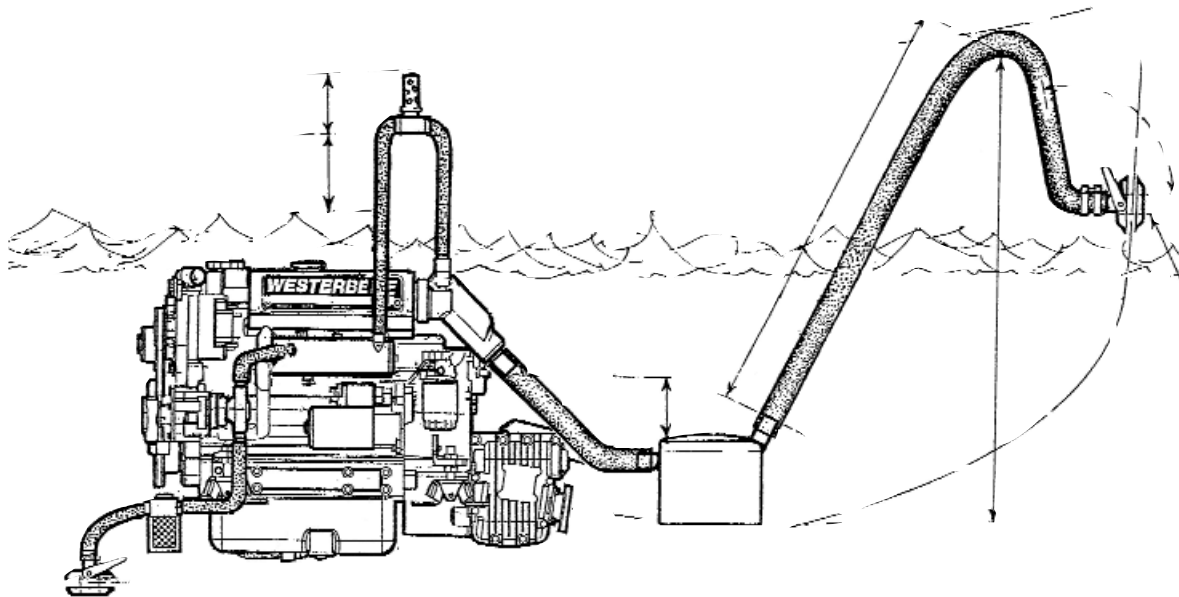




INSTALLATION MANUAL

MARINE ENGINES/GENERATORS

DIESEL AND GASOLINE



PUBLICATION #43268

2nd Edition

May 2004



WESTERBEKE CORPORATION • 150 JOHN HANCOCK ROAD
MYLES STANDISH INDUSTRIAL PARK • TAUNTON MA 02780
WEBSITE: WWW.WESTERBEKE.COM



Member National Marine Manufacturers Association

Gasoline with an ETHANOL content higher than 10% (E10) is **not allowed and may void warranty.**



 WESTERBEKE™
Engines & Generators

**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.

WARNING:

Exhaust gasses contain Carbon Monoxide, an odorless and colorless gas. Carbon Monoxide is poisonous and can cause unconsciousness and death. Symptoms of Carbon Monoxide exposure can include:

- *Dizziness*
- *Nausea*
- *Headache*
- *Weakness and Sleepiness*
- *Throbbing in Temples*
- *Muscular Twitching*
- *Vomiting*
- *Inability to Think Coherently*

IF YOU OR ANYONE ELSE EXPERIENCE ANY OF THESE SYMPTOMS, GET OUT INTO THE FRESH AIR IMMEDIATELY. If symptoms persist, seek medical attention. Shut down the unit and do not restart until it has been inspected and repaired.



A WARNING DECAL is provided by WESTERBEKE and should be fixed to a bulkhead near your engine or generator. WESTERBEKE also recommends installing CARBON MONOXIDE DETECTORS in the living/sleeping quarters of your vessel. They are inexpensive and easily obtainable at your local marine store.

SAFETY INSTRUCTIONS

INTRODUCTION

Read this safety manual carefully. Most accidents are caused by failure to follow fundamental rules and precautions. Know when dangerous conditions exist and take the necessary precautions to protect yourself, your personnel, and your machinery.

The following safety instructions are in compliance with the American Boat and Yacht Council (ABYC) standards.

PREVENT ELECTRIC SHOCK

▲ WARNING: Do not touch AC electrical connections while engine is running, or when connected to shore power. Lethal voltage is present at these connections!

- Do not operate this machinery without electrical enclosures and covers in place.
- Shut off electrical power before accessing electrical equipment.
- Use insulated mats whenever working on electrical equipment.
- Make sure your clothing and skin are dry, not damp (particularly shoes) when handling electrical equipment.
- Remove wristwatch and all jewelry when working on electrical equipment.
- Do not connect utility shore power to vessel's AC circuits, except through a ship-to-shore double throw transfer switch. Damage to vessel's AC generator may result if this procedure is not followed.
- Electrical shock results from handling a charged capacitor. Discharge capacitor by shorting terminals together.

PREVENT BURNS — HOT ENGINE

▲ WARNING: Do not touch hot engine parts or exhaust system components. A running engine gets very hot!

- Always check the engine coolant level at the coolant recovery tank.

▲ WARNING: Steam can cause injury or death!

- In case of an engine overheat, allow the engine to cool before touching the engine or checking the coolant.

PREVENT BURNS — FIRE

▲ WARNING: Fire can cause injury or death!

- Prevent flash fires. Do not smoke or permit flames or sparks to occur near the carburetor, fuel line, filter, fuel pump, or other potential sources of spilled fuel or fuel vapors. Use a suitable container to catch all fuel when removing the fuel line, carburetor, or fuel filters.
- Do not operate with a Coast Guard Approved flame arrester removed. Backfire can cause severe injury or death.
- Do not operate with the air cleaner/silencer removed. Backfire can cause severe injury or death.
- Do not smoke or permit flames or sparks to occur near the fuel system. Keep the compartment and the engine/generator clean and free of debris to minimize the chances of fire. Wipe up all spilled fuel and engine oil.
- Be aware — diesel fuel will burn.

PREVENT BURNS — EXPLOSION

▲ WARNING: Explosions from fuel vapors can cause injury or death!

- Follow re-fueling safety instructions. Keep the vessel's hatches closed when fueling. Open and ventilate cabin after fueling. Check below for fumes/vapor before running the blower. Run the blower for four minutes before starting your engine.
- All fuel vapors are highly explosive. Use extreme care when handling and storing fuels. Store fuel in a well-ventilated area away from spark-producing equipment and out of the reach of children.
- Do not fill the fuel tank(s) while the engine is running.
- Shut off the fuel service valve at the engine when servicing the fuel system. Take care in catching any fuel that might spill. DO NOT allow any smoking, open flames, or other sources of fire near the fuel system or engine when servicing. Ensure proper ventilation exists when servicing the fuel system.
- Do not alter or modify the fuel system.
- Be sure all fuel supplies have a positive shutoff valve.
- Be certain fuel line fittings are adequately tightened and free of leaks.
- Make sure a fire extinguisher is installed nearby and is properly maintained. Be familiar with its proper use. Extinguishers rated ABC by the NFPA are appropriate for all applications encountered in this environment.

SAFETY INSTRUCTIONS

ACCIDENTAL STARTING

▲ WARNING: Accidental starting can cause injury or death!

- Disconnect the battery cables before servicing the engine/generator. Remove the negative lead first and reconnect it last.
- Make certain all personnel are clear of the engine before starting.
- Make certain all covers, guards, and hatches are re-installed before starting the engine.

BATTERY EXPLOSION

▲ WARNING: Battery explosion can cause injury or death!

- Do not smoke or allow an open flame near the battery being serviced. Lead acid batteries emit hydrogen, a highly explosive gas, which can be ignited by electrical arcing or by lit tobacco products. Shut off all electrical equipment in the vicinity to prevent electrical arcing during servicing.
- Never connect the negative (-) battery cable to the positive (+) connection terminal of the starter solenoid. Do not test the battery condition by shorting the terminals together. Sparks could ignite battery gases or fuel vapors. Ventilate any compartment containing batteries to prevent accumulation of explosive gases. To avoid sparks, do not disturb the battery charger connections while the battery is being charged.
- Avoid contacting the terminals with tools, etc., to prevent burns or sparks that could cause an explosion. Remove wristwatch, rings, and any other jewelry before handling the battery.
- Always turn the battery charger off before disconnecting the battery connections. Remove the negative lead first and reconnect it last when servicing the battery.

BATTERY ACID

▲ WARNING: Sulphuric acid in batteries can cause severe injury or death!

- When servicing the battery or checking the electrolyte level, wear rubber gloves, a rubber apron, and eye protection. Batteries contain sulfuric acid which is destructive. If it comes in contact with your skin, wash it off at once with water. Acid may splash on the skin or into the eyes inadvertently when removing electrolyte caps.

TOXIC EXHAUST GASES

▲ WARNING: Carbon monoxide (CO) is a deadly gas!

- Ensure that the exhaust system is adequate to expel gases discharged from the engine. Check the exhaust system regularly for leaks and make sure the exhaust manifolds/water-injected elbow is securely attached.
- Be sure the unit and its surroundings are well ventilated. Run blowers when running the generator set or engine.
- Do not run the generator set or engine unless the boat is equipped with a functioning marine carbon monoxide detector that complies with ABYCA-24. Consult your boat builder or dealer for installation of approved detectors.
- For additional information refer to ABYC T-22 (educational information on Carbon Monoxide).

▲ WARNING: Carbon monoxide (CO) is an invisible odorless gas. Inhalation produces flu-like symptoms, nausea or death!

- Do not use copper tubing in diesel exhaust systems. Diesel fumes can rapidly destroy copper tubing in exhaust systems. Exhaust sulfur causes rapid deterioration of copper tubing resulting in exhaust/water leakage.
- Do not install exhaust outlet where exhaust can be drawn through portholes, vents, or air conditioners. If the engine exhaust discharge outlet is near the waterline, water could enter the exhaust discharge outlet and close or restrict the flow of exhaust. Avoid overloading the craft.
- Although diesel engine exhaust gases are not as toxic as exhaust fumes from gasoline engines, carbon monoxide gas is present in diesel exhaust fumes. Some of the symptoms or signs of carbon monoxide inhalation or poisoning are:

Vomiting	Inability to think coherently
Dizziness	Throbbing in temples
Headache	Muscular twitching
Nausea	Weakness and sleepiness

AVOID MOVING PARTS

▲ WARNING: Rotating parts can cause injury or death!

- Do not service the engine while it is running. If a situation arises in which it is absolutely necessary to make operating adjustments, use extreme care to avoid touching moving parts and hot exhaust system components.


SAFETY INSTRUCTIONS

- Do not wear loose clothing or jewelry when servicing equipment; avoid wearing loose jackets, shirts, sleeves, rings, necklaces or bracelets that could be caught in moving parts.
- Make sure all attaching hardware is properly tightened. Keep protective shields and guards in their respective places at all times.
- Do not check fluid levels or the drive belts' tension while the engine/generator is operating.
- Stay clear of the drive shaft and the transmission coupling when the engine is running; hair and clothing can easily be caught in these rotating parts.

HAZARDOUS NOISE

 **WARNING: High noise levels can cause hearing loss!**

- Never operate a generator without its muffler installed.
- Do not run an engine with the air intake (silencer) removed.
- Do not run engines or generators for long periods with their enclosures open.

 **WARNING: Do not work on machinery when you are mentally or physically incapacitated by fatigue!**

OPERATORS MANUAL

Many of the preceding safety tips and warnings are repeated in your Operators Manual along with other cautions and notes to highlight critical information. Read your manual carefully, maintain your equipment, and follow all safety procedures.

GASOLINE ENGINE AND GENERATOR INSTALLATIONS

Preparations to install an engine should begin with a thorough examination of the American Boat and Yacht Council's (ABYC) standards. These standards are a combination of sources including the USCG and the NFPA.

Sections of the ABYC standards of particular interest are:

- H-2 Ventilation
- P-1 Exhaust Systems
- P-4 Inboard Engines
- E-9 DC Electrical Systems

All installations must comply with the Federal Code of Regulations (FCR).

ABYC, NFPA AND USCG PUBLICATIONS FOR INSTALLING DIESEL ENGINES

Read the following ABYC, NFPA and USCG publications for safety codes and standards. Follow their recommendations when installing your engine.

ABYC (American Boat and Yacht Council)
"Safety Standards for Small Craft"

Order from:

ABYC
3069 Solomon's Island Rd.
Edgewater, MD 21037

NFPA (National Fire Protection Association)
"Fire Protection Standard for Motor Craft"

Order from:

NFPA
11 Tracy Drive
Avon Industrial Park
Avon, MA 02322

USCG (United States Coast Guard)
"USCG 33CFR183"

Order from:

U.S. Government Printing Office
Washington, D.C. 20404

INSTALLATION

When installing WESTERBEKE engines and generators it is important that strict attention be paid to the following information:

CODES AND REGULATIONS

Strict federal regulations, ABYC guidelines, and safety codes must be complied with when installing engines and generators in a marine environment.

SIPHON-BREAK

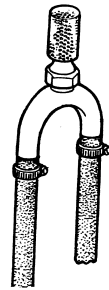
For installations where the exhaust manifold/water injected exhaust elbow is close to or will be below the vessel's waterline, provisions must be made to install a siphon-break in the raw water supply hose to the exhaust elbow. This hose must be looped a minimum of 20" above the vessel's waterline. ***Failure to use a siphon-break when the exhaust manifold injection port is at or below the load waterline will result in raw water damage to the engine and possible flooding of the boat.***

If you have any doubt about the position of the water-injected exhaust elbow relative to the vessel's waterline under the vessel's various operating conditions, ***install a siphon-break.***

NOTE: *A siphon-break requires periodic inspection and cleaning to ensure proper operation. Failure to properly maintain a siphon-break can result in catastrophic engine damage. Consult the siphon-break manufacturer for proper maintenance.*

EXHAUST SYSTEM

The exhaust hose must be certified for marine use. The system must be designed to prevent water from entering the exhaust under any sea conditions and at any angle of the vessels hull.



AVAILABLE FROM
YOUR WESTERBEKE
DEALER

A detailed 40 page Marine Installation Manual covering gasoline and diesel, engines and generators, is available from your WESTERBEKE dealer.

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INTRODUCTION

This marine Installation Manual covers all WESTERBEKE Engine and Generator models, both diesel and gasoline. The purpose of this manual is to provide boatyards and installers who are already familiar with installation procedures, additional detailed installation instructions to ensure the safest and most efficient operating conditions. These instructions may vary due to the many WESTERBEKE Engines and Generators available and the diversity of boat designs.

Proper location and installation of the engine or generator in the vessel are of prime importance. Factors in the installation that must be considered are:

1. **Ventilation**, to provide air for engine combustion and to remove heat produced by the engine/generator while operating.
2. **Exhaust System**, to properly discharge cooling water, quiet the exhaust, and expel exhaust gas. Install a siphon-break.
3. **Cooling Water Supply**, to cool the engine with a continuous flow of filtered raw water.
4. **Fuel System**, to provide an unrestricted fuel supply and properly filtered fuel to the fuel pump.
5. **Electrical Connections**, both AC and DC and proper grounding.
6. **Transmission Propeller Connections** (Engines only)

Please read this manual carefully and observe the safety precautions. Should your engine or generator require servicing, contact your WESTERBEKE dealer. For Serial Number location, Decal information or Parts Ordering information, refer to your WESTERBEKE Operators Manual.

INSTALLATION CODES AND SAFETY STANDARDS

Recommended publications concerning Safety Codes and standards are listed in this safety section. Following is a summary of what these standards include. Both the *U.S. Code* (USC), which are the laws passed by Congress, and the *Code of Federal Regulations* (CFR), which are agency generated rules, contain pertinent information.

Title 46 Chapter 43 of the USC applies specifically to recreational vessels. It gives the Secretary of Transportation the authority to set the standards for boats that are manufactured and operated in the United States. It also spells out the penalties for violation of the standards.

According to *Title 46 USC 4307*, a person may not manufacture, construct, assemble, offer for sale, introduce into interstate commerce, or import into the United States any recreational vessel that does not comply with the federal regulations. Any associated equipment or component used on one of these vessels must also be in compliance. Further, a person is prohibited from operating any vessel that does not comply with the regulations.

Within the CFRs are the detailed requirements applicable to boats with gasoline engines. The majority of requirements pertinent to recreational vessels are contained in *33 CFR Part 183*.

- *Subpart I—Electrical Systems 183.401–183.460*
- *Subpart J—Fuel Systems 183.501–183.572*
- *Subpart K—Ventilation 183.601–183.630*

Standards for marine carburetors and the requirements for the backfire flame arrester are contained in *46 CFR Subparts 25.35 and 58.10*. Also within *Subpart 58.10* are the exhaust manifold and exhaust system requirements for both gasoline and diesel engine installations. Several publications that address these federal mandates, making compliance easier, include:

- The USCG *Fuel System, Electrical System and Ventilation Compliance Guidelines*
- The USCG *Safety Standards for Backyard Boat Builders*
- The National Fire Prevention Association *NFPA–302 Fire Protection Standard for Pleasure and Commercial Motor Craft*
- The ABYC *Standards and Recommended Practices for Small Craft*

The ABYC Standards Manual is the most comprehensive and widely used reference. ABYC constantly revises and updates its “projects,” as it calls each topic section. The manual is easy to read and quite detailed. Adherence with these standards will put the recreational boater in compliance with federal mandates. Anyone considering installing an engine or generator should start with a thorough review of these standards:

- *H-2—Ventilation of Boats Using Gasoline*
- *H-24—Gasoline Fuel Systems*
- *P-1—Installation of Exhaust Systems*
- *P-4—Marine Inboard Engines*
- *E-9—DC Electrical Systems Under 50 Volts*

USCG “inspected vessels,” especially those carrying passengers for hire, are required to meet even more stringent standards than those discussed above. A very thorough review of the applicable CFRs is necessary before the Coast Guard arrives for their inspection.

Recommended Reading

For added information on installing Marine Engines and Generators, WESTERBEKE recommends the following books:

- *Elements of Yacht Design – Skene*
- *Marine Engines – Calder*
- *The Propeller Handbook – Gerr*

INTRODUCTION

PRODUCT SOFTWARE

Product software, (tech data, parts lists, manuals, brochures and catalogs) provided from sources other than WESTERBEKE are not within WESTERBEKE's control.

WESTERBEKE CANNOT BE RESPONSIBLE FOR THE CONTENT OF SUCH SOFTWARE, MAKES NO WARRANTIES OR REPRESENTATIONS WITH RESPECT THERETO, INCLUDING ACCURACY, TIMELINESS OR COMPLETENESS THEREOF, AND WILL IN NO EVENT BE LIABLE FOR ANY TYPE OF DAMAGE OR INJURY INCURRED IN CONNECTION WITH OR ARISING OUT OF THE FURNISHING OR USE OF SUCH SOFTWARE.

WESTERBEKE customers should also keep in mind the time span between printings of WESTERBEKE product software and the unavoidable existence of earlier WESTERBEKE manuals. In summation, product software provided with WESTERBEKE products, whether from WESTERBEKE or other suppliers, must not and cannot be relied upon exclusively as the definitive authority on the respective product. It not only makes good sense but is imperative that appropriate representatives of WESTERBEKE or the supplier in question be consulted to determine the accuracy and currentness of the product software being consulted by the customer.

NOTES, CAUTIONS AND WARNINGS

As this manual takes you through the installation procedures for your engine/generator, critical information will be highlighted by NOTES, CAUTIONS, and WARNINGS. An explanation follows:

NOTE: *An operating procedure essential to note.*

▲ CAUTION: *Procedures which, if not strictly observed, can result in the damage or destruction of your engine.*

▲ WARNING: *Procedures which, if not properly followed, can result in personal injury or loss of life.*

INSPECTION OF SHIPMENT

The engine/generator is shipped from the factory securely mounted and properly crated. Accessory equipment is shipped in a separate small box, usually packed within the engine's crate.

Before accepting shipment of the engine from the transportation company, the crate should be opened and the contents inspected for damage. If there is either visible or concealed damages, you should require the delivery agent to write "Received in damaged condition" on the delivery receipt. Also compare the contents of the shipment against the packing list and make sure that any discrepancies are properly noted. This is your protection against loss or damage. Claims concerning loss or damage must be made to the *carrier*, not to WESTERBEKE Corporation.

NOTE: *For safety reasons, the engine is NOT filled with lubricating oil for shipment. Before leaving the factory, however, each engine/generator is thoroughly tested with oil in its engine. This testing, among other things, provides all internal parts with a coating of oil. This oil acts as a preservative, providing reliable protection against corrosion for at least one year if the engine/generator is properly stored.*

ENGINE LOCATION AND MOUNTING

ENGINE LOCATION

The overall layout of the engine room should be planned for easy inspection, servicing, and handling of the engine. Thoroughly study all the equipment to be installed and make a paper plan to provide optimum engine room space. Consider the following:

- 1. Ventilation** – Since an increase in engine room temperature causes a reduction in the intake air and thus a drop in engine output, ventilation inside the engine room must be ample. See your Operators Manual for the ventilation requirements for your engine/generator.
 - a. Dimension and capacity with a ventilator installed
 - b. Dimension and capacity with an intake duct installed
- 2. Engine Room Height** – For engines having a top oil fill, the distance from the oil cap at the top of the rocker cover to the overhead must be enough that oil can easily be added.
- 3. Space to move the propeller shaft flange** – Allow approximately 3 - 4 in (7.7 - 10.0 cm) of space to move the flange toward the stern for changing the transmission, etc.
- 4. Exhaust System** – Make sure there is adequate space for all exhaust system components, including the exhaust silencer. See the *BASIC EXHAUST SYSTEMS* section in this manual.

ENGINE BED

A strong mounting bed contributes to the satisfactory alignment and operating of the engine. The bed must be rigidly constructed, and neither deflect nor twist when it is subjected to the engine's weight or to the pressures that the boat may experience while operating in rough seas. The bed must be strong enough to keep the engine's alignment within one or two thousandths of an inch at all times. The bed has to withstand the forward push of the propeller shaft. It is also critical that the beds are parallel to one another and to the line of the propeller shaft when viewed from above. They also must be offset an equal distance from the line of the propeller shaft.

In fiberglass hulls, we recommend that solid wooden support stringers similar to those in wooden hulls be formed and fitted, then glassed securely to the hull. This will allow the hanger bolts to be installed firmly in the wood, thereby reducing noise and transmitted vibration.

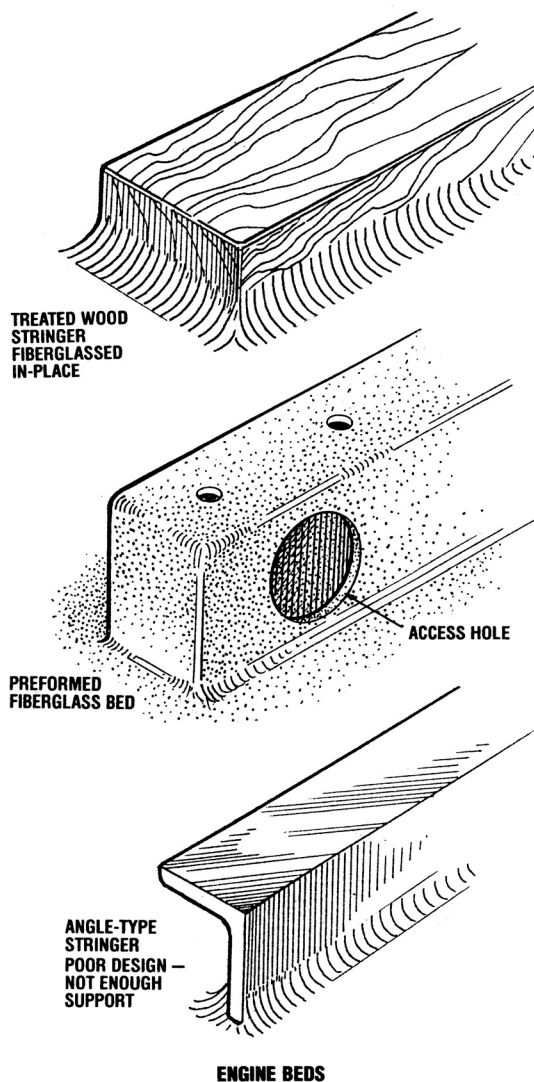
The stringers must be as wide or wider than the engine mounting isolator. Avoid excessive height. Isolator overhang and/or rounded stringer surfaces are detrimental to the flexible mounts' ability to retain vibration.

Supports between the bed stringers and supports extending at right angles from the stringers to the hull may be required for proper strength and to aid in the absorption of vibrations.

The engine bed must be constructed so that a wrench can be set at the engine base to retighten the engine mounting bolts at the mounting feet.

Many boat manufacturers are now providing preformed fiberglass mounting beds for their engine installations. These beds, when used, should be of sufficient thickness for proper support and should be well-glassed to the hull when installed.

Avoid the temptation to install the engine on a pair of angle irons glassed in place. Such a construction will allow vibration to pass through to the hull. Flexible engine mounts require a firm foundation.



When preparing the engine load, also plan out and build an engine drip pan. To simplify cleaning up after oil changes, consider a separate drip pan for use under the oil and fuel filters.

SSB RADIO/ELECTRONIC GROUNDING

If your boat needs a ground plane for a radio and other electronic gear, this is the ideal time to bond a substantial area of copper mesh into the base of the engine space while it is accessible.

ENGINE LOCATION AND MOUNTING

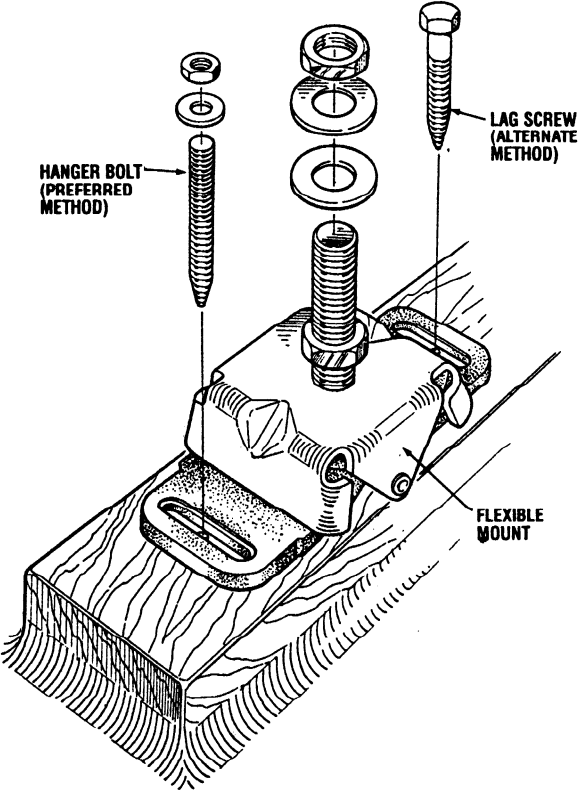
ENGINE MOUNTING

Bronze or stainless steel hanger bolts of appropriate size are recommended for use through the engine's flexible mounts. Less preferred are lag screws because their hold on the wood is weakened every time they are moved, whereas hanger bolts stay in position. If the nut on top of the hanger bolt is removed to allow the engine to be lifted, the hanger bolt itself remains in place as a stud. Consequently, the bond between the hanger bolt and the wood is not weakened by the removal of the nut or the engine.

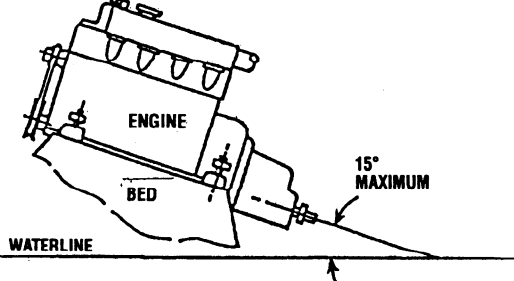
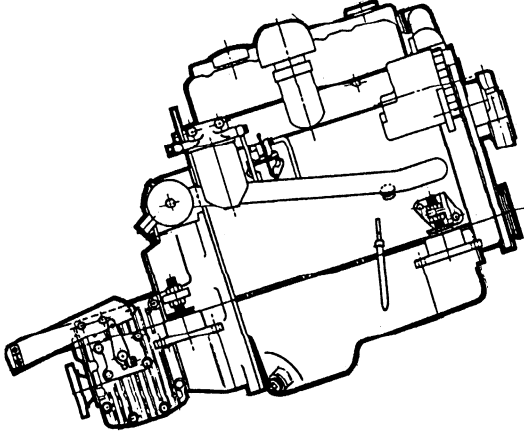
To screw a hanger bolt onto a stringer, thread two nuts onto the hanger bolt, jam them together, then turn the hanger bolt into the stringer using a wrench on the uppermost nut.

The engine's mounting angle cannot exceed 15° from the horizontal plane. Refer to the specification section in your operating manual for the angle limit of your engine.

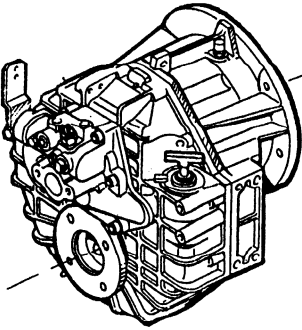
NOTE: There are various transmissions that provide down angle output flanges to help in positioning the engine on a more level plane.



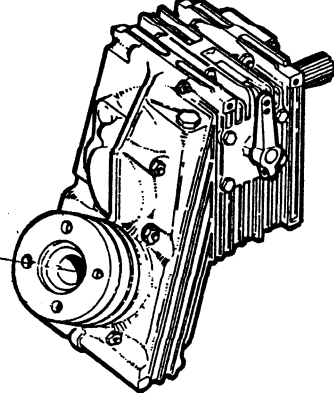
ENGINE MOUNTING



ENGINE'S MOUNTING ANGLE



OFFSET



V-DRIVE

TRANSMISSIONS

GENERATOR LOCATION AND MOUNTING

GENERATOR LOCATION

A solid, level mounting platform is very important for the proper operation of your generator. Select a location that will allow adequate space on all sides for ventilation and servicing, preferably on, and parallel with, the keel or vessel center line. Keep the generator away from living quarters, and away from bilge splash and vapors.

Make sure there is room to access the following service points:

- Negative and positive battery connections
- Fuel inlet and outlet connections
- Oil fill and oil drain hose
- Raw water inlet and outlet
- Location of the (owner supplied) fuel/water fuel filter.

A generator will rock on its mounts in rough seas, therefore clearance is necessary on all sides. Larger generators require up to a three-inch (76mm) clearance.

Avoid supporting the generator from bulkheads which can create drumming effects and transmit noise and vibration throughout the boat.

Generator location is preferable in the same room or compartment as the propulsion engine, as this is usually a well ventilated area, insulated, close to the fuel supply and the center of the electrical load distribution. However, a generator cannot be installed in the propulsion engine compartment unless specific conditions are met.

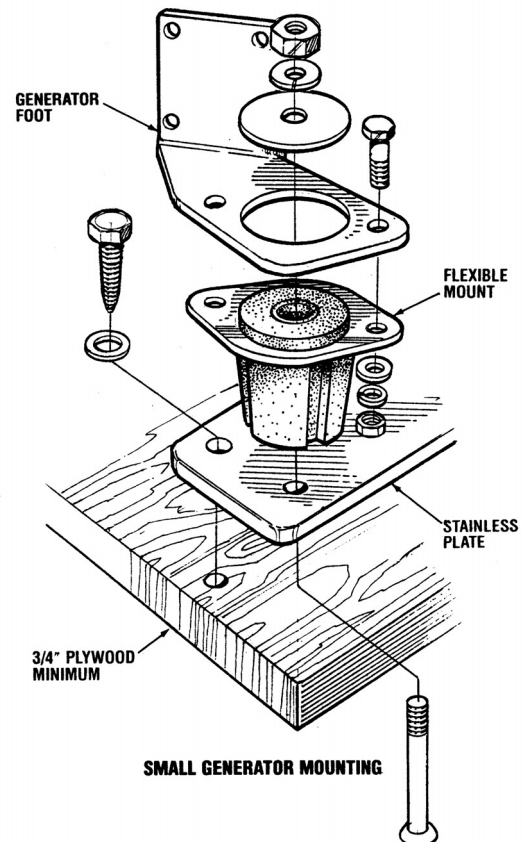
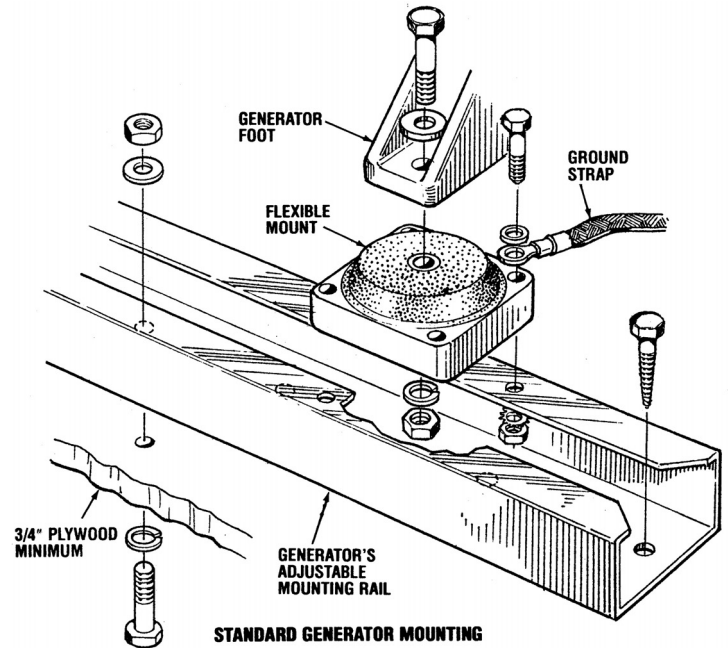
USCG regulation 33CFR183 pertains to gasoline fuel systems, and requires a generator operating in a gasoline fuel environment to be "ignition protected." This means a generator capable of operating in an explosive environment without igniting that environment. Properly installed and operated, a WESTERBEKE gasoline generator can operate in an explosive environment.

▲ WARNING: Gasoline fire or explosion can result in severe personal injury or death. Do not install a gasoline generator in the same room or compartment as a diesel engine or generator. The diesel unit may not be ignition protected and may ignite gasoline fumes. Be sure a gasoline generator is installed in its own room or compartment on a diesel powered boat.

Do not install a diesel generator in the same room or compartment as a gasoline engine.

GENERATOR MOUNTING

Generator mounting rails have numerous pre-drilled bolt holes to ensure that the generator is properly positioned and secured to its mounting platform.



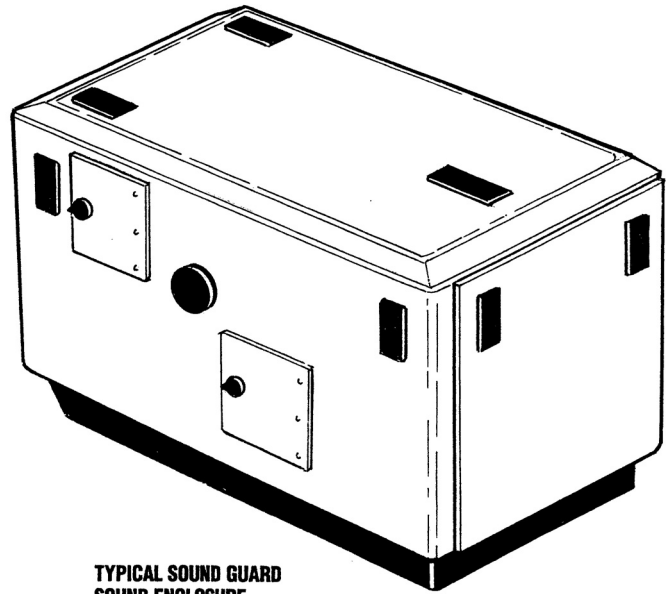
SOUND ENCLOSURE

There are custom designed sound enclosures for each model of WESTERBEKE generators. The Sound Guard is a rigid, attractive, easy to clean enclosure that reduces the generator noise to a pleasant hum. The enclosure can be assembled easily in close quarters.

Quick action fittings allow for easy access for inspection or routine maintenance of the generator. If major repairs are needed, all the panels can be disassembled in a few minutes. *No tools required.*

Sound Guard is pre-packaged with the skirt and base assembled to assure a safe arrival and easy assembly. WESTERBEKE provides the necessary fittings and connecting hoses for water, exhaust, fuel and battery attachments.

For a quiet, dependable sound enclosure, contact your WESTERBEKE dealer.



**TYPICAL SOUND GUARD
SOUND ENCLOSURE**

RIGGING AND LIFTING

The engine/generator is fitted with lifting eyes. Attach wire rope or chain slings capable of supporting the engine/generator's weight to the eyes and lift the engine/generator by means of tackle attached to these slings. The lifting eyes have been designed to carry the full weight; auxiliary slings are not necessary.

▲ WARNING: Slings must NOT be so short as to place stress on the lifting eyes. A sling must be long enough so that its angle to the vertical plane does not exceed 10° .

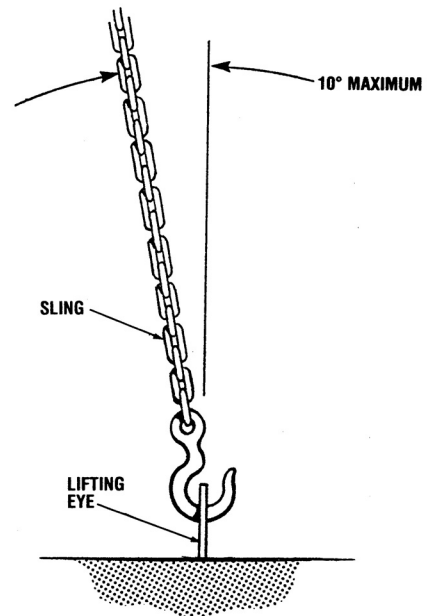
The general rule in moving an engine/generator is to ensure that all equipment used is adequately strong and firmly fixed in place. Move the engine/generator a little at a time and make sure it is firmly supported. Eliminate the possibility of accidents by avoiding haste. Do not lift by the crankshaft pulley.

▲ WARNING: Make certain all personnel stand clear during lifting and lowering operations.

In certain situations it may be necessary to lift the engine/generator in positions other than the horizontal position. Certain situations require it to be lowered endwise through a small hatchway which cannot be made larger. If the opening of the hatchway is extremely small, it is possible to reduce the outside dimensions of the engine/generator by removing external components such as the cooling system piping, the heat exchanger, certain filters, the mounting rails (on generators) and other obstructive components. These should be removed by a competent mechanic and special care should be taken to avoid damage to any exposed parts. Be careful not to allow dirt to enter any openings created by the removal of equipment. Reinstall the components in their original positions after the engine is in its installation area. Replace gaskets as needed for the parts that were removed.

If it becomes necessary to hoist the engine/generator front-end (pulley/drive belt end) upwards or rear-end (fly-wheel/generator end) upwards, the attachment of lifting slings must be done *carefully* to avoid damaging the parts on which the weight of the slings may bear.

NOTE: Rigging work is best done by someone experienced and competent in handling heavy machinery.



PROPELLER SHAFT ALIGNMENT

PROPELLER SHAFT COUPLING (Engines)

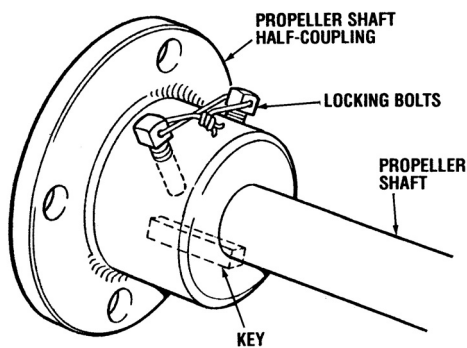
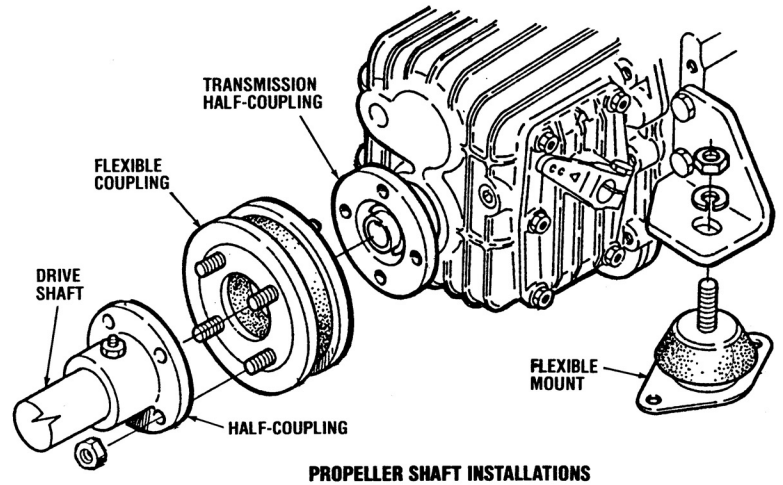
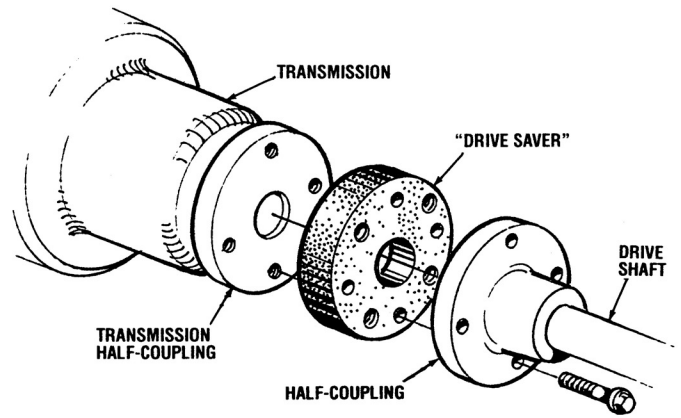
A propeller shaft half-coupling is available for all engine models. It is bored to shaft size for the specific order, and has either a keyway with set screws and two locking bolts, or is of the clamping type with a keyway.

This coupling is carefully machined to allow a slight forced-fit onto the shaft and to make an accurate mating surface between the coupling and the output flange of the transmission.

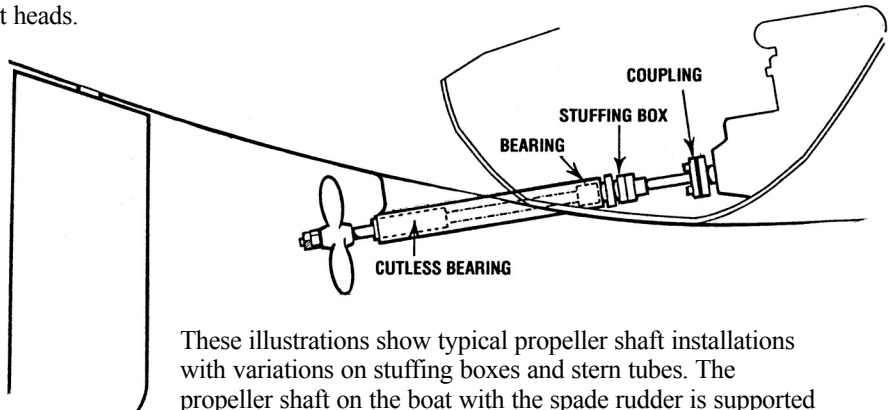
The forward end of the propeller shaft has a long straight keyway. Any burrs should be removed from the shaft's end. The coupling should be a light drive fit onto the shaft, and the shaft should not have to be scraped down or filed in order to get a fit. It is important that the key be properly fitted to both the shaft and to the coupling. The key should fit the side of the keyway closely but should not touch the top of the keyway in the hub of the coupling.

If driving the coupling over the shaft is difficult, the coupling can be expanded by heating it in a pail of boiling water. The face of the propeller coupling must be exactly perpendicular to the center line (axis) of the propeller shaft. Have a machine shop fit the coupling and face the coupling so that the mating surface of the flange is at a perfect right angle to the propeller shaft.

After driving the coupling over the shaft, remove the two locking bolts from the coupling and countersink the shaft below each locking bolt hole. Insert and tighten the two bolts, then wire the two bolt heads together with stainless wire. This will secure the coupling to the shaft. For additional security a stainless hose clamp can be tightened around the coupling shoulder and over the two bolt heads.



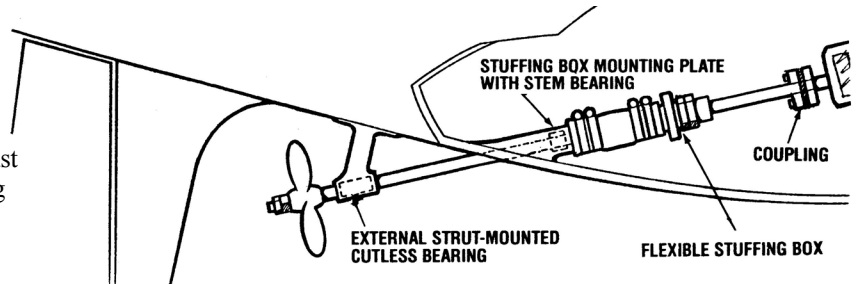
PROPELLER SHAFT COUPLING



These illustrations show typical propeller shaft installations with variations on stuffing boxes and stern tubes. The propeller shaft on the boat with the spade rudder is supported by the stern tube. An external strut supports the shaft on the other boat.

FLEXIBLE COUPLINGS

A flexible coupling or a "drive saver" can be installed between the WESTERBEKE shaft coupling and the transmission coupling to reduce vibration and absorb thrust and torque. This is an important consideration when using flexible engine mounts. Follow the manufacturers' recommendations and instructions.



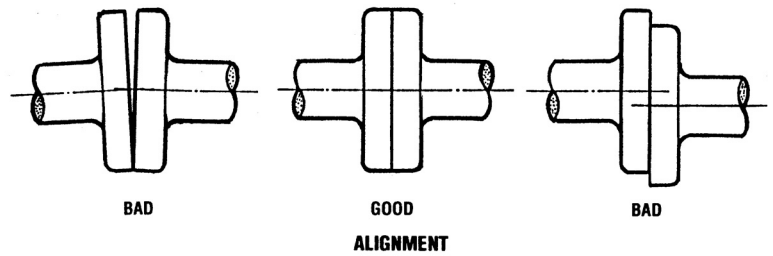
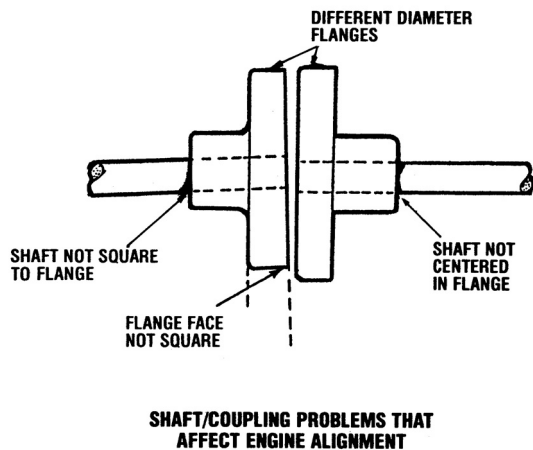
PROPELLER SHAFT ALIGNMENT

ALIGNMENT

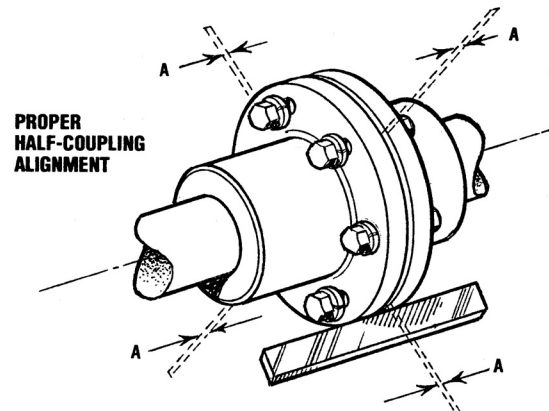
The engine must be exactly aligned with the propeller shaft. No matter what material is used to build a boat, the material will be flexible to some extent. The boat's hull will change its shape to a greater extent than is usually realized when the boat is launched and operated in the water. Therefore, it becomes extremely important to check the engine's alignment at frequent intervals and to correct any errors when they appear.

Misalignment between the engine and the propeller shaft often creates serious problems which are often blamed on other areas suspected of causing the trouble. Misalignment will cause excessive bearing wear, rapid shaft wear, and will, in many cases, reduce the life of the boat's hull by loosening the hull's fastenings. A bent propeller shaft will produce these same effects, therefore a perfectly straight propeller shaft is absolutely necessary. One result of misalignment may be leakage of transmission oil through the transmission's rear oil seal. If oil should leak from this seal, check and make sure that the alignment is within the limits prescribed.

Never attempt a final alignment when the boat is on land. The boat should be in the water and have had an opportunity to assume its final water form. The propeller shaft/transmission coupling alignment is best performed with the fuel and water tanks about half full, with all the usual equipment on board, and, on sailboats, after the mainmast has been stepped and the final rigging has been installed. Take sufficient time to make this alignment — don't be satisfied with less than perfect results.



The alignment is correct when the propeller shaft can be easily slipped backward and forward into the counterbore, and when a feeler gauge indicates that the flanges come together at all points. The alignment between the propeller shaft half-coupling and the transmission half-coupling can contain an error no greater than .001 in (.25 mm) per inch of the coupling diameter. For example, if your propeller shaft half-coupling is 3" (76mm) in diameter, the maximum error that can be allowed in the alignment is .003 in (.076mm).



In making the final check for alignment, the transmission half-coupling should be held in one position and the alignment with the propeller shaft half-coupling tested with the propeller shaft half-coupling in each of four positions A, while rotated 90° between each position. This test will also check whether the propeller shaft half-coupling is in exact alignment on its shaft. Then, keeping the propeller shaft half-coupling in one position, the alignment should be checked by rotating the transmission half-coupling in 90° increments, checking dimension A while in each 90° position until it has been rotated full-circle.

The engine's alignment should be rechecked after the boat has been in service for one to three weeks and, if necessary, the alignment performed again. Usually it will be found that the engine is no longer in alignment. This does not mean that the first alignment has been done improperly, rather, it means that the boat has taken some time to take its final shape and that the engine's bed and stringers have probably absorbed some moisture. It may even be necessary to realign the coupling halves again at a later time.

PROPELLER SELECTION

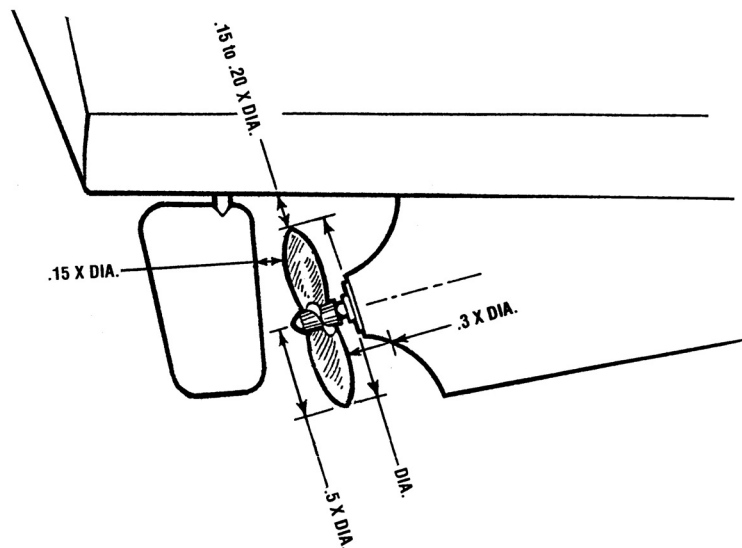
The type and size of propeller varies with the gear ratio and must be selected to fit the application, based upon boat tests. To utilize the full power of the engine and to achieve ideal loading conditions, use a propeller which will permit the engine to reach its full rated rpm at full throttle while under a normal load and while the boat is moving forward through the water.

The following information is needed to calculate and match a marine propeller to a boat.

- a. The engine output in hp.
- b. The maximum rpm of the engine.
- c. The reduction of the transmission.
- d. The maximum hull speed of the boat.
- e. The type of boat and its displacement.
- f. The waterline length (LWL).

Most propeller shops now have computer programs that will analyze all this data and select the propeller choices in number of blades, diameter and pitch. In-water testing however, is always the final answer.

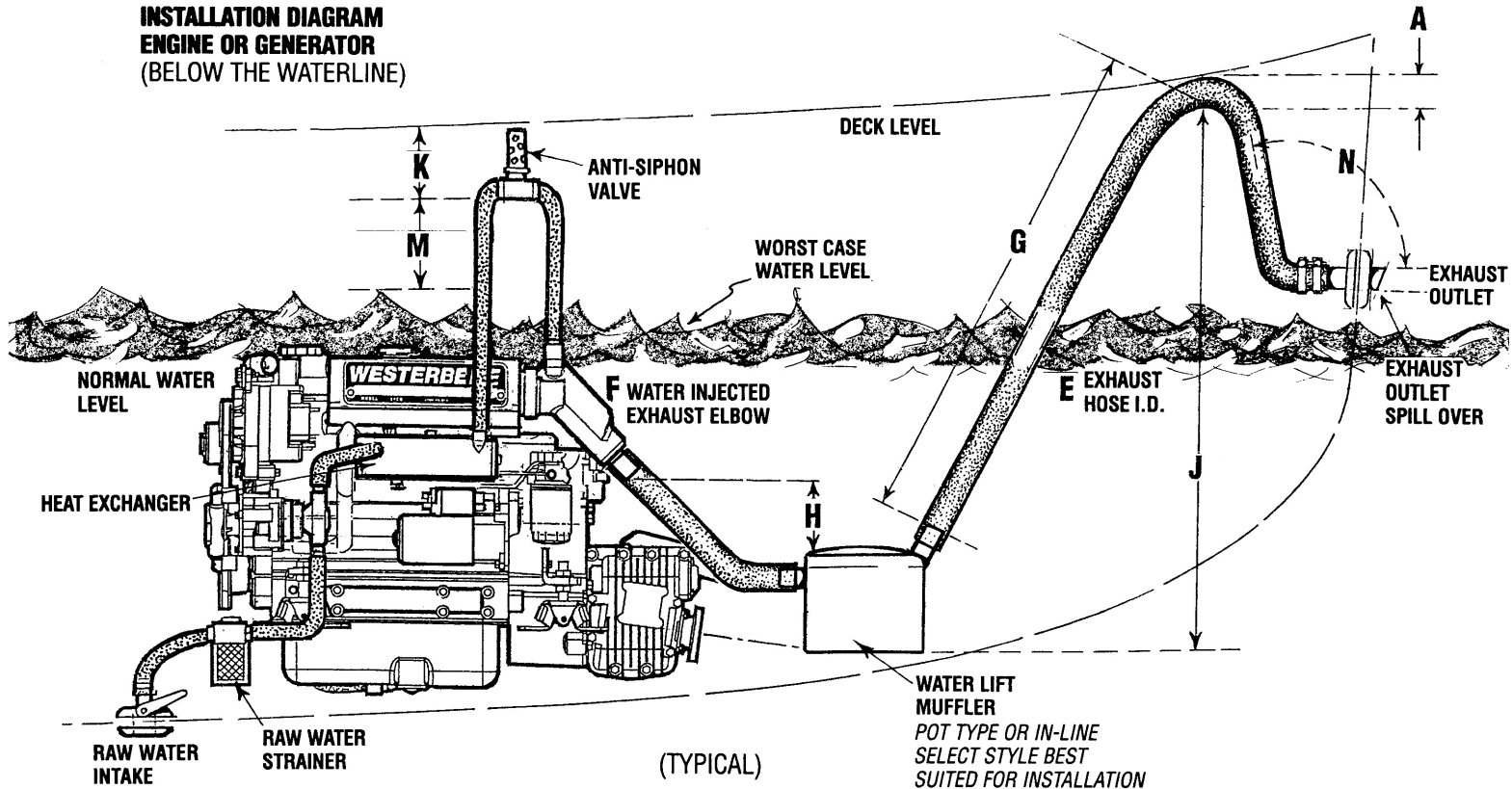
For more information on propellers, read *The Propeller Handbook* by Gerr published by *International Marine Publishers*.



MINIMUM PROPELLER CLEARANCES
From *THE PROPELLER HANDBOOK*

EXHAUST SYSTEM INSTALLATION

INSTALLATION DIAGRAM ENGINE OR GENERATOR (BELOW THE WATERLINE)



RECOMMENDED GUIDELINES

These guidelines dated February 2004 supercede all previous guidelines published by Westerbeke Corporation for all types of exhaust systems. Water intrusion is not covered by warranty because it is not caused by a product defect. Please study these guidelines carefully before planning your exhaust system installation.

Throughout these guidelines our use of the word “engine” is generic, it refers equally to either a propulsion engine or to the engine driving a generator set, sea water and raw water are the same.

Beyond conveying exhaust gases and cooling system sea water out of the boat, the other purpose of the exhaust system is to prevent sea water intrusion into the engine (at the exhaust outlet) under all conceivable conditions of boat trim, boat operation, sea conditions, and heel angle while not exceeding the manufacturer’s back pressure recommendations. Seawater intrusion is usually catastrophic to catalytic converters and engines. The engine/genset supplier is not in a position to judge what installation characteristics will prevent water intrusion in all conceivable circumstances. That judgment is the responsibility of the engine installer. What we as the manufacturer can do is advise the best practice, as we see it, leaving final judgments to the installer.

Sea Water Intrusion Through The Exhaust Outlet

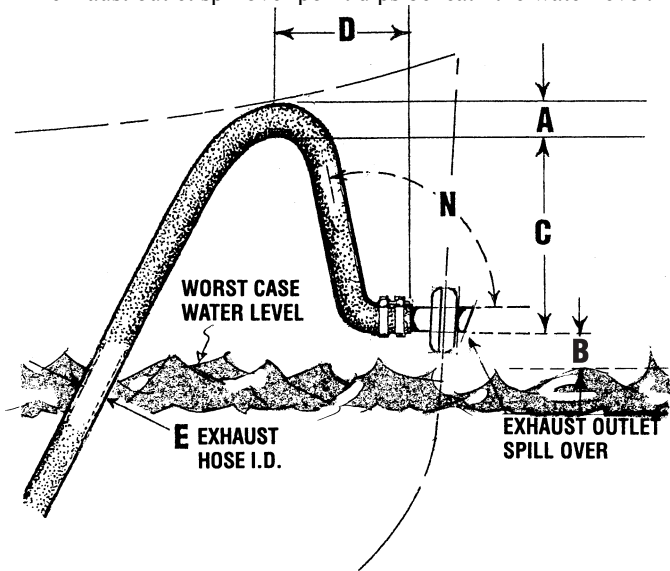
The diagram above illustrates a below waterline installation of an engine or genset. The letters **A** through **H** are the important dimensions that are discussed in detail in the following text:

Let’s start with **A**, the difference between the highest underside of the boat deck near the engine/generator and the high point of the exhaust run from the water lift muffler to the exhaust outlet. **A** should be minimized. There is every reason to attach the high point of the exhaust hose directly to the underside of the deck. There is no reason to fail to take full advantage of this maximum available height because it forms the primary barrier to water intrusion.

We need to define the water line for exhaust installation purposes. By water line we mean the highest point the water level can reach, at the location of the exhaust through hull fitting, from all conceivable causes - other than passing waves of a duration of not more than a second or two. This worst case water level could be caused by any of the following: backing down aggressively, turning aggressively, coming up onto a plane, decelerating off a plane, extreme boat trim, high seas, wallowing in following seas, heeling, etc. Hereafter these instructions will refer exclusively to this worst case water level as the relevant water level to plan a good installation.

EXHAUST SYSTEM INSTALLATION

This leads to **B**, the amount by which the spill over point of the exhaust outlet is above the worst case water level. **B** should be maximized (and certainly always positive). Then the exhaust loop height, **C**, from the high point spill over point to the through hull fitting spillover point, becomes a back up to **B** for preventing water intrusion, rather than being the primary defense – as becomes the case whenever the exhaust outlet spillover point dips beneath the water level.



But the height of **C** is also important. The only defense against momentary passing waves, when they immerse the exhaust outlet, is the exhaust loop height, **C**. If **A** has been minimized, **C** will probably be in excess of a couple of feet. The higher the better. Maximize this height, **C**, because it is your only defense against a passing wave, rogue waves included!

The verticality, **D**, of the hose run from the high point to the exhaust outlet is also important. When a momentarily rising water level immerses the exhaust outlet and is accompanied by water velocity towards that through hull fitting, it is easier for the intruding water to rise along a sloping hose towards the high point than to rise vertically towards that high point. Minimize **D** and keep this part of the exhaust hose as vertical as possible.

Similarly, it is desirable that angle **N** be a 90 degree angle with the exhaust hose rising vertically. This will further discourage water intrusion, especially when backing down, turning, or otherwise experiencing sea water velocity towards the exhaust outlet.

E is the inside diameter of the exhaust hose. This should be no less than **F**, the outside diameter of the generator's water injected exhaust elbow. **E** should only exceed **F** if exhaust system back pressure requirements are not met.

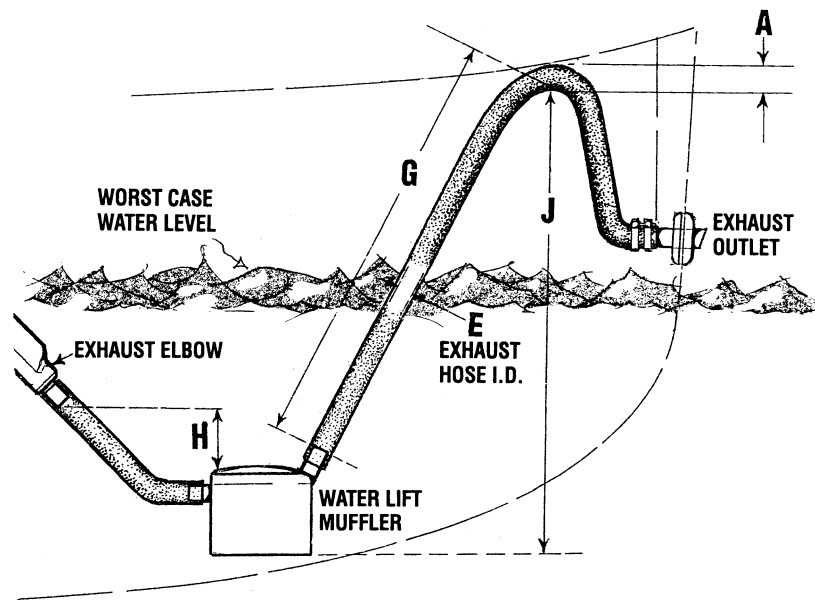
NOTE: When the length of **G** is more than 20 ft, increase the hose diameter **E** by 1/2 in to relieve back pressure.

G is the length of exhaust hose leading from the water lift muffler to the high point. The shorter this length, the lower the back pressure and the greater will be the reserve capacity inside a given water lift muffler. The shorter the better, but it is much more important to minimize **A** than to minimize **G**.

The water lift muffler should be sized to hold multiples of the volume of water that spills back from the exhaust high point when the engine/generator shuts off. The actual amount of normal spill back at shut down is a function of length **G**, the exhaust hose inside diameter, **E**, and the sea water pump flow rate. The larger the muffler the better. Remember - when all else fails and water comes pouring over the high point, only reserve capacity in the muffler can contain it and prevent it from entering the engine/generator.

H is the height of the engine's water injected exhaust elbow outlet above the top of the water lift muffler. This should be maximized. This length of hose is additional reserve capacity to contain both intruding water and splashing inside the water lift muffler.

J is the total height engine exhaust gas pressure must move water up hill – from the bottom of the muffler to the spillover point at the exhaust run high point. **J** is driven by other installation dimensions. It results from a conservative installation, rather than being a driving factor. In most installations, **J** would not exceed 4' (1.2m), this height should produce adequate exhaust system back pressure level.



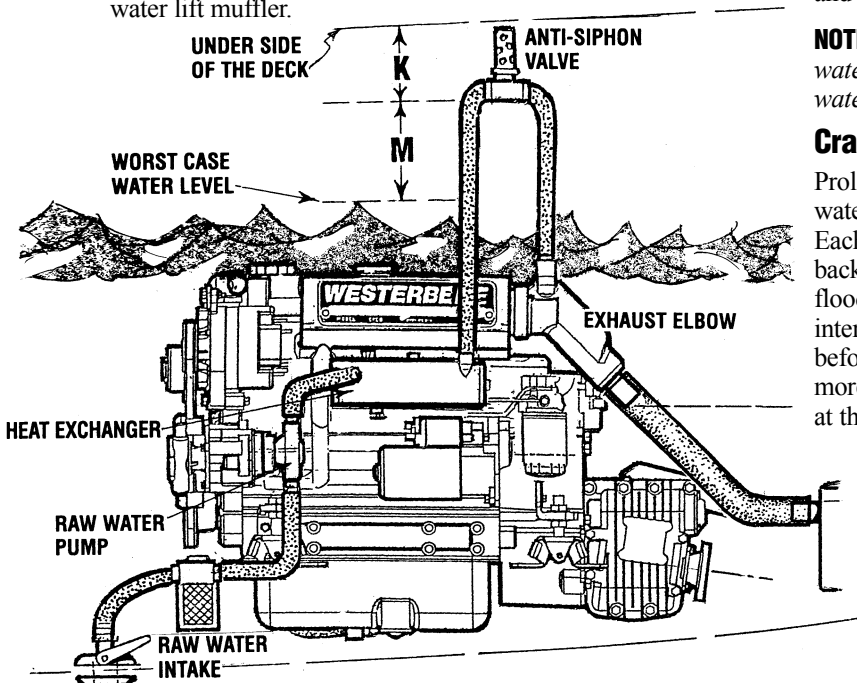
▲ WARNING: Use extreme care during installation to ensure a tight exhaust system. Exhaust gases are deadly.

EXHAUST SYSTEM INSTALLATION

Sea water Intrusion Through The Intake Seacock

Another means of water intrusion is through the sea water intake seacock. This can occur when any part of the sea water system or exhaust system are below the worst case water level (other than the seacock itself which is already below the water level, of course). What happens is that, upon engine shutdown, sea water siphons from the intake seacock, up through the sea water cooling circuit containing the sea water pump, heat exchanger, and water injected exhaust elbow, into the water lift muffler. This seawater will siphon past the impeller of the sea water pump and fill the muffler and all hoses attached to the muffler until the outside water level is reached. If the engine exhaust manifold is below the worst-case water level, seawater will simply pour into the cylinders, destroying the engine.

This form of water intrusion is avoided by the proper installation of an anti siphon valve in the sea water circuit between the sea water pump outlet and the water injected exhaust elbow inlet. Refer again to the generic drawing of a below water line engine/generator installation utilizing a water lift muffler.



K is the difference between the highest underside of the boat deck near the engine/generator and the anti siphon valve. **K** should be minimized. There is every reason to attach the anti-siphon valve directly to the underside of the deck. There is no reason to fail to take full advantage of this maximum available height because it forms the only barrier to water intrusion by siphoning. The anti siphon valve must be well above the worst case water level under all conceivable conditions of boat trim, boat operation, sea conditions, and heel angle. The anti-siphon break and the exhaust hose point should be located as near to the boats centerline as possible; especially on sailboats due to large and steady heeling. The siphon must be accessible for maintenance,

Generator-Not in Operation Water Intrusion

Boat operators may be accustomed to seeing a propulsion engine exhaust outlet dip beneath the water frequently when underway and think this is acceptable for a generator exhaust outlet as well. Not so! When the boat is underway, exhaust pressure keeps water out of the propulsion engine exhaust. But when the generator is not running, there is no exhaust pressure to keep water out of its exhaust outlet. The exhaust outlet of engines which may not be operating when the vessel is underway – sailboat engines and generators – must be well above the worst case water level.

Cumulative Process

Water intrusion between operations of the engine is a cumulative process. If just a little bit of water spills over the high point, but it happens many times, it will fill the muffler and endanger the engine. This could easily be the case for a power boat not using its generator or for a sailboat not using its engine. If you suspect that water is intruding, run the engine frequently until the suspected problem is confirmed and fixed.

NOTE: *Running the engine or Genset will normally preclude water intrusion as the exhaust flow under pressure prevents water from entering the exhaust outlet.*

Cranking the Starter: Draining the Muffler

Prolonged cranking of the starter may cause excessive sea water to build up between the engine and the high point. Each time cranking is interrupted additional water may spill back into the muffler. In time this cumulative spill back can flood the engine. Unusual cranking and/or cranking interruptions must be monitored and the muffler drained before excessive water buildup occurs. This may be made more convenient by installing a suitable, non-corrosive valve at the muffler drain fitting.

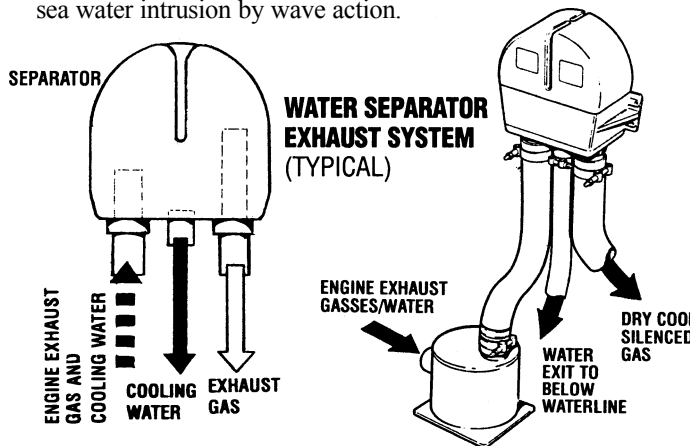
EXHAUST SYSTEM INSTALLATION

Check Valves

Various types of check valves are available and suitable for exhaust runs. Examples are in-line check valves offered by some exhaust component manufacturers and flapper valves on exhaust outlets. None of these may be considered as an alternative to a good installation. They can leak, they can foul, and they can open intermittently. Think of them as an emergency means to keep out that rogue wave or extreme following sea. Never rely on them to stay closed for more than a second or two. Read again "CUMULATIVE PROCESS" on the previous page.

Water Separators Exhaust Systems

Water separators are the latest innovation in exhaust systems. The separator uses gravity and centrifugal force to separate the cooling water from the exhaust gas and then discharges them separately under the vessels hull. This makes for a quiet and efficient system that reduces back pressure and prevents sea water intrusion by wave action.



Installation

The separator must be securely mounted as high as possible (point A in the previous diagrams) above the water lift muffler and well above the vessels waterline in all attitudes of operation.

The discharge (drain) hose for the separated cooling water must go directly and vertically down from the separator to a thru hull fitting on the hull below the waterline. This provides a very quiet exhaust.

The discharge (drain) hose for the exhaust gas must also go directly and vertically down to a thru hull fitting under the hull just above the waterline. This gas discharge hose will still contain some water, to prevent this water from becoming trapped and impeding the flow of gases, make certain the hose leads down hill without any loops or dips.

Water separators are manufactured by:

Halyard Limited
Whadden Business Park
Southampton Road
Whadden, Salisbury SP5-3HF
United Kingdom
www.halyard.eu.com

Centek Industries, Inc.
116 Plantation Oak Drive
P.O. Box 3028
Thomasville, GA 31799-3028
www.centekindustries.com

Dry Stack Exhaust Systems

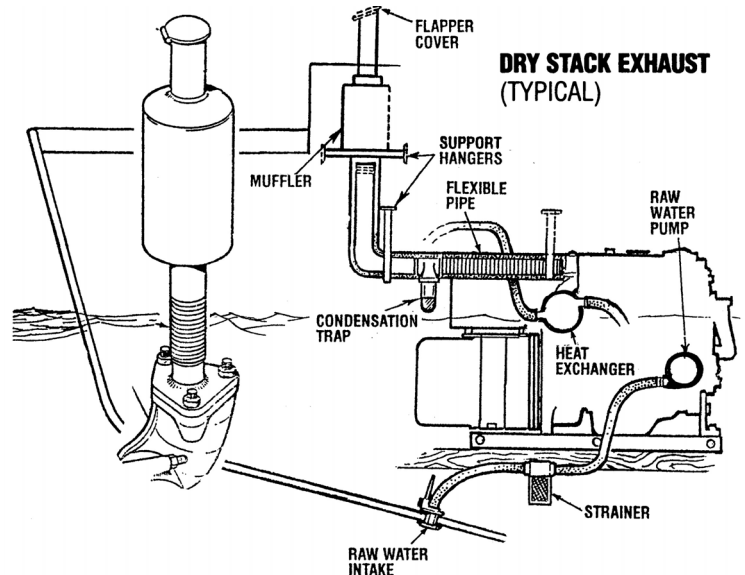
Commonly seen on commercial fishing boats, dry stack exhausts can also be used on trawler style pleasure boats. A dry stack exhaust directs the exhaust gas straight from the generator or engine without obstructions. A dry stack exhaust becomes very hot when the engine is operating and should not be close to any combustible materials (wood, fiberglass, etc.) unless it is properly shielded or insulated.

Make certain the exhaust and muffler are of sufficient diameter to clear the exhaust gasses and prevent excessive back pressure. Provisions must also be made for discharging the raw cooling water.

After final assembly, test run the generator and check all connections and elbows for exhaust leaks. A back-pressure test should also be performed at this time. Back pressure should not exceed 1.5 psi (0.11 kg/cm²).

Regulations require that the exhaust muffler be constructed of aluminized steel or other corrosion resistant material and be of welded or crimped construction. An approved spark arrestor must be installed with the muffler in gasoline installations.

NOTE: Liability for damage or injury and warranty expenses becomes the responsibility of the person installing an exhaust system. Contact WESTERBEKE or your WESTERBEKE dealer regarding any exhaust system problems.



Exhaust Back Pressure

After the installation is operational, exhaust back pressure must be measured at the outlet of the water injected exhaust elbow. Measure with an appropriate gauge or manometer. Operate a propulsion engine underway at cruising RPM. Operate a generator at rated load. As the engine/genset operates it continuously pushes the exhaust gases and raw water thru the exhaust system, up hill and overboard thru the exhaust outlet. This causes significant back pressure. Excessive back pressure reduces engine power, higher temperatures and can reduce the life of the engine.

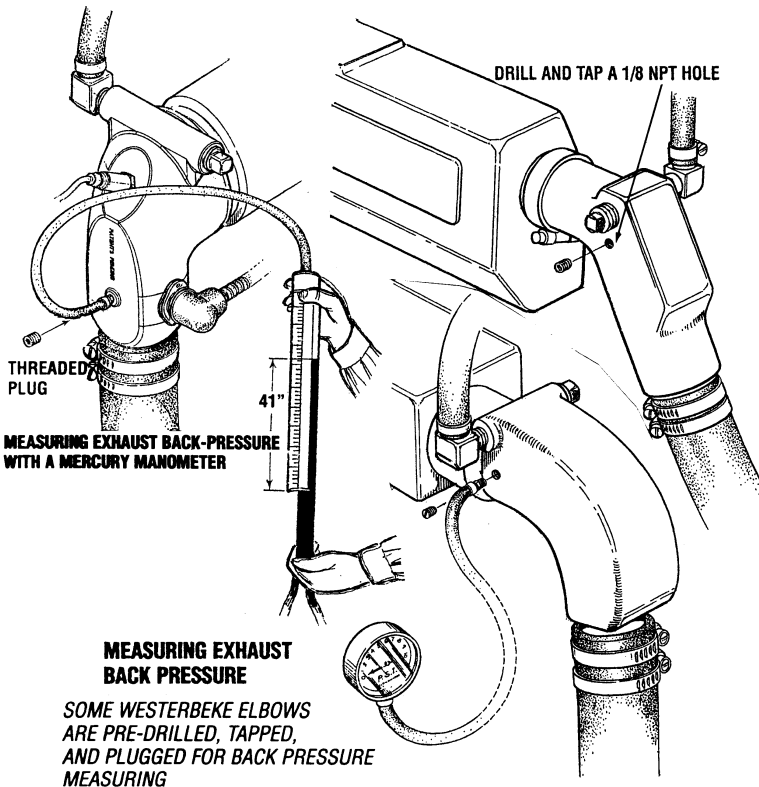
EXHAUST SYSTEM INSTALLATION

Exhaust Back Pressure (cont.)

Back pressure should not exceed 1.5 psi or 41" WC. Excessive back pressure can be reduced by increasing **E**, increasing the size of the water lift muffler, reducing **J**, and reducing **G**. However **A**, **C**, and **B** should not be compromised to relieve back pressure.

Back pressure should not exceed the following specifications:

3 inches of mercury



Sea Trial

A sea trial must be conducted to confirm that no water intrusion takes place, either via the exhaust outlet or via the sea water intake seacock. Do not operate the engine during the trial. Disconnect the exhaust hose at the muffler outlet and place it in an empty bucket (bucket #1). Disconnect the sea water hose entering the exhaust elbow and place it into a second empty bucket (bucket #2).

Select the worst sea conditions available. Operate the boat as aggressively as possible, putting it through as large a variety of operating situations as you would ever encounter. Operate the boat in this way for as long as possible.

Periodically verify that no water enters either bucket. Any water in bucket #1 is water intrusion via the exhaust outlet. Any water in bucket #2 is water intrusion via the sea water intake seacock. Either instance of water intrusion shows that the installation is not adequate, since you will someday experience conditions worse than the sea trial.

Exhaust Hose

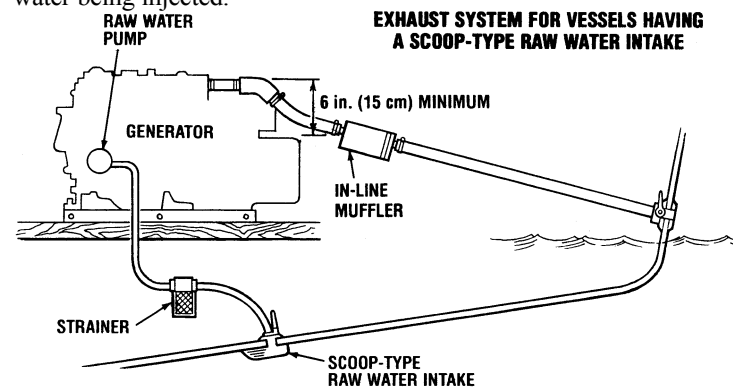
To ensure that engine/generator vibration doesn't transmit to the hull, most installations use flexible rubber exhaust hose for the water cooled section of the exhaust line because of the ease of installation and flexibility. This exhaust hose must be marine certified. Provide adequate support for the rubber hose, to prevent sagging, bending, and formation of water pockets. Always use corrosion resistant carriers and hangers.

For dry or custom pipe exhaust systems, use a flexible section, preferably of stainless steel, no less than 12" (30 cm) overall, threaded at each end and installed as close to the engine as possible. This flexible section should be installed with no bends and covered with insulating material. The exhaust line should be properly supported by brackets to eliminate any strain on the manifold flange studs.

▲ WARNING: Do not install rubber hose with sharp bends as this will reduce efficiency. Do not use rubber hose on dry type exhaust applications. Doing so may cause hose failure and leakage of deadly exhaust gas.

Make sure that the water discharge into the rubber hose section is behind a riser elbow or sufficiently below the exhaust flange so that water cannot possibly flow back into the engine. Also, in custom systems, make sure that entering raw water cannot spray directly against the inside of the exhaust piping. Otherwise excessive erosion will occur.

Dry components of the exhaust system between the exhaust manifold and the water injected exhaust elbow must be properly insulated to hold in the heat, prior to the cooling water being injected.



Scoop-Type Intake

Where generators are installed in very high speed vessels (50-60 knots), it has been necessary to use a scoop-type raw water intake to insure an adequate supply of cooling water to the generator. Generally, this is not recommended, but if it needs to be done, the generator must be mounted high enough so that the exhaust piping has a continuous downward pitch from the muffler to the exhaust outlet in the hull. The pitch should be adequate so that the muffler will continuously drain and no water can back-up into the engine (see illustration).

EXHAUST SYSTEM

EXHAUST ELBOW INSTALLATION

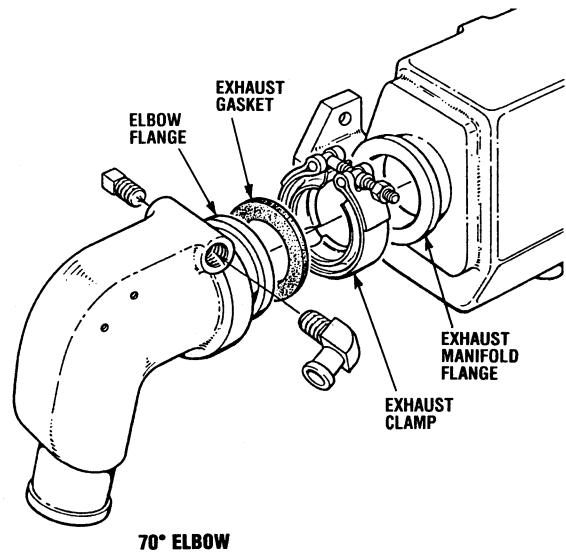
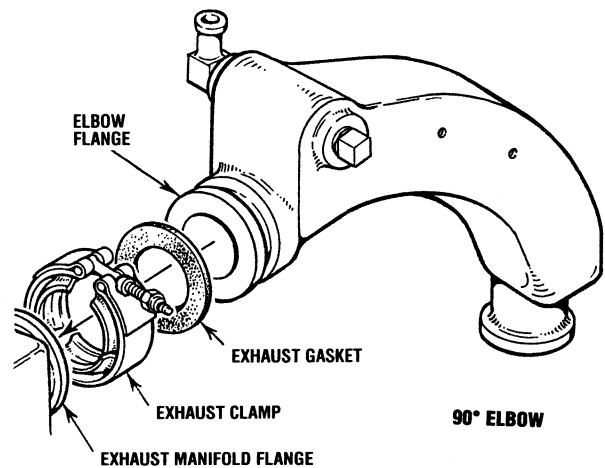
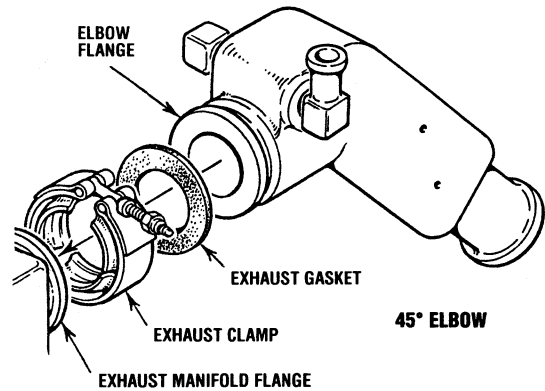
Exhaust elbows are standard on generators, optional on engines. For installation on your engine/generator, we offer 45° 70° and 90° exhaust elbows.

NOTE: Fabricated exhaust elbows or risers attached to the exhaust manifold shall not exceed 8 lbs. when unsupported.

1. Coat only one side of the exhaust gasket with *High Tack* (manufactured by *Permatex Company, Brooklyn, N.Y.*) adhesive sealant. Place this coated surface against the exhaust manifold's exhaust port flange (the gasket should stick to the flange without falling off).
2. Place the clamp over the elbow's flange. Place your exhaust elbow against the exhaust manifold's flange so the exhaust manifold's flange rests snug against the exhaust elbow's flange with the gasket centered between the two. Now slip the exhaust clamp over both flanges.
3. Tighten the clamp just enough so the exhaust elbow can remain attached to the manifold and still be rotated. The exhaust elbow discharge *must* be directed downward so the mixture of raw water and exhaust gases will flow/fall downward into the exhaust muffler which *must* be positioned below the exhaust elbow. There should be no loops or rises in the exhaust hose connected between the exhaust elbow and the muffler, as these would trap water and possibly allow water to flow back into the engine during starting or at shut-down.
4. Adjust the elbow by rotating it until the desired alignment with the exhaust piping is acquired.
5. Carefully tighten the clamp between 8 to 10 lb-ft, or 24 to 35 lb-in, or 0.27 to 0.41 kg-m.

▲ CAUTION: 10 lb-ft (1.4 kg-m) Torque Limit: approach the 10 lb-ft (1.4 kg-m) torque limit with caution. The clamp's threads will break if more than 10 lb-ft (1.4 kg-m) is applied to the clamp.

6. When the engine is started for the first time with the new elbow, check this exhaust manifold/elbow connection for leaks. If a leak exists, correct it immediately.



EXHAUST SYSTEM

EXHAUST SYSTEM PRECAUTIONS

Carbon Monoxide

The best protection against carbon monoxide poisoning is a daily inspection of the complete exhaust system. Check for leaks around manifolds, gaskets, and welds. Make sure exhaust lines are not heating surrounding areas excessively. If excessive heat is present, correct the situation immediately. If you notice a change in the sound or appearance of the exhaust system, shut down the unit immediately and have the system inspected and repaired at once by a qualified mechanic.

▲ WARNING: Carbon Monoxide Gas is Deadly!
Carbon monoxide is a dangerous gas that can cause unconsciousness and is potentially lethal. Some of the symptoms or signs of carbon monoxide inhalation or poisoning are:

- Dizziness
- Nausea
- Headache
- Weakness and Sleepiness
- Throbbing in Temples
- Muscular Twitching
- Vomiting
- Inability to Think Coherently

If you experience any of the above symptoms, get out into fresh air immediately.

A carbon monoxide warning decal has been provided by Westerbeke. Display this decal near your engine or generator, on your cabin bulkhead, or in some other nearby location.

NOTE: It is extremely important that a carbon monoxide detector be installed in your boat's living quarters. Make sure it is manufactured for the marine industry. They are inexpensive and easily available at your marine supplier.



Raw Water Erosion

When the engine's raw water is fed into an exhaust system so that the full stream of this water strikes a surface, erosion takes place. This erosion may cause premature failures. The proper design of either a water-jacketed or water-injected "wet" exhaust system to prevent this problem requires that the raw water inlet be positioned so that the entering stream of raw water does not directly strike a surface. In addition, the velocity of the entering raw water stream should be as low as possible, which can be achieved by having inlet fittings as big in diameter as possible.

Excessive Weight

Make sure there are no unnecessary objects suspended from any portion of the exhaust lines. Exhaust risers installed off the exhaust manifold **should not exceed 8 lbs** in total weight when rigidly constructed. Excessive weight could cause deflection or distortion of the manifold resulting in damage and/or internal leaks.

Insulation

Inspect insulated portions of the exhaust system to ensure there is no deterioration of the insulation.

Overcranking

Prolonged cranking intervals without the engine starting can result in filling the engine-mounted exhaust system with raw water coolant. This may happen because the raw water pump is pumping raw water through the raw water cooling system during cranking. This raw water can enter the engine's cylinders by the way of the exhaust manifold once the exhaust system fills. To prevent this from happening, close the raw water supply through-hull shut-off, drain the exhaust muffler, and correct the cause for the excessive engine cranking needed to obtain a start. Engine damage resulting from this type of raw water entry is not a warrantable issue.

ELECTRICAL SYSTEM

DC ELECTRICAL CONNECTIONS

WESTERBEKE engines and generators are supplied pre-wired and with plug-in connectors. Never make or break connections while the engine is running. Carefully follow all instructions on the wiring diagram supplied, especially those relating to fuse/circuit breaker requirements. Wiring diagrams are included in your Operators Manual.

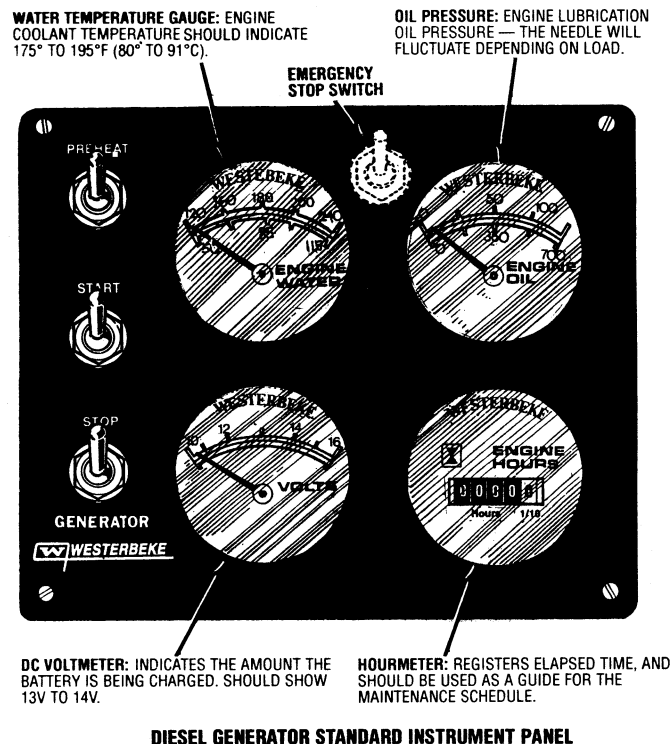
NOTE: WESTERBEKE manufactures marine engines and generators using components that meet very rigid safety standards. If a component on the engine or generator is replaced with one that is non-compliant, then the safety of the boat is jeopardized. Make certain that any engine component you replace is a genuine WESTERBEKE replacement part.

CONTROL PANELS FOR PROPULSION ENGINES

Two optional manually-operated control panels for propulsion engines are available from WESTERBEKE. These are the *ADMIRAL CONTROL PANEL* and the *CAPTAIN CONTROL PANEL*. Both panels come with 15 ft. (4.6 m) of connecting harness. The features of these two panels are described in detail at the end of this section.

DIESEL GENERATOR INSTRUMENT PANELS

All WESTERBEKE diesel generators come with a standard engine instrument panel (see illustration). With the exception of the 5.7/7.6 BTD, they are mounted in a panel box attached to the AC alternator. The panel faces the service side of the generator and can be rotated to suit particular installations.



The panel can also be remote mounted by using optional plug-in extension harnesses which are available in 15 ft. (4.6 m) increments. A maximum of two harnesses, 30 ft (9.2 m) can be connected. For longer distances, hard wiring can be used as shown in the Operators Manual. An optional cover plate is available to cover the face of the panel box when the instrument panel is remote mounted. An optional plate with pre-heat and start and stop switches is also available for mounting in place of the instrument panel for operation at the unit.

The 5.7/7.6 BTD comes standard with an instrument panel for remote mounting (see illustration) and one 15 ft (4.6 m) extension harness. Pre-heat and start and stop switches are provided on the unit.



Two instrument panels can be installed using the optional dual gauge sender kit. This second panel must be hard-wired by the installer

OPTIONAL INSTRUMENT PANEL (GASOLINE GENERATORS)

An optional instrument panel is available supplied with an engine oil pressure gauge, water temperature gauge, engine mounted alternator voltage gauge, engine operating hourmeter and control switches. This panel must be wired into the terminal strip in the main control panel on the engine/generator and must be mounted in a remote location where the instruments can be monitored and the switches activated.

NOTE: This panel must *not* be located in an engine or generator compartment because it is not ignition protected, and has not been Coast Guard approved.

OPTIONAL REMOTE START/STOP PANEL (DIESEL AND GASOLINE GENERATORS)

An optional remote Start/Stop panel is available containing three switches and a run indicator light (green). This panel must be wired into the terminal strip in the main control panel on the engine/generator and must be mounted in a remote location such as the vessel's wheelhouse.

NOTE: This panel must *not* be located in an engine or generator compartment because it is not ignition protected, and has not been Coast Guard approved.

ELECTRICAL SYSTEM

CONTROL WIRING

For control wiring, see the *DC WIRE SIZING* page in this manual.

NOTE: All wiring should be tied down with clamps or plastic ties, and spaced at intervals close enough to prevent chafing from vibration. Check to make sure all the harness connections are tight and that they are made to the appropriate terminals.

▲ CAUTION: *The electrical code will not allow DC wiring to be routed together with AC wiring.*

Refer to the wire size chart (DC) in this manual when selecting the wire size to be used between the engine control panel and remote start/stop panel. Use color codes to comply with ABYC Standards. See your WESTERBEKE Operators Manual for the remote panel wiring schematic.

NOTE: Generator AC load connections, shore power connections, voltage adjustments and all the necessary wiring diagrams are included in your WESTERBEKE Operators Manual.

AC WIRING (GENERATORS)

Various AC output voltages and frequencies are available for your generator. For these specifications, and for information about AC wiring connections and adjustments, refer to your Operators Manual.

The generator's data plate gives the voltage, current and frequency rating of the generator. A diagram of the various AC voltage connections is provided on the AC wiring decal that is affixed to the inside of the louvered cover at the generator end of the unit.

Recommended publications concerning electrical installation standards and safety codes are listed in the *SAFETY INSTRUCTIONS* section of this manual. Make sure that all electrical connections, tests and adjustments are performed by a qualified electrician.

BATTERIES

Starter batteries should be located as close to the engine or generator as possible to avoid voltage drop through long leads. Install a battery disconnect switch in the B+ cable so the battery can be disconnected when the engine/generator is serviced. It is bad practice to use the starter batteries for other services unless they require low amperage or are intermittent. In cases where there are substantial loads (from lights, refrigerators, radios, depth sounders, etc.) it is essential to have a complete, separate system and to provide charging current for this by means of a second alternator, dual output alternator or alternator output splitter. The output splitter is a standard marine accessory. It comes with complete instructions on how it can be integrated with an electrical system.

Starter batteries must be of a type which permits a high rate of discharge.

See your Operators Manual specifications for cold cranking ampere hours requirements. Most marine batteries on the market today have large cranking capacities. The battery compartment must be well ventilated to prevent accumulation of explosive battery gases.

Mount the battery in an acid-resistant tray on a platform above the floor. It must be secured to prevent shifting. If mounted in an engine compartment, always install a non-metallic cover to prevent battery damage and arcing from accidentally dropped tools. Be sure the battery connections are clean and tight, then cover the battery terminals with a dielectric grease to retard corrosion.

U.S. Coast Guard regulations and Marine Insurance Companies require that the ship's batteries have a fixed cover or holdown straps to keep the batteries in place should a rollover occur.

Carefully follow the recommended wire sizes shown in WESTERBEKE'S wiring diagrams for the battery connections:

BATTERY CABLE REQUIREMENTS						
Maximum Length of One Cable						
Cable Size	2	1	0	00	000	0000
Length ft.	4	5	7	9	11	14
Length m..	1.2	1.5	2.1	2.7	3.4	4.3

▲ WARNING: *Do not connect the starting battery until installation is complete. Accidental starting of the engine or generator could cause serious personal injury.*

GROUNDING

Generators and propulsion engines must be grounded in accordance with USCG regulation 33CFR183.415. The regulation requires that a common ground conductor be connected between the generator and the vessel's main propulsion engine's grounded cranking motor circuit.

The engine or generator must be bonded to the vessel's common bonding conductor with a bonding strap. If a metallic fuel line is installed between the fuel tank and the engine/generator shutoff valve, it too must be bonded to the same vessel common conductor.

This conductor prevents accidental passage of cranking current through the fuel systems and smaller electrical conductors common to engines and generators. This can happen if a cranking motor ground circuit becomes resistive or opens from corrosion, vibration, a bad cable, etc.

ELECTRICAL SYSTEM

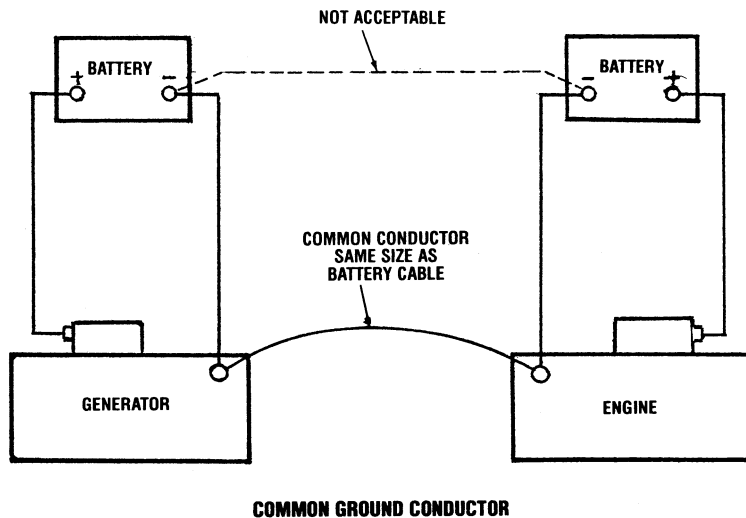
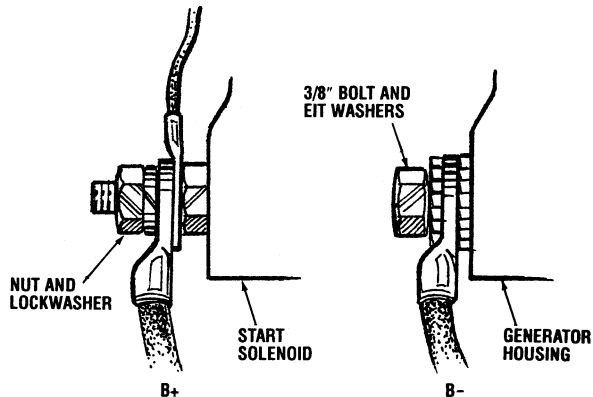
▲ WARNING: *An improper ground can cause severe personal injury or death from fire or explosion. Be sure to install a common ground conductor between all on-board cranking circuits.*

A common ground for (-) negative DC is located at the bellhousing of the engine/generator next to the starter in the form of a threaded grounding stud. This location is tagged. It is recommended that the battery ground be connected here. Failure to do so can cause arcing or resistance in the cranking circuit.

▲ WARNING: *The ignition of gasoline fuel or fumes can result in severe personal injury or death. Connect the engine/generator battery ground lead only at the location shown.*

Connect battery (+) positive to the starter solenoid terminal tagged for this connection.

The DC power source for the generator can be obtained from the main engine's starting battery. A battery disconnect switch should be installed in the B+ battery cable to the generator.



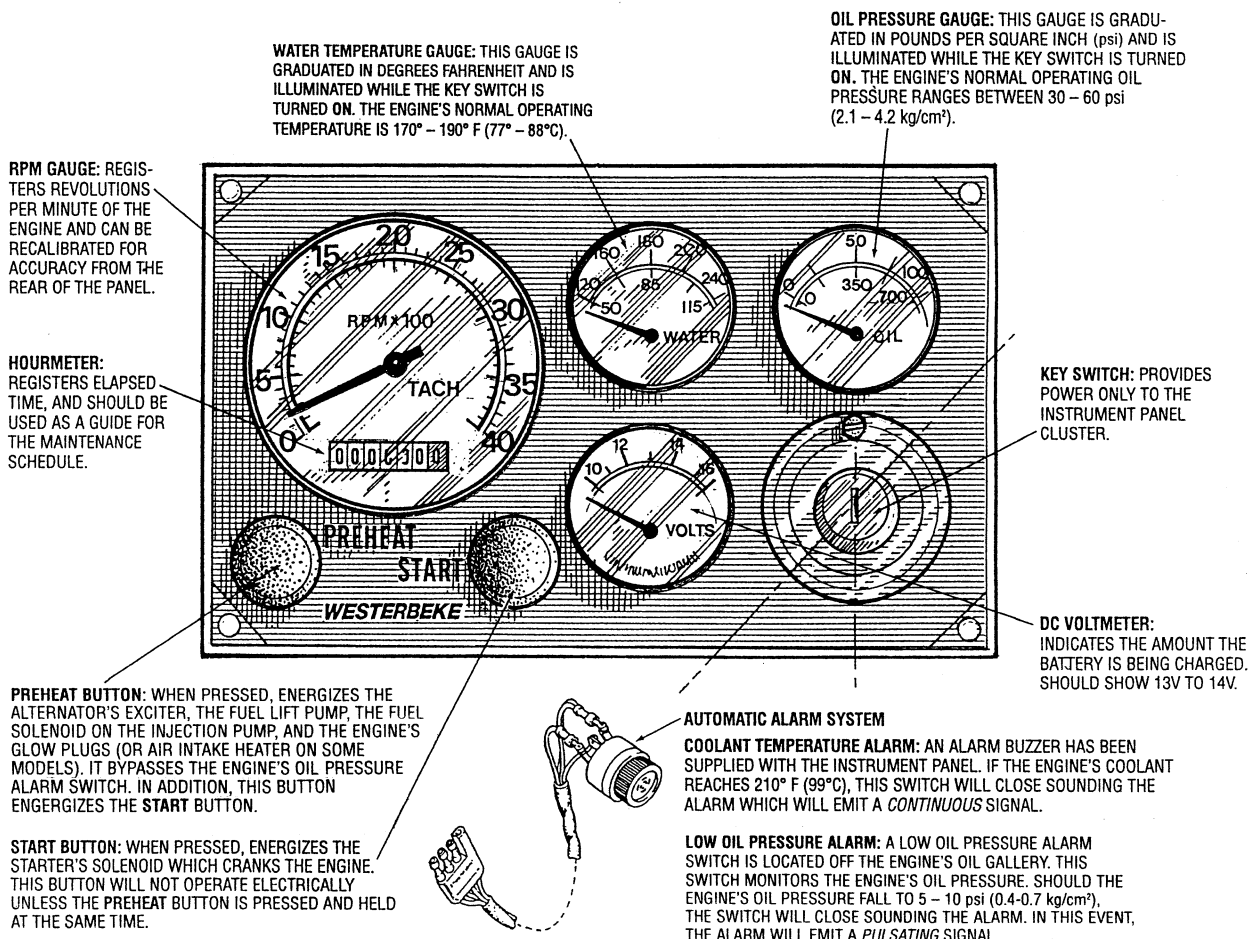
ADMIRAL CONTROL PANEL

DESCRIPTION

This manually-operated control panel is equipped with a KEY switch and RPM gauge with an ELAPSED TIME meter which measures the engine's running time in hours and in 1/10 hours. The panel also includes a WATER TEMPERATURE gauge which indicates water temperature in degrees Fahrenheit, an OIL PRESSURE gauge which measures the engine's oil pressure in pounds per square inch, and a DC control circuit VOLTAGE gauge which measures the system's voltage. All gauges are illuminated when the key switch is turned on and remain illuminated while the engine is in operation. The panel also contains two rubber-booted pushbuttons, one for PREHEAT and one for START.

When the engine is shut down with the key switch turned off, the water temperature gauge will continue to register the last temperature reading indicated by the gauge before electrical power was turned *off*. The oil pressure gauge will fall to zero when the key switch is turned *off*. The temperature gauge will once again register the engine's true temperature when electrical power is restored to the gauge.

A separate alarm buzzer with harness is supplied with every Admiral Panel. The installer is responsible for electrically connecting the buzzer to the four-pin connection on the engine's electrical harness. The installer is also responsible for installing the buzzer in a location where it will be dry and where it will be audible to the operator should it sound while the engine is running. The buzzer will sound when the ignition key is turned on and should silence when the engine has started and the engine's oil pressure rises above 15 psi (1.1 kg/cm²).



CAPTAIN CONTROL PANEL

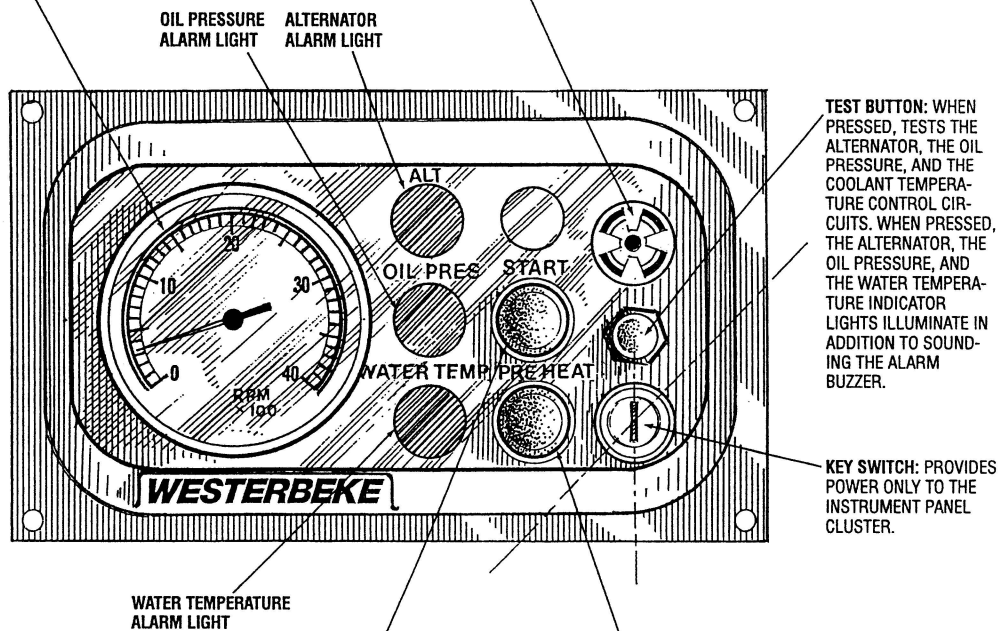
DESCRIPTION

This manually-operated control panel is equipped with a KEY switch, an RPM gauge, PREHEAT and START buttons, an INSTRUMENT TEST button and three indicator lamps, one for ALTERNATOR DISCHARGE, one for low OIL PRESSURE, and one for high ENGINE COOLANT TEMPERATURE.

The panel also includes an alarm buzzer for low OIL PRESSURE or high COOLANT TEMPERATURE. The RPM gauge is illuminated when the KEY switch is turned **on** and remains illuminated while the engine is in operation.

RPM GAUGE: REGISTERS REVOLUTIONS PER MINUTE OF THE ENGINE AND CAN BE RECALIBRATED FOR ACCURACY FROM THE REAR OF THE PANEL.

ALARM: THE ALARM WILL SOUND IF THE ENGINE'S OIL PRESSURE FALLS BELOW 5 - 10 psi (0.4 - 0.7 kg/cm²). IN THIS EVENT, THE ALARM WILL EMIT A *PULSATING* SIGNAL. THE ALARM WILL ALSO SOUND IF THE COOLANT TEMPERATURE IN THE FRESHWATER COOLING CIRCUIT RISES TO 210°F (99°C). IN THIS EVENT, THE ALARM WILL EMIT A *CONTINUOUS* SIGNAL. **NOTE:** THE ALARM WILL SOUND WHEN THE KEY SWITCH IS TURNED ON. THIS SOUNDING IS NORMAL. ONCE THE ENGINE STARTS AND THE ENGINE'S OIL PRESSURE REACHES 15 psi (1.1 kg/cm²), THE ALARM WILL SILENCE.



START BUTTON: WHEN PRESSED, ENERGIZES THE STARTER'S SOLENOID WHICH CRANKS THE ENGINE. THIS BUTTON WILL NOT OPERATE ELECTRICALLY UNLESS THE PREHEAT BUTTON IS PRESSED AND HELD AT THE SAME TIME.

PREHEAT BUTTON: WHEN PRESSED, ENERGIZES THE ALTERNATOR'S EXCITER, THE FUEL LIFT PUMP, THE FUEL SOLENOID ON THE INJECTION PUMP, AND THE ENGINE'S GLOW PLUGS (OR AIR INTAKE HEATER ON SOME MODELS). IT BYPASSES THE ENGINE'S OIL PRESSURE ALARM SWITCH. IN ADDITION, THIS BUTTON ENERGIZES THE START BUTTON.

FUEL SYSTEM

FUEL TANKS—GENERAL

It is very important that the design, construction and installation of all fuel system components meet the highest possible standards. Use only products specified for marine applications.

Fuel tanks for diesel engines and generators may be made of fiberglass, aluminum or stainless. Fuel tanks for gasoline engines and generators may be made of only fiberglass or aluminum; stainless is not appropriate for gasoline because improper welding can remove carbon leaving only steel, which will rust and then leak.

If the tank is made of fiberglass, be certain that the interior is gel-coated to prevent fibers from contaminating the fuel system. Copper or galvanized fuel tanks should not be used. The nominal thickness of a fuel tank depends on the material used. Any fitting or opening must be at the top of the tank. A drain plug at the bottom of the tank is not acceptable.

Avoid the use of fittings made of copper-based alloys such as brass as they will deteriorate the aluminum fittings.

Fastenings for an aluminum tank should be 300 series stainless steel.

It is not necessary to mount the tank above the engine level, as the fuel lift pump provided will raise the fuel from the tank. The amount of lift should be kept to a minimum (6 feet being maximum). If a tank is already installed above engine level, it can be utilized in this position.

Cleanliness and care are especially important when the fuel tank is installed because any dirt left in the tank will cause fouling when the engine is started for the first time.

▲ CAUTION: *Make sure the fuel tank filler is properly sealed to prevent water re-entry should it become awash. The fuel tank's vent should be routed so as to prevent water entry as well.*

The fuel tank's fuel pickup tube should be clear and unobstructed, without screens or gauze strainers. Make sure that all fittings are sufficiently tightened to prevent leaking.

Fuel tanks that are located below the engine's fuel system level *must* have their fuel return connection at the tank extending down into the tank in the same manner as the pickup tube; otherwise, air will replace fuel siphoning out of the engine's fuel system through the return.

The fuel tank's vent should be located so that its discharge route cannot allow water to enter through to the fuel tank(s). Moisture must not be allowed to accumulate in the vent's line.

Mount the fuel tank and secure it into position. The NFPA recommends that the bottom tanks be installed on slatted wooden platforms to help prevent moisture condensation. Cylindrical tanks should be set in chocks or cradles and securely fastened. Insulate all wood or metal surfaces from the tank surface with a non-abrasive and non-absorbent material.

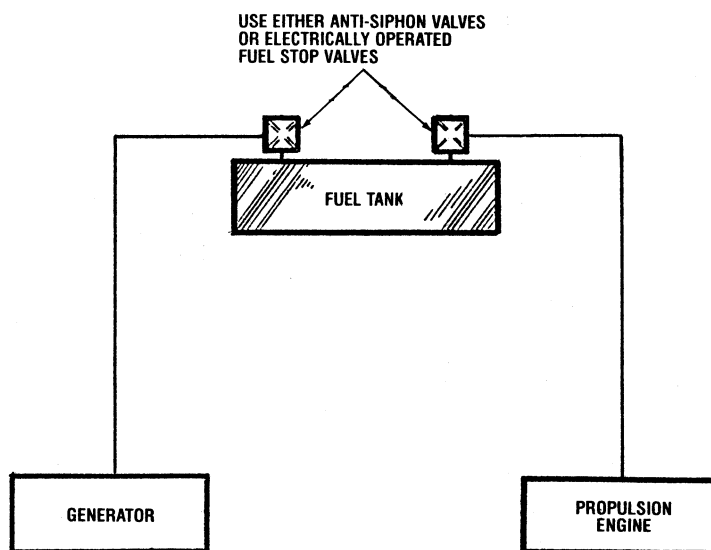
FUEL TANKS—GASOLINE

Tanks must be labeled with the manufacturer's name, tank material and capacity. They also must be marked that they have been pressure tested to the requirements of Title 33 CFR, sub part J. If either the fuel-fill fitting or the tank is metallic, it will need to be grounded. A 10-gauge or larger stranded copper wire must be fastened from the metal components to the boat's ground.

Design the fuel tank vent line so that gasoline cannot spill onto the boat. A loop in the vent line from the top of the tank to the underside of the deck and then to the through-hull fitting will prevent this. The line should drain back to the tank with no traps. The vent line should be no less than 9/160 I.D. The through-hull vent fittings must be equipped with a flame arrestor.

Fuel Tanks Located *Above* the Engine/Generator

A carburetor float valve cannot be trusted to hold back fuel in an installation having a fuel tank located at or above the engine/generator's fuel system. This type of system, with some or all of the fuel supply line to the carburetor routed below the level of the fuel tank's top, requires a shut-off valve to shut off the fuel supply to the engine or generator when the engine isn't running.



FUEL TANKS LOCATED ABOVE THE ENGINE/GENERATOR

FUEL TANKS/ FUEL SYSTEM

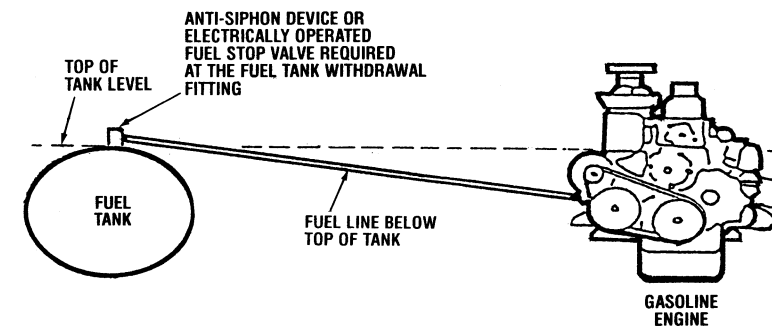
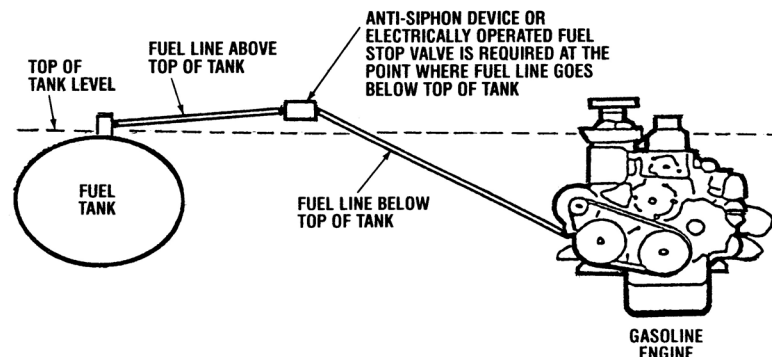
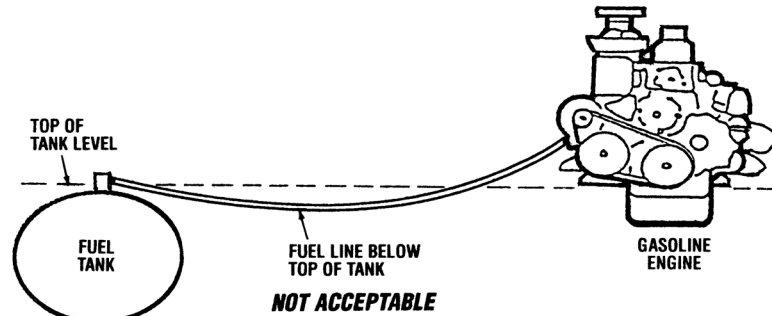
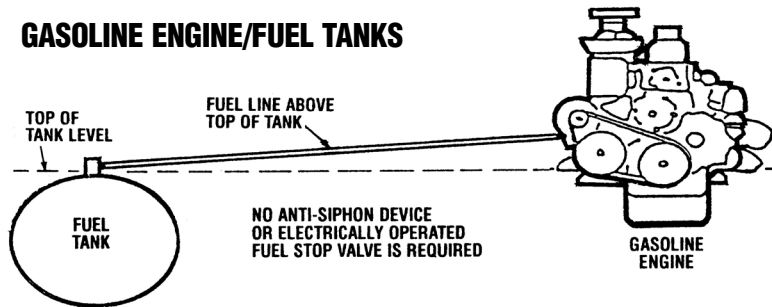
This shutoff valve is necessary to guard against the possibility of gasoline siphoning through the supply line to the carburetor and into the engine in case the carburetor float valve doesn't close, the carburetor needle valve doesn't operate properly, or the fuel line ruptures between the engine and the fuel tank at a point below the fuel level. The shut-off valve can be installed at the tank withdrawal fitting, or at a location where the line from the fuel tank will no longer remain above the fuel tank top level. It can be electrically operated automatically (with manual override) to open when the engine starts and close when it shuts down. A manually operated valve can also be used, operated either from the Start/Stop panel area or from the vessel's deck. The shut-off valve should be of the fuel oil type, and it is important that all joints be free of pressure leaks.

NOTE: The use of mechanical spring-type check valves instead of a solenoid shut-off valve is not recommended since these may tax the fuel lift pump's ability to draw fuel through a check valve. A check valve can trap debris under its seat which inhibits the valve's ability to close. In addition, if a check valve's cracking pressure is too high, it can contribute to vapor lock. Should a mechanical-type spring-loaded check valve be used, it should be an adjustable type, such as a Weatherhead #43 x 6. This adjustable type valve should be adjusted to have a cracking pressure that will prevent siphoning when the engine or generator is not operating but not so excessive as to prevent the fuel lift pump from drawing fuel through the valve.

Fuel Tanks Located *Below* the Engine/Generator

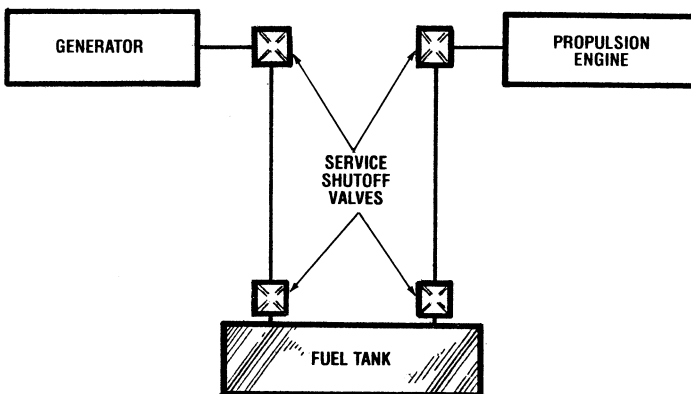
An installation having a fuel tank located below the engine or generator's fuel system, with the fuel supply line to the carburetor routed above the level of the fuel tank's top, does not require an anti-siphon shut-off valve, but does require two manually-operated service shut-off valves — one located at the fuel connection to the tank, and another located at the fuel connection to the engine/generator.

GASOLINE ENGINE/FUEL TANKS



DIESEL FUEL SYSTEM ANTI-SIPHON DEVICES

Fuel system anti-siphon devices should *not* be used with a diesel engine/generator. It is not necessary and, in addition, introduces air into the fuel which may cause erratic operation. The fuel system should include one or more fuel shutoff valves.



FUEL SYSTEM

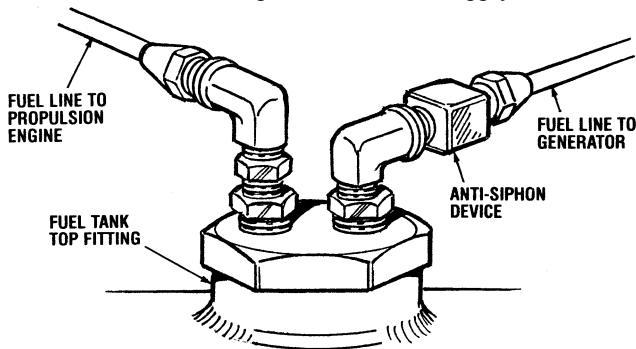
DUAL PURPOSE FUEL TANK

If you're running both a generator and a propulsion engine and they use the same fuel, you can use the same fuel tank. However, before that decision is made, the following factors must be considered:

- 4 There must be adequate fuel capacity for both engines — refer to the specifications section of your owner's manual for fuel consumption figures.
- 4 In diesel installations the fuel returning to the tank is warm. To obtain maximum engine efficiency, fuel delivered to the injectors must be cooled. The fuel tank volume must be adequate to cool the returned fuel.

If a fuel tank is shared, a fuel line tee should *not* be used. A tee can cause erratic genset operation due to fuel starvation. The genset's fuel pump does not have the capacity to overcome the draw of the propulsion engine's fuel pump.

This is true also of the return lines. Pressure from one engine could be higher than the other and force return fuel back into the lower-pressure engine injector. The return line should enter the tank as far as possible from the supply lines.



FUEL LINES

The proper installation of fuel lines is very important. All fuel line materials must be approved for marine installations and meet the requirements of both the USCG and the ABYC.

The fuel system should be installed in such a manner as to allow the engine-mounted fuel lift pump to maintain a positive inlet pressure to the injection pump under all operating conditions. As the fuel lift pump has a capacity in excess of that required by the injection pump, the overflow is piped to the fuel tank and should be connected at the top of the tank.

Great care should be taken to ensure that the fuel system is correctly installed so that airlocks are eliminated and precautions taken against dirt and water entering the fuel.

NOTE: *The fuel supply line to the engine/generator should be from its own pick-up in the fuel tank and NOT teed off the supply line to another engine/generator.*

Keep the fuel lines as far as possible from the exhaust pipe and hot engine areas; this is to keep the fuel at a minimum temperature to reduce the chance of vapor lock in gasoline installations.

Run fuel lines at the top level of the fuel tank to a point as close to the engine or generator as possible to reduce the danger of fuel siphoning out of the tank if the line should break.

Fuel piping should always be routed and securely anchored to prevent leaks from vibration and chafing. Fuel piping is usually secured by copper straps every 12-14 in (30-36 cm). Use as few connections as possible, and install the lines so they are accessible and protected. Avoid locked-in torsional stresses.

RIGID FUEL LINES

For installations with rigid fuel lines, Westerbeke recommends using copper tubing with suitable flared fittings, both for the supply line and the return line. Use seamless annealed double flared fuel lines that are approved for marine installations. Run the tubing in the longest pieces obtainable to avoid the use of unnecessary fittings and connectors. The minimum size of the fuel supply line and fuel return line is 1/4 inch, inside diameter.

When a copper fuel line is used, electrically bond the fuel line to the vessel's common bonding conductor with a suitable strap or 10 gauge wire.

FLEXIBLE FUEL LINES

If a rigid metallic fuel line is run into the engine/generator compartment, a length of flexible hose must be installed to absorb vibration from the engine/generator. Install a non-organic flexible hose without metal reinforcement between the rigid fuel line and the engine/generator to absorb the vibration. This line must be long enough to prevent binding or stretching because of engine/generator movement.

A flexible fuel line may also be installed between the fuel tank and the engine/generator for both the supply line and the return line. For the supply line, flexible hose may be installed from the fuel tank outlet to the fuel filter/water separator, and from the fuel filter/water separator to the engine-mounted fuel pump inlet.

Use suitable end fittings, and install all the hose in the longest runs possible to avoid the use of unnecessary fittings and connectors. There must not be an electrical connection between the hose end fittings as a bad ground in the cranking circuit will cause a wire-reinforced hose to become charged and ignite the fuel during cranking.

▲ WARNING: *Ignition of fuel can cause fire and severe personal injury or death. Be sure any flexible fuel line used between the fuel tank and the engine/generator meets ABYC and USCG requirements.*

FUEL SYSTEM

SHUT-OFF VALVES

Make sure your fuel system has positive shut-off valves; know their locations and how they operate.

NOTE: See the U.S. Coast Guard publication "Fuel System Compliance Guideline" for basic fuel system layouts and shut-off valve locations.

FUEL FILTERS

A primary fuel/water separator should be installed in the fuel supply line between the fuel tank and the engine/generator to help remove contaminants in the fuel before the fuel reaches the engine mounted fuel lift pump. It should be mounted in an accessible location for ease in monitoring for water and contaminants, and for servicing. Such contaminants can cause the failure of components, and such failures are not warrantable. A recommended type of fuel/water separator is available from the list of accessories. A secondary fuel filter is mounted on the engine/generator, and it has a replacement filter element.

After installation, test the fuel system for tightness per USCG specification 33CFR183.542.

FUEL

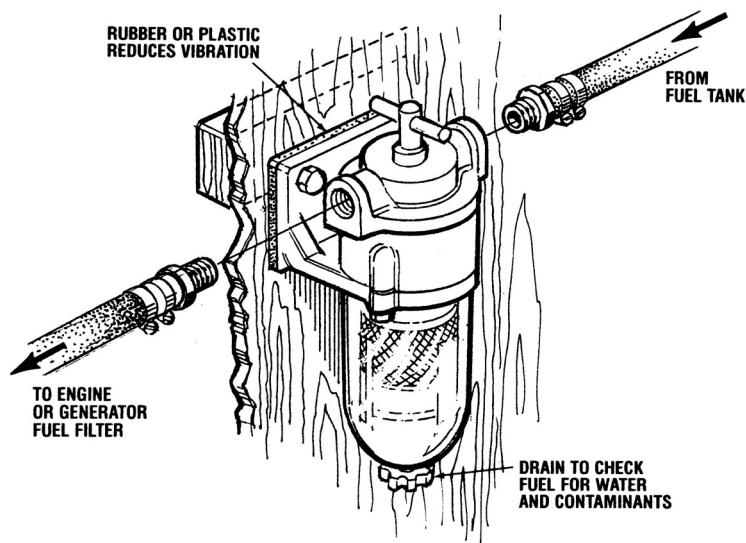
To insure satisfactory operation, an engine or generator must have a dependable supply of clean fuel.

Diesel Fuel – use No. 2 oil with a cetane rating of 45 or higher.

Gasoline – use unleaded 89 octane or higher.

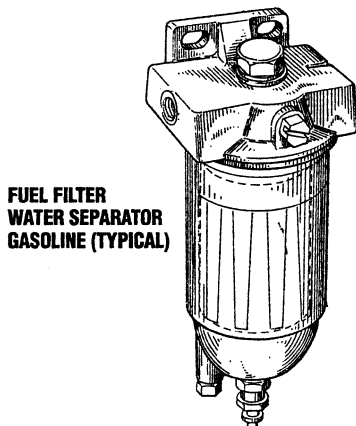
▲ WARNING: Gasoline leakage in or around the engine/generator compartment is a potential for fire and/or explosions. Repair leaks promptly and ensure that the compartment is properly ventilated.

Make sure there is a fire-extinguisher installed near the engine/generator and that it is properly maintained. Be familiar with its use. An extinguisher with the NFPA rating of ABC is appropriate for all applications.



FUEL FILTER/WATER SEPARATOR
Diesel Installation shown

NOTE: Fuel filters for gasoline installations must use metal bowls to meet Coast Guard regulations.



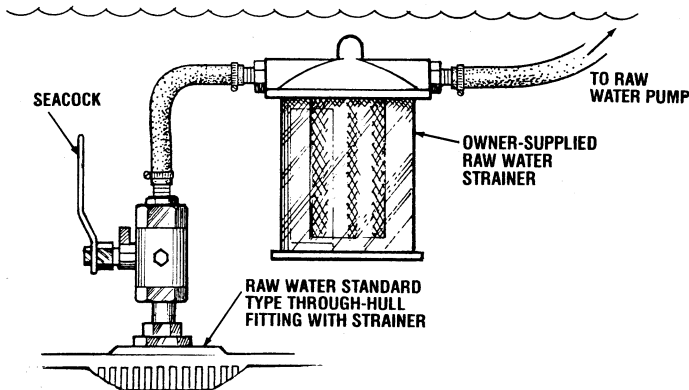
COOLING SYSTEM

RAW WATER INTAKE

Raw water should be supplied to the raw water pump through a standard-type through-hull fitting, located on the hull so as to be below the waterline during all angles of boat operation.

▲ CAUTION: *Do not use a high speed scoop-type through-hull fitting for the raw water supply for generators and auxiliary sailboat engines as it will tend to encourage siphoning. Water pressure against this type of fitting while the vessel is underway with the generator off or when sailing can push water past the raw water pump impeller and into the exhaust system, filling it and the engine as well.*

The raw water should be directed from the through-hull fitting through a seacock, to a visual-type raw water strainer, and then delivered to the pump. The strainer should be of the type that may be withdrawn for cleaning while the vessel is underway, and should be mounted below the waterline to ensure self-priming. Seacocks and strainers should be at least one size greater than the inlet thread of the raw water pump. Hoses routed from the through-hull fitting to the strainer and to the raw water pump should be wire-reinforced to prevent the hose from collapsing during the engine/generator's operation (suction from the pump may collapse a non-reinforced hose).



Make sure this system is in proper order. Check that the hull inlet, seacock and strainer are unobstructed. Inspect the raw water lines to make sure there are no collapsed sections which would restrict water flow. Make sure there are no air leaks at any of the connections; use double clamps on hose connections below the waterline.

Be sure that the raw water intake is clear of any cavitation created by the propellers.

The raw water intake to the engine or generator should be separate and not combined with any other inlet for the main engine(s) or air conditioners. The use of "sea chest" intakes is permissible but they must be engineered to provide an adequate supply of water for all equipment connected to them.

A through-hull fitting that is completely flush with the surface of the boat's hull and without an external strainer may be necessary for the generator raw water intake on very high-speed boats. The protrusion of a standard type through-hull fitting and a strainer can cause a venturi effect on the intake of a high speed boat, creating a suction which works against the raw water pump causing an inadequate supply of cooling water to the engine.

▲ CAUTION: *On some extremely high-speed boats, the use of a sea scoop type strainer may be necessary to provide an adequate supply of cooling to the generator when the boat is underway. If this is necessary, the exhaust piping from the generator must have a continuous downward pitch to the outlet at the transom so that no water can be trapped and back-up into the engine. A solenoid operated shut-off valve can also be installed in the raw water supply to the raw water pump and wired to close when the generator is not in operation.*

▲ CAUTION: *Water intrusion into the engine through the exhaust system is not covered by warranty.*

If a generator set is located above the waterline of the boat, it is good practice to provide a loop or loops above the inlet of the raw water pump in the raw water supply hose from the raw water strainer. The loop(s) provide a head of water on the raw water pump which, on start-up, lubricates the pump impeller until the pump starts drawing water from the intake.

RAW WATER OUTLET

Wire-reinforced flexible hose should be used between the raw water outlet on the heat exchanger and the exhaust system. This reduces vibration and permits the engine to be moved slightly when it's being realigned.

FITTINGS

All pipe and fittings should be of bronze. Use sealing compound or tape at all connections to prevent air leaks. The neoprene impeller in the raw water pump should never be run dry. All hose joints should be double clamped with 304/306 stainless-steel hose clamps. T-bolt clamps are even better but must be 304/306 stainless.

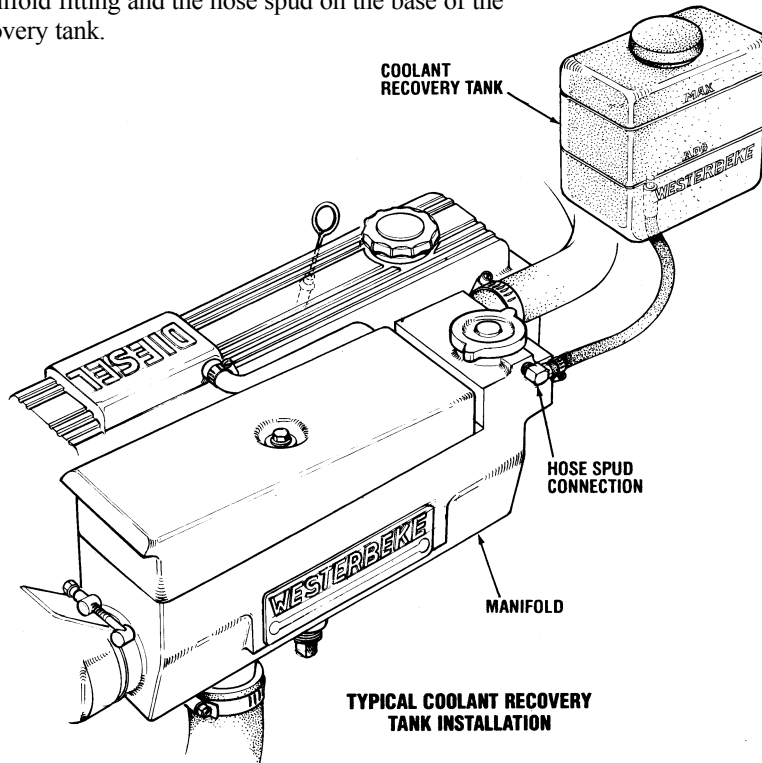
▲ CAUTION: *The use of common street elbows is not recommended in plumbing the raw water circuit. These generally have a very restrictive inside diameter. The use of machine-type fittings is preferred.*

COOLING SYSTEM

COOLANT RECOVERY TANK

A coolant recovery tank kit is supplied with each WESTERBEKE engine/generator. The purpose of this recovery tank is to allow for engine coolant expansion and contraction during engine operation, without the loss of coolant and without introducing air into the cooling system.

This coolant recovery tank should be installed at or above engine manifold level, in a location where it can be easily monitored. A wire mounting bracket is supplied with each kit, along with a 30 in (76 cm) length of clear plastic hose and clamps, to connect the hose between the engine's manifold fitting and the hose spud on the base of the recovery tank.



COOLANT

WESTERBEKE recommends a mixture of 50% antifreeze (good quality and compatible with aluminum components) and 50% distilled water.

ENGINE OIL

OIL SPECIFICATIONS

Refer to your Westerbeke Operator's Manual for the oil specifications for your engine/generator.

OIL DRAIN HOSE

An oil sump drain hose is located at the front or side of the engine. Oil may be drained from this hose by removing the cap and the discharge end of the hose from its mounting bracket and lowering the hose into a container. The hose cap fitting is 1/4 NPT and it can be extended, or have a pump added, for easier removal of the old oil.

When installing the engine make certain that this drain hose is accessible and that the drain hose fitting at the bottom of the engine oil pan is well clear of the boat's oil pan.

OIL DIPSTICK

If the engine is going to be mounted at an angle (instead of level), it's a good idea to add the proper amount of lube oil to the engine and check the dipstick before installation, with the engine level. After installation, check the dipstick to see where the oil now rests, and mark the dipstick at this point for future reference.

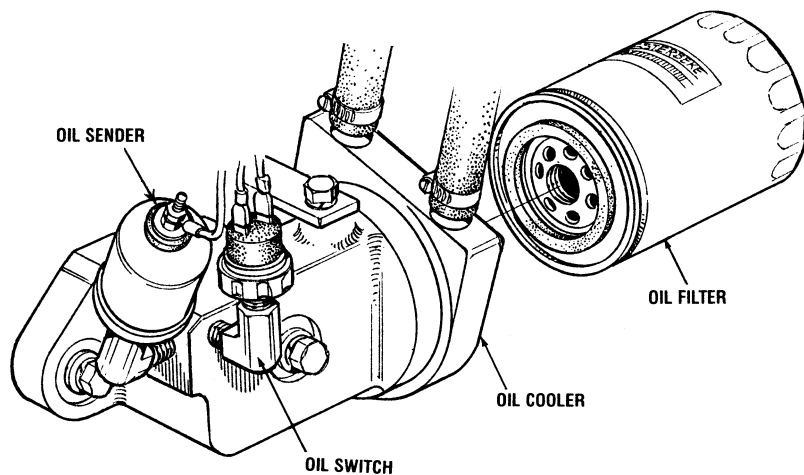
PRESSURE SENSING DEVICES

Oil pressure sensing devices, such as senders and switches, must not be connected to an engine's oil sump with the use of extended nipples or tees. The reason is simply that continued engine vibration causes fatigue of the fittings used to make such a connection. If these fittings fail during engine operation, lubricating oil will be lost and internal engine damage will result.

When additional sensing devices such as switches or sensors need to be installed that function on engine oil pressure, these devices *must* be bulkhead-mounted and connected to the oil sump using an appropriate grade of lubricating oil hose. Any fittings used to connect the hose to the gallery *must* be of steel or malleable iron composition. Brass must not be used for this application.

RELOCATING ENGINE PARTS

Any reassembly or relocation of engine parts such as fuel filters, dipstick senders and switches to accommodate a restricted engine space must be authorized by the WESTERBEKE Corporation and the work must be performed by a WESTERBEKE approved mechanic or the engine's warranty will be void. The oil filter can be relocated to a convenient bulkhead location by using a WESTERBEKE Remote Oil Filter kit.



TYPICAL OIL FILTER ASSEMBLY

NOTE: Oil filter assemblies vary with each engine model, switches, senders, coolers, etc. are shown in detail in all Operators Manuals.

REMOTE OIL FILTER

INSTALLATION

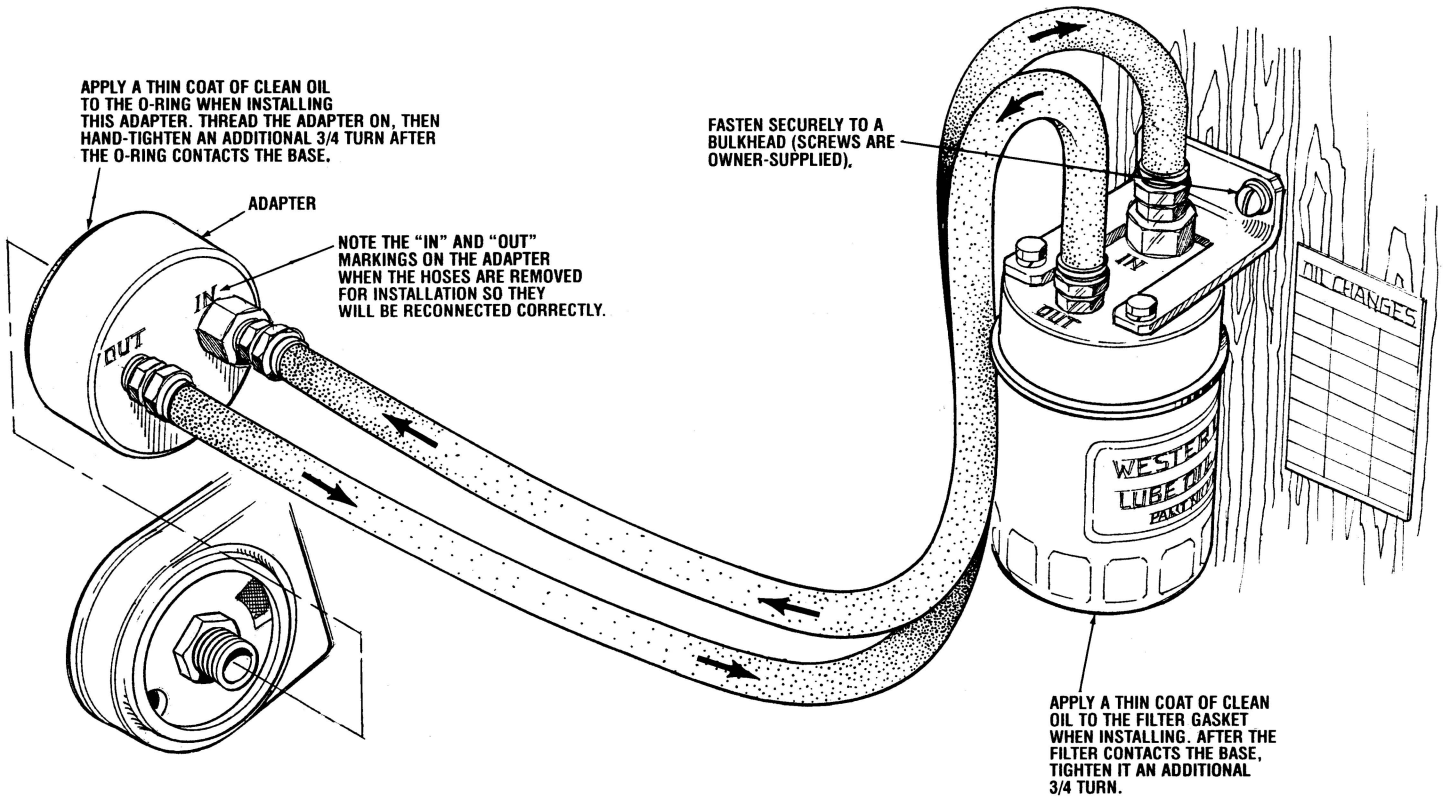
This popular accessory is used to relocate the engine's oil filter from the engine to a more convenient location such as an engine room bulkhead.

To install, simply remove the engine oil filter and thread on WESTERBEKE'S Remote Oil Filter kit as shown.

Always install this kit with the oil filter facing down, as illustrated.

Contact your WESTERBEKE dealer for more information.

NOTE: WESTERBEKE is not responsible for engine failure due to incorrect installation of the Remote Oil Filter.



VENTILATION

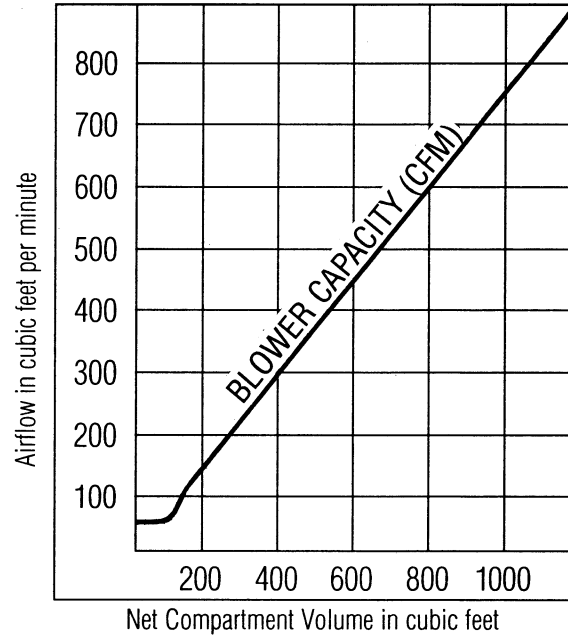
The ventilation requirements of the engine or generator include the following: combustion air is required for the engine's cylinders, and cooling air is required for the engine and generator electrical end and also for removing the heat produced during operation.

▲ WARNING: Ventilating air is required to clear the bilges, as well as the compartment in which the engine or generator is located, of potentially toxic and flammable vapors.

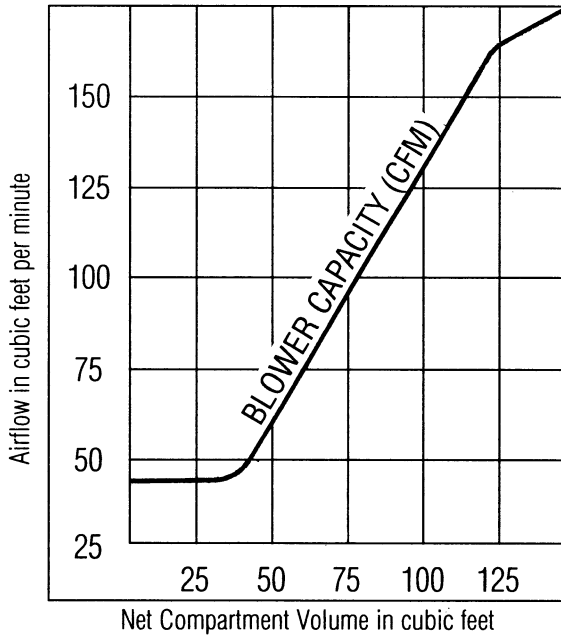
Keep in mind that hot air rises, so heated air should be removed from the upper area of the engine or generator compartment and cool fresh air should be directed to the lower areas of the compartment. Ventilation should be accomplished with the aid of power ventilation especially when the vessel is not underway.

Power ventilation incorporates a powered exhaust blower to draw air from the compartment and discharge to the atmosphere. The exhaust blower must meet a specific capacity rating based on compartment volume. The graph below is used to calculate the required capacity.

LARGE BOATS



SMALL BOATS



NOTE: See your Operators Manual for the ventilation requirements of your generator. Refer to the ABYC standards and U.S. Coast Guard regulations for ventilation requirements on both engines and generators.

WATER HEATER CONNECTIONS

INSTALLATION

Water heater hose connections vary from one engine to another. Refer to your WESTERBEKE Operators Manual for your engine's water heater connections.

NOTE: *Water heater connections are not standard on marine generator products.*

WESTERBEKE marine engines are equipped with connections for the plumbing of engine coolant to heat an on-board water heater. The water heater should be mounted in a convenient location either in a high or low position in relation to the engine, so that the connecting hoses from the heater to the engine can run in a reasonably direct line without any loops which might trap air.

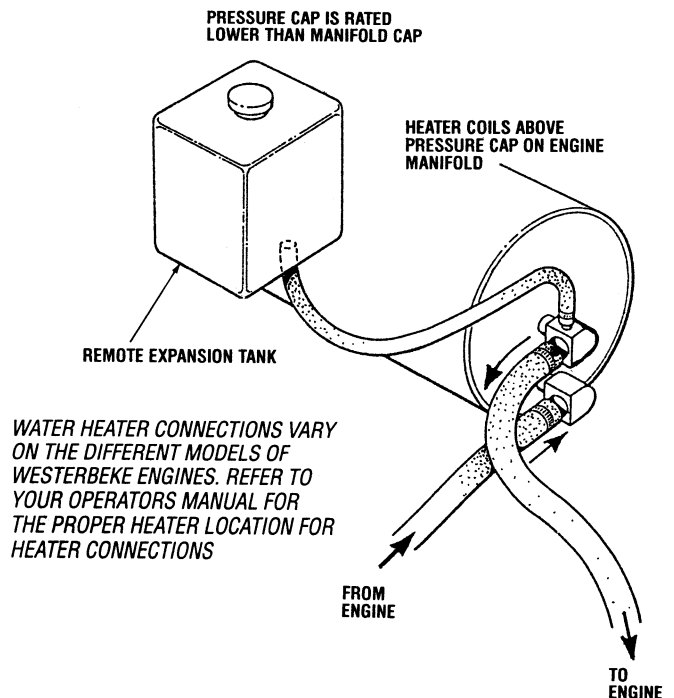
Hoses should rise continuously from their low point at the heater to the engine so that air will rise naturally from the heater to the engine. If trapped air is able to rise to the heater, then an air bleed petcock must be installed at the higher fitting on the heater for bleeding air while filling the system.

NOTE: *If any portion of the heating circuit rises above the engine's closed cooling system pressure cap, then a pressurized (aluminum) remote expansion tank must be installed in the circuit to become the highest point. Tee the remote expansion tank into the heater circuit, choosing the higher of the two connections for the return. Tee at the heater, and plumb a single line up to the tank's location and the other back to the engine's return. Install the remote expansion tank in a convenient location so the fresh water coolant level can easily be checked. The remote expansion tank will now serve as a check and system fill point. The plastic coolant recovery tank is not used when the remote expansion tank kit is installed, since this tank serves the same function. The remote expansion tank has an overflow fitting that should be directed by a hose to an area where any overflow will not cause damage.*

REMOTE EXPANSION TANK

The pressure cap on the engine's manifold should be installed after the engine's cooling system is filled with coolant. Finish filling the cooling system from the remote tank after the system is filled and is free of air and exhibits good coolant circulation. During engine operation, checking the engine's coolant should be done at the remote tank and not at the engine manifold cap. The hose connection from the heater to the remote expansion tank should be routed and supported so it rises continuously from the heater to the tank, enabling any air in the system to rise up to the tank and out of the system.

NOTE: *Air bleed petcocks are located on the engine's heat exchanger and on the thermostat housing. Open these petcocks when filling the engine's fresh water system to allow air in the coolant circuit to escape. Close tightly after all the air is removed.*

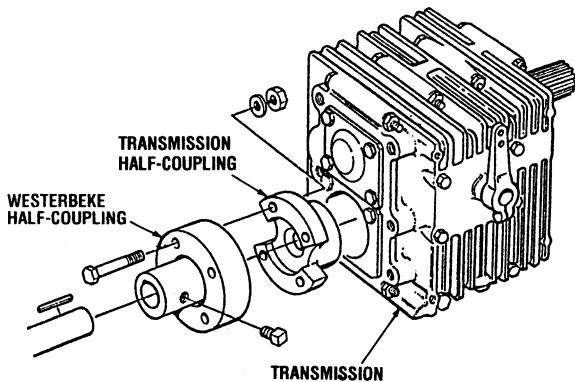


TRANSMISSIONS

SHIPMENT

For safety reasons, the transmission is *not* filled with transmission fluid during shipment and the selector lever is temporarily attached to the actuating shaft.

Before leaving the WESTERBEKE plant, each transmission undergoes a test run, with *Dextron III ATF* transmission fluid. The residual fluid remaining in the transmission after draining acts as a preservative and provides protection against corrosion for at least one year if properly stored.



TRANSMISSION FLUID

Fill the transmission with *Dextron III ATF*. The fluid level should be up to the mark on the dipstick. After checking the level, press the dipstick into the case and turn it to tighten. During the first 25 operating hours, inspect the bell housing, output shaft and transmission cooler for leakage. The fluid should be changed after the first 25 hours and every 300 hours thereafter.

NEUTRAL SWITCH

These transmissions are equipped with a neutral safety switch. This is to prevent the engine from starting in gear. Unless the transmission selector lever is perfectly aligned in neutral, the engine starter will not activate.

CONNECTION OF GEAR BOX WITH PROPELLER

Use a flexible connection between the transmission gearbox and the propeller shaft if the engine is flexibly mounted, in order to compensate for angular deflections. The installation of a special propeller thrust bearing is not required, since the propeller thrust will be taken by the transmission bearing, provided the value specified under *SPECIFICATIONS* is not exceeded. However, the output shaft should be protected from additional loads. Special care should be taken to prevent torsional vibration. When using a universal joint shaft, make certain to observe the manufacturers instructions.

Even with the engine solidly mounted, the use of flexible coupling or **DRIVESAVER* will reduce stress in the gearbox bearings caused by hull distortions, especially in wooden boats or where the distance between transmission output flange and stern gland is less than about 800mm.

**DRIVESAVER* is a product of Globe Marine, Rockland, MA.

CONTROL CABLES

NOTE: When installing the transmission, make certain that shifting is not impeded by restricted movability of the Bowden cable or rod linkage, by unsuitably positioned guide sheaves, too small a bending radius, etc. In order to mount a support for shift control cable connections, use the two threaded holes located above the shift cover on top of the gear housing. Refer to the *WESTERBEKE parts list*.

CONTROL CABLES

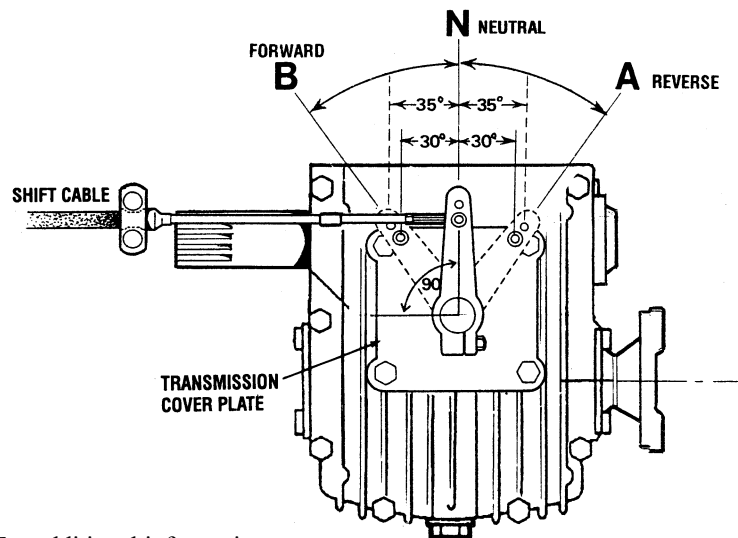
The transmission is suitable for single lever remote control. Upon loosening the retaining screw, the actuating lever can be moved to any position required for the control elements (cable or rod linkage). Make certain that the shift lever does not contact the actuating lever cover plate: the minimum distance between lever and cover should be 0.5mm.

The control cable or rod should be arranged at right angle to the actuating shift lever when in the neutral position. The neutral position of the operating lever on the control console should coincide with the neutral position of this lever.

The shifting travel, as measured at the pivot point of the actuating lever, between the neutral position and end positions **A** and **B** should be at least **35mm** for the outer and **30mm** for the inner pivot point.

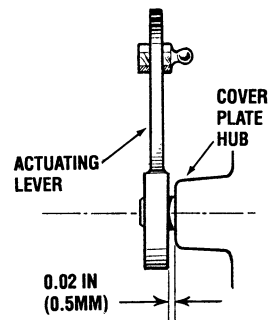
A greater amount of shift lever travel is in no way detrimental and is recommended. However, if the lever travel is shorter, proper clutch engagement might be impeded which, in turn, would mean premature wear, excessive heat generation and clutch plate failure. This would be indicated by slow clutch engagement or no engagement at all.

NOTE Check for proper lever travel at least each season.



For additional information contact:

ZF Industries
Marine US Headquarters
3131 SW 42nd Street
Fort Lauderdale, FL 33312
Tel.: (954) 581-4040
Fax: (954) 581-4077
WWW.ZF-MARINE.COM



TRANSMISSIONS

BORG WARNER VELVET DRIVE

Check the transmission fluid level on the dipstick. If the transmission has not been filled, fill with *Dextron III* and continue to use this fluid. During the first 50 hours of operation, keep a lookout for any leakage at the bell housing, output shaft, and transmission cooler. This fluid should be changed after the first 50 hours and approximately every 1000 operating hours or at winter lay-up.

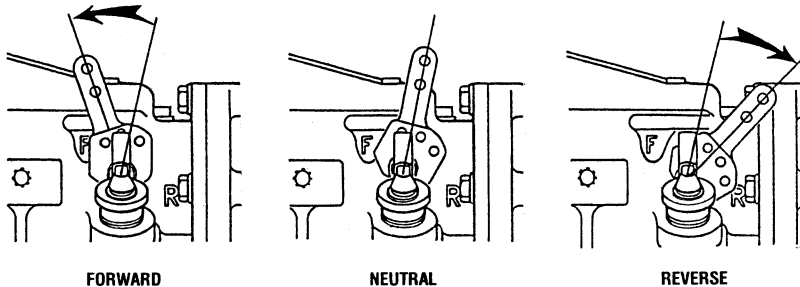
NOTE: *Some transmissions are equipped with a neutral safety switch. Unless the transmission shift lever is perfectly aligned in neutral the engine starter will not activate.*

Shift Lever Position

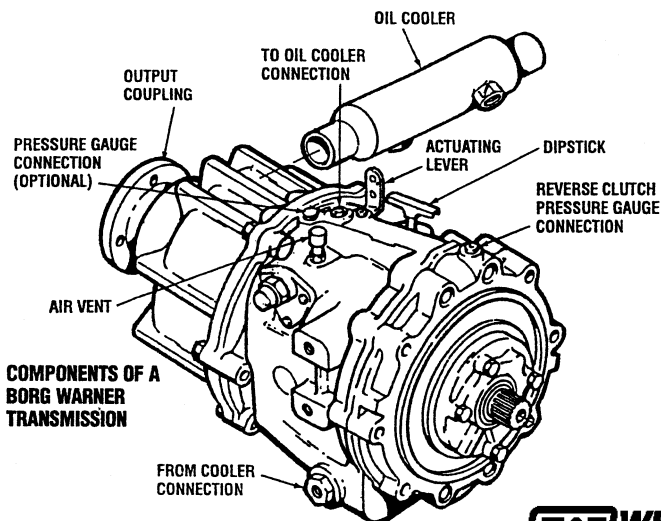
The shift control handle and linkage must position the shift lever on the transmission exactly in Forward (F), Neutral (N), and Reverse (R) shifting positions. A detent ball located behind the transmission shift lever must work freely to center the lever in each position. The shift control positions at the helm(s) must be coordinated with those of the Velvet Drive shift lever through shift mechanism adjustments. An improperly adjusted shift mechanism can cause damage to the transmission. The shifting mechanism and transmission shift lever should be free of dirt to ensure proper operation.

NOTE: *Do not remove the detent ball!*

NOTE: *If the boat moves backwards with the selector control in the forward position, shut off the engine! This problem may be the result of incorrect movement of the shift lever by the shift control.*



SHIFT LEVER POSITIONS



Shifting Into Gear

Place the transmission selector control in Neutral before starting the engine. Shifting from one selector position to another selector position may be made at any time below 1000 rpm and in any order. Shifts should be made at the lowest *practical* engine speed. Start the engine and set the throttle at idle speed; allow the transmission fluid to warm up for a few minutes.

Neutral

Move the shift control handle to the middle position. You should feel the detent. Center the shift lever on the transmission through the linkage to the selector lever. With the control in this position, hydraulic power is completely interrupted and the output shaft of the transmission does not turn.

Forward

Move the shift control handle to the forward position. You should feel the detent. The shift lever on the transmission is in the forward position. The output shaft and the propeller shaft move the boat in a forward direction.

Reverse

Move the shift control handle to the reverse position. You should feel the detent. The shift lever on the transmission is in the reverse position. The output shaft and the propeller should move the boat in a reverse direction (astern).

NOTE: *Moving the transmission shift lever from Neutral Position to Forward is always towards the engine. Reverse is always away from the engine.*

NOTE: *Be aware of any unusual noises or vibrations and investigate to determine the cause.*

NOTE: *Low engine idle rpm can produce damper plate and gear box chatter/rattle. This is the result of unstable rotation through the damper plate and the gear box. Increase the idle rpm until this chatter/rattle is eliminated.*

Refer to your transmission manufacturer's operator's manual for more detailed information on installation and operation.

For additional information on throttle and shift controls contact *Edson International, New Bedford, Massachusetts.*

FINAL INSTALLATION CHECKS

NOTE: Also refer to *PREPARATIONS FOR INITIAL START-UP* in your *Operator's Manual*.

Before starting the engine or generator complete the following checklist:

- Is there fuel in the tanks and are the fuel valves open?
- Has lube oil been added to the engine?
- Is there transmission fluid in the transmission?
- Has the proper coolant mix been added?
- Are the battery cables properly connected?
- Is the exhaust system secure and all connections tight?
- Is the transmission linkage positioned correctly? Is the gear in Neutral?
- Is the raw water petcock open? Is the raw water pump primed?
- Are the AC and load connection wires securely connected to the circuit breaker?

With the engine or generator running, check the following:

- Make certain that water is flowing from the exhaust.
- Check the instrument gauges for proper readings.
- Inspect the engine for fuel, water, coolant, and oil leaks.
- Listen for unusual sounds and vibrations.
- Will the engine shift in and out of gear?
- Can you throttle up to the recommended rpm's? Is the throttle action smooth?
- Apply a load to the generator; check the output frequency.

NOTE: See your operator's manual for the output adjustment.

After shutdown, check the engine or generator carefully. inspect all fluid levels, check hose clamps, fuel lines, etc.

ENGLISH TO METRIC CONVERSION CHART

Multiply Temperature	By	To get equivalent number of:
Degree Fahrenheit (°F)	$(°F-32) \div 1.8$	Degree Celsius (°C)
Multiply Acceleration	By	To get equivalent number of:
Foot/second ² (ft/sec ²)	0.3048	Meter/second ² (m/s ²)
Inch/second ² (in./sec ²)	0.0254	Meter/second ² (m/s ²)
Multiply Torque	By	To get equivalent number of:
Pound-inch (lb-in.)	0.11298	Newton-meters (N-m)
Pound-foot (lb-ft)	1.3558	Newton-meters (N-m)
Multiply Power	By	To get equivalent number of:
Horsepower (hp)	0.746	Kilowatts (kW)
Multiply Pressure or Stress	By	To get equivalent number of:
Inches of water (in. H ₂ O)	0.2491	Kilopascals (kPa)
Pounds/square in. (lb/in. ²)	6.895	Kilopascals (kPa)
Multiply Energy or Work	By	To get equivalent number of:
British Thermal Unit (Btu)	1055	Joules (J)
Foot-pound (ft-lb)	1.3558	Joules (J)
kilowatt-hour (kW-hr)	3,600,000. or 3.6 x 10 ⁶	Joules (J = one W/s)
Multiply Light	By	To get equivalent number of:
Foot candle (fc)	1.0764	Lumens/meter ² (lm/m ²)
Multiply Fuel Performance	By	To get equivalent number of:
Miles/gal (mile/gal)	0.4251	Kilometers/liter (km/L)
Gallons/mile (gal/mile)	2.3527	Liter/kilometer (L/km)
Multiply Velocity	By	To get equivalent number of:
Miles/hour (mile/hr)	1.6093	Kilometers/hour (km/hr)

Multiply Length	By	To get equivalent number of:
Inch (in.)	25.4	Millimeters (mm)
Foot (ft)	0.3048	Meters (m)
Yard (yd)	0.9144	Meters (m)
Mile (mile)	1.609	Kilometers (km)
Multiply Area	By	To get equivalent number of:
Inch ² (in. ²)	6452	Millimeters ² (mm ²)
Inch ² (in. ²)	6.45	Centimeters ² (cm ²)
Foot ² (ft ²)	0.0929	Meters ² (m ²)
Yard ² (yd ²)	0.8361	Meters ² (m ²)
Multiply Volume	By	To get equivalent number of:
Inch ³ (in. ³)	16387	Millimeters ³ (mm ³)
Inch ³ (in. ³)	16.387	Centimeters ³ (cm ³)
Inch ³ (in. ³)	0.0164	Liters (L)
Quart (qt)	0.9464	Liters (L)
Gallon (gal)	3.785	Liters (L)
Yard ³ (yd ³)	0.7646	Meters ³ (m ³)
Multiply Mass	By	To get equivalent number of:
Pound (lb)	0.4536	Kilograms (kg)
Ton (ton)	907.18	Kilograms (kg)
Ton (ton)	0.907	Tonne (t)
Multiply Force	By	To get equivalent number of:
Kilogram (kg)	9.807	Newtons (N)
Ounce (oz)	0.2780	Newtons (N)
Pound (lb)	4.448	Newtons (N)

WIRE SIZING

CONDUCTOR SIZES FOR 3% DROP IN VOLTAGE

Total Circuit Current in AMPS	Length of Conductor from Source of Current to Device and Back to Source – Feet																		
	10	15	20	25	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170
12 Volts — 3% Drop Wire Sizes (gauge) — Based on Minimum CM Area																			
5	18	16	14	12	12	10	10	10	8	8	8	6	6	6	6	6	6	6	6
10	14	12	10	10	10	8	6	6	6	6	4	4	4	4	2	2	2	2	2
15	12	10	10	8	8	6	6	6	6	4	4	2	2	2	2	1	1	1	1
20	10	10	8	6	6	6	4	4	2	2	2	2	1	1	1	0	0	0	2/0
25	10	8	6	6	6	4	4	2	2	2	1	1	0	0	0	2/0	2/0	2/0	3/0
30	10	8	6	6	4	4	2	2	1	1	0	0	0	2/0	2/0	3/0	3/0	3/0	3/0
40	8	6	6	4	4	2	2	1	0	0	2/0	2/0	3/0	3/0	3/0	4/0	4/0	4/0	4/0
50	6	6	4	4	2	2	1	0	2/0	2/0	3/0	3/0	4/0	4/0	4/0				
60	6	4	4	2	2	1	0	2/0	3/0	3/0	4/0	4/0	4/0						
70	6	4	2	2	1	0	2/0	3/0	3/0	4/0	4/0								
80	6	4	2	2	1	0	3/0	3/0	4/0	4/0									
90	4	2	2	1	0	2/0	3/0	4/0	4/0										
100	4	2	2	1	0	2/0	3/0	4/0											
24 Volts — 3% Drop Wire Sizes (gauge) — Based on Minimum CM Area																			
5	18	18	18	16	16	14	12	12	12	10	10	10	10	8	8	8	8	8	8
10	18	16	14	12	12	10	10	10	8	8	8	6	6	6	6	6	6	6	6
15	16	14	12	12	10	10	8	8	6	6	6	6	6	4	4	4	4	4	2
20	14	12	10	10	10	8	6	6	6	6	4	4	4	4	2	2	2	2	2
25	12	12	10	10	8	6	6	6	4	4	4	4	2	2	2	2	2	2	1
30	12	10	10	8	8	6	6	4	4	4	2	2	2	2	2	1	1	1	1
40	10	10	8	6	6	6	4	4	2	2	2	2	1	1	1	0	0	0	2/0
50	10	8	6	6	6	4	4	2	2	1	1	0	0	0	2/0	2/0	2/0	2/0	3/0
60	10	8	6	6	4	4	2	2	1	1	0	0	2/0	2/0	3/0	3/0	3/0	3/0	3/0
70	8	6	6	4	4	2	2	1	1	0	0	2/0	2/0	3/0	3/0	3/0	3/0	4/0	4/0
80	8	6	6	4	4	2	2	1	0	0	2/0	2/0	3/0	3/0	3/0	4/0	4/0	4/0	4/0
90	8	6	4	4	2	2	1	0	0	2/0	2/0	3/0	3/0	4/0	4/0	4/0	4/0	4/0	4/0
100	6	6	4	4	2	2	1	0	2/0	2/0	3/0	3/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0

CONDUCTOR SIZES FOR 10% DROP IN VOLTAGE

Total Circuit Current in AMPS	Length of Conductor from Source of Current to Device and Back to Source – Feet																		
	10	15	20	25	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170
12 Volts — 10% Drop Wire Sizes (gauge) — Based on Minimum CM Area																			
5	18	18	18	18	18	16	16	14	14	14	12	12	12	12	12	10	10	10	10
10	18	18	16	14	14	12	12	10	10	10	10	10	8	8	8	8	8	8	6
15	18	16	14	14	12	12	10	10	8	8	8	8	8	6	6	6	6	6	6
20	16	14	14	12	12	10	10	8	8	8	6	6	6	6	6	4	4	4	4
25	16	14	12	12	10	10	8	8	6	6	6	6	4	4	4	4	4	4	2
30	14	12	12	10	10	8	8	6	6	6	6	4	4	4	4	2	2	2	2
40	14	12	10	10	8	8	6	6	6	4	4	4	2	2	2	2	2	2	2
50	12	10	10	8	8	6	6	4	4	4	2	2	2	2	2	1	1	1	1
60	12	10	8	8	6	6	4	4	2	2	2	2	2	1	1	0	0	0	2/0
70	10	8	8	6	6	6	4	2	2	2	2	2	1	1	0	0	0	2/0	2/0
80	10	8	8	6	6	4	4	2	2	2	1	1	0	0	0	2/0	2/0	2/0	2/0
90	10	8	6	6	6	4	2	2	2	1	1	0	0	0	2/0	2/0	2/0	3/0	3/0
100	10	8	6	6	4	4	2	2	1	1	0	0	0	2/0	2/0	2/0	3/0	3/0	3/0
24 Volts — 10% Drop Wire Sizes (gauge) — Based on Minimum CM Area																			
5	18	18	18	18	18	18	18	18	16	16	16	14	14	14	14	14	14	14	12
10	18	18	18	18	18	16	16	14	14	14	12	12	12	12	12	10	10	10	10
15	18	18	18	16	16	14	14	12	12	12	10	10	10	10	8	8	8	8	8
20	18	18	16	16	14	14	12	12	10	10	10	10	8	8	8	8	8	8	6
25	18	16	16	14	14	12	12	10	10	10	8	8	8	8	8	6	6	6	6
30	18	16	14	14	12	12	10	10	8	8	8	8	8	6	6	6	6	6	6
40	16	14	14	12	12	10	10	8	8	8	6	6	6	6	6	4	4	4	4
50	16	14	12	12	10	10	8	8	6	6	6	6	4	4	4	4	4	4	2
60	14	12	12	10	10	8	8	6	6	6	6	4	4	4	4	2	2	2	2
70	14	12	10	10	8	8	6	6	6	6	4	4	4	2	2	2	2	2	2
80	14	12	10	10	8	8	6	6	6	4	4	4	2	2	2	2	2	2	2
90	12	10	10	8	8	6	6	6	4	4	4	2	2	2	2	2	2	1	1
100	12	10	10	8	8	6	6	4	4	4	2	2	2	2	2	1	1	1	1

Courtesy American Boat & Yacht Council, Inc.



DECIMAL TO METRIC EQUIVALENT CHART

Fractions of an inch	Decimal (in.)	Metric (mm)	Fractions of an inch	Decimal (in.)	Metric (mm)
1/64	0.015625	0.39688	33/64	0.515625	13.09687
1/32	0.03125	0.79375	17/32	0.53125	13.49375
3/64	0.046875	1.19062	35/64	0.546875	13.89062
1/16	0.0625	1.58750	9/16	0.5625	14.28750
5/64	0.078125	1.98437	37/64	0.578125	14.68437
3/32	0.09375	2.38125	19/32	0.59375	15.08125
7/64	0.109375	2.77812	39/64	0.609375	15.47812
1/8	0.125	3.175	5/8	0.625	15.87500
9/64	0.140625	3.57187	41/64	0.640625	16.27187
5/32	0.15625	3.96875	21/32	0.65625	16.66875
11/64	0.171875	4.36562	43/64	0.671875	17.06562
3/16	0.1875	4.76250	11/16	0.6875	17.46250
13/64	0.203125	5.15937	45/64	0.703125	17.85937
7/32	0.21875	5.55625	23/32	0.71875	18.25625
15/64	0.234375	5.95312	47/64	0.734375	18.65312
1/4	0.250	6.35000	3/4	0.750	19.05000
17/64	0.265625	6.74687	49/64	0.765625	19.44687
9/32	0.28125	7.14375	25/32	0.78125	19.84375
19/64	0.296875	7.54062	51/64	0.796875	20.24062
5/16	0.3125	7.93750	13/16	0.8125	20.63750
21/64	0.328125	8.33437	53/64	0.828125	21.03437
11/32	0.34375	8.73125	27/32	0.84375	21.43125
23/64	0.359375	9.12812	55/64	0.859375	21.82812
3/8	0.375	9.52500	7/8	0.875	22.22500
25/64	0.390625	9.92187	57/64	0.890625	22.62187
13/32	0.40625	10.31875	29/32	0.90625	23.01875
27/64	0.421875	10.71562	59/64	0.921875	23.41562
7/16	0.4375	11.11250	15/16	0.9375	23.81250
29/64	0.453125	11.50937	61/64	0.953125	24.20937
15/32	0.46875	11.90625	31/32	0.96875	24.60625
31/64	0.484375	12.30312	63/64	0.984375	25.00312
1/2	0.500	12.70000	1	1.00	25.40000

