

**GM Bedford  
Diesel**

# **220-330-500 Operators Manual**



### **SAFETY IS YOUR BUSINESS**

Safety, based on technical skill and years of experience, has been carefully built into your GM Bedford engine. Time, money and effort have been invested in making your diesel engine a safe product. The dividend you realize from this investment is your personal safety.

It should be remembered, however, that power-driven equipment is only as safe as the man who is at the controls. You are urged, as the operator of this diesel engine, to keep your fingers and clothing away from the revolving "V" belts, gears, blower, fan, drive shafts, etc.

An accident can be prevented with your help.

# Operators Manual

## GM Bedford Diesel Engines

220-330-500



**Detroit Diesel Allison**

Division of General Motors Corporation

Detroit, Michigan 48228

## **TO THE OPERATOR**

This manual contains instructions covering the care and operation of GM Bedford Diesel engines sold and serviced by Detroit Diesel Allison distributors and dealers. Sufficient descriptive material and illustrations are included to provide an understanding of the basic construction of the engines and the principles by which they function. Instructions pertaining to their major repair and overhaul are not included.

Familiarize yourself thoroughly with the contents of this manual before operating your GM Bedford engine. Refer to it also when making adjustments or performing maintenance. Whenever possible, rely on an *authorized Detroit Diesel Allison Service Outlet* for GM Bedford engine service. They stock Bedford service parts and have the specialized equipment and personnel with the technical background to provide the highest level of workmanship.

## **WARRANTY**

The GM Bedford new engine warranty is printed as part of the Detroit Diesel - Bedford Engine Delivery Notice (Form 17SE69). Copies of this form are available from *authorized Detroit Diesel Allison Service Outlets*.

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## DESCRIPTION

### PRINCIPLES OF OPERATION

The diesel engine, like the gasoline engine, produces power by the internal combustion process. The heat of fuel is converted into work in the cylinders 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 compression heat.

#### The Four Stroke Principle

GM Bedford engines are of four stroke design which means that intake, compression, power, and exhaust take place in two revolutions of the crankshaft. The four events are illustrated in Fig. 1.

*Intake Stroke:* The piston moves down the cylinder. As it does, it draws air into the cylinder through an open inlet valve. The valve closes when the piston reaches the bottom.

*Compression Stroke:* The piston returns up the bore compressing the air which is now trapped in the cylinder. Shortly before the piston reaches the top of its stroke, fuel is introduced into the combustion chamber via the injector.

*Power Stroke:* The intense heat generated by the highly compressed air ignites the finely atomized fuel. The rapid expansion of the burning gases within the cylinder forces the piston downward on its power stroke.

*Exhaust Stroke:* The piston again moves up the bore, driven by the energy being generated in the other cylinders. The exhaust valve is open and the upward moving piston expels the exhaust gases from the cylinder. When the piston reaches top dead center, the exhaust valve closes and the firing cycle is complete. The piston starts downward and another four stroke sequence begins.

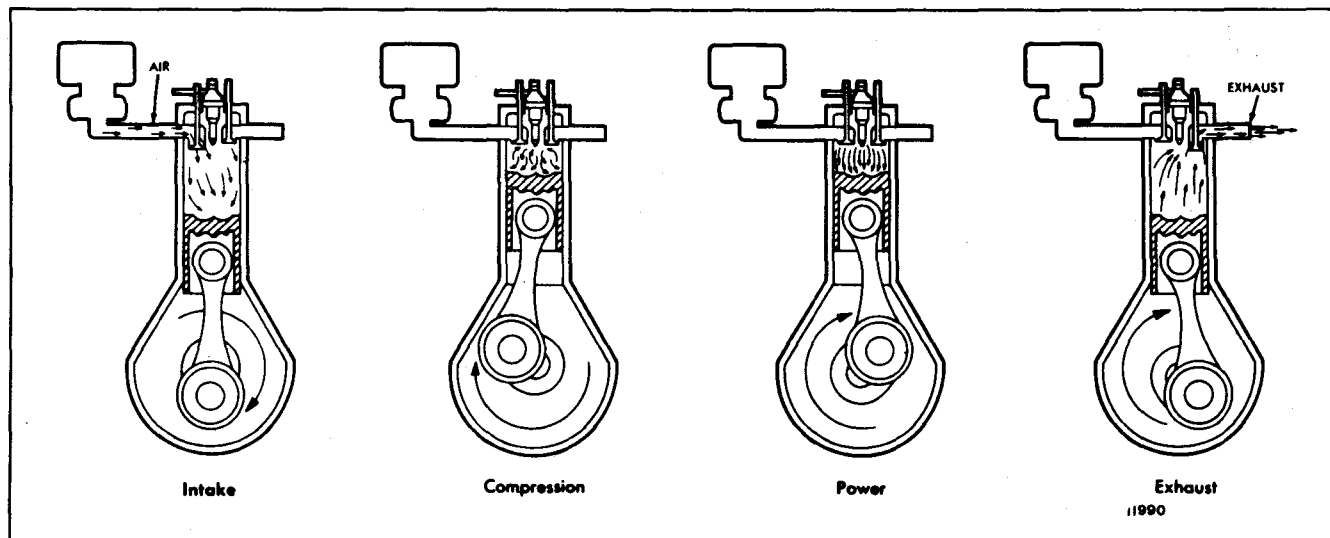


Fig. 1 - The Four Stroke Cycle

## GENERAL DESCRIPTION

Covered in this manual are the 220 cubic inch (3.6 litre) four cylinder engine and 330 and 500 cubic inch (5.4 and 8.2 litre) six cylinder engines. They are available as fan-to-flywheel or marine models. Injectors and cylinder components such as pistons, connecting rods, rings and bearings are interchangeable between the 220 and 330 engines.

All are of vertical, in-line overhead valve configuration and are liquid cooled. Operationally they employ compression ignition with direct fuel injection. Pistons have the combustion chamber formed in their crown and operate directly in the cylinder block. The camshaft and fuel injection pump are gear driven by the gear train mounted on the front of the engine. To accomplish correct valve opening and fuel injection timing, the camshaft and injection pump are rotated at one half engine (crankshaft) speed. The fuel injection pump is a distributor type which meters and pressurizes the fuel as well as times the delivery of fuel to the cylinders.

A gear type oil pump supplies lubrication to main, connecting rod, and camshaft bearings; also to gears, valve rockers and rocker shaft, and to other moving engine parts. Crankcase ventilation is accomplished in a closed system which leads from the side of the cylinder block and/or from beneath the valve rocker

cover to the engine air intake system. Fuel and full-flow lubricating oil filters contain replaceable elements.

Engine coolant is circulated in a closed 7 psi (48 kPa) pressure system by a centrifugal water pump, which is belt driven by the crankshaft. The coolant flows the entire length of the block, enters the cylinder head through two rear-located transfer ports and flows back up the head to the thermostat housing.

End to end coolant flow makes maximum sealing capability possible between the block and head. Depending upon the application, either a radiator and fan or heat exchanger and raw water pump are most generally used for removing heat from the coolant.

An air cleaner is used to filter the incoming air on most land-operated engines. An air silencer is used on the majority of marine engines.

Engine starting is provided by an electrical starting system. The starter motor is energized by a storage battery which is kept charged by a battery charging alternator with a suitable voltage regulator.

Engine speed is regulated by a mechanically or hydraulically operated governor depending upon the engine.

## GENERAL SPECIFICATIONS

	220	330	500
Number of Cylinders .....	4	6	6
Bore (in.) .....	4.0625	4.0625	4.562
Bore (mm) .....	103	103	116
Stroke (in.) .....	4.25	4.25	5.10
Stroke (mm) .....	108	108	129
Compression Ratio .....	17 to 1	17 to 1	17 to 1
Piston Displacement-cubic inches .....	220	330	500
Piston Displacement-litres .....	3.6	5.4	8.2
Firing Order .....	1-3-4-2	1-5-3-6-2-4	1-5-3-6-2-4
Drive Shaft Rotation .....	Right-Hand	Right-Hand	Right-Hand

**NOTE:** The instructions, specifications and illustrations contained in this manual are based on product information that was current at the time of approval for printing. If there is a question regarding the latest information, consult an *authorized Detroit Diesel Allison Service Outlet*. The right is reserved to make changes at any time without obligation.

**GENERAL DATA**

Fuel Injection Pump .....	C.A.V. distributor type (DPA). Driven at half engine speed from the timing gears at the front end of the engine. Fuel pump rotates in a clockwise direction when viewed from the front of engine.
Governor	
220 .....	Mechanically governed pump
330 .....	Hydraulically governed pump (Mechanical optional)
500 .....	Mechanically governed pump
Fuel Pump	
220 .....	Manually operated
330 .....	Camshaft operated
500 .....	Camshaft operated
Fuel Oil Filter .....	AC Delco
Engine Oil Filter .....	AC Delco full flow

**OIL PAN CAPACITIES**

DESCRIPTION	U.S. QUARTS	IMP PINTS	LITRES
220			
Standard .....	8.4	14.0	8.0
Deep Sump .....	10.2	17.0	9.7
330			
Standard .....	10.2	17.0	9.7
Deep Sump .....	11.4	19.0	10.8
500			
Standard .....	14.4	24.0	13.6
Deep Sump .....	16.8	28.0	15.9

## ENGINE OPTION PLATE AND SERIAL AND MODEL NUMBER DESIGNATION

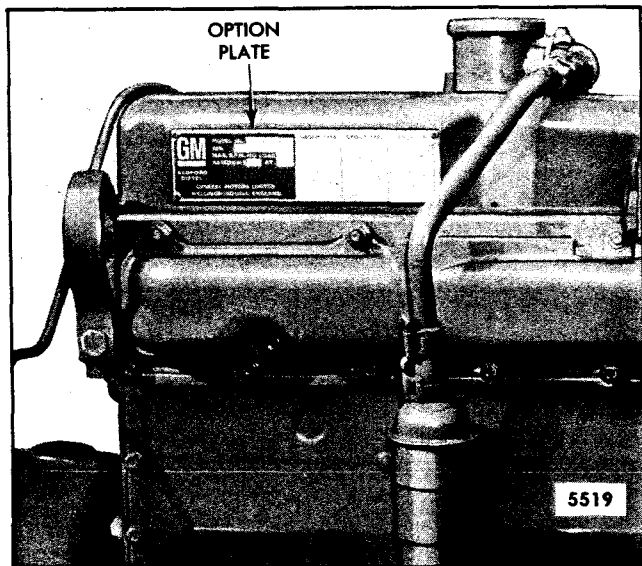


Fig. 2 - Option Plate

### Option Plate

The engine option plate is attached to the valve rocker cover as shown in Fig. 2

The option plate lists the engine model number and serial number. It also identifies the optional equipment used on the engine. The typical markings found on an option plate are illustrated in Fig. 3.

### Engine Serial Number

The serial number is actually two series of numbers separated by a slash (/) mark. The first series of numbers are issued by Vauxhall to identify the cylinder block and parts within the block, which they supply in the buildup of the engine. The second series of numbers are provided by the Power Industrial Division of General Motors Ltd., to cover the parts they furnish in completing the engine.

### Engine Model Number

An eight digit model numbering system is now used for the current GM Bedford engines and is shown in Fig. 4.

Former GM Bedford engines are identified as Models 220, 330 and 466. The model number is actually the total cubic inch displacement of the engine. Appearing after the model number on the option plate is the letter designation F/F for fan-to-flywheel, or M for marine.

### Parts Orders

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 for the equipment required, this number should also be included on the parts order. All groups of parts used on the engine are standard unless listed on the option plate.

<div style="display: flex; align-items: center;"> <div style="text-align: center; margin-right: 10px;">   <b>BEDFORD</b>  <b>DIESEL</b> </div> <div> <p>MODEL No <span style="border: 1px solid black; padding: 2px 20px;">C063-A100</span></p> <p>SERIAL No <span style="border: 1px solid black; padding: 2px 20px;"></span></p> <p>MAX. R.P.M. NO LOAD <span style="border: 1px solid black; padding: 2px 20px;"></span></p> <p>RATED B.H.P. <span style="border: 1px solid black; padding: 2px 20px;"></span></p> <p style="text-align: center;"><b>GENERAL MOTORS LIMITED, WELLINGBOROUGH, ENGLAND.</b></p> </div> </div>	<table style="width: 100%; border-collapse: collapse;"> <tr> <th style="text-align: left; border-bottom: 1px solid black;">GROUP</th> <th style="text-align: left; border-bottom: 1px solid black;">TYPE</th> <th style="text-align: left; border-bottom: 1px solid black;">GROUP</th> <th style="text-align: left; border-bottom: 1px solid black;">TYPE</th> </tr> <tr> <td style="border-right: 1px solid black; padding: 5px;">2.1000</td> <td style="border-right: 1px solid black; padding: 5px;">13</td> <td style="border-right: 1px solid black; height: 100px;"></td> <td style="height: 100px;"></td> </tr> </table>	GROUP	TYPE	GROUP	TYPE	2.1000	13		
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Fig. 3 - Option Plate Markings

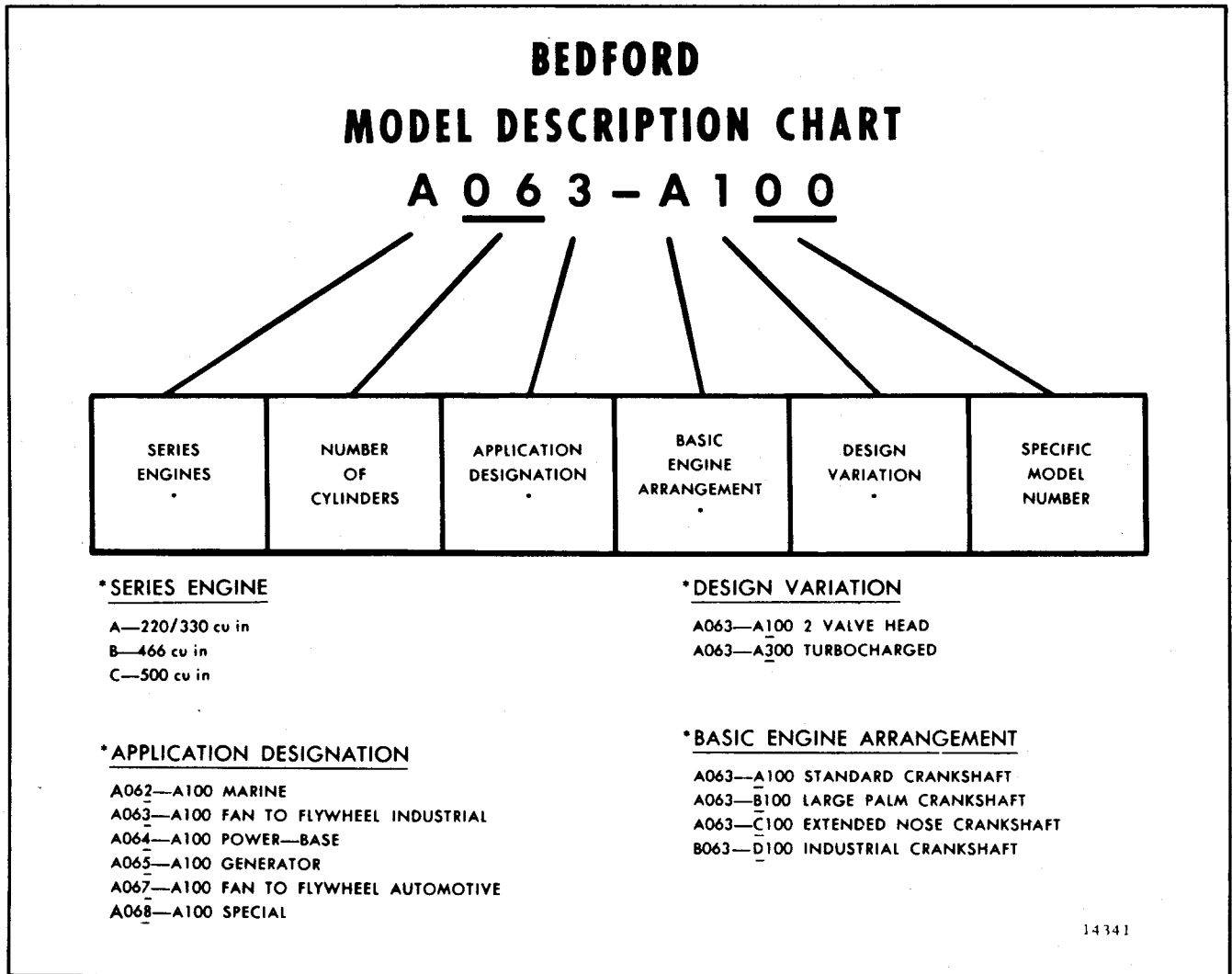


Fig. 4 - Current Model Numbering System

## ENGINE SYSTEMS

GM Bedford Diesel engines incorporate four basic systems which direct the flows of fuel oil, air, lubricating oil and coolant necessary for operation. The function and the major components of each of

these systems are described in this section. Instructions covering routine maintenance of each are also given.

### FUEL SYSTEM

The fuel system, Figs. 1 and 2, consists of a fuel pump, fuel injection pump and governor, filter(s), injectors, and injector supply and bleed return fuel lines.

Fuel is drawn from the supply tank (through the pre-filter, if used) and into the fuel pump. It is then passed through the main filter and into the fuel injection pump where it is metered, compressed, and delivered at timed intervals through specially-fitted high pressure fuel lines to the injectors.

Fuel oil fills the pump body at all times. During

operation a steady overflow of fuel from the pump is returned through an external line to the main filter where it is recirculated in the system. In the 220 engine a portion of the overflow fuel is vented through a second line which leads from the governor control housing on the injection pump to a line returning injector bleed fuel to the main fuel supply tank.

A restricted orifice, located in the fuel filter top cover on 330 and 500 engines (secondary vent line on 220 engines), maintains correct pump pressure.

The incoming and outgoing flow of fuel at the fuel

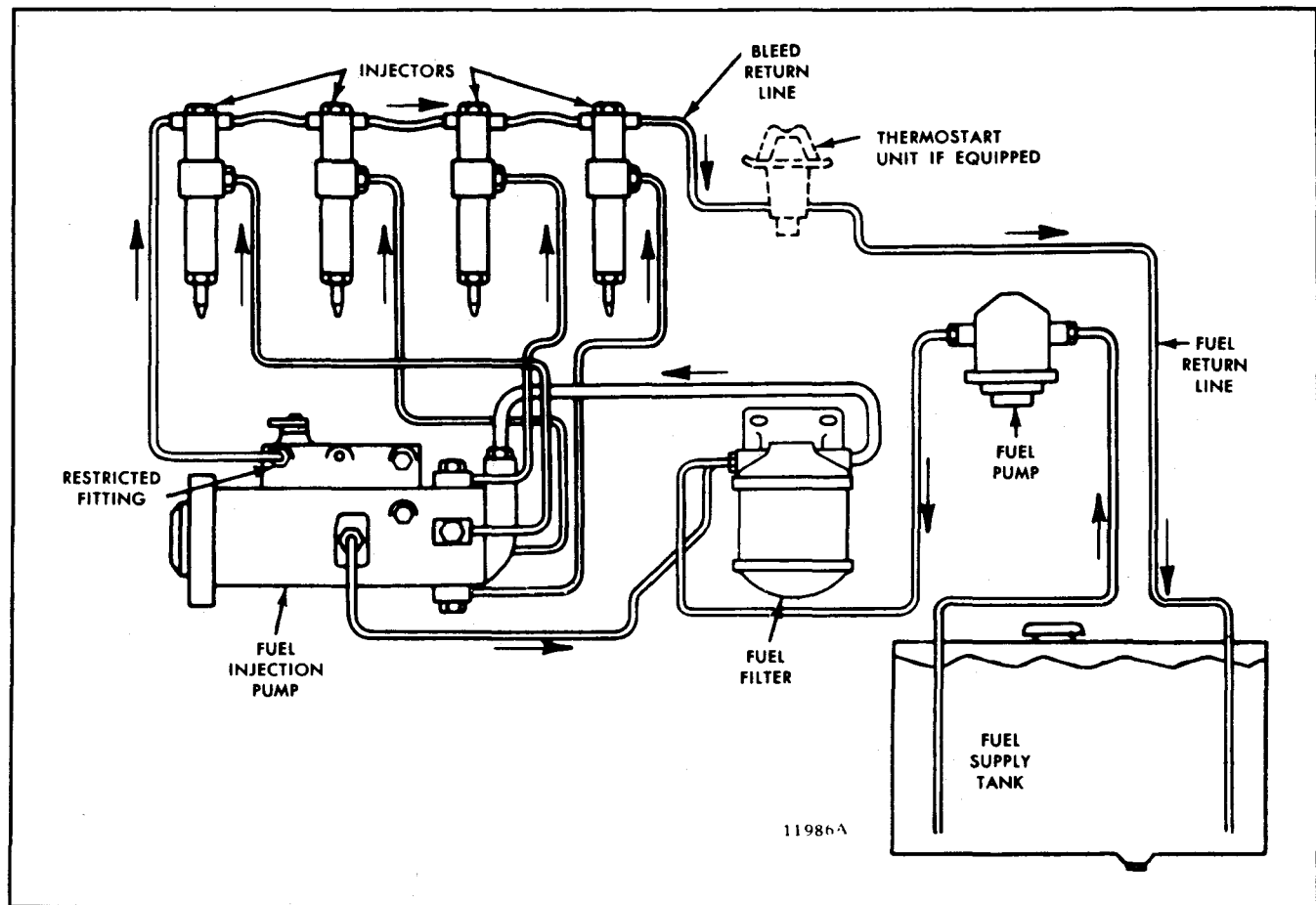


Fig. 1 - Diagram of Typical 220 Engine Fuel System

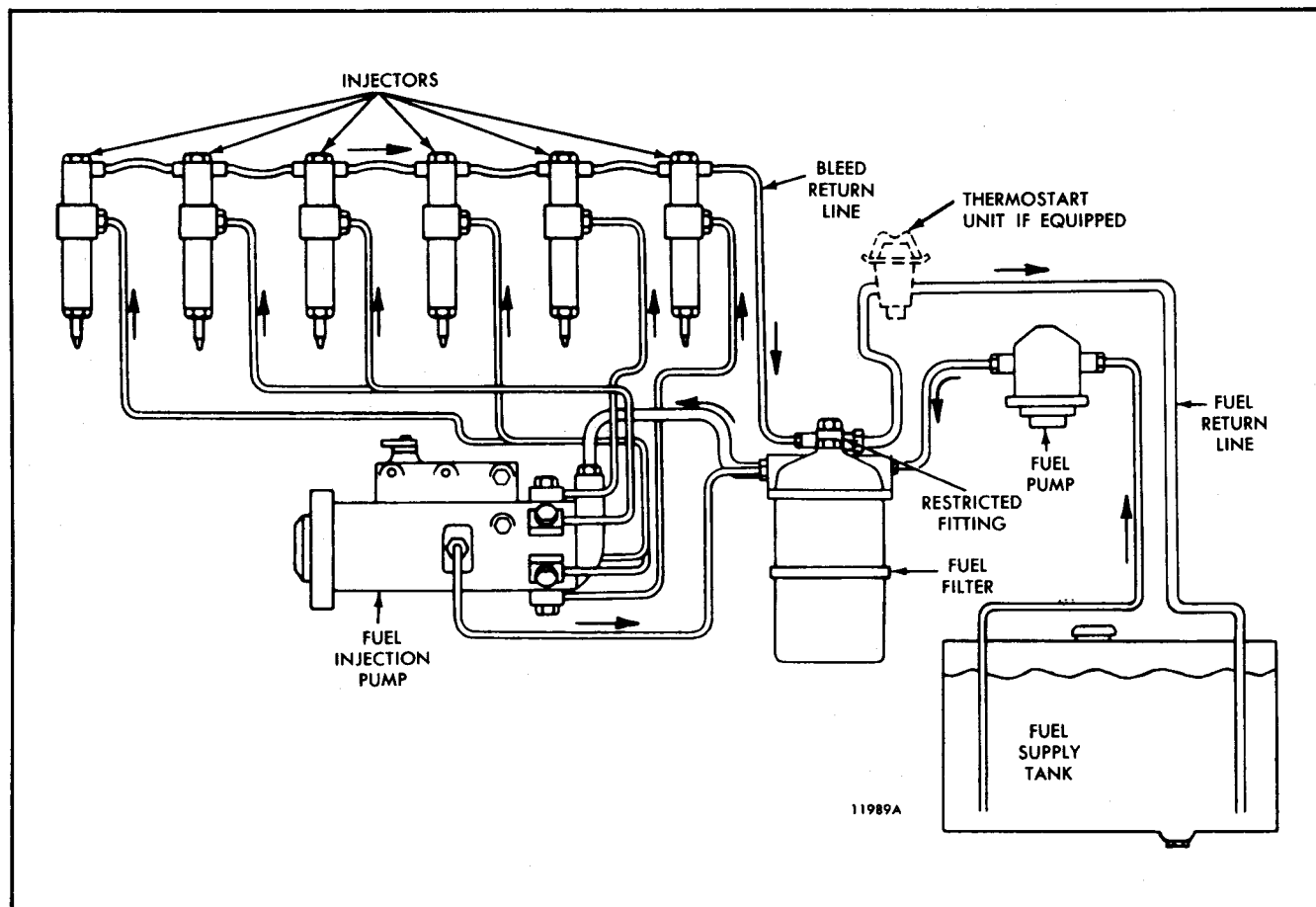


Fig. 2 - Diagram of Typical 500 Engine Fuel System

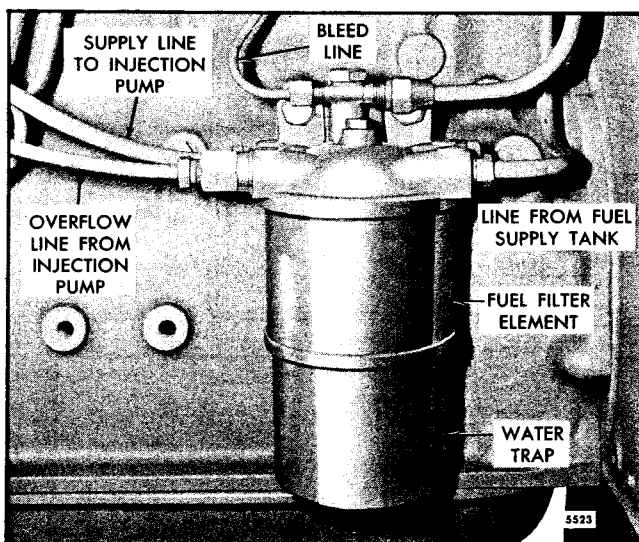


Fig. 3 - Combination Fuel Filter and Water Separator Mounting

filter top cover is shown in Fig. 3. The illustration is representative of a typical fuel filter and water separator mounting.

### Fuel Injector

Fuel is delivered to the injector as a high pressure charge and is atomized through four tiny holes in the nozzle tip into the combustion chamber. The condition of injectors should be inspected periodically. Neglect of injectors may lead to nozzle blockage which in turn can cause the pumping and distributing rotor within the injection pump to seize. Extensive idling is more harmful to injector performance than is continuous load operation.

Frequency of injector inspection will depend on the cleanliness and quality of the fuel and engine operating conditions. An injector check at least once every 500 hours is a suggested interval for standard operation. More frequent inspections may be necessary under severe conditions.

Because special tools and test equipment are required

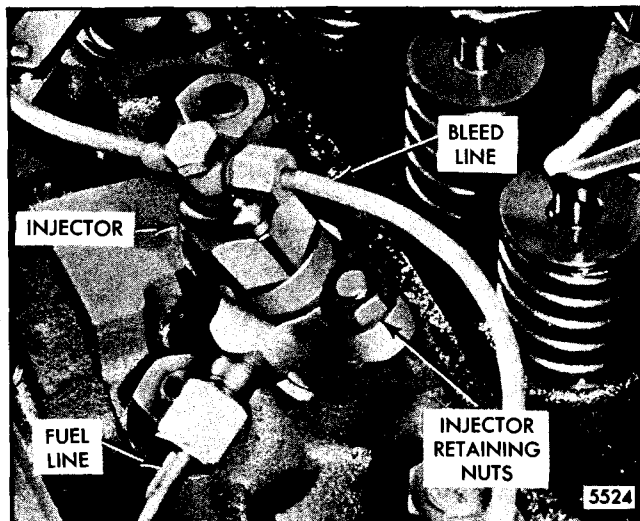


Fig. 4 - Injector in Cylinder Head

to service an injector, it is recommended that injectors be replaced as a unit. Remove the injector, Fig. 4, as follows:

1. Disconnect the injector supply and return fuel lines.

**NOTE:** Clean around the connections to prevent dirt from entering the openings in the injector when the lines are removed.

2. Remove the two nuts holding the injector.
3. Free the injector from its seat with a suitable prying instrument placed beneath the injector body. Remove the injector from the cylinder head.

#### Install the Injector

Install the injector as follows:

1. Install a new injector seat copper washer.
2. Hold the injector squarely in its sleeve in the cylinder head and tighten the two securing nuts finger tight. Then tighten each to 7-10 lb-ft (10-14 Nm) torque (dry threads).
3. Before connecting the fuel lines, rotate the engine with the starter and check for compression blow past the injector seat washer. If there is leakage, the injector is improperly seated. Remove the injector and check for cleanliness at the seating area and the condition of the sealing washer, before reinstalling the injector.
4. Install the supply and return fuel lines on the

injector finger tight, then tighten the fuel line connections with a 1/3 turn of the wrench.

#### Fuel Injection Pump

The current injection pump is a C.A.V. distributor type pump which is given the designation DPA. It is relatively simple in design and involves no ball or roller bearings, gears or high tension springs.

The pump is located on the left side of the cylinder block as shown in Fig. 5. The drive shaft of the pump is coupled to the timing gear shaft which is driven by the engine gear train. The pump is flange mounted to a carrier which is similarly attached to the timing gear shaft housing. When an air compressor or vacuum pump is installed, this equipment replaces the timing gear shaft housing. The pump drive shaft is then coupled to the compressor or vacuum pump drive shaft.

Pump timing is set at the factory and no additional adjustments should be required.

The injection pump is oil tight. During operation a controlled amount of fuel oil under pressure passes between moving components within the pump for lubricating purposes. No additional lubrication is required. Pressure maintained within the pump prevents the entry of dust, water and air.

#### Main Fuel Filter

The fuel filter is located between the fuel pump and the injection pump. The replaceable filter element removes impurities from the fuel.

The filter assembly, Fig. 6, consists of a top cover which is attached to the engine, a canister containing the paper filter element, and a bottom cover or base.

Replace the element every 500 hours under normal operating conditions as follows:

1. With the engine shut down, clean all dirt from the exterior of the filter.
2. Unscrew the center bolt in the top cover and remove the bottom cover and filter element. Discard the old element, gaskets and seal ring.
3. Clean the top and bottom cover with fuel oil and dry thoroughly.

**NOTE:** Do not use a cloth to clean.

4. Locate the new gaskets and seal ring properly. Be

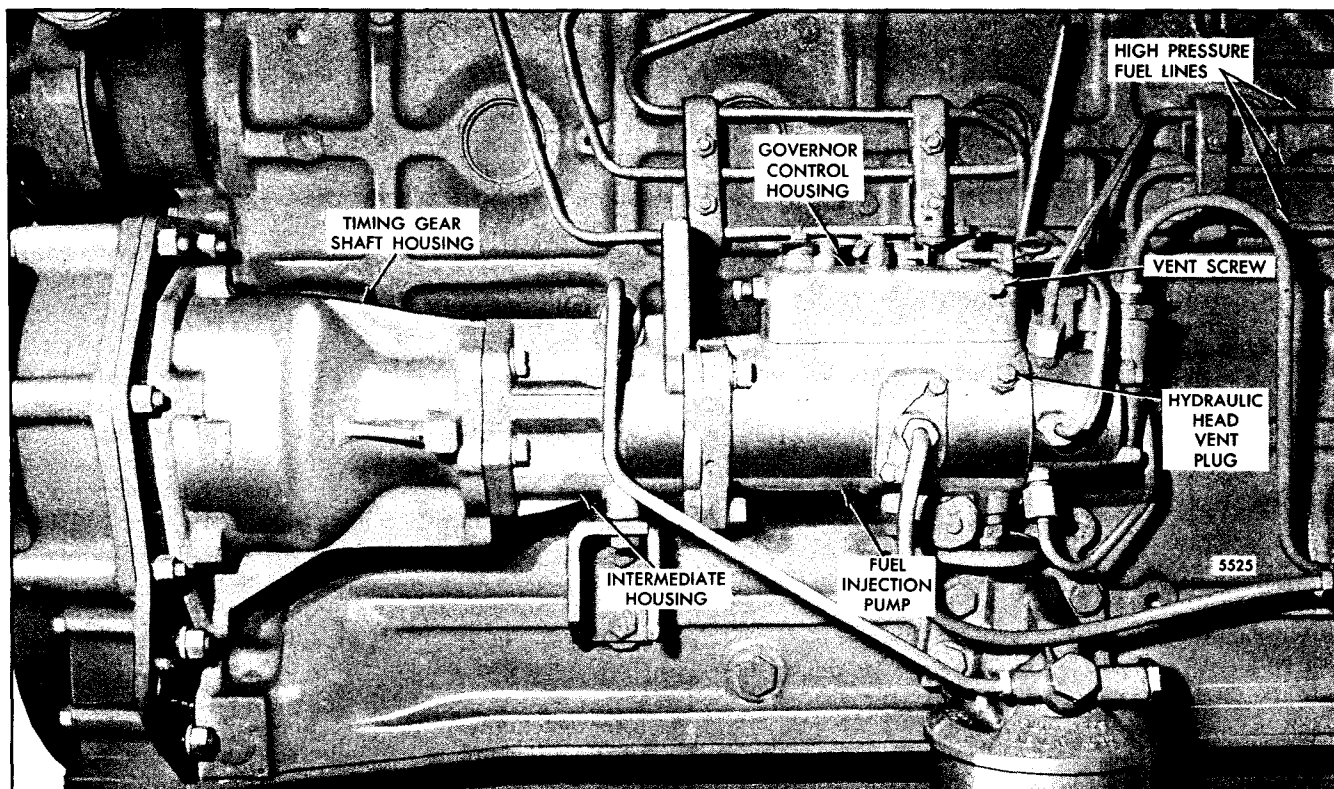


Fig. 5 - Fuel Injection Pump Mounting

sure they lay flat. Assemble the new element and bottom cover and bolt them securely to the top cover.

5. Air vent the system. Check for leaks after the engine starts.

The combination water separator and fuel filter assembly (Fig. 3) is comprised of a top cover, a canister and filter element, and a bottom cover consisting of a sediment bowl with a drain plug. This type of filter will require draining of the sediment bowl daily to remove any water and solids.

Customized fuel filtering systems such as heavy duty fuel filtration may differ in service requirements. Consult the supplier of the system for proper servicing instructions.

On some installations it is advisable to install a pre-filter in the system between the supply tank and fuel pump to filter the fuel as it leaves the supply tank.

### Fuel Pump

The fuel pump, shown in Fig. 7, incorporates a spring-loaded diaphragm which can be operated by a priming lever mounted on the exterior of the pump.

On 330 and 500 engines the fuel pump is camshaft driven during engine operation. The fuel pump on the 220 engine is always manual operated and functions only as a priming pump.

### Air Venting the Fuel System

Whenever fuel lines are removed or the filter element is replaced, or if the fuel tank has been run dry, it will be necessary to vent the system of air before attempting to start the engine.

1. Loosen any unused outlet plug (or the vent screw if provided) in the fuel filter cover. If no outlet is available, loosen the fuel "out" connection at the filter cover. Make sure the fuel pump rocker arm is in full contact with the pump cam. Operate the priming lever on the fuel pump until solid (air free) fuel emerges from the loosened plug or connection. Retighten the connection while continuing to operate the priming lever.

2. Loosen the threaded plug in the top of the fuel "in" connection at the injection pump. Operate the priming lever on the fuel pump until solid fuel emerges from the loosened plug. Retighten while continuing to operate the priming lever.

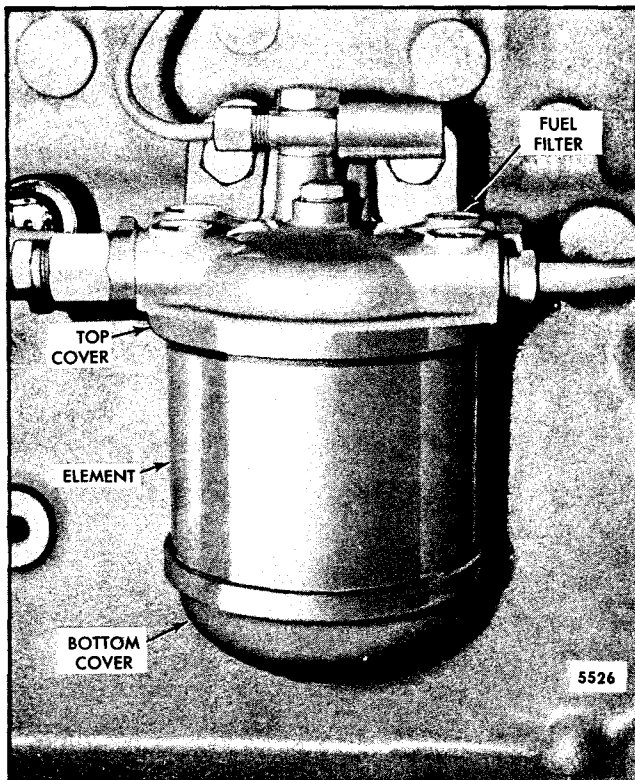


Fig 6 - Fuel Filter Mounting

3. Loosen the vent plug in the injection pump hydraulic head locking screw and the vent screw on

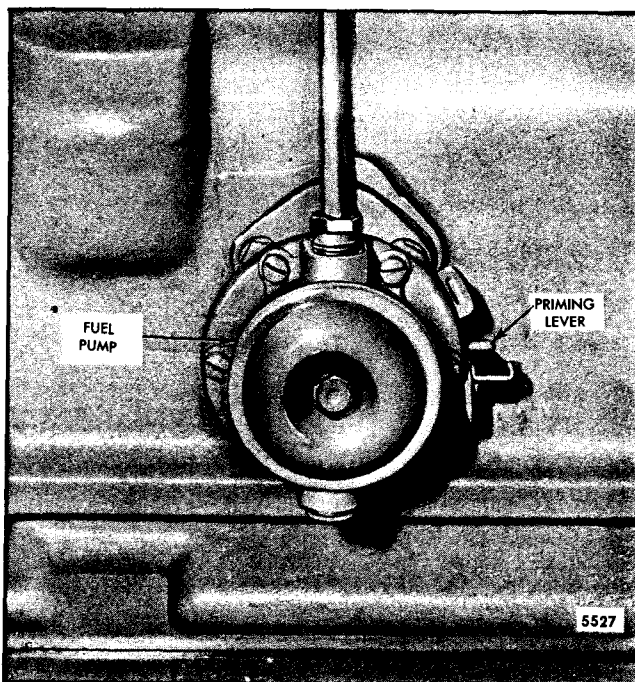


Fig. 7 - Fuel Pump Mounting (500 Engine)

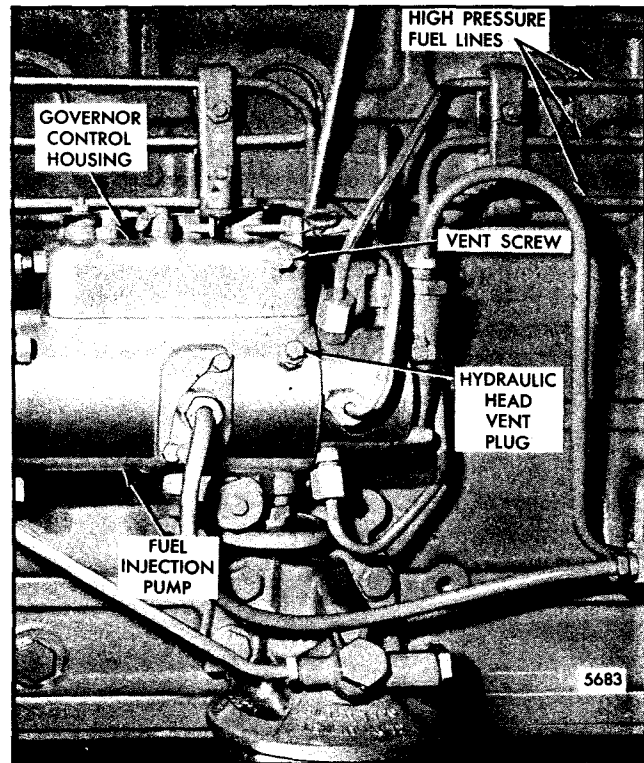


Fig. 8 - Injection Pump Vent Openings

the governor control housing, Fig. 8. (A banjo connection must be loosened to vent the governor control housing on 220 engine pumps). Operate the priming lever until solid fuel emerges from the loosened hydraulic head vent plug. Retighten the hydraulic head vent plug locking screw while continuing to operate the priming lever. Operate another 12 strokes after tightening.

4. Loosen any two injector supply fuel line connections. Set the throttle to the "fully open" position and the stop control in the "run" position. Crank the engine until solid fuel emerges from the loosened connections. Retighten the connections while continuing to prime.

5. Start the engine and run it at idle speed. When solid fuel oil emerges from the governor control housing vent screw (banjo connection on 220 engines), retighten the screw.

6. Check all vents and connections for leaks and retighten as necessary.

### GOVERNOR

The injection pump incorporates a governor which maintains accurate control of engine speed under all

load conditions by regulating the volume of fuel entering the pump's pumping and distributing rotor at every charge stroke.

A mechanically governed injection pump is used on 220 and 500 engines. The mechanical governor utilizes a set of speed-sensitive flyweights on the drive shaft of the pump. Inward or outward movement of the rotating flyweights, caused by changes in pump shaft speed, is transmitted through governor linkage to the fuel control lever to increase or decrease fuel input as load conditions require. The governor mechanism is

contained in the rectangularly-shaped control housing mounted on top of the pump body.

A hydraulically governed pump is used on 330 engines. An optional mechanical governor is also available. The hydraulic governor has no flyweights and requires less linkage. A sliding piston which is sensitive to hydraulic pressures regulates the admission of fuel in the pump rotor. Consequently, the hydraulically governed pump is smaller than the mechanically governed pump and has a smaller control housing.

## AIR SYSTEM

### AIR CLEANER

The air cleaner is mounted on the air intake manifold of the engine to protect interior working parts against abrasive dust and other airborne contaminants. Service instructions for air cleaners are provided in this section. If a different type of air cleaner other than what is covered here is in use, consult the supplier of the cleaner for service recommendations.

220 and 330:

Two types of air cleaners are offered: a light duty oil bath for normal operating conditions and a heavy duty, combination centrifugal and oil bath for heavier dust conditions. Complete service of both types is recommended after every 100 hours of operation.

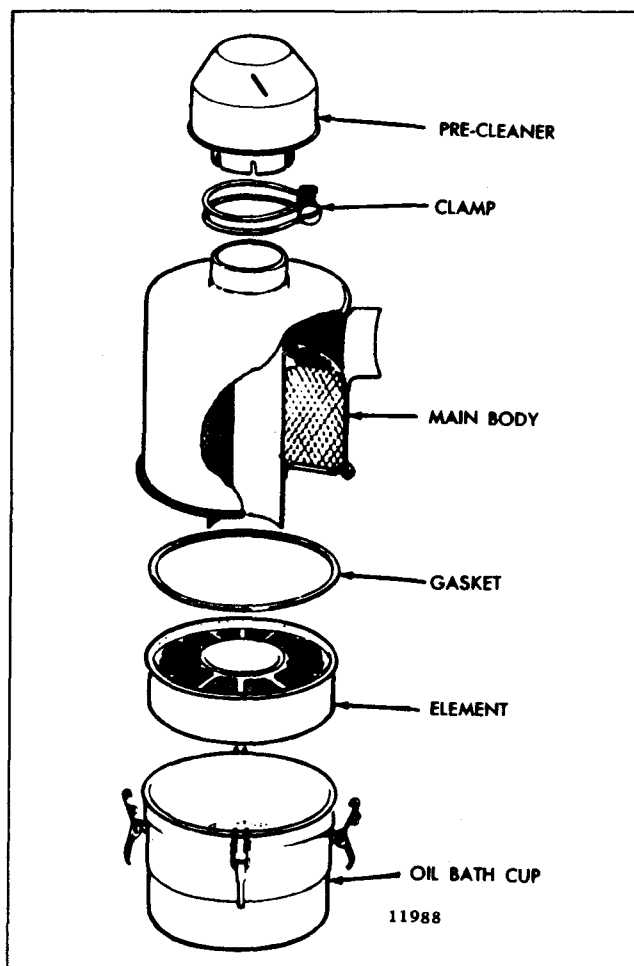


Fig. 9 - Combination Centrifugal Oil Bath Air Cleaner

Service the light duty air cleaner as follows:

1. Remove the crankcase breather pipe (and support bracket if used) from the air cleaner.
2. Loosen the clamp which attaches the air cleaner assembly to the air intake manifold. Remove the cleaner assembly.
3. Unscrew the wing nut from the top of the cleaner and remove the cover and gasket. Lift out the filter element.
4. Soak the element in fuel oil to loosen the dirt; then flush the element with clean fuel oil and allow it to dry thoroughly.
5. Pour the used oil from the oil bath cup. Wipe all traces of sediment from the cup. Push a lint-free cloth through the oil cup center tube to clean it.
6. Check the gasket and sealing surfaces to insure an air tight seal.
7. Fill the oil cup to the level indicated with the same oil as used in the engine crankcase. Assemble the filter element, gasket and cover and install the cleaner back on the engine.

**NOTE:** It is not necessary to pre-oil the filter element. This is done automatically when the engine is running.

**IMPORTANT:** Do not tighten the clamp which attaches the air cleaner to the inlet manifold until the crankcase breather pipe is properly located.

Service the heavy duty air cleaner (Fig. 9) as follows:

1. Loosen the clamp holding the pre-cleaner onto the main body of the air cleaner and remove the pre-cleaner.
2. Flush the pre-cleaner in fuel oil to remove dirt. Pay particular attention to the two slots on the outside of the pre-cleaner casing and the vanes on the inside of the casing. Remove excess fuel by blowing compressed air through the casing and allow it to dry thoroughly.
3. Release the toggle clips and remove the lower portion of the air cleaner assembly.
4. Lift out the removable filter element. Soak the

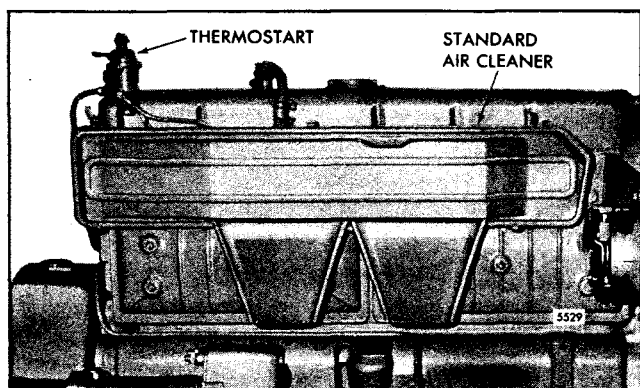


Fig.10 - Combination Air Cleaner and Air Inlet Manifold

element in fuel oil to loosen the dirt; then flush the element with clean fuel oil and allow it to dry thoroughly.

5. Pour the used oil from the oil bath cup. Remove the sediment and wipe the cup clean.

6. Push a lint-free cloth through the center tube of the air cleaner main body to clean it.

**NOTE:** The fixed filter element in the air cleaner main body will not require cleaning as frequently as the pre-cleaner, removable filter element and oil-bath cup. Periodically, however, the complete air cleaner assembly must be removed from the engine and disassembled as described above and the fixed filter element cleaned in the same manner as the removable element.

7. Refill the oil-bath cup to the level indicated with the same oil as used in the engine crankcase. Do not overfill. Install the oil cup, element and gasket on the main body making sure the gasket is in good condition and properly positioned.

**NOTE:** It is not necessary to pre-oil the filter element. This is done automatically when the engine is running.

500:

The standard air cleaner offered is a combination air cleaner and two-port inlet manifold as shown in Fig. 10. Two replaceable filter elements are retained in the manifold to filter the incoming air.

It will be necessary to remove the inlet manifold casing to service the replaceable paper elements. Clean the assembly including filter elements every 100 hours. Inspect the condition of the seal at the same time and replace it if damaged or worn. Replace the filter elements every 200 hours.

A heavy duty air cleaner is available as well. The dry-type Donaldson "Cyclopac" air cleaner consists of a main body containing ducting and sealing surfaces, a filter element, baffle and dust cup. The fins on the element give high speed rotation to the intake air, which separates a large portion of the dust from the air by centrifugal action. The plastic fins, the element and the gasket make up a single replaceable element assembly.

The dust is swept through a space in the side of the baffle and collects in the lower portion of the body. The dust remaining in the pre-cleaned air is removed by the element.

The dry-type air cleaner cannot be used where the atmosphere contains oil vapors. The dust bowl should be emptied daily or more often if required. The dust level should never be allowed to build up to within 1/2 inch (13 mm) of the slot in the dust cup baffle.

Consult the supplier of the Donaldson air cleaner for complete service instructions and the frequency of service.

## LUBRICATION SYSTEM

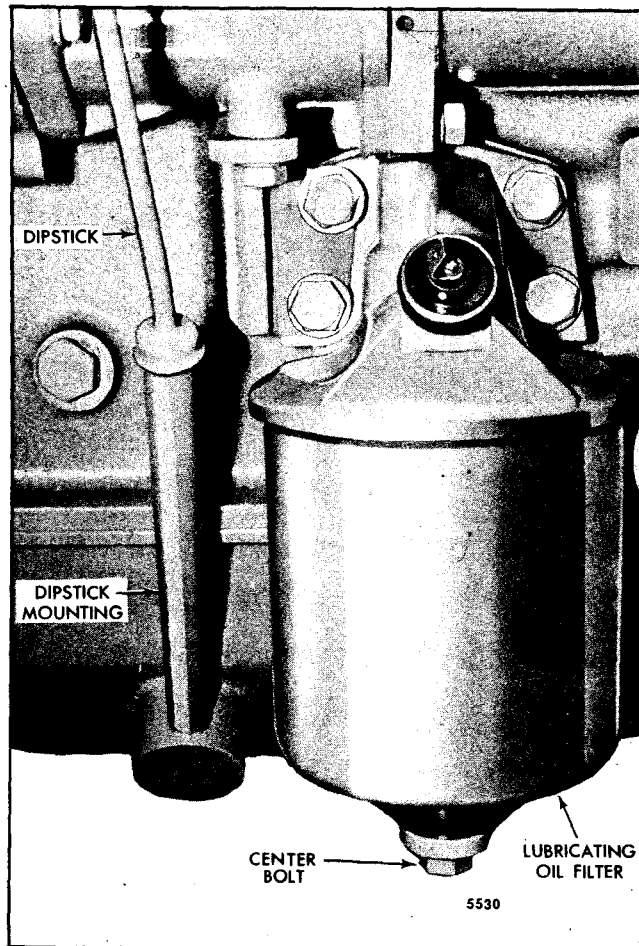


Fig. 11 Lubricating Oil Filter Mounting and Dipstick Location

The main components comprising the lubrication system are the oil pump and the full-flow oil filter. Marine engines incorporate an oil cooler which is normally attached to the heat exchanger.

Oil is drawn from the oil pan through the pump screen and is pumped through the oil filter into the main oil gallery in the cylinder block. The oil is then directed into drilled passages for distribution to bearings, gears, and other moving parts requiring lubrication and to the cylinder walls for lubrication of the pistons.

## Oil Filter

All the oil supplied the engine passes through the full-flow filter (Fig. 11). A spring loaded ball valve is located in the filter head to allow oil to by-pass the filter should it become plugged.

The filter element and gasket should be changed every 200 hours under normal operating conditions as follows:

1. Place a suitable container beneath the filter to catch spills. Disconnect electrical attachments if used.
2. Unscrew the center bolt at the bottom of the filter and remove the shell and element from the filter head.
3. Pour out the used oil and discard the element and gasket.
4. Wash the inside of the filter head and shell with the fuel oil to remove all traces of sludge.
5. Place a new gasket in the filter head. Assemble the element and shell and position the assembly on the gasket. When the shell assembly is located correctly, tighten the center bolt being careful not to damage the gasket.
6. After the engine is started, check for oil leaks.

## COOLING SYSTEM

The majority of GM Bedford Diesel engines use either a radiator and fan or heat exchanger and raw water pump cooling system. Each system uses a centrifugal type pump to circulate the coolant. The pump, mounted on the front of the block, is belt driven by the crankshaft.

Both systems incorporate a thermostat to maintain

normal engine operating temperature. While the engine is cold, the thermostat valve remains closed. The coolant, unable to flow into the radiator (or heat exchanger) upon reaching the thermostat housing, is returned through a by-pass line to the engine block. When the coolant circulating in the block and head reaches correct operating temperature, the thermostat valve begins to open and coolant circulation through the radiator (or heat exchanger) takes place.

## COOLING SYSTEM MAINTENANCE

Cooling system maintenance is two-fold in purpose. It should protect the system itself against deterioration and it should provide the proper coolant in the system.

### Maintaining the Coolant Level

Maintain the coolant level at approximately 1 inch (25 mm) below the radiator or heat exchanger filler neck. Check the level daily or before starting the engine.

### Draining the Cooling System

Drain the engine block by opening the drain cock located on the rear left-hand side of the block. To drain the radiator, open the drain cock located at the bottom tank of the radiator. Remove the radiator cap before draining the radiator or block.

*Marine Engines:* To drain the fresh water from the cooling system, remove the heat exchanger filler cap and open the drain cock located on the rear left-hand side of the engine block.

To drain the raw water from the system, open the hexagon drain plug in the end cover of the oil cooler. The oil cooler is cylindrical in shape and when viewed from the front of the engine is mounted on the right side of the heat exchanger.

The raw water pump has no drain tap and can only be drained by removing the end cover. The raw water pump is located at the front end of the engine and is belt driven by the crankshaft. To remove the pump cover, unscrew the six retaining screws.

### Replacing Drive Belts

To replace worn or deteriorating belts, proceed as follows:

*220 and 330 Engines:* Loosen the alternator attaching

bolts including the bolt that secures the alternator to the adjustable slotted brace, shown in Fig. 12. Slide the alternator toward the engine as far as the slotted brace will allow. This will place maximum slack in the belts. Slip the belts over the alternator pulley, then remove them from the crankshaft and fan/water pump pulleys.

*500 Engine:* An adjustable idler pulley maintains accessory drive belt tension. To remove the belts, loosen the locking bolt in the center of the idler pulley. This is necessary to allow the adjusting bolt to be turned without damaging its threads. Turn the adjusting bolt in a counter-clockwise direction as far as it will go. This moves the idler pulley in, toward the engine, placing maximum slack in the drive belts. Slip

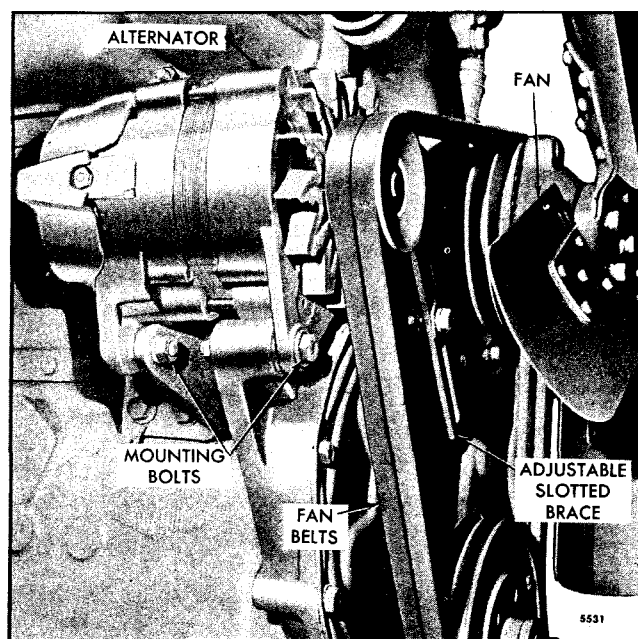


Fig. 12 - Typical Fan Belt Mounting (220 and 330 Engines)

the belts over the alternator pulley, then remove them from the crankshaft and fan/water pump pulleys.

**Marine Engines:** An additional pulley for driving the raw water pump is provided on heat exchanger cooled engines.

**All Engines:** If only one belt is in need of replacement, both belts must be changed. Belts are only serviced in pairs.

**NOTE:** If the engine is cranked to assist in starting the belts off the alternator pulley, proceed slowly and use extreme caution to avoid personal injury.

**CAUTION:** Do not attempt to turn the fan by hand to remove belts.

To install new belts, reverse the removal procedure. After installation, check belt tension as outlined in the *Preventive Maintenance* section, *Item 15*.

**NOTE:** Do not overtighten the drive belts. Overtightening of belts will overload water pump and alternator shafts and bearings and may lead to their early failure.

### Flushing the Cooling System

Flush the cooling system each spring and fall. The flushing operation cleans the system of antifreeze solution in the spring and removes the summer rust inhibitor in the fall, preparing the cooling system for a new solution. The flushing operation should be performed as follows:

1. Drain the previous season's solution from the engine.
2. Refill the cooling system with soft, clean water and a flushing agent. Add coolant slowly to insure a proper fill.
3. Start the engine and operate it for 15 minutes to thoroughly circulate the water.
4. Drain the cooling system completely. Repeat the flushing procedure until the coolant drains clean.
5. Refill the system with the solution required for the coming season.

**NOTE:** Whenever water is added to a hot engine, it must be done slowly to avoid rapid cooling which may cause distortion and possible cracking of engine castings.

### Cooling System Overheating

Overheating is usually indicated by boiling and loss of coolant. The most common causes of overheating are:

1. Coolant level is too low.
2. Coolant is being lost from drain cocks or faulty hoses.
3. Fan belts are too slack to operate pump and fan.
4. Coolant is dirty.
5. Radiator is clogged.

### Miscellaneous Cooling System Checks

Check for coolant leaks from the radiator, heat exchanger, water pump, and hoses. Tighten hose connections that are leaking but do not overtighten. Check for hose deterioration and replace if necessary.

### Cooling System Cleaners

A commercial descaler is sometimes required to remove scale and other unwanted deposits from the radiator and coolant passages of the engine. If the engine overheats and the coolant level, fan belt tension and condition of hoses are satisfactory, clean the cooling system with a quality descaling solvent. Neutralize the system immediately after using the solvent. Follow the instructions printed on the container of the descaling solvent.

After the solvent and neutralizer have been used, drain the engine and radiator and flush it with clean water. Then, fill the system with the proper cooling solution.

### Reverse-Flushing

Reverse-flushing involves directing hot water under pressure through the cooling system in an opposite direction of normal coolant flow to loosen and force out scale deposits.

The radiator is reverse-flushed as follows:

1. Drain the radiator. Remove the inlet and outlet hoses. Install the radiator cap.
2. Attach a hose to the top opening of the radiator to conduct water away from the engine.
3. Attach a hose to the bottom opening of the radiator and insert a flushing gun in the hose.

COOLING SYSTEM CAPACITIES (gallons)				
Engine	Models			
	Fan-to-Flywheel		Marine Including Heat Exchanger	
	<u>U.S.</u>	<u>Imperial</u>	<u>U.S.</u>	<u>Imperial</u>
220	2.1	1.7	2.9	2.4
330	2.7	2.2	3.4	2.9
500	2.6	2.1	5.0	4.1

4. Connect the water hose of the gun to the water source and the air hose to the compressed air source.

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.

**NOTE:** Apply air gradually. Do not exert more than 20 psi (138 kPa) air pressure. Too great a pressure may rupture a radiator tube.

6. Continue flushing until clean water is expelled from the radiator.

The cylinder block and cylinder head water passages are reverse-flushed as follows:

1. Remove the thermostat.

2. Attach a hose to the water inlet of the cylinder block to drain the water away from the engine.

3. Attach a hose to the water outlet at the top of the cylinder block and insert the flushing gun in the hose, connecting the water and air sources as outlined in the preceding Step 4.

4. Turn on the water and, when the water jackets are filled, turn on the air in short blasts, allowing the engine to fill with water between air blasts.

**NOTE:** Do not exert more than 30 psi (207 kPa) air pressure.

5. Continue flushing until the water from the engine runs clean.

#### Filling the Cooling System

When filling the cooling system, add the coolant slowly to insure a proper fill without air. If coolant is added too quickly, pockets of air may become trapped preventing the system from being completely filled. Whenever the engine appears to be full before the known coolant capacity has been added, drain the engine and start the fill procedure over. Another cause of air lock in the engine coolant passages could be a clogged vent hole in the thermostat. If this is suspected, remove the thermostat and check the vent hole for obstruction. When adding make up coolant, be sure it is properly inhibited.

## ENGINE EQUIPMENT

### COLD START AID

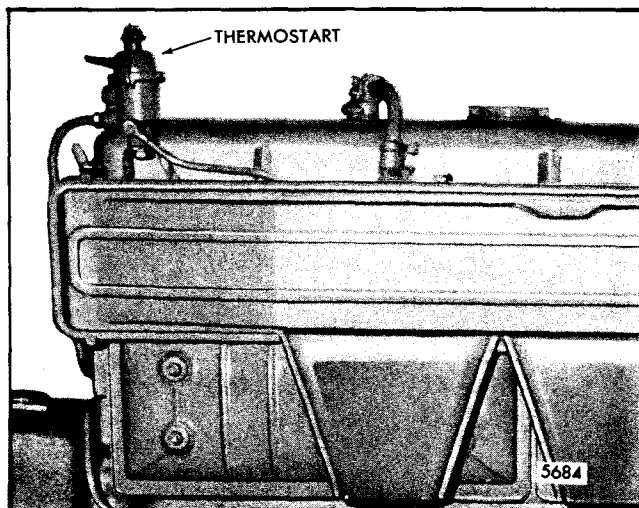


Fig. 1 - Thermostart Mounting

The Thermostart, shown in Fig. 1, is an electrically ignited fuel oil burner located in the engine air intake manifold for the purpose of heating the incoming air to facilitate cold weather starting.

Fuel is supplied to the Thermostart reservoir from the main fuel system and injector bleed return line.

When the Thermostart is switched on prior to a start, an electrical coil heats the inside of the unit causing a ball valve at the fuel inlet to unseat and admit fuel. The fuel is vaporized by the heating coil, then is burned by an extension of the heating coil in a perforated shield that projects into the air intake manifold. The flame, protected by the shield, heats the air that is drawn into the cylinders when the engine is cranked.

When the Thermostart is switched off, the air flow in the manifold cools the inside of the unit rapidly, and the ball valve seats, shutting off the fuel flow from the reservoir.

Any excess fuel reaching the reservoir flows back to the fuel tank through a return line.

The Thermostart is a sealed unit. Service requirements involve periodically removing the unit from the air intake manifold and brushing any carbon deposits from the flame shield, making sure all perforations are open.

**CAUTION:** If the engine is equipped with a cold start aid, DO NOT use ether start aid. Ether applied while the thermostart is in operation could cause a severe explosion.

## OPERATING INSTRUCTIONS

### PREPARATION FOR STARTING A NEW OR STORED ENGINE FOR THE FIRST TIME

Before an engine is shipped from the factory, the cooling and lubricating systems are drained and additional steps are taken to prevent corrosion and other troubles from occurring during storage or delivery to the user.

When preparing to start a new engine (or one that has been newly overhauled or has been in storage), the operator should first perform these operations.

**NOTE:** Any attempt to run the engine before these instructions are carried out may result in serious engine damage.

#### Protective Coverings

Remove the covers and tapes from all of the openings of the engine, fuel tank and electrical equipment. Do not overlook the exhaust outlet.

#### Air Cleaner

If the engine is equipped with an oil bath cleaner, fill the cleaner bowl to the proper level with the same lubricating oil used in the engine crankcase.

#### Cooling System

Make sure the coolant drain cocks located at the left rear side of the cylinder block and at bottom of the radiator are closed. Remove the filler cap and fill the cooling system with the coolant specified under *Engine Coolant* in the *Cooling System* section. Add the coolant slowly to insure a proper fill without air.

On the heat exchanger engines, replace the raw water pump impeller if it was removed prior to storage. Apply a suitable grease when installing the impeller to prevent wear during priming following engine startup. Install the pump end cover with six attaching screws.

#### Valve Clearances

Remove the valve rocker cover and adjust all valve clearances to .013 in. (.33 mm). It will generally be necessary to readjust the valve clearances when the engine warms up to operating temperature.

#### Lubricating System

With the valve rocker cover removed, pour two quarts of recommended engine lubricating oil over the rocker arms and valve springs. Install the valve rocker cover and fill the engine crankcase to the "full" mark on the dipstick. Use heavy-duty lubricating oil as specified under *Lubricating Oil Specifications* in the *Preventive Maintenance* section.

#### Fuel System

Fill the fuel supply tank with the fuel specified under *Diesel Fuel Oil Specifications* in the *Preventive Maintenance* section. If the system is equipped with a fuel supply valve, it must be opened. To insure prompt starting, prime the fuel system as outlined under *Air Venting the Fuel System* in the *Fuel System* section.

#### Drive Belts

Remove all paper strips from between the pulleys and belts. Check belt tension and correct it if necessary.

#### Crankshaft Nut

Check the crankshaft nut at the front end of the crankshaft to be sure that it is tight. This is sometimes removed for packing purposes.

#### Crankcase Breather System

Make sure the crankcase breather system is in tact and all connections are secure.

#### Marine Gear

If a marine gear box is installed, make sure the unit is filled to the proper level with the recommended grade of oil.

#### Starting System

Remove the protective grease from the starter and battery charging alternator terminals. Connect the electrical leads to a fully charged battery.

Start and run the engine as outlined in the *Operating Instructions* section. On heat exchanger engines, make sure after engine startup that water is flowing in the

raw water side of the cooling system or damage can result to the impeller.

### ROUTINE ENGINE OPERATION

OIL PRESSURE (pounds per square inch)			
Engine	Speed (rpm)		
	550	2000	Min. Safe Working Pressure (max. rpm)
220	15	50	25
330	15	50	25
500	30	47	25

### STARTING THE ENGINE

Before each daily engine start up, be sure that--

1. The cooling system is at the proper level.
2. The engine oil level is correct.
3. The fuel supply in the tank is adequate and the system is fully primed.
4. The clutch, if used, is disengaged.
5. The engine stop control is in the "run" position.

If a manual or automatic shutdown system is incorporated in the unit, the control must be set in the "open" position before starting the engine.

The engine will require the use of a cold weather starting aid to insure efficient starts if the ambient temperature is below 40 °F (4 °C).

### Routine Engine Starts

Start the engine as follows: Set the throttle in the "full fuel" position. Operate the starting motor controls. If the engine does not start within 30 seconds, cease cranking the engine and allow the starting motor to cool for 60 seconds before trying again. If the engine fails to start in four tries, an inspection should be made to determine the cause.

### Starting the Engine Using the Thermostart Cold Start Aid

Switch on the Thermostart and let it operate for 15 to 20 seconds. Then crank the engine to start. If the engine does not start in 10 seconds, stop cranking for 7 to 10 seconds leaving the Thermostart energized. Then resume cranking. As soon as the engine starts, turn off the Thermostart switch if it does not turn off automatically.

**CAUTION:** Do not use an ether starting aid when a Thermostart unit is being used to start the engine. If ether is applied while the Thermostart is in operation, a severe explosion could result.

### RUNNING THE ENGINE

#### Oil Pressure

Observe the oil pressure gage or indicator light immediately after starting the engine. If there is no oil pressure indicated within 10 to 15 seconds, stop the engine and determine the cause before restarting.

#### Temperature

The normal engine coolant temperature range is 170 ° to 199 °F (77 ° to 93 °C) (standard thermostat). Allow the engine to warm up for five minutes before applying a load. However, avoid unnecessary engine idling.

**NEW ENGINE RUN-IN****After 20 Hours**

After a new engine has been operated for 20 hours, the crankcase should be drained and new oil added. Lubricating oil filter element and gasket should be replaced also.

**During Run-In (30 Hours)**

A new engine will run-in most effectively under 75% load conditions. If it is possible to do so, restrict full load operation during the first 30 hours to 15 minute periods, and only when normal operating temperatures have been reached.

**NOTE:** When full load is necessary, operate the engine at 1000 to 1500 rpm at light or no load for five minutes before shutdown, to allow highly heated parts of the engine to partially cool thus avoiding distortion.

**After Run-In***Lubricating Oil Consumption*

Piston and rings eventually seat in the cylinder bores as part of the run-in process. Normal oil consumption will generally not be obtained until this process is complete.

*Fuel Oil Consumption*

Good fuel consumption will depend on these conditions:

1. Maintaining correct valve clearances.
2. Using recommended fuel oil.
3. Maintaining proper engine operating temperature.
4. Avoiding excessive idling.

## LUBRICATION AND PREVENTIVE MAINTENANCE

To obtain long life and the best performance from a GM Bedford Diesel engine, the operator must adhere to the following schedule and instructions on lubrication and preventive maintenance.

The time intervals given in the chart on the following page are actual operating hours of a unit. The daily instructions pertain to routine or daily starting of a unit and not to a new unit or one that has not been operated for a considerable period of time. For new or stored engines, refer to the instructions under *Preparation for Starting a New or Stored Engine for the First Time* in the *Operating Instructions* section before attempting to start the engine.

All *authorized Detroit Diesel Allison Service Outlets* are prepared to service units with the viscosity and grade of lubricants recommended on the following pages.

LUBRICATION AND PREVENTIVE  
MAINTENANCE CHARTTime Intervals  
(hours)

Item	Operation	Daily	8	50	100	200	500
1.	Engine Oil Level	O X					
2.	Engine Oil Change				O X		
3.	Engine Oil Filter					O X	
4.	Engine Oil Leaks				O X		
5.	Coolant Level	O X					
6.	Cooling System Care*						
7.	Coolant Leaks	O X			X	O	
8.	Fuel Filter	O X					O X
9.	Fuel Tank Level	O X	O X				
10.	Fuel Oil Leaks				O X		
11.	Air Cleaner Care*		.				
12.	Battery and Terminals					O X	
13.	Electrolyte Level			O X			
14.	Specific Gravity					O X	
15.	Fan Belt Tension				X	O	
16.	Engine Mounts					O X	
17.	Exhaust System					O X	
18.	Valve Clearances					O X	
19.	Throttle Linage				O X		

O - 220 and 330 Engines.

\*See item for service interval.

X - 500 Engine.

**Item 1 - Engine Oil Level**

Check the oil level daily before starting the engine. Maintain the oil level at the full mark on the dipstick without overfilling. Do not operate the engine when the oil level is below the low mark.

**Item 2 - Engine Oil Change**

Following the run-in period, change the oil in a new engine every 100 hours. The drain interval may then be increased or decreased when recommended by a qualified laboratory or oil supplier based on an oil sample analysis.

Drain the engine oil while the engine is warm and the oil is fluid and thoroughly agitated. More impurities will then be in suspension in the oil and will be drained from the crankcase.

Use oils of the correct grade as listed in the chart below. Good quality lubricants reduce carbon deposits, prevent battery overload by making starting easier and retain their lubricating qualities for longer periods.

**Item 3 - Engine Oil Filter**

Install a new oil filter element and gasket every 200 hours. Check for oil leaks, with the engine running, after every change.

**Item 4 - Engine Oil Leaks**

Check the entire lubricating system for leaks every 100 hours and tighten connections that are leaking. In

some cases new gaskets may be required to stop the leakage. Keep the engine exterior clean so that oil leaks can be detected right away.

**Item 5 - Coolant Level**

Check the coolant level in the radiator or heat exchanger tank daily and maintain it at approximately 1 inch (25 mm) below the filler neck.

**Item 6 - Cooling System Care**

Flush the cooling system each spring and fall and clean the system when required with a commercial descaler, neutralizing and rinsing afterwards according to the instructions on the container. Fill the system with soft water adding a good grade of rust inhibitor or a high boiling point antifreeze. (Refer to *Engine Coolant* in the *Cooling System* section for instructions).

**Item 7 - Coolant Leaks**

Check the entire cooling system for leaks at least every 200 hours. When tightening hose connections to correct a leak, do not overtighten. Check below the engine daily for signs of leaks.

**Item 8 - Fuel Filter**

Install a new fuel filter element and gasket every 500 hours. Drain a portion of the fuel from the combined water separator and fuel filter daily to remove water and other contaminants.

**Item 9 - Fuel Tank Level**

Check the fuel level in the supply tank daily before starting the engine. At the conclusion of the work day, fill the fuel tank. This will minimize condensation.

**Diesel Fuel Contamination**

The most common form of diesel fuel contamination is water. Water is harmful to fuel systems 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

LUBRICATION OIL RECOMMENDATIONS		
Ambient Temperature Conditions	MIL Specification*	Oil Grade
Above 90° F (32° C)	2104-B	SAE 30
+90° F to +10° F (+32° C to -12° C)	2104-B	SAE 20 or 20W
+10° F to -10° F** (-12° C to -23° C)	2104-B	SAE 10W

\*Minimum Standards

\*\*Below -10° F (-23° C), see an authorized Detroit Diesel Allison service outlet for instructions regarding sub-zero operation.

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 litre) per 125 gallons (473 litres) 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 commercially available biocides. There are two basic types on the market.

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.

Diesel fuel soluble type, such as "Biobor" manufactured by U. S. Borax or equivalent, 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 10 - Fuel Oil Leaks

Check all fuel lines and connections from the supply tank to the injectors for leaks at least once every 100 hours. Tighten loose connections being careful not to twist the fuel lines.

Using a screw driver, check the screws securing the clips to the injector fuel lines for tightness every 100 hours or sooner.

#### Item 11 - Air Cleaner Care

The recommended intervals for air cleaner service are as follows:

220 and 330:

Service both light duty and heavy duty air cleaners and check the condition of seals every 100 hours.

500:

Clean the standard air cleaner and filter element and check the condition of seals every 100 hours. Replace the filter element every 200 hours.

Complete service instructions for air cleaners are provided under *Air System* in the *Engine Systems* section.

#### Item 12 - Battery and Terminals

Check the condition of the battery every 200 hours. The top should be dry and clean. The terminals should be scraped clean if corroded and they should be protected with a coat of petroleum jelly.

#### Item 13 - Electrolyte Level

Check the electrolyte level in each battery cell every 50 hours and maintain the level just above the plates. In warm weather and in periods of high charge rate, check the electrolyte level more frequently.

**CAUTION:** Do not use a flame such as a lighted match to check the electrolyte level because of the possibility of explosion.

#### Item 14 - Specific Gravity

Check the specific gravity of the electrolyte in each cell of the battery every 200 hours.

The hydrometer readings should be approximately the same for each cell. Any appreciable variation will require a more intensive check of battery cells by a qualified serviceman.

#### Item 15 - Fan Belt Tension

New drive belts will stretch in the early stages of operation. Check the tension of new belts after one hour of operation, again at 50 hours, and then at every

SPECIFIC GRAVITY READINGS (at 80° F, 27° C)	
Battery	Hydrometer
Fully Charged	1.281 - 1.266
Half Charged	1.202 - 1.187
Discharged	1.111 - 1.098

200 hours thereafter. Replace both belts when one is worn.

Adjust the belt tension so that a firm push with the thumb at a point midway between two pulleys will depress the belt  $1\frac{1}{2}$  " (13 mm). It is possible to check belt tension with a suitable weight scale applied at a midway point between pulleys. On 220 and 330 engines, belt deflection should be  $1\frac{1}{2}$  " (13 mm) when a 5-7 lb. (22-31 N) pull is recorded by the scale. On 500 engines, a  $1\frac{1}{2}$  " (13 mm) deflection should occur at 11-13 lbs. (49-58 N) on the scale.

#### Item 16 - Engine Mounts

Check nuts and bolts on the engine front and rear mounts every 200 hours to be sure all are tight.

#### Item 17 - Exhaust System

Check the nuts and bolts securing the exhaust pipe to the manifold, the muffler to its support bracket and

the tail pipe mountings every 200 hours to be sure all are tight.

#### Item 18 - Valve Clearances

Check the valve clearances every 200 hours. The correct valve clearance at normal engine operating temperature is .013 " (.33 mm) for all valves. Adjust valves if required as outlined under *Engine Tune-Up Instructions*.

#### Item 19 - Throttle Linkage

Using the same oil as in the engine crankcase, lubricate the throttle linkage between the operator control lever and injection pump governor every 100 hours.

## DETROIT DIESEL FUEL OIL SPECIFICATIONS

### GENERAL CONSIDERATIONS

The quality of fuel oil used for high-speed diesel engine operation is a very important factor in obtaining satisfactory engine performance, long engine life, and acceptable exhaust.

Fuel selected should be completely distilled material. That is, the fuel should show at least 98 percent by volume recovery when subjected to ASTM D-86 distillation. Fuels marketed to meet Federal Specification VV-F-800 (grades DF-1 and DF-2) and ASTM Designation D-975 (grades 1-D and 2-D) meet the completely distilled criteria. Some of the general properties of VV-F-800 and ASTM D-975 fuels are shown below.

**FEDERAL SPECIFICATION & ASTM  
DIESEL FUEL PROPERTIES**

Specification or Classification Grade	VV-F-800 DF-1	ASTM D-975 1-D	VV-F-800 DF-2	ASTM D-975 2-D
Flash Point, min.	104° F 40° C	100° F 38° C	122° F 50° C	125° F 52° C
Carbon Residue (10% residuum), % max.	0.15	0.15	0.20	0.35
Water & Sediment, % by vol., max.	0.01	trace	0.01	0.05
Ash, % by wt., max.	0.005	0.01	0.005	0.01
Distillation Temperature, 90% by vol. recovery, min.	—	—	—	540° F (282° C)
max.	572° F (300° C)	550° F (288° C)	626° F (330° C)	640° F (338° C)
End Point, max.	626° F (330° C)	—	671° F (355° C)	—
Viscosity 100° F (38° C)				
Kinematic, cs. min.	1.4	1.4	2.0	2.0
Saybolt, SUS, min.	—	—	—	32.6
Kinematic, cs. max.	3.0	2.5	4.3	4.3
Saybolt, SUS, max.	—	34.4	—	40.1
Sulfur, % by wt., max.	0.50	0.50	0.50	0.50
Cetane No.	45	40	45	40

Residual fuels and domestic furnace oils are not considered satisfactory for Detroit Diesel engines; however, some may be acceptable. (See "DETROIT DIESEL FUEL OIL SPECIFICATIONS.")

**NOTE: Detroit Diesel Allison does not recommend the use of drained lubricating oil as a diesel fuel oil. Furthermore, Detroit Diesel will not be responsible for any engine detrimental effects which it determines resulted from this practice.**

All diesel fuel oil contains a certain amount of sulfur. Too high a sulfur content results in excessive cylinder wear due to acid build-up in the lubricating oil. For most satisfactory engine life, fuels containing less than 0.5% sulfur should be used.

Fuel oil should be clean and free of contamination. Storage tanks should be inspected regularly for dirt, water or water-emulsion sludge, and cleaned if contaminated. Storage instability of the fuel can lead to the formation of varnish or sludge in the tank. The

presence of these contaminants from storage instability must be resolved with the fuel supplier.

### DETROIT DIESEL FUEL OIL SPECIFICATIONS

Detroit Diesel Allison designs, develops, and manufactures commercial diesel engines to operate on diesel fuels classified by the ASTM as Designation D-975 (grades 1-D and 2-D). These grades are very similar to grades DF-1 and DF-2 of Federal Specification VV-F-800. Residual fuels and furnace oils, generally, are not considered satisfactory for Detroit Diesel engines. In some regions, however, fuel suppliers may distribute one fuel that is marketed as either diesel fuel (ASTM D-975) or domestic heating fuel (ASTM D-396) sometimes identified as furnace oil. In this case, the fuel should be investigated to determine whether the properties conform with those shown in the "FUEL OIL SELECTION CHART" presented in this specification.

The "FUEL OIL SELECTION CHART" also will serve as a guide in the selection of the proper fuel for various applications. The fuels used must be clean, completely distilled, stable, and non-corrosive. DISTILLATION RANGE, CETANE NUMBER, and SULFUR CONTENT are three of the most important properties of diesel fuels that must be controlled to insure optimum combustion and minimum wear. Engine speed, load, and ambient temperature influence the selection of fuels with respect to distillation range and cetane number. The sulfur content of the fuel must be as low as possible to avoid excessive deposit formation, premature wear, and to minimize the sulfur dioxide exhausted into the atmosphere.

To assure that the fuel you use meets the required properties, enlist the aid of a reputable fuel oil supplier. The responsibility for clean fuel lies with the fuel supplier as well as the operator.

During cold weather engine operation, the cloud point (the temperature at which wax crystals begin to form in diesel fuel) should be 10° F (6° C) below the lowest expected fuel temperature to prevent clogging of the fuel filters by wax crystals.

At temperatures below -20° F (-29° C), consult an authorized Detroit Diesel Allison service outlet, since particular attention must be given to the cooling system, lubricating system, fuel system, electrical system, and cold weather starting aids for efficient engine starting and operation.

**FUEL OIL SELECTION CHART**

Typical Application	General Fuel Classification	Final Boiling Point	Cetane No.	Sulfur Content
City Buses	No. 1-D	(Max) 550° F (288° C)	(Min) 45	(Max) 0.30%
All Other Applications	Winter No. 2-D Summer No. 2-D	675° F 675° F (357° C)	45 40	0.50% 0.50%

**NOTE: When prolonged idling periods or cold weather conditions below 32° F (0° C) are encountered, the use of lighter distillate fuels may be more practical. The same consideration must be made when operating at altitudes above 5,000 ft.**

**STATEMENT OF POLICY ON FUEL AND  
LUBRICANT ADDITIVES**

In answer to requests concerning the use of fuel and lubricating oil additives, the following excerpt has been taken from a policy statement of General Motors Corporation:

*"It has been and continues to be General Motors policy to build motor vehicles that will operate satisfactorily on the commercial fuels and lubricants of good quality regularly provided by the petroleum industry through retail outlets."*

Therefore, Detroit Diesel Allison does not recommend

the use of any supplementary fuel or lubricant additives. These include all products marketed as fuel conditioners, smoke suppressants, masking agents, re-odorants, tune-up compounds, top oils, break-in oils, graphitizers, and friction-reducing compounds.

**NOTE:** The manufacturer's warranty applicable to Detroit Diesel engines provides in part that the provisions of such warranty shall not apply to any engine unit which has been subject to misuse, negligence or accident. Accordingly, malfunctions attributable to neglect or failure to follow the manufacturer's fuel or lubricating recommendations may not be within the coverage of the warranty.

## ENGINE COOLANT

Engine coolant is considered as any solution which is circulated through the engine to provide the means for heat transfer from the various engine components. In general, water containing various materials in solution is used for this purpose.

The function of the coolant is basic in the design and the successful operation of the engine and must be carefully selected and properly maintained.

### COOLANT REQUIREMENTS

A suitable coolant solution must meet the following five 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.

The first four requirements are satisfied by combining a suitable water with reliable inhibitors. When operating conditions dictate the need for freeze protection, a solution of suitable water and a permanent antifreeze containing adequate inhibitors will provide a satisfactory coolant.

### WATER

Any water, whether of drinking quality or not, will produce a corrosive environment in the cooling system. Also, scale deposits may form on the internal surfaces of the cooling system due to the mineral content of the water. 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, sulfates, total hardness and dissolved solids. Chlorides and/or sulfates tend to accelerate corrosion, while hardness (percentage of magnesium and calcium present) 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 but not necessarily all the materials which make up dissolved solids. Water, within the limits specified in Tables 1 and 2, Figure 1, is satisfactory as an engine coolant when proper inhibitors are added.

### CORROSION INHIBITORS

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. Depletion of all types of inhibitors occur through

TABLE 1

	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

Refer to Table 2 for evaluation of water intended for use in a coolant solution.

TABLE 2

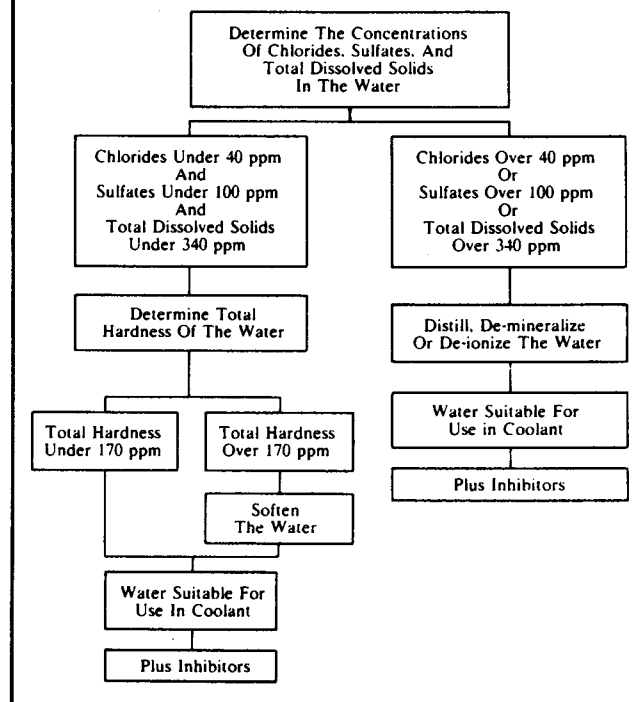


Fig. 1 - Water Characteristics

normal operation. Therefore, strength levels must be maintained by the addition of inhibitors at prescribed intervals. Always follow the supplier's recommendations on inhibitor usage and handling.

### Chromates

Sodium chromate and potassium dichromate are two of the best and more commonly used *water* system corrosion inhibitors. However, the restrictive use of these materials, due to ecology considerations, has deemphasized their use in favor of non-chromates. Care should be exercised in handling these materials due to their toxic nature.

Chromate inhibitors should *not* be used in permanent type antifreeze solutions. Chromium hydroxide, commonly called "green slime", can result from the use of chromate inhibitors with permanent type antifreeze. This material deposits on the cooling system passages, reducing the heat transfer rate (Fig. 2) and results in engine overheating. Engines which have operated with chromate inhibited water must be chemically cleaned before the addition of permanent 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: 1-1/4% of soluble oil in the cooling system increases fire deck temperatures 6% and a 2-1/2% concentration raises

fire deck temperature 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 permanent antifreeze solution.

## INHIBITOR SYSTEMS

An inhibitor system (Fig. 3) is a combination of chemical compounds which provide corrosion protection, pH control and water softening ability. Corrosion protection has been discussed earlier under the heading *Corrosion Inhibitors*. The 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 an integral part of permanent 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 aluminum or zinc support plate in preference to magnesium is recommended to eliminate 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.

### Bulk Inhibitor Additives

Commercially packaged inhibitor systems are available which can be added directly to the engine coolant or to bulk storage tanks containing coolant solution. Both chromate and non-chromate systems are

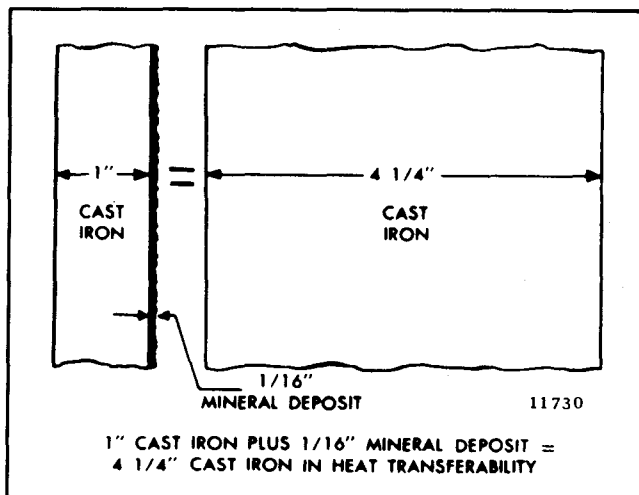


Fig. 2 - Heat Transfer Capacity

Inhibitor or Inhibitor System	Corrosion Inhibitor Type	Complete Inhibitor System	Inhibitor Compatibility		
			Water	Ethylene Glycol Base Antifreeze	*Methoxy Propanol Base Antifreeze
Sodium chromate	Chromate	No	Yes	No	No
Potassium dichromate	Chromate	No	Yes	No	No
Perry filter elements:					
5020 (type OS)	Chromate	Yes	Yes	No	No
S-453 (Spin-on)	Chromate	Yes	Yes	No	No
5030 (type OS)	Non-chromate	Yes	Yes	Yes	No
S-331 (Spin-on)	Non-chromate	Yes	Yes	Yes	No
5070 (type OS)	Non-chromate	Yes	Yes	Yes	No
S-473 (Spin-on)	Non-chromate	Yes	Yes	Yes	No
Lenroc filter element	Non-chromate	Yes	Yes	Yes	No
Fleetguard filter elements:					
DCA (canister)	Non-chromate	Yes	Yes	Yes	No
DCA (Spin-on) (Eth. Gly.)	Non-chromate	Yes	Yes	Yes	No
DCA (Spin-on) (Meth. Prop.)	Non-chromate	Yes	No	No	Yes
AC filter elements:					
DCA (canister)	Non-chromate	Yes	Yes	Yes	No
DCA (Spin-on)	Non-chromate	Yes	Yes	Yes	No
Luber-Finer filter elements:					
LW-4739 (canister)	Non-chromate	Yes	Yes	Yes	No
LFW-4744 (spin-on)	Non-chromate	Yes	Yes	Yes	No
Nalcool 2000 (liquid)	Non-chromate	Yes	Yes	Yes	No
Perry LP-20 (liquid)	Non-chromate	Yes	Yes	Yes	No
Sy-Cool (liquid)	Non-chromate	Yes	Yes	Yes	No
Lubercool (liquid)	Non-chromate	Yes	Yes	Yes	No
Dowtherm cooling sys- tem conditioner	Non-chromate	Yes	Yes	Yes	Yes

\*Dowtherm 209, equivalent.

Fig. 3 - Coolant Inhibitor Chart

available and care should be taken regarding inhibitor compatibility with other coolant constituents.

*Non-chromate inhibitor systems are recommended for use in GM Bedford Diesel engines.* These systems can be used with either water or permanent antifreeze solutions and provide corrosion protection, pH control and water softening. Some non-chromate inhibitor systems offer the advantage of a simple on-site test to determine protection level and, since they are added

directly to the coolant, require no additional hardware or plumbing.

All inhibitors become depleted through normal operation and additional inhibitor must be added to the coolant at prescribed intervals to maintain original strength levels. Always follow the supplier's recommendations on inhibitor usage and handling.

**NOTE:** Methoxy propanol base permanent

antifreeze (such as Dowtherm 209, or equivalent) must be re-inhibited only with compatible corrosion inhibitor systems.

### ANTIFREEZE

When freeze protection is required, a permanent antifreeze must be used. An inhibitor system is included in this type of antifreeze and no additional inhibitors are required on initial fill if a minimum antifreeze concentration of 30% by volume is used. Solutions of less than 30% concentration do not provide sufficient corrosion protection. Concentrations over 67% adversely affect freeze protection and heat transfer rates.

Ethylene glycol base antifreeze is recommended for use in GM Bedford Diesel engines. Methyl alcohol 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 may be used for freeze protection. Before installing methoxy propanol base antifreeze in a unit, the entire cooling system should be drained, flushed with clear water and examined for rust, scale, contaminants, etc. If deposits are present, the cooling system must be chemically cleaned with a commercial grade heavy-duty de-scaler.

The inhibitors in permanent antifreeze should be replenished at approximately 500 hour or 20,000 mile intervals with a non-chromate inhibitor system. Commercially available inhibitor systems may be used to re-inhibit antifreeze solutions.

### Sealer Additives

Several brands of permanent antifreeze are available with sealer additives. The specific type of sealer varies with the manufacturer. Antifreeze with sealer additives is *not recommended* for use in GM Bedford Diesel engines due to possible plugging throughout various areas of the cooling system.

### GENERAL RECOMMENDATIONS

All GM Bedford Diesel engines incorporate pressurized cooling systems which normally operate 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 properly maintained.

**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

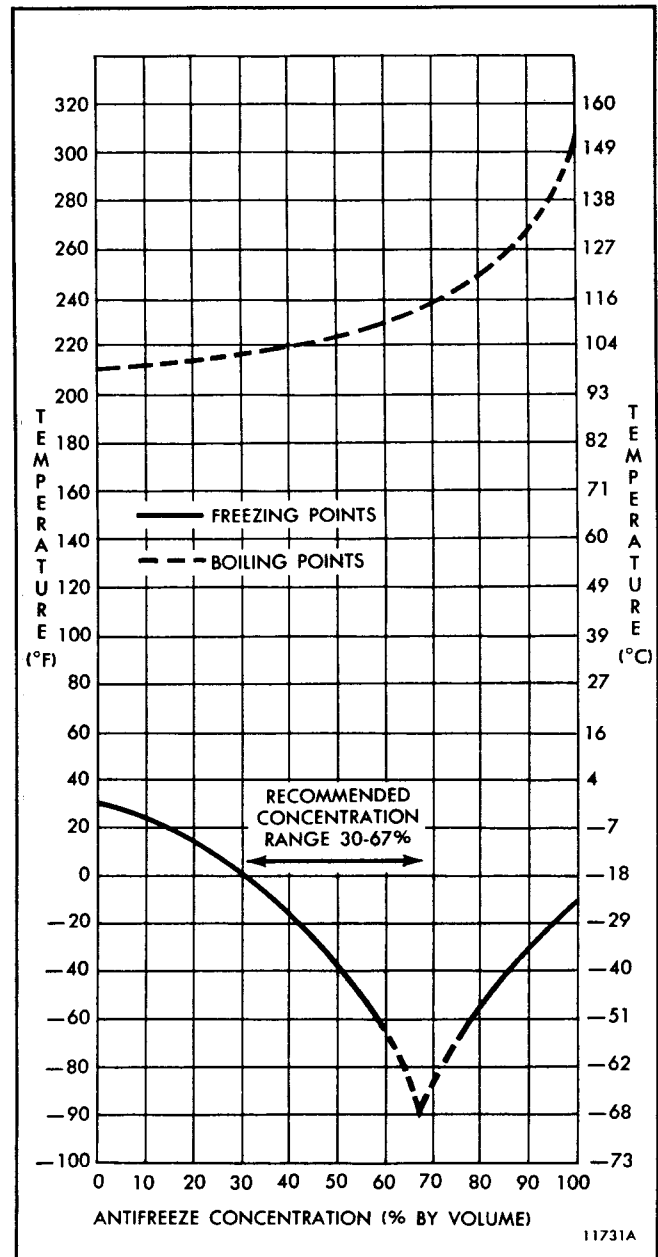


Fig. 4 - Coolant Freezing and Boiling Temperatures vs. Antifreeze Concentration (Sea Level)

and possible personal injury (scalding) from the hot liquid.

1. Always use a properly inhibited coolant.
2. Do not use soluble oil.
3. Maintain the prescribed inhibitor strength.
4. Always follow the manufacturer's recommendations on inhibitor usage and handling.

5. If freeze protection is required, always use a permanent antifreeze.
6. Re-inhibit antifreeze with a recommended non-chromate inhibitor system.
7. Chromate inhibitors should *never* be used with permanent antifreeze.
8. DO NOT mix ethylene glycol base antifreeze with methoxy propanol base antifreeze in the cooling system.
9. Sealer type antifreeze should *not* be used.
10. DO NOT use methyl alcohol base antifreeze.
11. Use extreme care when removing the radiator pressure control cap.

## ENGINE TUNE-UP PROCEDURES

### VALVE ADJUSTMENT

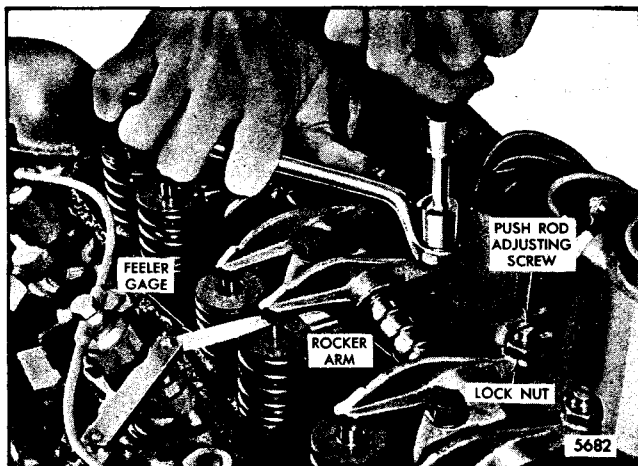


Fig. 1 - Adjusting Valve Clearance

The correct valve clearance at normal engine operating temperature is important for smooth, efficient operation of the engine. Insufficient valve clearance can result in misfiring cylinders, loss of compression and burned valve seats. Excessive valve clearance will result in noisy operation especially in the low speed range.

If the engine is not thoroughly warm, run it at a fast idle speed for at least 20 minutes before checking valve clearances.

First clean, then remove the valve rocker cover. On some models it will be necessary to remove the air cleaner as well. Check the tightness of the valve rocker shaft assembly to the cylinder head. The proper torque for rocker shaft bolts is 42 lb-ft (57 Nm) torque. Next, check the clearance between the valve stems and rocker arms with the engine at idle speed. The correct clearance at normal operating temperature is .013" (.33 mm) for all valves. If any valves need adjustment, proceed as follows:

1. Insert a .013" (.33 mm) feeler gage between the valve stem and rocker arm as shown in Fig. 1.
2. Loosen the locking nut at the push rod end of the rocker arm and turn the adjusting screw by means of a screw-driver or suitable tool until it just touches the feeler gage.
3. Back off the adjusting screw until the feeler gage can just be withdrawn.
4. Tighten the locknut.

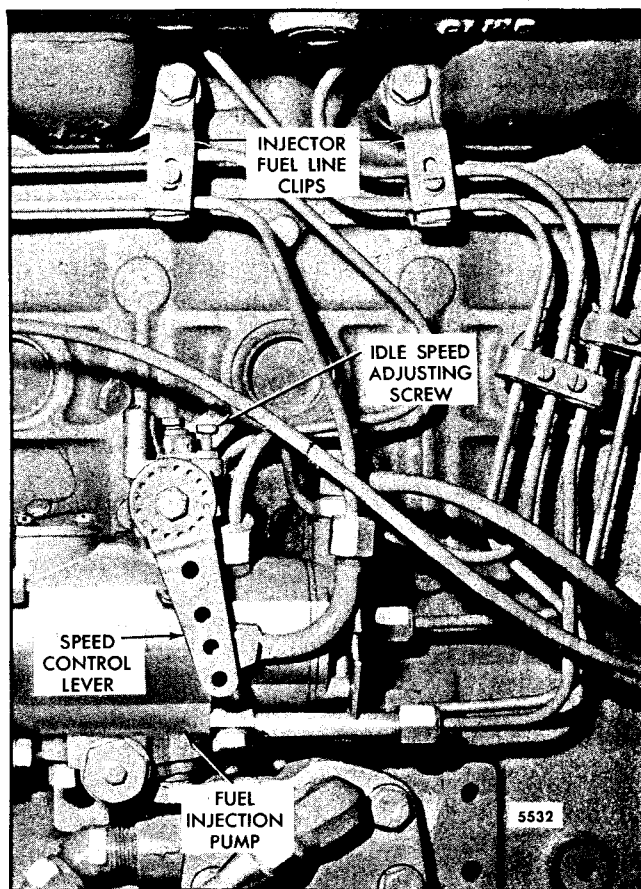
**ENGINE IDLE SPEED ADJUSTMENT**

Fig. 2 - Adjusting the Engine Idle Speed

The engine idle speed is set by a hexagon-headed stop screw located next to the fuel control lever on the governor control housing as shown in Fig. 2.

Adjust the idle screw as follows:

1. Run the engine until normal operating temperature is reached.
2. Loosen the idle stop screw locknut and adjust the stop screw to increase or decrease the idle speed. Clockwise rotation of the idle screw increases the idle speed. The engine should idle smoothly without surging at approximately 500 rpm. When the desired idle range is obtained, tighten the idle screw locknut.
3. With the throttle linkage connected, run the engine up to 3/4 maximum speed. Then release the throttle and allow the engine to return to idle speed. Repeat this procedure several times to be sure the engine returns promptly to the idle speed each time the throttle is released.

## STORAGE

### PREPARING ENGINE FOR STORAGE

When an engine is to be stored or removed from operation for a period of time, steps should be taken to protect the interior and exterior of the engine and exterior-mounted components from rust formation and corrosion.

It will be necessary to remove all rust or corrosion completely from any exposed parts 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.

Prepare the engine for storage as follows:

1. Drain the engine oil. Install a new lubricating oil filter element and gasket.
2. Fill the crankcase to the proper level with a 30 weight preservative lubricating oil MIL-L-21260, Grade 2 (PIO), or equivalent.
3. Be sure the cooling system is filled to the proper level with inhibited coolant.
4. Fill the fuel tank with enough rust preventive fuel oil, such as American Diesel Run-In Fuel (LF-4089), Mobil Tecrex, or equivalent to operate the engine for 10 minutes. Run the engine at 1000 rpm for the 10 minutes and shut it down.
5. Next, loosen all injector supply fuel line connections. Rotate the engine slowly by hand and spray a 30 weight preservative lubricating oil MIL-L-21260, Grade 2 (PIO), or equivalent into the air intake manifold with a high pressure spray gun. Retighten the fuel line connections at the injectors.
6. Remove the oil pan drain plug and drain the preservative lubricating oil from the engine.
7. Remove the fuel filter element and gasket and discard. Wash the filter shell in clean fuel oil and insert a new element. Fill the cavity between the element and shell about two-thirds full of the same rust preventive fuel oil as used in the fuel tank and reinstall the shell.
8. Drain and thoroughly flush the cooling system with clean, soft water and refill with a rust- inhibited coolant. Then drain the system again.
9. Clean and service the air cleaner or silencer if needed.
10. Be sure the following items are adequately sealed:
  - (a) Fuel pump or pre-filter inlet.
  - (b) Lubricating oil filler cap.
  - (c) Exhaust manifold outlet.
  - (d) Water pump inlet and outlet.
  - (e) Air intake opening.
  - (f) Dipstick opening.
  - (g) Crankcase breather opening(s).
  - (h) Fuel return outlet.
  - (i) Oil pressure switch opening.
  - (j) Alternator, starter motor, and terminals.
11. Be sure the clutch is disengaged from the flywheel if so equipped.
12. Remove the valve rocker cover and spray the top of the cylinder head, valve and rocker assemblies, and the underside of the rocker cover with a 30 weight preservative lubricating oil MIL-L-21260, Grade 2 (PIO), or equivalent.
13. Remove the battery and store it in a warm dry place. Clean and coat the battery connections with grease to prevent corrosion.
14. *Marine Models only:* Drain the raw water from the cooling system as follows:
  - (a) Drain the heat exchanger by removing the drain plug, located on the end cap of the cylindrical portion of the heat exchanger.
  - (b) Drain the raw water pump by removing the end cover held by six retaining screws.

**Storing New Engines**

All GM Bedford Diesel engines when shipped from the factory are protected against rust, corrosion, and other forms of deterioration for up to six months.

If a new engine is stored for a period in excess of six months, the engine fuel, lubrication and air intake systems should be re-inhibited and sealed openings rechecked as outlined above.

**RETURNING AN ENGINE TO SERVICE FOLLOWING STORAGE**

When preparing to start an engine that has been in storage, follow the instructions outlined under *Preparation for Starting a New or Stored Engine for the First Time* in the *Operating Instructions* section. Failure to prepare an engine for start-up following prolonged storage can result in damage to components.

After 20 hours of operation, the engine crankcase should be drained and refilled to the proper level with recommended lubricating oil. The oil filter element and gasket should be replaced also.