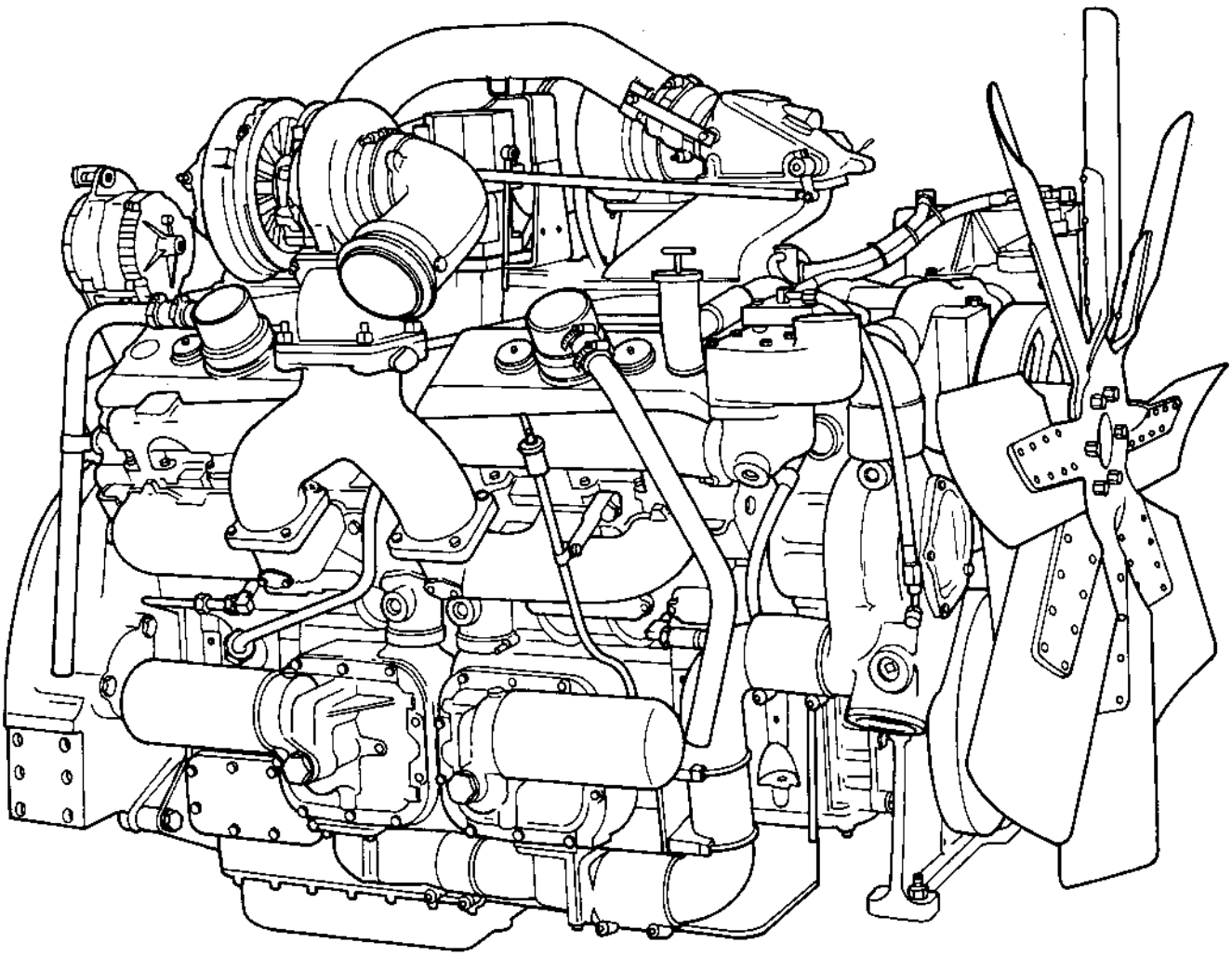
DETROIT DIESEL

Generator Set Power



Engine Operator's Guide

TP-5611

To The Operator

Safety, based on technical skill and years of experience, has been carefully built into your Detroit Diesel Generator Set engine. Time, money, and effort have been invested to make your engine a safe product. The dividend you realize from this investment is your personal safety.

Remember, however, that power-driven equipment is only as safe as the person operating the controls. You are urged, as the operator of this diesel engine, to keep fingers and clothing away from the revolving belts, drive shafts, etc. on the engine installation.

Throughout this guide **CAUTIONS** regarding personal safety and **NOTICES** regarding engine performance or service life will appear. To avoid personal injury and ensure long engine service life, always heed these instructions.

This guide contains instructions on the safe operation and preventive maintenance of your Detroit Diesel generator set engine. Maintenance instructions cover routine engine services such as lube oil and filter changes in enough detail to permit self-servicing, if desired.

The operator should become familiar with the contents of this manual before operating the engine or carrying out maintenance procedures.

Whenever possible, it will pay to rely on an *authorized Detroit Diesel service* outlet for all your service needs from maintenance to major parts replacement. *Authorized service outlets* worldwide stock factory original parts and have the specialized equipment and experienced, trained personnel to provide prompt preventive maintenance and skilled engine repairs.

The information and specifications in this publication are based on the information in effect at the time of approval for printing. Contact an *authorized Detroit Diesel 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 booklet entitled "Warranty Information on Detroit Diesel Generator Set Engines," available from authorized Detroit Diesel service outlets.

Keep this Operators Guide with the generator set at all times. It contains important operating, maintenance, and safety instructions.

Any questions should be directed to the local Detroit Diesel service outlet or nearest Detroit Diesel regional office.

California

Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

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Subject Page

Rating Definitions

Generator set engines are designed to give satisfactory service when applied in accordance with the following ratings (refer to the specific engine performance curve for the power output assigned to each of these types of service):

Standby Power Rating

This rating is applicable to heavy duty diesel generator sets and is subject to normal varying load factors used in the event of a utility power failure. In this and other emergency applications, the generator set may be operated at rated power until normal power is restored. Power loss may be experienced at elevated ambient temperature and high altitude. The generator set in standby applications will operate an average of less than 5% of the time over the course of a year and at an average load factor not to exceed 70% of the Standby Rating.

Limited Running Time Power Rating

This rating is applicable to heavy duty diesel generator sets when used as a utility type power source which will deliver rated power for a limited number of hours, up to 700 hours per year, where there are non-varying load factors and/or constant dedicated loads. The customer should be apprised of the fact that operation at high level constant loads will have a detrimental effect on expected engine life.

Prime Power Rating

This rating is applicable to heavy duty diesel generator sets when used as a utility type power source and is subject to normal varying load conditions, with an intermittent overload (of 10%) up to the standby power rating, for no more than one hour in every 12 hours of operation. When averaged over a 24 hour period, this load factor will not exceed 70% of the Prime Power Rating. Under these conditions, the generator set may be operated continuously for an unlimited number of hours. Power loss may be experienced at elevated ambient temperature and high altitude.

Continuous Power Rating

This rating is applicable to heavy duty diesel generator sets when used as a utility type power source which will deliver power 24 hours per day, for an unlimited number of hours per year, where there are non-varying load factors, and/or constant dedicated loads.

1. ENGINE MODEL, SERIAL NUMBER, OPTION GROUP DESIGNATION

The engine serial number and model number are stamped on the cylinder block in the following locations (as viewed from the flywheel end):

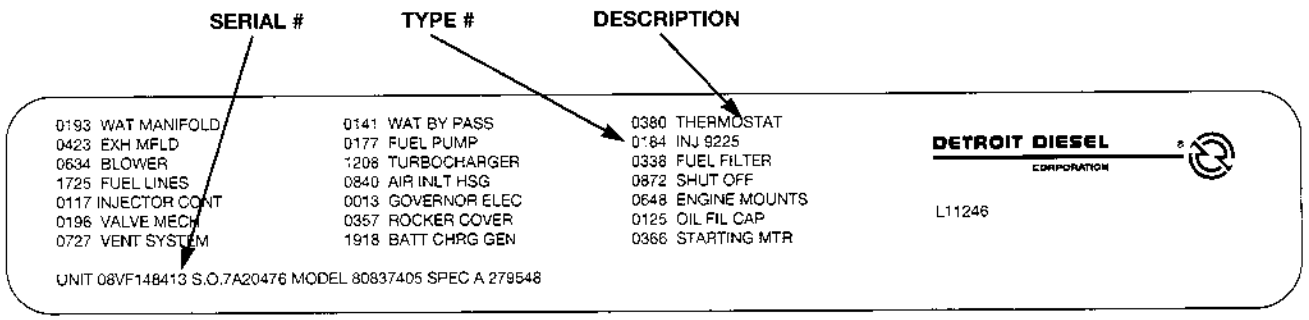
Inline 71	Left side, upper front corner
6V, 8V-71 6V, 8V-92 12V-71	Right side, upper front corner
12V, 16V-92 16V-71	Right side, upper rear corner
8V-149	Left rear corner of block, on rocker cover rail
12V, 16V, 20V-149	Right side of front block, on rocker cover rail
50, 60	Left side, just below the intake manifold and above the cast-in Detroit Diesel Logo.

Option Labels

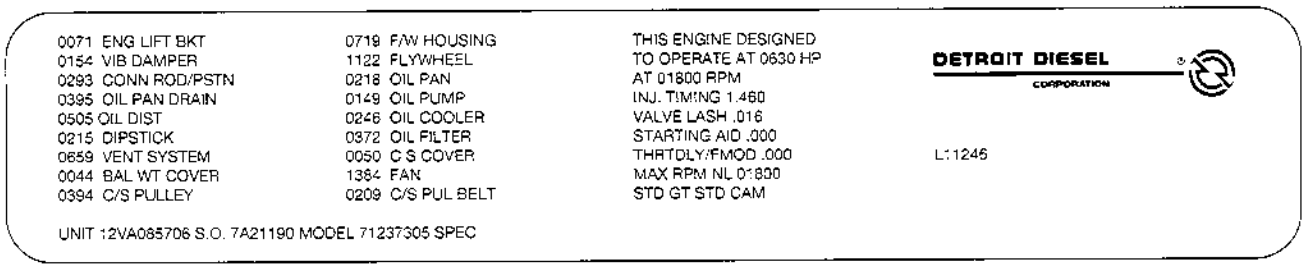
Computerized paper laminate engine option labels are attached to the valve rocker covers. These labels contain the engine serial number and model number and, in addition, list any optional equipment used on the engine. Labels also include required tune-up information (injector timing, valve lash, maximum, no-load RPM, etc.).

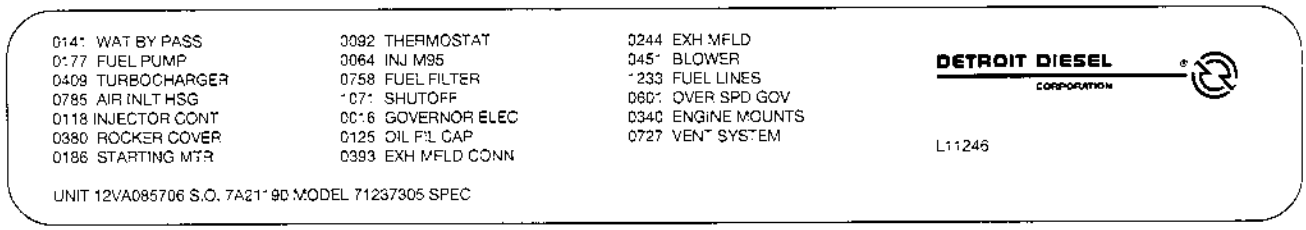
With any order for parts, the engine model and serial number must be given. If a type number is shown on the option label covering the equipment required, this number should also be included on the parts order. For example, if a thermostat is required for an 8V-92, the MPC (Master Parts Catalog) group number (see following pages) is 5.2000B. The type number taken from the option label is 0380. Refer to the proper parts catalog under section 5.2000B, find type 0380 and pick necessary parts and quantities.

Generator sets usually carry their own name plates. The model and serial number information on these plates is useful when ordering parts for these

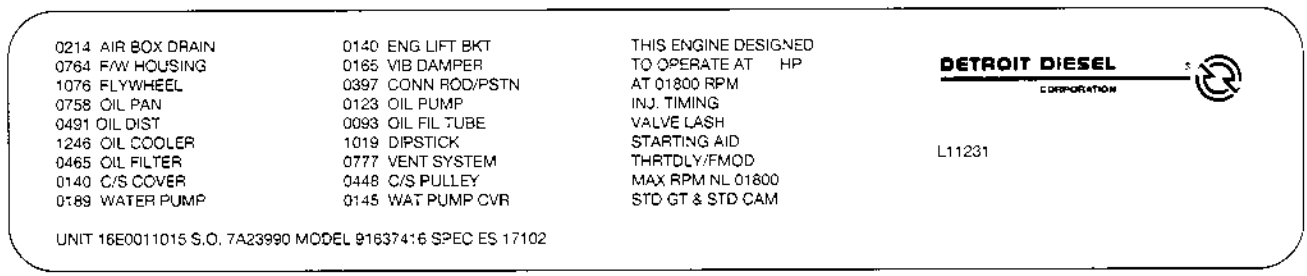


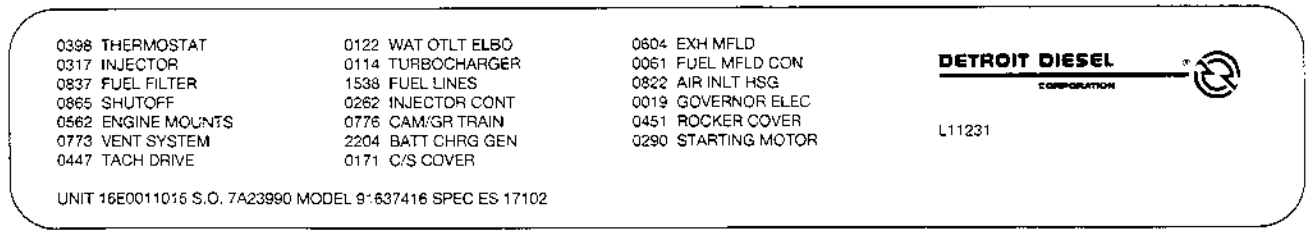
Typical 8V-92 Option Labels



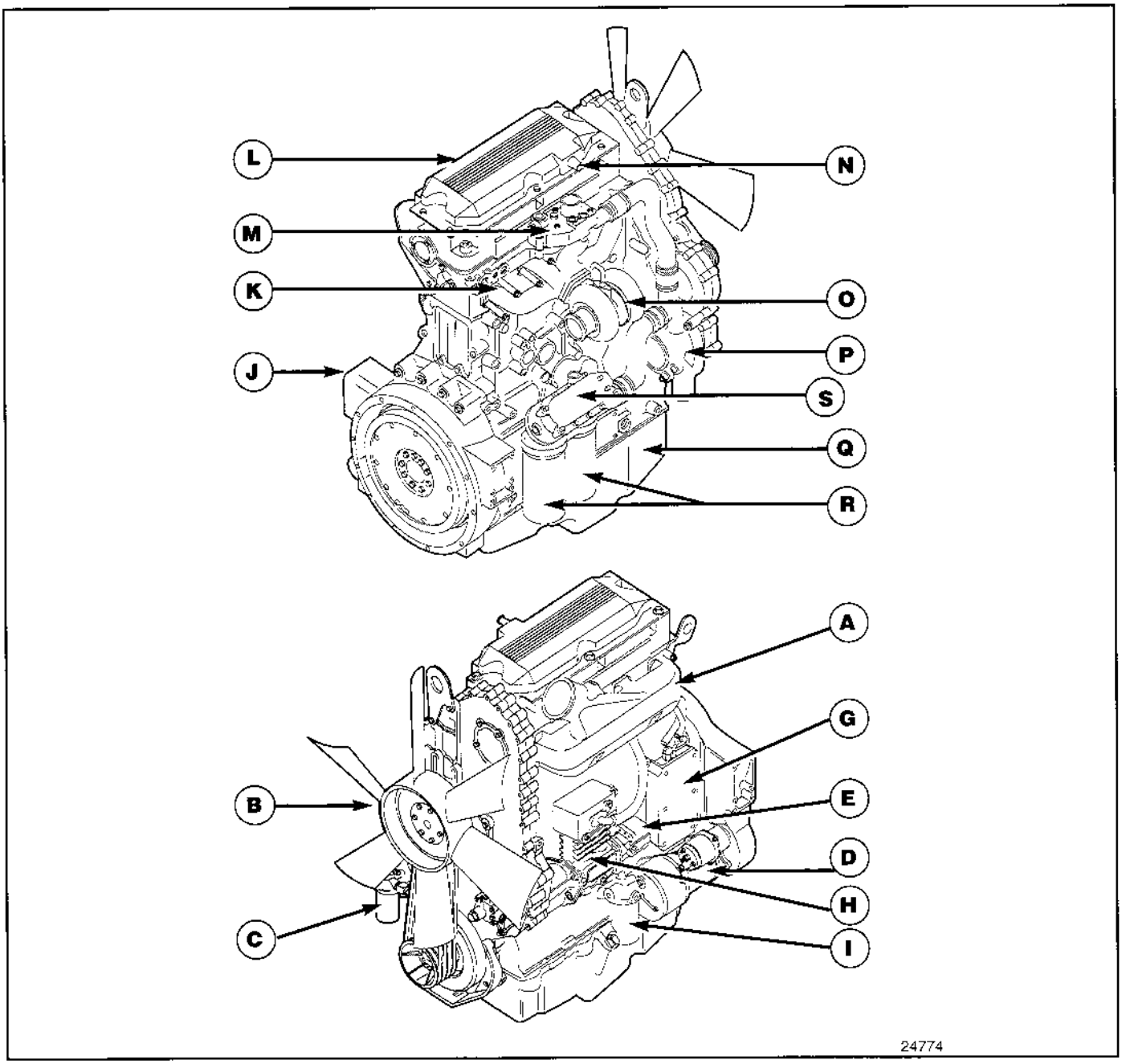


Typical 12V-71 Option Labels



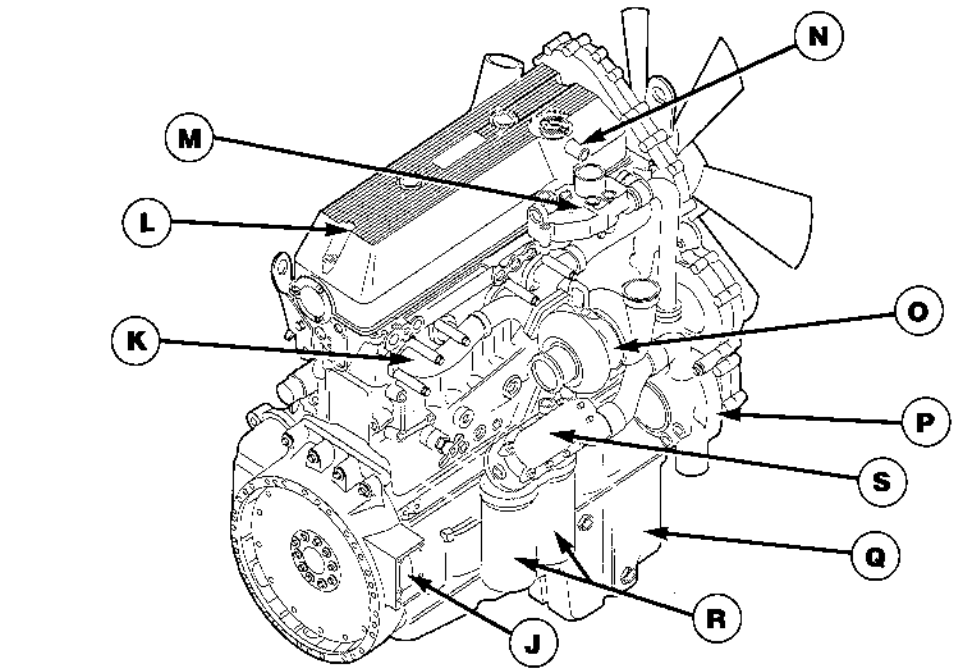


Typical 16V-149 Option Labels



Item	Description	MPC Group
A.	Air Intake Manifold	3.3000C
B.	Fan	5.4000A
C.	Coolant Filter/Inhibitor Element	5.7000A
D.	Electric Starting Motor	7.1000A
E.	Fuel Pump	2.2000
F.	Secondary Fuel Filter	2.3000A
G.	Electronic Control Module	2.1000B
H.	Air Compressor	12.4000A
I.	Primary Fuel Filter (Fuel/Water Separator Shown)	2.3000A

Item	Description	MPC Group
J.	Engine Mounts	11.1000A
K.	Exhaust System	6.1000A
L.	Rocker Cover	1.8000A
M.	Thermostats and Seals	5.2000B
N.	Crankcase Breather	4.8000A
O.	Turbocharger	3.5000A
P.	Water Pump	5.1000
Q.	Oil Pan	4.7000A
R.	Lubricating Oil Filters	4.2000A
S.	Oil Cooler	4.4000A



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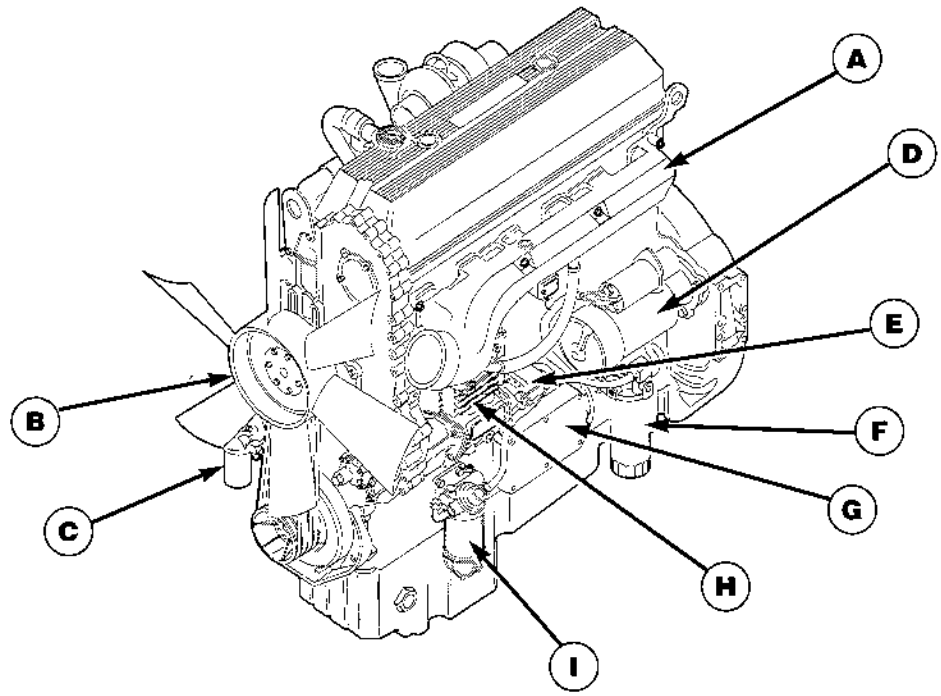

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Item	Description	MPC Group
A.	Air Intake Manifold	3.3000C
B.	Fan	5.4000A
C.	Coolant Filter/Inhibitor Element	5.7000A
D.	Electric Starting Motor	7.1000A
E.	Fuel Pump	2.2000
F.	Secondary Fuel Filter	2.3000A
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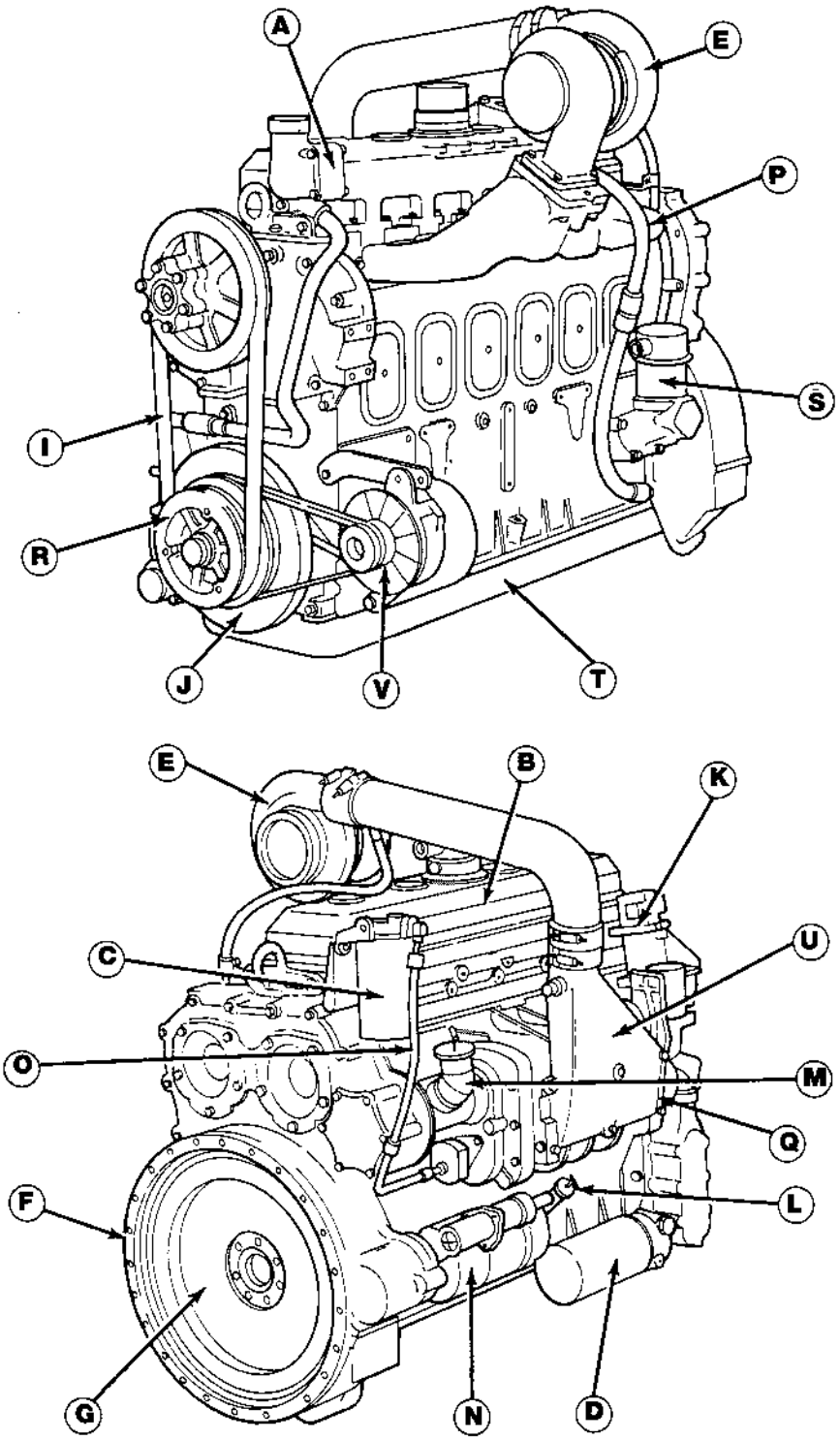
K.	Exhaust System	6.1000A
L.	Rocker Cover	1.8000A
M.	Thermostats and Seals	5.2000B
N.	Crankcase Breather	4.8000A
O.	Turbocharger	3.5000A
P.	Water Pump	5.1000
Q.	Oil Pan	4.7000A
R.	Lubricating Oil Filters	4.2000A
S.	Oil Cooler	4.4000A

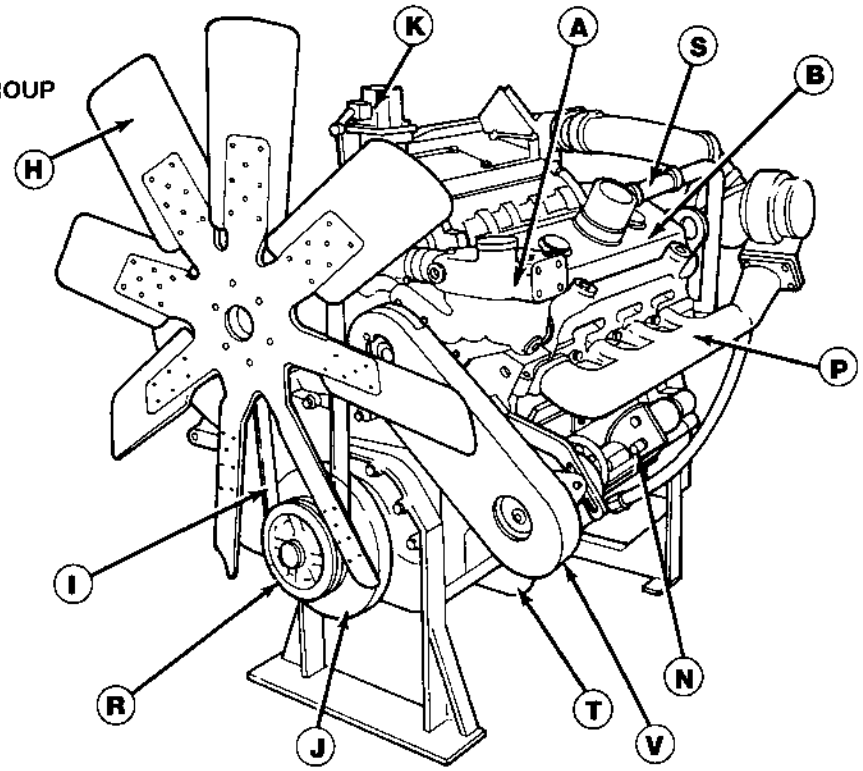
Series 71 (Inline 4/Inline 6)

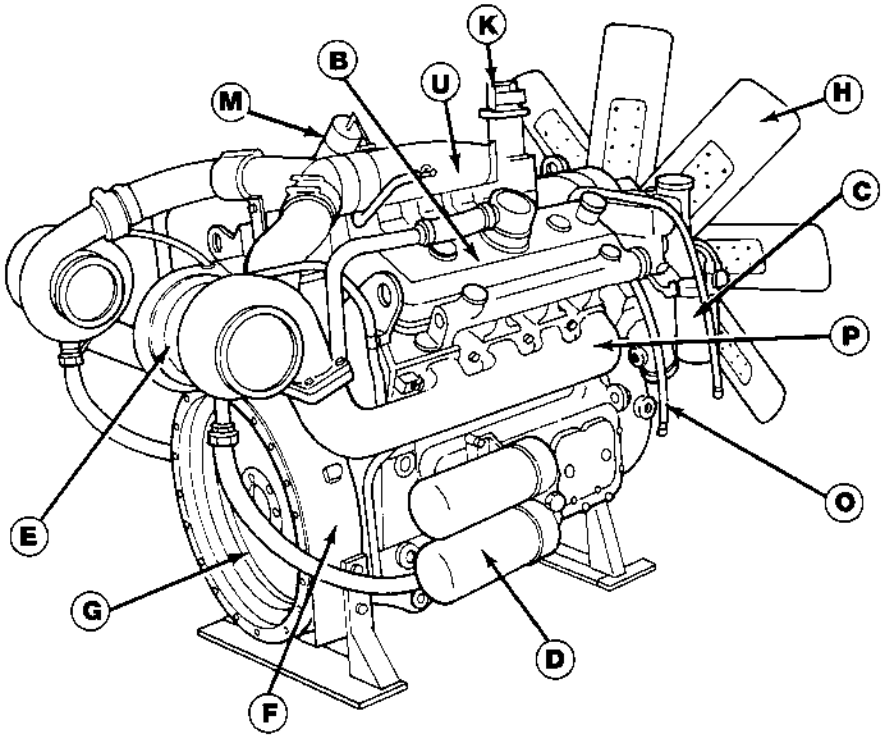
ITEM	DESCRIPTION	MPC GROUP
A	Thermostat	5.2000B
B	Injector	2.1000A
C	Fuel Filter	2.3000A
D	Oil Filter	4.2000A
E	Turbocharger	3.5000A
F	F/W Housing	1.5000A
G	Flywheel	1.4000A
H	Fan	5.4000A
I	Fan Belt	1.3000D
J	Vibration Damper	1.3000B
K	Governor	2.6000B
L	Oil Dipstick	4.6000A
M	Oil Filler Tube	4.5000A
N	Starter Motor	7.3000A
O	Fuel Lines	2.5000A
P	Exhaust Manifold	6.1000A
Q	Air Box Drain	1.1000A
R	C/S Pulley	1.3000C
S	Breather System	4.8000A
T	Oil Pan	4.7000A
U	Air Inlet Housing	3.3000A
V	Battery Charging Alternator	7.1000A



Series 92 (6V/8V)

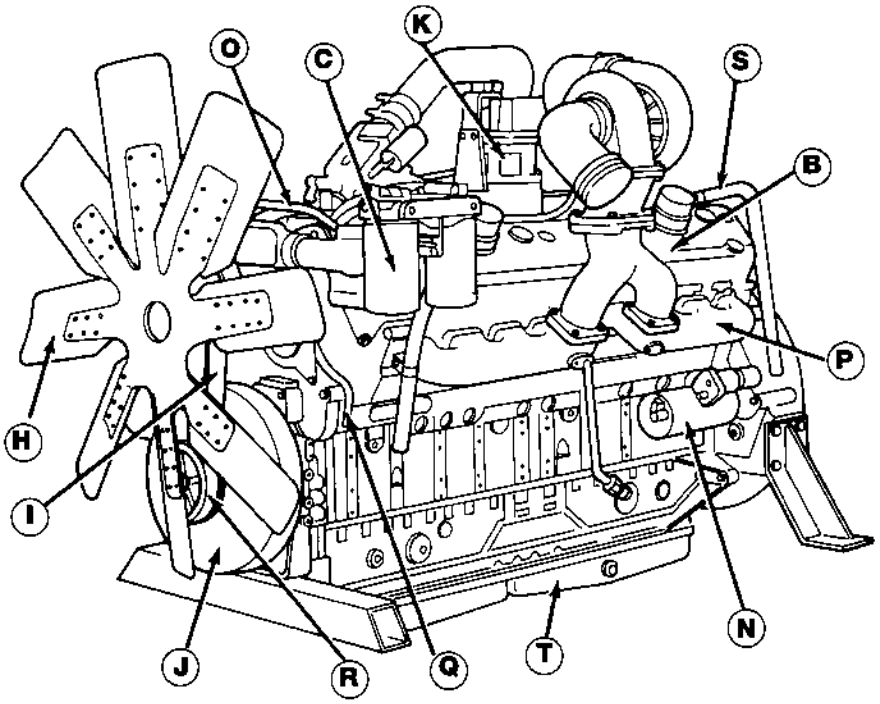
ITEM	DESCRIPTION	MPC GROUP
A	Thermostat	5.2000B
B	Injector	2.1000A
C	Fuel Filter	2.3000A
D	Oil Filter	4.2000A
E	Turbocharger	3.5000A
F	F/W Housing	1.5000A
G	Flywheel	1.4000A
H	Fan	5.4000A
I	Fan Belt	1.3000D
J	Vibration Damper	1.3000B
K	Governor	2.6000B
L	Oil Dipstick	4.6000A
M	Oil Filler Tube	4.5000A
N	Starter Motor	7.3000A
O	Fuel Lines	2.5000A
P	Exhaust Manifold	6.1000A
Q	Air Box Drain	1.1000A
R	C/S Pulley	1.3000C
S	Breather System	4.8000A
T	Oil Pan	4.7000A
U	Air Inlet Housing	3.3000A
V	Battery Charging Alternator	7.1000A

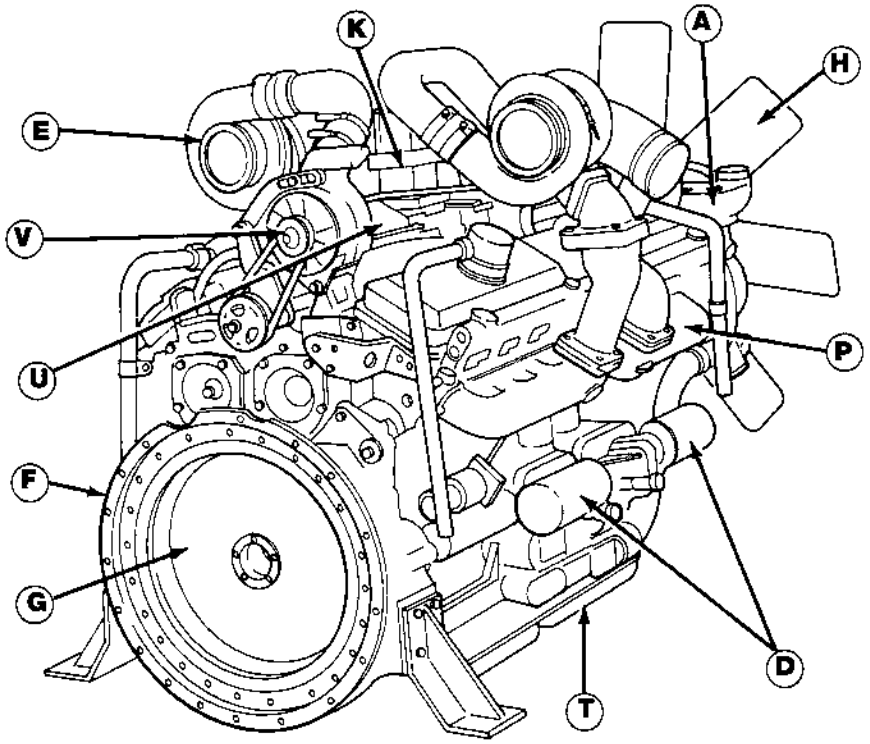




Series 92 (12V/16V)

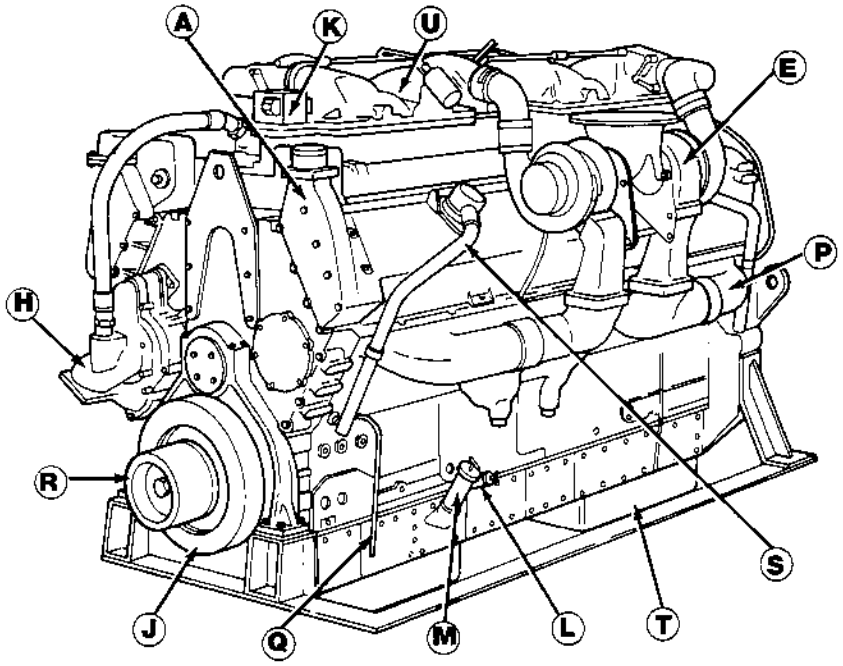
ITEM	DESCRIPTION	MPC GROUP
A	Thermostat	5.2000B
B	Injector	2.1000A
C	Fuel Filter	2.3000A
D	Oil Filter	4.2000A
E	Turbocharger	3.5000A
F	F/W Housing	1.5000A
G	Flywheel	1.4000A
H	Fan	5.4000A
I	Fan Belt	1.3000D
J	Vibration Damper	1.3000B
K	Governor	2.6000B
L	Oil Dipstick	4.6000A
M	Oil Filler Tube	4.5000A
N	Starter Motor	7.3000A
O	Fuel Lines	2.5000A
P	Exhaust Manifold	6.1000A
Q	Air Box Drain	1.1000A
R	C/S Pulley	1.3000C
S	Breather System	4.8000A
T	Oil Pan	4.7000A
U	Air Inlet Housing	3.3000A
V	Battery Charging Alternator	7.1000A

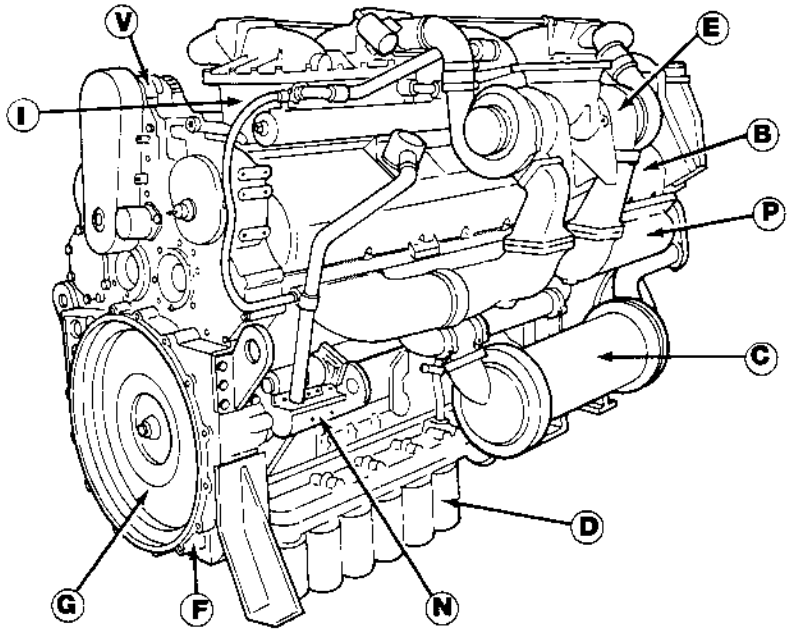




Series 149 (12V/16V/20V)

ITEM	DESCRIPTION	MPC GROUP
A	Thermostat	5.2000B
B	Injector	2.1000A
C	Oil Cooler	4.4000
D	Oil Filter	4.2000A
E	Turbocharger	3.5000A
F	F/W Housing	1.5000A
G	Flywheel	1.4000A
H	Fresh Water Pump	5.1000A
I	Intercooler	3.7001
J	Vibration Damper	1.3000B
K	Governor	2.6000B
L	Oil Dipstick	4.6000A
M	Oil Filler Tube	4.5000A
N	Starter Motor	7.3000A
P	Exhaust Manifold	6.1000A
R	C/S Pulley	1.3000C
S	Breather System	4.8000A
T	Oil Pan	4.7000A
U	Air Inlet Housing	3.3000A
V	Battery Charging Alternator	7.1000A





2. GENERATOR SET INSTALLATION FACTORS

Ventilation

Any internal combustion engine requires a liberal supply of cool, clean air for combustion. If the air entering the engine intake is too warm or too thin, the engine may not produce its rated power. Operation of the engine and generator radiates heat into the room and raises the temperature of the room air. Therefore ventilation of the generator room is necessary to limit room temperature rise and to make clean, cool intake air available to the engine. When the engine is cooled by a set-mounted radiator, the radiator fan must move great quantities of air through the radiator core. There must be enough temperature difference between the air and the water in the radiator to cool the water sufficiently before it recirculates through the engine. The generator set supplier can provide the maximum air temperature limit for which the cooling system is designed. The air temperature at the radiator inlet depends on the temperature rise of air flowing through the room from the inlet ventilator. By drawing air into the room and expelling it outdoors through a discharge duct, the radiator fan helps to maintain room temperature in the desirable range.

In providing ventilation, the objective is to maintain the room air at a temperature that is cool enough for efficient operation and full available power, but not so cold in winter that engine starting is difficult.

Circulation

Good ventilation requires adequate air flow into and out of the room and free circulation within the room. The room should be of sufficient size to allow free circulation of air so that temperatures are equalized and there are not pockets of stagnant air. The generator set should be located so that the engine intake draws air from the cooler part of the room. If there are two or more electric sets, avoid locating them so that air heated by the radiator of one set flows toward the engine intake or radiator fan of an adjacent set. A typical arrangement for adequate air circulation and ventilation is shown in the illustration. See Figure 1.

Ventilators

To bring in fresh air, there *should be* an inlet ventilator opening to the outside or at least an opening to another part of the building through which the required amount of air can enter. In smaller rooms, ducting may be used to bring air to the room or directly to the engine's air intake. In addition, an exit ventilator opening should be located on the opposite outside wall, preferably high up, to exhaust warm air. If the exit air ventilator is located in a lower position, sufficient air flow may be generated by convection. Otherwise, a fan must be installed in the exit ventilator.

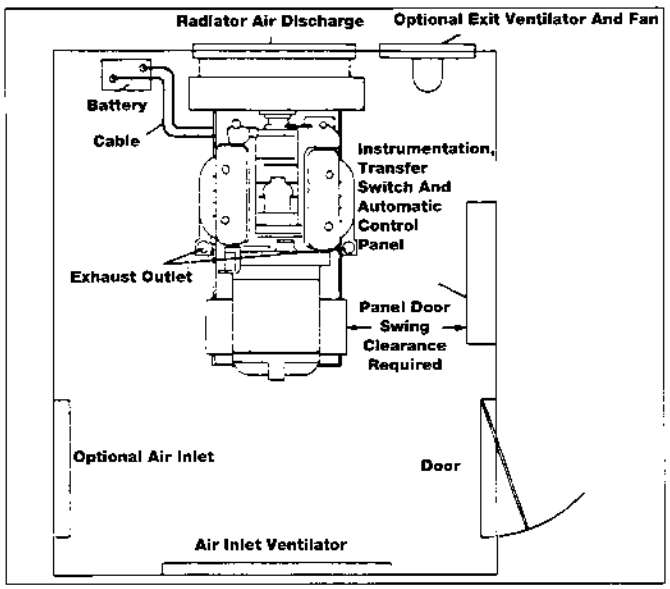


Figure 1. Typical arrangement for adequate air circulation and ventilation

Both the inlet and exit ventilators *should have* louvers for weather protection. These may be fixed, but preferably should be movable in cold climates. For automatic-starting electric sets, if the louvers are movable, they should be automatically operated and those on the air inlet ventilator should be programmed to open immediately upon starting the engine. Inlet louvers must be large enough to allow the intake air flow needed for satisfactory engine performance.

The louvers and fan in the exit ventilator may be thermostatically controlled so that the fan operates as needed and louver position is varied in response to room temperature. If the electric set is equipped with a set-mounted radiator and there is a discharge duct for

radiator air, most or all of the air required for room cooling is drawn into the room and discharged outdoors by the radiator fan. In this case the exit ventilator will be quite small (if required at all), and the exit ventilator fan probably will operate to exhaust a portion of the air flow outdoors only when the electric set is operating at high load or when outdoor temperature is high.

The signal for controlling the exit ventilator louvers and fan normally comes from a temperature sensor on a wall of the generator room. If temperatures at the engine are close to specified limits for engine intake or radiator inlet, the sensor may be located at one of these points. An economical alternative is to measure temperatures with the electric set operating at maximum load and set the wall thermostat low enough to assure cool air at the engine intake and radiator fan inlet.

Inlet Ventilator Size

Before calculating the inlet ventilator size, it is necessary to calculate the air flow required to limit the room temperature rise due to radiation when the electric set is operating at its rated load. Total heat radiated by the complete electric set, including the exhaust system in the room, should be taken into account.

Engine and generator heat radiation for engines and generators, when operating at standby rated power, are shown on engine specification sheets. Exhaust system radiation depends on the length of pipe within the room, the type of insulation used, and whether the silencer is located within the room or outside. It may be possible to insulate the exhaust piping and silencer so that heat radiation from this source may be neglected in calculating air flow required for room cooling. Calculate the required air flow using the total heat radiation and any temperature rise that may be accommodated without exceeding temperature limits at the radiator inlet or engine intake. Compare the calculated room ventilation air flow with the total of engine combustion air flow and radiator air flow discharged from the room. The larger flow is the required inlet ventilator air flow.

After determining the required air flow into the room, calculate the size of inlet ventilator opening to be installed in the outside wall. The inlet ventilator must be large enough so that the flow restriction at a selected air velocity will not generally exceed 0.2 in. H_2O, including the restriction of a screen and louver that may be used in the ventilator. The inlet air flow restriction must be very low, since this restriction adds to the radiator fan loss and to the engine combustion air inlet depression.

Screens, filters and louvers in the ventilators will tend to increase the air flow restriction. Therefore, the inlet air restriction may have to be reduced by increasing the area of the ventilator. Restriction values of air filters, screens and louvers should be obtained from manufacturers of these items.

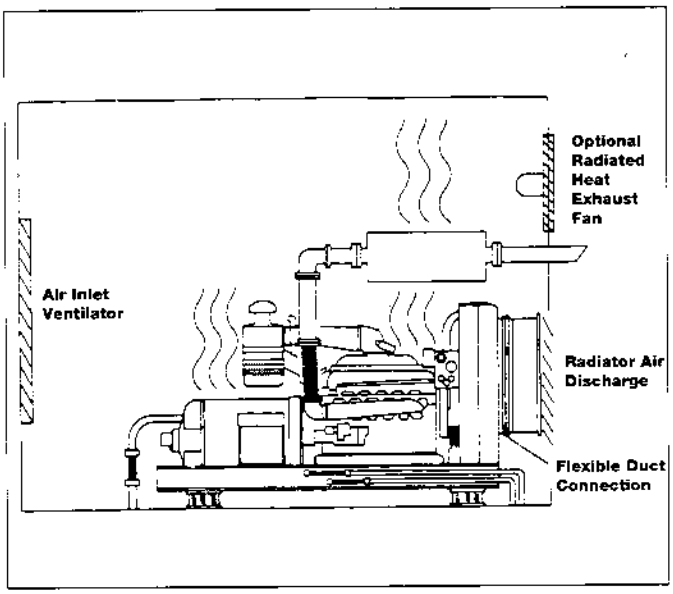


Figure 2. Heat radiation to room

Exit Ventilator Size

If the engine is cooled by a heat exchanger or remote radiator, the exit ventilator must be large enough to exhaust all of the air flowing through the room, except the relatively small amount that enters the engine intake. If the engine is cooled by a set-mounted radiator that discharges air outdoors through a duct, the exit ventilator size is based on that portion of the air flow required for room cooling which exceeds the total of radiator air flow plus combustion air flow. Exit ventilator should be sized to limit the restriction-to-radiator air flow to no more than 0.3 inches H_2O.

In some cases the total of radiator and combustion air flow will exceed the air flow required for room cooling—so, no exit ventilator is needed.

Engine Exhaust

Engine exhaust must be directed to the outside through a properly designed exhaust system that does not create excessive back pressure on the engine. A suitable exhaust silencer should be connected into the exhaust piping, either inside or outside the building. Exhaust system components located within the engine room should be insulated to reduce heat radiation. The outer end of the pipe should have an elbow or "U" shape and should be equipped with a rain cap to prevent rain or snow from entering the exhaust system. If the building is equipped with smoke detection system, the exhaust outlet should be positioned so it cannot set off the smoke detection alarm.

CAUTION:

Engine exhaust contains elements which may be harmful to persons or property. Exhaust stacks must be properly routed to an outdoor area in compliance with applicable laws and regulations. Keep engine exhaust away from building air inlets.

Exhaust Piping

For both installation economy and operating efficiency, engine location should make the exhaust piping as short as possible with minimum bends and restrictions. Usually the exhaust pipe extends through an outside wall of the building and continues up the outside of the wall to the roof. There should be a collar in the wall opening to absorb vibration and an expansion joint in the pipe to compensate for lengthwise thermal expansion or contraction. Another method is to connect the exhaust pipe into a flue or stack (provided local laws permit), thus eliminating the tail pipe that would otherwise run up to the roof. There should be an expansion joint in the pipe and a collar in the stack wall, and inside the stack, the end of the exhaust pipe should be directed upward. Directing the engine exhaust pipe upward avoids reflection of exhaust pulsations from the stack wall back into the exhaust pipe. Such pulsations may affect exhaust back pressure.

When the exhaust is connected into a flue or stack the silencer may be mounted inside the building so the exhaust gas passes through the silencer and then into the stack. The silencer may also be mounted vertically inside the stack. When mounted vertically inside the stack the silencer need not be insulated, but the stack may have to be larger to avoid air flow restriction. In rare cases, connecting into a stack may make it possible to eliminate the silencer, since exhaust pulsations might be sufficiently dissipated in a large stack to exit far enough above ground level to be less bothersome.

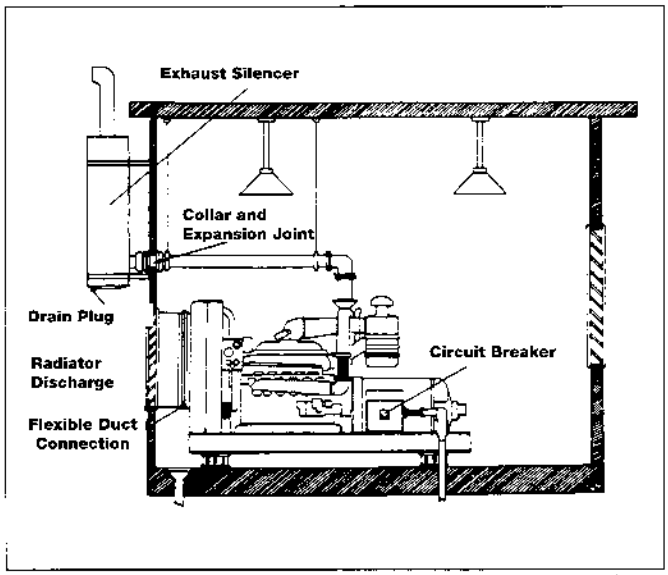


Figure 3. Typical installation outside vertically mounted exhaust

It is not recommended that the engine exhaust share a flue with a furnace or other equipment, since there is a possibility that back pressure caused by one will adversely affect operation of the other. In multi-engine installations, do not connect engine exhaust systems together, because exhaust gases from an operating engine can migrate back through a non-operating engine and cause severe engine damage.

The exhaust can be directed into a special stack that also serves as the outlet for radiator discharge air and may be sound insulated. The radiator discharge air enters below the exhaust gas inlet so that the rising radiator air mixes with the exhaust gas. The silencer may be located within the stack, or in the room with its tail pipe extending into the stack, and then upward. Air guide vanes should be installed in the stack to turn radiator discharge air vertically.

Exhaust Pipe Flexible Section

A flexible connection between the manifold and the exhaust piping system should be used to prevent transmission of engine vibration to the piping and building, and to isolate the engine and piping from forces due to thermal expansion, motion or weight of piping. A well-designed flex section will permit operation with ± 1/2-inch permanent displacement in any direction of either end of the section without damage. Not only must the section have the flexibility to compensate for a nominal amount of permanent mismatch between piping and manifold, but it must also yield readily to intermittent motion of the electric set on its spring isolators in response to load changes. The flexible connection should be specified with the electric set.

Exhaust Pipe Insulation

No exposed parts of the exhaust system should be near wood or other inflammable material. Exhaust piping inside the building should be covered with suitable insulation materials to protect personnel and to reduce room temperature. A sufficient layer of suitable insulating material surrounding the piping and silencer may virtually eliminate heat radiation to the room from the exhaust system. An additional benefit of the insulation is that it provides sound attenuation to reduce noise in the room.

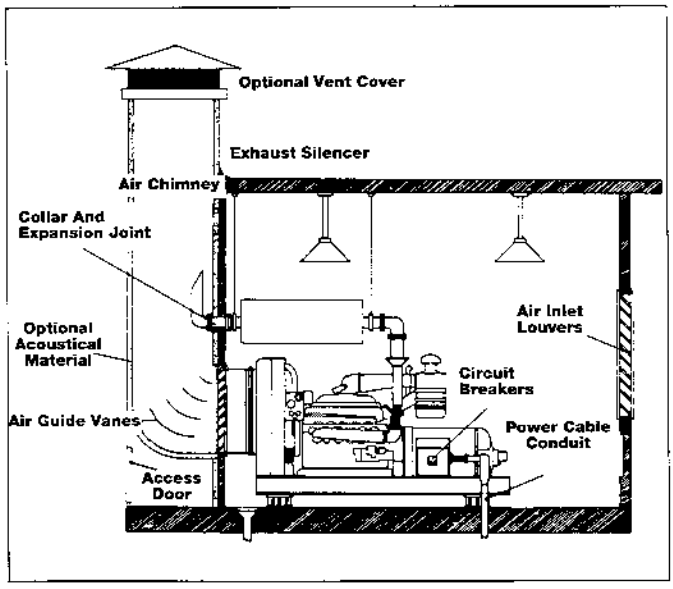


Figure 4. Horizontally mounted exhaust silencer

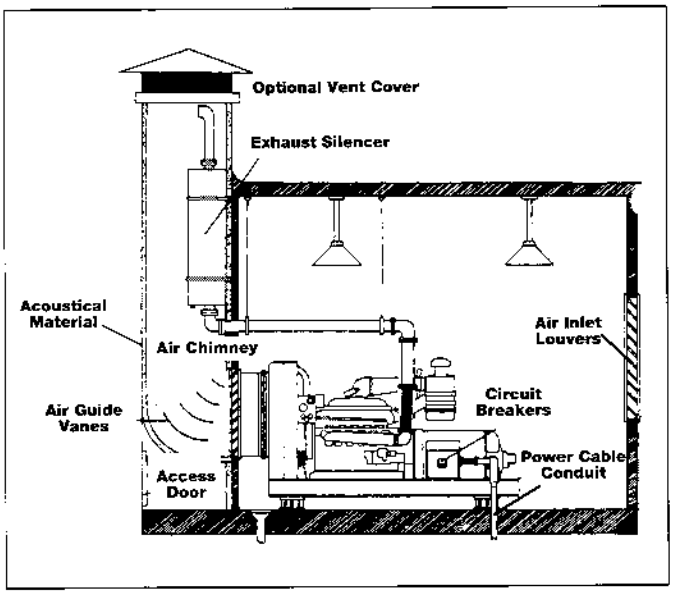


Figure 5. Vertically mounted exhaust silencer

Minimizing Exhaust Flow Restriction

Free flow of exhaust gases through the pipe is essential to minimize exhaust back pressure. Excessive exhaust back pressure seriously affects engine horsepower output, durability, and fuel consumption. By resisting the discharge of gases from the cylinder it causes poor combustion and higher operating temperatures. The major design factors that may cause high back pressure include:

- Exhaust pipe diameter too small
- Exhaust pipe too long
- Too many sharp bends in exhaust system
- Exhaust silencer restriction too high
- Standing pressure waves (at certain critical lengths).

Excessive restriction in the exhaust system can be avoided by proper design and construction. The effect of pipe diameter, length and the restriction of any bends in the system can be calculated to make sure your exhaust system is adequate without excessive back pressure. The longer the pipe, and the more bends it contains, the larger the diameter required to avoid excessive flow restriction and back pressure. The back pressure should be calculated during the installation planning stage to make certain it will be within the recommended limits for the engine.

When installing a generator set measure the exhaust pipe length from installation layout drawing. Take exhaust flow data and back pressure limits from the generator set engine specification sheet. Allowing for restrictions of the exhaust silencer and any elbows in the pipe, calculate the minimum pipe diameter so that the total system restriction will not exceed the recommended exhaust back pressure limit. Refer to Figure 6 for typical measurement procedure.

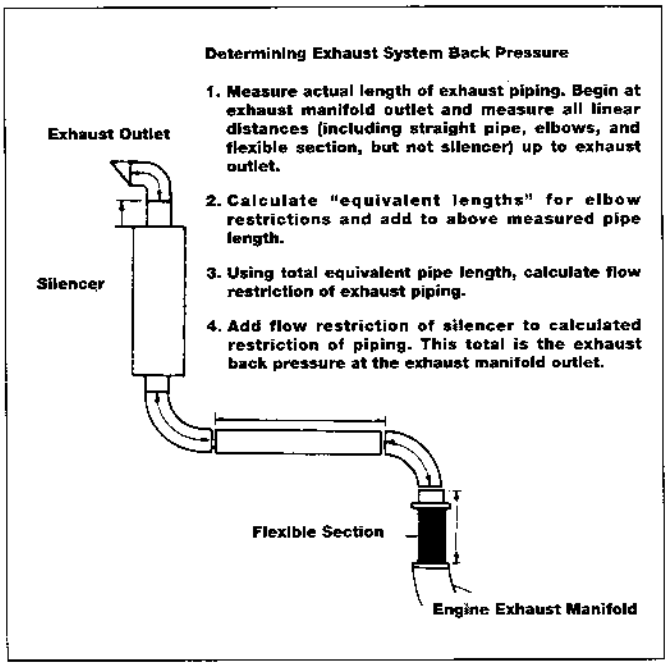


Figure 6. Measuring exhaust pipe length to determine exhaust back pressure

Allowance should be made for deterioration and scale accumulation that may increase restriction over a period of time.

Elbow restriction is most conveniently handled by calculating an equivalent length of straight pipe for each elbow and adding it to the total length of pipe. For a 90 degree elbow the equivalent length of straight pipe can be calculated as follows:

$$L = 2.50 \times D$$

where

L = equivalent of straight pipe, ft
D = diameter of pipe, inches

The following formulas are used to calculate the back pressure of an exhaust system:

$$P = \frac{CLRQ^2}{D^5}$$

Where:

P = back pressure in inches of mercury
C = .00059 for engine airflow* of 100 to 400 cfm
= .00056 for engine airflow* of 400 to 700 cfm
= .00049 for engine airflow* of 700 to 2000 cfm
= .00044 for engine airflow* of 2000 to 5400 cfm
L = length of exhaust pipe in feet
R = exhaust density in pounds per cubic foot
Q = exhaust gas flow in cubic feet per minute**
D = inside diameter of exhaust pipe in inches

$$R = \frac{41.1}{\text{Exhaust temperature °F} + 460°}$$

*Engine airflow is combustion air requirement from engine specification sheet

**Available from engine specification sheet

These formulas assume that the exhaust pipe is clean commercial steel or wrought iron. The back pressure is dependent on the surface finish of the piping, and an increase in the pipe roughness will increase the back pressure. The constant 41.1 is based on the weight of combustion air and fuel burned at rated load and SAE conditions. See engine specification sheet for exhaust gas temperature and air flow.

Exhaust Silencing

Excessive noise is objectionable in most locations. Since a large part of the electric set noise is produced in the engine's pulsating exhaust, this noise can be reduced to an acceptable level by using an exhaust silencer. The required degree of silencing depends on the location and may be regulated by law. For example, the noise of an engine is objectionable in a hospital area but generally is not as objectionable in an isolated pumping station.

⚠ CAUTION:

Excessive noise has been known to adversely affect hearing ability. Use proper ear protection when in the vicinity of the generator set. Note: The set could start at any time, so ear protection should be worn at all times.

Exhaust Silencer Selection

The silencer reduces noise in the exhaust system by dissipating energy in chambers and baffle tubes and by eliminating wave reflection that causes resonance. The silencer is selected according to the degree of silencing required by the site conditions and regulations. The size of silencer and exhaust piping should hold exhaust back pressure within limits recommended by the engine manufacturer.

According to their degree of silencing, silencers are rated "low degree" or "commercial," "moderate" or "semi-critical," and "high degree" or "critical."

- Low-Degree or Commercial Silencing—Suitable for industrial areas where background noise level is relatively high or for remote areas where partly muffled noise is permissible.
- Moderate-Degree of Semi-Critical Silencing—Suitable for localities where moderately effective silencing is required, such as semi-residential areas where a moderate background noise is always present.
- High-Degree or Critical Silencing—Provides maximum silencing for residential, hospital, school, hotel, store, apartment building and other areas where background noise level is low and generator set noise must be kept to a minimum.
- Cost is lowest for commercial silencers and highest for high-degree silencers. The high-degree type is most often required for generator set applications.

Silencers are normally available in two configurations:

- Silencers with end inlet and end outlet
- Silencers with side inlet and end outlet

This choice provides flexibility of installation, such as horizontal or vertical, above engine, on outside wall, etc. The side-inlet type permits 90 degree change of direction without using an elbow. Both silencer configurations should contain drain fittings in locations that assure the silencer can be drained in whatever attitude it is installed.

The silencer may be located close to the engine, with exhaust piping leading to the outside; or it may be located outdoors on the wall or roof. Locating the silencer close to the engine affords best overall noise attenuation because of minimum piping. Servicing and draining the silencer is likely to be more convenient when it is located indoors. However, mounting the silencer outside has the advantage that it may not need to be insulated. The job of insulating piping within the room is simpler when the silencer is outside, and the insulation can aid noise attenuation.

Regardless of where it is mounted, the silencer must be adequately supported so its weight is not applied to the engine's exhaust manifold or turbocharger. The silencer must fit into the space available without requiring extra bends in the exhaust piping, as these could cause high exhaust back pressure.

Silencers or exhaust piping within reach of personnel should be protected by guards or insulation. Indoors, it is preferable to insulate the silencer and piping because the insulation not only protects personnel, it also reduces exhaust system noise. Silencers mounted horizontally should be set at a slight angle with a drain fitting at the lowest point to allow the disposal of any accumulated moisture.

Sound Attenuation

If noise level must be limited, it should be specified in terms of maximum allowable free-air dbA at certain points one meter away from the electric set, when tested under conditions as defined in the Engine Manufacturers Association Procedure for Engine Sound Measurement. Then the power room installation must be designed to hold actual noise inside or outside the room to an acceptable level. Don't attempt to make this noise level unnecessarily low, because the means of achieving it may be too costly.

Use of resilient mounts for the generator set plus normal techniques for controlling exhaust, intake and radiator fan noise, should reduce noise to an acceptable level for many installations. If the remaining noise level is still too high, acoustic treatment of either the room or the electric set is necessary. Sound barriers can be erected around the set, or the walls of the generator room can be sound-insulated, or the electric set can be enclosed in a specially developed sound-insulated hood.

When it is desirable to protect operating personnel from direct exposure to electric set noise, the instruments and control station may be located in a separate sound-insulated control room.

Noise transmitted outside the building by the engine exhaust and radiator discharge can be reduced by having them discharge into a stack lined with non-inflammable acoustic material. A lined canopy above the stack reflects noise back into the stack and keeps out rain and snow.

Engine Cooling

A diesel engine is cooled by circulating a liquid coolant through the oil cooler and through passages in the engine block and head. Hot coolant emerging from the engine is cooled, then recirculated through the engine. Cooling devices are commonly coolant-to-air (radiator) or coolant-to-raw water (heat exchanger) types.

In the most common electric set installation, the engine coolant is cooled in a set-mounted radiator with air blown through the radiator core by an engine driven fan. Some installations use a remotely mounted radiator cooled by an electric motor-driven fan. Where there is a continuously available supply of clean, cool raw water, a heat exchanger may be used instead of a radiator. The engine coolant circulates through the heat exchanger and is cooled by the raw water supply.

An important advantage of a radiator cooling system is that it is self-contained. If a storm or accident disrupts the utility power source, it might also disrupt the water supply and disable any electric set whose supply of raw water depends upon a utility.

Whether the radiator is mounted on the electric set or mounted remotely, accessibility for servicing the cooling system is important. For proper maintenance, the radiator fill cap, the cooling system drain cocks, and the fan belt tension adjustment must all be accessible to the operator.

Set-Mounted Radiator

A set-mounted radiator is mounted on the electric set base in front of the engine. An engine-driven fan blows air through the radiator core, cooling the liquid engine coolant flowing through the radiator. A typical set mounted radiator system is illustrated in Figure 7.

Set-mounted radiators are of two types. One type is used with the cooling fan mounted on the engine. The fan is belt-driven by the crankshaft pulley in a two point drive. The fan blades project into the radiator shroud which has sufficient tip clearance for belt tension adjustment.

The other type of set-mounted radiator consists of an assembly of radiator, fan, drive pulley and adjustable idler pulley to maintain belt tension. The fan is mounted with its center fixed in a venturi shroud with very close tip clearance for high-efficiency performance. The fan drive pulley, idler pulley and engine crankshaft pulley are precisely aligned and connected in a three-point drive by the belts. This second type of set-mounted radiator is usually much quieter and more efficient than the first type. However, it is usually more expensive.

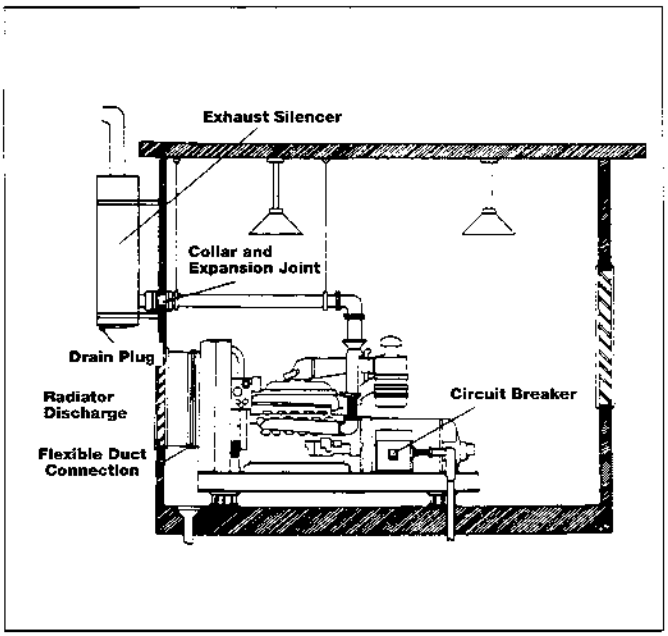


Figure 7. Typical set-mounted radiator

The proper radiator and fan combination will be furnished with the generator set. Air requirements for cooling a particular Detroit Diesel engine are given in the specification sheet. The radiator cooling air must be relatively clean to avoid clogging the radiator core. Adequate filtration of air flowing into the room should assure relatively clean air. However, if the air at the site normally contains a high concentration of dirt, lint, sawdust, or other matter, the use of a remote radiator, located in a cleaner environment, may alleviate a core clogging problem.

The discharge air from a set-mounted radiator should flow *directly* outdoors through a duct that connects the radiator to an opening in an outside wall. The engine should be located as close to the outside wall as possible to keep the ducting short. If the ducting is too long, it may be more economical to use a remote radiator. The total air flow restriction downstream of the radiator should not exceed 0.3 in. H_2O.

When the set-mounted radiator is to be connected to a discharge duct, a duct adapter should be specified for the radiator. A duct adapter is simply a framework around the air discharge side of the radiator core area whose edges are perpendicular to the frontal plane of the radiator. The adapter may contain a series of holes to facilitate attaching one end of a flexible duct section to the front of the radiator. A length of flexible duct material (rubber or suitable fabric) between the radiator and the fixed discharge duct is required to isolate vibration and provide freedom of motion between the electric set and the fixed duct.

NOTICE:

The discharge air must not be permitted to recirculate through the radiator. Hot discharge air provides no cooling ability when directed through the radiator.

Remote Radiator

A remote radiator with electric motor-driven fan can be installed in any convenient location away from the electric set. The fan may be driven by a thermostatically controlled motor which will only draw power from the electric set when required to cool the engine.

A well-designed remote radiator has many useful features and advantages that provide greater flexibility of electric set installations in buildings. For example, remote radiators might eliminate the need for radiator air ducts through the engine room wall and a more efficient venture shroud and fan can provide substantial reduction in horsepower required for engine cooling.

A remote radiator, located outdoors where there is less air flow restriction and air cooler than engine room air, may result in higher efficiency by allowing use of a smaller size radiator.

Remote radiators must be connected to the engine cooling system by coolant piping, including flexible sections between engine and piping. The higher cost of a remote radiator may be substantially offset by its higher efficiency and by the deduction of fan, mounting parts, belts and crankshaft pulley from the engine.

Remote Radiator/Hot Well System

In order to reduce the static head on the engine coolant system or to reduce the cost of antifreeze in a large system, a remote radiator mounted on the roof or other elevated location may be isolated from the engine by a hot well or mixing tank. The hot well is divided by a baffle into a hot side and a cold side. The baffle is perforated to permit enough flow between the two sides so that circulation through the radiator can be maintained and overflow avoided during engine warm-up when the engine thermostat shuts off flow to the hot side of the well.

The engine water pump draws coolant from the cold side and returns it from the engine to the hot side. A separate pump circulates coolant from the hot side of the hot well through the remote radiator and returns it to the cold side. See Figure 8.

When the engine is not operating, coolant drains from the remote radiator into the hot well, located inside the building, and thus avoids freezing in winter. The hot well or another isolation method must be used if the static head exceeds 50 feet. The hot-well tank must have sufficient capacity to store all of the coolant which drains back when the engine is not operating.

Remote Radiator/Heat Exchanger System

Another type of remote radiator system employs a heat exchanger at the engine in place of the hot well. In this application the heat exchanger functions as an intermediate heat exchanger to isolate the engine coolant system from the high static head of the remote radiator coolant. The engine pump circulates engine coolant through the engine and the element of the heat exchanger. A separate pump circulates radiator coolant between the remote radiator and the heat exchanger tank.

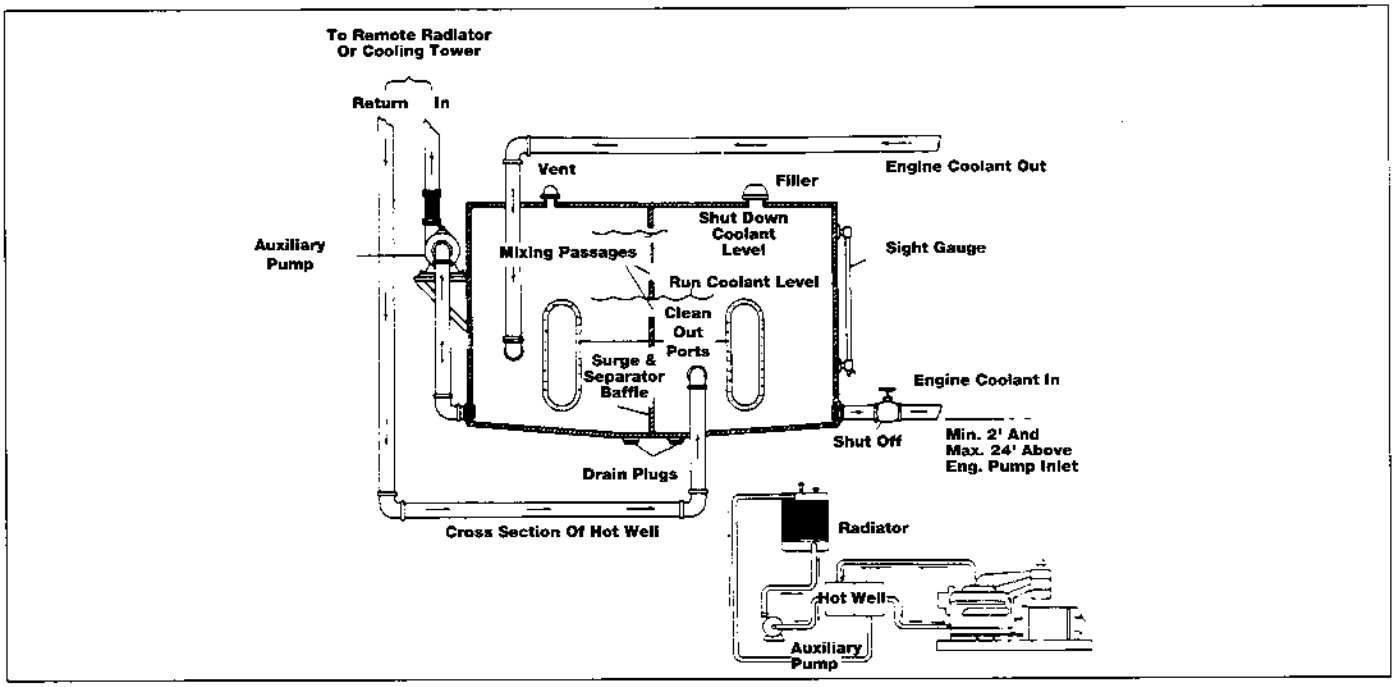


Figure 8. Typical remote radiator/hot well system

3. Engine Systems

Fuel System

The fuel system consists of the fuel injectors, fuel pipes, fuel manifolds (integral with the cylinder head on Series 71 and 92 engines, external on Series 149 engines), fuel pump, fuel strainer, fuel filter, and the necessary connecting fuel lines.

A fuel/water separator and filter are used in the fuel system to remove impurities from the fuel. The filter (marked "S" for secondary filter) removes the smaller particles.

Lubrication System

The lubricating oil system consists of an oil pump, oil cooler, full flow oil filter(s), bypass valves at the oil cooler and filter(s), and pressure regulator valves at the lube oil pump and in the cylinder block main oil gallery.

Air System

In the air system used on Detroit Diesel engines, outside air drawn into the engine passes through the air filter and is pulled into the turbocharger, where it is compressed. It then moves through the blower, where it is further compressed. An intercooler before the blower or an aftercooler after the blower may be used to further increase the density of the charge. The air then flows into the cylinders, where it is compressed by the pistons and mixed with atomized fuel from the injectors.

Dry type air cleaners should be used on turbocharged Detroit Diesel engines. For optimum protection of the engine from dust and other airborne contaminants, service these air cleaners when the maximum allowable air restriction has been reached, or annually.

Cooling System

Radiator or heat exchanger/raw water pump cooling systems are used on Detroit Diesel generator set engines. Each system has a centrifugal type fresh water pump to circulate coolant within the engine. Each system also incorporates thermostats to maintain normal engine operating temperature.

General Cooling System Design Criteria

It is important for the operator to understand that many factors must be considered when designing the overall cooling system. In order to meet minimum standards the following guidelines are presented for radiator (air to coolant) cooled applications.

Heat Sources—Total heat rejected to the coolant must be determined to properly size the radiator and fan arrangement so sufficient heat can be dissipated. This allows the thermostat(s) to control the coolant temperature at an optimum operating level. The cooling system must be able to control maximum engine coolant temperature regardless of the mode of operation.

Factors or components that will raise the temperature of the radiator inlet air or increase restriction to air flow must also be considered when selecting a radiator and fan:

- Engine radiated heat (blower fans)
- Generator radiated heat
- Exhaust system radiated heat
- Recirculated radiator discharge air
- Generator set room configuration

Engine Operating Temperatures—As a general rule the engine coolant-out temperature under normal operating conditions, will range from 10°F below to 15°F above the start-to-open temperature of the thermostat(s). The temperature differential between the engine coolant in and out is typically 10°F (5.5°C) at maximum engine speed and load. Maximum allowable engine coolant-out temperature is 210°F (200°F for Series 149 engines). This limit is necessary to control oil temperatures.

The engine coolant temperature rise and radiator coolant temperature drop values will be different whenever the engine and radiator flow rates are not the same or when auxiliary coolers are placed between the engine and the radiator.

Environmental and Operating Conditions—Both environmental and operating modes of the installation must be considered when designing the cooling system. Additional reserve capacity and special selection of components may be required for operation in the following cases:

- Extreme hot or cold ambient temperatures
- High altitude
- Arid, damp, dusty, oily, windy conditions
- Long term idle, full load operation
- Long term storage or standby operation
- Indoor/outdoor operation
- Serviceability limitations
- Infrequent maintenance intervals
- Severe shock or vibration

When engine performance is reduced due to external conditions, the heat rejected to the coolant generally increases. Engine performance is adversely affected by:

- High air inlet restriction
- High exhaust back pressure
- Elevated air inlet temperature
- Altitude

Operation in extremely cold ambients, at light loads, and/or during idling will require conservation of heat energy. Coolant temperatures must be maintained near the thermostat opening value to control engine oil at a satisfactory temperature level for good engine performance and reliability.

The cooling system ability to dissipate heat to the atmosphere is poorer with increased altitude operation because air density is less. This increases the cooling index (ATW) by 2°F (1.1°C) per 1000 feet (305m).

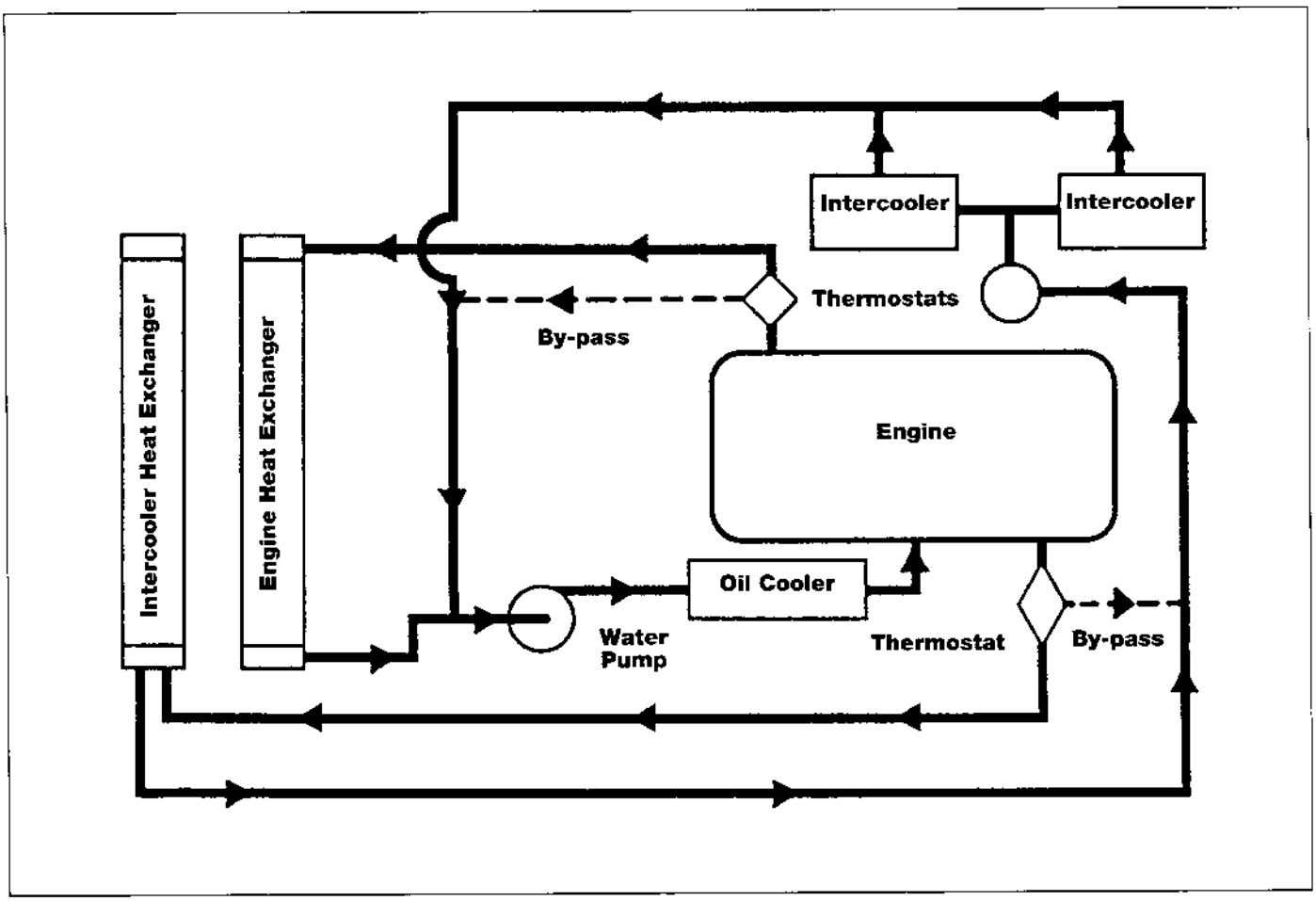


Figure 9. Integrated Liquid Charge Cooling Design Schematic

System Coolant Capacity—Total cooling system coolant capacity must be known in order to provide adequate expansion volume to the deaeration tank. The total capacity must include the basic engine, radiator, heater circuit, plumbing, etc. A minimum 6% expansion volume must be provided in the deaeration tank along with a 2% deaeration volume and sufficient reserve volume to meet drawdown capacity.

A combined minimum 8% expansion and deaeration volume must be provided in a coolant recovery bottle whenever used with the cooling system. Refer to Engineering Bulletin #50 (18SA353) for additional cooling system details. This bulletin is available though authorized Detroit Diesel service outlets.

Basic engine cooling system capacity is shown in the "Specifications" chart on page 60.

Integrated Liquid Charge Cooling (ILCC)—The ILCC cooling system (Figure 9) is required for the higher horsepower Series 149 engines. This system utilizes a single engine water pump and separate radiators to cool engine and intercooler coolant. Radiator manufacturers refer to the system as *two circuit, split flow, separate circuit cooling, advance charge cooling,* etc. Improved fuel economy and engine life are benefits of this system. Approximately 15% of the total water pump flow is diverted from the left side front cylinder block to a separate radiator. This radiator can experience water pressure up to 40 psig. Air box temperature is sensed to control the amount of coolant flow to this radiator. This radiator gives a large coolant temperature drop and the cooled coolant is routed directly to the intercoolers for improved charge air cooling.

Two fan clutch control switches are required when using an on/off or thermatic fan. One switch must sense the intercooler radiator coolant-out temperature and cause the fan to engage at 125°F ± 5°F (52°C ± 3°C). The other switch must sense engine coolant-out temperature (before thermostats) and engage fan 1-°F (5.6°C) after thermostat start-to-open temperature.

Separate Circuit Charged Cooling (SCCC) System—The SCCC cooling system (Figure 10) is required for the higher horsepower 149 engines. This system uses two water pumps and two radiators to separately cool the engine coolant and the intercooler

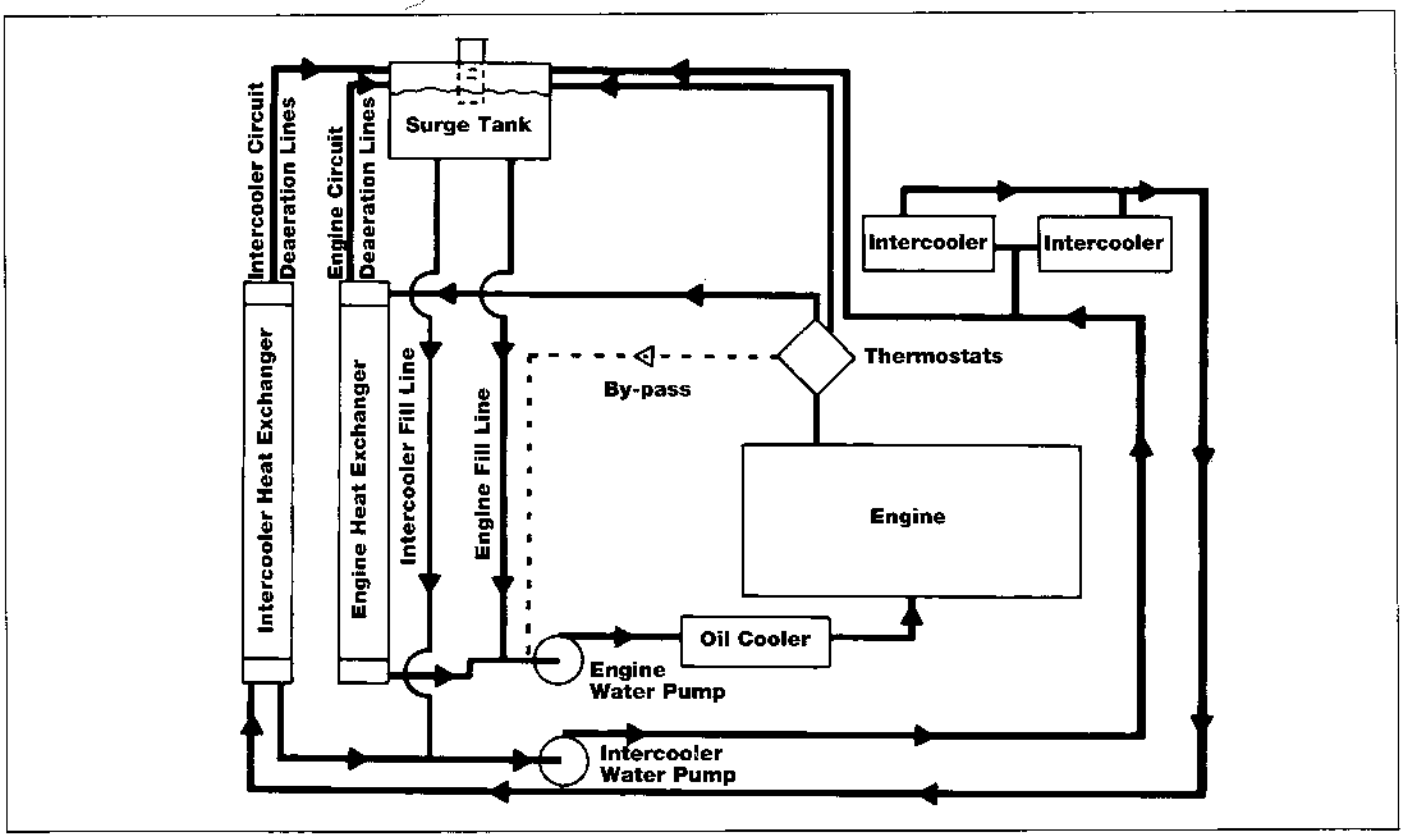


Figure 10. Separate Circuit Charged Cooling Design Schematic

coolant. A common surge tank with separate deaeration and fill lines to each circuit distinguishes this system from previous 149 cooling systems. Radiator manufacturers refer to the system as *two circuit, split flow, advance charge cooling,* etc.

The engine coolant circuit resembles the rapid warm-up system. The intercooler circuit operates continuously without thermostatic control. The radiator core provides a large temperature drop, and the coolant is routed directly to the intercoolers.

Two fan clutch control switches are required when using an on/off or thermatic fan. One fan *must* sense the intercooler radiator coolant-out temperature and cause the fan to engage at 125°F ± 5°F (52°C ± 3°C). The other switch fan *must* sense engine coolant-out temperature (before thermostats) and engage the fan 10°F (–12°C) after thermostats start-to-open temperature.

Jacket Water After Cooling (JWAC)—In JWAC V-92 models, coolant circulates from the water pump through the oil cooler, to the cylinder block where approximately 10% is shunted to the aftercooler and returned to the left-bank thermostat housing. In in-line 71 JWAC models, the coolant circulation is from the cylinder block through the aftercooler and to the cylinder head.

Inlet air is compressed by the turbocharger and directed to the blower. After passing through the blower, the air travels through the aftercooler. "Air in" is cooled from over 300°F (148°C) to approximately 200°F (93.3°C) at 85°F (29.4°C) ambient temperature under full-load conditions. The cool, dense air then travels from the aftercooler into the air box and cylinders for combustion. Other aspects of the JWAC in-line 71 and Series 92 cooling systems are identical to the standard non-aftercooled engines.

Jacket Water Heaters—Heaters of either the immersion type or tank type (often mounted on the generator set base) are recommended to improve engine startability, speed up load acceptance, and reduce exhaust smoke on start up. Heaters which are controlled by means of a thermostatic control are preferred. Typical thermostat settings engage the heater when the engine coolant temperature falls below 80° to 100°F (27° to 38°C) and disengages the heater when the coolant temperature rises above 100° to 120°F (38° to 49°C).

Electrical System

The electrical system generally consists of a starting motor, starting switch, battery-charging alternator, storage batteries, and the necessary wiring.

Governing System

Speed governors automatically control the fuel input to Detroit Diesel engines so as to maintain a given speed such as 1800 RPM or 1500 RPM. The governing of speed becomes more difficult as we try to govern more precisely and quickly as required for generator set applications.

Mechanical governors contain a speed sensing element (ball arms or fly weights) and a desired speed element (the speeder spring), and compare the two through the pilot valve position.

The electronic governor uses a speed sensor consisting of a magnetic pickup, mounted on the flywheel housing or the cam gear cover. As the gear teeth pass by the end of the magnetic sensor, an AC sine wave is generated. The frequency of the signal is proportional to engine speed. The AC signal is rectified (changed to DC). The actual speed signal is a DC voltage, the amplitude of which is proportional to desired speed. The electronic governor actuator then meters the proper amount of fuel to maintain the desired speed. A mechanical, hydraulic, electric or electronic governor may be installed on the engine.

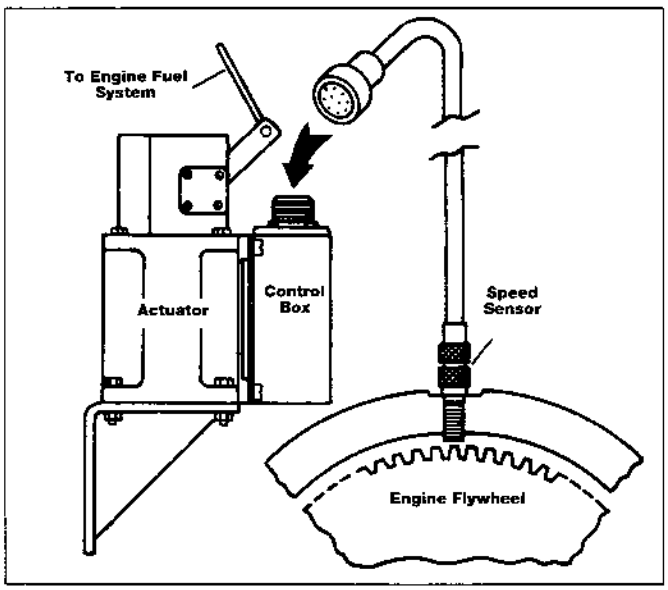


Figure 11. Schematic for Typical Electronic Governor

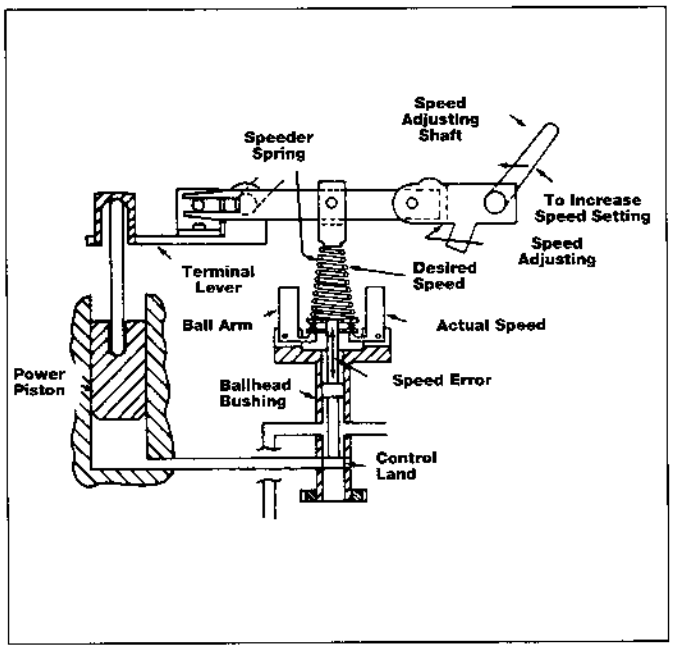


Figure 12. Schematic for Typical Mechanical Governor

Exhaust System

Hot exhaust gas flowing from the exhaust manifold(s) into the exhaust riser(s) is used to drive the turbocharger(s). Exhaust gases are then vented to atmosphere. See Section 2 for more detailed information.

4. Lubrication and Preventive Maintenance Intervals

The following is intended as a guide for establishing preventive maintenance intervals. The recommendations given should be followed as closely as possible to obtain long life and optimum performance from Detroit Diesel engines. Intervals indicated on the chart are time (hours) of actual operation.

The intervals shown apply only to the maintenance functions described. These functions should be coordinated with other regularly scheduled maintenance.

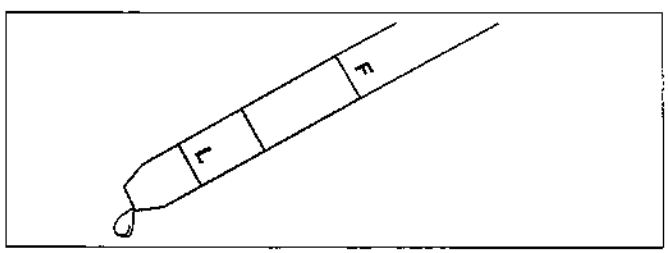
The "monthly" instructions are as required by NFPA code and are recommended by Detroit Diesel Corporation. The "daily" instructions are for prime power generator sets. They do not apply to a new engine or one that has not been operated for a considerable period of time. For new or stored engines, refer to the appropriate engine service manual. Follow instructions given under **Preparations for Starting the Engine the First Time** (Section 5).

Refer to pages 34-36 for detailed preventive maintenance schedules.

Preventive maintenance other than the "daily" check should be performed by *authorized Detroit Diesel service outlets*. DDC outlets have the trained personnel and special tools to properly perform these services.

Item 1 - Lubricating Oil

Check the oil level monthly for standby or daily for prime power generator sets, with the engine stopped. If necessary, add sufficient oil to raise the level to the proper mark on the dipstick. All diesel engines are designed to use some oil, so the periodic addition of oil is normal.



Check oil level with engine stopped

NOTICE:
If the oil level is constantly above normal and excess lube oil has not been added to the crankcase, consult with an *authorized Detroit Diesel service outlet* for the cause. Fuel or coolant dilution of lube oil can result in serious engine damage.

For lubricating oil change intervals, refer to "When to Change Oil" in the **How To** section of this guide. Before adding lube oil, refer to "How to Select Lubricating Oil" in the **How To** section.

Item 2 - Lubricating Oil Filter

Lubricating oil filters should be changed whenever the engine oil is changed. Before changing filters, refer to "How to Replace the Lube Oil Filter" in the How To section of this guide. Refer to "Specifications" (page 64) for required filter part number.

Item 3 - Oil Pressure

Under normal operation, oil pressure is noted each time the engine is started as well as during load test. Check and record pressure at the following intervals:

Series 71, 92	Every 700 hours
Series 149	Every 250 hours
Series 50, 60	Every 600 hours

Item 4 - Fuel/Water Separator, Filter

Drain water from fuel/water separator daily or as required. Primary and secondary fuel filters should be replaced according to PM chart on pages 34-36 or annually, whichever comes first (or sooner if plugging is indicated). Only those filters shown on page 64 should be used. Before changing filters, refer to "How to Replace the Fuel Filter and Strainer" in the **How To** section of this guide. The addition of aftermarket supplemental filtration systems may be used provided they do not replace the factory-installed system or reduce oil volumes or fuel pressures delivered to the engine.

Item 5 - Fuel and Fuel Tank

Before adding fuel, refer to "How To Select Fuel Oil" in the **How To** section of this guide.

Keep the fuel tank filled to reduce condensation. Condensation formed in a partially filled tank promotes the growth of microorganisms that can clog fuel filters and restrict fuel flow. To prevent microbe growth add a fungicide such as Biobor JF (or equivalent). Microbial activity may be confirmed with commercially available test kits. Follow the manufacturer's instructions for treatment. Avoid the use of fungicides containing halogenated compounds, since these may cause fuel system corrosion.

When small amounts of water are present, supplemental additives containing methyl carbitol or butyl cellusolve are effective. Follow the manufacturer's instructions for their use. *The use of isopropyl alcohol is no longer recommended due to its negative effect on fuel lubricity.*

The Following Fuel Additives Are NOT Allowed:

Used Lubricating Oil. Detroit Diesel specifically prohibits the use of drained lubricating oil in diesel fuel. Used lubricating oil contains combustion acids and particulate materials which erode injector components, resulting in loss of power and increased exhaust emissions. In addition, the use of drained lubricating oil will increase maintenance requirements due to filter plugging and combustion deposits.

Gasoline. The addition of gasoline to diesel fuel will create a serious fire hazard. The presence of gasoline in diesel fuel will reduce fuel cetane number and increase combustion temperatures. Tanks which contain such mixtures should be drained and cleaned as soon as possible.

Detroit Diesel Corporation will not be responsible for any detrimental effects which it determines resulted from the use of used lubricating oil or gasoline in the diesel fuel.

NOTICE:

Do not use galvanized steel or sheet metal tanks and galvanized pipes or fittings in any diesel fuel storage, delivery, or fuel system. The fuel oil will react chemically with the zinc coating, forming a compound which can clog filters and cause engine damage.

Item 6 - Fuel Lines, Flexible Hoses

Pre-Start Inspection. Check hoses as part of the pre-start inspection. Examine hoses for leaks, and check all fittings, clamps, and ties carefully. Make sure that hoses are not resting on 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 required.

⚠ CAUTION:

Personal injury and/or property damage may result from fire due to the leakage of flammable fluids such as fuel or lube oil.

Investigate leaks immediately to determine if fittings have loosened or cracked or if hoses have ruptured or worn through. Take corrective action immediately. Leaks are potentially detrimental to machine operation and will result in added expense caused by the need to replace lost fluids.

Service Life. A hose has a finite service life. With this in mind, all hoses should be thoroughly inspected at least every 500 operating hours (1,000 hours for fire-resistant fuel and lubricating oil hoses) and/or annually. Look for cover damage and/or indications of twisted, worn, crimped, brittle, cracked, or leaking lines. Hoses with their outer cover worn through or with damaged metal reinforcement should be considered unfit for further service.

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

Item 7 - Turbocharger, Exhaust Connections

Visually inspect the mountings, intake and exhaust ducting and connections for leaks daily. Check the oil inlet and outlet lines for leaks or restrictions to oil flow. Check for unusual noise or vibration and, if excessive, stop the engine and do not operate until the cause is determined.

The exhaust manifold retaining nuts, exhaust flange clamp, and other manifold connections should also be checked for leakage and tightened, if necessary.

Check heat-insulating exhaust system, turbo-charger, and turbocharger riser blankets for damage daily. Torn, matted, crushed, oil-soaked, or otherwise damaged insulation blankets **must** be replaced immediately.

⚠ CAUTION:

A special screen assembly is installed over the compressor inlet housings of all blower-mounted and front center-mounted turbochargers used on V-53, V-71, and Series 92 engines. The screen assembly protects the service technician from the exposed turbocharger compressor wheel when the engine must be operated with the air inlet piping removed. To avoid possible personal injury, do not remove the screen from the turbocharger.

The screen assembly, if applicable, forms a permanent part of the compressor inlet housing and must not be removed. Removing the screen assembly will result in a potential safety hazard created by the exposed rotating compressor wheel. Removing the screen assembly will also damage the assembly and the aluminum compressor housing. A damaged screen assembly or housing cannot be reused.

Item 8 - Battery

⚠ CAUTION:

To avoid possible personal injury and/or engine damage from accidental engine startup, always disconnect the battery before servicing the electrical system. To avoid alternator damage when removing battery connections, disconnect the negative (-) terminal first. Reconnect the negative terminal last.

Check the hydrometer "eye" of maintenance-free batteries for charge.

If lead-acid or low maintenance batteries are used, check the specific gravity of each cell every 150 hours. Check more frequently in warm weather due to the more rapid loss of water through evaporation. Maintain the electrolyte level according to the battery manufacturer's recommendations, but do not overfill. Overfilling can cause poor performance or early failure.

Keep the terminal side of the battery clean. When necessary, wash with a solution of baking soda and water. Rinse with fresh water. Do not allow the soda solution to enter the cells.

Inspect the cables, clamps, and hold-down brackets regularly. Clean and reapply a light coating of petroleum jelly when needed. Have corroded or damaged parts replaced. Keep batteries fully charged. Replace any battery that fails to hold a charge.

Periodically check battery connections for corrosion and tightness. If necessary, remove connections and wire brush any corrosion from terminals and cable ends. Replace damaged wiring.

Item 9 - Battery Charging Alternator

Have terminals checked for corrosion and loose connections and have wiring inspected for damaged or frayed insulation at the following intervals:

Series 71, 92	Every 700 hours
Series 149	Every 250 hours
Series 50, 60	Every 600 hours

Have wiring repaired or replaced as required.

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

1. Avoid grounding the output terminal. Grounding an alternator's output wire or terminal (which is always *hot*, regardless of whether or not the engine is running) and accidentally reversing the battery polarity will result in equipment damage.

2. Do not reverse battery connections. This can also cause damage.

3. Never disconnect the battery while the alternator is operating. Disconnecting the battery can result in damage to the alternator diodes. In applications which have two sets of batteries, switching from one set to the other while the engine is running will momentarily disconnect the batteries. *This can result in equipment damage.*

4. If a booster battery is to be used, batteries must be connected correctly (negative to negative, positive to positive) to avoid equipment damage.

5. Never use a fast charger with the batteries connected or as a booster for battery output.

Item 10 - Air Cleaners

A clogged air cleaner element will cause excessive intake restriction and a reduced air supply to the engine. This, in turn, can result in high operating temperatures, increased fuel consumption, inefficient engine operation, and engine malfunction or damage.

Dry type air cleaner elements (if used) should be replaced with new elements after one year of service or when the restriction indicator or manometer shows that the *maximum allowable air intake restriction* has been reached, whichever comes first. Check restriction indicator daily for prime power applications and monthly or at load test for standby applications.

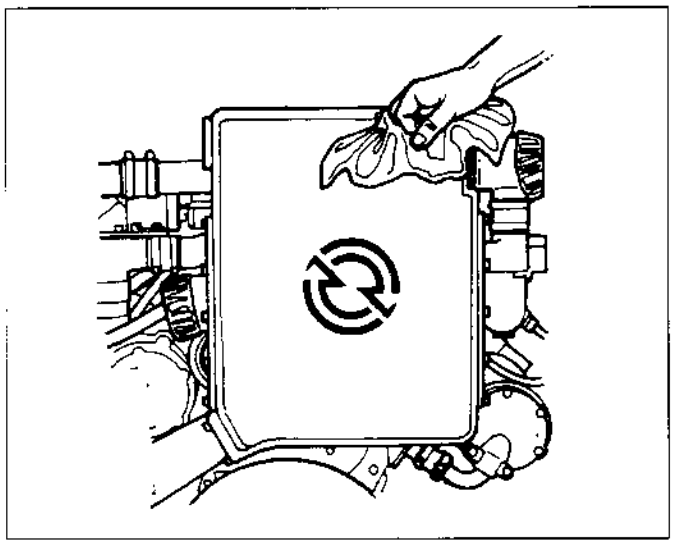
If reusable elements are used, the maximum element service life is still one year. Cleaning, drying, and inspection before reuse must be done per the manufacturer's recommendations, if any.

Inspect the entire air system for leaks. Look especially for torn air inlet piping or boots and loose or damaged clamps. Have worn or damaged parts repaired or replaced, as required. Retighten any loose connections.

Item 11 - Drive Belts

Drive belt tension should be checked daily for prime power applications and monthly for standby applications. Adjust as required. At this time belts should be inspected for splits, cracks and glazing, and replaced as required.

Item 12 - Cooling System/Radiator



Remove radiator or heat exchanger pressure control cap with caution.

⚠ CAUTION:

Do not remove the pressure control cap from the heat exchanger or radiator or attempt to drain the coolant until the engine has cooled. Once the engine has cooled, use extreme caution when removing the cap. The sudden release of pressure from a heated cooling system can result in a loss of coolant and possible personal injury (scalding, eye injury, etc.) from the hot liquid.

Check the coolant level and maintain it near the bottom of the filler neck on the radiator or heat exchanger tank when cold. On some installations this is done by checking an overflow bottle or sight glass. Add coolant as necessary, but *do not overfill*. Before adding coolant, refer to "How to Select Coolant" in the **How To** section of this guide.

Make a visual check in accordance with the applicable PM schedule on pages 34-36.

Precharge and Maintenance Elements. Spin-on coolant elements containing Detroit Diesel Selected Product supplemental inhibitors are used on all engines. These elements maintain proper inhibitor levels in the engine cooling system.

Engines are factory-equipped with a dual element head and *precharge* coolant elements. These elements charge the cooling system with Detroit Diesel Selected Product SCA's (supplemental coolant additives) at initial fill of the cooling system with coolant.

The concentration of SCA will gradually deplete during normal engine operation. Check the SCA concentration at 200 hour intervals (300 hour intervals for Series 149), or yearly, whichever comes first. Additional SCA **must** be added to the coolant when it becomes depleted below a specified level (see chart below). Maintenance dosage of SCA must only be added if nitrite concentration is *less than* 800 PPM. If nitrite concentration is *greater than* 800 PPM, do not add additional SCA.

NOTE: A nitrite concentration of 2400 PPM or greater on Series 149 engines requires immediate draining and flushing of the cooling system. Refill the system with new coolant and the proper Powercool® 3149 SCA dosage. Check the concentration level at the next maintenance interval.

SCA Concentration Limitations

	Minimum PPM	Maximum PPM
Boron (B)	1,000	1,500
Nitrite (NO2)	800	2,400
Nitrates (NO3)	1,000	2,000
Silicon (Si)	50	150
Phosphorous (P)	0	500
pH	7.0	10.5

SCA limits with GM6038-M or ASTM D 4985 (50/50 Coolant/Water Mixture)

Precharge elements must be installed any time the cooling system has been drained and refilled with new coolant.

Refer to **"Specifications"** (page 66) for required precharge and maintenance element part numbers.

Coolant Drain Interval. *Detroit Diesel recommends replacing coolant with permanent type antifreeze annually. However, a cooling system properly maintained and protected with Detroit Diesel Selected Product supplemental inhibitors can be operated up to two years or 4000 hours, whichever comes first. At this interval, the coolant **must** be drained and the cooling system cleaned thoroughly. The cooling system should then be replenished with an ethylene glycol-base antifreeze/water solution in the required concentration and the required Detroit Diesel Selected Product precharge elements should be installed on the dual element head. In extremely hot environments, clean, soft, properly inhibited water may be used in place of antifreeze.*

Cooling System Hoses. All cooling system hoses should be inspected at least every 500-600 hours for signs of deterioration and replaced, if necessary.

Coolant Strainer. Some Series 149 engines equipped with tube and shell oil coolers use coolant strainers to filter contaminants from the fresh water cooling system. Strainer baskets should be removed and cleaned annually on these engines.

Radiator. Inspect the outside of the radiator core every 500 hours and, if necessary, clean it with a quality grease solvent such as mineral spirits and dry it with compressed air.

⚠ CAUTION:

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

Do not use fuel oil, kerosene, or gasoline. Clean the radiator more frequently if the engine is operated in extremely dusty or dirty areas.

Item 13 - Thermostats and Seals

Thermostats should be removed and checked at the following intervals:

Series 71, 92	Every 6,000 hours
Series 149	Every 5,000 hours
Series 50, 60	Every 6,000 hours

If serviceable, reinstall with new seals. Thermostats and seals should be *replaced* at overhaul.

Item 14 - Water Pump

The water pump drain hole should be inspected for plugging every 500 hours (600 hours on Series 149 engines) and cleaned out, if necessary.

Item 15 - Fan Hub

The bearings in the fan hub assembly should be replaced with new bearings at major engine overhaul. The hub assembly should be packed with Mobilgrease HP or an equivalent lithium-base, multi-purpose grease before installing.

Item 16 - Emergency Shutdown

With the engine running at idle speed, the operation of the emergency shutdown should be checked at least once a year or every 500 hours of engine operation, whichever comes first. If the valve fails to shut down the engine, it **must** be readjusted to provide positive shutdown. *Authorized Detroit Diesel service outlets* are properly equipped to perform this service. The valve should be reset in the *open* position after the check has been made.

NOTICE:

Do not use the emergency shutdown for normal or routine engine stopping. Failure to observe this precaution can result in serious engine seal damage.

Item 17 - Crankcase Breather, Pressure

The integral crankcase breather assembly should be removed and the steel mesh pad cleaned in fuel oil every 1,000 hours.

Some engines may use an additional crankcase breather collection device. If so equipped, the drain should be checked every oil change period. Remove the oil reservoir and *replace* the filter element and gasket annually, or every 500 hours, whichever comes first.

These service intervals may be reduced depending on the severity of service.

The externally mounted crankcase breather assembly should be removed and the steel mesh pad cleaned in fuel oil every 1,000 hours. The cleaning period may be reduced or lengthened depending on severity of service.

Crankcase pressure should be checked and recorded every 1,000 hours. If an additional crankcase breather collection device is used, the crankcase pressure should be recorded with the unit attached and removed.

Item 18 - Air Box Drain Tube

Air flow from the air box drain tubes and check valves should be checked every 1000 hours with the engine running. If tubes or valves are clogged they should be removed, cleaned, and reinstalled. They should be cleaned periodically, even though a clogged condition is not apparent.

If the engine is equipped with an air box tank, drain the sediment periodically.

Item 19 - Engine Tune-up/Fuel Injectors

Series 149 engines **must** be tuned-up every 5,000 hours. **Tune-up must include replacement of injectors.**

Series 50 and Series 60 engine valve lash and injector heights must be measured after an initial period of 1,500 hours and adjusted, if necessary. Any adjustments beyond this point should be make only as required to maintain satisfactory engine performance.

There is no scheduled tune-up interval for other Detroit Diesel engines. As long as engine performance is satisfactory, no tune-up should be needed.

Minor adjustments in the valve and injector operating mechanism, governor, etc. may be required periodically to compensate for normal wear on parts.

Item 20 - Blower Bypass Valve

The blower bypass valve should be removed, cleaned in solvent (if necessary), and inspected every 3000 hours for Series 71 and Series 92 engines or 5000 hours for Series 149 engines. The valve should be checked for free operation and for scoring on the piston, piston guide, or sleeve assembly. Have repaired or replaced, as necessary.

Item 21 - Tachometer Drive

The tachometer drive (if fitted) should be lubricated every 300 hours for Series 71 and Series 92 engines or 250 hours for Series 149 engines at the grease fitting. Use an all-purpose grease (No. 2 grade).

Item 22 - Governor

For Barber Colman electronic governors the following connection and calibration procedures apply to the DYNA 8000 series governors:

Connection

1. With the remote speed potentiometer connected it will provide approximately a ±5% adjustable speed range.
2. For wide speed range applications, connect the wiper of the remote speed potentiometer to terminal 8 and use a value for resistor "R" that will provide the proper adjustable speed range.
3. When using an ILS unit, the remote speed potentiometer may be left connected to the controller as shown.
4. When an ILS unit is used, connect 3-wire shielded cable to terminals 6, 7 and 8. Connect drain shield wire to terminal 10 at the controller only. Other end of drain shield wire is to be cut off and taped.

Calibration and Adjustments

1. See reference guide before making any adjustments of the potentiometers, DROOP, I, GAIN and speed.
2. Power OFF — engine not operating
3. Initial potentiometer settings:

3.1 Set the I adjustment one division from zero and the GAIN at the third division from zero.

3.2 For isochronous operation, set DROOP counter-clockwise to minimum position.

3.3 For DROOP operation, set DROOP potentiometer clockwise to obtain desired amount of DROOP from no-load to full load. Turning potentiometer clockwise increases DROOP.

NOTICE:

If the full 35° rotation of the actuator shaft is used and the linkage adjusted to use only the active fuel range, the maximum obtainable DROOP would be approximately 12% at full load.

3.4 Set "Start Up Fuel" adjustment to 70%. Set "Ramp Time" adjustment to 30%.

4. If a remote speed potentiometer is used, set it to midrange. If the remote speed potentiometer is connected to terminals 6, 7 and 9, a resistor "R" in the wiper is not needed. This will provide approximately a ±5% adjustable speed range.
5. Start the engine.

5.1 Adjust the controller speed potentiometer until the engine is operating at the desired engine RPM. Clockwise increases engine RPM.

5.2 If the governor system is unstable, slightly reduce the I and GAIN settings.

NOTICE:

Except for the speed adjustment, the potentiometers have internal stops at the 0 and 100% positions.

6. With the engine unloaded, finalize the settings, I and GAIN adjustments as follows:

6.1 Turn the GAIN adjustment clockwise slowly until the actuator lever oscillates. (This will be a faster oscillation than was observed when the I was adjusted.) Reduce the GAIN adjustment slowly counterclockwise until the lever is stable. Upset the lever by hand. If the lever oscillates 3 to 5 diminishing oscillations and stops, the setting is correct.

If system performance-to-load changes is satisfactory, omit step 6.2

6.2 Reduce the GAIN setting counterclockwise one division. Next, turn the I adjustment fully clockwise while observing the actuator lever. If the lever does not become unstable, upset it by hand. When the lever slowly oscillates, turn the adjustment counterclockwise slowly until the lever is stable. Upset the lever again; it should oscillate 3 to 5 times and then become stable for optimum response.

NOTICE:

Use the settings of step 6.1 or step 6.2, whichever provides the best performance.

6.3 Unit is now calibrated.

For Woodward electronic governors:

INSTALLATION CHECKS

Checks For All Applications

The following steps check only the speed control and actuator. They must work correctly before paralleling the generator. Since most faults appear when the prime mover is first run, this step-by-step approach eliminates most problems before they occur.

If a Load Sensor is used, temporarily remove the wires at speed control terminals 11 and 12 and temporarily jumper terminals 11 to 12. The generator must not be paralleled during these tests. If a Ramp Generator is used, then also temporarily remove the wire at speed control terminal 10 that goes to the ramp generator. Leave the idle-rated switch wiring connected. Perform the checks in the order indicated. Terminal numbers in this section refer to the speed control.

1. Check that all electrical connections are correctly made and terminal screws are tight; the magnetic pickup is properly installed and the jam nut is tight; the actuator and linkage are securely fastened. If start-fuel limit is present turn the adjustment fully clockwise during these tests.

2. Do not start the prime mover now. Turn on governor power. If the fuse or breaker opens as soon as power is applied, the battery polarity (terminals 14 and 15) is probably reversed. The actuator shaft can jump when power is turned on but must quickly come back to the minimum fuel position. Check the battery voltage at terminal 1(+) and 2(-). It must be from 10 to 16 Vdc for models 1712/512 EPG control and from 20 to 32 Vdc for models 1724/524.

3. Disconnect any wiring or jumper on terminal 7. Measure voltage from 2(-) to 7(+). The voltage must be 7.2 ± 1 volt. If voltage is correct, then reinstall the wiring to terminal 7.

4. If idle speed is desired, connect a 50 Kohm potentiometer or fixed resistor to terminals 9 and 10 as shown in the typical wiring diagram. To calculate the value of a fixed resistor:

$$R = 17 \text{ Kilohm } \left(\frac{\text{Rated Speed}}{\text{Idle Speed}} - 1\right).$$

5. Put the idle-rated switch in the rated position or jumper terminal 9 and 10. Measure the voltage from terminal 7(+) to 2(-). Put the idle-rated switch in the idle position or remove the jumper. The voltage must increase. If it does not increase, check the speed trim pot, if used, and idle-rated switch wiring.

6. If a signal generator with an isolated output is available, the failsafe and actuator travel can be checked. Rated and idle speeds can be preset. If a signal generator is not available skip to step 7.

   Turn governor power off. Remove the magnetic pickup wires from terminals 5 and 6. Connect the signal generator to terminals 5 and 6. Set the output between 2 and 10 Vrms. The waveform can be sine, square, or triangular. Calculate the MPU frequency for idle and rated speeds.

6.1 CHECK FAILSAFE AND ACTUATOR TRAVEL. Set the signal generator frequency to about half idle speed. Set the idle-rated switch to "rated". Turn the signal generator and governor power on. The linkage must be at the maximum fuel position. Except for Detroit Diesel engines, verify linkage travel is limited by the prime mover fuel control, not by the actuator stop. Turn the signal generator off and remove the connections at terminals 5 and 6. The linkage should move to the minimum fuel position. Verify linkage travel is limited by the prime mover's fuel control, not by the actuator stop.

6.2 PRESET RATED SPEED

Set the signal generator for MPU frequency at rated speed and connect it to terminals 5 and 6. Put the idle-rated switch in the rated position. Set the speed trim pot, if connected, to mid-position. Observe the linkage position.

— *If the linkage is at the maximum fuel position:*
Slowly turn the rated speed pot CCW until the linkage just begins to move to the minimum fuel position.

— *If the linkage is at the minimum fuel position:*
Slowly turn the rated speed pot CW until the linkage just begins to move to the maximum fuel position.

Continue to very slowly adjust the rated speed pot in the appropriate direction, trying to stop the linkage between the minimum and maximum fuel stops. Because it is not possible to stop the motion, cease adjusting when the linkage moves slowly. The rated speed reference is now set very close to desired speed. A slight adjustment when the engine is running will achieve the exact speed.

6.3 PRESET IDLE SPEED

Preset idle speed only after presetting rated speed. Set the signal generator for MPU frequency at idle speed. Put the idle-rated switch in the idle position. Observe the linkage position.

— *If the linkage is at the maximum fuel position:*
Slowly turn the idle speed pot CCW until the linkage just begins to move to the minimum fuel position.

— *If the linkage is at the minimum fuel position:*
Slowly turn the idle speed pot CW until the linkage just begins to move to the maximum fuel position.

Continue to very slowly adjust the idle speed pot in the appropriate direction, trying to stop the linkage between the minimum and maximum fuel stops. Because it is not possible to stop the motion, cease adjusting when the linkage moves slowly. The idle speed reference is now set very close to desired speed. A slight adjustment when the engine is running will achieve the exact speed.

7. If the idle and rated speed pots were not preset with a signal generator, set the rated speed pot fully CCW.

8. Remove the MPU wires from speed control terminals 5 and 6. Measure the resistance of the MPU at the wire ends. It should be between 100 and 300 ohms. Reconnect the MPU wires.

9. Set the idle-rated switch for rated speed. Turn governor power on.

⚠ CAUTION:

***To protect against possible personal injury and/or property damage when starting* the engine, be prepared to make an emergency shutdown to protect against runaway or overspeed should the mechanical-hydraulic governor(s) or electric control(s), the actuator(s), fuel control(s), the driving mechanism(s), the linkage(s), or the controlled device(s) fail.**

10. GAIN & STABILITY

Set the gain and stability pots to mid-position. Connect an AC voltmeter to speed control terminals 5 and 6 to measure the MPU voltage. Start the prime mover and check the MPU voltage. It must be at least 1.5 Vrms while cranking.

— If the prime mover does not start check the linkage while cranking. If it is at the maximum fuel position the EPG is operating correctly. Check the fuel supply, ignition, etc.

— If the linkage is not at the maximum fuel position, cranking speed can be greater than the speed reference. Measure the resistance from speed

control terminal 9 to 10. It must be a short circuit (0 ohms). If not, the idle-rated switch is in the idle position or the switch or wiring is defective. Place in rated position or repair. If the resistance is 0 ohms the rated speed reference can be lower than cranking speed. Turn the rated speed pot CW four turns and try to restart. Be prepared to quickly adjust rated speed CCW to minimize over-speed if the prime mover starts. If it still doesn't start turn the rated speed pot fully CCW to minimize overspeed when it does start.

When the prime mover starts, slowly turn the gain pot back and forth to observe high and low frequency oscillation. Eliminate oscillation by slowly turning the gain pot for the stable region between high and low frequency oscillation. If the oscillation does not stop at the high-low crossover, turn the stability pot slightly CCW and slowly readjust the gain pot. Continue adjusting the stability pot slightly CCW followed by readjusting gain until the prime mover runs at a steady speed.

10.1 SET TRANSIENT RESPONSE

By turning gain slightly CW and stability slightly CCW, or vice-versa, it is possible to maintain stable speed and vary transient response. Increasing the gain and decreasing the stability causes shorter settling times at the expense of ringing. The use of chart recorder makes it easier to observe transient response.

Check response after each adjustment by momentarily changing speed. Repeat the following tuning procedure until the prime mover responds as desired. Note that settings with high gain and low stability can result in stable operation at normal temperatures and oscillation when the prime mover is cold.

— To decrease settling time turn the gain pot CW. Turn the stability pot CCW as required to eliminate oscillation and obtain desired response.

— To decrease ringing turn the stability gain pot CW. Turn the gain pot CCW as required to eliminate oscillation and obtain desired response.

— Check response by applying and removing load, manually hitting the linkage, or quickly switching to idle speed and back to rated.

11. SETTING SPEED REFERENCES

The prime mover should not be oscillating. Make sure the idle-rated switch is in the rated speed position. Adjust the rated speed pot for exactly rated speed. Set the idle-rated switch for idle speed. Adjust the idle speed pot for desired idle speed. Set the idle-rated switch back to rated.

Item 23 - Engine and Generator Mounts

Engine and generator mounting bolts and the condition of the mounting pads should be checked every 1,000 hours or annually (whichever comes first) and tightened or repaired, as required.

Before starting the engine, check the lubricating oil level and coolant level and add fluids as required. Drain water from the fuel/water separator, if equipped, and inspect the radiator and coolant hoses for leaks. Leaking or damaged hoses should be retightened or replaced, as required.

Item 24 - Load Test

The generator set should be started and exercised under load on a monthly basis (per NFPA recommendations).

When exercising the generator set, load should be at least 35% of nameplate rating. Operate the generator at that load or higher until coolant temperature becomes stable. This will evaporate any moisture that may have condensed in the crankcase and prevent wet-stacking.

If no load is available to put on the engine, Detroit Diesel recommends starting the engine for a period of time that would allow verification of oil pressure. When oil pressure stability is confirmed, shut the engine down.

Item 25 - Crankcase Pressure Monitor

The crankcase pressure monitor on Series 149 Engines should be checked every 250 hours.

SERIES 50 AND 60 GENERATOR DRIVE ENGINE MAINTENANCE SCHEDULE

ITEM REFER TO PRECEDING TEXT FOR EXPLANATION OF EACH ITEM	Prime, Daily	Standby, Monthly	HOURS							
			150	300	600	1000	1500	2000	3000	6000
1. Lubricating Oil	I	I*	STANDBY Replace every 150 hours or one year PRIME POWER Replace every 150 hours or one month							
2. Lubricating Oil Filter										
3. Oil Pressure	I	I*			I					
4. Fuel Filters, Water Separator	I	I*	R							
5. Fuel & Fuel Tank	I	I			I					
6. Fuel Lines, Flexible Hoses	I				I			R		
7. Turbo, Exhaust Connections	I				I					
8. Battery		I				I				
9. Battery Charging Alternator					I					
10. Air System, Cleaners	I	I			R					
11. Drive Belts	I	I	I					I		
12. Cooling System/Radiator	I	I*			I					
13. Thermostats and Seals									I	
14. Water Pump									I	
15. Fan Hub						I				
16. Emergency Shutdown				I						
17. Crankcase Breather				I		I				
19. Engine Tune-up/Injector#							I			
21. Tachometer Drive			I							
23. Engine/Generator Mounts						I				
24. LOAD TEST*		P								

I: Inspect R: Replace P: Perform

*: Perform these items at time of Load Test. Load Test should be at least 35% of the unit's full rated output.

SERIES 71 AND 92 GENERATOR DRIVE ENGINE MAINTENANCE SCHEDULE

ITEM REFER TO PRECEDING TEXT FOR EXPLANATION OF EACH ITEM.	Prime, Daily	Standby, Monthly	HOURS						
			300	500	700	1000	2000	3000	6000
1. Lubricating Oil	I	I*	STANDBY Replace every 150 hours or one year PRIME POWER Replace every 300 hours or one month						
2. Lubricating Oil Filter									
3. Oil Pressure	I	I*			I				
4. Fuel Filters, Water Separator	I	I*	R						
5. Fuel & Fuel Tank	I	I			I				
6. Fuel Lines, Flexible Hoses	I				I			R	
7. Turbocharged, Exhaust Connections	I				I				
8. Battery		I				I			
9. Battery Charging Alternator					I				
10. Air System, Cleaners	I	I			R				
11. Drive Belts	I	I	I					I	
12. Cooling System/Radiator	I	I*			I				
13. Thermostats and Seals									I
14. Water Pump									R
15. Fan Hub					I				
16. Emergency Shutdown				I					
17. Crankcase Breather				I		I			
18. Air Box Drain Tube						I			
19. Engine Tune-up/Injector			AS REQUIRED						
20. Blower Bypass Valve								I	
21. Tachometer Drive			I						
22. Governor				I					
23. Engine/Generator Mounts						I			
24. LOAD TEST*		P							

I: Inspect R: Replace P: Perform
*: Perform these items at time of Load Test. Load Test should be at least 35% of the unit's full rated output.

SERIES 149 GENERATOR DRIVE ENGINE MAINTENANCE SCHEDULE

ITEM REFER TO PRECEDING TEXT FOR EXPLANATION OF EACH ITEM.	Prime, Daily	Standby, Monthly	HOURS			
			250	500	1000	5000
1. Lubricating Oil	I	I*	STANDBY Replace every 150 hours or one year PRIME POWER Replace every 300 hours or one month			
2. Lubricating Oil Filter						
3. Oil Pressure	I	I*	I			
4. Fuel Filters, Water Separator	I	I*	R			
5. Fuel & Fuel Tank	I			I		
6. Fuel Lines, Flexible Hoses	I	I		I		
7. Turbocharger, Exhaust Connections	I	I*	I			
8. Battery		I			I	
9. Battery Charging Alternator			I			
10. Air System, Cleaners	I	I		R		
11. Drive Belts	I		I			
12. Cooling System/Radiator	I	I*	P			R
13. Thermostats and Seals						R
14. Water Pump			I			R
15. Fan Hub						
16. Emergency Shutdown				I		
17. Crankcase Breather				I	I	
18. Air Box Drain Tube					I	
19. Engine Tune-up/Fuel Injector						P/R
20. Blower Bypass Valve						I
21. Tachometer Drive			P			
22. Governor					I	
23. Engine/Generator Mounts					I	
24. LOAD TEST*		P				
25. Crankcase Pressure Monitor			I			

I: Inspect R: Replace P: Perform

*: Perform these items at time of Load Test. Load Test should be at least 35% of the unit's full rated output.

5. Operating Instructions

Preparations for Starting the Engine the First Time

When preparing to start a new or newly overhauled engine or an engine which has been in storage, perform all of the operations listed below. Failure to follow these instructions may result in serious engine damage. Before a routine start, see "Daily" checks in the **Lubrication and Preventive Maintenance charts** (pages 34-36).

Cooling System Checks

NOTICE:

If the generator set or engine is to be stored or unused for a period greater than six months, contact your local authorized Detroit Diesel service outlet to have proper procedures for engine storage performed.

⚠ CAUTION:

Before working on or near the generator set remove loose items of clothing or jewelry that could get caught in a moving part of the engine and cause personal injury. Safety glasses and hearing protection must also be worn.

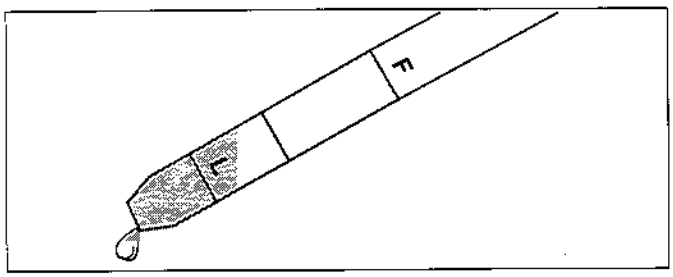
1. Make sure all the drain cocks in the cooling system are installed (drain cocks are often removed for shipping) and are closed tightly.
2. Open air bleed petcock if so equipped.
3. Remove radiator or heat exchanger fill cap and fill with an ethylene glycol-base antifreeze solution in the required concentration. In extremely hot environments, clean, soft, properly inhibited water may be used in the summer. For more detailed coolant recommendations, refer to **How to Select Coolant** (page 54). Keep the coolant level at the bottom of the filler neck to allow for expansion of the coolant. Add coolant until it stabilizes at the proper cold full level, usually the bottom of the filler neck extension or a sight glass indicator. If coolant recovery bottle is used, radiator surge tank must be completely filled and coolant added to proper level in the bottle.
4. Close all petcocks, once solid coolant is being expelled.
5. Entrapped air must be purged after filling the cooling system. To do this, allow the engine to warm-up without the fill cap installed, adding coolant as required. Run engine until thermostats have opened in order to purge entrapped air again adding coolant as required.

Install the fill cap after entrapped air has been purged and proper coolant level established.

Lubrication System Checks

The lubricating oil film on the rotating parts and bearings of a new or newly overhauled engine, or one which has been in storage for six months or more, may be insufficient when the engine is started for the first time. Insufficient lubrication at start-up can cause serious damage to engine components.

To insure an immediate flow of oil to all bearing surfaces at initial engine start-up, the engine lubrication system should be charged with a commercially available pressure pre-lubricator. If this is impractical, rocker covers should be removed and clean lubricating oil should be poured over the rocker arms. The oil should be the same weight and viscosity as that used in the crankcase. After pre-lubricating, add additional oil to bring the level to the proper mark on the dipstick. Refer to **How to Select Lubricating Oil** (page 44) for lubricant recommendation.



Check lube oil level before starting

Fuel System Checks

Fill the tank with the recommended fuel. Keeping tanks full reduces water condensation and helps keep fuel cool, which is important to engine performance. Full

tanks also reduce the chances for microbe (black slime) growth. Refer to **How to Select Diesel Fuel** (page 48) for fuel recommendation. Make sure fuel supply shutoff valves (if used) are open.

To insure prompt starting and even running, the fuel system must be primed if air has entered the fuel system. Priming is done by connecting a manual or electric priming pump to the secondary fuel filter. *Authorized Detroit Diesel service outlets* are properly equipped to perform this service.

Priming is not normally necessary if the filter elements are filled with fuel when installed and the manifolds in the head are not drained of fuel.

NOTICE:
Prolonged use of the starting motor and engine fuel pump to prime the fuel system can result in damage to the starter, fuel pump, and injectors, and cause erratic engine operation due to the amount of air in the lines and filters from the supply tank to the cylinder head.

If the engine is equipped with a fuel/water separator, drain off any water that has accumulated. Water in fuel can seriously affect engine performance and may cause engine damage.

NOTICE:
If the generator set or engine has been stored or unused for a period of six months or longer, contact your local authorized Detroit Diesel service outlet to check for properly operating fuel system and injectors prior to starting the engine. Failure to properly prelubricate the engine and prime the fuel system before putting a stored or unused engine back into service can result in engine damage at startup.

Other Checks

NOTE: If the generator set or engine has not been used for a period of six months or longer, the air, fuel, and lube oil filters may need to be changed.

Check drive belts to make sure they are in good condition (not cracked, torn, worn, or glazed) and are properly adjusted.

Make sure cable connections to the storage battery are clean and tight and battery electrolyte level is normal.

Check turbocharger(s) for signs of oil, coolant, or exhaust leaks. Leaks should be corrected before starting the engine. Check engine mounting bolts for tightness. Retighten, if necessary.

Starting the Engine

Before starting the engine the first time, perform the operations listed under **Preparations for Starting the Engine the First Time** (page 37).

If the engine has an emergency manual or automatic shutdown system, make sure the control is set in the *open* position before starting. The blower and turbocharger may be seriously damaged if the engine is cranked or run with the air shutdown in the *closed* position. On units with dual air shutdown housings, both shutdown valves must be in the *open* position before starting the engine.

Initial Engine Start

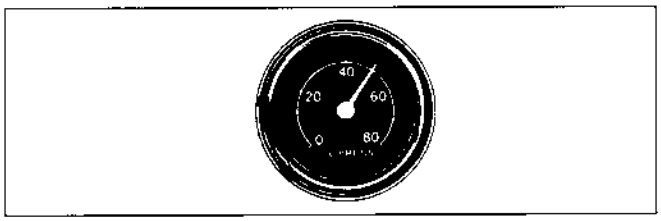
1. Press the starter switch firmly.
2. If the engine fails to start within 30 seconds, release the starter switch and allow the starting motor to cool at least two minutes before trying again. If the engine fails to start after four attempts, an inspection should be made to determine the cause.

   Starting tip: Some white smoke is normal at start-up when the engine is cold and will clear up shortly after the engine warms. However, if you experience excessive smoke at cold start-up, hold the governor in the "no fuel" position at the same time you press the starter button and crank the engine for a few seconds. Release the governor and continue to crank the engine until it starts (but not longer than 30 seconds). This will preheat the cylinders and reduce white smoke at start-up. Use of a jacket water heater with thermostat set at 120°F will also reduce white smoke.

NOTICE:
To prevent starting motor damage do not press the starter switch again after the engine has started.

NOTE: Jacket water heaters are required by code on some standby generator set applications. Detroit Diesel strongly recommends their use to aid in starting standby equipment.

Running the Engine



Check oil pressure gauge after starting

Oil Pressure

Observe the oil pressure gauge immediately after starting the engine. If no oil pressure is indicated within 10 to 15 seconds, stop the engine and check the oil level gauge. IF the oil level is OK, the engine lubrication system should be checked.

The *minimum* oil pressure should be at least 25 psi (172 kPa) at 1800 rpm. If pressure does not fall within these guidelines, it should be checked with a manual gauge.

⚠ CAUTION:

To avoid personal injury from the hot oil, do not operate the engine with rocker covers removed for any reason.

Warm-up

For routine operational checks and load tests, run the engine at no load for about five (5) minutes allowing it to warm up. Then, apply a load equal to or greater than 35% of the name plate rating. The unit should then be operated until temperatures stabilize.

Inspection

While the engine is idling, look for coolant, fuel, or lubricating oil leaks. If any are found, shut down the engine immediately and have leaks repaired *after* the engine has cooled.

Crankcase. If the engine oil was replaced, stop the engine after normal operating temperature has been reached. Allow the oil to drain back into the crankcase for approximately twenty (20) minutes, and check the oil level. If necessary, add oil to bring the level to the proper mark on the dipstick. Use only the heavy-duty oils recommended in **How to Select Lubricating Oil** (page 44) in this guide.

Turbocharger. Make a visual inspection of the turbocharger for oil or exhaust leaks, excessive noise or vibration. Stop the engine immediately if a leak or unusual noise or vibration is noted. **Do not restart the engine until the cause of the concern has been investigated and corrected.** *Authorized Detroit Diesel service outlets* are properly equipped to perform this service.

Avoid No Load Conditions

During long periods of no load operation the engine coolant temperature may 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. In order to maintain proper engine operating temperature, the generator set should be loaded at or above 35% of the nameplate rating.

Stopping the Engine

Normal stopping

Allow the engine to run at idle with no load for four (4) or five (5) minutes. This allows the engine to cool and permits the turbocharger(s) to slow down. After idling four or five minutes, shut down the engine.

NOTICE:

Stopping a turbocharged engine immediately after high speed operation may cause damage to the turbochargers, as they will continue to turn without an oil supply to the bearings.

Emergency Stopping

The emergency shutdown should be used only when the engine does not respond to the normal stop engine procedure.

To shut down the engine, simply activate the emergency shutdown control. This is an electrical switch or mechanical lever which is normally identified as such on the control panel.

NOTICE:

Never use the emergency shutdown system, except in an emergency. Use of the emergency shutdown can cause lubricating oil to be sucked past the oil seals and into the blower housing and may also cause turbocharger damage.

The air shutdown, located in the air inlet housing, must be reset by hand and the "emergency stop" knob pushed in before the engine is ready to start again.

NOTICE:

If the emergency air shutdown is used to stop the engine in an emergency situation, always have the shutdown checked for damage and for proper operation before the engine is returned to service. This is especially important if shutdown is made at high engine RPM. To ensure positive valve closure should another emergency shutdown be required, the shutdown must be checked and required repairs or adjustments made at this time. Failure to observe this precaution may permit engine run-on when the emergency shutdown is activated. This can result in severe engine damage.

DDEC III

The DDEC engine is equipped with an electronically controlled fuel injection system. This system not only helps to improve fuel economy and engine performance, it also helps to reduce cold starting time.

The DDEC engine has no mechanical governor. Engine horsepower, torque, idle, and engine speed are contained in the internal electronics.

There is no need for a throttle delay, since emission control is performed through the Electronic Control Module or ECM.

The DDEC engine has the ability to perform diagnostics for self-checks and continuous monitoring of other system components. DDEC also monitors oil temperature, oil pressure, coolant level, coolant temperature, coolant pressure, crankcase pressure, fuel pressure and temperature, and remote sensors. This diagnostic system is connected to the "Check Engine" and "Stop Engine" lights to provide a visual warning of a system malfunction.

The DDEC engine may be equipped with an engine protection system that features a 30 second, stepped-power shutdown. Both can be programmed with or without complete shutdown in the event a major engine malfunction occurs, such as low oil pressure, high oil temperature, high coolant temperature, low coolant pressure, or low coolant level. A crankcase pressure monitor is also available on Series 149 engines.

DDEC Power Requirements

Since the DDEC system is electronic, a battery is required to operate the computer.

The system operates at 12 or 24 volts. However, in the event of a power supply malfunction, the system will continue to operate at reduced voltage.

At reduced voltage, the electronic control system will detect a malfunction. When this occurs the "Check Engine" light will come on.

You should not notice any change in engine performance until the battery voltage drops to about 9 volts. At this point, the Electronic Control Module will go into "Back Up Control." You should then notice a change in engine operation, and at this time certain DDEC options will not function.

You will be able to operate the engine at reduced voltage until the battery voltage has reached the 6 volt range. At this point the system will no longer function and the engine will shut down.

While you can still operate the engine when the "Check Engine" light comes on, a report should be made to a Detroit Diesel technician as soon as possible.

NOTICE:
When the "Stop Engine" light comes on, the computer has detected a major malfunction in the engine that requires immediate attention. It is the operator's responsibility to shut down the engine as quickly as possible to avoid serious damage.

Welding Precaution

NOTICE:
To prevent damage to the DDEC electronic control system, disconnect the following **before** welding: battery power and ground cables and the power connector at the ECM (Electronic Control Module). **Serious damage to the ECM(s) and DDEC components may result from welding if *all* ECM connectors are not disconnected.**

Initial Engine Start
DDEC Industrial Engine

1. Turn on master power switch.

You will notice that the "Check Engine" and "Stop Engine" lights will come on. This is the result of the DDEC computer diagnosing the system to ensure everything is functional, including the light bulbs for the "Check Engine" and "Stop Engine" warning lights. If everything is okay, all lights will go out in approximately five seconds.

2. Start the engine by pressing the starter switch firmly.

NOTICE:
If the warning lights stay on, or if they do not come on momentarily after turning on the ignition, consult with a Detroit Diesel technician. Operating the engine under these circumstances may result in engine damage.

NOTICE:

To prevent serious starting motor damage, do not press the starter switch again after the engine has started.

If the engine fails to start within 15 seconds, release the starter switch and allow the starter motor to cool for 15 seconds before trying again. If the engine fails to start after four attempts, an inspection should be made to determine the cause.

Engine Protection

The "Stop Engine" malfunction is recorded in the Electronic Control Module. With the 30 second shutdown option, the engine will begin a 30 second, ramped power down. The unit will shut down completely, if programmed for shutdown.

To allow for the possibility of the "Stop Engine" automatic shutdown function being activated while the vehicle is operating in a critical situation, an override is provided.

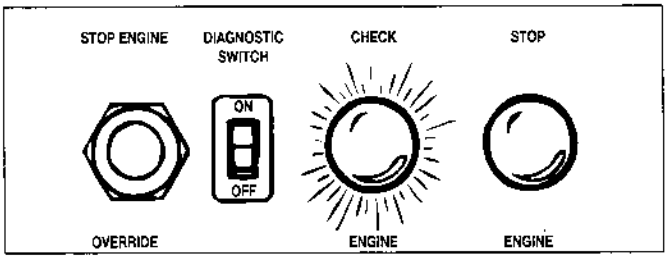
In this situation the operator may elect to "override" the automatic stop engine sequence by pressing the "Stop Engine Override" switch, located on the instrument panel, until a safe stop can be made. The operator only needs to press the override switch every 15 to 20 seconds to prevent engine shutdown from occurring.

NOTICE:

For some applications holding the "Stop Engine Override" switch in will not prevent the engine shutdown sequence. You must continue to reset the automatic shutdown system by pressing the "Stop Engine Override" switch at intervals of approximately 15 to 20 seconds.

An important thing to remember is that it takes 30 seconds from the time the automatic shutdown sequence begins until engine shutdown. Therefore, the operator **must** press the override switch just prior to engine shutdown to continue engine operation.

The immediate speed reduction option will bring engine rpm back to a predetermined speed. The engine may or may not shut down, depending on how it is programmed.



Typical shut-down override switch and engine lights

The engine should not be restarted after it has been shut down by the engine protection system unless the problem has been located and corrected.

The conditions that will cause the "Stop Engine" light to come on are:

— Loss of coolant
— High coolant temperature
— Low coolant pressure
— High oil temperature
— Low oil pressure
— High crankcase pressure
— Auxiliary shutdown

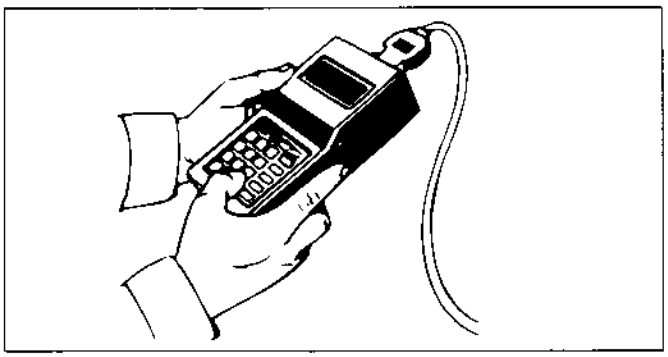
It is important to point out that whenever the "Check Engine" light or the "Stop Engine" light comes on, the DDEC computer will determine where the problem is, and will then store this information in its memory.

If the malfunction is intermittent, the "lights" will come on and go off as the computer senses the changing engine condition.

A special diagnostic tool is available that can be plugged into the engine computer memory to extract information related to the cause of the problem.

Once the malfunction has been corrected, the DDEC system will return the engine to normal operation.

The malfunction code recorded in the computer memory will remain until it is erased by a technician, using the diagnostic data reader.



Diagnostic data reader J38500

DDEC III

Diagnostic Codes

TO READ CODES: Use the diagnostic data reader or depress and hold the "Diagnostic Request" switch with the ignition on, engine at idle or not running. Press and hold the switch. Active codes will be flashed on the "Stop Engine" light, followed by the inactive codes being flashed on the "Check Engine" light. The cycle will repeat until the operator releases the diagnostic request switch.

Flash Code	DDEC Description
11	PTO input low voltage
12	PTO input high voltage
13	Coolant level circuit low voltage
14	Intercooler, coolant or oil temp. circuit high voltage
15	Intercooler, coolant or oil temp. circuit low voltage
16	Coolant level circuit high voltage
17	Bypass position circuit high voltage
18	Bypass position circuit low voltage
21	TPS circuit high voltage
22	TPS circuit low voltage
23	Fuel temp. circuit high voltage
24	Fuel temp. circuit low voltage
25	No codes
26	Aux. shutdown #1 or #2 active
27	Air temp. circuit high voltage
28	Air temp. circuit low voltage
31	Aux. output short or open circuit (high side)
32	SEL short or open circuit
33	Boost pressure circuit high voltage
34	Boost pressure circuit low voltage
35	Oil pressure circuit high voltage
36	Oil pressure circuit low voltage
37	Fuel pressure circuit high voltage
38	Fuel pressure circuit low voltage
41	Too many SRS (missing TRS)
42	Too few SRS (missing SRS)
43	Coolant level low
44	Intercooler, coolant or oil temp. high
45	Oil pressure low
46	Battery voltage low
47	Fuel pressure high
48	Fuel pressure low
52	A/D conversion fail
53	EEPROM write or nonvolatile fail
54	Vehicle speed sensor fault
55	J1939 data link fault
56	J1587 data link fault
57	J1922 data link fault
58	Torque overload
61	Injector response time long
62	Digital output open or short to battery
63	PWM open or short to battery
64	Turbo speed circuit failed
67	Coolant pressure circuit high or low
68	IVS switch fault, open or grounded circuit
71	Injector response time short
72	Vehicle overspeed
75	Battery voltage high
76	Engine overspeed with engine brake
81	Oil level or crankcase pressure circuit high voltage
82	Oil level or crankcase pressure circuit low voltage
83	Oil level or crankcase pressure high
84	Oil level or crankcase pressure low
85	Engine overspeed
86	Water pump or baro. pressure circuit high voltage
87	Water pump or baro. pressure circuit low voltage
88	Coolant pressure low

6. "HOW TO" SECTION

This section covers Detroit Diesel's recommendations on how to select lubricating oil, fuel oil, and coolant and includes basic engine maintenance procedures which can be performed by the operator. For a more detailed description of oil, fuel and filters, see "Engine Requirements—Fuel, Lubricating, Oil, and Filters," publication 7SE270. For more detailed description of coolants see the "Coolant Selections" publication 7SE298.

A. How to Select Lubricating Oil

Lubricant Selection in North America

The selection of the proper lubricating oil is important to achieve the long and trouble-free service which Detroit Diesel engines are designed to provide. The proper lubricating oil for all Detroit Diesel engines is selected based on SAE viscosity grade and API (American Petroleum Institute) service designation. Only oils licensed to display the American Petroleum Institute (API) symbol shown should be used.

Lubricant Selection Outside North America

Although the API service classification system is generally utilized worldwide, lubricants meeting Detroit Diesel requirements may not be marketed in all areas of the world. Selection of lubricants in these situations should be made based on viscosity grade first, ash content second, and performance specification third. Oils meeting API CF may be used if they also meet military specification Mil-L-2104 E or F. Oils which meet European CCMC D4 or D5 may also be used. Modification of oil drain interval may be necessary, depending on fuel quality. Contact Detroit Diesel Corporation for further guidance.

The Use of Supplemental Additives

Lubricants meeting the Detroit Diesel specifications outlined in this publication already contain a balanced additive treatment. The use of supplemental additives such as break-in oils, top oils, graphitizers and friction-reducing compounds, are generally not necessary and can even be harmful. These additives may be marketed as either oil treatments or engine treatments and are discouraged from use in Detroit Diesel engines. Engine damage resulting from the use of such materials is not covered by your Detroit Diesel Corporation warranty. Detroit Diesel will not provide statements beyond this publication relative to their use.

Marine Lubricants, Railroad Diesel Lubricants

The petroleum industry markets specialty lubricants for diesel engines designed specifically for marine propulsion or railroad locomotive use. These oils are characterized by their high TBN and the absence of magnesium and zinc in their composition. These lubricants take into consideration the unique environments and operational characteristics of this type of duty, and consequently, they are formulated quite differently from the types of lubricants specified by Detroit Diesel.

Marine and railroad lubricants may be used in two-stroke cycle engines provided they are SAE 40 viscosity grade and API CF-2. These oils may be selected for use when one of the following situations exists:

1. They are required in other equipment and only a single engine lubricant can be inventoried.

2. Where a high sulfur fuel is anticipated and there is a risk of resulting valve distress.

Specific product selection should be based on demonstrated performance provided by the oil supplier.

Synthetic Oils

Synthetic oils may be used in Detroit Diesel engines provided they are API licensed and meet the performance and chemical requirements of non-synthetic oils outlined in this publication. Synthetic oils offer improved low temperature flow properties and high temperature oxidation resistance. However, they are generally more costly than non-synthetic oils.

Product information about synthetic oils should be reviewed carefully. Performance additive systems often respond differently in synthetic oils. Only synthetic oils that do not contain viscosity improver additives may be used in Detroit Diesel two-stroke cycle engines. Their use does not permit extension of oil drain intervals.

Two-Stroke Cycle Engines
Detroit Diesel Series 53, 71, 92, 149

API Symbol:

SAE Viscosity Grade: 40
API Classification: CF-2
Sulfated Ash: less than 1.0% (less than 0.8% in Series 149 engines)

Lubrication Recommendation

Lubricants meeting these criteria have provided maximum engine life when used in conjunction with recommended oil drain and filter maintenance schedules.

API Performance category CF-2 represents an enhanced level of lubricant performance over the CD-II category which it replaces. Only API CF-2 oils should be used.

Sulfated Ash content as determined by ASTM D-874 is limited to 0.8% mass in Series 149 engines. Although not required, these lower ash oils may also be used in all series DDC two-cycle engines.

Engine oils meeting military specification Mil-L-2104 are intended for use in military engines. Due to the specific operating and life cycle requirements of military engine, the oils for these engines tend to be specialized toward that application. Military specified oils (Mil-L-2104 suffixes A through F) should not be used in commercial Detroit Diesel two-stroke cycle engines.

A more detailed description of each of these selection criteria may be found in a further section of this publication. Certain engine operating conditions may require exceptions to these requirements:

1. For continuous high temperature operation (over 200°F or 94°C Coolant Out), the use of an SAE grade 50 lubricant in DDCI two-stroke cycle Series 71 and 92 engines is required. SAE grade 50 lubricants are also required for all Series 149 engines where ambient temperatures are above 95°F (35°C).
2. At ambient temperatures below freezing (32°F or 0°C) sufficient starter cranking speed may not be achieved to start the engine with SAE 40 grade oils. Where starting aids are not available or at very cold temperatures (0 to -25°F or -18 to -32°C) even if starting aids are available, the use of multigrade SAE 15W-40 or monograde SAE 30 lubricants will improve startability.These lubricants must possess a High Temperature - High Shear Rate Viscosity (measured by ASTM D 4741 or equivalent of 3.70 cP minimum. **These oils must be replaced with monograde SAE 40 lubricants as soon as ambient conditions permit.**

Exception: Do not use multigrade or SAE 30 grade lubricants in Series 149 engines under any circumstances.

3. When the use of high sulfur fuel (greater than 0.5% mass) is unavoidable, the use of lubricants with higher alkalinity is recommended. Be aware that such lubricants may have a sulfated ash content above 1.0% mass. The use of high sulfur fuels also requires modification to oil drain intervals. For further information refer to "Oil Drain Intervals When Using High Sulfur Fuel"(page 46).
4. The use of multigrade and/or greater than 1% sulfated ash oils are exceptions for special circumstances. The use of such lubricants under normal circumstances may not provide satisfactory service.

Four-Stroke Cycle Engines
Detroit Diesel Series 30, 40, 50, 55, 60
and All Other Four-Stroke Cycle Engines

API Symbol:

SAE Viscosity Grade: 15W-40
API Classification: CG-4

Lubricant Requirements

Lubricants meeting these criteria have provided maximum engine life when used in conjunction with specified oil drain and filter maintenance schedules.

Lubricants meeting API Performance category CG-4 are intended for use primarily with low (0.05%) sulfur fuel and may be used in all Detroit Diesel 4-cycle engines. Compared to API CF-4, these oils have improved soot and deposit control, in addition to enhanced wear control. API CF-4 oils may be used when CG-4 is not available. Monograde oils are not recommended for use in these engines.

When the use of high sulfur fuel (greater than 0.5% mass sulfur) is unavoidable, higher alkalinity lubricants are recommended. High sulfur fuels require modification of oil drain intervals.

B. When to Change Oil

Oil Drain Intervals

During use, engine lubricating oil undergoes deterioration from combustion by-products and contamination. For this reason, regular oil drain intervals are necessary. These intervals, however, may vary in length depending upon engine operation, fuel quality, and lubricant quality. The oil drain interval may be established on recommendations of the Detroit Diesel Oil Analysis Program until the most practical oil change interval has been determined. Under no circumstances, however, should the drain intervals in the following chart be exceeded. All engine oil filters should be changed when the lube oil is changed.

Stationary Units Continuous	50, 60, 71, 92 & 149	300 Hours or 3 Months, whichever comes first
Stationary Units Standby	50, 60, 71, 92 & 149	150 Hours or 1 Year, whichever comes first

Table 3 Maximum Allowable Oil Drain Intervals

Dispose of used lubricating oil, filter, and gasket in an environmentally approved manner according to state and/or federal (EPA) recommendations.

Oil Drain Intervals When Using High Sulfur Fuel

When the continuous use of high sulfur fuel (greater than 0.5%) is unavoidable, lubricant selection and oil drain interval must be modified. A lubricant with a Total Base Number (TBN per ASTM D 2896) above 10 is recommended. It is likely that such a lubricant will also exhibit a sulfated ash above 1.0%. The proper oil drain interval must be determined by oil analysis when operating on high sulfur fuel. A reduction in TBN (D 2896) to one-third of the initial value provides a general drain interval guideline.

Waste Oil Disposal and Rerefined Oils

Detroit Diesel favors the recycling of waste oil and permits the use of rerefined oils in all engine product lines, provided the rerefined oils meet the SAE Viscosity and API specifications previously mentioned.

Consideration for the disposal of waste oil should begin when negotiating the purchase of new oil. Oil supplier selection criteria should include a proposal for handling waste oil. It is important to know exactly how

the oil will be disposed of since it is the generator, not the hauler, that is ultimately responsible for its proper disposal.

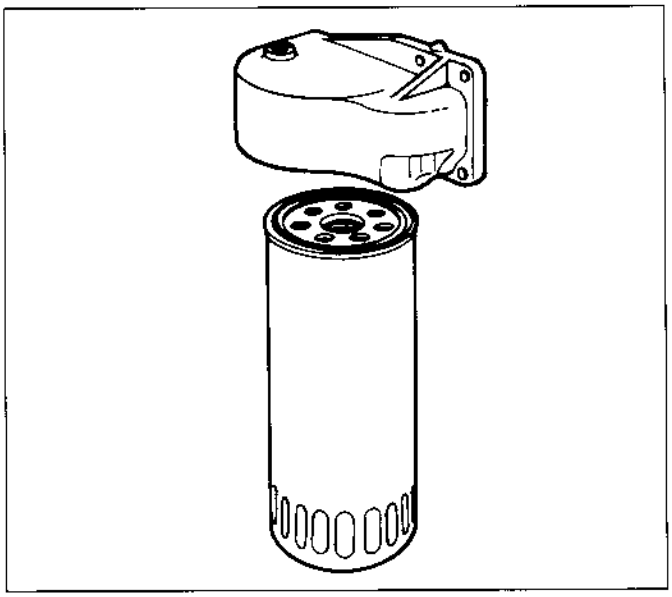
⚠ CAUTION:

Extended skin contact with used motor oil may be harmful and should be avoided.

C. How to Replace the Lube Oil Filter

The *spin-on type* filter consists of a shell, element, and gasket unitized into a single cartridge and a filter cover which includes a threaded sleeve to accept the spin-on filter cartridge(s).

Replace Spin-on Type Filter



Typical Series 71, 92 spin-on type oil filter assembly

1. Remove the spin-on filter cartridge using strap wrench tool J29917 (or equivalent) and a 1/2" drive socket wrench and extension.

2. Dispose of the used oil and filter in an environmentally approved manner according to state and/or federal (EPA) recommendations.

3. Clean the filter adaptor with a clean, lint-free cloth.

4. Lightly coat the filter gasket (seal) with clean engine oil or petroleum jelly.

5. Start the new filter on the adaptor and *tighten by hand* until the gasket touches the mounting adaptor head. Tighten an additional two-thirds turn.

NOTICE:

Overtightening may distort or crack the filter adaptor.

6. Add oil as required to bring the level to the "full" mark on the dipstick.

7. Start and run the engine for a short period and check for leaks. After any leaks have been corrected, stop the engine long enough for oil from various parts of the engine to drain back to the crankcase (approximately 20 minutes). Add oil as required to bring the level to the proper mark on the dipstick.

NOTICE:

If the oil level is constantly above normal and excess lube oil has not been added to the crankcase, consult with an *authorized Detroit Diesel service outlet* for the cause. Fuel or coolant dilution of lube oil can result in serious engine damage.

D. How to Select Diesel Fuel

Quality and Selection

The quality of fuel used is a very important factor in obtaining satisfactory engine performance, long engine life, and acceptable exhaust emission levels. Detroit Diesel engines are designed to operate on most diesel fuels marketed today. In general, fuels meeting the properties of ASTM Designation D 975 (grades 1-D and 2-D) have provided satisfactory performance. The ASTM D 975 specification, however, does not in itself adequately define the fuel characteristics required for assurance of fuel quality. The properties listed in the table below provide optimum engine performance.

General Fuel Classification	ASTM Test Method	No. 1-D	No. 2-D
API Gravity, @ 60°+++	D 287	40-44	34-38
Specific Gravity, @ 60°+++	D1298	0.806 - 0.825	0.835 -0.855
Flash Point, °C Min.	D 93	38	52
Viscosity, Kinematic cST @ 40°C	D 445	1.3 - 2.4	1.9 - 4.1
Sulfur wt%, Max.	D 2622	0.5 (0.05)++	0.5 (0.05)++
Cloud Point °F (°C)+	D 2500	Note 1	Note 1
Cetane No., Min.+	D 613	45	45
Cetane Index, Min.+	D 4737	40	40
Distillation Temperature,°F (°C)	D 86		
IBP, Typical+++		350 (177)	375 (191)
10% Typical+++		385 (196)	430 (221)
50% Typical+++		425 (218)	510 (256)
90%, Max.		500(260)	625 (329)
End Point, Max.+++		550 (288)	675 (357)
Water & Sediment, % Max.	D 2709	0.05	0.05
Ash,%, Max.	D 482	0.01	0.01
Carbon Residue on 10%, wt%, Max.	D 524	0.15	0.35
Copper Corrosion, Max.	D130	3b	3b
Accelerated Storage Stability Max.+++	D2274	15 mg/L	15 mg/L
Dupont Pad Test, Rating Max.+++	TM-F21-61	7	7
Lubricity, gm, Min.+++	D 5001 (mod)*	2800	2800

*As modified in the U.S. Army Scuffing BOCLE Test Method
+ Differs from ASTM D 975
++The sulfur content of diesel fuel for use in on-road vehicles is limited to 0.05% maximum.
+++Not Specified in ASTM D 975
Note 1: The cloud point should be 10°F (6°C) *below* the lowest expected fuel temperature to prevent clogging of fuel filters by wax crystals.
Note 2: When prolonged idling periods or cold weather conditions below 32°F (0°C) are encountered, the use of 1-D fuel is recommended.

Diesel Fuel Specification Table

Fuel Additives. Supplemental fuel additives are not recommended due to potential injector system or engine damage. Our experience has been that such additives increase operating costs without providing benefit. **The use of supplemental fuel additives does not necessarily void the engine warranty. However, repair expenses which result from fuel system or engine component malfunctions or damage attributed to their use will not be covered.** These products should be accompanied by performance data supporting their merit. It is not the policy of Detroit Diesel Corporation to test, evaluate, approve, or endorse such products.

Water Contamination

Some fuel additives provide temporary benefit when fuel is contaminated with water. They are not intended to replace good fuel handling practices. Where water contamination is a concern, the fuel system should be equipped with a fuel/water separator which should be serviced regularly. In marine and other environments where microbe growth is a problem, a fungicide such as Biobor JF (or equivalent) may be used. Microbial activity may be confirmed with commercially available test kits. Follow the manufacturer's instructions for treatment. Avoid the use of fungicides containing halogenated compounds, since these may cause fuel system corrosion.

When small amounts of water are present, supplemental additives containing methyl carbitol or butyl cellusolve are effective. Follow the manufacturer's instructions for their use. The use of isopropyl alcohol is no longer recommended due to its negative effect on fuel lubricity.

The Following Fuel Additives Are NOT Allowed:

Used Lubricating Oil Detroit Diesel specifically prohibits the use of drained lubricating oil in diesel fuel. Used lubricating oil contains combustion acids and particulate materials which erode injector components, resulting in loss of power and increased exhaust emissions. In addition, the use of drained lubricating oil will increase maintenance requirements due to filter plugging and combustion deposits. Refer to the section "Waste Oil Disposal and Rerefined Oils"(page 46) for recommendations on proper used oil disposal.

Gasoline The addition of gasoline to diesel fuel will create a serious fire hazard. The presence of gasoline in diesel fuel will reduce fuel cetane number and increase combustion temperatures. Tanks which contain such mixtures should be drained and cleaned as soon as possible.

Detroit Diesel Corporation will not be responsible for any detrimental effects which it determines resulted from the use of used lubricating oil or gasoline in the diesel fuel.

Diesel Fuel Storage

Fuel oil should be clean and free of contamination. Storage tanks and stored fuel should be inspected regularly for dirt, water, and sludge, and cleaned if contaminated. Diesel fuel tanks can be made of monel, stainless steel, black iron, welded steel or reinforced (non-reactive) plastic.

NOTICE:

Do not use galvanized steel or sheet metal tanks and galvanized pipes or fittings in any diesel fuel storage, delivery, or fuel system. The fuel oil will react chemically with the zinc coating, forming a compound which can clog filters and cause engine damage.

Filtration

Filters make up an integral part of fuel and lubricating oil systems. Proper filter selection and maintenance are important to satisfactory engine operation and service life. Filters, however, should be used to maintain a clean system, not to clean up a contaminated system.

Filter performance and test specifications vary between manufacturers. The filters shown in the Filter Charts (page 64) have been qualified to appropriate SAE performance specifications and meet Detroit Diesel requirements. Other brands of filters may be used, provided they have equivalent demonstrated performance.

Finer filtration will generally provide increased engine service life, but may require shorter filter change intervals. Detroit Diesel specifies filter performance based on the optimum combination of filter micron rating, filter capacity, and mechanical requirements (assembly integrity).

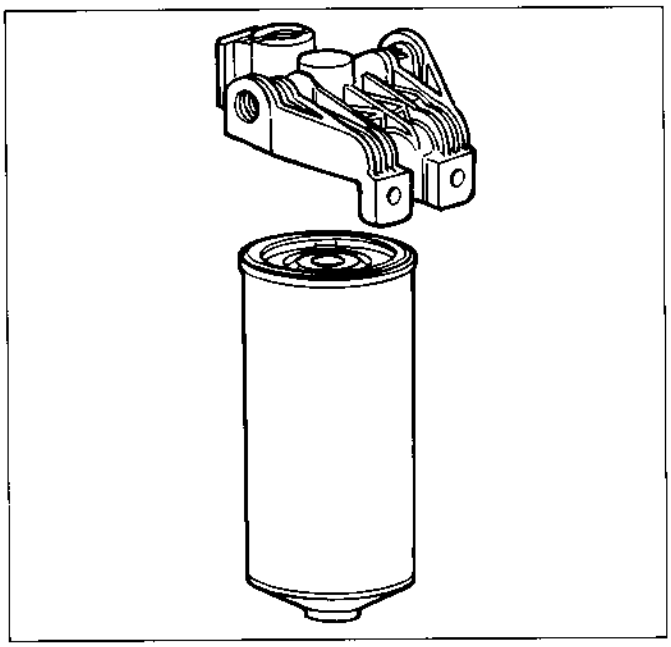
The addition of aftermarket supplemental filtration systems may be used, provided they do not replace the factory installed system or reduce oil volumes, pressures, or flow rates delivered to the engine. Fuel filters must be properly sized to provide the proper fuel flow to the engine. A fuel/water separator, if used, must be installed between the fuel tank and the inlet side of the engine fuel pump.

For more detailed information on fuel selection, refer to "Engine Requirements — Lubricating Oil, Fuel and Filters," form 7SE270, available from *authorized Detroit Diesel service outlets.*

E. How to Replace the Fuel Filter and Strainer

The *spin-on type* consists of a shell, element, and gasket unitized into a single cartridge and a strainer or filter cover which includes a threaded sleeve to accept the spin-on filter cartridge.

Replace Spin-on Type Filter Element



Typical spin-on fuel filter assembly

1. With the engine shut down, close the fuel shut-off valve (if equipped). Place a suitable container under the strainer or filter and unscrew the cartridge. Dispose of the cartridge in an environmentally approved manner according to state and/or federal (EPA) recommendations.
2. Fill a new replacement cartridge about two-thirds full with clean fuel oil. Coat the seal gasket lightly with clean fuel oil.
3. Install the new cartridge and tighten it two-thirds of a turn beyond gasket contact.

NOTICE:

Overtightening may distort or crack the filter adaptor.

4. Open the fuel shut-off valve (if equipped), start the engine, and check for leaks.

NOTICE:

To improve starting, have replacement filters filled with fuel and ready to install immediately after used filters are removed. This will prevent possible fuel siphoning, which can cause fuel system aeration.

If the engine fails to start after replacement of the fuel strainer and/or filter elements, the fuel system will require priming. Refer to ***"G. How to Prime the Fuel System"*** *for priming instructions.*

F. Engine Out of Fuel— How to Restart

When an engine has run out of fuel, there is a definite procedure to follow when restarting it.

1. Fill the fuel tank with the recommended grade of fuel. If only partial filling is possible, add a minimum of 10 gallons (38 liters) of fuel to the tank. Add a minimum of 25 gallons (95 liters) when starting a Series 149 engine.

NOTICE:

To avoid fuel injector damage at engine start-up, fuel systems **must** be primed if the engine has run out of fuel. Refer to ***"G. How to Prime the Fuel System"*** for priming instructions.

2. Prime the fuel system and start the engine.

G. How to Prime the Fuel System

System with Primary and Secondary Fuel Filters

1. Remove the primary fuel filter(s) only (spin-on or cartridge) from the engine.
2. Completely fill the primary filter(s) with **clean** fuel and reinstall.

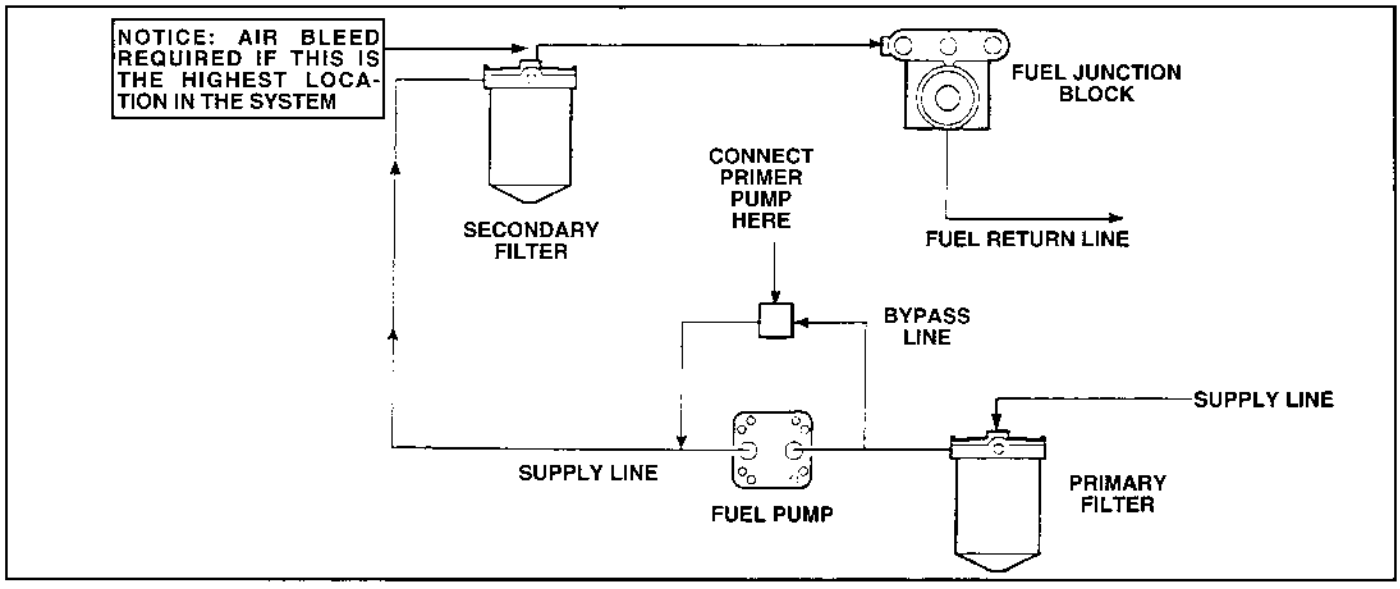
NOTICE:
To avoid fuel system contamination, do not remove the secondary fuel filter(s) from the engine.

3. Connect a fuel priming pump between the engine fuel pump inlet and the secondary filters as shown.
4. Prime the system until all air is purged.

NOTICE:
All the air **must** be eliminated from the fuel system to avoid injector damage at start-up.

NOTICE:
The priming pump **must** deliver enough pressure enough pressure to completely fill the system with fuel and expel all the air from it. However, to avoid fuel line or seal damage, do not allow fuel system pressure to exceed 100 psi (689 kPa) when priming.

5. Remove the priming pump and check to make sure all fittings, hoses, and filters are tight.
6. Start the engine and run at high idle for 2 - 3 minutes.
7. Shut down the engine and check for fuel leaks. Repair as required.



System with primary and secondary fuel filters

NOTICE:

Under no circumstances should the starting motor and fuel pump be used to prime the fuel filter and strainer. Prolonged use of the starting motor and fuel pump to prime the fuel system can result in damage to the starter, fuel pump, and injectors and cause erratic running of the engine due to the amount of air in the lines and filters.

H. Engine Storage

Preparing Engine for Storage

When an engine is to be stored or removed from operation for a period of time, special precautions should be taken to protect the interior and exterior of the engine, transmission and other parts from rust accumulation and corrosion. The parts requiring attention and the recommended preparations are given below.

It will be necessary to remove all rust or corrosion completely from any exposed part before applying rust preventive compound. Therefore, it is recommended that the engine be processed for storage as soon as possible after removal from operation.

The engine should be stored in a building that is dry and can be heated during the winter months. Moisture absorbing chemicals are available commercially for use when excessive dampness prevails in the storage area.

Temporary Storage (30 Days or Less)

To protect an engine for a temporary period of time, proceed as follows:

1. Drain the engine crankcase.
2. Fill the crankcase to the proper level with the recommended viscosity and grade of oil.
3. Fill the fuel tank with the recommended grade of fuel oil. Operate the engine for two minutes at 1200 rpm and no load. **Do not drain the fuel system or the crankcase after this run.**
4. Check the air cleaner and service it, if necessary.
5. If freezing weather is expected during the storage period, check the antifreeze/coolant for required freeze and inhibitor protection. Genuine Detroit Diesel **Power Cool** antifreeze or equivalent ethylene glycol-base antifreeze is recommended for all Detroit Diesel Engines. Propylene glycol-base antifreeze may also be used in Series 50 and 60 engines.

NOTE: If an antifreeze solution is not required during storage, flush the cooling system with a good rust inhibitor to prevent rusting of the outside diameter of the cylinder liners.

6. Clean the exterior of the engine (except electrical components) with fuel oil and dry with compressed air.

⚠ CAUTION:

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

7. Seal all engine openings. The material used must be waterproof, vaporproof and possess sufficient physical strength to resist puncture and damage from the expansion of entrapped air.

An engine prepared in this manner can be returned to service in a short time by removing the seals at the engine openings and by checking the engine coolant, fuel oil, lubricating oil and transmission oil levels.

Extended Storage (More than 30 Days)

To prepare an engine for extended storage (more than 30 days), follow this procedure:

1. Drain the cooling system and flush with clean, soft water. Refill with clean, soft water and add a rust inhibitor to the cooling system.
2. Circulate the coolant by operating the engine until normal operating temperature is reached.
3. Stop the engine.
4. Drain the engine crankcase, then reinstall and tighten the 3/4"-14 square, magnetic oil drain plug to 45-50 N•m (33-37 lb-ft) torque. Install new lubricating oil filters.
5. Fill the crankcase to the proper level with a 30-weight preservative lubricating oil MIL-L-21260C, Grade 2.
6. Drain the fuel tank. Refill with enough clean No. 1

diesel fuel or pure kerosene to permit the engine to operate for about ten minutes. If draining the fuel tank is not convenient, use a separate, portable supply of recommended fuel.

NOTE: If engines are stored where condensation of water in the fuel tank and biological contamination of fuel may be a problem, add a biocide such as Biobor JF (or equivalent) to the fuel. When using a biocide, follow the manufacturer's concentration recommendations, and observe all cautions and warnings.

7. Drain the fuel system and remove the fuel filters. Dispose of used filters in an environmentally responsible manner, according to state and/or federal (EPA) recommendations. Fill new filters with No. 1 diesel fuel or pure kerosene, and reinstall on the engine.
8. Operate the engine for five minutes to circulate the clean fuel oil throughout the engine. Be sure the engine fuel system is full. Disconnect the fuel return line and the inlet line at the primary filter and securely plug both to retain the fuel in the engine.
9. Service the air cleaner.
10. **Turbocharger**—Since turbocharger bearings are pressure lubricated through the external oil line leading from the oil filter adapter while the engine is operating, no further attention is required. However, the turbocharger air inlet and turbine outlet connections should be sealed off with moisture-resistant tape.

NOTICE:
Failure to properly seal off turbocharger air inlet and exhaust outlet openings before engine storage may permit air drafts to circulate through the turbocharger and rotate the turbine/compressor shaft without an adequate flow of lubricating oil to the center housing bearings. This can result in severe bearing damage.

11. Apply a non-friction rust preventive compound to all exposed engine parts.
12. Drain the engine cooling system.
13. Drain the preservative oil from the engine crankcase. Reinstall and tighten the drain plug.
14. Remove and clean the battery and battery cables with a baking soda-water solution and rinse with fresh water. Do not allow the soda solution to enter the battery. Add distilled water to the electrolyte (if necessary) and fully charge the battery. Store the battery in a cool (never below 0°C or 32°F) dry place. Keep the battery fully charged and check the level and specific gravity of the electrolyte regularly.
15. Insert heavy paper strips between the pulleys and drive belts to prevent sticking.
16. Seal all engine openings including the exhaust outlet, with moisture-resistant tape. Use cardboard, plywood or metal covers where practical.
17. Clean and dry the exterior painted surfaces of the engine and spray with a suitable liquid automobile body wax, a synthetic resin varnish, or a rust preventive compound.
18. Protect the engine with a good weather-resistant tarpaulin and store it under cover, preferably in a dry building which can be heated during the winter months.

Outdoor storage of engines is not recommended. If units must be kept out-of-doors, follow the preparation and storage instructions already given. Protect units with quality, weather-resistant tarpaulins (or other suitable covers) arranged to provide for air circulation.

NOTICE:
Do not use plastic sheeting for outdoor storage. Plastic is fine for indoor storage. When used outdoors, however, enough moisture can condense on the inside of the plastic to rust ferrous metal surfaces and pit aluminum surfaces. If a unit is stored outside for any extended period of time, severe corrosion damage can result.

The stored engine should be inspected periodically. If there are any indications of rust or corrosion, corrective steps must be taken to prevent damage to the engine parts. Perform a complete inspection at the end of one year and apply additional treatment as required.

Procedure for Restoring to Service an Engine that Has Been in Extended Storage

1. Remove the covers and tape from all of the openings of the engine, fuel tank and electrical equipment. Do not overlook the exhaust outlet.
2. Remove the plugs from the inlet and outlet fuel lines and reconnect the lines to their proper positions.
3. Wash the exterior of the engine with fuel oil to remove the rust preventive. **Do not wash electrical components.**
4. Remove the paper strips from between the pulleys and drive belts.
5. Fill the crankcase to the proper level with the required grade of lubricating oil. Use a pressure lubricator to insure all bearings and rocker shafts are lubricated.
6. Fill the fuel tank with the required fuel.
7. Close all drain cocks and fill the engine cooling system with clean, soft water and required inhibitors. If the engine is to be exposed to freezing temperatures, install genuine Detroit Diesel Power **Power Cool®** antifreeze or an equivalent ethylene glycol-base antifreeze solution which provides required freeze, boilover, and inhibitor protection. A quality, fully formulated propylene glycol-base antifreeze solution may also be used in Series 50 and Series 60 engines. Refer to How to Select Coolant (page 54).
8. Install and connect the battery. Make sure the average specific gravity of the battery is 1.260 or higher. Charge the battery if necessary.
9. Service the air cleaner, if required.
10. **Turbocharger**—Remove the covers from the turbocharger air inlet and turbine outlet connections. Reconnect piping as required. Prelube the turbocharger. Refer to the lubricating procedure outlined in "Preparations for Starting the Engine the First Time" (page 37).

NOTICE:
Engines which have not been properly prepared for storage must be examined by a Detroit Diesel-qualified mechanic to verify that all internal components are free to move without damage. In particular it is important to verify that old fuel has not gummed up inside the fuel system. Failure to properly prelube the engine or clean thickened fuel out of the fuel system prior to starting may result in severe engine damage at start-up.

11. After all preparations are completed, start the engine. The small amount of rust preventive compound which remains in the fuel system will cause smoky exhaust for a few minutes.

NOTE: Before subjecting the engine to a load or high speed, allow it to reach normal operating temperature. Then, monitor the DDEC Diagnostic Data Link for trouble codes.

NOTICE:
Under no circumstances should the starting motor and fuel pump be used to prime the fuel filters. Prolonged use of the starting motor and fuel pump to prime the fuel system can result in damage to the starter, fuel pump, and injectors and cause erratic running of the engine due to the amount of air in the lines and filters.

I. How to Select Coolant

Coolant for Series 53, 71, 92, 50, and 60 Engines

The following information applies to Series 53, 71, 92, 50, and 60 engines. When selecting coolant for Series 149 Engines, refer to "Coolant for Series 149 Engines" (page 57).

Antifreeze

Use genuine Detroit Diesel Power Cool or an equivalent fully formulated, inhibited ethylene glycol (IEG)-base coolant (low silicate formulation) that meets or exceeds the standard of either the GM

6038-M formulation (GM 1899-M performance), or ASTM D 4985 requirements.

In Series 50 and Series 60 engines, a 50/50 mix of quality fully formulated, inhibited propylene glycol antifreeze and water may also be used if it provides required freeze, boilover, and inhibitor protection. Do not mix ethylene glycol and propylene glycol antifreeze. Flush the cooling system thoroughly before replacing ethylene glycol with propylene glycol antifreeze.

A 50% **Power Cool** antifreeze/water solution is normally used as a factory fill. Concentrations over 67% are not recommended because of poor heat transfer capability, adverse freeze protection and possible silicate dropout. Concentrations below 33% offer little freeze, boilover or corrosion protection.

If Detroit Diesel Power Cool or equivalent precharged inhibited ethylene glycol (IEG) or precharged inhibited propylene glycol (IPC) is not used, Detroit Diesel Maintenance Product supplemental inhibitors must be added to the coolant at initial fill. Inhibitor levels in all coolants used must be maintained at proper concentration thereafter. Refer to "Inhibitor Test Procedures" (page 56) for inhibitor levels.

Antifreeze solution should be used year-round to provide freeze and boil-over protection as well as a stable environment for seals and hoses.

In extremely hot environments, clean, soft, properly inhibited water may be used if Detroit Diesel Maintenance Product supplemental corrosion inhibitors are also added in the right concentration. If water is used, supplemental coolant additive levels should be increased from 3% to 6% by volume (refer to **Specifications**, page 66).

Only non-chromate inhibitors should be used with coolant solutions.

Coolant must be tested for required inhibitor levels at the intervals shown under "Coolant Test Intervals" in this section. Adjust the concentration if not at the proper protection level.

Mix coolant/water solution at the proper concentration before adding to the cooling system. This should prevent over- or under-coolant concentration problems.

Methyl alcohol-based antifreeze is not recommended for use in Detroit Diesel engines because of its effect on the non-metallic components of the cooling system and its low boiling point.

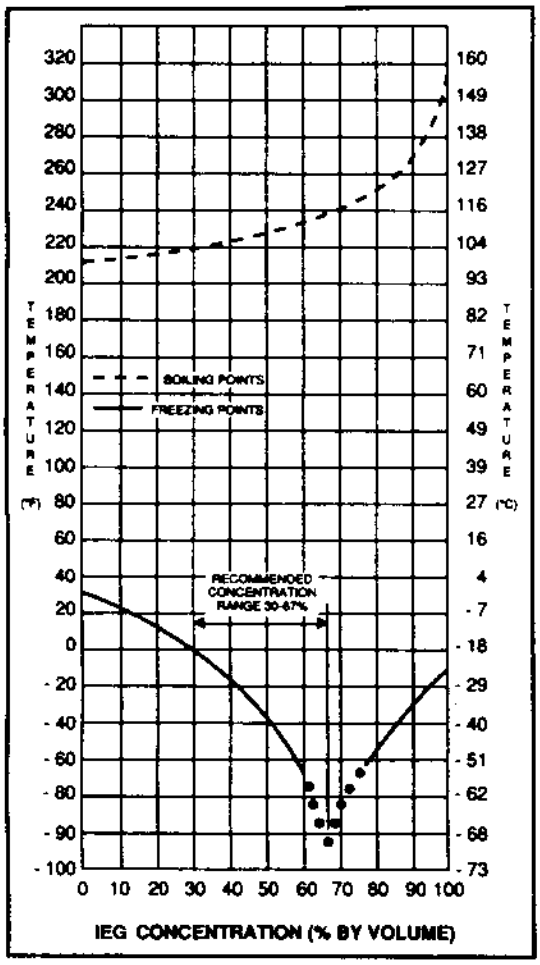
Methoxy propanol-based anti-freeze is also not recommended because it is not compatible with fluoroelastomer seals found in the cooling system.

Glycol-based coolants formulated for heating/ventilation/air conditioning (HVAC) are not recommended. These generally contain very high levels of phosphates, which can deposit on hot internal engine surfaces and reduce the heat transfer ability of the metal.

Coolant Drain Interval

A cooling system properly maintained and protected with supplemental inhibitors can be operated up to two years or 4,000 hours, whichever comes first.

At this interval the coolant must be drained and disposed of in an environmentally responsible manner, according to state and/or federal (EPA) recommendations, and the cooling system thoroughly cleaned.



Ethylene glycol coolant freezing and boiling temperatures vs. antifreeze concentration (sea level)

Over a period of time normal maintenance dosages of supplemental coolant additives (SCA's) and ethylene or propylene glycol could result in the total dissolved solids being raised to a level that could cause the cooling system to lose some of its efficiency.

Inspect all components that make up the cooling system and make necessary repairs at this time. Refill the cooling system with a recommended ethylene or propylene glycol-base coolant and water solution at the required concentration. Add required Detroit Diesel Maintenance Product cooling system inhibitors. After filling, run engine until thermostat(s) open and top off coolant to recommended full level. Reinstall fill/pressure cap.

NOTICE:
Do not use sealer additives in the cooling system. The presence of the gumming and gelling material in stop-leak additives could cause plugging in the cooling passages, which will adversely affect the cooling system.

Detroit Diesel Maintenance Product Inhibitors System

Detroit Diesel Maintenance Product supplemental coolant inhibitors are a combination of chemical compounds which provide corrosion protection, cavitation suppression and pH control, and prevent scale. These systems are available in various forms, such as coolant elements, liquid packages, and as integral parts of antifreeze.

Detroit Diesel Maintenance Product supplemental coolant inhibitors are water-soluble chemical compounds which protect the metallic surfaces of the cooling system against corrosive attack. Some of the more common corrosion inhibitors used in the Maintenance Product line are borates, nitrites, and silicates.

- pH control chemicals are used to maintain an acid-free solution.
- Water-softening chemicals deter formation of mineral deposits.
- Cavitation suppression chemicals minimize the formation of vapor pockets, preventing erosion of cooling system surfaces.

It is imperative that Detroit Diesel Maintenance Product supplemental inhibitor be added to all Detroit Diesel engines.

Detroit Diesel Maintenance Product cooling system products are nitrite/borate-based formulations. These products can be used with either water or water-and-coolant solutions and provide corrosion protection, pH control, and water softening. They offer the additional advantage of a simple on-site test to determine protection level.

Refer to **Specifications** (page 66) for required coolant filter/inhibitor precharge and maintenance elements.

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

NOTICE:
Overinhibiting with supplemental coolant additives or coolant concentrate can cause additive dropout. Always follow the coolant manufacturer's recommendations on usage and handling.

Soluble oils and chromate inhibitors are *not recommended* for use in Detroit Diesel engine cooling systems.

Inhibitor Test Procedures

Engine coolant must be tested for required inhibitor levels every 200 hours of engine operation or yearly, whichever comes first. Test kits and test strips are commercially available to check engine coolant for nitrite concentration. Inhibitor levels must be maintained within the ranges shown on the following chart:

Detroit Diesel Maintenance Products System		
	Min. PPM	Max. PPM
Boron (B)	1000	1500
Nitrite (NO2)	800	2400
Nitrates (NO3)	1000	2000
Silicon (Si)	50	150
Phosphorous (P)	0	500
pH	7.0	10.5

Selected Products Supplemental Coolant Additive Values with GM6038-M or ASTM D 4985 (50/50 Glycol/Water Mixture)

Coolant test strips that measure glycol and nitrite concentration are available from authorized Detroit Diesel service outlets under part number 23515917. A factory coolant analysis program is also available under part number 23508774.

Silicate/Phosphate Dropout

Excessive amounts of chemicals in the engine coolant can cause additive dropout, which creates a gel-type or crystaline deposit that reduces heat transfer and coolant flow.

The gel takes the color of the coolant in the wet state, but appears as a white powdery deposit when dry. Although silica gel is non-abrasive, it can pick up solid particles in the coolant and become gritty, causing excessive wear of water pump seals and other cooling system components. The wet gel can be removed by using a non-acid (alkali) type heavy-duty cleaner such as Nalprep® 2001 (sodium nitrite/sodium tetraborate), while the dried silicate requires engine disassembly and caustic solution or mechanical cleaning of individual components.

Phosphate can drop out of solution and crystallize on heat transfer surfaces and water pump seal faces. Phosphate may be removed by flushing the system with water to redissolve crystals.

The total amount of chemicals in the coolant can be controlled to desirable levels by using the referenced antifreeze at the needed freeze protection concentration, adding Detroit Diesel Maintenance Product inhibitors and water that meets Detroit Diesel requirements.

NOTICE:

Failure to use and maintain coolant and coolant inhibitor mixture at sufficient concentration levels can result in damage to the cooling system and its related components. Conversely, overconcentration of coolant and/or inhibitor can result in poor heat transfer, leading to engine overheat, additive dropout, or both. Always maintain concentrations at recommended levels.

Coolant for Series 149 Engines

Detroit Diesel recommends the following to ensure proper inhibiting of Series 149 engine cooling systems. When selecting coolant for Series 53, 71, 92, 50, and 60 engines, refer to "Coolant for Series 53, 71, 92, 50, and 60 Engines" (page 54).

1. Coolant used in Series 149 engines should have the lowest possible concentration of silicate and phosphate. There are no large areas of aluminum in contact with the coolant, so silicates are not required.
2. Water used *must* meet the specifications shown below.

	Maximum Allowable	
	Parts per Million	Grains per Gallon
Chlorides	40	2.5
Sulfates	100	5.8
Total Dissolved Solids	340	20
Total Hardness		
Magnesium & Calcium	170	10

Satisfactory Water Limits

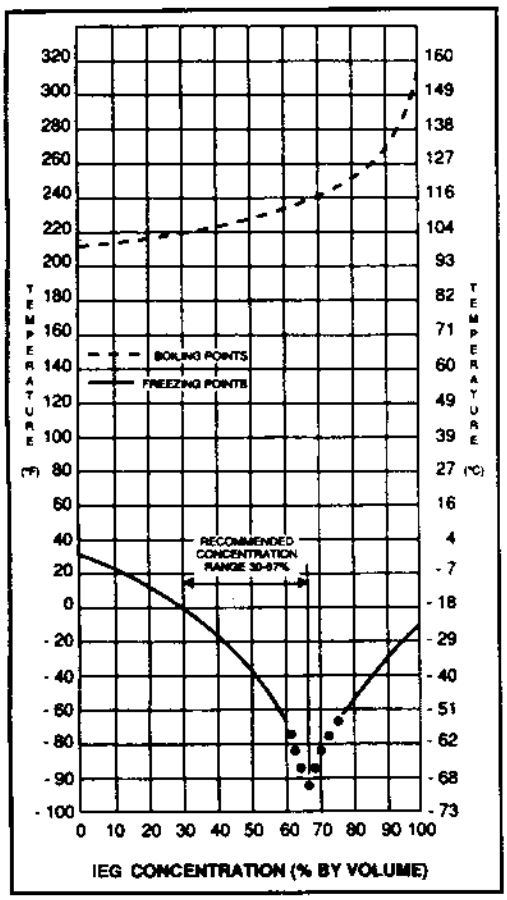
Detroit Diesel has found that DDC-branded coolant products are more tolerant to hard water than products that contain phosphates; but overly hard water can still cause problems. Examples of acceptable and non-acceptable city water sources are shown below. If in doubt about water, use deionized or distilled water.

WATER QUALITY						
SOURCE		**7SE-298**	**DETROIT**	**DALLAS**	**HIBBING**	**EDMONTON**
	UNITS	MAXIMUM				
CONDUCTIVITY	uS/Cm	NA	220	420	469	NA
SULFATE	PPM	100	23	44	29.2	44
CHLORIDE	PPM	40	9.5	34.9	10.2	12.4
SOLIDS TDS	PPM-mg/l	340	130	259	295	NA
HARDNESS	PPM	170	120	170	204	120
ACCEPTABILITY			YES	YES	NO	YES

Examples of water quality at various locations

3. Where freeze protection is required, use PowerCool fully formulated IEG antifreeze mixed in the range of 35% to 65% concentration with water that meets mineral concentration limits shown on page 57.

   Cooling system performance increases as the concentration of water increases, so use as little glycol as possible to obtain the freeze protection required for the area of operation. Refer to the concentration chart to determine the minimum amount of glycol needed.



Coolant Freezing and Boiling Temperatures vs. Inhibited Ethylene (IEG) Concentration (Sea Level)

Concentrations of PowerCool within the 35% to 65% range will provide the correct level of corrosion and cavitation protection without the use of additional SCA's at initial fill.

4. If an antifreeze other than PowerCool is used, it must meet the GM 1899 performance requirements as specified in publication 7SE298, *Coolant Selections for Engine Cooling Systems.* After installing antifreeze other than PowerCool, use PowerTrac® test strips to determine the *nitrite* level of the coolant. If the concentration of nitrite is over 800 PPM, no additional SCA should be added. If nitrite concentration is at or below 800 PPM, add a dose of PowerCool 3149. This can be done in one of three ways:

   - Use one pint of liquid PowerCool 3149 for every four gallons of water.
   - Use two 23518070 spin-on elements for cooling systems of up to 100 gallon capacity.
   - Use two 23518071 spin-on elements for cooling system capacities of 101 to 150 gallons.

When topping off the coolant, use the same concentration of low silicate antifreeze, PowerCool 3149, and water as originally installed. PowerCool 3149 part numbers are shown below.

Part Number	Description and Size
23518072	PowerCool 3149 - 1 Gallon
23518073	PowerCool 3149 - 5 Gallon
23518074	PowerCool 3149 - 55 Gallon
23518069	PowerCool 3149 Spin-on Element (4 Oz.)
23518070	PowerCool 3149 Spin-on Element (32 Oz.)
23518071	PowerCool 3149 Spin-on Element (53 Oz.)

PowerCool 3149 Liquid and Spin-on Element Part Numbers

5. In areas that require only water and SCA, fill the system with water meeting the limits shown on page 57. Add 3% PowerCool 3149 SCA and DD 3000 SCA. This can be done in either of the following ways:

   - Use one pint each of liquid PowerCool 3149 and DD-3000 for every eight gallons of water.
   - If coolant inhibitor canisters are used, install one each of the following for proper inhibiting.

Cooling System Capacity	PowerCool Element	Qty.	DD-3000 SCA Element	Qty.
Up to 100 Gallons	23518701	1	23508427	1
100 to 150 Gallons	23518071	1	2350828	1

PowerCool 3149 Liquid and Spin-on Element Part Numbers

When topping off the coolant, use the same concentration of PowerCool 3149, DD-3000, and water as originally installed.

Since Series 149 engine applications do not have aluminum in their cooling systems, the use of PowerCool 3149 SCA should provide all the protection required. However, many systems have add-on components which may contain aluminum. The use of a moderate amount of DD-3000 at initial fill as indicated above will protect these components with a safe level of silicate.

6. *At normal maintenance intervals check nitrite levels with PowerTrac strips and add PowerCool 3149 only when the nitrite level drops below 800 PPM in either antifreeze or water-only cooling systems. No other SCA's are required or should be used.*

J. How to Drain and Flush the Cooling System

⚠ CAUTION:

Do not remove the pressure control cap from the radiator or attempt to drain the coolant until the engine has cooled. Once the engine has cooled, use extreme care when removing the cap. The sudden release of pressure from a heated cooling system can result in a loss of coolant and possible personal injury (scalding) from the hot liquid.

1. With the engine cool, drain the previous solution from the engine and radiator. Dispose of the solution in an environmentally responsible manner according to state and/or federal (EPA) recommendations.
2. Refill the cooling system with clean, soft water and a good cooling system cleaning compound, such as Nalprep®. If the engine is warm, fill slowly to prevent the rapid cooling and distortation of the metal castings.
3. Start the engine and operate it for fifteen minutes to circulate the solution thoroughly.
4. Stop the engine and allow it to cool.
5. With the engine cool, drain the cooling system completely.
6. Refill the cooling system with clean, soft water and operate it for fifteen minutes.
7. Stop the engine and allow it to cool.
8. With the engine cool, drain the cleaner residue from the cooling system.
9. Refill the system with the proper mix of antifreeze and clean, soft water.
10. Entrapped air must be purged after filling the cooling system. With the radiator cap off, start and cycle the engine through its normal operating speed range. Add coolant as required.

Install the pressure cap after the coolant level has stabilized at the bottom of the radiator filler neck.

NOTICE:

If the engine overheats and the coolant level is satisfactory, the cooling system may require cleaning with a descaling solvent and backflushing. Authorized Detroit Diesel service outlets are properly equipped to perform these services.

In addition to the cleaning procedure, other components of the cooling system should be checked periodically to keep the engine operating at peak efficiency.

Hoses. Cooling system hoses should be inspected and any hose that shows obvious signs of damage or feels abnormally soft or hard should be replaced. Damaged clamps should be replaced. All external leaks should be corrected as soon as detected.

Coolant Filter/Conditioner Elements. These elements are treated with chemicals that soften coolant water, minimize scale deposits, maintain an acid-free environment, and act as a rust preventive.

Install a new precharge element at initial cooling system fill.

NOTE: If Detroit Diesel **Power Cool** antifreeze/coolant (or equivalent fully formulated, precharged antifreeze) *is* used, a *precharge* element is not required and should not be used. Coolant inhibitor levels *must* be checked at the intervals shown in **How to Select Coolant.**

K. When to Service the Dry Type Air Cleaner

Replace dry type air cleaner elements when the maximum allowable air cleaner restriction (20 inches of water or 5.0 kPa) has been reached, or annually, whichever comes first. Some air cleaners are equipped with a restriction indicator which aids in determining the servicing interval.

Cleaning and/or reusing dry paper type air cleaner elements is not recommended unless the cleaning method used removes clogging without damage to the element. Inspection and cleaning of elements must be done in accordance with the air cleaner manufacturer's recommendations, if any.

7. SERVICE PUBLICATIONS

Service manuals covering Detroit Diesel Series 50, 60, 71, 92, and 149 engines are listed below. Also shown are reference works which may be of interest to the owner/operator.

To purchase a copy of these publications, contact an authorized Detroit Diesel distributor. Check the Yellow Pages under "Engine, Diesel" or refer to the Worldwide Distributor and Dealer Directory (form 6SE280) for the distributor nearest you.

Description	Form No.
International Distributor/Dealer Directory	6SE281
North American Distributor/Dealer Directory	6SE280
Inline 71 Engine Service Manual	6SE164
V-71 Engine Service Manual	6SE193
Series 92 Engine Service Manual	6SE379
Series 149 Engine Service Manual	6SE313
Series 50 Engine Service Manual (Diesel & Natural Gas)	6SE50
Series 60 Engine Service Manual (Diesel & Natural Gas)	6SE483
Lube Oil, Fuel, Filter Recommendations	7SE270
Coolant Recommendations	7SE298
DDEC III Troubleshooting Guide	6SE492
Series 50 Troubleshooting Guide	6SE494
Series 60 Troubleshooting Guide	6SE493
DDEC III/IV, Single ECM Troubleshooting Guide	6SE497
Cooling System Guidelines – Engineering Bulletin #50	18SA353

8. CUSTOMER ASSISTANCE

The satisfaction and goodwill of the owners of Detroit Diesel engines are of primary concern to Detroit Diesel Corporation and its distributor/dealer organization.

As the owner of a Detroit Diesel Corporation product, you have a complete network of over 2,000 authorized service outlets in the U.S. and Canada, plus many outlets worldwide, that are prepared and anxious to meet your parts and service needs:

- Service by trained personnel.
- Sales teams to help determine your power requirements.
- In many areas, emergency service 24 hours a day.
- Complete parts support including reliabilt components.
- Product information and literature.

To further assure your complete satisfaction, we have developed the following procedure in the event you have a problem that has not been handled satisfactorily.

Step One

Discuss your problem with a member of management from the authorized Detroit Diesel service outlet. Frequently, complaints are the result of a breakdown in communication and can quickly be resolved by a member of management. If you have already discussed the problem with the Sales or Service Manager, contact the General Manager. If your complaint originates with a dealer, explain the matter to a management member of the distributorship with whom the dealer has his service agreement.

Step Two

When it appears that your problem cannot readily be resolved at the distributor level without additional assistance, contact the Detroit Diesel Corporation Regional Product Support or Operations Manager responsible for your local distributor. You will be assisted by a member of the Manager's staff, depending upon the nature of your problem.

Prior to this contact, have the following information available:

- Name and location of authorized service outlet.
- Type and make of equipment.
- Engine delivery date, serial and model number and accumulated hours of operation.
- Nature of problem.
- Chronological summary of engine's history.

Step Three

If you are still not satisfied, present the entire matter in writing or by phone to:

Vice President,
Customer Assurance
Detroit Diesel Corporation
13400 Outer Drive, West
Detroit, Michigan 48239-4001
Phone: (313) 592-7357

When contacting the regional or home office, please keep in mind that ultimately your problem will likely be resolved at the distributor or dealership, utilizing their facilities, equipment, and personnel. Therefore, it is suggested that your follow the above steps in sequence when experiencing a problem.

Identify the U.S. regional area from the map below:

Regional Offices Worldwide

Let us solve your power generation needs. Please contact the nearest Detroit Diesel Regional Office for assistance.

Eastern Region
W. Long Branch, New Jersey
187 Monmouth Park Hwy.
W. Long Branch,
NJ 07764
Phone: (732) 222-1888
Fax: (732) 222-3411

Southeast Region
Jacksonville, Florida
5111 Bowden Road
Jacksonville, FL 32216
Phone: (904) 448-8833
Fax: (904) 448-2444

Central Region
Detroit, Michigan
13400 Outer Drive, West
Detroit, MI 48239-4001
Phone: (313) 592-5990
Fax: (734) 762-1032

Southwest Region
Dallas, Texas
2771 LBJ Freeway
Suite 1036
Dallas, TX 75234
Phone: (972) 247-4313
Fax: (972) 247-4316

Western Region
Downey, California
10645 Studebaker Road
Downey, CA 90241
Phone: (562) 929-7016
FAX: (562) 864-0502

Canadian Region
London, Ontario
Detroit Diesel of
Canada Ltd.
150 Dufferin Ave.,
Suite 701
London, Ont. N6A 5N6,
Canada
Phone: (519) 661-0149
FAX: (519) 661-0171

Latin American Region
Miami, Florida
2277 N.W. 14th Street
Latin American Building
Miami, FL 33125, U.S.A.
Phone: (305) 637-1555
FAX: (305) 637-1580

Asian Region
Singapore
No. 1 Benoi Place
Singapore, 629923
Phone: (65) 865-1912
FAX: (65) 861-1618

Pacific Region
Australia
47 First Street
Black Rock, Victoria 3193
Australia
Phone: (61) 3-9589-0484
FAX: (61) 3-9589-6858

Europe, Middle East, Africa (EMA) Region
The Netherlands
Ridderpoort 9
2984 BG Ridderkerk
The Netherlands
Phone: (31) 1804-63208
FAX: (31) 1804-62062

Mexico
Detroit Diesel-Allison de
Mexico, S.A.
Av. Santa Rosa 58
Col. Ampliacion Norte
San Juan Ixtacala, Tlanepantla
C.P. 54160, Edo do Mexico
Phone: (525) 333-1802
FAX: (525) 333-1870

9. SPECIFICATIONS

SPECIFICATIONS

LUBRICATING OIL FILTERS		
Filter Type	**Detroit Diesel Part No.**	**Micron Rating**
Full Flow (53, 71, V-71, 92; 8, 12, 16V-149)	23518524	12
Full Flow (20V-149)	23518531	12
Full Flow (50,60)	23518480	28

FUEL FILTERS			
Filter Type	**Usage**	**Detroit Diesel Part No.**	**Micron Rating**
Primary	4-71 6/8V-71 & 92, 50, 60 12/16V-92, 24-V71, 149	23518527 23518481 23518528	25 25 25
Secondary	4- 71 6/8V-71 & 92, 50, 60 12/16V-92 & 149	23518526 23518482 23518532	8 8 8
Secondary (severe duty)	4-71 6/8V-71 & 92 12/16V-92 & 149	23518669 23518530 23518529	3 3 3

SPECIFICATIONS

Liquid SCA and Cleaners

PRODUCT	SIZE	DDC PART NO.
NALCOOL 2000® Liquid SCA	Pint (12 per case) Half Gallon (6 per case) 5 Gallon 55 Gallon	23507858 23507859 23507860 23507861
NALCOOL 3000® Liquid SCA	Pint (12 per case) Half Gallon (6 per case) 5 Gallon 55 Gallon	23507854 23507855 23507856 23507857
POWERCOOL 3149 SILICATE-FREE SCA	1 Gallon	23518072
	5 Gallons	23518073
	55 Gallons	23518074
	Spin-on Element (4 oz.)	23518069
	Spin-on Element (32 oz.)	23518070
	Spin-on Element (53 oz.)	23518071
NALPREP 2001® On-Line Cleaner	Half Gallon (6 per case) 5 Gallon 55 Gallon	23507862 23507863 23507864
NALCOOL 2015® Twin Pac Dry Chemical Heavy-Duty Cleaner/Conditioner	2 per case	23507867

Note: Nalcool 3000 is more compatible with hard water than Nalcool 2000. Use Nalprep 2001 for light deposits. Use Nalprep 2015 for heavy deposits or scale.

SPECIFICATIONS

Note: Information in the tables does not apply to Series 149 engines. For Series 149 engine coolant and inhibitor requirements, refer to "Coolant for Series 149 Engines" (page 57).

Initial Coolant Inhibitor Dosage Requirements IEG or IPG Plus Water Coolant Systems

	INITIAL FILL		
COOLING SYSTEM CAPACITY, GALLONS	QTY.	DDC PART NUMBER	NALCO PART NUMBER
1-4	1	23507545	DDF-3000.4
5-8	1	23508425	DDF-3000.8
9-12	1	23508426	DDF-3000.12
13-16	1	23507189	DDF-60.16
24-32	1	23508427	DDF-3000.32
47-52	1	23508428	DDF-3000.53
50-75	2	23508427	DDF-3000.32
75-100	2	23508428	DDF-3000.53
100-125	2	23508428	DDF-3000.53
125-150	2	23508428	DDF-3000.53
8-20	1	23503140	NF-2088*

*Need release use only per specific engine operator's guide instructions.

Maintenance Inhibitor Dosage Requirements IEG, IPG Precharged, and Water-Only Coolant Systems

	MAINTENANCE		
COOLING SYSTEM CAPACITY, GALLONS	QTY.	DDC PART NUMBER	NALCO PART NUMBER
1-4	1	23507545	DDF-3000
5-8	1	23507545	DDF-3000
9-12	1	23507545	DDF-3000
13-16	1	23507545	DDF-3000
24-32	1	23508425	DDF-3000.8
47-52	1	23508426	DDF-3000.12
50-75	2	23508426	DDF-3000.12
75-100	2	23507189	DDF-60
100-125	2	23507189	DDF-60
125-150	2	23508427	DDF-3000.32

Initial Coolant Inhibitor Dosage Requirements Water-Only Coolant Systems

Cooling System Capacity Gallons	SCA Element Quantity	Detroit Diesel SCA Element Part Number	Nalco Element Part Number	Additional SCA Liquid Required
3	1	23507545	DDF-3000.4	None
4	2	23507545	DDF-3000.4	None
5	1	23508425	DDF-3000.8	None
7	1	23508426	DDF-3000.12	None
10	1	23507189	DDF-60.16	None
15	2	23508426	DDF-3000.12	None
20	1	23508427	DDF-3000.32	None
25	1 1	23508427 23507545	DDF-3000.32 DDF-3000.4	None
30	1 1	23508427 23508426	DDF-3000.32 DDF-3000.12	None
35	1 1	23508427 23507189	DDF-3000.32 DDF-60.16	None
40	2	23508427	DDF-3000.32	None
50	2	23508427	DDF-3000.32	None
60	1 1	23508428 23508427	DDF-3000.53 DDF-3000.32	None
70	2	23508428	DDF-3000.53	None
85	2	23508428	DDF-3000.53	1 Gallon*
100	2	23508428	DDF-3000.53	2 Gallons*
125	2	23508428	DDF-3000.53	3 1/4 Gallons*
150	2	23508428	DDF-3000.53	5 Gallons*

*Use Nalcool 2000 or 3000 liquid SCA, or equivalent. Refer to "Liquid SCA and Cleaners" chart.

DETROIT DIESEL
CORPORATION

13400 Outer Drive, West / Detroit, Michigan 48239-4001
Telephone: 313-592-5000
www.detroitdiesel.com

TP-5611

6SE513 9510 As technical advancements continue, specifications will change.

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