ENTEC WEST, INC.

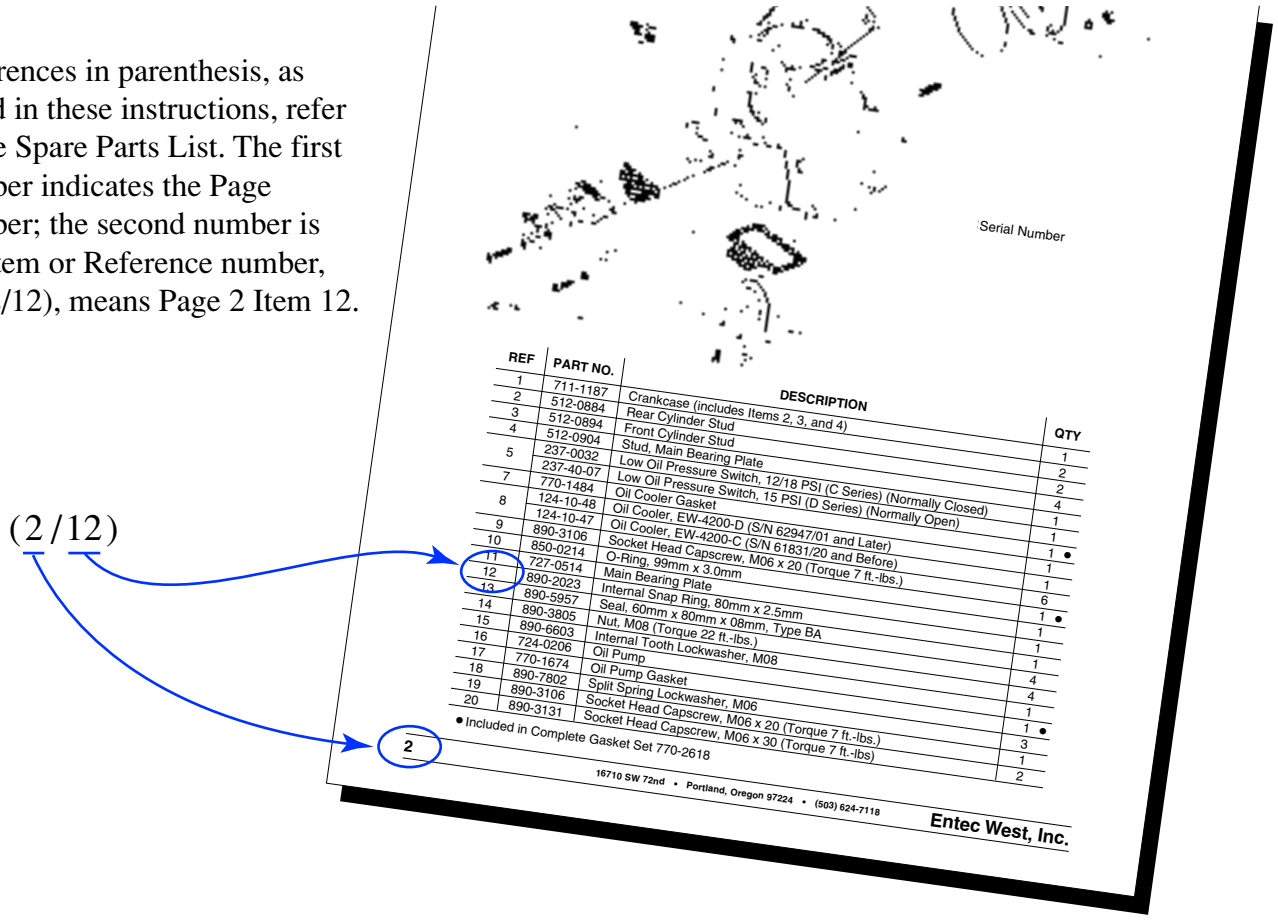
Marine Diesel Generators

Table of Contents

We congratulate you on your purchase of the Model EW-4200D generator. These operating instructions are based on the most recent state of development, and every possibile effort has been taken to exclude errors and omissions.

All those involved in the installation and operation of this unit should read the Installation Instructions and the Operating Instructions carefully, before installing and operating the generator. If any questions remain after reading these documents, we suggest you call the factory for further assistance.
1-800-458-5065

References in parenthesis, as noted in these instructions, refer to the Spare Parts List. The first number indicates the Page number; the second number is the Item or Reference number, ie: (2/12), means Page 2 Item 12.



The engine/generator has been thoroughly tested at the factory. All pertinent data including, but not limited to, oil pressure, output voltage, output current, and frequency, have been recorded in our permanent file system. All technical and/or service questions will be answered correctly, when the engine Serial Number is provided (2/0). When contacting us for assistance, please provide the Serial Number of your unit.

Serial Number

FUEL SYSTEM

In a normal installation, fuel is drawn out of the fuel tank through the primary “water/separator fuel filter” by the engine driven, diaphram type, Fuel Pump (3/50). From the Fuel Pump it goes first through the engine Fuel Filter (11/10), then to the Fuel Injection Pump (3/29).

It is important to know that most of the fuel delivered to the Fuel Injection Pump by the Fuel Pump, is surplus, and is returned to the fuel tank. The Fuel Pump is pumping at a rate of approximately 3.17 gallons per hour. The Fuel Injection Pump will only use 0.4 of a gallon per hour (when the generator is producing 30 amps of electrical power). The high volume of return flow provides a continuous cleaning action of the fuel through the vessel’s filter. This will help to keep the fuel in the tank clean.

WATER PUMPS

The Water Pumps are flexible impeller types. Each pump is complete and independent of the other, except the Raw Water Pump is “piggybacked” onto the Fresh Water Pump. The shaft tang of the Raw Water Pump extends beyond the pump housing and fits into the pump shaft slot of the Fresh Water Pump (21/0).

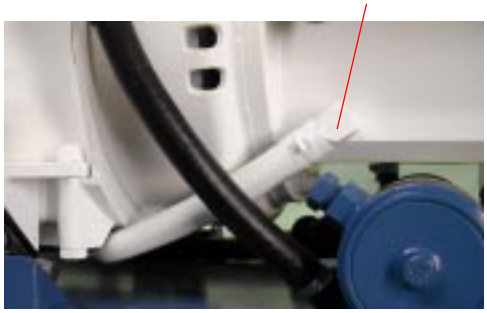
FRESH WATER COOLING SYSTEM

The cooling system is in two parts. The fresh water, closed loop system, and the raw water, open end system. The closed loop system uses a combination of fresh water and anti-freeze for the cooling medium. Beginning at the outlet of the Heat Exchanger (16/1), the coolant flows through the hose (16/17) into the rear, upper left corner of the Generator Housing (14/15).

Heat Exchanger Outlet

Generator Outlet

After circulating through the Generator Housing, it flows from the lower front, right side of the Generator Housing,



Input Side – Fresh Water Pump

through the Oil Cooler (2/8) in the base of the engine, to the input side of the Fresh Water Pump (front pump 15/9).

Bypass Tee

The pump pushes the coolant across the front of the engine to the Bypass Tee (15/17) connection on the cylinder. A portion of the mixture goes into the cylinder cooling passages, up through the cylinder ports (7/25) and into the cylinder head cooling chamber.

FRESH WATER COOLING SYSTEM (cont.)

The top of the Cylinder Head has a recess for the Thermostat (8/53). The coolant flow is held back until the Thermostat starts to open at approximately 170 degrees F.

As long as the Thermostat is closed, the excess flow will bypass the Cylinder and Cylinder Head, and go directly to the Reservoir (8/56) through the Bypass Hose (15/19).

Bypass Hose

Reservoir Outlet

When the Thermostat opens, the Cylinder and Cylinder Head flow goes through the thermostat and into the Reservoir, where it joins the bypass flow. From there the warm coolant returns to the Heat Exchanger (hose 16/16) where the accumulated heat is transferred to the raw water.

Reservoir Fill Plug

The closed loop cooling system has been charged, at the factory, with a 50/50 mixture of fresh water and permanent anti-freeze. The Reservoir (8/54), was specially designed to prevent over filling. The correct level is to the bottom of the threads. We recommend checking the level each time the oil is changed.

RAW WATER COOLING SYSTEM

The Raw Water Pump (rear half of 15/1) draws outside raw water from the sea cock and strainer and pushes it through a hose

Raw Water Inlet *Raw Water Outlet*

(16/13), into the Heat Exchanger (16/1). As it passes through the Heat Exchanger it absorbs heat from the fresh water coolant. The raw water is then discharged into the Exhaust Elbow where it is sprayed on the hot exhaust gases to cool them. It then flows with the exhaust gas into the typical "wet marine" exhaust system.

Exhaust Elbow Inlet

Heat Exchanger Inlet

CAUTION

Whenever the engine is cranked, the Raw Water Pump continues to pump water through the raw water system. With continued cranking, it is possible to fill the Exhaust Percolating Muffler, the Exhaust Hose, the Exhaust Elbow, and if the Exhaust Valve is open, the engine combustion chamber, with raw water. If the raw water is sea water, the damage to the engine can be severe. If this ever happens, corrective action must be taken at once. *If the engine will not start within 7 to 10 seconds, stop cranking!*

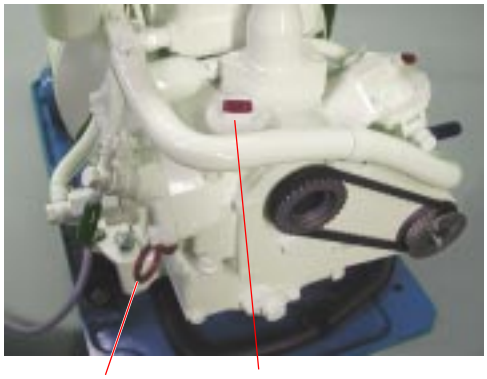
LUBRICATION

After the final test at the factory, the oil is removed from the engine to comply with Federal shipping laws. Therefore, it is necessary to put oil into the engine before attempting to start it.

The crankcase capacity is approximately 1.25 liters (1.33 quarts). The oil Dipstick has two marks on it (3/12). The upper one is the "full" mark and the lower one indicates "add oil." The distance between the two marks is equivalent to approximately 0.18 liters (0.19 quarts). *NEVER, NEVER,* overfill the engine. The best operating condition will be with the oil level slightly below the "full" mark.

The oil fill cap is located on the top of the gear cover (3/11). There is no oil filter on this engine.

The American Petroleum Institute classifies oil according to application. Within these classifications there are good, better, and outstanding oils for use in small diesel engines. We recommend a product marketed by Chevron Oil Co. called DELO-400. We suggest a multi-viscosity 15W-40 weight for all season use.



Dipstick *Oil Fill Cap*

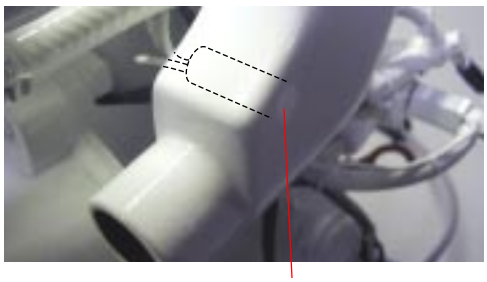
ENGINE CONTROL SYSTEM

The remote run/stop control for the engine is accomplished through the use of a special high pressure valve. When the valve is energized, it closes and the injection pump is allowed to deliver high pressure fuel to the injector. The engine is further controlled by three switches: water temperature, exhaust temperature, and oil pressure.

Water Temperature Switch. The water temperature switch (12/47) is located on the cylinder head. It is normally closed and will open when the engine coolant temperature rises to 185 degrees F. It will close again at approximately 160 degrees F.

Water Temperature Switch

Exhaust Temperature Switch. The exhaust temperature switch (16/19) is located in the casting wall of the Exhaust Elbow. It is normally closed and will open when the internal temperature of the elbow rises to 185 degrees F. It will close again at approximately 160 degrees F.



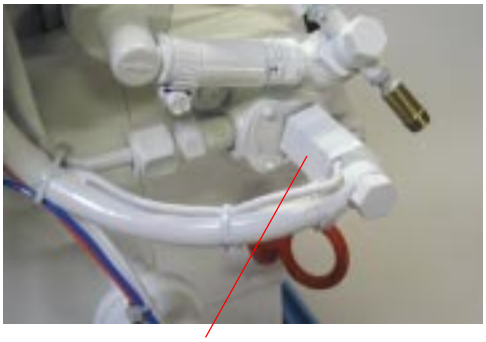
Exhaust Temperature Switch

Oil Pressure Switch. The oil pressure switch (2/5) is mounted on the left side of the engine, looking at the handcrank end. It is normally open and is set to close at 15 psi. It will open if the oil pressure falls below 12 psi.

Oil Pressure Switch

ENGINE CONTROL SYSTEM (cont.)

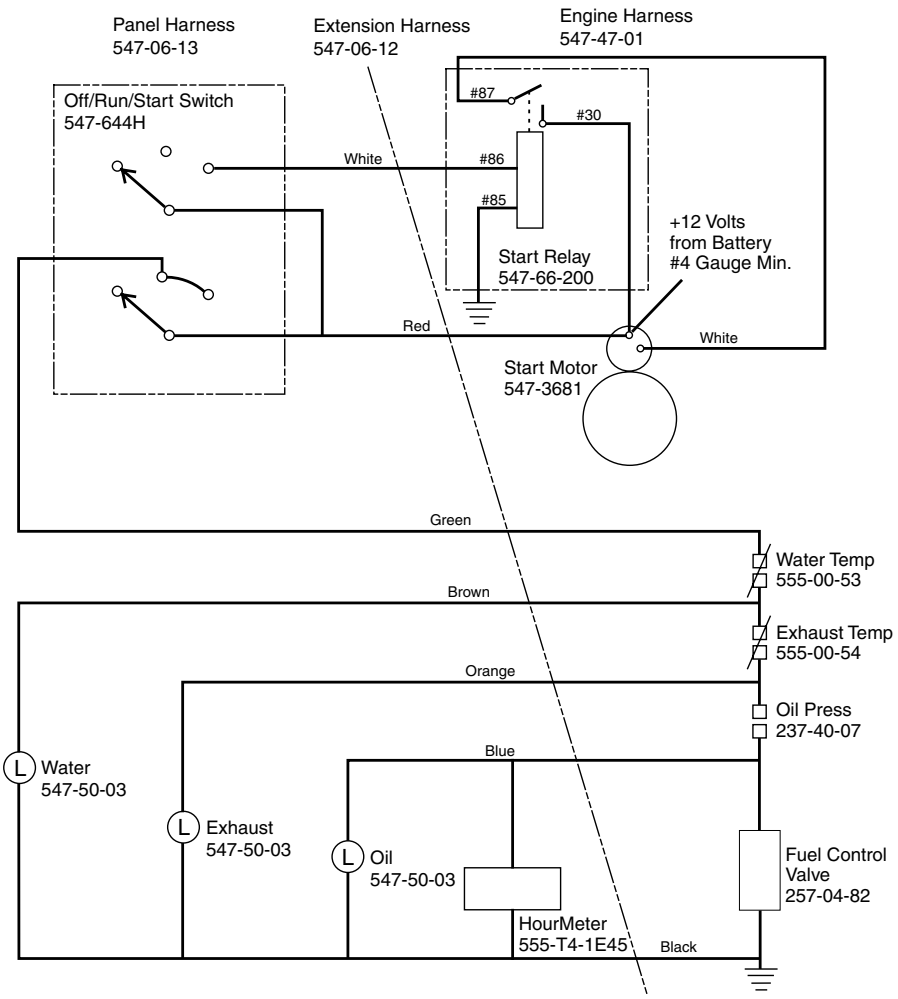
Fuel Control Valve. The Fuel Control Valve (6/18) is mounted on the Fuel Injection Pump. It is normally de-energized. In the de-energized position, the high pressure output from the Injection Pump is bypassed into the fuel return line. The injector does not receive fuel.



Fuel Control Valve

Off/Run/Start Switch. +12 volts is taken from the starter post, through the wiring harness (red wire), and applied to the terminals of the Off/Run/Start switch located on the control panel.

Run Position. When the Off/Run/Start switch is moved to the Run position, +12 volts is applied back through the harness (green wire) to one side of the water temperature switch. This switch is normally closed, so the +12 volts will pass through the switch to the exhaust temperature switch, and also through the harness (brown wire) to the water lamp. The water lamp will illuminate because the engine coolant temperature is below 185 degrees F.



Since the exhaust temperature switch is also closed, the +12 volts goes to the oil pressure switch, and also through the harness (orange wire) to the exhaust lamp. The exhaust lamp will illuminate because the exhaust temperature is also below 185 degrees F. The oil pressure switch is normally open, so the +12 volts will stop at this point with the two lamps illuminated.

ENGINE CONTROL SYSTEM (cont.)

Start Position. Moving the Off/Run/Start switch to the Start position allows +12 volts to flow the same as in the Run position. In addition, +12 volts flows through the harness (white wire) to the start relay (located on the top of the generator, by the start motor). With +12 volts applied, the relay energizes and the internal contacts close. The start motor begins to crank the engine and the internal oil pump begins to develop oil pressure and "floods" the bearings with oil.

When the oil pressure reaches 15 psi, the oil pressure switch closes. +12 volts then goes to the Fuel Control Valve, energizing it, and back to the panel through the harness (blue wire) to illuminate the oil lamp.

As soon as the Fuel Control Valve is energized, high pressure fuel is delivered to the injector, and the engine will start. The oil pump continues to deliver oil to the bearings and the oil pressure switch will stay closed. The hourmeter on the panel will also operate.

SAFETY STOPS

As described previously in the Off/Run/Start switch sequence, the entire switch and control system operates in series. If any one of the three switches opens, the circuit is broken and the engine will stop. Turning off the ship's 12 volt power will also stop the engine.

Understanding the Lamps

All Lamps Out. If the water temperature switch opens, because of high coolant temperature, the engine will stop and all of the lamps will go out.

Exhaust and Oil Lamps Out. If the exhaust temperature switch opens, because of high exhaust temperature, the engine will stop and the exhaust and oil lamps will go out.

Oil Lamp Out. If the engine oil pressure falls below 12 psi, the oil pressure switch will open. The engine will stop and the oil lamp will go out.

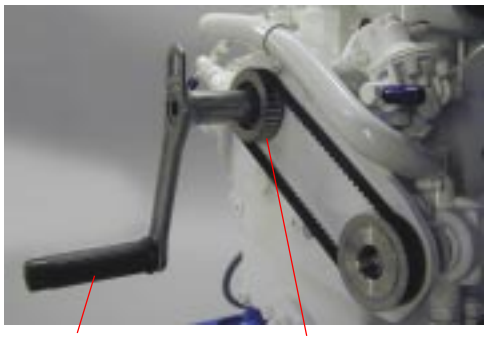
CAUTION: If battery power is turned off, the engine will stop!

STARTING THE ENGINE FOR THE FIRST TIME

Read and familiarize yourself with the description of the Engine Control System before attempting to start the engine (see System Descriptions).

Although the engine is shipped with the Injection Pump, high pressure line, Injector, and Fuel Transfer Pump filled with fuel, it is necessary to draw fuel from the vessel's tank to charge the primary filter and transfer pump fuel line. The following procedure will accomplish this and verify the system performance.

1. Place the Off/Run/Start switch in the Run position.
2. Place the Handcrank (20/6) into the Camshaft (3/45), located in the center of the Water Pump Drive Pulley. Rotate the crank counterclockwise until you feel hard resistance from the compression stroke.



Handcrank *Water Pump Drive Pulley*

3. Find the Fuel Transfer Pump (3/50) on the upper right side of the engine. Pump the Priming Lever for 20 to 30 strokes, in order to supply vessel fuel to the engine. Use the full movement of the lever. Only the *last few degrees* of motion will actually pump fuel.

Priming Lever

4. Locate the Compression Release Shaft (3/39) above the drive pulley. Note the small pin on the short shaft (the Compression Release Shaft) protruding from the side of the cam follower assembly. The pin should point toward the front of the engine (the 9 o'clock position) to indicate normal compression operation.

Small pin on the Compression Release Shaft

5. Place the Handcrank over the small pin on the Compression Release Shaft. Use the *first* slot in the tab on the Handcrank (it is the only slot that will fit in the 9 o'clock position). Rotate the pin and shaft to the 10:30 position (the Handcrank handle will stop against the valve cover). This locks the intake valve open and in the decompression mode — the engine will not return to the compression mode.

STARTING THE ENGINE FOR THE FIRST TIME (Continued)

CAUTION: CLOSE THE SEA COCK.

6. Put the Handcrank back into the Camshaft and rotate it counterclockwise. Crank fast enough to develop oil pressure. This will close the Oil Pressure Switch and make the oil light on the control panel come on. When this happens, power is applied to the Fuel Control Valve (6/18) and the Injection Pump is energized. Each time the rotation passes the position for fuel injection, the Injector will make a pronounced squeeking noise as it sprays fuel into the combustion chamber. If you do not hear the squeek, repeat the priming sequence (step 3) and try again.

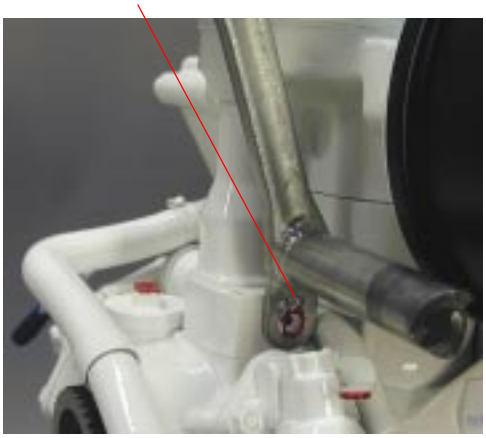
Oil Light on Control Panel

7. The next task is to return the engine to the normal compression mode. This will happen automatically when the Compression Release Shaft is rotated to unlock the intake valve.

   NOTE: This automatic feature will not function when the small pin points anywhere *between* the 9 o'clock and 12 o'clock positions.

   Use the *second* slot of the tab on the Handcrank to rotate the Compression Release Shaft to a position just past twelve o'clock (once again, the Handcrank will stop against the valve cover). This will program the Compression Release to index one step for each rotation of the camshaft. The Compression Release Shaft will index all the way around to the 9 o'clock position in approximately seven revolutions of the camshaft.

Handcrank – second slot



8. OPEN THE SEA COCK.

9. Put the Off/Run/Start switch on the control panel in the Start position. The engine will spin freely until the Camshaft completes the seven turns. On the seventh turn the Compression Release will reset itself to normal compression mode. When this happens, the engine will start. Quickly release the start switch and set it to the Run position.

   All three lights on the control panel should be illuminated and will remain so until the engine is stopped by the operator, or the safety system detects a problem (26/0).

NORMAL ENGINE STARTING

1. Place the Off/Run/Start switch on the control panel in the Start position. This feeds +12 volts to the Start Relay (located near the start motor) causing it to energize. The heavy internal contacts of the Start Relay close, and +12 volts is applied to the Start Solenoid on the Start Motor.

   The Start Motor cranks the engine, and two things happen simultaneously: the Oil Pump in the engine starts to pump oil into the galley; and oil flows to the bearings, lubricating them. The oil pressure rises from zero to the operating pressure. At 15 psi the Oil Pressure Switch closes and the +12 volts passes through the switch to the Fuel Control Valve energizing it, and to the oil light causing it to illuminate.

   As soon as the Fuel Control Valve is energized, high pressure fuel is delivered to the injector pipe and thus to the Injector. If the engine is operating normally, it will start in 3 to 7 seconds.

2. When it starts, quickly release the Start Switch and set it to the Run position. The control panel will show a “green board” (all lights green) and will remain green until the engine is stopped by the operator, or the safety system detects a problem (26/0).

Control Panel

CAUTION: If the engine has been properly maintained, and all of the external support systems, including raw water feed, fuel feed, battery power, etc., are functioning properly, the engine will normally start within 3 to 7 seconds. If the engine does not start within this time period, STOP and try only one more cranking attempt. DO NOT CONTINUE CRANKING ! ! !

GENERATING A.C. POWER

Starting the Engine

Start the engine and let it warm up for two or three minutes. Turn the ship's A.C. load off at the main breaker panel. Now turn the "Ship/Shore" switch to the SHIP or GEN position. Turn on some of the panel breaker switches until the generator is lightly loaded. Give the engine a few minutes to reach operating temperature, then load it to your electrical requirements.

Ship/Shore Switch on Optional Control Panel

Stopping the Engine

Before stopping the engine, switch off the individual A.C. loads and turn the "Ship/Shore" to the OFF or SHORE position. Let the engine run without load for three to five minutes so it can cool down.

> NOTE: If the unit has been operating under heavy load and stopped without a cooling off period, residual heat from the lower end of the engine can migrate upward and trip the Water Temperature Switch. If this happens, the alarm system will prevent re-starting the engine until it has completely cooled down.

EMERGENCY STOP

If the engine cannot be stopped by the remote control system it can be stopped manually with the Throttle Control (5/11). The control arm is located below the Fuel Transfer Pump. Rotate the arm clockwise to the stop and hold it there until the engine comes to a complete stop. Return the arm to the full counter-clockwise position after the engine stops.

> **CAUTION:** This is not a speed control. DO NOT! DO NOT! attempt to adjust this control.

Throttle Control Arm

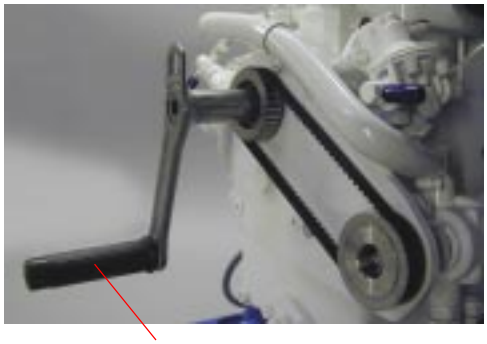
MANUAL HAND STARTING

Manual hand starting is similar, but not identical to, Starting the Engine for the First Time.

1. Follow steps 1 through 8 in Starting the Engine for the First Time.
2. Put the Off/Run/Start switch in the Run position.
3. Place the Handcrank in the Camshaft. Position your body to the front of the unit. Grasp the handcrank in your left hand and gently rotate it counterclockwise for two or three turns. This action will pre-lube the bearings.
3. Now crank energetically to build up inertia in the moving parts of the engine. Each time the handcrank makes one revolution, the compression release will automatically index one step. On the seventh turn the Compression Release will reset itself to normal compression mode. Do not slow down. Your body energy added to the inertia will help you pull through the compression stroke and create ignition. When this happens, the engine will start.

   All three lights on the control panel should be illuminated and will remain so until the engine is stopped by the operator, or the safety system detects a problem (26/0).

NOTE: Do not be afraid of the Handcrank. It will not back-fire. It will automatically disengage itself from the Camshaft. We suggest you try the manual start method for the first time when the engine is warm from running.



Handcrank on Camshaft

Control Panel

CHANGING THE OIL

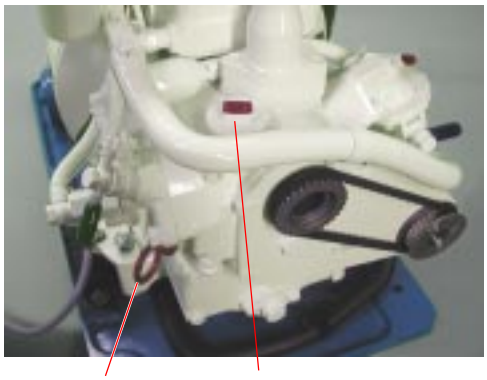
For best engine life, the oil should be changed every 75 to 100 hours, or annually, which ever occurs first.

The unit comes with a dipstick type oil pump for changing the oil. Start and run the engine for several minutes to get the oil warm. Stop the engine and remove the Dipstick. Insert the oil Dipstick Pump tube as deep into the engine as possible. Suck the oil out using the pump, and dispose of it according to EPA regulations.

Dipstick Oil Pump

Remove the oil Fill Cap and add one quart of approved oil. Replace the oil Fill Cap and Dipstick. Start the engine and let it run for one to two minutes. Stop the engine and check the level on the oil Dipstick. Adjust the level as necessary.

With practice, the amount of old oil removed will be just the right amount, so that adding one quart of new oil will bring the level up to the correct level.



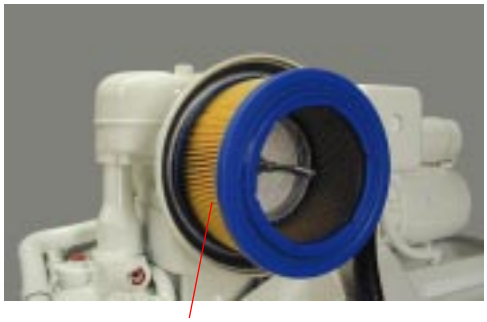
Dipstick *Oil Fill Cap*

Although there is an oil Drain Plug on the engine (3/15), it is too low on the generator to provide easy access for draining. Installation of an adapter at this location for drain pumps, etc. will automatically void the warranty.

Drain Plug – DO NOT USE!

AIR CLEANER

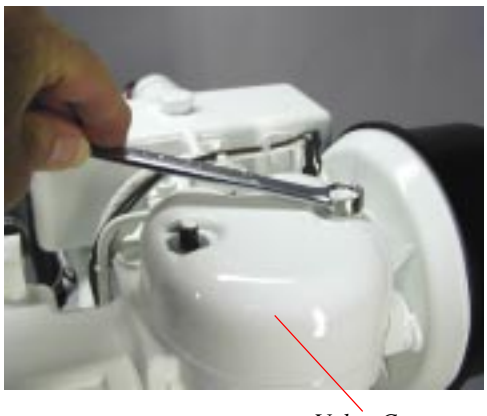
The Air Cleaner housing contains a dry element filter. Remove it and shake the accumulated dirt from it each time you change the oil. The element should be replaced every 250 to 300 hours.



Air Cleaner Element

VALVE ADJUSTMENT

The Intake and Exhaust Valve (8/4 & 11) clearance is set by the adjustments on the Rocker Arms (8/23 & 24). The adjustments must be made when the engine is at ambient temperature. Using a 13mm wrench, remove the two nuts and gaskets (8/44 & 41) on top of the Valve Cover (8/40). Gently lift the Valve Cover off the Cylinder Head.



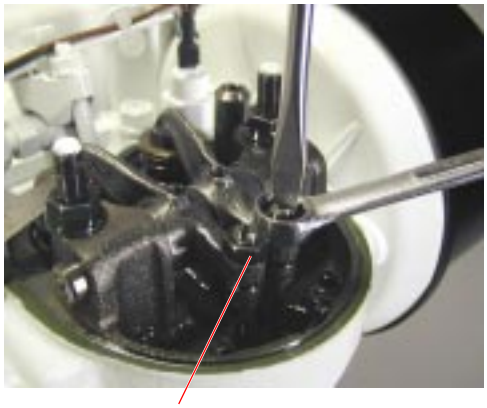
Valve Cover

Put the Handcrank into the Camshaft and rotate it counterclockwise until you feel hard resistance from compression. Check the gap between the valve stem and the anvil on the rocker with a feeler gauge. There should be a very slight drag with a .006 inch gauge.

Rocker Arm Anvil

If it is not correct, loosen the locknut (8/24) with an 11mm wrench. Adjust the clearance with a screwdriver in the slot of the adjustment screw (8/23). Hold the screw in position while tightening the locknut. Re-check the clearance. Both valves require the same clearance.

The valve clearance should be checked every 250 to 300 hours, or annually.



Locknut

HEAT EXCHANGER

The Heat Exchanger (16/1) utilizes cupro-nickel tubes. They should last for the life of the generator. However, the tubes can become clogged with silt and sea water contamination. To clean the tubes, remove the End Caps and gaskets on each end. Clear the tubes by pushing a stiff rod through them. Do not use a rod diameter greater than 11/64″.

The Heat Exchanger contains a sacrificial Zinc Insert in a plug (16/2). Examine it when checking the valve clearance and replace, as necessary. The Zinc is a readily available Type 1A.

Plug with Zinc Insert

Heat Exchanger End Cap

RAW WATER PUMP MAINTENANCE

The Impellers and Shaft Seals are normal wear items and do not have a “typical” life span. As such, it is common to change them on a regular basis; such as, with every other oil change. The condition of the raw water, ie: silt content, contamination, etc., contributes to the deterioration of these components and the frequency at which they should be replaced. The Impellers for both pumps are identical, but the Shaft Seals are different.

An exhaust temperature light going out (alarm) can indicate insufficient flow and therefore a worn raw water Impeller. The appearance of insufficient flow at the exhaust outlet can also suggest a worn raw water Impeller.

A falling coolant level, with no apparent leaks, can indicate a leaking raw water pump Seal (21/10). The engine coolant can follow the raw water pump shaft (21/2) through a worn Seal into the raw water pump chamber. Once in the raw water pump, the coolant will be pumped overboard with the waste raw water.

Impeller Removal

If it is necessary to replace the Seals or Impeller (21/4) in the raw water pump, follow these steps:

1. Clamp the raw water Outlet Hose (16/13) with vise grip pliers. This will prevent raw water from draining into the drip pan.
2. Remove the four screws (21/14) from the End Cap using a 7mm socket and 1/4″ drive ratchet. A box or open end wrench can also be used, but not as conveniently. Pull the End Cap (21/5) off the pump. Remove the paper Gasket (21/6).
4. Grip the Impeller with long nose pliers and pull the Impeller and Shaft assembly (21/2 & 4) out of the pump body. Remove the screw (21/13) from the Impeller and slide it off the Shaft.
5. Clean the deposits off the Shaft with 400 grit paper.

Impeller Installation

1. Remove the screw from the new Impeller. Lubricate the Shaft with light grease, put the new Impeller on the Shaft and insert the screw.
2. Lubricate the Impeller, vanes, front, back, and Shaft, with light grease. Insert the Shaft into the pump body and fold the vanes as necessary to insert the Impeller into the pump.
3. Lubricate both sides of a new Gasket and place it onto the body. Align the End Cap with the body and press it onto the Shaft. Install the screws and tighten them evenly.
   DO NOT OVER TIGHTEN THE SCREWS!

HOW COMPRESSION IGNITION WORKS

In a four cycle engine, four strokes of the piston are required to complete one cycle; Intake, Compression, Power, and Exhaust. With only one stroke providing power, a heavy rotating flywheel keeps the crankshaft turning through the other three strokes.

Intake Stroke. When the intake valve (8/4) is open and the piston (7/15) is pulled downward in the cylinder (7/27), air is drawn into the cylinder and fills the volume above the piston (intake stroke).

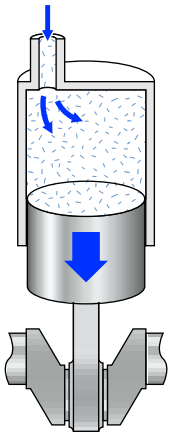
Compression. At the bottom of the stroke, the intake valve closes and the piston is pushed up toward the cylinder head. The trapped air is compressed into a small volume (the cup in the top of the piston) and heat is generated due to this compression. The smaller the volume the more heat is generated. When the heat in the compressed air can be concentrated in the piston cup so that it cannot escape into the cylinder walls, etc., the temperature of the compressed air will get *very* high.

Power Stroke. At the top of the compression stroke the fuel is sprayed into the very hot compressed air and ignites. As the fuel burns, the hot combusted gases expand, forcing the piston down. The force applied to the top of the piston in the downward motion is converted into rotary motion by the connecting rod and the crankshaft. This is called the power stroke.

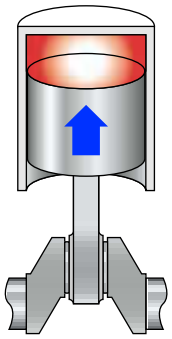
Exhaust Stroke. At the bottom of the power stroke, the exhaust valve (8/11) is opened and as the piston comes back up, the burned gases are expelled into the exhaust elbow (16/6). When the piston is back at the top, the exhaust valve closes, the intake valve opens, and the whole cycle is repeated. This is called a four cycle engine.

Piston Cup Design. The unique "cup" design in the top of the piston helps to contain the "heat of compression," and is what gives our engine the ability to start without the aid of glow plugs and/or heaters. It also makes it possible to start the engine with a handcrank.

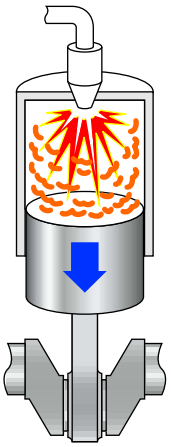
Piston Cup



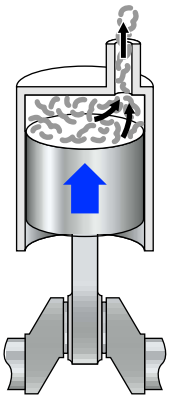
Intake



Compression



Power



Exhaust

Injection Pump and Injector. The injection pump is like a miniature piston and cylinder with a special valve. When the miniture piston is pulled down, fuel is drawn into the cylinder. When the piston is pushed up, the fuel is forced through a special check valve and into the high pressure pipe (11/11) leading to the injector. The pipe is full of fuel, so whatever quantity is forced into the pipe at the injection pump end, must come out at the injector end and into the injector. The injector is a special combination check valve and atomizer that will open when the pressure in the pipe reaches 2,900 psi. The injector has a tip with tiny holes that causes the fuel to be sprayed as a fine mist, or atomized. At the top of the compression stroke the fuel is sprayed into the very hot compressed air and ignites.

Ignition Temperature. To reach ignition temperatures during the compression stroke, the piston must travel at a fast enough speed to prevent the loss of heat. A weak battery, or dirty cable terminals, etc. will not turn the engine fast enough to prevent the heat loss.

The same is true for hand cranking speed. A timid hand cranker will never start the engine by hand.

Fuel Efficiency. The injection pump is controlled by the engine governor (7/12 & 13) and throttle control (5/1 –13) system that tells the injection pump how much fuel should be delivered to the injector. This quantity is established every single time the engine reaches the end of the compression stroke. You can think of the fuel flow as a series of fuel "slugs," happening at a rate of 1,800 times per minute for our 60 cycle generator. The injection pump always delivers just the right quantity fuel that the governor demands, to produce the horsepower needed, to make the exact amount of electrical power the vessel needs at any given point in time.

If the generator load was 30 amps, then calculate 0.4 gallon per hour fuel consumption, divided by 60 minutes per hour, and divide that by 1,800 injection pulses per minute, and you can get an idea of how small each "slug" of fuel is.

For Example: 231 cubic inches of fuel in a gallon, multiplied by 0.4, divided by 60, then divided by 1800, equals 0.00086 cubic inches of fuel per "slug".

$$231 \times 0.4 \div 60 \div 1800 = 0.00086$$

If the load was 10 amps, the "slug" would be approximately 1/3 of 0.00086 cubic inches, or 0.00029 cubic inches.