



INSTALLATION MANUAL

DIESEL GENERATORS

FOR

MOBILE APPLICATIONS

PUBLICATION #43400
1st Edition / June 1999



WESTERBEKE CORPORATION • AVON INDUSTRIAL PARK
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**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*
- *Throbbing in Temples*
- *Nausea*
- *Muscular Twitching*
- *Headache*
- *Vomiting*
- *Weakness and Sleepiness*
- *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.



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SAFETY INSTRUCTIONS

INTRODUCTION

Read these safety instructions 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 generator.

GENERAL

Use eye protection and suitable protective clothing when installing and servicing the generator. Make certain that the installation of the generator is performed by qualified personnel.

⚠ WARNING: *Improper installation, maintenance or service of the generator and its related equipment can cause personal injury, death or property damage.*

PREVENT ELECTRIC SHOCK

- Make sure all electrical installations are performed by a qualified licensed electrician. Follow all state and local electrical codes.
- Use extreme caution when working on electrical components.

⚠ WARNING: *High voltages can cause severe personal injury or death by electrocution. Do not touch AC electrical connections while the generator is running. Lethal voltage is present at these connections!*

- Do not operate the generator 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, rings and any other jewelry when working on electrical equipment. These articles can short out electrical contacts and cause a shock or burns.
- Always use a double-throw transfer switch with a standby generator. *Never connect a standby generator directly to a building's electrical system.* If this is done, dangerous voltages can flow from the generator to the utility line, creating a potential for electrocution, severe personal injury, or property damage. Make this connection only with an approved device and after the building's main switch has been opened. Consult a qualified electrician about using the generator for emergency power.
- Electrical shock results from handling a charged capacitor. Discharge capacitor by shorting terminals together with an insulated tool.

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 personal 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 personal injury or death!*

- Prevent flash fires. Do not allow any smoking, open flames, spark producing equipment or other sources of ignition or fire in the installation area or near the fuel tank, fuel system components or other potential sources of spilled fuel or fuel vapors. Use a suitable container to catch all fuel when removing the fuel line or fuel filters.
- Do not operate the generator with the air intake silencer removed. Backfire can cause severe injury or death.
- Keep the generator and generator compartment clean to minimize the risk of fire.
- Remove unnecessary oil and grease from the generator. Accumulated oil and grease can cause overheating with possible engine damage and a risk of fire. Wipe up all spilled fuel and engine oil. Keep the generator compartment free of debris. Do not store any equipment in the compartment or any supplies such as oil or rags.
- Be aware — diesel fuel will burn.

PREVENT BURNS — EXPLOSION

⚠ WARNING: *Explosions from fuel vapors can cause personal injury or death!*

- Use extreme care when handling and storing fuels. Keep fuel away from your generator. 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 hot or 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, spark

SAFETY INSTRUCTIONS

producing equipment or other sources of fire near the fuel tank, fuel system or generator when servicing. Ensure proper ventilation exists when servicing the fuel system.

- Fuel lines must be of steel piping. Have a flexible fuel line between the generator and the stationary fuel line in the vehicle. This flexible section must be 100% *non-metallic* to prevent it from being used as a conductor.
- Do not alter or modify the fuel system.
- Be sure all fuel supply lines have a positive shutoff valve.
- Be certain that fuel lines are secured and that fuel line fittings are adequately tightened and free of leaks.
- Make sure the generator's ventilation system provides a continuous flow of cooling air to prevent an accumulation of fuel vapors.
- 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.

ACCIDENTAL STARTING

⚠ WARNING: Accidental starting of the generator can cause personal injury or death!

- To prevent accidental starting and electrical arcing, do not connect the battery cables to the generator's starting battery until the generator is completely installed.
- Disconnect the battery cables before servicing the generator. Remove the negative lead first to reduce the risk of arcing and reconnect it last.
- Make certain all personnel are clear of the generator before starting.
- Make certain all covers and guards are re-installed before starting the generator.

BATTERY EXPLOSION

⚠ WARNING: Battery explosion can cause serious personal 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, to prevent burns or sparks that could cause an explosion. Remove wrist-watch, 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 personal 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

- 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 are securely attached and no warping exists. Pay close attention to the manifold and the exhaust pipe nipple.
- 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.
- Be sure the generator and its surroundings are well ventilated.
- Never sleep in a vehicle while the generator is running.

⚠ WARNING: Carbon monoxide (CO) is a deadly gas! It is invisible and odorless. Inhalation produces flu-like symptoms, nausea or death!

- Do not discharge exhaust gases under a vehicle. Direct exhaust gases away from vehicle windows, doors and any other openings. Close any openings that are either above or to the rear of the exhaust pipe(s) when the generator is operating.
- Make sure that the generator's compartment walls are vapor-tight to prevent exhaust gases from entering the vehicle operating area or the living quarters.
- Although diesel engine exhaust gases are not as toxic as exhaust fumes from gasoline engines, carbon monoxide

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gas is present in diesel exhaust fumes. Some of the symptoms or signs of carbon monoxide inhalation or poisoning are:

- Vomiting
- Dizziness
- Throbbing in temples
- Muscular twitching
- Intense headache
- Weakness and sleepiness

⚠ WARNING: *Never use discharged cooling air for heating purposes. It can contain toxic gases.*

AVOID MOVING PARTS

⚠ WARNING: *Do not touch any moving part on your generator during operation. Rotating parts can cause personal injury or death!*

- Do not service the generator while it is running. If a situation arises in which it is absolutely necessary to make operating adjustments while the generator is running, use extreme care to avoid touching moving parts and hot exhaust system components.
- Do not wear loose clothing or jewelry when servicing equipment; tie back long hair; 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 belt's tension while the generator is operating.

HAZARDOUS NOISE

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

- Never operate a generator without its muffler installed.
- Do not run a generator with the air intake silencer removed.
- Do not run a generator for a long period with its 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.

PUBLICATIONS FOR INSTALLING DIESEL GENERATORS

Read the following NFPA and ANSI publications for safety codes and standards. Follow their recommendations when installing your generator.

NFPA 70 *National Electric Code*

NFPA 79 *Electrical Standard for Industrial Machinery*

Order From:

National Fire Protection Association
11 Tracy Drive
Avon Industrial Park
Avon, MA 02322

ANSI A119.2/NFPA 501C

Standard for Recreational Vehicles

ANSI/RVIA EGS-1-1993

American National Standard

Engine Generator Sets

for Recreation Vehicle Safety Requirements

Order From:

Recreation Vehicle Industry Association
1896 Preston White Drive
Reston, VA 20191



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INTRODUCTION

GENERAL

This installation manual covers those Westerbeke generators that are designed for mobile applications. The purpose of this manual is to provide generator installation instructions that will insure the reliable starting of your generator, delivery of its rated output, safe operation, and ease of service and maintenance. These instructions are general in nature due to the many WESTERBEKE generator models available and the diversity of vehicle applications and designs. In addition to these instructions, the installation of your generator should be based on the specific requirements of your particular vehicle and any codes and regulations that may apply. Please read this manual carefully and observe the safety precautions. Common sense and good judgement are called for with all installations.

Should your generator require servicing, contact your WESTERBEKE dealer. For Serial Number location, Decal information or Parts Ordering information, refer to your WESTERBEKE Operator's Manual.

GENERATOR SELECTION AND PLANNING THE INSTALLATION

The electrical power requirements of the vehicle and the size and weight of the generator are your main considerations when choosing a generator. Where the generator is located in the vehicle and how its systems are configured are also very important.

The factors to consider for both selecting a generator and planning its installation are:

1. Load requirements
2. Size and weight of the generator
3. Location and mounting surface
4. Ventilation
5. Noise reduction
6. Exhaust system
7. Fuel supply
8. Service and maintenance accessibility
9. Electrical connections
10. Accessories
11. Protection from the weather

Refer to specific sections in this manual for information about the various systems that should be considered when planning your installation. Also refer to WESTERBEKE's Generator Data Sheets to get the specifications for individual generator models. For assistance with designing custom generator installations, contact your WESTERBEKE dealer.

ONE-SIDE SERVICING

For easy maintenance and service, most WESTERBEKE generators are designed with the main service points on one side of the generator. Remember this when planning your generator's location and installation.

LOAD REQUIREMENTS

When choosing a generator that will provide the necessary electrical power for your vehicle, consider the following:

1. The total loads to be used, i.e. pumps, heater, lights, refrigerator, air conditioner, etc. Note that starting loads are higher than running loads.
2. Loads that occur or might occur simultaneously.
3. Possible emergency loads.
4. New loads that may be added in the future.
5. Power Take Off (P.T.O.)
6. Deration due to temperature, humidity, barometric pressure and altitude.

AIR CONDITIONER LOADS

An air conditioner can use a substantial amount of power; it is usually the largest load for a generator in a recreational vehicle. Air conditioners are usually designed to run on commercial power, so care should be taken when choosing a generator because its size may depend on the air conditioner's characteristics.

The air conditioner's current draw will vary considerably as it passes through its operating phases: at initial start, the current draw will be high, then it will decrease, then increase as refrigerant is pumped, then decrease again when the temperature in the vehicle goes down; after running for a while, the air conditioner will stop. Restarting it will require the largest current draw because the internal temperature of the air conditioner's compressor has risen.

The type of air conditioner and its starting time are additional variables that can affect the air conditioner's current draw.

ANGLE OF OPERATION

Refer to the Specifications section in your Operator's Manual to find the maximum angle of operation for your generator model.

Operating the generator at an excessive angle, in any direction, can lead to various engine problems. Frequent operation and long running periods at an excessive angle increases the likelihood of a problem.

When selecting a generator, allow for the possibility that it may occasionally operate at an angle that exceeds its normal expected angle of operation.

DERATION

Temperature, humidity, barometric pressure and altitude can all affect the performance of your generator because these conditions can make your generator's diesel engine work harder. Take these deration factors into account when selecting your generator. Temperature, humidity and barometric pressure are all variable and transient weather-related conditions. Altitude is a constant condition, and its deration can be estimated.

INTRODUCTION

Altitude Deration. The lower density air (less oxygen) that exists at higher altitudes can cause engine power loss, resulting in a lower generator cooling capability. Each 1,000 ft (305 m) increase in altitude above 1,000 ft (305 m) above sea level can cause a 3% nominal deration.

Note: *Low air temperatures only diminish the engine's ability to start. This can be remedied by using a heavy-duty battery. See the battery size chart under BATTERIES.*

INSTALLATION CODES AND SAFETY STANDARDS

Recommended publications concerning installation codes and safety standards are listed in the *SAFETY INSTRUCTIONS* section of this manual.

Make certain that the installation of the generator is done by qualified personnel. Follow state and local electrical codes. All electrical installations should be done by a qualified licensed electrician.

⚠ WARNING: *Improper installation, service or maintenance of the generator and its related equipment can cause personal injury, death or property damage.*

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

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NOTES, CAUTIONS AND WARNINGS

As this manual takes you through the installation procedures for your generator, critical information will be highlighted by

NOTES, CAUTIONS, and WARNINGS. An explanation follows:

NOTE: *A procedure essential to note.*

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

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

INSPECTION OF SHIPMENT

The 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. WESTERBEKE's documentation package is attached to the generator's lifting eye.

Before accepting shipment of the generator from the transportation company, the crate should be opened and the contents inspected for damage. If there is either visible or concealed damage, 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 generator is not filled with lubricating oil for shipment. Before leaving the factory, however, each 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 generator is properly stored.*

GENERATOR LOCATION

There are three main locations for a vehicle's generator:

1. In a compartment at the side of the vehicle.
2. In a compartment transversing the vehicle.
3. In a dunnage pan (on the vehicle's rooftop).

The most important factors in choosing a generator compartment location are:

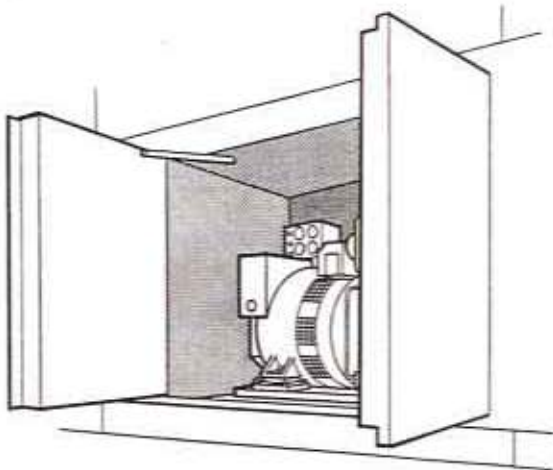
1. The size of the generator.
2. The size of the access opening.
3. The strength of the structural support for the generator.
4. The air intake and discharge capability.
5. Protection from outside elements.

Choose a location for the generator or generator compartment that will provide ample space on all sides for ventilation, servicing and maintenance. The most common location is in a compartment at the side of the vehicle.

SIDE COMPARTMENT INSTALLATION

Locating the generator in its own compartment at the side of the vehicle can protect it from extreme ambient temperatures, adverse weather conditions, road dirt, road splash and salt. It also allows easier installation of acoustic insulation or fire barrier materials. The compartment must be large enough to accommodate the generator and its minimum clearances to the compartment bulkheads and ceiling, including any acoustic insulation or fire barrier materials that might be used. The compartment location should allow the generator to be properly ventilated, and should be close to both the fuel supply and the center of the electrical load distribution. To avoid generator noise, locate the compartment away from a vehicle's living quarters.

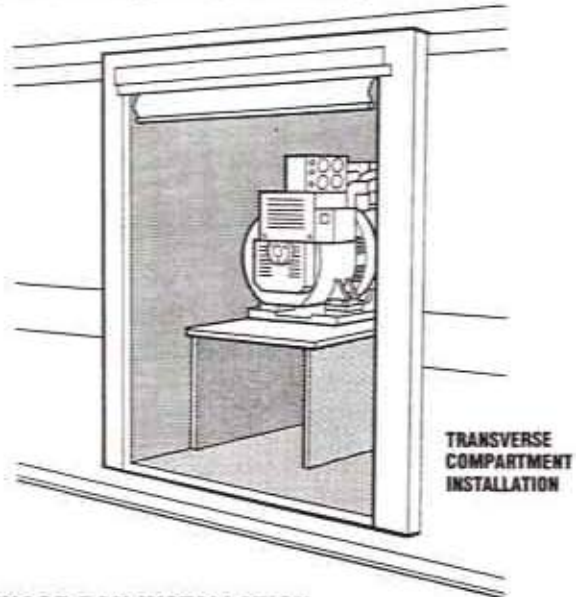
A side compartment can be designed with solid doors which would be open while the generator is being operated, or with louvered doors which could be closed while the generator is being operated.



SIDE COMPARTMENT INSTALLATION

TRANSVERSE COMPARTMENT INSTALLATION

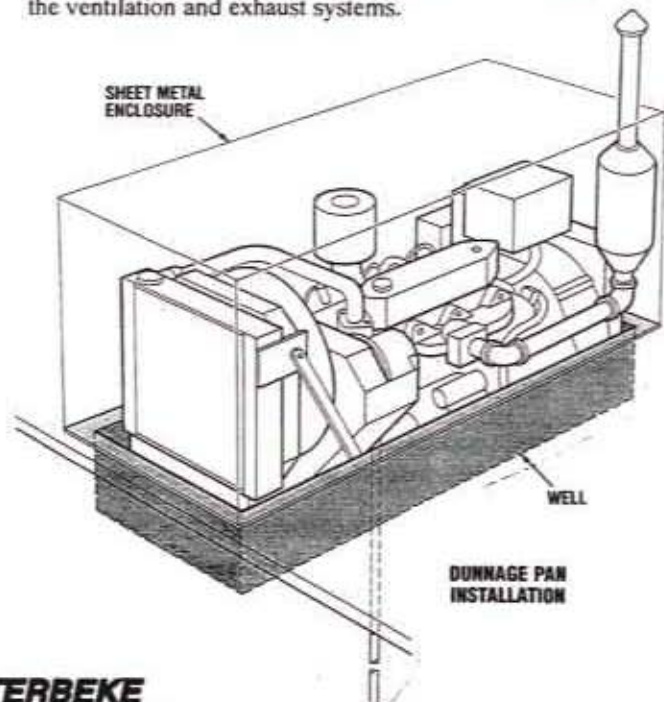
A transverse compartment goes through the vehicle, from one side to the other, and can be open at both ends. In a transverse compartment installation, the space must be large enough to allow ambient air to be used for the cooling air intake, so the generator can be run with the compartment doors closed. Access to the generator for maintenance and service can be affected by the generator's particular location in the compartment or by whatever other uses the transverse compartment may serve, such as storage.



TRANSVERSE COMPARTMENT INSTALLATION

DUNNAGE PAN INSTALLATION

In a dunnage pan installation (on a vehicle's rooftop), the generator is typically mounted in a well, and protected by a ventilated sheet metal enclosure. The open location of this type of installation provides more options for the design of the ventilation and exhaust systems.



DUNNAGE PAN INSTALLATION

COMPARTMENT DESIGN

COMPARTMENT SIZE

The generator compartment space must be large enough to contain the generator and meet its minimum requirements for ventilation clearances and exhaust system clearances from the compartment walls and ceiling (refer to the *VENTILATION* and *EXHAUST SYSTEM* sections). When planning these clearances, include any acoustic insulation or fire barrier materials that will be installed.

There should also be adequate space on all sides of the generator for servicing and maintenance. Allow enough space to access the following generator components:

1. Control panel
2. Air intake silencer/filter
3. Oil dipstick
4. Oil fill
5. Oil filter
6. Fuel inlet and outlet connections
7. Fuel/water separator fuel filter (owner supplied)
8. Fuel injectors
9. Manifold pressure cap
10. Coolant recovery tank
11. Coolant drain
12. Battery(s)
13. Generator mounting bolts (for retightening)

STRUCTURAL SUPPORT

It is very important to provide a structurally sound support framework for the generator, due to its weight and the weight of its compartment (or well, in the case of a dunnage pan installation). The best location is between the main frame members of the vehicle, but this location may not be possible for some installations.

The most common location for a generator compartment is at the side of the vehicle, but this location can be difficult to reinforce, if reinforcement is necessary. At this location, the inside edge of the compartment can be attached to the vehicle's frame and the outside edge of the compartment attached to the vehicle's body. If the bottom of the compartment is below the vehicle's main frame, then the compartment can be suspended from above.

ACCESS OPENING

Provide an opening into the compartment large enough to permit the generator to be removed. This opening can be at the side of the compartment or at the bottom of the compartment.

Design the compartment doors for easy maintenance, service and removal of the generator.

CLEARANCES

Measure the generator compartment carefully to provide the proper clearances. Make certain that these clearances permit the required intake of cool air and discharge of heated air when the generator is running, and provide for convection cooling with heated air escaping the compartment when the generator is shut down.

NOTE: *Since an increase in generator compartment temperature causes a reduction in the intake of cooling air and thus a drop in engine output, ventilation inside the compartment must be ample.*

A minimum 1" (25 mm) clearance should be allowed between the generator and a cooling air intake opening at the generator end. Allow for any restricted airflow that might be caused by grilles or ductwork.

Allow a minimum 3" (76mm) clearance between the generator and the walls or door of the compartment, and a 6" (152 mm) minimum clearance to the compartment ceiling. These same clearances apply to the generator's exhaust system components. Measure these clearances from any acoustic insulation or fire barrier materials that may be used. If the compartment is large, allow additional space at the generator end.

NOTE: *The clearances given above are minimum clearances. The size of your particular generator, the size of the generator's compartment, and the configurations of your cooling and exhaust systems are all factors that will influence the actual clearances that will be appropriate for your generator.*

COMPARTMENT CONSTRUCTION

SIDE COMPARTMENT CONSTRUCTION

Use steel angles, channels and boxes for the compartment's structural members, with sheet metal for the bulkheads, ceiling and compartment floor. Make sure the compartment is strong enough to withstand force and stress from any direction. These standards apply to all of the generator's possible locations.

Bulkheads

Line the generator compartment or separate the generator from the work area or living quarters with a fire barrier of galvanized steel (22 gauge minimum) or other noncombustible material of equal strength and quality. Install lighting on the compartment ceiling or bulkheads. Seal the compartment so it is vapor-tight, to prevent the entry of noxious fumes into the vehicle's interior.

⚠ WARNING: Do not use any flammable material directly above or around the generator compartment. Heat transferred from the generator through the compartment bulkheads, ceiling or floor could be high enough to discolor, char or ignite seat cushions, fiberboard or other flammable materials.

⚠ WARNING: Exhaust gases can cause severe personal injury or death. Make the compartment bulkheads vapor-tight to the interior of the vehicle to prevent exhaust fumes from entering the living quarters or work area.

Floor

A solid level compartment floor is very important for the proper operation of your generator. A sheet metal floor is preferred; plywood of a sufficient thickness can be used if it is protected with sheet metal.

⚠ CAUTION: Do not install any absorbent material on the compartment floor; it may absorb fuel or engine oil, creating a fire hazard.

Doors

A side compartment can be designed with solid doors which would be open while the generator is being operated, or with louvered doors which could be closed while the generator is being operated.

Holes for Mounting and Connections

Make four holes in the compartment floor for mounting the generator. To reduce the chance of the generator mounting bolts becoming loose, do not make these holes any larger than necessary.

Also make holes in the floor or elsewhere in the compartment for the following connections:

1. Exhaust pipe
2. Air outlet
3. Fuel supply and return lines
4. Oil drain (the oil drain hose must end below the vehicle's chassis)
5. Remote control panel harness (if used)
6. AC conduit
7. Battery cable

Holes through a wood floor must provide enough clearance to ensure that any exposed wood will not be a fire hazard.

Design the holes so they will not constrict or chafe the lines that pass through them. Use grommets where necessary to prevent chafing. Drill the holes through the frame members of the vehicle where possible.

⚠ WARNING: To avoid a fire hazard, do not locate the oil drain opening directly above the muffler.

NOTE: Do not route the fuel line through the vehicle's interior.

⚠ WARNING: To avoid a fire hazard, make a raised rim around the exhaust pipe outlet in the compartment floor so fuel cannot leak onto the exhaust system.

Make additional holes near the corners of the compartment floor as required, or in any other suitable location(s) on the floor, to ensure that fuel, oil or water cannot accumulate. Have as few holes as possible in the compartment floor, to reduce the noise level and to minimize the entry of road dirt, road splash and salt.

TRANSVERSE COMPARTMENT CONSTRUCTION

A transverse compartment goes through the vehicle, from one side to the other, and can be open at both ends. Transverse compartments are generally multi-use. The construction of the bulkheads and floor and the information on holes and insulation, as described under *SIDE COMPARTMENT CONSTRUCTION*, would also apply to transverse compartments, but could be modified by whatever other uses the transverse compartment may serve.

Roll-up doors are usually installed in a transverse compartment to allow easy access to the generator and unobstructed use of other equipment that may be kept in the compartment.

DUNNAGE PAN CONSTRUCTION

A dunnage pan installation is located on the vehicle's roof, usually to one side of the vehicle or the other. In a typical installation, the generator is mounted in a shallow sheet metal well, and is covered by a ventilated sheet metal enclosure with an access door. The generator's radiator faces outward. In general, the construction information given under *SIDE COMPARTMENT CONSTRUCTION* would also apply to a dunnage pan installation.

UNPACKING, RIGGING & LIFTING

UNPACKING

To remove the generator from its carton, follow this procedure:

1. Remove the banding straps.
2. Remove the staples from the top of the carton and open it, or, remove the cover if the carton has a cover.
3. Pull out the staples that hold the sides of the carton to the skid, then carefully remove the carton.
4. Remove the plastic covering from the generator.
5. Remove the plastic WESTERBEKE documentation package that is attached to the generator's lifting eye. This package contains the following items:
 - Operator's Manual
 - Parts List
 - Wiring Diagram and Wiring Schematic
 - Warranty forms
 - Spares & Accessories form
 - Carbon Monoxide (CO) Warning decal
 - California Proposition 65 Warning
6. Remove the accessories that were shipped with the generator, if any.
7. Remove the four mounting bolts that attach the generator to the skid.

RIGGING & LIFTING

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

WARNING: Check the capacity of the sling hoist before lifting the generator.

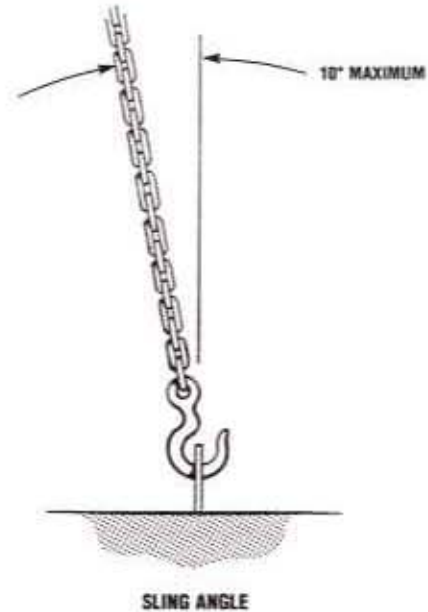
WARNING: Slings must NOT be so short as to place stress on the lifting eyes. A sling must be long enough so that its angle to the vertical plane does not exceed 10° (see illustration).

The general rule in moving a generator is to ensure that all equipment used is adequately strong and firmly fixed in place. Move the 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.

If it becomes necessary to hoist the generator front-end (pulley/drive belt end) upwards or rear-end (flywheel/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.



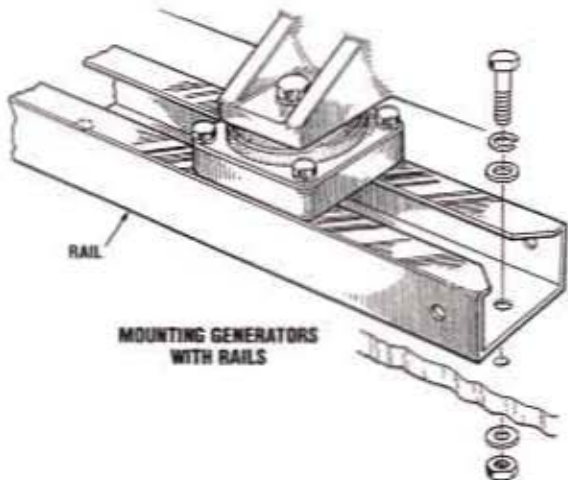
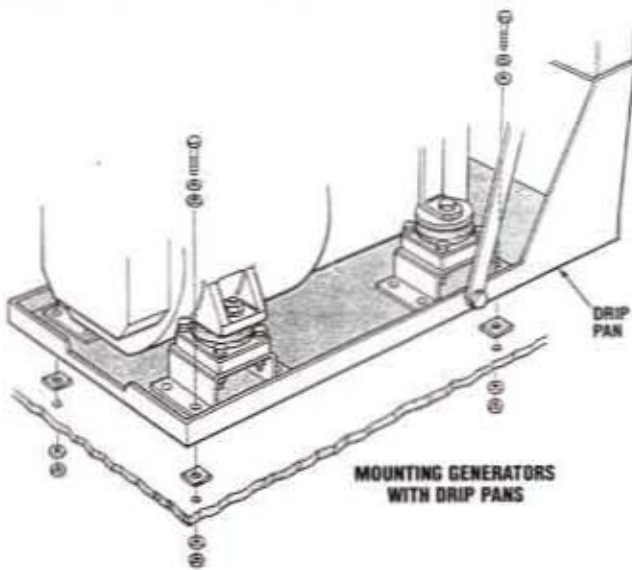
MOUNTING THE GENERATOR

MOUNTING

Mount the generator to the compartment floor with four sets of 1/2" dia. bolts, nuts and washers (see illustrations).

Generators mounted on drip pans have a predrilled hole through each of the four isolator brackets for mounting the generator to the compartment floor. Generators mounted on rails have either three or four (depending on the model) predrilled holes in the bottom of each rail for mounting to the compartment floor; use two holes in each rail. If the generator is being mounted with the bolts coming up through the bottom of the compartment floor, then each bolt's thread must not extend up more than 1/2" beyond the drip pan or rail. The use of fender washers will provide a more secure mounting, especially when the compartment floor is made of wood. Tighten all the bolts securely.

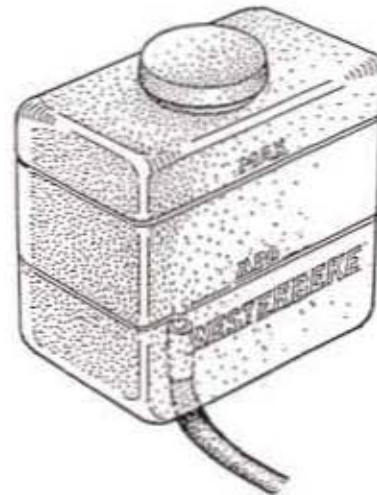
CAUTION: The rubber vibration isolators that are supplied with WESTERBEKE generators are designed to support the generator's weight. Do not use any other type of isolators.



COOLANT RECOVERY TANK

A coolant recovery tank kit is supplied with each WESTERBEKE 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.

The coolant recovery tank should be installed at, or above, the engine manifold level, in a convenient location where the coolant can be easily monitored and added. A wire mounting bracket is supplied with each kit along with a 30 inch 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. On Models 10.0 BTDR, 11.0 BTDR and 12.5 BTDR only, mounting holes for the coolant recovery tank are provided on the service side of the generator (see *COOLANT RECOVERY TANK* under *COOLING SYSTEM*).



COOLANT RECOVERY TANK

MOUNTING THE GENERATOR

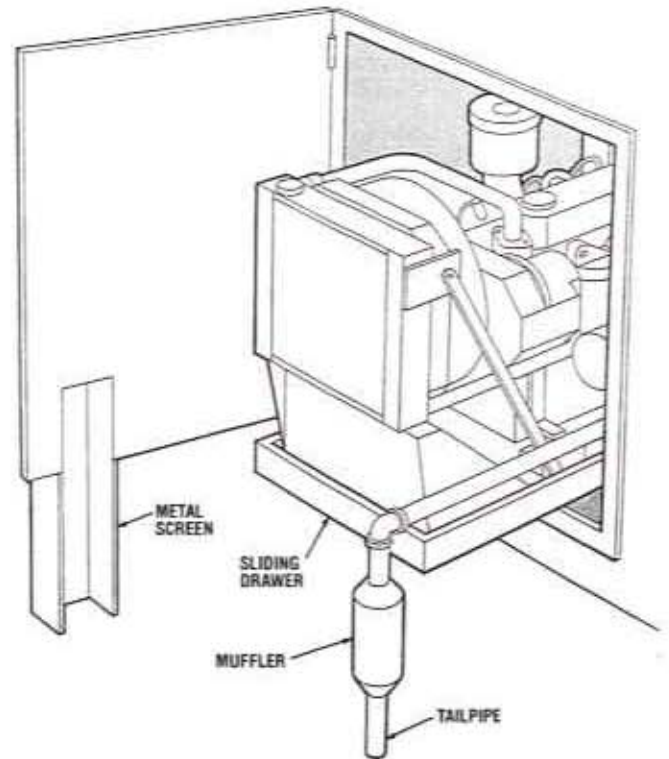
SLIDING DRAWER MOUNT

Mounting the generator on a sliding drawer or a roll-out tray is an alternative to mounting the generator in a fixed location. The sliding drawer allows the generator to be moved in or out of the vehicle, providing good ventilation and giving easy access for service and maintenance. The sliding drawer mount is more appropriate for commercial vehicles where minimal noise reduction may be acceptable and maximum noise reduction is not as essential as it would be for a recreational vehicle.

In a typical sliding drawer mount, the generator's radiator faces the compartment door, and the exhaust system slides in and out of the vehicle along with the generator. A means must be provided to hold the drawer in a fixed position both in and out of its compartment. With the generator in the compartment and the compartment door(s) closed, the muffler and tailpipe project out through the door, then bend downward. These exhaust system components require adequate support.

⚠ WARNING: *Contacting hot exhaust system components can cause severe burns. The muffler and tailpipe must be covered with a metal screen attached to the compartment door to prevent contact with these parts when the compartment door is shut.*

Sliding drawer mounts are generally custom-designed and built. Rollers may be used, with steel channels, boxes and angles for the structural members. The sliding drawer must be strong enough to support the entire weight of the generator and its related systems when extended outside of the vehicle. Because of the weight factor, sliding drawer installations are usually preferred for smaller generators, particularly those generators that will be removed from the vehicle for portable use.



SLIDING DRAWER MOUNT

VENTILATION & NOISE REDUCTION

GENERAL

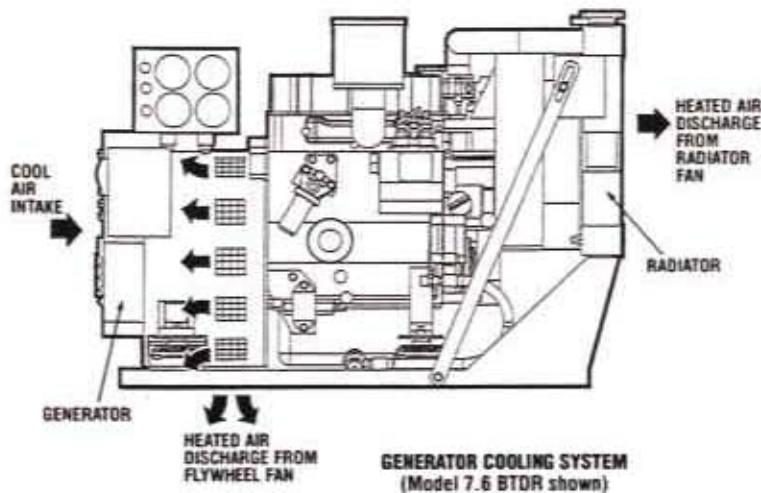
The ventilation system should be designed so it will always provide the necessary cooling air for the generator under all of the generator's anticipated operating conditions. For some vehicle applications, this would mean in all kinds of weather, under all conceivable road conditions.

Ventilation systems vary widely due to generator size and location. The generator's ventilation system and the generator compartment's acoustics should be designed at the same time, since the configuration of the ventilation system can influence acoustics and noise reduction, and acoustic materials can affect the efficiency of the ventilation system.

Design the ventilation system with as few restrictions as possible. The sufficient intake of clean, dry, cooling air for proper engine combustion, and the discharge of heated air while the generator is running, are both essential for the proper operation of the generator. They can directly affect the engine's output, fuel consumption and exhaust emissions. The cooling air requirement varies with the size of the generator. The size of the generator's discharge area at the radiator cannot be changed, therefore it is important to provide adequate intake and outlet openings to accommodate this discharge area. Provide for the necessary convection cooling of the generator when it is shut down.

AIR INTAKE /DISCHARGE

Two fans cool the generator. Cool air entering at the intake end of the unit is heated as it is drawn through and over the generator end. It is then discharged out through a centrifugal fan mounted to the flywheel. At the same time, heated air that is around the generator end and the engine is drawn through a large fan at the radiator end, pushed out through the radiator, then discharged.



Keep in mind that hot air rises, so cool fresh air should be directed to the lower area of the generator compartment, and the heated air should be removed from the upper area of the compartment.

The best location for the cooling air intake is at the side of the vehicle, as high as possible to keep out road dirt, dust and road splash. The intake may also be located in the vehicle's ceiling or roof. Do not locate the intake at the rear of the vehicle because the air pressure is lower at the rear of the vehicle when the vehicle is in motion. Avoid locating the intake where exhaust gases might be drawn into the ventilation system.

For side compartment or transverse compartment applications, the cooling air can be discharged from the generator's radiator into a plenum installed with a gasket next to the radiator, then directed through ductwork out of the vehicle. For a side compartment, the ductwork can go down through the vehicle's chassis; for a transverse compartment, the ductwork can go either out through the side of the vehicle or up through the vehicle's roof.

Make sure that the discharged air is not restricted in any way.

⚠ WARNING: Never use discharged cooling air for heating purposes. It can contain toxic gases.

When designing your ventilation system, refer to the following table for the total cooling air cfm required for your WESTERBEKE generator.

VENTILATION REQUIREMENTS

GENERATOR MODEL	TOTAL CFM REQUIRED FOR ENGINE COMBUSTION AND RADIATOR COOLING	
	60 Hz	50 Hz
5.0 BCDR	725	834
5.0 BCDAR	750	859
5.0 BCDBR	775	884
7.6 BTDR	724	833
8.0 BTDR	2186	2514
10.0 BTDR	2190	2518
11.0 BTDR	2190	2518
12.5 BT DAR	2190	2518
15.0 BTDBR	6319	7267
20.0 BEDAR	6330	7279
25.0 BEDR	6343	7294
32.0 BEDAR	6377	7333

VENTILATION & NOISE REDUCTION

LOUVERS, VENTS, GRILLES, BAFFLES

Louvers, vents and grilles can be installed in a generator compartment's bulkheads, ceiling, floor or door as needed for air intake. They can be particularly useful for installations where air intake is restricted. The free inlet areas of these materials can be obtained from the manufacturer.

Use metal grilles over the cooling air intake and discharge openings. Note that a grille will reduce an opening's area to between 60% and 90% of its original area. Louvers and vents can be used to allow the passage of air without admitting water.

Baffles are useful to reduce noise. They can be designed to indirectly admit the intake air while reducing noise by blocking the line-of-sight to the generator.

Many generator compartment designs can combine sound insulation with louvers, vents, grilles or baffles.

NOISE REDUCTION

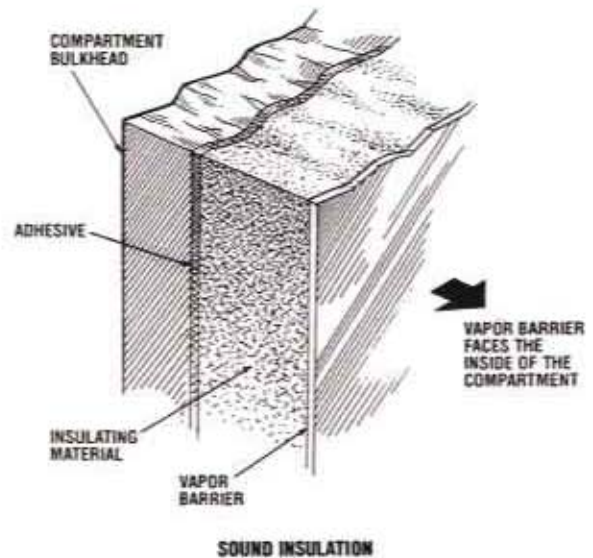
Whether or not noise reduction is an important factor in designing a generator installation depends on the type of vehicle and how it is used. Noise reduction can be essential in vehicles that use communications or computer equipment, or that have a command center. Recreational vehicles should have soundproof generator compartments.

Noise caused by generator vibration is reduced to a large extent by the generator's vibration isolators, which prevent vibration transmission to the vehicle's frame and bodywork.

Airborne noise from the generator and its related components can be reduced by lining the generator's compartment with 1 inch (25 mm) thick sound insulation material. Face the insulator's vapor barrier inward, then adhere the insulation to the compartment's bulkheads with adhesive (see illustration). Cover the seams with aluminum tape.

CAUTION: Make sure the compartment is vapor-tight, including around the door, before applying the insulating material.

WARNING: Be certain that the insulating material is non-combustible, and that it has not reduced the clearances in the compartment to less than the minimum clearance requirements.



EXHAUST SYSTEM

EXHAUST SYSTEM DESIGN

The generator's exhaust system vents the generator's engine exhaust gases out and away from the vehicle. It must be a separate system from the vehicle's propulsion engine exhaust system to prevent water vapor from one engine damaging the other engine.

Exhaust systems vary considerably, and each must be designed for the particular vehicle. Plan your exhaust system carefully. Ensure that it will not contact the road when the vehicle is operating on inferior road surfaces. Make sure that your exhaust system installation conforms with all applicable codes and regulations.

The exhaust line must be at least as large in diameter as the engine's exhaust manifold flange. Make certain the exhaust pipe and muffler are of sufficient diameter to clear the exhaust gasses and prevent excessive back-pressure. Long exhaust systems may require larger pipe sizes to prevent excessive back-pressure. Excessive back-pressure can also be avoided by not using street elbows and by having as few elbows as possible.

Configure the system with a minimum of restrictions so water or condensation cannot get back to the engine. A well-designed vapor-tight exhaust system will allow your generator to be run safely and quietly.

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 you may encounter.

WARNING: Use extreme care during installation to ensure that the exhaust system is tight and free of leaks. Exhaust gasses are deadly. A Carbon Monoxide warning decal is included in the Westerbeke documentation package for your generator. Display this decal in the vehicle's living space or in some other prominent location.

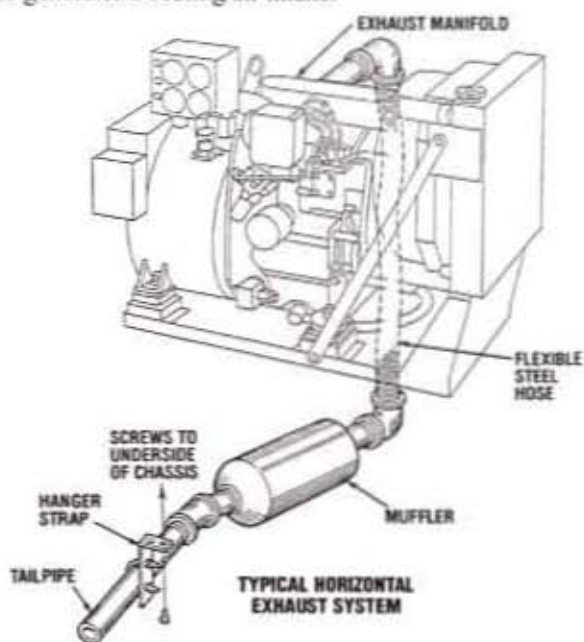
SUPPORTING THE EXHAUST SYSTEM

The exhaust system must be totally supported to prevent strain on the engine's exhaust manifold. Use automotive exhaust pipe hangers to suspend the exhaust system under the vehicle. Mount the hangers directly above the components being suspended, not at an angle. Mounting at an angle can cause damage to the exhaust system. Attach the hangers to the vehicle's steel frame, not to wood or any other materials. Do not twist the rubber sections of the hangers. Some installations may require damping supports or hangers to lessen the transmission of exhaust noise vibration.

HORIZONTAL EXHAUST SYSTEMS

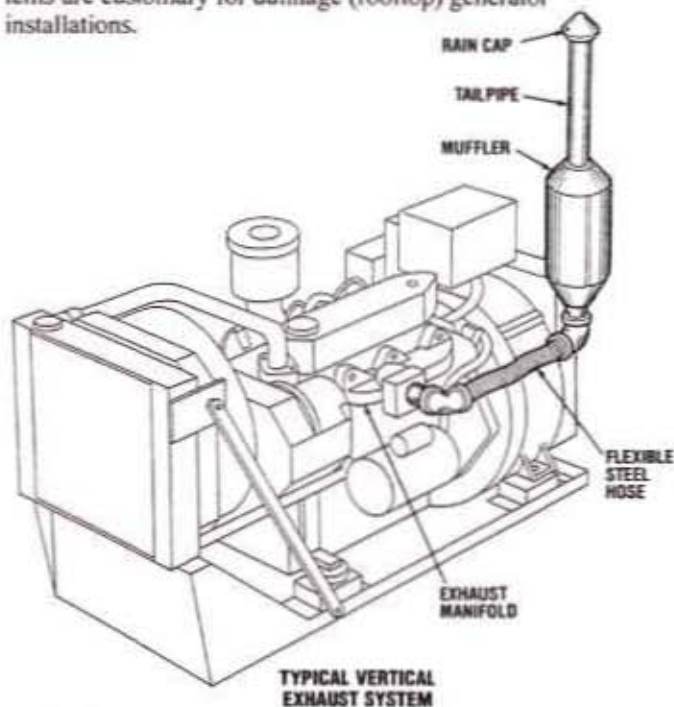
In both side compartment and transverse compartment type installations, the exhaust line can be run down through the

compartment floor, then angled back and out to the side of the vehicle so the outlet pipe is both below and aft of the generator. This is to keep the exhaust discharge away from the generator's cooling air intake.



VERTICAL EXHAUST SYSTEMS

For vertical exhaust systems, choose a location that is away from the generator's cooling air intake, and where exhaust noise will not affect the operator of the vehicle. Direct the exhaust outlet away from the operator's sight line. A vertical exhaust system must be flexibly attached to the engine's manifold and properly supported. The tailpipe must be protected against water entry by a raincap. Vertical exhaust systems are customary for dunnage (rooftop) generator installations.



EXHAUST SYSTEM

CLEARANCES

Provide adequate clearance for the exhaust pipe where it passes through the compartment floor to prevent damage from vibration and chafing. To avoid a fire hazard, make a raised rim around the exhaust pipe outlet in the compartment floor so fuel cannot leak onto the exhaust system.

The exhaust system must be at least 3 in. (76 mm) away from any combustible materials or rubber parts. It should not touch or be close to the fuel tank, fuel system, lubrication system, electrical wiring, starter motor, alternator or battery. Suitable insulating and/or shielding should be used where the proximity of these components to the fuel system is unavoidable.

INSULATION

Exposed exhaust piping, especially in a generator compartment, should be covered with non-asbestos heat-resistant lagging tape. The lagging will reduce ambient heat in the compartment and will protect against the possibility of severe burns due to accidental contact with the piping.

FLEXIBLE EXHAUST LINE

To ensure that generator vibration and thermal expansion will not damage the exhaust system, install a flexible section as close to the engine as possible. This section should be no less than 12 in. (31 cm) long overall and threaded at each end. It should be installed with no bends, covered with insulating material, and properly supported by brackets to prevent sagging, bending and strain on the manifold flange.

MUFFLERS

The exhaust system is the greatest source of noise in most generator installations. Exhaust gas, intermittently expelled from the engine's cylinders under high pressure, reverberates in the exhaust system producing noise that disseminates from the exhaust pipe, at the muffler's surface, and out of the tailpipe.

A well-designed exhaust system will provide efficient noise attenuation, and will minimize the engine power loss that is inherent in exhaust systems. When designing your exhaust system and choosing a muffler, consider the following:

1. The amount of noise reduction desired.
2. The appropriate muffler type and size for your application.
3. The available space for the muffler.
4. The amount of back-pressure that is acceptable.
5. The distance of the muffler from the exhaust manifold.

There are different types of mufflers available, each with its own characteristics. Three examples are the *baffle*, *absorption* and *expansion chamber* types. A muffler's shape can be either cylindrical or oval. The size of a muffler is defined by both the muffler's volume (3 to 5 times the engine's cubic inch capacity) and its cross-sectional area. The muffler's diameter (for a cylindrical muffler) should be at least four

times the diameter of its inlet pipe, and larger if possible. Locate the muffler closer to the exhaust manifold than to the tailpipe outlet. Contact your WESTERBEKE dealer for more information on the type of muffler that would be appropriate for your installation.

TAILPIPES

Connect the tailpipe to the muffler outlet with an automotive U-Bolt type muffler clamp. If necessary, install an automotive tailpipe hanger for additional support, and use these hangers every 2 to 3 feet (61-92 cm) for long tailpipe runs. Support the tailpipe at or near the vehicle's perimeter.

⚠ WARNING: Use only rigid steel tubing for the tailpipe. Do not use flexible tailpipe because it may fatigue and then leak or break due to vibration and/or road shock.

The tailpipe must terminate at least 1 in. (25 mm) beyond the vehicle's perimeter. If the tailpipe is to be on the same side of the vehicle as the generator's cooling air intake, then locate the tailpipe aft of the air intake to prevent exhaust gasses from entering the cooling air system and lowering the generator's efficiency. A vertical tailpipe must have a proper raincap.

⚠ WARNING: Do not terminate the tailpipe under the vehicle. Carbon monoxide may enter the vehicle's living space or work area through openings such as windows or vents that may not be permanently sealed. Aim the tailpipe away from all doors and windows. Close all openings above or to the rear of the tailpipe when the generator is running.

The tailpipe must terminate at least 3 ft. (92 cm) away from the vehicle's fuel filler spout. If using a tailpipe deflector, make certain it is large enough to prevent excessive back-pressure.

TEST RUN

After the exhaust system has been installed, the generator should be test run to check all the connections and elbows for exhaust leaks. See *INSTALLATION, PRESTART & INITIAL START-UP CHECKLISTS* in this manual. A back-pressure test should also be performed at this time.

BACK-PRESSURE

Exhaust systems normally produce resistance to the flow of exhaust gases, causing back-pressure. Back-pressure must be kept within a certain limit.

EXHAUST SYSTEM

Excessive back-pressure occurs when the flow of exhaust gases is restricted, resulting in a loss of engine power, poor fuel economy, and a high combustion temperature. These conditions will lead to overheating, shorter valve-head and valve-seat life, and excessive smoke.

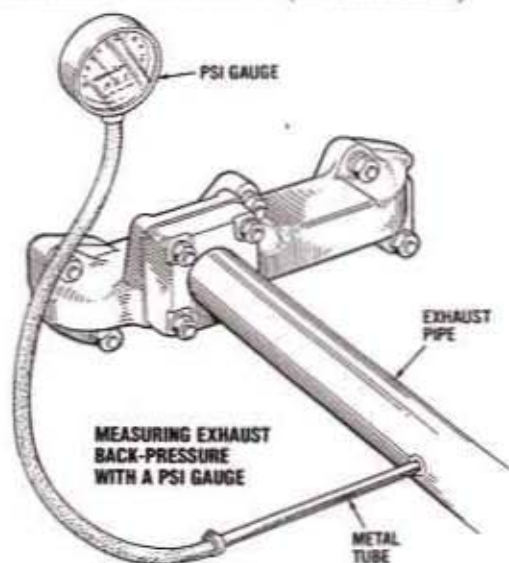
The restrictions in the exhaust system that can cause excessive back-pressure are:

1. The diameter of the exhaust pipe is too small.
2. The muffler is too small.
3. The exhaust pipe between the exhaust manifold and the muffler is too long.
4. There are too many sharp bends in the exhaust system. Limit the use of elbows and other fittings, as these will create flow restrictions.
5. Tailpipe deflector is too small.

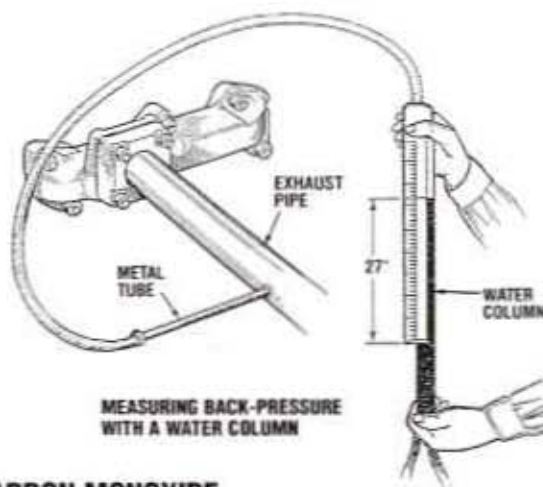
CAUTION: The use of common street elbows is not recommended in plumbing the exhaust system. These generally have a very restrictive inside diameter. The use of machine-type fittings is preferred.

Check the exhaust back-pressure before the generator is put into service. Measure the back-pressure after the engine has reached its normal operating temperature, and at the point where it is about to reach its rated load at either 1500 rpm (for 50 Hz applications) or 1800 rpm (for 60 Hz applications). Back pressure should not exceed 1.5 psi (0.11 kg/cm²).

To check the exhaust back-pressure, tap into the exhaust pipe near the exhaust manifold at a section free of bends, and install a metal tube. Then connect either a psi gauge or a water column to the metal tube (see illustrations).



A water column can be made by taping one end of a clear plastic tube along a yardstick and fitting the other end of the tube with a 1/4" NPT (National Pipe Thread) pipe fitting. The back pressure should not exceed 27 in. (69 cm) of water in the water column.



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 generator 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.

NOTE: A Carbon Monoxide warning decal is included in the WESTERBEKE documentation package for your generator. Display this decal in a visible location in the vehicle's living quarters or in a conspicuous location elsewhere for vehicles without living quarters.

CARBON MONOXIDE
WARNING DECAL



WARNING: It is extremely important that a carbon monoxide detector be installed in your vehicle's living quarters. They are inexpensive and easily available.

FUEL SYSTEM

GENERAL

It is very important that the design, construction and installation of all fuel system components meet the highest possible standards to insure that the fuel delivered to the engine will be clean, free of water and air, and at the correct pressure.

Plan the fuel system so that adequate fuel is delivered during all angles of vehicle operation. Make sure there is easy access to the fuel filler and that all of the fuel system components are accessible for servicing.

⚠ WARNING: *The improper installation of fuel system components can cause fire or explosion causing severe personal injury or death. Do not allow any smoking, open flames, spark producing equipment or other sources of ignition or fire in the installation area or near the fuel tank, fuel system components or other potential sources of spilled fuel or fuel vapors. Observe all of the safety precautions described in the SAFETY INSTRUCTIONS section of this manual.*

FUEL

Use No. 2 diesel fuel with a minimum cetane rating of 45. Use a winterized fuel blend when operating the generator in temperatures below freezing.

Use only clean diesel fuel, and keep it clean. The clearance of the fuel injection pump's components is critical; dirt particles that might pass through the filter can damage these finely finished parts. Purchase well-known brands of fuel. To keep the fuel clean and pure, install and regularly service a fuel filter/water separator between the fuel tank and the generator's engine.

FUEL TANKS

Fuel tanks may be made of fiberglass, aluminum or steel. If 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 fittings or openings must be at the top of the tank. A drain plug at the bottom of the tank is not acceptable.

Avoid 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

(1.8 m) 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 could cause fouling when the engine is started for the first time.

The fuel tank's fuel pickup tube should be clear and unobstructed, without screens or gauze strainers. It should be above the bottom of the tank to ensure that sediment and dirt are not drawn into it. The fuel return line should be arranged the same as the pickup, using a pickup-style tube. 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. Moisture must not be allowed to accumulate in the vent's line.

Common Fuel Tank

If your generator and your vehicle's propulsion engine use the same kind of fuel, then they could both use the same fuel tank. If this is the case, the vehicle manufacturer's installation instructions should be consulted. Also consider the following factors:

- There must be adequate fuel tank capacity for both the generator's engine and the vehicle's propulsion engine — refer to the WESTERBEKE data sheet for your generator to get the fuel consumption data.
- The fuel returning to the tank will be warm. To obtain maximum engine efficiency, fuel delivered to the injectors must be cooled, therefore the fuel tank volume must be adequate to cool the returned fuel.

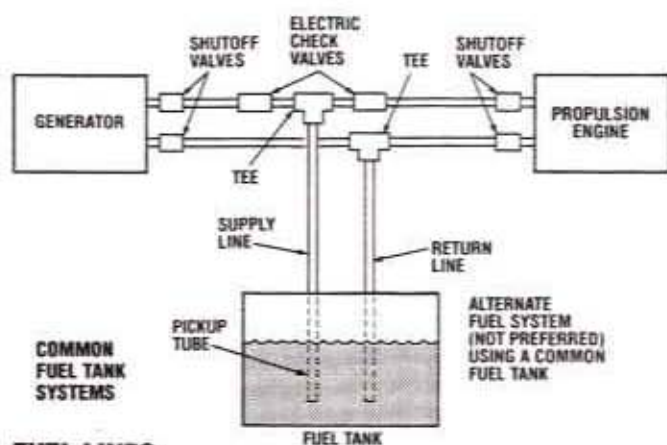
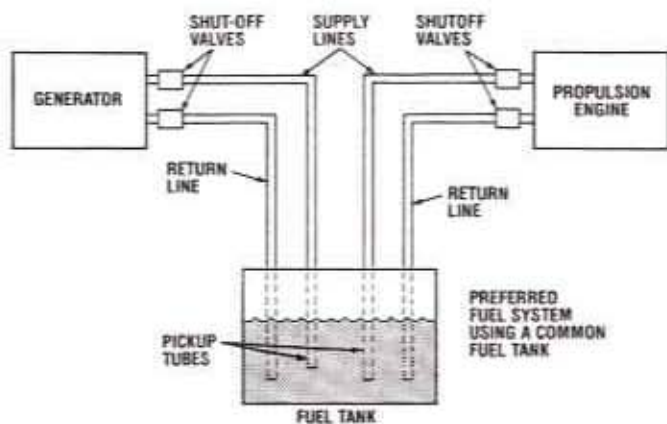
Note: *If an existing fuel tank cannot be tapped into, then the generator must have its own fuel tank.*

The fuel supply line to the generator should come from its own pick-up in the fuel tank and not lead off the supply line to the vehicle's propulsion engine unless necessary. A tee can cause erratic generator operation due to fuel starvation. The generator's fuel pump may not have the capacity to overcome the draw of the propulsion-engine's fuel pump.

This is also true 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 at a reasonable distance from the supply lines.

The generator's fuel pickup should not extend below the propulsion engine's fuel pickup. This is to ensure that the propulsion engine will continue to run so that the vehicle can be operated if the generator runs out of fuel.

FUEL SYSTEM



FUEL LINES

The fuel system should be designed and installed in such a way as to ensure that the engine-mounted fuel lift pump maintains a positive inlet pressure to the injection pump under all operating conditions.

Flexible Fuel Lines

Install a flexible non-organic fuel line without metal reinforcement between the rigid fuel line and the generator to absorb vibration. Make sure this line is long enough to prevent binding or stretching due to generator movement.

Flexible fuel lines should be used only where necessary to absorb vibration. Always use flexible non-organic tubing. Do not use wire-reinforced tubing where it can create an electrical path from the engine to any other part of the electrical system if there should be a bad ground or if the ground strap is removed. A bad ground in the cranking circuit could cause a wire-reinforced hose to become charged and ignite the fuel during cranking.

Rigid Fuel Lines

The proper installation of the fuel lines is very important. Keep the length of the fuel lines to a minimum. Westerbeke recommends using steel or rubber tubing with suitable flared fittings, both for the supply line and the return line. Use seamless annealed double-flared fuel lines. 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 ID.

Do not run the fuel lines together with electrical wiring. Route, support or shield fuel lines so they cannot contact the electrical wiring. Keep the fuel lines as far as possible from the exhaust system and hot engine areas. Keep the fuel line at least 2 in. (5 cm) away from an unshielded exhaust pipe.

Run the fuel lines, at a level not lower than the top of the fuel tank, to a location as close to the 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 supported and/or securely anchored to prevent leaks from vibration and chafing. Locate fuel lines, valves and fittings so that any leakage that may occur will not run off or drip on electrical system or exhaust system parts. Fuel piping is usually secured by copper straps every 12" to 14" (30 to 35 cm). Use as few connections as possible, and install the lines so they are accessible and protected. Avoid sharp bends and other configurations that might produce flow resistance or the trapping of air. Avoid locked-in torsional stresses. Use grommets to reduce vibration and prevent chafing where the fuel line passes through holes in bulkheads or partitions.

If the fuel lines are not made of metal, they should be bonded to the vehicle's frame.

After installation, check the fuel system for tightness.

SHUT-OFF VALVES

Make sure your fuel system has manual in-line positive fuel shut-off valve(s), to close the fuel line when the generator is serviced. A fuel shutoff valve is necessary in the return line if the fuel tank is located above the generator. Fuel shutoff valves are also necessary where the generator's fuel supply line is teed off the vehicle's fuel supply line.

FUEL FILTERS

A primary fuel filter/water separator should be installed in the fuel supply line between the fuel tank and the generator to help remove contaminants and water in the fuel before the fuel reaches the engine mounted fuel lift pump. Contaminants and water can cause the failure of components, and such failures are not warrantable. The fuel filter/water separator should be mounted in an accessible location for ease of monitoring and servicing. See the *ACCESSORIES* section for a recommended type of fuel filter/water separator.

A secondary fuel filter is supplied with the generator, and it has a replacement filter element.

AUXILIARY FUEL PUMPS

In a dunnage pan installation (on a vehicle's rooftop), an auxiliary fuel pump is usually added near the fuel tank. This is to provide additional lift to prevent the fuel from backing up due to the high location of the generator.

An auxiliary fuel pump may also be required in an installation where the generator is at a considerable distance from the fuel tank.

LUBRICATION SYSTEM

OIL SPECIFICATIONS

Use a heavy duty engine oil with an API classification of CF or CG-4, SAE 30, 10W-30 or 15W-40.

Change the engine oil after an initial 50 hours of break-in operation, then every 100 hours of operation thereafter. For the recommended oil viscosity, see the following chart:

OPERATING TEMPERATURE	OIL VISCOSITY
Above 68°F (20°C)	SAE 30, 10W-30, or 15W-40
41° -68°F (5°-20°C)	SAE 10W-30 or 15W-40
Below 41°F (5°C)	SAE 15 W-40

⚠ CAUTION: *Do not mix two or more brands of engine oil. Each brand contains its own additives, and they could react to produce properties harmful to your engine.*

OIL DRAIN HOSE

An oil sump drain hose is located either at the front or the side of the engine depending on the model. 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.

A pump can be added or the drain hose extended for easier removal of the old oil. When installing the generator make certain that this drain hose is accessible, and that it ends below the vehicle's chassis to avoid problems with spillage.

NOTE: *The old oil should be warm before draining.*

OIL PRESSURE SENSING DEVICES

Oil pressure sensing devices, such as senders and switches, must not be connected to an engine sump using extended nipples or tees. The reason is that continued engine vibration would cause these fittings to fatigue. If these fittings fail during engine operation, lubricating oil will be lost and internal engine damage will result.

When these sensing devices need to be installed, they *must* be mounted elsewhere and connected to the oil sump using an appropriate grade of flexible lubricating oil hose. Any fittings used to connect the hose to the sump *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 else the engine's warranty will be void. The oil filter can be relocated to a more convenient location by using a WESTERBEKE Remote Oil Filter Kit (see *ACCESSORIES*). This kit can be installed by the owner/operator.

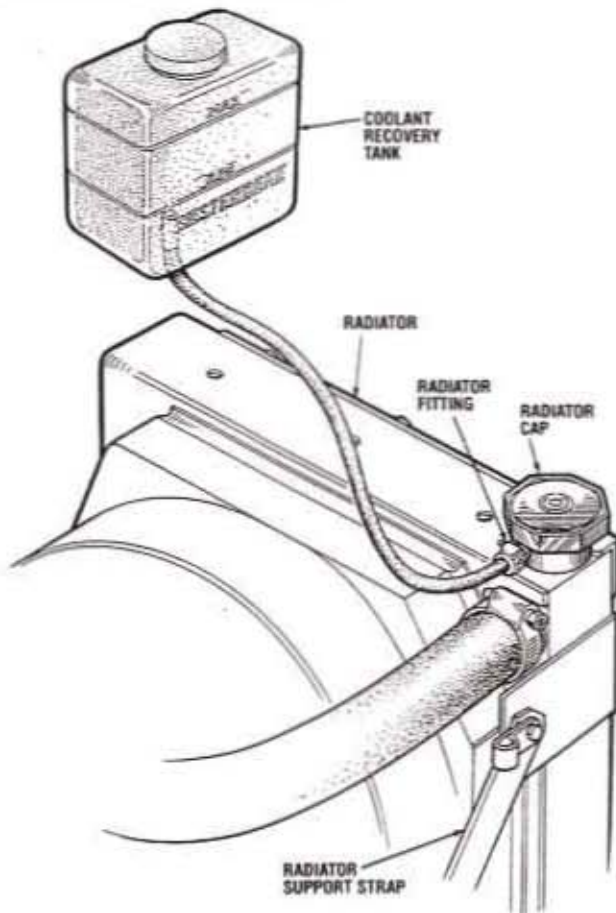
COOLING SYSTEM

COOLANT RECOVERY TANK

A coolant recovery tank kit is supplied with each WESTERBEKE 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.

The coolant recovery tank should be installed at a level equal to or above the top of the radiator, but this may not be possible for some installations. It should always be installed in a location where it can be easily monitored. On Models 10.0 BTDR, 11.0 BTDR and 12.5 BTDR only, there are mounting holes for the coolant recovery tank located in the radiator support and the radiator support strap on the service side of the generator.

A wire mounting bracket is supplied with each kit, along with a 30" (76 cm) length of clear plastic hose and clamps, to connect the hose between the radiator fitting and the connection on the base of the recovery tank.



COOLANT RECOVERY TANK INSTALLATION

COOLANT

WESTERBEKE recommends using a premix. If a premix is not available, use a mixture of 50% antifreeze and 50% distilled water for year-round use. Choose a good quality antifreeze that is compatible with aluminum engine components.

An antifreeze mixture will aid in cooling and will protect against an unexpected freeze. Antifreeze mixtures are beneficial to the engine's cooling system because they retard rust and scale formation and are beneficial to the service life of the coolant pump seal.

ANTIFREEZE PROTECTION	
Antifreeze Concentration	Freezing Temperature
13%	23°F (-5°C)
23%	14°F (-10°C)
30%	5°F (-15°C)
35%	-4°F (-20°C)
45%	-22°F (-30°C)
50%	-40°F (-40°C)
60%	-58°F (-50°C)

REMOTE RADIATORS

A remote radiator should be used under the following conditions:

- The particular location or configuration of the generator compartment will not allow adequate heated air discharge (see the *VENTILATION REQUIREMENTS* chart under *AIR INTAKE/DISCHARGE*).
- A radiator attached to the generator would make the generator too long to fit in its location.

Custom remote radiators are available from WESTERBEKE. For more information, contact your WESTERBEKE dealer. The following information will be necessary to provide a Remote Radiator package that will be appropriate for your vehicle.

- Type of vehicle.
- Generator model.
- Location of the generator on the vehicle.
- Location of the remote radiator on the vehicle.
- Distance from the generator to the remote radiator.
- Air-flow potential of the remote radiator location.

ELECTRICAL SYSTEM

WIRING DIAGRAMS & SCHEMATICS

A Wiring Diagram and Wiring Schematic are included in the documentation package that is furnished with each generator. They are also found in the Operators Manual for each generator. Make sure the wiring diagram or wiring schematic you are using is the correct one for your generator model.

DC ELECTRICAL CONNECTIONS

WESTERBEKE 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.

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 qualified personnel.

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

OPTIONAL REMOTE START/STOP PANEL

An optional remote Start/Stop panel is available containing three switches and a run indicator light (green) (see *ACCESSORIES*). This panel must be wired into the terminal strip in the main control panel on the generator, and mounted in a remote location.

NOTE: This panel must not be located in an engine or generator compartment because it is not ignition protected.

Refer to the *WIRE SIZING* page in this manual when selecting the wire size to be used between the generator control panel and the remote Start/Stop panel. See your WESTERBEKE Operators Manual for the remote panel wiring schematic.

AC AND DC WIRING

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.

NOTE: All wiring should be properly secured 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: Do not tie AC and DC wiring into the same bundle. Bundle and route them separately.

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.

GROUNDING THE GENERATOR

The generator including its AC output is grounded to the generator's base (a pan or two rails, depending on the model) with a braided ground strap. When installing the generator in the vehicle, the generator's base must be grounded to the vehicle's chassis with a suitable ground strap (owner-supplied). If the vehicle has an aluminum body, make sure the ground strap is bolted directly to the vehicle's steel chassis. If the generator's base is to be bolted directly to the chassis, then a ground strap from the generator's base to the chassis is not necessary.

WARNING: Make sure the generator is properly grounded. An improper ground can cause severe personal injury or death from fire or explosion.

GENERATOR FREQUENCY

Frequency is a direct result of the generator's engine speed:

When the generator is run at 1800 rpm, the AC voltage output frequency is 60 hertz.

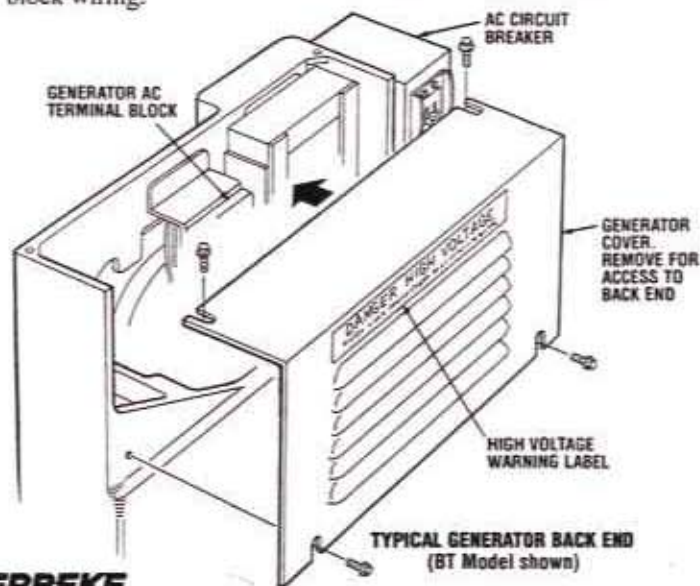
When the generator is run at 1500 rpm, the AC voltage output frequency is 50 hertz.

CHANGING THE GENERATOR FREQUENCY

WESTERBEKE generators are designed for operation at either 60 or 50 hertz, and can be easily field converted from one to the other. To field-convert the generator's output, refer to the Operators Manual or Service Manual, or contact your Westerbeke dealer.

NOTE: European and some other foreign countries may require 50 hertz AC generator operation.

When converting from 60 Hz to 50 Hz, it is necessary to replace the circuit breaker and reconfigure the AC terminal block wiring.



ELECTRICAL SYSTEM

CHANGING THE VOLTAGE

When changing the voltage from 120V to 120V/240V, the circuit breaker wiring and the AC terminal block wiring must be changed. See the Operators Manual.

For component testing and resistance values, refer to the Service Manual.

ENGINE SPEED ADJUSTMENT

After the generator has been placed in operation, there may be adjustments required for engine speed (hertz) during the engine's break-in period (first 50 hours) or after this period.

NOTE: *The engine speed on all models has been set at the factory, and in most cases, a speed adjustment should not be necessary.*

If an engine speed adjustment is necessary, a no-load voltage adjustment may also be required. These adjustments are considered normal maintenance.

For engine speed and no-load voltage adjustments, see your Operators Manual.

BATTERIES

CAUTION: *Batteries can be hazardous. Take the necessary safeguards to protect yourself, your personnel and your equipment. See BATTERY EXPLOSION and BATTERY ACID under SAFETY INSTRUCTIONS for the proper safety precautions.*

Battery Selection

Choose a starting battery and cables that will supply enough cranking power to start your generator under its various operating conditions. A starting battery must be a type that allows a high rate of discharge.

Westerbeke recommends selecting a starting battery having a Cold Cranking Amps (CCA) capacity that is at least three times the DC cranking current (engine cold) of your generator (see *Battery Capacity and DC Cranking Current* under **ELECTRICAL SYSTEM** in the **SPECIFICATIONS** section of your Operators Manual).

If the starter battery is to be used to provide power for other services, a larger capacity battery may be needed. Generally, it is not good practice to use the starter battery for other services unless those services require low amperage or are intermittent. In cases where there are substantial loads (lights, refrigerator, radio, etc.) it is essential to have a completely separate system, and to provide charging current for this system by means of a second alternator, dual alternator or alternator output splitter.

Using the vehicle's starter battery to operate the generator is not recommended because certain operating conditions might cause the battery to become discharged. In addition, long cable may be necessary, depending on the generator's location.

Battery Compartment

The best location for the battery is in its own compartment, away from the generator and any other spark-producing equipment, but close enough to the generator to avoid voltage drop due to long cables. Choose a location where any accidental leaks or electrolyte spills will not damage the generator or any of its wiring, fuel lines, battery cables, or any other equipment. The location should be away from sources of heat and vibration, and afford protection from rain, road splash and road dirt.

Make sure the battery compartment is appropriate for the battery you select. The compartment must be well ventilated to avoid the accumulation of explosive battery gases. Provide ventilation openings of at least 2 sq. in. (13 cm²) in both the top and bottom of the compartment.

Mounting the Battery

Mount the battery in an acid-resistant tray on a firm support. It must be rigidly secured with holdown straps or other means to prevent shifting.

If the battery is to be mounted in a propulsion engine's compartment, install a non-metallic cover to prevent battery damage and arcing from accidentally dropped tools.

Battery Cables

WESTERBEKE recommends using the following cable sizes to ensure starting in cold weather. The sizes shown will allow starting down to -20°F (-29°C). The cable lengths shown are from the battery to the generator.

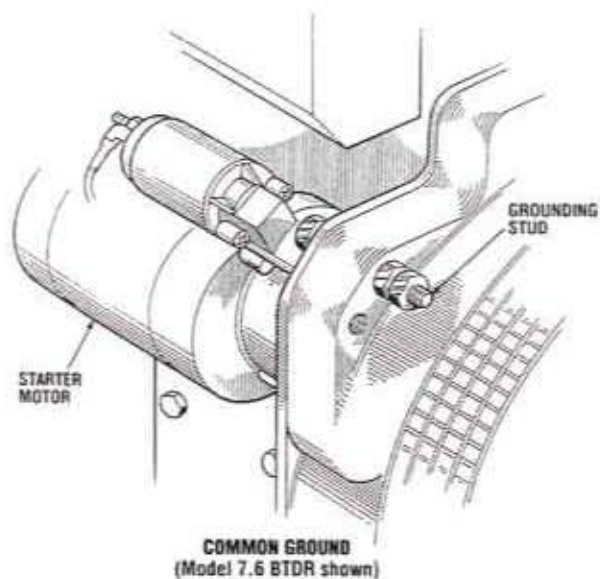
BATTERY CABLE REQUIREMENTS						
Maximum Length of One Cable						
Cable Size	2	1	0	00	000	0000
Length ft.	4	5	7	9	11	14
Length m	1.2	1.5	2.1	2.7	3.4	4.3

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

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

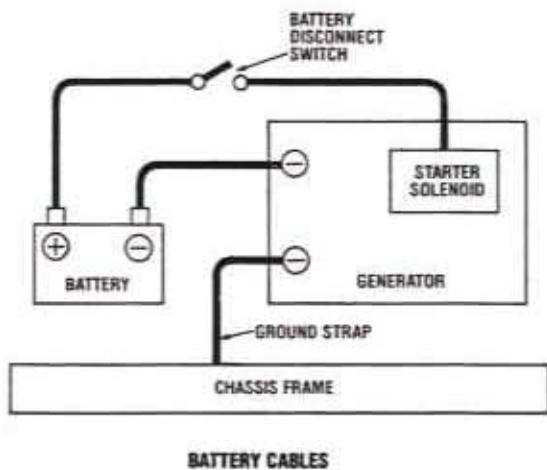
A common ground for negative (-) DC is located at the bell-housing of the generator next to the starter motor in the form of a threaded grounding stud. This location is tagged. The battery ground (-) must be connected here. Failure to do so can cause arcing or resistance in the cranking circuit.

ELECTRICAL SYSTEM



Make sure both (+) and (-) battery cables are the same size and that all the connections are tight. Have a little play in the cables to prevent stress at the battery terminals.

Install a battery disconnect switch in the B+ cable so the battery can be disconnected when the generator is serviced.



Battery Maintenance

The following preventive maintenance will increase the life of your battery. Be sure to observe all safety precautions.

1. Keep the battery charged. Recharge as soon as possible after use. Do not allow a discharged battery to sit for a long period of time. Avoid overcharging.
2. Maintain the level of the electrolyte. Add distilled water or drinking water to the level of the split ring. Always add water *before* recharging. Never let the electrolyte level drop as low as the top of the plates.
3. Keep the top of the battery clean and dry.
4. Make certain the cable connections are clean and tight.
5. Keep the battery terminals clean. Coat the terminals with a dielectric grease or petroleum jelly to reduce corrosion and oxidation.
6. Make sure the battery cables are properly identified as positive or negative before making a connection. Always connect the ground cable (negative) last.

INSTALLATION, PRESTART & INITIAL START-UP CHECK LISTS

Review the following checklists after your generator has been installed. Make sure that all applicable state and local electrical codes have been followed.

⚠ WARNING: Improper installation, maintenance or service of the generator and its related equipment can cause personal injury, death or property damage.

INSTALLATION CHECK LIST

- Is the compartment lined with metal or with a material of comparable strength and fire-resistance? Are its joints and edges sealed vapor-tight?
- Is the generator protected from the weather, road dirt and road splash?
- Is access to the generator adequate for easy routine maintenance, service and removal of the generator?
- Are holes into living spaces sealed to prevent entry of exhaust gases?
- Is the air inlet protected against the entry of road dirt, water and road splash?
- Are fuel lines and electrical wiring insulated from each other and protected from chafing? Are all connections and hose clamps tight?
- Is all electrical wiring correctly connected and properly tied down and/or supported?
- Are the exhaust system's components and fittings tight and secure?

PRESTART CHECK LIST

Before starting the generator, complete the following checklist. Also refer to *PREPARATIONS FOR INITIAL START-UP* in your Operators Manual.

- Is there fuel in the tank and are the fuel valves open? Check the piping for leaks. Prime the fuel system.
- Has lube oil been added to the engine? Check for leaks.
- Has the proper coolant mix been added? Vent air out of the system. Check for leaks.
- Check the battery electrolyte level. Are the battery cables properly connected?
- Check for loose bolts and nuts.
- Are the AC and load connection wires securely connected to the circuit breaker?

⚠ CAUTION: Make sure the Emergency Shutoff Switch is in the RUN (up) position. Note: This switch is located on the DC Control Box.

INITIAL START-UP CHECK LIST

- Allow the generator to come up to its operating temperature.
- Apply a load to the generator, and check the output frequency.
NOTE: See your Operators Manual for the output adjustment.
- Check the instrument gauges for proper readings.
- Inspect the engine for fuel, water, coolant, and oil leaks.
- Listen for unusual sounds and vibrations.

After shutdown, check the generator carefully. Inspect all fluid levels. Check the hose clamps and fuel lines.

DAILY & 50 HOUR MAINTENANCE CHECK LIST

It is very important to complete this check list to make certain your generator has been installed correctly, and to assure warranty protection. For safe operation and maximum service life, inspect your generator every day following the "Check Daily" portion of the chart. After the first 50 hours of operation, check all of the items in the chart. Be sure to follow all of the scheduled maintenance instructions.

NOTE: Some of the following maintenance procedures are easy but others are more difficult and may require the expert knowledge of a service mechanic.

⚠ WARNING: Never attempt to perform any service while the engine is running. Wear the proper safety equipment such as goggles and gloves, and use the correct tools for each job. Disconnect the battery terminals when servicing any of the generator's DC electrical equipment.

CHECK DAILY	CHECK AFTER 50 HOURS OF OPERATION	SCHEDULED MAINTENANCE	
<input type="checkbox"/>	<input type="checkbox"/>	FUEL SUPPLY	Make sure there is adequate fuel.
<input type="checkbox"/>	<input type="checkbox"/>	FUEL FILTER/WATER SEPARATOR	Check for water and dirt in the fuel. Drain or replace the filter if necessary.
<input type="checkbox"/>	<input type="checkbox"/>	ENGINE OIL LEVEL	Oil level should be between MAX and LOW on the dipstick.
<input type="checkbox"/>	<input type="checkbox"/>	COOLANT LEVEL	Check coolant at the recovery tank; if empty, check at the radiator. Add coolant if necessary.
<input type="checkbox"/>	<input type="checkbox"/>	VISUAL INSPECTION OF ENGINE	Check for fuel, oil and water leaks. Inspect wiring and electrical connections. Check to ensure that all nuts and bolts are tight. Check for worn belts.
	<input type="checkbox"/>	FUEL FILTER	Replace the fuel filter.
	<input type="checkbox"/>	ENGINE OIL & OIL FILTER	Replace the oil filter. Change the oil.
	<input type="checkbox"/>	AIR FILTER	Check the air filter; replace if necessary.
	<input type="checkbox"/>	ENGINE HOSES	Hoses should be hard and tight; replace if soft and spongy. Check and tighten all hose clamps.
	<input type="checkbox"/>	EXHAUST SYSTEM	Inspect for leaks. Check that all connections are tight.
	<input type="checkbox"/>	DRIVE BELTS	Inspect for proper tension (3/8"–1/2" (1–1.25 cm) deflection) and adjust if necessary. Check belt edges for wear.
	<input type="checkbox"/>	BATTERIES	Check electrolyte level. Make sure connections are tight. Clean off excessive corrosion.
	<input type="checkbox"/>	ELECTRONIC GOVERNOR CONTROL (If applicable)	Check and/or adjust the no-load speed in the panel, required hertz and the regulator board adjustment, as needed.
	<input type="checkbox"/>	GENERATOR CONNECTIONS	Check that AC connections are clean and secure with no chafing.

ACCESSORIES

For additional information about any of the following WESTERBEKE Generator accessories, contact your WESTERBEKE distributor.

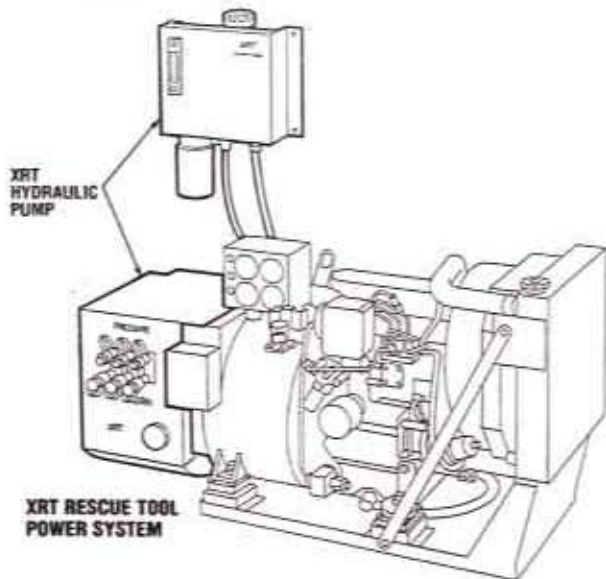
XRT HYDRAULIC PUMP Rescue Tool Power System

This high-pressure hydraulic pump is direct-driven by your WESTERBEKE generator, and provides remote "tool-only" power for fire and rescue vehicles.

The XRT Hydraulic Pump supplies continuous power for all makes of cutting, spreading and jacking tools, plus safety lighting, electrical accessories and reel-tool operation. It is available for WESTERBEKE generators from 5.0 KW to 70.0 KW. An Installation Manual is provided.

The XRT Hydraulic Pump features:

1. Quiet, safe running.
2. Long range full power over 100 ft. (30 m) from the pump.
3. Simultaneous tool operation with up to 3 ports.
4. All-oil compatibility.
5. Radiator cooling with a fan.



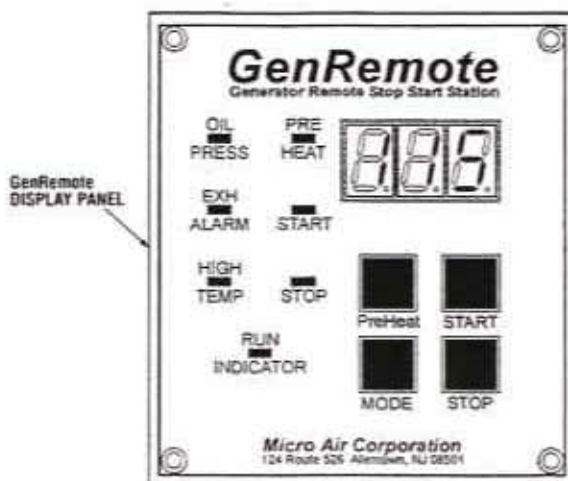
GenRemote REMOTE START/STOP STATION

The GenRemote system provides remote starting and stopping of the generator, and monitors both the generator's output and the engine's functions. This monitoring includes:

1. DC voltage
2. Oil pressure
3. Water temperature
4. AC voltage
5. AC current — L-1
6. AC current — L-2
7. Line frequency — hertz
8. Engine hours

The GenRemote system consists of a Power Logic Module, a Display Panel, and a six-conductor shielded Display Cable. The Power Logic Module is powered directly from the generator's starting battery and can be mounted in the generator's compartment or up to 10 ft (3 m) away. The Display Cable links the Power Logic Module to the Display Panel. The Cable is easily installed, and can be up to 500 ft. (152 m) long. An optional programmable automatic emergency shutdown feature is also available. An Operators Manual is provided.

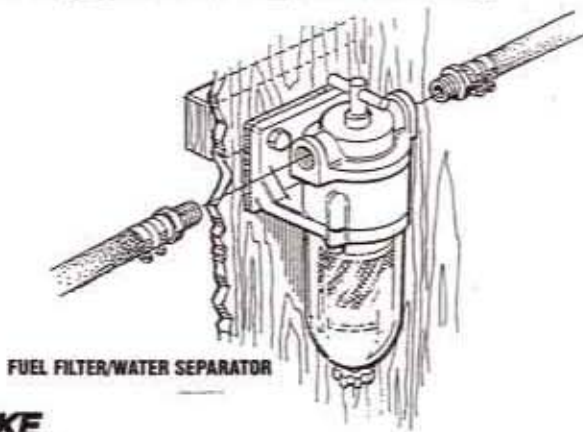
GenRemote's circuitry is isolated from your generator's electrical system, and will not interfere with your generator's normal operation. It is designed to interface with the existing sensors, and its digital display is easily calibrated to match the readings of your generator's gauges.



FUEL FILTER/WATER SEPARATOR

WESTERBEKE recommends that you install and regularly service a good quality, visual-type fuel filter/water separator between the fuel tank and the generator's engine. This is necessary to prevent any contaminants or water that may be in the fuel from reaching the fuel lift pump and causing damage to the fuel system components. Such damage is not warrantable.

It is the responsibility of the owner/operator to install the fuel filter/water separator. A typical example is shown below. This is the Raycor Model 500 MA (754-200 microns).



ACCESSORIES

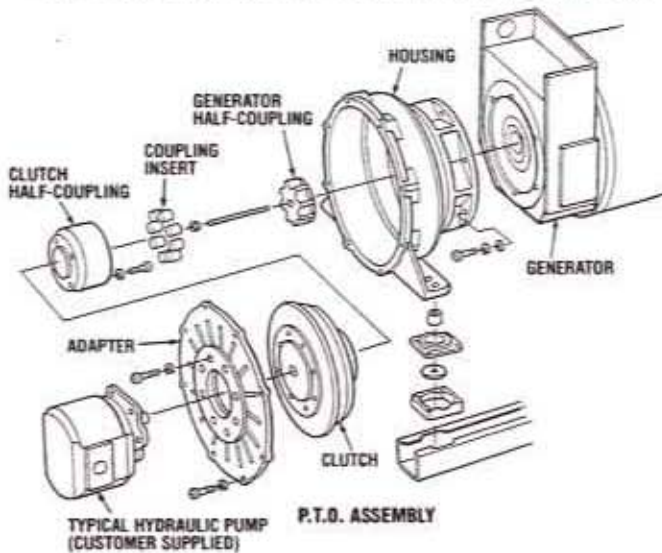
POWER TAKE-OFF (P.T.O.)

WESTERBEKE offers three types of power take-off devices. These devices allow a hydraulic pump, accessory tool or other equipment to be driven off the crankshaft through the generator, at the generator end of the unit.

Power Take-Off Assembly

Models 20.0 BEDAR, 25 BEDR, 32 BEDAR - PN39352

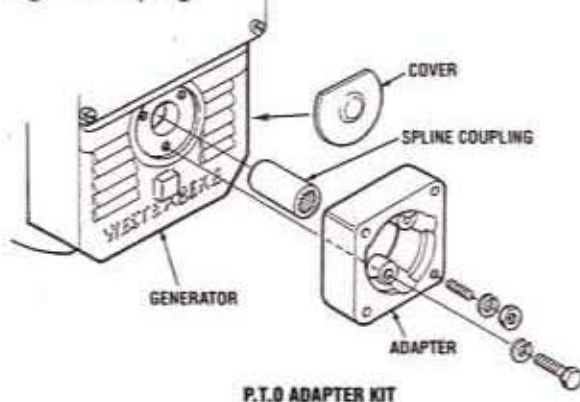
This P.T.O. is closely coupled to, and aligned with, the generator. It has a flexible coupling which drives an electromagnetic clutch. These components are mounted in an aluminum housing. Air flows through the housing, cooling the clutch and the flexible coupling. The hydraulic pump or other driven equipment attaches to an adapter plate located at the rear end of the housing. This P.T.O. is supported by a pair of vibration mounts attached to the generator's mounting rails.



Power Take-Off Adapter Kit

Models 5.0 BCDR, 7.6 BTDR, 8.0 BTDR - PN34786
Models 10.0 BTDR, 11.0 BTDR, 12.5 BTDR, 15.0 BTDBR - PN37134

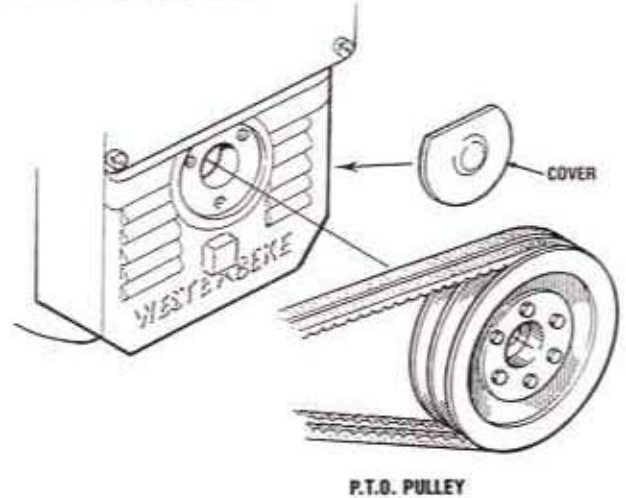
This kit consists of a spline coupling that screws onto the generator's armature shaft, an adapter, and attaching hardware. The hydraulic pump or other driven equipment mounts onto the generator housing with the adapter, and is driven through the coupling.



Power Take-Off Pulley

Available for all Models

This P.T.O. consists of a shaft-coupling that screws onto the generator's armature shaft and a pulley. Pulleys are available in different sizes, allowing this P.T.O. to drive a wide variety of belt-driven equipment.



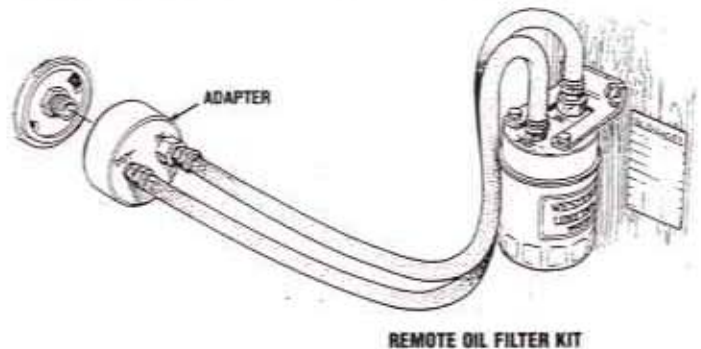
REMOTE OIL FILTER KIT

This popular accessory is used to relocate the engine's oil filter from the engine to a more convenient location.

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.



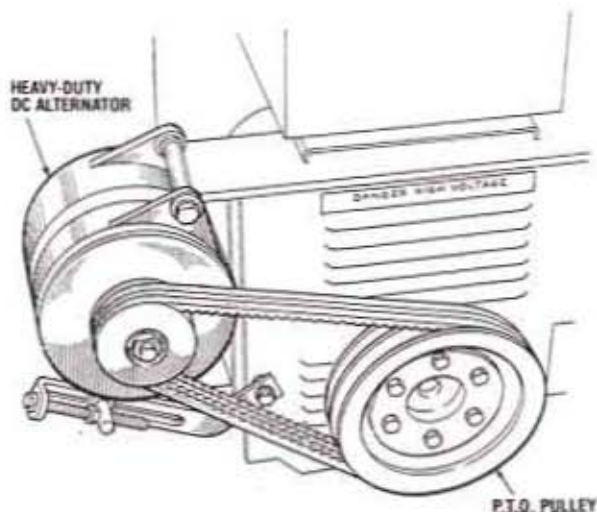
ACCESSORIES

HEAVY-DUTY MUFFLER

Your generator will run quieter with this hospital-grade muffler, but there may be a loss of power. For information about additional muffling and quieter generator operation, contact your WESTERBEKE dealer.

CONTINUOUS DUTY HIGH OUTPUT ALTERNATORS

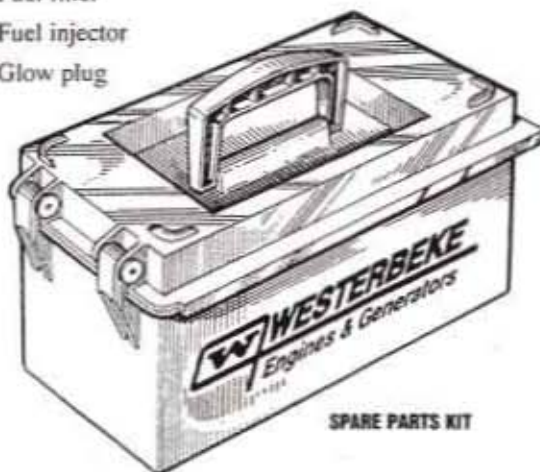
This heavy-duty DC Alternator will run lights, charge batteries, and provide back-up for operational electrical systems and equipment. WESTERBEKE's heavy-duty alternator package includes the alternator, two drive belts, belt guard, drive belt tensioner and external regulator.



SPARE PARTS KIT

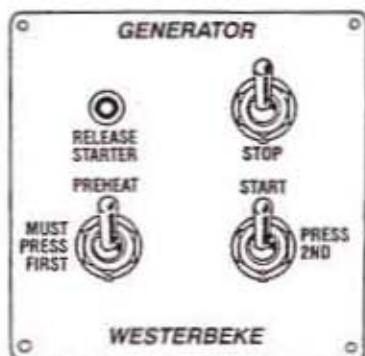
WESTERBEKE's Spare Parts Kit is packaged in a rugged hinged toolbox. The kit includes the following spare parts:

- Oil filter
- Thermostat kit
- Complete gasket kit
- Drive belt
- Fuel filter
- Fuel injector
- Glow plug



REMOTE START/STOP PANEL

This remote panel contains three switches and a run indicator light (green). The panel must be wired into the terminal strip in the panel on the generator, and mounted in a remote location. Note: it must *not* be located in an engine or generator compartment because it is not ignition-protected.



REMOTE START/STOP PANEL

STANDARD HARDWARE

BOLT HEAD MARKINGS

Bolt strength classes are embossed on the head of each bolt.

Customary (inch) bolts are identified by markings two to grade eight (strongest). The marks correspond to two marks less than the actual grade, i.e., a grade seven bolt will display five embossed marks.



Metric bolt class numbers identify bolts by their strength with 10.9 the strongest.



- NOTES:**
1. Use the torque values listed below when specific torque values are not available.
 2. These torques are based on clean, dry threads. Reduce torque by 10% when engine oil is used.
 3. Reduce torques by 30% or more, when threading capscrews into aluminum.

STANDARD BOLT & NUT TORQUE SPECIFICATIONS			
Capscrew Body Size (Inches) - (Thread)	SAE Grade 5 Torque Ft-Lb (Nm)	SAE Grade 6-7 Torque Ft-Lb (Nm)	SAE Grade 8 Torque Ft-Lb (Nm)
1/4 - 20 - 28	8 (11) 10 (14)	10 (14)	12 (16) 14 (19)
5/16 - 18 - 24	17 (23) 19 (26)	19 (26)	24 (33) 27 (37)
3/8 - 16 - 24	31 (42) 35 (47)	34 (46)	44 (60) 49 (66)
7/16 - 14 - 20	49 (66) 55 (75)	55 (75)	70 (95) 78 (106)
1/2 - 13 - 20	75 (102) 85 (115)	85 (115)	105 (142) 120 (163)
9/16 - 12 - 18	110 (149) 120 (163)	120 (163)	155 (210) 170 (231)
5/8 - 11 - 18	150 (203) 170 (231)	167 (225)	210 (285) 240 (325)
3/4 - 10 - 16	270 (366) 295 (400)	290 (380)	375 (508) 420 (569)
7/8 - 9 - 14	395 (536) 435 (590)	440 (597)	605 (820) 675 (915)
1 - 8 - 14	590 (800) 660 (895)	660 (895)	910 (1234) 990 (1342)

NOTE: Formula to convert Ft-Lbs to Nm (Newton Meters) multiply Ft-Lb x 1.356

METRIC BOLT & NUT TORQUE SPECIFICATIONS					
Bolt Dia.	Wrench Size	Grade 4.6 Ft-Lb (Nm)	Grade 4.8 Ft-Lb (Nm)	Grade 8.8 - 9.8 Ft-Lb (Nm)	Grade 10.9 Ft-Lb (Nm)
M3	5.5 mm	0.3 (0.5)	0.5 (0.7)	1 (1.3)	1.5 (2)
M4	7 mm	0.8 (1.1)	1 (1.5)	2 (3)	3 (4.5)
M5	8 mm	1.5 (2.5)	2 (3)	4.5 (6)	6.5 (9)
M8	10 mm	3 (4)	4 (5.5)	7.5 (10)	11 (15)
M9	13 mm	7 (9.5)	10 (13)	18 (25)	35 (26)
M10	16 mm	14 (19)	18 (25)	37 (50)	55 (75)
M12	18 mm	26 (35)	33 (45)	63 (85)	97 (130)
M14	21 mm	37 (50)	55 (75)	103 (140)	151 (205)
M16	24 mm	59 (80)	65 (115)	159 (215)	232 (315)
M18	27 mm	81 (110)	118 (160)	225 (305)	321 (435)
M20	30 mm	118 (160)	166 (225)	321 (435)	457 (620)
M22	33 mm	159 (215)	225 (305)	435 (590)	620 (840)
M24	36 mm	203 (275)	288 (390)	553 (750)	789 (1070)
M27	41 mm	295 (400)	417 (565)	811 (1100)	1154 (1565)
M30	46 mm	402 (545)	568 (770)	1103 (1495)	1571 (2130)
M33	51 mm	546 (740)	774 (1050)	1500 (2035)	2139 (2900)
M36	55 mm	700 (950)	992 (1345)	1925 (2610)	2744 (3720)

SEALANTS & LUBRICANTS

GASKETS/SEALANTS

Oil based PERMATEX #2 and it's HIGH TACK equivalent are excellent all purpose sealers. They are effective in just about any joint in contact with coolant, raw water, oil or fuel.

A light coating of OIL or LIQUID TEFLON can be used on rubber gaskets and O-rings.

LOCTITE hydraulic red sealant should be used on oil adapter hoses and the oil filter assembly.

Coat both surfaces of the oil pan gasket with high temp RED SILICONE sealer.

When installing gaskets that seal around water (coolant) passages, coat both sides with WHITE SILICONE grease.

High-copper ADHESIVE SPRAYS are useful for holding gaskets in position during assembly.

Specialized gasket sealers such as HYLOMAR work well in applications requiring non-hardening properties. HYLOMAR is particularly effective on copper cylinder-head gaskets as it resists fuel, oil and water.

Use LIQUID TEFLON for sealing pipe plugs and fillings that connect coolant passages. **Do not use tape sealants!**

BOLTS & FASTENERS/ASSEMBLIES

Lightly oil head bolts and other fasteners as you assemble them. Bolts and plugs that penetrate the water jacket should be sealed with PERMATEX #2 or HIGH TACK.

When assembling the flywheel, coat the bolt threads with LOCTITE blue.

Anti-seize compounds and thread locking adhesives such as LOCTITE protect threaded components yet allows them to come apart when necessary. LOCTITE offers levels of locking according to the job.

LITHIUM based grease is waterproof, ideal for water pump bearings and stuffing boxes.

Heavily oil all sliding and reciprocating components when assembling. **Always use clean engine oil!**



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	8	8	6	6	6	6	6	6	6	6	6	6
10	14	12	10	10	10	8	8	6	6	6	6	6	6	6	6	6	6	6	6
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	6	4	4	2	2	2	2	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	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							
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	10	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	0	0	0	0	2/0
50	10	8	6	6	6	4	4	2	2	2	1	1	0	0	2/0	2/0	2/0	3/0	3/0
60	10	8	6	6	4	4	2	2	1	1	0	0	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	8
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	1	1	1	0	0	2/0	2/0	2/0
80	10	8	8	6	6	4	4	2	2	2	1	1	0	0	2/0	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	16	14	14	14	14	14	14	12
10	18	18	18	18	18	18	16	16	14	14	14	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	6	6	6	6	6
30	18	16	14	14	12	12	10	10	8	8	8	8	6	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	4	4	4	2	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.



METRIC CONVERSIONS

INCHES TO MILLIMETERS

Inches	mm	Inches	mm
1	25.40	15	381.00
2	50.80	20	508.00
3	76.20	25	635.00
4	101.60	30	762.00
5	127.00	35	889.00
10	254.00	40	1016.00

MILLIMETERS TO INCHES

mm	Inches	mm	Inches
1	0.0394	15	0.5906
2	0.0787	20	0.7874
3	0.1181	25	0.9843
4	0.1575	30	1.1811
5	0.1969	35	1.3780
10	0.3937	40	1.5748

10 MILLIMETERS = 1 CENTIMETER, 100 CENTIMETERS = 1 METER = 39.37 INCHES (3.3 FEET)

INCHES TO METERS

Inches	Meters	Inches	Meters
1	0.0254	7	0.1778
2	0.0508	8	0.2032
3	0.0762	9	0.2286
4	0.1016	10	0.2540
5	0.1270	11	0.2794
6	0.1524	12	0.3048

METERS TO INCHES

Meters	Inches	Meters	Inches
0.1	3.937	0.7	27.559
0.2	7.874	0.8	31.496
0.3	11.811	0.9	35.433
0.4	15.748	1.0	39.370
0.5	19.685	1.1	43.307
0.6	23.622	1.2	47.244

TO CONVERT METERS TO CENTIMETERS, MOVE DECIMAL POINT TWO PLACES TO THE RIGHT

YARDS TO METERS

Yards	Meters	Yards	Meters
1	0.91440	6	5.48640
2	1.82880	7	6.40080
3	2.74320	8	7.31520
4	3.65760	9	8.22960
5	4.57200	10	9.14400

METERS TO YARDS

Meters	Yards	Meters	Yards
1	1.09361	6	6.56168
2	2.18723	7	7.65529
3	3.28084	8	8.74891
4	4.37445	9	9.84252
5	5.46807	10	10.93614

MOVE DECIMAL POINT FOR HIGHER VALUES — e.g. 6,000 METERS = 6,561.68 YARDS

POUNDS TO KILOGRAMS

lb	kg	lb	kg
1	0.454	6	2.722
2	0.907	7	3.175
3	1.361	8	3.629
4	1.814	9	4.082
5	2.268	10	4.536

KILOGRAMS TO POUNDS

kg	lb	kg	lb
1	2.205	6	13.228
2	4.409	7	15.432
3	6.614	8	17.637
4	8.818	9	19.842
5	11.023	10	22.046

GALLONS TO LITERS

Gallons	Liters	Gallons	Liters
1	3.79	10	37.86
2	7.57	20	75.71
3	11.36	30	113.57
4	15.14	40	151.42
5	18.93	50	189.28

LITERS TO GALLONS

Liters	Gallons	Liters	Gallons
1	0.26	60	15.66
2	0.53	90	23.77
5	1.32	120	31.32
10	2.64	150	39.62
20	5.28	180	47.54

PINTS TO LITERS

Pints	Liters	Pints	Liters
1	0.47	6	2.84
2	0.95	7	3.31
3	1.42	8	3.79
4	1.89	9	4.26
5	2.37	10	4.73

LITERS TO PINTS

Liters	Pints	Liters	Pints
1	2.11	6	12.68
2	4.23	7	14.79
3	6.34	8	16.91
4	8.45	9	19.02
5	10.57	10	21.13

TEMPERATURE

