dust. A loss of engine lubricating oil through the crankcase ventilator or the dipstick hole in the cylinder block is indicative of excessive crankcase pressure.

The causes of high crankcase pressure may be traced to excessive blow-by due to worn piston rings, a hole or crack in a piston crown, loose piston pin retainers, defective blower or cylinder head gaskets, or excessive exhaust back pressure. Also, the breather tube or crankcase ventilator should be checked for obstructions.

Check the crankcase pressure with a manometer connected to the oil level dipstick opening in the cylinder block. Check the readings obtained at various engine speeds with the *Engine Operating Conditions* in Section 13.2.

NOTICE: The dipstick adaptor must not be below the level of the oil when checking the crankcase pressure.

Exhaust Back Pressure

A slight pressure in the exhaust system is normal. How'ever, excessive exhaust back pressure seriously affects engine operation. It may cause an increase in the air box pressure with a resultant loss of efficiency of the blower. This means less air for scavenging which results in poor combustion and higher temperatures.

Causes of high exhaust back pressure are usually a result of an inadequate or improper type of muffler, an exhaust pipe which is too long or too small in diameter, an excessive number of sharp bends in the exhaust system, or obstructions such as excessive carbon formation or foreign matter in the exhaust system.

Check the exhaust back pressure, measured in inches of mercury, with a manometer.

Connect the manometer to an exhaust manifold (except on turbocharged engines). If no opening is provided, drill an 11/32" hole in the exhaust manifold companion flange and tap the hole to accommodate a 1/8" pipe plug.

On turbocharged engines, check the exhaust back pressure in the exhaust piping 6" to 12" from the turbine outlet (Fig. 1 of Section 13.2). The tapped hole must be in a comparatively straight pipe area for an accurate measurement.

Check the readings obtained at various speeds (at no-load) with the *Engine Operating Conditions* in Section 13.2.

 © Detroit Diesel Corporation

Air Box Pressure

Proper air box pressure is required to maintain sufficient air for combustion and scavenging of the burned gases. Low air box pressure is caused by a high air inlet restriction, an air leak from the air box or a clogged blower air inlet screen. Lack of power or black or grey exhaust smoke are indications of low air box pressure.

High air box pressure can be caused by partially plugged cylinder liner ports.

Check the air box pressure with a manometer connected to an air box drain tube.

Check the readings obtained at various speeds with the *Engine Operating Conditions* in Section 13.2.

Air Inlet Restriction

Excessive restriction of the air inlet will affect the flow of air to the cylinders and result in poor combustion and lack of power. Consequently the restriction must be kept as low as possible considering the size and capacity of the air cleaner. An obstruction in the air inlet system or dirty or damaged air cleaners will result in a high blower inlet restriction.

Check the air inlet restriction with a water manometer connected to a fitting in the air inlet ducting located 2" above the air inlet housing. When practicability prevents the insertion of a fitting at this point, the manometer may be connected to the engine air inlet housing. The restriction at this point should be checked at a specific engine speed. Then the air cleaner and ducting should be removed from the air inlet housing and the engine again operated at the same speed while noting the manometer reading.

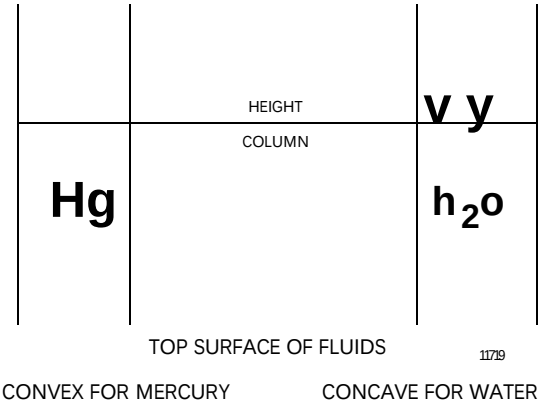


Fig. 2 - Comparison of Column Height for Mercury and Water Manometers

The difference between the two readings, with and without the air cleaner and ducting, is the actual restriction caused by the air cleaner and ducting.

On turbocharged engines, measure the air inlet restriction, at each turbocharger, with a water manometer connected in the large diameter of the air duct just before it is reduced to enter the turbocharger compressor (Fig. 1 in Section 13.2). There should not be more than 2" of water difference in the compressor inlet readings for turbochargers being supplied from a common air cleaner(s).

Check the normal air inlet vacuum at various speeds (at no-load) and compare the results with the *Engine Operating Conditions* in Section 13.2.

PROPER USE OF MANOMETER

The U-tube manometer is a primary measuring device indicating pressure or vacuum by the difference in the height of two columns of fluid.

Connect the manometer to the source of pressure, vacuum or differential pressure. When the pressure is imposed, add the number of inch s one column of fluid travels up to the amount the other column travels down to obtain the pressure (or vacuum) reading.

The height of a column of mercury is read differently than that of a column of water. Mercury does not wet the inside surface; therefore, the top of the column has a convex meniscus (shape). Water wets the surface and therefore has a concave meniscus. A mercury column is read by sighting horizontally between the top of the convex mercury surface (Fig. 2) and the scale. A water manometer is read by sighting horizontally between the bottom of the concave water surface and the scale.

Should one column of fluid travel further than the other column, due to minor variations in the inside diameter of the tube or to the pressure imposed, the accuracy of the reading obtained is not impaired.

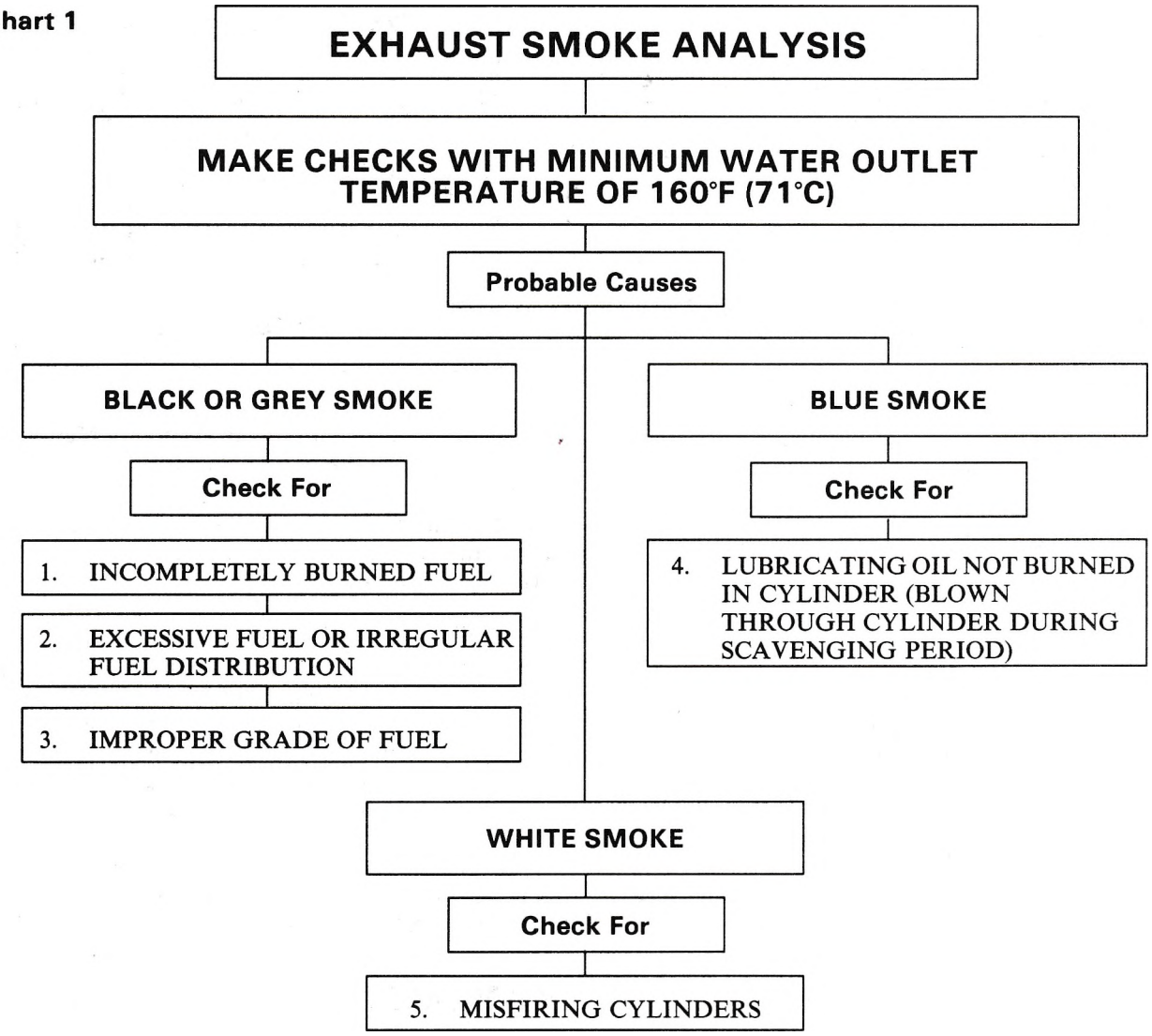
Refer to Table 2 to convert the manometer reading into other units of measurement.

PRESSURE CONVERSION CHART

	' water	-	.0735" mercury
	water	—	.0361 psi
	mercury	—	13.6000" water
	mercury	=	.4910 psi
i	psi	=	27.7000" water
i	psi	=	2.0360" mercury
i	psi	=	6.895 kPa
i	kPa		.145 psi

TABLE 2

Chart 1



 © Detroit Diesel Corporation

Chart 1

EXHAUST SMOKE ANALYSIS

— SUGGESTED REMEDY —

1. High exhaust back pressure or a restricted air inlet causes insufficient air for combustion and will result in incompletely burned fuel.

High exhaust back pressure is caused by faulty exhaust piping or muffler obstruction and is measured at the exhaust manifold outlet with a manometer. Replace faulty parts.

Restricted air inlet to the engine cylinders is caused by clogged cylinder liner ports, air cleaner or blower air inlet screen. Clean these items. Check the emergency stop to make sure that it is completely open and readjust it if necessary.

2. Check for improperly timed injectors and improperly positioned injector rack control levers. Time the fuel injectors and perform the appropriate governor tune-up.

Replace faulty injectors if this condition still persists after timing the injectors and performing the engine tune-up.

Avoid lugging the engine as this will cause incomplete combustion.

3. Check for use of an improper grade of fuel. Refer to ***Fuel Oil Recommendations*** in Section 13.3.

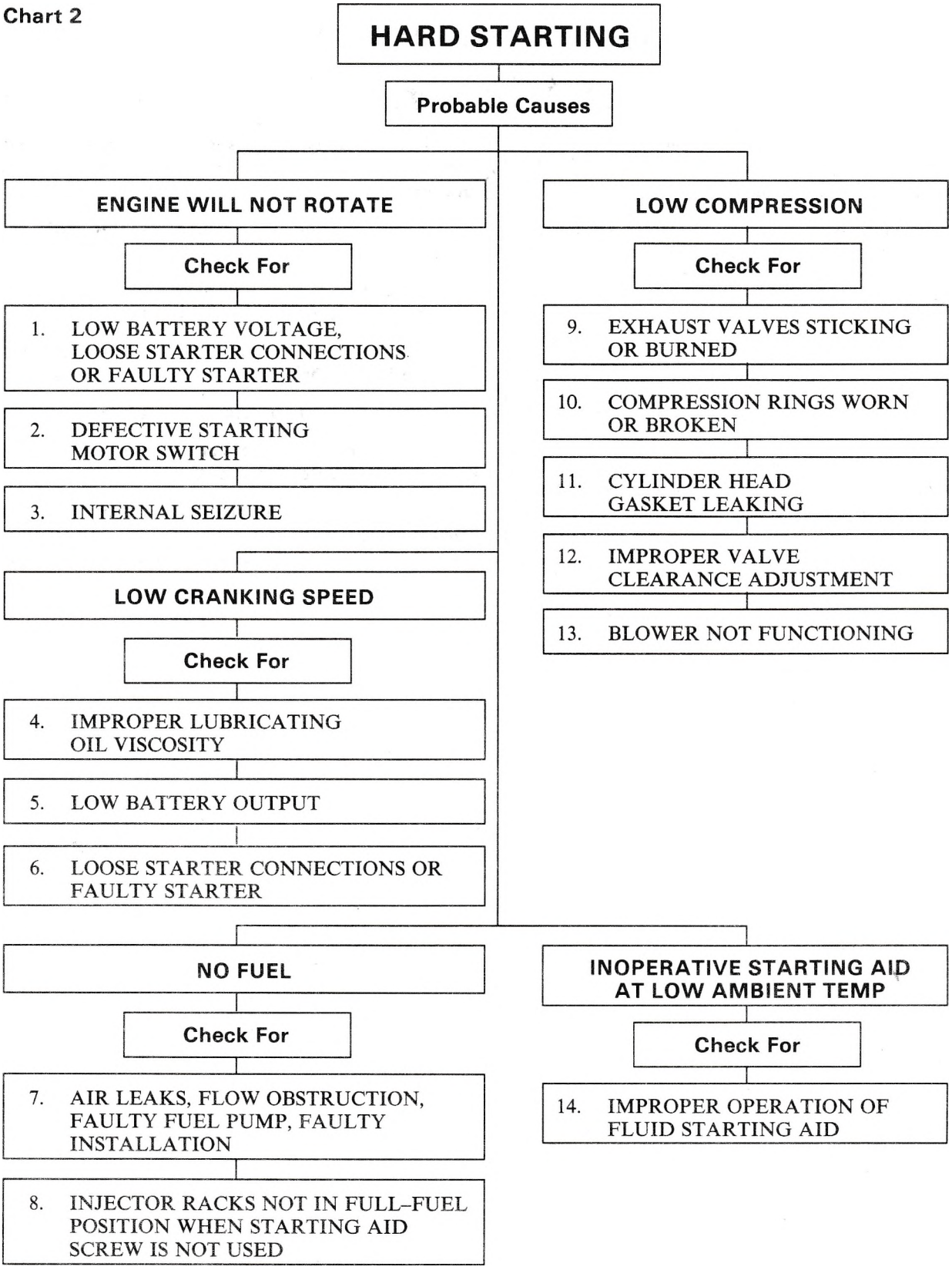
4. Check for internal lubricating oil leaks and refer to the ***High Lubricating Oil Consumption*** chart.

5. Check for faulty injectors and replace as necessary.

The use of low cetane fuel will cause this condition. Refer to ***Fuel Oil Recommendations*** in Section 13.3.

Check for low compression and consult the ***Hard Starting*** chart.

Chart 2



 © Detroit Diesel Corporation

Chart 2

HARD STARTING

SUGGESTED REMEDY

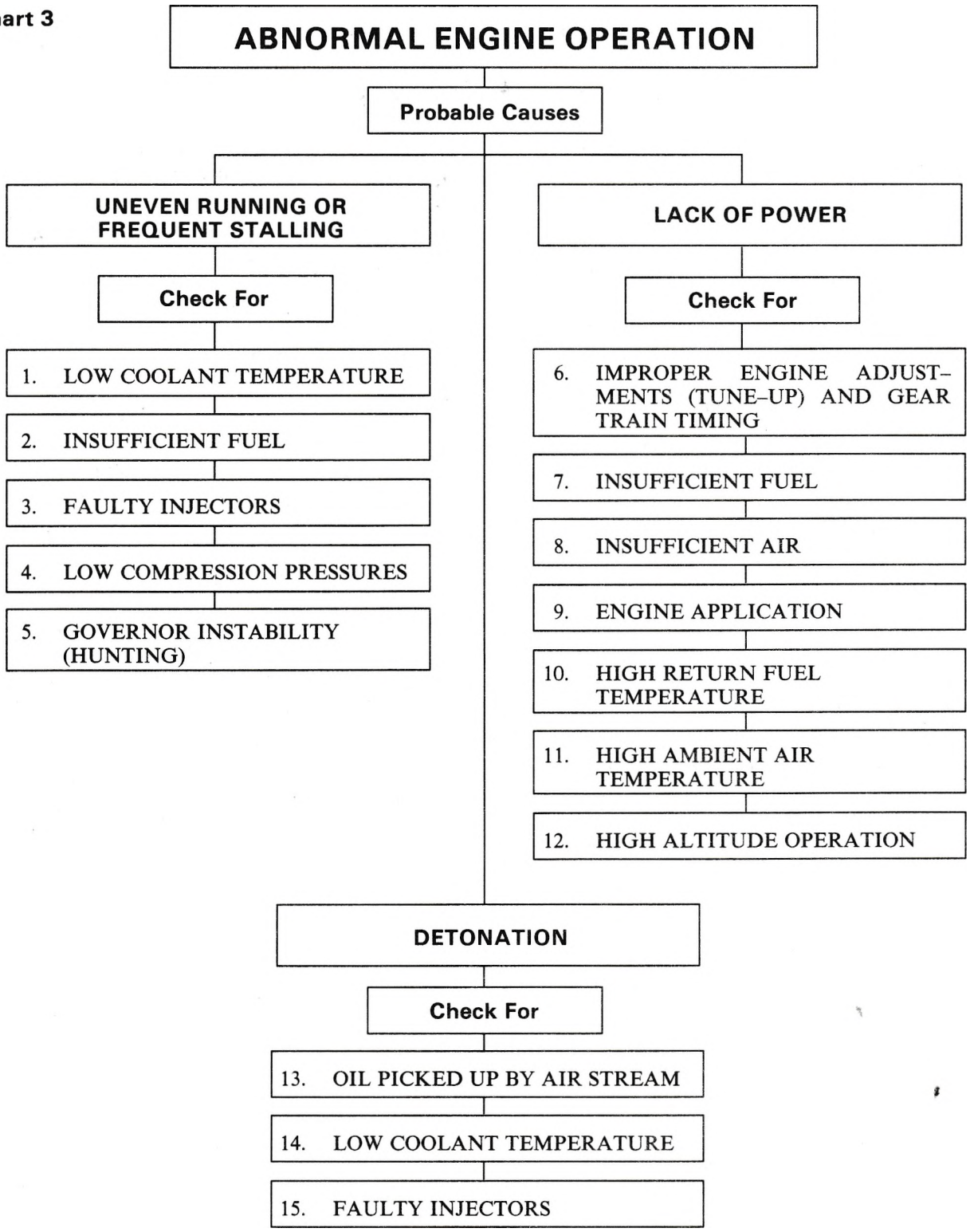
1. Refer to Items 2, 3 and 5 and perform the operations listed.
2. Replace the starting motor switch.
3. Hand crank the engine at least one complete revolution. If the engine cannot be rotated a complete revolution, internal damage is indicated and the engine must be disassembled to ascertain the extent of damage and the cause.
4. Refer to *Lubricating Oil Recommendations* in Section 13.3 for the recommended grade of oil.
5. Recharge the battery if a light load test indicates low or no voltage. Replace the battery if it is damaged or will not hold a charge.

   Replace terminals that are damaged or corroded.

   At low ambient temperatures, use of a starting aid will keep the battery fully charged by reducing the cranking time.
6. Tighten the starter connections. Inspect the starter commutator and brushes for wear. Replace the brushes if badly worn and overhaul the starting motor if the commutator is damaged.
7. To check for air leaks, flow obstruction, faulty fuel pump or faulty installation, consult the *No Fuel or Insufficient Fuel* chart.
8. Check for bind in the governor-to-injector linkage. Readjust the governor and injector controls if necessary.
9. Remove the cylinder head and recondition the exhaust valves.
10. Remove the air box covers and inspect the compression rings through the ports in the cylinder liners. Overhaul the cylinder assemblies if the rings are badly worn or broken.
11. To check for compression gasket leakage, remove the coolant filler cap and operate the engine. A steady flow of gases from the coolant filler indicates either a cylinder head gasket is damaged or the cylinder head is cracked. Remove the cylinder head and replace the gaskets or cylinder head.
12. Adjust the exhaust valve clearance.
13. Remove the blower drive shaft. Inspect the blower drive shaft and coupling. Replace damaged parts. Bar the engine over. If the engine does not rotate, remove the air inlet adaptor and visually inspect the blower rotors and end plates. If damaged, remove and overhaul the blower.
14. Operate the starting aid according to the instructions under *Cold Weather Starting Aids.*

%

Chart 3



 © Detroit Diesel Corporation

Chart 3

ABNORMAL ENGINE OPERATION

------- SUGGESTED REMEDY --------

1. Check the engine coolant temperature gage and, if the temperature does not reach 160-185°F (71-85°C) while the engine is operating, consult the *Abnormal Engine Coolant Temperature* chart.
2. Check engine fuel spill back and if the return is less than specified, consult the *No Fuel or Insufficient Fuel* chart.
3. Check the injector timing and the position of the injector racks. If the engine was not tuned correctly, perform an engine tune-up. Erratic engine operation may also be caused by leaking injector spray tips. Replace the faulty injectors.
4. Check the compression pressures within the cylinders and consult the *Hard Starting* chart if compression pressures are low.
5. Erratic engine operation may be caused by governor-to-injector operating linkage bind or by faulty engine tune-up. Perform the appropriate engine tune-up procedure as outlined for the particular governor used.
6. Perform an engine tune-up if performance is not satisfactory.

Check the engine gear train timing. An improperly timed gear train will result in a loss of power due to the valves and injectors being actuated at the wrong time in the engine's operating cycle.

7. Perform a *Fuel Flow Test* and, if less than the specified fuel is returning to the fuel tank, consult the *No Fuel or Insufficient Fuel* chart.
8. Check for damaged or dirty air cleaners and clean, repair or replace damaged parts.

Remove the air box covers and inspect the cylinder liner ports. Clean the ports if they are over 50% plugged.

Check for blower air intake obstruction or high-exhaust back pressure. Clean, repair or replace faulty parts.

Check the compression pressures (consult the *Hard Starting* chart).

9. Incorrect operation of the engine may result in excessive loads on the engine. Operate the engine according to the approved procedures.
10. Refer to Item 13 on Chart 4.
11. Check the ambient air temperature. A power decrease of .15 to .50 horsepower per cylinder, depending upon injector size, for each 10°F (5.6°C) temperature rise above 90°F (32.2°C) will occur. Relocate the engine air intake to provide a cooler source of air.
12. Engines lose horsepower with increase in altitude. The percentage of power loss is governed by the altitude at which the engine is operating.
13. Fill oil bath air cleaners to the proper level with the same grade and viscosity lubricating oil that is used in the engine.

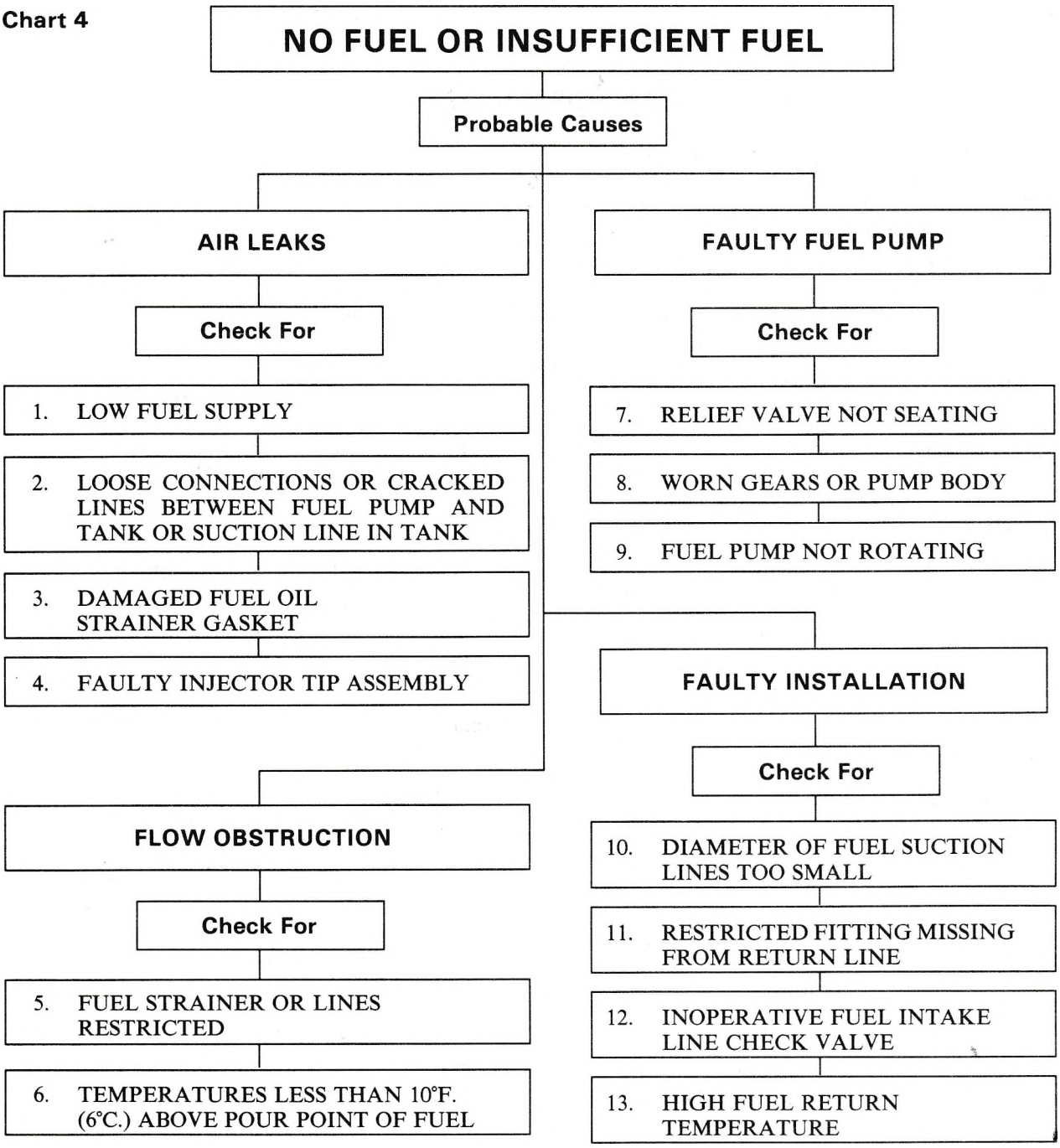
Clean the air box and drain tubes to prevent accumulations that may be picked up by the air stream and enter the engine's cylinders.

Inspect the blower oil seals by removing the air inlet housing and watching through the blower inlet for oil radiating away from the blower rotor shaft oil seals while the engine is running. If oil is passing through the seals, overhaul the blower.

Check for a defective blower-to-block gasket. Replace the gasket, if necessary.

14. Refer to Item 1 of this chart.
15. Check injector timing and the position of each injector rack. Perform an engine tune-up, if necessary. If the engine is correctly tuned, the erratic operation may be caused by an injector check valve leaking, spray tip holes enlarged or a broken spray tip. Replace faulty injectors.

Chart 4



 © Detroit Diesel Corporation

Chart 3

ABNORMAL ENGINE OPERATION

------- SUGGESTED REMEDY --------

1. Check the engine coolant temperature gage and, if the temperature does not reach 160-185°F (71-85°C) while the engine is operating, consult the *Abnormal Engine Coolant Temperature* chart.

2. Check engine fuel spill back and if the return is less than specified, consult the *No Fuel or Insufficient Fuel* chart.

3. Check the injector timing and the position of the injector racks. If the engine was not tuned correctly, perform an engine tune-up. Erratic engine operation may also be caused by leaking injector spray tips. Replace the faulty injectors.

4. Check the compression pressures within the cylinders and consult the *Hard Starting* chart if compression pressures are low.

5. Erratic engine operation may be caused by governor-to-injector operating linkage bind or by faulty engine tune-up. Perform the appropriate engine tune-up procedure as outlined for the particular governor used.

6. Perform an engine tune-up if performance is not satisfactory.

Check the engine gear train timing. An improperly timed gear train will result in a loss of power due to the valves and injectors being actuated at the wrong time in the engine's operating cycle.

7. Perform a *Fuel Flow Test* and, if less than the specified fuel is returning to the fuel tank, consult the *No Fuel or Insufficient Fuel* chart.

8. Check for damaged or dirty air cleaners and clean, repair or replace damaged parts.

Remove the air box covers and inspect the cylinder liner ports. Clean the ports if they are over 50% plugged.

Check for blower air intake obstruction or high exhaust back pressure. Clean, repair or replace faulty parts.

Check the compression pressures (consult the *Hard Starting* chart).

9. Incorrect operation of the engine may result in excessive loads on the engine. Operate the engine according to the approved procedures.

10. Refer to Item 13 on Chart 4.

11. Check the ambient air temperature. A power decrease of .15 to .50 horsepower per cylinder, depending upon injector size, for each 10°F (5.6°C) temperature rise above 90°F (32.2°C) will occur. Relocate the engine air intake to provide a cooler source of air.

12. Engines lose horsepower with increase in altitude. The percentage of power loss is governed by the altitude at which the engine is operating.

13. Fill oil bath air cleaners to the proper level with the same grade and viscosity lubricating oil that is used in the engine.

Clean the air box and drain tubes to prevent accumulations that may be picked up by the air stream and enter the engine's cylinders.

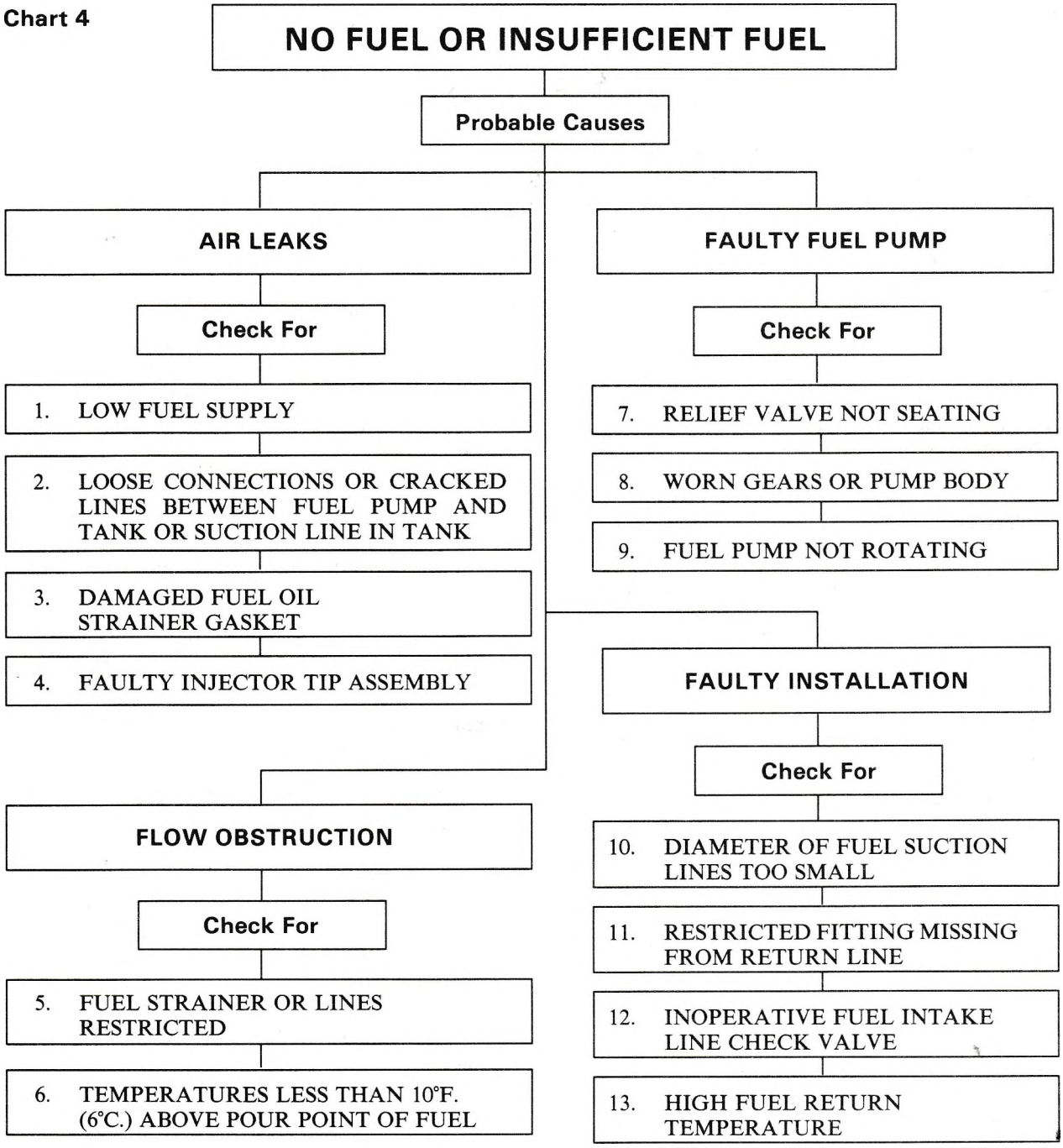
Inspect the blower oil seals by removing the air inlet housing and watching through the blower inlet for oil radiating away from the blower rotor shaft oil seals while the engine is running. If oil is passing through the seals, overhaul the blower.

Check for a defective blower-to-block gasket. Replace the gasket, if necessary.

14. Refer to Item 1 of this chart.

15. Check injector timing and the position of each injector rack. Perform an engine tune-up, if necessary. If the engine is correctly tuned, the erratic operation may be caused by an injector check valve leaking, spray tip holes enlarged or a* broken spray tip. Replace faulty injectors.

Chart 4



 © Detroit Diesel Corporation

Chart 4

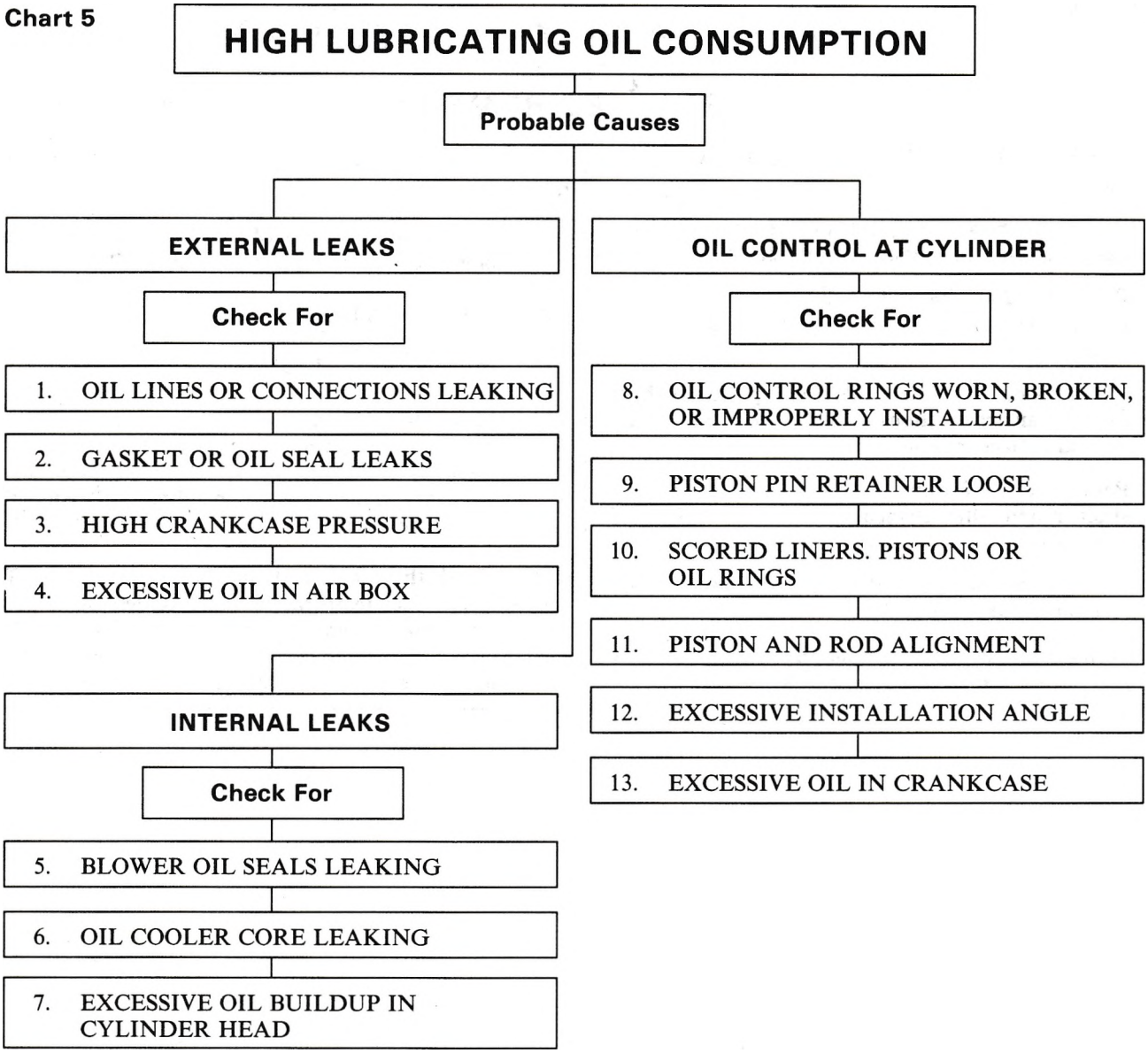
NO FUEL OR INSUFFICENT FUEL

------ SUGGESTED REMEDY ------- *

1. The fuel tank should be filled above the level of the fuel suction tube.
2. Perform a ***Fuel Flow Test*** and, if air is present, tighten loose connections and replace cracked lines.
3. Perform a ***Fuel Flow Test*** and, if air is present, replace the fuel strainer gasket when changing the strainer element.
4. Perform a ***Fuel Flow Test*** and, if air is present with all fuel lines and connections assembled correctly, check for and replace faulty injectors.
5. Perform a ***Fuel Flow Test*** and replace the fuel strainer and filter elements and the fuel lines, if necessary,
6. Consult the ***Fuel Oil Recommendations*** for the recommended grade of fuel.
7. Perform a ***Fuel Flow Test*** and, if inadequate, clean and inspect the valve seat assembly.
8. Replace the gear and shaft assembly or the pump body.
9. Check the condition of the fuel pump drive and blower drive and replace defective parts.
10. Replace with larger tank-to-engine fuel lines.
11. Install a restricted fitting in the return line.
12. Make sure that the check valve is installed in the line correctly; the arrow should be on top of the valve assembly or pointing upward. Reposition the valve if necessary. If the valve is inoperative, replace it with a new valve assembly.
13. Check the engine fuel spill-back temperature. The return fuel temperature must be less than 150°F (66°C) or a loss in horsepower will occur. This condition may be corrected by installing larger fuel lines or relocating the fuel tank to a cooler position.

*

Chart 5



 © Detroit Diesel Corporation

Chart 5

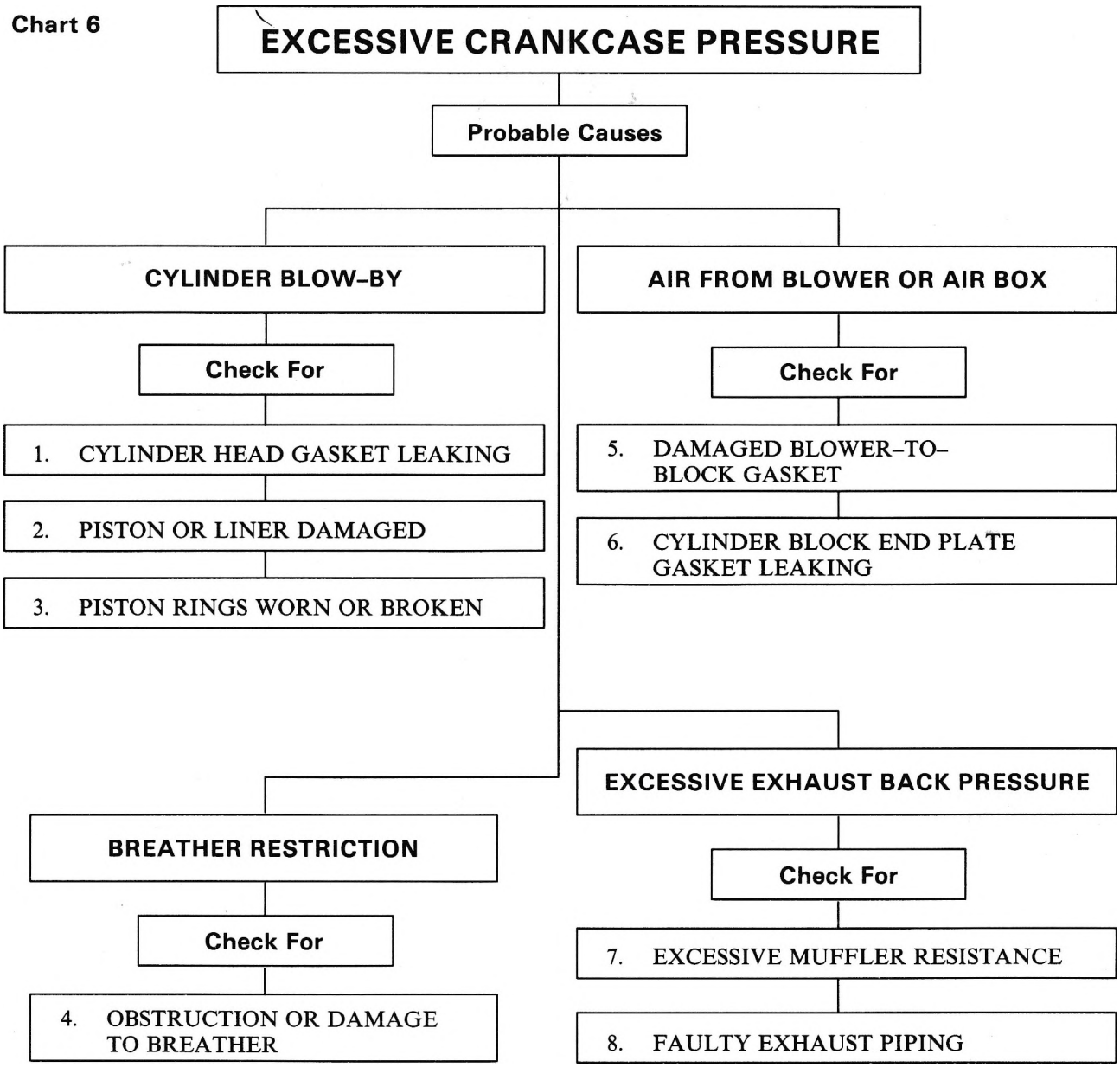
HIGH LUBRICATING OIL CONSUMPTION

---------- SUGGESTED REMEDY ----------

1. Tighten connections or replace defective parts.
2. Replace defective gaskets or oil seals.
3. Refer to the *Excessive Crankcase Pressure* chart.
4. Refer to the *Abnormal Engine Operation* chart.
5. Remove the air inlet housing and inspect the blower end plates while the engine is operating. If oil is seen on the end plate radiating away from the oil seal, overhaul the blower.
6. Inspect the engine coolant for lubricating oil contamination; if contaminated, replace the oil cooler core. Then use a good grade of cooling system cleaner to remove the oil from the cooling system.
7. Check for plugged or improper breather.
8. Replace the oil control rings.
9. Replace the piston pin retainer and defective parts.
10. Remove and replace the defective parts.
11. Check the crankshaft thrust washers for wear. Replace worn and defective parts.
12. Decrease the installation angle.
13. Fill the crankcase to the proper level only.

i

Chart 6



SUGGESTED REMEDY

1. Check the compression pressure and, if only one cylinder has low compression, remove the cylinder head and replace the head gaskets.
2. Inspect the piston and liner and replace damaged parts.
3. Install new piston rings.
4. Clean and repair or replace the breather assembly.
5. Replace the blower-to-block gasket.
6. Replace the end plate gasket.
7. Check the exhaust back pressure and repair or replace the muffler if an obstruction is found.
8. Check the exhaust back pressure and install larger piping if it is determined that the piping is too small, too long or has too many bends.

 © Detroit Diesel Corporation

Chart 7

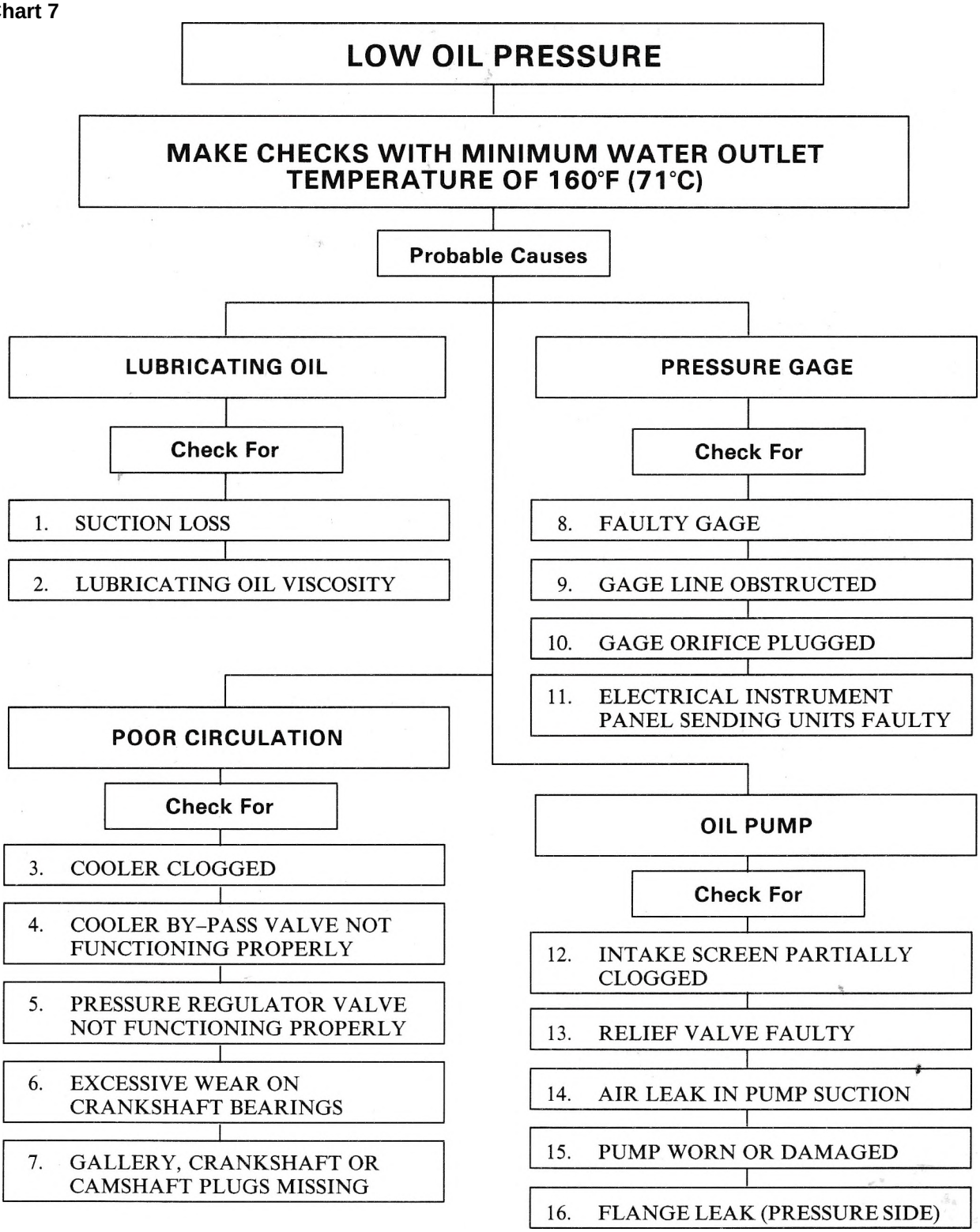

LOW OIL PRESSURE
MAKE CHECKS WITH MINIMUM WATER OUTLET TEMPERATURE OF 160°F (71°C)
Probable Causes
LUBRICATING OIL
Check For
1. SUCTION LOSS
2. LUBRICATING OIL VISCOSITY
POOR CIRCULATION
Check For
3. COOLER CLOGGED
4. COOLER BY-PASS VALVE NOT FUNCTIONING PROPERLY
5. PRESSURE REGULATOR VALVE NOT FUNCTIONING PROPERLY
6. EXCESSIVE WEAR ON CRANKSHAFT BEARINGS
7. GALLERY, CRANKSHAFT OR CAMSHAFT PLUGS MISSING
PRESSURE GAGE
Check For
8. FAULTY GAGE
9. GAGE LINE OBSTRUCTED
10. GAGE ORIFICE PLUGGED
11. ELECTRICAL INSTRUMENT PANEL SENDING UNITS FAULTY
OIL PUMP
Check For
12. INTAKE SCREEN PARTIALLY CLOGGED
13. RELIEF VALVE FAULTY
14. AIR LEAK IN PUMP SUCTION
15. PUMP WORN OR DAMAGED
16. FLANGE LEAK (PRESSURE SIDE)

Chart 7

LOW OIL PRESSURE

SUGGESTED REMEDY

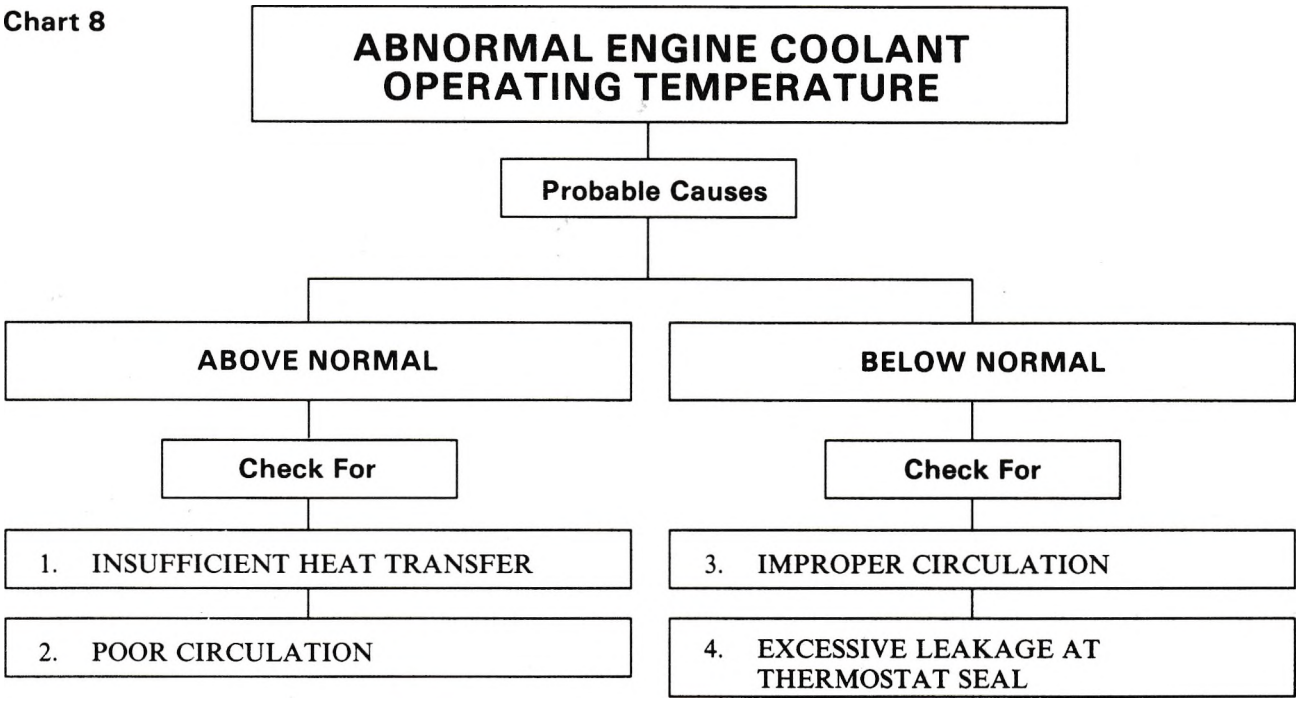
1. Check the oil and bring it to the proper level on the dipstick or correct the installation angle.
2. Consult the *Lubricating Oil Recommendations* in Section 13.3 for the recommended grade and viscosity of oil.

Check for fuel leaks at the injector nut seal ring and fuel pipe connections. Leaks at these points will cause lubricating oil dilution (refer to *Pressurize Fuel System - Check for Leaks* in Section 2.0).

3. A plugged oil cooler is indicated by excessively high lubricating oil temperature. Remove and clean the oil cooler core.
4. Remove the bypass valve and clean the valve and valve seat and inspect the valve spring. Replace defective parts.
5. Remove the pressure regulator valve and clean the valve and valve seat and inspect the valve spring. Replace defective parts.
6. Change the bearings. Consult the *Lubricating Oil Recommendations* in Section 13.3 for the proper grade and viscosity of oil. Change the oil filters.
7. Replace missing plugs.
8. Check the oil pressure with a reliable gage and replace the gage if found faulty.
9. Remove and clean the gage line; replace it, if necessary.
10. Remove and clean the gage orifice.
11. Repair or replace defective electrical equipment.
12. Remove and clean the oil pan and oil intake screen. Consult the *Lubricating Oil Recommendations* in Section 13.3 for the proper grade and viscosity of oil. Change the oil filters.
13. Remove and inspect the valve, valve bore and spring. Replace faulty parts.
14. Disassemble the piping and install new gaskets.
15. Remove the pump. Clean and replace defective parts.
16. Remove the flange and replace the gasket.

 © Detroit Diesel Corporation

Chart 8



SUGGESTED REMEDY

1. Clean the cooling system with a good cooling system cleaner and thoroughly flush to remove scale deposits.

Clean the exterior of the radiator core to open plugged passages and permit normal air flow.

Adjust fan belts to the proper tension to prevent slippage.

Check for an improper size radiator or inadequate shrouding.

Repair or replace inoperative temperature-controlled fan or inoperative shutters.

2. Check the coolant level and fill to the filler neck if the coolant level is low.

Inspect for collapsed or disintegrated hoses. Replace faulty hoses.

Thermostat may be inoperative. Remove, inspect and test the thermostat; replace if found faulty.

Check the water pump for a loose or damaged impeller.

Check the flow of coolant through the radiator. A clogged radiator will cause an inadequate supply of coolant on the suction side of the pump. Clean the radiator core.

Remove the coolant filler cap and operate the engine, checking for combustion gases in the cooling system. The cylinder head must be removed and inspected for cracks and the head gaskets replaced if combustion gases are entering the cooling system.

Check for an air leak on the suction side of the water pump. Replace defective parts.

3. The thermostat may not be closing. Remove, inspect and test the thermostat. Install a new thermostat, if necessary.

Check for an improperly installed heater.

4. Excessive leakage of coolant past the thermostat seal(s) is a cause of continued low coolant operating temperature. When this occurs, replace the thermostat seal(s).

STORAGE

PREPARING ENGINE FOR STORAGE

When an engine is to be stored or removed from operation for a period of time, special precautions should be taken to protect the interior and exterior of the engine, transmission and other parts from rust accumulation and corrosion. The parts requiring attention and the recommended preparations are given below.

It will be necessary to remove all rust or corrosion completely from any exposed part before applying a rust preventive compound. Therefore, it is recommended that the engine be processed for storage as soon as possible after removal from operation.

The engine should be stored in a building which is dry and can be heated during the winter months. Moisture absorbing chemicals are available commercially for use when excessive dampness prevails in the storage area.

TEMPORARY STORAGE (30 DAYS OR LESS)

To protect an engine for a temporary period of time, proceed as follows:

1. Drain the engine crankcase.
2. Fill the crankcase to the proper level with the recommended viscosity and grade of oil.
3. Fill the fuel tank with the recommended grade of fuel oil. Operate the engine for two minutes at 1,200 rpm and no load. Do not drain the fuel system or the crankcase after this run.
4. Check the air cleaner and service it, if necessary, as outlined in Section 3.1.
5. If freezing weather is expected during the storage period, add an ethylene glycol base antifreeze solution in accordance with the manufacturer's recommendations. Drain the raw water system and leave the drain cocks open.
6. Clean the entire exterior of the engine (except the electrical system) with fuel oil and dry it with compressed air.

CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

7. Seal all of the engine openings. The material used for this purpose must be waterproof, vaporproof and possess sufficient physical strength to resist puncture and damage from the expansion of entrapped air.

An engine prepared in this manner can be returned to service in a short time by removing the seals at the engine openings, checking the engine coolant, fuel oil, lubricating oil, transmission and priming the raw water pump, if used.

EXTENDED STORAGE (MORE THAN 30 DAYS)

To prepare an engine for extended storage, (more than 30 days), follow this procedure:

• 1. Drain the cooling system and flush with clean, soft water. Refill with clean, soft water and add a rust inhibitor to the cooling system (refer to *Corrosion Inhibitor* under *Coolant Specifications* in section 13.3).

2. Remove, check and recondition the injectors, if necessary, to make sure they will be ready to operate when the engine is restored to service.
3. Reinstall the injectors, time them and adjust the exhaust valve clearance.
4. Circulate the coolant by operating the engine until normal operating temperature is reachad (160°-185°F or 71°-85°C).
5. Stop the engine.
6. Drain the engine crankcase, then reinstall and tighten the drain plug. Install new lubricating oil filter elements and gaskets.
7. Fill the crankcase to the proper level with a 30-weight preservative lubricating oil MIL-L-21260C, Grade 2.

8. Drain the fuel tank. Refill with enough clean No. 1 diesel fuel or pure kerosene to permit the engine to operate for about ten (10) minutes. If it isn't convenient to drain the fuel tank (i.e., marine) use a separate portable supply of the recommended fuel.

   NOTICE: If engines in vehicles or marine units are stored where condensation of water in the fuel tank may be a problem, add pure, waterless isopropyl alcohol (isopropanol) to the fuel at a ratio of one pint to 125 gallons of fuel, or .010% by volume. Where biological contamination of fuel may be a problem, add a biocide such as Biobor JF, or equivalent to the fuel. When using a biocide, follow the manufacturer's concentration recommendations, and observe all cautions and warnings.

9. Drain and disassemble the fuel filter and strainer. Discard the used elements and gaskets. Fill the cavity between the element and shell with No. 1 diesel fuel or pure kerosene, and reinstall on the engine. If spin-on fuel filters and strainers are used, discard the used cartridges, fill the new ones with No. 1 diesel fuel or pure kerosene, and reinstall on the engine.

10. Operate the engine for five (5) minutes to circulate the clean fuel oil throughout the fuel system.

11. Refer to Section 3.1 and service the air cleaner.

12. MARINE GEAR

    a. Drain the oil completely and refill with clean oil of the recommended grade and viscosity. Remove and clean or replace the strainer and filter element.

    b. Start and run the engine at 600 rpm for ten (10) minutes to coat all of the internal parts of the marine gear with clean oil. Engage the clutches alternately to circulate clean oil through all of the moving parts.

13. Since turbocharger bearings are pressure lubricated through the external oil line leading from the engine cylinder block while the engine is operatiing, no further attention is required. However, the turbocharger air inlet and turbine outlet connections should be sealed off with moisture resistant tape.

14. Apply a *non-friction* rust preventive compound to all exposed parts. If convenient, apply the rust preventive compound to the engine flywheel. If not, disengage the clutch mechanism to prevent the clutch disc from sticking to the flywheel.

    NOTICE: Do not apply oil, grease or any wax base compound to the flywheel. The cast iron will absorb these substances which can "sweat" out during operation and cause the clutch to slip.

15. Drain the engine cooling system.

16. Drain the preservative oil from the engine crankcase. Reinstall and tighten the drain plug.

17. Remove and clean the battery and battery cables with a baking soda-water solution and rinse them with fresh water. Do not allow the soda solution to enter the battery. Add distilled water to the electrolyte, if necessary, and fully charge the battery. Store the battery in a cool (never below 32°F or O^0C) dry place. Keep the battery fully charged and check the level and the specific gravity of the electrolyte regularly.

18. Insert heavy paper strips between the pulleys and belts to prevent sticking.

19. Seal all engine openings, including the exhaust outlet, with moisture resistant tape. Use cardboard, plywood or metal covers where practical.

20. Clean and dry the exterior painted surfaces of the engine and spray with a suitable liquid automobile body wax, a synthetic resin varnish or a rust preventive compound.

21. Protect the engine with a good weather-resistant tarpaulin and store it under cover, preferably in a dry building which can be heated during the winter months.

Detroit Diesel Corporation does not recommend the outdoor storage of engines. Nevertheless, DDC recognizes that in some cases outdoor storage may be unavoidable. If units must be kept out-off-doors, follow the preparation and storage instructions already given. Protect units with quality, weather-resistant tarpaulins (or other suitable covers) arranged to provide air circulation.

NOTICE: Do not use plastic sheeting for outdoor storage. Plastic is fine for indoor storage. When used outdoors, however, enough* moisture can condense on the inside of the plastic to rust ferrous metal surfaces and pit aluminum surfaces. If a unit is stored outside for any extended period of time, severe corrosion damage can result.

The stored engine should be inspected periodically. If there are any indications of rust or corrosion, corrective steps must be taken to prevent damage to the engine parts. Perform a complete inspection at the end of one year and apply additional treatment, as required.

 © Detroit Diesel Corporation

PROCEDURE FOR RESTORING AN ENGINE TO SERVICE WHICH HAS BEEN IN EXTENDED STORAGE

1. Remove the covers and tape from all of the openings of the engine, fuel tank and electrical equipment. *Do not overlook the exhaust outlet.*
2. Wash the exterior of the engine with fuel oil to remove the rust preventive.
3. Remove the rust preventive from' the flywheel.
4. Remove the paper strips from between the pulleys and the belts.
5. Remove the drain plug and drain the preservative oil from the crankcase. Reinstall the drain plug. Then, refer to *Lubrication System* in Section 13.1 and fill the crankcase to the proper level, using a pressure prelubricator, with the recommended grade of lubricating oil.
6. Fill the fuel tank with the fuel specified under *Fuel oil* in Section 13.3.
7. Close all of the drain cocks and fill the engine cooling system with clean soft water and a rust inhibitor. If the engine is to be exposed to freezing temperatures, fill the cooling system with an ethylene glycol base antifreeze solution (refer to *Coolant Specifications* in Section 13.3).
8. Install and connect the battery.
9. Service the air cleaner as outlined in Section 3.1.
10. Check the marine gear; refill it to the proper level, as necessary, with the correct grade of lubricating oil.
11. Remove the covers from the turbocharger air inlet and turbine outlet connections. Refer to the lubricating procedure outlined in *Preparation for Starting Engine First Time* in Section 13.1.
12. After all of the preparations have been completed, start the engine. The small amount of rust preventive compound which remains in the fuel system will cause a smoky exhaust for a few minutes.

Before subjecting the engine to a load or high speed, it is advisable to check the engine tune-up.

%

$

ALPHABETICAL INDEX

Subject **Section**

A

Accessory drive..... 1.7.7
Adaptor—flywheel housing..... 1.5.1
Adjustments:
- Exhaust valve 14.1
- Exhaust valve bridge..... 1.2.2
- Exhaust valve clearance..... 14.1
- Fan belt 15.1
- Governoring devices—supplementary 14.14
- Governors and injector racks (see contents page) .. 14
- Governor shutdown solenoid..... 14.14
- Hydraulic governors (see contents page)..... 14
- Injector timing..... 14.2
- Mechanical governors (see contents page)..... 14
- Overspeed governors..... 7.4.3
- Shutdown switches 7.4.2
- Throttle delay mechanism 14.14

Air box drains..... 1.1.2
Air box pressure 15.2
Air cleaner..... 3.1
Air compressor 12.4
Air intake restriction..... 15.2
Air intake system 3
Air shutdown housing 3.3
Alarm system..... 7.4.2
Alternator—battery-charging 7.1
Antifreeze..... 13.3
Automatic shutdown..... 7.4.1

B

Balance engine..... 1.7
Balance weights..... 1.7
Batterj^r-storage 7.2
Battery-charging alternator..... 7.1
Bearings:
- Camshaft 1.7.2
- Checking clearance..... 1.0
- Connecting rod 1.6.2
- Crankshaft main..... 1.3.4
- Idler gear..... 1.7.3
- Outboard support (front)..... 1.3.5.1
- Outboard support (rear)..... 1.3.5.2

Belt adjustment—Fan..... 15.1
Block—cylinder..... 1.1
Block plugging chart..... 1.0
Blower:..... 3.4
- Bypass valve 3.4.2
- Clearance..... 3.4
- Drive gear and support 1.7.6
- Drive shaft..... 1.7.6
- Timing 3.4

Breather assembly..... 4.8
Bridge adjustment—exhaust valve 1.2.1
Bypass valve
- Oil cooler..... 4.4
- Oil filter..... 4.2
- Blower 3.4.2

C

Camshaft and bearings..... 1.7.2
Camshaft gears 1.7.3
Cap—pressure control 5.3.1
Charts:
- Block plugging 1.0
- Blower clearances..... 3.4
- Engine coolants..... 13.3
- Engine operating conditions 13.2
- Fuel oil selection..... 13.3
- Injector fuel output..... 2.1.1
- Injector timing gage 14.2
- Lubrication and preventive maintenance..... 15.1
- Troubleshooting:
  - Engine 15.2
  - Exhaust valves 1.0
  - Fuel injector 2.0

Cleaner—air..... 3.1
Cleaning procedure—general..... *
Clearances ..... *
Compression pressure..... 15.2
Compressor—air..... 12.4
Connecting rod 1.6.1
Connecting rod bearings..... 1.6.2
Coolant—engine 5, 13.3
Coolant—filter..... 5.7
Coolant pressure control cap..... 5.3.1
Coolant specifications..... 13.3
Cooler—engine oil..... 4.4
Cooler—marine gear oil..... 9.5.5
Cooling fan 5.4
Cooling system 5
Corrosion inhibitor..... 5
Cover—engine front 1.3.5
Cover—valve rocker..... 1.2.4
Crankcase pressure..... 15.2
Crankshaft: 1.3
- Bearings..... 1.3.4

© Detroit Diesel Corporation

Subject **Section Subject** **Section**

Oil seals 1.3.2
Outboard bearing support (front)..... 1.3.5.1
Outboard bearing support (rear)..... 1.3.5.2
Pulley..... 1.3.7
Timing gear..... 1.7.5
Vibration damper 1.3.6
Cross section views of engines..... *
Cylinder—misfiring..... 15.2
Cylinder block: 1.1
Cylinder head..... 1.2
Cylinder head handles 1.0
Cylinder liner..... 1.6.3

D

Damper—crankshaft gear 1.7.5
Damper—crankshaft vibration 1.3.6
Description—general ..... *
Diagrams:
Alarm system 7.4.2
Automatic shutdown 7.4.1
Blower shim location 3.4
Cooling system 5
Cylinder bore measurement..... 1.1
Cylinder liner measurement..... 1.6.3
Fuel system 2
Lubrication system..... 4
Synchronizing motor wiring 2.8.4
Diesel principle ..... *
Dipstick—oil level..... 4.6
Drains—air box..... 1.1.2
Drive:
Accessory..... 1.7.7
Blower 1.7.6
Hydraulic governor..... 2.8.3
Power take-off (rear) 8.1
Tachometer 7.4
Dynamometer test..... 13.2.1

E

Electrical system 7
Electrode—heat exchanger..... 5.5
Emergency stop knob..... 7.4
Engine:
Accessory arrangement ..... *
Assembly ..... *
Balance..... 1.7
Cleaning..... *
Coolant fan 5.4
Disassembly..... *
Emergency stop knob..... 7.4
Firing order..... *
General specifications..... *
Inspection ..... *
Lifting 1-1
Models..... *
Mounts, front trunnion 1.3.5
Operating conditions 13.2
Operating instructions 13.1
Out of fuel..... 15.2
Protective systems..... 7.4.1
Rotation..... *
Run-in instructions 13.2.1
Serial number ..... *
Specifications—overhaul (see specific part)
Storage..... 15.3
Test report..... 13.2.1
Timing—gear train..... 1.7.1
Troubleshooting 15.2
Tune-up..... 14
Work safety..... *
Exhaust back pressure 15.2
Exhaust manifold—air cooled..... 6.1
Exhaust manifold—water cooled 6.1.1
Exhaust system 6
Exhaust valves: 1.2.2
Bridge adjustment..... 1.2.1
Clearance adjustment..... 14.1
Guide and insert..... 1.2.2
Maintenance 1.2.2
Spring..... 1.2.2
Troubleshooting 1.0

F

Fan belt adjustment 15.1
Fan—engine cooling..... 5.4
Fan cooling system..... 5
Filters:
Coolant..... 5.7
Fuel 2.3
Injector..... 2.1.1
Oil..... $.. 4.2
Firing order..... *
Flexible fuel lines 2.0
Flushing cooling system..... 5
Flushing lubrication system..... 4
Flywheel..... 1.4
Flywheel housing 1.5
Flywheel housing adaptor 1.5.1
Follower—injector 2.0
Formula—torque..... 1.3

 © Detroit Diesel Corporation

Subject **Section Subject** **Section**

Fresh water pump....5.1
Front cover 1.3.5
Fuel flow—checking....2.0
Fuel flow—checking.... 15.2
Fuel injector.... 2.1.1
Fuel injector timing....14.2
Fuel injector tube 2.1.4
Fuel leaks—locating 2.0
Fuel lines 2.0
Fuel oil specifications....13.3
Fuel pump 2.2
Fuel strainer.... 2.3
Fuel system 2
Fuel pressurized 2.0

G

Gaskets-cylinder head 1.2
Gear:
- Blower drive 1.7.6
- Camshaft 1.7.3
- Crankshaft timing.... 1.7.5
- Flywheel ring gear 1.4
- Idler 1.7.3
- Marine 9
- Oil pump driving.... 4.1

Gear train and engine timing.... 1.7.1
General description . .
General information .
General procedures . .
General specifications
Generator—battery charging.... 7.1
Generator—power.... 7.5
Governing devices-supplementary 14.14
Governors (see contents page).... 2
Governor drive—hydraulic 2.8.3
Governor—overspeed.... 7.4.3

H

Head—cylinder.... 1.2
Heat exchanger 5.5
Heat exchanger cooling system 5
Housing—air shut-down 3.3
Housing—flywheel 1.5
Hydraulic governor adjustment.... 14.7.2
Hydraulic governor drive.... 2.8.3
Hydraulic governors.... 2.8

I

Idler gear.... 1.7.3
Impeller-raw water pump 5.0
Inhibitor—corrosion.... 13.3
Injector—fuel.... 2.1.1
Injector—troubleshooting 2.0
Injector
- Follower.... 2.0
- Operating mechanism.... 1.2.1
- Rack control adjustment 14
- Testing—checking 2.0
- Timing 14.2
- Tube.... 2.1.4

Insert—exhaust valve.... 1.2.2
Inspection—engine .... *
Inspection—magnetic particle.... 1.3
Instructions:
- Engine operating.... 13.1
- Engine run-in.... 13.2.1

Instrument mountings—anti-vibration 7.0
Instrument and panel.... 7.4
Intercooler—turbocharger.... 3.5.2

K

Keel Cooling System.... 5

L

Lapping blocks—refmishing 2.0
Lifting engine.... 1.1
Limiting speed governor.... 2.7.1
Limiting speed governor adjustment.... 14.3
Liner—cylinder.... 1.6.3
Lubricating oil:
- Cooler.... 4.4
- Filters.... 4.2
- Pump 4.1
- Specifications.... 13.3

Lubrication and preventive maintenance.... 15.1
Lubrication system 4

M

Magnetic particle inspection 1.3
Main bearings 1.3.4
Maintenance:
- Battery.... 7.2
- Coolant—filter 5.7
- Cooling system 5
- Cylinder head 1.2

© Detroit Diesel Corporation

Subject	Section
Exhaust valves	1.2.2
Fuel pump	2.2
Lubricating oil filter	4.2
Preventive	15.1
Manifold:	
Exhaust—air cooled	6.1
Exhaust—water cooled	6.1.1
Water	5.2
Manometer—use of	15.2
Manual shutdown	7.4.1
Marine gear	9
Marine gear oil cooler	9.5.5
Mechanical governors	2.7
Mechanical shutdown—automatic	7.4.1
Misfiring cylinder	15.2
Model designation chart	*
Model designation	*
Motor—electrical starting	7.3
Motor—governor synchronizing	2.8.4
Mountings—instrument	7.4

O

Oil cooler by-pass valve	4.4
Oil cooler—engine	4.4
Oil cooler—marine gear	9.5.5
Oil filter	4.2
Oil level dipstick	4.6
Oil pan	4.7
Oil pressure regulator and relief valve	4.1.1
Oil pump engine	4.1
Oil seals—crankshaft	1.3.2
Oil specifications—fuel	13.3
Oil specifications—lubricating	13.3
Oil strainer—fuel	2.3
Operating conditions	13.2
Operating instructions	13.1
Operation—principle of	
Option label	
Outboard bearing (front)	1.3.5.1
Outboard bearing (rear)	1.3.5.2
Overspeed governor	7.4.3

P

Pan—oil	4.7
Panel—instrument	7.4
Parts book—built-in	*
Piston and piston rings	1.6
Power generator	7.5
Power take-off	8.1
Pre-ignition—effects of	2.0
Pressurized fuel system	2.0
Preventive maintenance	15.1
Procedures—general	*
Pulley—crankshaft	1.3.7
Pump:	
Fuel	2.2
Lubricating oil	4.1
Raw water	5.6
Water	5.1
Push rod	1.2.1

R

Radiator	5.3
Radiator cooling system	5
Raw water pump	5.6
Raw water pump draining	5.0
Raw water pump impeller	5.0
Regulator—oil pressure	4.1.1
Restoring engine to service	15.3
Reverse flushing	5
Rings—piston	1.6
Rocker arms	1.2.1
Rocker cover	1.2.4
Rod—connecting	1.6.1
Rod—push	1.2.1
Rotation—engine	*
Run-in instructions	13.2.1

S

Seals—crankshaft oil	1.3.2
Serial number designation	*
Shutdown—Air	3.3
Shutdown—Solenoid	14.14
Shutdown—System	7.4.1
Sleeve—crankshaft oil seal	1.3.2
Specifications:	
Coolant	13.3
Fuel oil	13.3
General	*
Lubricating oil	13.3
Starting aid screw	14.3
Staring aid system	14.14
Starting engine	13.1
Starting motor	7.3
Starting system—checking	15.2
Stopping—engine	13.1
Storage—engine	15.3
Storage battery	7.2
Strainer—fuel oil	2.3

 © Detroit Diesel Corporation

Subject **Section**

Supplementary governing devices....14.14
Support—blower drive 1.7.6
Switch—Starting....7.4
Synchronizing motor—governor.... 2.8.4
System:
Air intake.... 3
Alarm.... 7.4.2
Cooling.... 5
Electrical 7
Engine protective 7.4.1
Exhaust 6
Fuel.... 2
Lubrication 4
Starting aid 14.14
Ventilating....4.8

T

Tachometer drive 7.4
Teflon plugs.... 1.0
Test—dynamometer 13.2.1
Test—fuel flow 2.0
Test fixture—injector 2.0
Test report 13.2.1
Thermostat.... 5.2.1
Throttle delay mechanism 14.14,15.1
Thrust washers—crankshaft 1.3.4
Timing:
Blower rotor 3.4
Crankshaft gear.... 1.7.5
Engine 1.7.1
Fuel injector 14.2
Timing gear—crankshaft 1.7.5
Torque formula.... 1.3
T roubleshooting:
Engine 15.2

Subject **Section**

Exhaust valve 1.0
Fuel injector 2.0
Fuel pump....2.0
Turbocharger....3.0
Tube—fuel injector.... 2.1.4
Tune-up procedures.... 14
Turbocharger....3.5
Turbocharger intercooler.... 3.5.2
Two-cycle principle .... *

V

Valve—blower bypass.... 3.4.2
Valve—oil cooler bypass 4.4
Valve Bridge adjustment—exhaust.... 1.2.1
Valve Clearance adjustment—exhaust 14.1
Valve Guide and insert—exhaust 1.2.2
Valve Operating mechanism—exhaust.... 1.2.1
Valves—exhaust 1.2.2
Variable speed governor.... 2.7.2
Variable speed governor adjustment....14.4
Ventilating system....4.8
Vibration damper—crankshaft 1.3.6

W

Washer—crankshaft thrust 1.3.4
Water filter....5.7
Water manifold.... 5.2
Water pump—engine 5.1
Wiring diagram:
Alarm bell 7.4.2
Alarm system 7.4.2
Automatic shutdown 7.4.1
Synchronizing motor (governor).... 2.8.4

*

"General Information Section

)

\

i

Detroit Diesel

149 ENGINE

SPECIFICATIONS

Bolt Torques, Firing Order, Adjust Valves, Adjust Injectors,
Set Linkages and adjust Hydraulic Governor

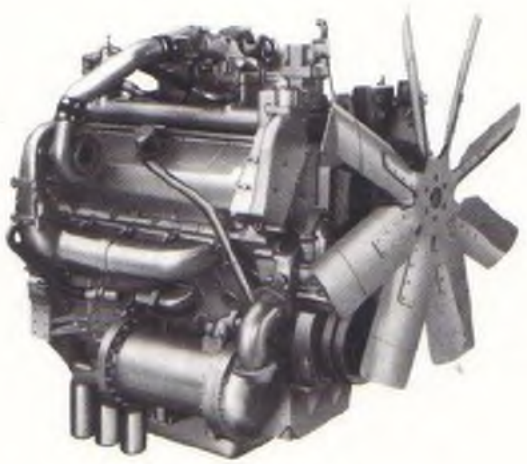


BDC Barrington Diesel Club

http://www.barringtondieselclub.co.za/

Detroit Diesel Industrial Model

8V-149TI 900 HP 800 HP



Horsepower Rating

Basic Engine	8V-149TI
Injector	190
Rated Gross Power	900 BHP (671 kW) @ 1900 RPM
Peak Torque	2607 lb ft (3535 N·m) @ 1400 RPM
Injector	160
Rated Gross Power	800 BHP (597 kW) @ 1900 RPM
Peak Torque	2350 lb ft (3187 N·m) @ 1200 RPM

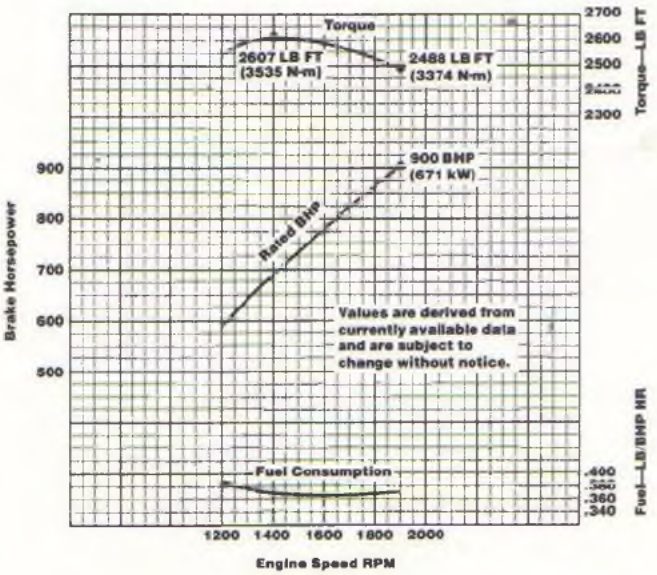
(Continuous Rating)

Injector	145
Gross Power	740 BHP (552 kW) @ 1900 RPM
Peak Torque	2157 lb ft (2925 N·m) @ 1400 RPM

Rated Fuel Consumption:

@ 900 BHP	.369 lbs/bhp-hr (224 g/kW-hr) 46.7 gals/hr (176.8 L/hr)
@ 800 BHP	.366 lbs/bhp-hr (223 g/kW-hr) 41.2 gals/hr (155.9 L/hr)

Performance Curve †



Rating Explanation

RATED BHP is the power rating for variable speed and load applications where full power is required intermittently.

CONTINUOUS BHP is the power rating for applications operating under a constant load and speed for long periods of time.

FUEL CONSUMPTION CURVE shows fuel used in pounds per brake horsepower hour.

POWER OUTPUT guaranteed within 5% at standard ambient conditions.

THIS RATING does not include power requirements for accessory and standard equipment. For complete engine specifications for your particular requirements, see your distributor or authorized Detroit Diesel Allison representative.

†Rating conditions of SAE: 77°F (25°C) and 29.31 in Hg (99kPa) Barometer (Dry)

General Specifications

Basic Engine	8V-149TI
Model	9083-7311
Number of Cylinders	8
Bore and Stroke	5.75 in × 5.75 in (146 mm × 146 mm)
Displacement	1195 cu in (19.6 liters)
Engine Type	Vee-2 cycle
Compression Ratio	16 to 1
Length	64 in (1625 mm)
Width	64 in (1625 mm)
Height	68 in (1727 mm)
Weight (dry)	6000 lbs (2727 kg)
Engine Coolant Capacity	91 qt (86.1 liters)
Total Engine Oil Capacity	124 qt (117.3 liters)
900 HP @ 1900 RPM:	
Engine Heat Rej.	28,350 BTU/min (499 kW)
Exhaust Temperature	745°F (396°C)
800 HP @ 1900 RPM:	
Engine Heat Rej.	25,200 BTU/min (443 kW)
Exhaust Temperature	710°F (377°C)

Approximate dimensions shown. For complete dimensional information refer to installation drawing 2SA489. For complete coolant specifications, see publication 7SE298. For complete fuel and lubricating oil specifications, see publication 7SE270.

Equipment Specifications

Alternator—24 volt, 65 amp

Blower—With bypass mechanism

Crankcase Pressure Monitor

Engine Oil Cooler—Tube and shell

Fan Bracket and Pulley Assembly Only

Flywheel—SAE #0

Flywheel Housing—SAE #0

Governor—Hydraulic

Intercooler

Oil Pan—Dual sump 15° angularity

Starter—24 volt

Turbocharger—Dual turbochargers, TV8401, 1.23 A/R

Additional options are also available. For a complete list, consult your authorized Detroit Diesel Allison representative.

Detroit Diesel Allison
Division of General Motors
13400 Outer Drive, West, Detroit, Michigan 48239-4001
(313/592-5000)

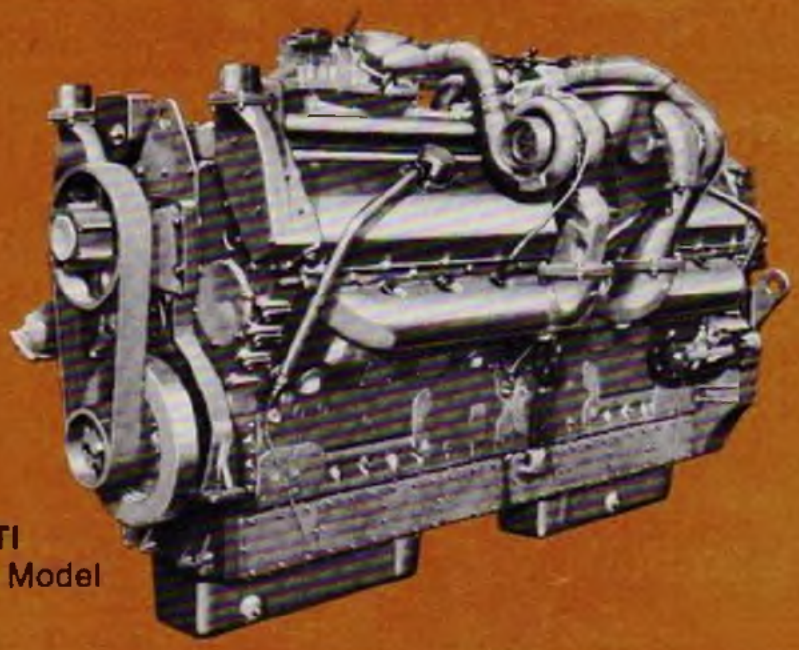
3SA322 10-87 As technical advancements continue, specifications will change. Litho in USA

Detroit Diesel Engines

fan-to-flywheel models

12V-149TI
1350 hp

16V-149TI
1800 hp



Typical 16V-149TI
Fan-to-Flywheel Model

specifications

Basic Engine	12V-149TI with 195 Injectors	16V-149TI with 195 Injectors
Model	9123-7301	9163-7301
Description	Turbocharged, Intercooled	Turbocharged, Intercooled
Number of Cylinders	12	16
Bore and Stroke	5.75 In x 5.75 In (146 mm x 146 mm)	5.75 In x 5.75 In (146 mm x 146 mm)
Displacement	1792 cu In (29.39 litres)	2389 cu In (39.18 litres)
Rated Power:*		
SAE: 85°F (29.4°C) and 29.00 In Hg (98.19kPa) Bar. (Dry)	1350 BHP (1007 kW) @1900 RPM	1800 BHP (1343 kW) @1900 RPM
Torque:*		
SAE: 85°F (29.4°C) and 29.00 In Hg (98.19 kPa) Bar. (Dry)	3840 lb ft (5206 N·m) @ 1600 RPM	5120 lb ft (6942 N·m) @ 1600 RPM
Compression Ratio	16 to 1	16 to 1
Approximate Dimensions:		
Length	91 In (2311 mm)	104 In (2642 mm)
Width	64 In (1626 mm)	64 In (1626 mm)
Height	69 In (1753 mm)	66 In (1676 mm)
Net Weight (dry)	9225 lbs (4184 kg)	10,865 lbs (4928 kg)

For complete dimensional information, refer to installation drawing 2SA374 for Model 9123-7301 and 2SA375 for Model 9163-7301

Preliminary - jacketwater intercooled

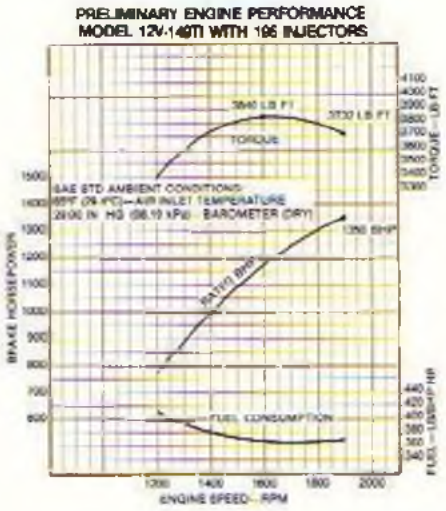
performance

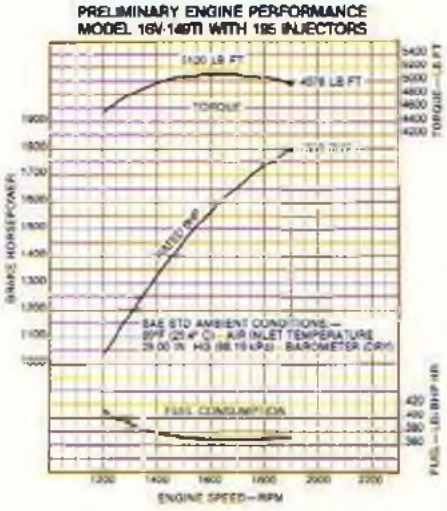
Rating Explanation

RATED BHP is the power rating for variable speed and load applications where full power is required intermittently. Performance may be derated to improve fuel economy and extend engine life.

FUEL CONSUMPTION CURVE shows fuel used in pounds per brake horsepower hour.

THESE RATINGS do not include power losses for accessories and standard equipment.





standard equipment

Air Inlet Housing

Alternator—24 v, 65 amp

Crankshaft Pulley—Poly-Vee

Engine Mounts—Trunnion mounts

Exhaust Manifold

Fan—52", 8-blade, suction (Model 9123-7301); Fan bracket and pulley assembly only (Model 9163-7301)

Flywheel—SAE #0

Flywheel Housing—SAE #0, dual starter pads

Fuel Filters

Governor—Variable speed

Injectors—Cam operated, unit type needle valve

Intercooler

Lube Oil Cooler

Lube Oil Filters—Full flow, dual can

Oil Pan—Dual sump, for 15° inclination angle

Starting Motors—Two 24-volt

Turbocharger—Four turbos

Vibration Damper—Thick, heavy, viscous

For a complete listing of standard and optional equipment, consult your authorized Detroit Diesel Allison representative

Specifications subject to change without notice.

Detroit Diesel Allison
Division of General Motors Corporation
13400 West Outer Drive Detroit, Michigan 48228
In Canada: Diesel Division, General Motors of Canada Limited London Ontario

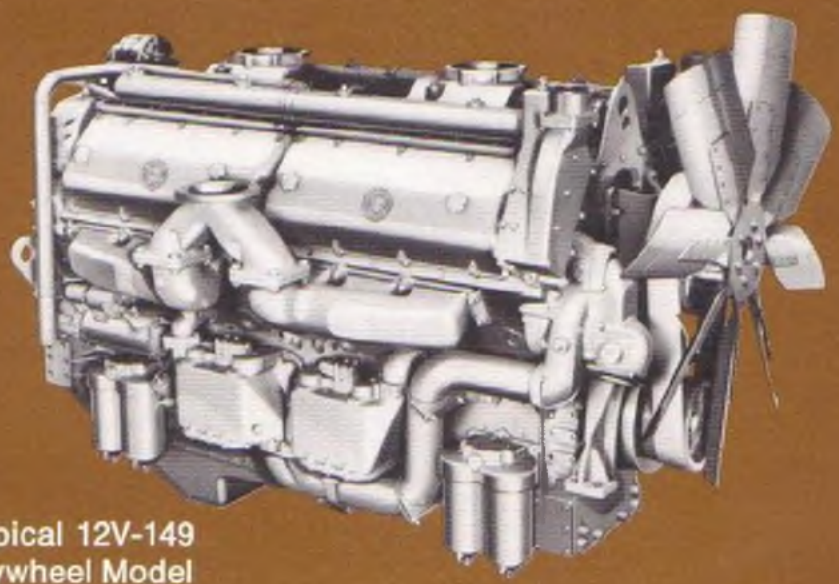
3SA126-01 10-78 Litho in USA

Detroit Diesel Engines

fan-to-flywheel models

12V-149
800 hp

12V-149T
1000 hp



Typical 12V-149
Fan-to-Flywheel Model

specifications

Basic Engine	12V-149 130 Injectors	12V-149T 150 Injectors
Model	9123-7000	9123-7300
Engine Type	Two Cycle	Two Cycle
Number of Cylinders	12	12
Bore and Stroke	5.75 in x 5.75 in (146 mm x 146 mm)	5.75 in x 5.75 in (146 mm x 146 mm)
Two Cycle Displacement (Every Downstroke a Powerstroke)	1792 cu in (29.39 litres)	1792 cu in (29.39 litres)
Rated Power: SAE: 85°F (29.4°C) and 29.00 in Hg (98.19 kPa) Bar. (Dry)	800 BHP (597 kW) @ 1900 RPM	1000 BHP (746 kW) @ 1900 RPM
Continuous Power: SAE: 85°F (29.4°C) and 29.00 in Hg (98.19 kPa) Bar. (Dry)	675 BHP (504 kW) @ 1800 RPM	———
Torque: SAE: 85°F (29.4°C) and 29.00 in Hg (98.19 kPa) Bar. (Dry)	2310 lbs ft (3132 N·m) @ 1500 RPM	2915 lbs ft (3952 N·m) @ 1500 RPM
Compression Ratio	17 to 1	17 to 1
Approximate Dimensions: Length Width Height	 92 in (2337 mm) 57 in (1448 mm) 67 in (1702 mm)	 91 in (2311 mm) 63 in (1600 mm) 69 in (1753 mm)
Net Weight (Mass) (dry)	8880 lbs (4028 kg)	9095 lbs (4125 kg)

For complete dimensional information, refer to installation drawing 2SA363 for Model 9123-7000 and 2SA362 for Model 9123-7300.

performance

Rating Explanation

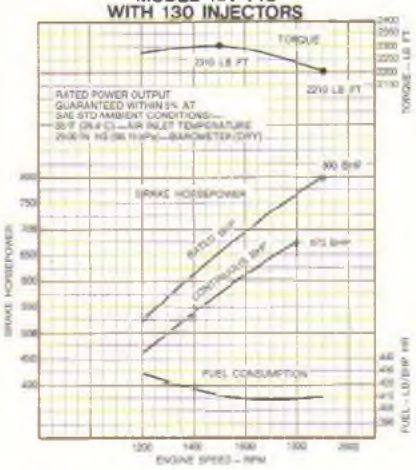
RATED BHP is the power rating for variable speed and load application where full power is required intermittently. Performance may be derated to improve fuel economy and extend engine life.

CONTINUOUS BHP is the power rating for applications operating under a constant load and speed for long periods of time.

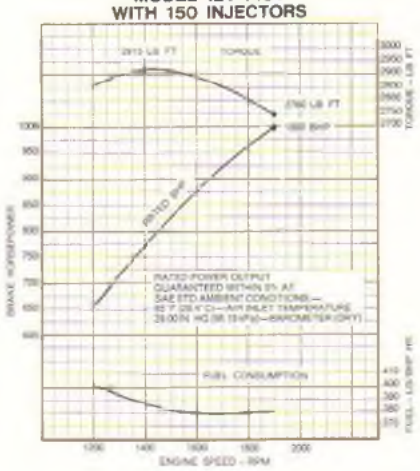
FUEL CONSUMPTION CURVE shows fuel used in pounds per brake horsepower hour.

THESE RATINGS do not include power requirements for accessory and standard equipment.

BASIC ENGINE PERFORMANCE
MODEL 12V-149
WITH 130 INJECTORS



BASIC ENGINE PERFORMANCE
MODEL 12V-149T
WITH 150 INJECTORS



standard equipment

Air Inlet Housing

Alternator—24 volt, 65 amp

Crankshaft Pulley—Poly-Vee

Engine Mounts—Front trunnion

Exhaust Manifold—Vertical Center Outlet

Fan—48 in (1229 mm), 8 blades, suction, Model 9123-7000 only; 52 in (1331 mm), 8 blades, suction, Model 9123-7300 only

Flywheel—SAE #0

Flywheel Housing—SAE #0, dual starter pads

Fuel Filters

Governor—Variable speed

Injectors—Cam operated, unit type, clean tip

Lube Oil Cooler

Lube Oil Filter—Full flow

Oil Pan—Stamped pan for 15° inclination angle, dual sump

Starting Motor—Two (2) 24 volt

Turbocharger—Model 9123-7300 only

For a complete listing of standard and optional equipment, consult your authorized Detroit Diesel Allison representative.

Specifications subject to change without notice.

Detroit Diesel Allison
Division of General Motors Corporation

13400 West Outer Drive Detroit, Michigan 48228

In Canada: Diesel Division, General Motors of Canada Limited London Ontario

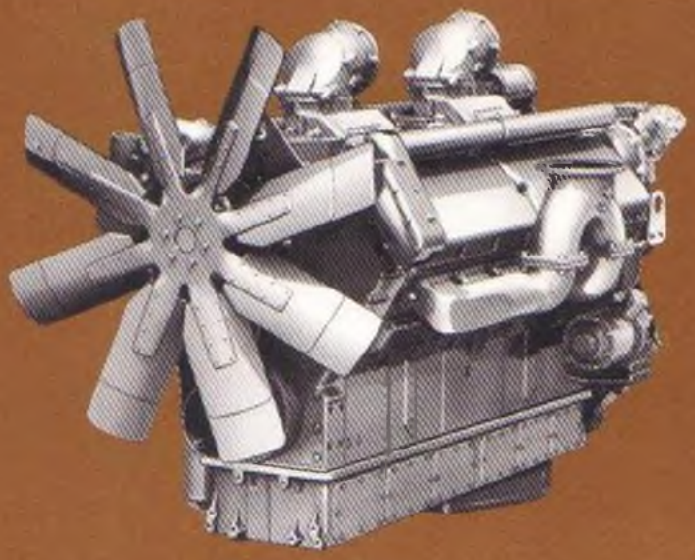
3SA122 2-78

Litho in U.S.A.

Detroit Diesel Engines

Industrial Models

12V-149 805 hp
16V-149 1070 hp



Typical 12V-149

specifications

Basic Engine	12V-149 130 Injectors	16V-149 130 Injectors
Model	9123-7000	9163-7000
Description	Naturally Aspirated	Naturally Aspirated
Number of Cylinders	12	16
Bore and Stroke	5.75 in × 5.75 in (146 mm × 146 mm)	5.75 in × 5.75 in (146 mm × 146 mm)
Displacement	1792 cu in (29.39 liters)	2389 cu in (39.18 liters)
Rated Gross Power: SAE: 77 °F (25 °C) and 29.31 in Hg (99 kPa) Barometer (Dry)	805 BHP (601 kW) @ 1900 RPM	1070 BHP (798 kW) @ 1900 RPM
Continuous Gross Power: SAE: 77 °F (25 °C) and 29.31 in Hg (99 kPa) Barometer (Dry)	675 BHP (504 kW) @ 1800 RPM	900 BHP (671 kW) @ 1800 RPM
Torque: SAE: 77 °F (25 °C) and 29.31 in Hg (99 kPa) Barometer (Dry)	2326 lb ft (3154 N•m) @ 1400 RPM	3106 lb ft (4212 N•m) @ 1400 RPM
Compression Ratio	17 to 1	17 to 1
Approximate Dimensions:		
Length	93 in (2362 mm)	110 in (2794 mm)
Width	59 in (1499 mm)	54 in (1372 mm)
Height	61 in (1549 mm)	60 in (1524 mm)
Net Weight (Dry)	8490 lbs (3851 kg)	10,490 lbs (4758 kg)

For complete dimensional information, refer to installation drawing 2SA363 for Model 9123-7000, and 2SA360 for Model 9163-7000.

performance

Rating Explanation

RATED BHP is the power rating for variable speed and load applications where full power is required intermittently.

CONTINUOUS BHP is the power rating for applications operating under a constant load and speed for long periods of time.

FUEL CONSUMPTION CURVE shows fuel used in pounds per brake horsepower hour.

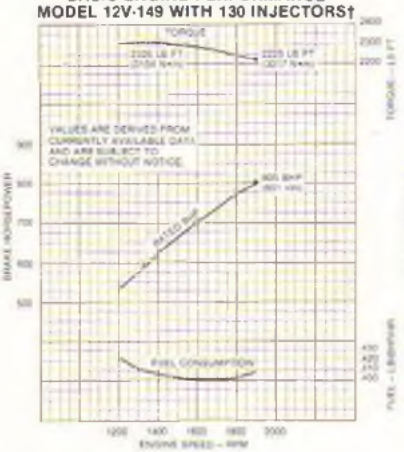
POWER OUTPUT guaranteed within 5% at standard ambient conditions.

THIS RATING does not include power requirements for accessory and standard equipment.

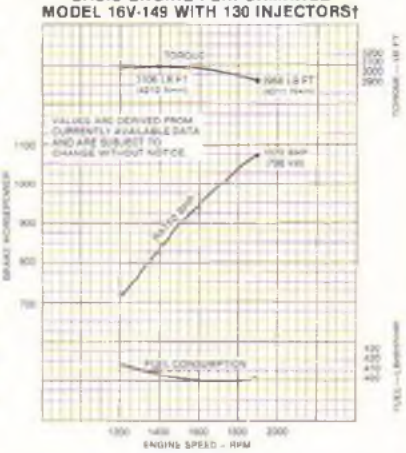
For complete engine specifications for your particular requirements, see your distributor or authorized Detroit Diesel Allison representative.

†Rating conditions of SAE: 77°F (25°C) and 29.31 in Hg (99 kPa) Barometer (Dry)

BASIC ENGINE PERFORMANCE MODEL 12V-149 WITH 130 INJECTORS†



BASIC ENGINE PERFORMANCE MODEL 16V-149 WITH 130 INJECTORS†



standard equipment

Air Box Drain Tubes
Air Inlet Housing
Alternator—24 volt, 65 amp
Crankshaft Pulley—Poly-Vee
Engine Mounts—Front trunnion
Exhaust Manifold
Fan—48 in (1229 mm), 8 blades, right-hand suction, 12V-149; 52 in (1331 mm), 8 blades, right-hand suction, 16V-149
Flywheel—SAE #0
Flywheel Housing—SAE #0
Fuel Filters
Governor—Variable speed
Injectors—Cam operated, unit type, clean tip
Lube Oil Cooler—Plate type
Lube Oil Filters—Full flow, spin on
Oil Pan—Stamped steel, dual sump, for 15° inclination angle
Starting Motor—Two (2) 24 volt
Vibration Damper—Thick, heavy, viscous

For a complete listing of standard and optional equipment, consult your authorized Detroit Diesel Allison representative.

WORLDWIDE REGIONAL OFFICES

Atlanta, Georgia (404/257-3630)
Naperville, Illinois (312/961-6750)
Dallas, Texas (214/659-5050)
Detroit, Michigan (313/556-5800)
Parsippany, New Jersey (201/993-4040)
Fremont, California (415/498-5200)
London, Ontario, Canada (519/452-5000)
Rotterdam, The Netherlands (31) 10-29-0000
Dandenong, Victoria, Australia (61) 3-797-7911
Athens, Greece (30) 1-6833-100
Coral Gables, Florida (305/446-4900)
Jurong Town, Singapore (65) 265-4697
Mexico City, Mexico (905) 250-4354

Detroit Diesel Allison
Division of General Motors
13400 Outer Drive, West, Detroit, Michigan 48239-4001
(313/592-5000)

OFFICES

Denver, Colorado, U.S.A.
Los Angeles, California, U.S.A.
Arlington, Virginia, U.S.A.
Antwerp, Belgium
Biel Bienne, Switzerland
Helsinki, Finland
Lisbon, Portugal
Oslo, Norway
Paris, France
Ruesselsheim, Germany
Stockholm, Sweden
Northampton, England
Johannesburg, South Africa
Nairobi, Kenya
Adelaide, Australia
Brisbane, Australia
Sydney, Australia
West Perth, Australia
Jakarta, Indonesia
Taipei, Taiwan
Tokyo, Japan
Beijing, China
Bogota, Colombia
Buenos Aires, Argentina
Lima, Peru
Santiago, Chile
Sao Paulo, Brasil

SA122 3-85

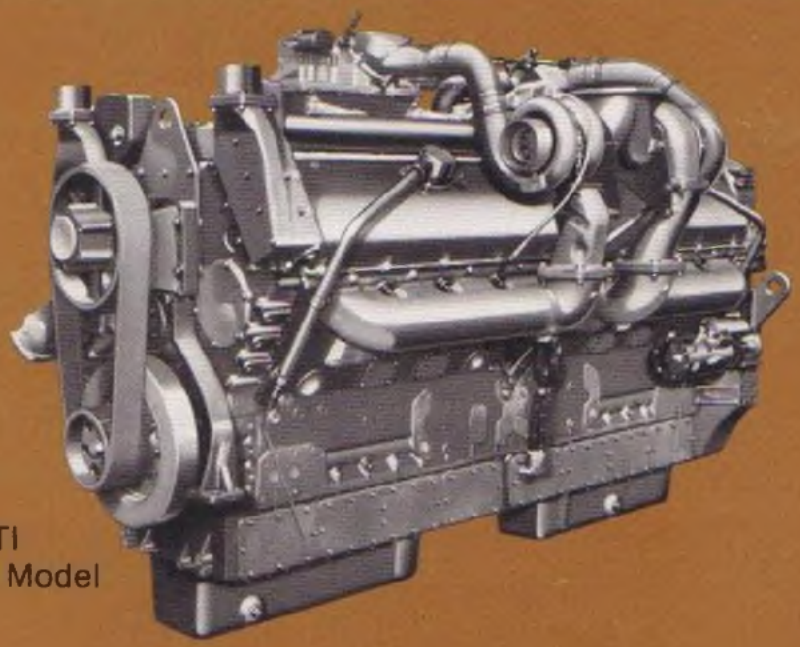
Information and specifications subject to change without notice or obligation. Litho in U.S.A

Detroit Diesel Engines

fan-to-flywheel models

12V-149TI
1350 hp

16V-149TI
1800 hp



Typical 16V-149TI
Fan-to-Flywheel Model

specifications

Basic Engine	12V-149TI with 195 Injectors	16V-149TI with 195 Injectors
Model	9123-7301	9163-7301
Description	Turbocharged, Intercooled	Turbocharged, Intercooled
Number of Cylinders	12	16
Bore and Stroke	5.75 in x 5.75 in (146 mm x 146 mm)	5.75 in x 5.75 in (146 mm x 146 mm)
Displacement	1792 cu in (29.39 litres)	2389 cu in (39.18 litres)
Rated Power:*		
SAE: 85°F (29.4°C) and 29.00 in Hg (98.19kPa) Bar. (Dry)	1350 BHP (1007 kW) @1900 RPM	1800 BHP (1343 kW) @1900 RPM
Torque:*		
SAE: 85°F (29.4°C) and 29.00 in Hg (98.19 kPa) Bar. (Dry)	3840 lb ft (5206 N·m) @ 1600 RPM	5120 lb ft (6942 N·m) @ 1600 RPM
Compression Ratio	16 to 1	16 to 1
Approximate Dimensions:		
Length	91 in (2311 mm)	104 in (2642 mm)
Width	64 in (1626 mm)	64 in (1626 mm)
Height	69 in (1753 mm)	66 in (1676 mm)
Net Weight (dry)	9225 lbs (4184 kg)	10,865 lbs (4928 kg)

For complete dimensional information, refer to installation drawing 2SA374 for Model 9123-7301 and 2SA375 for Model 9163-7301

Preliminary - jacketwater intercooled

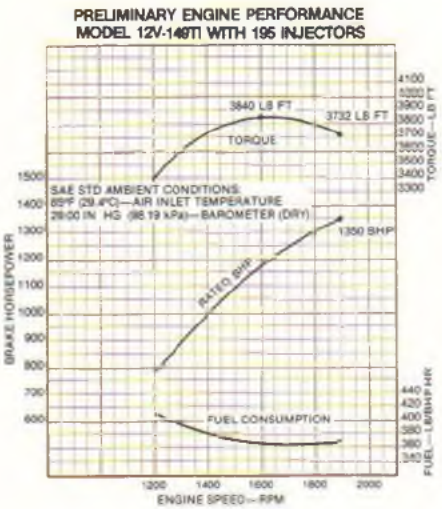
performance

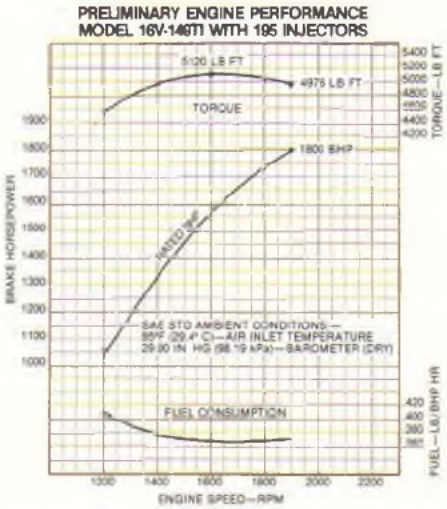
Rating Explanation

RATED BHP is the power rating for variable speed and load applications where full power is required intermittently. Performance may be derated to improve fuel economy and extend engine life.

FUEL CONSUMPTION CURVE shows fuel used in pounds per brake horsepower hour.

THESE RATINGS do not include power losses for accessories and standard equipment.





standard equipment

Air Inlet Housing

Alternator—24 v, 65 amp

Crankshaft Pulley—Poly-Vee

Engine Mounts—Trunnion mounts

Exhaust Manfold

Fan—52", 8-blade, suction (Model 9123-7301); Fan bracket and pulley assembly only (Model 9163-7301)

Flywheel—SAE #0

Flywheel Housing—SAE #0, dual starter pads

Fuel Filters

Governor—Variable speed

Injectors—Cam operated, unit type needle valve

Intercooler

Lube Oil Cooler

Lube Oil Filters—Full flow, dual can

Oil Pan—Dual sump, for 15° inclination angle

Starting Motors—Two 24-volt

Turbocharger—Four turbos

Vibration Damper—Thick, heavy, viscous

For a complete listing of standard and optional equipment, consult your authorized Detroit Diesel Allison representative

Specifications subject to change without notice.

Detroit Diesel Allison
Division of General Motors Corporation

13400 West Outer Drive Detroit, Michigan 48228

In Canada: Diesel Division General Motors of Canada Limited London Ontario

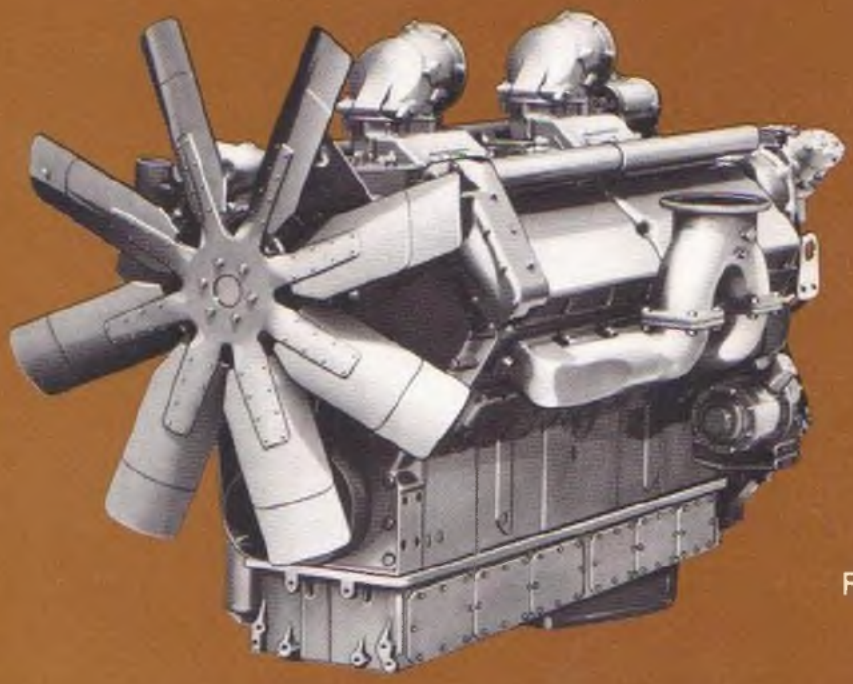
BSA126-01 10-78

Litho in USA

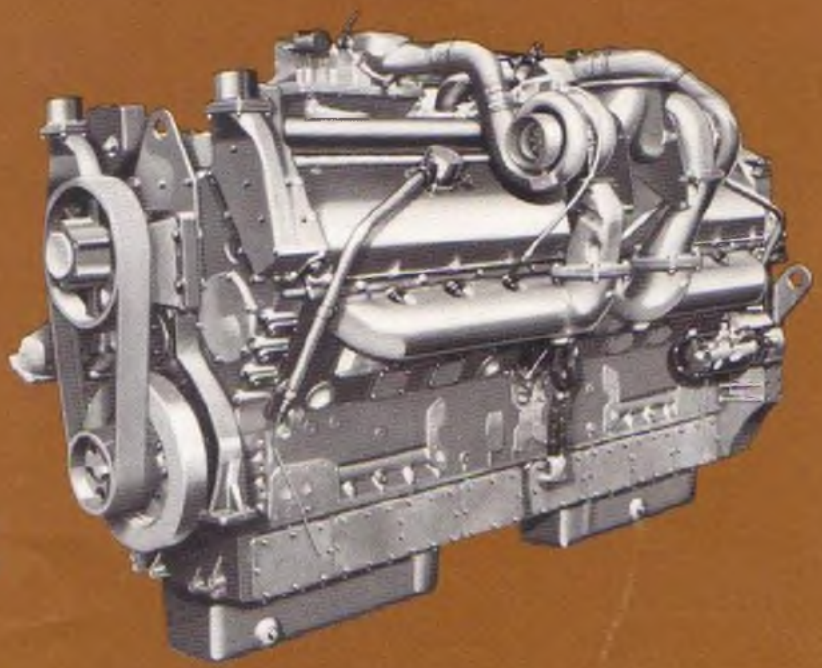
Detroit Diesel Engines

fan-to-flywheel models

12V-149	12V-149T	12V-149TI	12V-149TI	16V-149	16V-149T	16V-149TI	16V-149TI
805 hp	1050 hp	1200 hp	1350 hp	1070 hp	1400 hp	1600 hp	1800 hp



Typical 12V-149
Fan-To-Flywheel Model



Typical 16V-149TI
Fan-To-Flywheel Model

Basic Engine	12V-149 130 Injectors	12V-149T 145 Injectors	12V-149TI 160 Injectors	12V-149TI 190 Injectors
Model	9123-7000	9123-7300	9123-7301	9123-7311
Description	Naturally Aspirated	Turbocharged	Turbocharged Intercooled	Turbocharged Intercooled
Number of Cylinders	12	12	12	12
Bore and Stroke	5.75 in × 5.75 in (146 mm × 146 mm)	5.75 in × 5.75 in (146 mm × 146 mm)	5.75 in × 5.75 in (146 mm × 146 mm)	5.75 in × 5.75 in (146 mm × 146 mm)
Displacement	1792 cu in (29.39 liters)	1792 cu in (29.39 liters)	1792 cu in (29.39 liters)	1792 cu in (29.39 liters)
Rated Gross Power: SAE: 77°F (25°C) and 29.31 in Hg (99 kPa) Barometer (Dry)	805 BHP (601 kW) @ 1900 RPM	1050 BHP (783 kW) @ 1900 RPM	1200 BHP (895 kW) @ 1900 RPM	1350 BHP (1007 kW) @ 1900 RPM
Continuous Gross Power: SAE: 77°F (25°C) and 29.31 in Hg (99 kPa) Barometer (Dry)	675 BHP (504 kW) @ 1800 RPM	675 BHP (504 kW) @ 1800 RPM	810 BHP (604 kW) @ 1800 RPM	810 BHP (604 kW) @ 1800 RPM
Torque: SAE: 77°F (25°C) and 29.31 in Hg (99 kPa) Barometer (Dry)	2326 lb ft (3154 N•m) @ 1400 RPM	3116 lb ft (4225 N•m) @ 1200 RPM	3480 lb ft (4719 N•m) @ 1200 RPM	3909 lb ft (5301 N•m) @ 1400 RPM
Compression Ratio	17 to 1	17 to 1	16 to 1	16 to 1
Approximate Dimensions:				
Length	93 in (2362 mm)	93 in (2362 mm)	93 in (2362 mm)	93 in (2362 mm)
Width	59 in (1499 mm)	62 in (1575 mm)	62 in (1575 mm)	62 in (1575 mm)
Height	61 in (1549 mm)	68 in (1727 mm)	70 in (1778 mm)	70 in (1778 mm)
Net Weight (Dry)	8490 lbs (3851 kg)	9030 lbs (4096 kg)	9110 lbs (4132 kg)	9110 lbs (4132 kg)

For complete dimensional information, refer to installation drawing 2SA363 for Model 9123-7000, 2SA490 for Model 9123-7300, 2SA491 for Model 9123-7301 and 9

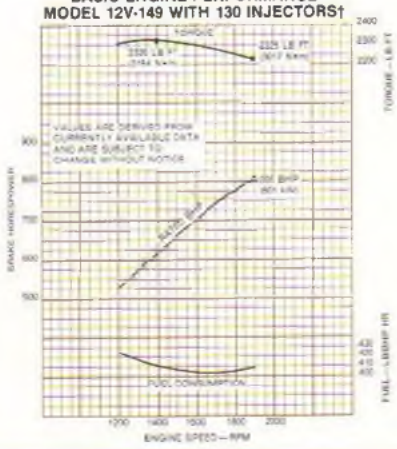
Rating Explanation

RATED BHP is the power rating for variable speed and load applications where full power is required intermittently.

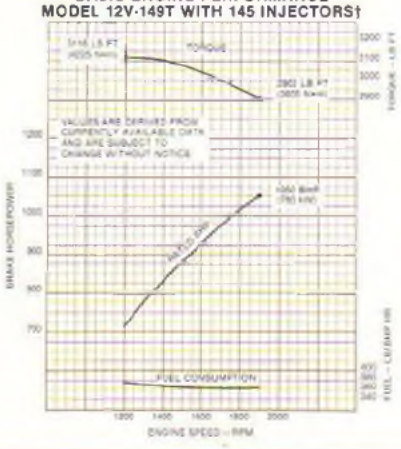
CONTINUOUS BHP is the power rating for applications operating under a constant load and speed for long period of time.

For complete engine specifications for your particular requirements, see your distributor or authorized Detroit Diesel Allison representative

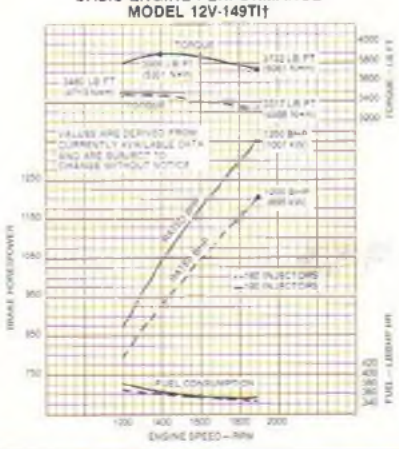
BASIC ENGINE PERFORMANCE MODEL 12V-149 WITH 130 INJECTORS†



BASIC ENGINE PERFORMANCE MODEL 12V-149T WITH 145 INJECTORS†



BASIC ENGINE PERFORMANCE MODEL 12V-149TI†



specifications

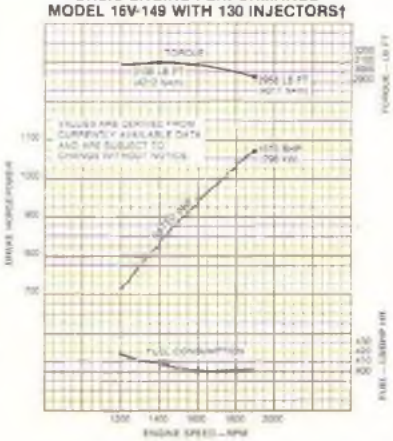
16V-149 130 Injectors	16V-149T 145 Injectors	16V-149TI 160 Injectors	16V-149TI 190 Injectors
9163-7000	9163-7300	9163-7301	9163-7311
Naturally Aspirated	Turbocharged	Turbocharged Intercooled	Turbocharged Intercooled
16	16	16	16
5.75 in × 5.75 in (146 mm × 146 mm)	5.75 in × 5.75 in (146 mm × 146 mm)	5.75 in × 5.75 in (146 mm × 146 mm)	5.75 in × 5.75 in (146 mm × 146 mm)
2389 cu in (39.18 liters)	2389 cu in (39.18 liters)	2389 cu in (39.18 liters)	2389 cu in (39.18 liters)
1070 BHP (798 kW) @ 1900 RPM	1400 BHP (1044 kW) @ 1900 RPM	1600 BHP (1194 kW) @ 1900 RPM	1800 BHP (1343 kW) @ 1900 RPM
900 BHP (671 kW) @ 1800 RPM	900 BHP (671 kW) @ 1800 RPM	1080 BHP (806 kW) @ 1800 RPM	1080 BHP (806 kW) @ 1800 RPM
3106 lb ft (4212 N•m) @ 1400 RPM	4213 lb ft (5713 N•m) @ 1400 RPM	4689 lb ft (6358 N•m) @ 1400 RPM	5290 lb ft (7173 N•m) @ 1400 RPM
17 to 1	17 to 1	16 to 1	16 to 1
110 in (2794 mm) 54 in (1372 mm) 60 in (1524 mm) 10,490 lbs (4758 kg)	106 in (2692 mm) 64 in (1626 mm) 67 in (1702 mm) 10,690 lbs (4849 kg)	106 in (2692 mm) 64 in (1626 mm) 68 in (1727 mm) 11,210 lbs (5085 kg)	106 in (2692 mm) 64 in (1626 mm) 68 in (1727 mm) 11,210 lbs (5085 kg)

123-7311, 2SA360 for Model 9163-7000, 2SA492 for Model 9163-7300, and 2SA493 for Model 9163-7301 and Model 9163-7311.

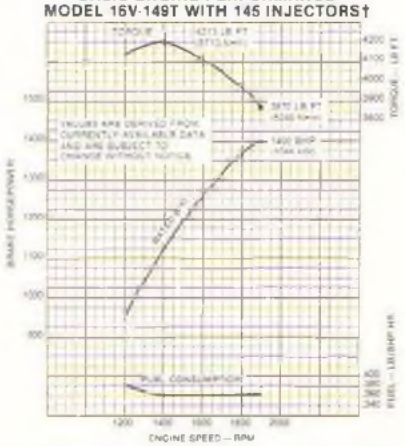
performance

FUEL CONSUMPTION CURVE shows fuel used in pounds per brake horsepower hour.
THESE RATINGS do not include power requirements for accessory and standard equipment.
†Rating conditions of SAE: 77 °F (25 °C) and 29.31 In Hg (99 kPa) Barometer (Dry)

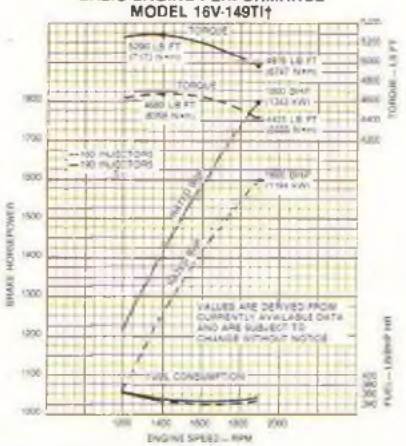
BASIC ENGINE PERFORMANCE MODEL 16V-149 WITH 130 INJECTORS†



BASIC ENGINE PERFORMANCE MODEL 16V-149T WITH 145 INJECTORS†



BASIC ENGINE PERFORMANCE MODEL 16V-149TI†



standard equipment

Air Box Drain Tubes

Air Inlet Housing

Alternator—24 volt, 65 amp

Crankshaft Pulley—Poly-Vee

Engine Mounts—Front trunnion

Exhaust Manifold

Fan—48 in (1229 mm), 8 blades, right-hand suction, 12V-149 only; 52 in (1331 mm), 8 blades, right-hand suction, 12V-149T, 12V-149TI, & 16V-149 only; fan bracket and pulley assembly, 16V-149T & 16V-149TI only

Flywheel—SAE #0

Flywheel Housing—SAE #0

Fuel Filters

Governor—Variable speed

Injectors—Cam operated, unit type, clean tip

Intercooler—12V-149TI & 16V-149TI only

Lube Oil Cooler

Lube Oil Filters—Full flow

Oil Pan—Stamped steel, dual sump, for 15° inclination angle

Starting Motor—Two (2) 24 volt

Turbocharger—12V-149T, 12V-149TI, 16V-149T, & 16V-149TI only

Vibration Damper—Thick, heavy, viscous

For a complete listing of standard and optional equipment, consult your authorized Detroit Diesel Allison representative.

Information and specifications subject to change without notice or obligation.

WORLDWIDE REGIONAL OFFICES

Atlanta, Georgia (404/257-3630)
Naperville, Illinois (312/961-6750)
Dallas, Texas (214/659-5050)
Detroit, Michigan (313/556-5800)
Parsippany, New Jersey (201/993-4040)
Fremont, California (415/498-5200)
London, Ontario, Canada (519/452-5000)
Rotterdam, The Netherlands (31) 10-29-0000
Dandenong, Victoria, Australia (61) 3-797-7911
Athens, Greece (30) 1-770-6669
Coral Gables, Florida (305/446-4900)
Jurong Town, Singapore (65) 265-4697
Mexico City, Mexico (905) 250-4354

OFFICES
Denver, Colorado, U.S.A.
Los Angeles, California, U.S.A.
Antwerp, Belgium
Biel Bienne, Switzerland
Helsinki, Finland
Lisbon, Portugal
Oslo, Norway
Paris, France
Ruesselsheim, Germany
Stockholm, Sweden
Northampton, England
Johannesburg, South Africa
Nairobi, Kenya
Adelaide, Australia
Brisbane, Australia
Sydney, Australia
West Perth, Australia
Jakarta, Indonesia
Taipei, Taiwan
Tokyo, Japan
Bogota, Colombia
Buenos Aires, Argentina
Lima, Peru
Santiago, Chile
Sao Paulo, Brasil

Detroit Diesel Allison

GM

Detroit Diesel Allison
Division of General Motors

13400 Outer Drive, West, Detroit, Michigan 48239-4001
(313/592-5000)

3SA122 3-84

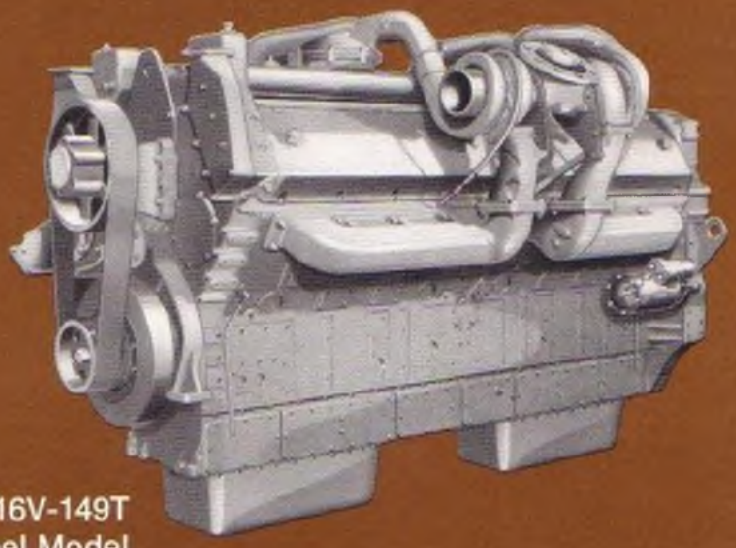
Litho in U.S.A

Detroit Diesel Engines

fan-to-flywheel models

16V-149
1060 hp

16V-149T
1325 hp



Typical 16V-149T
Fan-to-Flywheel Model

specifications

Basic Engine	16V-149 130 Injectors	16V-149T 150 Injectors
Model	9163-7000	9163-7300
Description	Naturally Aspirated	Turbocharged
Engine Type	Two Cycle	Two Cycle
Number of Cylinders	16	16
Bore and Stroke	5.75 in x 5.75 in (146 mm x 146 mm)	5.75 in x 5.75 in (146 mm x 146 mm)
Two Cycle Displacement (Every Downstroke a Powerstroke)	2389 cu in (39.18 litres)	2389 cu in (39.18) litres)
Rated Power: SAE: 85°F (29.4°C) and 29.00 in Hg (98.19 kPa) Bar (Dry)	1060 BHP (791 kW) @ 1900 RPM	1325 BHP (988 kW) @ 1900 RPM
Continuous Power: SAE: 85°F (29.4°C) and 29.00 in Hg (98.19 kPa) Bar (Dry)	900 BHP (671 kW) @ 1800 RPM	—— ——
Torque: SAE: 85°F (29.4°C) and 29.00 in Hg (98.19 kPa) Bar (Dry)	3080 lb ft (4176 N·m) @ 1500 RPM	3880 lb ft (5261 N·m) @ 1400 RPM
Compression Ratio	17 to 1	17 to 1
Approximate Dimensions: Length Width Height Net Weight (Mass) (dry)	 108 in (2743 mm) 54 in (1372 mm) 68 in (1727 mm) 10540 lbs (4781 kg)	 109 in (2769 mm) 64 in (1626 mm) 72 in (1829 mm) 10840 lbs (4917 kg)

For complete dimensional information, refer to installation drawing 2SA360 for Model 9163-7000 and 2SA359 for Model 9163-7300

performance

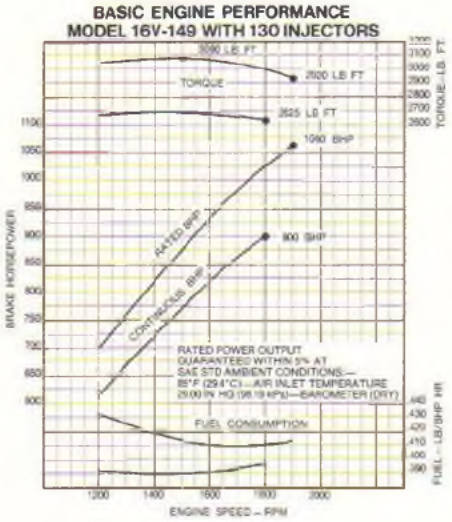
Rating Explanation

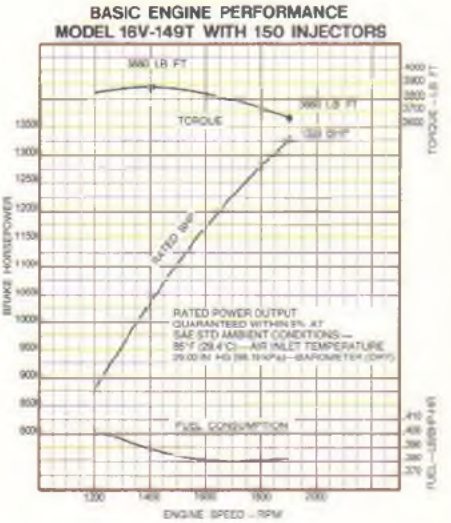
RATED BHP is the power rating for variable speed and load application where full power is required intermittently. Performance may be derated to improve fuel economy and extend engine life.

CONTINUOUS BHP is the power rating for applications operating under a constant load and speed for long periods of time.

FUEL CONSUMPTION CURVE shows fuel used in pounds per brake horsepower hour.

THESE RATINGS do not include power requirements for accessory and standard equipment.





standard equipment

Air Inlet Housing

Alternator—24 volt, 65 amp

Crankshaft Pulley—Poly-Vee

Engine Mounts—Front trunnion

Exhaust Manifold

Fan—52 In (1331 mm), 8 blades, suction, Model 9163-7000 only; Fan bracket and pulley assembly, Model 9163-7300 only

Flywheel—SAE #0

Flywheel Housing—SAE #0, dual starter pads

Fuel Filters

Governor—Variable speed

Injectors—Cam operated, unit type, clean tip

Lube Oil Cooler

Lube Oil Filter—Full flow

Oil Pan—Stamped lower pan for 15° inclination angle, dual sump

Starting Motor—Two (2) 24 volt

Turbocharger—Model 9163-7300 only

For a complete listing of standard and optional equipment, consult your authorized Detroit Diesel Allison representative.

Specifications subject to change without notice.

Detroit Diesel Allison
Division of General Motors Corporation

13400 West Outer Drive Detroit, Michigan 48228

In Canada: Diesel Division, General Motors of Canada Limited London Ontario

3SA123 1-78

Litho in U.S.A.

HYDRAULIC GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

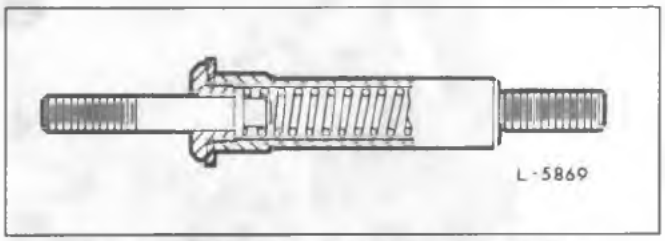


Fig. 1 – Throttle Delay Yield Link Assembly

Adjust the governor and the injector rack control levers after adjusting the exhaust valve clearance and timing the injectors.

Effective with engines built April 1, 1980 a throttle delay yield link assembly (Fig. 1) replaces the vertical link assembly, for those applications where a throttle delay mechanism is used in conjunction with the hydraulic governor (refer to Section 14.14).

Adjust Governor Linkage And Position Injector Rack Control Levers

1. Clean and remove the valve rocker cover from each cylinder bank.
2. Loosen all of the inner and outer injector rack control lever adjusting screws or loosen all of the adjusting screws and locknuts. Be sure all of the control levers are free on the injector control tubes.
3. Disconnect the yield link assembly or vertical link assembly from the governor operating lever (Fig. 2). Do not remove the lever. On current engines, remove the small cover from the governor control housing and disconnect the yield link or vertical link from the left–bank operating lever (Fig. 3). On former engines, remove the small cover on top of the engine front cover and disconnect the vertical link from the bellcrank lever (Fig. 4).

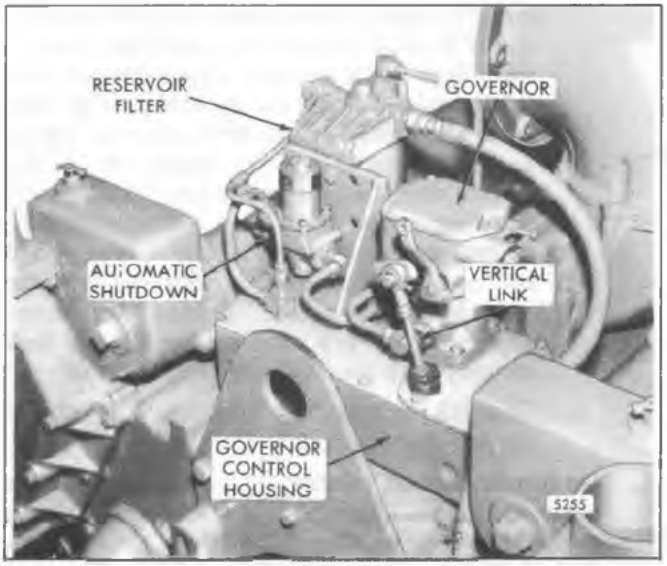


Fig. 2 – Hydraulic Governor Mounting and Linkage (Current with Vertical Link)

The letters R and L indicate the injector location in the right or left cylinder bank, as viewed from the rear of the engine. The cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the No. 1L and No. 1R injector rack control levers first to establish a guide for adjusting the remaining levers.

The injectors incorporate an injector rack stop. The stop limits the travel of the injector rack and has been preset at the factory. *Under no circumstances should the injector stop setting be altered.*

4. **On current engines,** position the linkage setting gage J 23475–01 as shown in Fig. 5. This will place the left–bank operating lever in the correct *no–fuel* position.

The former gage J 23475 can only be used with current engines that have 120, 130, 140 or 150mm fuel injectors. Gage J 23475–01 can be used on engines equipped with any size fuel injector.

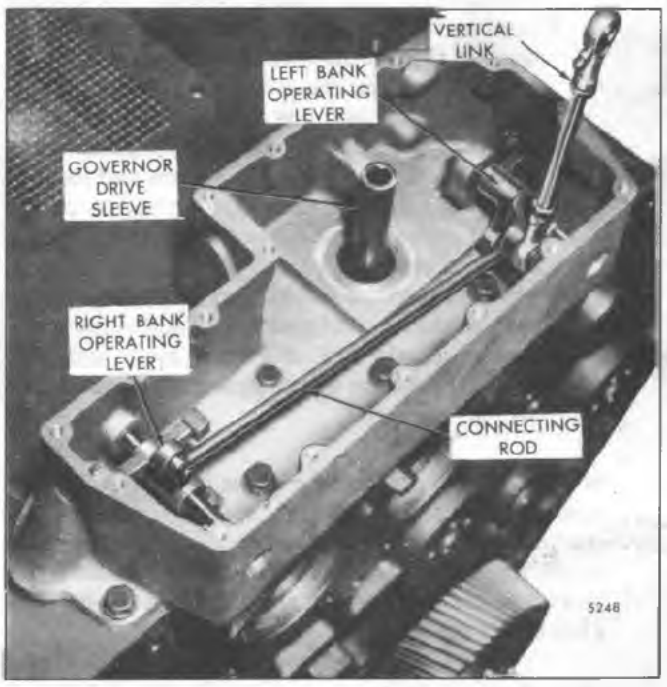


Fig. 3 – Governor Control Housing and Linkage (Current with Vertical Link)

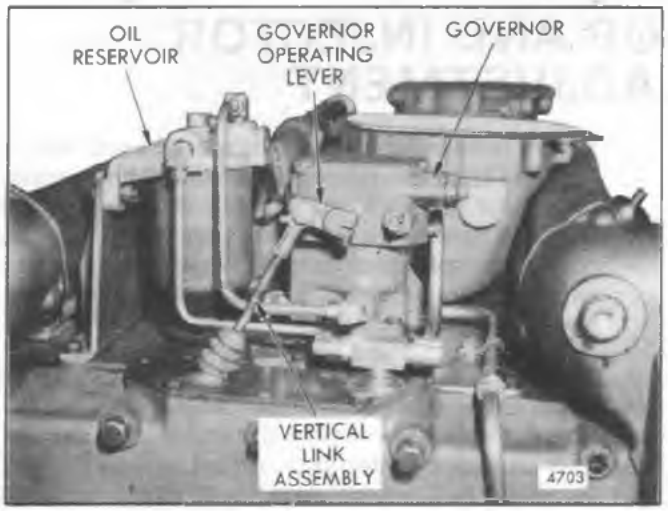


Fig. 4 – Hydraulic Governor Mounting and Linkage (Former with Vertical Link))

At the *no–fuel* position, the distance from the top of the main cover on the governor control housing to the center line of the bolt hole on the arm of the left–bank operating lever (which carries the yield link or vertical link) is 1.80".

Maintain the above dimension and set the No. 1L and No. 1R injector rack control levers, as follows:

a. With the fuel rod on the right–bank injector control tube removed and the fuel rod on the left–bank injector control tube installed, turn down the outer adjusting screw (two screw assembly) of the No. 1L injector rack control lever until the ball end of the lever is just snug against the injector rack (with the rack in the *no–fuel* position). Turn down the inner adjusting screw until it bottoms lightly on the injector control tube. Then alternately tighten both adjusting screws. On the one screw and locknut assembly, tighten the adjusting screw of the No. 1 injector rack control lever until the rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted (with the rack in the *no– fuel* position). Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut. Refer to Fig. 6.

NOTICE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24–36 **lb–in** (3–4 N·m) torque.

b. Remove the gage and install the right–bank injector control tube fuel rod.

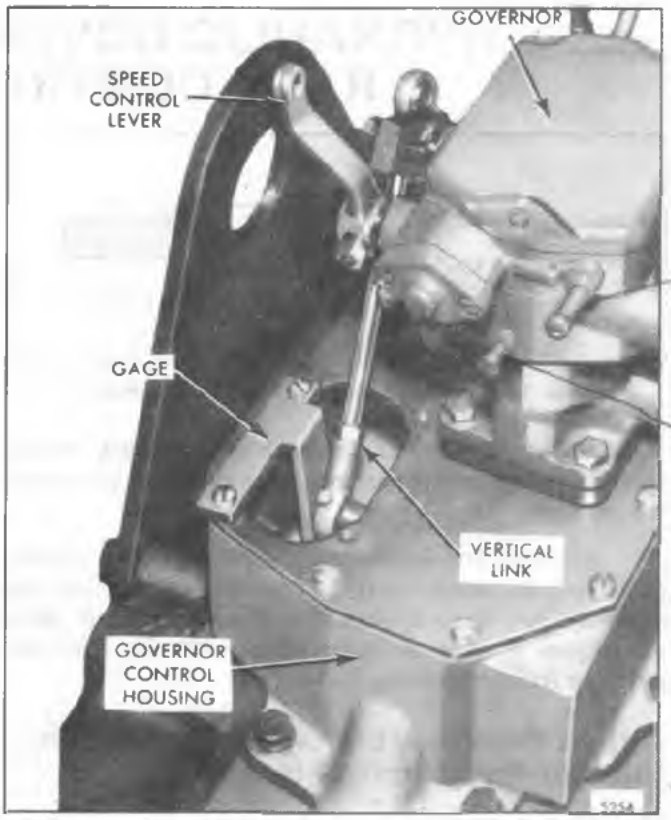


Fig. 5 – Positioning of Current Governor Operating Link with Vertical Link (Gage J 23475–01)

c. Move the No. 1 left bank injector control lever to the full–fuel position by depressing the arm of the left–bank operating lever (which carries the yield link or vertical link).

d. Hold this position and turn down the inner adjusting screw (two screw assembly) in the No. 1R injector rack control lever until the ball end of the lever is just snug against the injector rack. Turn down the outer adjusting screw until it bottoms lightly on the injector control tube. Then alternately tighten both adjusting screws to 24–36 **lb–in** (3–4 N·m) torque. On the one screw and locknut assembly, tighten the adjusting screw of the No. 1R injector rack control lever until the rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut.

e. This will place the No. 1 right–bank injector in the *full–fuel* position.

5. **On former engines,** position the elongated pin in the bellcrank (the pin which carries the left–bank fuel rod) so that it lines up with the center bolt of the bellcrank from vertical to approximately 1/16" off center toward the right cylinder bank (Fig. 7).

 © Detroit Diesel Corporation

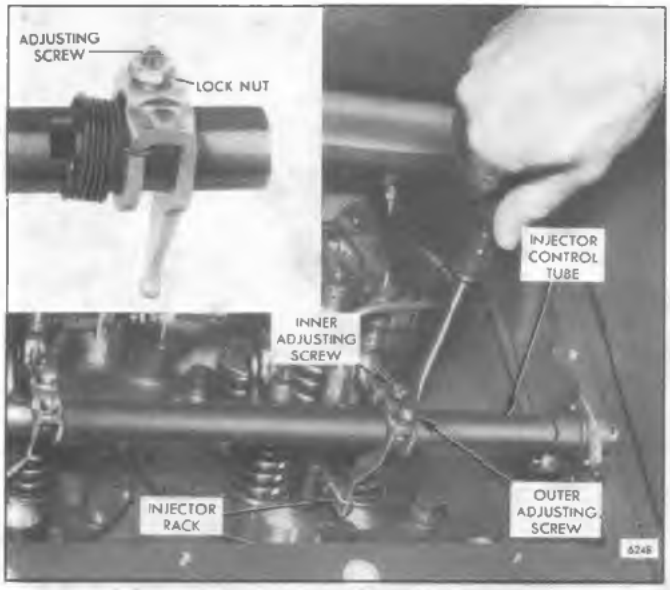


Fig. 6 – Positioning the No. 1 Injector Rack Control Lever

a. With the fuel rod on the right–bank injector control tube removed and the fuel rod on the left–bank injector control tube installed, turn down the outer adjusting screw of the No. 1L injector rack control lever until the ball end of the lever is just snug against the injector rack (with the rack in the no–fuel position). Refer to Fig. 5.

b. Turn down the inner adjusting screw until it bottoms lightly on the injector control tube. Then alternately tighten both adjusting screws. The recommended torque of the adjusting screws is 24–36 **lb–in** (3–4 N·m) torque.

c. Install the right–bank fuel rod.

d. Hold the bellcrank lever in the full–fuel position and turn down the inner adjusting screw in the No. 1R injector rack control lever until the ball end of the lever is just snug against the injector rack.

e. Turn down the outer adjusting screw until it bottoms lightly on the injector control tube. Then alternately tighten both adjusting screws to 24–36 **lb–in** (3–4 N·m) torque.

6. Check the adjustment of the No. 1L and No. 1R injector control racks in the full–fuel position by moving the left–bank operating lever (current) or the bellcrank (former) and determine if the adjustment between the two injector control racks is equal.

a. Grasp each injector control rack (one at a time) with the thumb and index finger and, using a push–pull rotating motion, note the amount of movement of each lever within the rack opening

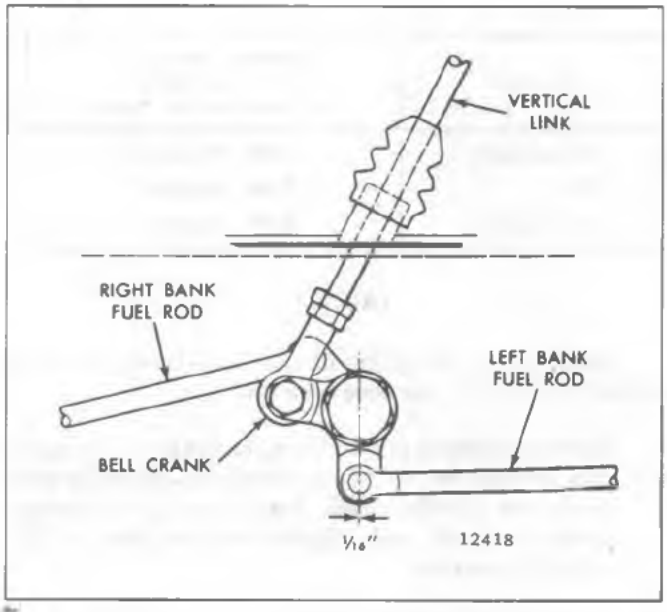
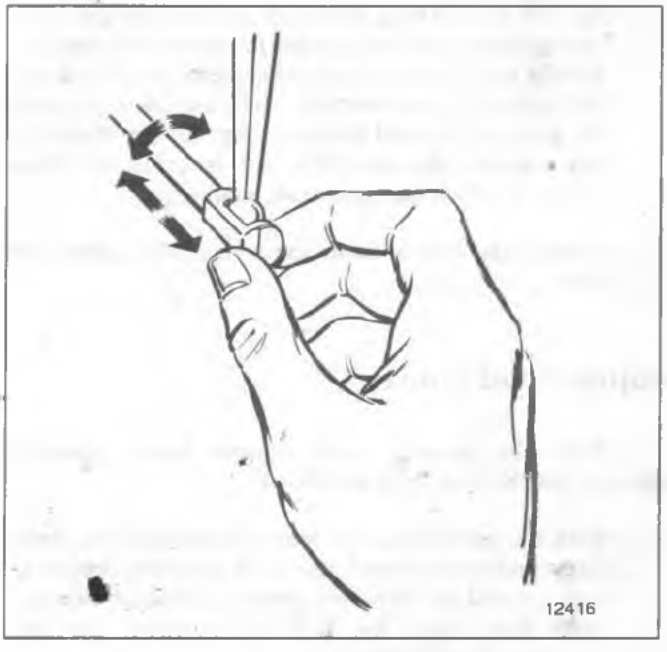


Fig. 7 – Positioning of the Bellcrank (Former Engines)

(Fig. 8). If the movement is the same for both, the two rack control levers are in adjustment. If the movement is not the same, loosen either the inner or outer adjusting screw (two screw assembly) of the No. 1R rack control lever and adjust the lever until both the No. 1L and No. 1R levers are balanced. On the one screw and locknut assembly, loosen the locknut on the No. 1R rack control lever and turn the adjusting screw clockwise or counterclockwise until both the No. 1L and No. 1R levers are balanced. Tighten the locknut securely.



8 – Checking Injector Rack Movement

Governor	Distance Between Center Lines of End Bearing Bolt Holes
SG (current)	7.00" (Approx.)
PSG	7.44" (Approx.)
SG (former)	8.88" (Approx.)

TABLE 1

Never alter the setting of the No. 1L injector rack control lever after it has once been set.

7. Set the remaining injector rack control levers, using he No. 1R and No. 1L control levers as a guide for each respective cylinder bank. Use a spring of suitable length to hold each injector control tube in the full–fuel position.

8. Remove the governor cover.

9. Adjust the load limit screw to obtain a distance of 2" from the outside face of the boss on the governor subcap to the end of the screw.

10. Position the governor operating lever on the shaft toward the left cylinder bank (on *current* engines) or toward the right cylinder bank (on *former* engines) so that the center of the bolt hole is approximately 5/16" above a horizontal line through the shaft (with the lever in the no–fuel position).

11. Refer to Table 1 and adjust the length of the yield link or vertical link so that the bolt holes of the levers and the rod end bearings are lined up with the governor lever and the injector racks are in the no–fuel position. Always install the throttle delay yield link of a Series 149 hydraulic governor with the yieldable end inside the governor control housing (Fig. 1). Positioned in this manner the yieldable end is protected from abrasives which can accelerate shaft wear.

12. Replace the two bolts in the levers and tighten the bolts.

Adjust Load Limit

With the injector rack control levers properly adjusted, set the load limit as follows:

1. With the governor cover removed and the load limit screw locknut loosened, move the governor operating lever toward the full–fuel position until the injector racks just reach the full–fuel position. Do not overstress the linkage.

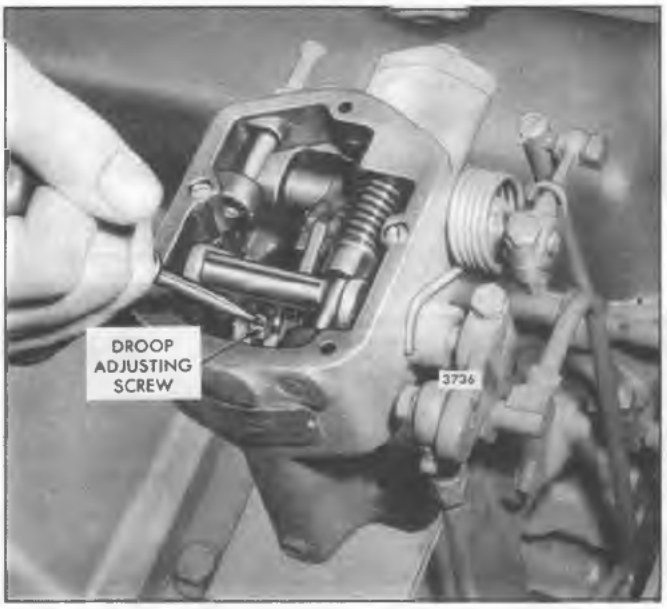


Fig. 9 – Adjusting Speed Droop

2. Turn the load limit adjusting screw inward until the injector racks just loosen on the ball ends of the control levers.

3. Release the governor operating lever and hold the load limit screw while tightening the locknut. Install the governor cover.

Adjust Governor Speed Droop

INTERNAL DROOP ADJUSTMENT

The purpose of adjusting the speed droop is to establish a definite engine speed at no load with a given speed at rated full load. The governor speed droop is set at the factory and further adjustment should be unnecessary.

However, if the governor has been overhauled, the speed droop must be readjusted.

If a full–rated load can be established on the engine, and the fuel rods, injector rack control levers and the load limit have been adjusted, set the speed droop as follows:

1. Start the engine and run it at approximately one–half the rated no–load speed until the lubricating oil temperature stabilizes. When the engine lubricating oil is cold, the governor regulation may be erratic. Regulation will become increasingly stable as the temperature of the oil increases.

2. Stop the engine and remove the governor cover.

3. Loosen the locknut and back off the maximum speed adjusting screw approximately 5/8".

 © Detroit Diesel Corporation

4. Loosen the droop adjusting screw. Move the droop adjusting bracket so that the screw is midway between the ends of the slot in the bracket. Tighten the screw (Fig. 9).

5. With the throttle in the *run* position, adjust the engine speed until the engine is operating at 3% to 5% above the recommended full–load speed. Use an accurate tachometer to determine the engine speed.

6. Apply the full–rated load on the engine and readjust the engine speed to the correct full–load speed.

7. Remove the load and note the engine speed after the speed stabilizes under no load. If the speed droop is correct, the engine speed will be approximately 3% to 5% higher than the full–load speed.

8. If the speed droop is too high, stop the engine, loosen the droop adjusting screw and move the adjusting bracket *in* toward the center of the governor. Tighten the adjusting screw. If the speed droop is too low, move the bracket *out,* away from the center of the governor.

The speed droop in governors which control engines driving generators in parallel must be identical, otherwise the electrical load will not be equally divided.

Adjust the speed droop bracket in each governor to obtain the desired variation between engine no–load and full–load speeds. The recommended speed droop for generator sets operating in parallel is 50 rpm (2–1/2 cycles) for units operating at 1000 or 1200 rpm and 75 rpm (2–1/2 cycles) for units operating at 1500 or 1800 rpm (Table 2).

However, this droop recommendation may be varied to suit the individual application.

EXTERNAL DROOP CONTROL

Some PSG type governors are equipped with an external adjustable droop control. This permits the speed droop to be adjusted without removing the governor cover. With this feature, a unit can be paralleled with another unit that is operating at constant frequency (zero droop). The incoming unit must have its droop bracket set in the maximum position while it is being paralleled and while operating in parallel. When it is desired to stop the unit operating at constant frequency, shift the load to the incoming unit and move the governor droop bracket to zero droop.

Full Load	No-Load
50 cycles 1000 rpm	52.5 cycles 1050 rpm
60 cycles 1200 rpm	62.5 cycles 1250 rpm
50 cycles 1500 rpm	52.5 cycles 1575 rpm
60 cycles 1800 rpm	62.5 cycles 1875 rpm

TABLE 2

Then, adjust the outgoing unit to maximum droop, remove it from the line and stop the engine. The incoming unit will now be carrying the load and operating at constant frequency (zero droop).

Adjust the governor speed droop as follows:

1. Start the engine and run it at approximately one–half of the rated full–load speed until the lubricating oil temperature stabilizes.

2. Remove the load from the engine.

3. Back off the compensation needle valve to release any air that may be trapped in the system. Turn the needle valve in slowly to reduce governor "hunting". The correct needle valve setting will be between 1/8 and 1/2 turn open.

4. Back out the maximum droop setting screw.

5. Loosen the droop adjusting knob and move the slide all the way toward the minimum adjusting screw. Then tighten the knob.

6. Loosen the locknut on the maximum speed adjusting screw and turn the screw out until 5/8" of the threads are exposed.

7. With the engine operating at the recommended full–load speed, apply the full–rated load and recheck the engine speed If required, readjust the engine to full–load speed.

8. Remove the load and note the engine speed. If the zero droop setting is correct, the engine speed will remain constant. If the engine speed is higher, loosen the droop adjusting knob and set the slider to a reduced droop position.

9. When the desired minimum droop setting is reached, turn the minimum droop setting screw inward until it contacts the droop linkage within the governor. This will be felt by a step–up of resistance while turning the adjusting screw. Lock the adjusting screw in this position.

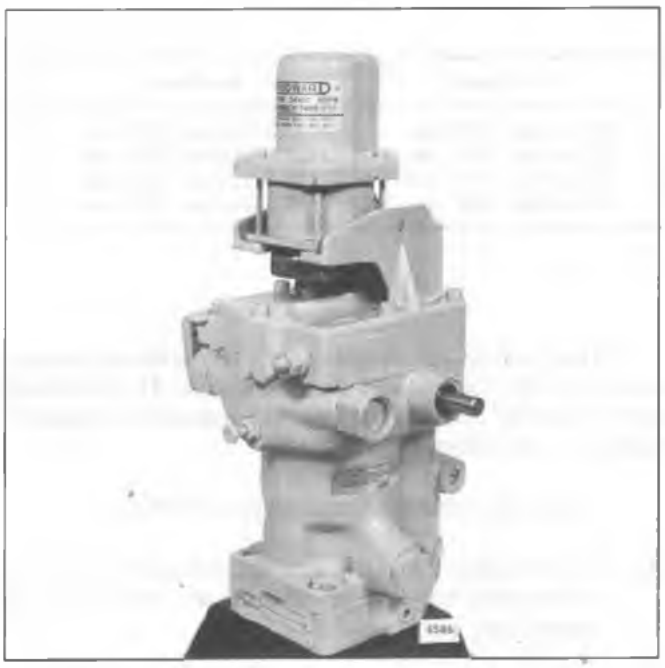


Fig. 10 – Typical Synchronizing Motor Mounting

10. Loosen the droop adjusting knob and slide the droop bracket in a direction to increase the droop. Perform Steps 7 and 8 to check the droop until the desired maximum speed droop is attained.

11. When the desired maximum droop setting is reached, loosen the locknut and turn the maximum droop setting screw inward until it contacts the droop slider arm. Lock the adjusting screw in this position.

12. Recheck the minimum and maximum droop setting as outlined in Steps 7 and 8 and adjust the adjustment screws, if necessary, until the correct settings are obtained.

Adjust Maximum No–Load Speed

With the speed droop properly adjusted, set the maximum no–load speed as follows:

1. With the engine operating at no load, adjust the speed until the engine is operating at approximately 8% higher than the rated full–load speed.

2. Turn the maximum speed adjusting screw in until the screw contacts the throttle linkage internally, limiting the maximum speed of the engine at 8% above the rated full–load speed (Fig. 10).

3. Hold the screw and tighten the locknut.

Governors With Synchronizing Motor

Some hydraulic governors are equipped with a reversible electric synchronizing motor mounted on the governor cover (Fig. 10).

The adjustments are the same as on a governor without a motor. However, the governor cover and motor assembly must be removed when setting the engine speed droop (except on the PSG type governor equipped with an external droop adjustment). The cover and motor must be reinstalled to check the speed droop.

 © Detroit Diesel Corporation

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD	(lb–ft)	(Nom)
Camshaft coupling bolt (early 12V only)	5/16–24	20–24	27–33
Exhaust valve bridge adjusting screw nut	5/16–24	20–25	27–34
Camshaft coupling bolt (early 12V only)	3/8–24	45–50	61–68
Exhaust valve adjusting screw nut	3/8–24	30–35	41–47
Fuel pump drive coupling disc bolt	3/8–24	50–55	68–75
Camshaft coupling bolt (current)	7/16–20	57–61	77–83
*Crankshaft coupling bolts (2–piece crankshaft)	7/16–20	70–80	95–108
Injector fuel pipe nut (large)	7/16–20	18–22	24–30
Injector fuel pipe nut (small)	7/16–24	18–22	24–30
*Block attaching bolts	1/2–13	75–85	102–115
Camshaft bearing cap bolts	1/2–13	90–100	122–136
Fuel pipe connector nut	1/2–13	35–40	47–54
Idler gear hub retaining bolt	1/2–13	80–90	108–122
Rocker arm shaft bolt	1/2–13	90–100	122–136
*Block attaching bolts	1/2–20	85–95	115–129
*Connecting rod–to–piston pin bolt	1/2–20	35–45 + 60°–80°	47–61 + 60°–80°
*Crankshaft coupling bolts (2–piece crankshaft)	1/2–20	100–110	136–150
Exhaust manifold to block stud nuts	1/2–20	50–55	68–75
Bearing cap nut (oil pan removed)	9/16–18	45–55 + 130°–150°	61–75 + 130°–150°
Bearing cap nut (oil pan installed)	9/16–18	125–135	170–183
*Connecting rod cap nut (oil pan installed)	9/16–18	130–140	177–190
• *Connecting rod cap nut (oil pan removed)	9/16–18	45–55 + 130°–150°	61–75 + 130°–150°
*Cylinder head bolt	9/16–18	140–150	190–204
*Block attaching bolts	5/8–11	160–175	217–238
*Flywheel bolt (see Sect. 1.4)	5/8–18		
Vibration damper hub to crankshaft bolt	5/8–18	180–190	244–258
*Block attaching bolts	3/4–10	270–290	366–393
*Main bearing cap bolt	3/4–10	280–290	379–393
Accessory drive pulley nut	3/4–16	120–140	163–190
Crankshaft pulley bolt	1 1/4–7	450–500	610–678
Front PTO hub nut	1 1/4–12	325–350	441–475
Blower drive support nut	1 7/16–16	50–60	68–81
Accessory gear locknuts	2 1/2–18	280–300	379–407
Idler gear locknuts (spanner, standard hex)	2.548–18	280–300	379–407
• Idler gear Locknut (hex w/locking lip)	2.548–18	300–320	407–434
Camshaft gear locknut (spanner, standard hex)	3.137–12	280–300	379–407
• Camshaft gear locknut (hex w/locking lip)	3.137–12	300–320	407–434

*Lubricate threads with International Compound No. 2, or equivalent (refer to Parts Catalog or Microfiche, Section 12.8000A).

 © Detroit Diesel Corporation

ENGINE TIMING

The correct relationship between the crankshaft and the two camshafts must be maintained to properly control fuel injection, the opening and closing of the exhaust valves and engine balance.

The crankshaft timing gears can be mounted in only one position since one attaching bolt hole is offset. Therefore, when the engine is properly timed, the timing marks on the various gears will match (Figs. 3, 4 and 5). Early engines did not include a dot in the timing marks.

Special care should be exercised when aligning the timing marks of the front gear train idler gears as the difference in thickness of the two gears may give the appearance of misalignment.

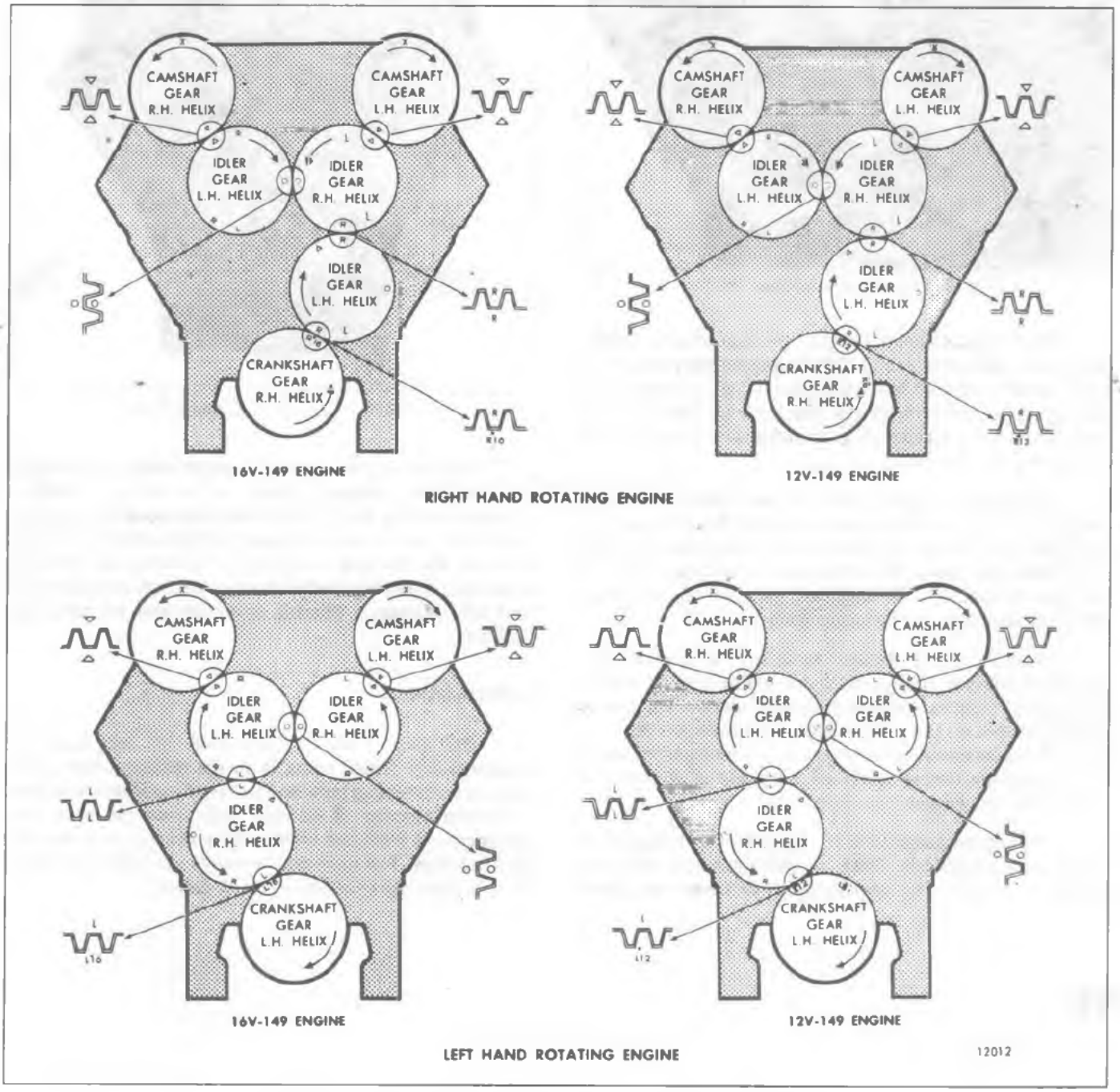
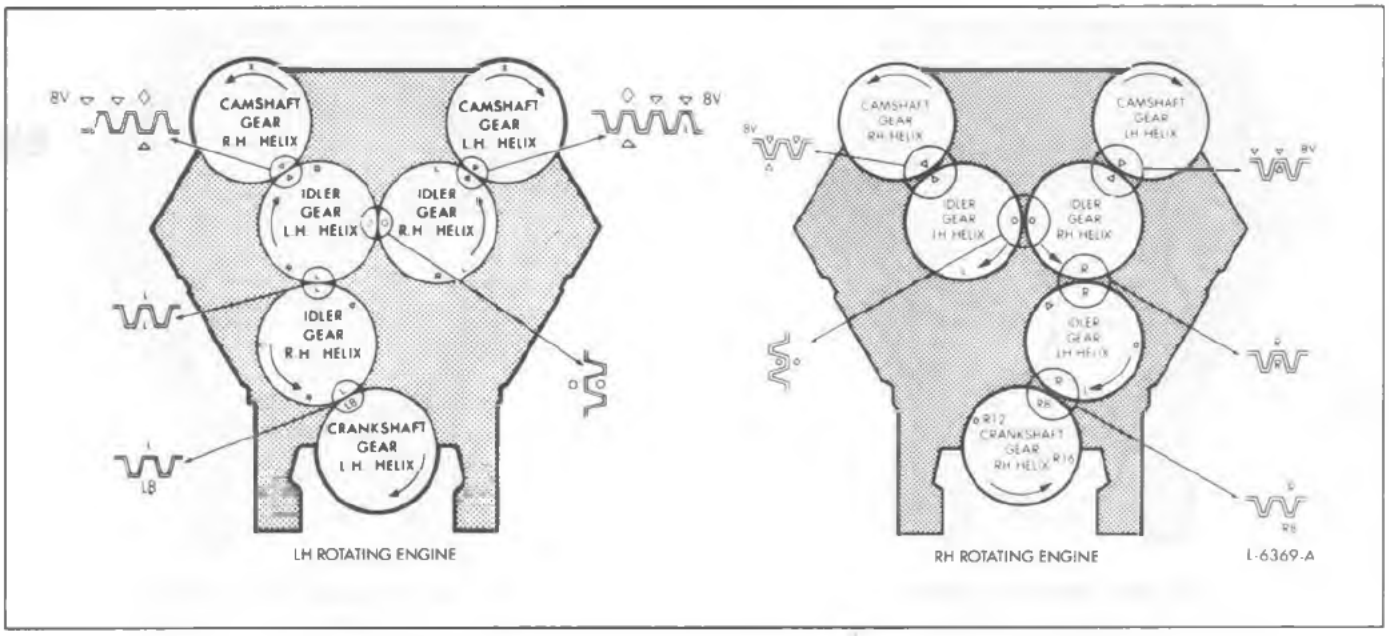


FIG. 3 – Rear Gear Train Timing Marks — 12V And 16V Engines

 © Detroit Diesel Corporation



• Fig. 4 – Rear Gear Train Timing Marks – 8V Engines

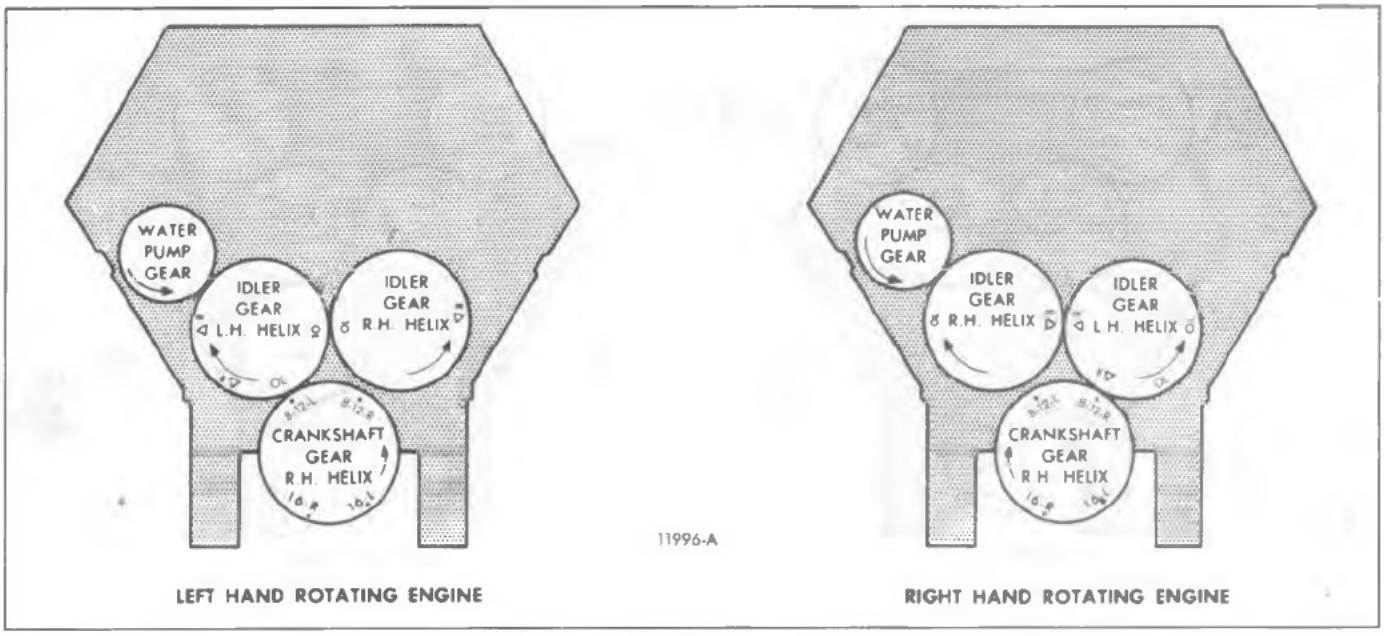
An engine which is *out of time* may result in preignition, uneven running and a loss of power.

When an engine is suspected of being out of time due to an improperly assembled gear train, a quick check can be made without having to remove the flywheel and flywheel housing by following the procedure outlined below.

Check Engine Timing

Access to the vibration damper or crankshaft pulley, to mark the top–dead–center position of the selected piston, and to the front end of the crankshaft (or to the flywheel), for turning the crankshaft, is necessary when performing the timing check. Then, proceed as follows:

1. Remove one valve rocker cover. Discard the gasket.
2. Select any cylinder for the timing check.
3. Remove the injector (at the cylinder selected) as outlined in Section 2.1.1.
4. Carefully slide a rod, approximately 12" long, through the injector tube until the end of the rod rests on top of the piston. Place the throttle in the *no–fuel* position. Then, turn the crankshaft slowly in the direction of engine rotation. Stop when the rod reaches the end of its upward travel. Remove the rod and turn the crankshaft, opposite the direction of rotation, between 1/16 and 1/8 of a turn.
5. Select a dial indicator with .001" graduations and a spindle movement of at least one inch. Provide an extension for the indicator spindle. The extension must be long enough to contact the piston just before it reaches the end of its upward stroke. Also, select suitable mounting attachments for the indicator so it can be mounted over the injector tube in the cylinder head.
6. Mount the indicator over the injector tube. Check to be sure the indicator spindle is free in the injector tube and is free to travel at least one inch.
7. Attach a suitable pointer to the engine front cover. The outer end of the pointer should extend over the top of the crankshaft pulley (or vibration damper).
8. Turn the crankshaft slowly in the direction of engine rotation until the indicator hand just stops moving. Continue turning the crankshaft until the indicator hand starts to move again.
9. Set the dial indicator to zero. Then, turn the crankshaft approximately .075" in the direction of engine rotation. Rotate the crankshaft in the opposite direction to .050" from the zero setting.
10. Scribe a line on the crankshaft pulley (or vibration damper) in line with the end of the pointer.
11. Turn the crankshaft in the opposite direction of engine rotation, through the point where the indicator stops, to approximately .075" from the zero setting. Rotate the crankshaft back in the direction of engine rotation to .050" from the zero setting.
12. Scribe a second line on the vibration damper (or crankshaft pulley) in line with the end of the pointer.



• Fig. 5 – Front Gear Train Timing Marks – 12V and 16V Engines

13. Scribe a third line half way between the first two lines. This is top dead center. If the crankshaft pulley retaining bolt has loosened, tighten it to 450–500 lb–ft (610–678 N•m) torque.

14. Remove the dial indicator and rod from the engine.

15. Install the injector as outlined in Section 2.1.1. Then, adjust the valve clearance (Section 14.1) and time the injector (Section 14.2).

16. Turn the crankshaft, in the direction of engine rotation, until the exhaust valves in the selected cylinder are completely open. Reinstall the dial indicator so the indicator spindle rests on top of the injector follower. Set the indicator dial on zero, then, turn the crankshaft slowly, in the direction of engine rotation, until the center mark on the pulley is in line with the pointer.

17. Note the reading on the dial indicator and compare it with the following:

    1. If the indicator reading is .306" to .326", the engine is in time.
    2. If the indicator reading is .268" to .288", timing is retarded one tooth.
    3. If the indicator reading is .337" to .357", timing is advanced one tooth.

18. After completing the timing check, remove the dial indicator. Also, remove the pointer from the engine front cover.

19. Using a new gasket, reinstall the valve rocker cover.

 © Detroit Diesel Corporation

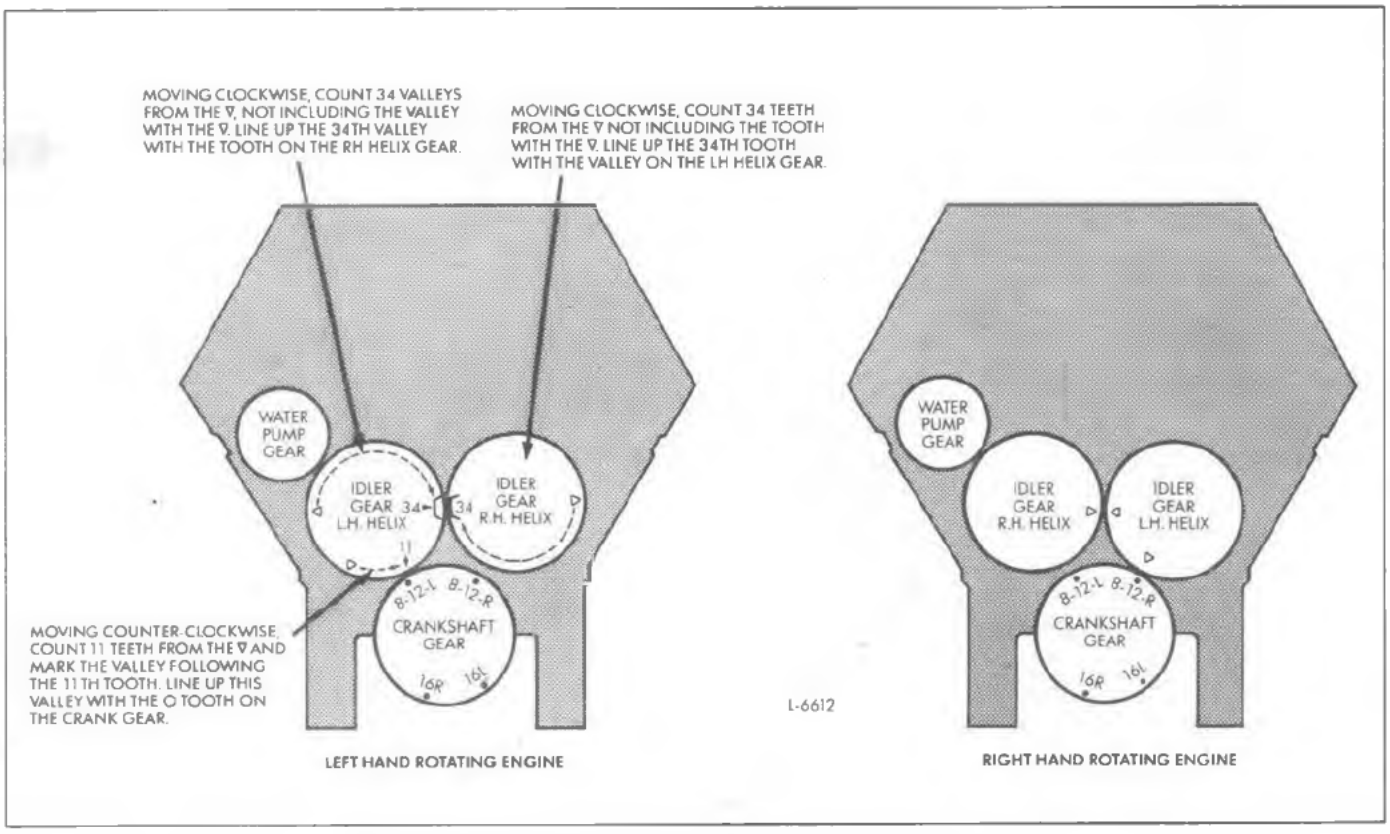


Fig. 6 – Front Gear Train Timing Marks – 8V–149 Engine

GENERAL SPECIFICATIONS

	8V	12V	16V
Type	2 Cycle	2 Cycle	2 Cycle
Number of Cylinders	8	12	16
Bore (inches)	5.75	5.75	5.75
Bore (mm)	146	146	146
Stroke (inches)	5.75	5.75	5.75
Stroke (mm)	146	146	146
Total Displacement – (cubic inches)	1195	1792	2389
Total Displacement – (liters)	19.6	29.39	39.18
Compression Ratio (standard and turbocharged engines)		17:1	17:1
Compression Ratio (intercooled turbocharged engines)*	16:1	16:1	16:1

* Note: Certain high output turbocharged — intercooled engines also have 14:1 and 15:1 compression ratios.

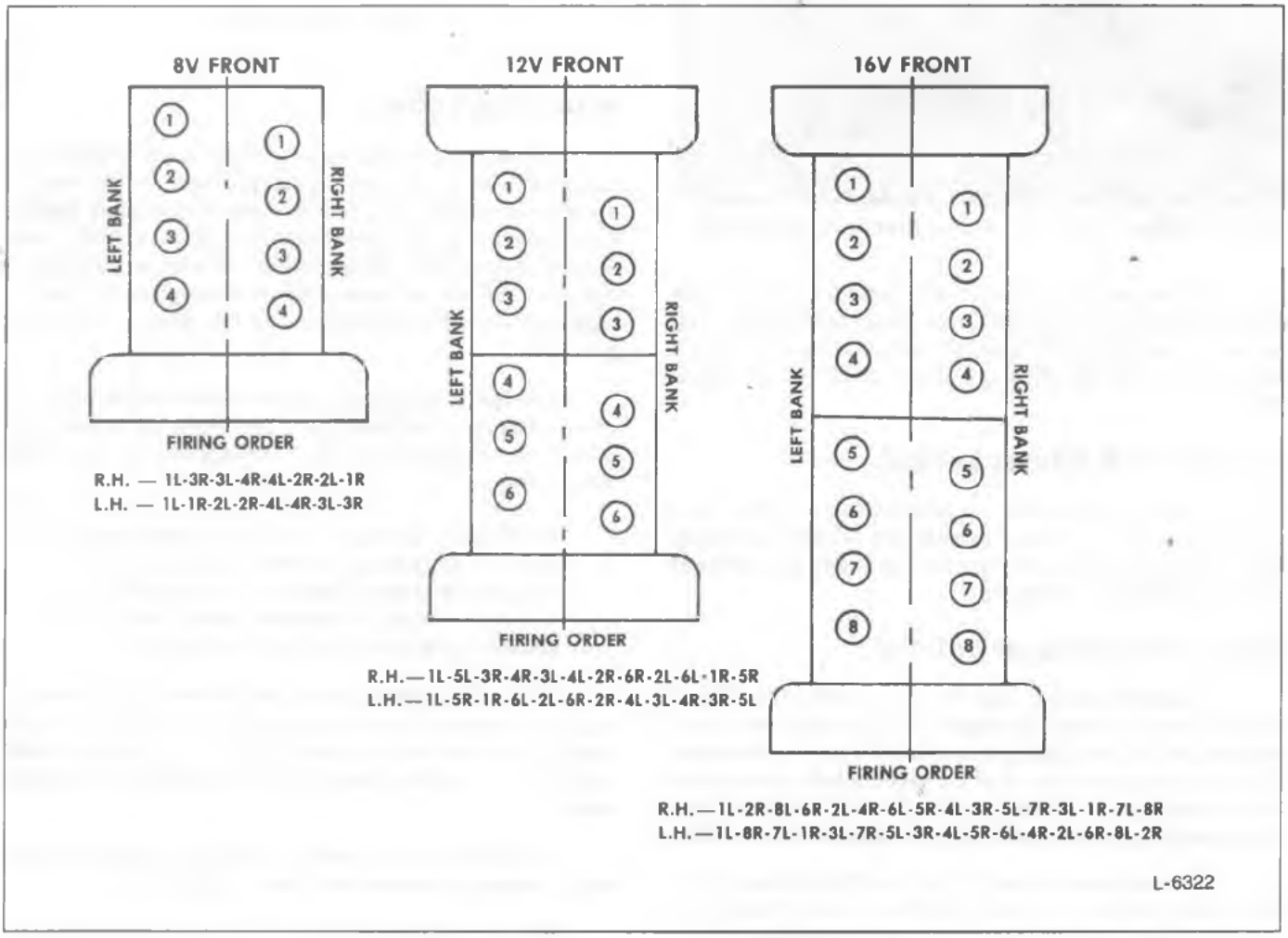


Fig. 3 – Cylinder Designation and Firing Order

FUEL INJECTOR TIMING

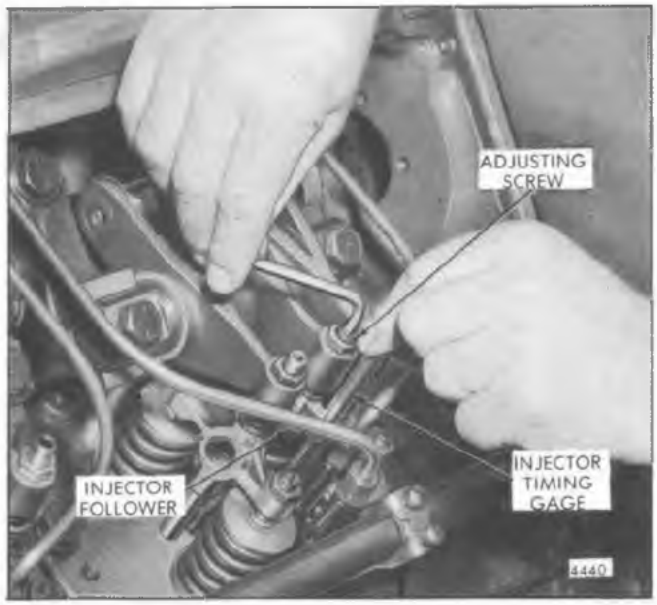


Fig. 1 – Timing Fuel Injector

All of the injectors can be timed in firing order sequence during one full revolution of the crankshaft. Refer to the *General Specifications* at the front of the manual for the firing order.

Time Fuel Injector

After the exhaust valve clearance has been adjusted (Section 14.1), time the fuel injectors as follows:

1. Place the governor speed control lever in the *idle speed* position. If a stop lever is provided, secure it in the *stop* position.

2. Rotate the crankshaft, with the starting motor or with engine barring tool J 22582 (refer to Section 1.2.2), until the exhaust valves are fully depressed on the particular cylinder to be timed.

   • CAUTION: To reduce the risk of personal injury when barring over or bumping the starter while performing an engine tune–up, personnel should keep their hands and clothing away from the engine as there is a remote possibility the engine could start.

Injector	Timing Gage Dimension	Timing Gage Tool No.	Camshaft Timing
120	2.1750"	J 22412	Std.
130	2.1750"	J 22412	Std.
140	2.1750"	J 22412	Std.
*140	2.2050"	J 24283	Std.
145	2.2050"	J 24283	Std.
150	2.1750"	J 22412	Std.
*150	2.2050"	J 24283	Std.
155	2.2050"	J 24283	Std.
*160	2.2050"	J 24283	Std.
165	2.1750"	J 22412	Std.
*165	2.2050"	J 24283	Std.
170	2.1750"	J 22412	Std.
*170	2.2050"	J 24283	Std.
*180	2.2050"	J 24283	Std.
185	2.2050"	J 24283	Std.
*190	2.2050"	J 24283	Std.
*195	2.1850"	J 29116	Std.
230	2.1750"	J 22412	Std.
240	2.1850"	J 29116	Std.
270	2.1850"	J 29116	Std.
290	2.1750"	J 22412	Std.
315	2.1750"	J 22412	Std.
6810	2.1750"	J 22412	Std.
*7110	2.2050"	J 24283	Std.

*Used on turbocharged-intercooled engines.
Notice: Do not mix 190 and 7110 injectors in the same engine. L-6627

• TABLE 1 – INJECTOR TIMING

NOTICE: If a wrench is used on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left–hand direction of rotation because the bolt may be loosened.

3. Place the small end of the injector timing gage (refer to Table 1 for the correct timing gage) in the hole provided in the top of the injector body with the flat of the gage toward the injector follower (Fig. 1).

4. Loosen the injector rocker arm adjusting screw locknut.

5. Turn the adjusting screw to adjust the injector rocker arm until the extended part of the gage will just pass over the top of the injector follower.

6. Hold the adjusting screw and tighten the locknut to 30–35 lb–ft (41–47 N·m) torque. Check the adjustment and, if necessary, readjust the rocker arm.

7. Time the remaining injectors in the same manner as outlined above.

8. If no further engine tune–up is required, install the valve rocker covers, using new gaskets.

SPECIFICATIONS

Specifications, clearances and wear limits are listed below. It should be specifically noted that the clearances apply only when all new parts are used at the point where the various specifications apply. This also applies to references within the text of the manual. The column entitled "Limits" in this Chart lists the amount of wear or increase in clearance which can be tolerated in used engine parts and still ensure satisfactory performance. It should be emphasized that the figures given as "Limits" must be qualified by the judgement of personnel responsible for installing new parts. These wear limits are, in general, listed only for the parts more frequently replaced in engine overhaul work. For additional information, refer to the text.

TABLE OF SPECIFICATIONS, NEW CLEARANCES AND WEAR LIMITS

These limits also apply to oversize and undersize parts.

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
CYLINDER BLOCK			
Block bore:			
Diameter (upper pilot)	6.5220"	6.5240"	6.5260"
Diameter (seal ring lands)	6.5010"	6.5030"	6.5050"
Diameter (water jacket)	6.4000"	6.4020"	6.4040"
Out–of–round		.0015"	
Taper		.0015"	
*Cylinder liner counterbore:			
Diameter	6.9080"	6.9140"	
Depth	.4920"	.4960"	
Main bearing bore:			
Inside diameter	5.1870"	5.1880"	
Camshaft bearing bore:			
Inside diameter (former)	2.1510"	2.1520"	
Inside diameter (current)	2.1505"	2.1525"	
CYLINDER HEAD			
Exhaust valve seat counterbore:			
Diameter	1.8965"	1.8975"	
Depth	.4010"	.4060"	
Exhaust valve seat insert runout		.0020"	.0020"
Exhaust valve:			
Stem diameter	.3722"	.3730"	
Valve head–to–cylinder head	Flush	.017"recess	.032"recess
Exhaust valve guide:			
Height above cylinder head	1.1400"	1.1800"	
Diameter—inside	.3750"	.3760"	
Clearance—valve–to–guide	.0020"	.0038"	.0060"
Exhaust valve bridge guide:			
Height above cylinder head (press fit)	2.3900"	2.4100"	
ROCKER ARMS AND SHAFTS			
Diameter—rocker shaft	1.2295"	1.2300"	
Diameter—inside (rocker arm bushing)	1.2310"	1.2320"	
Clearance—shaft–to–bushing	.0010"	.0025"	.0040"
Clearance—cam roller bushing–to–pin			.0100"

*Prior to engines 12E–1703 and 16E–361.

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
CRANKSHAFT			
Journal diameter—main bearing	4.8720"	4.8730"	
Journal diameter—connecting rod bearing	3.8730"	3.8740"	
Journal diameter—outboard bearing	5.9990"	6.0000"	
Journal out–of–round		.00025"	.0010"
Journal taper		.0005"	.0015"
# Runout on journals—total indicator reading:			
12V (mounted on No. 1 and No. 8 journals):			
At No. 2 and No. 7 journals		.0020"	
At No. 3 and No. 6 journals		.0040"	
At No. 4 and No. 5 journals		.0060"	
16V (mounted on No. 1 and No. 10 journals):			
At No. 2 and No. 9 journals		.0020"	
At No. 3 and No. 8 journals		.0040"	
At No. 4 and No. 7 journals		.0060"	
At No. 5 and No. 6 journals		.0080"	
Thrust washer thickness	.1630"	.1660"	
End play (end thrust clearance)	.0040"	.0140"	.0180"
MAIN BEARINGS			
Inside diameter (vertical axis)	4.8760"	4.8782"	
Bearing–to–journal clearance	.0030"	.0062"	.0072"
Bearing thickness (90° from parting line)	.1550"	.1555"	.1544"
OUTBOARD BEARING			
Inside diameter (installed)	6.0033"	6.0087"	
Clearance—bearing–to–journal	.0033"	.0097"	
PISTONS (FLOATING SKIRT)			
Piston:			
Height	6.6610"	6.6710"	
Diameter at top:			
Current	5.7030"	5.7050"	
Former	5.7010"	5.7030"	
Diameter of skirt (3" below top):			
Current (effective with 12E–1463 and 16E–218)	5.7394"	5.7416"	
(2E–673 to 12E–1463 and 16E–16 to 16E–218)	5.7388"	5.7410"	
Former	5.7368"	5.7390"	
Clearance—piston skirt–to–liner:			
Current (effective with 12E–1463 and 16E–218)	.0074"	.0116"	
(2E–673 to 12E–1463 and 16E–16 to 16E–218)	.0080"	.0122"	
Former	.0100"	.0142"	
PISTON CARRIER (FLOATING SKIRT PISTON)			
Height (bottom to thrust platform)	3.6060"	3.6090"	3.6050"
Thrust plate thickness	.0995"	.1010"	.0945"
Clearance—snap ring–to–carrier	.0030"	.0130"	

Runout tolerance given for guidance when regrinding crankshaft. When runout on adjacent journals is in opposite direction, the sum must not exceed .003" total indicator reading. When runout on adjacent journals is in the same direction, the difference must not exceed .003" total indicator reading. When high spots of runout on adjacent journals are at right angles to each other, the sum must not exceed .004" total indicator reading, or .002" on each journal.

 © Detroit Diesel Corporation

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
PISTONS (CROSS-HEAD)			
Piston crown:			
Saddle–to–crown distance	2.7205"	2.7275"	
Diameter:			
At top edge	5.7040"	5.7070"	
Below both compression rings	5.7370"	5.7410"	
Above and below seal ring groove	5.4110"	5.4160"	
Above and below Bearing saddle	4.2200"	4.2250"	
Seal ring:			
Gap (in skirt counterbore)	.0020"	.0270"	
Side clearance	.0005"	.0030"	.0040"
Piston skirt:			
+Diameter	5.7404"	5.7426"	
Clearance—skirt–to–liner (former)	.0064"	.0106"	
Clearance—skirt–to–liner (current)	.0066"	.0109"	
Seal ring bore	5.4400"	5.4450"	
Piston pin bore	2.3909"	2.3919"	
PISTON RINGS			
Compression rings:			
Gap (wide gap rings)	.0550"	.0750"	
Gap (standard rings)	.0450"	.0550"	
Clearance—ring–to–groove:			
No. 1 (top)	.0045"	.0081"	
No. 2	.0105"	.0130"	
No. 3	.0045"	.0070"	
No. 4	.0045"	.0070"	
Oil control rings:			
Gap	.0170"	.0320"	
Clearance—ring–to–groove:			
Upper	.0015"	.0055"	
Upper (turbocharged engine)	.0010"	.0035"	
Lower	.0015"	.0055"	
PISTON PIN			
Diameter	2.3873"	2.3877"	
Slipper bearing (bushing) thickness at center	.0870"	.0880"	.0860"
CONNECTING ROD			
Side clearance (normal) between rods	.0180"	.0260"	
CONNECTING ROD BEARINGS			
Inside diameter	3.8755"	3.8775"	
Bearing–to–journal clearance	.0015"	.0045"	.0055"
Bearing thickness (90° from parting line)	.1550"	.1555"	.1544"

+Diameter above and below the piston may be 5.7370".

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
CYLINDER LINER			
Outside diameter:			
Upper pilot	6.5200"	6.5210"	
Below ports	6.3980"	6.3990"	
Inside diameter	5.7488"	5.7513"	
Clearance—liner pilot–to–block bore	.0010"	.0040"	
Out–of–round (inside diameter)		.0010"	.0020"
Taper (inside diameter)		.0010"	.0020"
*Depth of flange BELOW block	.0390"	.0450"	
GEAR TRAIN			
Gear backlash (between all gears)	.0015"	.0080"	.0100"
Clearance—Crankshaft–to–bushing (in front crankshaft gear)	.0010"	.0030"	
CAMSHAFT			
Journal diameter	1.9940"	1.9945"	
Runout at intermediate journal (when mounted on end journals)		.0020"	
Thrust plate thickness	.3680"	.3720"	
Clearance—thrust plate–to–camshaft thrust shoulder	.0130"	.0220"	.0260"
CAMSHAFT BEARINGS			
Inside diameter (vertical axis)	2.0004"	2.0024"	
Clearance—bearing–to–shaft	.0059"	.0084"	.0100"
FRONT IDLER GEAR			
Inside diameter — bushing	2.6270"	2.6280"	
Outside diameter — idler gear hub	2.6240"	2.6250"	
BLOWER DRIVE GEAR			
Inside diameter—bushing	1.8770"	1.8780"	
Clearance—hub–to–gear bushing	.0010"	.0025"	.0050"
Thrust washer (drive support) thickness	.2350"	.2450"	
Thrust washer (gear) thickness	.1190"	.1210"	
End play (between thrust washers)	.0020"	.0180"	

*Prior to engines 12E–1703 and 16E–361.

 © Detroit Diesel Corporation

EXHAUST VALVE CLEARANCE ADJUSTMENT

The correct exhaust valve clearance at normal engine operating temperature is important for smooth, efficient operation of the engine.

Insufficient valve clearance can result in loss of compression, misfiring cylinders and, eventually, burned valve seats and valve seat inserts. Excessive valve clearance will result in noisy operation, increased valve face wear and valve lock damage.

Whenever a cylinder head is overhauled, the exhaust valves are reconditioned or replaced, or the valve operating mechanism is replaced or disturbed in any way, the valve clearance must first be adjusted to the cold setting to allow for normal expansion of the engine parts during the engine warm–up period. This will ensure a valve setting that is close enough to the specified clearance to prevent damage to the valves when the engine is started.

The exhaust valve bridges must be adjusted and the adjustment screws locked securely at the time the cylinder head is installed on the engine. The necessary adjustment procedure is outlined in Section 1.2.2.

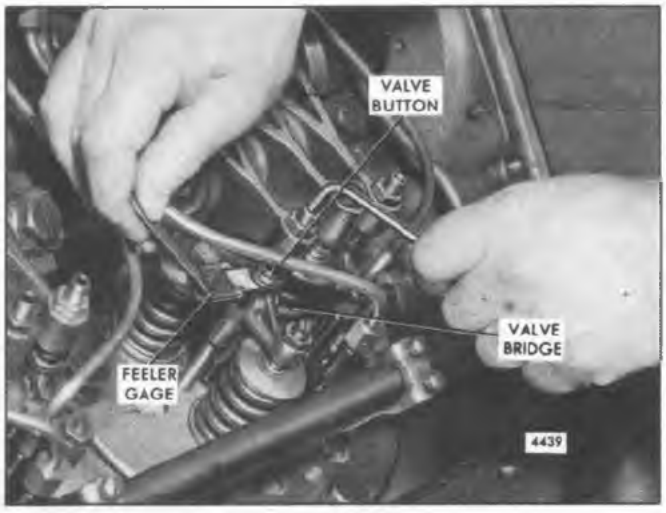


Fig. 1 – Adjusting Valve Clearance

The exhaust valve bridge balance should be checked when a general valve adjustment is performed. After the bridges are balanced, adjust the valve clearance. Do not disturb the exhaust valve bridge adjusting screw.

All of the exhaust valves may be adjusted in firing order sequence during one full revolution of the crankshaft. Refer to the *General Specifications* at the front of the manual for the engine firing order.

Valve Clearance Adjustment (Cold Engine)

1. Remove the loose dirt from the valve rocker covers and remove the covers. Discard the gaskets. Cover all drain cavities in the cylinder block to prevent foreign material from entering.
2. Place the governor speed control lever in the *idle* position. If a stop lever is provided, secure it in the *stop* position.
3. Rotate the crankshaft, by using either barring tool J 22582 or the starting motor, until the injector follower is fully depressed on the particular cylinder to be adjusted. If a wrench is used on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left–hand direction of rotation or the bolt may loosen.

   CAUTION: To reduce the risk of personal injury when barring over or "bumping" the starter while performing an engine tune–up, personnel should keep their hands and clothing away from the engine as there is a remote possibility the engine could start.

4. Loosen the exhaust valve adjusting screw locknut on the rocker arm.
5. Place a .016" feeler gage (J 9708–01) between the end of the valve button and the pallet of the valve bridge (Fig. 1). Adjust the valve adjusting screw to obtain a smooth pull on the feeler gage.
6. Remove the feeler gage and tighten the locknut to 30–35 lb–ft (41–47 N·m) torque.
7. Recheck the clearance and adjust, if necessary.
8. Adjust and check the remaining exhaust valves in the same manner as above.

Valve Clearance Adjustment (Hot Engine)

Maintaining normal engine operating temperature is particularly important when making the final exhaust valve clearance adjustment. If the engine is allowed to cool before setting any of the valves, the clearance when running at full load may become insufficient.

1. With the engine at normal operating temperature (see Section 13.2), recheck the exhaust valve clearance with feeler gage J 9708–01. At this time, if the valve clearance is correct, a .012" feeler gage will pass freely between the valve button and the valve bridge.
2. After the exhaust valve clearance has been adjusted, check the fuel injector timing (Section 14.2).















