Detroit Diesel Engines

53 Operators Manual

Detroit Diesel Allison

Service and Parts Information

6SE337 (Rev. 11/84)

Operators Manual

Series 53 Engines

Detroit Diesel Allison
13400 Outer Drive, West
Detroit, Michigan 48239-4001

NOTE:
Additional copies of this service manual may be purchased from Detroit Diesel Allison Distributors. See your yellow pages—under Engines, Diesel.

Printed in U.S.A.

TO THE OPERATOR

This manual contains instructions on the operation and preventive maintenance of your Detroit Diesel engine. Sufficient descriptive material, together with numerous illustrations, is included to enable the operator to understand the basic construction of the engine and the principles by which it functions. This manual does not cover engine repair or overhaul.

Whenever possible, it will pay to rely on an authorized *Detroit Diesel Allison Service Outlet* for all your service needs from maintenance to major parts replacement. Authorized service outlets in the U.S. and Canada stock factory original parts and have the specialized equipment and personnel with technical knowledge to provide skilled and efficient workmanship.

The operator should familiarize himself thoroughly with the contents of the manual before running an engine, making adjustments, or carrying out maintenance procedures.

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

WARRANTY

The applicable engine warranty is contained in the form entitled WARRANTY INFORMATION on DETROIT DIESEL ENGINES, available from authorized Detroit Diesel Allison Service Outlets.

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DESCRIPTION

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; thus, during one half of its operation, the four-cycle engine functions merely as an air pump.

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 (Scavenging - Fig. 1).

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 (Compression - Fig. 1).

Shortly before the piston reaches its highest position, the required amount of fuel is sprayed into the combustion chamber by the unit fuel injector (Power - Fig. 1). 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 halfway down, allowing the burned gases to escape into the exhaust manifold (Exhaust - Fig. 1). 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".

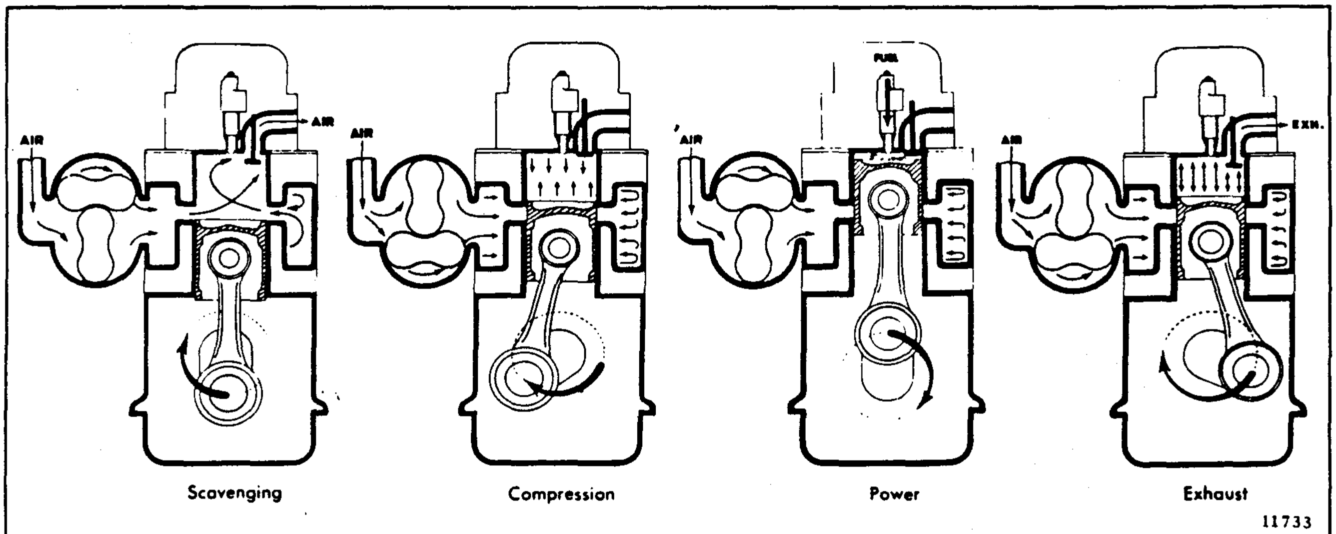


Fig. 1 - The Two-Stroke Cycle

ENGINE SYSTEMS

The Series 53 Detroit Diesel engines incorporate four basic systems which direct the flow of fuel, air, lubricating oil and engine coolant.

A brief description of each of these systems and their components, and the necessary maintenance and adjustment procedures are given in this manual.

FUEL SYSTEM

The fuel system (Figs. 1 and 2) consists of the fuel injectors, fuel pipes, fuel manifolds (integral with the cylinder head), fuel pump, fuel strainer, fuel filter and the necessary connecting fuel lines.

On In-line engines, a restricted fitting is located in the cylinder head fuel return manifold outlet to maintain pressure within the fuel system. On V-type engines, this restricted fitting is located in the left-bank cylinder head.

Fuel is drawn from the supply tank through the fuel strainer and enters the fuel pump at the inlet side. Upon leaving the pump under pressure, the fuel is forced through the fuel filter and into the fuel inlet manifold where it passes through fuel pipes into the inlet side of each fuel injector. The fuel is filtered through elements in the injectors and atomized through small spray tip orifices into the combustion chamber. Surplus fuel, returning from the injectors, passes through the fuel return manifold and connecting fuel lines back to the fuel tank.

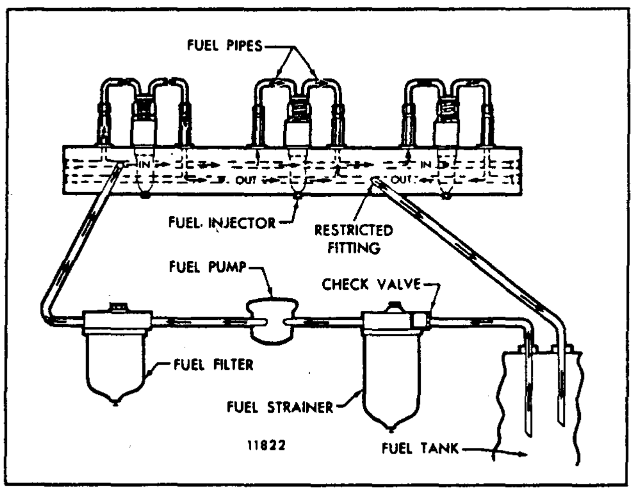


Fig. 1 - Schematic Diagram of Typical Fuel System (In-Line Engine)

The continuous flow of fuel through the injectors helps to cool the injectors and remove air from the fuel system.

A check valve may be installed between the fuel strainer and the source of supply as optional equipment to prevent fuel drain back when the engine is not running.

FUEL INJECTOR

The fuel injector combines in a single unit all of the parts necessary to provide complete and independent fuel injection at each cylinder. The injector creates the high pressure necessary for fuel injection, meters the proper amount of fuel, atomizes the fuel and times the injection into the combustion chamber.

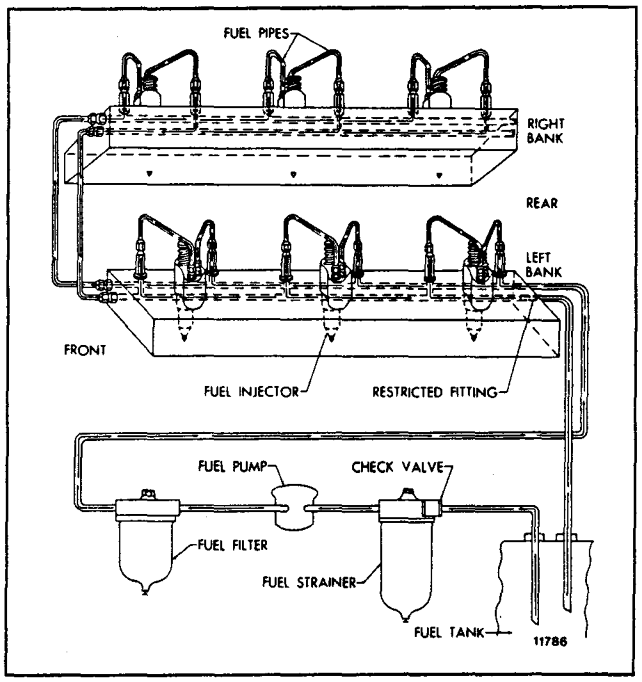


Fig. 2 - Schematic Diagram of Typical Fuel System - V-type Engine

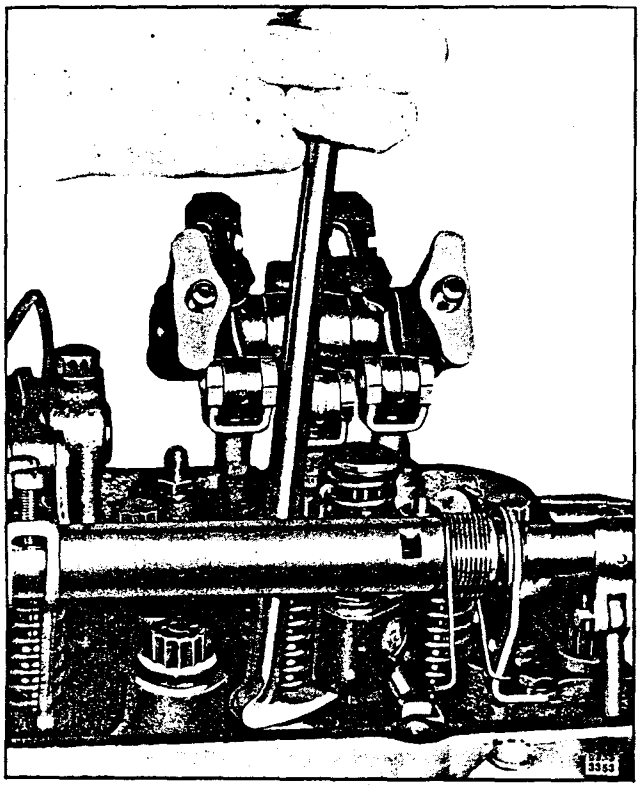


Fig. 3 - Removing Injector from Cylinder Head

Since the injector is one of the most important and carefully constructed parts of the engine, it is recommended that the engine operator replace the injector as an assembly if it is not operating properly. Authorized *Detroit Diesel Allison Service Outlets* are properly equipped to service injectors.

Remove Injector

An injector may be removed in the following manner:

1. Clean and remove the valve rocker cover. Discard the gasket(s).

2. Disconnect the fuel pipes from both the injector and the fuel connectors.

3. Immediately after removing the fuel pipes, cover the injector inlet and outlet fittings with shipping caps to prevent dirt from entering.

4. Turn the crankshaft manually in the direction of engine rotation or crank the engine with the starting motor, if necessary, until the rocker arms for the particular cylinder are aligned in a horizontal plane.

> **NOTE:** 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 could be loosened. Remove the starting motor and use a pry bar against the teeth of the flywheel ring gear to turn the crankshaft.

5. Remove the two rocker shaft bracket bolts and swing the rocker arm assembly away from the injector and valves.

6. Remove the injector clamp bolt, washer and clamp.

7. Loosen the adjusting screws and locknuts on the injector rack control lever and slide the lever away from the injector.

8. Free the injector from its seat and lift it from the cylinder head (Fig. 3).

9. Cover the injector hole in the cylinder head to keep foreign particles out of the cylinder.

Install Injector

Before installing an injector, be sure the beveled seat of the injector tube is free from dirt particles and carbon deposits.

A new or reconditioned injector may be installed by reversing the sequence of operations given above for removal.

Be sure the injector is filled with fuel oil. If necessary, add clean fuel oil at the inlet filter until it runs out the outlet filter.

> **NOTE:** On four valve cylinder heads, there is a possibility of damaging the exhaust valves if the exhaust valve bridge is not resting on the ends of the exhaust valves when tightening the rocker shaft bracket bolts. Therefore, note the position of the exhaust valve bridge before, during and after tightening the rocker shaft bracket bolts.

Do not tighten the injector clamp bolt to more than 20-25 lb-ft (27-34 Nm) torque, as this may cause the moving parts of the injector to bind. Tighten the rocker shaft bolts to 50-55 lb-ft (68-75 Nm) torque.

Align the fuel pipes and connect them to the injector and the fuel connectors. Use socket J 8932-01 and a torque wrench to tighten the fuel pipe nuts to 12-15 lb-ft (16-20 Nm) torque.

> **NOTE:** Do not bend the fuel pipes and 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.

Time the injector, position the injector rack control lever and adjust the exhaust valve clearance (cold setting) as outlined in the engine tune-up procedure. If all of the injectors have been replaced, perform a complete tune-up on the engine. Use a new gasket(s) and reinstall the valve rocker cover.

FUEL PUMP

A positive displacement gear-type fuel pump is attached to the governor or blower on the In-line engines and to the flywheel housing on the V-type engines.

A spring-loaded relief valve, incorporated in the pump body, normally remains in the closed position, operating only when the pressure on the outlet side (to the fuel filter) becomes excessive due to a plugged filter or fuel line.

The fuel pump incorporates two oil seals. Two tapped holes are provided in the underside of the pump body, between the oil seals, to permit a drain tube to be attached. If fuel leakage exceeds one drop per minute, the seals must be replaced. An authorized *Detroit Diesel Allison Service Outlet* is properly equipped to replace the seals.

Fuel pumps are furnished in either left or right-hand rotation, according to the engine model, and are stamped RH or LH. These pumps are not interchangeable and cannot be rebuilt to operate in an opposite rotation.

FUEL STRAINER and FUEL FILTER

Bolt-On Type

A replaceable-element type fuel strainer and fuel filter are used in the fuel system to remove impurities from the fuel (Fig. 4). The strainer removes the larger particles and the filter removes the small foreign particles.

The fuel strainer and fuel filter are basically identical in construction, both consisting of a cover, shell and replaceable element. Since the fuel strainer is placed between the fuel supply tank and the fuel pump, it functions under suction; the fuel filter, which is installed between the fuel pump and the fuel inlet manifold in the cylinder head, operates under pressure.

Replace the elements as follows:

1. With the engine shut down, place a suitable container under the fuel strainer or filter and open the drain cock. The fuel will drain more freely if the cover nut is loosened slightly.

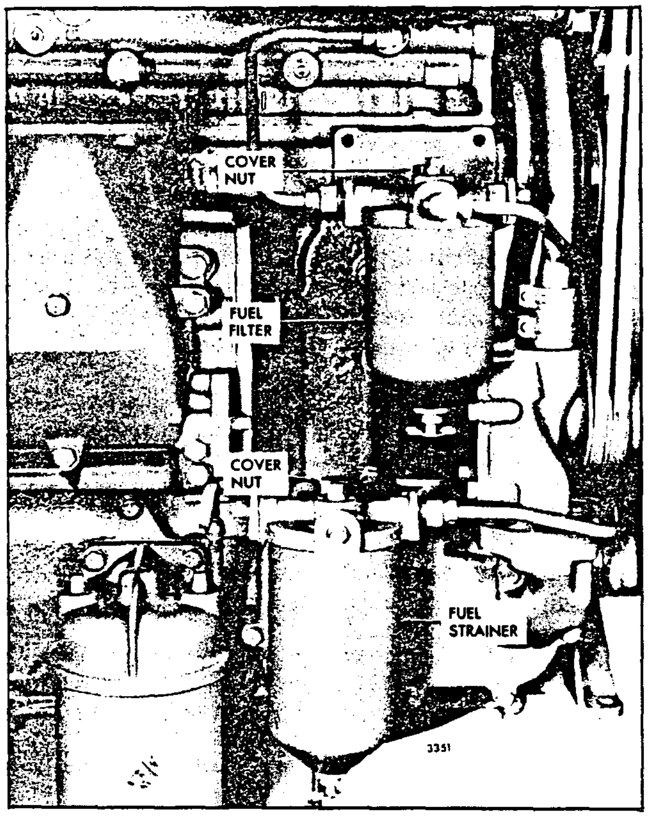


Fig. 4 - Typical Fuel Strainer and Fuel Filter Mounting (Bolt-On Type)

2. Support the shell, unscrew the cover nut and remove the shell and element.

3. Remove and discard the element and gasket. Clean the shell with fuel oil and dry it with a cloth or compressed air.

4. Place a new element, which has been thoroughly soaked in clean fuel oil, over the stud and push it down on the seat. Close the drain cock and fill the shell approximately two-thirds full with clean fuel oil.

5. Affix a new shell gasket, place the shell and element into position under the cover and start the cover nut on the shell stud.

6. Tighten the cover nut only enough to prevent fuel leakage.

7. Remove the plug in the strainer or filter cover and fill the shell with fuel. Fuel system primer J 5956 may be used to prime the fuel system.

8. Start and operate the engine and check the fuel system for leaks.

Spin-On Type

A spin-on fuel strainer and fuel filter is used on certain engines (Fig. 5). The spin-on filter cartridge consists of a shell, element and gasket combined into a unitized replacement assembly. No separate springs or seats are required to support the filters.

The filter covers incorporate a threaded sleeve to accept the spin-on filter cartridges. The word "Primary" is cast on the fuel strainer cover and the word "Secondary" is cast on the fuel filter cover for identification.

No drain cocks are provided on the spin-on filters. Where water is a problem, it is recommended that a water separator be installed. Otherwise, residue may be drained by removing and inverting the filter. Refill the filter with clean fuel oil before reinstalling it.

A 1" diameter twelve-point nut on the bottom of the filter is provided to facilitate removal and installation.

Replace the filter as follows:

1. Unscrew the filter (or strainer) and discard it.

2. Fill a new filter replacement cartridge about two-thirds full with clean fuel oil. Coat the seal gasket lightly with clean fuel oil.

3. Install the new filter assembly and tighten it to one-half of a turn beyond gasket contact.

4. Start the engine and check for leaks.

FUEL TANK

Refill the fuel tank at the end of each day's operation to prevent condensation from contaminating the fuel.

> **NOTE:** A galvanized steel tank should never be used for fuel storage because the fuel oil reacts chemically with the zinc coating to form powdery flakes which quickly clog the fuel strainer and filter and damage the fuel pump and the fuel injectors.

ENGINE OUT OF FUEL

The problem in restarting the 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 the engine.

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 ten gallons (38 liters) 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.

In some instances, it may be necessary to remove a valve rocker cover and loosen a fuel pipe nut in order 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.

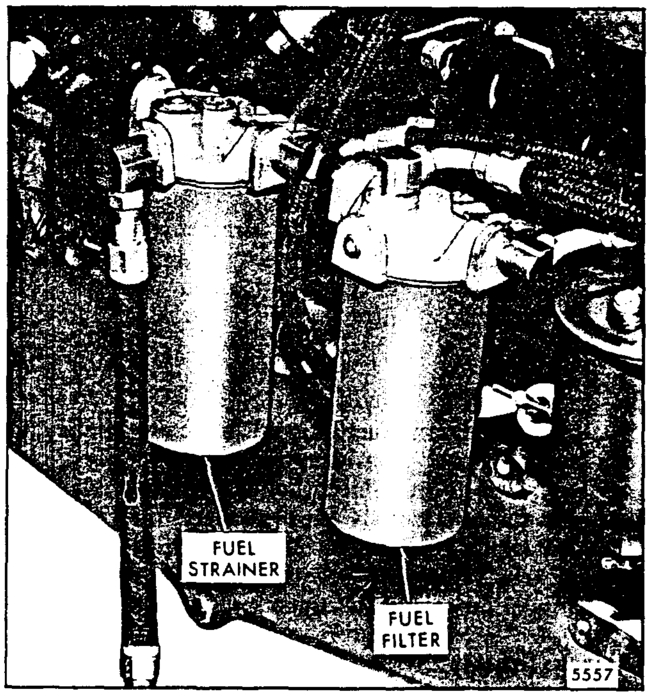


Fig. 5 - Typical Fuel Strainer and Fuel Filter Mounting (Spin-On Type)

AIR SYSTEM

In the scavenging system used in two-cycle engines, (Figs. 6 and 7) 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, each cylinder is filled with fresh, clean air which provides for efficient combustion.

The air, entering the blower from the air silencer or air cleaner, is picked up by the blower rotor lobes and carried to the discharge side of the blower. 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 liner creates a uniform swirling motion to the intake air as it enters the cylinder. This motion persists throughout the compression stroke and facilitates scavenging and combustion.

AIR CLEANERS

Several types of air cleaners are available for use with industrial engines. The light-duty oil bath air cleaner is used on most models. However, a heavy-duty oil bath type or a dry type air cleaner may be installed where the engine is operating in heavy dust concentrations.

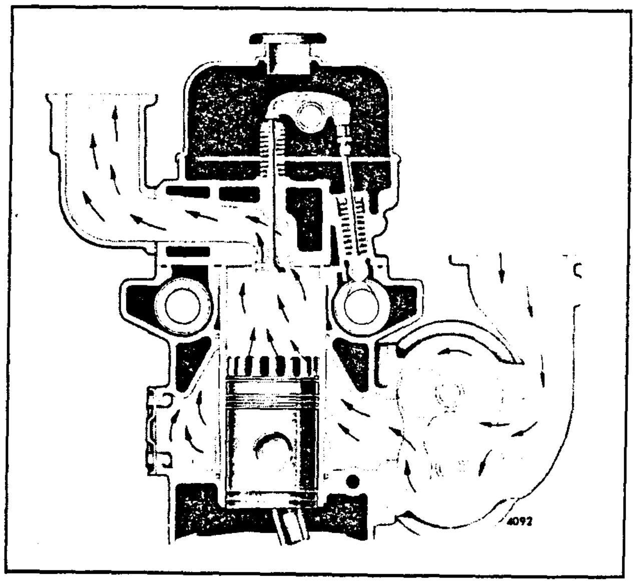


Fig. 6 - Air Intake System Through Blower and Engine (In-line Engine)

The air cleaners are designed for fast, easy disassembly to facilitate efficient servicing. Maximum protection of the engine against dust and other forms of air contamination is possible if the air cleaner is serviced at regular intervals.

Oil Bath

The *light-duty oil bath type air cleaner* consists of a metal wool cleaning element supported inside of a housing which contains an oil reservoir (Fig. 8). A chamber beneath the oil reservoir serves as a silencer for the incoming air to the blower. Air is drawn into the cleaner by the blower and passes over the top of the oil bath, where a major portion of the dirt is trapped, then up through the metal wool, where the finer particles are removed, and then down the central duct to the blower.

The *heavy-duty oil bath type air cleaner* consists of the body and fixed filter assembly which filters the air and condenses the oil from the air stream so that only dry air enters the engine. (Fig. 9). The condensed oil is returned to the cup where the dirt settles out of the oil and the oil is recirculated. A removable element assembly removes a major part of the dust from the air stream thereby decreasing the dust load to the fixed element. An inner cup, which can be removed from the outer (oil cup), acts as a baffle in directing the oil-laden air to the element, and also controls the amount of oil in circulation and meters the oil to the element. The oil

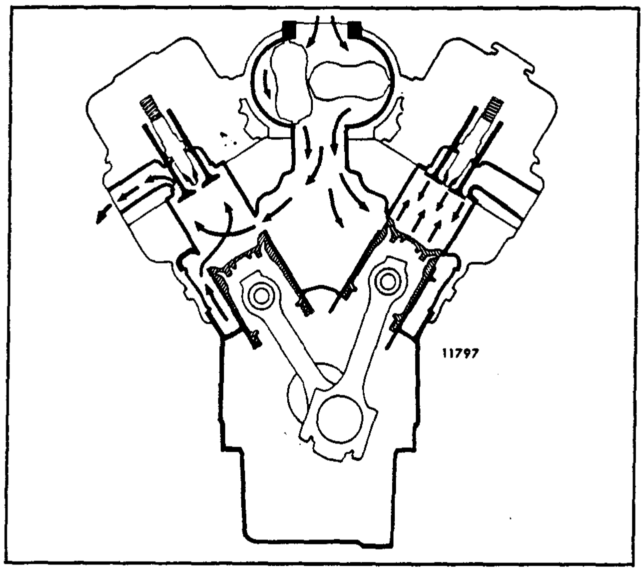


Fig. 7 - Air Intake System Through Blower and Engine (6V-53 Engine)

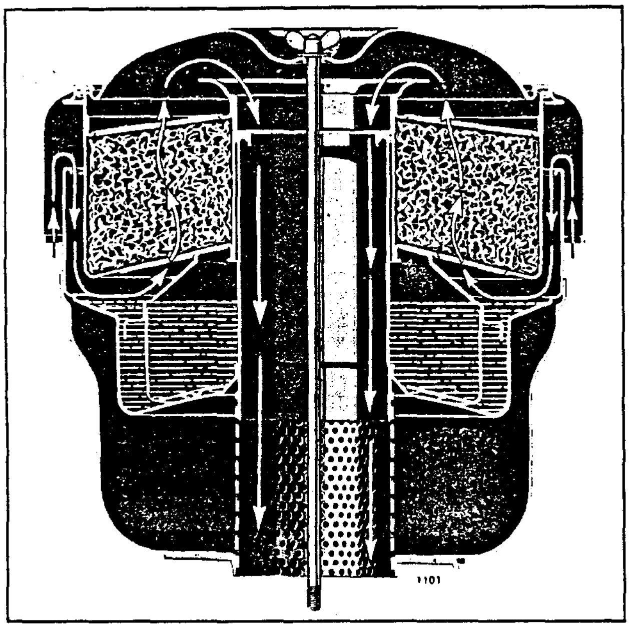


Fig. 8 - Typical Light-Duty Oil Bath Air Cleaner

cup supports the inner cup and is a reservoir for oil and a settling chamber for dirt.

Service the *light-duty* oil bath air cleaner as follows (Fig. 8):

1. Loosen the wing bolt and remove the air cleaner assembly from the air inlet housing. The cleaner may then be separated into two sections; the upper section or body assembly contains the filter element, the lower section consists of the oil cup, removable inner cup or baffle and the center tube.

2. Soak the body assembly and element in fuel oil to loosen the dirt; then flush the element with clean fuel oil and allow it to drain thoroughly.

3. Pour out the oil, separate the inner cup or baffle from the oil cup, remove the sludge and wipe the baffle and outer cup clean.

4. Push a lint-free cloth through the center tube to remove dirt or oil.

5. Clean and check all of the gaskets and sealing surfaces to ensure air tight seals.

6. Refill the oil cup to the oil level mark only, install the baffle and reassemble the air cleaner.

7. Check the air inlet housing before installing the air cleaner assembly on the engine. The inlet will be dirty if air cleaner servicing has been neglected or if dust-laden

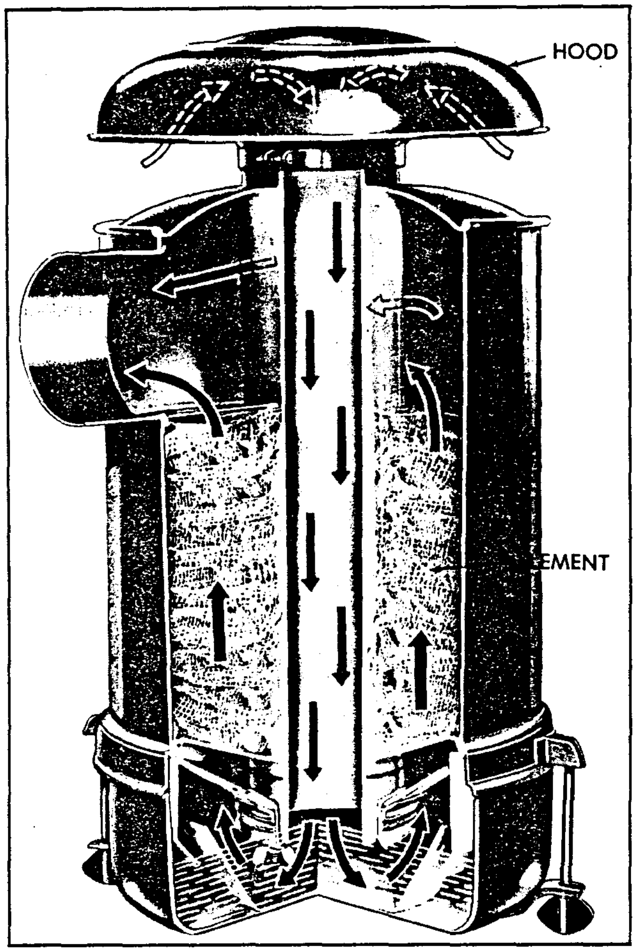


Fig. 9 - Typical Heavy-Duty Oil Bath Air Cleaner

air has been leaking past the air cleaner or air inlet housing seals.

8. Make sure that the air cleaner is seated properly on the inlet housing and the seal is installed correctly. Tighten the wing bolt until the air cleaner is securely mounted.

Service the *heavy-duty* oil bath air cleaner as follows (Fig. 9):

1. Loosen the wing nuts and detach the lower portion of the air cleaner assembly.

2. Remove the detachable screen by loosening the wing nuts and rotating the screen one-quarter turn.

One of the most important steps in properly cleaning the tray type oil bath air cleaner is a step that is most overlooked. Unless the filter tray is thoroughly cleaned, satisfactory performance of the engine cannot be realized. The presence of fibrous material found in the air is often underestimated and is the main cause of the malfunctioning of heavy-duty air cleaners. This material comes from plants and trees during their budding season and later from airborne seed from the same sources. Fig. 10 illustrates the severity of plugging in a tray that is 50% plugged. The solid black areas in the mesh are accumulations of this fibrous material. When a tray is plugged in this manner, washing in a solvent or similar washing solution will not clean it satisfactorily. It must be blown out with high pressure air or steam to remove the material that accumulates between the layers of screening. When a clean tray is held up to the light, an even pattern of light should be visible. It may be necessary, only as a last resort, to burn off the lint. Extreme care must be taken to prevent melting the galvanized coating in the tray screens. Some trays have equally spaced holes in the retaining baffle. Check to make sure that they are clean and open. Fig. 11 illustrates a thoroughly cleaned tray. The dark spots in the mesh indicate the close overlapping of the mesh and emphasize the need for using compressed air or steam. It is suggested that users of heavy-duty air cleaners have a spare tray on hand to replace the tray that requires cleaning. Having an extra tray available makes for better service and the dirty tray can be cleaned thoroughly as recommended. Spare trays are well worth their investment.

3. Pour out the oil, separate the inner cup or baffle from the oil or outer cup, remove the sludge and wipe the baffle and outer cup clean.

4. Clean and inspect the gaskets and sealing surfaces to ensure an air tight seal.

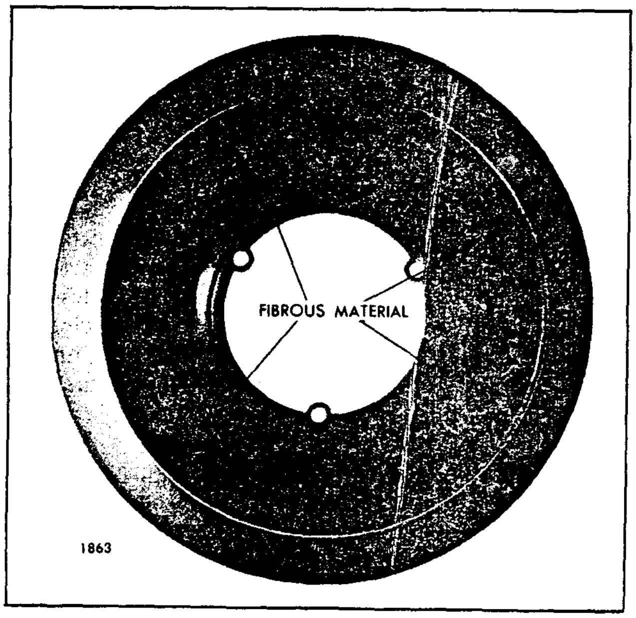


Fig. 10 - Air Cleaner Tray (Plugged)

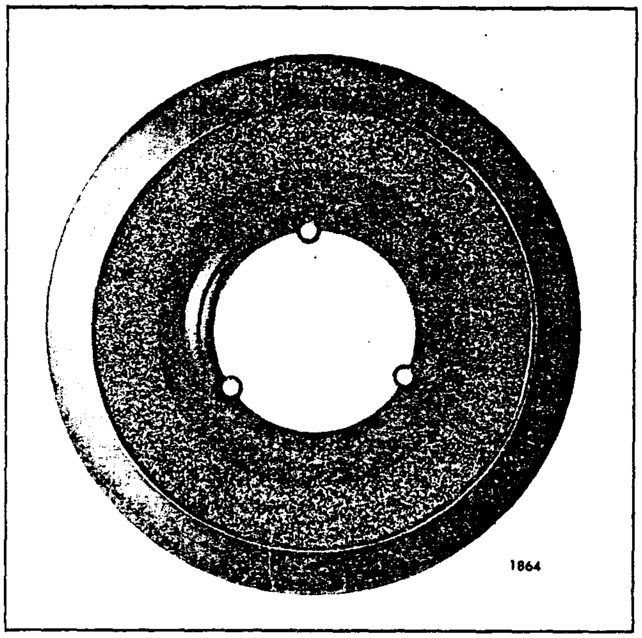


Fig. 11 - Air Cleaner Tray (Clean)

5. Reinstall the baffle in the oil cup and refill to the proper oil level with the same grade of oil being used in the engine.

6. Remove the hood and clean by brushing, or by blowing out with compressed air. Push a lint-free cloth through the center tube to remove dirt or oil from the walls.

7. Inspect the lower portion of the air cleaner body and center tube each time the oil cup is serviced. If there are any indications of plugging, the body assembly should be removed from the engine and cleaned by soaking and then flushing with clean fuel oil. Allow the unit to drain thoroughly.

8. Place the removable element in the body assembly. Install the body if it was removed from the engine for servicing.

9. Install the outer cup and baffle assembly. Be sure the cup is tightly secured to the body assembly.

All oil bath air cleaners should be serviced as operating conditions warrant. At no time should more than 1/2" of "sludge" be allowed to form in the oil cup or the area used for sludge deposit, nor should the oil cup be filled above the oil level mark.

Dry Type

The *United Specialties* dry-type air cleaner consists of a body, dust unloader and element clamped to a base (Fig. 12).

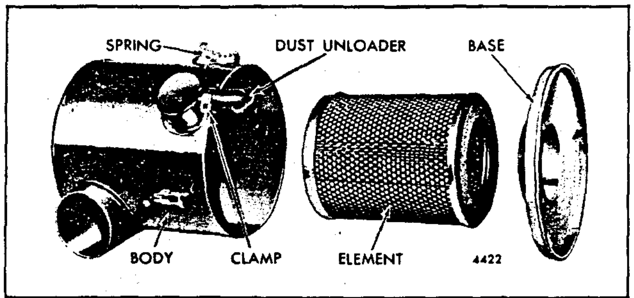


Fig. 12 - United Specialties Dry Type Air Cleaner

Air is drawn through the cleaner intake pipe and is automatically set into a circular motion. This positive spinning of the dirty air "throws out" the heavier particles of dust and dirt where they are collected in the dust port, and then expelled through the dust unloader. The circular action continues even during low air intake at engine idle speeds.

The *United Specialties* dry-type air cleaner should be serviced, as operating conditions warrant, as follows:

1. Loosen the clamp screw and check the dust unloader for obstruction or damage.

2. Unlock the spring clamps that hold the cleaner body to the cleaner base which is bolted to the air inlet housing. Remove the body, and then remove the element from the cleaner base.

3. The paper pleated air cleaner element can be cleaned as follows:

a. For a temporary expedient in the field, tap the side or end of the element carefully against the palm of your hand.

NOTE: Do not tap the element against a hard surface. This could damage the element.

b. Compressed air can be used when the major contaminant is dust. The compressed air (not to exceed 100 psi or 689 kPa) should be blown through the element in a direction opposite to the normal air flow. Insert the air nozzle inside of the element and gently tap and blow out the dust with air. When cleaning the dust from the outside element, hold the nozzle at least 6" from the element.

c. Wash the element if compressed air is not available, or when the contaminant is carbon, soot, oily vapor or dirt which cannot be removed with compressed air.

d. Agitate the element in warm water containing a non-sudsing detergent.

Do not use solvents, oil, fuel oil, gasoline or water hotter that your hand can stand.

Preceding the washing, it helps to direct air (not exceeding 100 psi or 689 kPa) through the element in a direction opposite the normal air flow to dislodge as much dust as possible. Reverse flush with a stream of water (not exceeding 40 psi or 276 kPa) until the water runs clean to rinse all loosened foreign material from the element. Shake out excess water from the element and allow it to dry thoroughly. Do not attempt to remove excess water by using compressed air.

4. Inspect the cleaned element with a light bulb after each cleaning for damage or rupture. The slightest break in the element will admit sufficient airborne dirt to cause rapid failure of piston rings. If necessary, replace the element.

5. Inspect the gasket on the end of the element. If the gasket is damaged or missing, replace the element.

6. Install the element on the base with the gasket side of the element down against the base. Place the body over the element and base and tighten the spring clamps by hand.

7. Replace the element after 10 washings or 1 year of service, whichever comes first, or any time damage is noted.

8. Install the dust unloader and tighten the clamp.

The *Farr* dry-type air cleaner is designed to provide highly efficient air filtration under all operating conditions and is not affected by engine speed (Fig. 13). The cleaner assembly consists of a cleaner panel with a replaceable impregnated paper filter element.

The cleaner panel and replaceable filter element are held together in a steel housing with fasteners.

The deflector vanes impart a swirling motion to the air entering the air cleaner and centrifuge the dust particles against the walls of the tubes. The dust particles are then carried to the dust bin at the bottom of the cleaner by approximately 10% bleed-off air and are finally discharged into the atmosphere. The cleaner panel is fully effective at either high or low velocities.

The remainder of the air in the cleaner reverses direction and spirals back along the discharge tubes again centrifuging the air. The filtered air then reverses direction again and enters the replaceable filter element through the center portion of the discharge tubes. The air is filtered once more as it passes through the pleats of the impregnated paper element before leaving the outlet port of the cleaner housing.

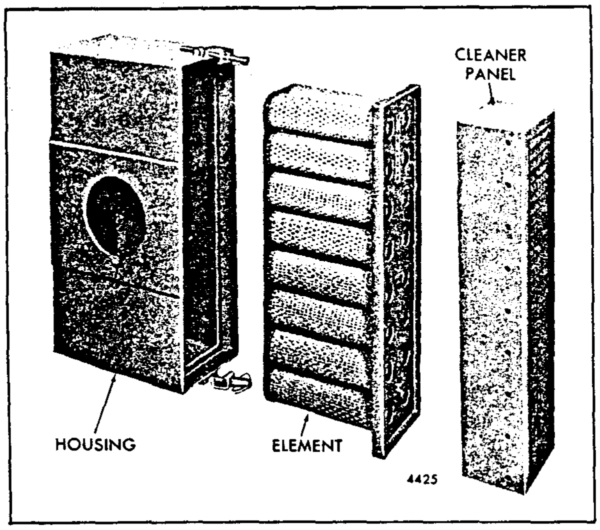


Fig. 13 - Farr Dry Type Air Cleaner

The cleaner panel tends to be self-cleaning. However, it should be inspected and any accumulated foreign material removed during the periodic replacement of the impregnated paper filter element. Overloading of the paper element will not cause dirt particles to bypass the filter and enter the engine, but will result in starving the engine for air.

The filter element should be replaced, as operating conditions warrant, as follows:

1. Loosen the wing nuts on the fasteners and swing the retaining bolts away from the cleaner panel.

2. Lift the cleaner panel away from the housing and inspect it. Clean out any accumulated foreign material.

3. Withdraw the paper filter element and discard it.

4. Install a new filter element.

5. Install the cleaner panel and secure it in place with the fasteners.

AIR SILENCER

The air silencer, used on some marine engines, is bolted to the air intake side of the blower housing. The silencer has a perforated steel partition welded in place parallel with the outside faces, enclosing flame-proof, felted cotton waste which serves as a silencer for air entering the blower.

While no servicing is required on the air silencer proper, it may be removed when necessary to replace the air inlet screen. This screen is used to filter out any large foreign particles which might seriously damage the blower assembly.

AIR BOX DRAINS

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 the air box pressure through air box drain tubes mounted on the side of the cylinder block.

The air box drains must be open at all times. With the engine running, a periodic check is recommended for air flow from the air box drain tubes. Liquid accumulation on the bottom of the air box indicates a drain tube may be plugged. Such accumulations can be seen by removing the cylinder block air box cover(s) and should be wiped out with rags or blown out with compressed air. Then, remove the drain tubes and connectors from the cylinder block and clean them thoroughly.

Some engines are equipped with an air box drain check valve. Refer to the *Lubrication and Preventive Maintenance* (see Section 5) for service instructions.

CRANKCASE VENTILATION

Harmful vapors which may form within the engine are removed from the crankcase, gear train and valve compartment by a continuous, pressurized ventilation system.

A slight pressure is maintained within the engine crankcase by the seepage of a small amount of air from the airbox past the piston rings. This air sweeps up through the engine and is drawn off through a crankcase breather.

In-line engines are equipped with a breather assembly which is mounted on the rocker cover or the flywheel housing. The 6V engines incorporate a breather assembly mounted inside of the upper engine front cover.

The wire mesh pad (element) in the breather assemblies should be cleaned if excessive crankcase pressure is observed. If it is necessary to clean the element, remove the breather housing from the flywheel housing (In-line engines) and the upper engine front cover (6V engines). Wash the element in fuel oil and dry it with compressed air. Reinstall the element and the breather assembly.

LUBRICATING SYSTEM

The Series 53 engine lubricating system, illustrated in Figs. 16 and 17, includes an oil intake screen and tube assembly, an oil pump, a pressure regulator, a full-flow oil filter or bypass filter with bypass valve and an oil cooler with a bypass valve.

Lubricating oil from the pump passes from the lower front cover through short oil galleries in the cylinder block. From the block, the oil flows to the full-flow oil filter, then through the oil cooler (if used) and back into the front engine cover and cylinder block oil galleries for distribution to the various engine bearings. The drains from the cylinder head(s) and other engine parts lead back to the oil pan.

Oil pressure is regulated by a pressure relief valve mounted in the engine front cover. Oil cooler and oil filter bypass valves prevent the stoppage of oil flow if these items become plugged.

OIL FILTERS

Each engine is equipped with a full-flow type lubricating oil filter (Figs. 14 and 15). If additional filtering is required, a bypass type oil filter may also be installed.

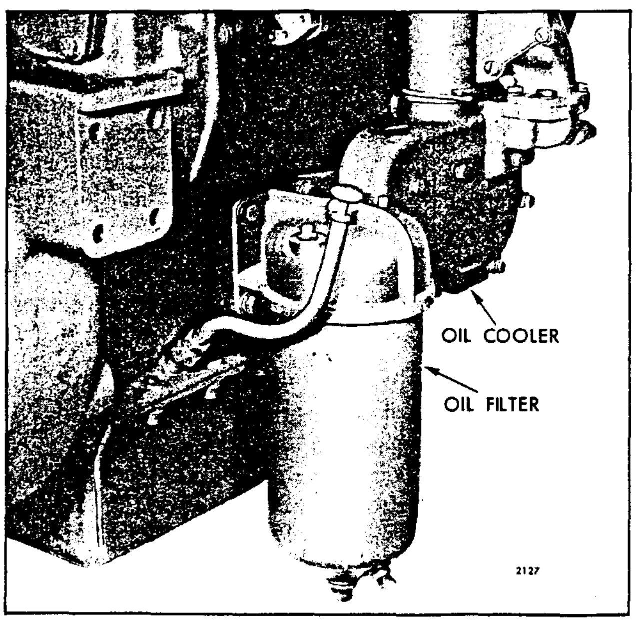


Fig. 14 - Typical In-Line Engine Oil Filter Mounting

All of the oil supplied to the engine passes through the full-flow filter that removes the larger foreign particles without restricting the normal flow of oil.

The bypass filter assembly, when used, continually filters a portion of the lubricating oil that is being bled off the oil gallery when the engine is running. Eventually all of the oil passes through the filter, filtering out minute foreign particles that may be present.

The lubricating oil filter elements should be replaced, each time the engine oil is changed, as follows:

1. Remove the drain plug and drain the oil.

2. The filter shell, element and stud may be detached as an assembly, after removing the center stud from the base. Discard the gasket.

3. Clean the filter base.

4. Discard the used element, wipe out the filter shell and install a new element on the center stud.

5. Place a new gasket in the filter base, position the shell and element assembly on the gasket and tighten the center stud carefully to prevent damaging the gasket or center stud.

6. Install the drain plug and, after the engine is started, check for oil leaks.

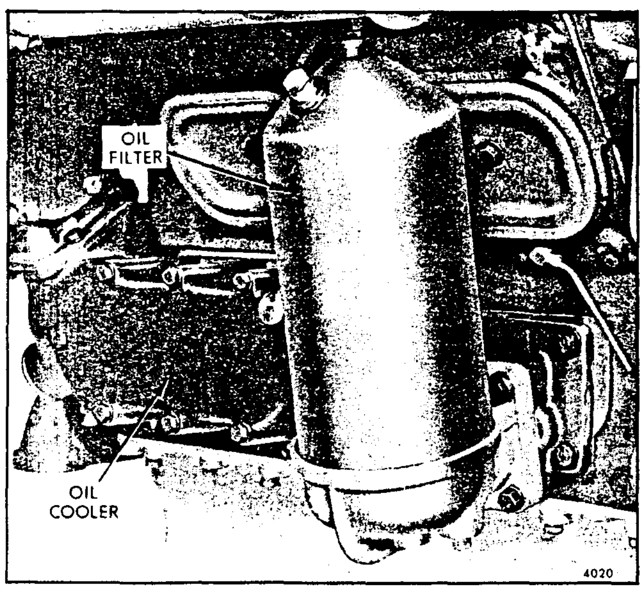
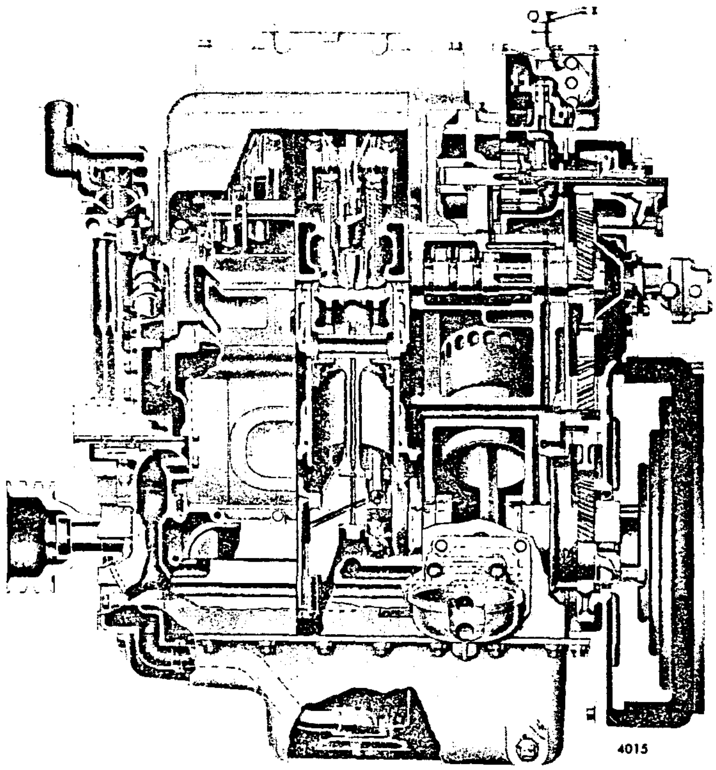
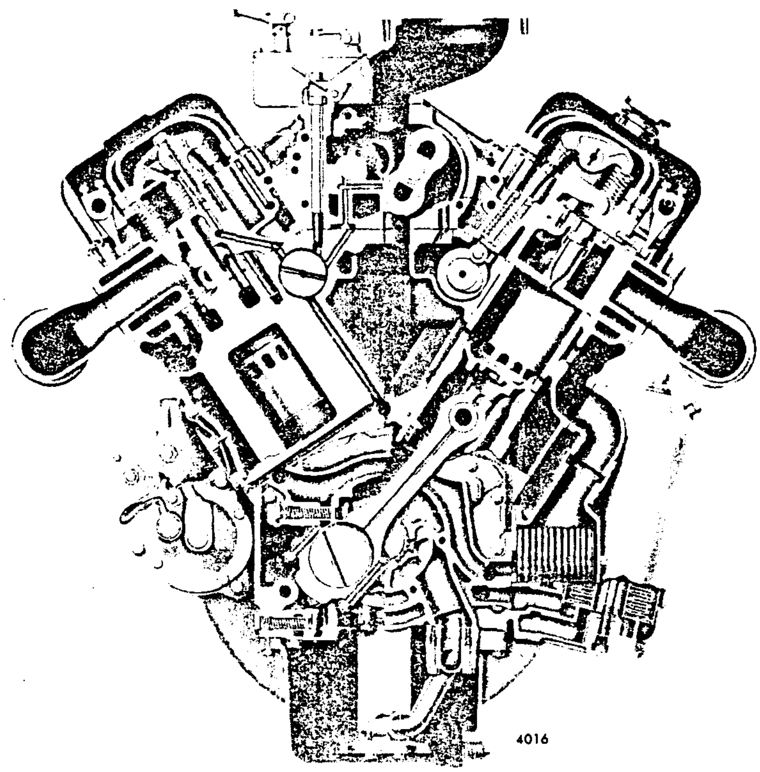


Fig. 15 - Typical V-Type Engine Oil Filter Mounting





Cross Section Views of a Typical 6V-53 Engine

ENGINE MODEL AND SERIAL NUMBER DESIGNATION

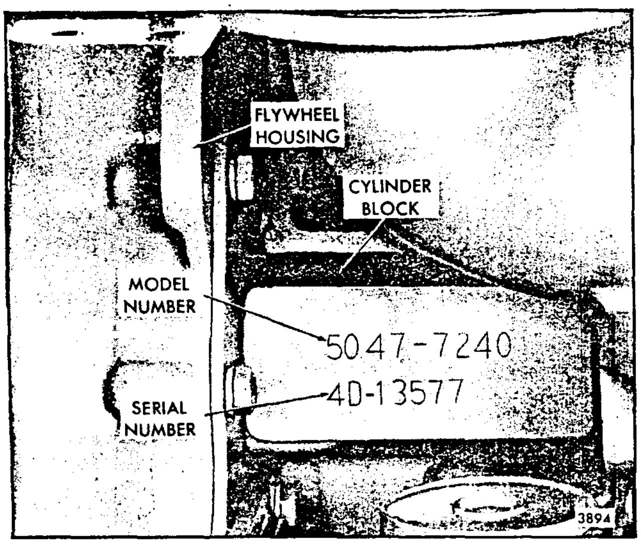


Fig. 5 - Typical Model and Serial Numbers as Stamped on Cylinder Block (In-Line Engine)

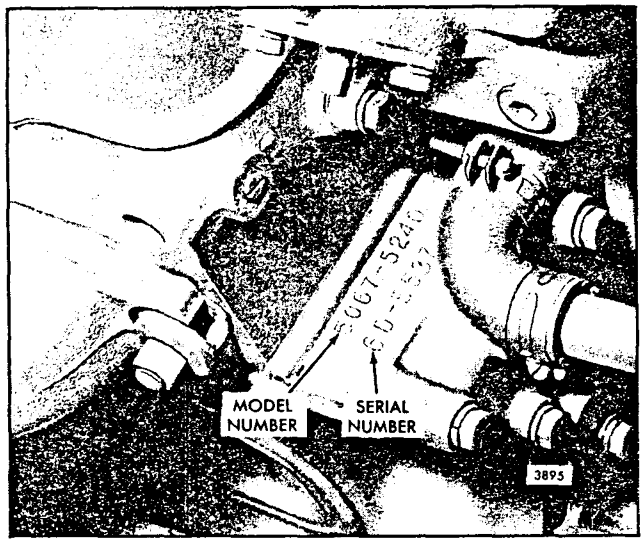


Fig. 6 - Typical Model and Serial Numbers as Stamped on Cylinder Block (6V Engine)

On the In-line engines, the model number and serial number are stamped on the right-hand side of the cylinder block in the upper rear corner (Fig. 5). The model number and serial number on the V-type engine is located on the top right- hand front corner of the cylinder block, as viewed from the rear of the engine (Fig. 6).

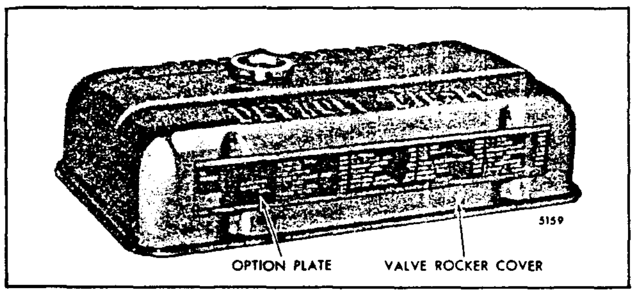


Fig. 7 - Option Plate

An option plate, attached to the valve rocker cover, is also stamped with the engine serial number and model number and, in addition, lists any optional equipment used on the engine (Fig. 7).

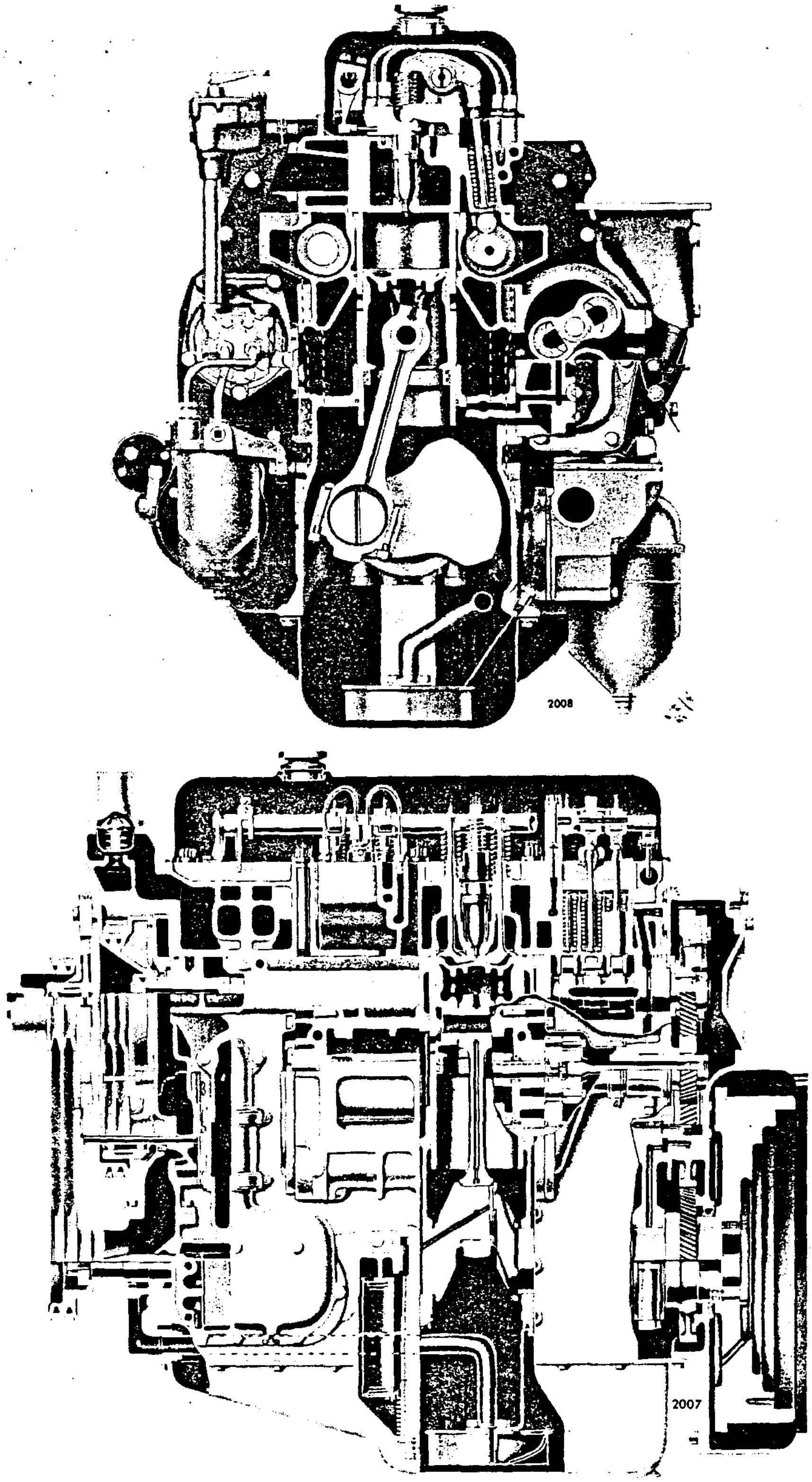
With any order for parts, the engine model number and serial number must be given. In addition, if a type number is shown on the option plate covering the equipment required, this number should also be included on the parts order.

Power takeoff assemblies, torque converters, hydraulic marine gears, etc. may also carry name plates pertaining to the particular assembly to which they are attached. The information on these name plates is useful when ordering parts for these assemblies.

BUILT-IN PARTS BOOK

The *Built-In Parts Book* is a photo etched aluminum plate (Option Plate) that fits into a holding channel on the engine valve rocker cover and contains the necessary information required when ordering parts. It is recommended that the engine user read the section on the *Built-In Parts Book* in order to take full advantage of the information provided on the engine option plate.

Numerous exploded view type illustrations are included to assist the user in identifying and ordering service parts.



Cross Section Views of a Typical In-Line Engine

5 0 6 3 — 5 2 0 0

SERIES 53	NUMBER OF CYLINDERS	APPLICATION DESIGNATION	BASIC ENGINE ARRANGEMENT * (see below)	DESIGN VARIATION	SPECIFIC MODEL NUMBER
5	06	3	5	2	00

APPLICATION DESIGNATION

5062-3000 MARINE
5063-5200 FAN to F/W-INDUSTRIAL
5064-5200 POWER-BASE
5065-5200 GENERATOR
5067-5040 FAN to F/W VEHICLE
5082-5000 MARINE
5083-5000 FAN to F/W INDUSTRIAL
5087-5040 FAN to F/W VEHICLE

DESIGN VARIATION

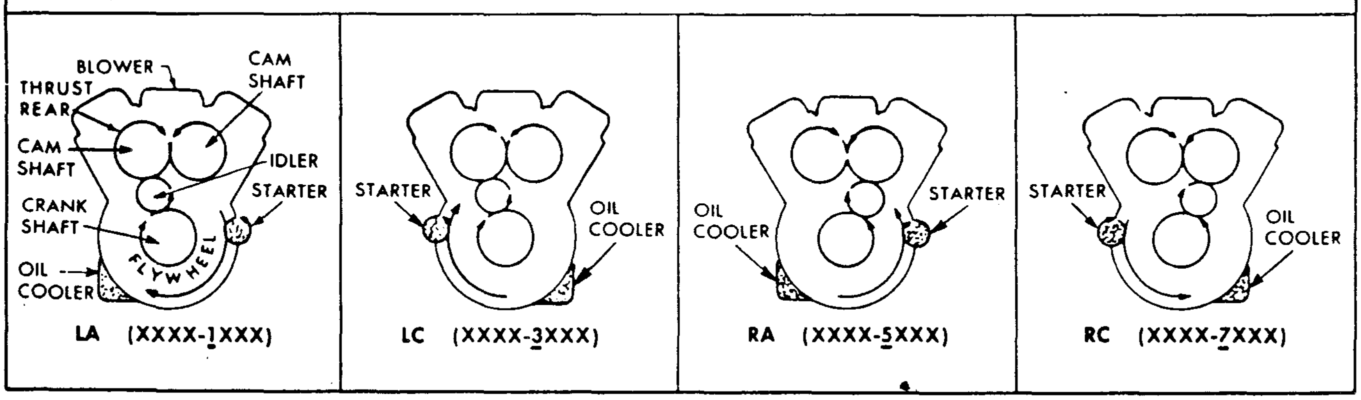
5062-3000 "N" ENGINE
5063-5200 4 VALVE HEAD
5063-5300 TURBOCHARGED

*** BASIC ENGINE ARRANGEMENTS**

Rotation: R-(right) and L-(left) designates rotation as viewed from the end of the engine opposite the flywheel.

Type: A and C designates location of starter and oil cooler as viewed from the flywheel end of the engine.

Cylinder Bank: Left and right cylinder banks are determined from the flywheel end of the engine.



ALL ABOVE VIEWS FROM REAR FLYWHEEL END OF ENGINE

11783

Fig. 3 · 6V Engine Model Description, Rotation and Accessory Arrangement

GENERAL SPECIFICATIONS

	3-53	4-53	6V-53
Type	2 Cycle	2 Cycle	2 Cycle
Number of Cylinders	3	4	6
Bore (inches)	3.875	3.875	3.875
Bore (mm)	98	98	98
Stroke (inches)	4.5	4.5	4.5
Stroke (mm)	114	114	114
Compression Ratio (Nominal)(Standard Engines)	17 to 1	17 to 1	17 to 1
Compression Ratio (Nominal)("N" Engines)	21 to 1	21 to 1	21 to 1
Total Displacement - cubic inches	159	212	318
Total Displacement - liters	2.61	3.48	5.22
Number of Main Bearings	4	5	4

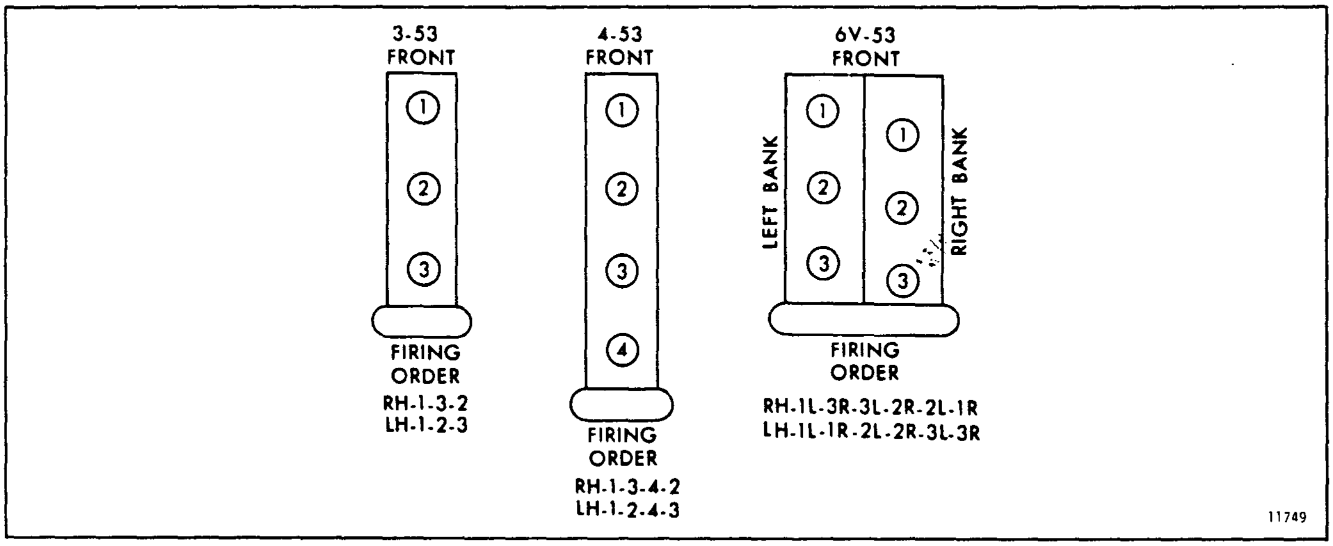


Fig. 4 - Series 53 Cylinder Arrangement

GENERAL DESCRIPTION

The Series 53 engines covered in this manual have the same bore and stroke and use many of the same parts.

The In-line engines, including the inclined marine models, include standard accessories such as the blower, water pump, governor and fuel pump, which, on some models, may be located on either side of the engine regardless of the direction the crankshaft rotates. Further flexibility in meeting installation requirements is achieved with the cylinder head which can be installed to accommodate the exhaust manifold on either side of the engine.

The V-type engine uses many In-line engine parts, including the 3-53 cylinder head. The blower is mounted on top of the engine between the two banks of cylinders and is driven by the gear train. The governor is mounted on the rear end of the 6V-53 blower.

The meaning of each digit in the model numbering system is shown in Figs. 2 and 3. The letter L or R indicates left or right-hand engine rotation as viewed from the front of the engine. The letter A,B,C or D designates the blower and exhaust manifold location on the In-line engines as viewed from the rear of the engine while the letter A or C designates the location of the oil cooler and starter on the 6V-53 engine.

Each engine is equipped with an oil cooler, replaceable element type lubricating oil filter, fuel oil strainer, fuel oil filter, an air cleaner or air silencer, a governor, a heat exchanger and raw water pump or a fan and radiator and a starting motor.

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

Oil is drawn by suction from the oil pan through the intake screen and pipe to the oil pump where it is pressurized and delivered to the oil filter and the oil cooler. From the oil cooler, the oil enters oil galleries in the cylinder block and cylinder head for distribution to the main bearings, connecting rod bearings, camshaft bearings, rocker arm mechanism and other functional parts.

Coolant is circulated through the engine by a centrifugal type water pump. Heat is removed from the coolant, which circulates in a closed system, by the radiator or heat exchanger. Control of the engine temperature is accomplished by thermostats that regulate the flow of the coolant within the cooling system.

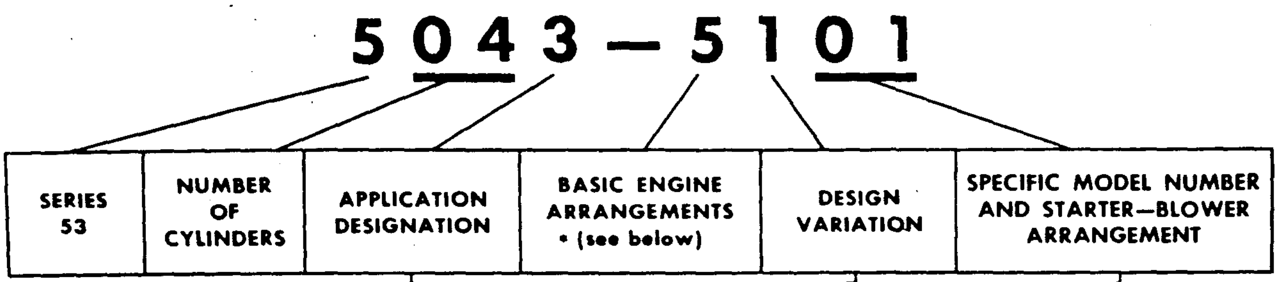
Fuel is drawn from the supply tank through the fuel strainer and enters a gear type fuel pump at the inlet side. Upon leaving the pump under pressure, the fuel is forced through the fuel filter into the inlet manifold where it passes through fuel pipes into the inlet side of the fuel injectors. The fuel is filtered through elements in the injectors and then atomized through small spray tip orifices into the combustion chamber. Excess fuel is returned to the fuel tank through the fuel outlet galleries and connecting lines.

Air for scavenging and combustion is supplied by a blower 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 air silencer.

Engine starting is provided by an electric starting system. The electric starting motor is energized by a storage battery. A battery-charging alternator, with a built-in voltage regulator, serves to keep the battery charged.

The engine speed is regulated by a mechanical or hydraulic type engine governor, depending upon the engine application.

MODEL DESCRIPTION



APPLICATION DESIGNATION

5042-5100	MARINE
5043-5100	FAN TO F/W—INDUSTRIAL
5044-5100	POWER-BASE
5045-5100	GENERATOR
5047-5100	FAN TO F/W—VEHICLE

DESIGN VARIATION

5043-5000	"N" ENGINE
5043-5100	2 VALVE HEAD
5043-5200	4 VALVE HEAD
5042-2302	TURBOCHARGER

STARTER—BLOWER ARRANGEMENT

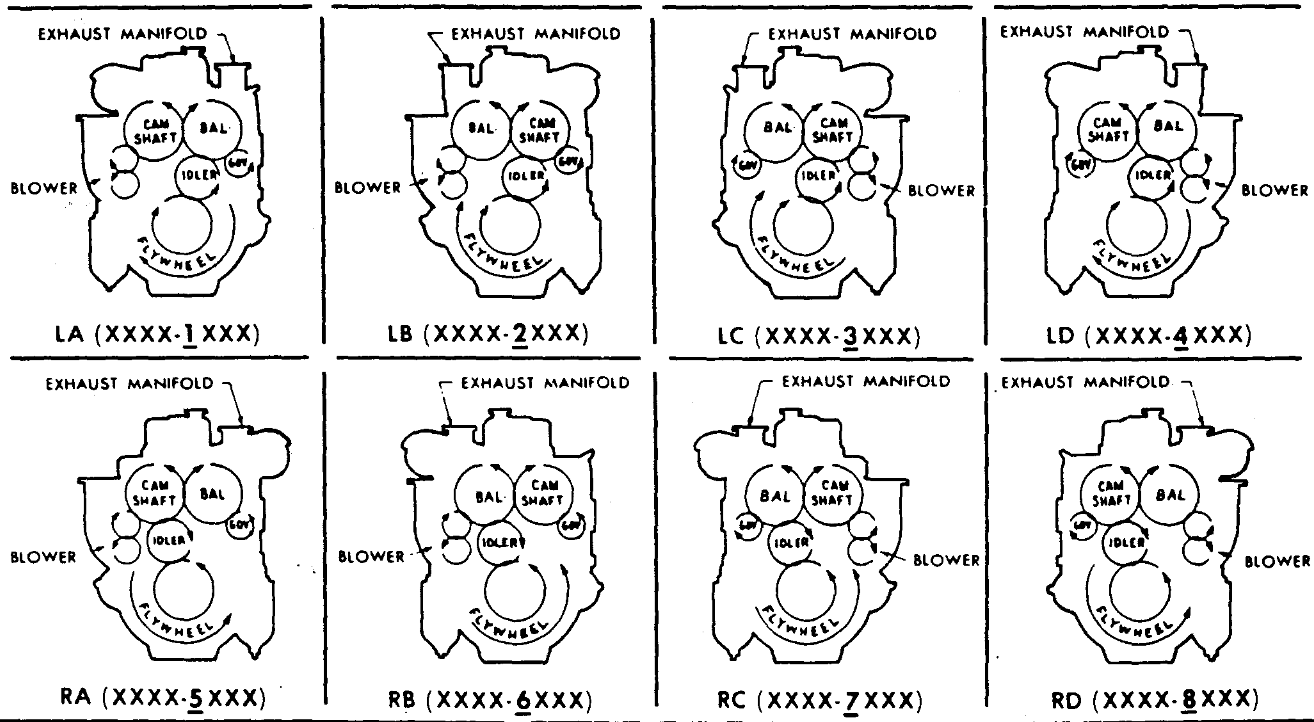
Odd number in last digit designates starter opposite blower.

Even number in last digit designates starter same side as blower.

*** 2, 3, 4-53 BASIC ENGINE ARRANGEMENTS**

Rotation: R-(right) and L-(left) designates rotation as viewed from the end of the engine opposite the flywheel.

Type: A-B-C-D designates location of exhaust manifold and blower as viewed from the flywheel end of the engine.



ALL ABOVE VIEWS FROM REAR (FLYWHEEL) END OF ENGINE

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Fig. 2 - In-Line Engine Model Description, Rotation and Accessory Arrangement

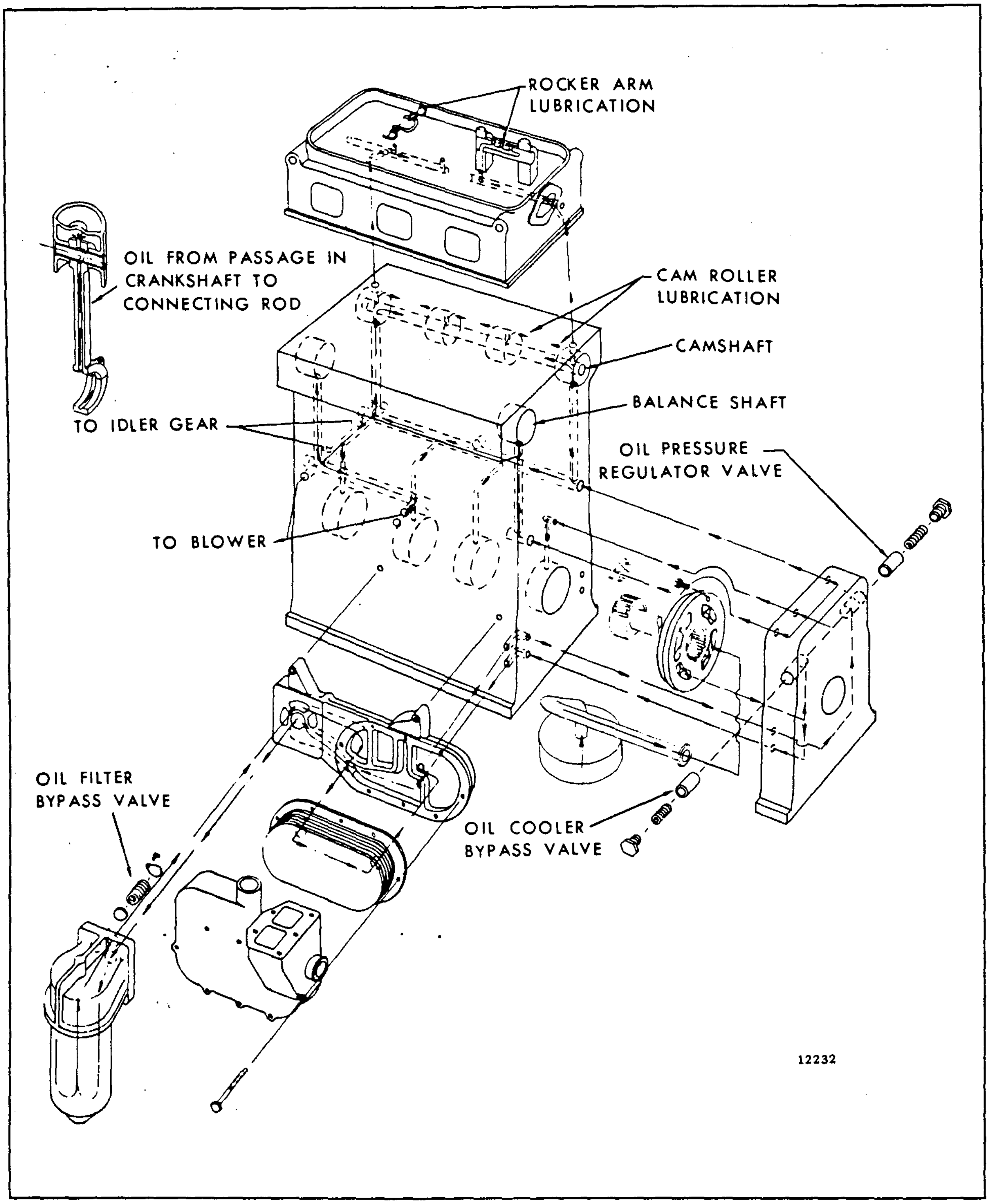


Fig. 16 - Schematic Diagram of Typical In-Line Engine Lubricating System

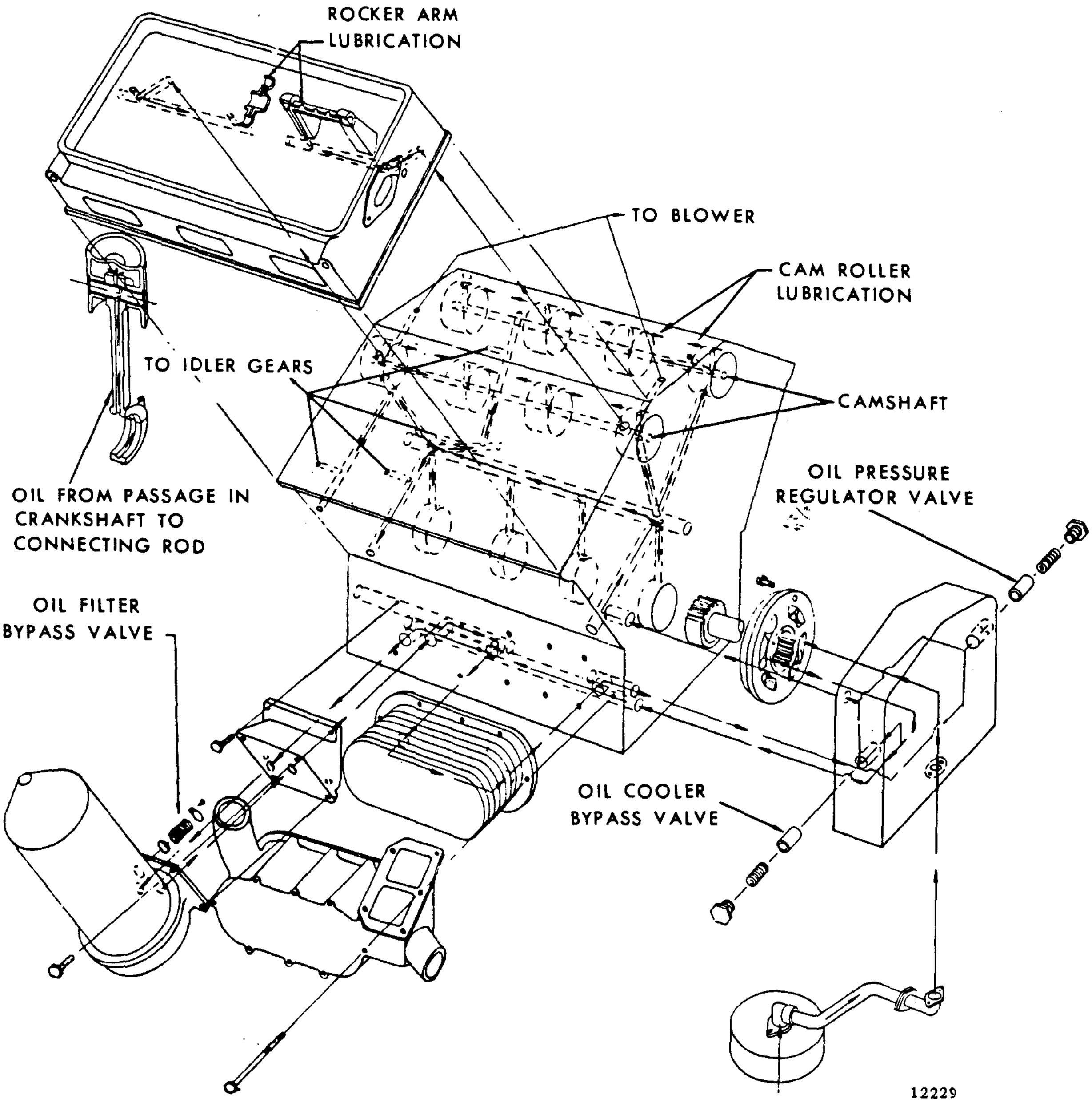


Fig. 17 - Schematic Diagram of Typical 6V Engine Lubricating System

COOLING SYSTEM

One of three different types of cooling systems is used on a Series 53 engine: radiator and fan, heat exchanger and raw water pump, or keel cooling. A centrifugal type water pump is used to circulate the engine coolant in each system. Each system incorporates thermostats to maintain a normal operating temperature of 160-185° F (71-85° C) or 170-187° F (77-86° C). Typical engine cooling systems are shown in Figs. 18 and 19.

RADIATOR and FAN COOLING

The engine coolant is drawn from the bottom of the radiator core by the water pump and is forced through the oil cooler and into the cylinder block. The coolant circulates up through the cylinder block into the cylinder head, then to the water manifold and thermostat housing. From the thermostat housing, the coolant returns to the radiator where it passes down a series of tubes and is cooled by the air stream created by the fan.

When starting a cold engine or when the coolant is below operating temperature, the coolant is restricted at the thermostat housing(s) and a bypass provides water circulation within the engine during the warm-up period.

HEAT EXCHANGER COOLING

In the heat exchanger cooling system, the coolant is drawn by the circulating pump from the bottom of the expansion tank through the engine oil cooler, then through the engine the same as in the radiator and fan system. Upon leaving the thermostat housing, the coolant either passes through the heat exchanger core or bypasses the heat exchanger and flows directly to the water pump, depending on the coolant temperature.

While passing through the core of the heat exchanger, the coolant temperature is lowered by raw water, which is drawn by the raw water pump from an outside supply. The raw water enters the heat exchanger at one side and is discharged at the opposite side.

To protect the heat exchanger element from electrolytic action, a zinc electrode is located in both the heat exchanger inlet elbow and the raw water pump inlet elbow and extends into the raw water passage.

The length of time a heat exchanger will function satisfactorily before cleaning will be governed by the kind of coolant used in the engine and the kind of raw water used. Soft water plus a rust inhibitor or an ethylene glycol base antifreeze should be used as the engine coolant.

When foreign deposits accumulate in the heat exchanger to the extent that cooling efficiency is impaired, such deposits can, in most instances, be removed by circulating a flushing compound through the fresh water circulating system without removing the heat exchanger. If this treatment does not restore the engine's normal cooling characteristics, contact an authorized *Detroit Diesel Allison Service Outlet.*

KEEL COOLING

The keel cooling system is similar to the heat exchanger system, except that the coolant temperature is reduced in the keel cooler. In this system, the coolant is drawn by the circulating pump from the bottom of the expansion tank through the engine oil cooler. From the cooler the flow is the same as in the other systems. Upon leaving the thermostat housing, the coolant is bypassed directly to the bottom of the expansion tank until the engine operating temperature, controlled by the thermostat, is reached. As the engine temperature increases, the coolant is directed to the keel cooler, where the temperature of the coolant is reduced before flowing back to the expansion tank.

COOLING SYSTEM MAINTENANCE

Engine Coolant

The function of the engine coolant is to absorb the heat, developed as a result of the combustion process in the cylinders, from the component parts such as exhaust valves, cylinder liners and pistons which are surrounded by water jackets. In addition, the heat absorbed by the oil is also removed by the engine coolant in the oil-to-water oil cooler.

For the recommended coolant, refer to *Coolant Specifications* in Section 5.

Cooling System Capacity

The capacity of the basic engine cooling system (cylinder block, head, thermostat housing and oil cooler housing) is shown in Table 1.

To obtain the complete amount of coolant in the cooling system of an engine, the additional capacity of the radiator, hoses, etc. must be added to the capacity of the basic engine. The capacity of radiators and related

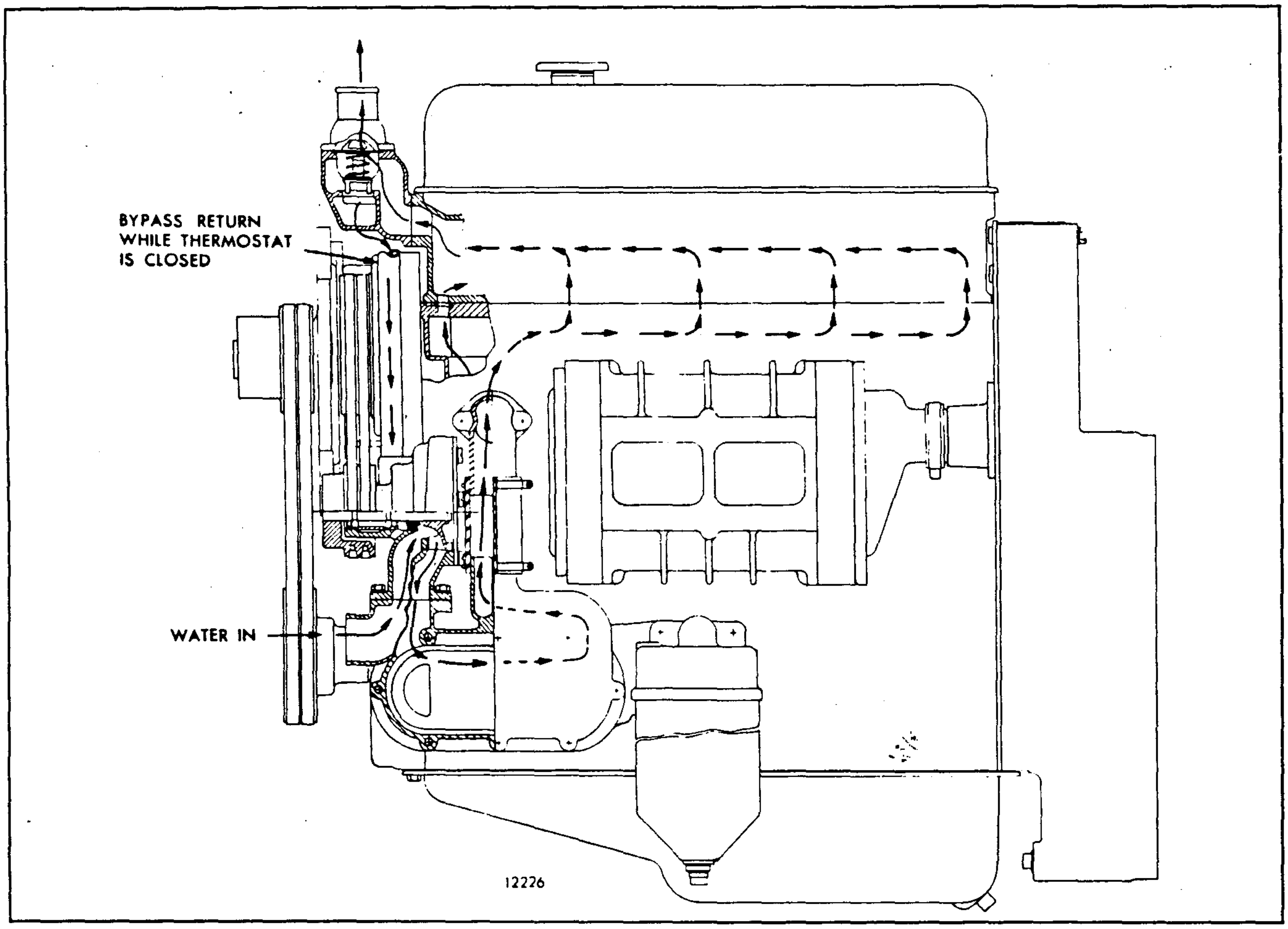


Fig. 18 - Typical Cooling System for In-Line Engines

equipment should be obtained from the equipment supplier.

Fill Cooling System

Before starting an engine, close all of the drain cocks and fill the cooling system completely. 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 normal operating temperature has been reached, allowing the coolant to expand to its maximum, check the coolant level. The coolant level should be within 2" of the top of the filler neck.

Should a daily loss of coolant be observed, and there are no apparent leaks, there is a possibility of gases 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 from the overflow pipe to a water container. Bubbles in the water in the container during engine operation will indicate this leakage. Another method for observing air in the cooling system is by inserting a transparent tube in the water outlet line.

Drain Cooling System

The engine coolant is drained by opening the cylinder block and radiator (heat exchanger) 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 or plugs are located on each side of the 4-53 and 6V cylinder blocks. The 3-53 cylinder block has a drain cock or plug located on the side of the block opposite the oil cooler. Drain cocks or plugs on both sides of the engine must be opened to drain the engine completely.

In addition to the drains on the cylinder blocks, the In-line engines have a drain cock located on the bottom of the oil cooler housing. The V-type engines have two

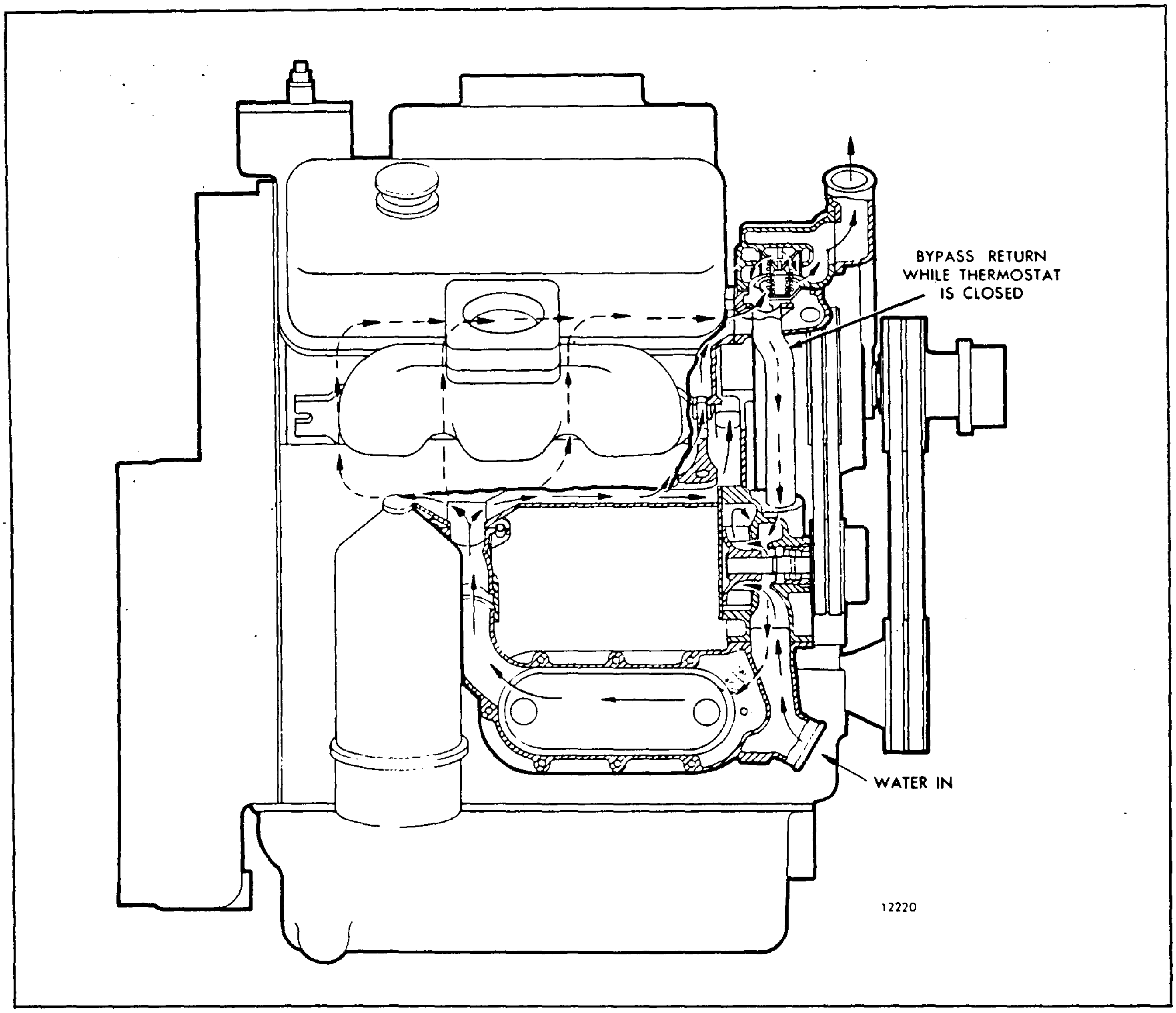


Fig. 19 - Typical Cooling System for V-Type Engine

drain cocks that must be opened when draining the system. Radiators, etc., that do not have a drain cock, are drained through the oil cooler housing drain.

COOLING SYSTEM CAPACITY CHART (BASIC ENGINE)		
ENGINE	CAPACITY	
	Quarts	Liters
3-53	8	7.6
4-53	9	8.5
6V-53	14	13.2

TABLE 1

To insure that all of the coolant is drained completely from an engine, 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 engines not adequately protected by antifreeze. Leave all of the drain cocks open until refilling the cooling system.

The exhaust manifolds of marine engines are cooled by the same coolant used in the engine. Whenever the engine cooling system is drained, each exhaust manifold drain cock, located on the bottom near the exhaust outlet, must be opened.

Raw water pumps are drained by loosening the cover attaching screws. It may be necessary to tap the raw water pump cover gently to loosen it. After the water has been removed, tighten the screws.

Flushing Cooling System

The cooling system should be flushed 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. 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 15 minutes to circulate the water thoroughly.

4. Drain the cooling system completely.

5. Refill the system with the solution required for the coming season.

Cooling System Cleaners

If the engine overheats and the fan belt tension and water level are satisfactory, clean and flush the entire cooling system. Remove scale formation by using a quality descaling solvent. Immediately after using the solvent, neutralize the system with the neutralizer. It is important that the directions printed on the container of the descaling solvent be thoroughly read and followed.

After the solvent and neutralizer have been used, completely drain the engine and radiator and reverse flush before filling the cooling 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 engine.

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.

> **NOTE:** 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 thermostat and the water pump.

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.

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.

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 thermostat and the radiator pressure cap should be checked and replaced, if found defective. The cooling system hoses should be inspected and any hose that feels abnormally hard or soft should be replaced immediately.

Also, check the hose clamps to make sure they are tight. All external leaks should be corrected as soon as detected. The fan belt must be checked and adjusted to provide the proper tension, and the fan shroud must be tight against the radiator core to prevent recirculation of air which may lower cooling efficiency.

Water Pump

A centrifugal-type water pump is mounted on top of the engine oil cooler housing, either on the right-hand or left-hand side of the engine, depending upon the engine model and rotation. It circulates the coolant through the cooling system.

The pump is belt driven, by either the camshaft or balance shaft (In-line engines) or by one of the camshafts (V-type engines).

An impeller is pressed onto one end of the water pump shaft, and a water pump drive pulley is pressed onto the opposite end. The pump shaft is supported on a sealed double-row combination radial and thrust ball bearing. Coolant is prevented from creeping along the shaft toward the bearing by a seal. The shaft and bearing constitute an assembly and are serviced as such, since the shaft serves as the inner race of the ball bearing.

The sealed water pump shaft ball bearing is filled with lubricant when assembled. No further lubrication is required.

Contact an authorized *Detroit Diesel Allison Service Outlet* if more information is needed.

Raw Water Pump

The raw water pump (Figs. 20 and 21) is a positive displacement pump, used for circulating raw water through the heat exchanger to lower the temperature of the engine coolant. It is driven by a coupling from the end of the camshaft.

Seal failure is readily noticed by a flow of water visible at the openings in the raw water pump housing, located between the pump mounting flange and the inlet and outlet ports. These openings must remain open at all times.

The impeller, cam and wear plate assembly, and water seal assembly may be serviced without removing the pump from the engine as outlined below.

1. Remove the cover and gasket.

2. Note the position of the impeller blades to aid in the reassembly. Then, grasp a blade on each side of the impeller with pliers and pull the impeller off of the shaft.

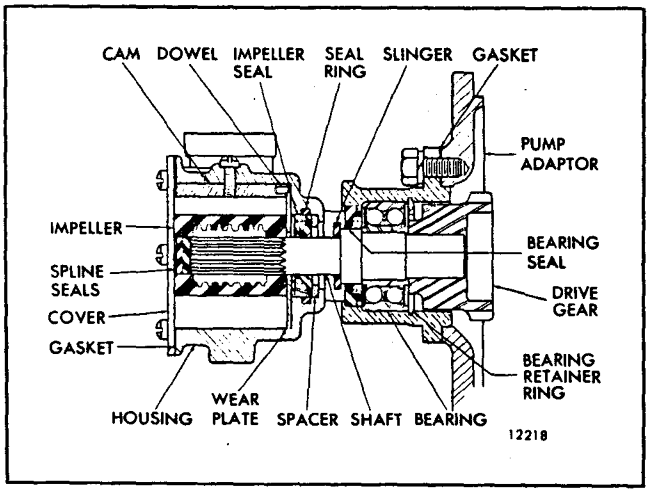


Fig. 20 - Raw Water Pump Used on In-Line Engine

3. The neoprene spline seal(s) can be removed from the impeller by pushing a screw driver through the impeller from the open end.

> **NOTE:** If the impeller is reuseable, exercise care to prevent damage to the splined surfaces.

4. Remove the cam retaining screw and withdraw the cam and wear plate assembly.

5. Remove the seal assembly from the pump used on a V-type engine by inserting two wires with hooked ends between the pump housing and seal with the hooks over the edge of the carbon seal. Remove the seal seat and gasket in the same way.

6. The seal may be removed from the pump used on the In-line engine by drilling two holes in the seal case and placing metal screws in the holes so that they may be grasped and pulled with pliers. Then, remove the rubber seal ring.

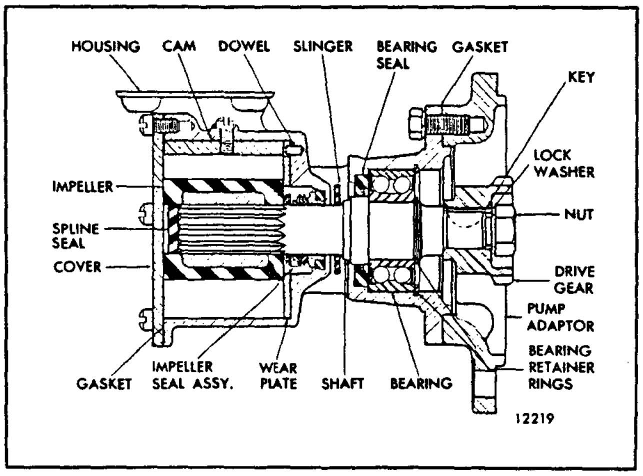


Fig. 21 - Raw Water Pump Used on V-Type Engine

7. Clean and inspect the impeller, cam and wear plate assembly and water seal. The impeller must have a good bond between the neoprene and the metal. If the impeller blades are damaged, worn or have taken a permanent set, replace the impeller. Reverse the wear plate if it is worn excessively and remove any burrs. Replace the seal, if necessary.

8. Install the seal assembly in the pump used on a V-type engine as follows:

a. If the seal seat and gasket were removed, place the gasket and seal seat over the shaft and press them into position in the seal cavity.

b. Place the seal ring securely in the ferrule, and with the carbon seal and washer correctly positioned against the ferrule, slide the ferrule over the shaft and against the seal seat. Use care to ensure that the seal ring is contained within the ferrule so that it grips the shaft.

c. Install the flat washer and then the marcel washer.

A new seal may be installed in the pump used on the In-line engine by placing the rubber seal ring in its groove, starting the seal (with the lip facing the impeller cavity) over the shaft and tapping it into place against the seal spacer.

9. Install the cam and wear plate assembly. The wear plate is round and is doweled to the cam. The wear plate must be installed with the cam in the pump housing as an assembly.

10. Apply a non-hardening sealant to the cam retaining screw and the hole in the pump body to prevent any leakage. Then, hold the cam with the tapped hole aligned and secure it with the screw.

11. Compress the impeller blades to clear the offset cam and press the impeller on the splined shaft. The blades must be correctly positioned to follow the direction of rotation.

12. Install the neoprene splined seal(s) in the bore of the impeller.

13. Turn the impeller several revolutions in the normal direction of rotation to position the blades.

14. Affix a new gasket and install the pump cover.

The Jabsco raw water pump is equipped with a synthetic rubber impeller. Since synthetic rubber loses its elasticity at low temperatures, impellers made of natural rubber should be installed when it is necessary to pump raw water that has a temperature below 40° F (4° C).

The natural rubber impeller can be identified by a stripe of green paint between two of the impeller blades.

ENGINE EQUIPMENT

INSTRUMENT PANEL, INSTRUMENTS AND CONTROLS

The instruments generally required in the operation of a diesel engine consist of an oil pressure gage, a water temperature gage, an ammeter and a mechanical tachometer (Fig. 1). Also, closely related and usually installed in the general vicinity of these instruments are certain controls consisting of an engine starter switch, an engine stop knob, an emergency stop knob and, on certain applications, the engine hand throttle.

Torqmatic converters are equipped with an oil pressure gage and, in some instances, an oil temperature gage. These instruments are mounted on a separate panel.

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 under *Running* in the *Engine Operating Instructions* (see Section 4), the engine should be stopped and the cause of low oil pressure determined and corrected before the engine is started again.

Water Temperature Gage

The engine coolant temperature is registered on the water temperature gage.

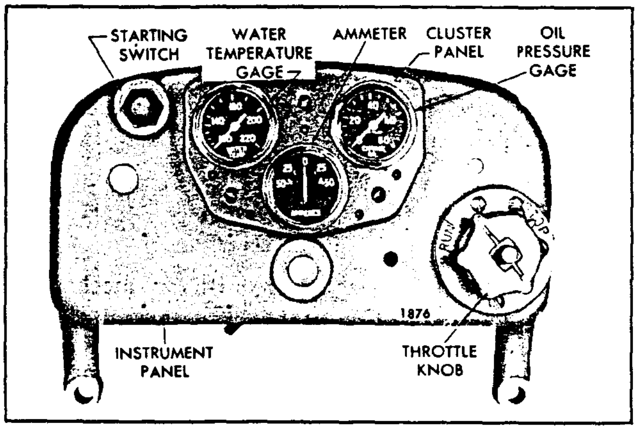


Fig. 1 - Typical Instrument Panel

Ammeter

An ammeter is incorporated 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 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 alternator. If lights or other electrical equipment are connected into the circuit, the ammeter will show discharge when these items are operating or the engine speed is reduced.

Tachometer

The tachometer is driven by the engine and registers the speed of the engine in revolutions per minute (rpm).

Engine Starting Motor Switch

The starting switch is mounted on the instrument panel with the contact button extending through the front face of the panel. The switch is used to energize the starting motor. As soon as the engine starts, release the switch.

Stop Knob

A stop knob is used on most applications to shut the engine down. When stopping an engine, the 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, the stop knob should be pulled and held until the engine stops. Pulling on the stop knob manually places the injector racks in the *no-fuel* position. The stop knob should be returned to its original position after the engine stops.

When an emergency shut down is necessary, the stop knob should be pulled immediately and held until the engine stops.

Emergency Stop Knob
(Engines with Air Shutoff Valve)

In an emergency, or if after pulling the stop knob, the engine continues to operate, the emergency stop knob may be pulled to stop the engine. The emergency stop knob, when pulled, will trip the air shutoff valve located between the air inlet housing and the blower and shut off the air supply to the engine. Lack of air will prevent further combustion of the fuel and stop the engine.

The emergency stop knob must be pushed back in after the engine stops so the air shutoff valve can be opened for restarting after the malfunction has been corrected.

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 PROTECTIVE SYSTEMS

MANUAL SHUTDOWN

The manually operated emergency engine shutdown device, mounted in the air inlet housing, is used 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 overspeeding of the engine, the shutdown device will prevent damage to the engine by cutting off the air supply and thus stopping the engine.

The shutdown device consists of an air shutoff valve mounted in the air inlet housing which is retained in the open position by a latch. A cable assembly is used to remotely trip the latch. Pulling the emergency shutdown knob all the way out will stop the engine. After the engine stops, the emergency shutdown knob must be pushed all the way in and the air shutoff valve manually reset before the engine can be started again.

AUTOMATIC MECHANICAL SHUTDOWN

The automatic mechanical shutdown system (Fig. 3) is designed to stop the engine if there is a loss of oil pressure, loss of engine coolant, overheating of the engine coolant, or overspeeding of the engine. Engine oil pressure is utilized to activate the components of the system.

A coolant temperature-sensing valve and an adaptor and copper plug assembly are mounted on the exhaust manifold outlet. The power element of the temperature-sensing valve is placed against one end of the copper plug, and the other end of the plug extends into the exhaust manifold. Engine coolant is directed through the adaptor and passes over the power element of the valve. Engine oil, under pressure, is directed through a restricted fitting to the temperature-sensing valve and to an oil pressure actuated bellows located on the air inlet housing.

The pressure of the oil entering the bellows overcomes the tension of the bellows spring and permits the latch to retain the air shutoff valve in the open position. If the oil pressure drops below a predetermined value, the spring in the bellows will release the latch and permit the air shutoff valve to close and thus stop the engine.

The overspeed governor, used on certain applications, consists of a valve actuated by a set of spring-loaded weights. Engine oil is supplied to the valve through a connection in the oil line between the bellows and the temperature-sensing valve. An outlet in the governor valve is connected to the engine oil sump. Whenever the engine speed exceeds the overspeed governor setting, the valve (actuated by the governor weights) is moved from its seat and permits the oil to flow to the engine sump. This decreases the oil pressure to the bellows, thus actuating the shutdown mechanism and stopping the engine.

A restricted fitting, which will permit a drop in oil pressure great enough to actuate the shutdown mechanism, is required in the oil line between the cylinder block oil gallery and the shutdown sensing devices.

To be sure the protective system will function properly if an abnormal engine condition occurs, have the system checked periodically by your local *Detroit Diesel Allison Service Outlet.*

Also, make sure the air shutoff valves close each time the engine is shut down.

Operation

To start an engine equipped with a mechanical shutdown system, first manually open the air shutoff valve, and then press the engine starting switch. As soon as the engine starts, the starting switch may be released, but the air shutoff valve must be held in the open position until the engine oil pressure increases sufficiently to permit the bellows to retain the latch in the open position.

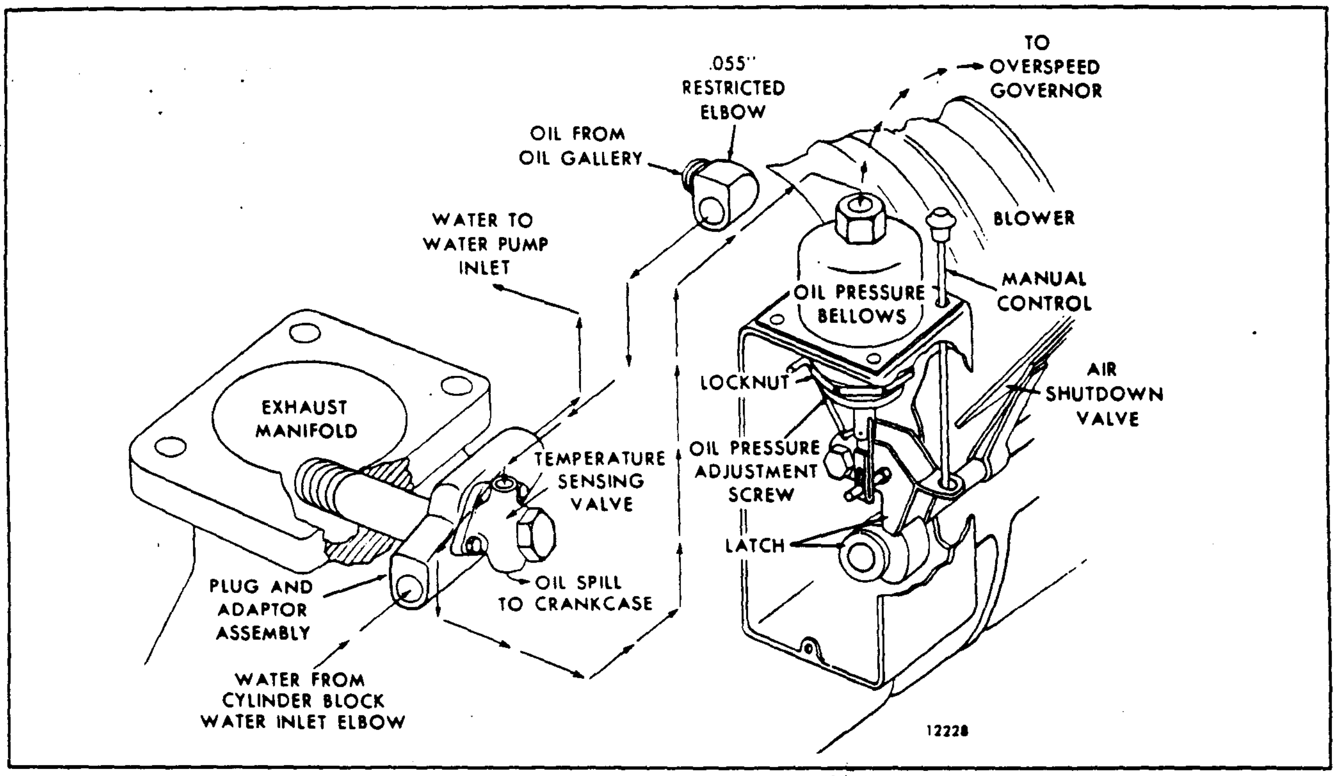


Fig. 2 - Mechanical Shutdown System Schematically Illustrated

During operation, if the engine oil pressure drops below the setting of the pressure sensitive bellows, the spring within the bellows will release the latch and permit the air shutoff valve to close, thus stopping the engine.

If the engine coolant overheats, the temperature-sensing valve will open and permit the oil in the protective system to flow to the engine crankcase. The resulting decrease in oil pressure will actuate the shutdown mechanism and stop the engine. Also, if the engine loses its coolant, the copper plug will be heated up by the hot exhaust gases passing over it and cause the temperature-sensing valve to open and actuate the shutdown mechanism.

Whenever the engine speed exceeds the overspeed governor (if used) setting, the oil in the line flows to the sump, resulting in a decrease in oil pressure. The oil pressure bellows then releases the latch and permits the air shutoff valve to close.

When an engine is stopped by the action of the shutdown system, the engine cannot be started again until the particular device which actuated the shutdown mechanism has returned to its normal position. *The abnormal condition which caused the engine to stop must be corrected before attempting to start it again.*

AUTOMATIC ELECTRICAL SHUTDOWN

The automatic electrical shutdown system protects the engine against a loss of coolant, overheating of the coolant, loss of oil pressure, or overspeeding (Fig. 3). 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, the 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. The water temperature switch remains open.

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 to approximately 203° F (95° C) will close the contacts in the water temperature switch, thus closing the

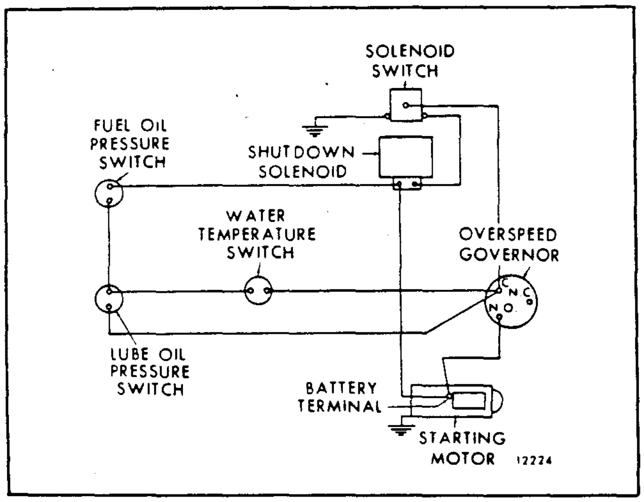


Fig. 3 - Automatic Electrical ShutDown System Diagram

electrical circuit and activating the shutdown mechanism.

The water temperature switch consists of a temperature-sensing valve and a micro-switch. The valve contacts a copper plug (heat probe) which extends into the exhaust manifold outlet. Engine water is directed over the power element of the valve and should the water temperature exceed approximately 203° F (95° C), the valve will close the contacts in the micro-switch and energize the shutdown circuit. If a loss of water occurs, the heat of the exhaust gases will be transmitted through the copper plug to the temperature-sensing valve and cause the shutdown circuit to be activated.

If the engine speed exceeds the high speed setting of the overspeed governor, the governor switch will close and activate the shutdown mechanism.

When the engine is shut down, the decrease in speed will open the governor switch, and the decrease in oil and fuel pressures will close the oil pressure switch and open the fuel pressure switch, thus de-energizing the circuit.

The cause of the abnormal conditions must then be determined and corrected before the engine is started again. Also, the air shutoff valve must be manually reset in the open position before the engine can be started.

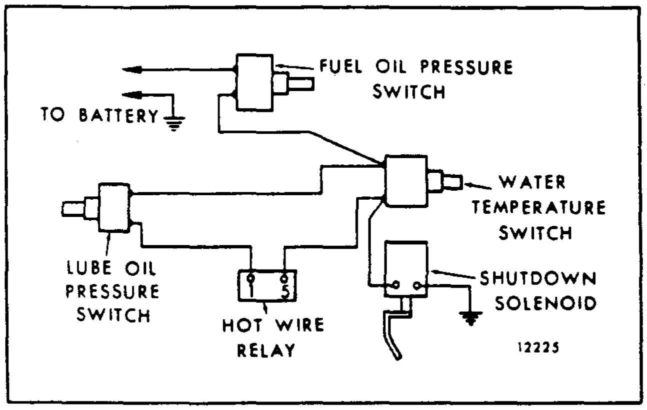


Fig. 4 - Automatic Electrical ShutDown System Incorporating Hot Wire Relay

Some engines are equipped with an electrically operated automatic shutdown system which incorporates a hot wire relay (Fig. 4).

Since the fuel pressure builds up rapidly, the fuel oil pressure switch could close before the lubricating oil pressure switch opens and stop the engine. The hot wire relay, however, delays the closing of the fuel oil pressure switch for several 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 through the hot wire relay to the solenoid. The few seconds required to heat the hot wire relay 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.

The water temperature switch, which remains open during normal engine operation, is installed in the side of the thermostat housing. The switch contacts close when the water temperature reaches approximately 205° F (96° C) and activate the shutdown solenoid.

ALARM SYSTEM

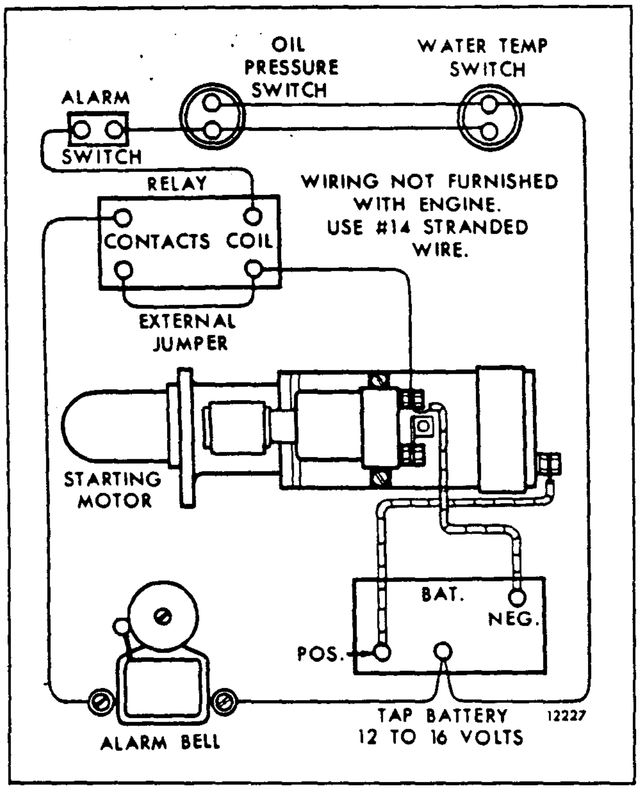


Fig. 5 - Alarm System Wiring Diagram

The alarm system is similar to the automatic electrical shutdown system, but uses a warning bell in place of the air shutoff valve solenoid (Fig. 5). The bell warns the engine operator if the engine coolant overheats or the oil pressure drops below the safe operating limit.

When the engine is started and the oil pressure is sufficient to open the oil pressure switch contacts (opening pressure is stamped on the switch cover), the alarm switch must be turned on manually to put the system in operation. The water temperature switch is normally open. Should the engine coolant exceed 205° ± 5° F (96° ± 3° C), the water temperature switch will close the electrical circuit and sound the alarm bell. Likewise, if the oil pressure drops below the setting of the oil pressure switch, the switch will close and cause the bell to ring. The bell will continue to ring until the engine operator turns the alarm switch off. The alarm switch must also be turned off before a routine stop since the decreasing oil pressure will close the oil pressure switch and cause the bell to ring.

If the alarm bell rings during engine operation, stop the engine immediately and determine the cause of the abnormal condition. *Make the necessary corrections before starting the engine again.*

STARTING SYSTEMS

ELECTRICAL STARTING

The electrical system on the engine generally consists of a battery-charging alternator, a starting motor, voltage regulator, storage battery, starter switch and the necessary wiring. Additional electrical equipment may be installed on the engine at the option of the owner.

Starting Motor

The starting motor has a Sprag overrunning clutch. Pressing the starting switch engages the starting motor pinion with the teeth of the flywheel ring gear and energizes the starting motor. The starting motor drives the pinion and rotates the crankshaft. When the engine begins to operate, the Sprag clutch permits the pinion to overrun on its shaft, until the starting switch is released, and prevents overspeeding the starting motor.

Starter Switch

To start the engine, a switch is used to energize the starting motor. Release the switch immediately after the engine starts.

Battery-Charging Alternator

The battery-charging alternator provides the electrical current required to maintain 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.

Alternator Precautions

Precaustions must be taken when working on or around an alternator. The diodes and transistors in the alternator circuit are very sensitive and can be easily destroyed.

Avoid grounding 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 whether or not the engine is running, and 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 an alternator. Polarization is not necessary and is harmful.

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.

Regulator

A voltage regulator is introduced into the electrical system to regulate the voltage and current output of the battery-charging alternator and to maintain a fully charged storage battery.

Storage Battery

The lead-acid storage battery is an electrochemical device for converting chemical energy into electrical energy.

The battery has three major functions:

1. It provides a source of electrical power 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 of the unit exceed the output of the alternator.

The battery is a perishable item which requires periodic servicing. A properly cared for battery will give long and trouble-free service.

1. 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 top 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.

3. Inspect the cables, clamps and hold-down bracket regularly. Clean and reapply a light coating of grease when needed. Replace corroded, damaged parts.

4. Use the standard, quick in-the-unit battery test as the regular service test to check battery condition.

5. Check the electrical system if the battery becomes discharged repeatedly.

> **CAUTION:** Explosive gas may remain in or around the battery for several hours after it has been charged. Sparks or flame can ignite this gas causing an explosion which could shatter the battery. Flying pieces of the battery structure and splash of electrolyte can cause personal injury.

If the engine is to be stored for more than 30 days, remove the battery. The battery should be stored in a cool, dry place. Keep the battery fully charged and check the level of the electrolyte regularly.

The *Lubrication and Preventive Maintenance* section of this manual (Section 5) covers the servicing of the starting motor and alternator.

Consult an authorized *Detroit Diesel Allison Service Outlet* for information regarding the electrical system.

GOVERNORS

Horsepower requirements of an engine may vary continually due to the fluctuating loads; therefore, some means must be provided to control the amount of fuel required to hold the engine speed reasonably constant during such load fluctuations. To accomplish this control, one of three types of governors is used on the engines. Installations requiring maximum and minimum speed control, together with manually controlled intermediate speeds, ordinarily use a *limiting speed* mechanical governor. Applications requiring a near constant engine speed, under varying load conditions, that may be changed by the operator, are equipped with a *variable speed* mechanical governor. The *hydraulic governor* is used where uniform engine speed is required, under varying load conditions, with a minimum speed droop.

Lubrication

The mechanical governors are lubricated by oil splash from the engine gear train. Oil entering the governor is directed by the revolving governor weights to the various moving parts requiring lubrication.

The hydraulic governor is lubricated by oil under pressure from the engine.

Service

Governor difficulties are usually indicated by speed variations of the engine. However, speed fluctuations are not necessarily caused by the governor and, therefore, when improper speed variations become evident, the unit should be checked for excessive load, misfiring or bind in the governor operating linkage. If none of these conditions are contributing to faulty governor operation, contact an authorized *Detroit Diesel Allison Service Outlet.*

TRANSMISSIONS

POWER TAKEOFF ASSEMBLIES

The front and rear power takeoff units are basically similar in design, varying in clutch size to meet the requirements of a particular application. The power takeoff unit is attached to either an adaptor (front power takeoff) or the engine flywheel housing (rear power takeoff).

Clutch Adjustment

These instructions refer to field adjustment for clutch facing wear. Frequency of adjustment depends upon the amount and nature of the load. To ensure a long clutch facing life and the best performance, the clutch should be adjusted before slippage occurs.

When the clutch is properly adjusted, a heavy pressure is required at the outer end of the hand lever to move the throwout linkage to the "over center" or locked position.

Adjust the clutch as follows:

1. Disengage the clutch with the hand lever.

2. Remove the inspection hole cover to expose the clutch adjusting ring. Rotate the clutch, if necessary, to bring the adjusting ring lock within reach.

3. Remove the clutch adjusting ring spring lock screw and lock from the inner clutch pressure plate and adjusting ring. Then, while holding the clutch drive shaft to prevent the clutch from turning, turn the clutch adjusting ring counterclockwise (Fig. 6) and tighten the clutch until the desired pressure on the outer end of the hand lever, or at the clutch release shaft (Fig. 7), is obtained (Table 1).

When properly adjusted, the approximate pressure required at the outer end of the hand lever to engage

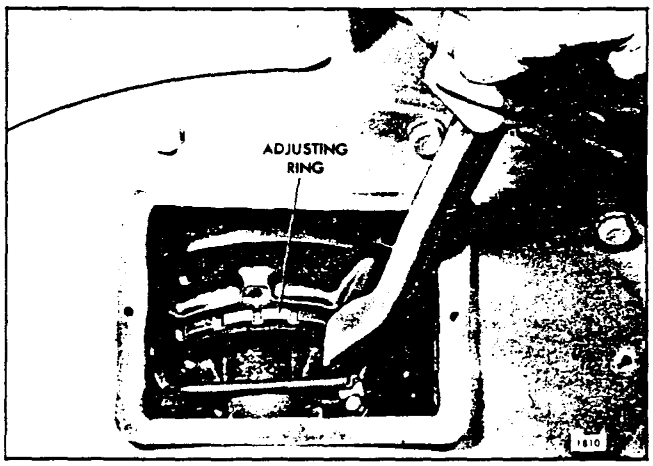


Fig. 6 - Adjusting Clutch

Clutch Diameter	Hand Lever Length	Pressure PSI	Pressure kPa	Torque lb-ft	Torque Nm
8"	15 1/2"	55	379	56-63	76-85
10"	15 1/2"	80	552	87-94	113-127
*11 1/2"	15 3/8"	100	689	129	175
11 1/2"	20"	105	724	112-120	152-163

*Twin Disc Clutch

TABLE 1

the various diameter clutches is shown in Table 1. These specifications apply only with the hand lever which is furnished with the power takeoff.

A suitable spring scale may be used to check the pounds pressure required to engage the clutch. However, a more accurate method of checking the clutch adjustment is with a torque wrench (Fig. 7).

To fabricate an adaptor, saw the serrated end off of a clutch hand lever and weld a 1-1/8" nut (across the hex) on it (Fig. 7). Then, saw a slot through the nut.

When checking the clutch adjustment with a torque wrench, engage the clutch slowly and note the amount of torque immediately before the clutch engages (goes over center). The specified torque is shown in Table 1.

The thrust load on the bronze clutch release bearing should be kept at an absolute minimum. Therefore, the hand lever should be positioned on the shaft as near the

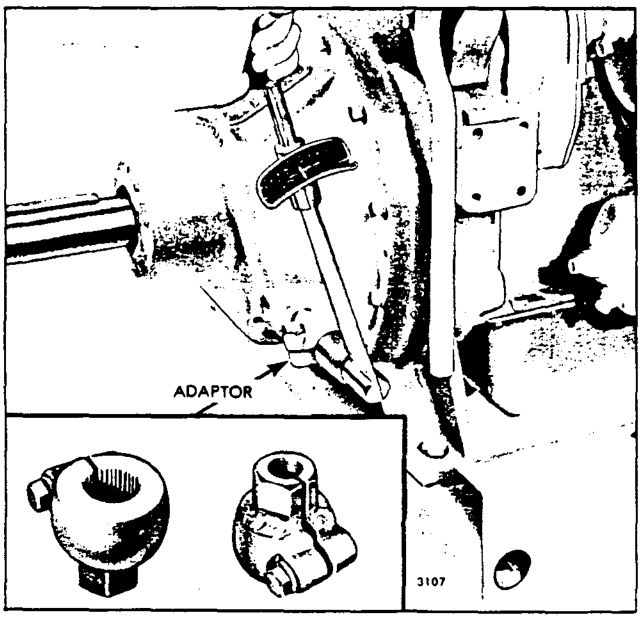


Fig. 7 - Checking Clutch Adjustment with a Torque Wrench and Adaptor

12 o'clock or 6 o'clock position as possible. The 9 and 3 o'clock positions are to be avoided.

Make a final clutch adjustment with the engine running as follows:

1. Start the engine and operate it at idling speed (approximately 500 rpm) with the clutch disengaged. The speed will be sufficient to move the segments out to the operating position.

2. Check the pressure required to engage the clutch. The engagement pressure should be the same as that following the adjustment. If the clutch engages at a lower pressure, the adjustment was probably made against the unworn portion of the facing.

3. Stop the engine and readjust the clutch, making sure all disc segments are properly positioned. Install the inspection hole cover.

TORQMATIC CONVERTERS

The Torqmatic converter is a self contained unit which transfers and multiplies the torque of the prime mover. This unit transmits the power through the action of oil instead of through gears and in addition to multiplying the torque also acts as a fluid coupling between the engine and the equipment to be powered. The converter will automatically adjust the output torque to load requirements.

There are various combinations of Torqmatic converters with features such as: an automotive or industrial flange on the shaft, an hydraulically operated lock-up clutch, a manual input disconnect clutch, and an accessory drive for either a governor or tachometer.

Check the oil level daily. If the converter is equipped with an input disconnect clutch, additional checks and service will be necessary daily or at intervals determined by the type of operation.

Adjust the disconnect clutches as outlined under power takeoff clutch adjustment.

Contact an authorized *Detroit Diesel Allison Service Outlet* for service on Torqmatic converters.

WARNER MARINE GEAR

The Warner hydraulic marine gear assembly consists of an hydraulically operated multiple disc clutch in combination with an hydraulically actuated reversing gear train, an oil pressure regulator, an oil sump independent of the engine oil system and an oil cooler mounted on the engine.

Oil pressure for the operation of the marine gear is provided by an oil pump incorporated within the gear housing and driven continuously while the engine is running. The oil is delivered under pressure from the pump to a combination marine gear control valve and pressure regulator valve.

The pressure regulator valve maintains constant pressure over a wide speed range and the control valve directs the oil under pressure to either the forward or reverse piston cylinder. The operating oil pressure range for the marine gear at operating speed is 120 to 140 psi (827 to 965 kPa) and the maximum oil temperature is 225° F (107° C). Minimum oil pressure is 100 psi (689 kPa) at idle speed (600 rpm).

Shifting from forward to reverse drive through neutral may be made at any speed; however, it is advisable to shift at low speeds, below 1,000 engine rpm, to avoid damage to the engine, reverse gear or shaft.

The marine reverse and reduction gear is lubricated by pressure and splash. The quantity of oil in the marine gear will vary with the inclination of the engine and must be properly maintained to the *full* mark on the dipstick to ensure satisfactory operation.

It is recommended that vessels utilizing a marine gear have a suitable locking device or brake to prevent rotation of the propeller shaft when the vessel is not under direct propulsion. If the marine gear is not in operation and the forward motion of the vessel causes the propeller shaft to rotate, lubricating oil will not be circulated through the gear because the oil pump is not in operation. Overheating and damage to the marine gear may result unless rotation of the propeller shaft is prevented.

Consult an authorized *Detroit Diesel Allison Service Outlet* for major repairs or reconditioning of the marine gear.

OPERATING INSTRUCTIONS

ENGINE OPERATING INSTRUCTIONS

PREPARATION FOR STARTING ENGINE FIRST TIME

Before starting an engine for the first time, carefully read and follow these instructions. Attempting to run the engine before studying these instructions may result in serious damage to the engine.

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* in Section 5.

Cooling System

Install all of the drain cocks or plugs in the cooling system (drain cocks are removed for shipping).

Open the cooling system vents, if the engine is so equipped.

Remove the filler cap and fill the cooling system with clean, soft water or add an ethylene glycol base antifreeze, if the engine will be exposed to freezing temperatures (refer to *Coolant Specifications* in Section 5). Keep the liquid level about two inches below the filler neck to allow for fluid expansion.

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.

NOTE: 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. Insufficient lubrication at start-up can cause serious damage to the engine components.

To ensure an immediate flow of oil to all bearing surfaces at initial engine start-up, DDA recommends that the engine lubrication system by 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 pre-lubricator hose.

2. Remove the valve rocker cover(s) 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.

3. If the engine is turbocharged, disconnect the oil supply lines at the turbocharger bearing (center) housing and fill the bearing housing cavities with approximately one pint of the recommended grade of clean engine oil. Turn the rotating assemblies by hand to coat all internal surfaces with oil and reinstall the turbocharger oil supply lines.

4. After 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 pre-lubricator hose, plug the main oil gallery hole and replace all components previously removed.

6. Before initial engine start-up, DDA also recommends cranking the engine with the governor in the no-fuel position until oil pressure registers on the gage.

For engine lubricating oil recommendations, see *Lubrication Specifications* in Section 5 or contact a Detroit Diesel Allison distributor.

If a pressure prelubricator is not available, fill the crankcase to the proper level with *heavy-duty* lubricating oil as specified under *Lubrication Specifications* in Section 5. Then, pre-lubricate 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.

Turbocharger

After installing a rebuilt or new turbocharger, it is very important that all moving parts of the turbocharger center housing be lubricated as follows:

CAUTION: Do not hold the compressor wheel, for any reason, while the engine is running. This could result in personal injury.

1. Clean the area and disconnect the oil inlet (supply) line at the bearing (center) housing.

2. Fill the bearing housing cavity with clean engine oil. Turn the rotating assembly by hand to coat all of the internal surfaces with oil.

3. Add additional clean engine oil to completely fill the bearing housing cavity and reinstall the oil line. Clean off any spilled oil.

4. 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 psi or 69 kPa at idle speed).

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 specified under *Lubrication and Preventive Maintenance* in Section 5.

Fuel System

Fill the fuel tank with the fuel specified under *Fuel Specifications* (see Section 5).

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 filters. To be sure the injectors are lubricated and in order to have less resistance to priming flow caused by the static fuel pump, priming through the 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.

> **NOTE:** 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 is 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* (see Section 5).

Storage Battery

Check the battery. The top should be clean and dry, the terminals tight and protected with a coat of petroleum jelly and the electrolyte must be at the proper level.

When necessary, check the battery 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 acccrdance with the applicable local electrical codes.

> **NOTE:** 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* in Section 5.

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. The blower will be seriously damaged if operated with the air shutoff valve in the closed position.

The engine may require the use of a cold weather starting aid if the ambient temperature is below 40° F (4° C). The instructions for the use of a cold weather fluid starting aid will vary dependent on the type being used. Reference should be made to these instructions before attempting a cold weather start.

> **CAUTION:** Starting fluid used in capsules is highly inflammable, toxic and possesses sleep inducing properties.

Initial Engine Start (Electric)

Start an engine equipped with an electric starting motor as follows:

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. On hydraulic governors, make sure the stop knob is pushed all the way in. Then, press the starting motor switch firmly. If the engine fails to start within 30 seconds, release the starting 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.

> **NOTE:** To prevent serious damage to the starter, if the engine does not start, do not press the starting switch again while the starting motor is running.

RUNNING

Oil Pressure

Observe the oil pressure gage immediately after starting the engine. If there is no pressure indicated within 10 to 15 seconds, stop the engine and check the lubricating oil system. The minimum oil pressure should be at least 18 psi (124 kPa) at 1,200 rpm. The oil pressure at normal operating speed should be 40-60 psi (276-414 kPa).

Warm-Up

Run the engine at part throttle and no load for approximately five minutes, allowing it to warm-up before applying a load.

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.

Clutch

Do not engage the clutch at engine speeds over 1,000 rpm.

Inspection

While the engine is running at operating temperature, check for coolant, fuel or lubricating oil leaks. Tighten the line connections where necessary to stop leaks.

Engine Temperature

Normal engine coolant temperature is 160-185° F (71-85° C) or 170-187° F (77-86° C) depending on application.

Crankcase

If the engine crankcase was refilled, stop the engine after normal operating temperature has been reached. Allow the oil to drain back into the crankcase for approximately twenty minutes and check the oil level. Add oil, if necessary, to bring it to the proper level on the dipstick. *Do not overfill.*

Use only the *heavy duty* lubricating oil specified under *Lubrication Specifications* in Section 5.

Cooling System

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 or an ethylene glycol base antifreeze (refer to *Coolant Specifications* in Section 5).

Marine Gear

Check the marine gear oil pressure. The operating oil pressure range for the marine gear at operating speed is 120 to 160 psi (827 to 1103 kPa) and minimum oil pressure is 100 psi (689 kPa) at idle speed (600 rpm).

Turbocharger

Make a visual inspection of the turbocharger for leaks and excessive vibration. Stop the engine immediately if there is an unusual noise in the turbocharger.

Do not restart the engine until the cause of the noise is corrected.

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.

When prolonged engine idling is necessary, maintain at least 800 rpm.

STOPPING

Normal Stopping

1. Release the load and decrease the engine speed. Put all shift levers in the *neutral* position.

2. Allow the engine to run at half speed or slower with no load for four or five minutes, then move the stop lever to the *stop* position to shut down the engine.

Emergency Stopping

To stop an engine (normal or emergency) equipped with the spring-loaded (one screw) design injector control tube, pull the governor stop lever to the *stop* position. 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.

> **NOTE:** 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 valve, located on the blower air inlet housing, 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

Allow the oil to drain back into the crankcase for approximately twenty minutes 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 specified under *Lubrication Specifications* in Section 5.

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* in Section 5 and perform all of the daily maintenance operations. Also, perform the operations required for the number of hours 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.

ALTERNATING CURRENT POWER GENERATOR SET

OPERATING INSTRUCTIONS

These instructions cover the fundamental procedures for operating an alternating current power generator set (Fig. 1). The operator should read these instructions before attempting to operate the generator set.

Never operate a generator set for a short (15 minute) interval - the engine will not reach normal operating temperature in so short a period.

Avoid operating the set for extended periods at no load.

Ideally, operate the set for one hour with at least 40% load (generator rating).

When a test must be made with a line load of less than 40% of the generator rating, add a supplementary load.

Connect the supplementary load to the load terminals of the control cabinet circuit breaker so that the generator can be "loaded" whenever the breaker is closed.

Make certain that the supplementary load is such that it can be controlled to permit a reduction in the load should a normal load increase occur while the set is operating. Locate the supplementary load outside the engine room, if desirable, to provide adequate cooling.

Loading the generator set to 40% of the generator rating and operating it for one-hour intervals will bring the engine and generator to normal operating temperatures and circulate the lubricants properly. Abnormal amounts of moisture, carbon and sludge are due primarily to low internal operating temperatures which are much less likely to occur when the set is tested properly.

PREPARATION FOR STARTING

Before attempting to start a new or an overhauled engine or an engine which has been in storage, perform all of the operations listed under *Preparation for Starting Engine First Time.* Before a routine start, see *Daily Operations* in the *Lubrication and Preventive Maintenance Chart* (see Section 5).

In addition to the *Engine Operating Instructions*, the following instructions also apply when operating an alternating current power generator set.

1. Before the first start, check the generator main bearing oil reservoir. If necessary, add sufficient lubricating oil, of the same grade as used in the engine crankcase, to bring it to the proper level on the sight gage. *Do not overfill.*

2. Check the interior of the generator for dust or moisture. Blow out dust with low pressure air (25 psi or 172 kPa maximum). If there is moisture on the interior of the generator, it must be dried before the set is started. Refer to the appropriate Delco Products Maintenance Bulletin.

3. The air shutoff valve located in the air inlet housing must be in the *open or reset* position.

4. Refer to Fig. 1 and place the circuit breaker in the *off* position.

5. If the generator set is equipped with synchronizing lamps, place the lamp switch in the *off* position.

6. Turn the voltage regulator rheostat knob counterclockwise to its lower limit.

7. Make sure the power generator set has been cleared of all tools or other objects which might interfere with its operation.

STARTING

If the generator set is located in a closed space, start the ventilating fan or open the doors and windows, as weather permits, to supply ample air to the engine.

The engine may require the use of a cold weather starting aid if the ambient temperature is below 40° F (4° C). The instructions for the use of a cold weather fluid starting aid will vary dependent on the type being used. Reference should be made to these instructions before attempting a cold weather start.

> **CAUTION:** Starting fluid used in capsules is highly inflammable, toxic and possesses sleep inducing properties.

Press the throttle button and turn the throttle control counterclockwise to a position midway between *run* and *stop* (Fig. 1). Then, press the starting switch firmly.

If the engine fails to start within 30 seconds, release the starting 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.

> **NOTE:** To prevent serious damage to the starter, if the engine does not start, do not press the starting switch again while the starting motor is rotating.

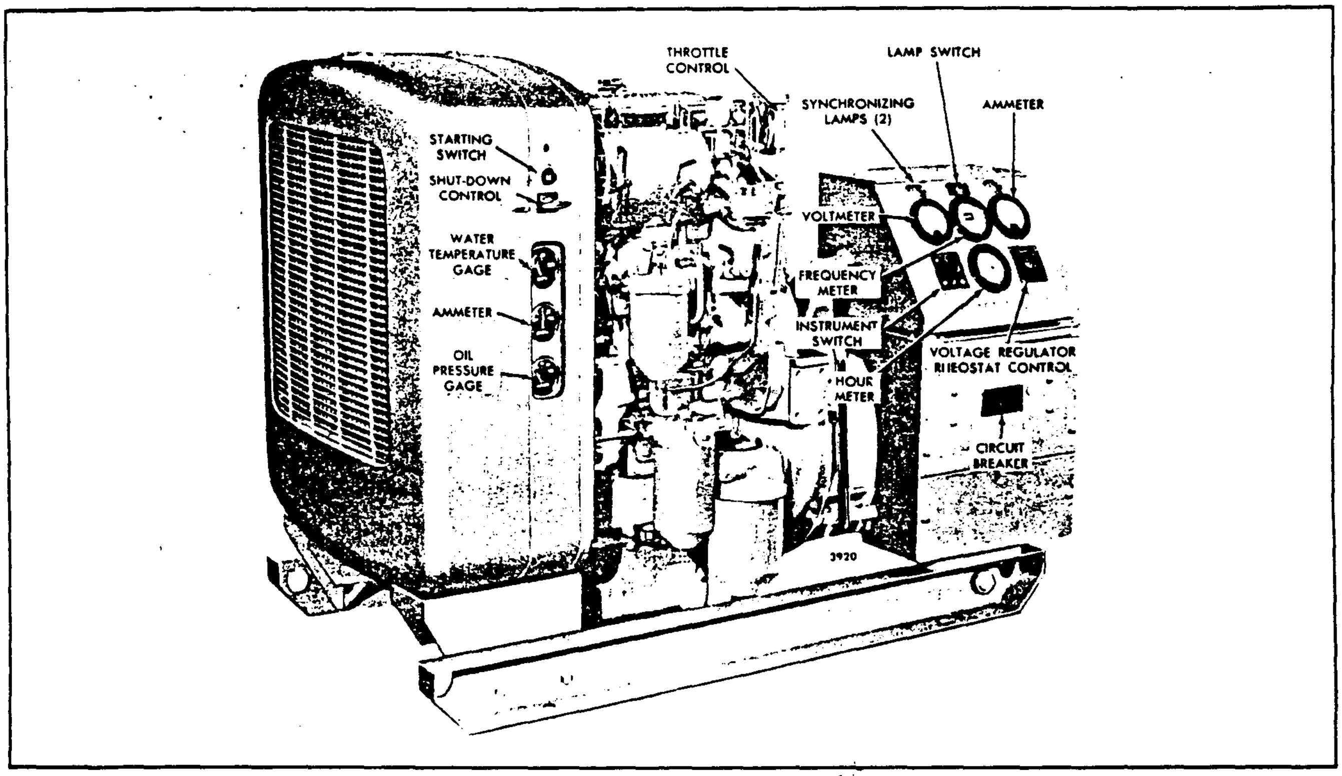


Fig. 1 - Location of Controls on Power Generator Set

RUNNING

Observe the engine oil pressure gage immediately after starting the engine. If there is no oil pressure indicated within 10 to 15 seconds, stop the engine and check the engine lubricating system. If the oil pressure is observed to be normal, increase the throttle setting to cause the engine to run at its synchronous speed.

PREPARING GENERATOR FOR LOAD

After the engine is warmed up (or the oil pressure has stabilized) prepare the generator set for load as follows:

1. Bring the engine up to the rated speed.

2. Turn the instrument switch to the desired position.

3. Turn the voltage regulator rheostat knob slowly in a clockwise direction to raise the voltage, while watching the voltmeter, until the desired voltage is attained.

4. If the generator set is equipped with a frequency meter, adjust the engine speed with the vernier throttle knob until the desired frequency is indicated on the meter.

5. Make sure all power lines are clear of personnel, then place the circuit breaker control in the *on* position.

Perform Step 5 only if the generator set is not being paralleled with an existing power source. If it is being paralleled with a power source already on the line, read and follow the instructions under *Paralleling* before turning the circuit breaker control to the *on* position.

PARALLELING

If the load conditions require an additional unit to be placed on the line, the following instructions will apply to power generator sets of equal capacity, with one generator set in operation on the line.

1. Prepare the generator set to be paralleled as outlined under *Preparation For Starting, Starting, Running* and Items 1 through 4 under *Preparing Generator for Load.*

2. Check the voltmeter (Fig. 1); the voltage must be the same as the line voltage. Adjust the voltage regulator rheostat control if the voltages are not the same.

3. Place the synchronizing lamp switch, of the generator set to be paralleled, in the *on* position.

4. Turn the vernier throttle knob until both units are operating at approximately the same frequency as

indicated by the slow change in the brilliancy of the synchronizing lamps.

5. When the synchronizing lamps glow and then go out at a very slow rate, time the dark interval. Then, in the middle of this interval, turn the circuit breaker control to the *on* position. This places the incoming generator set on the line, with no load. The proper share of the existing load must now be placed on this generator.

6. The division of the kilowatt load between the alternating current generators operating in parallel depends on the power supplied by the engines to the generators as controlled by the engine governors and is practically independent of the generator excitation. Divide the kilowatt load between the generators by turning the vernier throttle knob counterclockwise on the incoming generator and clockwise on the generator that has been carrying the load (to keep the frequency of the generators constant) until both ammeters read the same, indicating that each generator is carrying its proper percentage of the total kilowatt load.

7. The division of the reactive KVA load depends on the generator excitation as controlled by the voltage regulator. Divide the reactive load between the generators by turning the voltage regulator rheostat control on the incoming generator (generally counter-clockwise to raise the voltage) until the ammeters read the same on both generator sets and the sum of the readings is minimum.

The generator sets are equipped with a resistor and current transformer connected in series with the voltage coil of the regulator (cross-current compensation) which equalizes most but not all of the reactive KVA load between the generators.

8. When the load is 80% power factor lagging (motor and a few lights only), turn the vernier throttle knob on the incoming generator until the ammeter on that unit reads approximately 40% of the total current load.

9. Rotate the voltage regulator rheostat control on the incoming (generator counterclockwise to raise the voltage) until the ammeters read the same on both units.

If a load was not added during paralleling, the total of the two ammeter readings should be the same as the reading before paralleling. Readjust the voltage regulator rheostat on the incoming generator, if necessary.

10. To reset the load voltage, turn the voltage regulator rheostat controls slowly on each unit. It is necessary to turn the controls the same amount and in the same direction to keep the reactive current equally divided.

Power generator sets with different capacities can also be paralleled by dividing the load proportionately to their capacity.

STOPPING

The procedure for stopping a power generator set or taking it out of parallel is as follows:

1. Turn off all of the load on the generator when stopping a single engine unit.

2. Shift the load from the generator when taking it out of parallel operation by turning the vernier throttle knob until the ammeter reads approximately zero.

3. Place the circuit breaker control in the *off* position.

4. Turn the voltage regulator rheostat control in a counterclockwise direction to the limit of its travel.

5. Press the throttle button and turn the throttle control to **stop** to shut down the engine.

When performing a tune-up on a generator set that will be operated in parallel with another unit, adjust the speed droop as specified in *Engine Tune-Up* (see Section 6).

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 Chart are time (hours) 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 4.

INDUSTRIAL OFF HIGHWAY AND MARINE — HRS.	TIME INTERVALS DLY.	8	50	100	150	200	300	500	700	1,000	2,000
1. — Lubricating Oil	X				X						
2. — Fuel Tank	X							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		
11. — Throttle and Clutch Controls						X					
12. — Lubricating Oil Filter								X		X	
13. — Fuel Strainer and Filter							X				
14. — Coolant Filter and Water Pump*								X			
15. — Starting Motor*											
16. — Air Systems									X		
17. — Exhaust System									X		
18. — Air Box Drain Tube										X	
19. — Emergency Shutdown									X		
21. — Radiator									X		
22. — Shutter Operation									X		
23. — Oil Pressure									X		
24. — Overspeed Governor								X			
26. — Throttle Delay*											
27. — Battery-Charging Alternator						X					
28. — Engine and Transmission Mounts											X
29. — Crankcase Pressure											X
30. — Air Box Check Valves*											
31. — Fan Hub*									X		
32. — Thermostats and Seals									X		
33. — Blower Screen										X	
34. — Crankcase Breather										X	
36. — Engine Tune-Up*											
37. — Heat Exchanger Electrodes								X		X	
38. — Raw Water Pump	X										
39. — Power Generator				X			X				
40. — Power Take-Off		X	X					X			
41. — Marine Gear	X					X					
42. — Torqmatic Converter	X		X					X			

*See Item

Item 1 - Lubricating Oil

Check the lubricating oil level with the engine stopped. If the engine has just been stopped, wait approximately twenty 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.

NOTE: 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 external oil lines.

Change the lubrication oil at the intervals shown in Table 1.

Service Application	Max. Engine Oil Change Internal Diesel Fuel Sulfur Content % By Wt. Max. 0 to .50
Industrial and Machine	150 Hours

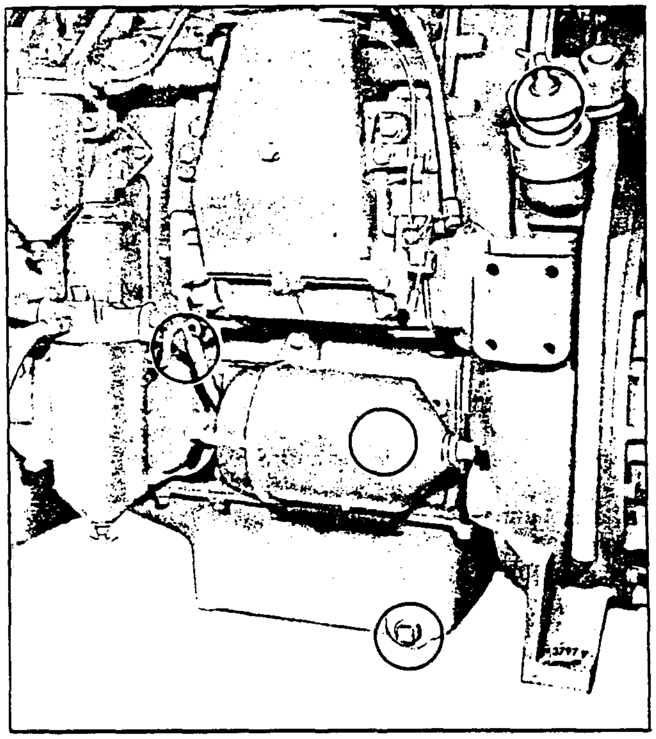
TABLE 1

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 *Lubrication Specfications* in this section.

Item 2 - Fuel Tank

Keep the fuel tank filled to reduce condensation to a minimum. Select the proper grade of fuel in accordance with the *Fuel Specifications* in this section.



Items 1 and 12

Open the drain at the bottom of the fuel tank every 500 hours to drain off any water and/or sediment.

Every 12 months or 700 hours tighten all fuel tank mountings and brackets. 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.

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 promtes the growth of mircobiological organisms (microbes). These microbes clog fuel filters with a "slime" and 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 (0.5 liter) per 125 gallons (473 liters) fuel (or 0.10% by volume).

Marine units in storage are particularly susceptible to mircobe growth. The mircobes 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 commerically 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 500 operating hours (1,000 hours for the fire-resistant fuel and lube hoses and heat-insulating turbo/exhaust system blanket) and/or annually. 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.

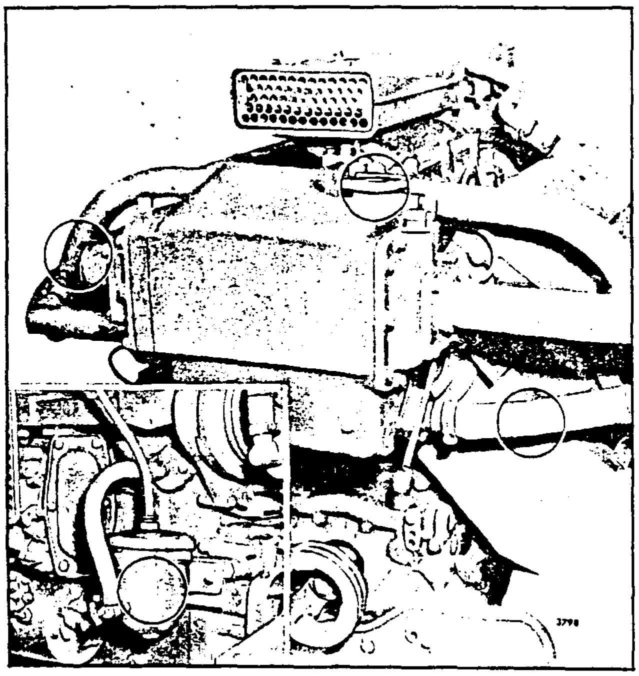
All hoses in or out of machinery should be replaced during major overhaul and/or after a maximum of five years service. The new fire-resistant fuel and lube hose assemblies do not require automatic replacement after five years of service or at major overhaul.

Item 4 - Cooling System

Check the coolant level daily and maintain it near the top of the heat exchanger tank or radiator upper tank. 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 every 1,000 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 (refer to *Coolant Specifications* in this section). 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



Items 4 and 14

of the cooling system is required, it should be reverse flushed.

Inspect all of the cooling system hoses at least once every 700 hours for signs of deterioration. Replace the hoses, if necessary.

Item 5 - Turbocharger

Inspect the mountings, intake and exhaust ducting and connections for leaks. Check the oil inlet and outlet lines for leaks or restrictions to air flow. Check for unusual noise or vibration and, if excessive, remove the turbocharger and correct the cause.

Item 6 - Battery

Check the specific gravity of the electrolyte in each cell of the battery every 100 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 100 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.

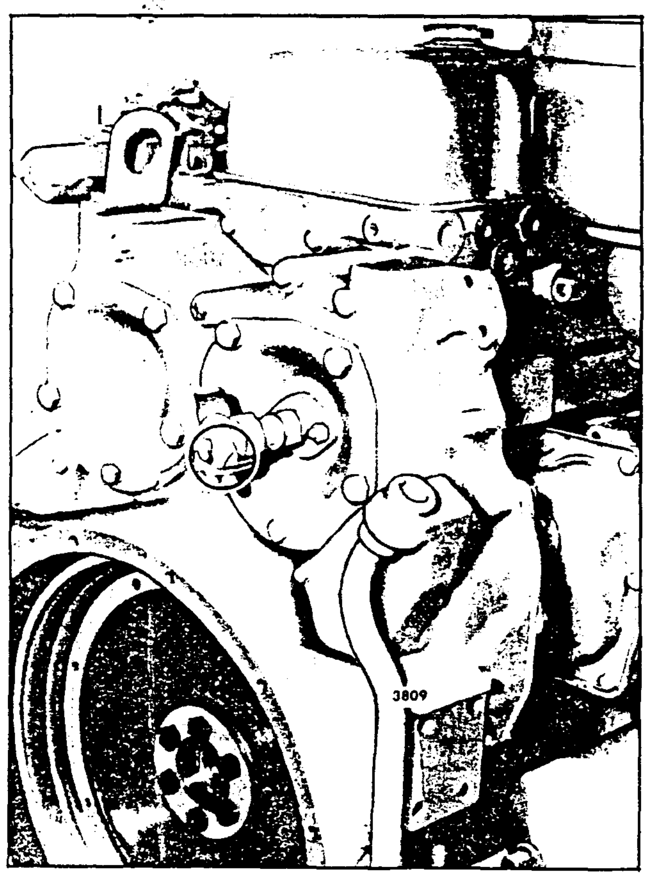
Item 8 - Air Cleaner

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.

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.



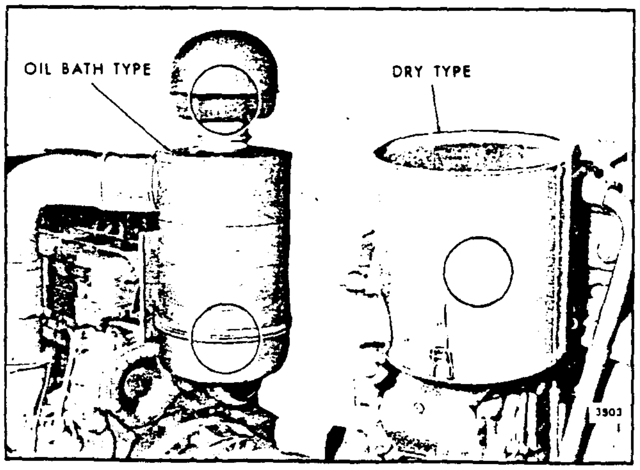
Item 7

It is recommended that the body and fixed element in the heavy-duty oil bath type air cleaner be serviced every 500 hours or as conditions warrant.

Dry Type

Secondary (safety) elements should *not* be cleaned or reused.

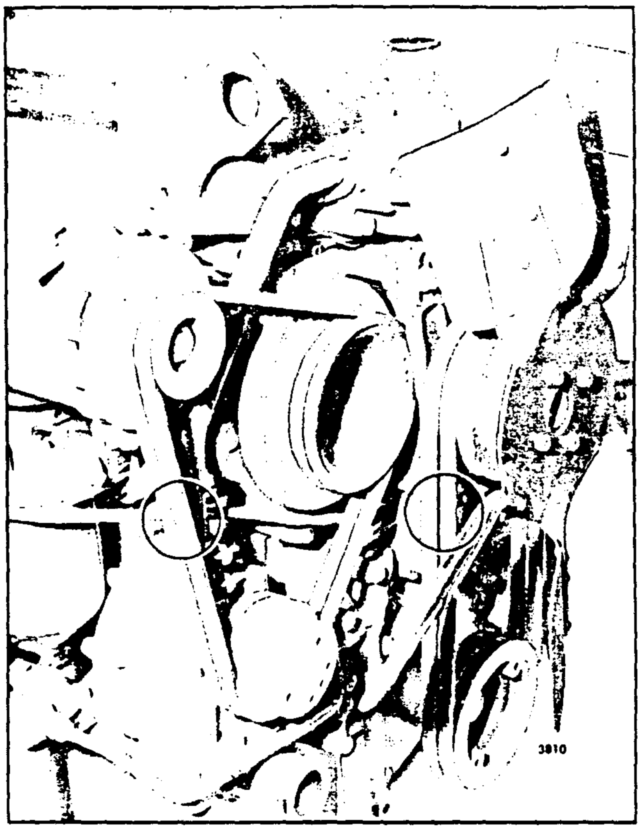
Dry type elements should be discarded and replaced with new elements after one year of service or when the maximum allowable air intake restriction has been reached, whichever comes first. In cases where the air cleaner manufacturer recommends cleaning or washing the elements, the maximum service life is still one year or maximum restriction. Cleaning, washing and inspection must be done per the manufacturer's recommendations. Inspection and replacement of the cover gaskets must also be done per the manufacturer's recommendations.



Item 8

Item 9 - Drive Belts

New standard V-belts will stretch after the first few hours of operation. Run the engine for 15 **seconds** to seat the belts, then readjust the tension. Check the belts and tighten the fan drive, pump drive, battery-charging alternator and other accessory drive belts after 1/2 hour and again after 8 hours of operation. Thereafter, check the tension of the drive belts every 200 hours and adjust, if necessary. Belts should be neither too tight nor too loose. Belts which are too tight impose excess loads on crankshaft, fan and/or alternator bearings, shortening both belt and bearing life. Excessively overtightened belts can result in crankshaft breakage. A loose belt will slip.



Item 9

Replace all belts in a set when one is worn. Single belts of similar size should not be used as a substitute for a matched belt set; premature belt wear can result because of belt length variation. All belts in a matched belt set are within .032" of their specified center distances.

Adjust the belt tension so that a firm push with the thumb, at a point midway between the two pulleys, will depress the belt 1/2" to 3/4". If belt tension gage J 23600-B or equivalent is available, adjust the belt tension as outlined in the Chart.

Model	Fan Drive		Generator Drive		
	2 or 3 belts	Single belt	Two 3/8" or 1/2" belts	One 1/2" belt	One 9/16" belt
3,4-53	40-50	-	40-50	50-70	40-50
6V-53	60-80	80-100	40-50	50-70	40-50
All	For 3-point or triangular drive use a tension of 90-120.				

BELT TENSION CHART (lbs/belt)

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.

Item 10 - Air Compressor

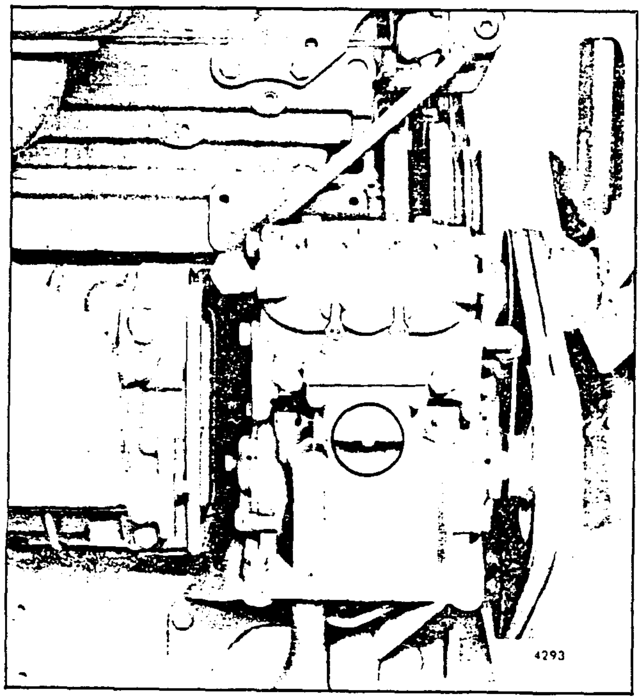
Remove and wash all of the polyurethane sponge strainer parts every 150 operating hours. The strainer element should be cleaned or replaced. If the element is cleaned, it should be washed in a commercial solvent or a detergent and water solution. The element should be saturated in clean engine oil, then squeezed dry before replacing it in the strainer. Be sure to replace the air strainer gasket if the entire strainer is removed from the compressor intake.

For replacement of the air strainer element, contact the nearest Bendix Westinghouse dealer; replace with the polyurethane element, if available.

Every 12 months or 700 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

Every 200 hours lubricate the limiting speed governor speed control shaft (In-line 53) through a grease fitting



Item 10

located in the end of the shaft. 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 the clutch control levers and all other control mechanisms, as required, with engine oil.

Item 12 - Lubricating Oil Filter

Install new oil filter elements and gaskets at a *maximum* of 500 hours or each time the engine oil is changed, whichever occurs first. Any deviation, such as changing filters every other oil change, should be based on a laboratory analysis of the drained oil and the used filter elements to determine if such practice is practical for proper protection of the engine.

Make a visual check of all lubricating oil lines for wear and chafing. If any indication of wear is evident, replace the oil lines and correct the cause.

When the engine is equipped with a turbocharger:

> **CAUTION:** Do not hold the compressor wheel, for any reason, while the engine is running. This could result in personal injury.

1. Disconnect the oil inlet (supply) line at the bearing (center) housing.

2. Fill the bearing housing cavity with clean engine oil. 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.

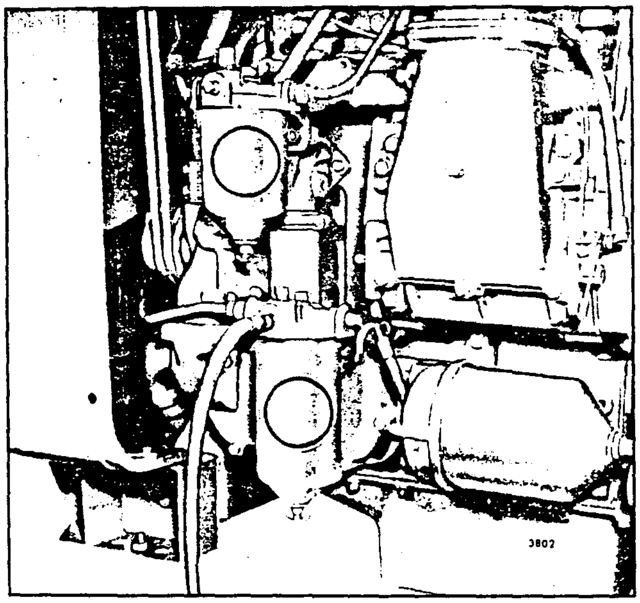
4. Start and run the engine at idle until oil pressure and supply has reached all of the turbocharger moving parts. A good indicator that all the moving parts are getting lubrication is when the oil pressure gage registers pressure (10 psi - 69 kPa at idle speed).

If the engine is equipped with a governor oil filter, change the element every 1,000 hours.

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.



Item 13

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). At normal operating speeds (1,800-2,800 rpm), the fuel pressure is 45 to 70 psi (310 to 483 kPa). Change the fuel filter elements whenever the inlet restriction (suction) 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 45 psi (310 kPa).

Item 14 - Coolant Filter and Water Pump

If the cooling system is protected by a coolant filter and conditioner, the filter element should be changed every 500 hours. Select the proper coolant filter element in accordance with the instructions given in *Coolant Specifications* in this section. 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.

Inspect the water pump drain hole every 6 months for plugging. If plugged, clean out the drain hole with a tool made from a front crankshaft seal or equivalent.

Replace the water pump seal after it has been in service for 6,000 hours.

Item 15 - Starting Motor

The electrical starting motor is lubricated at the time of original assembly. Oil can be added to the oil wicks, which project through each bushing and contact the armature shaft, by removing the pipe plugs on the outside of the motor. The wicks should be lubricated whenever the starting motor is taken off the engine or disassembled.

The Sprag overrunning clutch drive mechanism should be lubricated with a few drops of light engine oil whenever the starting motor is overhauled.

Item 16 - Air System

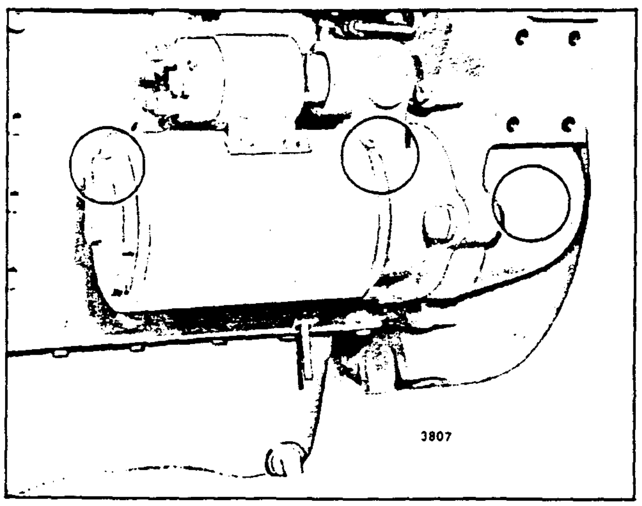
Check all of the connections in the air system to be sure they are tight. Check all hoses for punctures or other damage and replace, if necessary.

Item 17 - Exhaust System

Check the exhaust manifold retaining nuts, exhaust flange clamp and other connections for tightness. Check for proper operation of the exhaust pipe rain cap, if one is used.

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



Item 15

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

With the engine running at idle speed, check the operation of the emergency shutdown every 700 hours. Reset the air shutdown valve in the open position after the check has been made (see Section 3).

Item 21 - Radiator

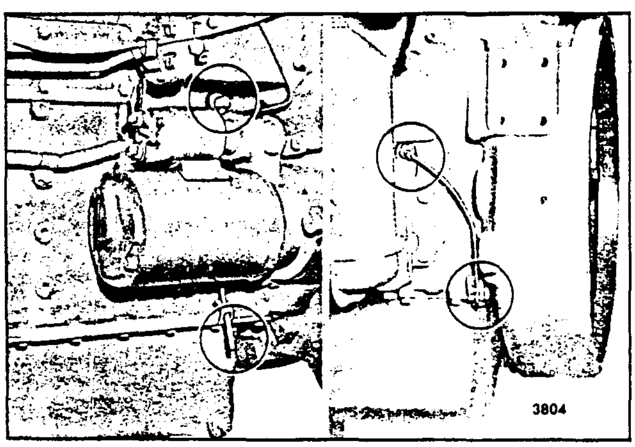
Inspect the exterior of the radiator core every 700 hours and, if necessary, clean it with a quality grease solvent such as mineral spirits and dry it with compressed air. *Do not use fuel oil, kerosene or gasoline.* It may be necessary to clean the radiator more frequently if the engine is being operated in extremely dusty or dirty areas.

Item 22 - Shutter Operation

Check the operation of the shutters and clean the linkage and controls.

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 700 hours.



Item 18

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 500 hours. Avoid excessive lubrication and do not lubricate the governor while the engine is running.

Item 26 - Throttle Delay

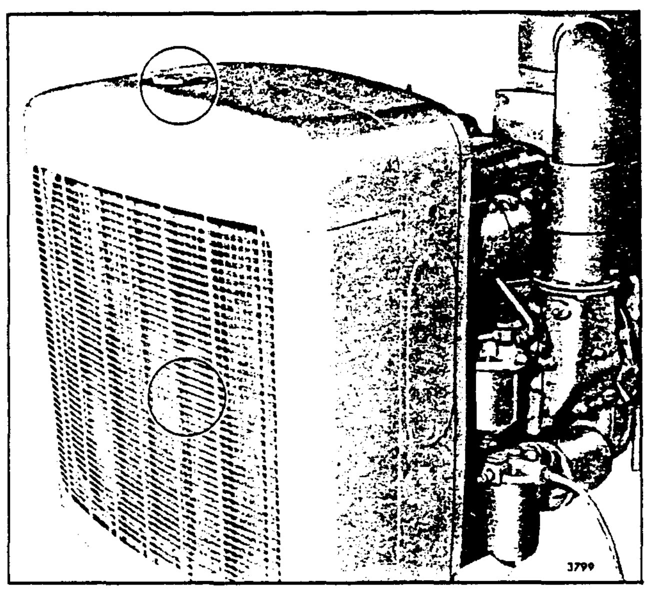
Inspect and adjust, if necessary, every 30 months.

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 6).

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. If more than a drop of fuel oil leaks, replace the check valve.

Item 27 - Battery-Changing Alternator

Inspect the terminals for corrosion and loose connections and the wiring for frayed insulation.



Item 21

Lubricate the battery-charging alternator bearings or bushings with 5 or 6 drops of engine oil at the hinge cap oiler every 200 hours.

Some alternators have a built-in supply of grease, while others use sealed bearings. In these cases, additional lubrication is not necessary.

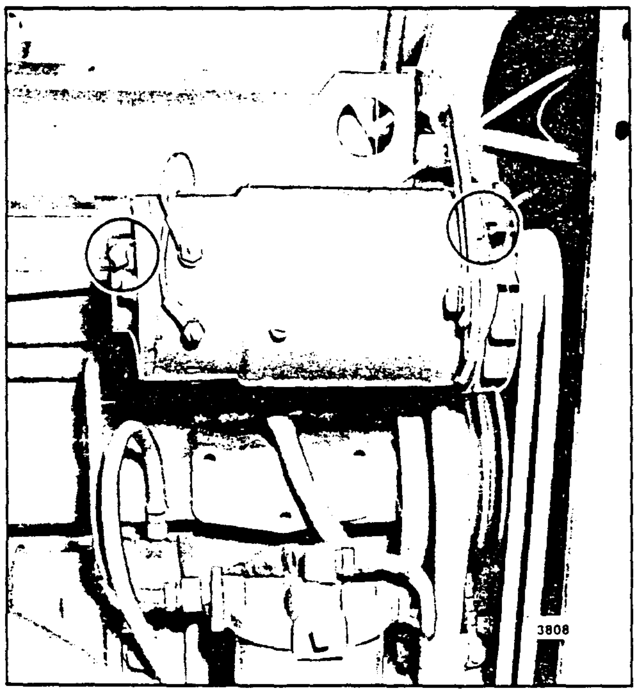
On alternators, the slip rings and brushes can be inspected through the end frame assembly. If the slip rings are dirty, they should be cleaned with 400 grain or finer polishing cloth. Never use emery cloth to clean the slip rings. Hold the polishing cloth against the slip rings with the alternator in operation and blow away all dust after the cleaning operation. If the slip rings are rough or out of round, replace them.

Item 28 - Engine and Transmission Mounts

Check the engine and transmission mounting bolts and the condition of the mounting pads every 2,000 hours. Tighten and repair, as necessary.

Item 29 - Crankcase Pressure

Check and record the crankcase pressure every 2,000 hours.



Item 27

Item 30 - Air Box Check Valves

Every 3,000 hours remove, clean in solvent and blow out the lines with compressed air. Inspect for leaks after servicing.

Item 31 - Fan Hub

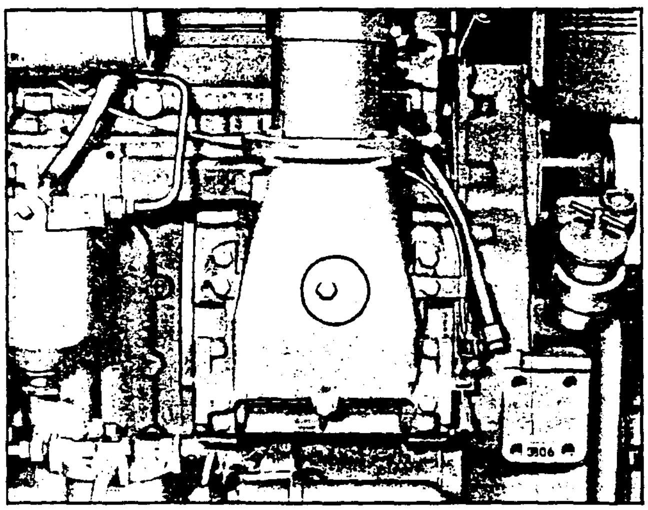
If the fan bearing hub assembly is provided with a grease fitting, use a hand grease gun and lubricate the bearings with one shot of Texaco Premium RB grease, or an equivalent Lithium base multi-purpose grease, every 700 hours.

Every 4,000 hours clean, inspect and repack the fan bearing hub assembly with the above recommended grease.

At a major engine overhaul, remove and discard the bearings in the fan hub assembly. Pack the hub assembly, using new bearings, with Texaco Premium RB grease or an equivalent Lithium base multi-purpose grease.

Item 32 - Thermostats and Seals

Check the thermostats and seals at 5,000 hours or once a year(preferably at the time the cooling system is prepared for winter operation). The thermostats should *always* be replaced at overhaul. Replace the seals, if necessary.



Item 33

Item 33 - Blower Screen

Inspect the blower screen and gasket assembly every 1,000 hours and, if necessary, clean the screen in fuel oil and dry it with compressed air. Install the screen and gasket assembly with the screen side of the assembly toward the blower. Inspect for evidence of blower seal leakage.

Item 34 - Crankcase Breather

Remove the externally mounted crankcase breather assembly every 1,000 hours and wash the steel mesh pad in clean fuel oil. This cleaning period may be reduced or lengthened according to severity of service.

Clean the breather cap, mounted on the valve rocker cover, in clean fuel oil every time the engine oil is changed.

Item 36 - Engine Tune-Up

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 mechanisms, governor, etc. should only be required periodically to compensate for normal wear on parts.

Item 37 - Heat Exchanger Electrodes and Core

Every 500 hours, drain the water from the heat exchanger raw water inlet and outlet tubes. Then, 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.

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, contact a *Detroit Diesel Allison Service Outlet.*

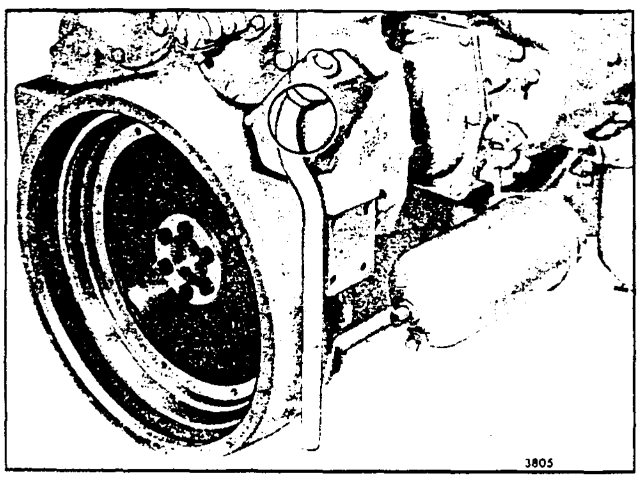
Item 38 - Raw Water Pump

Check the prime on the raw water pump; the engine should not be operated with a dry pump. Prime the pump, if necessary, by removing the pipe plug provided in the pump inlet elbow and adding water. Reinstall the plug.

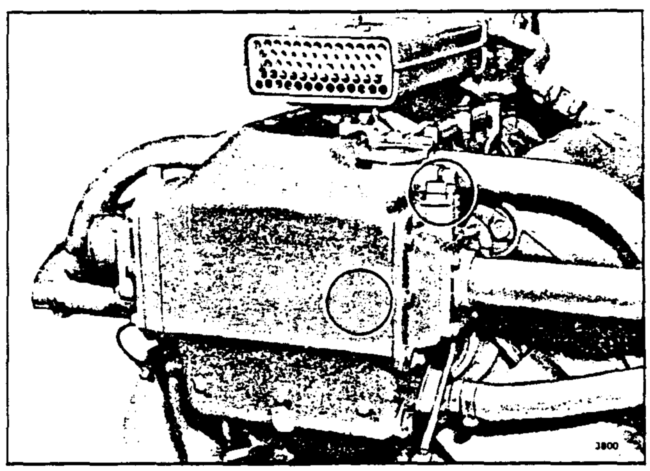
Item 39 - Power Generator

The power generator requires lubrication at only one point -- the ball bearing in the end frame.

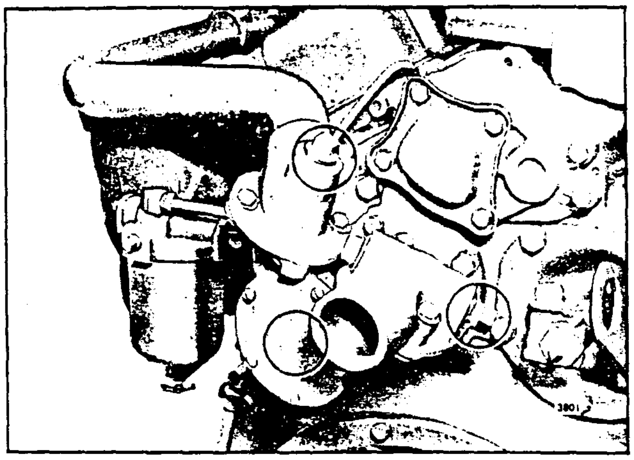
If the bearing is oil lubricated, check the oil level in the sight gage every 300 hours; change the oil every six months. Use the same grade and viscosity *heavy-duty* oil as specified for the engine. Maintain the oil level to the line on the sight gage. *Do not overfill.* After adding



Item 34



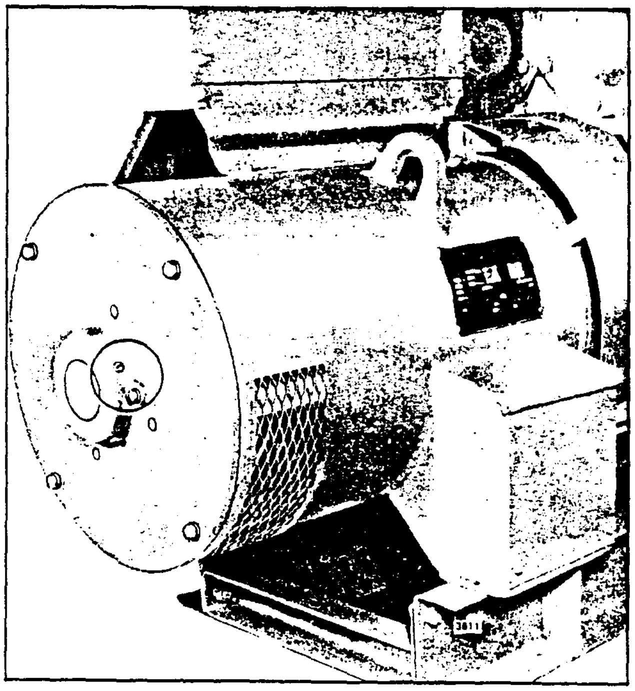
Item 37



Item 38

oil, recheck the oil level after running the generator for several minutes.

If the bearing is grease lubricated, a new generator has sufficient grease for three years of normal service. Thereafter, it should be lubricated at one year intervals. To lubricate the bearing, remove the filler and relief plugs on the side and the bottom of the bearing reservoir. Add grease until new grease appears at the relief plug opening. Run the generator a few minutes to vent the excess grease; then reinstall the plugs.



Item 39

The following greases, or their equivalents, are recommended:

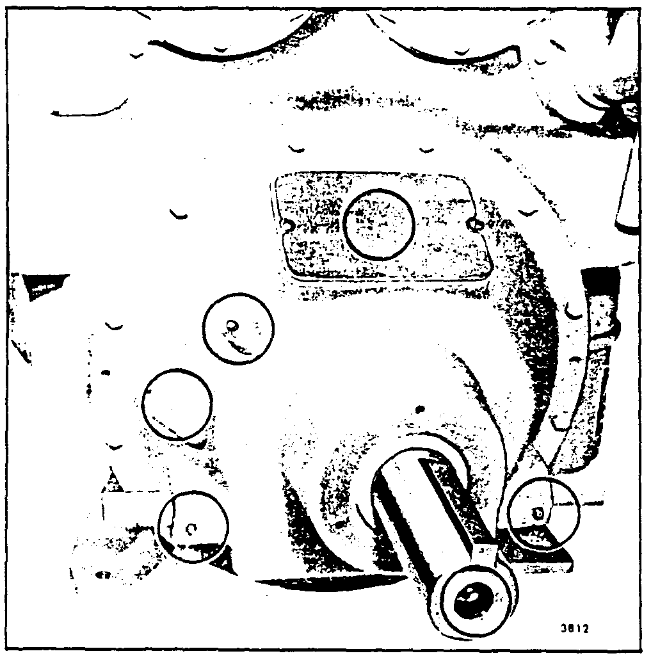
Keystone 44H . . . . Keystone Lubrication Co.
BRB Lifetime . . . . Socony Vacuum Oil Co.
NY and NJ F926 or F927 . NY and NJ Lubricant Co.

After 100 hours on new brushes, or brushes in generators that have not been in use over a long period, remove the end frame covers and inspect the brushes, commutator and collector rings. If there is no appreciable wear on the brushes, the inspection interval may be extended until the most practicable period has been established (not to exceed six months). To prevent damage to the commutator or the collector rings, do not permit the brushes to become shorter than 3/4 inch.

Keep the generator clean inside and out. Before removing the end frame covers, wipe off the loose dirt. The loose dirt and dust may be blown out with low pressure air (25 psi or 172 kPa maximum). Remove all greasy dirt with a cloth.

Item 40 - Power Takeoff

Lubricate all of the power takeoff bearings with an all purpose grease such as Shell Alvania No. 2, or equivalent. Lubricate sparingly to avoid getting grease on the clutch facings.



Item 40

Open the cover on the side of the clutch housing (8" and 10" diameter clutch) and lubricate the clutch release sleeve collar through the grease fitting every 8 hours. On the 11-1/2" diameter clutch, lubricate the collar through the fitting on the side of the clutch housing every 8 hours.

Lubricate the clutch drive shaft pilot bearing through the fitting in the outer end of the drive shaft (8" and 10" diameter clutch power takeoffs) every 50 hours of operation. One or two strokes with a grease gun should be sufficient. The clutch drive shaft pilot bearing used with the 11-1/2" diameter clutch power takeoff is prelubricated and does not require lubrication.

Lubricate the clutch drive shaft roller bearings through the grease fitting in the clutch housing every 50 hours under normal operating conditions (not continuous) and more often under severe operating conditions or continuous operation.

Lubricate the clutch release shaft through the fittings at the rear of the housing every 500 hours of operation.

Lubricate the clutch levers and links sparingly with engine oil every 500 hours of operation. Remove the inspection hole cover on the clutch housing and lubricate the clutch release levers and pins with a hand oiler. To avoid getting oil on the clutch facing, do not over lubricate the clutch release levers and pins.

Check the clutch facing for wear every 500 hours. Adjust the clutch, if necessary.

Item 41 - Marine Gear

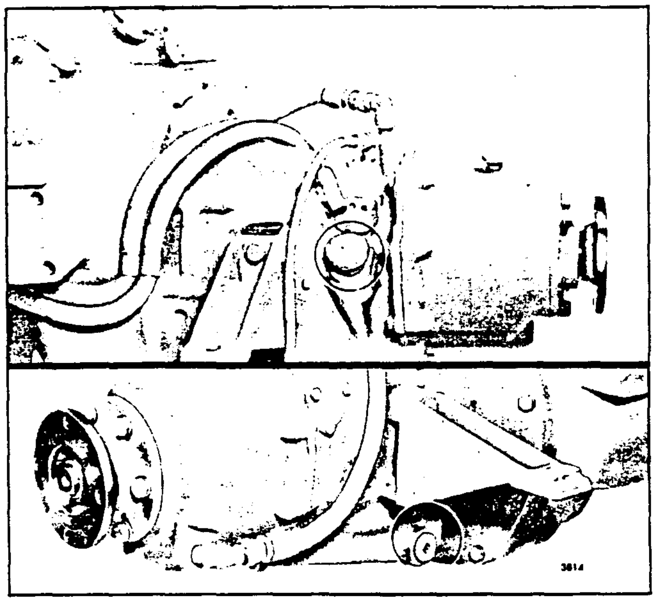
WARNER MARINE GEAR:

Check the oil level daily. Start and run the engine at idle speed for a few minutes to fill the lubrication system. Stop the engine. Then, immediately after stopping the engine, check the oil level in the marine gear. Bring the oil level up to the proper level on the dipstick. Use the same grade of lubricating oil that is used in the engine. *Do not overfill.*

Change the oil every 200 hours. After draining the oil from the unit, clean the removable oil screen thoroughly before refilling the marine gear with oil.

TWIN DISC MARINE GEAR:

Check the marine gear oil level daily. Check the oil level with the engine running at low idle speed and the gear in neutral. Keep the oil up to the proper level on the dipstick. Use oil of the same *heavy-duty* grade and viscosity that is used in the engine.



Item 41

Change the oil every 200 hours. Remove and clean the oil inlet strainer screen after draining the oil and before refilling the marine gear. The strainer is located in the sump at the lower end of the pump suction line. When refilling after an oil drain, bring the oil up to the proper level on the dipstick (approximately 5 quarts or 4.7 liters).

Item 42 - Torqmatic Converter

Check the oil level in the Torqmatic converter and supply tank daily. The oil level must be checked while the converter is operating, the engine idling and the oil is up to operating temperature (approximately 200° F or 93° C). If the converter is equipped with an input disconnect clutch, the clutch must be engaged.

Check the oil level after running the unit a few minutes. The oil level should be maintained at the proper level on the dipstick. If required, add hydraulic transmission fluid type "C-2" (Table 2). *Do not overfill* the converter as too much oil will cause foaming and high oil temperature.

The oil should be changed every 500 hours of operation. Also, the oil should be changed whenever it shows traces of dirt or effects of high operating temperature as evidenced by discoloration or strong odor. If the oil shows metal contamination, contact an authorized *Detroit Diesel Allison Service Outlet* as this usually requires disassembly. Under severe operating conditions, the oil should be changed more often.

Prevailing Ambient Temperature	Recommended Oil Specification
Above −10°F (−23°C)	Hydraulic Transmission Fluid, Type C-2.
Below −10°F (−23°C)	Hydraulic Transmission Fluid, Type C-2. Auxiliary preheat required to raise temperature in the sump to a temperature above −10°F. (−23°C)

TABLE 2 - OIL RECOMMENDATIONS

The converter oil breather, located on the oil level indicator (dipstick), should be cleaned each time the converter oil is changed. This can be accomplished by allowing the breather to soak in a solvent, then drying it with compressed air.

The full-flow oil filter element should be removed, the shell cleaned and a new element and gasket installed each time the converter oil is changed.

Lubricate the input clutch release bearing and ball bearing and the front disconnect clutch drive shaft bearing every 50 hours with an all purpose grease. Grease fittings are provided on the clutch housing. This time interval may vary depending upon the operating conditions. Over lubrication will cause grease to be thrown on the clutch facing, causing the clutch to slip.

The strainer (in the Torqmatic transmission) and the hydraulic system filters should be replaced or cleaned with every oil change.

FUEL 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 emission levels.

COMPLETELY DISTILLED FLUID

Fuel selected should be completely distilled material. That is, the fuel should show at least 98% 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. The differences in properties of VV-F-800 and ASTM D-975 fuels are shown in the following table.

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 NORTH AMERICA	VV-F-800, DF-2 OTHER	ASTM D-975 2-D
Flash Point, min.	38°C 100°F	38°C 100°F	52°C 125°F	56°C 133°F	52°C 125°F
Carbon Residue (10% residuum), mass % max.	0.15	0.15	0.35	0.20	0.35
Water & Sediment, % by vol, max.	—	0.05	—	—	0.05
Ash, % by wt., max.	0.01	0.01	0.01	0.02	0.01
Distillation Temperature, 90% by vol. recovery, min.	—	—	—	—	282°C 540°F
max.	288°C 550°F	288°C 550°F	338°C 640°F	357°C 675°F	338°C 640°F
End Point max.	330°C 626°F	—	370°C 698°F	370°C 698°F	—
Viscosity Kinematic, cSt, min. @ 40°C	1.3	1.3	1.9	1.8@20°C	1.9
Saybolt, SUS, min. @ 100°F	—	—	—	—	32.6
Kinematic, cSt, max. @ 40°C	2.9	2.4	4.1	9.5@20°C	4.1
Saybolt, SUS, max. @ 100°F	—	34.4	—	—	40.1
Sulfur, mass % max.	0.50	0.50	0.50	0.70	0.50
Cetane No., min.	45	40.0	45	45	40.0

FUEL CLEANLINESS

Fuel oil should be clean and free of contamination. Storage tanks and stored fuel 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.

FUEL SULFUR CONTENT

The *sulfur content* of the fuel should be as low as possible to avoid premature wear, excessive deposit formation, and minimize the sulfur dioxide exhausted into the atmosphere. Limited amounts can be tolerated, but the amount of sulfur in the fuel and engine operating conditions can influence corrosion and deposit formation tendencies.

The detrimental effect of burning high sulfur fuel is reflected in Detroit Diesel lube oil change interval recommendations. Detroit Diesel recommends that the Total Base Number (TBN-ASTM D-664) of the lube oil be monitored frequently and that the oil drain interval possibly be reduced. Consult the FUEL OIL SELECTION CHART.

FUEL OIL SELECTION CHART

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

*No. 2-D diesel fuel may be used in city coach engine models that 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 the 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 lighter distillate fuels may be more practical. The same consideration must be made when operating at altitudes above 5,000 ft.

IGNITION QUALITY-CETANE NUMBER

There is a delay between the time the fuel is injected into the cylinder and the time that ignition occurs. The duration of this delay is expressed in terms of *cetane number* (rating). Rapidly ignited fuels have high cetane numbers (50 or above). Slowly ignited fuels have low cetane numbers (40 or below). The lower the ambient temperature, the greater the need for a high cetane fuel that will ignite rapidly.

Difficult starting may be experienced if the cetane number of the fuel is too low. Furthermore, engine knock and puffs of white smoke may be experienced during engine warmup especially in severe cold weather when operating with a low cetane fuel. If this condition is allowed to continue for any prolonged period, harmful fuel derived deposits will accumulate within the combustion chamber. Consult the FUEL OIL SELECTION CHART.

DISTILLATION END 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 *distillation end point* (ASTM D-86). The distillation (boiling) range of diesel fuels should be low enough to permit complete vaporization at combustion chamber temperatures. The combustion chamber temperature depends on ambient temperature, engine speed, and load. Mediocre to poor vaporization is more apt to occur during severe cold weather and/or prolonged engine idling and/or light load operation. Therefore, engines will show better performance operating under the conditions described above when lower distillation end point fuels are used. Consult the FUEL OIL SELECTION CHART.

CLOUD POINT

The *cloud point* is that temperature at which wax crystals begin to form in diesel fuel. The selection of a suitable fuel for low temperature operability is the responsibility of the fuel supplier and the engine user. Consult the FUEL OIL SELECTION CHART.

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.

Burner fuels (furnace oils or domestic heating fuels) generally require an open flame for satisfactory combustion. The ignition quality (cetane rating) of burner fuels (ASTM D-396) is poor when compared to diesel fuels (ASTM D-975).

In some regions, however, fuel suppliers may distribute one fluid that is marketed as either diesel fuel (ASTM D-975) or domestic heating fuel (ASTM D-396) sometimes identified as burner, furnace, or residual fuel. Under these circumstances, the fuel should be investigated to determine whether the properties conform with those indicated in the FUEL OIL SELECTION CHART.

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, Sulfur Content, and Cloud Point* are four of the most important properties of diesel fuels that must be controlled to insure satisfactory engine operation. Engine speed, load, and ambient temperature all influence the selection of diesel fuels with respect to distillation range and cetane number.

All diesel fuels contain a certain amount of sulfur. Too high a sulfur content results in excessive cylinder wear. For most satisfactory engine life, fuels containing less than 0.5% sulfur should be used.

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 in order to prevent clogging of the fuel filters by wax crystals.

A reputable fuel oil supplier is the only one who can assure you that the fuel you receive meets the *Distillation End Point, Cetane Number, Sulfur Content, and Cloud Point* property limits shown in the FUEL OIL SELECTION CHART. The responsibility for clean fuel that meets Detroit Diesel Allison specifications lies with the fuel supplier as well as the operator.

At temperatures below +32°F (0°C) particular attention must be given to cold weather starting aids for efficient engine starting and operation.

NUMEROUS FUELS BURNED IN DETROIT DIESEL ENGINES

Numerous fuels meeting the properties shown in the FUEL OIL SELECTION CHART may be used in Detroit Diesel engines. The table (next page) shows some of the alternate fuels (some with sulfur and/or cetane limits) that have been burned in Detroit Diesel engines. Among these are No. 1 and No. 2 diesel fuels, kerosene, aviation turbine (jet) fuels, and burner fuels.

PROPOSED ASTM D-975, GRADE 3-D

Detroit Diesel Allison does NOT recommend the use of proposed grade 3-D diesel fuel in any of its engines. This grade of fuel was proposed, but not accepted by, the ASTM.

The grade 3-D which was proposed is undesireable in that it possesses poor ignition quality (i.e., lower cetane), allows greater sulfur content (up to 0.70% by weight), allows the formation of more carbon deposits (Conradson carbon residue), and allows the blending of heavier, more viscous boiling point fractions that are difficult to burn. The latter tend to increase combustion chamber deposits. This type of fuel usually manifests poor cold

FUELS BURNED IN DETROIT DIESEL ENGINES

ASTM Designation	Federal Standard	Military Spec.	NATO Code	Grade	Description/Comments
D-975				1-D 2-D	Diesel Fuel
D-396				1, 2	Burner Fuel (Furnace Oil) ***Caution: If Used, The Max. Sulfur Content Allowed Is 0.50 WT. % and the Minimum Cetane No. Is 45. (See Fuel Oil Selection Chart).***
	VV-F-800		F-54	1, 2	DF-1 Winter Grade. DF-2 Regular Grade
	VV-F-800		F-56		DF-A (Arctic Grade). Limited Supply For Military.
		MIL-T-5624		JP-5	Kerosene
D-1655		MIL-T-83133	F-34	JP-8	Jet A-1. Kerosene Type Plus Special Anti-Icer
D-1655			F-35		Jet A, Kerosene
		MIL-F-16884	F-76	DFM	Diesel Fuel - Marine (DFM). ***Caution: If Used, The Max. Sulfur Content Allowed Is 0.50 WT. %.***
		MIL-F-5161		JP-6	Referee Grade JP-5 Type Jet Fuel. Limited Quantities Supplied To Military Only.

weather properties (wax formation tendencies). In addition, the poor ignition quality adversely affects noise and emission levels.

A comparison of ASTM D-975 grade 2-D and the proposed grade 3-D fuel properties is shown in the following table.

USING DRAINED LUBE OIL IN DIESEL FUEL

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

BURNING MIXTURES OF DIESOHOL AND GASOHOL AND/OR ADDING ALCOHOL AND/OR GASOLINE TO DIESEL FUEL

Very small amounts of isopropyl alcohol (isopropanol) may be used to preclude fuel line freeze-up in winter months. No more than ONE PINT of isopropyl alcohol should be added to 125 GALLONS of diesel fuel for adequate protection.

Commercially marketed DIESOHOL or GASOHOL or GASOLINE should never be added to diesel fuel. An explosive and fire hazard exists if these blends are mixed and/or burned.

COMPARISON OF ASTM D-975 GRADE 2-D AND PROPOSED GRADE 3-D PROPERTIES

Property	Grade: Recommended 2-D	Grade: Not Recommended 3-D
Cetane No., Min.	40.0	37.0
Sulfur, WT. %, Max.	0.50	0.70
Carbon Residue On 10% Residuum, %, Max.	0.35	0.40
Viscosity @ 40° Celsius, Centistokes	1.9 - 4.1	2.0 - 7.0
Distillation		
deg. Celsius (Fahrenheit)		
90% Recovery, Max.	338 (640)	360 (680)

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. It is accordingly contrary to the policy of General Motors to recommend the regular and continued use of supplementary additives in fuels and lubricants."

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, reodorants, tune-up compounds, top oils, break-in oils, graphitizers, and friction-reducing compounds.

NOTICE: 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.

LUBRICATION SPECIFICATIONS

GENERAL CONSIDERATIONS

All diesel engines require heavy-duty lubricating oils. Basic requirements of such oils are lubricating quality, high heat resistance, and control of contaminants.

LUBRICATING QUALITY. The reduction of friction and wear by maintaining an oil film between moving parts is the primary requisite of a lubricant. Film thickness and its ability to prevent metal-to-metal contact of moving parts is related to oil viscosity. The optimums for Detroit Diesel engines are SAE 40 or 30 weight.

HIGH HEAT RESISTANCE. Temperature is the most important factor in determining the rate at which deterioration or oxidation of the lubricating oil will occur. The oil should have adequate thermal stability at elevated temperatures, thereby precluding formation of harmful carbonaceous and/or ash deposits.

CONTROL OF CONTAMINANTS. The piston and compression rings must ride on a film of oil to minimize wear and prevent cylinder seizure. At normal rates of consumption, oil reaches a temperature zone at the upper part of the piston where rapid oxidation and carbonization can occur. In addition, as oil circulates through the engine, it is continuously contaminated by soot, acids, and water originating from combustion. Until they are exhausted, detergent and dispersant additives aid in keeping sludge and varnish from depositing on engine parts. But such additives in excessive quantities can result in detrimental ash deposits. If abnormal amounts of insoluble deposits form, particularly on the piston in the compression ring area, early engine failure may result.

Oil that is carried up the cylinder liner wall is normally consumed during engine operation. The oil and additives leave carbonaceous and/or ash deposits when subjected to the elevated temperatures of the combustion chamber. The amount of deposits is influenced by the oil composition, additive content, engine temperature, and oil consumption rate.

OIL QUALITY is the responsibility of the oil supplier. (The term "oil supplier" is applicable to refiners, blenders, and rebranders of petroleum products). Oil quality can also be affected by handling cleanliness, contamination, dirt, water, etc.

There are hundreds of commercial crankcase oils marketed today. Obviously, engine manufacturers or users cannot completely evaluate the numerous commercial oils. The selection of a suitable lubricant in consultation with a reliable oil supplier, observance of his oil drain recommendations (based on used oil sample analysis and experience), and proper filter maintenance will provide the best assurance of satisfactory oil performance.

It should be noted that lube oil manufacturers may reformulate an oil while maintaining the same API classification, or may reformulate to a new API classification and continue the brand name designation. For example, SE oils being reformulated to SF letter code classification may perform differently after this reformulation. A close working relationship with the lube oil manufacturer should be maintained so that any reformulation can be reviewed and a decision made as to its effect on continued satisfactory performance.

COLD WEATHER OPERATION

Two important considerations relate to satisfactory operation under cold ambient temperature conditions. These are: (1) the ability to crank the engine fast enough to secure starting, and (2) providing adequate lubrication to internal wearing surfaces during starting and warm-up. Once started and warmed up, external ambient temperatures have little effect on internal engine temperatures. Both cold weather considerations can be adequately met through proper lube oil selection and the use of auxiliary heat prior to starting. Auxiliary heat can be used in the form of jacket water and oil pan heaters, hot air space heaters applied to engine compartments, or some combination of these.

Proper oil selection and oil heat can assure lubricant flow immediately upon starting. Improper oil selection and oil heat may result in starting with cold oil congealed in the oil pan, and little or no oil flow for lubricating internal parts once the engine has started.

Proper oil selection and jacket water heating can assure cranking capability by maintaining an oil film on cylinder walls and bearing surfaces in a condition which provides low friction, and hence, less cranking effort to achieve cranking speeds necessary for reliable starting. Improper oil selection and jacket water heating may result in congealed oil films on cylinder walls and bearing surfaces, which result in high friction loads and more cranking effort than is available, thus preventing sufficient cranking speeds to assure reliable starting.

LUBE OIL SPECIFICATIONS

API PERFORMANCE DESIGNATIONS, LUBE SUPPLIER, AND BRAND NAMES

Lubricants are blended to meet specific industry accepted tests developed by the American Society for Testing and Materials (ASTM). The service for which these products are intended is defined by the American Petroleum Institute (API). The lube supplier markets these products under a specific brand or trade name. The container identification indicates whether the contents meet or exceed specific API letter code designations (example: SF, CD).

RECOMMENDATION

Lubricating oils that meet the following performance levels, viscosity grades, sulfated ash limits and zinc requirements are recommended for Detroit Diesel engines. It is also recommended that the oil supplier provide to the user evidence of satisfactory performance of his products in Detroit Diesel engines.

LUBE OIL PERFORMANCE LEVELS

Lubricants are formulated to meet all the performance criteria defined in either commercial (API) and/or military specifications. Table L-1 shows the current commercial industry and military oil performance levels. The API letter designations are defined in SAE recommended practice J-183 published in the SAE Handbook.

Specific oil performance level recommendations for Detroit Diesel engines are indicated in Table L-1.

TABLE L-1
LUBE OIL PERFORMANCE LEVELS

API PERFORMANCE DESIGNATION		COMPARABLE MILITARY SPECIFICATION	RECOMMENDED FOR USE IN DDA ENGINES		COMMENTS & CURRENT API OR MILITARY QUALIFICATION STATUS
DIESEL ENGINES	GASOLINE ENGINES		2-CYCLE	4-CYCLE	
CB	—	MIL-L-2104A (Supplement 1)	YES	NO	Obsolete, still limited availability.
CC	—	MIL-L-2104B	YES	NO	Obsolete, still readily available.
CD	—	MIL-L-45199B (Series 3)	YES	NO	Still limited availability.
CC	SE	MIL-L-46152	YES	YES	Obsolete Diesel performance, intended for passenger cars burning gasoline.
CC	SF	NONE	YES	YES	Primarily for passenger cars burning gasoline.
CD	SC	MIL-L-2104C	YES	YES	Current spec. for heavy duty diesel powered military vehicles, acceptable for commercial diesel powered vehicles.
CD	SE		YES	YES	Diesel performance requirements are current. Gasoline fueled passenger cars performance requirements are obsolete.
CD	SF		YES	YES	Meet current diesel & gasoline performance requirements.
—	SF		NO	YES	Service station lubes.

VISCOSITY GRADES

Single grade SAE-40 and 30 lubricants are preferred and recommended for use in all Detroit Diesel 2-cycle engines. Table L-2 shows a viscosity grade selection chart as related to ambient temperatures. Note that 15W-40 multigrade oils are recommended as a third choice for Series 53, 71 and 92 engines only when ambient temperatures are below 32°F (0°C). Multigrade oils, including 15W-40, should never be used in Series 149 engines.

TABLE L-2
VISCOSITY — SAE GRADE SELECTION CHART

Ambient Temperature		ENGINE SERIES								
		149		92, 71, 53			8.2L			
		2-CYCLE		2-CYCLE			4-CYCLE			
Deg. Fahr.	Deg. Celsius	First	Second	First	Second	Third	First	Second	Third	Fourth
↕ 50	↕ 10	** SAE 40	SAE 30	SAE 40	SAE 30	None	15W-40	10W-40	20W-40	30
↕ 32	↕ 0	SAE (40)	SAE 30 *	SAE (40)	SAE 30 *	None	* 15W-40	* 10W-40	* 20W-40	None
↕ 0	↕ −18	SAE (40)	SAE (30)	SAE (40)	SAE (30)	* 15W-40	(15W-40)	* 10W-40	(20W-40)	None
↕ −25	↕ −32	SAE (40)	SAE (30)	SAE (40)	SAE (30)	(15W-40)	(15W-40)	(10W-40)	(20W-40)	None

( ) Numbers in parentheses indicate that starting aids are required.

* Usually unaided starts can be accomplished.

** SAE 50 grade lube oil is recommended if the top tank coolant temperature is 195°F or above. (CAUTION: Do not use SAE-50 grade lube oil when or where cold ambient temperatures prevail.)

OTHER MULTIGRADE OILS

15W-40 oils are the only acceptable multigrade lubricants that should be considered in Series 53, 71 and 92 engines if prolonged cold ambient temperatures below 32°F (0°C) are expected. Detroit Diesel Allison does not recommend the use of any multigrade oils other than 15W-40 in these 2-cycle engines. Never use any kind of multigrade oils in Series 149 engines.

OIL CHANGES

CONDITION A: THE SULFUR CONTENT OF THE DIESEL FUEL IS LESS THAN 0.50% BY WEIGHT

Table L-3 shows the initial oil drain intervals recommended for all Detroit Diesel engines. Oil drain intervals may be increased or decreased depending upon the condition of the lubricant. Used lube oil analysis guidelines, indicating contamination limits, are shown elsewhere in Table L-4. DDA recommends that if the total base number (TBN by ASTM D-664) is reduced to 1.0 or if the TBN (ASTM-2896) is reduced to 2.0, the oil should be drained immediately.

CONDITION B: THE SULFUR CONTENT OF THE DIESEL FUEL IS GREATER THAN 0.50% BY WEIGHT

The detrimental effects of burning high sulfur fuel are known in industry. The use of high sulfur diesel fuel may be unavoidable in some locations.

The use of high TBN/ash oils (TBN greater than 10, ash up to 2.500% by weight) is recommended to counteract corrosion.

The trend manifested by extremely high TBN oils (TBN greater than 20/ash between 2.000 to 2.500% by weight) is to drop several TBN numbers and then level off. The condition of the used oil under these circumstances is that it has retained some alkaline reserve (neutralization power) but will become overloaded with suspended solids that tend to become insoluble, resulting in the formation of excessive engine deposits. Therefore, 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.

TABLE L-3

RECOMMENDED LUBE OIL DRAIN AND FULL-FLOW FILTER CHANGE INTERVALS WHEN BURNING LOW SULFUR DIESEL FUELS (0.5% BY WT. OR LESS)*

SERVICE APPLICATION	ENGINE SERIES	ENGINE DESIGN	LUBE OIL DRAIN INTERVAL**	FILTER CHANGE INTERVAL
Hwy. Truck & Inter-City Buses	71 & 92 8.2L	2-Cycle 4-Cycle	20,000 Miles 6,000 Miles	20,000 Miles 6,000 Miles
City Transit Coaches & Pick-Up & Delivery Truck Service (Stop-and-Go) Short Distance	53, 71, 92 8.2L	2-Cycle 4-Cycle	12,000 Miles 6,000 Miles	12,000 Miles 6,000 Miles
Industrial & Marine	53, 71, 92 8.2L	2-Cycle 4-Cycle	150 Hours 150 Hours	150 Hours 150 Hours
Large Industrial & Marine	149 (NA) 149 (T)	2-Cycle 2-Cycle	500 Hrs. or One Yr. 300 Hrs. or One Yr.	500 Hrs. or One Yr. 300 Hrs. or One Yr.
Stationary (Stand-By) Engines	53, 71, 92 149 8.2L	2-Cycle 2-Cycle 4-Cycle	150 Hrs. or One Yr. 150 Hrs. or One Yr. 150 Hrs. or One Yr.	150 Hrs. or One Yr. 150 Hrs. or One Yr. 150 Hrs. or One Yr.
Generator Sets (Prime Power)	53, 71, 92	2-Cycle	500 Hrs. or One Mo.	500 Hrs. or One Mo.

* See sections indicating Detroit Diesel's recommendations when burning high sulfur content (0.5% by Wt. or more) diesel fuels.

** May be increased or decreased, depending on the results obtained from used lube oil analysis.

FULL-FLOW FILTER CHANGE PERIOD

Table L-3 shows the DDA recommended full-flow filter change period for the various service applications. The filter element should be changed at the same time the crankcase oil is drained. Filter life is affected by heat and vibration in addition to contaminant filtration. Filter change should not exceed 25,000 miles/500 hours maximum.

TABLE L-4

USED LUBE OIL ANALYSIS GUIDELINES

These values indicate the need for an immediate oil change, but do not necessarily indicate internal engine problems requiring engine teardown. Characteristics relating to lube oil dilution should trigger corrective action to identify and fix the source(s) of leaks, if these values are realized.

	ASTM Designation	ENGINE SERIES — WARNING LIMITS 2-CYCLE Series 149	2-CYCLE Series 92	2-CYCLE Series 71	2-CYCLE Series 53	4-CYCLE Series 8.2L
Pentane Insolubles, Wt. %	D-893	1.00	1.00	1.00	1.00	1.00
Carbon (Soot) Content Wt. % Max.	TGA †	0.80	0.80	0.80	0.80	2.00
Viscosity at 100°F, SUS	D-445 & D-2161					
% Max. Increase		40.0	40.0	40.0	40.0	40.0
% Max. Decrease		15.0	15.0	15.0	15.0	15.0
Total Base Number (TBN), Min	D-664	1.00	1.00	1.00	1.00	1.00
Total Base Number (TBN), Min	D-2896	2.00	2.00	2.00	2.00	2.00
Water Content (Dilution), Vol. %, Max.	D-85	0.30	0.30	0.30	0.30	0.30
Flash Point, °F, Max. Reduction	D-92	40.0	40.0	40.0	40.0	40.0
Fuel Dilution, Vol. %, Max.	—	1.00	2.50	2.50	2.50	2.50
Glycol Dilution, PPM, Max.	D-2982	1000.00	1000.00	1000.00	1000.00	1000.00
Iron Content, PPM, Max.	‡	35	150	150	150	250
Sodium Content, PPM Max. Allowed Over Lube Oil Baseline	‡	50	50	50	50	50
Boron Content, PPM, Max. Allowed Over Lube Oil Baseline	‡	20	20	20	20	20

† TGA = Thermogravimetric analysis used and recommended by Detroit Diesel. No ASTM procedure designation.

‡ Elemental analyses are conducted using either emission spectographic or atomic absorption instruments. Neither method has ASTM designation.

FREQUENCY OF LUBE OIL SAMPLES FOR ANALYSIS

The interval at which used lube oil samples may be obtained for analysis can be scheduled for the same period as when other preventative maintenance is conducted. For example, in highway truck applications, a sample may be obtained every 10,000 miles when engines are brought in for fuel and coolant filter replacement. (Reference instructions in Detroit Diesel Engine Service Manuals).

USED LUBE OIL ANALYSIS PROGRAM

A used lube oil analysis program is recommended for monitoring the condition of the crankcase oil in all engines.

Primarily, used lube oil analyses indicate the condition of the oil but not necessarily the condition of the engine. Never tear down an engine based solely on the analysis results obtained from a single used oil sample. However, the condition of the engine should be investigated using conventional mechanical and/or electronic diagnostic instruments. Frequently, visual inspections are all that is required to detect problem areas related to engine wear. It is also prudent to obtain another oil sample from the suspected distressed unit for analysis.

Abnormal concentrations of some contaminants such as diesel fuel, coolant, road salt, or airborne dirt cannot be tolerated for prolonged periods. Their presence will be reflected in accelerated engine wear, which can result in less than optimum engine life. The oil should be changed immediately if any contamination is present in concentrations exceeding the warning limits shown in Table L-4.

Experience in specific engine applications operating specific model engines is a prerequisite for proper interpretation of laboratory used lube oil sample analysis results. It is imperative to remember, in scrutinizing laboratory used lube oil sample results, that it is the change in value or deviation from baseline data obtained from the new oil (same brand or mixture of brands) that is significant. This is especially important to remember in investigations such as wear metal analysis, total base number and viscosity determinations.

SULFATED ASH LIMIT (ASTM D-874)

There is a performance trade-off when using either high or low ash oils. High ash oils (greater than 1.000% by weight) sometimes provide excessive exhaust valve and ring groove deposits but have shown superior anti-wear performance on compression rings and cylinder liners. Low ash oils, historically, have shown minimal engine deposit formation tendencies but premature wear has been experienced in some applications. As indicated in the oil changes section, low ash oils do not provide sufficient neutralization capability when high sulfur diesel fuels are used.

Therefore, DDA recommends that low ash (less than 1.000% by weight) oils continue to be used where satisfactory performance has been experienced. High ash oils (2.500% by weight max.) may be used under the following circumstances:

A. At locations where high sulfur diesel fuels (greater than 0.50% by weight) are continuously used.

B. At locations, regardless of the fuel sulfur content, where the oil supplier has submitted documented, conclusive evidence to the user that the lubricant provided satisfactory field test performance in Detroit Diesel engines.

ZINC CONTENT

The zinc content (zinc diorganodithiophosphate) of all low ash (less than 1.000% by weight) lube oils recommended for use in Detroit Diesel 2-cycle and 4-cycle engines shall be a minimum of 0.07% by weight. This requirement is waived where single grade SAE-40, intermediate viscosity index lubricants qualified for use in Electro-Motive Division (EMD) diesel engines are used in Detroit Diesel engines.

Some specific high ash oils (2.500% by weight maximum) do not contain zinc additives. These oils may be used under the following circumstances:

1. Where diesel fuels with greater than 0.50% by weight sulfur content are continuously used.

2. The oil supplier has submitted documented, conclusive evidence to the user that the lubricant has provided satisfactory field test performance in Detroit Diesel engines.

EVIDENCE OF SATISFACTORY PERFORMANCE

It is recommended that evidence of satisfactory lubricant performance in Detroit Diesel 2-cycle engines be obtained from the oil supplier prior to procurement. Controlled oil performance evaluations in field test engines are recommended. 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. This information is summarized in Table L-5. The candidate test oil-operated engines should all operate for the mileage/hours indicated. Fuel and lube oil consumption should be monitored during the test period. Any serious mechanical problems experienced should be recorded. All of the oil test engines should be disassembled at the conclusion of the oil test period and inspected. The following oil performance parameters should be compared:

- Ring sticking tendencies and/or ring conditions
- Piston skirt scuffing and cylinder liner wear and scuffing
- Exhaust valve face and seat deposits
- Piston pin and connecting rod bushing wear (Note: Trunk pistons used in Series 53 engines)
- Overall valve train and bearing wear levels.

TABLE L-5
INDIVIDUAL USER SERVICE APPLICATION LUBE FIELD TESTING

ENGINE SERIES	SERVICE APPLICATION	TEST DURATION	NO. ENGINES ON CANDIDATE TEST OIL	NO. SISTER ENGINES ON REFERENCE BASELINE SAE 40 or SAE 30
53	Pickup & Delivery Metro Area	50,000 Miles	5	5
71 & 92	Hwy. Truck 72,000 Lbs. GCW	200,000 Miles	5	5
149	Off Road Rear Dump 120 Ton	10,000 Hours	3*	3*

* Single Grade Only — No multigrades recommended for Series 149 engines.

MIL-L-46167 ARCTIC LUBE OILS FOR NORTH SLOPE AND OTHER EXTREME SUB-ZERO OPERATIONS

Lubricants meeting this specification are used in Alaska and other extreme sub-zero locations. Generally, they may be described as 5W-20 multigrade lubricants made up of synthetic base stock and manifesting low volatility characteristics. Although they have been used successfully in some severe cold regions, Detroit Diesel Allison does not consider their use as desirable as the use of SAE-40 or SAE-30 oils with auxiliary heating aids. For this reason, they should be considered only where engine cranking is a severe problem and auxiliary heating aids are not available on the engine.

SYNTHETIC OILS

Synthetic lubricants may be used in Detroit Diesel 2-cycle engines provided the ash limit, zinc requirements, and specified oil performance levels (for example, CD/SE or MIL-L-2104B, etc.) shown elsewhere in this specification are met. Viscosity grades SAE-40 or SAE-30 are recommended.

MISCELLANEOUS FUEL AND LUBRICANT INFORMATION

ENGINE OIL CLASSIFICATION SYSTEM

The American Petroleum Institute (API), the Society of Automotive Engineers (SAE), and the American Society for Testing and Materials (ASTM) jointly have developed the present commercial system for designating and identifying motor oil classifications. The table in this section shows a cross-reference of current commercial and military lube oil identification and specification systems.

CROSS-REFERENCE OF LUBE OIL CLASSIFICATION SYSTEM

API CODE LETTERS	COMPARABLE MILITARY OR COMMERCIAL INDUSTRY SPECIFICATION
CA	MIL-L-2104A
CB	Supplement 1
CC	MIL-L-2104B (See Note Below)
CD	MIL-L-45199B (Series 3)
‡	MIL-L-46152 (Supersedes MIL-L-2104B Military Only)
□	MIL-L-2104C (Supersedes MIL-L-45199B for Military Only)
SA	None
SB	None
SC	Auto Passenger Car 1964 MS Oils - Obsolete System
SD	Auto Passenger Car 1968 MS Oils - Obsolete System
SE	Auto Passenger Car 1972 MS Oils - Obsolete System
SF	Auto Passenger Car 1980 Production

‡ Oil performance meets or exceeds that of CC and SE oils.
□ Oil performance meets or exceeds that of CD and SC oils.

NOTE: MIL-L-2104B lubricants are obsolete for military service applications only.
MIL-L-2104B lubricants are currently marketed and readily available for commercial use.

Consult the following publications for complete descriptions:

1. Society of Automotive Engineers (SAE) Technical Report J-183a.
2. Federal Test Method Standard 791a.

PUBLICATION AVAILABLE SHOWING COMMERCIAL "BRAND" NAME LUBRICANTS

A list of "brand" name lubricants distributed by the majority of worldwide oil suppliers can be purchased from the Engine Manufacturers Association (EMA). The publication is titled *EMA Lubricating Oils Data Book for Heavy-Duty Automotive and Industrial Engines.* The publication shows the brand names, oil performance levels, viscosity grades, and sulfated ash contents of most "brands" marketed.

ENGINE MANUFACTURERS ASSOCIATION
111 EAST WACKER DRIVE
CHICAGO, ILLINOIS 60601

Upon request, the Detroit Diesel Allison Regional Office will counsel with customers in selecting a lubricating oil that will be suitable for their specific needs.

STATEMENT OF POLICY ON FUEL AND LUBRICANT ADDITIVES

See statement at the end of "FUEL OILS" section.

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

Any water, whether of drinking quality or not, 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

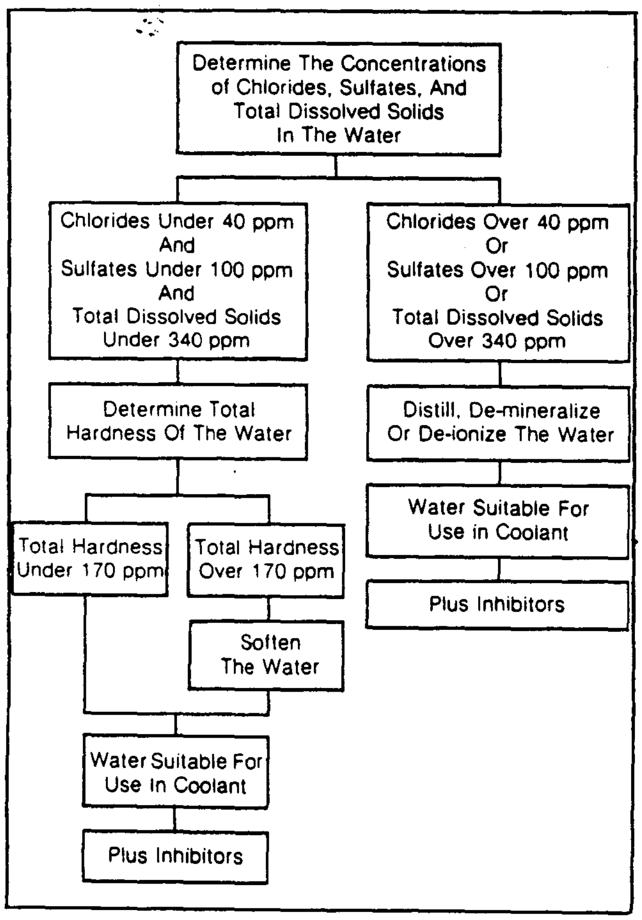


TABLE 2

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. 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-worse-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).

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.

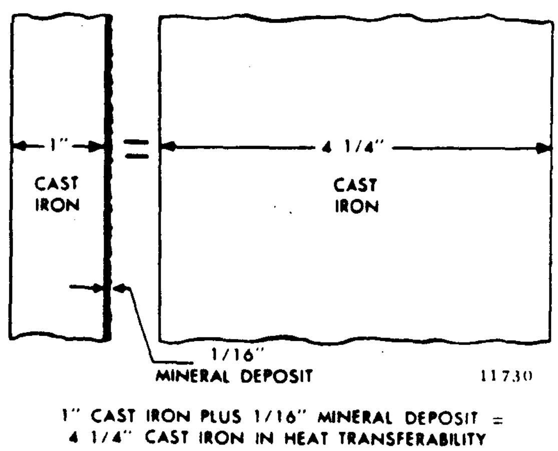


Fig. 1 - Heat Transfer Capacity

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 resulting in engine overheating (Fig. 1). 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 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-antifreeze solution.

INHIBITOR SYSTEMS

An inhibitor system is a combination of chemical compounds which provide corrosion 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 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. Some 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.

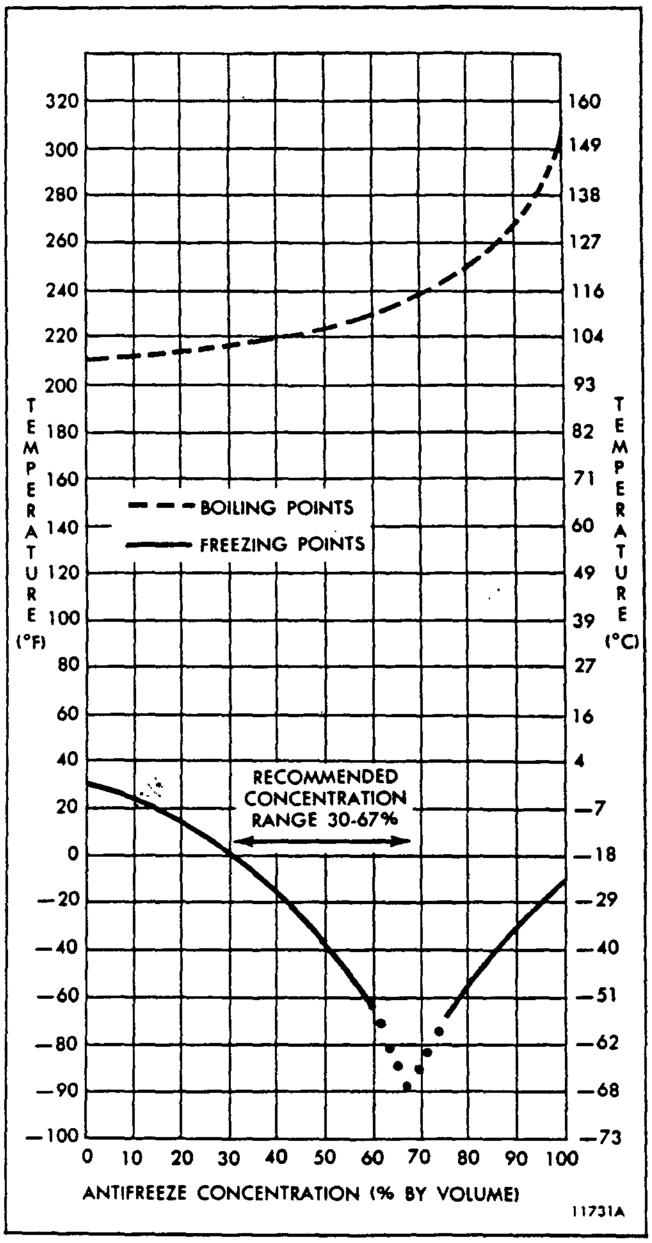


Fig. 2 - Coolant Freezing and Boiling Temperatures vs. Antifreeze Concentration (Sea Level)

All inhibitors become depleted through normal operation and additional inhibitor must be added to the coolant as required to maintain original strength levels. 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.

ANTIFREEZE

When freeze protection is required, an antifreeze meeting GM Specification 1899M 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 (Fig. 2).

Ethylene glycol base antifreeze is recommended for use in all Detroit Diesel engines. Methyl alcohol base anitfreeze 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.

Before installing ethylene glycol base antifreeze in a unit that has previously operated with methoxy propanol, the entire cooling system should be drained, flushed with clean water, and examined for rust, scale contaminants, etc. If deposits are present, the cooling system must be chemically cleaned with a commerical grade heavy-duty descaler.

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 intervals.

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.

Sealer Additives

The use of antifreeze containing sealer additives or the addition of sealer additive to any type coolant in Detroit Diesel engines is not recommended due to plugging possibilities throughout various areas of the cooling system, including cooling system bleed holes and water pump drain holes.

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 properly 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. Sculling 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.

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 meeting GM Specification 1899M.

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. Do not use sealer additives or antifreeze containing sealer additives.

11. Do not use methyl alcohol base antifreeze.

12. Use extreme care when removing the radiator pressure control cap.

13. Do not add inhibitor supplements to *new* antifreeze solutions.

14. 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.*

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 mechanisms, 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 the cylinder head, governor or injectors have been replaced or overhauled, then certain tune-up adjustments are required. Accurate tune-up adjustments are very important if maximum performance and economy are to be obtained.

If a supplementary governing device, such as a load limit device, is used, it must be 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.

> **CAUTION:** To prevent the possibility of personal injury, use turbocharger inlet shield J 26554-A anytime the turbocharger inlet is exposed.

Use a new valve rocker cover gasket(s) after the tune-up is completed.

Tune-Up Sequence for Mechanical Governor

> **CAUTION:** Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover, 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.

1. Adjust the exhaust valve clearance.

2. Time the fuel injectors.

3. Adjust the governor gap.

4. Position the injector rack control levers.

5. Adjust the maximum no-load speed.

6. Adjust the idle speed.

7. Adjust the buffer screw.

8. Adjust the throttle booster spring (variable speed governor only).

9. Adjust the supplementary governing device (if used).

Tune-Up Sequence for Hydraulic Governor

1. Adjust the exhaust valve clearance.

2. Time the fuel injectors.

3. Adjust the fuel rod.

4. Position the injector rack control levers.

5. Adjust the load limit screw.

6. Adjust the speed droop.

7. Adjust the maximum no-load speed.

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 the cylinder head is overhauled, the exhaust valves reconditioned or replaced, or the valve operating mechanism is replaced or disturbed in any way, the valve clearance must 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 which is close enough to the specified clearance to prevent damage to the valves when the engine is started.

All of the exhaust valves may be adjusted, in firing order sequence, during one full revolution of the crankshaft. Refer to Section 1 of the manual for the engine firing order.

TWO VALVE CYLINDER HEADS

Valve Clearance Adjustment (Cold Engine)

1. Remove the loose dirt from the valve rocker cover(s) and remove the cover(s). Discard the gasket(s).

2. Place the governor speed control lever in the *idle* speed position. If a stop lever is provided, secure it in the *stop* position.

3. Rotate the crankshaft, manually or with the starting motor, until the injector follower is fully depressed on the particular cylinder to be adjusted.

NOTE: 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 could be loosened.

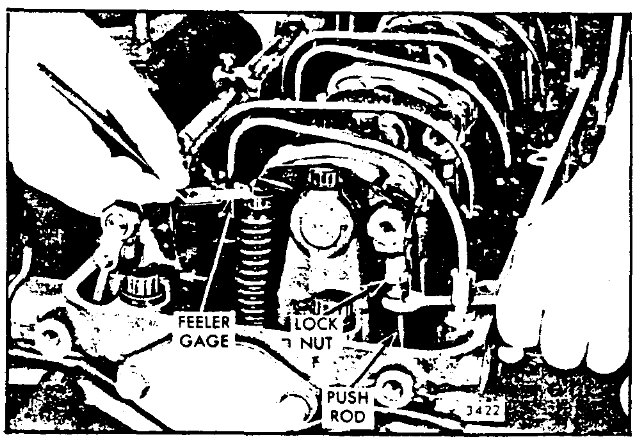


Fig. 1 - Adjusting Valve Clearance (Two-Valve Cylinder Head)

4. Loosen the exhaust valve rocker arm push rod locknut.

5. Place a .011" feeler gage (J 9708-01) between the exhaust valve stem and the rocker arm (Fig. 1). Adjust the push rod to obtain a smooth "pull" on the feeler gage.

6. Remove the feeler gage. Hold the push rod with a 5/16" wrench and tighten the locknut with a 1/2" wrench.

7. Recheck the clearance. At this time, if the adjustment is correct, the .010" feeler gage (J 9708-01) will pass freely between the valve stem and the rocker arm, but the .012" feeler gage will not pass through. Readjust the push rod, if necessary.

8. Adjust and check the remaining exhaust valves in the same manner as outlined above.

Valve Clearance Adjustment (Hot Engine)

It is *not* necessary to make a final hot engine exhaust valve clearance adjustment after a cold engine adjustment has been performed. However, if a hot engine adjustment is desired, use the following procedure.

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.

NOTE: Since these adjustments are normally made while the engine is stopped, it may be necessary to run the engine between adjustments to maintain normal operating temperature.

1. With the engine at normal operating temperature, set the exhaust valve clearance with feeler gage J 9708-01. At this time, if the valve clearance is correct, the .008" feeler gage will pass freely between the end of the valve stem and the rocker arm and the .010" feeler gage will not pass through. Readjust the push rod, if necessary.

2. After the exhaust valve clearance has been adjusted, check the fuel injector timing.

Check Exhaust Valve Clearance Adjustment

1. With the engine operating at 100° F (38° C) or less, check the valve clearance.

2. If a .011" feeler gage (±.004") will pass between the valve stem and the rocker arm bridge, the valve clearance is satisfactory. If necessary, adjust the push rod.

FOUR VALVE CYLINDER HEADS

Valve Clearance Adjustment (Cold Engine)

1. Remove the loose dirt from the valve rocker cover(s) and remove the cover(s). Discard the gaskets.

2. Place the governor speed control lever in the *idle* speed position. If a stop lever is provided, secure it in the *stop* position.

3. Rotate the crankshaft, manually or with the starting motor, until the injector follower is fully depressed on the particular cylinder to be adjusted.

> **NOTE:** 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 could be loosened.

4. Loosen the exhaust valve rocker arm push rod locknut.

5. Place a .026" feeler gage (J 9708-01) between the end of one exhaust valve stem and the rocker arm bridge (Fig. 2). Adjust the push rod to obtain a smooth "pull" on the feeler gage.

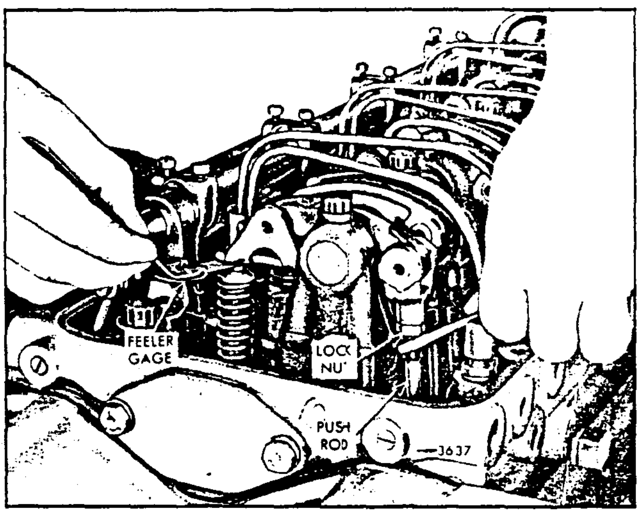


Fig. 2 - Adjusting Valve Clearance (Four-Valve Cylinder Head)

6. Remove the feeler gage. Hold the push rod with a 5/16" wrench and tighten the locknut with a 1/2" wrench.

7. Recheck the clearance. At this time, if the adjustment is correct, the .025" gage will pass freely between the end of one valve stem and the rocker arm bridge, but the .027" gage will not pass through. Readjust the push rod, if necessary.

8. Adjust and check the remaining exhaust valves, in the same manner as above.

Valve Clearance Adjustment (Hot Engine)

It is *not* necessary to make a final hot engine exhaust valve clearance adjustment after a cold engine adjustment has been performed. However, if a hot engine adjustment is desired, use the following procedure.

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.

> **NOTE:** Since these adjustments are normally made while the engine is stopped, it may be necessary to run the engine between adjustments to maintain normal operating temperature.

1. With the engine at normal operating temperature, set the exhaust valve clearance with feeler gage J 9708-01. At this time, if the valve clearance is correct, the .023" gage will pass freely betweeen the end of one valve stem and the rocker arm bridge, but the .025" feeler gage will not pass through. Readjust the push rod, if necessary.

2. After the exhaust valve clearance has been adjusted, check the fuel injector timing.

Check Exhaust Valve Clearance Adjustment

1. With the engine operating at 100° F (38° C) or less, check the valve clearance.

2. If a .026" feeler gage (±.006") will pass between the valve stem and the rocker arm bridge, the valve clearance is satisfactory. If necessary, adjust the push rod.

FUEL INJECTOR TIMING

To time an injector properly, the injector follower must be adjusted to a definite height in relation to the injector body.

All of the injectors can be timed, in firing order sequence, during one full revolution of the crankshaft. Refer to Section 1 of the manual for engine firing order.

Time Fuel Injector

After the exhaust valve clearance has been adjusted, time the fuel injector as follows:

TRUNK PISTONS

INJECTOR	TIMING DIMENSION	TIMING GAGE	CAMSHAFT TIMING	ENGINE
35	1.484"	J 1242	Standard	53 (2 valve)
35	1.508"	J 8909	Standard	(Reefer Car)
40	1.484"	J 1242	Standard	53, V53
45	1.484"	J 1242	Standard	53, V53
S40	1.460"	J 1853	Standard	53, V53
S45	1.460"	J 1853	Standard	53, V53
S50	1.460"	J 1853	Standard	53, (2 valve)
L40	1.460"	J 1853	Standard	(Lift Truck)
N35	1.460"	J 1853	—	—
N35	1.484"	J 1242	Standard	—
N35	1.508"	J 8909	Standard	Reefer Car
N40	1.460"	J 1853	Standard	53N, V53N
N40	1.460"	J 1853	Standard	—
N45	1.460"	J 1853	Standard	53N, V53N
N45	1.460"	J 1853	Standard	—
N45	1.484"	J 1242	Standard	—
N50	1.460"	J 1853	Standard	53N, V53N
N50	1.460"	J 1853	Standard	—
N60	1.460"	J 1853	—	—
N60	1.460"	J 1853	Standard	SGS*
N65	1.508"	J 8909	Standard	4-53T
N65	1.508"	J 8909	Standard	Industrial & SGS*
N65	1.460"	J 1853	Standard	SGS*
N65	1.508"	J 8909	Standard	Generator
N70	1.460"	J 1853	Standard	Marine
N70	1.460"	J 1853	—	—
N70	1.460"	J 1853	Standard	SGS*
M40	1.460"	J 1853	Standard	SGS*
M55	1.460"	J 1853	Standard	SGS*
M60	1.460"	J 1853	Standard	SGS*
5N65	1.460"	J 1853	Standard	6V-53T
5N65	1.460"	J 1853	Standard	Marine
5N45	1.460"	J 1853	Standard	—
5A50	1.490"	J 29066	Standard	Industrial
5A50	1.484"	J 1242	Standard	6V-53T†
5A55	1.496"	J 9595	Standard	Industrial
5A55	1.484"	J 1242	Standard	3-53T†
5A55	1.484"	J 1242	Standard	6V-53T†
5A60	1.496"	J 9595	Standard	Industrial & SGS*
5A60	1.484"	J 1242	Standard	SGS*
5A60	1.484"	J 1242	Standard	3-53T†

For automotive applications, refer to Section 14.
*Special Gov't. Sale.
†With bypass blower.

TABLE 1 (Injector Timing)

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, manually or with the starting motor, until the exhaust valves are fully depressed on the particular cylinder to be timed.

> **NOTE:** 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 could be loosened.

3. Place the small end of the injector timing gage in the hole provided in the top of the injector body with the flat of the gage toward the injector follower (Fig. 3). Refer to Tables 1 and 2 for the correct timing gage.

CROSS-HEAD PISTONS

INJECTOR	TIMING DIMENSION	TIMING GAGE	CAMSHAFT TIMING	ENGINE
5C50	1.480	J 29065	Standard	4-53T 6V-53T
5E50	1.480	J 29065	Standard	3-53T
5C55	1.480	J 29065	Standard	4-53T 6V-53T
5E55	1.480	J 29065	Standard	3-53T
5C60	1.480	J 29065	Standard	4-53T 6V-53T
5E60	1.480	J 29065	Standard	3-53T

TABLE 2 (Injector Timing)

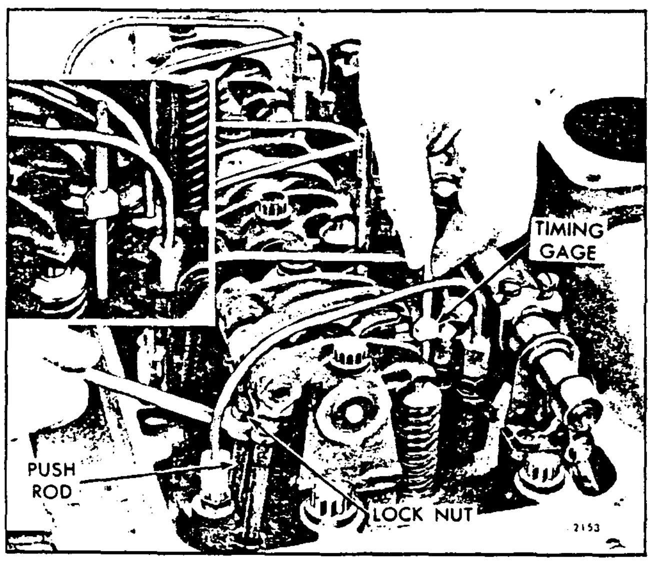


Fig. 3 - Timing Fuel Injector

4. Loosen the injector rocker arm push rod locknut.

5. Turn the push rod and 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 push rod and tighten the locknut. Check the adjustment and, if necessary, readjust the push rod.

7. Time the remaining injectors in the same manner as outlined above.

8. If no further engine tune-up is required, reinstall the valve rocker cover(s), using new gasket(s).