

# Installation

## Marine Generator Sets



Pleasure Craft Models:

**40-200EOZDJ**  
**33-175EFOZDJ**

Commercial Models:

**40-200EOZCJ**  
**33-175EFOZCJ**

Controller:

Decision-Maker® 3500

# KOHLER®



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# Safety Precautions and Instructions

**IMPORTANT SAFETY INSTRUCTIONS.** Electromechanical equipment, including generator sets, transfer switches, switchgear, and accessories, can cause bodily harm and pose life-threatening danger when improperly installed, operated, or maintained. To prevent accidents be aware of potential dangers and act safely. Read and follow all safety precautions and instructions. **SAVE THESE INSTRUCTIONS.**

This manual has several types of safety precautions and instructions: Danger, Warning, Caution, and Notice.

## **DANGER**

Danger indicates the presence of a hazard that **will cause severe personal injury, death, or substantial property damage.**

## **WARNING**

Warning indicates the presence of a hazard that **can cause severe personal injury, death, or substantial property damage.**

## **CAUTION**

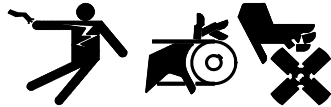
Caution indicates the presence of a hazard that **will or can cause minor personal injury or property damage.**

## **NOTICE**

Notice communicates installation, operation, or maintenance information that is safety related but not hazard related.

Safety decals affixed to the equipment in prominent places alert the operator or service technician to potential hazards and explain how to act safely. The decals are shown throughout this publication to improve operator recognition. Replace missing or damaged decals.

## Accidental Starting

|                                                                                                                                                                                                                                                                                          |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <b>WARNING</b>                                                                                                                                                                                         |
|                                                                                                                                                                                                         |
| <b>Accidental starting.</b><br><b>Can cause severe injury or death.</b><br><br>Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery. |

**Disabling the generator set.** **Accidental starting can cause severe injury or death.** Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

## Engine Backfire/Flash Fire

|                                                                                                                                                |
|------------------------------------------------------------------------------------------------------------------------------------------------|
|  <b>WARNING</b>                                             |
|                                                             |
| <b>Risk of fire.</b><br><b>Can cause severe injury or death.</b><br><br>Do not smoke or permit flames or sparks near fuels or the fuel system. |

**Servicing the fuel system. A flash fire can cause severe injury or death.**

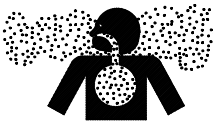
Do not smoke or permit flames or sparks near the fuel injection system, fuel line, fuel filter, fuel pump, or other potential sources of spilled fuels or fuel vapors. Catch fuels in an approved container when removing the fuel line or fuel system.

**Servicing the air cleaner. A sudden backfire can cause severe injury or death.** Do not operate the generator set with the air cleaner/silencer removed.

**Combustible materials. A sudden flash fire can cause severe injury or death.** Do not smoke or permit flames or sparks near the generator set. Keep the compartment and the generator set clean and free of debris to minimize the risk of fire. Catch fuels in an approved container. Wipe up spilled fuels and engine oil.

**Combustible materials. A fire can cause severe injury or death.** Generator set engine fuels and fuel vapors are flammable and explosive. Handle these materials carefully to minimize the risk of fire or explosion. Equip the compartment or nearby area with a fully charged fire extinguisher. Select a fire extinguisher rated ABC or BC for electrical fires or as recommended by the local fire code or an authorized agency. Train all personnel on fire extinguisher operation and fire prevention procedures.

## Exhaust System

|                                                                                                                                                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>⚠ WARNING</b>                                                                                                                                 |
|                                                                 |
| <p><b>Carbon monoxide. Can cause severe nausea, fainting, or death.</b></p> <p>The exhaust system must be leakproof and routinely inspected.</p> |

**Carbon monoxide symptoms. Carbon monoxide can cause severe nausea, fainting, or death.** Carbon monoxide is a poisonous gas present in exhaust gases. Carbon monoxide is an odorless, colorless, tasteless, nonirritating gas that can cause death if inhaled for even a short time. Carbon monoxide poisoning symptoms include but are not limited to the following:

- Light-headedness, dizziness
- Physical fatigue, weakness in joints and muscles
- Sleepiness, mental fatigue, inability to concentrate or speak clearly, blurred vision
- Stomachache, vomiting, nausea

If experiencing any of these symptoms and carbon monoxide poisoning is possible, seek fresh air immediately and remain active. Do not sit, lie down, or fall asleep. Alert others to the possibility of carbon monoxide poisoning. Seek medical attention if the condition of affected persons does not improve within minutes of breathing fresh air.

**Inspecting the exhaust system. Carbon monoxide can cause severe nausea, fainting, or death.** For the safety of the craft's occupants, install a carbon monoxide detector. Never operate the generator set without a functioning carbon monoxide detector. Inspect the detector before each generator set use.

**Operating the generator set. Carbon monoxide can cause severe nausea, fainting, or death.** Be especially careful if operating the generator set when moored or anchored under calm conditions because gases may accumulate. If operating the generator set dockside, moor the craft so that the exhaust discharges on the lee side (the side sheltered from the wind). Always be aware of others, making sure your exhaust is directed away from other boats and buildings.

## Fuel System

|                                                                                                                                         |
|-----------------------------------------------------------------------------------------------------------------------------------------|
| <b>⚠ WARNING</b>                                                                                                                        |
|                                                        |
| <p><b>Explosive fuel vapors. Can cause severe injury or death.</b></p> <p>Use extreme care when handling, storing, and using fuels.</p> |

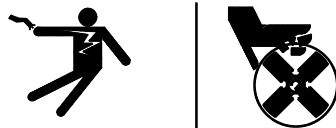
**The fuel system. Explosive fuel vapors can cause severe injury or death.** Vaporized fuels are highly explosive. Use extreme care when handling and storing fuels. Store fuels in a well-ventilated area away from spark-producing equipment and out of the reach of children. Never add fuel to the tank while the engine is running because spilled fuel may ignite on contact with hot parts or from sparks. Do not smoke or permit flames or sparks to occur near sources of spilled fuel or fuel vapors. Keep the fuel lines and connections tight and in good condition. Do not replace flexible fuel lines with rigid lines. Use flexible sections to avoid fuel line breakage caused by vibration. Do not operate the generator set in the presence of fuel leaks, fuel accumulation, or sparks. Repair fuel systems before resuming generator set operation.

**Draining the fuel system. Explosive fuel vapors can cause severe injury or death.** Spilled fuel can cause an explosion. Use a container to catch fuel when draining the fuel system. Wipe up spilled fuel after draining the system.

## Hazardous Noise

|                                                                                                                                                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>⚠ CAUTION</b>                                                                                                                                 |
|                                                               |
| <p><b>Hazardous noise. Can cause hearing loss.</b></p> <p>Never operate the generator set without a muffler or with a faulty exhaust system.</p> |

## Hazardous Voltage/ Moving Parts

|                                                                                                                                                                                |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>⚠ WARNING</b>                                                                                                                                                               |
|                                                                                             |
| <p><b>Hazardous voltage. Moving parts. Can cause severe injury or death.</b></p> <p>Operate the generator set only when all guards and electrical enclosures are in place.</p> |

**Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death.** Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

**Grounding electrical equipment. Hazardous voltage can cause severe injury or death.** Electrocuting is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

**Disconnecting the electrical load. Hazardous voltage can cause severe injury or death.** Disconnect the generator set from the load by turning off the line circuit breaker or by disconnecting the generator set output leads from the transfer switch and heavily taping the ends of the leads. High voltage transferred to the load during testing may cause personal injury and equipment damage. Do not use the safeguard circuit breaker in place of the line circuit breaker. The safeguard circuit breaker does not disconnect the generator set from the load.

**Short circuits. Hazardous voltage/current can cause severe injury or death.** Short circuits can cause bodily injury and/or equipment damage. Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

**Electrical backfeed to the utility. Hazardous backfeed voltage can cause severe injury or death.** Connect the generator set to the building/marina electrical system only through an approved device and after the building/marina main switch is turned off. Backfeed connections can cause severe injury or death to utility personnel working on power lines and/or personnel near the work area. Some states and localities prohibit unauthorized connection to the utility electrical system. Install a ship-to-shore transfer switch to prevent interconnection of the generator set power and shore power.

**Testing live electrical circuits. Hazardous voltage or current can cause severe injury or death.** Have trained and qualified personnel take diagnostic measurements of live circuits. Use adequately rated test equipment with electrically insulated probes and follow the instructions of the test equipment manufacturer when performing voltage tests. Observe the following precautions when performing voltage tests: (1) Remove all jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Do not touch the enclosure or components inside the enclosure. (4) Be prepared for the system to operate automatically. *(600 volts and under)*

## Hot Parts

|                                                                                                                                                                                                                |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <b>WARNING</b>                                                                                                             |
|                                                                                                                             |
| <p><b>Hot coolant and steam. Can cause severe injury or death.</b></p> <p>Before removing the pressure cap, stop the generator set and allow it to cool. Then loosen the pressure cap to relieve pressure.</p> |

## Notice

|                                                                                                                                                                                                                                        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>NOTICE</b>                                                                                                                                                                                                                          |
| <p><b>This generator set has been rewired from its nameplate voltage to</b></p> <div style="border: 1px solid black; height: 50px; width: 150px; margin: 10px auto;"></div> <p style="text-align: right; font-size: small;">246242</p> |

### NOTICE

**Voltage reconnection.** Affix a notice to the generator set after reconnecting the set to a voltage different from the voltage on the nameplate. Order voltage reconnection decal 246242 from an authorized service distributor/dealer.

### NOTICE

**Fuse replacement.** Replace fuses with fuses of the same ampere rating and type (for example: 3AB or 314, ceramic). Do not substitute clear glass-type fuses for ceramic fuses. Refer to the wiring diagram when the ampere rating is unknown or questionable.

### NOTICE

**Saltwater damage.** Saltwater quickly deteriorates metals. Wipe up saltwater on and around the generator set and remove salt deposits from metal surfaces.

## Notes

# Section 1 Introduction

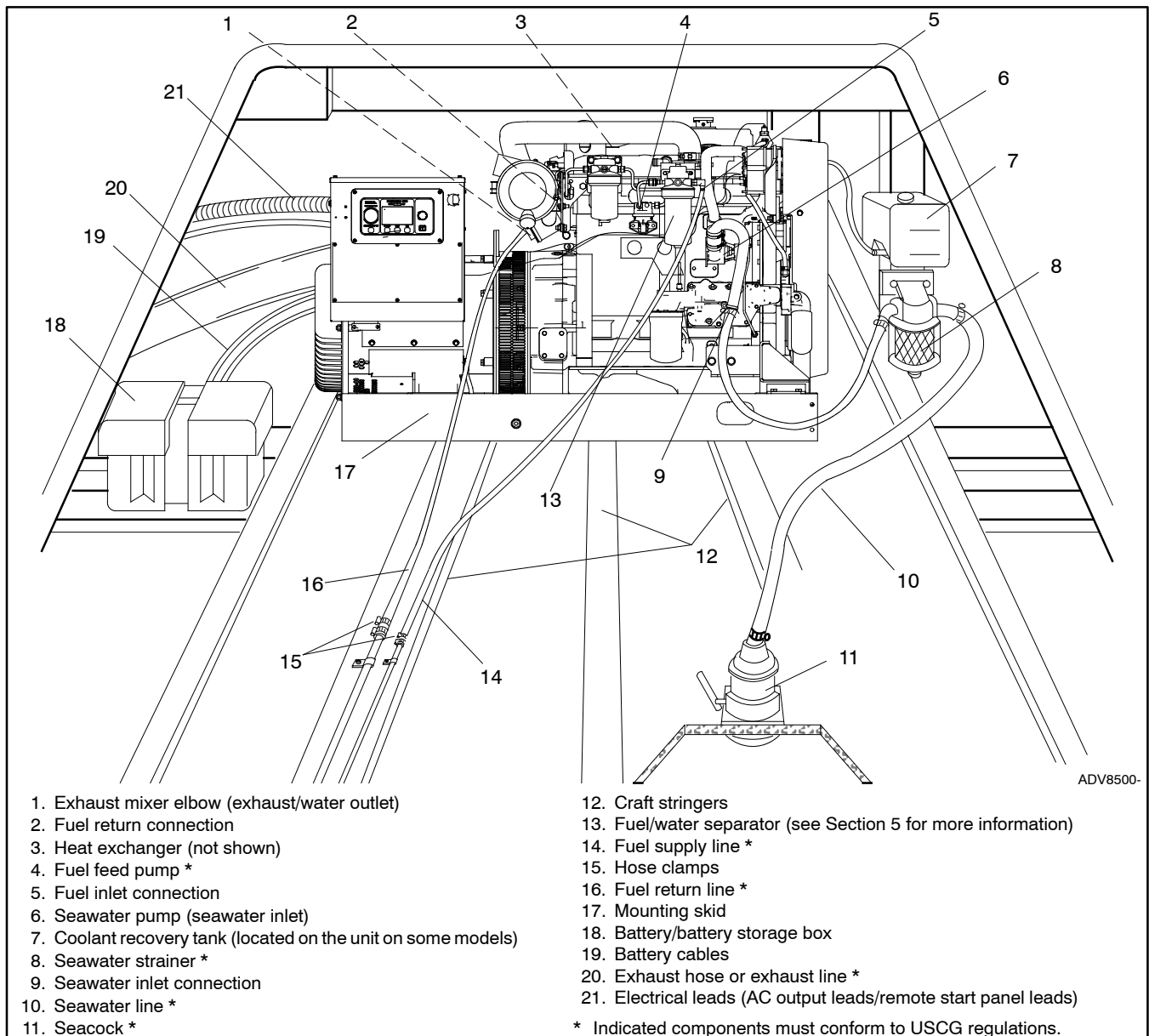
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The safe and successful operation of a marine power system depends primarily on the installation. See Figure 1-1. Use this manual as a guide to install the marine generator set. For operating instructions, refer to the operation manual.

**Note: Only qualified persons should install the generator set.**

Marine generator set installations must comply with all applicable regulations and standards.

Use the specification sheets as a guide in planning your installation. Use current dimension drawings and wiring diagrams.



**Figure 1-1** Typical Generator Set Location and Mounting (40EOZDJ Model Shown Without Sound Shield)

**Note:** See text for complete explanation of installation requirements.

**Note:** Use two hose clamps on each end of all flexible exhaust hose connections.

## 1.1 Decision-Maker® 3500 Controller Information

The following data must be resident for the controller to function.

- **Application program** contains the software that controls system operation. The application file was preprogrammed in the *original* controller at the factory.
- **Personality profile** is specific to the engine and alternator and was preprogrammed in the *original* controller at the factory.

A backup disk of the personality profile and application program is supplied in the junction box of the generator set. Typically, the Kohler authorized distributor/dealer passes this disk onto the owner. Inform the owner to store this disk for possible future use such as controller replacement or other circumstances requiring a backup.

**Note:** If the personality disk is NOT available, request a replacement from Kohler Co. using the generator set serial number or order number.

- **User parameters** unique to an installation include timer values, setpoints, generator set data such as voltage and input/output selections. These parameters are typically set up for or by the installer at the time of installation. User parameters are typically recorded on the personality profile disk, a separate backup disk/drive, or written on a paper form.

**Note:** If the user parameters are included on the personality disk, the disk label should indicate Site Program—Yes.

**Note:** After the unit is set up on the vessel, Kohler authorized distributor/dealer saves any user parameter changes to an external medium. The installer or a Kohler authorized distributor/dealer passes this information onto the owner. Inform the owner to store this information for possible future use such as controller replacement or other circumstances requiring a backup.

**Note:** Controller service replacement kits do not include the three files. The service technician *must* install the three files into the replacement controller.

## Section 2 Location and Mounting

### 2.1 General Considerations

The key to installation is location. Before making final plans for locating a generator set, consider the following.

#### Installation Location Considerations

1. Choose a location that allows adequate space for cooling and exhaust system installation, fuel system installation, ventilation, and service access to the generator set (engine and generator).
2. Use craft stringers or other available structural members capable of supporting the generator set's weight.
3. Seal the generator set's engine room from the cabin to prevent exhaust gases and fuel vapors from entering the cabin.

See the current generator set specification sheet or Section 7 of this manual for generator set dimensions and weights. See Figure 1-1 for a typical installation.

### 2.2 Location

Locate the generator set to allow easy service access to the generator set's engine, controller, cooling, and fuel system components. The engine compartment is often the ideal location for the generator set if the propulsion engine(s) does not obstruct access to the generator set and controller.

Allow clearance for vibration and cooling during operation. Allow a minimum of 38 mm (1.5 in.) clearance on all sides (top, front, rear, and sides) of a generator set without an optional sound shield. For sound-shielded units, allow 305 mm (12 inches) minimum clearance for the left-rear door and front door (intake and discharge openings). Also, allow space for the power takeoff (PTO) option, if equipped.

### Marine Generator Set Installations in European Union Member Countries

This generator set is specifically intended and approved for installation below the deck in the engine compartment. Installation above the deck and/or outdoors would constitute a violation of European Union Directive 2000/14/EC noise emission standard.

*Kohler ignition-protected generator sets carry a UL1500 marine mark (decal). Check for this mark to ensure that your specific model is ignition protected. USCG Regulation 183.410 requires ignition-protected devices only in gasoline/gaseous-fueled environments.*

### 2.3 Mounting

Mount the generator set as high as possible to avoid contact with bilge splash and lower-lying vapors and to allow for downward pitch of the exhaust line toward the exhaust outlet.

Kohler Co. recommends mounting the generator set on a flat board attached to the craft stringers. Craft stringers generally provide the best generator set support. Ensure that the structural members can support the generator set's weight and withstand its vibration.

The generator set includes vibration mounts and a mounting tray or skid. If desired, install additional vibration isolating pads underneath the generator set's base. Use the four mounting holes in the mounting tray to mount the generator set securely to the craft.

For angular operating limits, consult the operation manual.

## Notes



## 3.1 Ventilation

Engine combustion, generator cooling, and expulsion of flammable and lethal fumes require ventilation. Provide ventilation compliant with USCG regulations governing the sizing of vents and other considerations.

As a rule, size each inlet- and outlet-vent area to a minimum of 13 sq. cm/30.5 cm (2 sq. in. per ft.) of the craft's beam. Should this rule conflict with USCG regulations, follow USCG regulations. For applications with screened inlets, double the size (4 sq. in. per ft.) of the hull/deck openings. Extend the vent ducts to bilges to expel heavier-than-air fumes.

For generator sets mounted in the engine compartment, increase the air flow to allow for the generator set's requirements. Install optional detection devices to cause alarm, warning, or engine shutdown should dangerous fumes accumulate in the compartment.

See the generator set specification sheet that shipped with the generator set for air requirements. The air intake silencer/cleaner provides combustion air to the engine. Do not compromise the recommended minimum clearance (shown in Section 2) between a duct opening and enclosure wall. The engine/generator performance will decline if you compromise these guidelines. See Figure 3-1 for allowable intake restriction.

**Note:** ISO 3046 derates apply. See Appendix C.

| Model                                    | Allowable Intake Restriction                  |
|------------------------------------------|-----------------------------------------------|
| 40-200EOZDJ/EOZCJ<br>33-175EFOZDJ/EFOZCJ | 25 in. H <sub>2</sub> O<br>(6.25 kPa) or less |

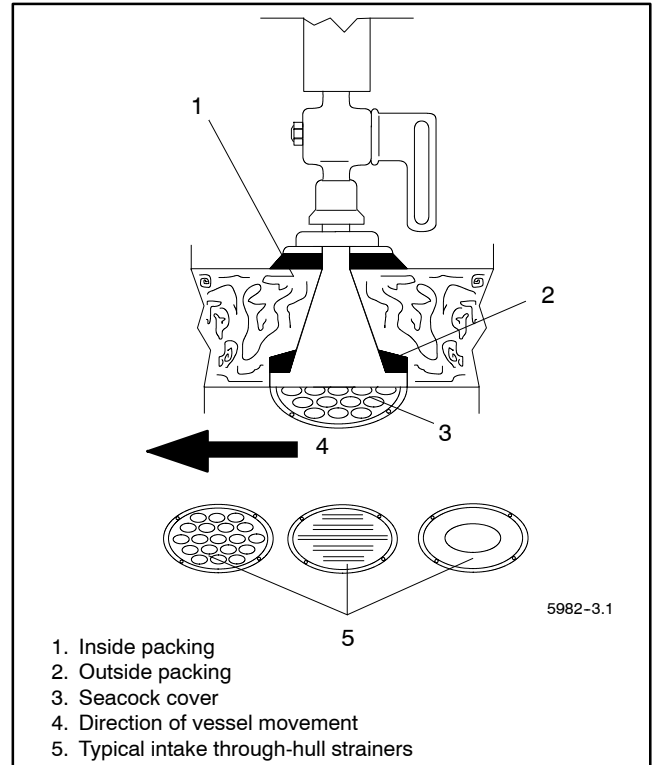
**Figure 3-1** Combustion Air Intake Restriction

## 3.2 Cooling System Components

Design the marine generator set's cooling system to include the following features.

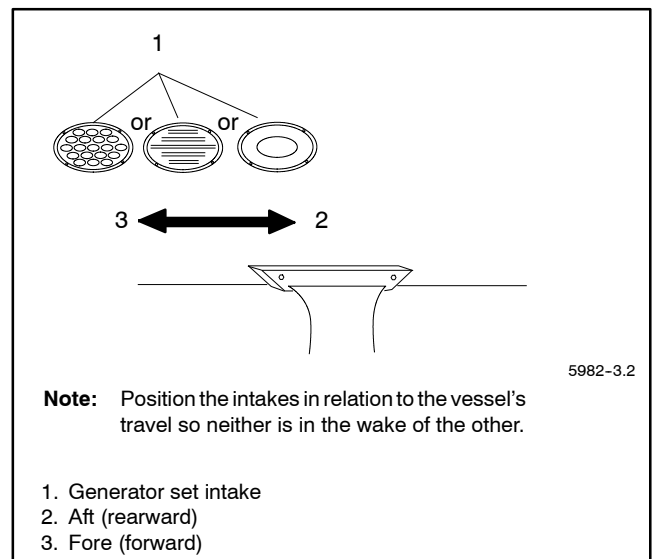
### 3.2.1 Intake Through-Hull Strainer (Seacock Cover)

Install a screened-intake, through-hull strainer to prevent entry of foreign objects. Use perforated, slotted-hole, or unrestricted-hole design strainers. See Figure 3-2 for examples of typical strainers. The inner diameter of the strainer opening must be equal to or greater than the inner diameter of the water line hose to the seawater pump.



**Figure 3-2** Seacock Installation

Do not align the strainer (in relation to the direction of travel) with any other through-hull intakes. See Figure 3-3. Flush mount the recommended through-hull strainer. Install slotted-hole-design strainers with the slots parallel to the direction of the vessel's movement.



**Figure 3-3** Intake Strainer

Do not use a speed scoop or cup design intake through-hull strainer because it can cause a ramming effect and force water upward, past the seawater pump, and into the engine cylinders when the vessel is moving and the generator set is shut down.

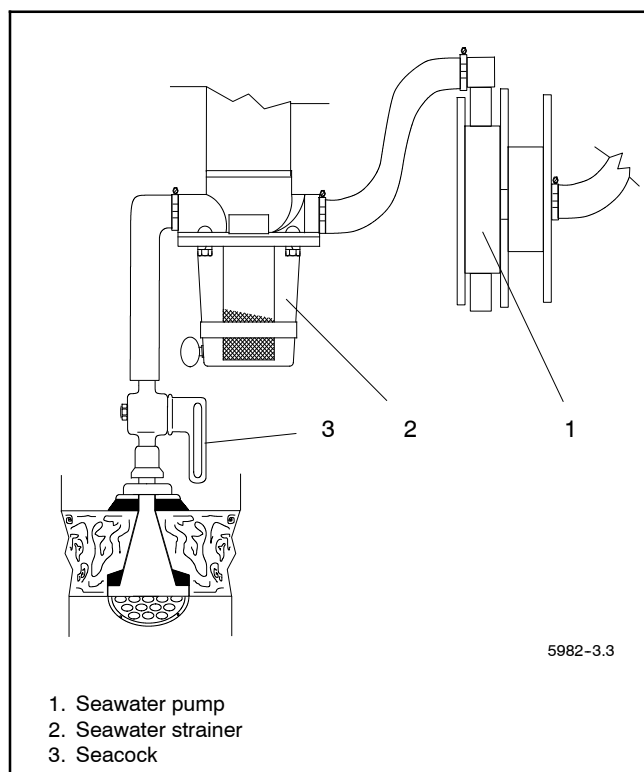
Do not use hull designs incorporating sea chests or other designs that provide a positive pressure to the raw water pump for the intake through-hull strainers. Positive pressure forces water past the raw water pump and into the engine. A sea chest is a concave molded-in-the-hull chamber that aligns to the direction of travel. A sea chest configuration applies a positive pressure similar to a scoop-type through-hull strainer.

### 3.2.2 Seacock

Mount the seacock to the hull, assemble it to the intake, and ensure that it is accessible for operation. Figure 3-2 shows a typical installation.

Avoid overcaulking the seacock. Excess caulk reduces water flow and, in some cases, develops a barrier that can force water upward, past the seawater pump, and into the engine cylinders when the vessel is moving and the generator set is shut down.

### 3.2.3 Seawater Strainer



**Figure 3-4** Seawater Strainer

Mount the seawater strainer to the seacock or permanent structure at a point not higher than the seawater pump. Ensure that the strainer is accessible for service. See Figure 3-4 for a typical installation.

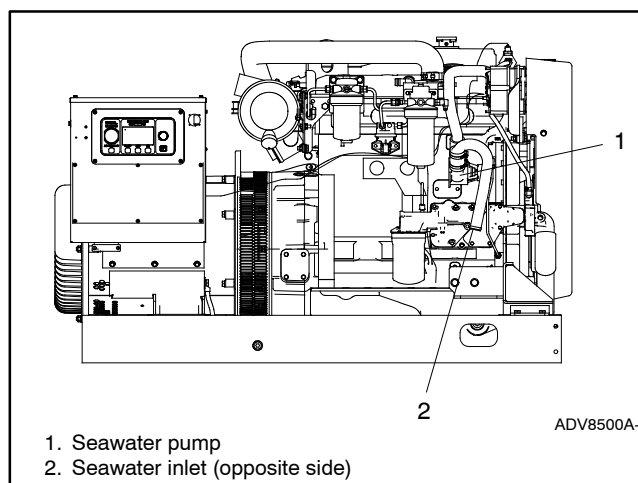
Some seawater strainers include a seacock and an intake through-hull strainer.

Maximum seawater inlet pressure at the seawater pump is 34.5 kPa (5 psi) at rest, as well as underway at all speeds. Excessive pressure will cause water ingestion.

### 3.2.4 Water Lines

Water lines from the seacock to the engine-driven seawater pump are usually constructed of flexible hose. Connect a flexible section of hose to the seawater pump to allow for vibrational motion of the generator set during operation. Support a nonflexible water line within 102 mm (4 in.) of its connection to the flexible section.

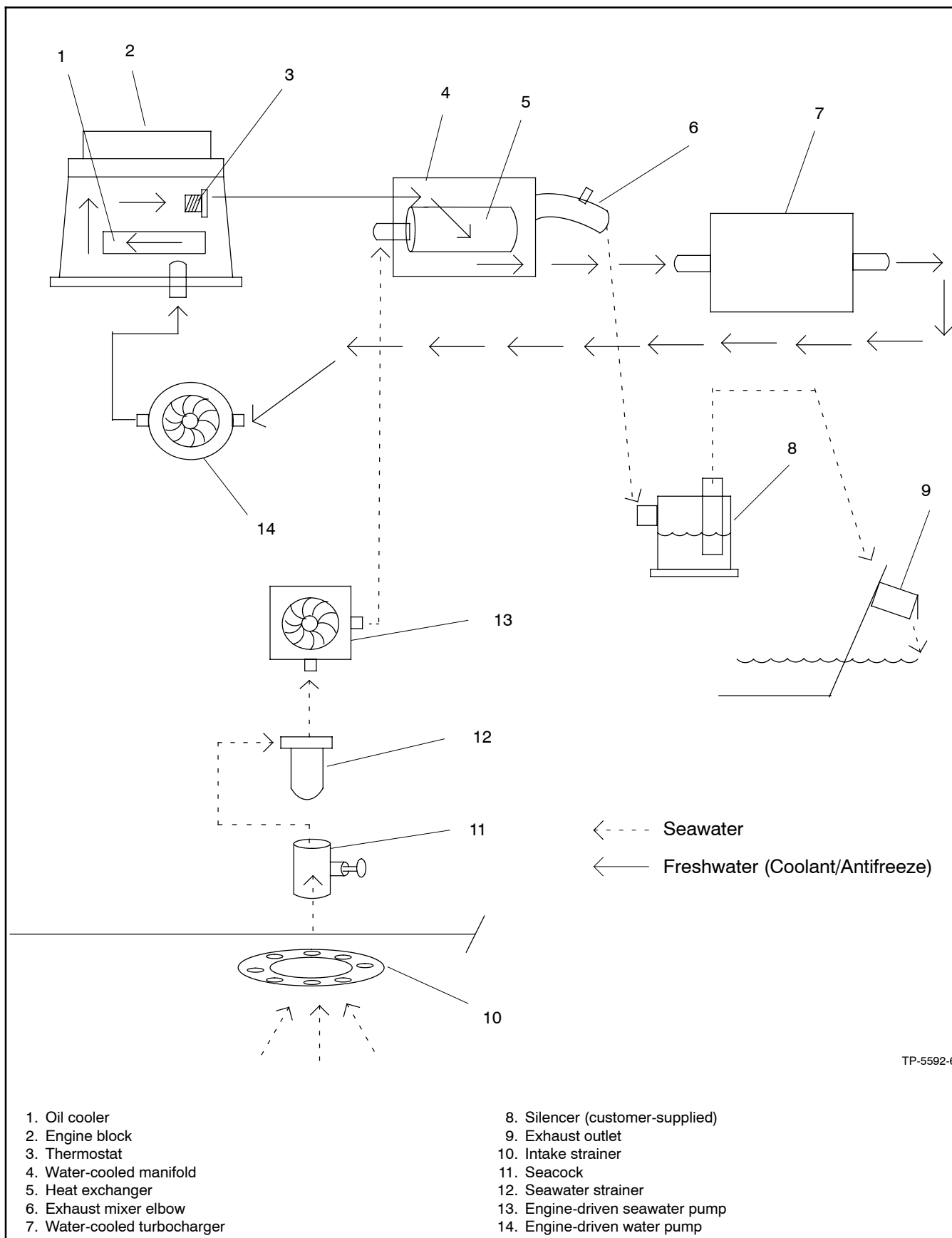
Keep the seawater hose as straight and short as possible. If the hose is too long, usually over 4.6 m (15 ft.), water suction problems may occur. See Section 7 for the inlet water line hose size and the seawater connection to the seawater pump inlet. Avoid running the inlet pipe above the generator. See Figure 3-5 for the seawater inlet connection.



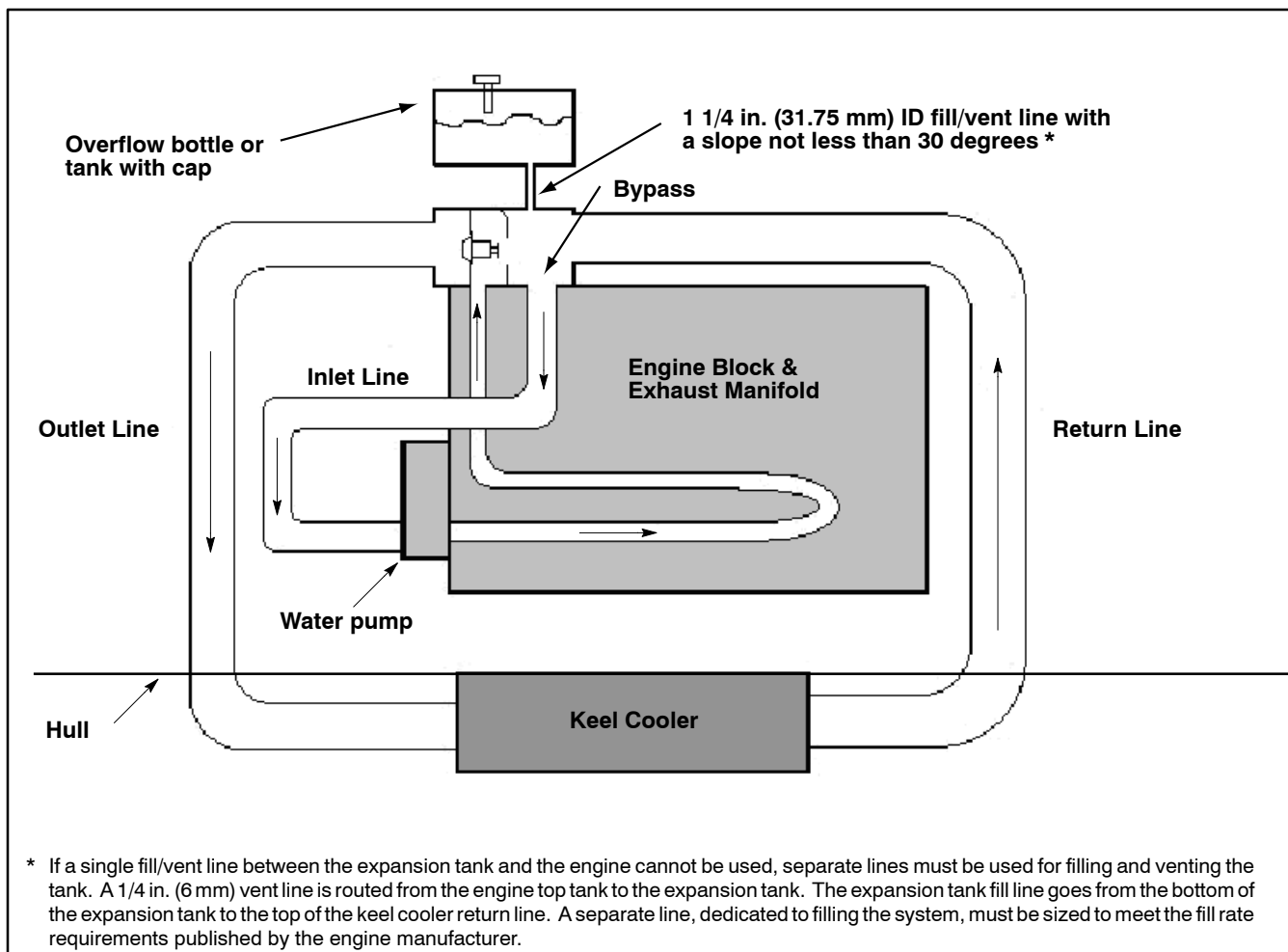
**Figure 3-5** Seawater Inlet Connection (Located on non-service side), Typical

### 3.2.5 Closed Heat Exchanger

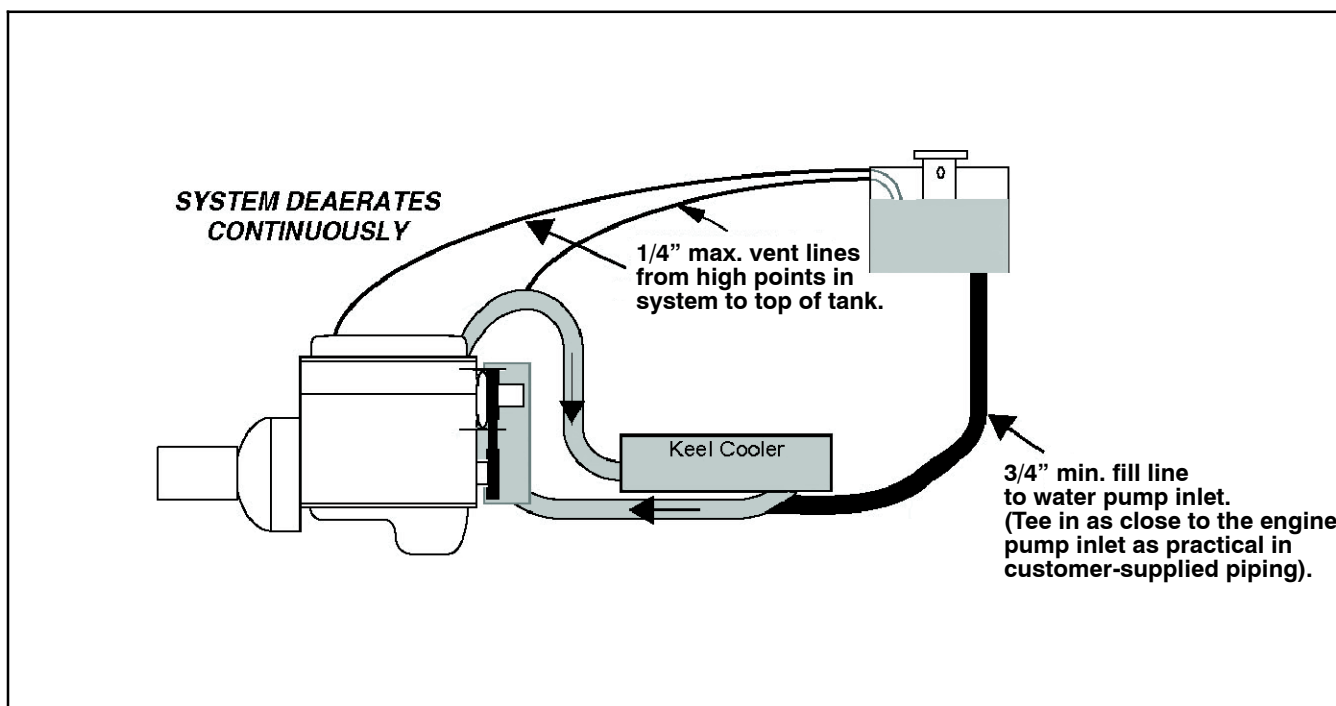
A closed heat exchanger is the best cooling method for most applications. See Figure 3-6 for a typical installation. Provide space to access the water-cooled exhaust manifold pressure cap.



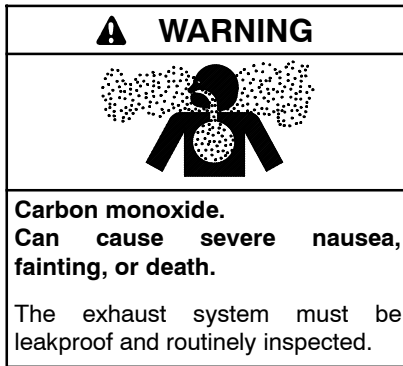
**Figure 3-6** Typical Closed/Heat Exchanger Cooling System (40-99EOZD(C)J/33-80EFOZD(C)J Models)



**Figure 3-7** Keel Cooling System Installation (Single Fill/Vent Line)



**Figure 3-8** Keel Cooling System Installation (Multiple Vent Lines)



**Carbon monoxide symptoms.** Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is a poisonous gas present in exhaust gases. Carbon monoxide is an odorless, colorless, tasteless, nonirritating gas that can cause death if inhaled for even a short time. Carbon monoxide poisoning symptoms include but are not limited to the following:

- Light-headedness, dizziness
- Physical fatigue, weakness in joints and muscles
- Sleepiness, mental fatigue, inability to concentrate or speak clearly, blurred vision
- Stomachache, vomiting, nausea

If experiencing any of these symptoms and carbon monoxide poisoning is possible, seek fresh air immediately and remain active. Do not sit, lie down, or fall asleep. Alert others to the possibility of carbon monoxide poisoning. Seek medical attention if the condition of affected persons does not improve within minutes of breathing fresh air.

**Inspecting the exhaust system.** Carbon monoxide can cause severe nausea, fainting, or death. For the safety of the craft's occupants, install a carbon monoxide detector. Never operate the generator set without a functioning carbon monoxide detector. Inspect the detector before each generator set use.

**Operating the generator set.** Carbon monoxide can cause severe nausea, fainting, or death. Be especially careful if operating the generator set when moored or anchored under calm conditions because gases may accumulate. If operating the generator set dockside, moor the craft so that the exhaust discharges on the lee side (the side sheltered from the wind). Always be aware of others, making sure your exhaust is directed away from other boats and buildings.

## 4.1 Types

Kohler® generator sets covered in this manual use either wet or dry exhaust systems. Dry exhaust systems are common in commercial applications. See the engine manual for specifications.

**Note:** Silencer selection is the responsibility of the installer but must meet the parameters outlined in this manual.

## 4.2 Exhaust Lines

Use water-cooled exhaust lines in all marine installations. Keep the lines as short and straight as possible. NFPA 302 Fire Protection Standard for Pleasure and Commercial Motor Craft, Clause 4-3, recommends using two corrosion-resistant hose clamps with a minimum width of 13 mm (1/2 in.) on each end of the flexible exhaust hose connections. Kohler Co. requires a downward pitch of at least 13 mm per 30.5 cm (1/2 in. per running foot). Use a flexible exhaust hose that conforms to UL Standard 1129 for the engine's wet exhaust components between the mixer elbow and the exhaust outlet.

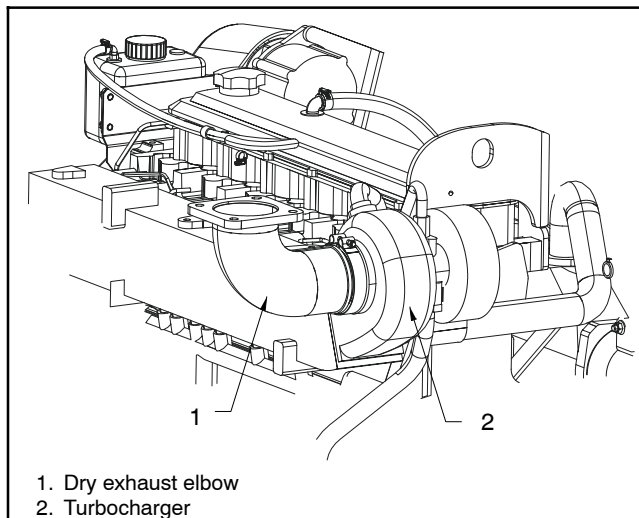
See Figure 4-1 for minimum recommended exhaust line hose selection. See Section 7 for exhaust outlet size and location.

| Models                              | Min.<br>Wet Exhaust<br>Hose<br>Diameter<br>mm (in.) | Min.<br>Dry Exhaust<br>Hose<br>Diameter<br>mm (in.) |
|-------------------------------------|-----------------------------------------------------|-----------------------------------------------------|
| 40EOZD(C)J<br>33EFOZD(C)J           | 89 (3.5)                                            | 89 (3.5)                                            |
| 40/50EFOZD(C)J                      | 102 (4.0)                                           | 102 (4.0)                                           |
| 55/65EOZD(C)J<br>45/55EFOZD(C)J     | 102 (4.0)                                           | 102 (4.0)                                           |
| 80/99EOZD(C)J<br>70/80EFOZD(C)J     | 127 (5.0)                                           | 102 (4.0)                                           |
| 125/150EOZD(C)J<br>100/125EFOZD(C)J | 127 (5.0)                                           | 102 (4.0)                                           |
| 200EOZD(C)J<br>175EFOZD(C)J         | 127 (5.0)                                           | 127 (5.0)                                           |

**Figure 4-1** Exhaust Hose Sizes (Minimum)

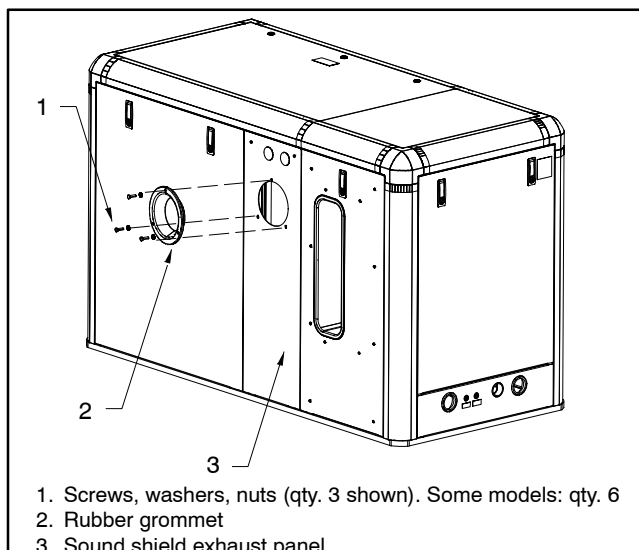
### 4.3 Sound Shielded Units with Dry Exhaust

For units equipped with a dry exhaust and sound shield, insulate the exhaust system inside of the sound shield to the turbocharger/manifold. Use fiberglass exhaust tape/wrap (or equivalent) and secure with stainless wire (or material suitable for use in a marine environment). The exhaust system around the elbow inside of the sound shield must be insulated so that temperatures do not exceed 88°C (190°F). See Figure 4-2.



**Figure 4-2** Dry Exhaust/Turbocharger Location (Shown with Sound Shield removed)

**55-200EOZDJ/40-175EFOZDJ Models:** For sound shield applications using dry exhaust, remove and discard the rubber grommet, if equipped (used only on wet-exhaust applications) from the sound shield exhaust panel before connecting the dry exhaust elbow. See Figure 4-3.

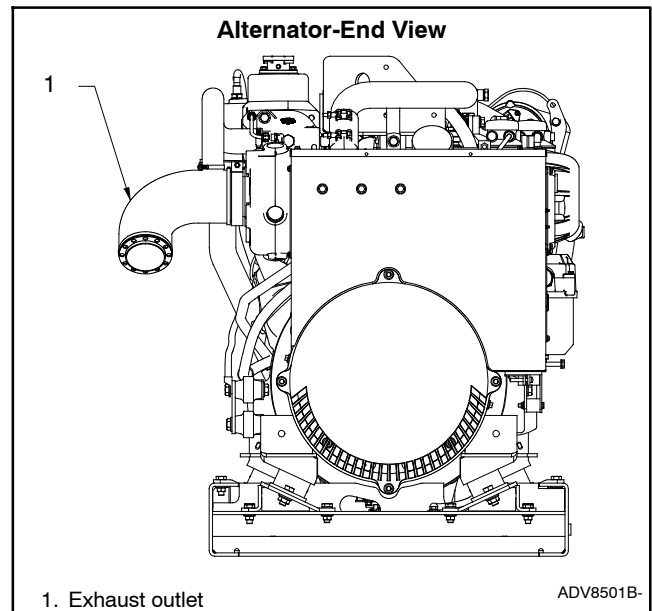


**Figure 4-3** Rubber Grommet Location

### 4.4 Exhaust System Location, Mounting, and Installation

**Note:** Should any information regarding installation conflict with USCG regulations, follow USCG regulations.

Mount the silencer independently to eliminate stress on the exhaust system and the exhaust manifold/mixer elbow. See Section 7 for the mixer elbow water line hose size. See Figure 4-4 for the exhaust connection to the mixer elbow. Provide an adequate hose length from the exhaust mixer to the silencer to allow for generator set movement.



**Figure 4-4** Mixer Elbow/Exhaust Connection, Typical

Locate the exhaust outlet at least 10 cm (4 in.) above the waterline when the craft is loaded to maximum capacity. Install an exhaust port with the flap at the exhaust (transom) outlet to prevent water backup in following seas or when moving astern (backward). A lift in the exhaust piping before the piping exits the craft prevents backwash. See Figure 4-6, item 2. Support the exhaust lines to prevent the formation of water pockets.

Exhaust system installation guidelines for various generator set locations follow. Information and illustrations of stern- (rear) exhaust installations also apply to side-exhaust installations. Where exhaust lines require passage through bulkheads, use port (left)- or starboard (right)- side exhaust outlets, also in applications in which long exhaust lines to the transom (rear) could cause excessive back pressure. See Figure 4-5 for allowable back pressures.

| Model                                    | Maximum Allowable Exhaust Back Pressure,<br>≤ kPa<br>(in. H <sub>2</sub> O) |
|------------------------------------------|-----------------------------------------------------------------------------|
| 40-200EOZDJ/EOZCJ<br>33-175EFOZDJ/EFOZCJ | 7.5 (30) *                                                                  |

\* Under ALL engine loading conditions.

**Figure 4-5** Allowable Exhaust Back Pressures

#### 4.4.1 Above-Waterline Installation

Install a customer-supplied silencer with the silencer's outlet at a maximum of 3 m (10 horizontal ft.) from the center of the engine's exhaust outlet. See Figure 4-6. Mount a typical silencer with the inlet and outlet horizontal and with the drain plug down. Use an exhaust hose pitch of at least 13 mm per 30.5 cm (0.5 in. per running foot). Some silencers require two support brackets or hanger straps for installation to stringers or other suitable structure. Follow the instructions provided with the silencer. Install any lift (see Figure 4-6, item 2) in the exhaust line below the engine exhaust manifold outlet.

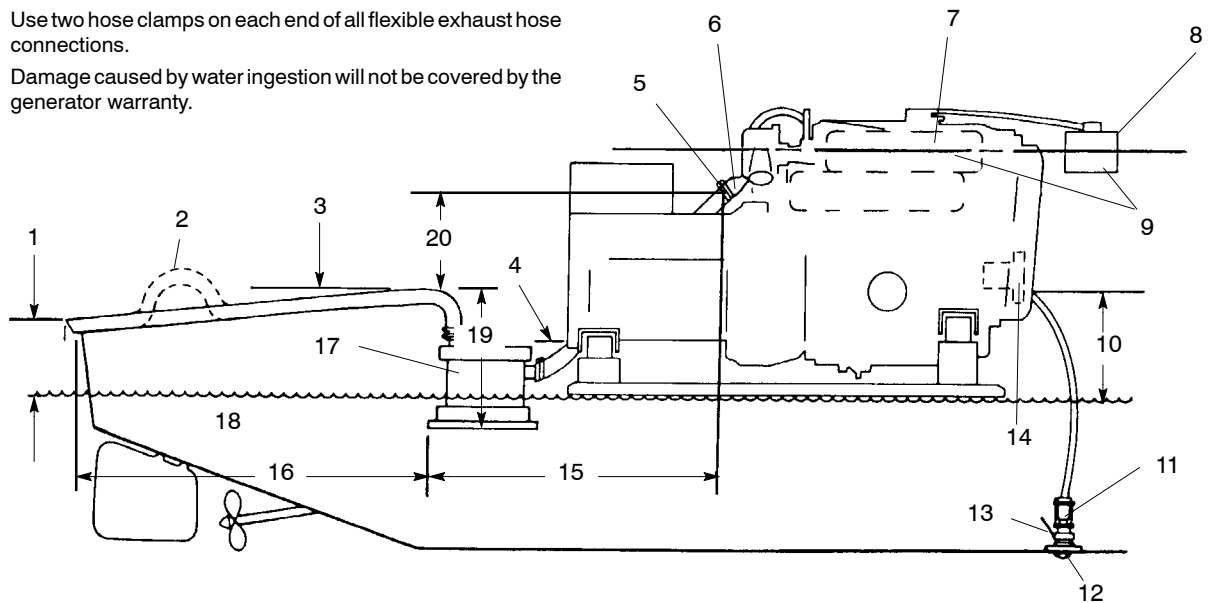
**Note:** Data applies to both rear- and side-exhaust installations.

**Note:** Numbers in illustration refer to callouts below and not to dimensions.

**Note:** Read the text for complete explanation of dimensions and other installation considerations.

**Note:** Use two hose clamps on each end of all flexible exhaust hose connections.

**Note:** Damage caused by water ingestion will not be covered by the generator warranty.



1. Minimum exhaust outlet distance above waterline of 10 cm (4 in.). Note: Vessel fully loaded
2. Slight lift improves silencing and prevents water backwash into the silencer (keep below the level of the exhaust manifold outlet)
3. Minimum exhaust hose pitch of 1.3 cm per 30.5 cm (0.5 in. per ft.)
4. Minimum exhaust hose pitch of 1.3 cm per 30.5 cm (0.5 in. per ft.)
5. Exhaust manifold outlet
6. Exhaust mixer elbow
7. Heat exchanger (locations vary by model)
8. Coolant recovery tank (located on the unit on some models)
9. Locate the coolant recovery tank at the same height as the heat exchanger

10. Maximum seawater pump lift of 3 m (10 ft.)
11. Seawater strainer
12. Intake strainer
13. Seacock
14. Engine-driven seawater pump
15. Maximum distance between silencer and exhaust mixer elbow of 3 m (10 ft.)
16. Maximum distance between silencer and exhaust outlet of 1.5 m (5 ft.)
17. Silencer (customer-supplied)
18. Waterline
19. Maximum silencer vertical lift of 1.2 m (4 ft.)
20. Kohler recommends locating the generator set at elevation that exhaust mixer is above the highest point of the exhaust outlet hose.

**Figure 4-6** Typical Above-Waterline Installation

#### 4.4.2 Mid/Below-Waterline Installation

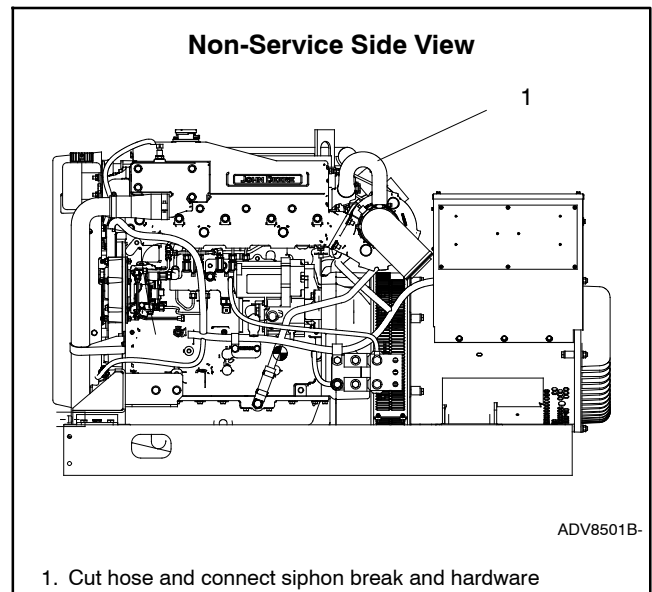
Follow USCG regulations for installing an antisiphon provision to prevent raw water entry into the engine. Use the siphon break if the exhaust manifold outlet is located less than 23 cm (9 in.) above the waterline when the craft is loaded to maximum capacity. Install the siphon break at least 31 cm (1 ft.) above the waterline using the instructions provided with the siphon break kit.

**Note:** An improperly installed siphon break will cause engine damage and may void the warranty.

Install the siphon break above the highest point in the exhaust line between the heat exchanger and the exhaust mixer. See Figure 4-7 for the siphon break connection. Support the siphon break and hoses to maintain their position and function. Allow a slight offset to clear the stringers or other permanent structures. Protect the siphon break air inlet from dirt and debris.

**Note:** To prevent water leakage on the generator set, do not mount the siphon break directly over the generator set.

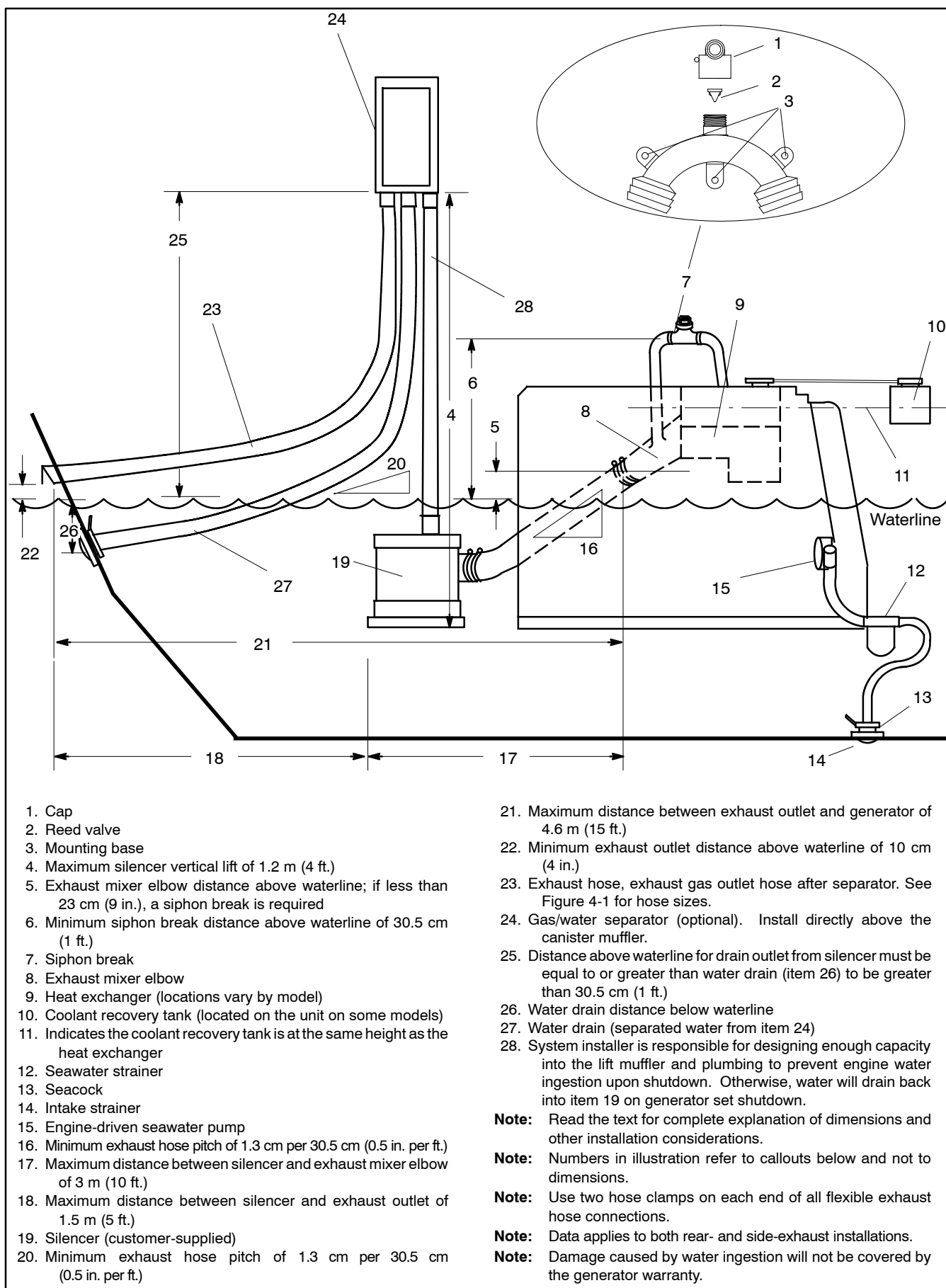
**Note:** Ensure that the siphon break's cap is tight before operating the generator set.



**Figure 4-7** Siphon Break Connection (Typical for Non-Sound Shielded Units)

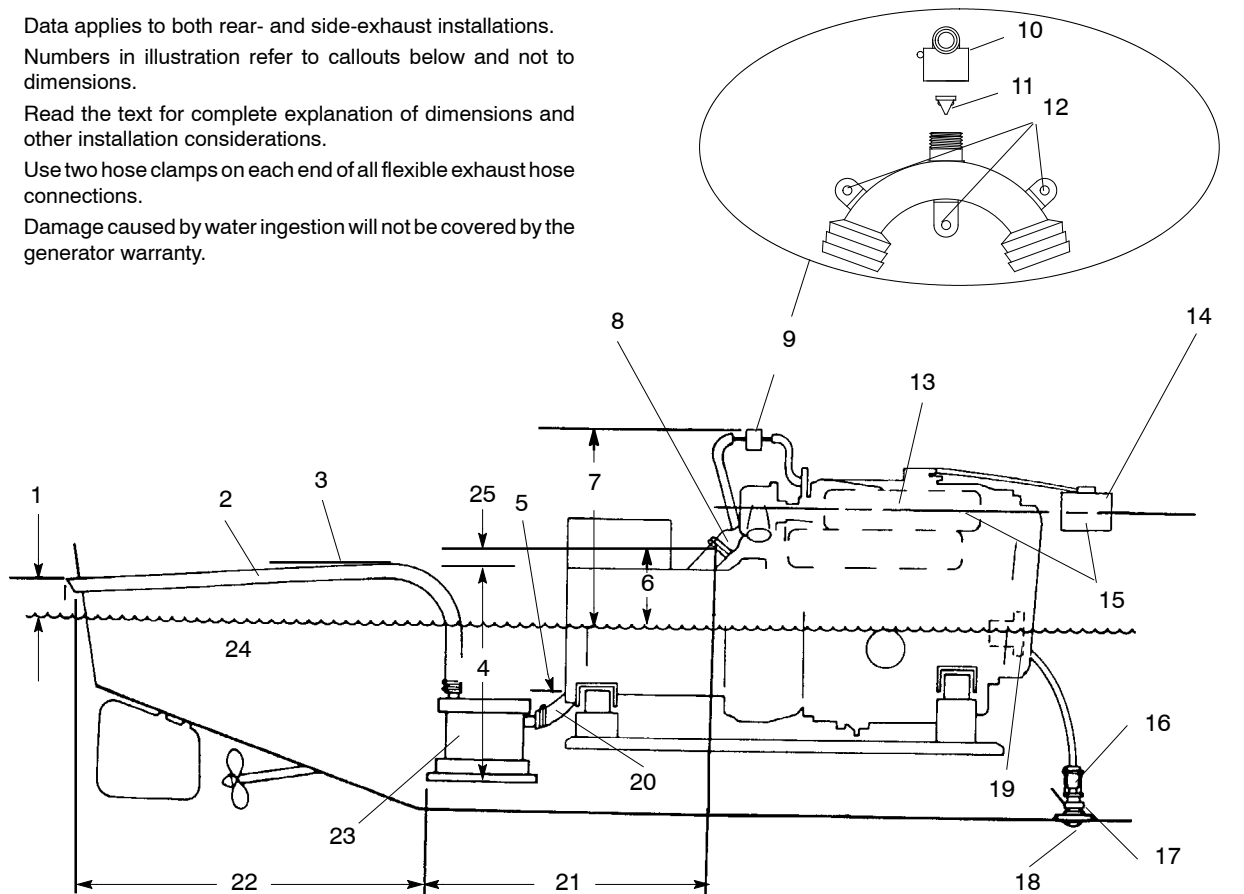
Mount a typical silencer's base no more than 1.2 m (4 ft.) below the highest point in the exhaust line. Attach a separate wood mounting base to the hull stringers or other suitable structures. Use the silencer manufacturer's recommendation for securing the silencer to the hull. Mount the silencer with the outlet not more than 3 m (10 horizontal ft.) from the engine's exhaust manifold outlet. Use a USCG-type certified marine exhaust hose.





**Figure 4-8** Typical Mid- and Below-Waterline Installation with Optional Gas/Water Separator

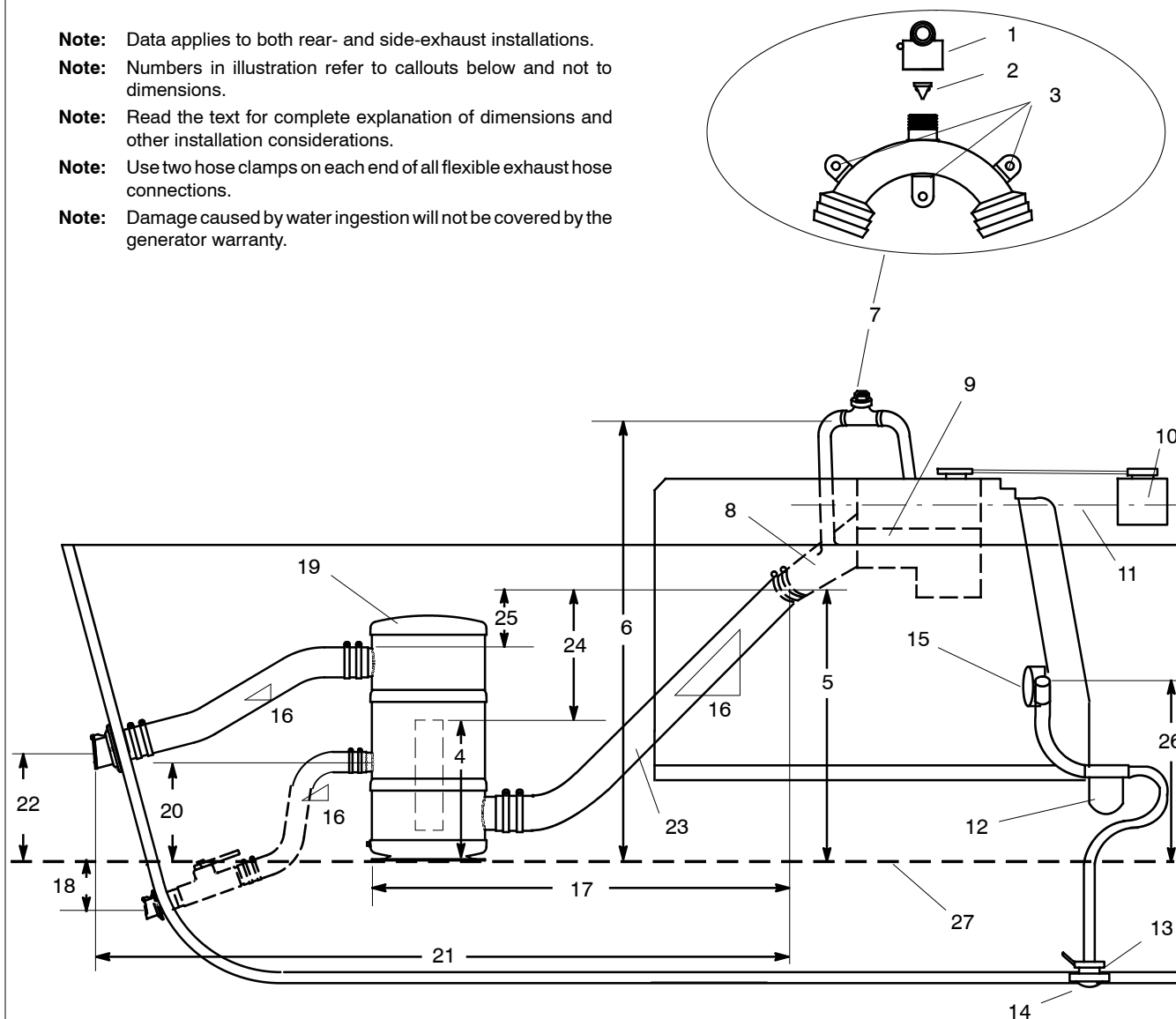
- Note:** Data applies to both rear- and side-exhaust installations.
- Note:** Numbers in illustration refer to callouts below and not to dimensions.
- Note:** Read the text for complete explanation of dimensions and other installation considerations.
- Note:** Use two hose clamps on each end of all flexible exhaust hose connections.
- Note:** Damage caused by water ingestion will not be covered by the generator warranty.



1. Minimum exhaust outlet distance above waterline of 10 cm (4 in.)
2. Exhaust hose (see Figure 4-1 for hose sizes)
3. Minimum exhaust hose pitch of 1.3 cm per 30.5 cm (0.5 in. per ft.)
4. Maximum silencer vertical lift of 1.2 m (4 ft.)
5. Minimum exhaust hose pitch of 1.3 cm per 30.5 cm (0.5 in. per ft.)
6. Exhaust mixer elbow distance above waterline; if less than 23 cm (9 in.), a siphon break is required
7. Minimum siphon break distance above waterline of 30.5 cm (1 ft.)
8. Exhaust mixer elbow
9. Siphon break
10. Cap
11. Reed valve
12. Mounting base
13. Heat exchanger (locations vary by model)
14. Coolant recovery tank (located on the unit on some models)
15. Indicates the coolant recovery tank is at the same height as the heat exchanger
16. Seawater strainer
17. Seacock
18. Intake strainer
19. Engine-driven seawater pump
20. Install optional water lock here
21. Maximum distance between silencer and exhaust mixer elbow of 3 m (10 ft.)
22. Maximum distance between silencer and exhaust outlet of 1.5 m (5 ft.)
23. Silencer (customer-supplied)
24. Waterline
25. Kohler recommends locating the generator set at elevation that exhaust mixer is above the highest point of the exhaust outlet hose.

**Figure 4-9** Typical Mid- and Below-Waterline Installation

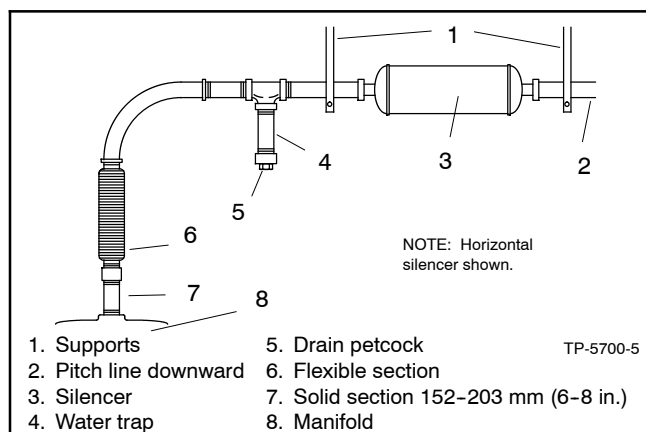
- Note:** Data applies to both rear- and side-exhaust installations.
- Note:** Numbers in illustration refer to callouts below and not to dimensions.
- Note:** Read the text for complete explanation of dimensions and other installation considerations.
- Note:** Use two hose clamps on each end of all flexible exhaust hose connections.
- Note:** Damage caused by water ingestion will not be covered by the generator warranty.



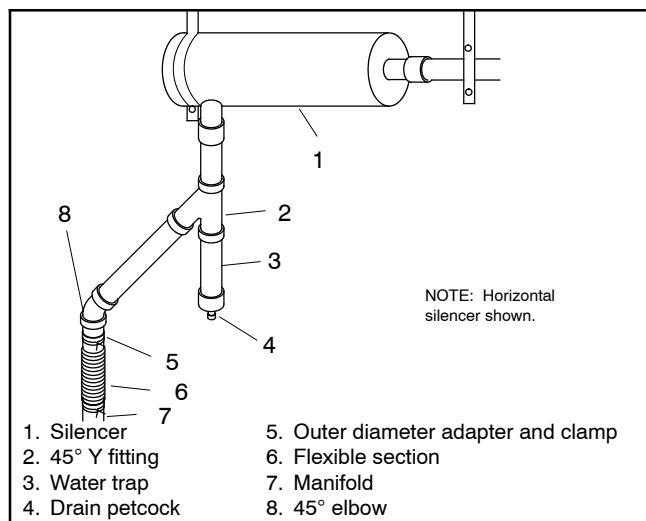
1. Cap
2. Reed valve
3. Mounting base
4. Maximum silencer internal vertical lift of 1.2 m (4 ft.)
5. Exhaust mixer elbow distance above waterline; if less than 23 cm (9 in.), a siphon break is required
6. Minimum siphon break distance above waterline of 30.5 cm (1 ft.)
7. Siphon break
8. Exhaust mixer
9. Heat exchanger
10. Coolant recovery bottle
11. Indicates the coolant recovery tank is at the same height as the heat exchanger
12. Seawater strainer
13. Seacock
14. Intake strainer
15. Engine-driven seawater pump
16. Minimum exhaust hose pitch of 1.3 cm per 30.5 cm (0.5 in. per ft.)
17. Maximum distance between silencer and exhaust mixer elbow of 3 m (10 ft.)
18. Water drain distance below waterline
19. Combination silencer that contains lift muffler and gas water separating sections in single component (customer-supplied)
20. Distance above waterline for drain outlet from silencer must be equal to or greater than water drain (item 18) to be greater than 30.5 cm (1 ft.)
21. Exhaust outlet to be diameter appropriate so exhaust back pressure does not exceed limit at engine exhaust manifold
22. Minimum exhaust outlet distance above waterline of 10 cm (4 in.)
23. Exhaust hose
24. Height of internal lift tube to be below generator exhaust manifold
25. Kohler recommends generator be located at elevation that exhaust mixer elbow is above silencer exhaust outlet
26. Seawater pump lift
27. Waterline

**Figure 4-10** Exhaust System

Satisfactory generator set performance requires proper exhaust system installation. Figure 4-11 and Figure 4-12 show typical arrangements for commercial marine exhaust systems.

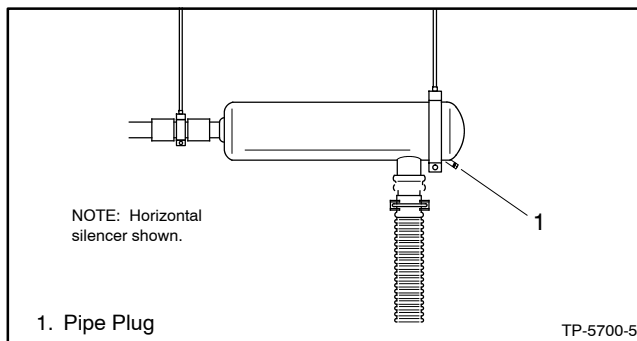


**Figure 4-11** Exhaust System, End Inlet Silencer

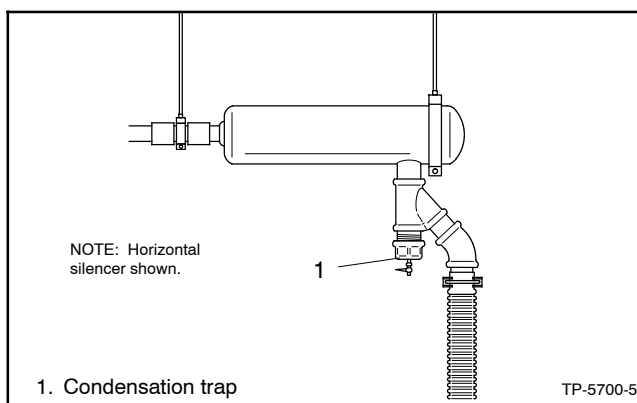


**Figure 4-12** Exhaust System, Side Inlet Silencer

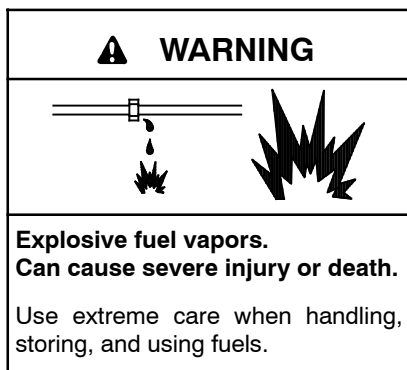
Ensure that there is a means to periodically drain condensation in exhaust, such as a silencer equipped with a drain plug (see Figure 4-13), or a wye- or tee-type condensation trap with a drain plug, or petcock installed between the engine and silencer (see Figure 4-14).



**Figure 4-13** Silencer Condensation Drain Plug



**Figure 4-14** Condensation Trap

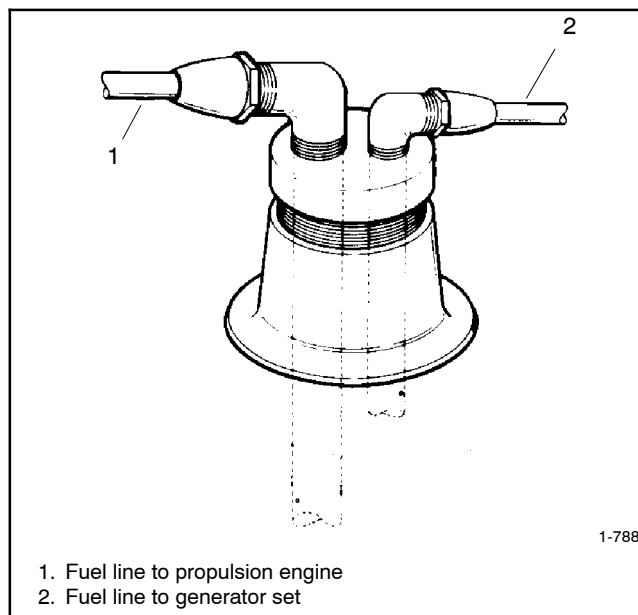


Do not modify the tank or the propulsion engine fuel system. Equip the craft with a tank that allows one of the two pickup arrangements.

**Note:** Fuel system installations must conform to USCG regulations.

### 5.1 Fuel Tank

Most marine generator sets draw fuel from the same fuel tank as the craft's propulsion engine(s). If the tank's fuel pickup opening allows a multiple dip tube, use a multiple dip tube arrangement. See Figure 5-1. The multiple dip tube arrangement incorporates a shorter dip tube for the generator set and a longer dip tube for the propulsion engine. With this arrangement, the generator set runs out of fuel before the propulsion engine during a low fuel supply situation. Equip the fuel system with a fuel/water separator to remove any accumulated dirt and water.



**Figure 5-1** Multiple Dip Tube Arrangement

m:is:102:001

## 5.2 Fuel Lines

Return the generator set fuel return line to the fuel tank. Locate the fuel return line as far as practical from the fuel pickup to allow the tank fuel to cool the return fuel before delivery back to the fuel injectors. Incoming fuel cools the injectors to achieve maximum engine efficiency.

**Note:** Do not tee into the main propulsion engine's fuel line.

Under no circumstances should the propulsion engine and generator set share pickup or return lines (through a tee arrangement) that would allow the larger engine to starve fuel from the smaller engine. It is possible that the operation of either engine could completely drain the fuel line of the other engine and make starting difficult.

Use a flexible hose section to connect the metallic line from the fuel tank to the engine's fuel pump inlet connection point. Also, use a flexible hose section to connect the metallic line from the fuel tank to the fuel return connection point. The flexible section allows vibrational motion of the generator set during operation.

| Model                                    | Fuel Line ID Size mm (in.) |
|------------------------------------------|----------------------------|
| 40-200EOZDJ/EOZCJ<br>33-175EFOZDJ/EFOZCJ | 9.7 (3/8)                  |

**Figure 5-2** Fuel Line ID Size

See Figure 5-2 for the ID size of the customer-supplied fuel line that connects to the fuel pump and fuel return. Route the fuel lines from the fuel tank in a gradual incline to the engine. Do not exceed the height of the generator set and do not route fuel lines above the generator set. Comply with USCG regulation 46CFR182.20 regarding fuel lines and supports.

See Section 7 for fuel feed pump inlet connection and fuel return line connection.

## 5.3 Fuel Filters

Conform to USCG regulations regarding inline fuel filters or strainers.

## 5.4 Fuel/Water Separator

A fuel/water separator is standard on 33-200 kW models. Consult the engine operation manual for service procedure.

## 5.5 Fuel Pump Lift

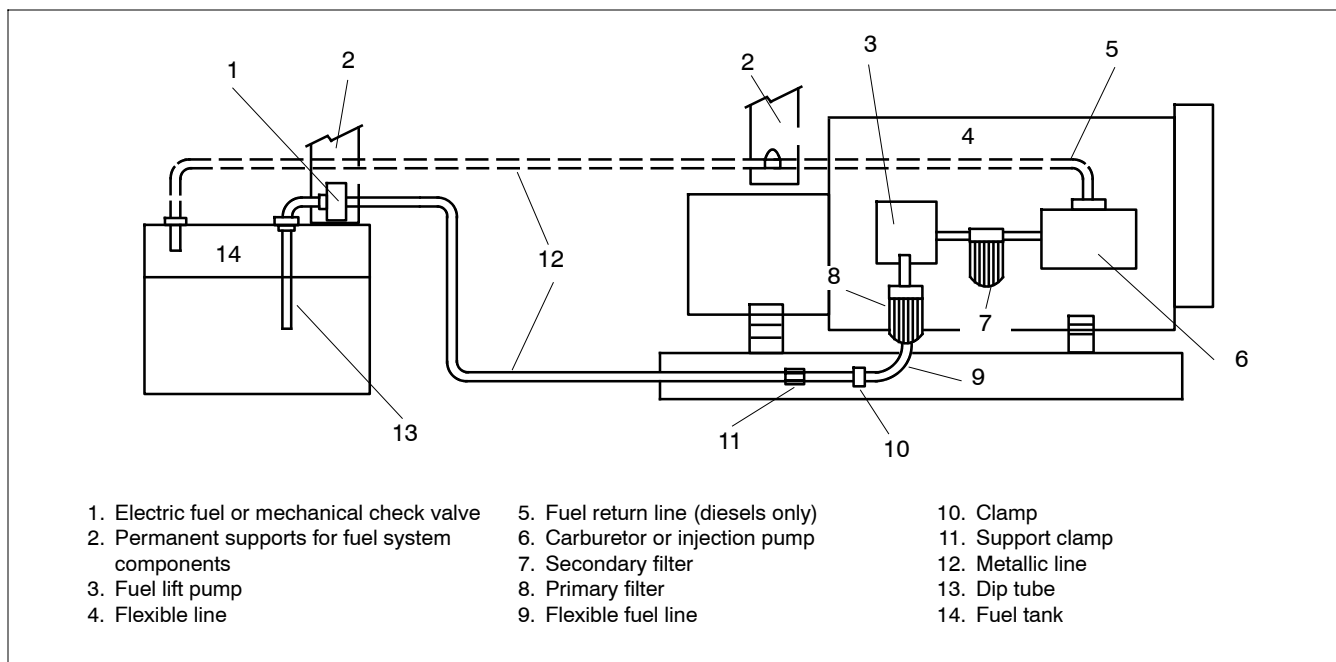
See Figure 5-3 for fuel pump lift capabilities.

| Model                                                                                                                                                                                                                                                                                                      | Fuel Pump Lift m (ft.) |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| <u>Pleasure Craft:</u><br>40EOZDJ/33EFOZDJ<br>40EFOZDJ<br>50EFOZDJ<br><u>Commercial Craft:</u><br>40EOZCJ/33EFOZCJ<br>40EFOZCJ<br>50EFOZCJ                                                                                                                                                                 | 3 (10)                 |
| <u>Pleasure Craft:</u><br>55EOZDJ/45EFOZDJ<br>65EOZDJ/55EFOZDJ<br>80EOZDJ/70EFOZDJ<br>99EOZDJ/80EFOZDJ<br>125EOZDJ/100EFOZDJ<br>150EOZDJ/125EFOZDJ<br><u>Commercial Craft:</u><br>55EOZCJ/45EFOZCJ<br>65EOZCJ/55EFOZCJ<br>80EOZCJ/70EFOZCJ<br>99EOZCJ/80EFOZCJ<br>125EOZCJ/100EFOZCJ<br>150EOZCJ/125EFOZCJ | 2.4 (7.9)              |
| <u>Pleasure Craft:</u><br>200EOZDJ/175EFOZDJ<br><u>Commercial Craft:</u><br>200EOZCJ/175EFOZCJ                                                                                                                                                                                                             | 3 (10)                 |

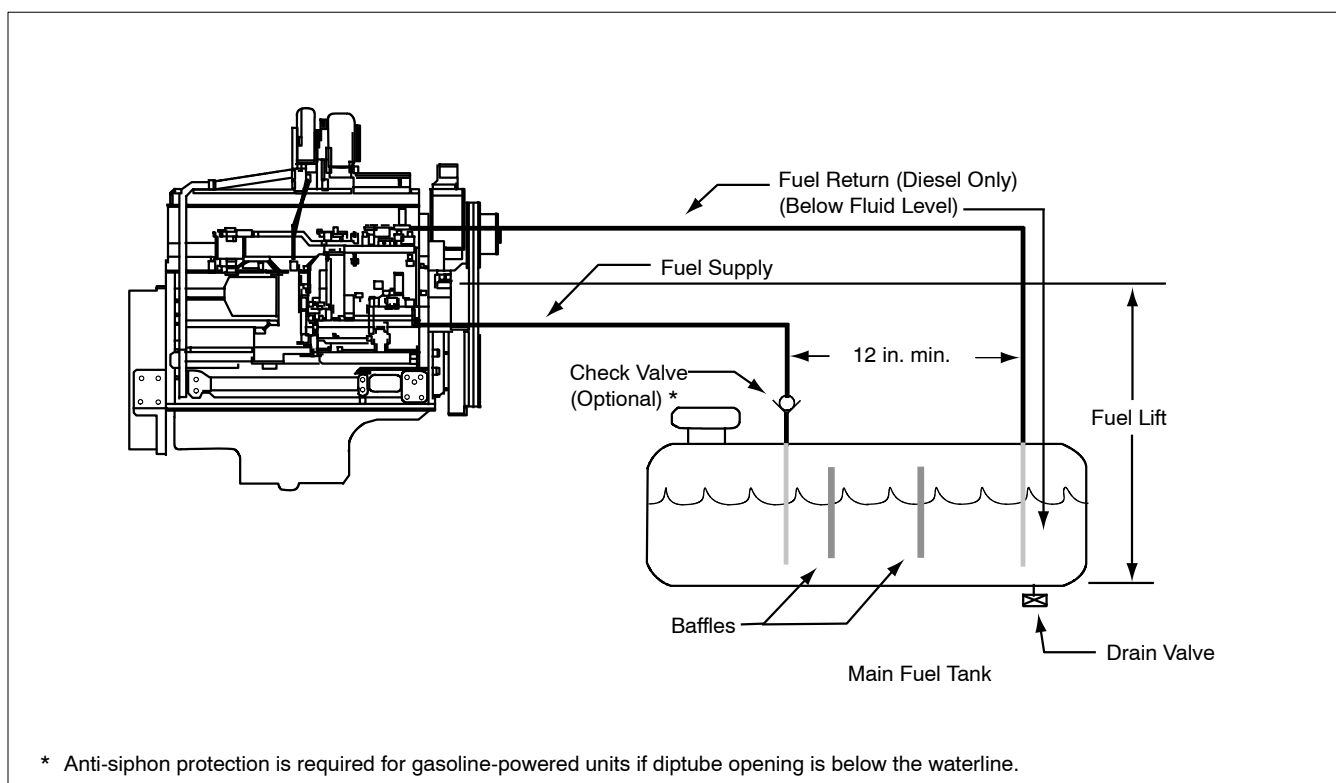
**Figure 5-3** Fuel Pump Lift

## 5.6 Fuel Consumption

Consult the current generator set specification sheets for generator set fuel consumption rates.



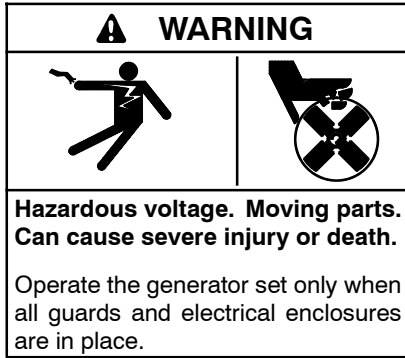
**Figure 5-4** Fuel System, Typical



**Figure 5-5** Fuel System, Typical

## Notes





**Electrical backfeed to the utility. Hazardous backfeed voltage can cause severe injury or death.** Connect the generator set to the building/marina electrical system only through an approved device and after the building/marina main switch is turned off. Backfeed connections can cause severe injury or death to utility personnel working on power lines and/or personnel near the work area. Some states and localities prohibit unauthorized connection to the utility electrical system. Install a ship-to-shore transfer switch to prevent interconnection of the generator set power and shore power.

## 6.1 AC Voltage Connections

Make AC connections to the generator set inside the junction box. Typically, the generator set connects to a ship-to-shore transfer switch that allows the use of shore/utility power when docked or generator set power when docked or at sea. The wiring then connects to a main circuit breaker box (panel board) that distributes branch circuits throughout the craft. See Section 8 for reconnection of the generator set.

## 6.2 Circuit Protection

The AC circuit breakers (optional) protect the wiring from the AC circuit breakers to the vessel's distribution panel. AC circuit breakers trip when they detect a fault in the output circuit.

After correcting the fault, reset the AC circuit breaker(s) by placing them in the ON position. Restart the unit. Do not start the unit under load. See Figure 6-1 and Figure 6-2 for AC circuit breaker ratings. The unit's voltage configuration determines the circuit breaker selection.

**Note:** Circuit breaker ampere rating and availability are subject to change.

### 6.2.1 Circuit Breaker Considerations

**Mounting location.** Mount the circuit breakers in the generator set's junction box. See Section 6.2.2.

**Sizing.** Use the generator set voltage/frequency configuration to determine the circuit breaker amperage. If the generator set voltage configuration changes, change the circuit breaker to provide optimum protection.

For circuit breaker application and selection information, contact an authorized distributor/dealer.

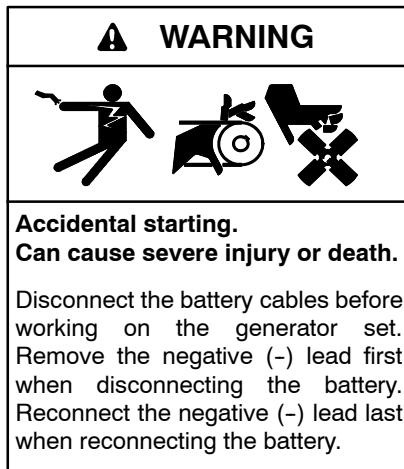
Have a qualified electrician or technician install circuit breakers and reconnect the generator set. Comply with all governing standards and codes.

| Amps | Max. Voltage | Model(s)                                                                                  |
|------|--------------|-------------------------------------------------------------------------------------------|
| 70   | 600          | 40EOZD(C)J, 33EFOZD(C)J                                                                   |
| 80   | 600          | 40EFOZD(C)J, 45EFOZD(C)J                                                                  |
| 90   | 480          | 40EFOZD(C)J, 45EFOZD(C)J                                                                  |
| 100  | 480          | 55EOZD(C)J, 45EFOZD(C)J, 50EFOZD(C)J                                                      |
| 125  | 480          | 50EFOZD(C)J, 65EOZD(C)J, 55EFOZD(C)J                                                      |
| 125  | 600          | 33EFOZD(C)J                                                                               |
| 150  | 480          | 80EOZD(C)J, 70EFOZD(C)J                                                                   |
| 150  | 600          | 40EOZD(C)J, 33EFOZD(C)J, 40EFOZD(C)J                                                      |
| 175  | 480          | 99EOZD(C)J, 70EFOZD(C)J, 80EFOZD(C)J                                                      |
| 175  | 600          | 40EOZD(C)J, 33EFOZD(C)J, 40EFOZD(C)J, 45EFOZD(C)J                                         |
| 200  | 600          | 40EFOZD(C)J, 50EFOZD(C)J, 55EOZD(C)J                                                      |
| 250  | 600          | 50EFOZD(C)J, 55EOZD(C)J, 45EFOZD(C)J, 65EOZD(C)J, 55EFOZD(C)J, 125EOZD(C)J, 100EFOZD(C)J  |
| 400  | 600          | 80EOZD(C)J, 70EFOZD(C)J, 99EOZD(C)J, 80EFOZD(C)J, 150EOZD(C)J, 100EFOZD(C)J, 125EFOZD(C)J |
| 600  | 600          | 125EOZD(C)J, 150EOZD(C)J, 100EFOZD(C)J, 125EFOZD(C)J                                      |

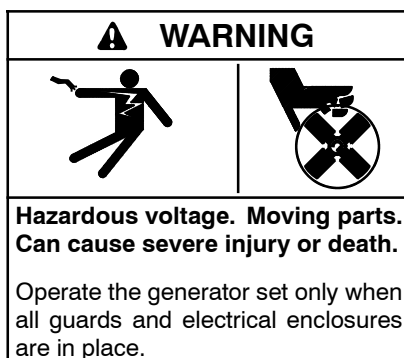
**Figure 6-1** 3-Pole AC Circuit Breaker Ratings (33–150 kW Models), Listed By Amps

| Amps | Model(s)                                                                                 |
|------|------------------------------------------------------------------------------------------|
| 63   | 33EFOZD(C)J                                                                              |
| 80   | 40EOZD(C)J, 33EFOZD(C)J, 40EFOZD(C)J, 45EFOZD(C)J                                        |
| 100  | 40EFOZD(C)J, 50EFOZD(C)J, 55EOZD(C)J, 45EFOZD(C)J                                        |
| 125  | 33EFOZD(C)J, 50EFOZD(C)J, 65EOZD(C)J, 55EFOZD(C)J                                        |
| 160  | 40EOZD(C)J, 33EFOZD(C)J, 40EFOZD(C)J, 80EOZD(C)J, 70EFOZD(C)J                            |
| 200  | 40EOZD(C)J, 40EFOZD(C)J, 50EFOZD(C)J, 55EOZD(C)J, 45EFOZD(C)J                            |
| 250  | 50EFOZD(C)J, 55EOZD(C)J, 45EFOZD(C)J, 65EOZD(C)J, 55EFOZD(C)J, 125EOZD(C)J, 100EFOZD(C)J |
| 400  | 80EOZD(C)J, 70EFOZD(C)J, 100EFOZD(C)J, 150EOZD(C)J, 125EFOZD(C)J                         |
| 630  | 125EOZD(C)J, 100EFOZD(C)J, 150EOZD(C)J, 125EFOZD(C)J                                     |
| 800  | 200EOZD(C)J, 175EFOZD(C)J                                                                |

**Figure 6-2** 4-Pole AC Circuit Breaker Ratings (33–200 kW Models), Listed By Amps



**Disabling the generator set. Accidental starting can cause severe injury or death.** Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.



**Grounding electrical equipment. Hazardous voltage can cause severe injury or death.** Electrocution is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

**Short circuits. Hazardous voltage/current can cause severe injury or death.** Short circuits can cause bodily injury and/or equipment damage. Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

**Electrical backfeed to the utility. Hazardous backfeed voltage can cause severe injury or death.** Connect the generator set to the building/marina electrical system only through an approved device and after the building/marina main switch is turned off. Backfeed connections can cause severe injury or death to utility personnel working on power lines and/or personnel near the work area. Some states and localities prohibit unauthorized connection to the utility electrical system. Install a ship-to-shore transfer switch to prevent interconnection of the generator set power and shore power.

## 6.2.2 Circuit Breaker Installation

1. Place the generator set master switch in the OFF position.
2. Disconnect the generator set engine starting battery, negative (-) lead first.
3. Remove the six screws from the right side junction box panel and remove the panel.
4. Install the circuit breaker on the new panel with the screws and washers. Position the ON side of the circuit breaker toward the rear of the junction box. See Figure 6-3.
5. Attach stator leads L1, L2, and L3 to the extension leads (if supplied) or to the line side of the circuit breaker. See Figure 8-3.

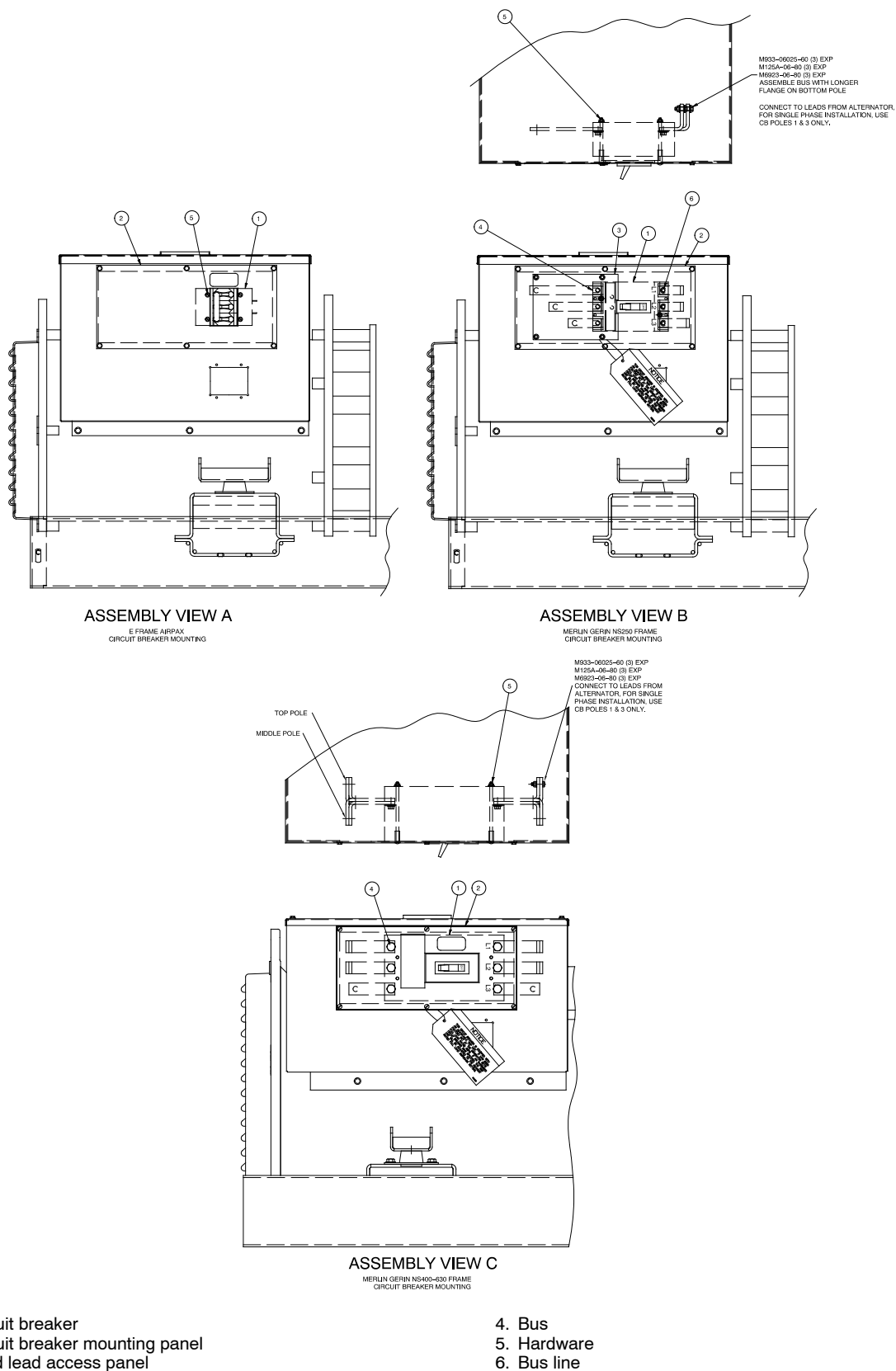
**Note:** Insulate leads with electrical tape after connecting extension leads to stator leads.

6. Connect the neutral connection stator leads to the L0 stud.

**Note:** Verify that terminal positions and previously made line lead connections allow room for load connections to load studs.

7. Connect the load side of the circuit breaker to customer-supplied craft wiring. Connect the neutral lead to the L0 stud. See Figure 8-3.
8. Attach the new panel to the junction box using the original six screws. See Figure 6-3.

9. Check that the generator set master switch is in the OFF position. Reconnect the generator set engine starting battery, negative (-) lead last.



JW250000

**Figure 6-3** Circuit Breaker Mounting, Typical

## 6.3 Installation In Steel or Aluminum Vessels

Installation of a generator set in a vessel constructed of a material capable of conducting current (e.g., steel or aluminum) is subject to considerations not normally encountered in fiberglass or wood vessels. These differences include equipment grounding, grounding of neutral conductors, ground-fault protection, and isolation of galvanic currents.

**Note:** Isolated ground kits are available as options for steel- or aluminum-hulled vessels. Consult your local dealer/distributor for more information.

The scope of these topics is too extensive to be fully discussed here. Consult your local marine authority for more information.

Before installing the generator set, check the available wiring diagrams in the operation manual to become familiar with the electrical system.

## 6.4 Installation Regulations

The U.S. Coast Guard governs generator set installation in U.S. pleasurecraft and commercial vessels. Refer to the applicable regulations below:

### U.S. Pleasurecraft Installation Regulations

Title 33CFR, Chapter I, U.S. Coast Guard, Part 183

1. Subpart I—Electrical Equipment
2. Subpart J—Fuel Systems

### U.S. Commercial Vessel Installation Regulations

Title 46CFR, Chapter I, U.S. Coast Guard

1. Part 111—Electrical Systems
2. Part 182—Machinery Installation

## 6.5 Battery

Batteries and their installation must conform to USCG Regulations 183.420 (a) through (g). Provide generator sets with batteries separate from the propulsion engine's whenever possible. The starting/charging systems of both the generator set and the engine must have a common negative (–) ground.

USCG Regulation 183.415, Grounding, requires connection of a common conductor to each grounded cranking-motor circuit. Size the conductor to match the larger of the engine's two battery cables. Figure 6-4 lists recommended minimum cable sizes for generator set battery connections at various generator set-to-battery distances. Connecting a common conductor to each grounded cranking motor circuit prevents the starting motor current from using alternative electrical paths should the cranking motor ground circuit be restricted or open because of oxidation or loose hardware. Alternative electrical paths include metallic fuel lines that can pose a hazard. See Section 7 for locations of the battery connections to the generator set.

|                                            | Required Battery Cable (Minimum) |     |                |       |
|--------------------------------------------|----------------------------------|-----|----------------|-------|
|                                            | 2.5 m (8.3 ft.)                  |     | 5 m (16.4 ft.) |       |
| Battery Voltage                            | 12V                              | 24V | 12V            | 24V   |
| 40–65EOZDJ/EOZCJ<br>33–50EFOZDJ/EFOZCJ     | # 0                              | # 4 | # 3/0          | # 2   |
| 80–99EOZDJ/EOZCJ<br>70–80EFOZDJ/EFOZCJ     | # 2/0                            | # 2 | # 4/0          | # 1/0 |
| 125–200EOZDJ/EOZCJ<br>100–175EFOZDJ/EFOZCJ | # 2/0                            | # 2 | # 4/0          | # 1/0 |

**Figure 6-4** Battery Cable Sizing Recommendations

m:sc:001:001

Kohler Co. recommends using one 12-volt battery (or two for 24-volt systems, as the spec requires) to start the generator. See Figure 6-5 for minimum cold cranking amps (CCA) recommendations.

| <b>12-Volt Starting Battery Size CCA<br/>at -18°C (0°F) or 100 Amp. Hr.</b>                                                                                                                          |            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>Models</b>                                                                                                                                                                                        | <b>CCA</b> |
| 40EOZDJ and 33EFOZDJ<br>40EOZCJ and 33EFOZCJ                                                                                                                                                         | 640        |
| 40EFOZDJ<br>40EFOZCJ<br>50EFOZDJ<br>50EFOZCJ<br>55EOZDJ and 45EFOZDJ<br>55EOZCJ and 45EFOZCJ<br>65EOZDJ and 55EFOZDJ<br>65EOZCJ and 55EFOZCJ                                                         | 625        |
| 80EOZDJ and 70EFOZDJ<br>80EOZCJ and 70EFOZCJ<br>99EOZDJ and 80EFOZDJ<br>99EOZCJ and 80EFOZCJ<br>125EOZDJ and 100EFOZDJ<br>125EOZCJ and 100EFOZCJ<br>150EOZDJ and 125EFOZDJ<br>150EOZCJ and 125EFOZCJ | 925        |
| 200EOZDJ and 175EFOZDJ<br>200EOZCJ and 175EFOZCJ                                                                                                                                                     | 1100       |

**Figure 6-5** Battery Recommendations

**Note: Gauge senders.** Gauge senders are available for most generator sets. If using customer-supplied gauges, be sure they are compatible with generator set senders. Contact an authorized Kohler® service distributor/dealer. Gauges and senders are available as service items from an authorized Kohler® service distributor/dealer.

Various wiring harnesses, Y-connectors, pigtail harnesses, remote control panels, and remote annunciator panels are available.

## 6.8 Paralleling Generator Sets

See Section 9 for information on paralleling generator sets.

## 6.6 Wiring

Use only stranded copper wire. Conform to USCG Regulations 183.425 through 183.460 for wire gauges and insulation, conductor temperature ratings, sheath stripping, conductor support and protection, conductor terminals and splices, and over-current protection (circuit breakers, fuses). Use rubber grommets and cable ties as necessary to protect and secure the wire from sharp objects, the exhaust system, and moving parts.

## 6.7 Remote Connection

Kohler Co. offers several remote panels for connection to the generator set. Contact your local Kohler® distributor/dealer for detailed descriptions. Kohler Co. also offers wiring harnesses in various lengths with a connector keyed to the controller box connector. A “pigtail” harness is also offered which includes the appropriate connector on one end and has pigtails that the installer can use to connect to a customer-supplied start/stop switch or separate lights and hourmeter. Consult wiring diagrams, ADVs, and instruction sheets for connection information/details.

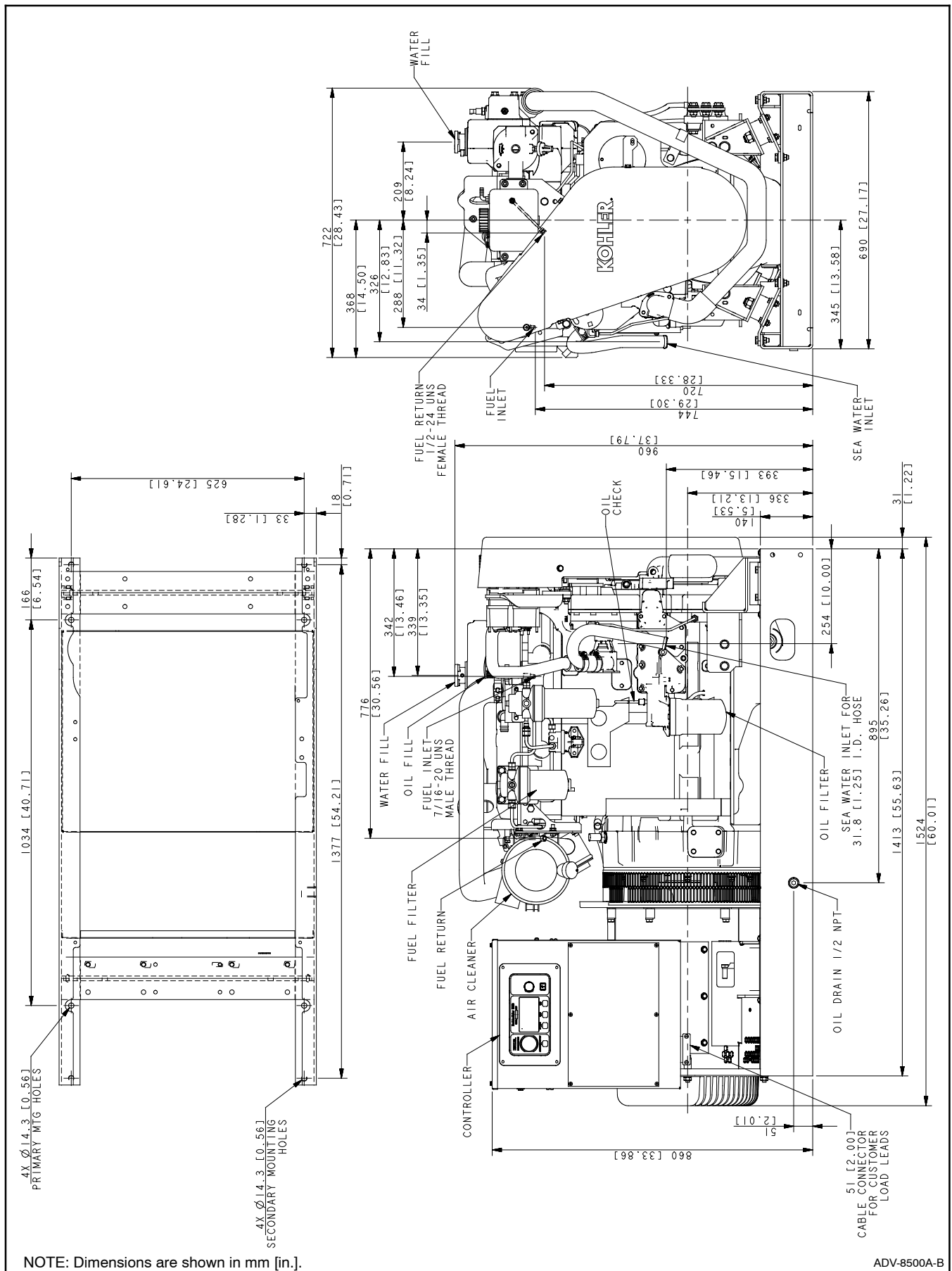
## Notes

## Section 7 Installation Drawings

Use the drawings in this section for installation purposes. Consult the supplier and verify that the drawings are the most current for your specifications. Installation drawings show exhaust outlet locations, fuel inlet and return connections, siphon break locations, and battery connections. See Figure 7-1 for installation drawing identification.

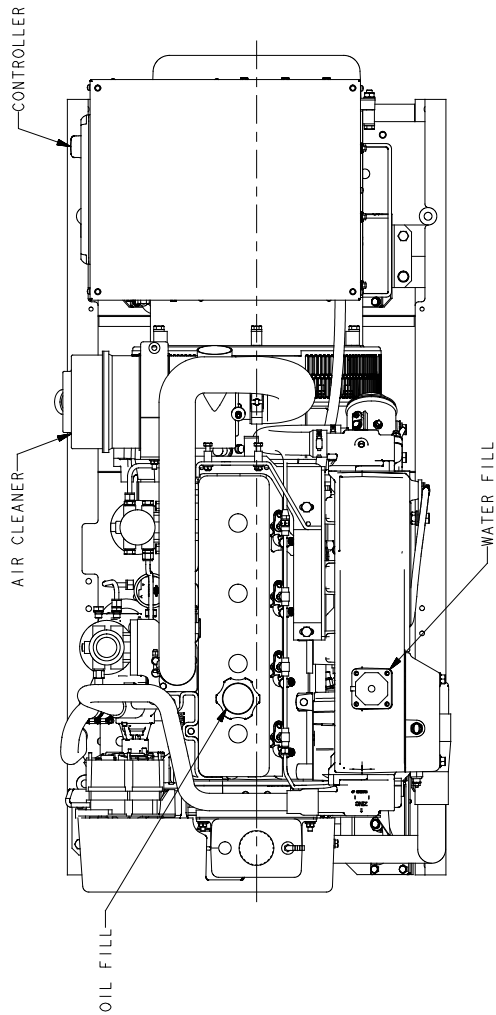
| Model No.                                                                              | Drawing     | Page |
|----------------------------------------------------------------------------------------|-------------|------|
| 40EOZD(C)J and 33EFOZD(C)J                                                             |             |      |
| open unit (sheet 1 of 2)                                                               | ADV-8500A-B | 36   |
| open unit (sheet 2 of 2)                                                               | ADV-8500B-B | 37   |
| with sound shield<br>(not available on EOZCJ/<br>EFOZCJ models)                        | ADV-8503-   | 38   |
| with radiator                                                                          | ADV-8505A-C | 48   |
| with electric clutch                                                                   | ADV-8505B-C | 49   |
| with keel cooling & dry exhaust                                                        | ADV-8505C-C | 50   |
| 40EFOZD(C)J<br>50EFOZD(C)J<br>55EOZD(C)J and 45EFOZD(C)J<br>65EOZD(C)J and 55EFOZD(C)J |             |      |
| open unit (sheet 1 of 2)                                                               | ADV-8501A-B | 39   |
| open unit (sheet 2 of 2)                                                               | ADV-8501B-B | 40   |
| with sound shield<br>(not available on EOZCJ/<br>EFOZCJ models)                        | ADV-8504-   | 41   |
| with radiator                                                                          | ADV-8505A-C | 48   |
| with electric clutch                                                                   | ADV-8505B-C | 49   |
| with keel cooling & dry exhaust                                                        | ADV-8505C-C | 50   |
| 80EOZD(C)J and 70EFOZD(C)J<br>99EOZD(C)J and 80EFOZD(C)J                               |             |      |
| open unit (sheet 1 of 2)                                                               | ADV-8506A-C | 42   |
| open unit (sheet 2 of 2)                                                               | ADV-8506B-C | 43   |
| with sound shield<br>(not available on EOZCJ/<br>EFOZCJ models)                        | ADV-8507-A  | 44   |
| with radiator                                                                          | ADV-8505A-C | 48   |
| with electric clutch                                                                   | ADV-8505B-C | 49   |
| with keel cooling & dry exhaust                                                        | ADV-8505C-C | 50   |
| 125EOZD(C)J and 150EFOZD(C)J<br>100EOZD(C)J and 125EFOZD(C)J                           |             |      |
| open unit (sheet 1 of 2)                                                               | ADV-8508A-A | 45   |
| open unit (sheet 2 of 2)                                                               | ADV-8508B-A | 46   |
| with sound shield<br>(not available on EOZCJ/<br>EFOZCJ models)                        | ADV-8509-   | 47   |
| with radiator                                                                          | ADV-8505A-C | 48   |
| with electric clutch                                                                   | ADV-8505B-C | 49   |
| with keel cooling & dry exhaust                                                        | ADV-8505D-C | 51   |
| 200EOZD(C)J and 175EFOZD(C)J                                                           |             |      |
| open unit (sheet 1 of 2)                                                               | ADV-8747A-  | 52   |
| open unit (sheet 2 of 2)                                                               | ADV-8747B-  | 53   |
| with sound shield<br>(not available on EOZCJ/<br>EFOZCJ models)                        | ADV-8748-   | 54   |
| with keel cooling & dry exhaust                                                        | ADV-8764-   | 55   |

**Figure 7-1** Installation Drawings  
(33–200 kW Models)



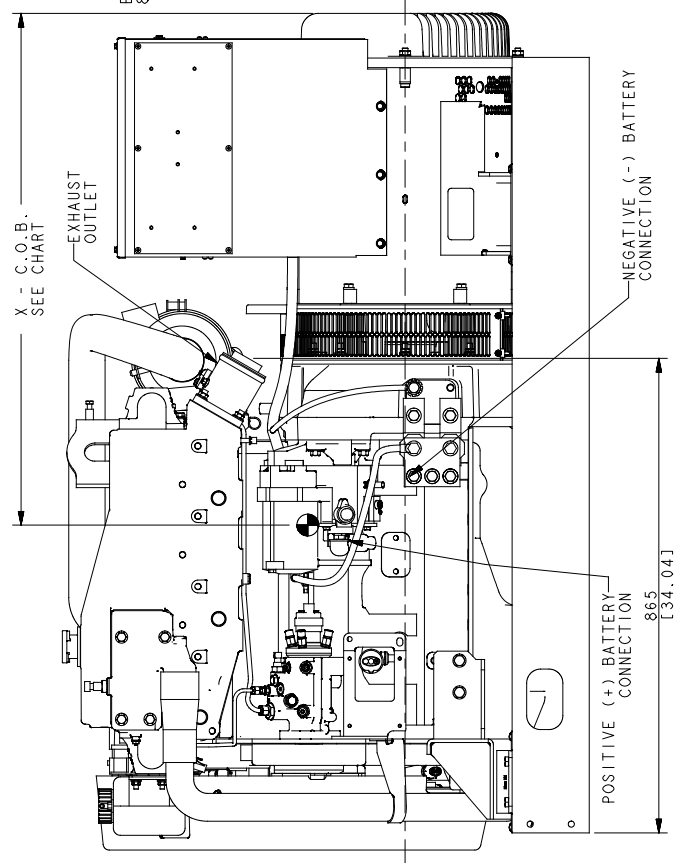
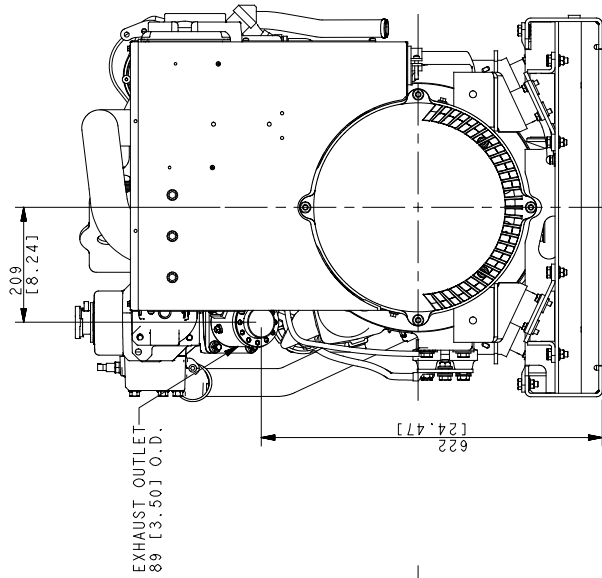
**Figure 7-2** Dimension Drawing, 40EOZD(C)J & 33EFOZD(C)J (Open Unit Sheet 1 of 2)





| MODEL            | WEIGHT        |                | C.O.B. (DIM "X") |  |
|------------------|---------------|----------------|------------------|--|
|                  | WET -KG [LBS] | DRY - KG [LBS] | MM [IN]          |  |
| 40EOZDJ/33EFOZDJ | 935 [2060]    | 910 [2005]     | 851 [33.5]       |  |

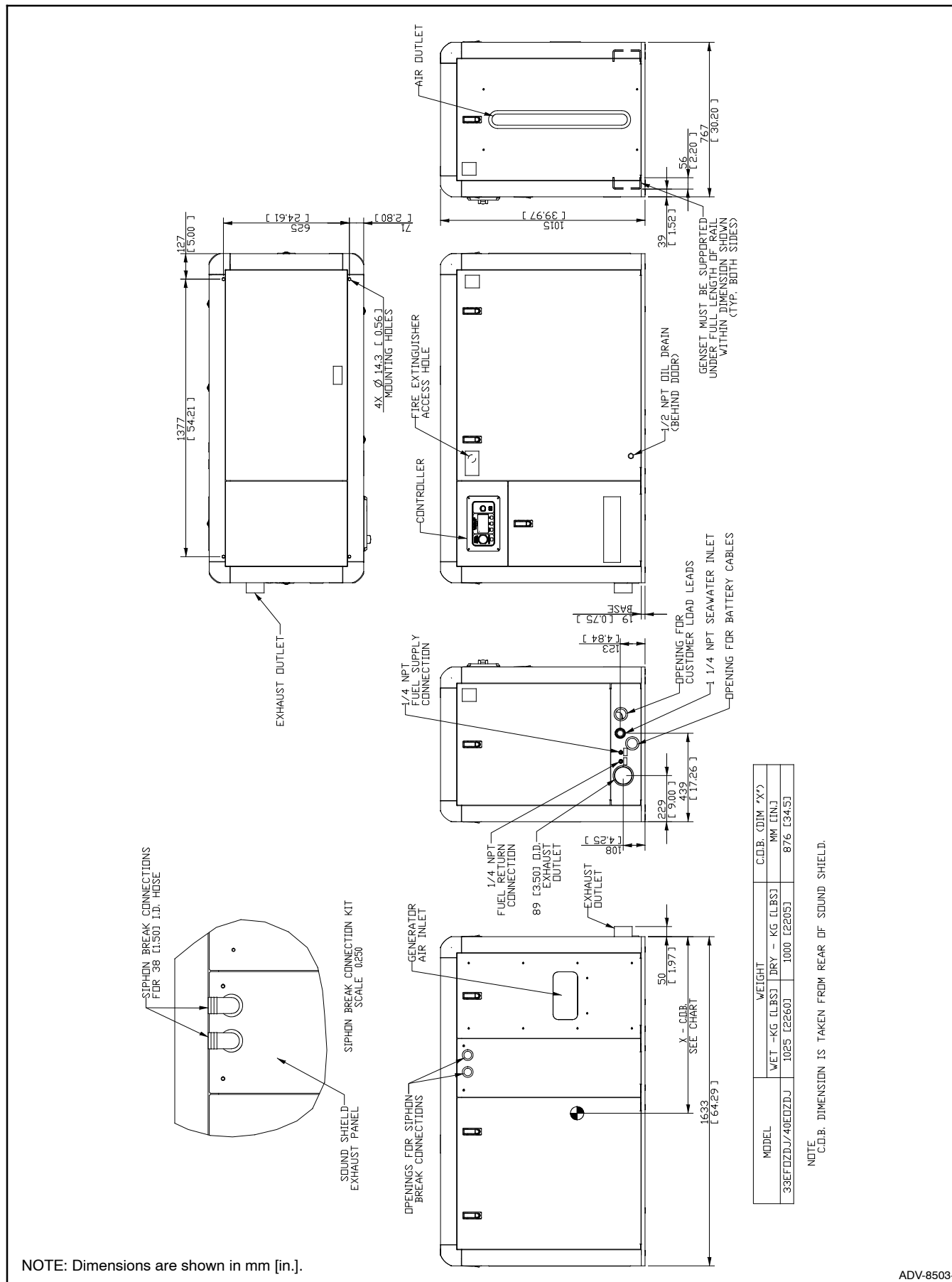
NOTE  
C.O.B. DIMENSION IS TAKEN FROM REAR  
OF ALTERNATOR END BRACKET.



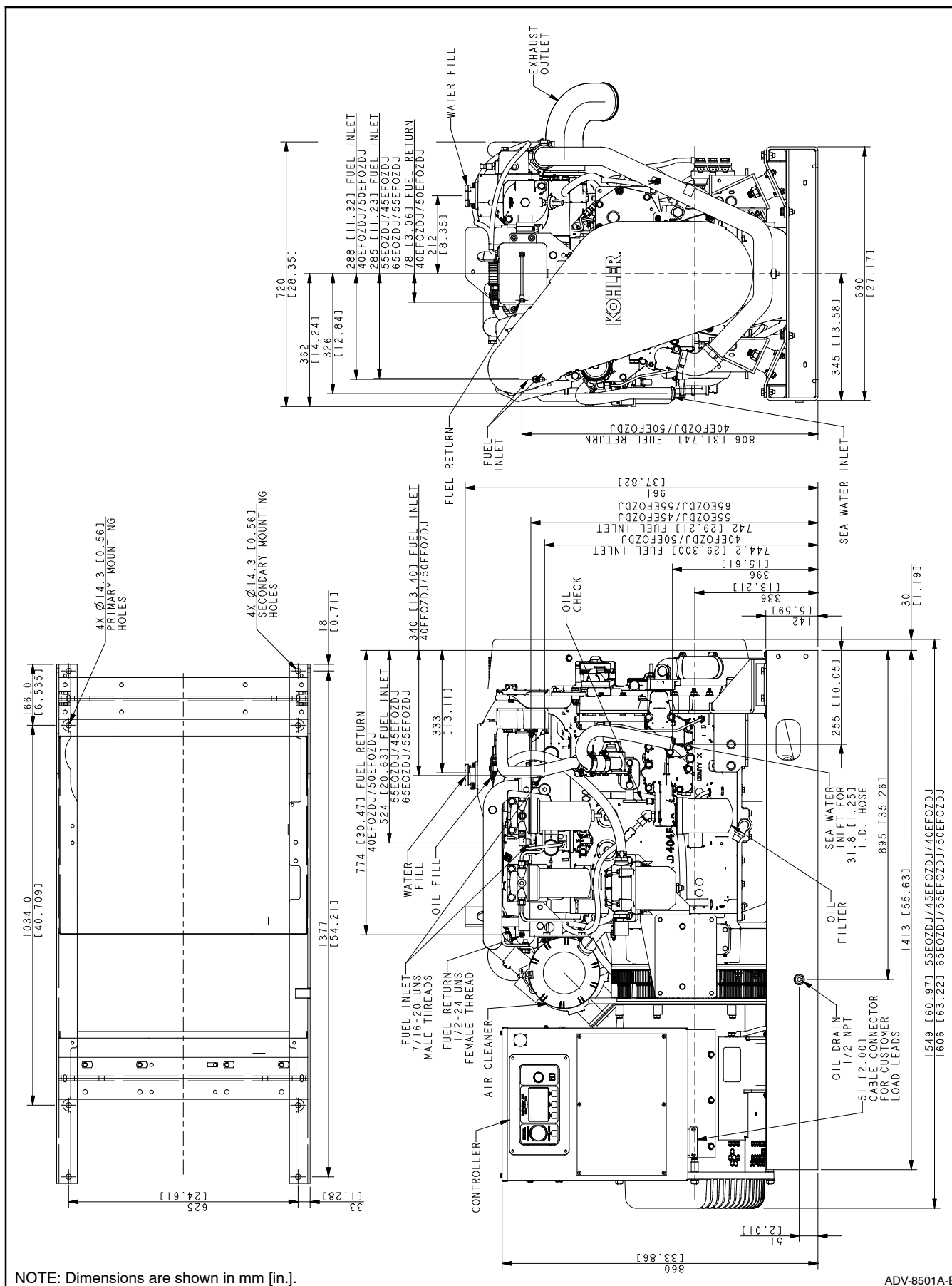
NOTE: Dimensions are shown in mm [in.].

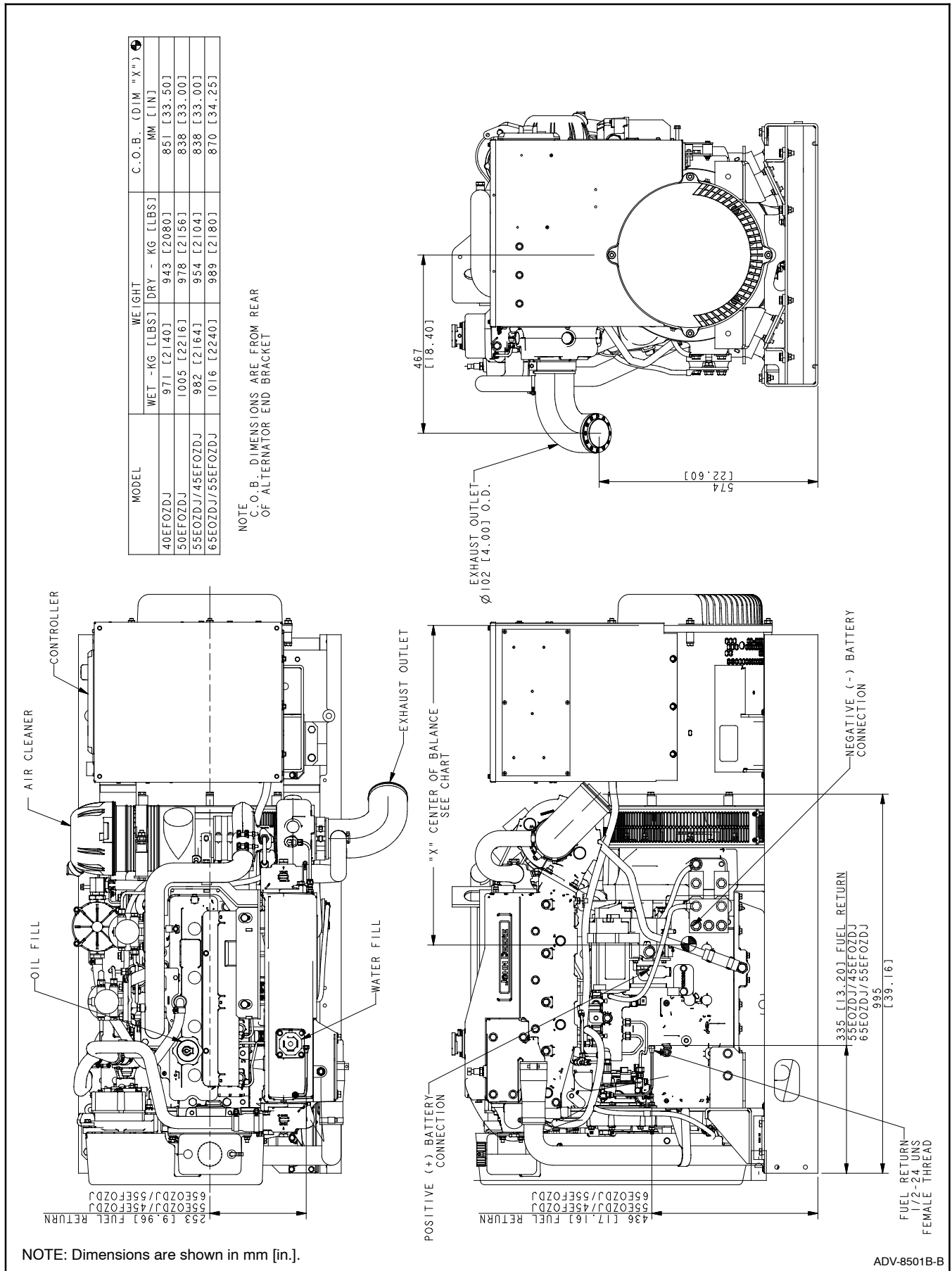
ADV-8500B-B

**Figure 7-3** Dimension Drawing, 40EOZD(C)J & 33EFOZD(C)J (Open Unit Sheet 2 of 2)

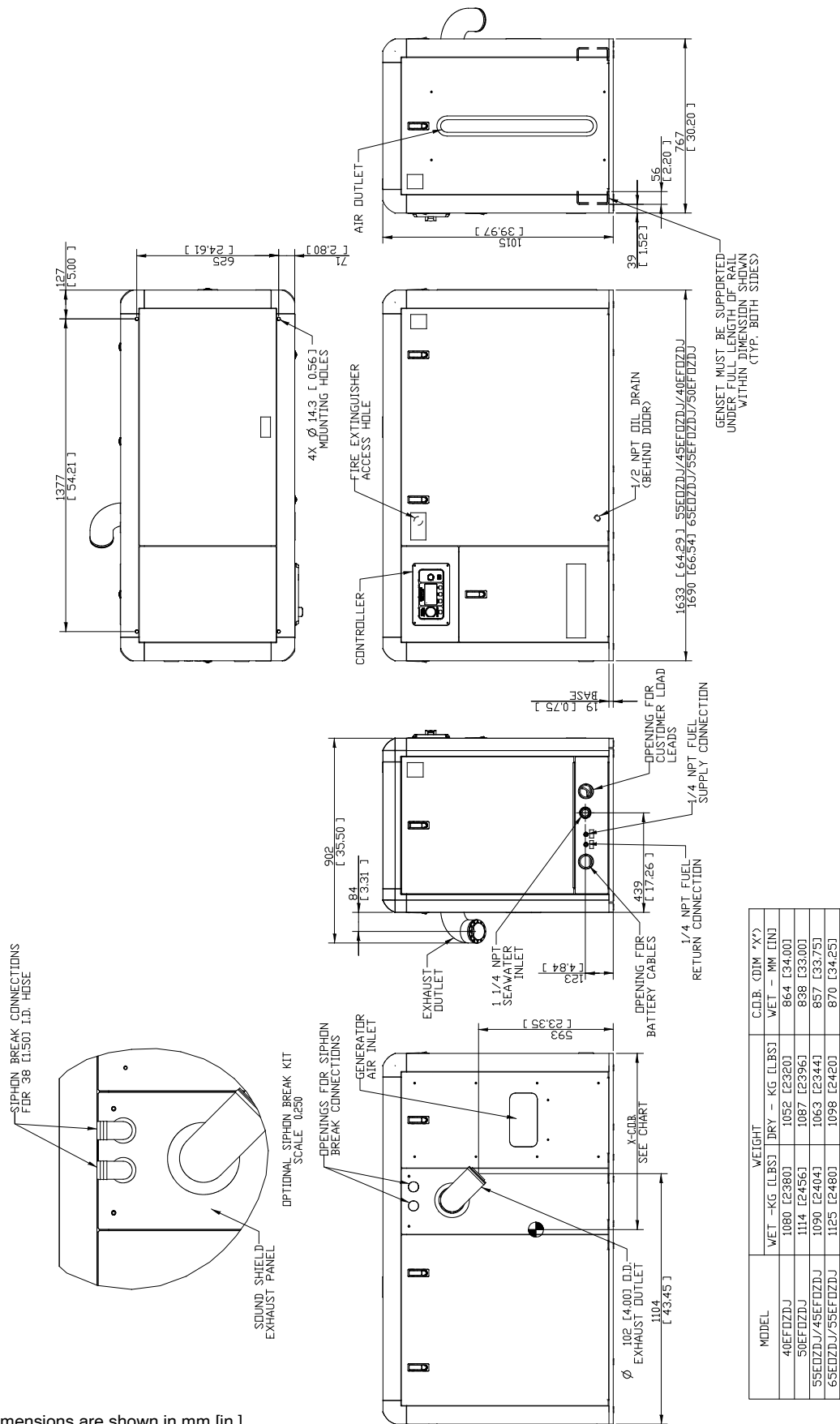


**Figure 7-4** Dimension Drawing, 40EOZDJ & 33EFOZDJ (with Sound Shield)



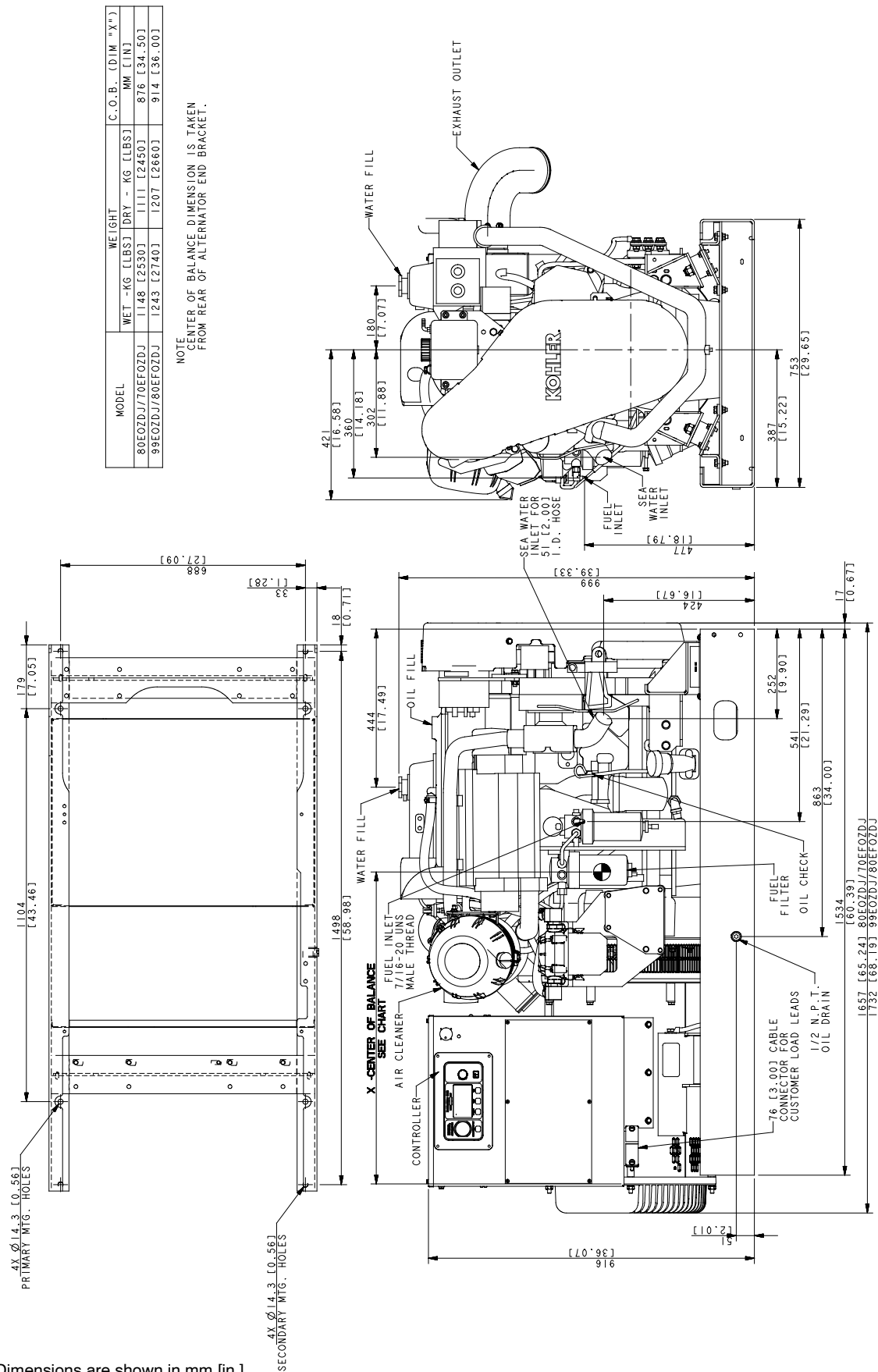


**Figure 7-6** Dimension Drawing, 40/50EFOZD(C)J & 55/65EOZD(C)J & 45/55EFOZD(C)J (Open Unit Sheet 2 of 2)



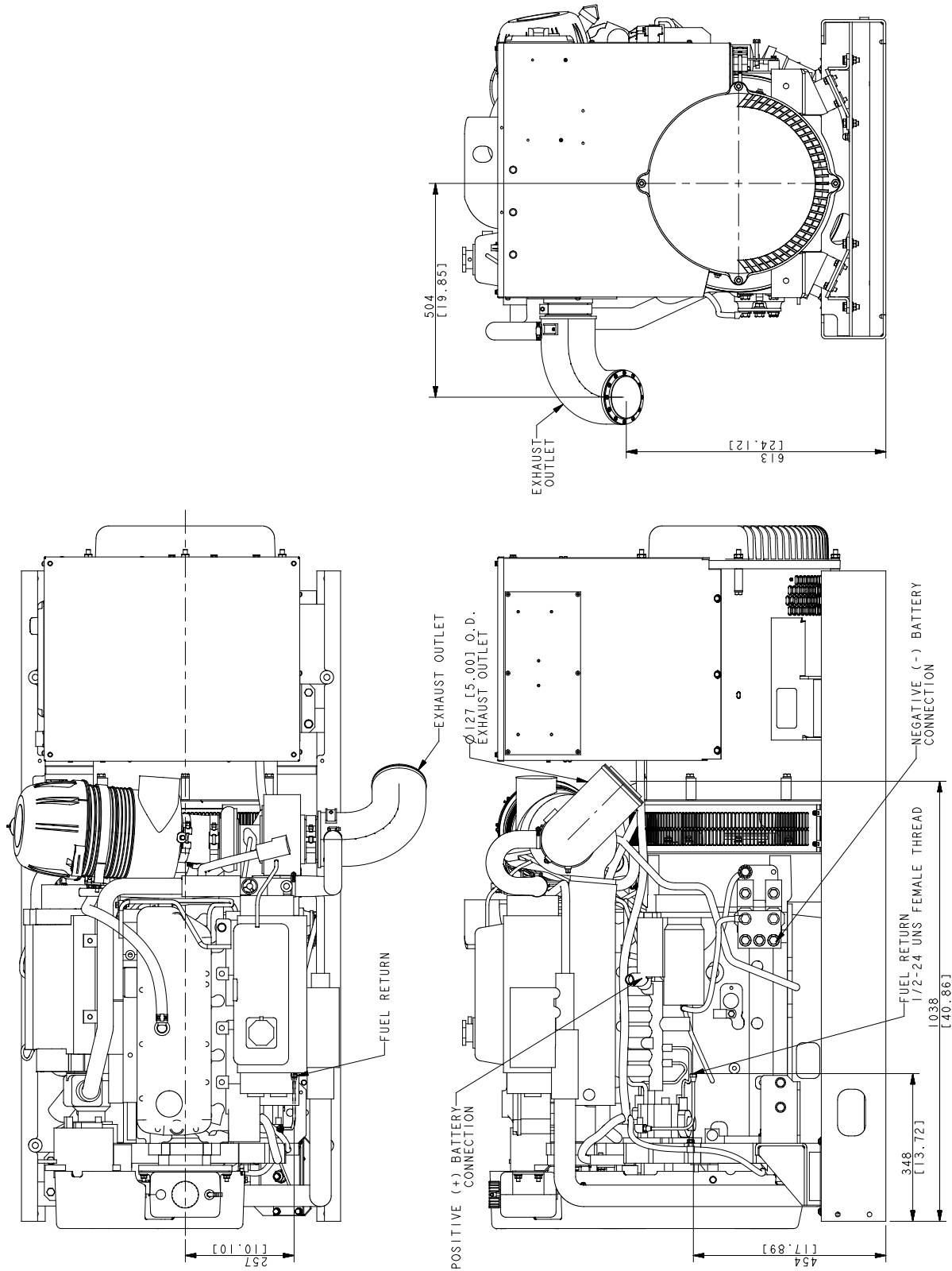
ADV-8504-

**Figure 7-7** Dimension Drawing, 40/50EFOZDJ & 55/65EOZDJ & 45/55EFOZDJ (with Sound Shield)



ADV-8506A-C

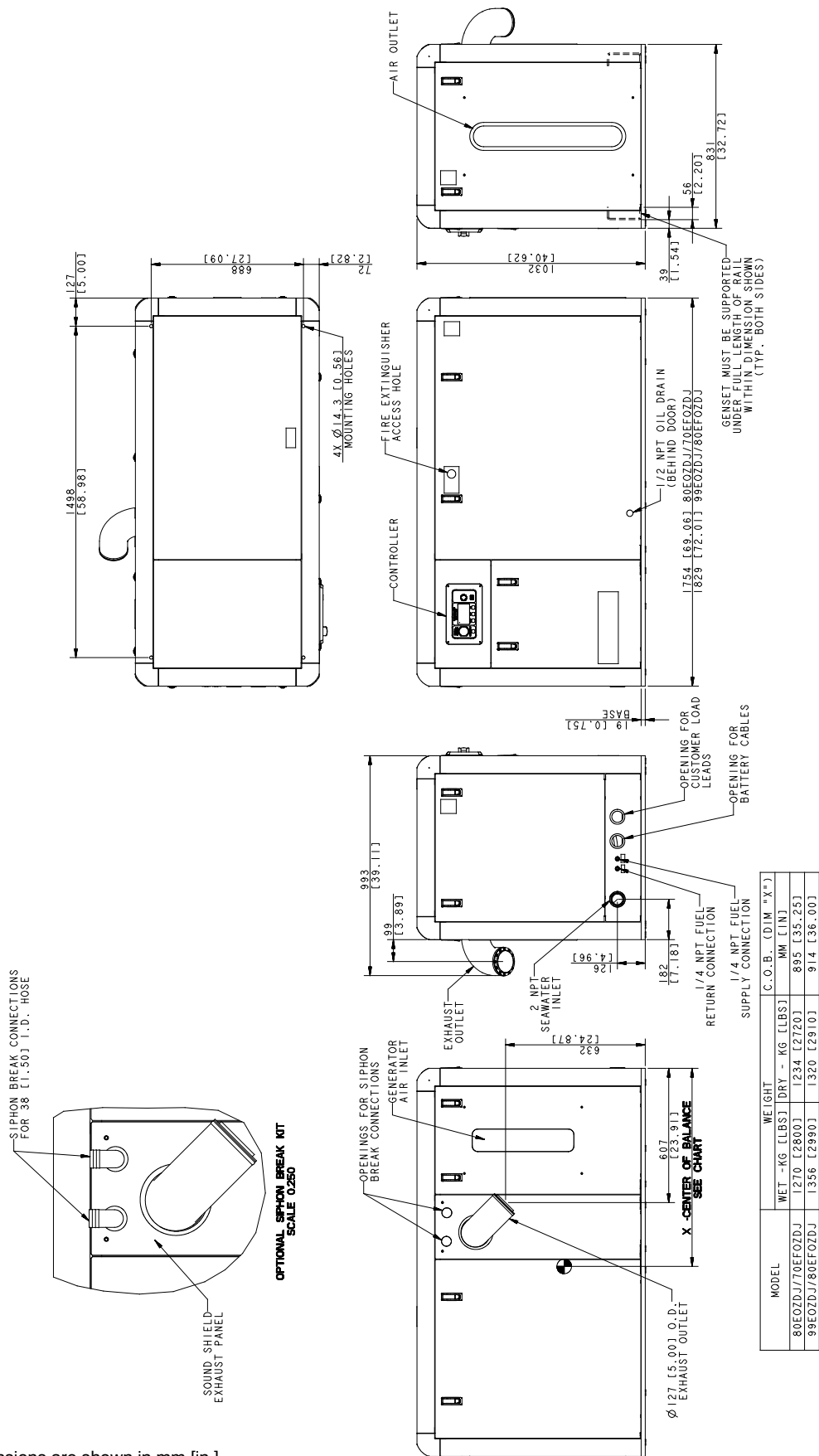
**Figure 7-8** Dimension Drawing, 80/99EOZD(C)J & 70/80EFOZD(C)J (Open Unit Sheet 1 of 2)



NOTE: Dimensions are shown in mm [in.].

ADV-8506B-C

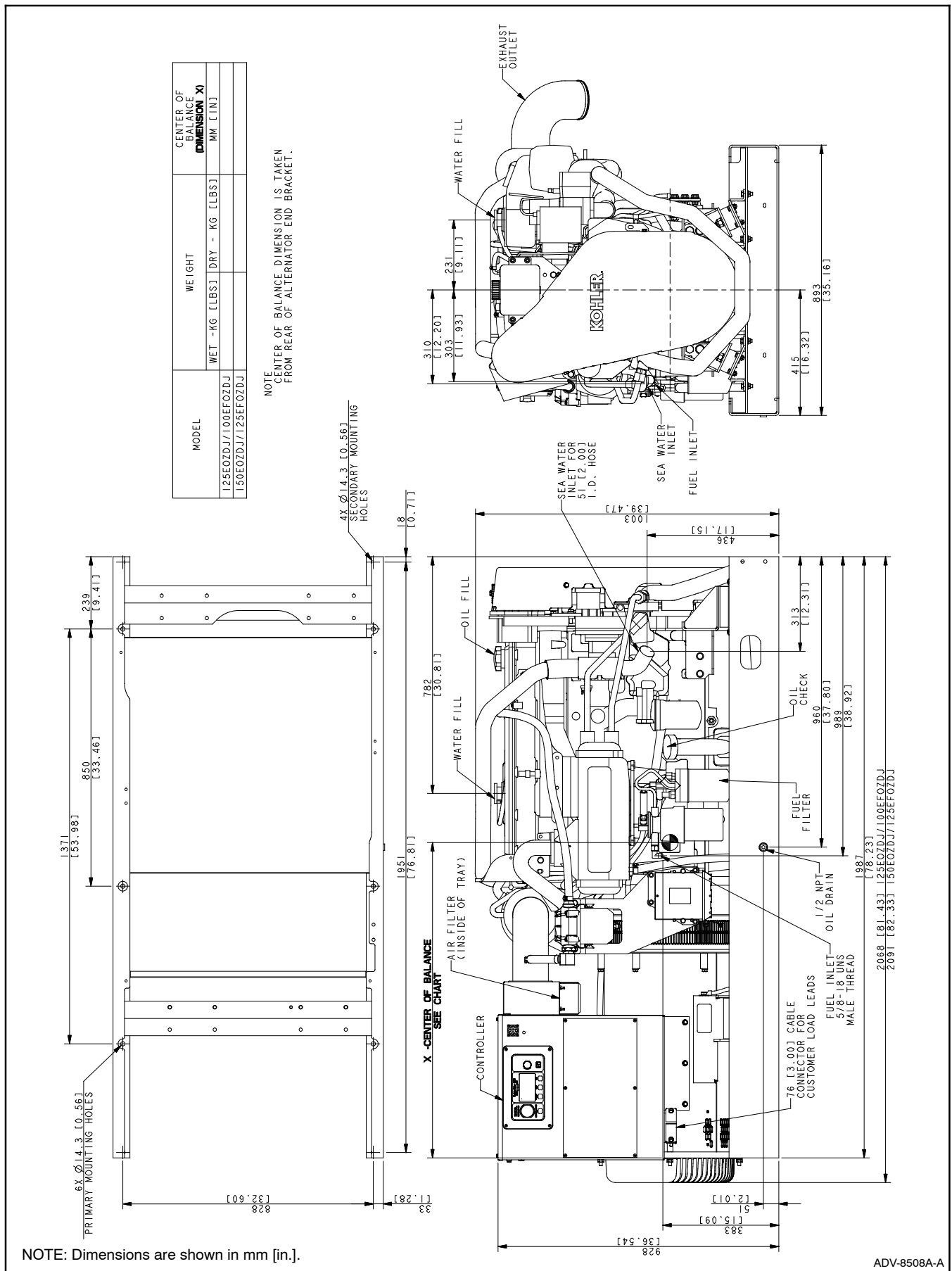
**Figure 7-9** Dimension Drawing, 80/99EOZD(C)J & 70/80EFOZD(C)J (Open Unit Sheet 2 of 2)



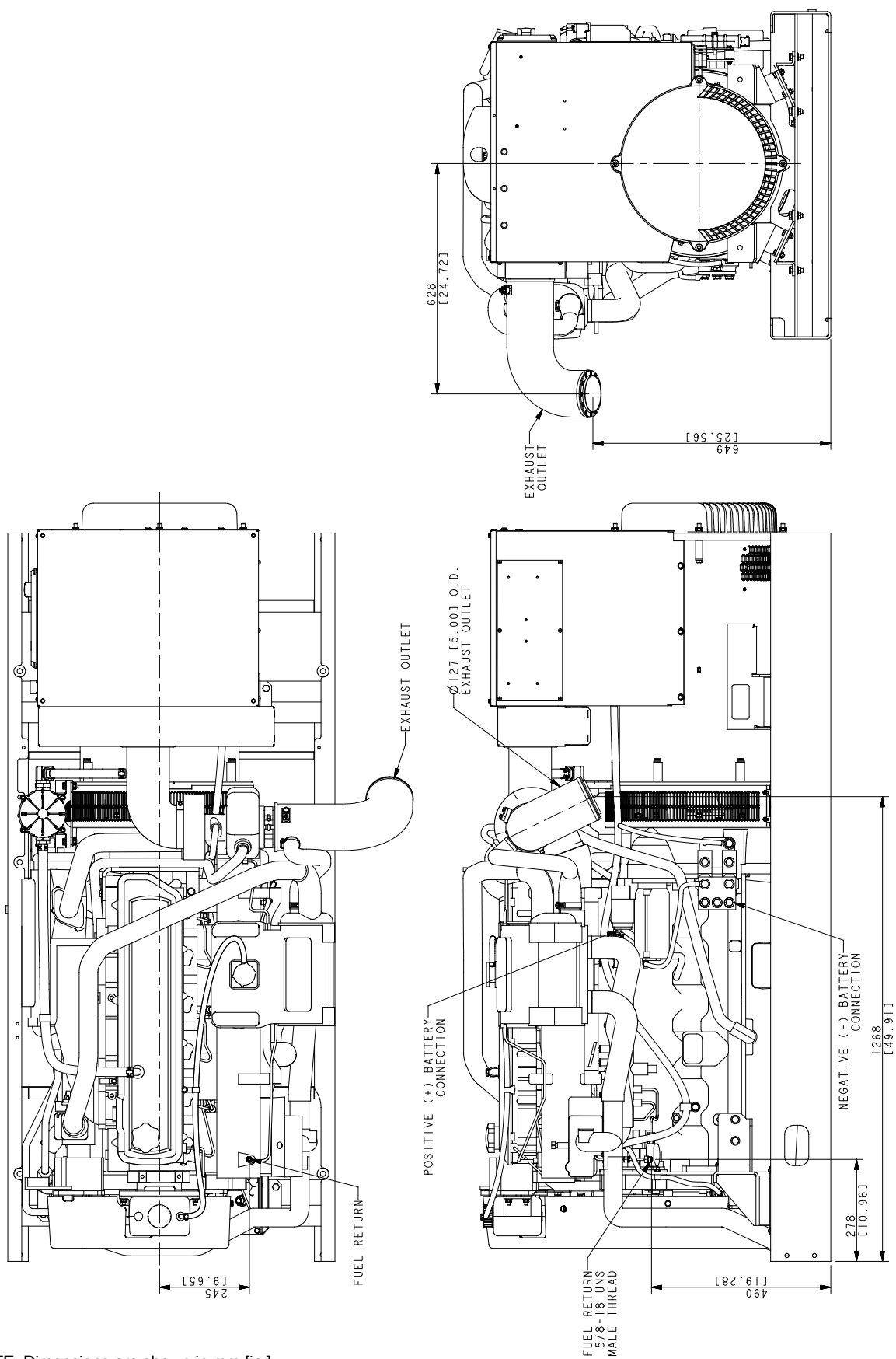
ADV-8507-A

**Figure 7-10** Dimension Drawing, 80/99EOZDJ & 70/80EFOZDJ (with Sound Shield)





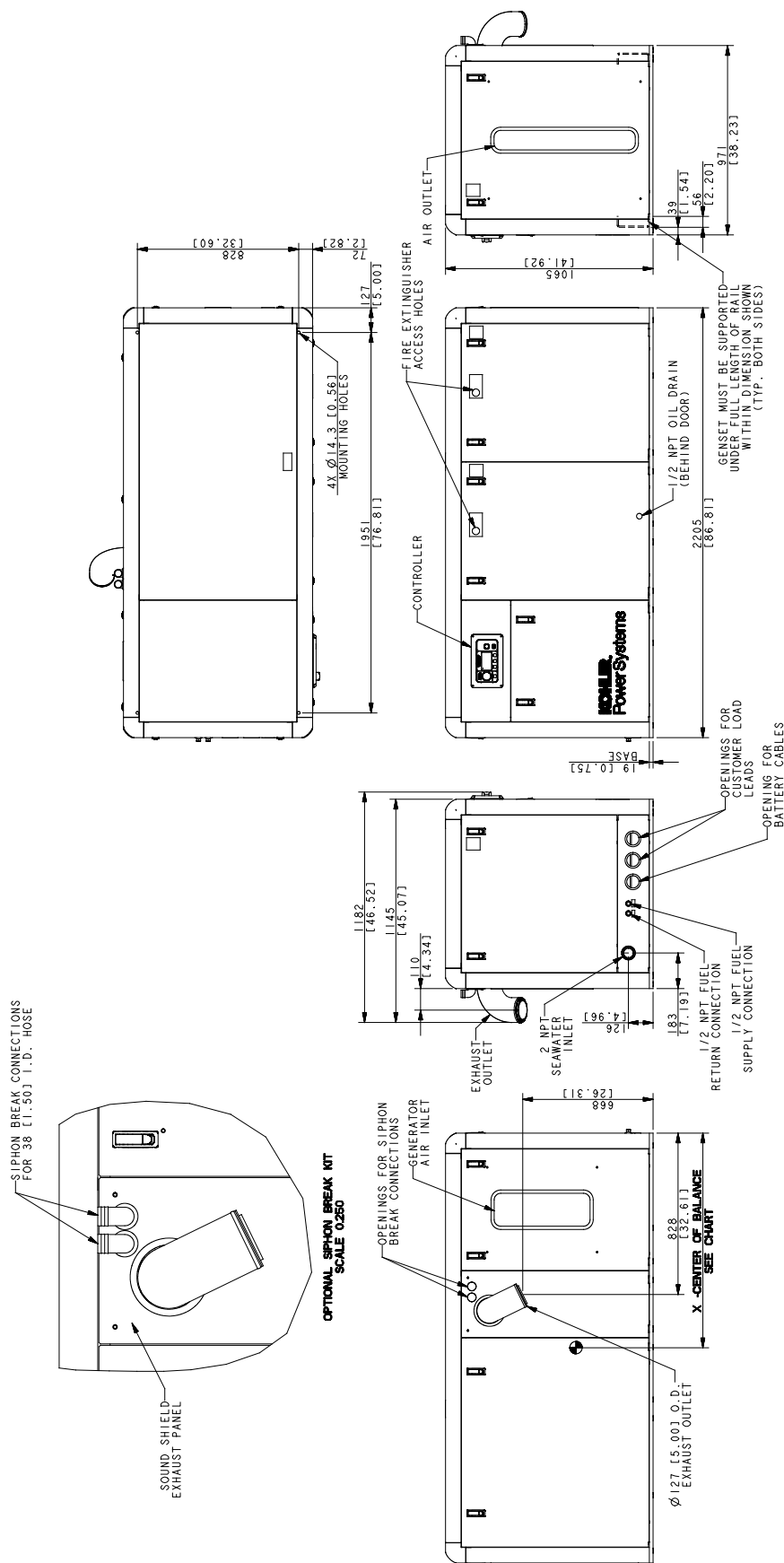
**Figure 7-11** Dimension Drawing, 125/150EOZD(C)J & 100/125EFOZD(C)J (Open Unit Sheet 1 of 2)



NOTE: Dimensions are shown in mm [in.].

ADV-8508B-A

**Figure 7-12** Dimension Drawing, 125/150EOZD(C)J & 100/125EFOZD(C)J (Open Unit Sheet 2 of 2)



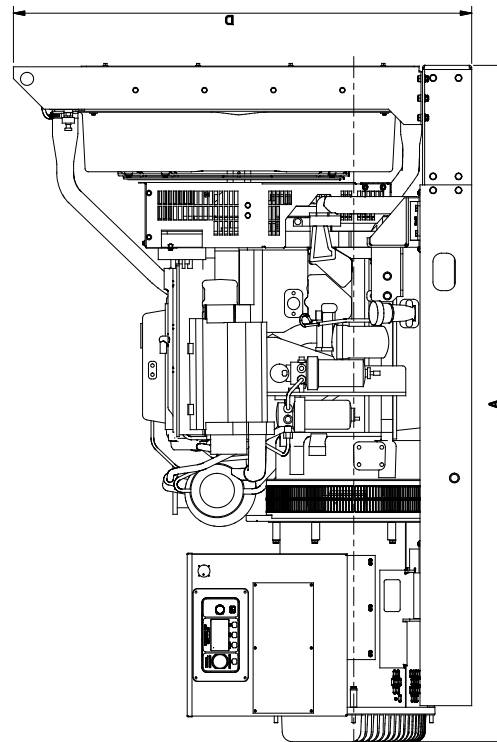
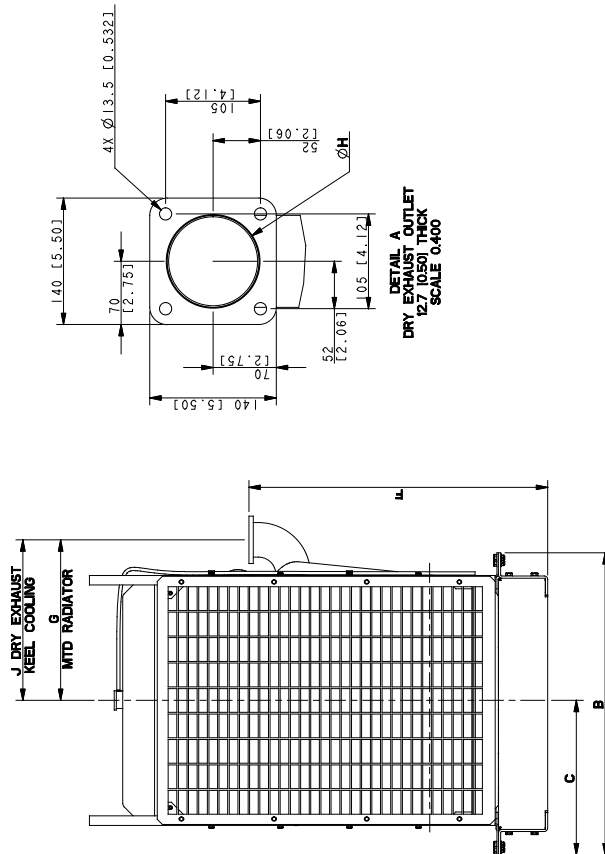
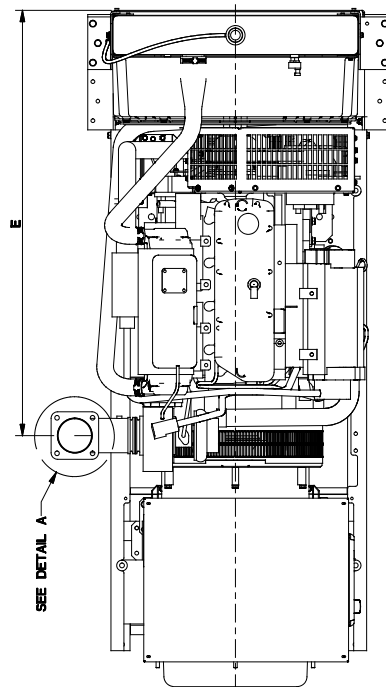
| MODEL                | WEIGHT                       | CENTER OF BALANCE DIMENSION |
|----------------------|------------------------------|-----------------------------|
| 125EOZD/J/100EFOZD/J | WET -KG [LBS] DRY - KG [LBS] | MM [IN]                     |
| 150EOZD/J/125EFOZD/J |                              |                             |

NOTE  
CENTER OF BALANCE DIMENSION IS  
TAKEN FROM REAR OF SOUND SHIELD.

ADV-8509-

**Figure 7-13** Dimension Drawing, 125/150EOZD(C)J & 100/125EFOZD(C)J (with Sound Shield)

| DIMENSION  | 40EOZDJ<br>33EFOZDJ | 55EOZDJ<br>40EFOZDJ | 65EOZDJ<br>50EFOZDJ | 80EOZDJ<br>70EFOZDJ | 99EOZDJ<br>80EFOZDJ | 125EOZDJ<br>100EFOZDJ | 150EOZDJ<br>125EFOZDJ |
|------------|---------------------|---------------------|---------------------|---------------------|---------------------|-----------------------|-----------------------|
| A          | 1858 [73.15]        | 1884 [74.14]        | 1941 [76.40]        | 1992 [78.43]        | 2067 [81.38]        | 2466 [97.10]          | 2498 [98.00]          |
| B          | 827 [32.57]         | 827 [32.57]         | 827 [32.57]         | 890 [35.05]         | 890 [35.05]         | 1129 [44.45]          | 1129 [44.45]          |
| C          | 414 [16.28]         | 414 [16.28]         | 414 [16.28]         | 455 [17.92]         | 455 [17.92]         | 564 [22.22]           | 564 [22.22]           |
| D          | 1465 [57.68]        | 1465 [57.68]        | 1465 [57.68]        | 1477 [58.15]        | 1477 [58.15]        | 1475 [58.07]          | 1475 [58.07]          |
| E          | 1288 [50.71]        | 1243 [48.93]        | 1243 [48.93]        | 1253 [49.31]        | 1253 [49.31]        | 1582 [62.30]          | 1582 [62.30]          |
| F          | 793 [31.20]         | 821 [32.33]         | 821 [32.33]         | 880 [34.65]         | 880 [34.65]         | 951 [37.43]           | 951 [37.43]           |
| G RAD      | 210 [8.25]          | 455 [17.91]         | 455 [17.91]         | 473 [18.62]         | 473 [18.62]         | 475 [18.68]           | 475 [18.68]           |
| H          | 89 [3.50]           | 102 [4.00]          | 102 [4.00]          | 102 [4.00]          | 102 [4.00]          | 102 [4.00]            | 102 [4.00]            |
| J KEEL/DRY | 210 [8.25]          | 454 [17.87]         | 611 [24.06]         | 500.53 [19.70]      | 500.53 [19.70]      | 612 [24.14]           | 612 [24.14]           |

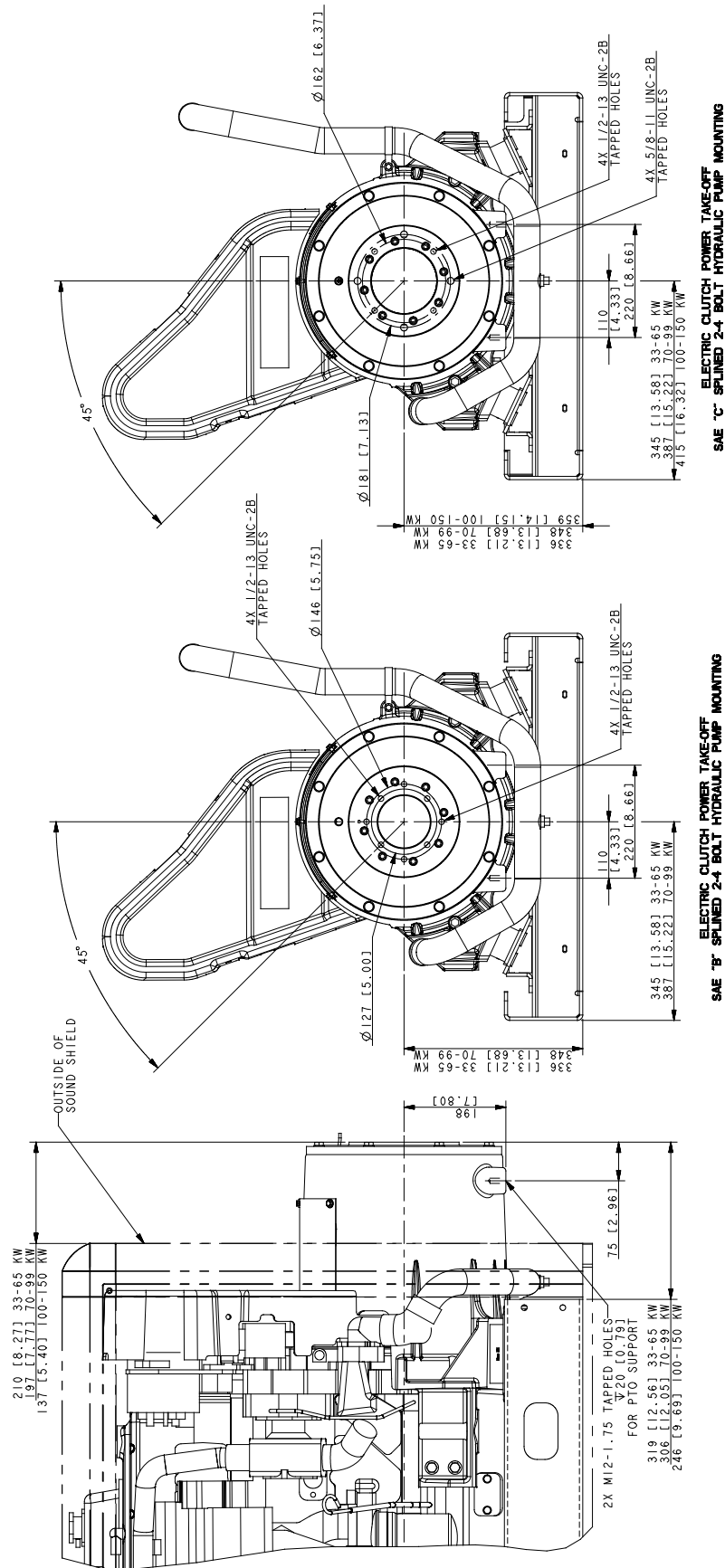


DETAIL A  
DRY EXHAUST OUTLET  
12.7 (0.50) THICK  
SCALE 0:400

NOTE: Dimensions are shown in mm [in.].

ADV-8505A-C

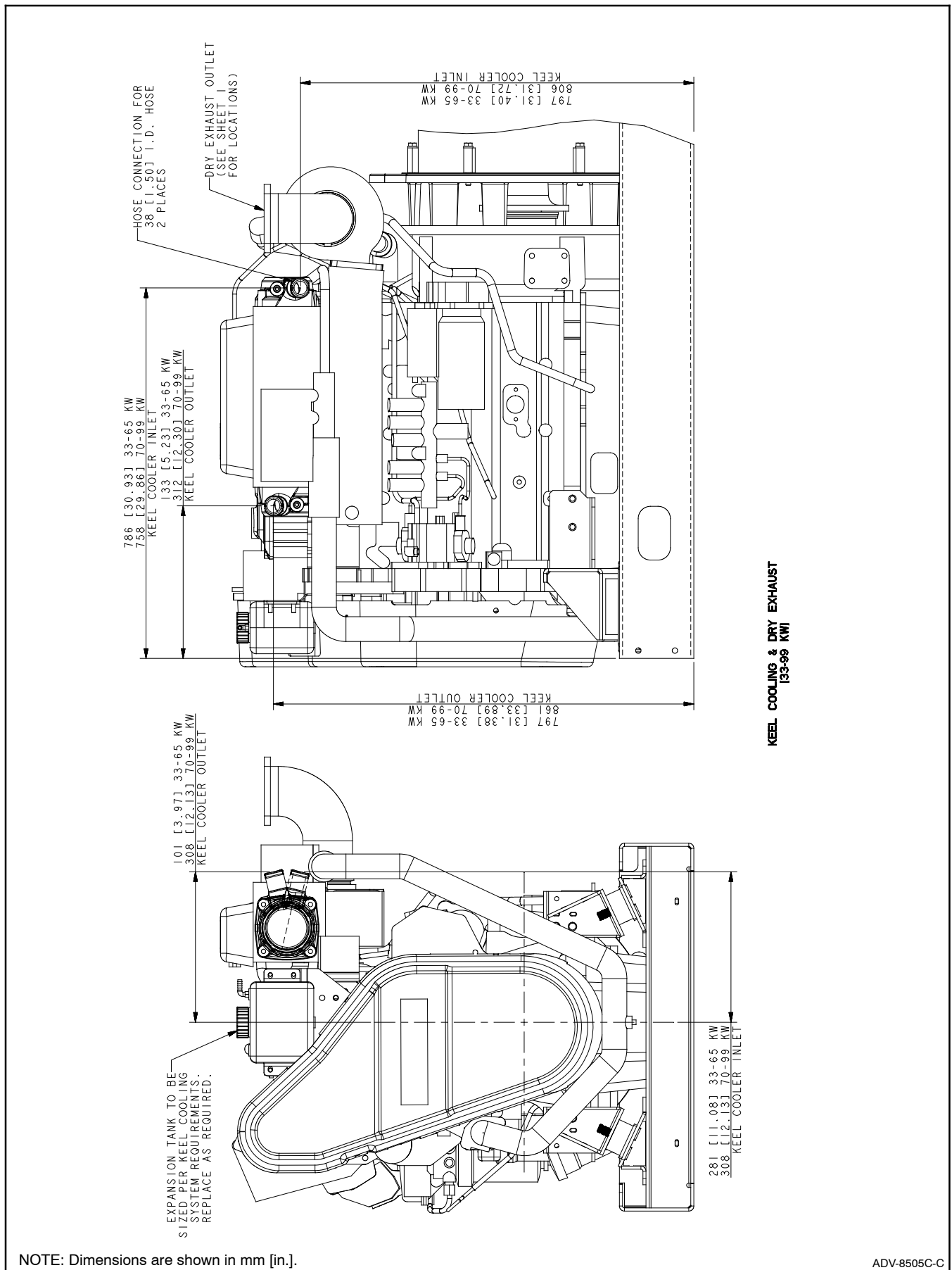
**Figure 7-14** Dimension Drawing, 40-150EOZD(C)J & 33-125EFOZD(C)J (with Unit-Mounted Radiator)



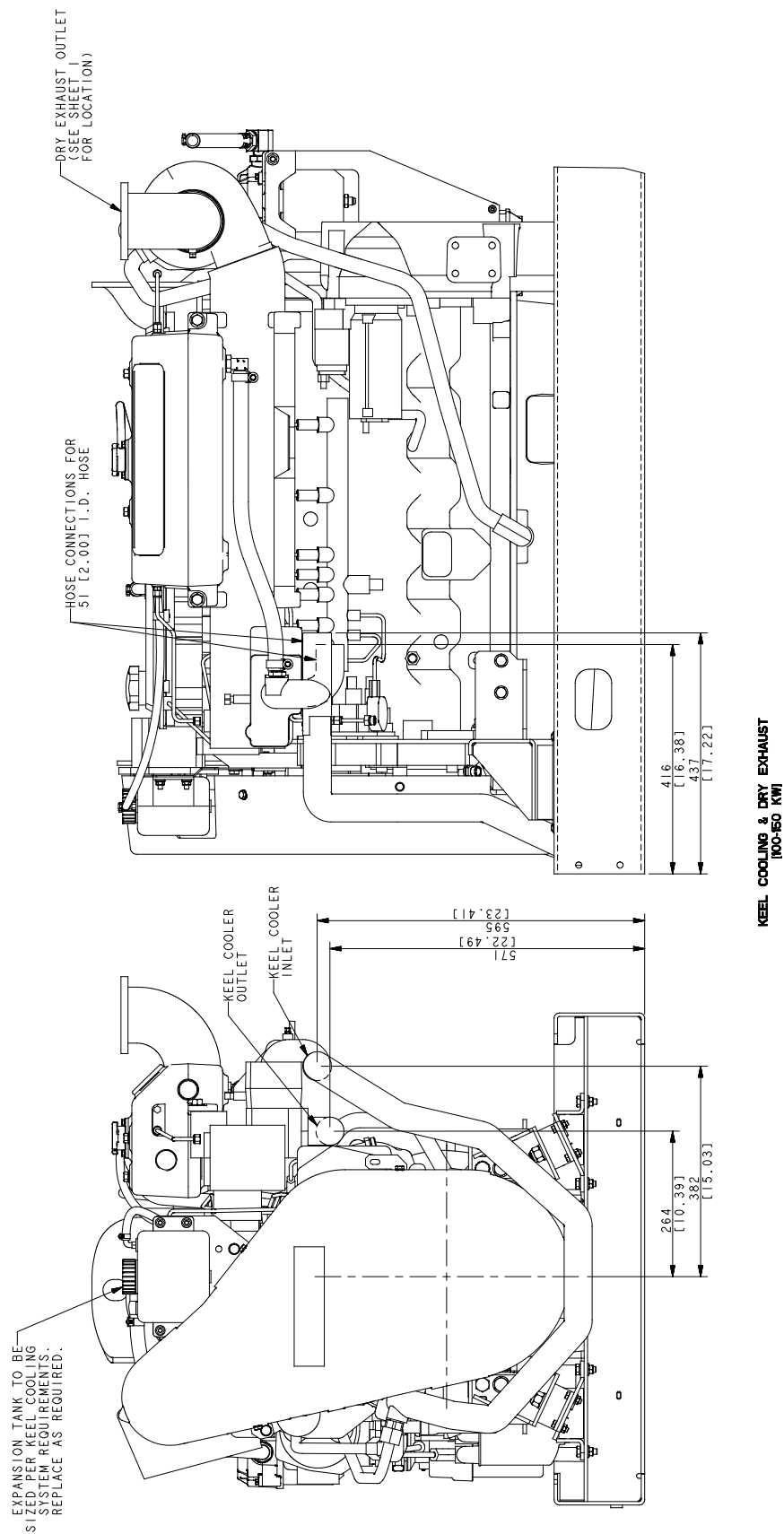
NOTE: Dimensions are shown in mm [in.].

ADV-8505B-C

**Figure 7-15** Dimension Drawing, 40-150EOZD(C)J & 33-125EFOZD(C)J (with Electric Clutch PTO)



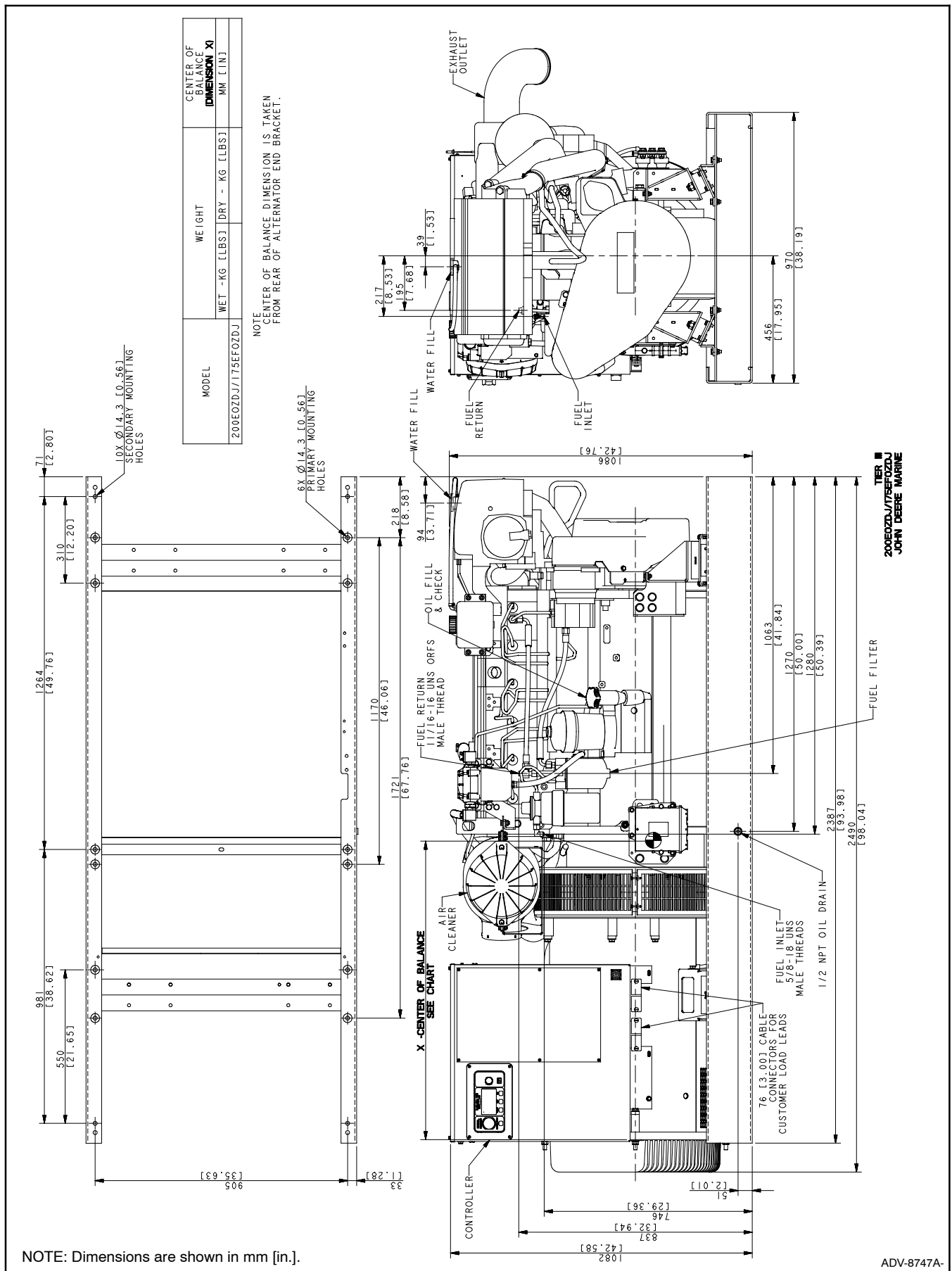
**Figure 7-16** Dimension Drawing, 40-99EOZD(C)J & 33-80EFOZD(C)J (with Keel Cooling & Dry Exhaust)



NOTE: Dimensions are shown in mm [in.].

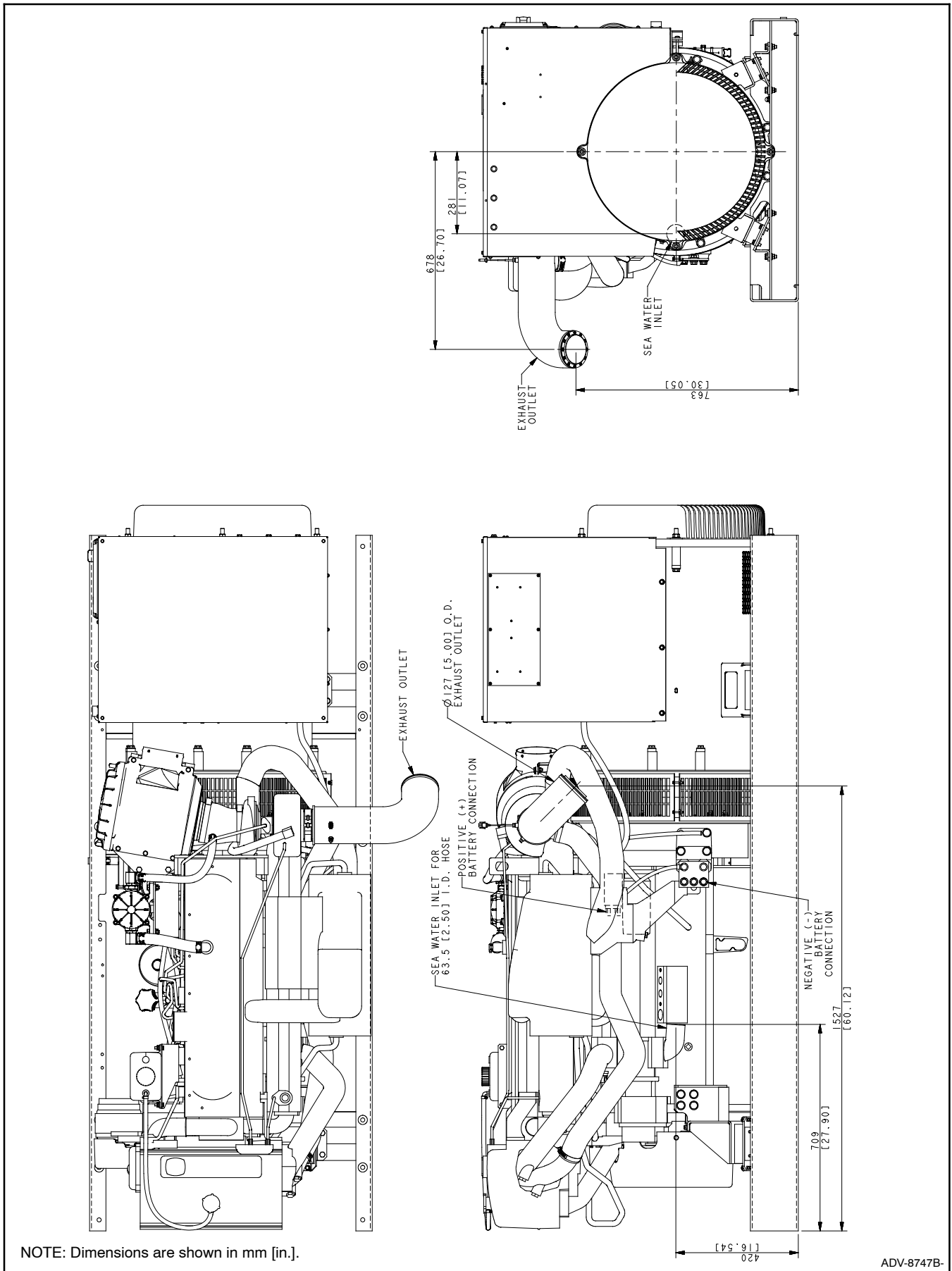
ADV-8505D-C

**Figure 7-17** Dimension Drawing, 125/150EOZD(C)J & 100/125EFOZD(C)J (with Keel Cooling & Dry Exhaust)

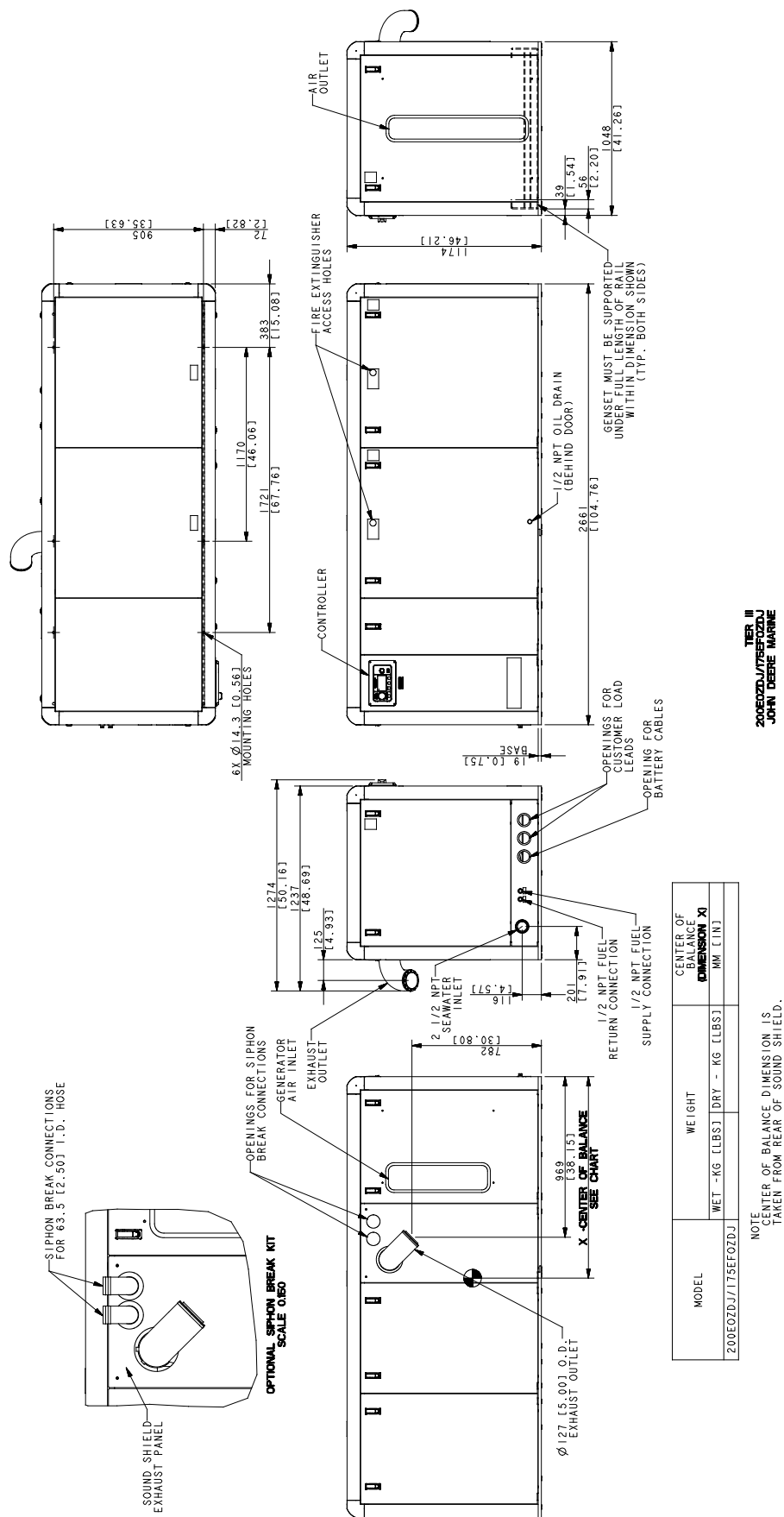


**Figure 7-18** Dimension Drawing, 200EOZD(C)J & 175EFOZD(C)J (Open Unit Sheet 1 of 2)





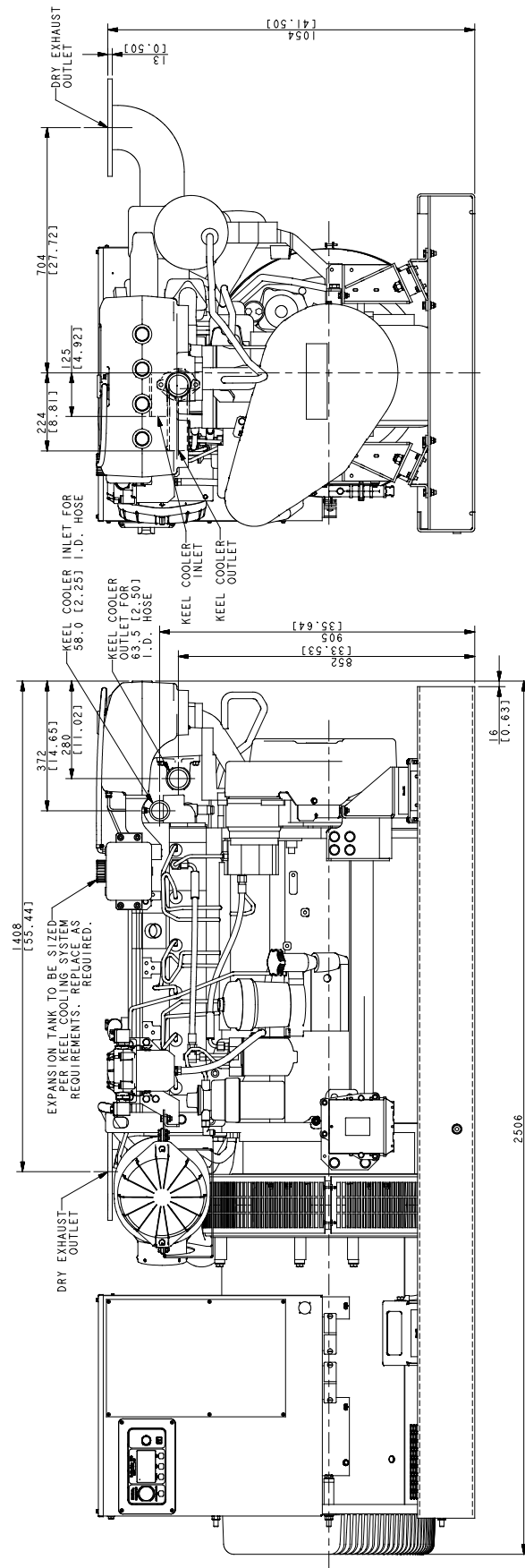
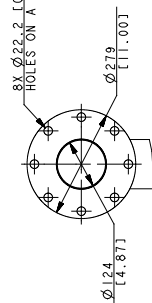
**Figure 7-19** Dimension Drawing, 200EOZD(C)J & 175EFOZD(C)J (Open Unit Sheet 2 of 2)



TER III  
200EOZD/J/175EFOZD/J  
JOHN DEERE MARINE

**Figure 7-20** Dimension Drawing, 200EOZD(C)J & 175EFOZD(C)J (with Sound Shield)

8X Ø22.2 [0.87] EQUALLY SPACED  
HOLES ON A 241.3 [9.50] D.B.C.



KEEL COOLING & DRY EXHAUST

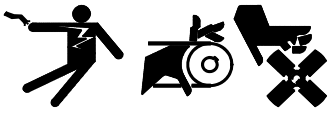
NOTE: Dimensions are shown in mm [in.].

ADV-8764-

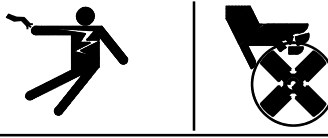
**Figure 7-21** Dimension Drawing, 200EOZD(C)J & 175EFOZD(C)J (with Keel Cooling & Dry Exhaust)

## Notes

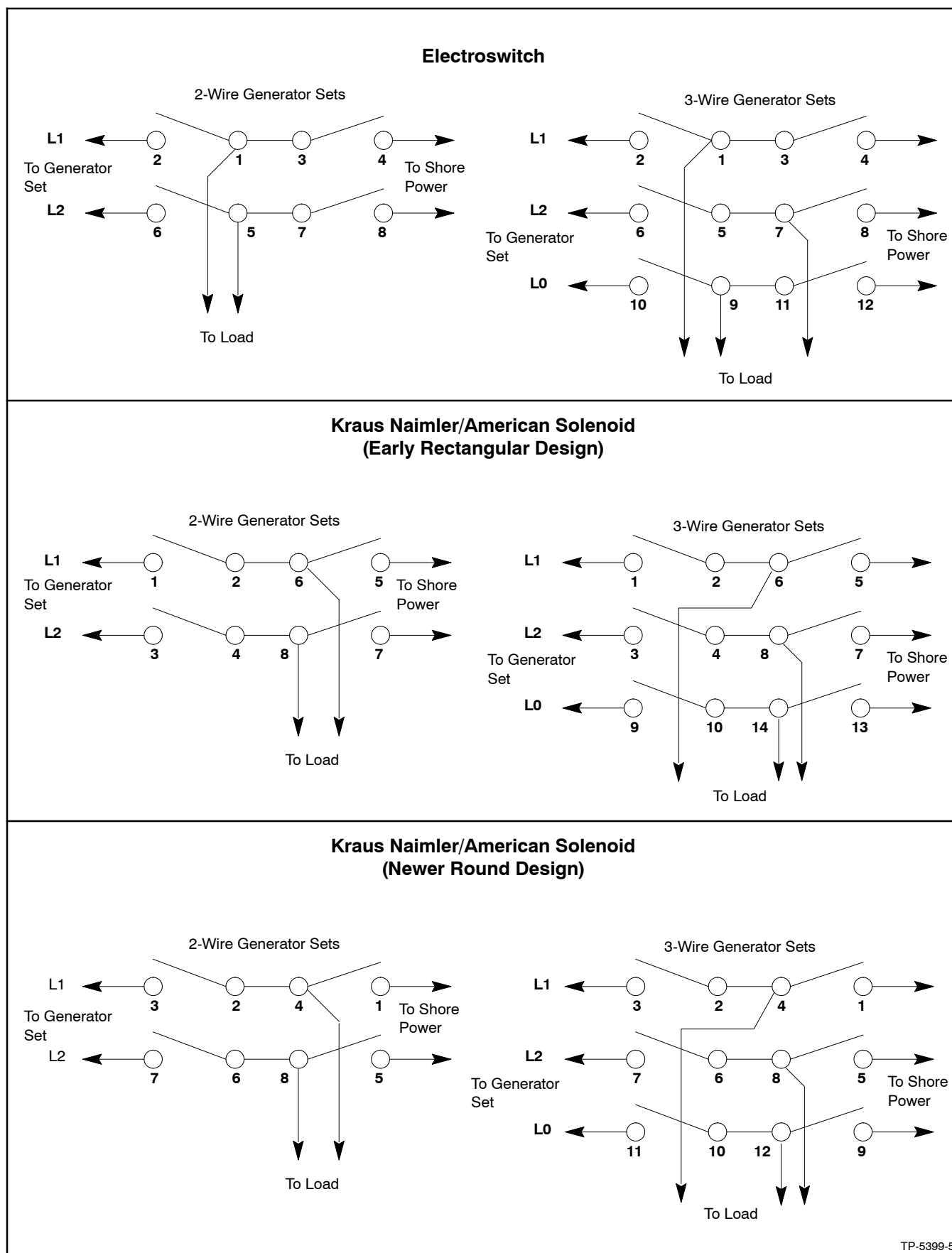
## Section 8 Reconnection/Adjustments

|                                                                                                                                                                                                                                                                                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>⚠ WARNING</b>                                                                                                                                                                                                                                                                   |
|                                                                                                                                                                                                   |
| <b>Accidental starting.<br/>Can cause severe injury or death.</b><br><br>Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery. |

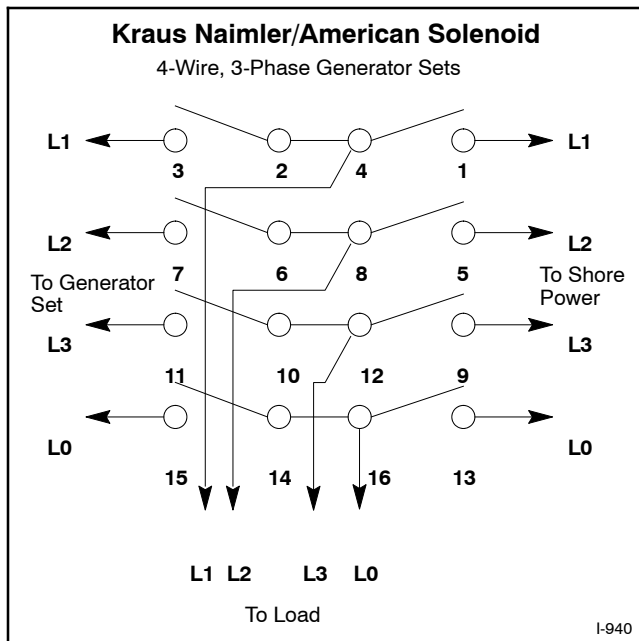
**Disabling the generator set. Accidental starting can cause severe injury or death.** Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

|                                                                                                                                                                             |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>⚠ WARNING</b>                                                                                                                                                            |
|                                                                                           |
| <b>Hazardous voltage. Moving parts.<br/>Can cause severe injury or death.</b><br><br>Operate the generator set only when all guards and electrical enclosures are in place. |

**Grounding electrical equipment. Hazardous voltage can cause severe injury or death.** Electrocutation is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.



**Figure 8-1** Marine Manual (Ship-to-Shore) Transfer Switch



**Figure 8-2** Marine Manual (Ship-to-Shore) Transfer Switch, continued

## NOTICE

**Voltage reconnection.** Affix a notice to the generator set after reconnecting the set to a voltage different from the voltage on the nameplate. Order voltage reconnection decal 246242 from an authorized service distributor/dealer.

### Twelve-Lead Reconnection Procedure

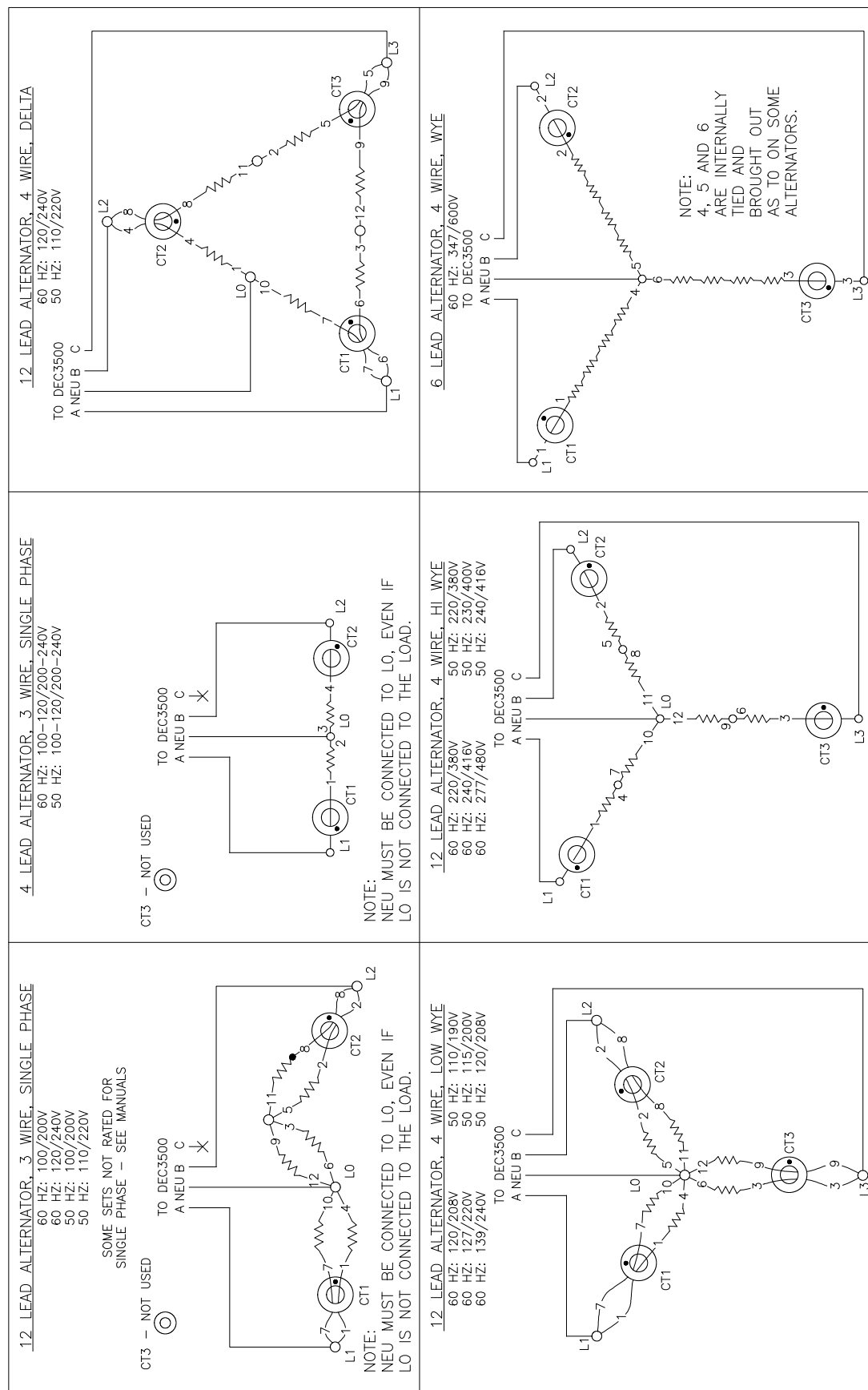
1. Place the generator start/stop switch in the STOP position.
2. Disconnect generator set engine starting battery, negative (-) lead first.
3. Disconnect power to battery charger, if equipped.
4. Use Figure 8-3 to determine the generator set voltage configuration. Note the original voltage and reconnect the generator set as needed. For units with current transformers (CTs) and connect the leads according to the diagram for the desired phase and voltage.

## 8.1 Twelve-Lead Reconnection

The reconnection procedure details voltage reconnections only. If the generator set requires frequency changes, adjust the governor and voltage regulator. See the generator set service manual for information regarding frequency adjustment.

The following information illustrates the reconnection of twelve-lead generator sets. In all cases, conform to the National Electrical Code (NEC).

Reconnect the stator leads of the generator set to change output phase or voltage. Refer to the following procedure and connection schematics. Follow all safety precautions at the front of this manual and in the text during the reconnection procedure.



PHASE ROTATION

A B C  
L1 L2 L3

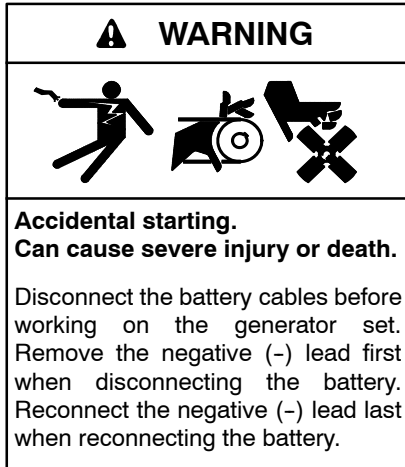
NOTES:  
CURRENT TRANSFORMER DOT OR "H1" TOWARD GENERATOR.  
CURRENT TRANSFORMERS NOT USED ON ALL SETS.  
SOME STATORS HAVE DUAL LEADS. ALWAYS CONNECT LEADS OF THE SAME LABEL TOGETHER.

DEC3500

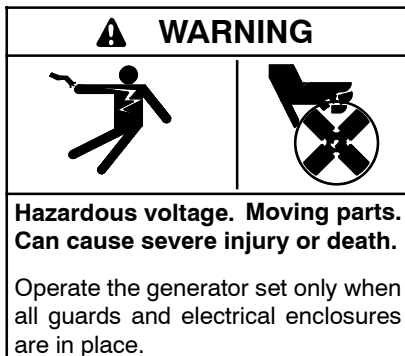
Figure 8-3 Generator Reconnection (ADV-5875F-U)



## Section 9 Paralleling Generator Sets



**Disabling the generator set. Accidental starting can cause severe injury or death.** Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.



**Grounding electrical equipment. Hazardous voltage can cause severe injury or death.** Electrocutation is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

### Introduction

Read and follow the safety precautions included in this manual. Pay attention to the decals on the equipment and follow the instructions below.

- All personnel involved in handling, site preparation, installation, testing, operation, and maintenance should be thoroughly familiar with the information in this manual and the customer drawings provided before working on this equipment.
- Never make interlocks inoperative or operate the equipment with any safety barriers removed.
- Always assume that all high-voltage parts are energized until it is certain that they are de-energized.
- Use only test equipment rated for the service intended.
- Check interconnection diagrams and make sure there are no potential backfeed sources.
- Never disconnect the main trip source of energized equipment.
- Use out-of-service tags and padlocks when working on equipment. Leave tags in place until the work is completed and the equipment is ready to be put back into service.
- The complete assembly arrangement determines if the top or bottom contacts are the line side; both can be energized when the circuit breaker is removed from the compartment.
- Do not use liquid fire extinguishers or water on electrical fires. Before extinguishing fires within the assembly, be absolutely certain that the main power source is disconnected and the main and all feeder breakers are tripped.

The Decision-Maker® 3500 generator set controller provides generator set advanced control, system monitoring, and system diagnostics for paralleling multiple generator sets.

The Decision-Maker® 3500 interfaces the generator set to other power system equipment and other network management systems using standard industry network communications.

The controller uses unique software logic to manage sophisticated functions, such as voltage regulation, synchronizing and load-sharing controls, and protective relays for paralleling up to eight generator sets.

## Decision-Maker® 3500 Controller Features Include:

- Isochronous (real and reactive) load sharing with other Decision-Maker® 3500 equipped generator sets.
- Random first-on logic to prevent two or more generator sets from closing to a dead bus.
- Automatic synchronizer with dead bus closing.
- Soft loading and unloading.
- Protective relay functions include:
  - Loss of field
  - Over current
  - Over frequency
  - Over power
  - Over voltage
  - Reverse power
  - Under frequency
  - Under voltage
- Generator management allows unneeded generators to be stopped to conserve fuel.
- Load control logic permits prioritization of supplied loads, allowing critical load to retain power in a failure scenario.

A generator set needs to be configured and set up correctly to work in paralleling applications. This section covers:

- Paralleling Basics (see Section 9.1)
- Paralleling Considerations (see Section 9.2)
- Paralleling Set Up (see Section 9.3)
- Paralleling Troubleshooting (see Section 9.4, Section 9.5, and Section 9.6)
- Generator Management Setup (see Section 9.7)
- Load Add/Shed Configuration (see Section 9.8)

## 9.1 Paralleling Basics

### 9.1.1 Why Parallel Generator Sets

Some reasons to parallel generator sets are:

- Redundancy
- Increased power capacity
- Decreased fuel consumption
- Reduced chance of wet stacking/fuel on water
- Increased reliability
- Greater flexibility
- Individual generators can be serviced in prime power applications

## 9.1.2 Paralleling Functions

There are two methods of paralleling:

1. **PGEN.** The Decision-Maker® 3500 is a full-featured paralleling controller. It offers integrated control for synchronizing, load sharing, protective relays, generator management, and load add/shed. This functionality is performed automatically by the Decision-Maker® 3500 controller. PGEN requires an RS-485 between each of the paralleling generators for paralleling operation.
2. **Remote Speed and Voltage Bias.** The Decision-Maker® 3500 controller is also capable of accepting a speed and voltage bias from an external paralleling control. In these applications, the external paralleling control performs all of the required functionality and the Decision-Maker® 3500 controller merely provides a control interface and protective functions for the generator set.

**Note:** For external speed and voltage bias, the PGEN communication's cable should not be connected between generators.

TB13 is located inside the junction box and contains the connection points for external speed and voltage bias control and accommodates 0–5 volt input for active control. See the table below and the wiring diagrams in the Operation Manual for more information.

|                           | Connection |
|---------------------------|------------|
| Speed Bias Negative (-)   | TB13-SBN   |
| Speed Bias Positive (+)   | TB13-SBP   |
| Voltage Bias Negative (-) | TB13-VBN   |
| Voltage Bias Positive (+) | TB13-VBP   |

External paralleling requires the external speed and voltage bias inputs to be enabled. Using SiteTech™, under the **Synchronization Control** parameter change the setting to the following:

**External Bias Inputs:** **True**

**Note:** For more information on SiteTech™, see TP-6701 SiteTech™ Software Operation Manual.

With the external bias enabled, the engine speed is set based on the voltage between SBP and SBN:

- Voltage < 0.5V: Engine Run Speed
- Voltage = 0.5V: 95% of Engine Run Speed
- Voltage = 2.5V: Engine Run Speed
- Voltage = 4.5V: 105% of Engine Run Speed
- Voltage > 4.5V: Engine Run Speed

With the external bias enabled, the output voltage is set based on the voltage between VBP and VBN:

- Voltage < 0.5V: Voltage Regulator Average Voltage Adjustment
- Voltage = 0.5V: 90% of Voltage Regulator Average Voltage Adjustment
- Voltage = 2.5V: Voltage Regulator Average Voltage Adjustment
- Voltage = 4.5V: 110% of Voltage Regulator Average Voltage Adjustment
- Voltage > 4.5V: Voltage Regulator Average Voltage Adjustment

The Decision-Maker® 3500 controller reads the voltage on the speed and voltage bias inputs every 50 ms (20 times per second) and passes the new target to the voltage regulator and the ECM.

Reactive droop should be enabled on the Decision-Maker® 3500 when paralleling with another generator set (either in simple or intelligent paralleling). The slope should be identical on all generators in the paralleling system (the default is 1.0%). Reactive droop can be configured using either SiteTech™ or the User Interface (UI) at the controller:

Using SiteTech™, under the **Reactive Power Load Sharing** parameter.

Using the UI, under the

**Generator Info -> Voltage Regulation Menu** and **Generator Info -> Paralleling Operation -> Sharing Setup** Menus.

**Note:** Non-ECM engines will require an electronic governor (Woodward APECs) and an appropriate Kohler governor calibration in order to permit speed adjustment.

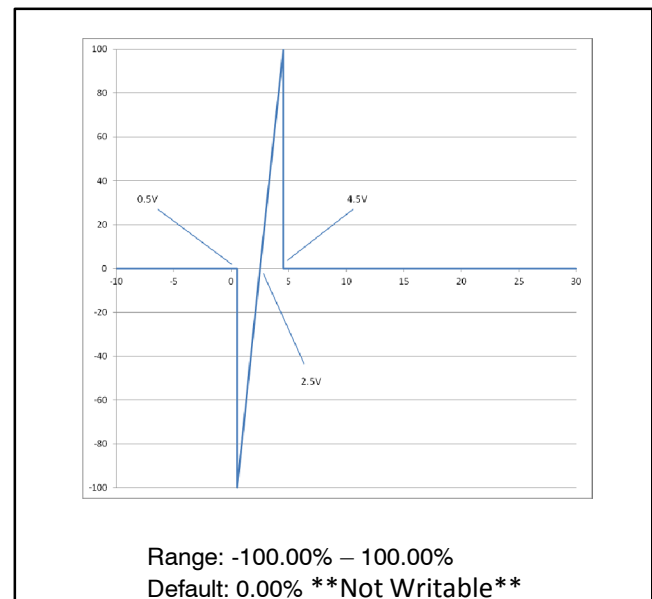
**Speed Bias** is the amount that the controller is attempting to adjust the output frequency of the generator (100% bias = +5% on the engine speed, -100% = -5% on the engine speed). The controller adjusts the Speed Bias to match frequency and phase with the paralleling bus.

**Note:** The Speed Bias can also be controlled by an external device if the External Bias Inputs Enabled parameter is true, the Stand Alone Operation parameter is false, no other generators are visible on the PGEN communications channel, and the voltage applied to the speed bias input is between 0.5V and 4.5V.

The External Speed Bias Input (SBP and SBN) is a voltage measuring channel capable of reading from -10V to 30V DC. The input is normally pulled down to -3.3V, but can be overridden by applying a voltage to the input.

The voltage that the controller sees on the voltage measuring channels is visible in the **Analog Voltage Input Metered Relative Value** under the **Programmable Analog Voltage Input 108** parameter heading. The input is polarity sensitive.

The Speed Bias is interpreted by the controller as shown in Figure 9-1.



**Figure 9-1** Speed Bias

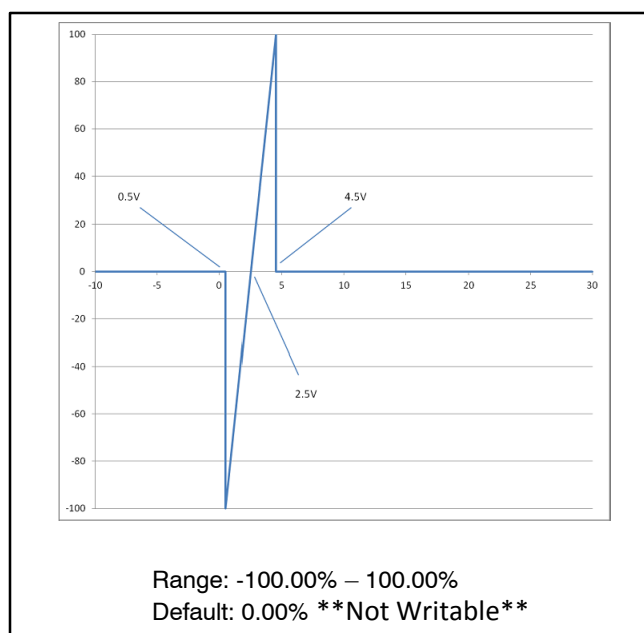
**Voltage Bias** is the amount that the controller is attempting to adjust the output voltage (100% bias = +10% on the output voltage, -100% = -10% on the output voltage). The controller adjusts the voltage bias to match the generator voltage to the bus voltage.

**Note:** The Voltage Bias can also be controlled by an external device if the External Bias Inputs Enabled parameter is true, the Stand Alone Operation parameter is false, no generators are visible on the PGEN communications channel, and the voltage applied to the voltage bias input is between 0.5V and 4.5V.

The External Voltage Bias Input (VBP and VBN) is a voltage measuring channel capable of reading from -10V to 30V DC. The input is normally pulled down to -3.3V, but can be overridden by applying a voltage to the input.

The voltage that the controller sees on the voltage measuring channels is visible in the **Analog Voltage Input Metered Relative Value** under the **Programmable Analog Voltage Input 107** parameter heading. The input is polarity sensitive.

The Voltage Bias is interpreted by the controller as shown in Figure 9-2



**Figure 9-2** Voltage Bias

## Synchronizing

Before a generator set can operate in parallel with another generator set, its electrical output must be synchronized (matched) to the power source it will parallel. The parameters that must be matched are:

- Frequency
- Phase Angle
- Voltage
- Phase Rotation (for 3-phase applications)

The synchronizer will issue a breaker close command when the frequency difference, phase angle, and voltage difference are within an acceptable range and the phase rotation matches.

**Note:** The Decision-Maker® 3500 synchronizer will not attempt to match voltage, frequency, or phase if the phase rotation of the bus doesn't match that of the generator set.

For PGEN paralleling, the synchronizing is handled within the Decision-Maker® 3500 controller.

For Remote Speed and Voltage Bias paralleling, the synchronizing is handled by an external controller, typically supplied on switchgear.

## Real (kW) Load Control

When generator sets are running in parallel (electrically connected), the load controller controls the generator sets so each generator set is supplying its proportional share of power to the load while maintaining rated frequency. This is isochronous load sharing.

The load controller communicates (analog or digital) to the other load controllers and determines how much power each generator set should supply.

For PGEN paralleling, the load controller is within the Decision-Maker® 3500 controller.

For Remote Speed and Voltage Bias paralleling, the load control is performed by an external controller, typically supplied on switchgear.

## Reactive (kVAR) Control (Isolated Bus)

When generator sets are paralleled, the voltage output of each generator set must be equal. Reactive power control is needed between the generator sets to ensure that each is supplying its share of the reactive load and to minimize circulating currents. This can be done in one of two ways:

1. **Active Control (Used in PGEN Paralleling and some external paralleling).** The reactive load controller communicates (analog or digital) to the other reactive load controllers to maintain the same proportional kVAR output while maintaining the system's nominal voltage.
2. **Passive Control (Used in Droop Paralleling).** The voltage regulators are operated in droop, biasing the regulator to equalize reactive power output of the generators. There is no active control from the controller.

## 9.2 Paralleling Considerations

### 9.2.1 Generator Requirements

#### Alternator and Connections

Units to be paralleled must have the same frequency, the same number of phases, the same voltage, and the same phase rotation. The latter merely means that the voltages across the terminals must reach their maximum and minimum values in the same order. Otherwise, the magnetic forces would try to turn the rotors in opposite directions.

The pitch of the paralleled alternators needs to be the same or excessive circulating currents may occur.

#### Engine

If not already equipped, the engine must be up-fitted with an electronic isochronous governor in order to allow paralleling of the unit. This governor allows the Decision-Maker® 3500 controller to control speed, allowing load sharing and synchronizing.

#### Motorized Paralleling Circuit Breaker

The Decision-Maker® 3500 controller provides control of a single motor-operated breaker to selectively close on or off the bus. For motorized paralleling breakers, there are two options:

- On the generator set, pre-wired from the factory.
- Remotely mounted. Customer needs to wire to status, trip, close, charge motor, and bus sensing. See the wiring diagram in the operation manual for more information.

**Note:** The motor operator breaker requires a constant supply voltage of 24–30VDC. Supply voltages below 24VDC will result in failure of the motor operator breaker.

#### Speed Control (Required for Paralleling Done Via Remote Speed and Voltage Bias Method)

The Decision-Maker® 3500 controller will accept an input from the paralleling controller. This is the way the paralleling controller adjusts the frequency and controls the power output of the generator set.

The Decision-Maker® 3500 controller has the ability to accept a remote speed adjust input of:

- 0.5 – 4.5 volts  $\pm 5\%$  (values supplied outside of this range will default the setting to nominal)

**Note:** Some engines may limit this speed adjust to no more than approx.  $+3.5\%$ .

Modbus® is a registered trademark of Schneider Electric.

#### Voltage Regulator

The voltage regulator is integral to the Decision-Maker® 3500 controller and is capable of accepting remote input for voltage adjustment. It adjusts to:

- 0.5 – 4.5 volts  $\pm 10\%$  (values supplied outside of this range will default the setting to nominal)

#### Generator Set Protection

A reverse power relay senses the direction of power flow. Each generator's Decision-Maker® 3500 controller contains a reverse power relay. If any unit in the system has a malfunction such as a loss of fuel causing real power to flow into the generator, the reverse power relay will sense the reverse power and disconnect the unit from the system. If reverse power relays are not used, units still running will drive the unit that has stopped with the alternator acting as a motor.

### 9.2.2 Paralleling Controller—PGEN

#### Starting and Stopping Generator Set

The Decision-Maker® 3500 controller has supervisory control over paralleling. There are several methods that can be used to start and stop the generator set (consult the operation manual for more detail):

- CAN gauge
- Modbus®
- Kohler SiteTech™ software
- AUTO-RUN/AUTO-OFF button
- RUN button
- Contacts 3 and 4 for remote signal

#### Frequency and Real (kW) Power

Depending on the state of the paralleling motorized breaker, the Decision-Maker® 3500 controls the frequency or kW output of the generator set by sending a signal to the engine governor over J1939 (CAN).

- **Motorized Paralleling Breaker Open.** The generator set speed (frequency) will vary with this signal. This would be the case while synchronizing.
- **Motorized Paralleling Breaker Closed.** If the generator set parallel motorized breaker is closed and the generator set is operating in parallel with another power source, this signal will control the kW load provided by the generator.

## Voltage and Reactive (kVAR) Power

The Decision-Maker® 3500 controls the generator set's output voltage.

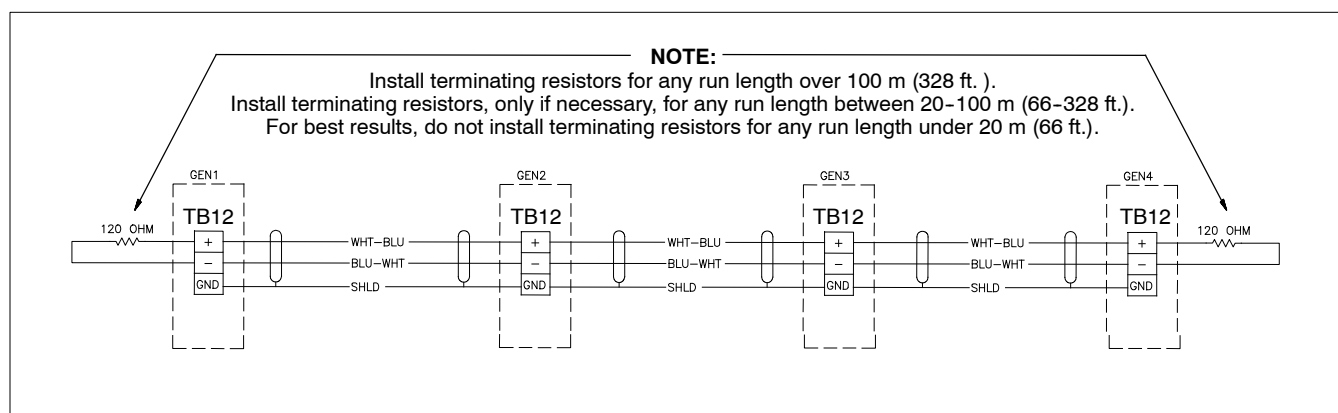
The generator set response to the signal varies depending on the state of its paralleling motorized breaker.

- **Motorized Paralleling Circuit Breaker Open.** If the motorized circuit breaker is open, the output voltage will change. This would be the case while synchronizing.
- **Motorized Paralleling Circuit Breaker Closed.** If the motorized circuit breaker is closed and the generator set is operating in parallel with another power source, this signal will control the kVAR load provided by the generator.

## 9.3 Paralleling Set Up

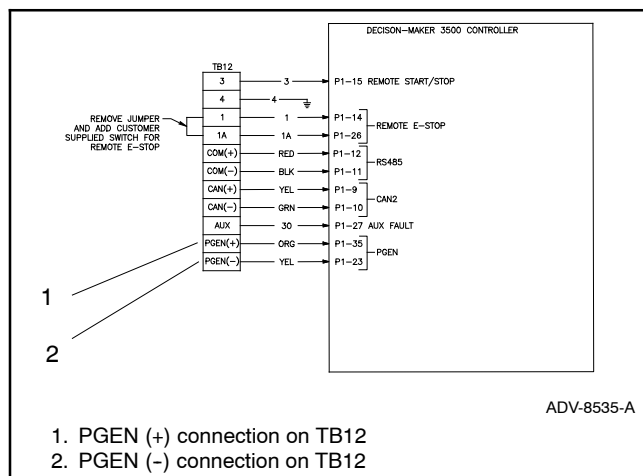
### 9.3.1 PGEN Communication Wiring

In order to parallel two or more generator sets using PGEN, a communication wire is required. Use a Belden cable #9841 (or equivalent) shielded twisted-pair communication cable. Connect the shield to ground at one end only. Tighten the connections to 0.5 Nm (4.4 in. lbs.). The PGEN connection between the generator sets is always required when the generator sets connect to a common bus. See Figure 9-3.

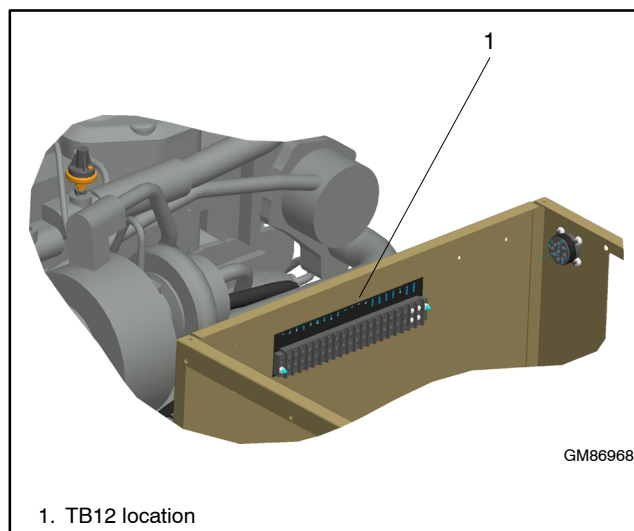


**Figure 9-3** Paralleling System Interconnection Diagram

PGEN connections are made on terminal block TB12. TB12 is located in the generator set junction box. See Figure 9-5 for TB12 location. See Figure 9-4 for PGEN connection locations. A small portion of the wiring diagram is shown in Figure 9-4. See the operation manual for the complete wiring diagram.



**Figure 9-4** Terminal Block TB12 PGEN Connections



**Figure 9-5** TB12 Terminal Block Location

### 9.3.2 Paralleling Gain Setting

The Decision-Maker® 3500 controller is preset with factory defaults for each generator model number in the personality profile. These gains should perform adequately for most applications, but it may be necessary to perform adjustment of advanced settings.

The Decision-Maker® 3500 controller uses PID (Proportional, Integral, and Derivative) type gains as explained below:

- **Proportional gain** controls the response time or sensitivity when a change, due to an error, is needed. Too high or too low of a gain value can create instability as it can make the system too sensitive or damped. Too sensitive of a gain value makes the control loop “chase” the target. A small gain makes the control loop slow to respond to a target change. Proportional gain is the primary component in making an output change.
- **Integral gain** controls how aggressive the output change will be. Too high of a gain value can cause an overshoot of the target when an output change is needed. This gain should start small and in some instances will be a fairly small value when compared to the proportional or derivative gains.
- **Derivative gain** controls the overshoot and settling time of an output change. Too low of a gain value can cause “ringing” or oscillation of an output change as the target is met. Derivative gain may not be needed in some installations as the proportional and integral gains do the bulk of the work on an output change. If the system has some instability after an output change that eventually goes away, increase the derivative gain.

### Tuning Example

Before beginning, ensure that all generator set controllers are connected to a PC via a USB cable and that all controllers are shown in SiteTech™ under the “Manage Parallel Devices” mode located at the top of the SiteTech™ screen.

**Note:** For more information on SiteTech™, see TP-6701 SiteTech™ Software Operation Manual.

If the factory-set gains are deemed inadequate, the Real Power Load Sharing gains are most likely the gains that need adjustment. Synchronizing parameters like phase match window, synchronization frequency match window, and voltage match window and their associated gains are factory-set and should not need adjustment.

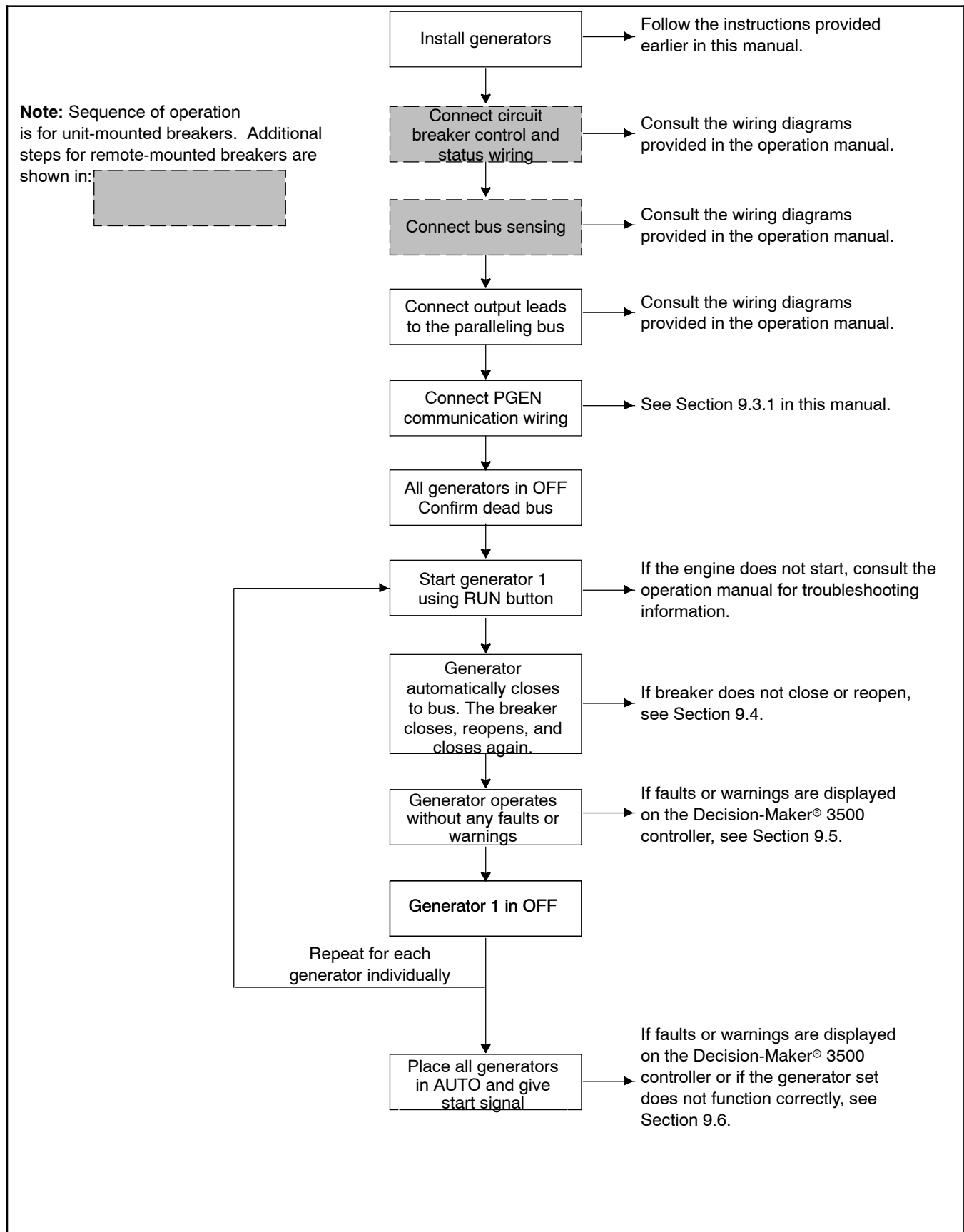
Monitoring Generator Total Real Power (located in the Generator Metering tab in SiteTech™) on all paralleled generator sets simultaneously and observing the behavior of a changing load condition provides an indication of whether an adjustment is needed. If the paralleled generator sets are able to share load at varying load steps without errors, the proportional gain is likely ok. Some shift of load from generator set to generator set is normal, but the actual kW of load movement should be minimized. If a large load movement is observed from generator set to generator set, start by decreasing the integral gain. If the load shift is happening at a high frequency, increase the derivative gain. In general, increasing the derivative gain makes the load shift happen slower. Reducing the integral gain makes the amplitude of the load being shifted smaller.

Reactive Power Load Sharing gains can be adjusted in the same way (monitor Generator Total Reactive Power located in the Generator Metering tab in SiteTech™), but it's unlikely that the factory gains will need any adjustment. Always start with the Real Power Load Sharing gains.

Any of the other Decision-Maker® 3500 controller PID gains can be adjusted using the same method explained above, however note that the derivative gains for most other parameters are disabled from the factory.

**Note:** All factory gains are values of 1 so it is simple to revert back to the factory defaults.

### 9.3.3 Decision-Maker® 3500 Paralleling Sequence of Operation



**Figure 9-6** Sequence of Operation



## 9.4 Troubleshooting When Breaker Does Not Close to Bus

### 9.4.1 Faults Not Shown

| Step | Potential Cause                        | Explanation                                                                                                                                                                                                                                                                               | Troubleshooting                                                                                                                                                                                                                                                                      |
|------|----------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | PGEN communication not operational     | The controller must have seen PGEN communication with at least one other node at some time since the last power cycle event before it will close the breaker.                                                                                                                             | In <i>Controller Config</i> -> <i>Communication Setup</i> , verify the PGEN Nodes Online is at least 2. If so, continue troubleshooting at Step 8 otherwise, continue on to Step 2.                                                                                                  |
| 2    | Single generator application           | There is only one generator on site, but the controller is expecting to see PGEN communication. The controller supports this scenario if the controller is configured in Standalone mode. Standalone mode can be set using the standalone input to the controller or in Kohler SiteTech™. | Configure a digital input to Standalone mode and assert it, or set Standalone mode in Kohler SiteTech™. Note, Standalone mode should only be asserted if there is only one generator set at the site.                                                                                |
| 3    | PGEN wiring not connected correctly    | PGEN communicates over an RS-485 connection. RS-485 requires that the network be connected in a daisy-chain configuration, terminated at 120 Ohms at either end of the network and that positive (B) and negative (A) polarity be maintained.                                             | Verify wiring, all PGEN + connections should be connected with daisy-chain wire (Belden #9841 or equivalent). Verify terminations are at the end of the network. Verify that there are no unintentional or loose connections.                                                        |
| 4    | Baud rate misconfigured                | One of the controllers on the network is attempting to communicate at a different baud rate than the other controllers. This results in collisions on the communication bus and incorrect interpretation of the data.                                                                     | In <i>Controller Config</i> -> <i>Communication Setup</i> , verify that the baud rate of all generators on the network matches. Default is 57,600 baud.                                                                                                                              |
| 5    | Interference                           | The PGEN network is seeing noise which makes it difficult for the generator controllers to communicate.                                                                                                                                                                                   | Verify that PGEN network uses Belden #9841 or equivalent. Verify that the shield drain for the cable is grounded at only one end.                                                                                                                                                    |
| 6    | Short circuit in communication wiring  | The RS-485 communication wires are short-circuited together.                                                                                                                                                                                                                              | In <i>Controller Config</i> -> <i>Communication Setup</i> , verify the PGEN Node ID is less than 16. If not, check the PGEN wiring for short circuits. Otherwise, continue troubleshooting to Step 7.                                                                                |
| 7    | Intermittent connection in PGEN wiring | Although the generator controllers can occasionally communicate, the connection is unreliable. This can be caused by a short or open circuit.                                                                                                                                             | It is not uncommon for small communications wire to not connect directly to a terminal block well. Verify there are no loose wiring connections or "whiskers" at the PGEN terminal blocks. "Fork", "ring", or "crow's feet" connectors are preferred for terminal block connections. |
| 8    | Unable to establish first-on lock      | The generator is trying to close to a dead bus but it is not receiving permission from one of the other nodes to allow it to do so. This can occur if one of the other nodes has seen a node removed from the network.                                                                    | Cycle power on all generators.                                                                                                                                                                                                                                                       |

## 9.4.2 Faults Shown

| Step                                                       | Potential Cause                                                             | Explanation                                                                                                                                                                                       | Troubleshooting                                                                                                                                                                                                                                                                                                |
|------------------------------------------------------------|-----------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Fault: System Voltage Mismatch Between Generators</b>   |                                                                             |                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                |
| 1                                                          | System voltage is not equivalent                                            | One of the controllers on the network is configured differently than the other controllers. This will inhibit any of the generators from closing to the bus.                                      | Verify the system voltage of all the generators match the requirements of the site.                                                                                                                                                                                                                            |
| <b>Fault: System Frequency Mismatch Between Generators</b> |                                                                             |                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                |
| 1                                                          | System frequency is not equivalent                                          | One of the controllers on the network is configured differently than the other controllers. This will inhibit any of the generators from closing to the bus.                                      | Verify the system frequency of all the generators match the requirements of the site.                                                                                                                                                                                                                          |
| <b>Fault: Phase Connection Mismatch Between Generators</b> |                                                                             |                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                |
| 1                                                          | Phase connection is not equivalent                                          | One of the controllers on the network is configured differently than the other controllers. This will inhibit any of the generators from closing to the bus.                                      | Verify the phase connection of all the generators match the requirements of the site.                                                                                                                                                                                                                          |
| <b>Fault: Live Bus Sensed When Dead Bus Expected</b>       |                                                                             |                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                |
| 1                                                          | Bus is considered to be live                                                | The controller is measuring voltage on the paralleling bus. This will inhibit the breaker from closing.                                                                                           | Check bus for residual voltage (sometimes induced by large transformers or motors). Possibly, adjust the Dead Bus Threshold to accommodate the residual voltage.                                                                                                                                               |
| 2                                                          | Bus sensing is not connected                                                | The controller may see voltage on the paralleling bus when the generator is operating and the bus sensing is disconnected.                                                                        | Verify the bus sensing wiring is connected to the load side of the motor-operated breaker for this generator.                                                                                                                                                                                                  |
| <b>Fault: Close Attempt<br/>Fault: Fail to Close</b>       |                                                                             |                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                |
| 1                                                          | Breaker is unable to close                                                  | The controller is attempting to close the circuit breaker but the breaker is not closing.                                                                                                         | Watch the ready flag on the motor operator of the circuit breaker, if equipped. If it indicates not ready when the engine is stopped and toggles to the ready state when the generator is trying to close the breaker, the trip coil is acting correctly. Continue at Step 5 otherwise, continue on to Step 2. |
| 2                                                          | Trip is not removed from the circuit breaker                                | The controller is attempting to close the circuit breaker but the breaker is not closing because the trip coil is still energized.                                                                | If the ready flag of the motor operator indicates ready when the engine is stopped, continue at Step 3 otherwise, continue on to Step 4.                                                                                                                                                                       |
| 3                                                          | CB trip relay is wired as normally open                                     | The controller is expecting that the trip on the circuit breaker is a normally-closed contact. This is intentional as it holds a trip on the breaker if the controller is removed.                | Verify the CB trip relay is wired to hold a trip on the breaker when the relay is not energized.                                                                                                                                                                                                               |
| 4                                                          | Incorrect wiring between the CB trip relay and the trip coil on the breaker | The CB trip relay is operating correctly but the trip coil on the breaker is remaining energized. This could be due to incorrect wiring between the generator controller and the circuit breaker. | Verify the wiring to the circuit breaker.                                                                                                                                                                                                                                                                      |
| 5                                                          | Close is not applied to the circuit breaker                                 | The breaker trip is removed but the controller is not able to close the breaker.                                                                                                                  | Verify the wiring between the generator controller and the circuit breaker close coil. Check the close coil to ensure that it is not defective.                                                                                                                                                                |
| 6                                                          | Breaker is not charged                                                      | The breaker is receiving the signal to close but the energizing spring is not charged.                                                                                                            | Verify the motor operator is receiving voltage at the appropriate contacts to allow it to wind the spring.                                                                                                                                                                                                     |

| Step                                                                             | Potential Cause                                      | Explanation                                                                                                                                                                                                                | Troubleshooting                                                                                                                                                                                         |
|----------------------------------------------------------------------------------|------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Fault: Close Attempt</b><br><b>Fault: Fail to Close</b><br><b>(Continued)</b> |                                                      |                                                                                                                                                                                                                            |                                                                                                                                                                                                         |
| 7                                                                                | Breaker is not powered                               | The 24V electronics on the circuit breaker require an external 24V source on a 12V generator.                                                                                                                              | Verify the 24V input which exists on paralleling generators is receiving 24VDC in the correct polarity.                                                                                                 |
| 8                                                                                | Wiring to power is not complete                      | There is no voltage to the CB close relay on this circuit breaker.                                                                                                                                                         | Connect the supply to the CB close relay to either 24V from wire #70 or an external 24VDC supply (with battery storage).                                                                                |
| 9                                                                                | Breaker status feedback is not valid, no bus sensing | The breaker closes but the controller does not see a change in status. The controller cannot see the bus is energized as the bus sensing is not connected correctly on any generators on the network.                      | Verify the wiring on the circuit breaker to ensure that it is connected correctly. Verify bus wiring for all nodes. Verify the generator output is connected to the line side of the generator breaker. |
| <b>Fault: CB Status</b><br><b>Warning: Bus Sensing Not Connected</b>             |                                                      |                                                                                                                                                                                                                            |                                                                                                                                                                                                         |
| 1                                                                                | Breaker status feedback is not valid, no bus sensing | The breaker closes but the controller does not see a change in status. The controller cannot see the bus is energized as the bus sensing is not connected correctly on this generator, but another generator is connected. | Verify the wiring on the circuit breaker to ensure that it is connected correctly. Verify bus wiring for this generator.                                                                                |
| <b>Fault: CB Status or Continuous Breaker Cycling</b>                            |                                                      |                                                                                                                                                                                                                            |                                                                                                                                                                                                         |
| 1                                                                                | Breaker status feedback is not valid                 | The breaker closes but the controller does not see a change in status. The controller sees the bus is now live.                                                                                                            | Verify the wiring on the circuit breaker to ensure that it is connected correctly.                                                                                                                      |

## 9.5 Troubleshooting When Breaker Does Close to Bus

### 9.5.1 Faults Shown

| Step                                      | Potential Cause                                                                      | Explanation                                                                                                                                                                                                                                                                                                                    | Troubleshooting                                                                                                                                                                                                                                                                                                                   |
|-------------------------------------------|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Fault: Close Attempt</b>               |                                                                                      |                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                   |
| <b>Fault: Fail to Close</b>               |                                                                                      |                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                   |
| 1                                         | Breaker status feedback is not valid, no bus sensing                                 | The breaker closes but the controller does not see a change in status. The controller cannot see the bus is energized as the bus sensing is not connected correctly on any generators on the network.                                                                                                                          | Verify the wiring on the circuit breaker to ensure that it is connected correctly. Verify bus wiring for all nodes. Verify the generator output is connected to the line side of the generator breaker.                                                                                                                           |
| <b>Fault: CB Status</b>                   |                                                                                      |                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                   |
| 1                                         | Breaker status feedback is not connected                                             | The breaker closes but the controller does not see a change in status. The controller sees the bus is now live.                                                                                                                                                                                                                | Verify the wiring on the circuit breaker to ensure that it is connected correctly.                                                                                                                                                                                                                                                |
| 2                                         | Breaker status is short circuited                                                    | The controller sees the breaker is closed even when it is not trying to open it.                                                                                                                                                                                                                                               | Verify connection of the breaker status wiring at the circuit breaker.                                                                                                                                                                                                                                                            |
| 3                                         | Breaker status feedback is connected to the wrong contacts                           | The controller sees open status for the breaker after telling it to close, closed status after telling it to open.                                                                                                                                                                                                             | The controller is expecting the breaker status to be an "A" contact. Verify the circuit breaker auxiliary contacts are either:<br>11 and 14<br>21 and 24<br>31 and 34 or<br>41 and 44.<br>If the breaker status contacts are removable, make sure that they are inserted in one of the OF slots and that the wires go to 1 and 4. |
| 4                                         | Breaker status feedback is connected to a latching contact                           | The breaker status indicated that it closed when it was triggered to close but it did not indicate that it was open when the breaker opened. This fault will only occur if the bus sensing is connected correctly (the controller sees the voltage go to 0 when the breaker is triggered to open).                             | Verify the breaker status input to the controller is connected directly to an auxiliary contact on the circuit breaker.                                                                                                                                                                                                           |
| <b>Fault: Bus Phase Rotation Mismatch</b> |                                                                                      |                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                   |
| 1                                         | All of the bus sensing wires are incorrectly connected                               | The bus sensing wires must be connected to phase A, phase B, and phase C of the bus. If any two connections are reversed, the controller can detect the reversed connections. This fault will only occur if all three wires are incorrectly connected.                                                                         | Verify the bus metering connections.                                                                                                                                                                                                                                                                                              |
| 2                                         | The phase connections on the paralleling breaker are inconsistent with the generator | The power leads from the generator to the paralleling circuit breaker must be connected consistently. Phase A from the generator must go to phase A of the line side of the paralleling (motor operated) breaker, phase B from the generator to phase B of the breaker and phase C of the generator to phase C of the breaker. | Verify the output cable connections.                                                                                                                                                                                                                                                                                              |
| 3                                         | Generator sensing is connected incorrectly                                           | The controller measurement leads are not connected to the appropriate output phases or the phases are incorrectly labeled.                                                                                                                                                                                                     | Verify the sensing leads from the controller are connected to the appropriate output leads from the generator. L1 should connect to phase A, L2 to phase B, L3 to phase C, L0 to neutral.                                                                                                                                         |
| 4                                         | Breaker to bus wiring is inconsistent                                                | In applications where the bus sensing is taken from a location other than the load side of the paralleling breaker, it is possible to connect the wiring incorrectly between the load side of the output breaker and the paralleling bus.                                                                                      | Verify the cable connections from the paralleling breaker to the paralleling bus.                                                                                                                                                                                                                                                 |

| Step                                                 | Potential Cause                                                                      | Explanation                                                                                                                                                                                                                                                                                                                     | Troubleshooting                                                                                                                                                                       |
|------------------------------------------------------|--------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Fault: Bus Voltage Amplitude Mismatch-Phase A</b> |                                                                                      |                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                       |
| 1                                                    | The phase A voltage of the bus does not match the generator                          | The voltage measured on the bus sensing for phase A does not match the voltage measured on phase A of the generator.                                                                                                                                                                                                            | Verify the bus sensing wire for phase A is connected to phase A of the load side of the paralleling breaker and there are no breaks in the wire.                                      |
| <b>Fault: Bus Voltage Amplitude Mismatch-Phase B</b> |                                                                                      |                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                       |
| 1                                                    | The phase B voltage of the bus does not match the generator                          | The voltage measured on the bus sensing for phase B does not match the voltage measured on phase B of the generator.                                                                                                                                                                                                            | Verify the bus sensing wire for phase B is connected to phase B of the load side of the paralleling breaker and there are no breaks in the wire.                                      |
| <b>Fault: Bus Voltage Amplitude Mismatch-Phase C</b> |                                                                                      |                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                       |
| 1                                                    | The phase C voltage of the bus does not match the generator                          | The voltage measured on the bus sensing for phase C does not match the voltage measured on phase C of the generator.                                                                                                                                                                                                            | Verify the bus sensing wire for phase C is connected to phase C of the load side of the paralleling breaker and there are no breaks in the wire.                                      |
| <b>Fault: Bus Voltage Amplitude Mismatch</b>         |                                                                                      |                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                       |
| 1                                                    | The bus metering is not connected correctly                                          | The bus metering is not connected to the appropriate lugs of the load side of the paralleling breaker (but there is some voltage present).                                                                                                                                                                                      | Verify the bus sensing wire for all three phases is connected to the appropriate lugs on the load side of the paralleling breaker and there are no breaks in any of the wires.        |
| 2                                                    | The generator metering is not connected correctly                                    | The generator metering is not connected to the output of the generator.                                                                                                                                                                                                                                                         | Verify the generator metering is sensed at the output of the generators. A common mistake is to connect the metering to the center tap voltages V7, V8, V9.                           |
| <b>Fault: Phase Angle Mismatch</b>                   |                                                                                      |                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                       |
| 1                                                    | All of the bus sensing wires are incorrectly connected                               | The bus sensing wires must be connected to phase A, phase B and phase C of the bus. If any two connections are reversed, the controller can detect the reversed connections. This fault will only occur if all three wires are incorrectly connected.                                                                           | Verify the bus metering connections.                                                                                                                                                  |
| 2                                                    | The phase connections on the paralleling breaker are inconsistent with the generator | The power leads from the generator to the paralleling circuit breaker must be connected consistently. Phase A from the generator must go to phase A of the line side of the paralleling (motor operated) breaker, phase B from the generator to phase B of the breaker, and phase C of the generator to phase C of the breaker. | Verify the output cable connections.                                                                                                                                                  |
| 3                                                    | Generator sensing is connected incorrectly                                           | The controller measurement leads are not connected to the appropriate output phases or the phases are incorrectly labeled.                                                                                                                                                                                                      | Verify sensing leads from the controller are connected to the appropriate output leads from the generator. L1 should connect to phase A, L2 to phase B, L3 to phase C, L0 to neutral. |
| 4                                                    | Breaker to bus wiring is inconsistent                                                | In applications where the bus sensing is taken from a location other than the load side of the paralleling breaker, it is possible to connect the wiring incorrectly between the load side of the output breaker and the paralleling bus.                                                                                       | Verify cable connections from the paralleling breaker to the paralleling bus.                                                                                                         |
| <b>Fault: Bus Frequency Mismatch</b>                 |                                                                                      |                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                       |
| 1                                                    | Abnormal condition                                                                   | Bus frequency is not similar to generator frequency with breaker closed.                                                                                                                                                                                                                                                        | Verify bus metering is connected correctly. Reset the controller.                                                                                                                     |

| Step                                                  | Potential Cause                                                                               | Explanation                                                                                                                                     | Troubleshooting                                                                                                                          |
|-------------------------------------------------------|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Fault: Bus Sensing Phases A and B are Reversed</b> |                                                                                               |                                                                                                                                                 |                                                                                                                                          |
| 1                                                     | The bus sensing for phase A is connected to phase B of the paralleling bus and vice versa     | Phase angle from generator to bus is about 180° and bus rotation is backwards.                                                                  | Verify wiring between bus sensing inputs and load side of paralleling breaker.                                                           |
| 2                                                     | The wiring between the generator and the paralleling breaker is incorrect                     | Phase angle from generator to bus is about 180° and bus rotation is backwards.                                                                  | Verify wiring between generator and paralleling breaker.                                                                                 |
| 3                                                     | The generator metering is not connected correctly                                             | Phase angle from generator to bus is about 180° and bus rotation is backwards.                                                                  | Verify metering connections on the generator. L1 should connect to the phase A output lead. L2 to phase B, L3 to phase C, L0 to neutral. |
| <b>Fault: Bus Sensing Phases B and C are Reversed</b> |                                                                                               |                                                                                                                                                 |                                                                                                                                          |
| 1                                                     | The bus sensing for phase B is connected to phase C of the paralleling bus and vice versa     | Phase angle from generator to bus is about -120° and bus rotation is backwards.                                                                 | Verify wiring between bus sensing inputs and load side of paralleling breaker.                                                           |
| 2                                                     | The wiring between the generator and the paralleling breaker is incorrect                     | Phase angle from generator to bus is about -120° and bus rotation is backwards.                                                                 | Verify wiring between generator and paralleling breaker.                                                                                 |
| 3                                                     | The generator metering is not connected correctly                                             | Phase angle from generator to bus is about -120° and bus rotation is backwards.                                                                 | Verify metering connections on the generator. L1 should connect to the phase A output lead. L2 to phase B, L3 to phase C, L0 to neutral. |
| <b>Fault: Bus Sensing Phases C and A are Reversed</b> |                                                                                               |                                                                                                                                                 |                                                                                                                                          |
| 1                                                     | The bus sensing for phase A is connected to phase C of the paralleling bus and vice versa     | Phase angle from generator to bus is about 120° and bus rotation is backwards.                                                                  | Verify wiring between bus sensing inputs and load side of paralleling breaker.                                                           |
| 2                                                     | The wiring between the generator and the paralleling breaker is incorrect                     | Phase angle from generator to bus is about 120° and bus rotation is backwards.                                                                  | Verify wiring between generator and paralleling breaker.                                                                                 |
| 3                                                     | The generator metering is not connected correctly                                             | Phase angle from generator to bus is about 120° and bus rotation is backwards.                                                                  | Verify metering connections on the generator. L1 should connect to the phase A output lead. L2 to phase B, L3 to phase C, L0 to neutral. |
| <b>Fault: Bus Sensing Not Connected</b>               |                                                                                               |                                                                                                                                                 |                                                                                                                                          |
| 1                                                     | No wires connect the bus sensing on the generator to the load side of the paralleling breaker | Wiring not connected between load side of the paralleling breaker and the bus metering.                                                         | Verify that the bus sensing is connected.                                                                                                |
| 2                                                     | No leads connect the generator output to the line side of the paralleling breaker             | The leads connecting the output of the generator to the paralleling breaker are not connected.                                                  | Verify that the leads connecting the generator to the paralleling breaker are connected.                                                 |
| 3                                                     | The line circuit breaker is open                                                              | The line circuit breaker (at the generator) is open, disconnecting the output from the generator from the line side of the paralleling breaker. | Verify that the line circuit breaker is closed.                                                                                          |

| Step                                                             | Potential Cause                                                        | Explanation                                                                                                                                                                                                                | Troubleshooting                                                                                                              |
|------------------------------------------------------------------|------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| <b>Fault: Bus Sensing Connected to Generator Side of Breaker</b> |                                                                        |                                                                                                                                                                                                                            |                                                                                                                              |
| 1                                                                | Bus metering is connected to the wrong side of the paralleling breaker | The controller sees the bus voltage always matches the generator voltage, even when the breaker contacts indicate that the breaker is open.                                                                                | Verify the bus metering is connected on the load side of the paralleling breaker.                                            |
| 2                                                                | Breaker is closed and status feedback is not connected                 | The controller sees that the bus voltage always matches the generator voltage, even when the breaker contacts indicate that the breaker is open.                                                                           | Verify the paralleling breaker control wiring is connected correctly and the status feedback is connected to an "A" contact. |
| <b>Fault: Failure to Open</b>                                    |                                                                        |                                                                                                                                                                                                                            |                                                                                                                              |
| 1                                                                | Wiring between CB trip relay and trip coil is not connected            | The CB trip relay is releasing, but the coil in the breaker is not energizing, hence the breaker is not opening.                                                                                                           | Verify wiring to the trip coil (A4) is connected correctly.                                                                  |
| 2                                                                | CB trip relay is not receiving 24V power                               | The CB trip relay is releasing, but there is no voltage to apply to the trip coil. This is most likely to occur when the generator has a 12V battery and there is an external battery bank to operate the circuit breaker. | Verify the CB trip relay has a 24VDC supply which is common to the CB close relay and charge motor.                          |

## 9.6 Troubleshooting When Running in AUTO

### 9.6.1 Faults Shown

| Step                                                 | Potential Cause                                                                                                               | Explanation                                                                                                                                                                                                                                                                                                                                                                                                                                           | Troubleshooting                                                                                                                                                                                                                                                                                                       |
|------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Fault: Generator Phase Rotation Mismatch</b>      |                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                       |
| 1                                                    | This generator is wired with the opposite phase rotation of all the other generators on the paralleling bus                   | The controller has validated that the bus metering is accurate relative to this generator, if the bus phase rotation is backwards to the generator, the phase rotation must really be different.                                                                                                                                                                                                                                                      | Verify wiring between this generator and the paralleling breaker. It may be necessary to reverse two phases between the generator and the paralleling breaker and then to reverse the sensing at the bus to match. This generator should be started and closed to a dead bus again to validate the changes.           |
| 2                                                    | The wiring between the paralleling breaker and the paralleling bus is incorrectly connected (two phases are reversed)         | Voltage from other generators comes into this generator as incorrect phase rotation because the wiring connections to the paralleling bus are reversed, even though the rotation of the other generators is identical to the rotation of this generator.                                                                                                                                                                                              | Verify wiring between the paralleling breaker and the paralleling bus. It may be necessary to reverse the connection of two of the leads. This generator should be started and closed to a dead bus again to validate the changes.                                                                                    |
| 3                                                    | The generator which is connected to the paralleling bus has the opposite phase rotation of this generator and all others      | Voltage from the other generator comes into this generator as incorrect phase rotation because the wiring connections from the other generator to the paralleling bus are reversed, even though the rotation of the other generators is identical to the rotation of this generator.                                                                                                                                                                  | Verify wiring between the paralleling breaker and the paralleling bus of the other generator. It may be necessary to reverse two phases between the paralleling breaker and the paralleling bus on the other generator. The other generator should be started and closed to a dead bus again to validate the changes. |
| <b>Fault: Dead Bus Sensed When Live Bus Expected</b> |                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                       |
| 1                                                    | The wiring was not connected between the load side of the paralleling breaker for this generator and the paralleling bus      | This generator controller observed accurate bus voltage when it closed the breaker, the other generator controller did the same, but the bus of this generator is not connected to the bus of the other generator. The other generator is energizing the load, this generator cannot energize the load as there is a disconnected wiring between this generator and the paralleling bus.                                                              | Verify wiring between the paralleling breaker and the paralleling bus of this generator.                                                                                                                                                                                                                              |
| 2                                                    | The wiring was not connected between the load side of the paralleling breaker for the other generator and the paralleling bus | This generator controller observed accurate bus voltage when it closed the breaker, the other generator controller did the same, but the bus of this generator is not connected to the bus of the other generator. The other generator is not energizing the load because it is not connected to it—this generator may be able to energize the load, but there is no simple way of telling this without connecting the output of the other generator. | Verify wiring between the paralleling breaker and the paralleling bus of the other generator.                                                                                                                                                                                                                         |
| <b>Fault: Bus Voltage Out of Spec</b>                |                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                       |
| 1                                                    | The generators which are connected to the paralleling bus are overloaded                                                      | When the generators which are supplying a load are overloaded, their engine speed will decrease, resulting in a decrease in output voltage. Sometimes this decrease in output voltage is sufficient to allow the generators to recover.                                                                                                                                                                                                               | Verify the load requirements are met by a single generator. If not, it may be necessary to connect several low priority loads to load shed outputs from the paralleling generators to avoid overloading a single generator.                                                                                           |
| 2                                                    | Excessive cable lengths from generators to paralleling bus                                                                    | Although a single generator can handle the load, the cables which connect the generator to the paralleling bus are too long or too small of gauge, resulting in insufficient bus voltage.                                                                                                                                                                                                                                                             | Increase wire size on the generator connection leads.                                                                                                                                                                                                                                                                 |



| Step                                                               | Potential Cause                                                                                   | Explanation                                                                                                                                                                                                                                                                                                                                                    | Troubleshooting                                                                                                                                                                                                             |
|--------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Fault: Bus Frequency Out of Spec</b>                            |                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                             |
| 1                                                                  | The generators which are connected to the paralleling bus are overloaded                          | When the generators which are supplying a load are overloaded, their engine speed will decrease, resulting in a decrease in output voltage. Sometimes this decrease in output voltage is sufficient to allow the generators to recover.                                                                                                                        | Verify the load requirements are met by a single generator. If not, it may be necessary to connect several low priority loads to load shed outputs from the paralleling generators to avoid overloading a single generator. |
| <b>Fault: Failure to Synchronize</b>                               |                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                             |
| 1                                                                  | Varying load requirements drive generator frequency unstable                                      | Heavy variations in the load on a generator will cause the speed of the generator to vary significantly. It can be difficult to synchronize with a generator with continuously changing frequency.                                                                                                                                                             | Adjustment of synchronizing dwell time or synchronizing gains may improve ability to synchronize.                                                                                                                           |
| 2                                                                  | Fuel variations or other environmental factors cause the generator frequency regulation to suffer | When the frequency regulation is impeded by atmospheric conditions or fuel quality, the ability to synchronize may be affected. Not only is the bus varying more than normal, but it is more difficult for the generator to control speed while synching.                                                                                                      | It may be necessary to adjust the synchronizing gains.                                                                                                                                                                      |
| 3                                                                  | Different sized units or units of different fuel types                                            | The factory synchronizing gains were calibrated for equal-sized units. The response of a large unit to a small one is slightly different than two small units. A diesel generator has significantly better frequency regulation than a natural gas generator.                                                                                                  | It may be necessary to adjust the synchronizing gains.                                                                                                                                                                      |
| <b>Fault: Generator Voltage Average Line to Line: High Warning</b> |                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                             |
| 1                                                                  | Metering calibration issue                                                                        | All the generators on the paralleling bus attempt to control to the same voltage. If one has incorrect calibration, it may see this voltage as a much higher level than the other generators, resulting in a protective relay trip.                                                                                                                            | Verify the controller is measuring voltage accurately. If not, re-calibrate it.                                                                                                                                             |
| 2                                                                  | Voltage drop on generator connection leads                                                        | If the generator is sourcing high current through too small of output leads, the voltage drop in these cables may require the generator to run at an increased voltage to supply the necessary current to the paralleling bus.                                                                                                                                 | Install oversized connecting leads for the generator to minimize voltage drop between the generator and the paralleling bus.                                                                                                |
| 3                                                                  | Attempting to operate a generator in base-load mode while it is connected to a variable load      | The speed bias and voltage bias control real and reactive load in base-load mode against a source with a nearly constant frequency and voltage (such as a utility source). If the generator is disconnected from the utility source, the speed and voltage will deviate to either extreme of the bias range, depending on the target load and the actual load. | Install contacts in series with the base-load mode input to the controller which are disconnected when the utility source is disconnected from the paralleling bus.                                                         |
| <b>Fault: Generator Voltage Average Line to Line: Low Warning</b>  |                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                             |
| 1                                                                  | Metering calibration issue                                                                        | All the generators on the paralleling bus attempt to control to the same voltage. If one has incorrect calibration, it may see this voltage as a much lower level than the other generators, resulting in a protective relay trip.                                                                                                                             | Verify the controller is measuring voltage accurately. If not, re-calibrate it.                                                                                                                                             |
| 2                                                                  | Attempting to operate a generator in base-load mode while it is connected to a variable load      | The speed bias and voltage bias control real and reactive load in base-load mode against a source with a nearly constant frequency and voltage (such as a utility source). If the generator is disconnected from the utility source, the speed and voltage will deviate to either extreme of the bias range, depending on the target load and the actual load. | Install contacts in series with the base-load mode input to the controller which are disconnected when the utility source is disconnected from the paralleling bus.                                                         |

| Step                                                   | Potential Cause                                                                              | Explanation                                                                                                                                                                                                                                                                                                                                                    | Troubleshooting                                                                                                                                                     |
|--------------------------------------------------------|----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Fault: AC Frequency: High Warning</b>               |                                                                                              |                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                     |
| 1                                                      | Attempting to operate a generator in base-load mode while it is connected to a variable load | The speed bias and voltage bias control real and reactive load in base-load mode against a source with a nearly constant frequency and voltage (such as a utility source). If the generator is disconnected from the utility source, the speed and voltage will deviate to either extreme of the bias range, depending on the target load and the actual load. | Install contacts in series with the base-load mode input to the controller which are disconnected when the utility source is disconnected from the paralleling bus. |
| <b>Fault: AC Frequency: Low Warning</b>                |                                                                                              |                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                     |
| 1                                                      | Attempting to operate a generator in base-load mode while it is connected to a variable load | The speed bias and voltage bias control real and reactive load in base-load mode against a source with a nearly constant frequency and voltage (such as a utility source). If the generator is disconnected from the utility source, the speed and voltage will deviate to either extreme of the bias range, depending on the target load and the actual load. | Install contacts in series with the base-load mode input to the controller which are disconnected when the utility source is disconnected from the paralleling bus. |
| <b>Fault: Generator Total Real Power: High Warning</b> |                                                                                              |                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                     |
| 1                                                      | Continuous overload                                                                          | The generator breaker will trip to protect the generator from damage due to excessive loads.                                                                                                                                                                                                                                                                   | Ensure that the load is low enough for a single generator to support it.                                                                                            |
| <b>Fault: Generator Total Real Power: Low Warning</b>  |                                                                                              |                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                     |
| 1                                                      | Loss of fuel pressure                                                                        | The generator breaker will trip to prevent generator operation. Otherwise, power could be absorbed from other generators causing potential damage to the fuel system by operating without lubrication.                                                                                                                                                         | Ensure that the generator has sufficient fuel to support load. Connect a fuel level sensor and place Generator Management in Fuel Level Equalization mode.          |
| 2                                                      | Quick ramp rate settings                                                                     | The real power may overshoot when in a real power control situation such as base load or system control.                                                                                                                                                                                                                                                       | It may be necessary to adjust the load control gains.                                                                                                               |
| 3                                                      | Different sized units or units of different fuel types.                                      | The real power may overshoot when in a real power control situation such as a load ramp or a quickly changing customer load.                                                                                                                                                                                                                                   | It may be necessary to adjust the kW load sharing gains.                                                                                                            |
| 4                                                      | Different engine speed adjust settings                                                       | Setting the Engine Speed Adjust parameter high on a generator will result in that generator providing more real power than the other generators. It is possible to drive the other generators offline in light loading conditions.                                                                                                                             | Set the engine speed adjustment similarly on all generators.                                                                                                        |
| <b>Fault: Generator Current Average: High Warning</b>  |                                                                                              |                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                     |
| 1                                                      | Excessive reactive load                                                                      | The generator breaker will trip to prevent the generator from damage due to excessive stator current. Note, the controller also has a heat-model-based alternator protection algorithm (which will shut the generator down).                                                                                                                                   | Ensure that the load is low enough for a single generator to support it.                                                                                            |

| Step                                                                        | Potential Cause                                                                                                 | Explanation                                                                                                                                                                                                                         | Troubleshooting                                                                                                                           |
|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Fault: Generator Total Reactive Power: Low Warning</b>                   |                                                                                                                 |                                                                                                                                                                                                                                     |                                                                                                                                           |
| 1                                                                           | Different sized units                                                                                           | The reactive power may overshoot when in a power control situation such as a load ramp or a quickly changing customer load.                                                                                                         | It may be necessary to adjust the kVAR load sharing gains.                                                                                |
| 2                                                                           | Different automatic voltage regulator settings                                                                  | Setting the Engine Speed Adjust parameter high on a generator will result in that generator providing more real power than the other generators. It is possible to drive the other generators offline in light loading conditions.  | Set the voltage regulator average voltage adjustment to the same value on all connected generators.                                       |
| 3                                                                           | Different voltage calibrations                                                                                  | Because each generator will attempt to match the target output voltage, generators with incorrect calibration may be targeting a different output voltage, thus generating or absorbing VARs.                                       | Verify the controller is measuring voltage accurately. If not, re-calibrate.                                                              |
| 4                                                                           | Failure in voltage regulator or activator board                                                                 | The generator breaker will trip to prevent the generator from absorbing VARs from the other generators. Providing power while absorbing VARs may cause that alternator to slip a pole—potentially damaging the rotor or crankshaft. | Verify the voltage regulator and activator are ok. Perform load tests to verify.                                                          |
| <b>Fault: Generator Management Enabled: Erroneous Data Received Warning</b> |                                                                                                                 |                                                                                                                                                                                                                                     |                                                                                                                                           |
| 1                                                                           | Two generators that are communicating on the network have different Order Selection modes                       | Generator management will not operate if any generators on the PGEN network have different Order Selection modes.                                                                                                                   | Adjust the Order Selection mode on any generator on the network to set the Order Selection mode in all controllers.                       |
| 2                                                                           | Two generators that are communicating on the network have different Stability delays                            | Generator management will not operate if any generators on the PGEN network have different Stability delays.                                                                                                                        | Adjust the Order Selection mode on any generator on the network to set the Stability delay in all controllers.                            |
| 3                                                                           | Two generators that are communicating on the network have different Redundancy Requirements                     | Generator management will not operate if any generators on the PGEN network have different Redundancy Requirements.                                                                                                                 | Adjust the Order Selection mode on any generator on the network to set the Redundancy Requirements in all controllers.                    |
| 4                                                                           | Two generators that are communicating on the network have different Maximum Run Time Hour Difference Thresholds | Generator management will not operate if any generators on the PGEN network have different Maximum Run Time Hour Difference Thresholds.                                                                                             | Adjust the Order Selection mode on any generator on the network to set the Maximum Run Time Hour Difference Threshold in all controllers. |
| 5                                                                           | Two generators that are communicating on the network have different Maximum Fuel Level Difference Thresholds    | Generator management will not operate if any generators on the PGEN network have different Maximum Fuel Level Difference Thresholds.                                                                                                | Adjust the Order Selection mode on any generator on the network to set the Maximum Fuel Level Difference Threshold in all controllers.    |

## 9.7 Generator Management Setup

Generator Management starts and stops generators based on the requirements of the load. The order in which the generators are started or stopped is determined according to one of the following:

- **Manual/Fixed**—The starting order of the generators is determined at the time of configuration (It is adjustable at a later time through the menu on the controller display). The controllers automatically negotiate to ensure that no two units have the same order number – setting the order number on one controller which conflicts with the order of another controller will cause the two controllers to exchange order numbers.
- **Run Time**—The starting order of the generators is determined based on the run time hours on the generators. The generator with the most run time hours will stop first and start last. Generators which are already running are allowed to continue to run until their run time hours exceed stopped the run time hours of a stopped generator by an adjustable threshold.
- **Fuel Level**—The starting order of the generators is determined based on the fuel level remaining in the supply tanks for the generators. This option is only valid if the generators have indication of fuel level.

### Typical Applications for Manual Order Selection Mode:

- Units of various sizes are operated in a prime power application and the generator management settings are optimized for minimal fuel consumption.
- An older unit is intended to accumulate most of the run time hours because it is scheduled for replacement soon.
- Some units are quieter or located more remotely than other units, making them more desirable to operate.
- A unit is in need of maintenance but is still operational—this unit can be used if necessary, but should not operate more than is necessary.

### Typical Applications for Run Time Order Selection Mode:

- Normal Standby Power systems without special requirements.
- Multiple generator system where all generators are of identical size and age, where the generator run time should remain essentially identical.
- Prime power applications where the generators are all of similar size.

### Typical Applications for Fuel Level Order Selection Mode:

- Prime power applications where the generators have individual fuel tanks and have level indication on the fuel tanks.
- Standby applications where the generators have individual fuel tanks and have level indication on the fuel tanks.

#### 9.7.1 Manual Order Selection Setup:

The Generator Management order should be configured so that the generator which is preferred to run has the lowest order. If the controllers are communicating over PGEN, changing the order on one generator will cause the order of the other generators to rearrange to accommodate the changed order of the one generator.

The Manual Start order can be changed through the menu on the controller display at any time after the commissioning of the site is complete.

#### 9.7.2 Run Time Order Selection Setup

When Run Time Order Selection Mode is selected, Generator Management will automatically adjust the order of the connected generators based on their run time hours. The order of each should reflect the relative run time of that generator if all the generators are running or all the generators are stopped. The generator with the lowest run time will be started first.

Because a generator will not be accumulating run time when it is stopped, it is necessary to add a stability threshold to each generator which is not running or the generators will start 12 minutes after they stop (0.2 hours). This threshold is called the Generator Management Run Time Threshold.

Configure the threshold to allow the generators to equalize run time without starting and stopping each generator unnecessarily. The factory default is 12.0 hours—one of the running generators will have to have 12.0 fewer hours than the generator that is stopped before the generator will start. Once that generator is online, the generator with the most run time hours will stop.

#### 9.7.3 Fuel Level Selection Setup

When Run Time Order Selection Mode is selected, Generator Management will automatically adjust the order of the connected generators based on their fuel level. The order of each should reflect the relative fuel level of that generator if all the generators are running or

all the generators are stopped. The generator with the most fuel will be started first.

Because a generator will not be consuming fuel when it is stopped, it is necessary to add a stability threshold to each generator which is not running or the generators will start as soon as 1% of the running generator's fuel is consumed. This threshold is called the Generator Management Fuel Level Threshold.

Configure the threshold to allow the generators to equalize run time without starting and stopping each generator unnecessarily. The factory default is 10% of fuel level—one of the running generators will have to have 10% less fuel than the generator that is stopped before the generator will start. Once that generator is online, the generator with the least fuel will stop.

## 9.7.4 Paralleling Parameters

### Generator Management Enabled

Set this to true if Generator Management is desired for this application

### Generator Management Stability Delay

The Stability Delay is intended to ensure that all loads have returned to their normal demand before Generator Management considers stopping a generator.

All generators will be told to run until the Stability Delay has expired.

### Generator Management Minimum Gens Online

The Minimum Gens Online parameter will allow the system to be configured to require at least 1 generator or to require at least 2 generators. If set to 2 Generators, the system will always keep one more generator online than is required.

**Note:** The default setting is 2.

### Generator Management Min Load Shed Priority

The Minimum Load Shed Priority is the priority which has to be online to allow Generator management to become active (start the stability timer). This parameter should match the maximum load shed priority that is connected to an actual load.

The default setting is 6 (load priority 6 must be online before generator management becomes active).

### Generator Start Percentage

The Generator Start Percentage is the percent load on the running generators above which this generator will begin timing for the Generator Start Delay.

The default setting is 80%, this means that the other generators will have more than 80% load on them before this generator will begin timing for the Generator Start Delay.

### Generator Stop Percentage

The Generator Stop Percentage is the percent load on the other running generators below which this generator will begin timing for the Generator Stop Delay. The Stop percentage is calculated as if this generator was not running (the percent load on the remaining generators).

The default setting is 60%, this means that the total load on all the running generators is low enough that all the running generators other than this one will have less than 60% load on them if they were supporting the load. The order 1 generator does not stop.

### Generator Start kW

The Generator Start kW is calculated based on the Start kW's of each of the generators with a lower order number and the Start percentage for this generator. The Start kW is the total load on the bus above which this generator will begin timing for the Generator Start Delay.

### Generator Stop kW

The Generator Stop kW is calculated based on the Stop kW's of each of the generators with a lower order number and the Stop percentage for this generator. The Stop kW is the total load on the bus below which this generator will begin timing for the Generator Stop Delay.

### Generator Start Delay

The Generator Start Delay is the time delay in seconds for this generator to start. Because the start delay is actually a curve based on the difference between the actual kW and the start kW of this generator, the start delay is actually the time for the generator to start with a 10% overload.

### Generator Stop Delay

The Generator Stop Delay is the time delay in seconds for this generator to stop. Because the stop delay is actually a curve based on the difference between the actual kW and the stop kW of this generator, the start delay is actually the time for the generator to start with 10% less load than the stop kW.

## 9.8 Load Add/Shed Configuration

The Load Add/Shed configuration (also known as load control) is intended to remove non-critical loads from the generator in the event of a condition where the generator capacity is insufficient to support the load. This allows the critical loads to receive power until the load decreases or the capacity increases.

### 9.8.1 Load Add/Shed Setup

#### Generator Maximum Percent Capacity

This is the maximum load on the generator which the Load Add/Shed will automatically allow. If the load exceeds this level, no additional loads will be added until the load decreases below this level. The time to add a load increases as the load approaches this level.

#### Generator Overloaded Percent

This is the maximum load that the generator will support before it begins to shed load. The time to shed a load decreases as the load on the generator increases.

#### Load Priority Configuration

The Load Shed priorities are events which can be assigned to programmable IO. Priorities 1 and 2 are defaulted to RDO outputs 3 and 4. The priorities can be configured to outputs on the 14 relay dry contact kit or each controller on the network can be given consecutive assignments to the existing IO.

For Example:

Generator #1—Load Shed Priority 1 and Load Shed Priority 2

Generator #2—Load Shed Priority 3 and Load Shed Priority 4

Generator #3—Load Shed Priority 5 and Load Shed Priority 6

**Note:** The load control outputs behave similarly on each of the generators. If an output is configured for Load Shed Priority 1 on all generators, they will all shed and add at the same time.

**Note:** The advantage of setting a few load shed outputs on each controller is that if one generator has the battery removed for service, the load control outputs on the other controllers are still able to shed loads (allowing the system to shed non-critical loads and continue supplying critical loads with power). The priorities that are shed may be more important than the priorities that are controlled by the disconnected generator but at least the critical loads will not lose power due to an overload condition.

## 9.9 ECU Parameter Settings (55-200EOZD(C)J and 40-175EFOZD(C)J Models)

If encountering throttle input fault codes (e.g.: SPN 29 and/or SPN 91) and/or applications that require changes to the engine governor droop settings, follow the steps in Section 9.9.

**Note:** Have setup and adjustments of the ECU performed only by an authorized Kohler distributor/dealer. The setup and adjustments are password protected.

**Note:** In order to ensure the most current files are used, download the files onto your laptop immediately before visiting the vessel's generator set. While at your facility, have a good Internet connection for data transfer to your laptop.

The following procedure(s) are performed by authorized Kohler distributors/dealers who have access to John Deere's Service Advisor and who have been trained on how to use John Deere's Service Advisor.

**Note:** Service Advisor 5 is referenced in this section.

1. Login to John Deere's Service Advisor software. Enter your User Name and Password. Click the "Sign In" button. See Figure 9-7.

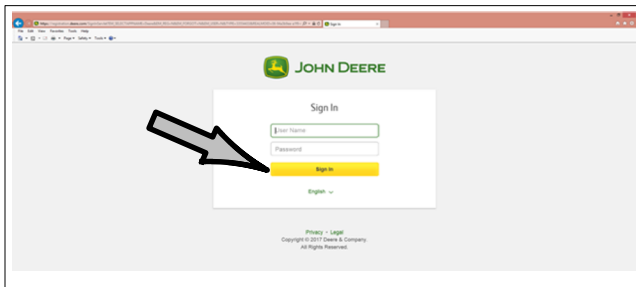


Figure 9-7 Sign In Screen

2. Click the "I Agree" button. See Figure 9-8.



Figure 9-8 License Agreement Screen

3. Click the "Jobs" icon. See Figure 9-9.

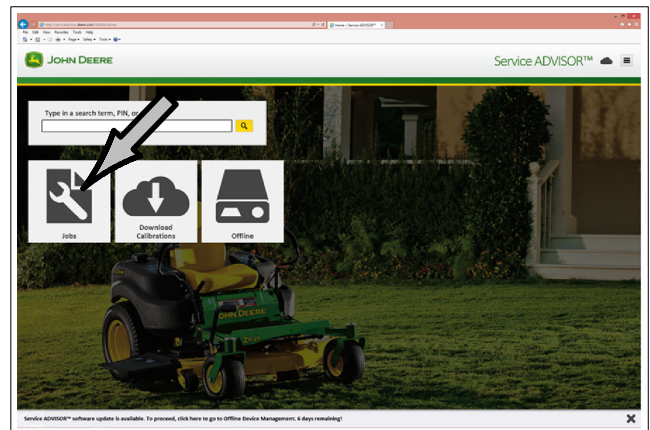


Figure 9-9 Jobs Icon Screen

4. If a job has already been created, open that existing job and proceed to Step 9. If there is not an existing job, create a new job by clicking on "Start a New Job". See Figure 9-10.

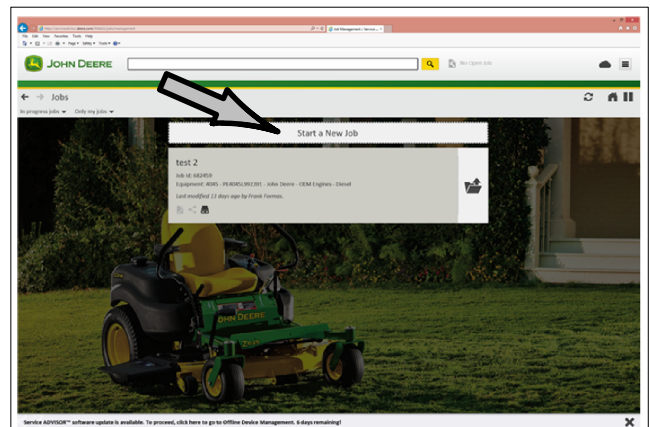


Figure 9-10 Start a New Job Screen

5. Enter a user-determined job name (and other information, if necessary). Click "Next" to proceed. See Figure 9-11.

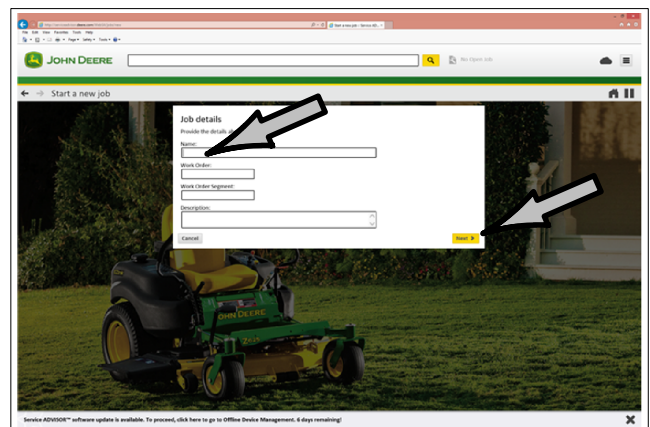
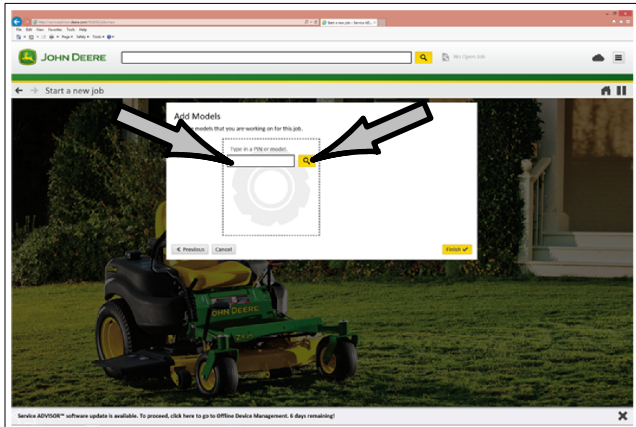


Figure 9-11 Job Details Screen

6. Enter the engine model (example 4045, 6068, 6090), then click the magnifying glass (search) button. See Figure 9-12 and Figure 9-13.

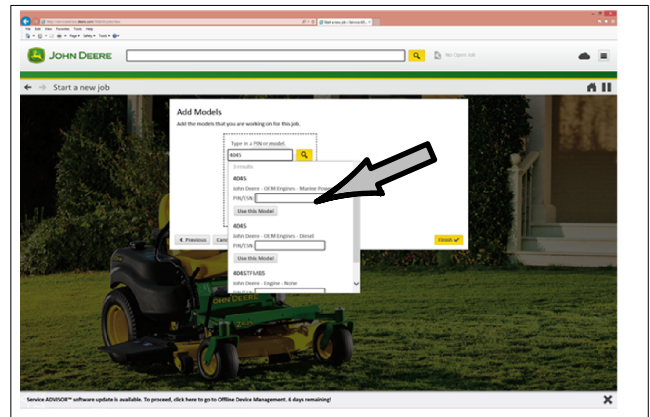


**Figure 9-12** Model Search Screen

| Engine Model | Generator Set Model |
|--------------|---------------------|
| 4045TFM75    | 40EFOZDJ            |
|              | 40EFOZCJ            |
|              | 50EFOZDJ            |
|              | 50EFOZCJ            |
| 4045TFM85    | 55EOZDJ/45EFOZDJ    |
|              | 55EOZCJ/45EFOZCJ    |
|              | 65EOZDJ/55EFOZDJ    |
|              | 65EOZCJ/55EFOZCJ    |
| 4045AFM85    | 80EOZDJ/70EFOZDJ    |
|              | 80EOZCJ/70EFOZCJ    |
|              | 99EOZDJ/80EFOZDJ    |
|              | 99EOZCJ/80EFOZCJ    |
| 6068AFM85    | 125EOZDJ/100EFOZDJ  |
|              | 125EOZCJ/100EFOZCJ  |
|              | 150EOZDJ/125EFOZDJ  |
|              | 150EOZCJ/125EFOZCJ  |
| 6090AFM85    | 200EOZDJ/175EFOZDJ  |
|              | 200EOZCJ/175EFOZCJ  |

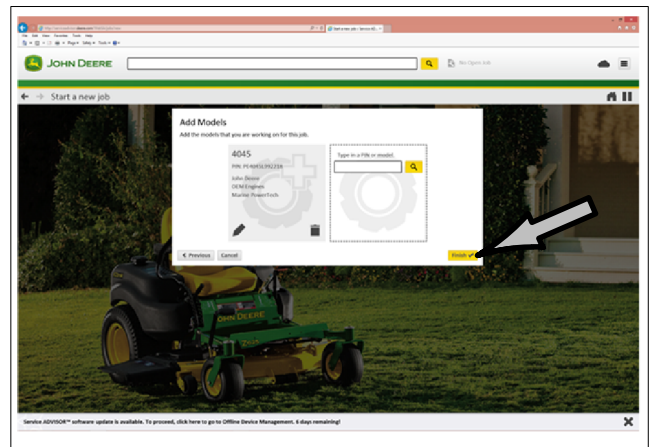
**Figure 9-13** Engine/Generator Cross Reference Chart

7. In the box, under John Deere - OEM Engines - Marine PowerTech, enter the Engine Serial Number (ESN). Then click the “Use this Model” button. See Figure 9-14.



**Figure 9-14** Engine Serial Number Screen

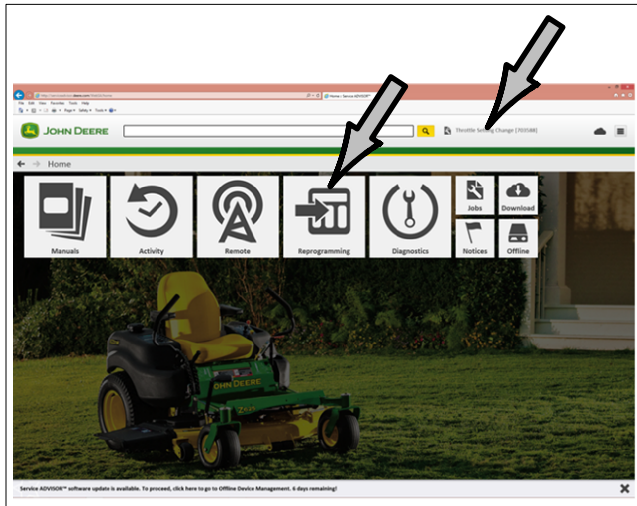
8. Click the “Finish” button. See Figure 9-15.



**Figure 9-15** Finish Screen

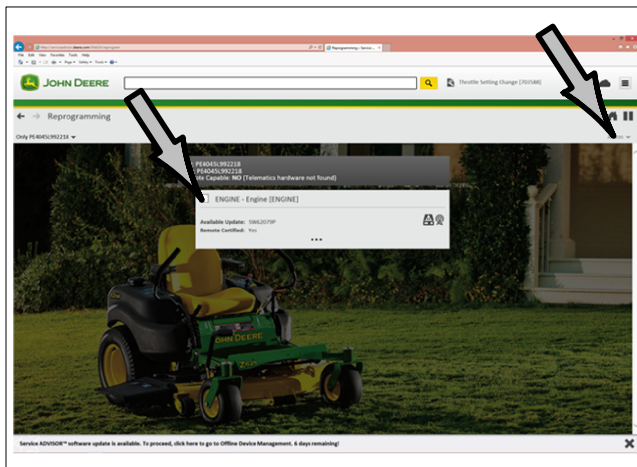


9. **Note:** The Job Name should appear in upper right portion of menu. Click “Reprogramming”. See Figure 9-16.



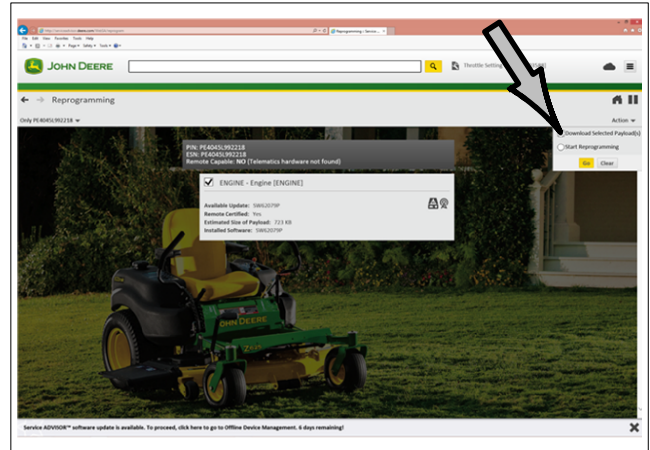
**Figure 9-16** Reprogramming Screen

10. Check the box next to ENGINE to make selection and activate the “Action” drop-down list in the upper right portion of the screen. See Figure 9-17.



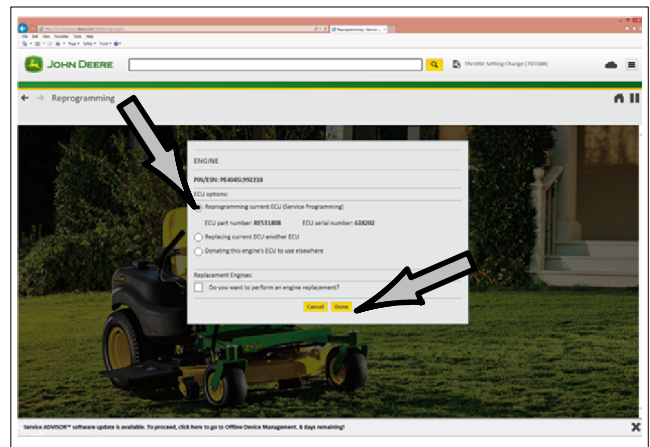
**Figure 9-17** Action Drop-Down Screen

11. Click the Action down arrow button to open the drop-down box. With “Download Select Payload(s)” selected, click the “Go” button. See Figure 9-18.



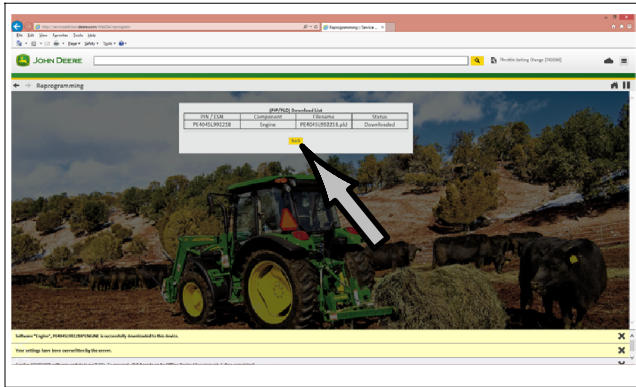
**Figure 9-18** Download Selected Payload(s) Screen

12. With “Reprogramming current ECU” selected, click the “Done” button. See Figure 9-19.



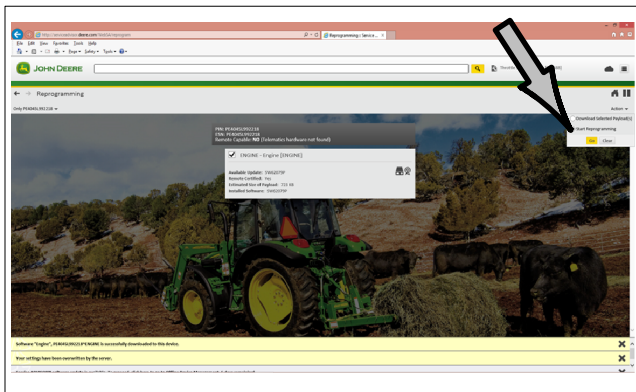
**Figure 9-19** Reprogramming Current ECU Screen

13. After the status changes to “Downloaded” (from “Downloading”), click the “Back” button. See Figure 9-20.



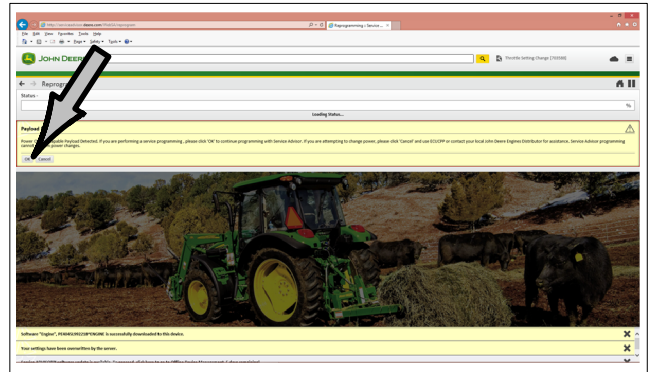
**Figure 9-20** Downloaded Status Screen

14. At the screen shown in Figure 9-21:
- Check the box next to ENGINE to make selection and activate the “Action” drop-down list in the upper right section.
  - Click the Action down arrow button, to open the drop-down box. With “Start Reprogramming” selected, click the “Go” button. See Figure 9-21.



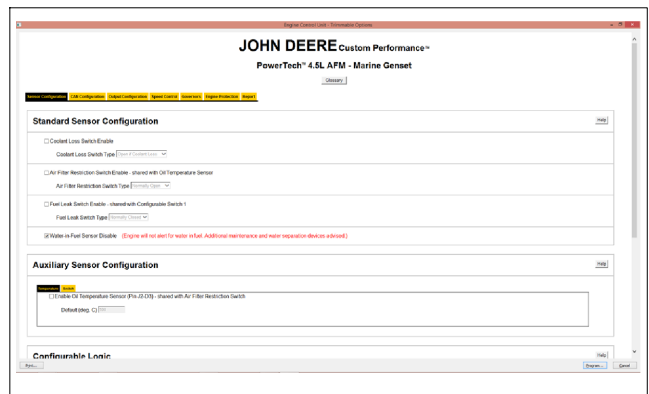
**Figure 9-21** Start Reprogramming Screen

15. If notice messages appear and are not applicable, select the “OK” button and proceed. See Figure 9-22.



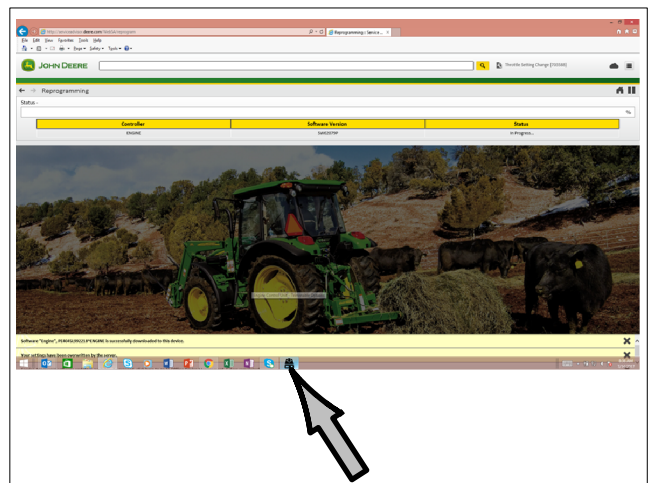
**Figure 9-22** Notice Screen

16. A new window opens with the ECU parameters that can be selected and changed. See Figure 9-23.



**Figure 9-23** ECU Parameters Screen

**Note:** Sometimes this window doesn't open automatically but shows up on the hidden windows icon menu bar. To open the window, simply select the icon. See Figure 9-24.



**Figure 9-24** ECU Parameters Screen

## 9.9.1 Throttle Input Settings

If encountering fault codes SPN 29 and SPN 91, confirm against the factory default settings shown below.

1. To check or change throttle input settings, select the Speed Control tab. See Figure 9-25.
  2. Ensure that a checkmark appears in the box next to **Disable All Throttle**. If this box is checked, all available selections (see below) are disabled (unchecked).
- Digital Throttle
  - Primary Analog Throttle
  - Secondary Analog Throttle
  - PWM Throttle

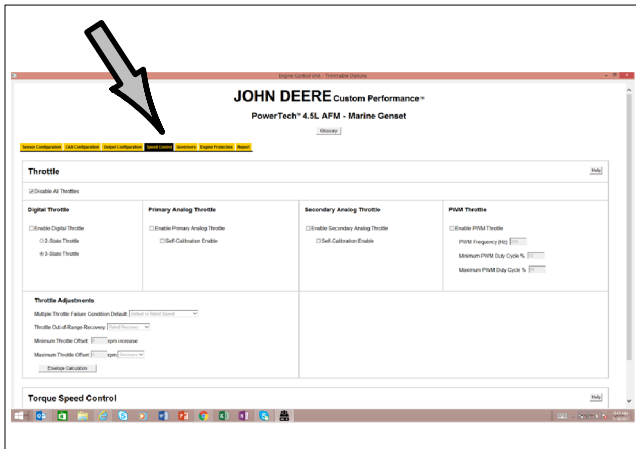


Figure 9-25 Speed Control (Top Half of Menu)

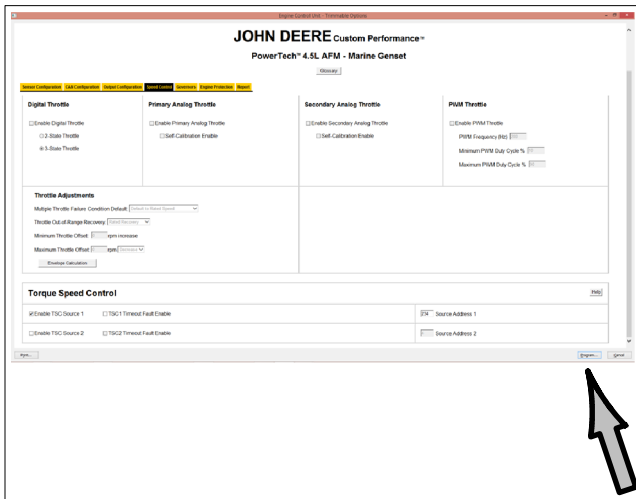


Figure 9-26 Speed Control (Bottom Half of Menu)

3. If reprogramming, select the “Program” button when you have a link established with the ECU and the ECU is powered. See Figure 9-26.

**Note:** Kohler SiteTech™ is needed to power the ECU on these generator set models.

## 9.9.2 Droop Settings

1. To check or change droop settings, select the Governors tab and open the drop-down list for **RPM of Droop**.
2. Ensure that the 1.7 Hz (50 rpm) is selected from the drop-down list next to **RPM of Droop**.

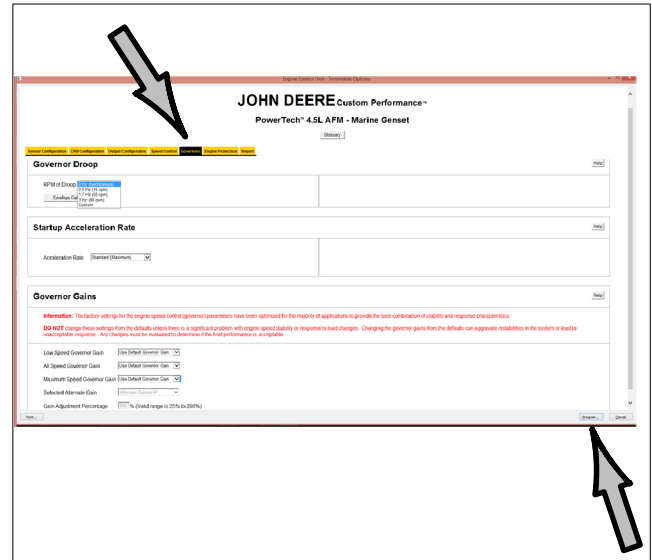


Figure 9-27 Governor Control

3. If reprogramming, select the “Program” button when you have a link established with the ECU and the ECU is powered. See Figure 9-27.

**Note:** Kohler SiteTech™ is needed to power the ECU on these generator set models.

## Notes

# Appendix A Generator Selection and Wattage Requirements

Consider total wattage requirements (lights, motors, appliances) when selecting a generator set or when sizing wattage usage in which available space and construction limit the size of the generator set.

## Motors

When figuring generator set capacity requirements for loads that include electric motors, consider the high current demanded by the motors during startup. The inrush or starting current is typically 2-3 times higher than that required when the motor reaches normal operating speed. Allow reserve for inrush demands plus other loads which could be on the line as the electric motor starts. Use Figure 1 as a guide when selecting generator set capacity requirements involving motor loads.

| Motor HP | Starting (Inrush) Watts | Running Watts |
|----------|-------------------------|---------------|
| 1/4      | 750                     | 330           |
| 1/3      | 1000                    | 400           |
| 1/2      | 1500                    | 600           |
| 3/4      | 2000                    | 750           |
| 1        | 3300                    | 1100          |
| 2        | 4000                    | 2000          |
| 3        | 5000                    | 3000          |

**Figure 1** Motor Requirements

## Lighting

To calculate lighting load, add the wattage of each generator set-operated lamp. Note that not all of the lights or lamps are on the generator set AC circuit; some

are DC powered by a 12-volt battery. Make sure the calculated total wattage includes only lights actually on the generator set AC circuit.

## Air Conditioners

The starting characteristics of air conditioners vary greatly; one 12,000 Btu unit has, for example, lower starting requirements than a 10,000 Btu unit of another variety. When using only one unit, there is usually no starting problem, provided the lighting and appliance load is not too high when starting the unit.

Simultaneous starting of two air conditioning units, however, can present problems if the generator set capacity is marginal. Because of the variation in starting characteristics among air conditioners, this publication makes no statements regarding multiple-motor starting capabilities of the generator set covered. Consider delayed starting or use of easy-starting devices on air conditioner units whenever simultaneously starting more than one motor.

See Figure 2 for typical air conditioner requirements. Information will vary with manufacturer.

## Appliances

Generator sets often furnish AC for appliances such as TV, stereo, electric water heater, etc. With the exception of the resistance-type loads such as the water heater, requirements for appliances are usually low. Do not overlook such loads when figuring total requirements. Allow reserve capacity for anticipated appliance loads to avoid overloading a generator set.

| Air Conditioner Size (Btu/Hr.) |       |      |       |      |        |      |        |      |        |
|--------------------------------|-------|------|-------|------|--------|------|--------|------|--------|
|                                | 7,000 |      | 9,000 |      | 12,000 |      | 16,000 |      | 24,000 |
| Voltage                        | 115   | 230  | 115   | 230  | 115    | 230  | 115    | 230  | 230    |
| Full load amps                 | 9.3   | 4.8  | 9.9   | 5.0  | 11.8   | 6.3  | 16.3   | 8.0  | 11.6   |
| Rated load amps                | 7.7   | 4.0  | 7.0   | 3.5  | 8.9    | 4.8  | 13.0   | 6.2  | 10.2   |
| Locked rotor amps              | 34.0  | 20.0 | 40.0  | 20.0 | 50.0   | 31.0 | 75.0   | 36.0 | 56.0   |
| Starting (inrush) watts        | 3910  | 4600 | 4600  | 4600 | 5750   | 7130 | 8630   | 8280 | 12,900 |
| Running watts                  | 886   | 920  | 805   | 805  | 1020   | 1100 | 1500   | 1430 | 2350   |

**Figure 2** Typical Marine Air Conditioner Requirements, 60 Hz

## Appendix B Abbreviations

The following list contains abbreviations that may appear in this publication.

|           |                                                                                            |                             |                                                                                      |                                                                                          |                                                      |
|-----------|--------------------------------------------------------------------------------------------|-----------------------------|--------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|------------------------------------------------------|
| A, amp    | ampere                                                                                     | cfm                         | cubic feet per minute                                                                | exh.                                                                                     | exhaust                                              |
| ABDC      | after bottom dead center                                                                   | CG                          | center of gravity                                                                    | ext.                                                                                     | external                                             |
| AC        | alternating current                                                                        | CID                         | cubic inch displacement                                                              | F                                                                                        | Fahrenheit, female                                   |
| A/D       | analog to digital                                                                          | CL                          | centerline                                                                           | FHM                                                                                      | flat head machine (screw)                            |
| ADC       | advanced digital control;<br>analog to digital converter                                   | cm                          | centimeter                                                                           | fl. oz.                                                                                  | fluid ounce                                          |
| adj.      | adjust, adjustment                                                                         | CMOS                        | complementary metal oxide<br>substrate (semiconductor)                               | flex.                                                                                    | flexible                                             |
| ADV       | advertising dimensional<br>drawing                                                         | com                         | communications (port)                                                                | freq.                                                                                    | frequency                                            |
| Ah        | amp-hour                                                                                   | coml                        | commercial                                                                           | FS                                                                                       | full scale                                           |
| AHWT      | anticipatory high water<br>temperature                                                     | Coml/Rec                    | Commercial/Recreational<br>connection                                                | ft.                                                                                      | foot, feet                                           |
| AISI      | American Iron and Steel<br>Institute                                                       | conn.                       | continued                                                                            | ft. lb.                                                                                  | foot pounds (torque)                                 |
| ALOP      | anticipatory low oil pressure                                                              | cont.                       | continued                                                                            | ft./min.                                                                                 | feet per minute                                      |
| alt.      | alternator                                                                                 | CPVC                        | chlorinated polyvinyl chloride                                                       | ftp                                                                                      | file transfer protocol                               |
| Al        | aluminum                                                                                   | crit.                       | critical                                                                             | g                                                                                        | gram                                                 |
| ANSI      | American National Standards<br>Institute (formerly American<br>Standards Association, ASA) | CSA                         | Canadian Standards<br>Association                                                    | ga.                                                                                      | gauge (meters, wire size)                            |
| AO        | anticipatory only                                                                          | CT                          | current transformer                                                                  | gal.                                                                                     | gallon                                               |
| APDC      | Air Pollution Control District                                                             | Cu                          | copper                                                                               | gen.                                                                                     | generator                                            |
| API       | American Petroleum Institute                                                               | cUL                         | Canadian Underwriter's<br>Laboratories                                               | genset                                                                                   | generator set                                        |
| approx.   | approximate, approximately                                                                 | CUL                         | Canadian Underwriter's<br>Laboratories                                               | GFI                                                                                      | ground fault interrupter                             |
| APU       | Auxiliary Power Unit                                                                       | cu. in.                     | cubic inch                                                                           | GND,  | ground                                               |
| AQMD      | Air Quality Management District                                                            | cw.                         | clockwise                                                                            | gov.                                                                                     | governor                                             |
| AR        | as required, as requested                                                                  | CWC                         | city water-cooled                                                                    | gph                                                                                      | gallons per hour                                     |
| AS        | as supplied, as stated, as<br>suggested                                                    | cyl.                        | cylinder                                                                             | gpm                                                                                      | gallons per minute                                   |
| ASE       | American Society of Engineers                                                              | D/A                         | digital to analog                                                                    | gr.                                                                                      | grade, gross                                         |
| ASME      | American Society of<br>Mechanical Engineers                                                | DAC                         | digital to analog converter                                                          | GRD                                                                                      | equipment ground                                     |
| assy.     | assembly                                                                                   | dB                          | decibel                                                                              | gr. wt.                                                                                  | gross weight                                         |
| ASTM      | American Society for Testing<br>Materials                                                  | dB(A)                       | decibel (A weighted)                                                                 | H x W x D                                                                                | height by width by depth                             |
| ATDC      | after top dead center                                                                      | DC                          | direct current                                                                       | HC                                                                                       | hex cap                                              |
| ATS       | automatic transfer switch                                                                  | DCR                         | direct current resistance                                                            | HCHT                                                                                     | high cylinder head temperature                       |
| auto.     | automatic                                                                                  | deg., °                     | degree                                                                               | HD                                                                                       | heavy duty                                           |
| aux.      | auxiliary                                                                                  | dept.                       | department                                                                           | HET                                                                                      | high exhaust temp., high<br>engine temp.             |
| avg.      | average                                                                                    | dia.                        | diameter                                                                             | hex                                                                                      | hexagon                                              |
| AVR       | automatic voltage regulator                                                                | DI/EO                       | dual inlet/end outlet                                                                | Hg                                                                                       | mercury (element)                                    |
| AWG       | American Wire Gauge                                                                        | DIN                         | Deutsches Institut für Normung<br>e. V. (also Deutsche Industrie<br>Normenausschuss) | HH                                                                                       | hex head                                             |
| AWM       | appliance wiring material                                                                  | DIP                         | dual inline package                                                                  | HHC                                                                                      | hex head cap                                         |
| bat.      | battery                                                                                    | DPDT                        | double-pole, double-throw                                                            | HP                                                                                       | horsepower                                           |
| BBDC      | before bottom dead center                                                                  | DPST                        | double-pole, single-throw                                                            | hr.                                                                                      | hour                                                 |
| BC        | battery charger, battery<br>charging                                                       | DS                          | disconnect switch                                                                    | HS                                                                                       | heat shrink                                          |
| BCA       | battery charging alternator                                                                | DVR                         | digital voltage regulator                                                            | hsg.                                                                                     | housing                                              |
| BCI       | Battery Council International                                                              | E <sup>2</sup> PROM, EEPROM | electrically-erasable<br>programmable read-only<br>memory                            | HVAC                                                                                     | heating, ventilation, and air<br>conditioning        |
| BDC       | before dead center                                                                         | E, emer.                    | emergency (power source)                                                             | HWT                                                                                      | high water temperature                               |
| BHP       | brake horsepower                                                                           | ECM                         | electronic control module,<br>engine control module                                  | Hz                                                                                       | hertz (cycles per second)                            |
| blk.      | black (paint color), block<br>(engine)                                                     | EDI                         | electronic data interchange                                                          | IBC                                                                                      | International Building Code                          |
| blk. htr. | block heater                                                                               | EFR                         | emergency frequency relay                                                            | IC                                                                                       | integrated circuit                                   |
| BMEP      | brake mean effective pressure                                                              | e.g.                        | for example ( <i>exempli gratia</i> )                                                | ID                                                                                       | inside diameter, identification                      |
| bps       | bits per second                                                                            | EG                          | electronic governor                                                                  | IEC                                                                                      | International Electrotechnical<br>Commission         |
| br.       | brass                                                                                      | EGSA                        | Electrical Generating Systems<br>Association                                         | IEEE                                                                                     | Institute of Electrical and<br>Electronics Engineers |
| BTDC      | before top dead center                                                                     | EIA                         | Electronic Industries<br>Association                                                 | IMS                                                                                      | improved motor starting                              |
| Btu       | British thermal unit                                                                       | El/EO                       | end inlet/end outlet                                                                 | in.                                                                                      | inch                                                 |
| Btu/min.  | British thermal units per minute                                                           | EMI                         | electromagnetic interference                                                         | in. H <sub>2</sub> O                                                                     | inches of water                                      |
| C         | Celsius, centigrade                                                                        | emiss.                      | emission                                                                             | in. Hg                                                                                   | inches of mercury                                    |
| cal.      | calorie                                                                                    | eng.                        | engine                                                                               | in. lb.                                                                                  | inch pounds                                          |
| CAN       | controller area network                                                                    | EPA                         | Environmental Protection<br>Agency                                                   | Inc.                                                                                     | incorporated                                         |
| CARB      | California Air Resources Board                                                             | EPS                         | emergency power system                                                               | ind.                                                                                     | industrial                                           |
| CAT5      | Category 5 (network cable)                                                                 | ER                          | emergency relay                                                                      | int.                                                                                     | internal                                             |
| CB        | circuit breaker                                                                            | ES                          | engineering special,<br>engineered special                                           | int./ext.                                                                                | internal/external                                    |
| CC        | crank cycle                                                                                | ESD                         | electrostatic discharge                                                              | I/O                                                                                      | input/output                                         |
| cc        | cubic centimeter                                                                           | est.                        | estimated                                                                            | IP                                                                                       | internet protocol                                    |
| CCA       | cold cranking amps                                                                         | E-Stop                      | emergency stop                                                                       | ISO                                                                                      | International Organization for<br>Standardization    |
| ccw.      | counterclockwise                                                                           | etc.                        | et cetera (and so forth)                                                             | J                                                                                        | joule                                                |
| CEC       | Canadian Electrical Code                                                                   |                             |                                                                                      | JIS                                                                                      | Japanese Industry Standard                           |
| cert.     | certificate, certification, certified                                                      |                             |                                                                                      | k                                                                                        | kilo (1000)                                          |
| cfh       | cubic feet per hour                                                                        |                             |                                                                                      | K                                                                                        | kelvin                                               |
|           |                                                                                            |                             |                                                                                      | kA                                                                                       | kiloampere                                           |
|           |                                                                                            |                             |                                                                                      | KB                                                                                       | kilobyte (2 <sup>10</sup> bytes)                     |
|           |                                                                                            |                             |                                                                                      | KBus                                                                                     | Kohler communication protocol                        |
|           |                                                                                            |                             |                                                                                      | kg                                                                                       | kilogram                                             |

|                      |                                                      |           |                                                     |         |                                                                       |
|----------------------|------------------------------------------------------|-----------|-----------------------------------------------------|---------|-----------------------------------------------------------------------|
| kg/cm <sup>2</sup>   | kilograms per square centimeter                      | NBS       | National Bureau of Standards                        | RTU     | remote terminal unit                                                  |
| kgm                  | kilogram-meter                                       | NC        | normally closed                                     | RTV     | room temperature vulcanization                                        |
| kg/m <sup>3</sup>    | kilograms per cubic meter                            | NEC       | National Electrical Code                            | RW      | read/write                                                            |
| kHz                  | kilohertz                                            | NEMA      | National Electrical Manufacturers Association       | SAE     | Society of Automotive Engineers                                       |
| kJ                   | kilojoule                                            | NFPA      | National Fire Protection Association                | scfm    | standard cubic feet per minute                                        |
| km                   | kilometer                                            | Nm        | newton meter                                        | SCR     | silicon controlled rectifier                                          |
| kOhm, kΩ             | kilo-ohm                                             | NO        | normally open                                       | s, sec. | second                                                                |
| kPa                  | kilopascal                                           | no., nos. | number, numbers                                     | SI      | <i>Système international d'unités</i> , International System of Units |
| kph                  | kilometers per hour                                  | NPS       | National Pipe, Straight                             | SI/EO   | side in/end out                                                       |
| kV                   | kilovolt                                             | NPSC      | National Pipe, Straight-coupling                    | sil.    | silencer                                                              |
| kVA                  | kilovolt ampere                                      | NPT       | National Standard taper pipe thread per general use | SMTP    | simple mail transfer protocol                                         |
| kVAR                 | kilovolt ampere reactive                             | NPTF      | National Pipe, Taper-Fine                           | SN      | serial number                                                         |
| kW                   | kilowatt                                             | NR        | not required, normal relay                          | SNMP    | simple network management protocol                                    |
| kWh                  | kilowatt-hour                                        | ns        | nanosecond                                          | SPDT    | single-pole, double-throw                                             |
| kWm                  | kilowatt mechanical                                  | OC        | overcrank                                           | SPST    | single-pole, single-throw                                             |
| kWth                 | kilowatt-thermal                                     | OD        | outside diameter                                    | spec    | specification                                                         |
| L                    | liter                                                | OEM       | original equipment manufacturer                     | specs   | specification(s)                                                      |
| LAN                  | local area network                                   | OF        | overfrequency                                       | sq.     | square                                                                |
| L x W x H            | length by width by height                            | opt.      | option, optional                                    | sq. cm  | square centimeter                                                     |
| lb.                  | pound, pounds                                        | OS        | oversize, overspeed                                 | sq. in. | square inch                                                           |
| lbm/ft <sup>3</sup>  | pounds mass per cubic feet                           | OSHA      | Occupational Safety and Health Administration       | SMS     | short message service                                                 |
| LCB                  | line circuit breaker                                 | OV        | overvoltage                                         | SS      | stainless steel                                                       |
| LCD                  | liquid crystal display                               | oz.       | ounce                                               | std.    | standard                                                              |
| LED                  | light emitting diode                                 | p., pp.   | page, pages                                         | stl.    | steel                                                                 |
| Lph                  | liters per hour                                      | PC        | personal computer                                   | tach.   | tachometer                                                            |
| Lpm                  | liters per minute                                    | PCB       | printed circuit board                               | TB      | terminal block                                                        |
| LOP                  | low oil pressure                                     | pF        | picofarad                                           | TCP     | transmission control protocol                                         |
| LP                   | liquefied petroleum                                  | PF        | power factor                                        | TD      | time delay                                                            |
| LPG                  | liquefied petroleum gas                              | ph., ∅    | phase                                               | TDC     | top dead center                                                       |
| LS                   | left side                                            | PHC       | Phillips® head Crimptite® (screw)                   | TDEC    | time delay engine cooldown                                            |
| L <sub>wa</sub>      | sound power level, A weighted                        | PHH       | Phillips® hex head (screw)                          | TDEN    | time delay emergency to normal                                        |
| LWL                  | low water level                                      | PHM       | pan head machine (screw)                            | TDES    | time delay engine start                                               |
| LWT                  | low water temperature                                | PLC       | programmable logic control                          | TDNE    | time delay normal to emergency                                        |
| m                    | meter, milli (1/1000)                                | PMG       | permanent magnet generator                          | TDOE    | time delay off to emergency                                           |
| M                    | mega (10 <sup>6</sup> when used with SI units), male | pot       | potentiometer, potential                            | TDON    | time delay off to normal                                              |
| m <sup>3</sup>       | cubic meter                                          | ppm       | parts per million                                   | temp.   | temperature                                                           |
| m <sup>3</sup> /hr.  | cubic meters per hour                                | PROM      | programmable read-only memory                       | term.   | terminal                                                              |
| m <sup>3</sup> /min. | cubic meters per minute                              | psi       | pounds per square inch                              | THD     | total harmonic distortion                                             |
| mA                   | milliampere                                          | psig      | pounds per square inch gauge                        | TIF     | telephone influence factor                                            |
| man.                 | manual                                               | pt.       | pint                                                | tol.    | tolerance                                                             |
| max.                 | maximum                                              | PTC       | positive temperature coefficient                    | turbo.  | turbocharger                                                          |
| MB                   | megabyte (2 <sup>20</sup> bytes)                     | PTO       | power takeoff                                       | typ.    | typical (same in multiple locations)                                  |
| MCCB                 | molded-case circuit breaker                          | PVC       | polyvinyl chloride                                  | UF      | underfrequency                                                        |
| MCM                  | one thousand circular mils                           | qt.       | quart, quarts                                       | UHF     | ultrahigh frequency                                                   |
| megggar              | megohmmeter                                          | qty.      | quantity                                            | UIF     | user interface                                                        |
| MHz                  | megahertz                                            | R         | replacement (emergency)                             | UL      | Underwriter's Laboratories, Inc.                                      |
| mi.                  | mile                                                 | rad.      | power source                                        | UNC     | unified coarse thread (was NC)                                        |
| mil                  | one one-thousandth of an inch                        | RAM       | radiator, radius                                    | UNF     | unified fine thread (was NF)                                          |
| min.                 | minimum, minute                                      | RDO       | random access memory                                | univ.   | universal                                                             |
| misc.                | miscellaneous                                        | ref.      | relay driver output                                 | URL     | uniform resource locator (web address)                                |
| MJ                   | megajoule                                            | rem.      | reference                                           | US      | undersize, underspeed                                                 |
| mJ                   | millijoule                                           | Res/Coml  | remote                                              | UV      | ultraviolet, undervoltage                                             |
| mm                   | millimeter                                           | RFI       | Residential/Commercial radio frequency interference | V       | volt                                                                  |
| mOhm, mΩ             | milliohm                                             | RH        | round head                                          | VAC     | volts alternating current                                             |
| MOhm, MΩ             | megohm                                               | RHM       | round head machine (screw)                          | VAR     | voltampere reactive                                                   |
| MOV                  | metal oxide varistor                                 | rly.      | relay                                               | VDC     | volts direct current                                                  |
| MPa                  | megapascal                                           | rms       | root mean square                                    | VFD     | vacuum fluorescent display                                            |
| mpg                  | miles per gallon                                     | rnd.      | round                                               | VGA     | video graphics adapter                                                |
| mph                  | miles per hour                                       | RO        | read only                                           | VHF     | very high frequency                                                   |
| MS                   | military standard                                    | ROM       | read only memory                                    | W       | watt                                                                  |
| ms                   | millisecond                                          | rot.      | rotate, rotating                                    | WCR     | withstand and closing rating                                          |
| m/sec.               | meters per second                                    | rpm       | revolutions per minute                              | w/      | with                                                                  |
| mtg.                 | mounting                                             | RS        | right side                                          | WO      | write only                                                            |
| MTU                  | Motoren-und Turbinen-Union                           | RTDs      | Resistance Temperature Detectors                    | w/o     | without                                                               |
| MW                   | megawatt                                             |           |                                                     | wt.     | weight                                                                |
| mW                   | milliwatt                                            |           |                                                     | xfrm    | transformer                                                           |
| μF                   | microfarad                                           |           |                                                     |         |                                                                       |
| N, norm.             | normal (power source)                                |           |                                                     |         |                                                                       |
| NA                   | not available, not applicable                        |           |                                                     |         |                                                                       |
| nat. gas             | natural gas                                          |           |                                                     |         |                                                                       |











**TP-6862 3/18e**

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