Operation Manual

Diesel Engine
Series 60®
Marine Application

6SE559 (0702)

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.

42824

To the Operator

This guide contains instructions on the safe operation and preventive maintenance of your MTU® Detroit Diesel® Series 60® engine used in pleasure craft or commercial marine applications. Maintenance instructions cover routine engine services such as lubricating oil and filter changes in enough detail to permit self-servicing, if desired.

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

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, pulleys, 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.

Whenever possible, it will benefit you to rely on an *authorized* MTU 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 MTU Detroit Diesel service outlet for information on the latest revision. The right is reserved to make changes at any time without obligation.

NOTICE:

Failure to check and maintain Supplemental Coolant Additive (SCA) levels at required concentrations will result in severe damage (corrosion) to the engine cooling system and related components. Coolant must be inhibited with the recommended SCAs listed in the **How-To** section of this engine operator's guide. In addition, the engine can be equipped with a coolant filter/inhibitor system as an installed option or as an after-sale item.

WARRANTY

The applicable engine warranty is contained in the **WARRANTY** Sections of this guide and in the booklet "Warranty Information for Series 60 Engines," available from authorized MTU Detroit Diesel service outlets.

Keep this Operator's Guide with the engine installation at all times. It contains important operating, maintenance, and safety instructions.

Trademark Information

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INTRODUCTION

This guide is intended for use by the operator of a MTU Detroit Diesel Series 60 engine used in a pleasure craft marine or commercial marine application.

NON-GENUINE AND REBUILT COMPONENT QUALITY ALERT

In recent years, electronic engine controls have been instrumental in aiding engine manufacturers in meeting the stringent emission requirements of the U.S. Environmental Protection Agency (EPA) and the California Air Resources Board (CARB) and also in meeting the ever-increasing performance demands of the customer.

Electronic controls and components have significantly increased in sophistication, but the fundamental objective remains the same — precise timing and delivery of fuel. The very heart of the MTU Detroit Diesel electronic controls is the Electronic Unit Injector (EUI). The proper functioning of the EUI is absolutely paramount if the benefits of electronic controls are to be realized.

Detroit Diesel Corporation has built over 650,000 engines with electronic unit injectors — more than anyone else in the business. MTU Detroit Diesel cautions that the indiscriminate rebuilding of precision components, without the benefit of specifications, specialized equipment, and knowledge of the electronic operating system, will jeopardize performance or lead to more serious problems, and can take the engine outside of compliance with U.S. EPA or CARB emissions standards.

CAUTION SUMMARY

The following cautions must be observed by the operator of the vehicle or equipment in which this engine is installed and/or by those performing basic engine preventive maintenance. Failure to read and heed these cautions and exercise reasonable care for personal safety and the safety of others when operating the vehicle/equipment or performing basic engine preventive maintenance may result in personal injury and engine and/or vehicle/equipment damage.

Engine Operation

Observe the following cautions when operating the engine.

WARNING:

PERSONAL INJURY

To avoid injury from loss of vehicle/vessel control, the operator of a DDEC equipped engine must not use or read any diagnostic tool while the vehicle/vessel is moving.

WARNING:

PERSONAL INJURY

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

- **Always start and operate an engine in a well ventilated area.**
- **If operating an engine in an enclosed area, vent the exhaust to the outside.**
- **Do not modify or tamper with the exhaust system or emission control system.**

WARNING:

PERSONAL INJURY

To avoid injury from engine shutdown in an unsafe situation, ensure the operator knows how to override the stop engine condition on a DDEC-equipped unit.

Preventive Maintenance

Observe the following cautions when performing preventative maintenance.

WARNING:

PERSONAL INJURY

To avoid injury when working near or on an operating engine, remove loose items of clothing and jewelry. Tie back or contain long hair that could be caught in any moving part causing injury.

WARNING:

HOT OIL

To avoid injury from hot oil, do not operate the engine with the rocker cover(s) removed.

WARNING:

PERSONAL INJURY

To avoid injury from rotating belts and fans, do not remove and discard safety guards.

WARNING:

PERSONAL INJURY

To avoid injury from slipping and falling, immediately clean up any spilled liquids.

WARNING:

FIRE

To avoid injury from fire, do not smoke or allow open flames when working on an operating engine.

WARNING:

FIRE

To avoid injury from fire, contain and eliminate leaks of flammable fluids as they occur. Failure to eliminate leaks could result in fire.

CAUTION:

USED ENGINE OIL

To avoid injury to skin from contact with the contaminants in used engine oil, wear protective gloves and apron.

WARNING:

PERSONAL INJURY

To avoid injury from hot surfaces, wear protective gloves, or allow engine to cool before removing any component.

WARNING:

PERSONAL INJURY

To avoid injury when working on or near an operating engine, wear protective clothing, eye protection, and hearing protection.

WARNING:

PERSONAL INJURY

To avoid injury, use care when working around moving belts and rotating parts on the engine.

WARNING:

PERSONAL INJURY

To avoid injury when using caustic cleaning agents, follow the chemical manufacturers usage, disposal, and safety instructions.

WARNING:

FIRE

To avoid injury from combustion of heated lubricating-oil vapors, stop the engine immediately if an oil leak is detected.

WARNING:

PERSONAL INJURY

To avoid injury from contact with rotating parts when an engine is operating with the air inlet piping removed, install an air inlet screen shield over the turbocharger air inlet. The shield prevents contact with rotating parts.

WARNING:

HOT COOLANT

To avoid scalding from the expulsion of hot coolant, never remove the cooling system pressure cap while the engine is at operating temperature. Wear adequate protective clothing (face shield, rubber gloves, apron, and boots). Remove the cap slowly to relieve pressure.

WARNING:

FIRE

To avoid injury from fire from a buildup of volatile vapors, keep the engine area well ventilated during operation.

Electrical System

Observe the following cautions when jump starting an engine, charging a battery, or working with the vehicle/application electrical system.

WARNING:

Battery Explosion and Acid Burn

To avoid injury from battery explosion or contact with battery acid, work in a well ventilated area, wear protective clothing, and avoid sparks or flames near the battery. If you come in contact with battery acid:

- □ **Flush your skin with water.**
- □ **Apply baking soda or lime to help neutralize the acid.**
- □ **Flush your eyes with water.**
- □ **Get medical attention immediately.**

WARNING:

ELECTRICAL SHOCK

To avoid injury from electrical shock, do not touch battery terminals, alternator terminals, or wiring cables while the engine is operating.

WARNING:

PERSONAL INJURY

To avoid injury from accidental engine startup while servicing the engine, disconnect/disable the starting system.

Cooling System

Observe the following cautions when servicing the cooling system.

WARNING:

PERSONAL INJURY

To avoid injury from slipping and falling, immediately clean up any spilled liquids.

WARNING:

HOT COOLANT

To avoid scalding from the expulsion of hot coolant, never remove the cooling system pressure cap while the engine is at operating temperature. Wear adequate protective clothing (face shield, rubber gloves, apron, and boots). Remove the cap slowly to relieve pressure.

Air Intake System

Observe the following cautions when working on the air intake system.

WARNING:

PERSONAL INJURY

To avoid injury from hot surfaces, wear protective gloves, or allow engine to cool before removing any component.

WARNING:

PERSONAL INJURY

To avoid injury from contact with rotating parts when an engine is operating with the air inlet piping removed, install an air inlet screen shield over the turbocharger air inlet. The shield prevents contact with rotating parts.

Fuel System

Observe the following cautions when fueling the vehicle or working with the fuel system.

WARNING:

FIRE

To avoid injury from fire, keep all potential ignition sources away from diesel fuel, including open flames, sparks, and electrical resistance heating elements. Do not smoke when refueling.

WARNING:

FIRE

To avoid injury from fire, contain and eliminate leaks of flammable fluids as they occur. Failure to eliminate leaks could result in fire.

WARNING:

FIRE

To avoid injury from fire caused by heated diesel-fuel vapors:

- **Keep those people who are not directly involved in servicing away from the engine.**
- **Stop the engine immediately if a fuel leak is detected.**
- **Do not smoke or allow open flames when working on an operating engine.**
- **Wear adequate protective clothing (face shield, insulated gloves and apron, etc.).**
- **To prevent a buildup of potentially volatile vapors, keep the engine area well ventilated during operation.**

WARNING:

FIRE

To avoid increased risk of a fuel fire, do not mix gasoline and diesel fuel.

Starting Aids

Observe the following cautions when using starting aids.

WARNING:

FLAMES, EXPLOSION AND TOXICITY

To avoid injury from flames, explosion, and toxicants when using ether, the following precautions must be taken:

- **Always wear goggles when testing.**
- **If fluid enters the eyes or if fumes irritate the eyes, wash eyes with large quantities of clean water for 15 minutes. A physician, preferably an eye specialist, should be contacted.**
- **Contents of cylinder are under pressure. Store cylinders in a cool dry area. Do not incinerate, puncture or attempt to remove cores from cylinders.**

WARNING:

FLAMES, EXPLOSION AND TOXICITY

To avoid injury from flames, explosion, and toxicants when using ether, the following precautions must be taken:

- **Do not smoke when servicing ether system.**
- **Work in well ventilated area.**
- **Do not work near open flames, pilot flames (gas or oil heaters), or sparks.**
- **Do not weld or carry an open flame near the ether system if you smell ether or otherwise suspect a leak.**

Compressed Air

Observe the following cautions when using compressed air.

WARNING:

EYE INJURY

To avoid injury from flying debris when using compressed air, wear adequate eye protection (face shield or safety goggles) and do not exceed 276 kPa (40 psi) air pressure.

Lubricating Oil and Filters

Observe the following cautions when replacing the engine lubricating oil and filters.

WARNING:

PERSONAL INJURY

To avoid injury from slipping and falling, immediately clean up any spilled liquids.

WARNING:

FIRE

To avoid injury from combustion of heated lubricating-oil vapors, stop the engine immediately if an oil leak is detected.

WARNING:

FIRE

To avoid injury from fire, do not smoke or allow open flames when working on an operating engine.

WARNING:

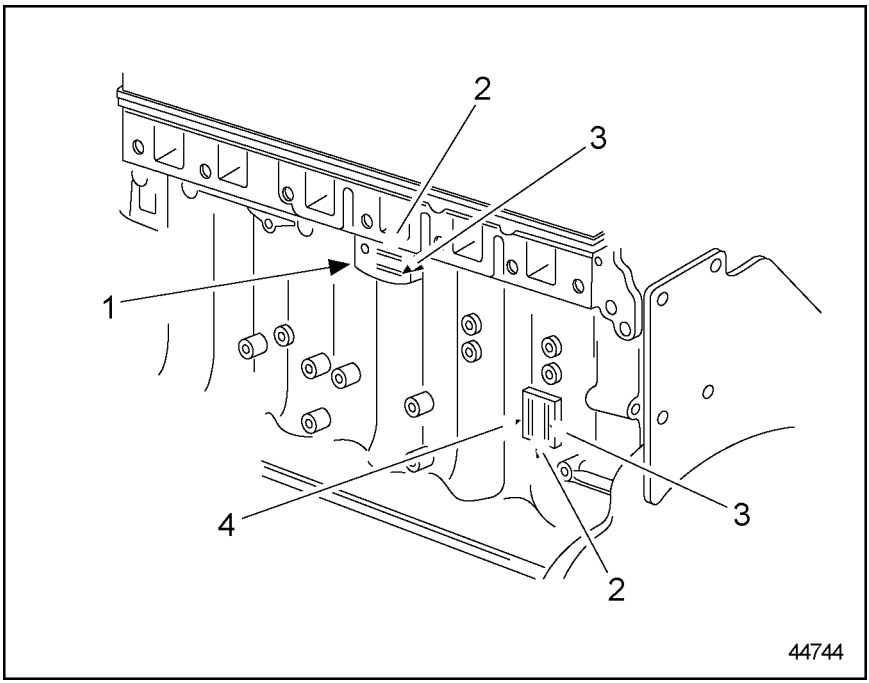
FIRE

To avoid injury from fire from a buildup of volatile vapors, keep the engine area well ventilated during operation.

ENGINE MODEL AND SERIAL NUMBER DESIGNATION

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

- □ Pleasure craft marine engine — Center, rear on a vertical machined pad near the flywheel housing. See Figure 1.
- □ Left side on a machined pad just below the intake manifold and above the cast-in MTU Detroit Diesel logo.



1. Commercial Marine Location
2. Engine Serial Number
3. Engine Model Number
4. Pleasure Craft Marine Location

Figure 1 Locations of Engine Serial Number and Model Number

Option Labels

Computerized engine option labels are attached to the valve rocker cover. 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 (injection 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.

Marine gears generally carry their own name plates. The model and serial number information on these plates is useful when ordering parts for these assemblies.

Certification Labels

If required, a certification label is attached to the valve rocker cover. This label certifies that the engine conforms to federal and certain state emissions regulations for its particular application. It also gives the operating conditions under which certification was made. .

OPERATING INSTRUCTIONS FOR A FIRST TIME START

When preparing to start a new or newly overhauled 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 the "Daily" checks for your engine in the **Maintenance Interval Schedules** section.

WARNING:

PERSONAL INJURY

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

- **Always start and operate an engine in a well ventilated area.**
- **If operating an engine in an enclosed area, vent the exhaust to the outside.**
- **Do not modify or tamper with the exhaust system or emission control system.**

WARNING:

PERSONAL INJURY

To avoid injury when working near or on an operating engine, remove loose items of clothing and jewelry. Tie back or contain long hair that could be caught in any moving part causing injury.

System Checks

Perform the following system checks before starting for the first time.

Cooling System Checks

Check the cooling system as follows:

1. Make sure all drain cocks in the cooling system are installed (drain cocks are often removed for shipping) and are closed tightly.
2. Remove the expansion tank or heat exchanger tank pressure control cap and fill with required coolant. Refer to How to Select Coolant in the **HOW-TO SECTION** of this guide.
3. Entrapped air must be purged after filling the cooling system. To do this, allow the engine to warm up with the pressure cap removed. With the marine gear

in neutral, increase engine speed above 1,000 rpm and add coolant as required.

4. Make sure the drain cocks on the water-cooled exhaust manifold and turbocharger (if equipped) are closed securely.

NOTICE:

Failure to install a new gasket or seal *or* failure to tighten cover bolts securely can result in pump leakage at startup and inefficient heat exchanger cooling.

5. On heat exchanger-cooled engines, remove the cover from the raw water pump. Visually inspect the impeller for signs of damaged or broken vanes. Replace the impeller, if damaged. Reinstall the cover with a *new* gasket or seal, and tighten cover bolts securely.
6. Check sea water strainers and remove any accumulations of seaweed or debris. Strainers act as filters between the intake through-hull fittings and the raw water pump(s) and are easily fouled. Make sure all though-hull valves, other valves in the cooling system, and raw sea water lines are open.

NOTICE:

Failure to prime the raw water pump may result in damage to the pump impeller and engine overheating.

7. Before starting the engine, prime the raw water pump by removing the pipe plug or zinc provided in the pump outlet elbow and pouring at least a pint of water into the pump. Reinstall the plug or zinc and tighten securely.

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.

NOTICE:

Insufficient lubrication at startup can cause serious damage to engine components.

To ensure an immediate flow of oil to all bearing surfaces at initial engine startup, the engine lubrication system should be charged with a commercially available pressure pre-lubricator through the main oil gallery.

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. See Figure 2.

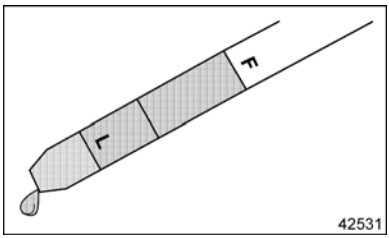


Figure 2 Check Lubricating Oil Level Before Starting

For lubricant recommendation, refer to How to Select Lubricating Oil in the **HOW-TO SECTION** of this guide.

Extended Storage — An engine in storage for an extended period of time (over winter, for example) may accumulate water in the oil pan through normal condensation of moisture (always present in the air) on the cold, internal surfaces of the engine. Lubricating oil diluted by water cannot provide adequate bearing protection at engine startup.

For this reason, MTU Detroit Diesel recommends replacing the engine lubricating oil and filters after extended storage.

NOTICE:
Failure to eliminate water-diluted lubricating oil may lead to serious engine damage at startup.

Marine Gear — Make sure the marine gear is filled to the proper level with the fluid recommended by the gear manufacturer. Do not overfill.

Fuel System Checks

Fill the tanks 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 chance for microbe (black slime) growth.

For fuel recommendations, refer to How to Select Fuel Oil in the **HOW-TO SECTION** of this guide. Make sure the fuel shutoff valve (if used) is open.

To ensure prompt starting and even running, the fuel system *must* be primed if air has entered the fuel system.

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 may cause erratic engine operation due to the amount of air in the lines and filters from the fuel supply tank to the cylinder head.

Priming is done by connecting a manual or electric priming pump to the *secondary* fuel filter adaptor. Authorized MTU Detroit Diesel service outlets are properly equipped and have the trained technicians to perform this service.

Priming is not normally required if the filter elements are filled with clean fuel when installed and the manifolds are not drained of fuel.

NOTICE:

Under no circumstances should a starting aid such as ether be used to start the engine.

If the engine is equipped with a Sea Pro® fuel processor or a fuel/water separator, drain off any water that has accumulated. Water in fuel can seriously affect engine performance and may cause engine damage. MTU Detroit Diesel recommends installation of a Sea Pro fuel processor or a fuel/water separator wherever water contamination is a concern.

Other Checks

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 batteries are clean and tight. Check the hydrometer "eye" of maintenance-free batteries for charge. See Figure 3.

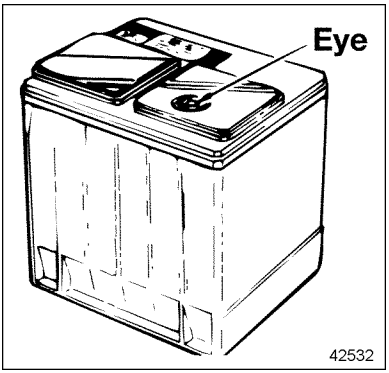


Figure 3 Maintenance-Free Battery "Eye"

If lead-acid or low-maintenance batteries are used, make sure battery electrolyte level is normal.

Check the turbocharger for signs of oil, exhaust or coolant leaks (if water cooled). Leaks should be corrected before starting the engine.

Check engine mounting bolts for tightness. Retightened bolts if necessary.

NOTE:
If engine mounting bolts are loose, check the engine alignment before running the engine. Authorized MTU Detroit Diesel service outlets are properly equipped and have the trained technicians to perform this service.

Starting the Engine

Before starting the engine the first time, refer to System Checks section and perform the operations listed.

If the engine has an emergency manual or automatic shutdown system, make sure the control is set in the *open* position before starting.

NOTICE:
The turbocharger may be seriously damaged if the engine is cranked with the air shutdown in the *closed* position.

NOTE:
Pleasure craft marine engines are equipped with a Kim Hotstart® system for rapid cold weather starting. Commercial marine engines may require the use of a cold weather starting aid if ambient temperature is below 40°F (4°C). **Do not use ether start systems to start marine engines.**

Initial Engine Start

To start the engine, make sure the marine gear is in neutral and turn the ignition key on. Both the Check Engine and Stop Engine lights on the Marine Interface Module (MIM) (located on the engine) 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 warning lights. If everything is OK, both lights will go out in approximately five seconds.

The electronic display panels at the control bridge also complete a self-diagnostic check when the ignition key is turned on.

The Electronic Display Module (EDM) does not contain warning lights, but features the words STOP and CHECK on the EDM panel face. See Figure 4.

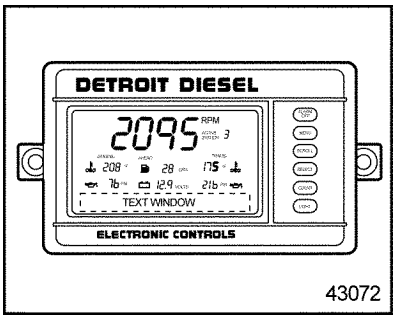


Figure 4 EDM

When the ignition key is turned on, the EDM checks every segment on the panel face and sets itself for display of engine parameters.

Should a system fault be present at any time, both display versions will present on the screen the diagnostic code number and a brief description of the fault condition.

⚠ WARNING:

PERSONAL INJURY

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

- **Always start and operate an engine in a well ventilated area.**
- **If operating an engine in an enclosed area, vent the exhaust to the outside.**
- **Do not modify or tamper with the exhaust system or emission control system.**

Start the engine *after* the electronic self-checks are completed. Start the engine by pressing the starter switch firmly.

NOTICE:

If the warning lights on the MIM stay on *or* if they do not come on momentarily after turning the ignition key, consult with a DDEC technician. In the former case the bridge displays will show the active fault codes. Operating the engine under these circumstances may result in engine damage.

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

NOTICE:

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

Running the Engine

While the engine is operating, monitor the oil pressure and avoid excessive idling.

Oil Pressure

Observe the oil pressure gage immediately after starting the engine. A good indicator that all moving parts are getting lubrication is when the oil pressure gage registers pressure (5 psi [35 kPa] at idle speed). If no pressure is indicated within 10 to 15 seconds, stop the engine and check the lubrication system. The pressure should not drop below 28 psi (193 kPa) at 1800 rpm, and normal operating pressure should be higher. If oil pressure does not fall within these guidelines, it should be checked with a manual gage.

WARNING:

HOT OIL

To avoid injury from hot oil, do not operate the engine with the rocker cover(s) removed.

Warm-Up

Run the engine at idle for about five (5) minutes to allow it to warm up before applying a load.

Inspection

While the engine is idling, check the following systems and components.

Marine Gear — While the engine is idling, check the marine gear for proper oil level and add oil as required.

Raw Water System — Check that raw water is flowing out of the exhaust pipe or raw water discharge pipe.

Fluid Leaks — Look for coolant, fuel or lubricating oil leaks.

WARNING:

HOT COOLANT

To avoid scalding from the expulsion of hot coolant, never remove the cooling system pressure cap while the engine is at operating temperature. Wear adequate protective clothing (face shield, rubber gloves, apron, and boots). Remove the cap slowly to relieve pressure.

If any are found, shut down the engine immediately and have the leaks repaired after the engine has cooled.

Cooling System — Entrapped air must be purged after filling the cooling system. To do this, start the engine and allow it allow it to warm up without the pressure cap installed. With the marine gear in neutral, increase engine speed above 1000 rpm and add coolant as required. Vent the petcock on the water return line at the water-jacketed turbocharger (if used) until coolant (no air) comes out. Close the petcock. Install the pressure cap after the coolant level has stabilized at the bottom of the heat exchanger tank filler neck. Refill the recovery bottle as needed if coolant is drawn into the engine while purging the air.

If all of the coolant is drawn out of the recovery bottle when the engine cools, remove the pressure cap from the heat exchanger or expansion tank and check to make sure the coolant level is at the bottom of the filler neck. Add coolant as required, replace the pressure cap and fill the recovery bottle to the "Full Cold" level, or no more than one-quarter of its volume.

NOTICE:

Failure to properly fill the cooling system and purge it of air can result in serious engine damage. *Do not overfill the coolant recovery bottle, since this can result in spillage as the coolant expands during engine operation.*

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, then check the oil level. If necessary, add oil to bring the level to the proper mark on the dipstick. Refer to How to Select Lubricating Oil in the **HOW-TO SECTION** of this guide and use only the heavy-duty oils recommended.

Turbocharger — Make a visual inspection of the turbocharger for oil leaks, coolant leaks (if water cooled), exhaust leaks, excessive noise or vibration. Stop the engine immediately if a leak or unusual noise or vibration is noted.

WARNING:

PERSONAL INJURY

To avoid injury from slipping and falling, immediately clean up any spilled liquids.

Do not restart the engine until the cause of the concern has been investigated and corrected. Authorized MTU Detroit Diesel service outlets are properly equipped to perform this service.

Avoid Unnecessary Idling

Whenever possible, avoid unnecessary idling.

WARNING:

PERSONAL INJURY

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

- **Always start and operate an engine in a well ventilated area.**
- **If operating an engine in an enclosed area, vent the exhaust to the outside.**
- **Do not modify or tamper with the exhaust system or emission control system.**

During long engine idling periods with the marine gear in neutral, the engine coolant temperature may fall below the normal operating range. The incomplete combustion of fuel in a cold engine will cause crankcase oil dilution, formation of lacquer or gummy deposits on the valves, pistons, and rings, and rapid accumulation of sludge in the engine. When prolonged idling is necessary, maintain at least 800 – 1000 rpm.

Stopping the Engine

Stop an engine under normal operating conditions as follows:

1. Reduce engine speed to normal idle and put shift levers in the neutral position.
2. Allow the engine to run between idle and 1000 rpm with no load for four or five minutes. This allows the engine to cool and permits the turbocharger to slow down. After four or five minutes, shut down the engine.

NOTICE:

Stopping a turbocharged engine immediately after high-speed operation without allowing a sufficient cool-down period may cause damage to the turbocharger, as it will continue to turn without an oil supply to the bearings.

Emergency Jump Starting

Use the following procedure to start the engine of a vessel with a “low battery” or one that will not crank the engine fast enough to start.

NOTICE:

Do not use this procedure if the battery of the disabled vessel will not accept a charge or is frozen. Attempting to start the engine under these conditions may result in cranking system damage.

The DDEC IV system operates on 12 or 24 volts DC. If a DDEC IV engine with an electric starting motor requires emergency jump starting, *do not exceed 32 volts DC.*

WARNING:

Battery Explosion and Acid Burn

To avoid injury from battery explosion or contact with battery acid, work in a well ventilated area, wear protective clothing, and avoid sparks or flames near the battery. If you come in contact with battery acid:

- □ **Flush your skin with water.**
- □ **Apply baking soda or lime to help neutralize the acid.**
- □ **Flush your eyes with water.**
- □ **Get medical attention immediately.**

NOTICE:

Jump starting with voltages greater than those indicated *or* reversing battery polarity may damage the Electronic Control Module (ECM).

WARNING:

BATTERY EXPLOSION

To avoid injury from battery explosion when jump starting the engine, do not attach the cable end to the negative terminal of the disabled battery.

NOTICE:

Failure to connect jumper cables in the proper sequence can result in alternator and/or equipment damage.

Before attempting to jump start the engine, make sure the jumper cables are connected properly (positive to positive, negative to negative ground) and in the proper sequence (negative to negative ground *last*).

NOTICE:

The following procedure must be performed exactly as outlined. Failure to observe precautions and/or follow this sequence may result in alternator and/or equipment damage.

1. Prevent possible shorting of the system by removing metal rings, watches, or jewelry and not allowing metal tools to contact the positive (+) terminal of the battery.
2. Place the marine gear of the disabled vessel in neutral and turn the ignition to the *off* position.
3. Turn off lights, heater, air conditioner, and any other electrical loads in the disabled vessel and the booster vessel.
4. Connect one end of the first jumper cable to the positive (+) terminal of the dead battery. Connect the other end to the positive (+) terminal of the booster battery.
5. Connect one end of the second jumper cable to the negative (-) terminal of the booster battery. Connect the other end to an engine bolt head or good metallic contact (ground) on the disabled vessel.
6. Start the engine of the booster vessel and allow it to run for a minute or two to help charge the battery of the disabled vessel.
7. Turn the ignition of the disabled vessel to the *on* position and attempt to start the engine.
8. As soon as the engine starts, remove the jumper cables in reverse order of attachment:
   [a] Disconnect the negative ground cable on the newly started engine *first*.
   [b] Remove the negative cable.
   [c] Disconnect and remove the positive cable.
9. Allow the newly started engine to warm up before putting a load on it.

DETROIT DIESEL ELECTRONIC CONTROLS

Marine engines having MTU Detroit Diesel Electronic Controls (DDEC) can be equipped with a display option designed to warn the operator of an engine malfunction. This option is a standard LCD panel, the Electronic Display Module (EDM), displaying critical power train parameters. See Figure 5.

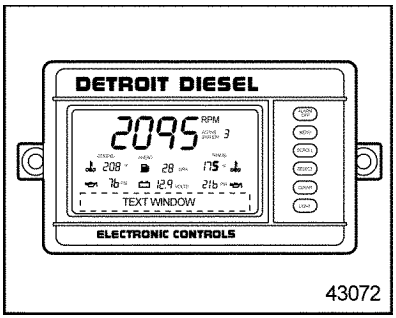


Figure 5 Electronic Display Module

The DDEC engine is equipped with an electronically controlled fuel injection system.

DDEC engines have the ability to perform diagnostics for self-checks and continuous monitoring of other system components. Depending on the application, DDEC electronics can also monitor oil temperature, coolant temperature, oil pressure, fuel spill pressure, coolant level and remote sensors (if used). This diagnostic system is connected to the "Check Engine" and "Stop Engine" lights and the bridge displays to provide a visual warning of a system malfunction.

In the event a major engine malfunction occurs, such as low oil pressure, high oil temperature, low coolant pressure, or high coolant temperature, the "Stop Engine" lights are turned on. The electronic displays at the bridge present the diagnostic code numbers and a brief word description of the fault on the display screen.

DDEC IV Operation

NOTE:
This engine is equipped with DDEC software. This software generally assures optimal engine performance. The installation of software upgrades may cause minor changes in features and engine performance.

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 voltage less than 10.5 volts, the electronic control system will detect a malfunction. When this occurs, the "Check Engine" light will come on and a diagnostic code will show on the bridge display. See Figure 5. You may notice a change in engine operation, because DDEC operates with reduced accuracy below 10.5 volts.

You will be able to operate the engine at reduced voltage until the battery voltage has reached a point where it will no longer function and the engine will shut down.

You can still operate the engine and proceed to your destination when the Check Engine Light (CEL) comes on. However, *this condition should be reported to an authorized DDEC 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 to avoid serious damage.**

The Stop Engine malfunction is recorded in the Electronic Control Module (ECM) for later retrieval by the service technician. Depending on ECM DDEC calibration, some or all of the following conditions will cause the Stop Engine Light (SEL) to come on:

- □ Loss of coolant (low coolant level)
- □ High oil temperature
- □ Low oil pressure
- □ Auxiliary warning
- □ High coolant temperature
- □ Low coolant pressure

It is important to point out that whenever the CEL or the SEL illuminate, 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.

Diagnostic Data Reader

The Diagnostic Data Reader (DDR) is a special diagnostic tool that can be plugged into the engine computer data link to extract information related to the cause of the problem. See Figure 6.

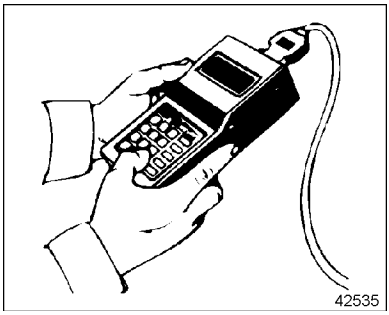


Figure 6 Diagnostic Data Reader J-38500

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

The DDR can distinguish between codes now active and those stored in the historic code memory (inactive).

The malfunction code recorded in the computer memory will remain until it is erased by a technician.

Diagnostic codes are listed in Table 1, Table 2, and Table 3.

WARNING:

PERSONAL INJURY

To avoid injury from loss of vehicle/vessel control, the operator of a DDEC equipped engine must not use or read any diagnostic tool while the vehicle/vessel is moving.

Data Recording Capability

DDEC Reports, standard in all DDEC IV engines, is a data recording capability. DDEC Reports contain information on pilot activities, engine performance and critical incidents reporting. This information is also available in DDEC III, but must be activated by MTU Detroit Diesel Corporation at the request of the customer. The information in both DDEC III and DDEC IV can be extracted with Detroit Diesel Diagnostic Data Link (DDL) 2.0) software. DDEC III information may only be extracted with ProManager® 2.0 software. To perform the extraction, at least a 486 computer with 16 MB RAM is required.

Flash Code	DDEC III/IV Description	Flash Code	DDEC III/IV Description
11	VSG sensor input voltage low	**31**	Aux. high side open circuit or short to ground
12	VSG sensor input voltage high	**32**	CEL or SEL short to battery (+) or open circuit
13	Coolant level sensor input voltage low	**33**	Turbo boost sensor input voltage high
13	Second coolant level sensor input voltage low	**34**	Turbo boost sensor input voltage low
14	Oil or coolant temp. sensor input voltage high	**35**	Oil pressure sensor input voltage high
15	Oil or coolant temp. sensor input voltage low	**36**	Oil pressure sensor input voltage low
16	Coolant level sensor input voltage high	**37**	Fuel pressure sensor input voltage high
16	Second coolant level sensor input voltage high	**37**	Fuel restriction sensor input voltage high
23	Fuel temp. sensor input voltage high	**38**	Fuel pressure sensor input voltage low
24	Fuel temp. sensor input voltage low	**38**	Fuel restriction sensor input voltage low
25	No active codes	**39**	EGR valve not responding
26	Aux. engine shutdown #1 or #2 input active	**39**	VNT vanes not responding
27	Air inlet or intake air temp. sensor input voltage high	**41**	Too many SRS (missing TRS)
28	Air inlet or intake air temp. sensor input voltage low	**42**	Too few SRS (missing SRS)

Table 1 DDEC III System Diagnostic Codes

Flash Code	DDEC III/IV Description	Flash Code	DDEC III/IV Description
43	Coolant level low	**53**	EEPROM write error
44	Oil or coolant or intake manifold or air inlet temp. high	**53**	Out of calibration
45	Oil pressure low	**55**	J1939 data link fault
46	ECM battery voltage low	**55**	Missing other ECM information
46	RTC backup battery voltage low	**55**	Proprietary link fault slave/master
46	Sensor supply voltage low	**56**	J1587 data link fault
47	Fuel or air inlet or turbo boost pressure high	**57**	J1922 data link fault
48	Fuel or air inlet or turbo boost pressure low	**58**	Torque overload
48	EGR temperature low	**61**	Injector response time long
48	TCO temperature low	**62**	Auxiliary output fault
48	EGR delta pressure low	**63**	PWM fault
51	TCO temperature failed high	**64**	Turbo speed sensor input fault
52	ECM A/D conversion fail	**64**	Turbo overspeed
53	ECM non-volatile memory fault	**65**	Air filter restriction sensor fault

Table 2 DDEC III System Diagnostic Codes

Flash Code	DDEC III/IV Description	Flash Code	DDEC III/IV Description
66	Oil filter restriction fault	**81**	EGR temperature circuit failed high
67	Air inlet pressure circuit failed high/low	**82**	EGR temperature circuit failed low
68	Idle validation switch open circuit or short to ground	**82**	Oil level, crankcase pressure, exhaust temp. input voltage low
71	Injector response time short	**82**	Injection control pressure circuit failed low
72	Vehicle overspeed	**83**	Oil level, crankcase pressure, exhaust temp. input voltage high
72	Oxygen sensor fault	**84**	Oil level, crankcase pressure low
73	Air filter restriction high	**85**	Engine overspeed
74	Oil filter restriction high	**86**	Baro. pressure circuit failed high
75	Sensor supply or ECM battery voltage high	**86**	External pump pressure sensor input voltage high
75	RTC backup battery voltage high	**87**	External pump pressure sensor input voltage low
77	Miscellaneous faults –	**87**	Baro. pressure circuit failed low
81	EGR delta pressure circuit failed high	**88**	Coolant pressure low
81	Oil level, crankcase pressure, exhaust temp. input voltage high	**89**	Fuel filter restriction high
81	Injection control pressure circuit failed high	**89**	Maintenance monitor coolant level fault

Table 3 DDEC IV System Diagnostic Codes

ENGINE SYSTEMS

The engine systems are the following:

Fuel System

The fuel system consists of the DDEC electronic fuel system controls, fuel injectors, fuel manifolds (integral with the cylinder head), fuel pump, primary and secondary fuel filters, and the necessary connecting fuel lines.

The primary filter (marked “P”) or combination filter and fuel/water separator removes large impurities from the fuel. The secondary filter (marked “S”) removes the smaller particles.

Lubrication System

The lubricating oil system consists of an oil pump, oil cooler, two full-flow oil filters or a single high-volume full flow oil filter, bypass valves at the oil pump and oil filter adaptor with an oil control thermostat, and oil pressure regulator valve and oil bypass valve in the cylinder block vertical oil gallery.

Air System

Air is drawn through the air separator/air silencer or air cleaner and flows into the turbocharger, where it is compressed. From here it passes into the charge air cooler and then into the air intake manifold. It then flows into the cylinders, where it mixes with atomized fuel from the injectors.

Cooling System

Heat exchanger or keel-cooled systems are used on Series 60 marine engines.

These systems have a centrifugal type fresh water pump to circulate coolant within the engine. The flow of coolant is controlled by two full-blocking thermostats located in a housing attached to the right side of the cylinder head.

Electrical System

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

Exhaust System

Hot exhaust gas flowing from the water-cooled exhaust manifold is used to drive the turbocharger.

MAINTENANCE

The following is intended as a guide for establishing preventive maintenance intervals.

Maintenance Interval Schedules

Recommended maintenance intervals for Series 60 pleasure craft marine engines are listed in Table 4, Table 5, and Table 6. Recommended maintenance intervals for Series 60 commercial marine engines are listed in Table 7, Table 8, and Table 9.

NOTICE:

Adhere to all cautions listed in the CAUTION SUMMARY section of this guide when performing any maintenance.

NOTICE:

Failure to check and maintain Supplemental Coolant Additive (SCA) levels at required concentrations will result in severe damage (corrosion) to the engine cooling system and related components. Coolant must be inhibited with the recommended SCAs listed in this guide. Refer to How to Select Coolant in the **HOW-TO SECTION** of this guide. In addition, the engine can be equipped with a coolant filter/inhibitor system as an installed option or as an after-sale item.

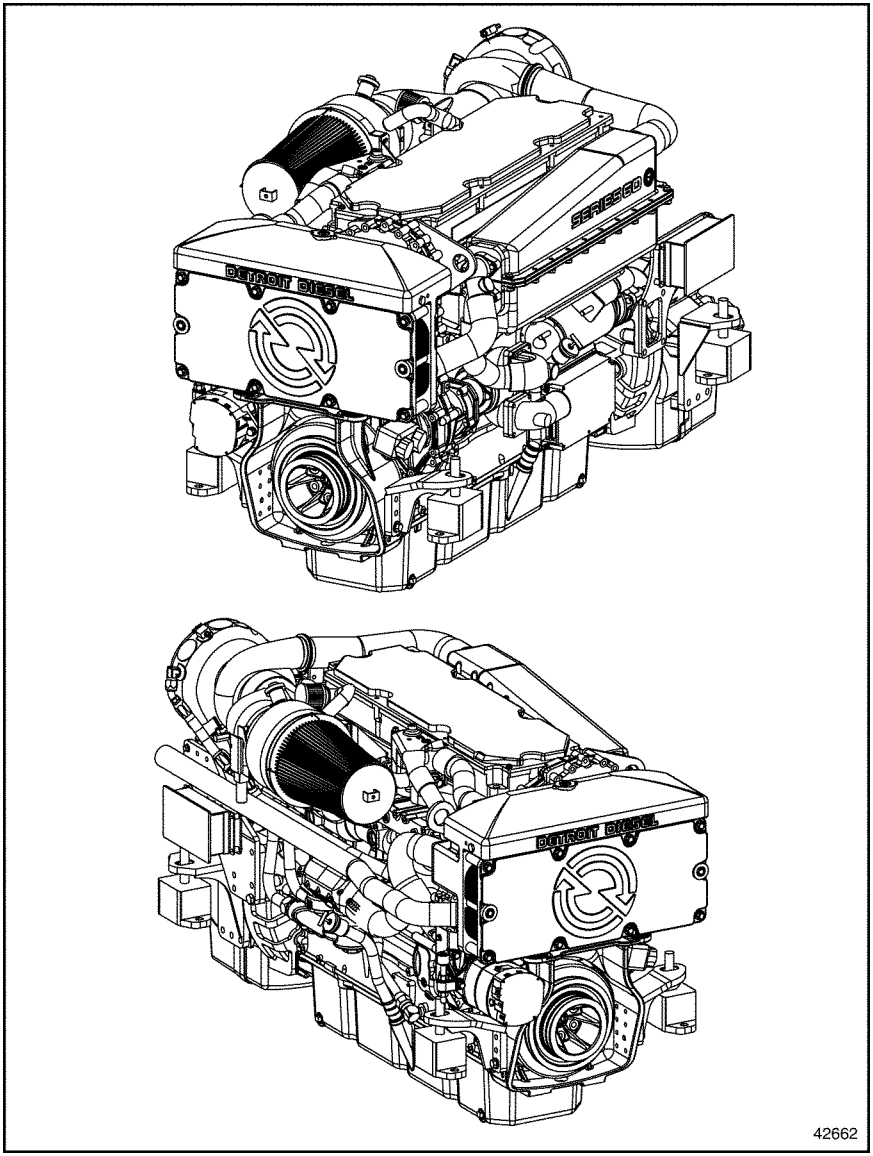


Figure 7 Typical Pleasure Craft Marine Engine

Items* to Check Daily	Procedure
1. Lubricating Oil	I
2. Fuel Tank	I
3. Fuel Lines, Flexible Hoses	I
4. Cooling System	I
5. Turbocharger, Exhaust Connections	I
14. Air System, Cleaners	I
16. Oil Pressure	I
23. Marine Gear	I

* All items are described in Preventive Maintenance Intervals.
I – Inspect, service, correct, or replace as necessary.

Table 4 Pleasure Craft Marine Engines – Daily Engine Maintenance

Hours	150†	250	500	1000	3000	Ea. Mon	Ea. Yr	2 Yrs
Item*	Procedure							
1. Lubricating Oil	Change lubricating oil every 250 hours of operation or every year, whichever comes first.							
2. Fuel, Fuel Tank	–	I	–	–	–	–	I	–
3. Fuel Lines, Flexible Hoses	–	–	–	–	–	–	I	–
4. Cooling System, Coolant	–	I	–	R	–	–	–	R
5. Turbocharger, Exhaust Connections	–	–	I	–	–	–	I	–
6. Battery	–	–	–	–	–	I	–	–
7. Drive Belts	–	I	–	–	R	–	–	–
9. Lubricating Oil Filter	Replace filters when lubricating oil is changedt.							
10. Fuel Filters	–	R	–	–	–	–	–	–
11. Water Pump, Seal	–	–	–	–	–	–	I	–
12. Coolant Filter, Conditioner	–	I	–	–	–	–	I	–
13. Cranking Motor	Follow Manufacturer's Recommendations							
14. Air System	–							
• Filter Element	I	–	–	R‡	–	I	–	–
• Air Separator	I	–	–		R	–	–	–
• CCV X'r Tube, V. L. Valve	I	–	–	–	–	I	–	–
• Crankcase Breather	–	–	–	I	–	–	–	I

* All items are described in Preventive Maintenance Intervals.
† Inspect every 150 hours or weekly, whichever comes first.
I – Inspect, service, correct, or replace as necessary.
R – Replace.

Table 5 Pleasure Craft Marine Engines – Regular Engine Maintenance

Hours	150†	250	500	1000	3000	Ea. Mon	Ea. Yr	2 Yrs
Item*	Procedure							
15. Exhaust System	–	I‡	–	–	–	–	–	–
16. Oil Pressure	–	–	I	–	–	–	I	–
17. Battery-Charging Alternator	–	I	–	–	–	–	I	–
18. Engine, Marine Gear Mounts	–	–	–	I	–	–	I	–
19. Crankcase Pressure	–	–	–	I	–	–	–	I
20. Thermostats, Seals	–	–	–	R	–	–	–	R
21. Engine Tune-Up	–	–	–	I & A	–	–	–	–
22. Marine Gear	–	–	–	I	–	–	–	–
23. Marine Gear Oil Cooler	I	–	–	R	–	–	–	I
24. Raw Water System Zincs	I§	–	–	–	–	–	I	–
25. Raw Water Pump	–	–	I	–	–	–	I	–
26. Charge Air Cooler	I	–	–	I	–	–	I	–
27. Heat Exchanger	–	–	–	I	–	–	–	–
29. Vibration Damper	Replace at major engine overhaul or earlier if dented or leaking.							
30. Flywheel Housing	–	I	–	–	–	–	–	–

* All items are described in Preventive Maintenance Intervals.
† Inspect every 150 hours or weekly, whichever comes first.
‡ Inspect every 250 hours or once a year, whichever comes first.
§ Replace at 75% usage.
I Inspect, service, correct, or replace as necessary.
R – Replace.
A – Adjust.

Table 6 Pleasure Craft Marine Engines – Regular Engine Maintenance (continued)

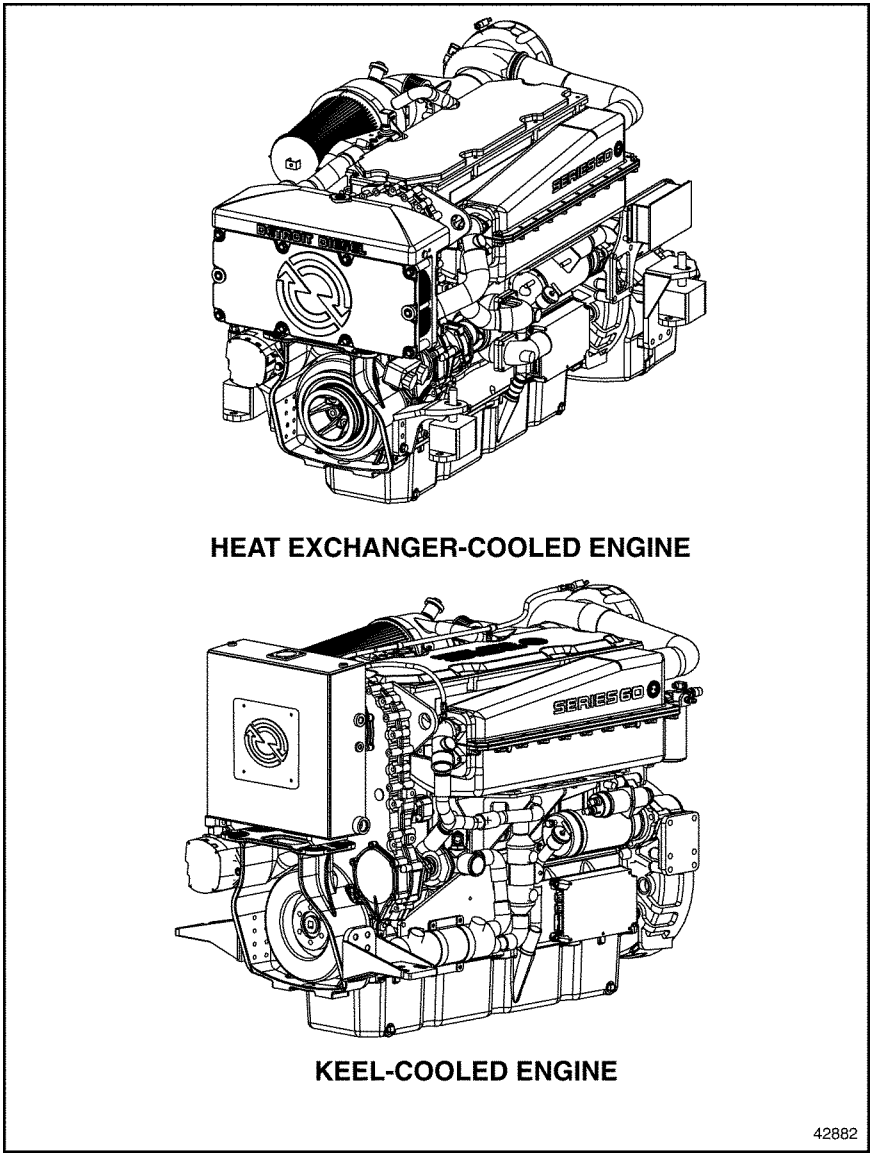


Figure 8 Typical Commercial Marine Engines

Items* to Check Daily	Procedure
1. Lubricating Oil	I
2. Fuel Tank	I
3. Fuel Lines, Flexible Hoses	I
4. Cooling System	I
5. Turbocharger, Exhaust Connections	I
14. Air System, Cleaners	I
16. Oil Pressure	I
23. Marine Gear	I

* All items are described in Preventive Maintenance Intervals.
I – Inspect, service, correct, or replace as necessary.

Table 7 Commercial Marine Engines – Daily Engine Maintenance

Hours	150†	250	500	1000	2000	3000	4000	Ea. Mon	Ea. Yr	2 Yrs
Item*	Procedure									
1. Lubricating Oil	Change lubricating oil every 250 hours of operation or every year, whichever comes first.									
2. Fuel, Fuel Tank	–	I	–	–	–	–	–	–	–	–
3. Fuel Lines, Flex Hoses	–	–	I	R	–	–	–	–	R	–
4. Cooling Sys, Coolant	–	I	–	–	–	–	R	–	–	R‡
5. Turbo, Exhaust Connections	–	I	–	–	–	–	–	I	I	–
6. Battery	–	I	–	–	–	–	–	I	I	–
7. Drive Belts	I	–	–	–	R	–	–	I	–	–
9. Lubricating Oil Filters	Replace filters when lubricating oil is changed.									
10. Fuel Filters	–	R	–	–	–	–	–	–	–	–
11. Water Pump, Seal	I	–	–	–	–	–	–	I	–	–
13. Cranking Motor	Follow Manufacturer's Recommendations.									
14. Air System	–									
• Filter Element	I	–	–	R§	–	–	–	I	–	–
• Air Separator Assembly	I	–	–	–	–	R	–	–	–	–
• CCV X'r Tube, V. L. Valve	I	–	–	–	–	–	–	I	–	–
• Crankcase Breather	I	–	–	–	–	–	–	I	–	–
16. Oil Pressure	–	–	–	I	–	–	–	–	–	–

* All items are described in Preventive Maintenance Intervals.
† Inspect every 150 hours or weekly, whichever comes first.
‡ Replace every 4000 hours or two years, whichever comes first.
§ Replace every 1000 hours or five cleanings, whichever comes first.
I – Inspect, service, correct, or replace as necessary.
R – Replace.
A – Adjust.

Table 8 Commercial Marine Engines – Regular Engine Maintenance

Hours	150†	250	500	1000	2000	3000	4000	Ea. Mon	Ea. Yr	2 Yrs
Item*	Procedures									
17. Battery-Charging Alternator	–	I	–	–	–	–	–	I	I	–
18. Engine, Marine Gear Mounts	–	–	–	I	–	–	–	–	I	–
19. Crankcase Pressure	–	–	I	–	–	–	–	–	I	–
20. Thermostats, Seals	–	I	–	–	–	–	R	–	–	–
21. Engine Tune-Up	–	–	–	I & A	–	–	–	–	–	–
22. Marine Gear	–	I	–	–	–	–	–	–	I	–
23. Marine Gear Oil Cooler	–	I	–	R	–	–	–	–	–	–
24. Raw Water System Zincs	I‖	–	–	–	–	–	–	–	–	–
26. Charge Air Cooler	I	–	–	–	–	–	–	I	–	–
27. Heat Exchanger	–									
• Core	–	I	–	–	–	–	I	–	–	–
• Isolators	–	I	–	–	–	–	I	–	–	–
• Radiator Cap	–	I	–	–	–	–	I	–	–	–
29. Vibration Damper	–	I	Replace at major engine overhaul or earlier if dented or leaking.							
30. Flywheel Housing	–	I	–	–	–	–	–	–	–	–

* All items are described in Preventive Maintenance Intervals.
† Inspect every 150 hours or weekly, whichever comes first.
‖ Replace at 75% usage.
I – Inspect, service, correct, or replace as necessary.
R – Replace.
A – Adjust.

Table 9 Commercial Marine Engines – Regular Engine Maintenance (continued)

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 your engine. Maintenance intervals indicated 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 "Daily" instructions apply to routine or daily starting of the engine.

For new or stored engines, refer to the MTU Detroit Diesel *Series 60 Service Manual* (6SE660). Follow instructions under ***Preparations for Starting the Engine the First Time***.

Preventive maintenance other than the "Daily" checks should be performed by authorized MTU Detroit Diesel service outlets. These outlets have the trained personnel and special tools to properly perform all services.

If it is necessary to clean an area before performing a service item, keep the following in mind to avoid engine damage:

NOTICE:

Do not apply steam or solvent directly to the battery-charging alternator, starting motor, DDEC components, sensors or other electrical components, as damage to electrical equipment may result.

Welding Precaution

NOTICE:

Failure to isolate the DDEC system from high current flow can result in severe Electronic Control Module (ECM) damage. To prevent damage to the ECM and other DDEC components, disconnect battery power and ground cables and the 5–pin power connector at the ECM before welding.

Item 1 – Lubricating Oil

Check the oil level daily with the engine stopped. If the engine has just been stopped and is warm, wait approximately 20 minutes to allow the oil to drain back into the oil pan before checking. Add the proper grade of oil to maintain the correct level on the dipstick. See Figure 9.

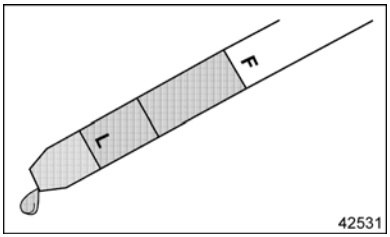


Figure 9 Check Oil Level Daily

All diesel engines are designed to use some oil, so the periodic addition of oil is normal.

NOTICE:

Do not overfill. Oil may be blown out through the crankcase breather if the crankcase is overfilled.

Before adding lubricating oil, refer to How to Select Lubricating Oil in the **HOW-TO SECTION** of this guide.

NOTICE:

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

Change lubricating oil and filters every 250 hours of operation or every year, whichever comes first. When using fuel with a sulfur content higher than 0.05 mass percent, refer to When to Change Oil in the **HOW-TO SECTION** of this guide.

Item 2 – Fuel and Fuel Tank

Keep the fuel tank filled to reduce condensation. Before adding fuel, refer to How to Select Fuel Oil in the **HOW-TO SECTION** of this guide. See Figure 10.

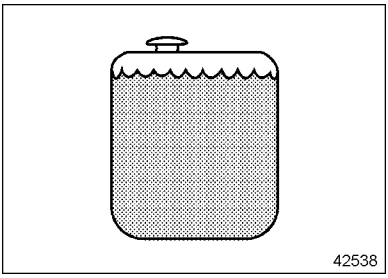


Figure 10 Filled Fuel Tank

Refill the tank at the end of each day's operation to prevent condensation from contaminating the fuel. Condensation formed in a partially filled tank promotes the growth of microorganisms that can clog fuel filters and restrict fuel flow.

WARNING:

PERSONAL INJURY

To avoid injury from improper use of chemicals, follow the chemical manufacturer's usage, handling, and disposal instructions. Observe all manufacturer's cautions.

To prevent microbe growth, add a biocide to the fuel tank or primary fuel supply. Follow manufacturer's usage, handling, and safety precautions.

Water accumulation can be controlled by using additives containing methyl carbitol or butyl cellusolve. Follow manufacturer's usage, handling, and safety precautions.

If equipped with a drain, open the drain at the bottom of the fuel tank every 6 months or 250 hours to drain off any water and/or sediment.

Every 12 months or 500 hours tighten all fuel tank mountings and brackets. Every 6 months or 250 hours, check the seal in the fuel tank cap, the breather hole in the cap and the condition of the flexible fuel lines. Repair or replace the parts, as necessary.

NOTICE:

Galvanized steel fuel tanks, fittings, pipes or supply lines should never be used, because the fuel reacts chemically with the zinc coating to form powdery flakes that can quickly clog the fuel filters and damage the fuel pump and injectors.

Item 3 – Fuel Lines and Flexible Hoses

A pre-start inspection of hoses and fuel lines is recommended.

Leaks — Make a visual check for fuel leaks at all engine-mounted fuel lines and connections, and at the fuel tank suction and return lines. Leaks in this area may best be detected by checking for an accumulation of fuel under the tank.

WARNING:

FIRE

To avoid injury from fire, contain and eliminate leaks of flammable fluids as they occur. Failure to eliminate leaks could result in fire.

Hoses and Fittings — Check hoses daily as part of the pre-start inspection. Examine hoses for leaks, and check all fittings, clamps and ties carefully. Make sure 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. If fittings have loosened or cracked or if hoses have ruptured or worn through, take corrective action immediately. Leaks are not only potentially detrimental to machine operation, but they can also result in added expense caused by the need to replace lost fluids.

Hose 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 reinforcements 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 (5) years of service.

NOTE:
Fire-resistant fuel and lube oil hose assemblies do not require automatic replacement after five years of service or at major overhaul, but should be inspected carefully before being put back into service.

Item 4 – Cooling System and Coolant

The cooling system must be *full* for proper operation of the engine. Check the coolant level daily and maintain it near the bottom of the filler neck on the heat exchanger tank or charge air cooler tank.

On some installations, this is done by checking an overflow bottle or sight glass.

⚠ WARNING:

HOT COOLANT

To avoid scalding from the expulsion of hot coolant, never remove the cooling system pressure cap while the engine is at operating temperature. Wear adequate protective clothing (face shield, rubber gloves, apron, and boots). Remove the cap slowly to relieve pressure.

NOTICE:

Failure to check and maintain SCA levels at required concentrations will result in severe damage (corrosion) to the engine cooling system and related components. Coolant *must* be inhibited with the recommended SCA's listed in this guide. In addition, the engine can be equipped with a coolant filter/inhibitor system as an installed option or as an after-sale item.

A low coolant level sensor installed in the tank will activate an audible alarm or flashing light on the control panel. Add coolant as required, but do not overfill. Before adding coolant, refer to How to Select Coolant in the **HOW-TO SECTION** of this guide.

Coolant Level — Make a daily visual check for cooling system leaks. Look for an accumulation of coolant when the engine is running and when it is stopped. Coolant leaks may be more apparent on a engine when it is cold.

Coolant Inhibitors — The inhibitors in antifreeze solutions *must* be replenished with a non-chromate corrosion inhibitor supplement when indicated by testing the coolant.

Refer to How to Select Coolant in the **HOW-TO SECTION** of this guide for required test intervals and inhibitor levels.

Coolant Drain Interval — MTU Detroit Diesel recommends replacing coolant at the intervals listed in Table 10. Refer to How to Select Coolant. in the *HOW-TO SECTION* of this guide

A coolant system properly maintained and protected with supplemental coolant inhibitors can be operated up to the intervals listed in Table 10.

Coolant Type	Coolant Replacement Interval
A 30/70 mix of *POWER COOL*® fully formulated, inhibited ethylene glycol antifreeze and water or a 30/70 mix of fully formulated, inhibited propylene glycol antifreeze and water.	With proper maintenance* coolant can be operated 2 years or 4,000 hours, whichever comes first. At this time the cooling system must be completely drained and cleaned before refill.
A 30/70 mix of phosphate-free TMC RP-329 “Type A“ (propylene glycol) antifreeze and water.	With proper maintenance* coolant can be operated for the life of the engine until overhaul.† For life to overhaul, pre-charged coolant in combination with a need-release filter *must* be used. At this time the cooling system must be completely drained and cleaned before refill.
A 30/70 mix of Organic Acid Technology (OAT) coolant and water.	With proper maintenance coolant can be operated 4 years or 10,000 operating hours, whichever comes first. ‡ At this time the cooling system must be completely drained and cleaned before refill.

* Proper maintenance involves periodic evaluation using PowerTrac® 3-Way Coolant Test Strips and the addition of required SCA, as indicated by the test strip.

† To verify coolant acceptability, submit a sample to MTU Detroit Diesel Inc for coolant analysis every 6 months or 250 operating hours, whichever comes first. Submit sample using PowerTrac coolant analysis kit, part number 23516921 (IEG/IPG coolant) or 23523398 (organic coolant).

‡ OAT coolants require the addition of an extender every 2 years or 5,000 hours, whichever comes first. Use 1 pint to 20 gallons of OAT coolant.

Table 10 Coolant Drain Intervals

At these intervals the coolant *must* be drained and disposed of in an environmentally responsible manner according to state and/or federal (EPA) recommendations.

Refer to How to Select Coolantin the **HOW-TO SECTION** and the Supplemental Coolant Additive Test Procedures section and use the required supplemental additives or filter/conditioner elements required.

Cooling System Hoses — All cooling system hoses should be inspected every 250 hours for signs of deterioration and replaced, if required.

Item 5 – Turbocharger and Exhaust Connections

WARNING:

PERSONAL INJURY

To avoid injury from hot surfaces, wear protective gloves, or allow engine to cool before removing any component.

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.

WARNING:

PERSONAL INJURY

To avoid injury when working on or near an operating engine, wear protective clothing, eye protection, and hearing protection.

Check for unusual noise or vibration and, if excessive, stop the engine and do not operate until the cause is determined.

Inspect the air-to-water charge cooler for dirt, oil, etc. buildup and wash off every 12 months or 500 hours. Check the cooler, ductwork, and flexible connections for leaks and have repaired or replaced, as required.

Check heat-insulating exhaust system blankets (if used) for damage on a daily basis. Torn, matted, crushed, oil-soaked or otherwise damaged insulation blankets *must* be replaced immediately.

Item 6 – Battery

WARNING:

PERSONAL INJURY

To avoid injury from accidental engine startup while servicing the engine, disconnect/disable the starting system.

Check the hydrometer “eye” of maintenance-free batteries for charge monthly. See Figure 11 .

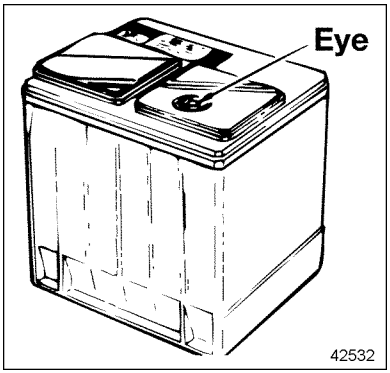


Figure 11 Maintenance-Free Battery “Eye”

If lead-acid or low-maintenance batteries are used, check the specific gravity of each cell every 150 operating 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 battery 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.

If the engine is to be out of service for more than 30 days, remove the batteries and store in a cool, dry place. Keep batteries fully charged, if possible. 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 7– Drive Belts

Belts should be neither too tight nor too loose. Belts that are too tight impose extra loads on the crankshaft and alternator bearings, shortening both belt and bearing life. Excessively overtightened belts can result in crankshaft breakage. A loose belt will slip and may cause damage to accessory components.

WARNING:

PERSONAL INJURY

To avoid injury from rotating belts and fans, do not remove and discard safety guards.

Use a belt tension gage, such as Kent-Moore® toolJ-23586–B (V-belt), tool BT-3373-F (poly-V belt), or J-41251-B (PowerBand® and 12–rib poly-V belt), or equivalent, when tensioning drive belts. Tension belts to the values listed in Table 11.

V-Belts — New standard V-belts will stretch after the first few hours of operation. Tighten V-belts to the tension listed in Table 11. Run the engine for 10 to 15 minutes under load to seat the belts, then readjust tension. Check and retension belts after 1/2 hour and again after 8 hours of operation. Thereafter, check the tension of the drive belts every 250 hours and adjust, if necessary.

If a belt tension gage is not available, adjust the belt tension so that a firm push with the thumb, at a point midway between the two pulleys, will depress the belt .50 in. – .75 in. (13 – 19 mm).

Alternator Drive		
Belt	**New**	**Used**
Two 1/2–in. V-Groove	125 lbs (556 N)	100 lbs (445 N)
2–Groove PowerBand	200 lbs (890 N)	150 lbs (667 N)
12–Rib Poly-V	350 lbs (1,557 N)	250 lbs (1,112 N)
6–Rib Poly-V	220 lbs (979 N)	180 lbs (801 N)

Table 11 Drive Belt Tensioning

2-Groove Powerband — To tension a new PowerBand drive belt with the manual tensioner, tighten the belt to 200 lbs (890 N), then run the engine for 10 minutes at 1200 rpm. Stop the engine and allow a 10 – 15 minute cool down period. Check tension. If less than 150 lbs (667 N), retension to 150 lbs (667 N). Following initial tensioning, measure belt tension every 250 hours. Retension belt to 150 lbs (667 N) at these intervals.

6 and 12–Rib Poly-V Belt — Tighten a new belt to the tension listed in Table 11 in the New belt column, run the engine for 10 to 15 minutes under load to seat the belts, then readjust tension. Check and retension belts after 1/2 hour and again after 8 hours of operation. Thereafter, check the tension of the drive belts every 250 hours and adjust, if necessary, to the tension in the Used belt value listed in Table 11.

Belt Replacement — Drive belts (V and poly-V) should be replaced every 2,000 hours regardless of their condition.

Replace all belts in a set when one is worn. Single belts of similar size should not be used as a substitute for a matched belt set. Premature belt wear can result because of belt length variation. All belts within a matched set are within .032 in. (0.8 mm) of their specified center distances.

When installing or adjusting an accessory drive belt, also check the torque on the bracket mounting bolts. Retighten as required.

Item 8 – Air Cleaner

The dry-type air cleaner element, if used, should be inspected every 250 hours. Replace the element, if necessary.

NOTICE:

Do not allow the air inlet restriction to exceed 20 in. H_2O (5.0 kPa) under any engine operating conditions. A clogged air cleaner element will cause excessive intake restriction and a reduced air supply to the engine. This, in turn, can result in increased fuel consumption, inefficient engine operation and reduced engine life.

Check the gaskets for deterioration and replace, if necessary.

If the dry type air cleaner is equipped with an aspirator, check for aspirator damage or clogging. Clean and repair as necessary.

Inspect the entire air system for leaks daily. 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 loose connections.

Air Cleaner Replacement — Dry type air cleaner elements should be replaced after one year of service or when the maximum allowable air intake restriction has been reached, whichever comes first. Refer to When to Service the Dry Type Air Cleaner in the **HOW-TO SECTION** of this guide for additional information.

Item 9 – Lubricating Oil Filters

WARNING:

PERSONAL INJURY

To avoid injury from slipping and falling, immediately clean up any spilled liquids.

Install new spin-on oil filters at a **maximum** of 250 hours or each time the engine oil is changed, whichever comes first.

Install the new filters, turning them until they contact the gasket fully with no side movement. Turn full-flow filters an additional 2/3 turn **by hand**, or as per instructions printed on the filter. See Figure 12.

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

Check for oil leaks after starting the engine.

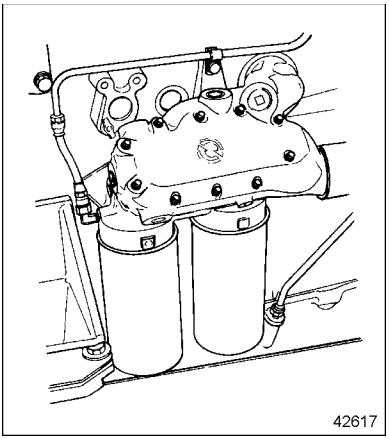


Figure 12 Lubricating Oil Filters

Item 10 – Fuel Filters

The fuel pressure at the cylinder head fuel inlet fitting and the inlet restriction at the fuel pump indicate when filters are plugged and need replacing. In a clean system the maximum pump inlet restriction should not exceed 6 in. Hg (20.3 kPa). In a dirty system it must not exceed 12 in. Hg (41 kPa).

NOTE:
Filter change intervals may be shortened to conform with established preventive maintenance schedules, but should never be extended.

Spin-On Filters — Install new spin-on primary and secondary fuel filter elements on engines every 250 operating hours. Replace spin-on filter elements immediately if plugging is indicated, regardless of hour intervals.

For pleasure craft and heat exchanger-cooled commercial marine secondary filter location, see Figure 13.

Sea Pro 150 or 300 Filters — Install new Sea Pro 150 (single element) or 300 (dual element, see Figure 14) primary spin-on fuel filter elements every 250 hours. Replace elements immediately if plugging is indicated, regardless of hour intervals.

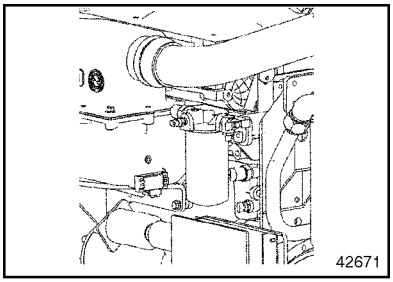


Figure 13 Secondary Fuel Filter

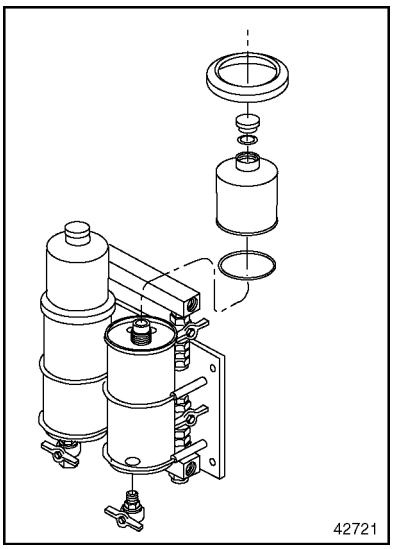


Figure 14 Sea Pro 300 Fuel Filter Assembly

Sea Pro 152 or 511 Filters —
Sea Pro 152 or 511 Filters – Install new Sea Pro 152 (single element) or 511 (dual element) cartridge style filter elements when the fuel level

in the see-through cover reaches the top of the element or after one year of service, whichever comes first. See Figure 15.

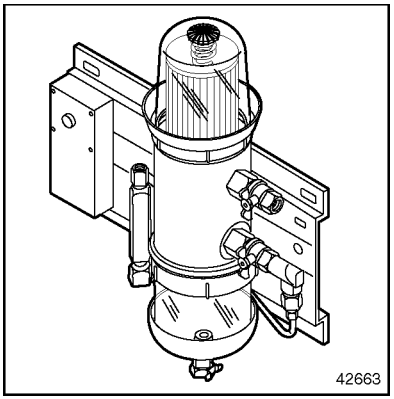


Figure 15 Sea Pro 152 Filter Installation

Item 11 – Water Pump Drain Hole and Seal

The water pump drain hole should be inspected every 250 hours to make sure it is open. A small chemical build-up or streaking at the drain hole may occur. **This is not an indication of a defective water pump or seal.** Remove the build-up with a mild detergent cleaner and a brush. If coolant does not leak from the drain hole under normal conditions, do not replace the water pump. If coolant is leaking from the drain hole, then the pump shaft seal has failed and the water pump must be replaced.

Item 12 – Coolant Filter/Inhibitor Element

If the cooling system is protected by an SCA element, the coolant must be tested every 250 hours or yearly, whichever comes first, and the element replaced, if required. See Figure 16.

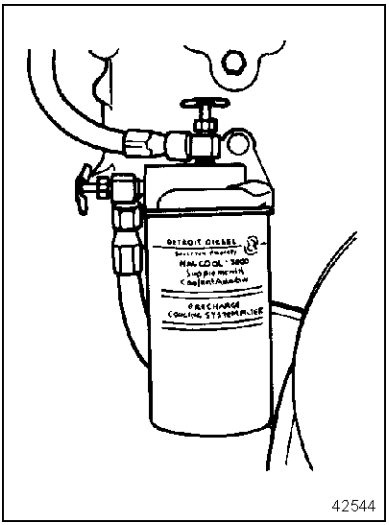


Figure 16 Coolant Inhibitor Element

For SCA test procedures, refer to How to Select Coolant in the **HOW-TO SECTION** and the Supplemental Coolant Additive Test Procedures section. Use the coolant filter element required. Refer to SPECIFICATIONS section for the part number.

The valves mounted on the filter adaptor head *must* be opened after the element is replaced.

Item 13 – Cranking Motor

For information, contact an authorized Delco Remy® or Leece-Neville® service center.

Item 14 – Air System

All the connections in the air system should be checked to make sure they are tight every 250 hours. Check all hoses and ducting for punctures, deterioration or other damage and replace, if necessary.

If marine engine air separators are installed (see Figure 17), the restriction indicator showing *red* indicates the maximum allowable air restriction has been reached.

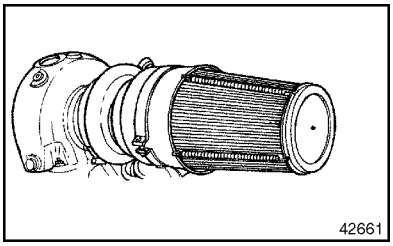


Figure 17 Typical Air Separator Installation

Air Separator Assembly — Inspect the air separator housing for cracks or obvious damage every 250 hours. Replace if damaged. The air separator assembly must be replaced after 2000 hours of operation.

Filter Element — The filter elements must be cleaned every 250 hours of engine operation. Filter elements must be replaced after five cleanings or after 1250 hours of operation, whichever comes first.

Vacuum Limiter Valve — The vacuum limiter valve must be cleaned and the elements reoiled every 250 hours of engine operation. Vacuum limiters must be replaced every two years or after 1000 hours of operation, whichever comes first.

Crankcase Breather — The internally mounted (in the engine rocker cover) crankcase breather assembly *should be removed and the steel mesh pad washed in clean fuel oil* every 1,000 hours of operation.

This cleaning period may be reduced or lengthened according to the severity of service. See Figure 18.

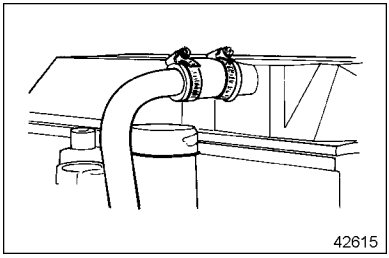


Figure 18 Internal Rocker Cover Breather Location

The rocker cover-mounted breather assembly (P/N: 23512984) used in the closed crankcase breather system *should be replaced* every 4000 operating hours. It is not reusable and no attempt should be made to clean or reuse it. See Figure 19.

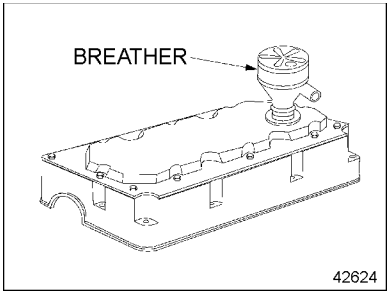


Figure 19 Rocker Cover-Mounted Breather Location

Item 15 – Exhaust System

Have exhaust manifold retaining bolts and other connections checked for tightness and retightened, if necessary.

Authorized MTU Detroit Diesel distributors are properly equipped to perform this service.

Item 16 – Oil Pressure

Under normal operation, oil pressure is noted each time the engine is started. If the installation is equipped with warning lights rather than pressure indicators, engine oil pressure should be checked and recorded every 500 hours for pleasure craft marine engines and every 600 hours for commercial marine engines.

Item 17 – Battery-Charging Alternator

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.

WARNING:

Battery Explosion and Acid Burn

To avoid injury from battery explosion or contact with battery acid, work in a well ventilated area, wear protective clothing, and avoid sparks or flames near the battery. If you come in contact with battery acid:

- □ **Flush your skin with water.**
- □ **Apply baking soda or lime to help neutralize the acid.**
- □ **Flush your eyes with water.**
- □ **Get medical attention immediately.**

1. An alternator's output wire or terminal is always “hot,” whether or not the engine is running. Grounding the output terminal and accidentally reversing the battery polarity will result in equipment damage.
2. Do not reverse battery connections. This can also cause damage.
3. The battery diodes can be damaged if the battery is disconnected while the alternator is operating. In applications which have two (2) sets of batteries, switching from one set to the other while the engine is running will momentarily disconnect the batteries and result in equipment damage.
4. If a booster battery is to be used, batteries must be connected correctly (positive to positive, negative to negative) to avoid equipment damage.
5. Never use a fast charger with the batteries connected or as a booster for battery output.

Delco-Remy and Leece-Neville Alternator Service Requirements — Terminals should be checked for corrosion and loose connections and wiring inspected for damage and frayed insulation. Have wiring repaired or replaced, as required. Check torque on alternator mounting bolts and bracketing. Retighten, if necessary. For information on the alternator assembly, contact an authorized Delco-Remy or Leece-Neville distributor.

Item 18 – Engine and Marine Gear Mounts

The engine and marine gear mounting bolts and the condition of the mounting pads should be checked every 1000 hours. Tighten and/or repair as necessary.

NOTE:
If the mounting bolts are loose, the engine and gear alignment must be checked before engine can be run.

Item 19 – Crankcase Pressure

The crankcase pressure should be checked and recorded every 500 hours for pleasure craft marine engines and every 1000 hours for commercial marine engines.

Item 20 – Thermostats and Seals

Replace the thermostats and seals on pleasure craft marine engines 1000 hours or two years, whichever comes first. Replace thermostats and seals on commercial marine engines every 10,000 hours or two years, whichever comes first.

Item 21 – Engine Tune-Up

There is no scheduled interval for performing an engine tune-up. However, the valve lash and injector heights *must* be measured and, if necessary, adjusted at the period listed in Table 12.

Item 22 – Marine Gear

Check the marine gear oil level daily and fill to the proper level with the required lubricant. For MTU Detroit Diesel (Twin Disc®) marine gears, refer to the oil and filter maintenance requirements listed in Table 13.

Item 23 – Marine Gear Oil Cooler

Replace the marine gear oil cooler every 4 years or 4,000 hours, whichever comes first.

Engine Application	Valve Lash and Injector Height Measurement/ Adjustment Period
Pleasure Craft Marine Engines	1,000 Hours
Commercial marine Engines	1,100 Hours

Table 12 Valve Lash and Injector Height Adjustment

Oil Service Class		
Use API service classification CD, CD II, CF-2 or CF-4 engine oil which is certified to pass TO2 or TO4 and C-4 specifications or meet the requirements of MIL-L-2104E. Engine oil may be used, provided it meets these specifications.		
Oil Viscosity		
Sump Temperature, also Oil Temperature into Heat Exchanger		**Recommended Oil Viscosity**
During Startup	**Steady Operating Conditions**	
–	Below 150°F (66°C)	This operating condition is not approved.
32°F (0°C) Min.	150 – 185°F (66 – 85°C)	SAE 40 engine oil 1.12:1 – 2.54:1
32°F (0°C) Min.	150 – 185°F (66 – 85°C)	SAE 40 engine oil 3.10:1 – 4.95:1
32°F (0°C) Min.	175 – 210°F (80 – 99°C)	SAE 40 engine oil 3.10:1 – 4.95:1
–	Above 210°F (99°C)	This operating condition is not approved
Oil and Filter Change Interval		
First oil and filter change should take place after 10 hours and thereafter every 1000 hours of operation for both oil and filter element, or 6 months, whichever occurs first.		
Filter Screen		
Remove and clean after the first 10 hours and thereafter every 1000 hours of operation, or 6 months, whichever occurs first.		

Table 13 DDC (Twin Disc) Marine Gear Lubricating Oil and Filter Change Requirements

Item 24 – Raw Water System Zincs

Raw water system "Zincs" should be checked initially at 60 hours, then every 150 hours or yearly. Electrodes are generally found in the heat exchanger assembly, the raw water pump elbows, the fuel cooler and the marine gear auxiliary coolers. Clean with a wire brush if serviceable. Replace if badly deteriorated.

NOTICE:

Stray current (electrolysis) will cause accelerated engine raw water system corrosion. If electrodes are badly corroded, the system should be checked for stray current (electrolysis). Authorized MTU Detroit Diesel distributors are properly equipped to perform this service.

Item 25 – Raw Water Pump

A raw water pump seal malfunction is indicated by leakage of water from the openings in the pump housing. These openings, located between the pump mounting flange and the inlet and outlet ports, must remain open at all times. Leaky seals require replacement. Worn or brittle flexible impellers should be replaced. The raw water pump body or liner should also be checked for cracks or wear and replaced, if necessary. Authorized MTU Detroit Diesel service outlets are properly equipped to perform these services.

Item 26 – Charge Air Cooler

Check the condensate drains on the bottom of the charge air cooler on pleasure craft and current commercial marine engines every 150 hours or once a year, whichever occurs first. See Figure 20.

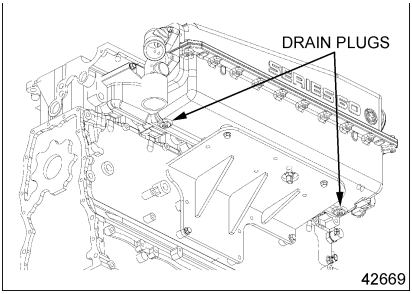


Figure 20 Location of Charge Air Cooler Condensate Drains on Pleasure Craft and Commercial Marine Engines

Ensure the drains are not plugged, fouled or obstructed. Check hoses for plugging every 150 hours or once a year, whichever comes first.

NOTICE:

To avoid damaging the RTV seal around the charge cooler base, do not use solvent when cleaning this area.

The charge air cooler/intake manifold assembly should be removed, cleaned and inspected every 1,000 hours or two years, whichever occurs first.

The charge air cooler on keel-cooled commercial marine engines does not require periodic maintenance, other than normal cleaning and flushing when the engine coolant is replaced. The engine-mounted auxiliary raw water pump used to circulate coolant through the charge air cooler should be examined periodically to make sure the weep hole is open and unblocked. A plugged weep hole may lead to water pump seal and bearing damage, which could cause pump malfunction.

Item 27 – Heat Exchanger

Inspect the heat exchanger every 1,000 hours for pleasure craft marine engines and every 3,000 hours or every two years (whichever comes first) for commercial marine engines and clean as follows: Flush the heat exchanger core with a mild solvent and rinsed with clean, fresh water to remove any dirt or other contaminants from the element. Authorized MTU Detroit Diesel distributors are properly equipped and have the trained personnel to perform this service.

Heat Exchanger Core — Inspect the heat exchanger core every 250 hours and replace as necessary.

Heat Exchanger Isolators — Inspect the heat exchanger isolators every 250 hours and replace as necessary.

Heat Exchanger Radiator Cap — Inspect the heat exchanger radiator cap every 250 hours and replace as necessary.

Item 28 – Fuel Cooler

The fuel cooler should be cleaned every 1000 hours or two years, whichever comes first. On heat exchanger-cooled marine engines, the fuel cooler is part of the heat exchanger assembly. To clean, flush the sea water side of the heat exchanger core with a mild solvent and rinse with clean, fresh water. On keel-cooled marine engines, the fuel cooler is attached to a plate on the left-front side of the block below the expansion tank. See Figure 21.

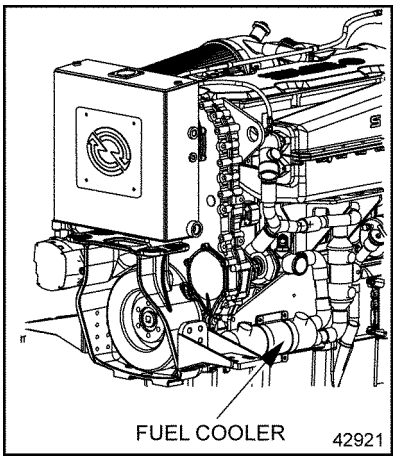


Figure 21 Fuel Cooler Location – Keel-Cooled Commercial Marine Engine

To clean, disconnect the coolant inlet and outlet lines. *Do not disconnect the fuel inlet and outlet lines.* Flush the fuel cooler core with a mild solvent and rinse with clean, fresh water. Reconnect coolant inlet and outlet lines.

Item 29 – Vibration Damper

The viscous vibration damper should be inspected after 250 hours and replaced at any major engine overhaul or if dented or leaking. See Figure 22.

NOTICE:

Failure to replace a damaged vibration damper when required may result in severe engine damage.

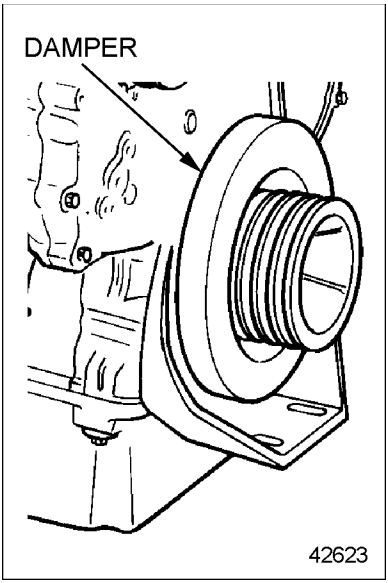


Figure 22 Viscous Vibration Damper

Heat from normal engine operation may, over a period of time, cause the fluid within the viscous vibration damper to break down and lose its dampening properties. For this reason, the viscous vibration damper *must* be replaced at time of normal major engine overhaul, regardless of apparent condition.

Item 30 – Flywheel Housing

Heating and cooling from normal engine operation can cause the flywheel housing bolts to loose torque and become loose. The flywheel housing bolts should be inspected every 250 hours for looseness. If the bolts are loose, remove the flywheel and retorque the bolts.

HOW-TO SECTION

This section covers MTU 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.

NOTICE:

The manufacturers warranty applicable to Series 60 engines provides in part that the provisions of such warranty shall not apply to any engine unit that has been subject to misuse, negligence or accident. Accordingly, malfunctions attributable to neglect or failure to follow the manufacturers fuel or lubricating recommendations may not be within the coverage of the warranty.

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 MTU Detroit Diesel engines are designed to provide. The proper lubricating oil for all MTU Detroit Diesel engines is selected based on SAE viscosity grade and American Petroleum Institute (API) service designation.

Only oils licensed to display the API lubricant service mark should be used. See Figure 23.

Lubricant Requirements

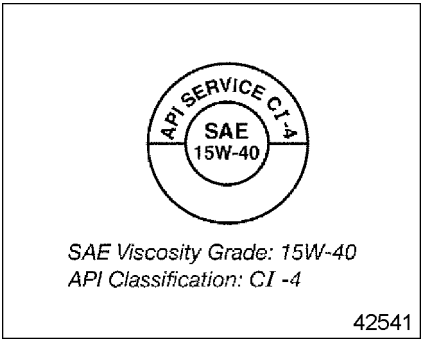


Figure 23 API Lubricant Service Mark

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

API Chi oils may be used when CI-4 oils are not available. However, their use may require a reduction in oil drain interval, depending upon the application and the fuel sulfur level.

API Service Category CI-4 is intended for use with cooled Exhaust Gas Recirculation (EGR) engines meeting 2002 and later exhaust emission regulations. Compared to the older API Chi Category, the new API CI-4 engine oils have improved performance in wear protection at higher used oil soot levels and extended oil drain capability. Lubricants meeting API Service Category CI-4 are required for use in 2002 and newer engines, and are recommended for use in all MTU Detroit Diesel Series 60 engines.

At ambient temperatures below –20° C (–4° F) when sufficient starter speed cannot be achieved with SAE 15W-40 oils, the use of 5W-XX oils and 10W-XX oils, where XX is 30 or 40, is allowed to improve startability, provided they are API CI-4 (October 2002 and later– build engines) or API Chi (1998 through September 2002–build engines) and have demonstrated field performance in MTU Detroit Diesel engines. These oils must possess a HT/HS of 3.7 minimum. **Monograde oils should not be used in Series 60 engines, regardless of API service classification.**

When the use of high sulfur fuel (greater than 0.05% mass sulfur) is unavoidable, high alkalinity (TBN) lubricants are recommended. High sulfur fuels require modification to oil drain intervals. For further information, refer to MTU Detroit Diesel technical publication, *Fluids and Lubricants Specification* (A001061/29E), available from authorized MTU Detroit Diesel distributors.

Synthetic Oils

Synthetic oils may be used in MTU 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.

Refer to MTU Detroit Diesel technical publication, *Fluids and Lubricants Specification* (A001061/29E) for the recommended synthetic oils for all MTU Detroit Diesel engines in marine applications. Synthetic oils provide maximum performance and protection in Series 60 pleasure craft marine engines along with superior cold starting ability, as compared to conventional SAE 40 oils.

The Use of Supplemental Additives

Lubricants meeting the MTU Detroit Diesel specifications outlined in this publication already contain a balanced additive treatment. Supplemental additives 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 MTU Detroit Diesel engines. **Engine damage resulting from the use of such materials is not covered by your MTU Detroit Diesel Corporation warranty.** MTU Detroit Diesel will not provide statements beyond this publication relative to their use.

WARNING:

FIRE

To avoid injury from combustion of heated lubricating-oil vapors, stop the engine immediately if an oil leak is detected.

WARNING:

FIRE

To avoid injury from fire, do not smoke or allow open flames when working on an operating engine.

When to Change Oil

The length of time an engine may operate before an oil change depends upon the lubricant and fuel used, engine oil consumption, and the operating cycle.

WARNING:

FIRE

To avoid injury from fire from a buildup of volatile vapors, keep the engine area well ventilated during operation.

Oil Drain Intervals

The **maximum interval** at which the engine may operate before the oil and filters must be changed is listed in Table 14. Oil analysis may be used to determine whether this interval should be shortened, but it should not be used to lengthen the interval.

CAUTION:

USED ENGINE OIL

To avoid injury to skin from contact with the contaminants in used engine oil, wear protective gloves and apron.

The use of fuels with sulfur content above 0.05 mass percent will require a shortening of drain intervals and/or the use of a higher TBN oil. Oil drain intervals are listed in Table 14. For detailed information, refer to MTU Detroit Diesel technical publication, *Fluids and Lubricants Specification* (A001061/29E) available from authorized MTU Detroit Diesel distributors.

Engine Application	Drain Interval
Pleasure Craft Marine	250 Hours or 1 Year, whichever comes first
Commercial Marine	250 Hours or 1 Year, whichever comes first

Table 14 Maximum Oil Drain and Filter Change Interval (Fuel Sulfur 0.05 Weight Percent or Less)

Disposing of Waste Oil

Dispose of used lubricating oil and filters in an environmentally responsible manner, according to federal (EPA) and/or state recommendations. The disposal of waste oil may be best addressed by the engine oil supplier, who may accept responsibility for proper disposal of this material as part of the business of providing lubricant.

How to Replace the Lubricating Oil Filters

Filters are an integral part of the lubricating oil system. Proper filter selection and maintenance are important to satisfactory engine performance and service life. Filters should be used to maintain a clean system, not to clean up a contaminated system. Filter part numbers are listed in Table 25 in the **SPECIFICATIONS** section of this guide.

Replace Spin-On Type Oil Filter

Replace spin-on type oil filters as follows:

WARNING:

PERSONAL INJURY

To avoid injury from slipping and falling, immediately clean up any spilled liquids.

1. Place a suitable container under the engine oil pan, remove drain plug and drain the lubricating oil. Replace the drain plug and tighten securely.
2. Remove spin-on filters using tool J-29917 , or equivalent, and a 1/2-inch drive socket wrench and extension. See Figure 24.
3. Dispose of used oil and filters in an environmentally responsible manner, according to federal (EPA) and/or state recommendations.
4. Clean the filter gasket-contact surface on the adaptor head with a clean, lint-free cloth.
5. Fill the new filters with clean lubricating oil and lightly coat the filter gaskets (seals) with the same oil.

NOTICE:

Do not overtighten filters. Overtightening may crack or distort the filter adaptor.

6. Start the new filters on the adaptor head and tighten by hand until the gaskets touch the mounting adaptor head. Tighten filters an additional two-thirds turn **by hand,** or as per instructions printed on the filter.

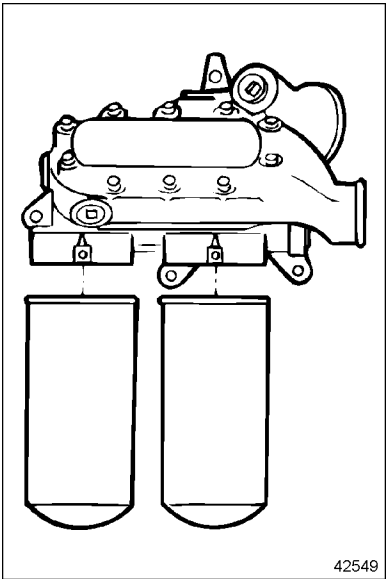


Figure 24 Spin-On Oil Filters

7. Add oil as required to bring the level to the "Full" mark on the dipstick.

WARNING:

PERSONAL INJURY

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

- □ **Always start and operate an engine in a well ventilated area.**
- □ **If operating an engine in an enclosed area, vent the exhaust to the outside.**
- □ **Do not modify or tamper with the exhaust system or emission control system.**

8. 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 "Full" mark on the dipstick.

NOTICE:

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

How to Select Fuel Oil

MTU Detroit Diesel engines are designed to operate on most diesel fuels marketed today.

Quality

Fuel quality is an important factor in obtaining satisfactory engine performance, long engine life, and acceptable exhaust emission levels.

In general, fuels meeting the properties of ASTM designation D 975 (grades 1-D and 2-D) have provided satisfactory performance.

The fuels used must be clean, completely distilled, stable, and non-corrosive. For more information regarding the significance of these properties and selection of the proper fuel, refer to MTU Detroit Diesel technical publication, *Fluids and Lubricants Specification* (A001061/29E) available from authorized MTU Detroit Diesel distributors.

Fuel Contamination

Generally, fuel contamination occurs as the result of improper fuel handling. The most common types of contamination are water, dirt, and microbial growth ("black slime"). The formation of varnishes and gums resulting from poor stability or extended storage ("stale fuel") also affects fuel quality. The best treatment for contamination is prevention by maintaining a clean storage system and choosing a reputable fuel supplier.

Supplemental 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 MTU Detroit Diesel Corporation to test, evaluate, approve or endorse such products.

Prohibited Additives

The following fuel additives are not allowed and MUST NOT be mixed with diesel fuel:

Used Lubricating Oil — MTU Detroit Diesel specifically prohibits the use of used lubricating oil in diesel fuel. Used lubricating oil contains combustion acids and particulate materials which can severely erode fuel 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 —

WARNING:

FIRE

To avoid increased risk of a fuel fire, do not mix gasoline and diesel fuel.

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.

WARNING:

FIRE

To avoid injury from fire caused by heated diesel-fuel vapors:

- □ **Keep those people who are not directly involved in servicing away from the engine.**
- □ **Stop the engine immediately if a fuel leak is detected.**
- □ **Do not smoke or allow open flames when working on an operating engine.**
- □ **Wear adequate protective clothing (face shield, insulated gloves and apron, etc.).**
- □ **To prevent a buildup of potentially volatile vapors, keep the engine area well ventilated during operation.**

MTU Detroit Diesel Corporation will not be responsible for any detrimental effects it determines resulted from adding drained lubricating oil or gasoline to the diesel fuel.

How to Replace the Fuel Filters

Filters are an integral part of the fuel system. Proper filter selection and maintenance are important to satisfactory engine operation and service life. Filters should be used to maintain a clean system, not to clean up a contaminated system. Recommended filters are listed in Table 24 in the **SPECIFICATIONS** section of this guide.

Spin-on type primary and secondary fuel filters are used on Series 60 engines. The spin-on type filter consists of a shell, element and gasket unitized into a single cartridge and a filter adaptor which includes threaded inserts to accept the spin-on cartridges. An optional fuel/water separator may be installed in place of the standard primary filter.

Replace Spin-On Type Primary or Secondary Fuel Filter Elements

Replace spin-on fuel filter elements as follows:

1. Shut down the engine and allow it to cool.
2. With the engine at ambient temperature and cool to the touch, place a suitable container under the filter.
3. A fuel shutoff valve may be installed on the discharge side of the secondary fuel filter. If installed, turn the handle on the shutoff valve to the **closed** position (perpendicular to the valve.

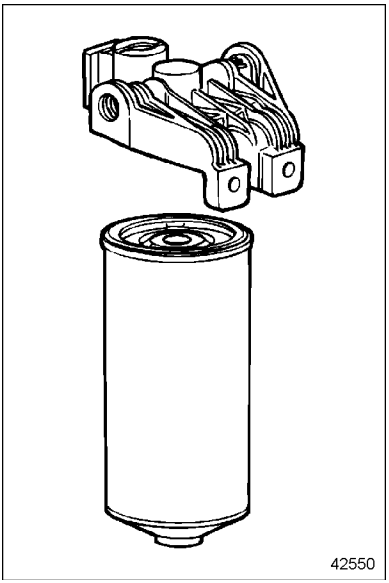


Figure 25 Typical Spin-On Type Fuel Filter

NOTICE:

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

4. Using a suitable band type filter wrench, remove the primary and secondary spin-on fuel filters. See Figure 25. Dispose of the filters in an environmentally responsible manner, according to federal (EPA) and/or state recommendations.
5. If not previously filled, fill new replacement filters with clean diesel fuel and coat the gaskets lightly with the fuel oil.

NOTICE:

Do not overtighten the filter. Overtightening may crack or distort the adaptors.

6. Thread the new filters onto the adaptor inserts until the gaskets make full contact with the adaptor head and no side movement is evident. Tighten filters an additional one-half turn **by hand,** or as indicated on the filter.
7. Turn the handle on the shutoff valve to the **open** position (in line with the valve).
8. Start the engine and check for leaks. Shut down the engine. Correct any leaks with the engine off.

If the engine fails to start after filter replacement, the fuel system will require priming with tool J-5956, or equivalent. Authorized MTU Detroit Diesel distributors are properly equipped to perform this service.

NOTICE:

The starting motor and fuel pump must never be used to prime the fuel filters; this 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 fuel lines and filters.

Replace Fuel/Water Separator

If an optional primary filter/water separator is installed, replace the element as follows:

1. Shut down the engine and allow it to cool.
2. With the engine at ambient temperature and cool to the touch, place a suitable container under the filter.

3. A fuel shutoff valve may be installed on the discharge side of the fuel/water separator. If installed, turn the handle on the shutoff valve to the **closed** position (perpendicular to the valve.
4. Drain off some fuel by opening the drain valve.
5. Using a strap wrench, remove the element and bowl together, then remove the bowl from the element. The filter and bowl have right-hand threads, so turn counter-clockwise to remove.
6. Clean the bowl and the O-ring seal.

NOTICE:

To avoid damaging the bowl or the filter, do not use tools when tightening.

7. Apply a light coating or clean fuel or grease to the O-ring seal and install onto the see-through bowl. Thread the bowl onto the new filter and tighten **by hand**.
8. Apply a light coating of clean fuel oil or grease to the new O-ring seal on the top of the new spin-on filter. Thread the filter and bowl assembly onto the filter head and tighten **by hand** until snug.
9. To eliminate air from the filter, operate the primer pump on the filter head (if equipped) until the fuel purges at the filter assembly.
10. Start the engine and check for leaks. Shut down the engine and correct any leaks.

Replace Sea Pro 152 or 511 Fuel Filter Element

The Sea Pro 152 diesel fuel filter system (see Figure 26) consists of a permanently mounted fuel processor, a replaceable filter element and sealing grommet assembly, a filter spring, a see-through cover and seal, a cover collar, and a vent cap and seal. The Sea Pro 511 assembly is the dual processor version of this system.

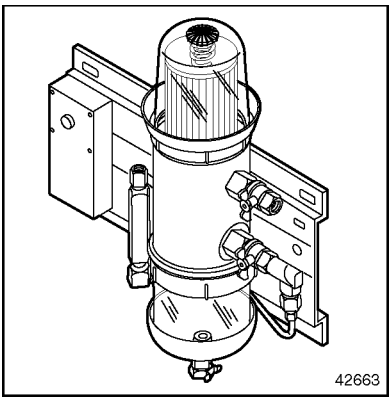
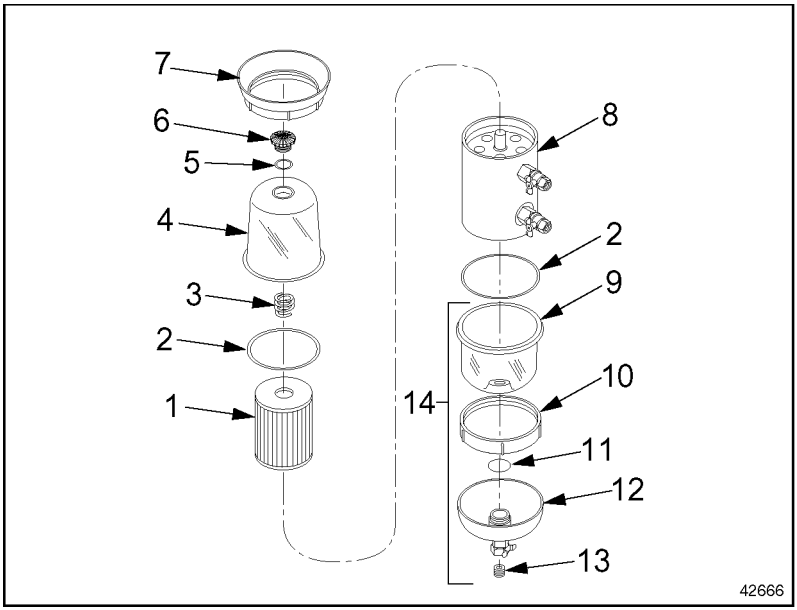


Figure 26 Sea Pro 152 Fuel Processor/Filter Assembly

Replace the Sea Pro 152 or 511 element(s) as follows:

1. Shut down the engine and allow it to cool.
2. With the engine at ambient temperature and cool to the touch, place a suitable container under the fuel processor.
3. Turn the inlet and outlet valves on the fuel processor to the **closed** position (perpendicular to the valves) and loosen the vent cap on the see-through cover. See Figure 27.
4. Remove the plug from the drain valve at the base of the water separator bowl, open the valve and drain the fuel until it is below the level of the collar holding the see-through cover. Close the drain valve and replace the plug. The drained fuel may be returned to the tank.
5. Using filter collar/vent cap wrench (P/N: 232002) supplied with the fuel processor, remove the collar by turning counter-clockwise. Remove the cover, filter spring and cover seal ring by lifting straight up and over the filter element.
6. Dispose of the used element in an environmentally responsible manner, according to federal (EPA) and/or state recommendations.
7. Before installing the new filter element, wipe the sealing surface on top of the processor body clean with a clean cloth or paper towel.



1. Filter Element
2. O-Ring Seal
3. Spring (Part of Cover)
4. See-Through Cover
5. O-Ring Seal
6. Vent Cap
7. Retainer Collar/Deflector
8. Fuel Processor
9. See-Through Bowl
10. Retainer Collar
11. Deflector & Drain Valve Assembly
12. Drain Valve Plug
13. Water Filter Bowl & Collar Assembly

Figure 27 Sea Pro 152 Fuel Processor/Filter Assembly

8. Check that a sealing grommet is included in the base of the replacement filter element; install the element onto the center stud by pushing down and twisting slightly to seat the element.
9. Check that the filter spring is installed at the top of the cover. If missing, this spring must be

replaced to ensure proper filter operation. Wipe the cover lip and cover seal clean.

NOTICE:

To avoid cover or vent cap damage, do not use tools to tighten the vent cap.

10. After making sure the seal is properly positioned at the base of the cover, install the cover and collar over the filter and onto the fuel processor. Tighten the collar securely **by hand**.
11. Using filter collar/vent cap wrench 232002 or equivalent, remove the vent cap from the top of the cover by turning counter-clockwise, then open only the fuel inlet valve on the processor body. *Do not open the outlet valve at this time.*
12. Fill the cover to the top of the filter element with clean fuel by operating the electric primer pump. After ensuring the O-ring seal is installed on the vent cap, reinstall the cap and tighten **by hand**.
13. Open the outlet valve on the processor body and start the engine. When the lubrication system reaches its normal operating pressure, increase engine speed to high idle for 2 to 3 minutes.

NOTE:

Do not allow the fuel level in the see-through cover to fall below the top of the collar, since this may lead to interruption of the fuel flow and engine stalling.

14. After the air is purged and with the engine still running, *slowly* loosen the vent cap. The fuel level in the cover will start falling. When the fuel level falls to the top of the retainer collar/deflector, tighten the vent cap quickly **by hand**.
15. With the engine running, check for leaks. Shut down the engine. Correct any leaks with the engine off.

NOTE:

The see-through filter cover will not fill completely during engine operation. It will gradually fill over time as the filter medium becomes plugged. The filter element does nor require changing until the fuel level has risen to the top of the element, or after one year of service, whichever comes first.

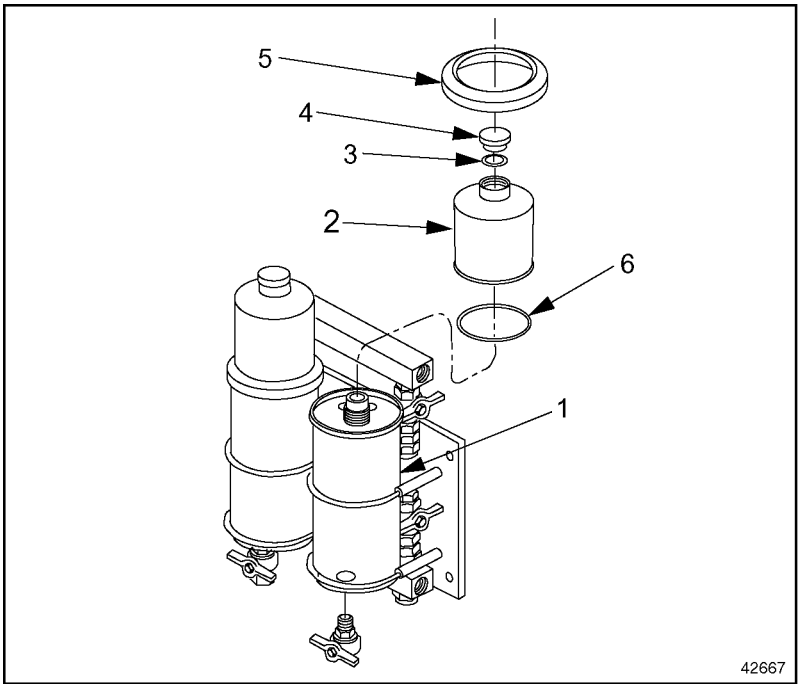
NOTE:

The secondary fuel filter element must be changed at regular 250-hour intervals.

Replace Sea Pro 300 or 150 Primary Fuel Filter Element

See Figure 28 for the Sea Pro 300 diesel fuel processor system.

The Sea Pro 300 diesel fuel filter system consists of dual fuel processor assemblies secured to a mounting plate with two U-bolts, washers and nuts; replaceable spin-on filter element assemblies with vent caps and seal rings; and reusable element splash guards. The processors are plumbed so that one can be in use while the other is being serviced.



1. Fuel Processor Body
2. Spin-on Filter Element
3. Vent Cap Seal
4. Vent Cap
5. Splash Guard
6. Perimeter Seal

Figure 28 Sea Pro 300 Fuel Processor Assembly

The Sea Pro 150 assembly is the single processor version of this system.

MTU Detroit Diesel recommends shutting down the engine and allowing it to cool to engine room temperature before replacing the fuel filter elements. Where this is not possible or where filter elements must be changed "on the run," the following cautions should be observed:

WARNING:

FIRE

To avoid injury from fire caused by heated diesel-fuel vapors:

- **Keep those people who are not directly involved in servicing away from the engine.**
- **Stop the engine immediately if a fuel leak is detected.**
- **Do not smoke or allow open flames when working on an operating engine.**
- **Wear adequate protective clothing (face shield, insulated gloves and apron, etc.).**
- **To prevent a buildup of potentially volatile vapors, keep the engine area well ventilated during operation.**

Replace the Sea Pro 150 or 300 primary fuel filter element as follows:

1. If possible, stop the engine and allow it to cool to ambient temperature.
2. Close the fuel inlet and outlet valves on the fuel processor, if installed.

NOTE:
If a Sea Pro 300 assembly is used and the engine must remain running, switch fuel flow to the clean filter before closing the fuel inlet and outlet valves on the processor of the filter being replaced.

3. Place a suitable container under the processor body. Open the vent plug on top of the element being replaced, then remove the plug from the bottom drain valve. Open the valve and allow about a pint of fuel to drain. This will remove most of the fuel from the element. Close the drain valve and replace the valve plug.
4. Using a suitable strap type filter wrench, remove the element by rotating it counter-clockwise.

NOTE:
Fuel remaining in the element will be caught in the deep well in which the element sits and drain back into the processor.

5. Remove the plastic splash guard from the element and retain for reuse. Dispose of the used element and drained fuel in an environmentally friendly manner, according to federal (EPA) and/or state recommendations.

NOTE:
The *center hole* in the processor is the *clean fuel* outlet. To avoid possible fuel contamination, cover the top of the processor with a clean cloth immediately after the filter element is removed.

6. Check the new element to ensure the O-ring seal just inside the center opening of the element and the perimeter seal at the filter base are installed. *Do not install the element if either seal is missing, since this will result in fuel leakage.*
7. Wipe the perimeter seal contact surface on top of the processor with a clean cloth. Lubricate the center O-ring seal and the perimeter seal with clean fuel oil.

NOTICE:

Do not use a strap wrench or other tool to tighten the spin-on element. Overtightening may result in filter element or fuel processor damage or both.

8. Install the element onto the processor stud by pressing down on the element and rotating clockwise to engage the threads. **Tighten by hand only.** Install the plastic splash guard onto the element and push down until firmly seated over the fuel processor well.

NOTICE:

Do not use a tool to tighten the filter vent cap. Overtightening may result in vent plug or fuel processor damage or both.

9. If a fuel primer pump is not installed, remove the vent cap at the top of the element and fill with clean fuel. Replace the plug and *tighten by hand only.*
10. If a fuel primer pump is installed, prime the system as follows:
    [a] Remove the vent cap on the filter element.
    [b] Turn the fuel flow valve to "Prime System."
    [c] Push the momentary switch above the primer pump until fuel is visible in the sight glass on the processor body.
    [d] Continue pushing the switch for an additional 5 to 10 seconds to fill the filter.

[e] Replace the vent cap and tighten *by hand* until secure.

[f] Open the fuel inlet and outlet valves on the fuel processor.

[g] Start the engine and check for leaks. Shut down the engine. Correct any leaks with the engine off.

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.

NOTICE:

The starting motor and fuel pump must never be used to prime the fuel filters; this 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 fuel lines and filters.

Spin-On Filters — Use the following procedure for an engine with spin-on filters.

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.
2. Close the fuel shutoff valve (if installed) on the secondary filter head and remove the spin-on fuel filters. Fill with clean fuel through the fuel inlet holes (the outer ring of small holes on the element) to ensure the fuel is filtered.

NOTICE:

Do not use a strap wrench or other tool to tighten the spin-on element. Overtightening may result in filter element or adaptor head damage.

3. Thread the elements onto the adaptor inserts until the gaskets make full contact with the adaptor head and no side movement is evident. Tighten filters **by hand,** an additional one-half turn or as indicated on the filter.
4. Open the fuel shutoff valve (if installed), start the engine and check for leaks. Shut down the engine before correcting leaks.

NOTE:

If the engine fails to start after replacement of fuel filters, the fuel system will require priming with tool J-5956 , or equivalent. Authorized MTU Detroit Diesel distributors are properly equipped to perform this service.

Sea Pro Filters — Use the following procedure for an engine with a Sea Pro fuel processor:

1. Remove the vent cap from the top of the filter by turning counter-clockwise. Fill the cover full of *clean* fuel.

NOTICE:

To avoid cover or vent dap damage, do not use tools to tighten the vent cap.

2. After making sure the O-ring seal is installed on the vent cap, reinstall the vent cap and tighten **by hand** only.

NOTICE:

Do not allow the fuel level in the see-through cover to fall below the top of the collar, since this may lead to interruption of the fuel flow and engine stalling.

3. Start the engine and allow the lubrication system to reach its normal operating pressure, then increase engine speed to high idle for 2 to 3 minutes. After the air is purged and with the engine still running, loosen the vent cap on the filter cover. The fuel level in the cover will start falling. When the fuel level falls to the top of the cover retainer collar, tighten the vent cap quickly **by hand**.

NOTE:

If the engine fails to start after filling fuel filters, the fuel system will require priming with tool J-5956, or equivalent. Authorized MTU Detroit Diesel distributors are properly equipped to perform this service.

How to Select Coolant

Definitions

This section covers selection of the required coolant for Series 60 marine engines. To help ensure complete understanding of the information, the definitions of the following terms are provided:

Antifreeze — Ethylene glycol or propylene glycol containing a corrosion inhibitor package and which meets an appropriate heavy-duty specification (i.e., TMC RP-329 for ethylene glycol or TMC RP-330 for propylene glycol).

Coolant — The fluid mixture circulating in the engine cooling system, typically a mixture of water and antifreeze.

Drop-Out — Precipitated sludge or deposit formation in or on cooling system components.

Fully Formulated Antifreeze — Antifreeze that contains all the necessary inhibitors to protect a diesel engine and does not, therefore, require a pre-charge of SCA before its first use.

Initial-Fill Coolant — The coolant used in a new or rebuilt engine, or any time the cooling system is emptied and then refilled with new coolant.

OAT — Organic Acid Technology. An inhibitor system based on organic acid inhibitors, instead of traditional North American inhibitor formulations.

SCA — Supplemental Coolant Additive. SCAs are used in a preventive maintenance program to prevent corrosion, cavitation, and the formation of deposits.

Approved Coolants

The approved and preferred coolants for Series 60 *heat exchanger-cooled* pleasure craft marine and commercial marine engines are listed in Table 15. The approved and preferred coolants for Series 60 *keel-cooled* commercial marine engines are listed in Table 16.

NOTICE:

Required specifications for water, ethylene glycol, propylene glycol, inhibitor packages and inhibitor concentration are included in this section. To avoid possible engine damage from inadequate or overconcentrated coolant, this information should be read thoroughly before the coolant is replaced.

Once installed, these coolants should be maintained according to the procedures discussed in the Maintenance in this section.

Coolant Fill Option	Product
Ethylene Glycol & Water + OAT Inhibitors	DDC *POWER COOL* Plus Marine (30/70) Pre-mix
Water Only + OAT Inhibitors *	Water + DDC *POWER COOL* Plus 6000

* Water-only coolant systems offer no freeze protection and should not be used where ambient temperatures can fall to 32°F (0°C).

Table 15 Initial Fill Coolant Options – Heat Exchanger-Cooled Pleasure Craft Marine and Commercial Marine Engines

Coolant Fill Option	Product
Ethylene Glycol & Water + Conventional Corrosion Inhibitors *	DDC *POWER COOL*
Commercial Equivalent of DDC *POWER COOL*	Fully Formulated TMC RP-329 Type A Antifreeze & Water
Propylene Glycol & Water + Conventional Corrosion Inhibitors *	Fully Formulated TMC RP-330 Type A Antifreeze & Water
Ethylene Glycol & Water + OAT Inhibitors *	DDC *POWER COOL* Plus
Water Only + Conventional Corrosion Inhibitors †	Water + DDC *POWER COOL* Plus 3000
Water Only + OAT Inhibitors†	DDC *POWER COOL* Plus 6000

* Preferred Coolants

† Water-only coolant systems offer no freeze protection and should not be used where ambient temperatures can fall to 32°F (0°C).

Table 16 Initial Fill Coolant Options – Keel-Cooled Commercial Marine Engines

Ethylene Glycol & Water Plus SCA Inhibitor or Propylene Glycol & Water Plus SCA Inhibitor — These products are available as fully formulated, phosphate-free, Extended Service Interval (ESI) coolants. They are commercially available from MTU Detroit Diesel (recommended) and other manufacturers as either a concentrated antifreeze or as a pre-mixed antifreeze. The pre-mixed antifreeze is ready for use; the concentrated coolant must be mixed with water prior to use.

Detroit Diesel *POWER COOL* (P/N: 23512138) is the preferred ethylene glycol coolant. If other commercial brands of ethylene glycol are used, they must be equivalent to *POWER COOL* . MTU Detroit Diesel does not market a propylene glycol coolant.

If a propylene glycol coolant is used, it must also meet the following requirements:

- Fully formulated ethylene glycol-based, low silicate antifreeze or coolant must meet TMC RP-329 and TMC RP-330 “Type A” requirements.
- *Fully formulated antifreeze does not require a dosage of SCA prior to initial use.*

Mixing EG or PG Antifreeze and Water — A concentrated Ethylene Glycol (EG) or Propylene Glycol (PG) antifreeze is mixed with water meeting the required quality standards listed in Table 19 and fill the cooling system.

If a pre-diluted, fully formulated coolant is purchased, fill the cooling system. An antifreeze concentration over 67% (67% antifreeze, 33% water) is *not recommended* due to poor heat transfer, reduced freeze protection (IEG only), and possible silicate dropout. **For pleasure craft marine engines a maximum of 30% ethylene glycol is recommended for proper heat transfer and freeze protection.**.

See Figure 29 for propylene glycol-based coolant concentration versus freezing and boiling temperatures.

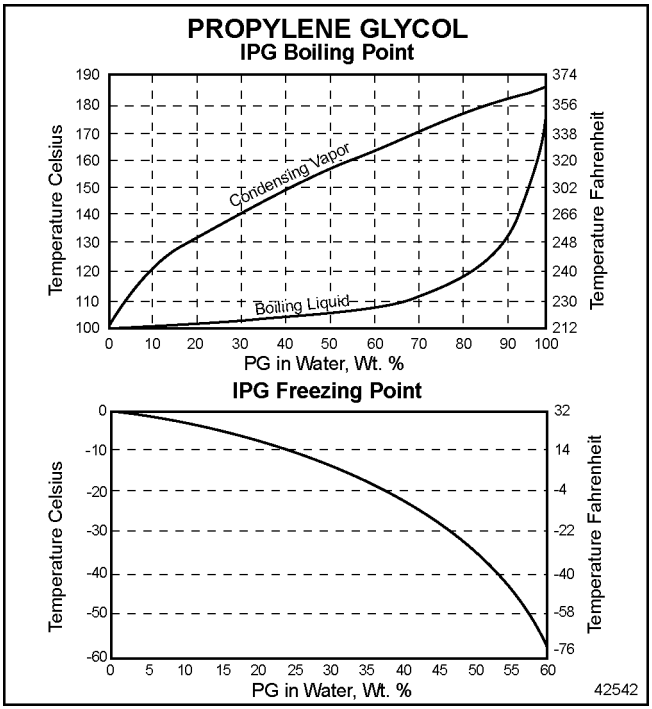


Figure 29 Coolant Temperatures vs. IPG Concentration (Sea Level)

See Figure 30 for ethylene glycol-based coolant concentration versus freezing and boiling temperatures.

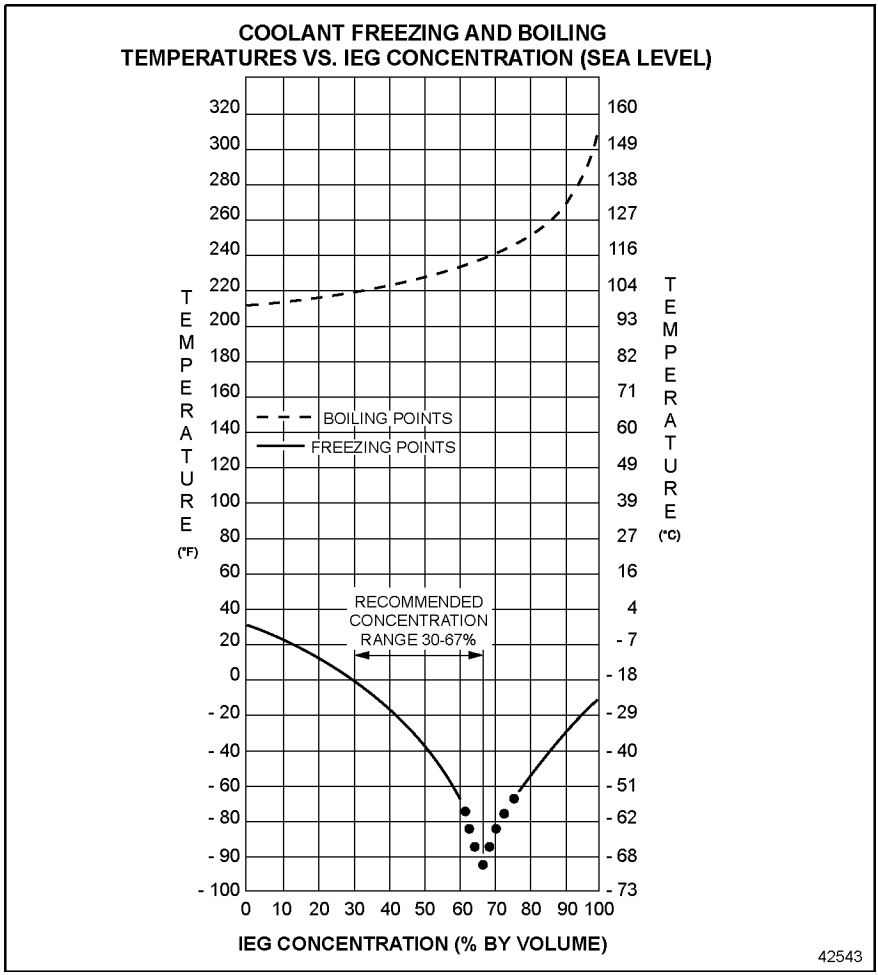


Figure 30 Coolant Temperatures vs. IEG Concentration (Sea Level)

Always verify that the freeze point and nitrite concentration of the antifreeze/water mixture are correct by using a *POWER Trac*® 3–Way Coolant Test Strip. If chemical analysis is used, elements in the coolant must fall within the limits listed in Table 17.

Recycled Antifreeze — Antifreeze or coolant recycled by reverse osmosis, distillation, and ion exchange, properly re-inhibited to meet TMC RP-329 Type A or TMC RP-330 Type A requirements has been demonstrated to provide service equivalent to virgin antifreeze. Recycled antifreeze or coolants of these types are *preferred.* Other recycled coolants, especially coolants recycled through filtration processes, are *not recommended*.

Ethylene Glycol/Water + OAT Inhibitor or Propylene Glycol/Water + OAT Inhibitor — Ethylene glycol and propylene glycol are also available with a nitrided Organic Acid Technology (OAT) corrosion package. These coolants require less maintenance over the useful life of the engine. OAT coolants, maintained as detailed in the Maintenance section of this guide, may be operated up to 4 years or 10,000 operating hours, whichever comes first. The cooling system should either be equipped with a "blank" coolant filter, or the coolant filter and piping may be omitted from the system.

OAT fully formulated antifreezes are available as concentrated and pre-mixed. Concentrated antifreezes should be mixed at a 30/70 ratio (30% antifreeze, 70% water).

Fully Formulated Glycol Coolant Concentration Limits	
Boron	125 – 500 PPM
Nitrite	900 – 3200 PPM
Nitrate	200 – 3200 PPM
Silicon	50 – 250 PPM
Phosphorous	0 PPM
pH	8.0 – 11.0

Table 17 Fully Formulated Glycol Coolant Limits with TMC RP-329, TMC RP-330 Chemistry Type A (50/50 Coolant/Water Mixture with SCA Inhibitors)

OAT coolants should not be mixed with conventional coolants. If they are mixed, no damage will result, but the long-life advantages of the OAT coolant will be lost. In this event, the coolant should be maintained as a fully formulated IEG coolant, not as an OAT (Organic Acid Technology) coolant.

Detroit Diesel markets a, OAT-inhibited ethylene glycol coolant, DDC *POWER COOL* Plus Marine (30/70) pre-mix, which contains all the required additives. *POWER COOL* Plus Marine is recommended for heat exchanger-cooled marine engines where antifreeze protection is required. If a non-DDC OAT antifreeze is used, it must conform to TMC 338 specification. *Do not add extender to new OAT antifreeze or coolant.*

Water Only + SCA or Water Only + OAT Inhibitor — In *warm climates,* raw water temperature above 80°F (27°C), a coolant based on water with corrosion inhibitors is approved for use. Water-only systems need to be treated with the proper dosage of corrosion inhibitors. MTU Detroit Diesel-approved SCAs or OAT corrosion inhibitors *must* be added to the water to provide required corrosion and cavitation erosion protection. OAT inhibitors such as *POWER COOL* Plus 6000 are available for water-only systems. Inhibitor should be mixed at 7.5% – 10% by volume with water.

POWER COOL 3000 SCA inhibitors should be mixed at 5% by volume with water. This is 1 quart of additive for every 5 gallons of water. Liquid SCA's are available in a variety of sizes. *POWER COOL* 3000 coolant concentration limits are listed in Table 18.

***POWER COOL* 3000 Coolant Concentration Limits (5% *POWER COOL* 3000/ 95% Water)**	
Boron	125 – 500 PPM
Nitrite	900 – 3200 PPM
Nitrate	0 – 1000 PPM
Silicon	50 – 250 PPM
Phosphorous	0 PPM
pH	8.0 – 11.0

Table 18 *POWER COOL* 3000 Coolant Concentration Limits

Coolant filters are also available for different cooling capacities. Coolant filters release the proper amount of SCA at initial fill.

NOTE:
Do not use POWER Trac 3–Way Test Strips to test OAT coolant.

For a list of *POWER COOL* products, refer to the SPECIFICATIONS section of this guide.

Water Requirements — Distilled, reverse osmosis-purified, or de-ionized water which eliminates the adverse effects of minerals in tap water is preferred. High levels of dissolved chlorides, sulfates, magnesium, and calcium in some tap water causes scale deposits and/or corrosion. These deposits have been shown to result in water pump failures and poor heat transfer, resulting in overheating. If tap water is used, the mineral content in the water must be below the maximum allowable limits listed in Table 19.

NOTICE:

Do not add additional SCA to new, fully formulated antifreeze or coolant. This can result in dropout and/or the formation of deposits.

Coolants Not Recommended

The following coolants are *not recommended* for use in Series 60 engines:

All Antifreezes and Coolants Containing Phosphate — These coolants should be avoided. Drop out, overheating and water pump seal failures can result from the use of coolant or inhibitor packages based on phosphate.

Automotive Type Coolants — These coolants generally contain high levels of phosphate and silicate, offer no liner pitting protection, and are *not suitable* for use in MTU Detroit Diesel engines.

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

Table 19 Satisfactory Water Limits – Make-Up Only

Methyl Alcohol-Based Antifreeze — These coolants must not be used because of its effect on the non-metallic components of the cooling system and its low boiling point.

Methoxy Propanol-Based Antifreeze — These coolants must not be used because it is not compatible with the fluoroelastomer seals found in the cooling system.

Glycol-Based Coolants Formulated for HVAC — These coolants formulated for Heating/Ventilation/Air Conditioning (HVAC) should not be used. They generally contain high levels of phosphates, which can deposit on hot internal engine surfaces and reduce heat transfer.

Additives Not Recommended

Soluble oil and chromate additives are *not recommended* for use in Series 60 engines.

Soluble Oil Additives — These additives are not approved for use in MTU Detroit Diesel engine cooling systems. A small amount of oil adversely affects heat transfer. For example, a 1.25% concentration of soluble oil increases fire deck temperature 6%. A 2.50% concentration increases fire deck temperature 15%. The use of soluble oil additives may result in engine overheating and/or damage.

Chromate Additives — These additives are not approved for use in MTU Detroit Diesel engine cooling systems. Chromate additives can form chromium hydroxide, commonly called “green slime.” This, in turn, can result in engine damage due to poor heat transfer. Cooling systems operated with chromium-inhibited coolant must be chemically cleaned with *POWER COOL* dry chemical cooling system cleaner/conditioner listed in Table 35 in the Specifications section (or equivalent sulfamic acid/sodium carbonate cleaner) and flushed.

Maintenance

The cooling system must be full for proper operation of the engine. Coolant must be maintained with the proper concentration of SCA.

Topping Off Coolant — Coolant and coolant inhibitor levels should be checked every 250 hours or yearly, whichever comes first.

WARNING:

HOT COOLANT

To avoid scalding from the expulsion of hot coolant, never remove the cooling system pressure cap while the engine is at operating temperature. Wear adequate protective clothing (face shield, rubber gloves, apron, and boots). Remove the cap slowly to relieve pressure.

If topping off is needed, add coolant which is identical to the initial fill coolant.

Supplemental Coolant Additives for Fully Formulated Coolant — The concentrations of some inhibitors will gradually deplete during normal engine operation. SCAs replenish the protection for cooling system components. The coolant *must* be maintained with the proper concentration of SCA. Detroit Diesel *POWER COOL* and *POWER COOL* Plus maintenance SCAs are recommended. The proper application of SCA will provide:

- □ pH control.
- □ Restored inhibitor levels to prevent corrosion.
- □ Water softening to deter formation of mineral deposits.
- □ Cavitation protection to protect wet sleeve cylinder liners.

NOTICE:

Failure to properly maintain coolant with SCA can result in damage to the cooling system and its related components. Conversely, over-concentration of SCA inhibitor can result in poor heat transfer, leading to engine damage. Always maintain concentrations at recommended levels. *Do not use traditional SCAs with OAT coolant.*

Coolant Maintenance Intervals — Check the nitrite concentration every 250 hours of operation or every year, whichever comes first, with a *POWER Trac* 3–Way Test Strip.

Nitrite levels *must* be within the ranges listed in Table 17. Additional SCA *must* be added to the coolant when it becomes depleted, as indicated by a nitrite concentration of 900 PPM or less.

If the nitrite concentration is greater than 900 PPM, do not add additional SCA. If the nitrite concentration is above 3200 PPM, the system is over-inhibited and should be partially drained and filled with the recommended coolant type listed in Table 20.

	Water Solution	Antifreeze Solution Pre-mixed Coolant with Water
Products	*POWER COOL* 3000 (P/N 23507855)	*POWER COOL* (P/N 23518918)
Initial Fill	3 % by Volume *POWER COOL* 3000	100 % by Volume *POWER COOL*
Monitoring	POWER Trac Test Strip	
Maintenance	Check for depletion; add *POWER COOL* 3000 to maintain 3 % by volume concentration	Add SCA or dilute coolant as needed

NOTE: The recommended water quality is deionized water as listed in Table 19 or as specified in DDC publication 7SE298.

Table 20 Initial Fill Options – Pleasure Craft and Commercial Marine Engines

In this case the EG or PG should contain no inhibitors and should conform to ASTM D4985. This will dilute the over-concentrated inhibitors.

NOTE:
In non-OAT systems, nitrite concentration of 5000 PPM or higher on a Series 60 engine suggests problematic additive over-concentration. This condition *must* be corrected by immediate draining and flushing of the cooling system. Refill the system with new, fully formulated or pre-charged coolant. Check the nitrite concentration level at the next maintenance interval with a POWER Trac 3-Way Test Strip.

Supplemental Coolant Additive Test Procedures

Detroit Diesel POWER Trac 3-Way Coolant Test Strips should be used to measure nitrite and glycol concentrations. Cavitation/corrosion is indicated on the strip by the level of nitrite concentration. Freeze/boil over protection is determined by glycol concentration. Test strip part numbers are listed in Table 36 in the Specifications section.

WARNING:

HOT COOLANT

To avoid scalding from the expulsion of hot coolant, never remove the cooling system pressure cap while the engine is at operating temperature. Wear adequate protective clothing (face shield, rubber gloves, apron, and boots). Remove the cap slowly to relieve pressure.

For best results make the test while the coolant is between 50 – 140°F (10.0 – 60°C). Wait at least 60, but not longer than 75 seconds before reading the nitrite level. Use the test strips as follows:

1. Dip the strip into coolant for one second. Remove and shake briskly to eliminate excess fluid.
2. Immediately compare the pad end (% glycol) to the color chart on the container.
3. Sixty seconds (one minute) after dipping, compare the nitrite pad to the color chart.
4. Color change of the additive indicator (middle pad) indicates the presence of inhibitor that is not approved by MTU Detroit Diesel.

Promptly replace and tighten the test strip container cap after each use. Discard unused strips if they have turned light pink or tan.

A factory coolant analysis program is available through authorized MTU Detroit Diesel service outlets. Part numbers are listed in Table 36 in the **SPECIFICATIONS** section. To verify coolant acceptability, submit a sample for coolant analysis every one (1) year or 3,000 operating hours, whichever comes first.

Need Release Coolant Filters (Non-OAT Systems)

Spin-on coolant filters are available for MTU Detroit Diesel engines. Membranes in the filters release SCAs before the coolant approaches a corrosive condition, protecting the engine from corrosion. The elements release the SCA charge as needed, as opposed to the maintenance SCA elements, which instantaneously release the SCA charge. Coolant filter elements should be replaced after one (1) year, 2,000 operating hours, or anytime the coolant system has been contaminated, whichever comes first.

Dropout

Excessive amounts of some inhibitors in the coolant can cause a gel or crystalline deposit that reduces heat transfer and coolant flow. The deposit, called "dropout," takes the color of the coolant when wet, but appears as a white or gray powder when dry. It can pick up solid particles in the coolant and become gritty, causing excessive wear of water pump seals and other cooling system components.

WARNING:

PERSONAL INJURY

To avoid injury when using caustic cleaning agents, follow the chemical manufacturers usage, disposal, and safety instructions.

The wet gel can be removed by using a non-acid (alkali) type heavy-duty cleaner, such as Detroit Diesel *POWER COOL* On-Line Cleaner (sodium nitrite/sodium tetraborate). Cleaner part numbers are listed in Table 35.

NOTE:
If the gel is allowed to dry, it is necessary to disassemble the engine and clean it with a caustic solution or physically clean individual components.

Coolant Extender Inhibitor Additive for "OAT" Coolant

The inhibitors in OAT coolant must also be maintained, but less often than traditional SCA-type coolants. A portable test is available to test the levels of OAT inhibitors in coolant. Where this is not used, testing has determined that a OAT coolant extender package should be added to the coolant at two (2) years or 5,000 hours, whichever comes first. The proper maintenance dosages for all OAT coolants are listed in Table 20, reflecting 0.6% by volume extender. This dosage should be added to the water-only and the glycol systems at the same interval.

The proper application of extender to OAT coolant will provide:

- □ pH Control
- □ Restored inhibitor levels to prevent corrosion
- □ Cavitation protection to protect wet sleeve cylinder liners

NOTE:
Do not use traditional SCAs in OAT coolant, and do not use OAT extender in traditional coolant.

OAT Coolant Drain Interval — A properly maintained OAT-inhibited coolant will last four (4) years or 10,000 operating hours, whichever comes first. At this time the coolant should be drained, and the cooling system should be thoroughly cleaned, flushed, and filled with new, properly inhibited OAT coolant.

Chronic Coolant System Problems

The most commonly seen coolant system problems result from maintenance and formulation factors such as:

- □ Hard water
- □ Dilution of the coolant by the addition of untreated water
- □ Over dosage or under dosage of corrosion inhibitors
- □ Improper corrosion inhibitor (most often phosphated)
- □ Mixing SCAs
- □ Improper testing

Detroit Diesel Cooling System Maintenance Products

***POWER COOL* SCAs —** *POWER COOL* SCAs are water-soluble chemical compounds. These products are available in coolant filter elements, liquid packages, and in fully formulated *POWER COOL* antifreeze.

NOTE:
POWER COOL 3000 liquid SCA is more compatible with hard water than POWER COOL 2000 SCA.

***POWER COOL* Coolant Filter Elements —** POWER COOL coolant filter elements (spin-on canisters) are available in various sizes suitable for cooling systems of varying capacities. Selection of the proper element size is vital when pre-charging non-fully formulated coolant (i.e., water) at initial fill and at maintenance intervals. **A fully formulated antifreeze must not have SCA added at initial fill. Do not use SCA-containing filters with OAT antifreeze or coolant.** The need for maintenance elements is determined by the results of the nitrite concentration test performed at each cooling system interval. *Do not automatically install maintenance elements at maintenance intervals, unless the nitrite concentration falls below 900 parts per million.*

***POWER COOL* Cleaners —** *POWER COOL* Liquid On-Line Cleaner is used for light deposits. *POWER COOL* Dry Chemical Cleaner/Conditioner is used for heavy deposits or scale.

Summary of Coolant Recommendations

WARNING:

HOT COOLANT

To avoid scalding from the expulsion of hot coolant, never remove the cooling system pressure cap while the engine is at operating temperature. Wear adequate protective clothing (face shield, rubber gloves, apron, and boots). Remove the cap slowly to relieve pressure.

1. Always maintain the engine coolant to meet MTU Detroit Diesel specifications.
2. Only use water that meets the specifications listed in Table 19. Distilled, de-mineralized (reverse osmosis) or de-ionized water is preferred.
3. The proper dosage of inhibitors *must* be included in the coolant at initial fill for all MTU Detroit Diesel engines. This dosage is usually included in the fully formulated antifreeze used, or it may need to be added if water alone or if less than 50% antifreeze is used. *The user is urged to refer to the full text of this section to determine the proper dosage.* Mixing of different manufacturers' technologies (brands) could cause cooling system problems.
4. Maintain the inhibitor at the prescribed concentration. Test the nitrite concentration by using a titration kit or Detroit Diesel POWER Trac 3-Way Coolant Test Strips. Add SCA only if the nitrite concentration is below 900 PPM. *Do not use SCA in OAT coolant, and do not use POWER Trac 3-Way Coolant Test Strips to test OAT coolant.*
5. Do not use another manufacturer's test kit to measure the SCA concentration of Detroit Diesel maintenance products.
6. Pre-mix coolant makeup solutions to the proper concentration before adding to the cooling system.
7. Do not mix OAT and other coolants in the same engine.
8. Do not use automotive coolants or coolants with phosphates.
9. Where antifreeze/boil over protection is required, use only antifreeze that meets TMC RP-329 “Type A” (EG) or TMC RP-330 “Type A” (PG) specifications. Always maintain coolant at the proper level.

10. Do not use the following in MTU Detroit Diesel engine cooling systems:
    - □ Soluble oil
    - □ High silicate, automotive-type antifreeze
    - □ Chromate SCAs
    - □ Methoxy propanol-based coolant
    - □ Methyl alcohol-based coolant
    - □ Sealer additives or coolant containing sealer additives.
    - □ HVAC coolant
    - □ Phosphated coolants

Coolant Life of Glycol Coolant — A *properly maintained* cooling system, filled with phosphate-free coolant consisting of the required mix of antifreeze and water per TMC RP-329 "Type A" (EG) or TMC RP-330 "Type A" (PG) specifications can be operated for the life of the engine until overhaul.

The proper maintenance involves periodic evaluation using POWER Trac 3-Way Coolant Test Strips and the addition of SCA as needed, indicated by the strip test. To verify coolant acceptability, submit a sample for coolant analysis every one (1) year or 3,000 operating hours, whichever comes first. Submit the sample in a DDC POWER Trac Coolant Test Bottle. Required part numbers are listed in Table 36.

Coolant Life of OAT Coolant — A properly maintained OAT coolant may be operated four (4) years or until overhaul, whichever comes first. At this time the system *must* be completely drained, thoroughly cleaned, and refilled.

OAT Coolants require the addition of an extender at two (2) years or 5,000 hours, whichever comes first. Use 1 pint of extender for every 20 gallons of coolant.

Coolant Life of Other Coolants — Other properly maintained coolants may be operated up to two (2) years or 4,000 operating hours, whichever comes first. At this time the system *must* be completely drained, thoroughly cleaned, and refilled.

How to Drain and Flush the Cooling System

WARNING:

HOT COOLANT

To avoid scalding from the expulsion of hot coolant, never remove the cooling system pressure cap while the engine is at operating temperature. Wear adequate protective clothing (face shield, rubber gloves, apron, and boots). Remove the cap slowly to relieve pressure.

1. With the engine cool, drain the previous solution from the engine and heat exchanger. Dispose of the coolant in an environmentally friendly 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 those listed in Table 35 in the Specifications section. If the engine is warm, *fill slowly* to prevent the rapid cooling and distortion 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 required coolant. Refer to How to Select Coolant in the **HOW-TO SECTION** of this guide.
10. Entrapped air must be purged after filling the cooling system. To do this, start the engine and allow it to warm up without the pressure cap installed. Open any petcocks found on the thermostat housing and water-cooled turbocharger to vent air from the system. Close petcocks when a steady stream of coolant (no bubbles) appears. With the marine gear(s) in neutral, increase engine speed above 1000 RPM and add coolant as required.
11. Install the pressure cap after the coolant level has stabilized at the bottom of the heat exchanger filler neck.

NOTICE:

If the engine overheats and the coolant level is satisfactory, the cooling system may require cleaning with a descaling solvent and back flushing. Authorized MTU 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.

NOTE:
If Detroit Diesel ***POWER COOL*** antifreeze/coolant (or equivalent fully formulated, precharged antifreeze) is used, a precharge element is not required. Coolant inhibitor levels *must* be checked at 250–hour intervals.

Hoses

Cooling system hoses should be inspected every 250 operating hours or one (1) year which ever comes first and any hose that shows obvious signs of damage or feels abnormally soft or hard should be replaced. Damaged clamps should also be replaced. All external leaks should be corrected as soon as detected.

When to Service the Dry Type Air Cleaner

Replace or clean dry type air cleaner elements when the maximum allowable air cleaner restriction (20 in. H_2O [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 approved to a maximum of five (5) cleanings. Cleaning of elements *must* be done in accordance with the air cleaner manufacturer's recommendations, if any.

BASIC TROUBLESHOOTING

This section covers basic troubleshooting of engine operation or performance malfunctions and their probable causes.

Objectionable Exhaust Symptoms and Probable Causes			
Probable Causes	Symptoms		
	Black or Gray Smoke	Blue Smoke	White Smoke
Damaged or dirty air cleaner	X	–	–
Improper grade of fuel	X	–	–
Excessive exhaust back pressure	X	–	–
Misfiring cylinders	–	–	X
Lubricating oil not burned in cylinder (being burned in exhaust manifold or turbocharger)	–	X	–
Faulty injector timing	X	–	–
Faulty oil control rings	–	X	–
Excessive installation angle	–	X	–
Excessive oil in crankcase	–	X	–
High ambient temperature	X	–	–
Thin air (high altitude)	X	–	–
Cetane rating of fuel too low	–	–	X
Air in the fuel system	–	–	X
Low boost pressure	X	–	–

Hard Starting Symptoms and Probable Causes			
Probable Causes	**Symptoms**		
	Engine Will Not Rotate	**Low Cranking Speed**	**Engine Cranks But Will Not Start**
Low Battery Voltage	X	X	–
Loose cranking motor connections	X	–	–
Faulty cranking motor	X	X	
Faulty cranking motor switch	X	X	X
Internal seizure	X	–	–
Improper lube oil	–	X	–
Circuit breaker/electronic control malfunction	–	–	X
Fuse blown or missing	–	–	X
Insufficient Fuel Supply			
Air in fuel	–	–	X
Out of fuel	–	–	X
Loose fuel connections	–	–	X
Cracked fuel lines	–	–	X
Obstructed fuel filters/lines	–	–	X
Faulty fuel pump	–	–	X
Faulty injector operation	–	–	X
Restricted fuel fitting missing	–	–	X
DDEC Malfunction	–	–	X
Installation/operation of fuel check valve or shutoff valve	–	–	X
Low Compression			
Worn intake or exhaust valves	–	–	X
Worn piston rings/liners	–	–	X
Leaking cylinder head gasket	–	–	X
Improper intake and exhaust valve adjustments	–	–	X

Abnormal Engine Operation Symptoms and Probable Causes			
Probable Causes	**Symptoms**		
	Rough Running or Frequent Stalling	**Low Power**	**Detona-tion**
Misfiring cylinder	X	X	–
Insufficient fuel	X	X	–
High return fuel temperature	X	X	–
Low compression	X	X	–
DDEC malfunction	X	X	–
High air inlet restriction/exhaust back pressure	–	X	–
Engine application	–	X	–
High air inlet temperature	–	X	–
High altitude operation	–	X	–
Incorrect engine gear train timing	–	X	–
Low coolant temperature	–	–	X
Oil picked up by inlet airstream	–	–	X
Faulty injector operation	–	–	X
Incorrect injector height setting	–	X	X

Abnormal Engine Operating Condition Symptoms and Probable Causes		
Probable Causes	**Symptoms**	
	High Lubricating Oil Consumption	**Low Oil Pressure**
Loose connections	X	–
Cracked lines	X	–
Damaged gaskets or seal rings	X	–
Lube oil loss at breather tube or dipstick tube (Indicates high crankcase pressure)	X	–
Leaking oil cooler	X	–
Leaking valve stem seals	X	–
Worn/broken oil control rings	X	–
Scored liner and/or piston	X	–
Excessive engine installation angle	X	–
Crankcase overfilled	X	–
Plugged crankcase breather	X	–
Oil level low	–	X
Improper oil viscosity (fuel in the oil)	–	X
Faulty oil pressure regulator valve	–	X
Worn crankshaft, camshaft or connecting rod bearings	–	X
Missing cup plugs in rocker arm shafts	–	X
Faulty oil pressure relief valve	–	X
Air leaks in oil pump (suction side)	–	X
Worn or damaged oil pump	–	X
Faulty oil pressure gage	–	X
Faulty electrical components (for gage)	–	X
Plugged oil orifice or obstructed oil line	–	X

Abnormal Engine Coolant Temperature Symptoms and Probable Causes		
Probable Causes	**Symptoms**	
	Above Normal Temperature	**Below Normal Temperature**
Restricted cooling system passages	X	–
Restricted charge air cooler or heat exchanger core passages	X	–
Obstruction in front of charge air cooler	X	–
Slipping fan drive belts	X	–
Low coolant level	X	–
Damaged hoses	X	–
Faulty thermostats	X	–
Faulty water pump	X	–
Faulty heat exchanger or expansion tank pressure cap	X	–
Air in coolant	X	
Thermostats not fully closed	–	X
Leakage around thermostat seals	–	X

ENGINE 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, marine gear and other parts from rust accumulation and corrosion. The parts requiring attention and the recommended preparations are given below.

PREPARING ENGINE FOR STORAGE

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 the engine for a temporary period of time (30 days or less), follow this procedure:

1. With the engine at ambient temperature and cool to the touch, drain engine crankcase oil into a suitable container. Dispose of the oil in an environmentally friendly manner, according to state and/or federal (EPA) recommendations.
2. Fill the crankcase (using the engine main oil gallery) to the proper level with the recommended viscosity and grade of oil. Refer to the How to Select Lubricating Oil in the **HOW-TO SECTION** of this guide.
3. Fill the fuel tank with the recommended grade of fuel oil. Refer to the How to Select Fuel Oil in the **HOW-TO SECTION** of this guide. Operate the engine for two (2) minutes at 1200 rpm and no load. **Do not drain the fuel system or the crankcase after this run.**
4. Check the air separator or 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. Add antifreeze solution to the cooling system in accordance with MTU Detroit Diesel's recommendations. Refer to How to Select Coolant in the

HOW-TO SECTION of this guide.

NOTE:
If an antifreeze solution is not required during storage, flush the cooling system with a good soluble oil (3% – 5% by volume) rust inhibitor to prevent rusting of the outside diameter of the cylinder liners.

WARNING:

EYE INJURY

To avoid injury from flying debris when using compressed air, wear adequate eye protection (face shield or safety goggles) and do not exceed 276 kPa (40 psi) air pressure.

6. Clean the exterior of the engine (except electrical parts) with fuel oil and dry with compressed air.
7. Seal all engine openings. The material used must be waterproof, vapor proof 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 marine gear 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. With the engine at ambient temperature and cool to the touch, drain the engine crankcase oil into a suitable container. Remove the oil filters. Dispose of the oil and filters in an environmentally friendly manner, according to state and/or federal (EPA) recommendations. Replace the drain plug and tighten to 45 – 50 N·m (33 – 37 lb·ft) torque.
5. Install new lubricating oil filters. Fill the crankcase (using the engine main oil gallery) to the proper level with Tectyl® 930A preservative lubricating oil or an equivalent 30–weight preservative lubricating oil meeting Mil-L-21260C, Grade 2 Specification.

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 (10) minutes. If draining the fuel tank is not convenient, use a separate, portable supply of recommended fuel.

WARNING:

PERSONAL INJURY

To avoid injury from improper use of chemicals, follow the chemical manufacturer's usage, handling, and disposal instructions. Observe all manufacturer's cautions.

NOTE:
If engines are stored where condensation of water in the fuel tank may be a problem, additives containing methyl carbitol or butyl cellusolve may be added to the fuel. Follow manufacturer's instructions for treatment. Where biological contamination of fuel may be a problem, add a biocide such as Biobor® JF (or equivalent) to the fuel. When using a biocide, follow the manufacturer's concentration recommendations and observe all cautions and warnings.

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 the new filters with No. 1 diesel fuel or pure kerosene and install on the engine.
8. Operate the engine for five (5) minutes to circulate the clean fuel throughout the engine. Be sure the engine fuel system is full.
9. Stop the engine and allow to cool. Then disconnect the fuel return line and the inlet line at the primary filter and securely plug both to retain the fuel in the engine.
10. **Marine Gear:** Follow the manufacturer's recommendations for prolonged storage.
11. **Power Take-Off:** If equipped, follow manufacturer's recommendations for prolonged storage.

NOTICE:

Failure to properly seal off the 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.

12. **Turbocharger:** Since turbocharger bearings are pressure lubricated through the external oil line leading from the oil filter adaptor while the engine is operating, no further attention is required. However, the turbocharger air inlet and turbine exhaust outlet connection must be sealed off with moisture-resistant tape.
13. Apply a non-friction rust preventive compound to all exposed engine parts. If convenient, apply the rust preventive compound to the engine flywheel. If not, disengage the clutch mechanism to prevent the clutch disc from sticking to the flywheel.

NOTE:
Do not apply oil, grease or any wax-based compound to the flywheel. The cast iron will absorb these substances, which can "sweat" out during operation and cause the clutch to slip.

14. Drain the engine cooling system.
15. Drain the preservative oil from the engine crankcase. Reinstall and torque the 3/4" – 14 square, magnetic drain plug to 45 – 50 N·m (33 – 37 lb·ft).
16. 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.
17. Insert heavy paper strips between the pulleys and drive belts to prevent sticking.
18. Seal all engine openings, including the exhaust outlet, with moisture-resistant tape. Use cardboard, plywood or metal covers where practical.
19. 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.

20. 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 the engine 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

If an engine has been in extended storage, prepare it for service as follows:

1. Remove the covers and tape from all 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 rust preventive from the flywheel. Flush any soluble oil rust inhibitor (if used) in the cooling system.
5. Remove the paper strips from between the pulleys and drive belts.
6. Fill the crankcase (using the engine main oil gallery) to the proper level with the required grade of lubricating oil. Use a pressure lubricator to ensure all bearings and rocker shafts are lubricated.
7. Fill the fuel tank with the required fuel.

8. 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 COOL*** antifreeze or an equivalent ethylene glycol-based or propylene glycol-based antifreeze solution which provides required freeze, boil over, and inhibitor protection. Refer to How to Select Coolant in the **HOW-TO SECTION** of this guide.
9. Install and connect the battery. Make sure the average specific gravity of the battery is 1.260 or higher. Charge the battery, if necessary.
10. Service the air cleaner, if required.
11. **Marine Gear:** Follow the manufacturer's recommendations covering the return of the marine gear to service.
12. **Turbocharger:** Remove the covers from the turbocharger air inlet and turbine outlet connections. Reconnect piping as required. Prelube the turbocharger center bearing housing. Refer to the Lubrication System Checks section.
13. Check to make sure the charge air cooler is unblocked and free of debris.

⚠ WARNING:

PERSONAL INJURY

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

- □ **Always start and operate an engine in a well ventilated area.**
- □ **If operating an engine in an enclosed area, vent the exhaust to the outside.**
- □ **Do not modify or tamper with the exhaust system or emission control system.**

14. After all preparations are completed, start the engine.

NOTE:
The small amount of rust preventive 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 (DDL) for trouble codes.

SERVICE PUBLICATIONS

The service manual covering MTU Detroit Diesel Series 60 engines and various reference works which may be of interest to the owner/operator are listed in Table 21.

To purchase a copy of any of these publications, contact an authorize MTU Detroit Diesel distributor in the U.S. or Canada. Check the Yellow Pages under "Engine, Diesel" or refer to the Distributor and Dealer Directory listed below for the distributor or service outlet nearest you.

Description	Form No.
MTU Series 60 Engine Service Manual	6SE660
DDEC III/IV Single ECM Troubleshooting Guide	6SE497
U.S. and Canada Distributor/Dealer Directory	6SE280
International Distributor/Dealer Directory	6SE281
Series 50/60 Service Outlet Directory	6SA336
Fluids and Lubricants Specification	A001061/29E
Coolant Requirements for Engine Cooling Systems	7SE298
Technician's Guide – Used Lubricating Oil Analysis	7SE398
Technician's Guide – Turbocharger	7SE374
Technician's Guide – Cooling System	7SE390

Table 21 Service Publications

CUSTOMER ASSISTANCE

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

MTU DETROIT DIESEL NAFTA OFF-HIGHWAY REGIONAL OFFICE LOCATIONS

EASTERN REGION (Off-Highway)
Jacksonville, Florida
5111 Bowden Road
Jacksonville, FL 32216
Phone: 904-448-1011
Fax: 904-448-2444

WESTERN REGION (Off-Highway)
Dallas, Texas
2711 LBJ Freeway
Suite 1036
Dallas, TX 75234
Phone: 972-247-4313
Fax: 972-247-4316

MTU DETROIT DIESEL INTERNATIONAL REGIONAL OFFICE LOCATIONS

ASIAN REGION (Off-Highway)
Singapore
No. 16 Benoi Crescent
Singapore 629979
Phone: (65) 861-5922
Fax: (65) 865-1618

EUROPE, MIDDLE EAST, AFRICA (EMA) REGION (Off-Highway)
The Netherlands
Ridderpoort 9
2984 BG Ridderkerk
The Netherlands
Phone: (31) 180-442-900
Fax: (31) 1804-62062

PACIFIC REGION (Off-Highway)
Australia
488 Blackshaws Road
Altona North, Victoria 3025
Australia
Phone: (61) 3 9243-9292
Fax: (61) 3 9243-9262

LATIN AMERICAN REGION (Off-Highway)
Miami, Florida
2277 N.W. 14th Street
Miami, FL 33125-0068
Phone: 305-637-1555
Fax: 305-637-1580

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

SOUTH AMERICAN REGION (Off-Highway)
Calle 80 No. 8-14
Of. #101 P.O. Box 53382
Bogota, Colombia
Phone: (57) 1-211-4480
Fax: (57) 1-211-4053

Road Service in the U.S. or Canada

If you require service for any reason in the U.S. or Canada, you may call the **1–877–DDC—BOAT** customer service locator phone number. A voice or touch tone-activated menu will guide you to the closest MTU Detroit Diesel marine distributor. Not all problems are engine related and not all problems are covered by engine or vessel warranties. *YOU MAY BE RESPONSIBLE FOR REPAIR EXPENSES.*

Before calling Customer Assistance, please do the following:

- □ Check coolant level
- □ Check fuel level
- □ Check DDEC fuses
- □ Check for fuel leaks
- □ Make sure manual shutoff valve (if installed) on the fuel filter adaptor, fuel processor body or fuel supply line is open.
- □ Check the oil level on the dipstick
- □ Check diagnostic codes against those listed in Table 1, Table 2, and Table 3.

If you call, have the following information available:

- □ Engine model and serial number
- □ Vessel make and model
- □ Accumulated hours
- □ Vessel owner/company name

Working with MTU Detroit Diesel Service Outlets

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

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

We recognize, however, that despite the best intentions of everyone concerned, misunderstandings may occur. Normally, any situation that arises in connection with the sale, operation or service of your product will be handled by the authorized service outlet in your area. In the U.S. and Canada, check the Yellow Pages for the MTU Detroit Diesel service outlet nearest you.

To further assure your complete satisfaction, we have developed the following procedure to be followed 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 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 a service agreement.

Step Two

When it appears that your problem cannot be readily resolved at the distributor level without additional assistance, contact the MTU Detroit Diesel Regional Product Support Manager 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:

- □ Engine model number* 606 _ .
- □ Engine serial number* 06R0_ _ _ .
- □ Type and make of vessel
- □ Engine delivery date and accumulated hours of operation.
- □ Nature of problem.
- □ Chronological summary of engine's history.
- □ Name and location of authorized service outlet.

*** Important:** Your engine model number and serial number should be written on the lines provided. They will identify your engine and all service parts, plus provide warranty and extended coverage information.

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

Vice President, Customer Assurance
MTU Detroit Diesel Inc
13400 Outer Drive, West
Detroit, MI 48239–4001
Phone: 313–592–7000
FAX: 313–592–5717

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

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WARRANTY INFORMATION – PLEASURE CRAFT

TERMS OF COVERAGE:

Uses

This warranty applies to the first retail purchaser and subsequent owners during the WARRANTY PERIOD of new MTU Detroit Diesel Series 60 Engines including new MTU Detroit Diesel marine transmissions supplied and used in combination with the aforementioned engines (referred to as Engine) and attached raw water pump, starting motor and alternator (referred to as Accessories) manufactured by MTU Detroit Diesel Inc and/or supplied by MTU Detroit Diesel Inc, MTU Detroit Diesel of Canada Limited, or MTU Detroit Diesel Overseas Distribution (all which are collectively referred to as MTUDDI) which are used in non-commercial marine pleasure craft applications.

Defects

This warranty covers Engine REPAIRS to correct any malfunction occurring during the WARRANTY PERIOD resulting from defects in material or workmanship.

Repairs

To obtain warranty repairs, you must request the needed repairs within the WARRANTY PERIOD from an authorized MTU Detroit Diesel service outlet. Only new genuine parts or remanufactured parts or components supplied or approved by MTU Detroit Diesel Inc will be used. MTU Detroit Diesel Inc may, at its discretion, replace rather than repair components. A reasonable time must be allowed to perform the warranty repair. Repairs will be performed during normal business hours.

Warranty Period

The WARRANTY PERIOD begins on the date the Engine is delivered to the first retail purchaser or put in use prior to sale at retail, whichever date comes first, and ends at the time limits listed in Table 22.

Warranty Period				
Item	**Time Limita-tions**	**Repair Charge to Be Paid by Owner**		
	Months	**Parts**	**Repair Labor**	**Engine R & R Labor**
Engine	0 – 24	No Charge	No Charge	100% of Service Outlet's Normal Charge
Major Components*	25 – 60	No Charge	No Charge	100% of Service Outlet's Normal Charge
Accessories	0 – 12	No Charge	No Charge	100% of Service Outlet's Normal Charge

* Cylinder Block, Crankshaft, Camshaft, Fresh Water Pump Housing, Flywheel, Flywheel Housing, Oil Cooler Housing/Adapter, Front Cover, Oil Pan, Connecting Rod Forgings and Exhaust Manifold

Table 22 Marine Pleasure Craft Engine Warranty Period

Like Replacement Engine

Engine(s) supplied by MTU Detroit Diesel Inc as a replacement for an Engine still under warranty will assume the identity of the Engine being replaced and be entitled to the remaining warranty coverage.

Service Supplies

The cost of service supplies such as coolant, oil and filters which are not reusable due to a warrantable repair is covered by this warranty.

Mechanic's Travel Expenses

MTU Detroit Diesel Inc will pay reasonable travel expenses for the repairing mechanic to travel to and from the repair site (dock).

THIS WARRANTY DOES NOT COVER:

Repairs Due to Accidents, Misuse, Alteration, Storage

Damage, Negligence or Certain Modifications

Repairs due to an accident, misuse, alteration, misapplication, storage damage, negligence or modification exceeding MTU Detroit Diesel specifications are not covered by this warranty.

Engine Removal and Reinstallation

Labor and material costs for Engine removal and reinstallation, when necessary to make a warranty repair, are not covered by this warranty.

Non-MTU Detroit Diesel Supplied/Manufactured Components

MTU Detroit Diesel Inc is not responsible for repair of components and/or assemblies which are manufactured or supplied by another manufacturer, such as non-MTU Detroit Diesel marine transmissions, power take-offs, intake and exhaust systems. Such items are covered by the equipment manufacturer.

Maintenance

MTU Detroit Diesel Inc is not responsible for the cost of maintenance or repairs due to the lack of performance of required maintenance services as recommended by MTU Detroit Diesel Inc, or the failure to use fuel, oil, lubricants and coolant meeting MTU Detroit Diesel-recommended specifications. Performance of the required maintenance and use of proper fuel, oil, lubricants and coolant are the responsibility of the owner. Refer to the MAINTENANCE section in this guide for full details.

Incidental or Consequential Damage

MTU Detroit Diesel Inc is not responsible for incidental or consequential costs or expenses which the owner may incur as a result of a malfunction or failure covered by this warranty, such as communication expenses, meals, lodging, overtime, towing and any associated docking or harbor charges, loss of use of the Engine or vessel, loss of time, inconvenience, cargo loss or damage, and other similar costs and expenses.

Other Limitations

THIS LIMITED WARRANTY IS THE ONLY WARRANTY APPLICABLE TO THE ENGINE AND ACCESSORIES AS USED IN MARINE PLEASURE CRAFT APPLICATIONS. DETROIT DIESEL CORPORATION MAKES NO OTHER WARRANTIES EXPRESS OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. DETROIT DIESEL CORPORATION SHALL NOT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES AS DESCRIBED ABOVE.

Some states do not allow the limitation of how long this warranty may last or the limitation or exclusion of incidental or consequential damages, so the above may not apply to you. This warranty gives you specific legal rights, and you may also have other rights which may vary from state to state.

WARRANTY INFORMATION – COMMERCIAL MARINE

TERMS OF COVERAGE:

Uses

This warranty applies to the first retail purchaser and subsequent owners during the WARRANTY PERIOD of new MTU Detroit Diesel Series 60 engines including new MTU Detroit Diesel marine transmissions supplied and used in combination with the aforementioned engines (referred to as Engine) and attached raw water pump, air compressor, air starter, alternator, and hydraulic pump (referred to as Accessories) manufactured by MTU Detroit Diesel Inc and/or supplied by MTU Detroit Diesel Inc, MTU Detroit Diesel of Canada Limited, or MTU Detroit Diesel Overseas Distribution (all which are collectively referred to as MTUDDI) which are used in commercial marine applications.

Defects

This warranty covers Engine REPAIRS to correct any malfunction occurring during the WARRANTY PERIOD resulting from defects in material or workmanship.

Repairs

To obtain warranty repairs, you must request the needed repairs within the WARRANTY PERIOD from an authorized MTU Detroit Diesel service outlet. Only new genuine parts or remanufactured parts or components supplied or approved by MTU Detroit Diesel Inc will be used. MTU Detroit Diesel Inc may, at its discretion, replace rather than repair components. A reasonable time must be allowed to perform the warranty repair. The owner is responsible for the percentage of repair costs listed in Table 23. Repairs will be performed during normal business hours.

Warranty Period

The WARRANTY PERIOD begins on the date the Engine is delivered to the first retail customer or put in use prior to sale at retail, whichever date occurs first and ends at the time limits shown below:

Warranty Period				
Item	Warranty Limitations (Whichever Occurs First)		Repair Charge to Be Paid by Owner	
	Months	Engine Hours	Parts	Labor
Engine	0 – 12	No Limit	No Charge	No Charge
Accessories	0 – 12	0 – 2,000	No Charge	No Charge
Upon expiration of the 12 month warranty coverage, but within 12,000 hours of use, the warranty continues to apply as follows:				
Block, Crankshaft and Connecting Rods (assemblies)	13 – 36	0 – 12,000	No Charge	100% of service outlet's normal charge

Table 23 Commercial Marine Engine Warranty Period

Service Supplies

The cost of service supplies such as coolant, oil and filters which are not reusable due to needed repairs is covered by this warranty.

Like Replacement Engine

Engine(s) supplied by MTU Detroit Diesel Inc as a replacement for an Engine still under warranty will assume the identity of the Engine being replaced and be entitled to the remaining warranty coverage.

Mechanic's Travel Expenses

MTU Detroit Diesel Inc will pay reasonable travel expenses for the repairing mechanic to travel to and from the repair site (dock).

THIS WARRANTY DOES NOT COVER:

Repairs Due to Accidents, Misuse, Alteration, Storage

Damage, Negligence or Certain Modifications

Repairs due to an accident, misuse, alteration, misapplication, storage damage, negligence or modification exceeding MTU Detroit Diesel specifications are not covered by this warranty.

Engine Removal and Reinstallation

Labor and material costs for Engine removal and reinstallation, when necessary to make a warranty repair, are not covered by this warranty.

Non-MTU Detroit Diesel Supplied/Manufactured Components

MTU Detroit Diesel Inc is not responsible for repair of components and/or assemblies which are manufactured or supplied by another manufacturer, such as non-MTU Detroit Diesel marine transmissions, power take-offs, intake and exhaust systems. Such items may be covered by the manufacturer or supplier.

Maintenance

MTU Detroit Diesel Inc is not responsible for the cost of maintenance or repairs due to lack of performance of required maintenance services as recommended by MTU Detroit Diesel Inc, or the failure to use fuel, oil, lubricants and coolant meeting MTU Detroit Diesel-recommended specifications. Performance of the required maintenance and use of proper fuel, oil, lubricants and coolant are the responsibility of the owner. Refer to the MAINTENANCE section of this guide for full details.

Incidental or Consequential Damage

MTU Detroit Diesel Inc is not responsible for incidental or consequential costs or expenses which the owner may incur as a result of a malfunction or failure covered by this warranty, such as communication expenses, meals, lodging, overtime, towing, and any associated docking or harbor charges, loss of use of the Engine or vessel, loss of time, inconvenience, cargo loss or damage, and other similar costs and expenses.

Other Limitations

The performance of REPAIRS is the exclusive Owner's remedy under this warranty. MTU Detroit Diesel Inc does not authorize any person to assume or create for it any other obligation or liability in connection with the Engine or the Accessories.

THIS LIMITED WARRANTY IS THE ONLY WARRANTY APPLICABLE TO THESE ENGINES AND ACCESSORIES AS USED IN COMMERCIAL MARINE APPLICATIONS. MTU DETROIT DIESEL INC MAKES NO OTHER WARRANTIES EXPRESS OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. MTU DETROIT DIESEL INC SHALL NOT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES AS DESCRIBED ABOVE.

Some states do not allow the limitation of how long this warranty may last or the limitation or exclusion of incidental or consequential damages, so the above may not apply to you. This warranty gives you specific legal rights, and you may also have other rights which may vary from state to state.

SPECIFICATIONS

LUBRICATING OIL, FILTERS, ENGINE OIL CAPACITY

Lubricating Oil

Oil Name and Description	Part Number	Size
POWER GUARD 1300 Super SAE 15W-40, CI-4	23512703	1 Gallon
POWER GUARD 1300 Super SAE 15W-40, CI-4	23512741	5 Gallons
POWER GUARD 1300 Super SAE 15W-40, CI-4	23512704	55 Gallons
Delvac® 1 SAE 5W-40, CI-4 Synthetic	delvac1jug	1 Gallon
Delvac 1 SAE 5W-40, CI-4 Synthetic	delvac1pail	5 Gallons
Delvac 1 SAE 5W-40, CI-4 Synthetic	delvac1drum	55 Gallons
POWER GUARD 1240 SAE 40W, CF-2	23512701	1 Gallon
POWER GUARD 1240 40W, CF-2	23512734	5 Gallons
POWER GUARD 1240 40W, CF-2	23512702	55 Gallons
POWER GUARD Gold SAE 40W, CF-2 Synthetic	23520323	1 Gallon
POWER GUARD Gold SAE 40W, CF-2 Synthetic	23520324	5 Gallons

Table 24 DDC POWER GUARD Lubricating Oil

Fuel and Lubricating Oil Filters

FUEL FILTER REQUIREMENTS – Series 60 Regular Service	
Filter Type	**MTU Detroit Diesel Part No.**
Primary — Spin-On	23518481
Primary Fuel/Water Separator — Spin-On*	23512317*
Secondary — Spin-On	23518482
Primary — Fuel Pro® 380/382 Element	23521528 or 23529168†
LUBRICATING OIL FILTER REQUIREMENTS	
Filter Type	**MTU Detroit Diesel Part No.**
Full Flow	23527033
Full Flow (High Capacity)	DELF3998

* Optional. May be used in place of, but not together with, the primary filter.

† Elemax® extended service element (optional).

Table 25 Fuel and Lubricating Oil Filter Requirements

Engine Oil Capacity

OIL PAN CAPACITY
All Series 60 pleasure craft and commercial marine engines require the same amount of lubricating oil: 32 quarts to the LOW mark ..... Without Oil Filters 38 quarts to the FULL mark ..... Without Oil Filters
TOTAL OIL CAPACITY OF THE ENGINE 43 quarts to the FULL mark ..... With oil filters installed and filters and oil galleries charged.

Table 26 Oil Pan and Engine Oil Capacity

POWER COOL ENGINE PRODUCTS

POWER COOL Fully Formulated IEG Coolant

Coolant Type	Part Number	Description
Concentrated	23512138	1 Gallon Jug – 6 Per Case
	23512139	55 Gallon Drum
	23529295	330 Gallon Tote
	23512140	Bulk Delivery – 1,000 Gallon Min.
Pre-Blended 50:50	23528203	1 Gallon Jug – 6 Per Case
	23518918	55 Gallon Drum
	23528544	330 Gallon Tote
	23513503	Bulk Delivery – 1,000 Gallon Min.

Table 27 *POWER COOL* Fully Formulated IEG Coolant

POWER COOL 2000 Supplemental Coolant Additive

Coolant Type	Part Number	Description
For *POWER COOL* IEG Coolant	23507858	Pint Bottle – 12 Per case
	23507859	One-Half Gallon Jug – 6 Per Case
	23507860	5 Gallon Pail
	23507861	55 Gallon Drum

Table 28 *POWER COOL* 2000 Supplemental Coolant Additive

POWER COOL 3000 Supplemental Coolant Additive

Coolant Type	Part Number	Description
For *POWER COOL* IEG Coolant	23507854	Pint Bottle – 12 Per Case
	23507855	One-Half Gallon Jug – 6 Per Case
	23507856	5 Gallon Pail
	23507857	55 Gallon Drum

Table 29 *POWER COOL* 3000 Supplemental Coolant Additive

POWER COOL 3000 Supplemental Additive Coolant Filters

Coolant Type	Part Number	Description
For *POWER COOL* IEG Coolant	23507545	4 Ounce (1 Pint Equivalent)
	23508425	8 Ounce (2 Pint Equivalent)
	23508426	12 Ounce (3 Pint Equivalent)
	23507189	16 Ounce (4 Pint Equivalent)
	23508427	32 Ounce (8 Pint Equivalent)
	23508428	53 Ounce (13 Pint Equivalent)

Table 30 *POWER COOL* 3000 Supplemental Additive Coolant Filters

POWER COOL Supplemental Additive Need Release Coolant Filters

Coolant Type	Part Number	Description
For *POWER COOL* IEG Coolant	23516488	For 0 – 8 Gallon Systems
	23516489	For 8 – 20 Gallon Systems

Table 31 *POWER COOL* SUPPLEMENTAL ADDITIVE NEED RELEASE COOLANT FILTERS

POWER COOL Plus Extended Life OAT Coolant

Coolant Type	Part Number	Description
Concentrated	23519397	1 Gallon Jug – 6 Per Case
	23519394	55 Gallon Drum
	23519395	Bulk Delivery – 1,000 Gallon Min.
Pre-Blended 50:50	23519396	One Gallon Jug – 6 Per Case
	23519398	55 Gallon Drum
	23519399	Bulk Delivery – 1,000 Gallon Min.
Pre-Blended 3070 Marine	23524676	55 Gallon Drum
	23524677	5 Gallon Pail

Table 32 *POWER COOL* Plus Extended Life OAT Coolant

POWER COOL Plus Extender for Use with *POWER COOL* Plus OAT Coolant

Coolant Type	Part Number	Description
For *POWER COOL* Plus	23519400	Quart Bottle – 6 Per Case

Table 33 *POWER COOL* Plus Extender for Use with *POWER COOL* Plus OAT Coolant

POWER COOL Plus 6000 OAT Inhibitor for Water-Only Systems

Coolant Type	Part Number	Description
Water Only	23522127	1 Gallon Jug – 6 Per Case
	23522128	5 Gallon Pail

Table 34 *POWER COOL* Plus 6000 OAT Inhibitor for Water-Only Systems

POWER COOL Cooling System Cleaners

Coolant Type	Part Number	Description
On-Line Cleaner	200164	One-Half Gallon Jug – 6 Per Case
	200105	5 Gallon Pail
	200155	55 Gallon Drum
Twin Pack	201549	Twin Pack – 2 Per Case

Table 35 *POWER COOL* Cooling System Cleaners

POWER Trac Coolant Testing and Analysis Products

Application	Part Number	Description
Indicates Nitrite, Molybdate & Glycol Levels	23519401	3-Way Coolant Test Strips (Single Foil Packs)
Indicates Nitrite, Molybdate & Glycol Levels	23519402	3-Way Coolant Test Strips (Bottle of 50)
Indicates Nitrite, Molybdate & Glycol Levels	23522774	3-Way Coolant Test Strips (Bottle of 10)
Complete IEG/IPG Coolant Analysis	23516921	Coolant Analysis Bottle (Carton of 6)
Organic Coolant Analysis	23523398	Laboratory Coolant Analysis Bottle (Carton of 6)

Table 36 POWER Trac Coolant Testing and Analysis Products

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