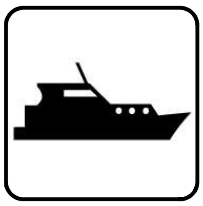
Installation

Marine Generator Sets



Models:

14/16/21/24/32/40EKOZD
12/13.5/17/18/20.5/28/35EFKOZD

Controller:

Decision-Maker® 3500

KOHLER®

TP-7045 2/23d

Table of Contents

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 a hazardous situation which, if not avoided, will result in death or serious injury.

WARNING

WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION

CAUTION indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE

NOTICE is used to address practices not related to physical injury.

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

WARNING

Accidental starting.
Can cause severe injury or death.

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

WARNING

Risk of fire.
Can cause severe injury or death.

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

⚠ WARNING

Carbon monoxide.
Can cause severe nausea, fainting, or death.

The exhaust system must be leakproof and routinely inspected.

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

⚠ WARNING

Explosive fuel vapors.
Can cause fires and severe burns.

If a gaseous odor is detected, ventilate the area and contact an authorized service technician.

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

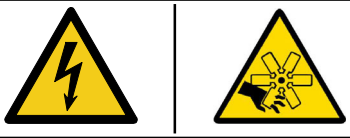
⚠ CAUTION

Hazardous noise.
Can cause hearing loss.

Never operate the generator set without a muffler or with a faulty exhaust system.

Hazardous Voltage/ Moving Parts

⚠ DANGER



Hazardous voltage. Moving parts. Will cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Servicing the generator set when it is operating. Exposed moving parts will 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 will 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.

Disconnecting the electrical load. Hazardous voltage will 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 will 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.

Testing the voltage regulator. Hazardous voltage can cause severe injury or death. High voltage is present at the voltage regulator heat sink. To prevent electrical shock do not touch the voltage regulator heat sink when testing the voltage regulator. *(PowerBoost™, PowerBoost™ III, and PowerBoost™ V voltage regulator models only)*

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 will 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

⚠ WARNING

Hot coolant and steam.
Can cause severe injury or death.

Before removing the pressure cap, stop the generator set and allow it to cool. Then loosen the pressure cap to relieve pressure. Fill system before starting unit.

⚠ WARNING

Hot engine and exhaust system.
Can cause severe injury or death.

Do not work on the generator set until it cools.

Servicing the exhaust system. Hot parts can cause severe injury or death. Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.

Notice

NOTICE

This generator set has been rewired from its nameplate voltage to

246242

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

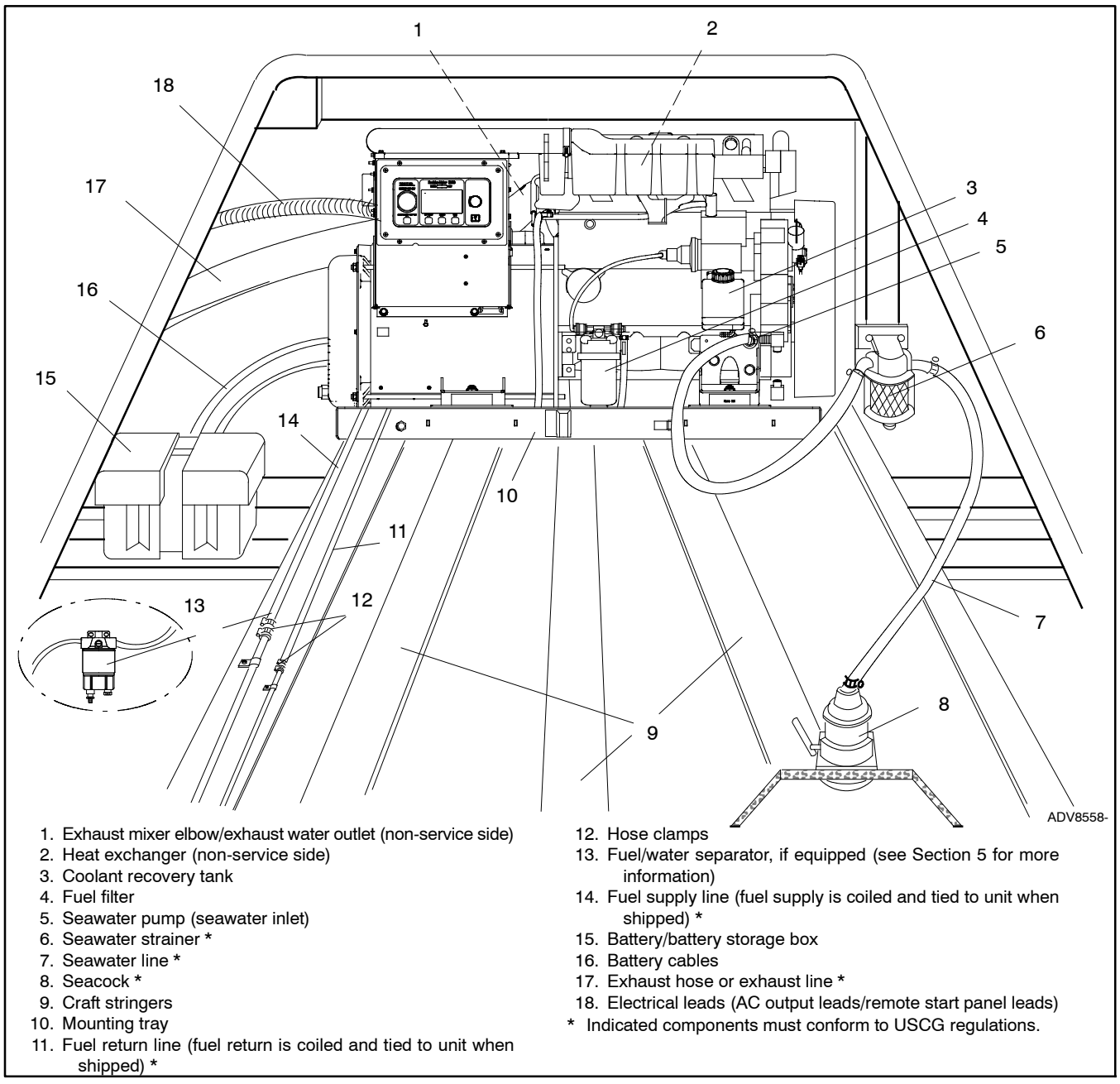
1.1 General

Information in this publication represents data available at the time of print. Kohler Co. reserves the right to change this publication and the products represented without notice and without any obligation or liability whatsoever.

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.

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.



1. Exhaust mixer elbow/exhaust water outlet (non-service side)
2. Heat exchanger (non-service side)
3. Coolant recovery tank
4. Fuel filter
5. Seawater pump (seawater inlet)
6. Seawater strainer *
7. Seawater line *
8. Seacock *
9. Craft stringers
10. Mounting tray
11. Fuel return line (fuel return is coiled and tied to unit when shipped) *
12. Hose clamps
13. Fuel/water separator, if equipped (see Section 5 for more information)
14. Fuel supply line (fuel supply is coiled and tied to unit when shipped) *
15. Battery/battery storage box
16. Battery cables
17. Exhaust hose or exhaust line *
18. Electrical leads (AC output leads/remote start panel leads)

* Indicated components must conform to USCG regulations.

Figure 1-1 Typical Generator Set Location and Mounting (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.

1.2 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.

  Typically, the Kohler authorized distributor/dealer creates a backup of the personality profile and 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: If the personality profile is NOT available, request a replacement from Kohler Aftermarket Parts Department.

  Enter an aftermarket parts order for part number *PROFILE.* Include in the order notes the generator set model, specification number, serial number, generator set modifications, and email of recipient.

- **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.

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 Lifting the Generator Set

The engine lifting eye is engineered to lift the weight of the marine generator set. See Section 7 for the lifting eye location. Always use lifting equipment with sufficient capacity to lift the generator set. Consult the generator set specification sheet for generator set weights.

Note: A slight lift of 15° or less is acceptable.

2.3 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. Refer to the instruction sheet for minimum clearances for sound-shielded units. 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.

2.4 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 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 of 38 mm (1.5 in.) 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, ≤ kPa (in. H_2O)
14EKOZD (1 and 3 Phase) 16EKOZD (1 and 3 Phase)	2.4 (9.6)
12EFKOZD (1 and 3 Phase) 13.5EFKOZD (1 and 3 Phase)	1.5 (6.0)
21EKOZD (1 and 3 Phase) 24EKOZD (1 and 3 Phase)	2.2 (8.8)
17EFKOZD (3 Phase) 18EFKOZD (1 Phase) 20.5EFKOZD (1 and 3 Phase)	2.0 (8.0)
32EKOZD (1 and 3 Phase)	4.5 (18)
28EFKOZD (1 and 3 Phase)	3.5 (14)
40EKOZD (1 and 3 Phase)	6 (24)
35EFKOZD (1 and 3 Phase)	4 (16)

Figure 3-1 Combustion Air Intake Restriction

3.2 Cooling System Components

The marine generator set's cooling system requires the following components.

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.

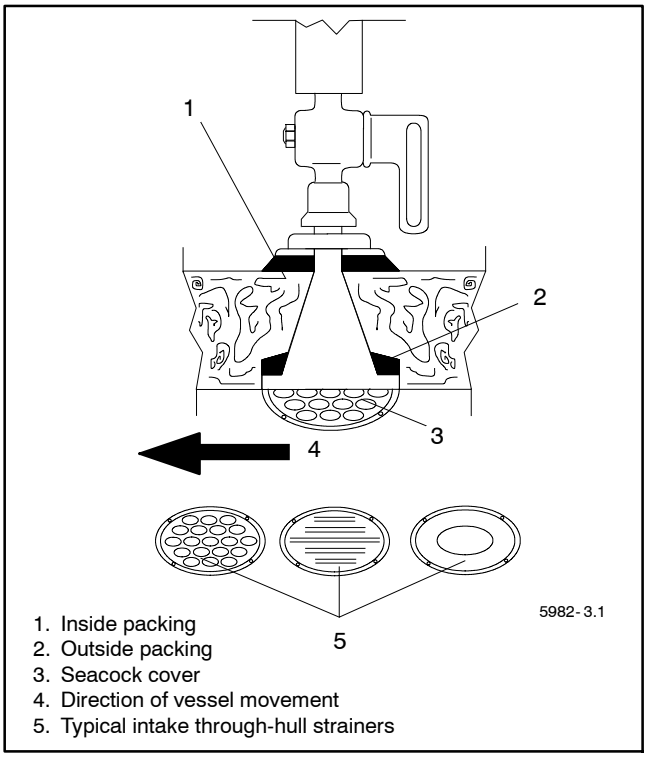
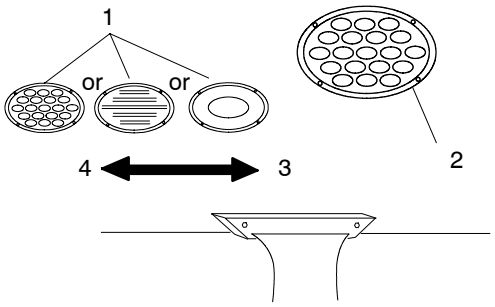


Figure 3-2 Seacock Installation, Typical

Do not align the strainer (in relation to the craft's 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.



Note: Position the intakes in relation to the vessel's travel so neither is in the wake of the other.

1. Generator set intake
2. Intake
3. Aft (rearward)
4. Fore (forward)

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 hulls 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 vessel's direction of travel. A sea chest configuration applies 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.

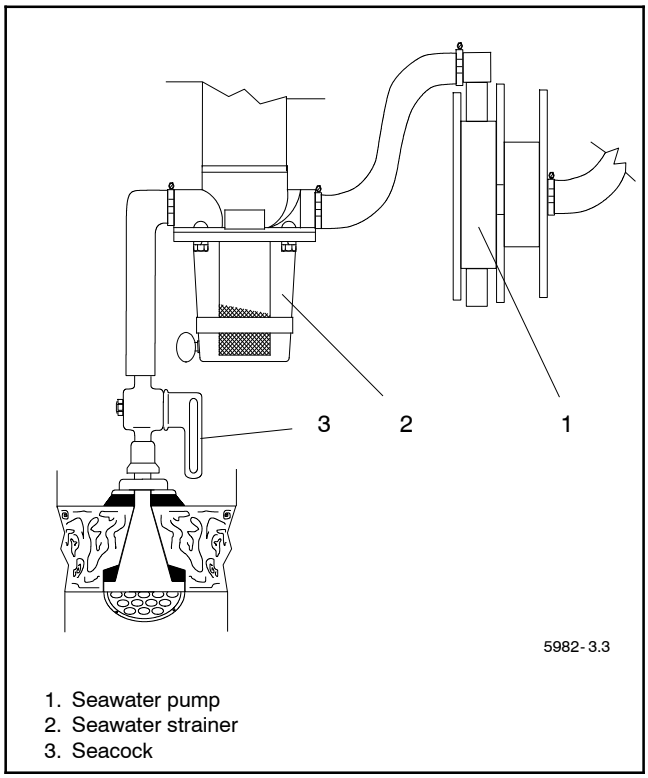
Avoid overcaulking the seacock. Excess caulk reduces water flow and, in some cases, develops a barrier that can force water upward, past the seawater pump, and into the engine cylinders when the vessel is moving and the generator set is shut down.

3.2.3 Seawater Strainer

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.



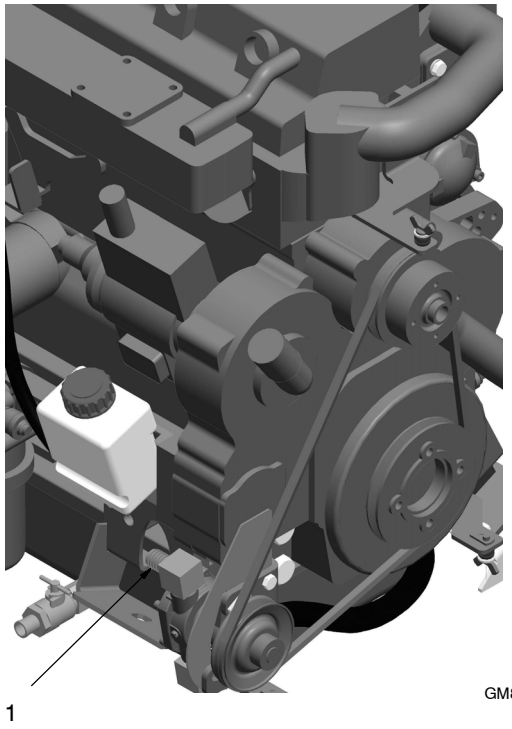
1. Seawater pump
2. Seawater strainer
3. Seacock

Figure 3-4 Seawater Strainer

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 the generator set to vibrate 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 hose connection to the seawater pump inlet.

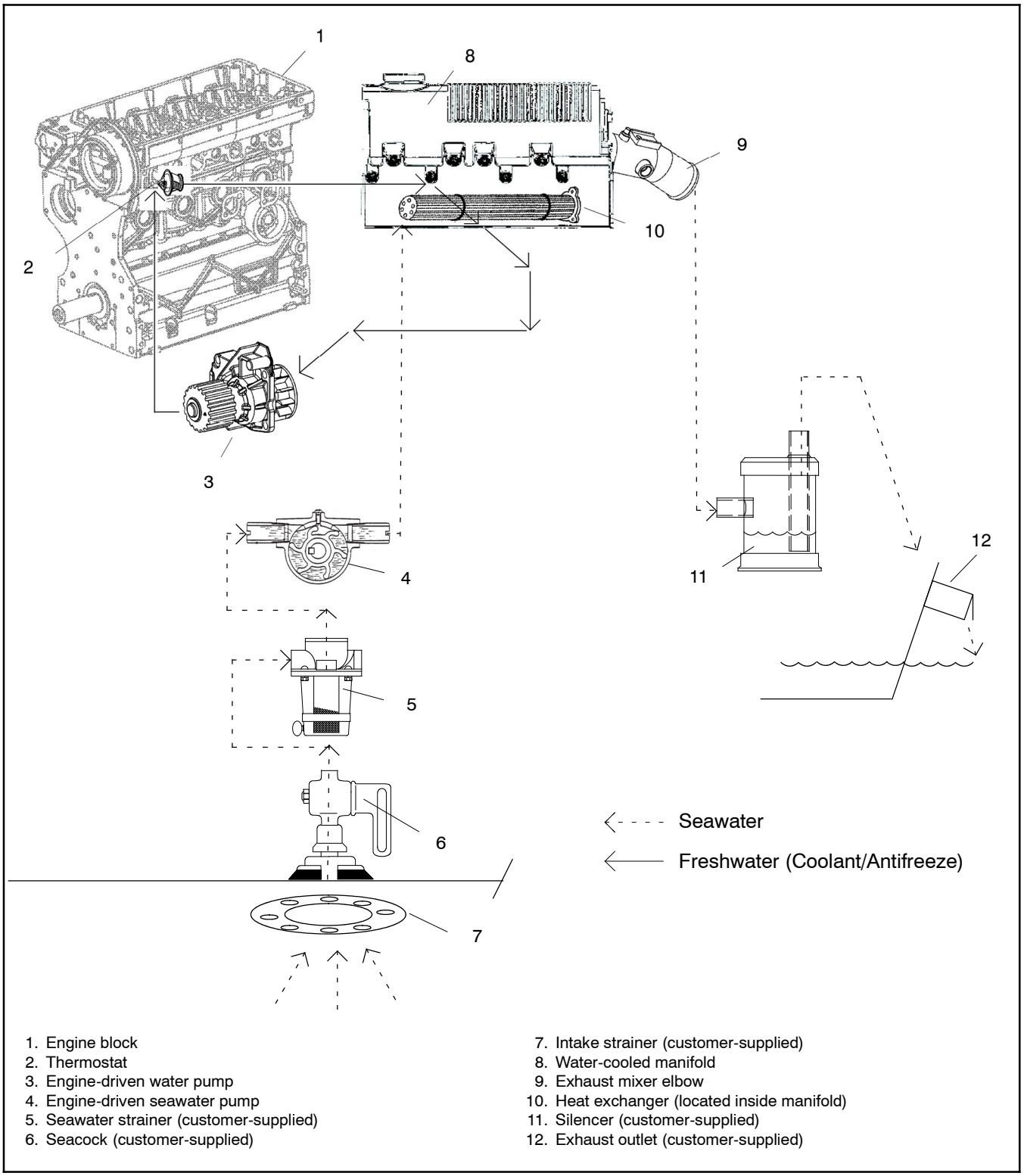


1. Seawater pump inlet

Figure 3-5 Seawater Inlet Connection (Located at the Inlet to the Seawater Pump), 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.



1. Engine block
2. Thermostat
3. Engine-driven water pump
4. Engine-driven seawater pump
5. Seawater strainer (customer-supplied)
6. Seacock (customer-supplied)
7. Intake strainer (customer-supplied)
8. Water-cooled manifold
9. Exhaust mixer elbow
10. Heat exchanger (located inside manifold)
11. Silencer (customer-supplied)
12. Exhaust outlet (customer-supplied)

Figure 3-6 Typical Closed/Heat Exchanger Cooling System

⚠ WARNING

Carbon monoxide.
Can cause severe nausea, fainting, or death.

The exhaust system must be leakproof and routinely inspected.

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.

Note: Do not use copper tubing in diesel exhaust systems. Sulfur in diesel exhaust causes rapid deterioration of copper tubing exhaust systems, resulting in exhaust/water leakage.

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.

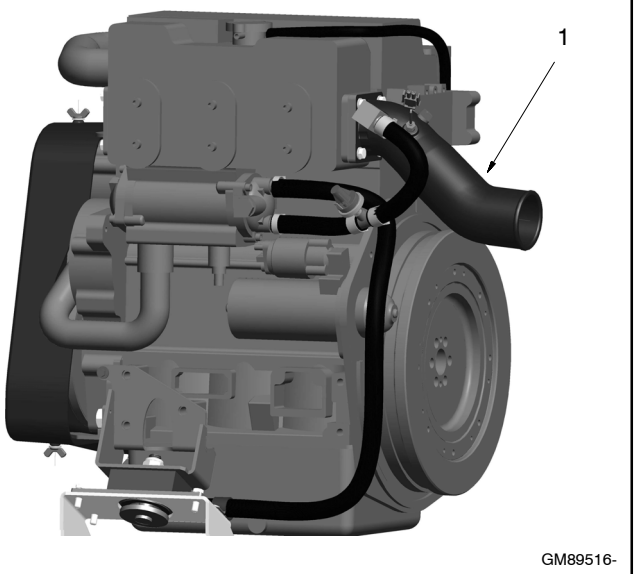
4.2 Exhaust Lines

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.

4.3 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 4-1 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.



1. Water/exhaust outlet

Figure 4-1 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 4-3, item 1. Support the exhaust lines to prevent the formation of water pockets.

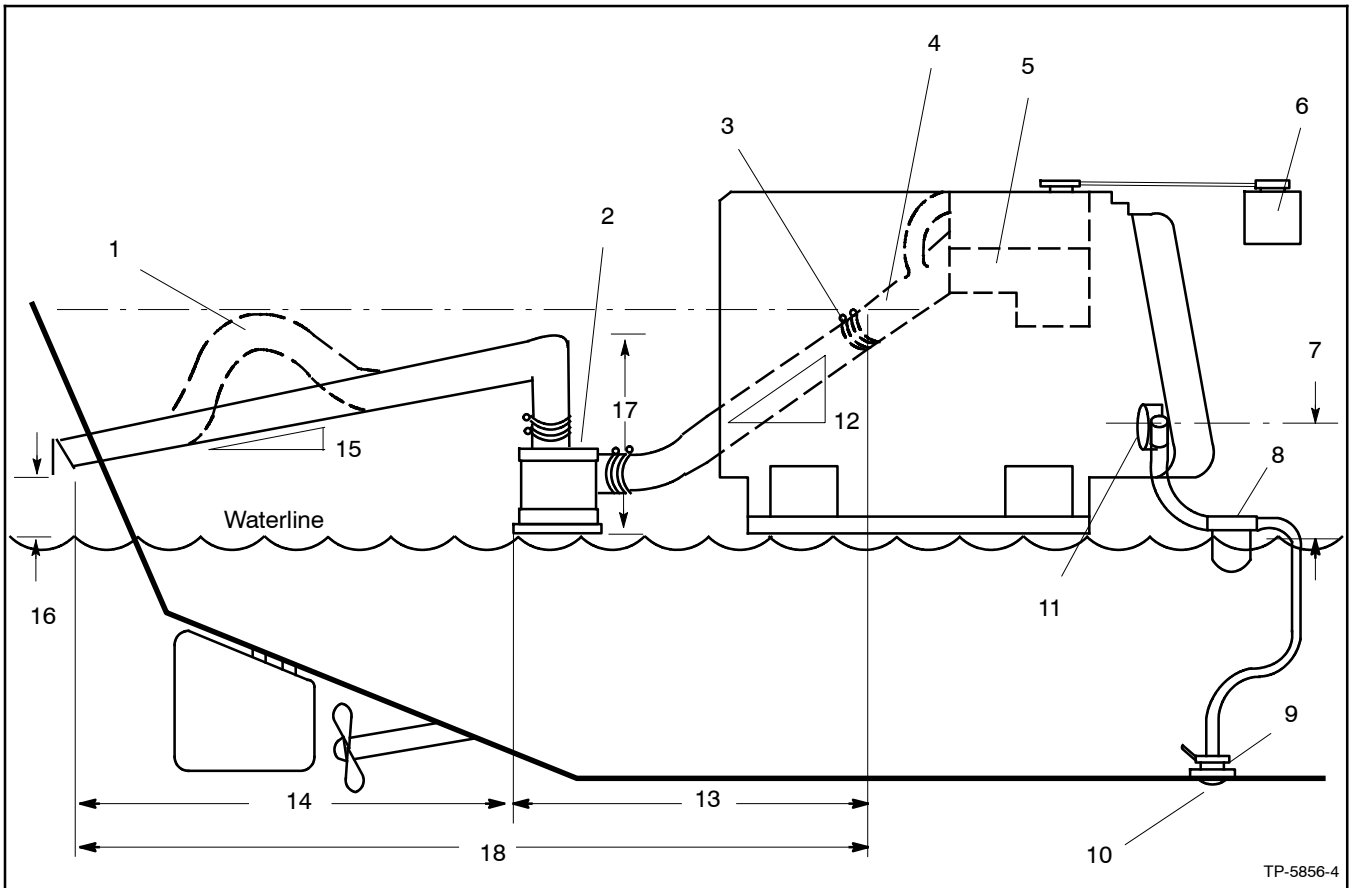
Exhaust system installation guidelines for various generator set locations follow. Information and illustrations of stern- (rear) exhaust installations also apply to side-exhaust installations. Where exhaust lines require passage through bulkheads, use port (left)- or starboard (right)- side exhaust outlets, also in applications in which long exhaust lines to the transom (rear) could cause excessive back pressure. See Figure 4-2 for allowable back pressures.

Model	Allowable Exhaust Back Pressure, ≤ kPa (in. H_2O)
14EKOZD (1 and 3 Phase) 16EKOZD (1 and 3 Phase)	8.5 (34.1)
12EFKOZD (1 and 3 Phase) 13.5EFKOZD (1 and 3 Phase)	5.0 (20.0)
21EKOZD (1 and 3 Phase) 24EKOZD (1 and 3 Phase)	8.5 (34.1)
17EFKOZD (3 Phase) 18EFKOZD (1 Phase) 20.5EFKOZD (1 and 3 Phase)	7.0 (28.1)
32EKOZD (1 and 3 Phase)	11.0 (44.2)
28EFKOZD (1 and 3 Phase)	9.0 (36.1)
40EKOZD (1 and 3 Phase)	12.0 (48.2)
35EFKOZD (1 and 3 Phase)	9.0 (36.1)

Figure 4-2 Allowable Exhaust Back Pressures

4.3.1 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 4-3. 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 4-3, item 1) in the exhaust line below the engine exhaust manifold outlet.



1. Slight lift improves silencing and prevents water backwash into the silencer (keep below the level of the exhaust manifold outlet)
2. Silencer (customer-supplied)
3. Exhaust manifold outlet
4. Exhaust mixer elbow
5. Heat exchanger (locations vary by model)
6. Coolant recovery tank (located on the unit on some models)
7. Maximum seawater pump lift of 1 m (3 ft.)
8. Seawater strainer
9. Seacock
10. Intake strainer
11. Engine-driven seawater pump
12. Minimum exhaust hose pitch of 1.3 cm per 30.5 cm (0.5 in. per ft.)
13. Maximum distance between silencer and exhaust mixer elbow of 3 m (10 ft.)
14. Maximum distance between silencer and exhaust outlet of 1.5 m (5 ft.)
15. Minimum exhaust hose pitch of 1.3 cm per 30.5 cm (0.5 in. per ft.)
16. Minimum exhaust outlet distance above waterline of 10 cm (4 in.). Note: Vessel fully loaded.
17. Maximum silencer vertical lift of 1.2 m (4 ft.)
18. If the total exhaust length exceeds 4.6 m (15 ft.), Kohler recommends increasing the exhaust hose to the next larger diameter. See Figure 4-2 and Figure 4-5.

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

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

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

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

Figure 4-3 Typical Above-Waterline Installation

4.3.2 Mid/Below-Waterline Installation

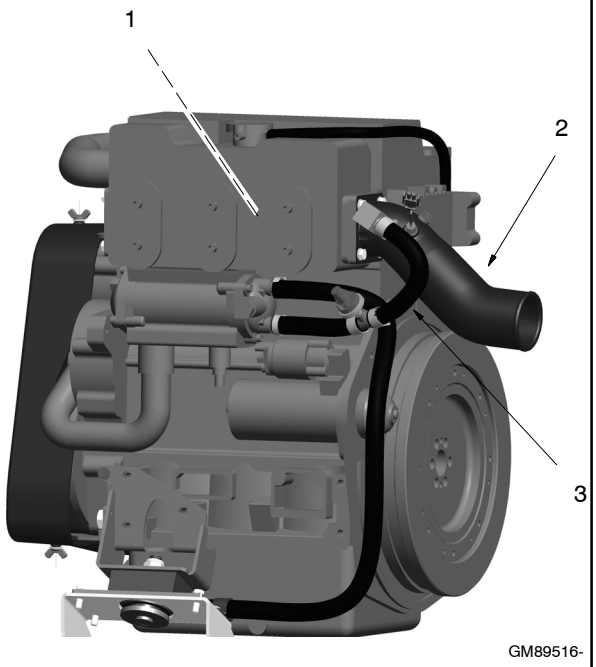
Follow USCG Regulations for installing an antisiphon provision to prevent raw water entry into the engine. Use the siphon break if the exhaust manifold outlet is located less than 23 cm (9 in.) above the waterline when the craft is loaded to maximum capacity. Install the siphon break at least 31 cm (1 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 4-4 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.



1. Heat exchanger (located inside the manifold)
2. Exhaust mixer
3. Cut hose and connect siphon break and hardware (rotate the fitting on the mixer if necessary)

Figure 4-4 Siphon Break Connection, Typical

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.

Models without Sound Shield	Models with Sound Shield	Exhaust Hose Diameter mm (in.)
14EKOZD/12EFKOZD (1 and 3 Phase) 16EKOZD/13.5EFKOZD (1 and 3 Phase) 21EKOZD/18EFKOZD (1 Phase) 21EKOZD/17EFKOZD (3 Phase) 24EKOZD/20.5EFKOZD (1 and 3 Phase)	14EKOZD/12EFKOZD (1 and 3 Phase) 16EKOZD/13.5EFKOZD (1 and 3 Phase) 21EKOZD/18EFKOZD (1 Phase) 21EKOZD/17EFKOZD (3 Phase) 24EKOZD/20.5EFKOZD (1 and 3 Phase)	76 (3.0)
32EKOZD/28EFKOZD (1 and 3 Phase) 40EKOZD/35EFKOZD (1 and 3 Phase)	32EKOZD/28EFKOZD (1 and 3 Phase) 40EKOZD/35EFKOZD (1 and 3 Phase)	89 (3.5)

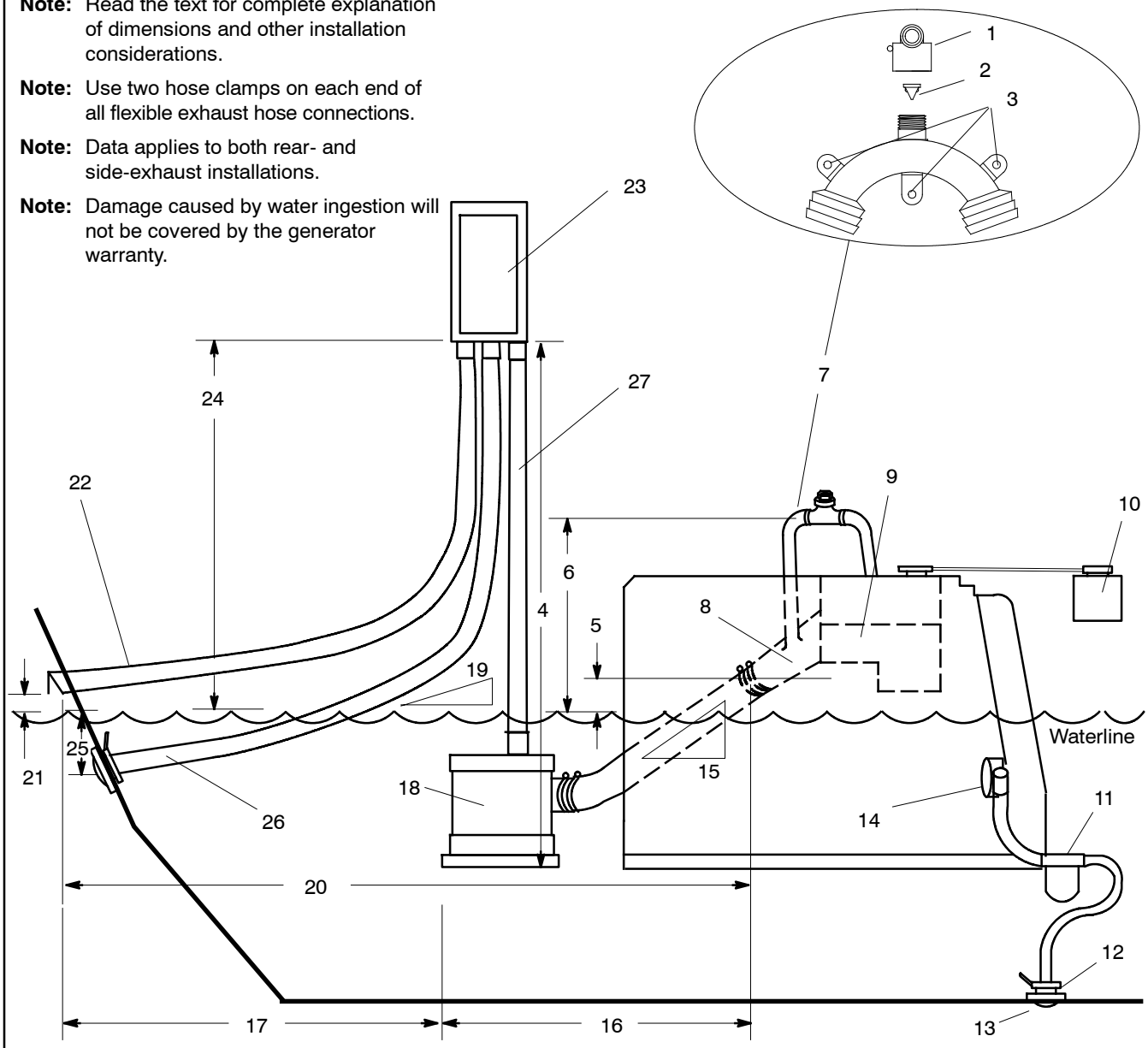
Figure 4-5 Exhaust Hose Sizes

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.

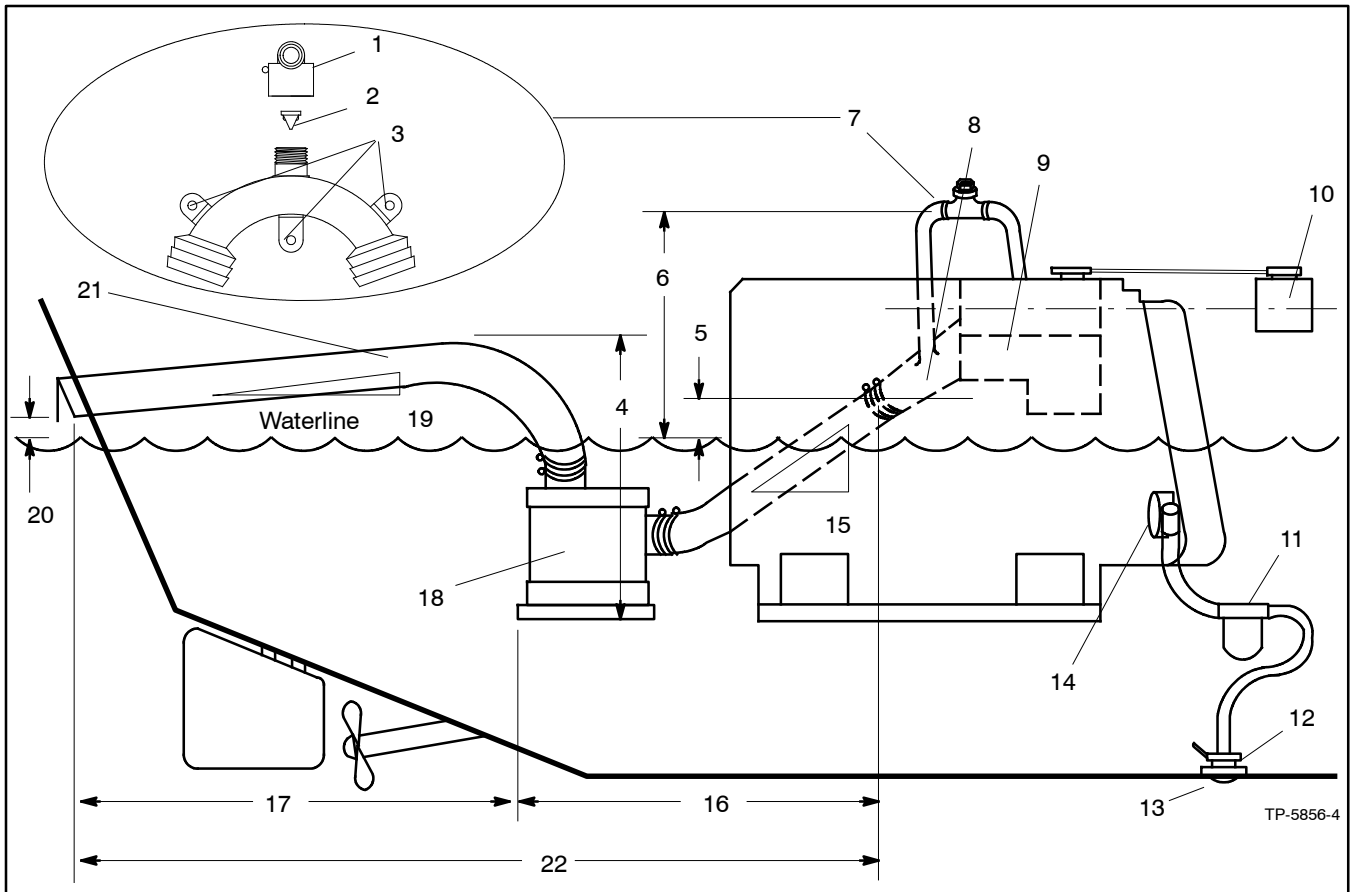
Note: Data applies to both rear- and side-exhaust installations.

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 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 elbow
9. Heat exchanger (locations vary by model)
10. Coolant recovery tank (located on the unit on some models)
11. Seawater strainer
12. Seacock
13. Intake strainer
14. Engine-driven seawater pump
15. Minimum exhaust hose pitch of 1.3 cm per 30.5 cm (0.5 in. per ft.)
16. Maximum distance between silencer and exhaust mixer elbow of 3 m (10 ft.)
17. Maximum distance between silencer and exhaust outlet of 1.5 m (5 ft.)
18. Silencer (customer-supplied)
19. Minimum exhaust hose pitch of 1.3 cm per 30.5 cm (0.5 in. per ft.)
20. Maximum distance between exhaust outlet and generator of 4.6 m (15 ft.)
21. Minimum exhaust outlet distance above waterline of 10 cm (4 in.)
22. Exhaust hose (exhaust gas outlet hose after separator)
23. Gas/water separator (optional). Install directly above the canister muffler.
24. Distance above waterline for drain outlet from silencer must be equal to or greater than water drain (item 17) to be greater than 30.5 cm (1 ft.)
25. Water drain distance below waterline
26. Water drain (separated water from item 23)
27. System installer is responsible for designing enough capacity into the lift muffler and plumbing to prevent engine water ingestion upon shutdown. Otherwise, water will drain back into item 18 on generator set shutdown.

Figure 4-6 Typical Mid- and Below-Waterline Installation with Optional Gas/Water Separator



1. Cap
2. Reed valve
3. Mounting base
4. Maximum silencer 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 elbow
9. Heat exchanger (locations vary by model)
10. Coolant recovery tank (located on the unit on some models)
11. Seawater strainer
12. Seacock
13. Intake strainer
14. Engine-driven seawater pump
15. Minimum exhaust hose pitch of 1.3 cm per 30.5 cm (0.5 in. per ft.)
16. Maximum distance between silencer and exhaust mixer elbow of 3 m (10 ft.)
17. Maximum distance between silencer and exhaust outlet of 1.5 m (5 ft.)
18. Silencer (customer-supplied)
19. Minimum exhaust hose pitch of 1.3 cm per 30.5 cm (0.5 in. per ft.)
20. Minimum exhaust outlet distance above waterline of 10 cm (4 in.)
21. Exhaust hose (see Figure 4-5 for hose sizes)
22. If the total exhaust length exceeds 4.6 m (15 ft.), Kohler recommends increasing the exhaust hose to the next larger diameter. See Figure 4-2 and Figure 4-5.

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

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

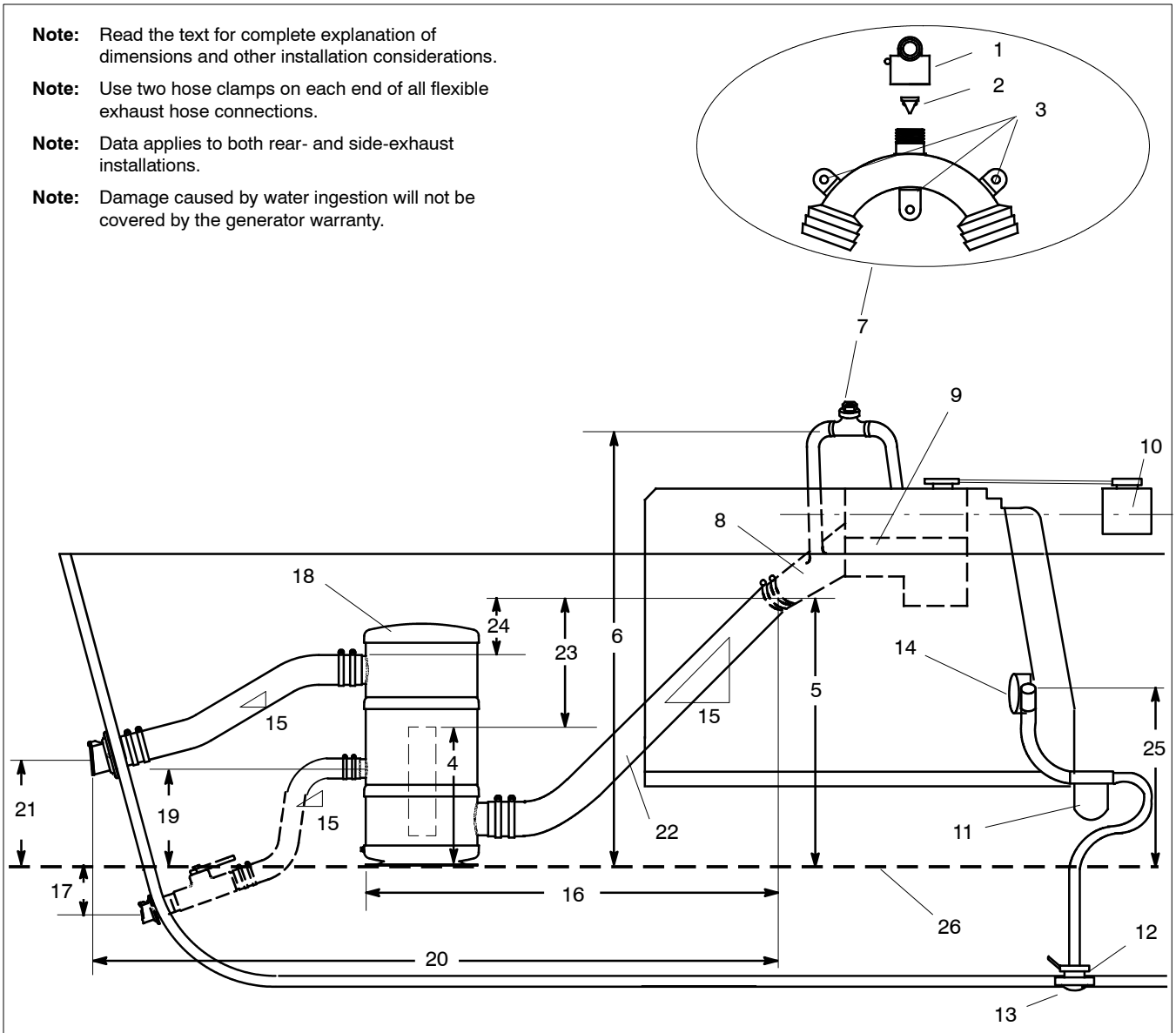
Figure 4-7 Typical Mid- and Below-Waterline Installation

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

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. Seawater strainer
12. Seacock
13. Intake strainer
14. Engine-driven seawater pump
15. Minimum exhaust hose pitch of 1.3 cm per 30.5 cm (0.5 in. per ft.)
16. Maximum distance between silencer and exhaust mixer elbow of 3 m (10 ft.)
17. Water drain distance below waterline
18. Combination silencer that contains lift muffler and gas water separating sections in single component (customer-supplied)
19. Distance above waterline for drain outlet from silencer must be equal to or greater than water drain (item 17) to be greater than 30.5 cm (1 ft.)
20. Exhaust outlet to be diameter appropriate so exhaust back pressure does not exceed limit at engine exhaust manifold
21. Minimum exhaust outlet distance above waterline of 10 cm (4 in.)
22. Exhaust hose
23. Height of internal lift tube to be below generator exhaust manifold
24. Kohler recommends generator be located at elevation that exhaust mixer elbow is above silencer exhaust outlet
25. Seawater pump lift
26. Waterline

Figure 4-8 Exhaust System with Combination Silencer/Gas Water Separator

Notes

⚠ WARNING

Explosive fuel vapors.
Can cause fires and severe burns.

If a gaseous odor is detected, ventilate the area and contact an authorized service technician.

Note: 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.

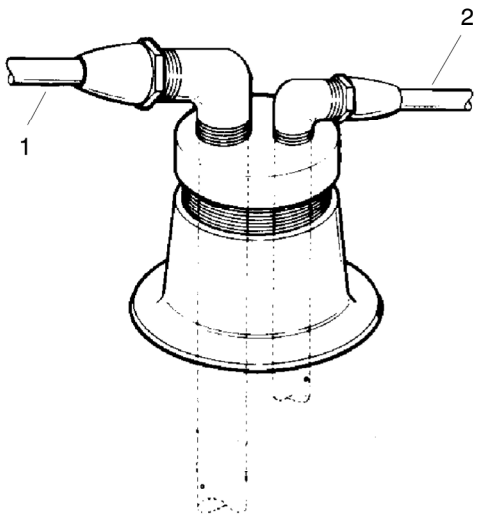
Note: Fuel system installations must conform to USCG Regulations.

Note: Use pipe sealant on all threaded fittings to prevent fuel leakage. Use pipe sealant that resists gasoline, grease, lubrication oil, common bilge solvents, salt deposits, and water.

5.1 Fuel Tank

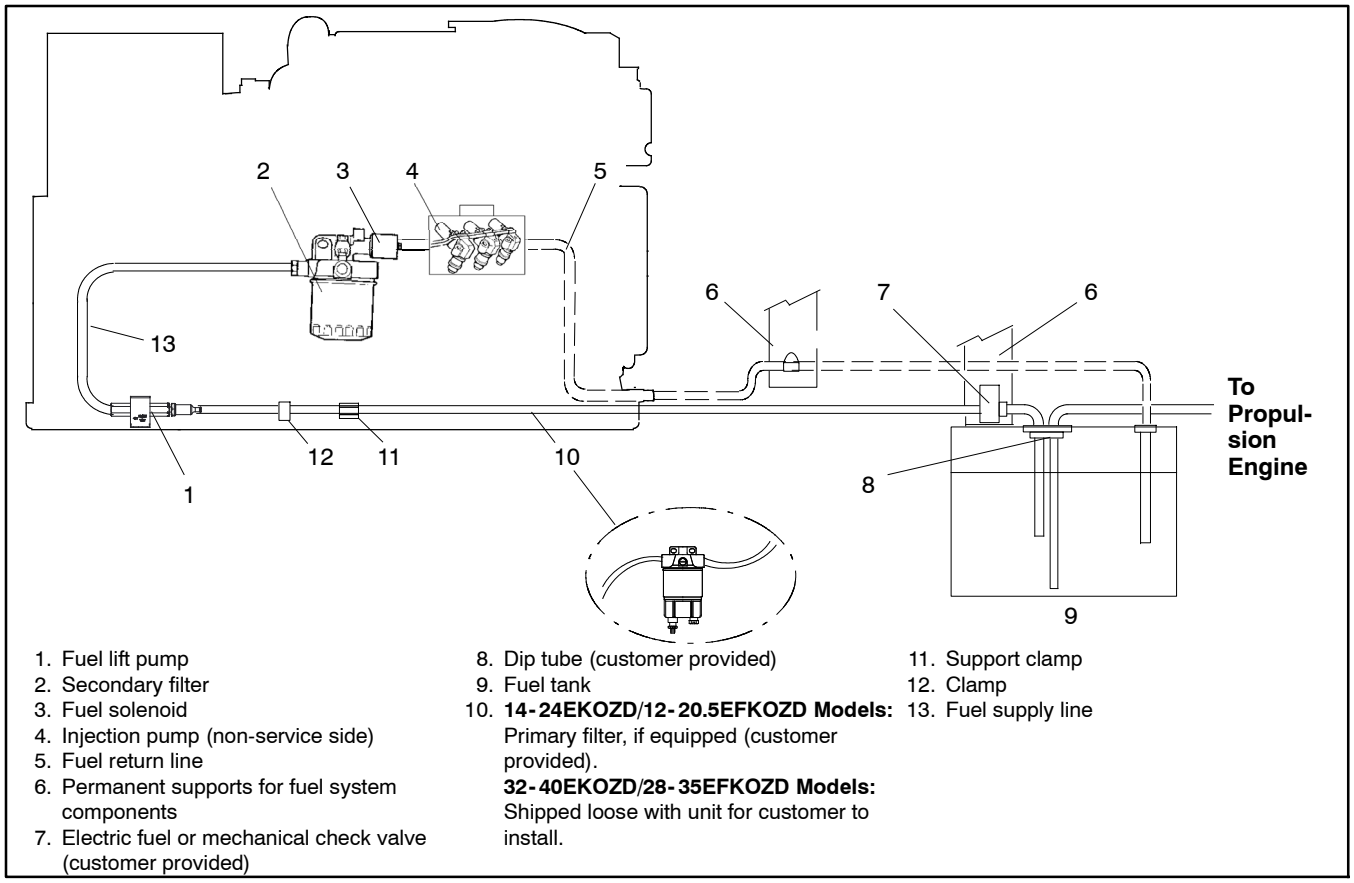
Most marine generator sets draw fuel from the same fuel tank as the craft's propulsion engine(s). If the tank's fuel pickup opening allows a multiple dip tube, use a multiple dip tube arrangement. See Figure 5-1. The multiple dip tube arrangement incorporates a shorter dip tube for the generator set 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.

Design the fuel system to have a continuous slope from the fuel tank to the customer connection point on the generator set.



1. Fuel line to propulsion engine
2. Fuel line to generator set

Figure 5-1 Multiple Dip Tube Arrangement



1. Fuel lift pump
2. Secondary filter
3. Fuel solenoid
4. Injection pump (non-service side)
5. Fuel return line
6. Permanent supports for fuel system components
7. Electric fuel or mechanical check valve (customer provided)
8. Dip tube (customer provided)
9. Fuel tank
10. **14-24EKOZD/12-20.5EFKOZD Models:** Primary filter, if equipped (customer provided).
    32-40EKOZD/28-35EFKOZD Models: Shipped loose with unit for customer to install.
11. Support clamp
12. Clamp
13. Fuel supply line

Figure 5-2 Fuel System, Typical

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.

Note: **Fuel Return Dip Tube.** Kohler Co. recommends utilizing a fuel return dip tube located below the fuel supply dip tube. This will prevent air from entering the return lines, draining the fuel injection pump, and thus causing starting failure or hard starting of the generator set. The dip tube depth should be at least as deep as the main engine fuel pick-up dip tube.

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 the generator set to vibrate during operation.

Model	Fuel Line ID Size mm (in.)	
	Fuel Inlet	Fuel Return
14-24EKOZD/12-20.5EFKOZD	8 (5/16) min.	6 (1/4) min.
32-40EKOZD/28-35EFKOZD		

Figure 5-3 Fuel Line ID Size

See Figure 5-3 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.

The fuel inlet and return lines must not exceed the restriction limits specified in Figure 5-4. For fuel delivery systems that are pressurized due to factors such as (but not limited to) the use of remotely installed fuel boost pump or fuel level heights above the fuel injection pump, the maximum pressure for the system is 5.9 in. Hg (20 kPa).

Model	Fuel Line Restriction in. Hg (kPa)	
	Fuel Inlet *	Fuel Return †
14-24EKOZD/12-20.5EFKOZD	-3.6 (-12.2)	5.9 (20)
32-40EKOZD/28-35EFKOZD	-7.4 (-25)	5.9 (20)

* Fuel inlet is measured at the inlet to the fuel pump.

† Fuel return is measured at the return connection point of the engine.

Figure 5-4 Fuel Line Restriction, Max.

5.2.1 Fuel Line Selection and Application for 32/40EKOZD and 28/35EFKOZD Models

The following items describe fuel line selection and application. Never use the fuel piping or fuel line clamps to ground any electrical equipment.

Use materials which do not contain the below listed metals.

- Barium (Ba)
- Calcium (Ca)
- Copper (Cu)
- Lead (Pb)
- Magnesium (Mg)
- Phosphorous (P)
- Potassium (K)
- Sodium (Na)
- Zinc (Zn)

These metals react adversely with diesel fuel to form deposits on the fuel system causing a gradual decrease in fuel system efficiency and eventually can cause fuel system failure. Use of such materials may affect fuel system warranty.

Note: The KDI TCR engines require that the above metals are not present in the fuel system components.

5.3 Fuel Filters

Conform to USCG Regulations regarding inline fuel filters or strainers.

5.4 Fuel/Water Separator

Install a fuel/water separator between the fuel tank and the electric fuel pump.

14-24EKOZD/12-20.5EFKOZD Models, if equipped: The fuel/water separator must contain a primary filter of 30-50 micron filtration capability, sized for at least 15 gph to allow for the return fuel flow.

32-40EKOZD/28-35EFKOZD Models: Primary fuel filter (part number GM41013 or equivalent) is required to be installed in the fuel system prior to and below the generator set. See Figure 5-5 for the filtration and water separation efficiency requirements.

32-40EKOZD/28-35EFKOZD Models		
Particle Separation	Particle Size (um)	Efficiency (%)
	4	98.5
	5	99
	6	99.5
Water Separation	Drop Size (um @D50)	Efficiency (%)
	150	99
	1000	99

Figure 5-5 Primary Fuel Filter Specifications

5.5 Fuel Pump Lift

See Figure 5-6 for fuel pump lift capabilities.

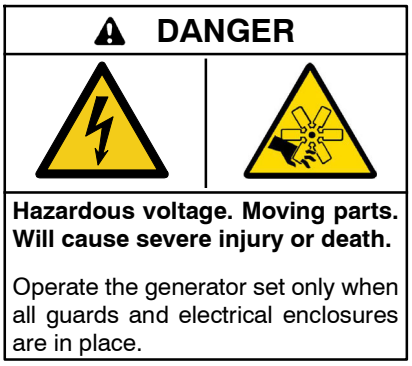
Model	Fuel Pump Lift m (ft.)
14EKOZD/12EFKOZD (1 and 3 Phase)	1.2 (4)
16EKOZD/13.5EFKOZD (1 and 3 Phase)	
21EKOZD/18EFKOZD (1 Phase)	
21EKOZD/17EFKOZD (3 Phase)	
24EKOZD/20.5EFKOZD (1 and 3 Phase)	
32EKOZD/28EFKOZD (1 and 3 Phase)	
40EKOZD/35EFKOZD (1 and 3 Phase)	

Figure 5-6 Fuel Pump Lift

5.6 Fuel Consumption

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

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. The unit's voltage configuration determines the circuit breaker selection.

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

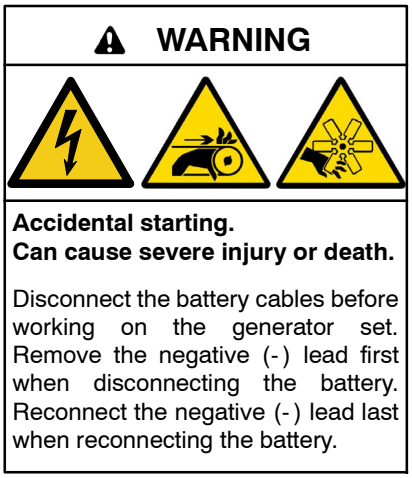
6.2.1 Circuit Breaker Considerations

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

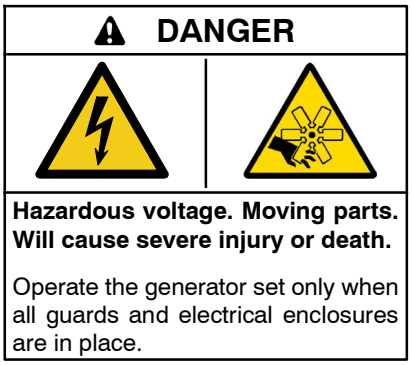
Sizing. Use the generator set voltage/frequency configuration to determine the circuit breaker amperage. If the generator set voltage configuration changes, change the circuit breaker to provide optimum protection.

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.



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 will 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 will 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. Press the generator set OFF/RESET button to shut down the generator set.
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 6-2.
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: Kohler® marine diesel generator sets are fully frequency adjustable and voltage reconnectable. To determine reconnection options, check the model's specification sheet.

   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.

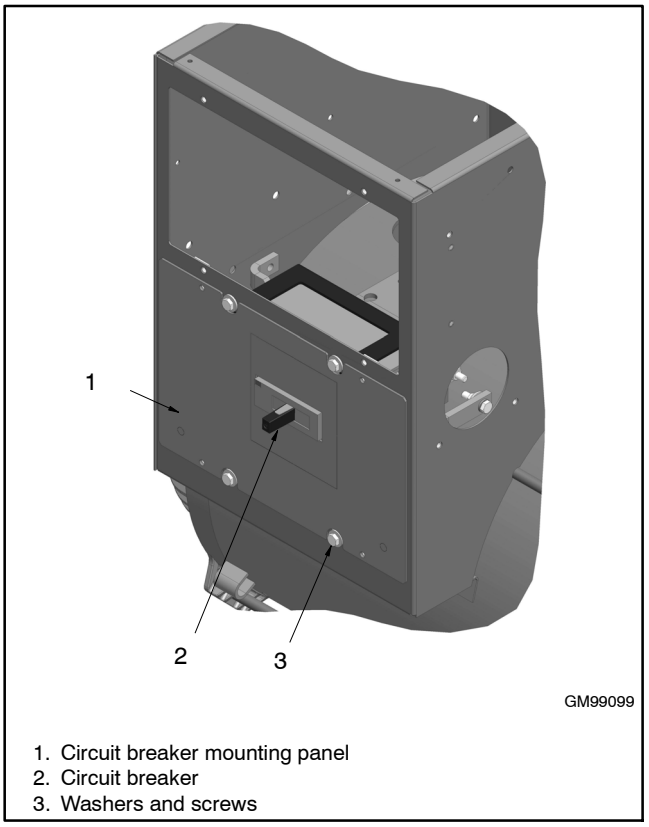
7. Connect the load side of the circuit breaker to customer-supplied craft wiring. Connect the neutral lead to the L0 stud. See Figure 8-3.

Note: Wire material. Use stranded copper for all wiring. Use wire gauges and insulation, conductor temperature ratings, sheath stripping, conductor support and protection, conductor terminals and splices, and overcurrent protection (circuit breakers, fuses) that conform to standards and codes.

Note: Follow USCG Regulations CFR33, Part 183 (Pleasurecraft) and CFR46 (Commercial Craft) for marine applications.

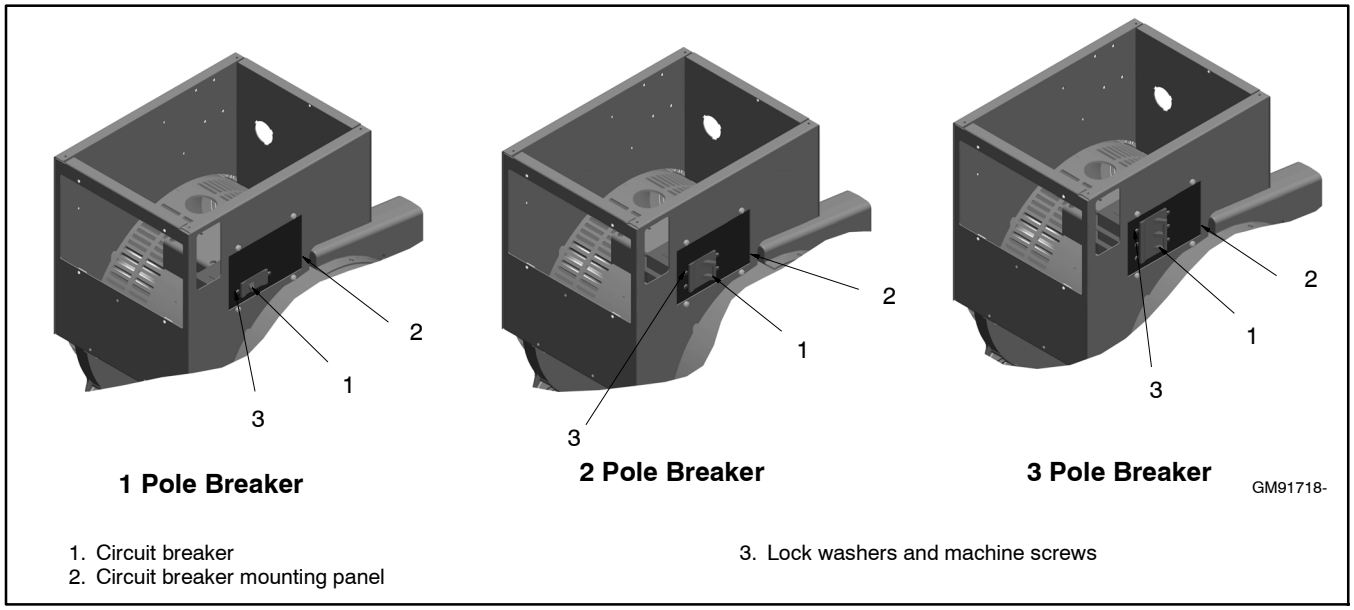
Note: Wire protection. Use plastic bushings, rubber grommets, and/or cable ties as necessary to protect and secure wiring from sharp objects, the exhaust system, and any moving parts.

8. Attach the new panel to the junction box using the original six screws.
9. Check that the generator set master is OFF. Reconnect the generator set engine starting battery, negative (-) lead last.



1. Circuit breaker mounting panel
2. Circuit breaker
3. Washers and screws

Figure 6-1 Circuit Breaker Mounting, Typical (32-40EKOZD/28-35EFKOZD Models shown)



1. Circuit breaker
2. Circuit breaker mounting panel
3. Lock washers and machine screws

Figure 6-2 Circuit Breaker Mounting, Typical (14-24EKOZD/12-20.5EFKOZD Models shown)

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

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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 6-3 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)			
Distance (from battery to generator set)	2.5 m (8.3 ft.)		5 m (16.4 ft.)	
Battery Voltage	12V	24V	12V	24V
14EKOZD/12EFKOZD (1 and 3 Phase) 16EKOZD/13.5EFKOZD (1 and 3 Phase) 21EKOZD/18EFKOZD (1 Phase) 21EKOZD/17EFKOZD (3 Phase) 24EKOZD/20.5EFKOZD (1 and 3 Phase)	# 2	# 4	# 1/0	# 2
32EKOZD/28EFKOZD (1 and 3 Phase) 40EKOZD/35EFKOZD (1 and 3 Phase)	# 1/0	# 3	# 4/0	# 1/0

Figure 6-3 Battery Cable Sizing Recommendations

Kohler Co. recommends using one 12-volt battery (or two for 24-volt systems, as the spec requires) to start the generator. See Figure 6-4 for minimum cold cranking amps (CCA) recommendations.

12-Volt Starting Battery Size CCA at - 15°C (5°F) or 100 Amp. Hr.	
Models	**CCA**
14EKOZD/12EFKOZD (1 and 3 Phase)	650
16EKOZD/13.5EFKOZD (1 and 3 Phase)	
21EKOZD/18EFKOZD (1 Phase)	
21EKOZD/17EFKOZD (3 Phase)	
24EKOZD/20.5EFKOZD (1 and 3 Phase)	
32EKOZD/28EFKOZD (1 and 3 Phase)	1000
40EKOZD/35EFKOZD (1 and 3 Phase)	

Figure 6-4 Battery Recommendations

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.

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.

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
14EKOZD/12EFKOZD 16EKOZD/13.5EFKOZD (1 and 3 phase)	ADV-8880A- ADV-8880B-	36 37
with sound shield	ADV-8881A-B ADV-8881B-B ADV-8881C-B ADV-8881D-B	40 41 42 43
accessories	ADV-8882A-A ADV-8882B-A	44 45
21- 24EKOZD 17- 20.5EFKOZD (1 and 3 phase)	ADV-8883A- ADV-8883B-	38 39
with sound shield	ADV-8881A-B ADV-8881B-B ADV-8881C-B ADV-8881D-B	40 41 42 43
accessories	ADV-8882A-A ADV-8882B-A	44 45
32- 40EKOZD 28- 35EFKOZD (1 and 3 phase) with engine group numbers: GM101305-GA1 - - GA8	ADV-8857A-B ADV-8857B-B	46 47
with sound shield	ADV-8858A-B ADV-8858B-B	50 51
accessories	ADV-8859A-A ADV-8859B-A	52 53
32- 40EKOZD 28- 35EFKOZD (1 and 3 phase) with engine group numbers: GM118203-GA1 - - GA8	ADV-9908A- ADV-9908B-	48 49
with sound shield	ADV-8858A-B ADV-8858B-B	50 51
accessories	ADV-8859A-A ADV-8859B-A	52 53

Figure 7-1 Installation Drawings

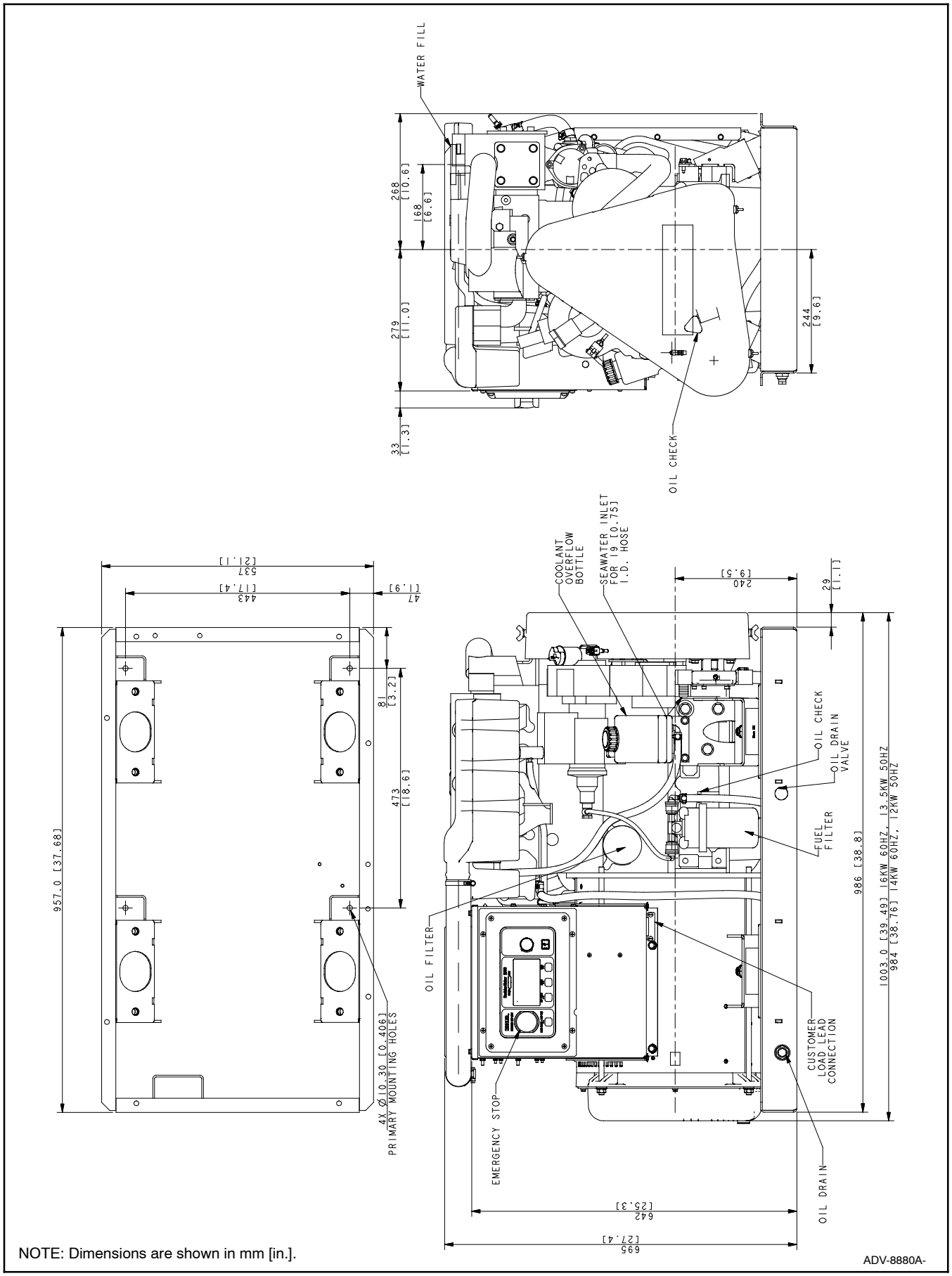


Figure 7-2 Dimension Drawing, 14/16EKOZD and 12/13.5EFKOZD (Sheet 1 of 2)

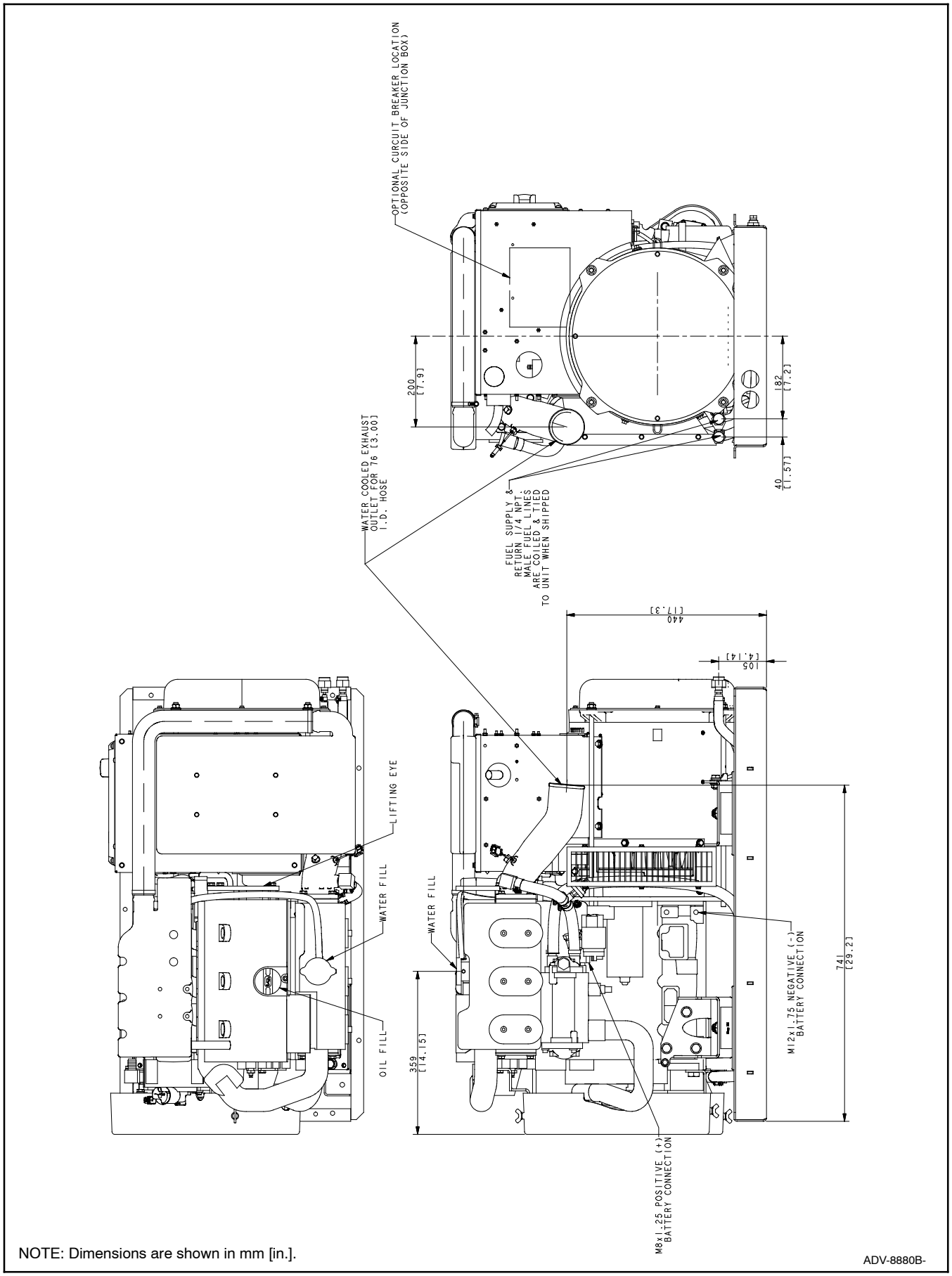


Figure 7-3 Dimension Drawing, 14/16EKOZD and 12/13.5EFKOZD (Sheet 2 of 2)

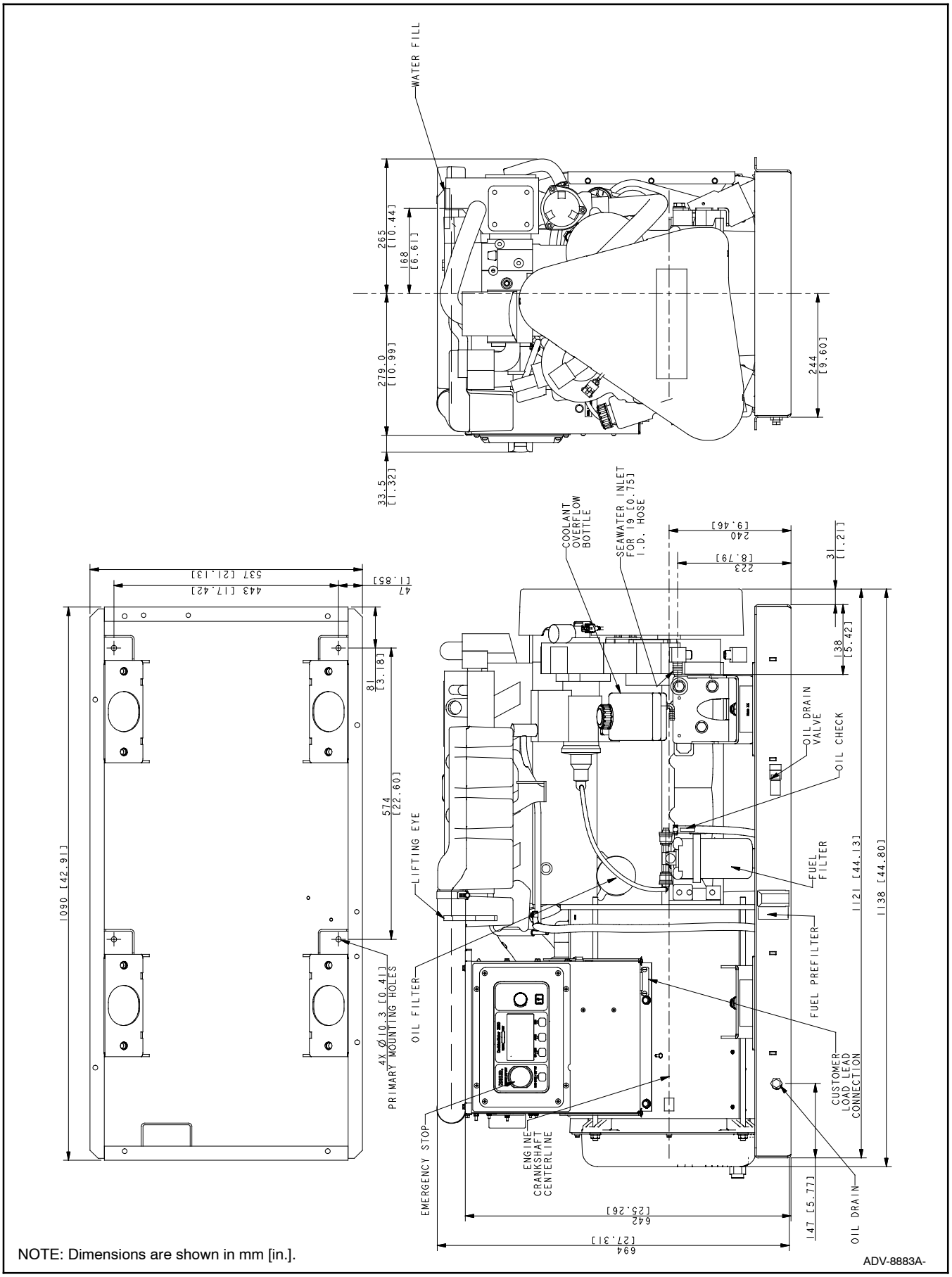


Figure 7-4 Dimension Drawing, 21- 24EKOZD and 17- 20.5EFKOZD (Sheet 1 of 2)

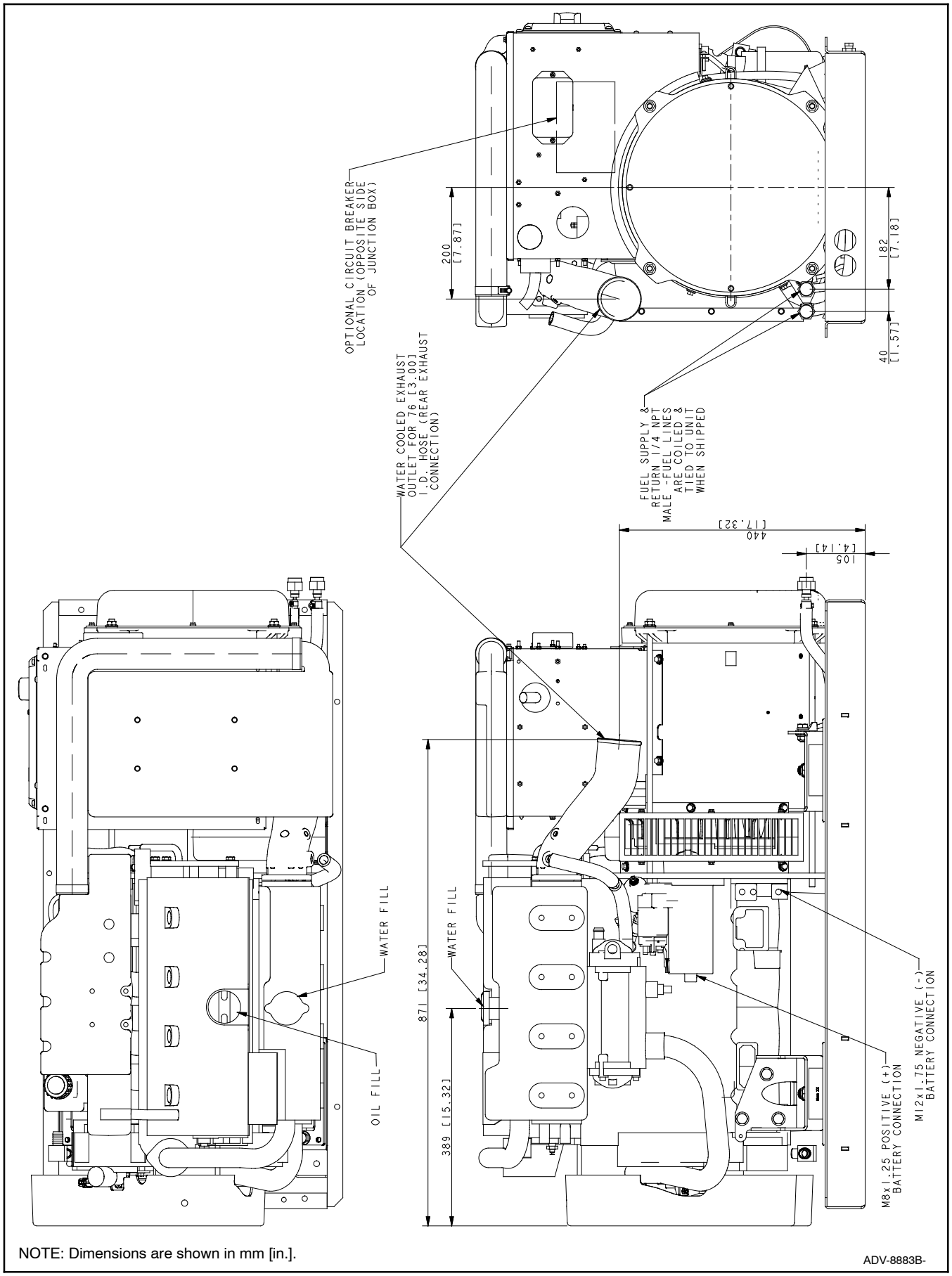


Figure 7-5 Dimension Drawing, 21- 24EKOZD and 17- 20.5EFKOZD (Sheet 2 of 2)

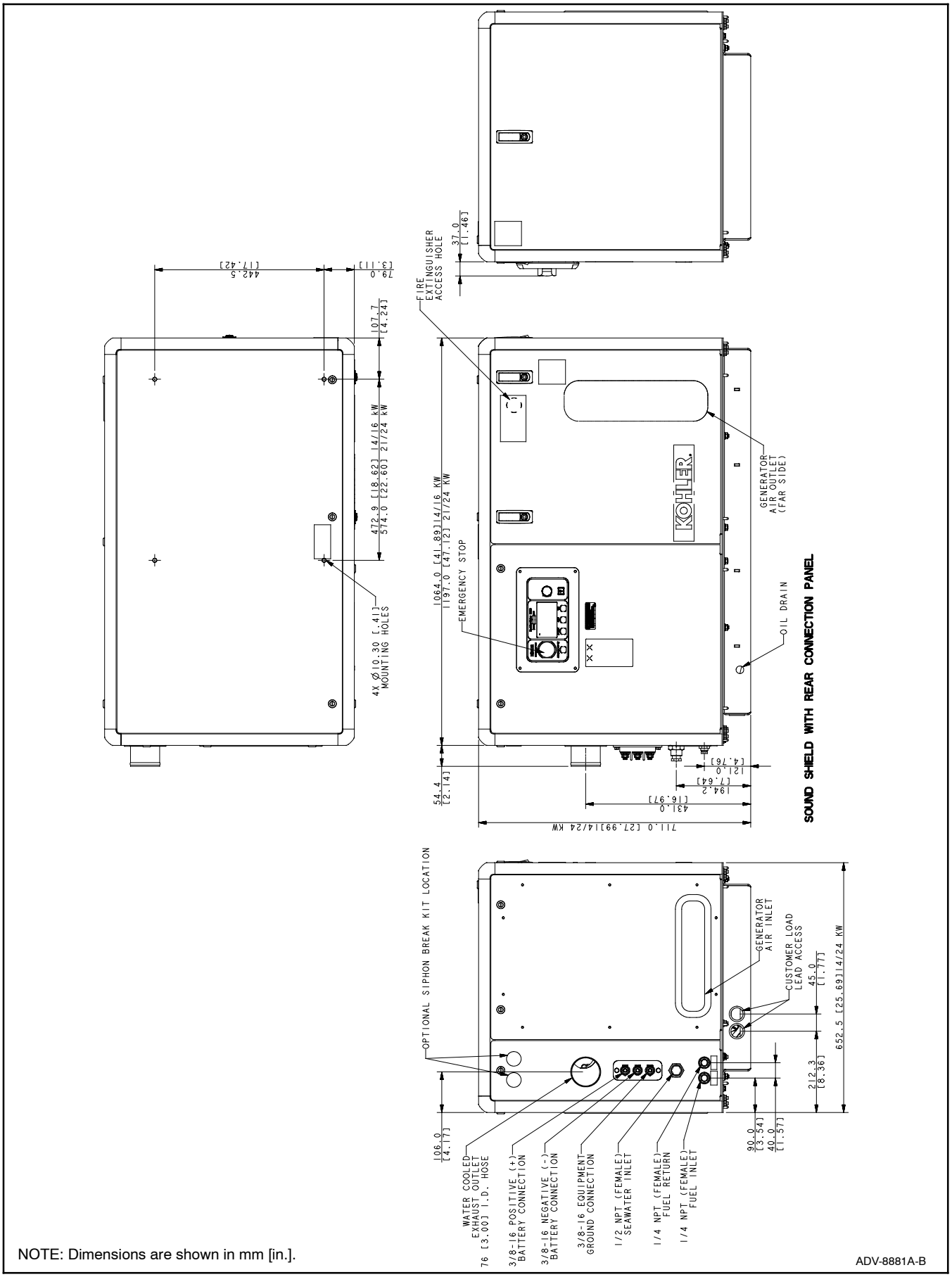


Figure 7-6 Dimension Drawing—Sound Shield, 14- 24EKOZD and 12- 20.5EFKOZD (Sheet 1 of 4)

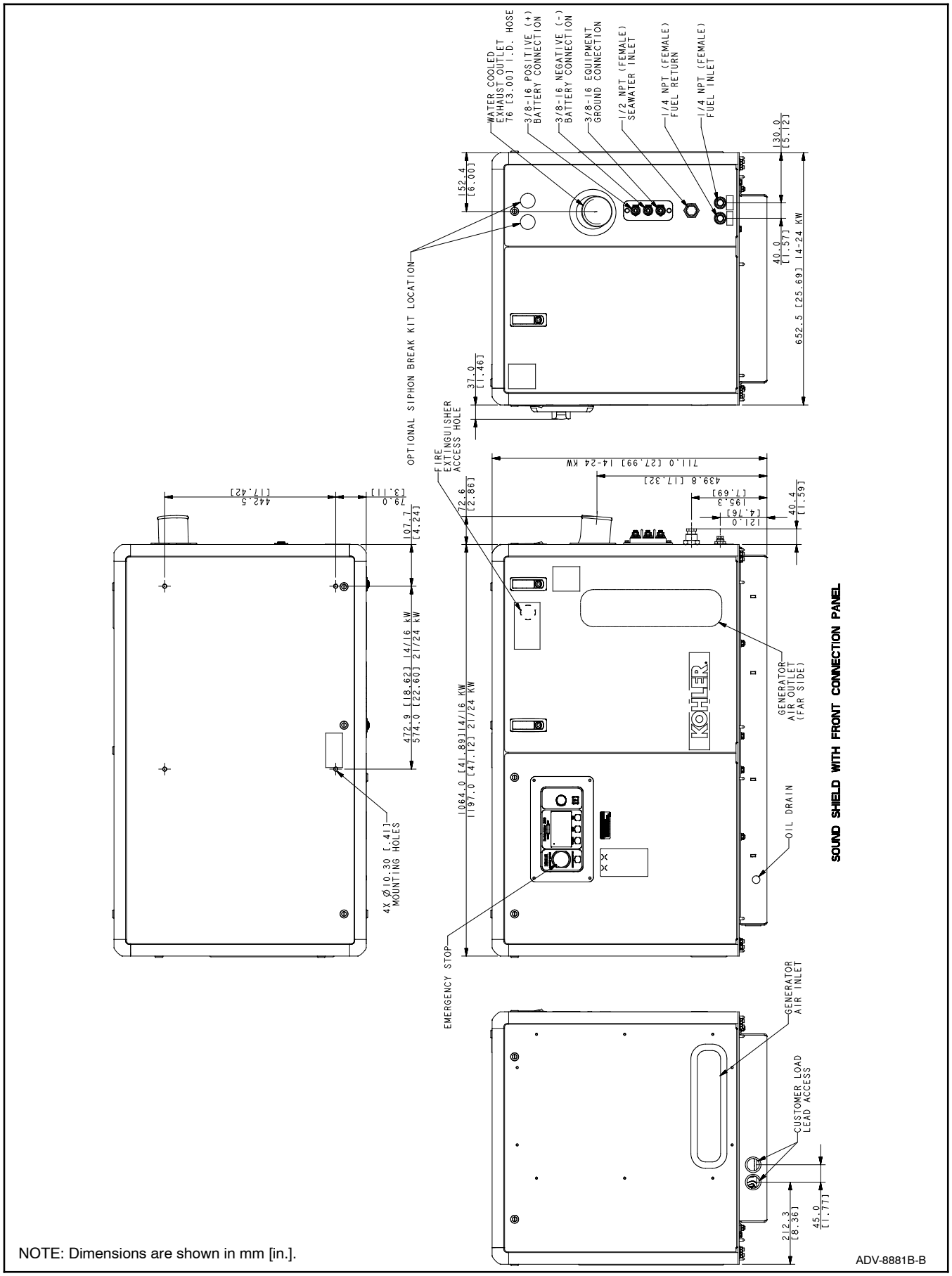


Figure 7-7 Dimension Drawing—Sound Shield, 14- 24EKOZD and 12- 20.5EFKOZD (Sheet 2 of 4)

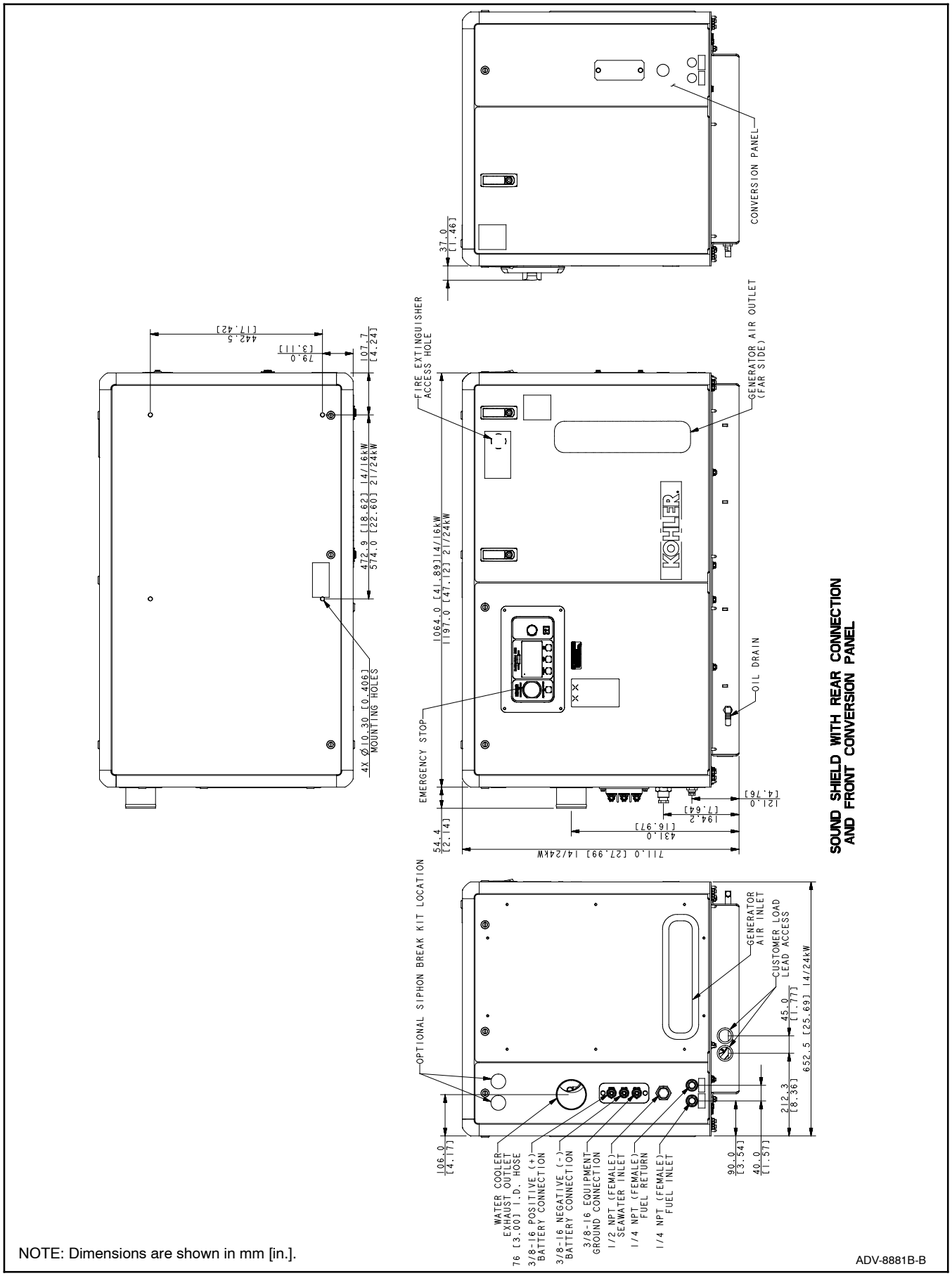


Figure 7-8 Dimension Drawing—Sound Shield, 14- 24EKOZD and 12- 20.5EFKOZD (Sheet 3 of 4)

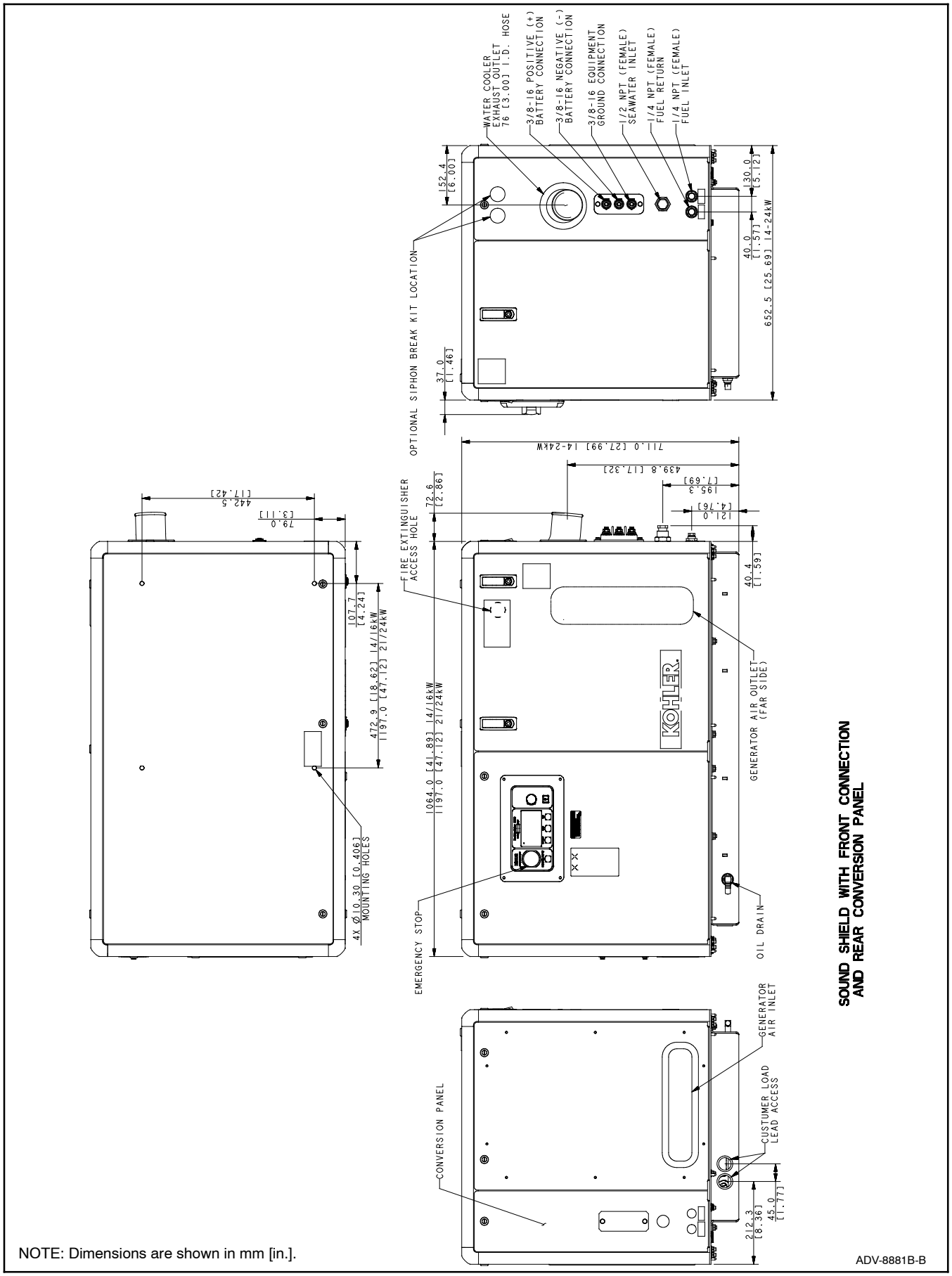


Figure 7-9 Dimension Drawing—Sound Shield, 14- 24EKOZD and 12- 20.5EFKOZD (Sheet 4 of 4)

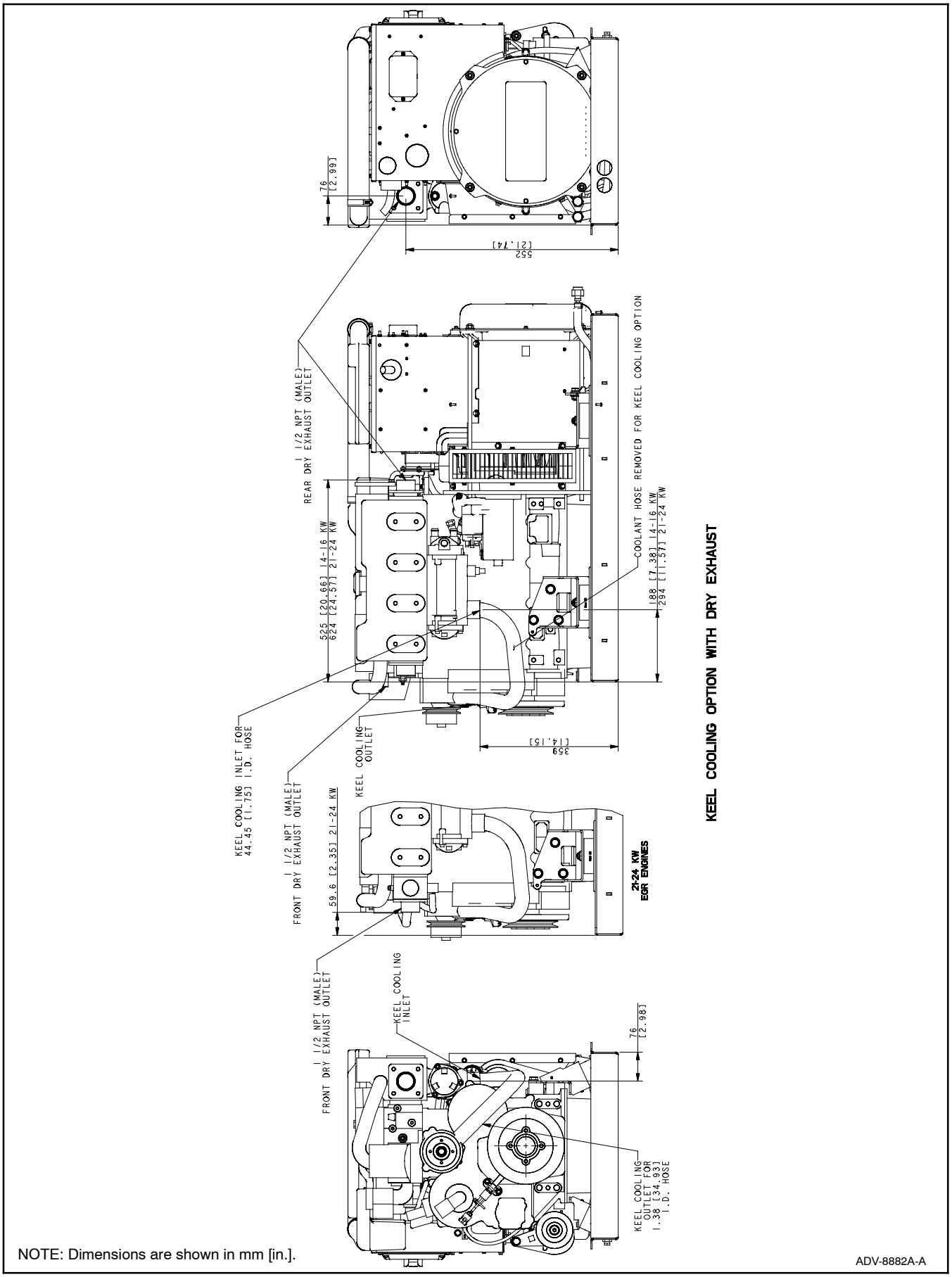


Figure 7-10 Dimension Drawing—Accessories, 14- 24EKOZD and 12- 20.5EFKOZD (Sheet 1 of 2)

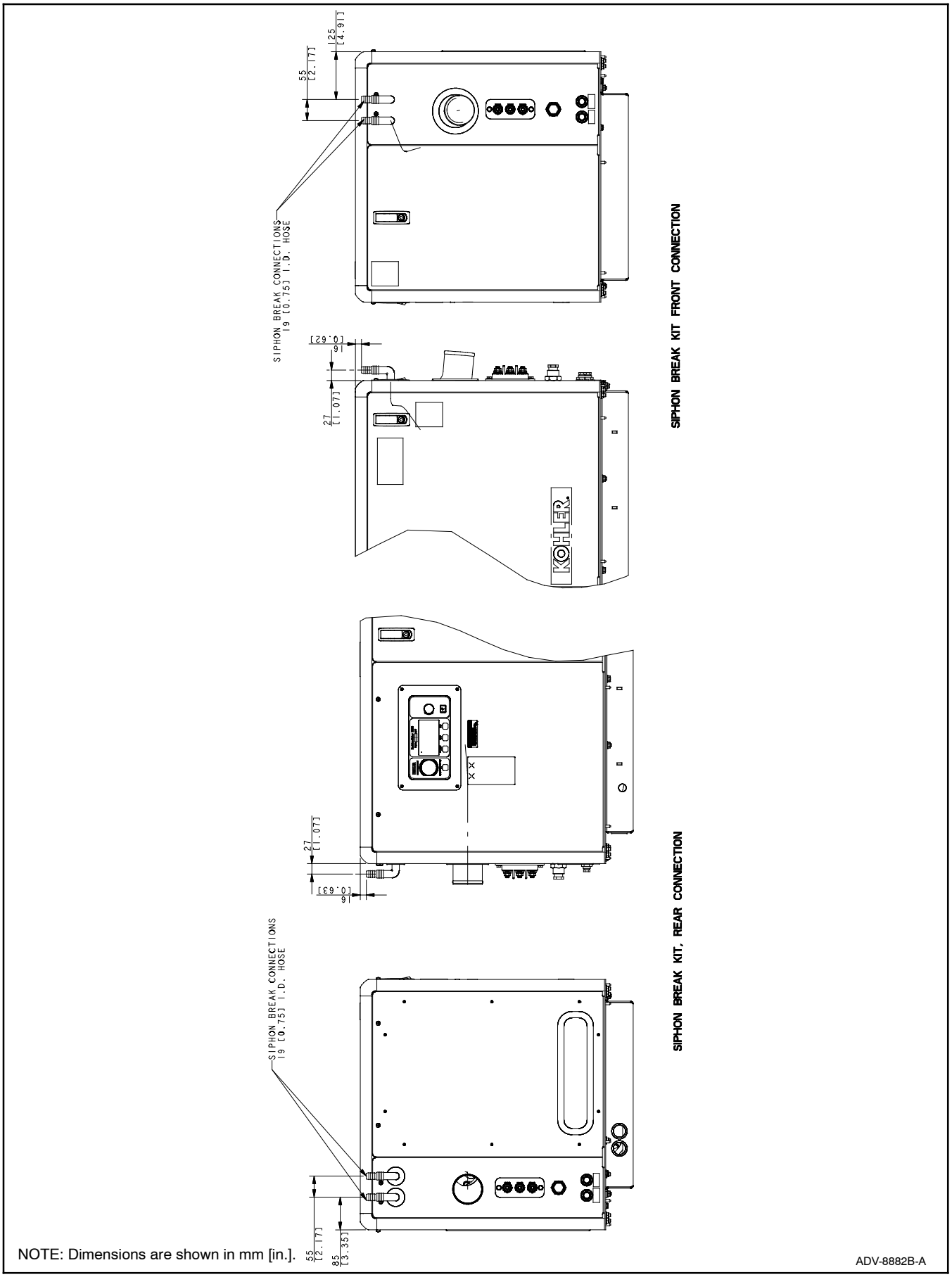


Figure 7-11 Dimension Drawing—Accessories, 14- 24EKOZD and 12- 20.5EFKOZD (Sheet 2 of 2)

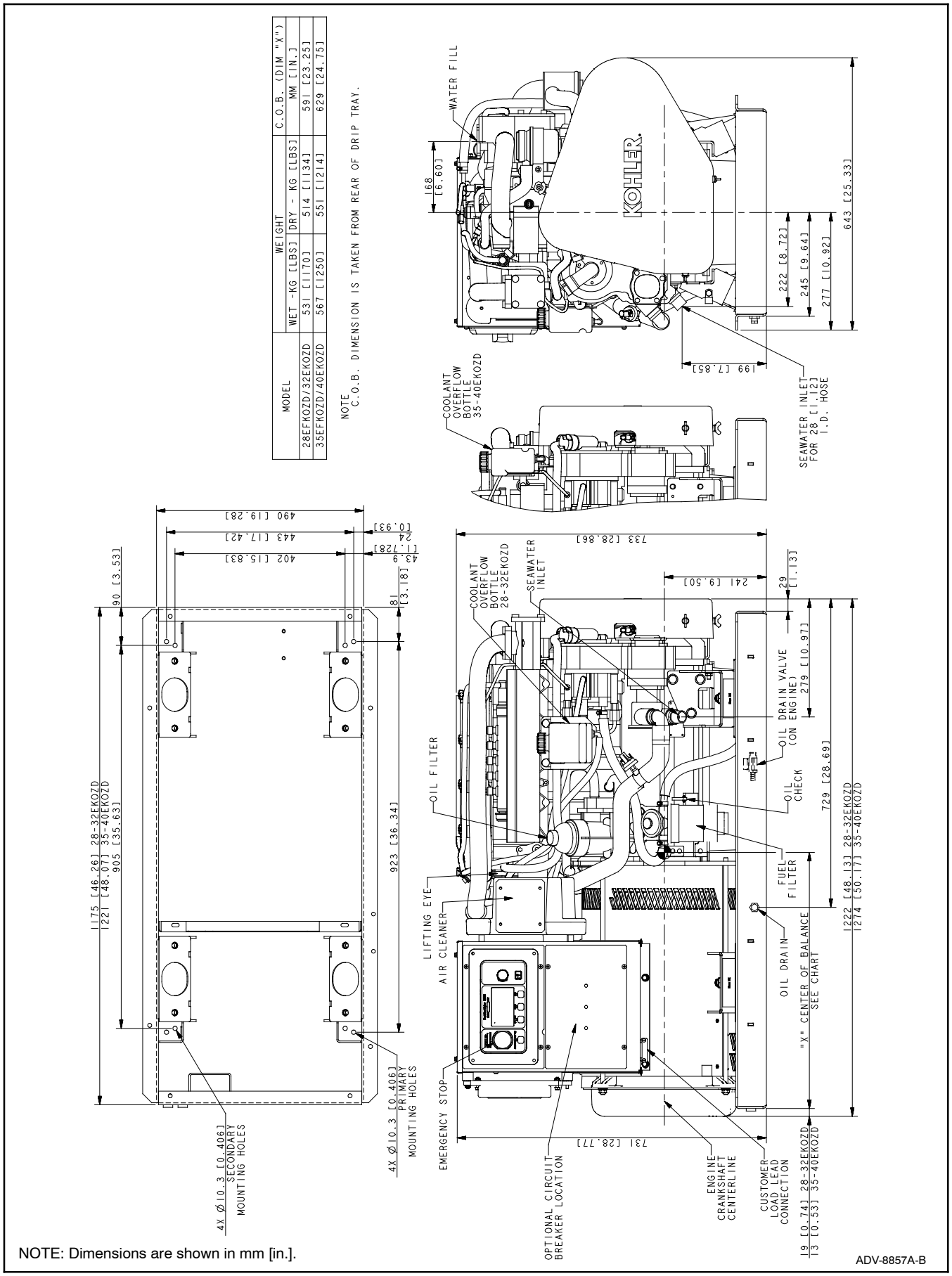
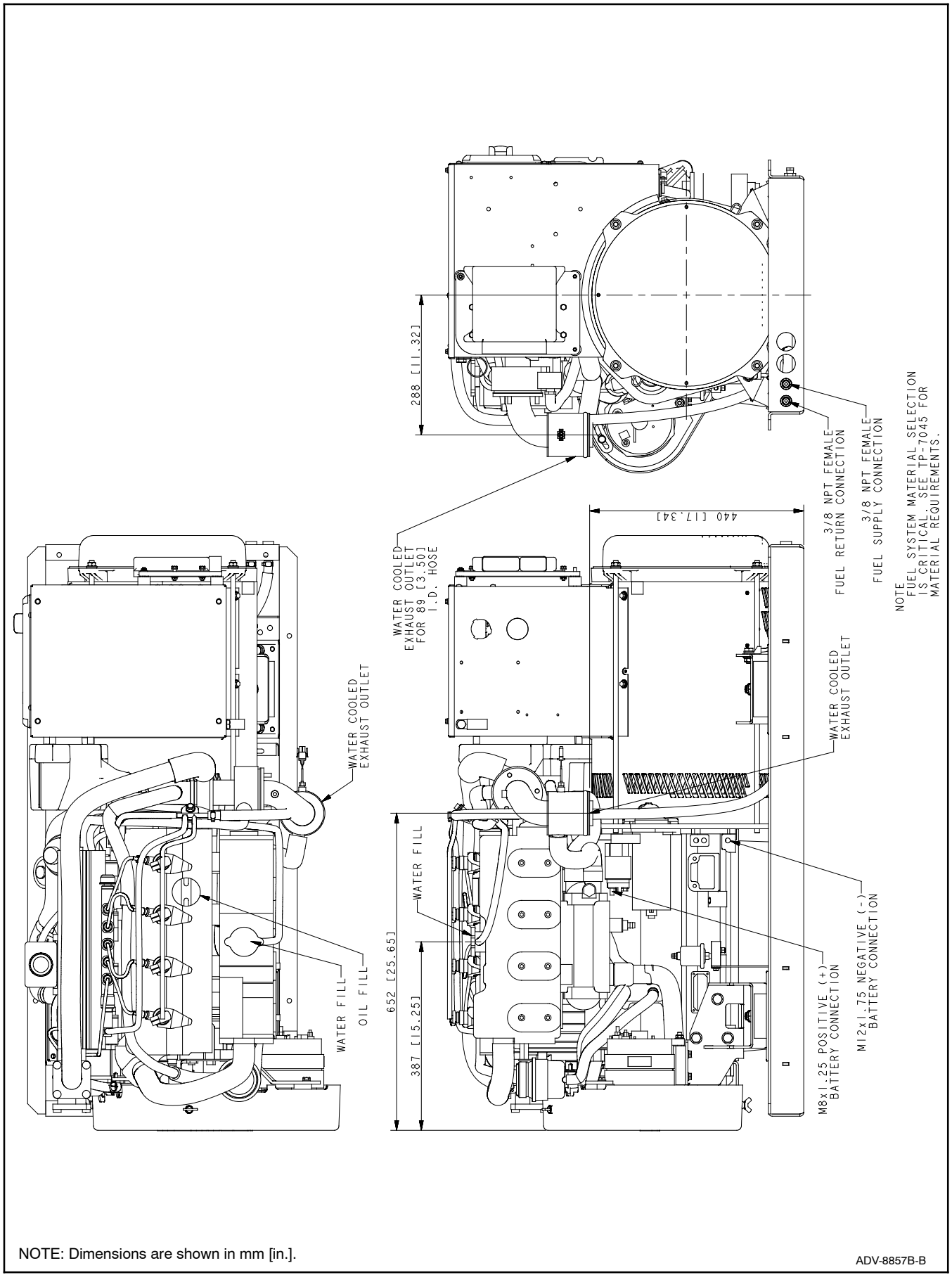


Figure 7-12 Dimension Drwg, 32/40EKOZD 28/35EFKOZD w/ Engine Group No. GM101305-GA1- GA8 (Sht. 1 of 2)



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

ADV-8857B-B

Figure 7-13 Dimension Drwg, 32/40EKOZD 28/35EFKOZD w/ Engine Group No. GM101305-GA1- GA8 (Sht. 2 of 2)

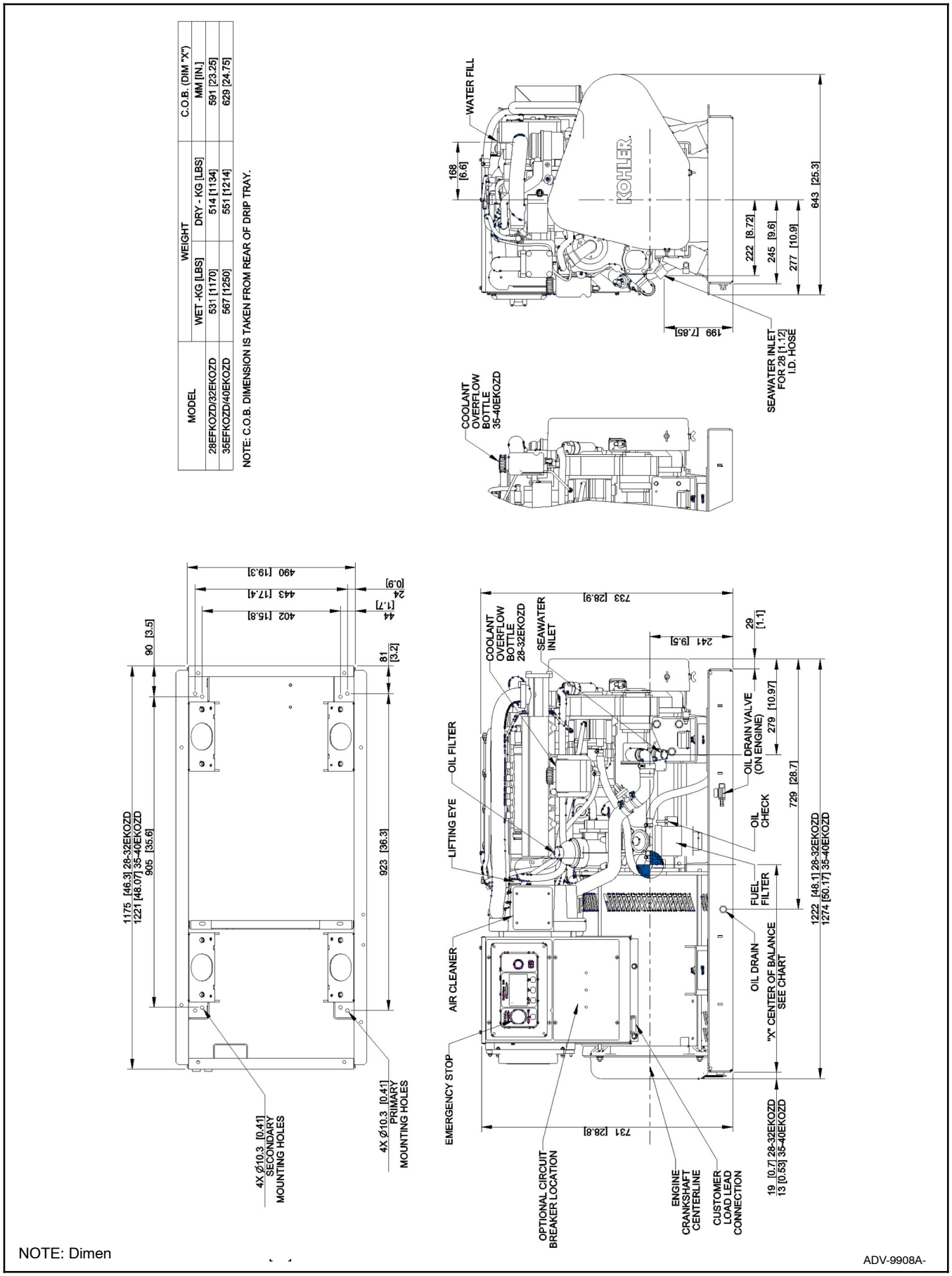
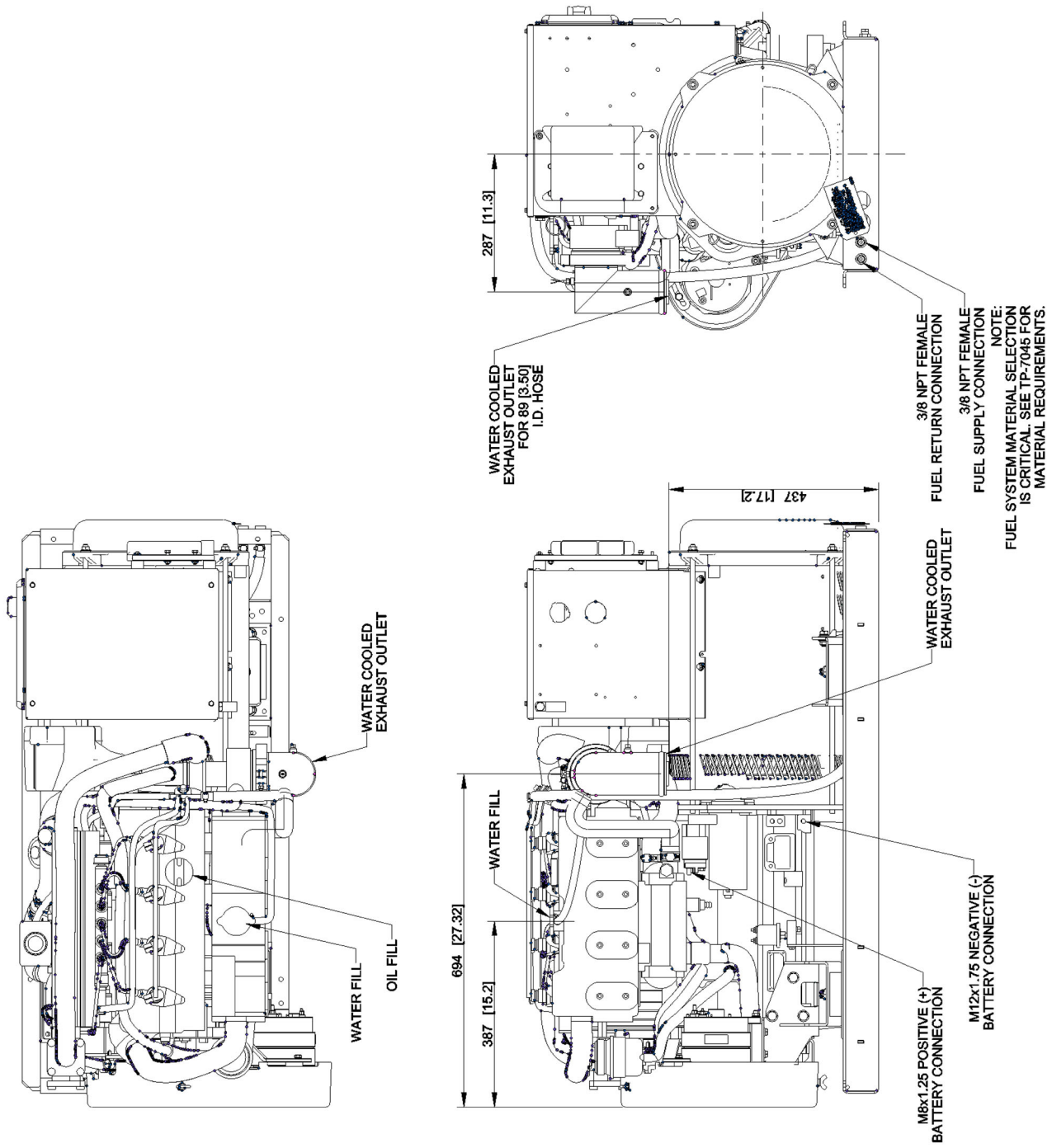


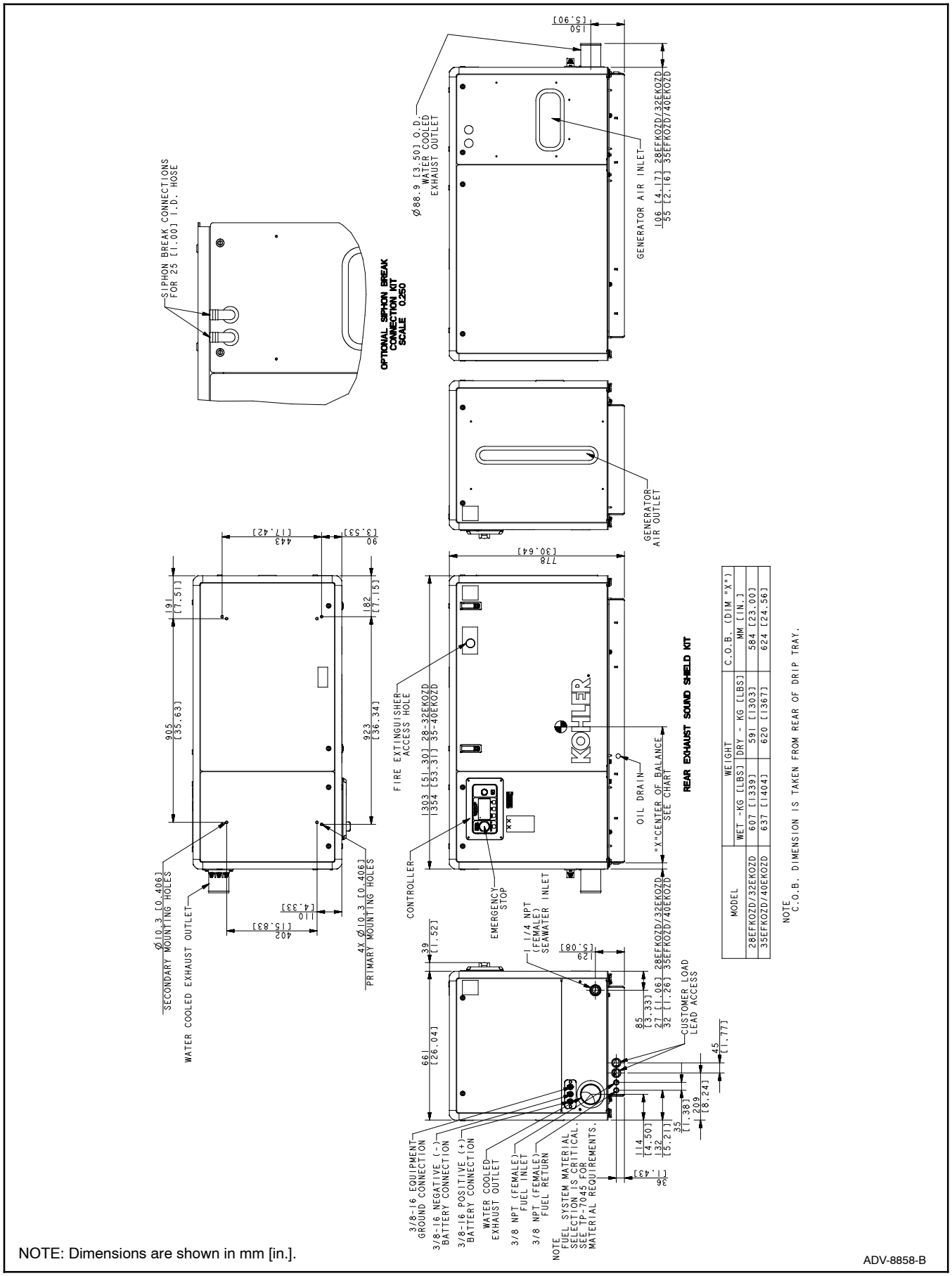
Figure 7-14 Dimension Drwg, 32/40EKOZD 28/35EFKOZD w/ Engine Group No. GM118203-GA1 - GA8 (Sht. 1 of 2)



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

ADV-9908B-

Figure 7-15 Dimension Drwg, 32/40EKOZD 28/35EFKOZD w/ Engine Group No. GM118203-GA1- GA8 (Sht. 2 of 2)



MODEL	WEIGHT		C.O.B. (DIM "X")
	WET - KG [LBS]	DRY - KG [LBS]	MM [IN.]
28EFKOZD/32EKOZD	607 [1339]	591 [1303]	584 [23.00]
35EFKOZD/40EKOZD	637 [1404]	620 [1367]	624 [24.56]

Figure 7-16 Dimension Drawing—Sound Shield, 32/40EKOZD and 28/35EFKOZD (Sheet 1 of 2)

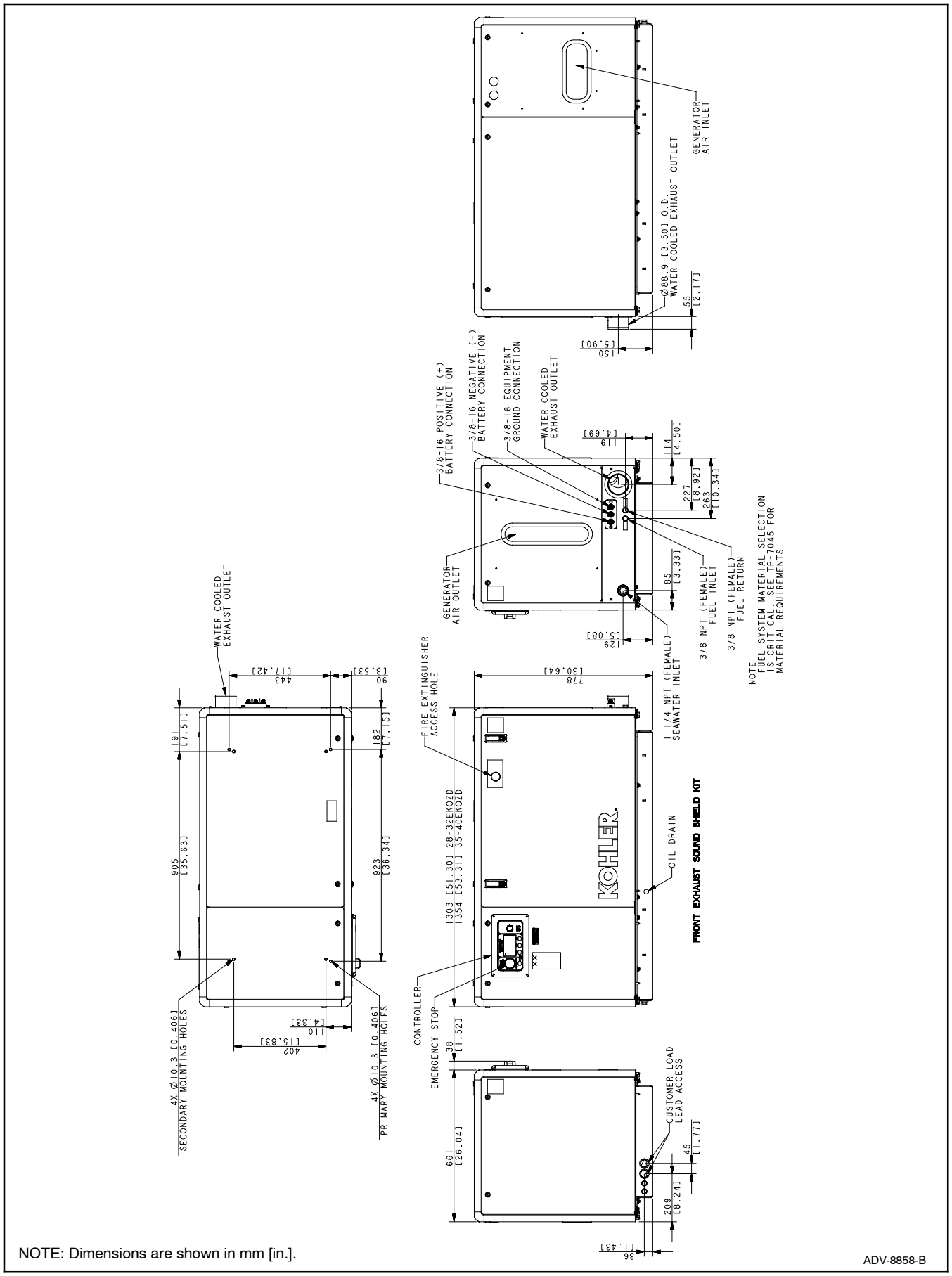
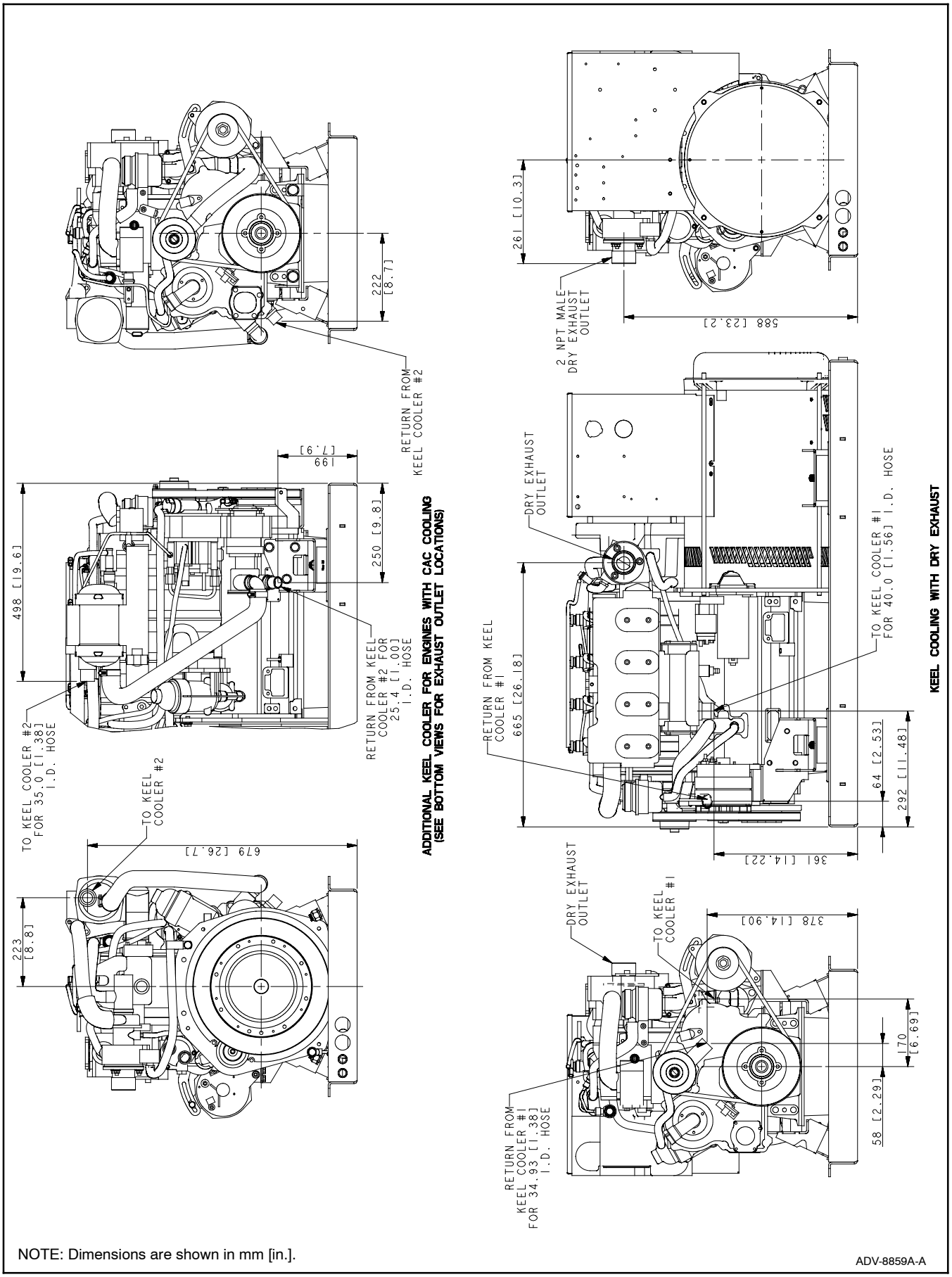


Figure 7-17 Dimension Drawing—Sound Shield, 32/40EKOZD and 28/35EFKOZD (Sheet 2 of 2)



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

ADV-8859A-A

Figure 7-18 Accessory Drawing—Keel Cooling with Dry Exhaust, 32/40EKOZD and 28/35EFKOZD (Sheet 1 of 2)

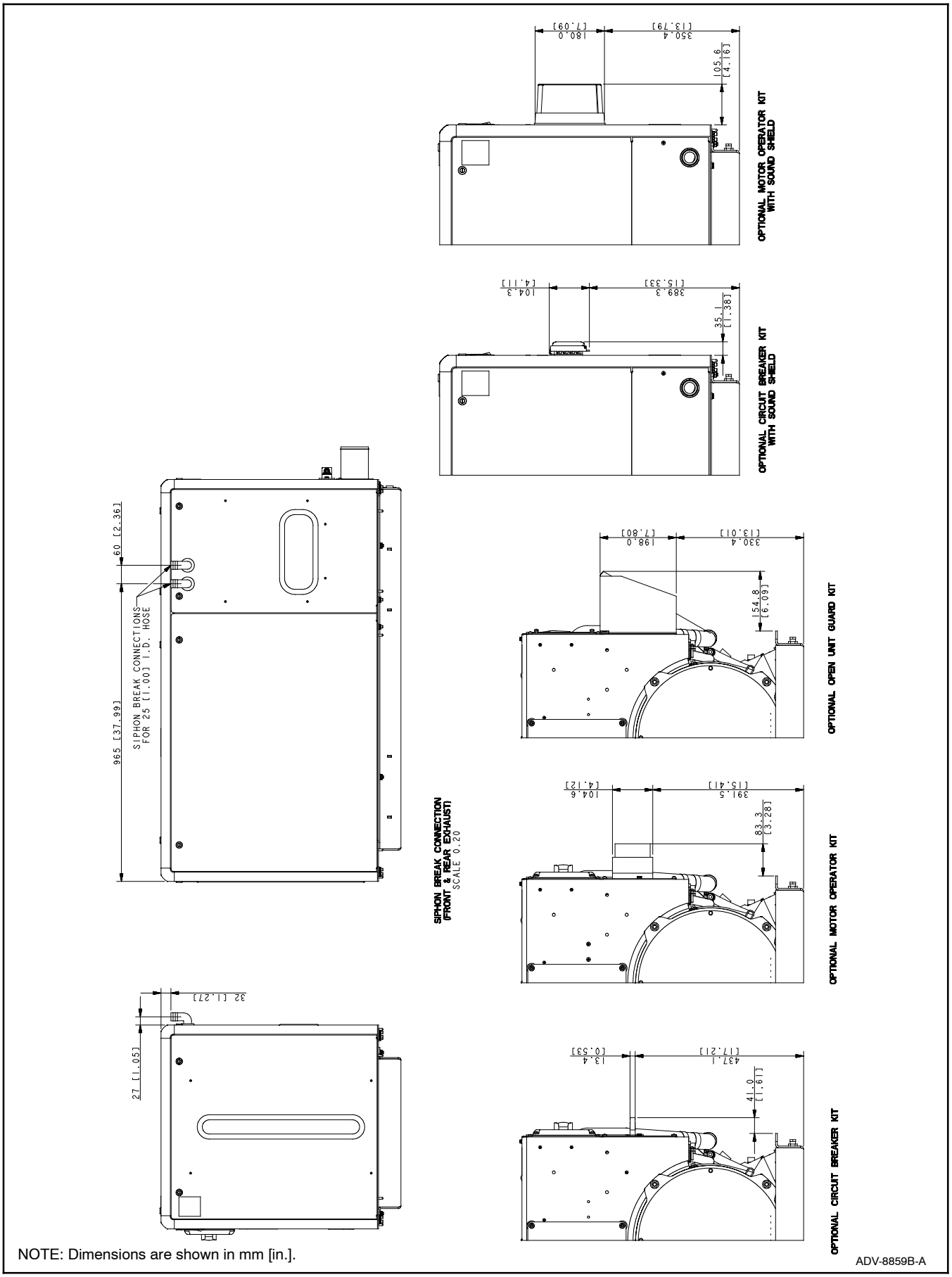


Figure 7-19 Accessory Drawing—Siphon Break Connection, 32/40EKOZD and 28/35EFKOZD (Sheet 2 of 2)

Notes

8.1 Voltage Reconnection

Use the following voltage reconnection procedure to change the voltage of 4- and 12-lead generator sets. Frequency changes require voltage regulator *and* governor adjustments.

Refer to the following procedure and the connection schematics. Follow the safety precautions at the front of this manual and in the procedure text and observe National Electrical Code (NEC) guidelines.

NOTICE

This generator set has been rewired from its nameplate voltage to

246242

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.

Note: Equipment damage. Verify that the voltage ratings of the transfer switch, line circuit breakers, and other accessories match the selected line voltage.

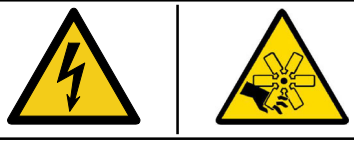
⚠ WARNING

Accidental starting.
Can cause severe injury or death.

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.

⚠ DANGER



Hazardous voltage. Moving parts. Will cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Grounding electrical equipment. Hazardous voltage will 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 will 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.

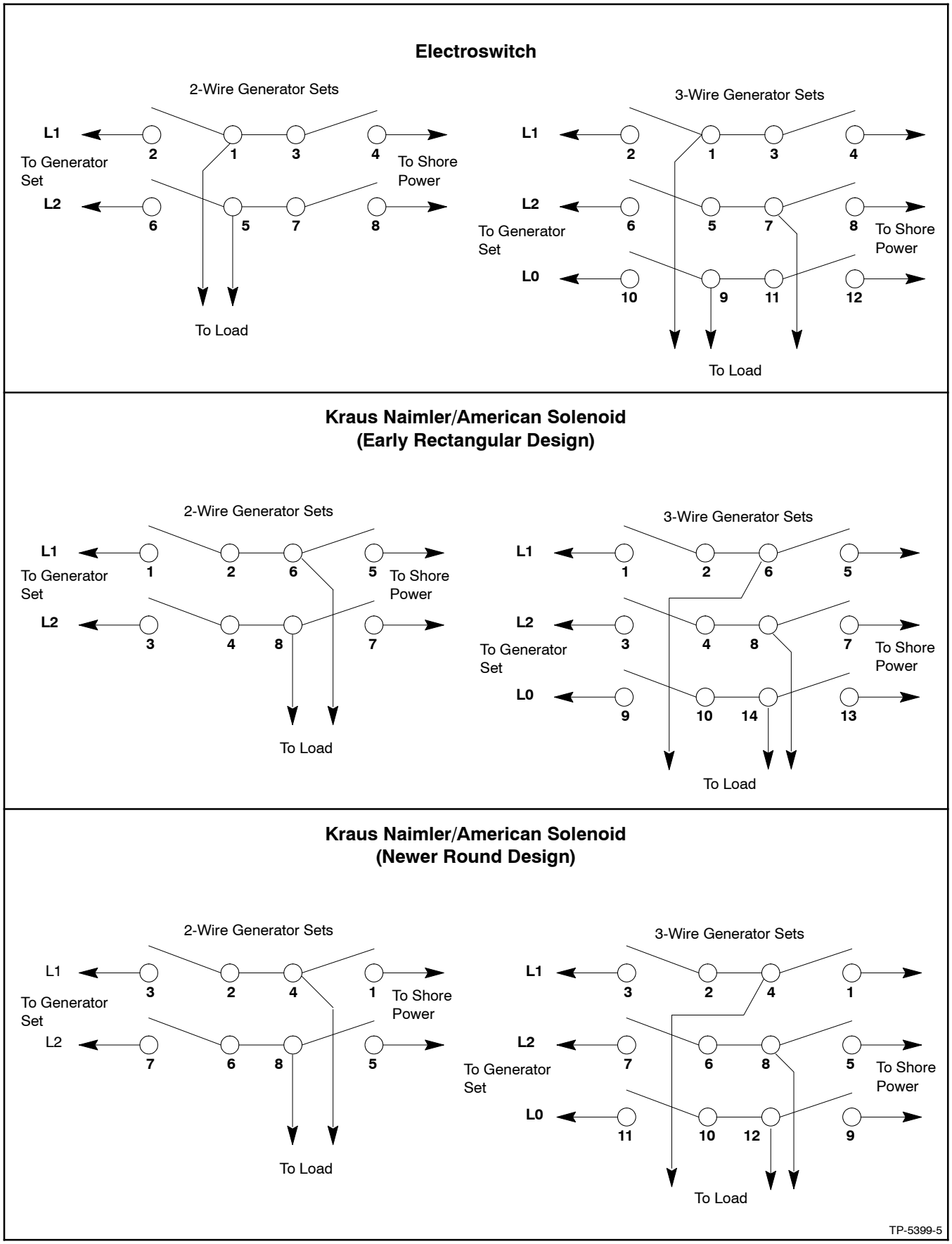


Figure 8-1 Marine Manual (Ship-to-Shore) Transfer Switch

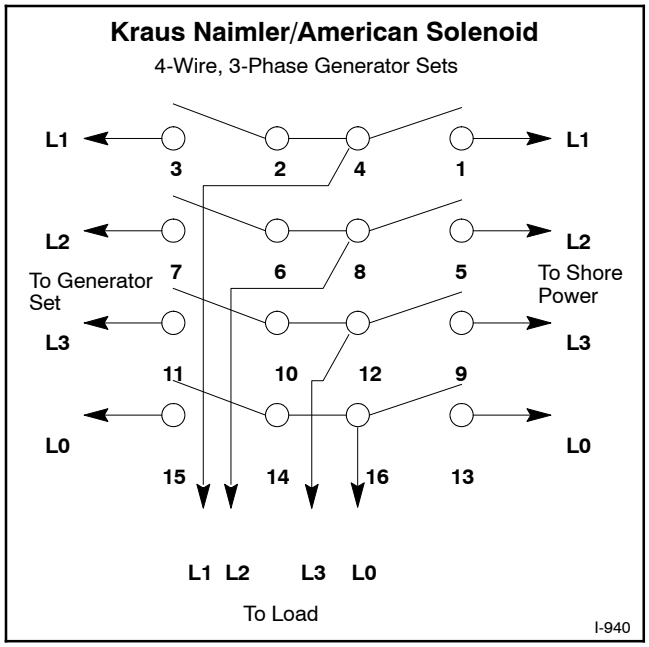


Figure 8-2 Marine Manual (Ship-to-Shore) Transfer Switch, continued

8.2 Twelve-Lead Reconnection

The reconnection procedure details voltage reconnections only.

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.

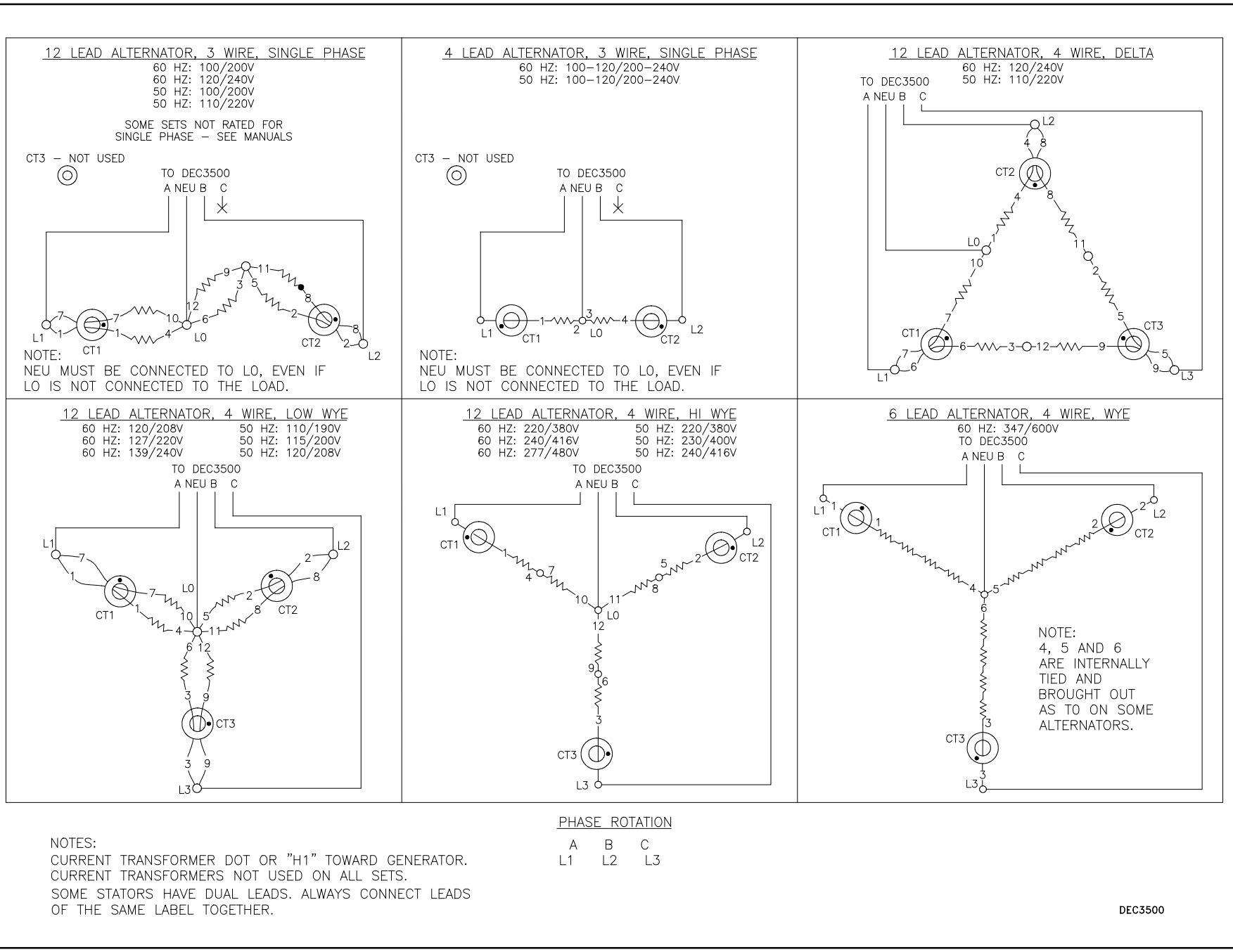
NOTICE

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. Press the generator set OFF/RESET button to shut down the generator set.
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, route leads through current transformers (CTs) and connect the leads according to the diagram for the desired phase and voltage.

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



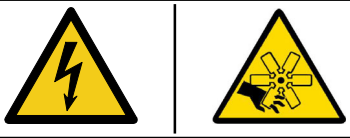
⚠ WARNING

Accidental starting.
Can cause severe injury or death.

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) 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.

⚠ DANGER



Hazardous voltage. Moving parts.
Will cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Grounding electrical equipment. Hazardous voltage will 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.

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.

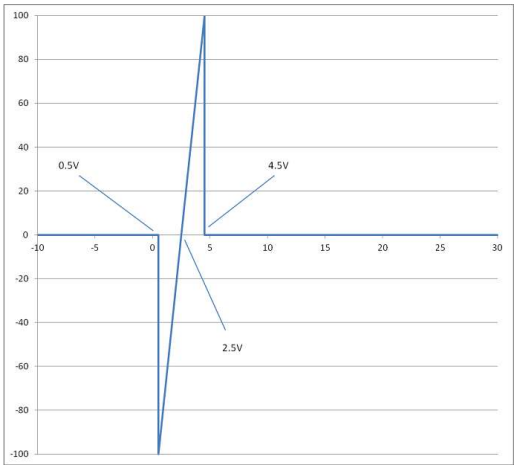
Speed Bias is the amount that the controller is attempting to adjust the output frequency of the generator (100% bias = +5% on the engine speed, - 100% = - 5% on the engine speed). The controller adjusts the Speed Bias to match frequency and phase with the paralleling bus.

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.



Range: -100.00% – 100.00%
Default: 0.00% **Not Writable**

Figure 9-1 Speed Bias

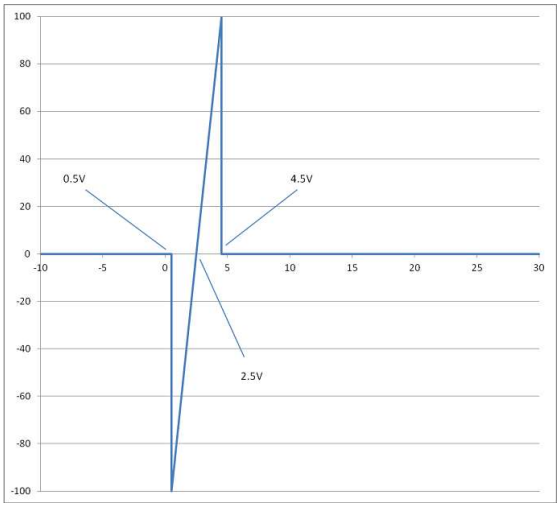
Voltage Bias is the amount that the controller is attempting to adjust the output voltage (100% bias = +10% on the output voltage, - 100% = - 10% on the output voltage). The controller adjusts the voltage bias to match the generator voltage to the bus voltage.

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



Range: -100.00% – 100.00%
Default: 0.00% **Not Writable**

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 is one option:

- 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 ±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%.

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 ±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.

Modbus® is a registered trademark of Schneider Electric.

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.

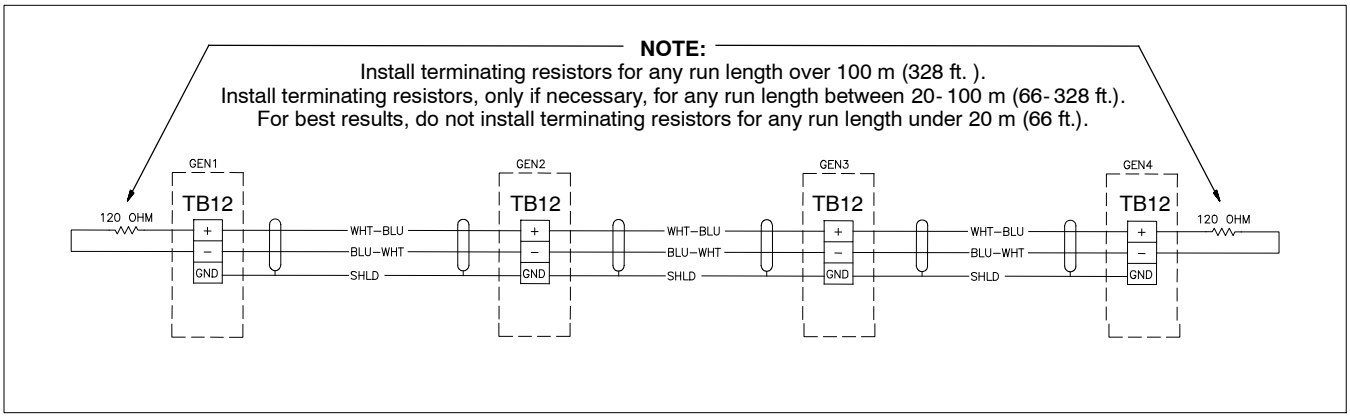
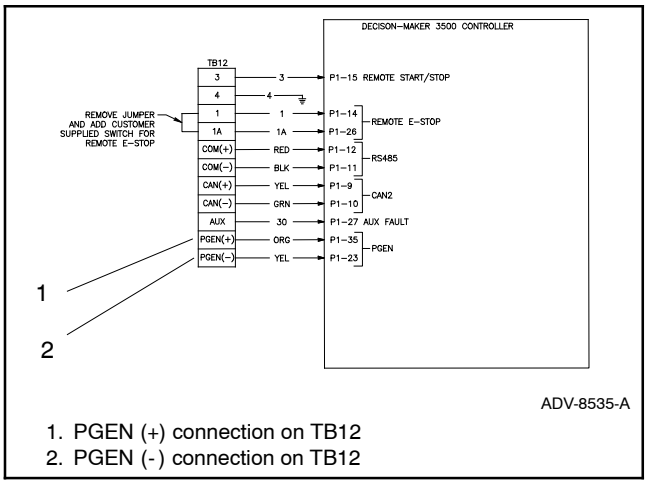


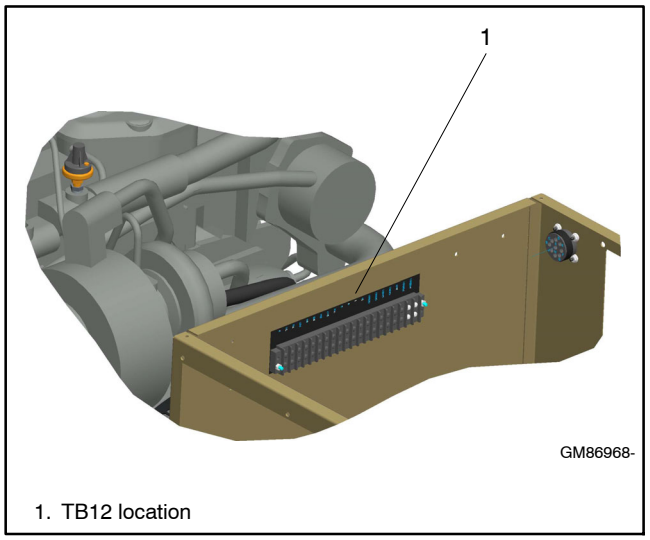
Figure 9-3 Paralleling System Interconnection Diagram

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.



1. PGEN (+) connection on TB12
2. PGEN (-) connection on TB12

Figure 9-4 Terminal Block TB12 PGEN Connections



1. TB12 location

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

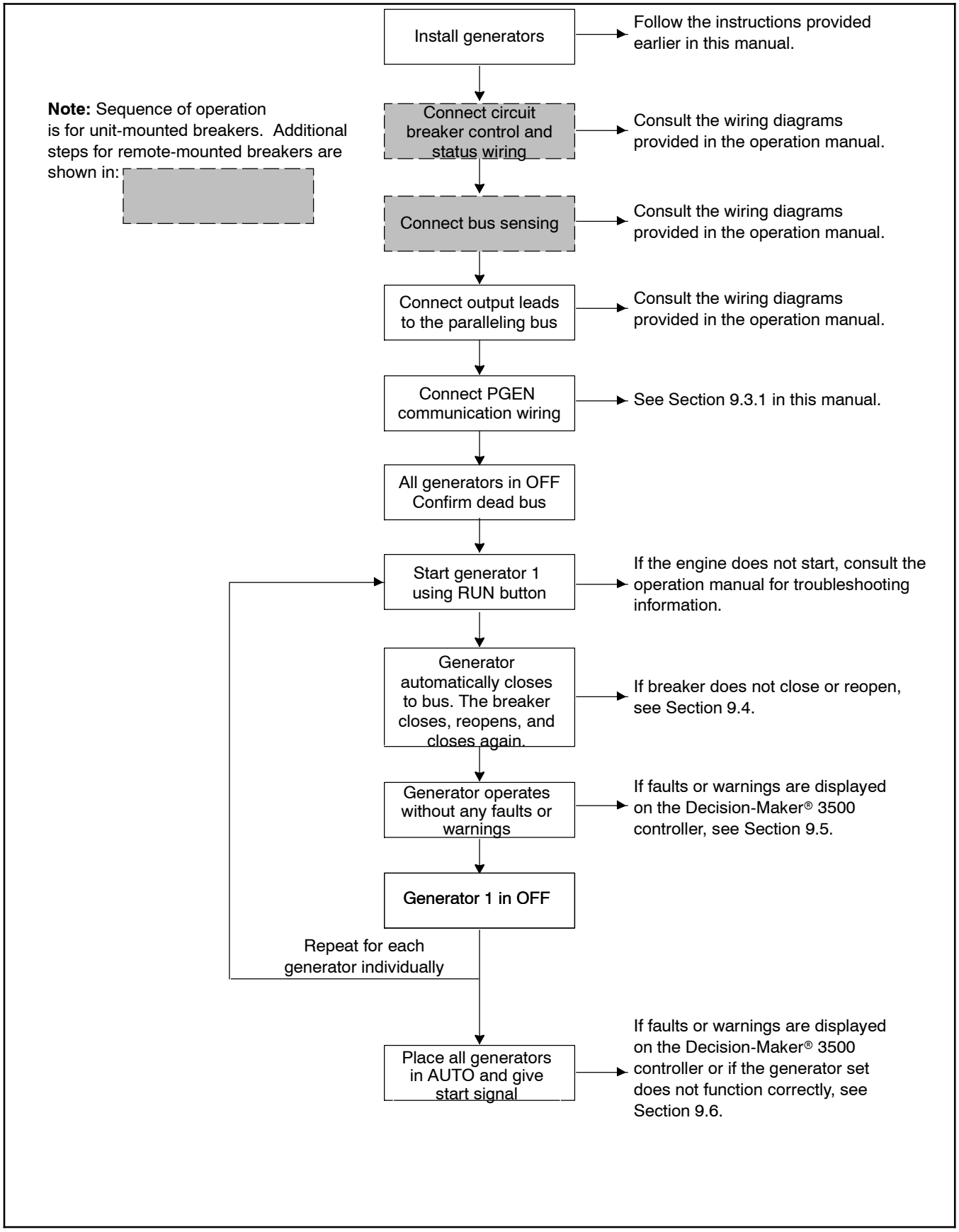


Figure 9-6 Sequence of Operation

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 *Controller Config -> Communication Setup*, 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 *Controller Config -> Communication Setup*, 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 *Controller Config -> Communication Setup*, 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
Fault: System Voltage Mismatch Between Generators			
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.
Fault: System Frequency Mismatch Between Generators			
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.
Fault: Phase Connection Mismatch Between Generators			
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.
Fault: Live Bus Sensed When Dead Bus Expected			
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.
Fault: Close Attempt **Fault: Fail to Close**			
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
Fault: Close Attempt Fault: Fail to Close (Continued)			
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.
Fault: CB Status Warning: Bus Sensing Not Connected			
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.
Fault: CB Status or Continuous Breaker Cycling			
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
Fault: Close Attempt **Fault: Fail to Close**			
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.
Fault: CB Status			
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: 11 and 14 21 and 24 31 and 34 or 41 and 44. 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.
Fault: Bus Phase Rotation Mismatch			
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
Fault: Bus Voltage Amplitude Mismatch- Phase A			
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.
Fault: Bus Voltage Amplitude Mismatch- Phase 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.
Fault: Bus Voltage Amplitude Mismatch- Phase C			
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.
Fault: Bus Voltage Amplitude Mismatch			
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.
Fault: Phase Angle Mismatch			
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.
Fault: Bus Frequency Mismatch			
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
Fault: Bus Sensing Phases A and B are Reversed			
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.
Fault: Bus Sensing Phases B and C are Reversed			
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.
Fault: Bus Sensing Phases C and A are Reversed			
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.
Fault: Bus Sensing Not Connected			
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
Fault: Bus Sensing Connected to Generator Side of Breaker			
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.
Fault: Failure to Open			
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
Fault: Generator Phase Rotation Mismatch			
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.
Fault: Dead Bus Sensed When Live Bus Expected			
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.
Fault: Bus Voltage Out of Spec			
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
Fault: Bus Frequency Out of Spec			
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.
Fault: Failure to Synchronize			
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.
Fault: Generator Voltage Average Line to Line: High Warning			
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.
Fault: Generator Voltage Average Line to Line: Low Warning			
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
Fault: AC Frequency: High Warning			
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.
Fault: AC Frequency: Low Warning			
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.
Fault: Generator Total Real Power: High Warning			
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.
Fault: Generator Total Real Power: Low Warning			
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.
Fault: Generator Current Average: High Warning			
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
Fault: Generator Total Reactive Power: Low Warning			
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.
Fault: Generator Management Enabled: Erroneous Data Received Warning			
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 kWs 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 kWs 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.

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
ABDC	after bottom dead center
AC	alternating current
A/D	analog to digital
ADC	analog to digital converter
adj.	adjust, adjustment
ADV	advertising dimensional drawing
AHWT	anticipatory high water temperature
AISI	American Iron and Steel Institute
ALOP	anticipatory low oil pressure
alt.	alternator
Al	aluminum
ANSI	American National Standards Institute (formerly American Standards Association, ASA)
AO	anticipatory only
API	American Petroleum Institute
approx.	approximate, approximately
AR	as required, as requested
AS	as supplied, as stated, as suggested
ASE	American Society of Engineers
ASME	American Society of Mechanical Engineers
assy.	assembly
ASTM	American Society for Testing Materials
ATDC	after top dead center
ATS	automatic transfer switch
auto.	automatic
aux.	auxiliary
A/V	audiovisual
avg.	average
AVR	automatic voltage regulator
AWG	American Wire Gauge
AWM	appliance wiring material
bat.	battery
BBDC	before bottom dead center
BC	battery charger, battery charging
BCA	battery charging alternator
BCI	Battery Council International
BDC	before dead center
BHP	brake horsepower
blk.	black (paint color), block (engine)
blk. htr.	block heater
BMEP	brake mean effective pressure
bps	bits per second
br.	brass
BTDC	before top dead center
Btu	British thermal unit
Btu/min.	British thermal units per minute
C	Celsius, centigrade
cal.	calorie
CARB	California Air Resources Board
CB	circuit breaker
cc	cubic centimeter
CCA	cold cranking amps
ccw.	counterclockwise
CEC	Canadian Electrical Code
cfh	cubic feet per hour
cfm	cubic feet per minute
CG	center of gravity
CID	cubic inch displacement
CL	centerline
cm	centimeter
CMOS	complementary metal oxide substrate (semiconductor)
cogen.	cogeneration
Com	communications (port)
conn.	connection
cont.	continued
CPVC	chlorinated polyvinyl chloride
crit.	critical
CRT	cathode ray tube
CSA	Canadian Standards Association
CT	current transformer
Cu	copper
cu. in.	cubic inch
cw.	clockwise
CWC	city water-cooled
cyl.	cylinder
D/A	digital to analog
DAC	digital to analog converter
dB	decibel
dBA	decibel (A weighted)
DC	direct current
DCR	direct current resistance
deg., °	degree
dept.	department
dia.	diameter
DI/EO	dual inlet/end outlet
DIN	Deutsches Institut fur Normung e. V. (also Deutsche Industrie Normenausschuss)
DIP	dual inline package
DPDT	double-pole, double-throw
DPST	double-pole, single-throw
DS	disconnect switch
DVR	digital voltage regulator
E, emer.	emergency (power source)
EDI	electronic data interchange
EFR	emergency frequency relay
e.g.	for example (*exempli gratia)*
EG	electronic governor
EGSA	Electrical Generating Systems Association
EIA	Electronic Industries Association
EI/EO	end inlet/end outlet
EMI	electromagnetic interference
emiss.	emission
eng.	engine
EPA	Environmental Protection Agency
EPS	emergency power system
ER	emergency relay
ES	engineering special, engineered special
ESD	electrostatic discharge
est.	estimated
E-Stop	emergency stop
etc.	et cetera (and so forth)
exh.	exhaust
ext.	external
F	Fahrenheit, female
fglass.	fiberglass
FHM	flat head machine (screw)
fl. oz.	fluid ounce
flex.	flexible
freq.	frequency
FS	full scale
ft.	foot, feet
ft. lbs.	foot pounds (torque)
ft./min.	feet per minute
g	gram
ga.	gauge (meters, wire size)
gal.	gallon
gen.	generator
genset	generator set
GFI	ground fault interrupter
GND, ⏚	ground
gov.	governor
gph	gallons per hour
gpm	gallons per minute
gr.	grade, gross
GRD	equipment ground
gr. wt.	gross weight
H x W x D	height by width by depth
HC	hex cap
HCHT	high cylinder head temperature
HD	heavy duty
HET	high exhaust temperature
hex	hexagon
Hg	mercury (element)
HH	hex head
HHC	hex head cap
HP	horsepower
hr.	hour
HS	heat shrink
hsg.	housing
HVAC	heating, ventilation, and air conditioning
HWT	high water temperature
Hz	hertz (cycles per second)
IC	integrated circuit
ID	inside diameter, identification
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IMS	improved motor starting
in.	inch
in. H_2O	inches of water
in. Hg	inches of mercury
in. lbs.	inch pounds
Inc.	incorporated
ind.	industrial
int.	internal
int./ext.	internal/external
I/O	input/output
IP	iron pipe
ISO	International Organization for Standardization
J	joule
JIS	Japanese Industry Standard
k	kilo (1000)
K	kelvin
kA	kiloampere
KB	kilobyte (2^{10} bytes)

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

Appendix C Generator Set Output Ratings Procedure

Kohler Co. develops the kilowatt output rating of a Kohler® marine generator set based upon the calculations specified in ISO 3046 and ISO 8528-1. The calculations *correct* for environmental variables encountered in a generator set installation. Figure 1 outlines the calculations. Figure 2 contains examples of how heat variables affect generator set ratings.

Generator Output $_{corrected}$ = Generator Output $_{observed}$ x Correction Factor
Output power is expected to be within ±5% of the specified rating when corrected to reference conditions. Correction factors are determined using the following formulas:
1. For naturally aspirated compression-ignition engines (power limited by excess air): C.F. = [1.175 (29.2 / Dry Barometer in. Hg)^{1} (Temperature °F + 460/537)$^{.75}$ - .175] x Alternator Efficiency $_{Reference}$ / Alternator Efficiency $_{Observed}$
2. For turbocharged compression ignition engines: C.F. = [1.175 (29.2 / Barometer $_{Observed}$ in. Hg)$^{.7}$ (Temperature °F + 460/537)^{2} - .175] x Alternator Efficiency $_{Reference}$ / Alternator Efficiency $_{Observed}$
3. For turbocharged and intercooled compression ignition engines: C.F. = [1.175 (29.2 / Barometer $_{Observed}$ in. Hg)$^{.7}$ (Temperature °F + 460/537)$^{1.2}$ - .175] x Alternator Efficiency $_{Reference}$ / Alternator Efficiency $_{Observed}$
Reference conditions: Temperature: 77°F; Pressure: 29.2 in. Hg dry barometer. Kohler sound shield increases ambient intake air approx. 12°F Approximate derates: Temperature: approximately 1% per 10°F (turbocharged engines have a greater derate); Pressure (altitude): approximately 4% per 1000 ft. (1 in. Hg)

Figure 1 Generator Output

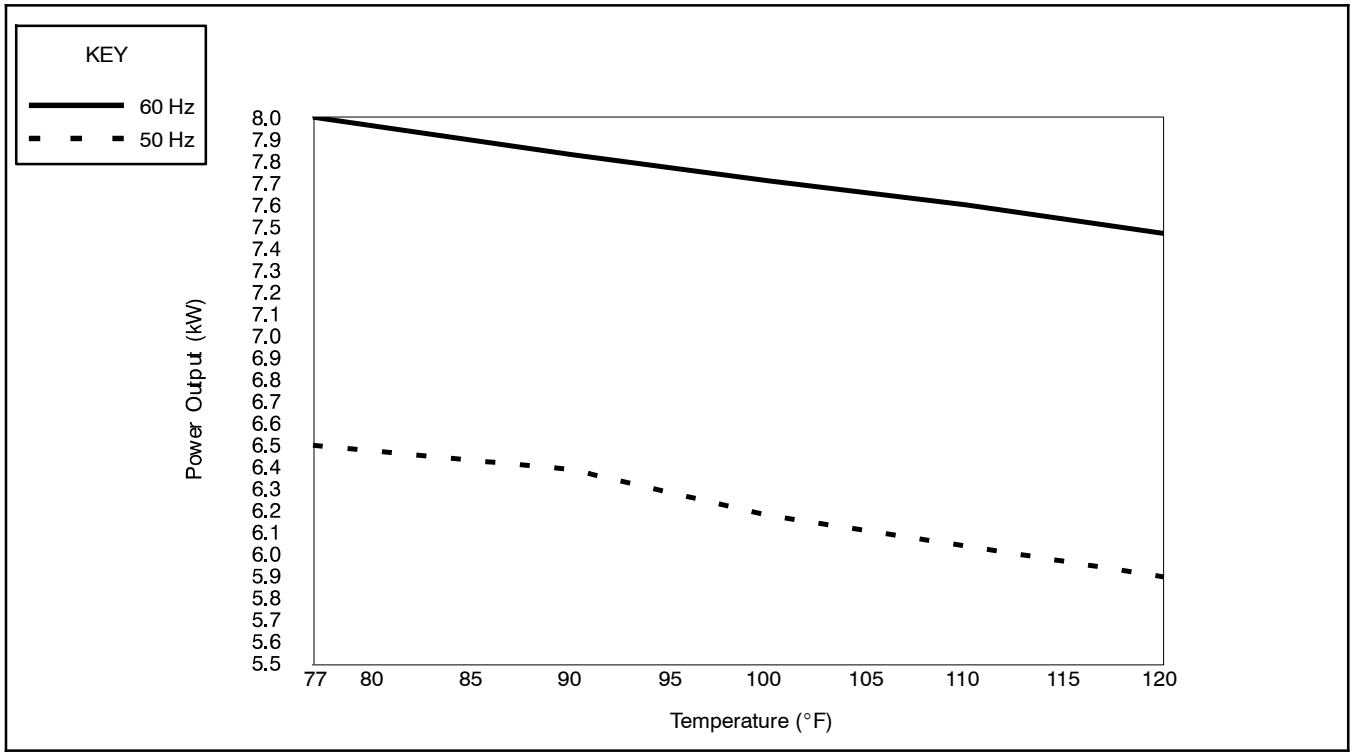


Figure 2 Example: 6.5EFOZ/8EOZ kW Derates (ISO 3046/ISO 8258-1)

TP-7045 2/23d

Original Instructions (English)

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